SUNCOR ENERGY

Project Millennium Application

Submitted to **Alberta Energy and Utilities Board** and **Alberta Environmental Protection**

Supplemental Information Response
1998

Project Millennium
Taking Suncor into the 21st Century

SUNCOR ENERGY

OIL SANDS

Suncor Energy Inc.
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August 6, 1998

D.I.R. Henderson, P. Eng
Staff Engineer
Mine Development Group
Alberta Environment & Utility Board
640-5 Avenue SW
Calgary AB T2P 3G4

Dear Mr. Henderson

Supplemental Information Request
Suncor Millennium Project
EUB Application No. 980197, Registered 21 April 1998
EPEA Application No. 014-094, WRA File No. 27549/27551

Attached is Suncor's response to the above request. The responses have been prepared according to the request document referred to in your letter of July 28, 1998.

In addition to supplemental responses, the report includes a section on new information which provides an update of Project Millennium as well as revised SO_2 dispersion modelling analyses, ozone modelling analyses, revised particulate and aerosols analyses, and additional health analyses. Re-submitted items, as indicated in the errata, are included in the appendices for replacement into the Project Millennium Application binders.

We are delivering the specified number of copies of our response to the EUB & AEP.

Please call me at (403)743-6892 with any matters related to the Supplemental response.

Yours truly

SUNCOR ENERGY OIL SANDS

for Mark Shaw
Director
Sustainable Development

DK/af

Attachment

cc: Ralph Dyer, AEP, Annette Trimbee, AEP, Richard Houlihan, EUB,
Fred Hnytka, DFO, Ryerson Christie, CEAA

Project Millennium

Taking Suncor into the 21st Century

SUPPLEMENTAL INFORMATION RESPONSE

AUGUST 6, 1998

SUNCOR ENERGY

Common Name	*Scientific Name*
VEGETATION	
Club-moss Family	**LYCOPODIACEAE**
Stiff Club-moss	*Lycopodium annotinum*
Running Club-moss	*L. clavatum*
Tree Club-moss	*L. obscurum*
Little Club-moss Family	**SELAGINELLACEAE**
Little Club-moss	*Selaginella selaginoides*
Horsetail Family	**EQUISETACEAE**
Common Horsetail	*Equisetum arvense*
Swamp Horsetail	*E. fluviatile*
Meadow Horsetail	*E. pratense*
Woodland Horsetail	*E. sylvaticum*
Dwarf Scouring Rush	*E. scirpoides*
Adder's-tongue Family	**OPHIOGLOSSACEAE**
Grape Fern	*Botrychium virginianum*
Fern Family	**POLYPODIACEAE**
Narrow Spinulose Shield Fern	*Dryopteris carthusiana*
Oak Fern	*Gymnocarpium dryopteris*
Ostrich Fern	*Matteuccia struthiopteris*
Cypress Family	**CUPRESSACEAE**
Ground Juniper	*Juniperus communis*
Pine Family	**PINACEAE**
Balsam Fir	*Abies balsamea*
Larch	*Larix laricina*
White Spruce	*Picea glauca*
Black Spruce	*P. mariana*
Jack Pine	*Pinus banksiana*
Cattail Family	**TYPHACEAE**
Common Cattail	*Typha latifolia*
Bur-reed Family	**SPARGANIACEAE**
Narrow-Leaved Bur-reed	*Sparganium angustifolium*
Giant Bur-reed	*S. eurycarpum*
Pondweed Family	**POTAMOGETONACEAE**
Various-leaved Pondweed	*Potamogeton gramineus*
Pondweed	*P. obtusifolius*
Clasping-leaf Pondweed	*P. richardsonii*
Arrow-grass Family	**JUNCAGINACEAE**
Arrow-grass	*Triglochin maritima*
Slender Arrow-grass	*T. palustris*
Scheuchzeria Family	**SCHEUCHERIACEAE**
Scheuchzeria	*Scheuchzeria palustris*
Water-plantain	**ALISMATACEAE**
Arrowhead	*Sagittaria cuneata*
Grass Family	**GRAMINEAE**
Tickle Grass	*Agrostis scabra*
Macoun's Wild Rye	*Agrohordeum macounii*

Common Name	*Scientific Name*
Slender Wheat Grass	*Agropyron trachycaulum*
Water Foxtail	*Alopecurus aequalis*
Slough Grass	*Beckmannia syzigachne*
Fringed Brome	*Bromus ciliatus*
Awnless Brome	*B. inermis*
Marsh Reed Grass	*Calamagrostis canadensis*
Northern Reed Grass	*C. inexpansa*
Narrow Reed Grass	*C. stricta*
Drooping Wood Reed	*Cinna latifolia*
Tufted Hair Grass	*Deschampsia cespitosa*
Canada Wild Rye	*Elymus canadensis*
Hairy Wild Rye	*E. innovatus*
Northern Rough Fescue	*Festuca saximontana*
Tall Manna Grass	*Glyceria grandis*
Sweet Grass	*Hierochloe odorata*
Foxtail Barley	*Hordeum jubatum*
Rough-leaved Rice Grass	*Oryzopsis asperifolia*
Northern Rice Grass	*O. pungens*
Reed Canary Grass	*Phalaris arundinacea*
Common Reed Grass	*Phragmites australis*
Wood Blue Grass	*Poa interior*
Fowl Bluegrass	*P. palustris*
Kentucky Bluegrass	*P. pratensis*
False Melic	*Schizachne purpurascens*
Cord Grass	*Spartina pectinata*
Slender Wedge Grass	*Sphenopholis intermedia*
Needle Grass	*Stipa curtiseta*
Sedge Family	**CYPERACEAE**
Silvery-flowered Sedge	*Carex aenea*
Water Sedge	*C. aquatilis*
Golden Sedge	*C. aurea*
Bebb's Sedge	*C. bebbii*
Brownish Sedge	*C. brunnescens*
Hair-Like Sedge	*C. capillaris*
Beautiful Sedge	*C. concinna*
Short Sedge	*C. curta (in. C. brunnescens group)*
Dewey's Sedge	*C. deweyana*
Two-stamened Sedge	*C. diandra*
Two-seeded Sedge	*C. disperma*
Northern Bog Sedge	*C. gynocrates*
Sand Sedge	*C. houghtoniana*
Inland Sedge	*C. interior*
Lakeshore Sedge	*C. lacustris*
Bristle-stalked Sedge	*C. leptalea*
Hairy-fruited Sedge	*C. lasiocarpa*
Mud Sedge	*C. limosa*

Common Name	*Scientific Name*
Norway Sedge	*C. norvegica*
Beacked Sedge	*C. utriculata*
Few-fruited Sedge	*C. oligosperma*
Bog Sedge	*C. paupercula*
Peck's Sedge	*C. peckii*
Meadow Sedge	*C. praticola*
Raymond's Sedge	*C. raymondii*
Ross' Sedge	*C. rossii*
Turned Sedge	*C. retrorsa*
Sartwell's Sedge	*C. sartwellii*
Sprengel's Sedge	*C. sprengellii*
Hay Sedge	*C. siccata*
Twin-flowered Sedge	*C. tenuiflora*
Sheathed Sedge	*C. vaginata*
Needle Spike-rush	*Eleocharis acicularis*
Creeping Spike-rush	*E. palustris*
Close-sheathed Cotton-grass	*Eriophorum brachyantherum*
Slender Cotton -grass	*E. gracile*
Tall Cotton-grass	*E. polystachion*
Sheathed Cotton-grass	*E. vaginatum*
Tufted Bulrush	*Scirpus cespitosus*
Small-fruited Bulrush	*S. microcarpus*
Arum Family	**ARACEAE**
Sweet Flay	*Acorus americanus*
Water Arum	*Calla palustris*
Duckweed Family	**LEMNACEAE**
Common Duckweed	*Lemna minor*
Ivy Duckweed	*L. trisulca*
Rush Family	**JUNCACEAE**
Wire Rush	*Juncus balticus*
Toad Rush	*J. bufonius*
Chestnut Rush	*J. castaneus*
Slender Rush	*J. tenuis*
Big-head Rush	*J. vaseyi*
Small-flowered Wood Rush	*Luzula parviflora*
Lily Family	**LILIACEAE**
Fairybells	*Disporum trachycaulum*
Rough-fruited Fairybells	*D. trachycarpum*
Western Wood Lily	*Lilium philadelphicum*
Wild Lily-of-the-valley	*Maianthemum canadense*
Star-flowered Solomon's-seal	*Smilacina stellata*
Three-leaved Solomon's-seal	*S. trifolia*
Twisted-stalk	*Streptopus amplexifolius*
Sticky False Asphodel	*Tofieldia glutinosa*
Iris Family	**IRIDACEAE**
Common Blue-eyed Grass	*Sisyrinchium montanum*

Common Name	*Scientific Name*
Orchid Family	**ORCHIDACEAE**
Pale Coral-root	*Corallorhiza trifida*
Yellow Lady's-slipper	*Cypripedium calceolus*
Lesser Rattlesnake-plantain	*Goodyera repens*
Northern Green Orchid	*Habenaria hyperborea*
Blunt-leaved Orchid	*H. obtusata*
Round-leaved Orchid	*H. orbiculata*
Bracted Orchid	*H. viridis*
Round-leaved Orchid	*Orchis rotundifolia*
Ladies'-tresses	*Spiranthes romanzoffiana*
Willow Family	**SALICACEAE**
Balsam Poplar	*Populus balsamifera*
Trembling Aspen	*P. tremuloides*
Little-tree Willow	*Salix arbusculoides*
Beaked Willow	*S. bebbiana*
Hoary Willow	*S. candida*
Pussy Willow	*S. discolor*
Satin willow	*S. drummondiana*
Sandbar Willow	*S. exigua*
Grey-leaved Willow	*Salix glauca*
Shinning Willow	*S. lucida*
Yellow Willow	*S. lutea*
Myrtle-leaved Willow	*S. myrtillifolia*
Bog Willow	*S. pedicellaris*
Basket Willow	*S. petiolaris*
Flat-leaved Willow	*S. planifolia*
Mountain Willow	*S. pseudomonticola*
Balsam Willow	*S. pyrifolia*
Scouler's Willow	*S. scouleriana*
Autumn Willow	*S. serissima*
Sweet Gale Family	**MYRICACEAE**
Sweet Gale	*Myrica gale*
Birch Family	**BETULACEAE**
Green Alder	*Alnus crispa*
River Alder	*A. tenuifolia*
Bog Birch	*Betula glandulosa*
Alaska Birch	*B. neoalaskana*
White Birch	*B. papyrifera*
Dwarf Birch	*B. pumila*
Beaked Hazelnut	*Corylus cornuta*
Nettle Family	**URTICACAEAE**
Common Nettle	*Urtica dioica*
Sandalwood Family	**SANTALACEAE**
Bastard Toad-flax	*Comandra umbellata*
Northern Bastard Toad-flax	*Geocaulon lividum*
Mistletoe Family	**LORANTHACEAE**

Common Name	*Scientific Name*
Dwarf Mistletoe	*Arceuthobium americanum*
Buckwheat Family	**POLYGONACEAE**
Water Smartweed	*Polygonum amphibium*
Striate Knotweed	*P. erectum*
Pale Persicaria	*P. lapathifolium*
Alpine Bistort	*P. viviparum*
Western Dock	*Rumex occidentalis*
Narrow-leaved Dock	*R. triangulivalis*
Goosefoot Family	**CHENOPODIACEAE**
Strawberry Blite	*Chenopodium capitatum*
Pink Family	**CARYOPHYLLACEAE**
Nodding Chickweed	*Cerastium nutans*
Blunt-leaved Sandwort	*Moehringia lateriflora*
Long-leaved Chickweed	*Stellaria longifolia*
Long-stalked Chickweed	*S. longipes*
Water-lily Family	**NYMPHAEACEAE**
Yellow Pond-lily	*Nuphar variegatum*
Hornwort Family	**CERATOPHYLLACEAE**
Hornwort	*Ceratophyllum demersum*
Crowfoot Family	**RANUNCULACEAE**
Red and White Baneberry	*Actaea rubra*
Canada Anemone	*Anemone canadensis*
Cut-leaved Anemone	*A. multifida*
Small Wood Anemone	*A. parviflora*
Prairie Crocus	*A. patens*
Blue Columbine	*Aquilegia brevistyla*
Marsh Marigold	*Caltha palustris*
Floating Marsh-marigold	*Caltha natans*
Goldthread	*Coptis trifolia*
Tall Larkspur	*Delphinium glaucum*
Small-flowered Crowfoot	*Ranunculus abortivus*
Seaside Crowfoot	*R. cymbalaria*
Yellow Water Crowfoot	*R. gmelinii*
Boreal Buttercup	*R. hyperboreus*
Lapland Buttercup	*R. lapponicus*
Macoun's Buttercup	*R. macounii*
Bristly Buttercup	*R. pensylvanicus*
Cursed Buttercup	*R. sceleratus*
Flat-fruited Meadow Rue	*Thalictrum sparsiflorum*
Veiny Meadow Rue	*T. venulosum*
Fumitory Family	**FUMARIACEAE**
Golden Corydalis	*Corydalis aurea*
Pink Corydalis	*C. sempervirens*
Mustard Family	**CRUCIFERAE**
Hairy Rock Cress	*Arabis hirsuta*
Lyre-leaved Rock Cress	*A. lyrata*

Common Name	***Scientific Name***
Pennsylvanian Bitter Cress	*Cardamine pensylvanica*
Green Tansy Mustard	*Descurainia pinnata*
Grey Tansy Mustard	*D. richardsonii*
Annual Whitlow-grass	*Draba nemorosa*
Wormseed Mustard	*Erysimum cheiranthoides*
Common Peppergrass	*Lepidium bourgeauanum*
Common Peppergrass	*L. densiflorum*
Yellow Cress	*Rorippa palustris*
Pitcher-plant Family	**SARRACENIACEAE**
Pitcher-plant	*Sarracenia purpurea*
Sundew Family	**DROSERACEAE**
Sundew	*Drosera rotundifolia*
Saxifrage Family	**SAXIFRAGACEAE**
Golden Iowense	*Chrysosplenium iowense*
Bishop's-cap	*Mitella nuda*
Grass-of-Parnassus Family	**PARNASSIACEAE**
Northern Grass-of-Parnassus	*Parnassia palustris*
Currant or Gooseberry Family	**GROSSULARIACEAE**
Skunk Currant	*Ribes glandulosum*
Wild Black Currant	*R. hudsonianum*
Bristly Black Currant	*R. lacustre*
Wild Gooseberry	*R. oxyacanthoides*
Wild Red Currant	*R. triste*
Rose Family	**ROSSACEAE**
Saskatoon	*Amelanchier alnifolia*
Woodland Strawberry	*Fragaria vesca*
Wild Strawberry	*F. virginiana*
Yellow Avens	*Geum macrophyllum*
Silverweed	*Potentilla anserina*
White Cinquefoil	*P. arguta*
Plains Cinquefoil	*Potentilla bipinnatifida*
Shrubby Cinquefoil	*P. fruticosa*
Graceful Cinquefoil	*P. gracilis*
Rough Cinquefoil	*P. norvegica*
Marsh Cinquefoil	*P. palustris*
Three-toothed Cinquefoil	*P. tridentata*
Pin Cherry	*Prunus pensylvanica*
Choke Cherry	*P. virginiana*
Prickly Rose	*Rosa acicularis*
Dwarf Raspberry	*Rubus arcticus*
Cloudberry	*R. chamaemorus*
Wild Red Raspberry	*R. idaeus*
Dewberry	*R. pubescens*
Pea Family	**LEGUMINOSAE**
American Milk Vetch	*Astragalus americanus*
Yukon Milk Vetch	*A. bodinii*

Common Name	*Scientific Name*
Canadian Milk Vetch	*A. canadensis*
Pretty Milk Vetch	*A. eucosmus*
Wild Licorice	*Glycyrrhiza lepidota*
Alpine Hedysarum	*Hedysarum alpinum*
Northern Hedysarum	*H. boreale*
Creamy Pea Vine	*Lathyrus ochroleucus*
Showy Loco-weed	*Oxytropis splendens*
Wild Vetch	*Vicia americana*
Geranium Family	**GERANIACEAE**
Bicknell's Geranium	*Geranium bicknellii*
Flax family	**LINACEAE**
Wild Blue Flax	*Linum lewisii*
Milkwort Family	**POLYGALACEAE**
Fringed Milkwort	*Polygala paucifolia*
Touch-me-not Family	**BALSAMINACEAE**
Spotted Touch-me-not	*Impatiens capensis*
Water-starwort Family	**CALLITRICHACEAE**
Vernal Water-starwort	*Callitriche verna*
Crowberry Family	**EMPETRACEAE**
Crowberry	*Empetrum nigrum*
Buckthorn Family	**RHAMNACEAE**
Alder-leaved Buckthorn	*Rhamnus alnifolia*
Rockrose Family	**CISTACEAE**
Sand Heather	*Hudsonia tomentosa*
Violet Family	**VIOLACEAE**
Early Blue Violet	*Viola adunca*
Western Canada Violet	*V. canadensis*
Marsh Violet	*V. palustris*
Kidnet-leaved Violet	*V. renifolia*
Oleaster Family	**ELAEAGNACEAE**
Wolf Willow	*Elaeagnus commutata*
Canadian Buffaloberry	*Shepherdia canadensis*
Evening Primrose Family	**ONAGRACEAE**
Small Enchanter's Nightshade	*Circaea alpina*
Fireweed	*Epilobium angustifolium*
Northern Willowherb	*E. ciliatum*
Purple-leaved Willowherb	*E. glandulosum*
Narrow-leaved Willowherb	*E. leptophyllum*
Mare's-tail Family	**HIPPURIDACEAE**
Common Mare's-tail	*Hippuris vulgaris*
Ginseng Family	**ARALIACEAE**
Wild Sarasparilla	*Aralia nudicaulis*
Carrot Family	**UMBELLIFERAE**
Bulb-bearing Waterhemlock	*Cicuta bulbifera*
Water-hemlock	*C. maculata*
Cow Parsnip	*Heracleum lanatum*

Common Name	*Scientific Name*
Water Parsnip	*Sium suave*
Dogwood Family	**CORNACEAE**
Bunchberry	*Cornus canadensis*
Red-osier Dogwood	*C. stolonifera*
Wintergreen Family	**PYROLACEAE**
One-flowered Wintergreen	*Moneses uniflora*
One-sided Wintergreen	*Orthilia secunda*
Common Pink Wintergreen	*Pyrola asarifolia*
Greenish-flowered Wintergreen	*P. chlorantha*
Indian-pipe Family	**MONOTROPACEAE**
Indian Pipe	*Monotropa uniflora*
Heath Family	**ERICACEAE**
Bog Rosemary	*Andromeda polifolia*
Alpine Bearberry	*Arctostaphylos rubra*
Common Bearberry	*A. uva-ursi*
Leather-leaf	*Chamaedaphne calyculata*
Creeping Snowberry	*Gaultheria hispidula*
Northern Bog-laurel	*Kalmia polifolia*
Common Labrador Tea	*Ledum groenlandicum*
Northern Labrador Tea	*L. palustre*
Small Bog Cranberry	*Oxycoccus microcarpus*
Bog Cranberry	*O. quadripetalus*
Dwarf Blueberry	*Vaccinium caespitosum*
Blueberry	*V. myrtilloides*
Bog Cranberry	*V. vitis-idaea*
Primrose Family	**PRIMULACEAE**
Shooting Star	*Dodecatheon pulchellum*
Tufted Loosestrife	*Lysimachia thyrsiflora*
Northern Starflower	*Trientalis borealis*
Arctic Starflower	*T. europaea*
Gentian Family	**GENTIANACEAE**
Felwort	*Gentianella amarella*
Spurred Gentian	*Halenia deflexa*
Buck-bean Family	**MENYANTHACEAE**
Buck-bean	*Menyanthes trifoliata*
Dogbane Family	**APOCYNACEAE**
Spreading Dogbane	*Apocynum androsaemifolium*
Indian Hemp	*A. cannabinum*
Dogbane	*A. x medium*
Phlox Family	**POLEMONIACEAE**
Collomia	*Collomia linearis*
Jacob's-ladder	*Polemonium acutiflorum*
Borage Family	**BORAGINACEAE**
Beggar-ticks	*Lappula occidentalis*
Tall Mertensia	*Mertensia paniculata*
Mint Family	**LABIATAE**

Common Name	*Scientific Name*
Giant Hyssop	*Agastache foeniculum*
American Dragonhead	*Dracocephalum parviflorum*
Western Water Horehound	*Lycopus asper*
Northern Water Horehound	*L. uniflorus*
Wild Mint	*Mentha arvensis*
Marsh Skullcap	*Scutellaria galericulata*
Marsh Hedge Nettle	*Stachys palustris*
Figwort Family	**SCROPHULARIACEAE**
Purple Paint-brush	*Castilleja raupii*
Cow-wheat	*Melampyrum lineare*
Labrador Lousewort	*Pedicularis labradorica*
Swamp Lousewort	*P. parviflora*
Yellow Rattle	*Rhinanthus minor*
American Brooklime	*Veronica americana*
Hairy Speedwell	*V. peregrina*
Marsh Speedwell	*V. scutellata*
Bladderwort Family	**LENTIBULARIACEAE**
Common Butterwort	*Pinguicula vulgaris*
Common Bladderwort	*Utricularia vulgaris*
Madder Family	**RUBIACEAE**
Northern Bedstraw	*Galium boreale*
Labrador Bedstraw	*G. labradoricum*
Small Bedstraw	*G. trifidum*
Sweet-scented Bedstraw	*G. triflorum*
Honeysuckle Family	**CAPRIFOLIACEAE**
Twin-flower	*Linnaea borealis*
Fly Honeysuckle	*Lonicera caerulea*
Twining Honeysuckle	*L. dioica*
Bracted Honeysuckle	*L. involucrata*
Snowberry	*Symphoricarpos albus*
Buckbrush	*S. occidentalis*
Low-bush Cranberry	*Viburnum edule*
High-bush Cranberry	*V. opulus*
Moschatel Family	**ADOXACEAE**
Moschatel	*Adoxa moschatellina*
Valerian Family	**VALERIANACEAE**
Northern Valerian	*Valeriana dioica*
Bluebell Family	**CAMPANULACEAE**
Bluebell	*Campanula rotundifolia*
Lobelia Family	**LOBELIACEAE**
Kalm's Lobelia	*Lobela kalmii*
Composite Family	**COMPOSITAE**
Common Yarrow	*Achillea millefolium*
Many-flowered Yarrow	*A. sibirica*
Small-leaved Pussytoes	*Antennaria parvifolia*
Leafy Arnica	*Arnica chamissonis*

Common Name	Scientific Name
Biennial Sagewort	*Artemisia biennis*
Plains Wormwood	*A. campestris*
Dragonwort	*A. dracunculus*
Marsh Aster	*Aster borealis*
Fringed Aster	*A. ciliolatus*
Showy Aster	*A. conspicuus*
Creeping White Prairie Aster	*A. falcatus*
Western Willow Aster	*A. hesperius*
Smooth Aster	*A. laevis*
Purple-stemmed Aster	*A. puniceus*
Nodding Beggar-ticks	*Bidens cernua*
Northern Daisy Fleabane	*Erigeron acris*
Horseweed	*E. canadensis*
Philadelphia Fleabane	*E. philadelphicus*
Common Tall Sunflower	*Helianthus nuttallii*
Narrow-leaved Hawkweed	*Hieracium umbellatum*
Artic Coltsfoot	*Petasites frigidus*
Palmate-leaved Coltsfoot	*P. palmatus*
Arrow-leaved Coltsfoot	*P. sagittatus*
Vine-leaved Coltsfoot	*P. vitifolius*
Marsh Ragwort	*Senecio congestus*
Rayless Ragwort	*S. indecorus*
Balsam Groundsel	*S. pauperculus*
Canada Goldenrod	*Solidago canadensis*
Flat-topped Goldenrod	*S. graminifolia*
Northern Goldenrod	*S. multiradiata*
Mountain Goldenrod	*S. spathulata*
Perennial Sow Thistle	*Sonchus arvensis*
INVERTEBRATES	
chironomid midge larva	*Chironomus tentans*
amphipod	*Hyalella azteca*
oligocaete worm	*Lumbriculus variegatus*
stoneflies	Order *Plecoptera*
mayflies	Order *Ephemeroptera*
dragonflies and damselflies	Order *Odonata*
caddisflies	Order *Trichoptera*
water flea	*Daphnia magna*
water flea	*Ceriodaphnia dubia*
FISH	
Arctic grayling	*Thymallus arcticus*
brook stickleback	*Culaea inconstans*
bull trout	*Salvelinus confluentus*
burbot	*Lota lota*
cisco	*Coregonus artedi*
emerald shiner	*Notropis atherinoides*

Common Name	*Scientific Name*
fathead minnow	*Pimephales promelas*
finescale dace	*Phoxinus neogaeus*
flathead chub	*Platygobio gracilis*
goldeye	*Hiodon alosoides*
Iowa darter	*Etheostoma exile*
lake chub	*Couesius plumbeus*
lake whitefish	*Coregonus clupeaformis*
longnose dace	*Rhinichthys cataractae*
longnose sucker	*Catostomus catostomus*
mountain whitefish	*Prosopium williamsoni*
ninespine stickleback	*Pungitius pungitius*
northern pike	*Esox lucius*
northern redbelly dace	*Phoxinus eos*
pearl dace	*Margariscus margarita*
rainbow trout	*Oncorhynchus mykiss*
river shiner	*Notropis blennius*
shiner species	*Notropis sp.*
slimy sculpin	*Cottus cognatus*
spoonhead sculpin	*Cottus ricei*
spottail shiner	*Notropis hudsonius*
trout-perch	*Percopsis omiscomaycus*
walleye	*Stizostedion vitreum*
white sucker	*Catostomus commersoni*
yellow perch	*Perca flavescens*
REPTILES AND AMPHIBIANS	
red-sided garter snake	*Thamnophis sirtalis*
boreal chorus frog	*Pseudacris triseriata*
Canadian toad	*Bufo hemiophrys*
northern leopard frog	*Rana pipiens*
wood frog	*Rana sylvatica*
BIRDS	
alder flycatcher	*Empidonax alnorum*
American coot	*Fulica americana*
American crow	*Corvus brachyrhynchos*
American kestrel	*Falco sparverius*
American redstart	*Setophaga ruticilla*
American robin	*Turdus migratorius*
American white pelican	*Pelecanus erythrorhynchos*
American wigeon	*Anas americana*
bald eagle	*Haliaeetus leucocephalus*
barn swallow	*Hirundo rustica*
bay-breasted warbler	*Dendroica castanea*
black-and-white warbler	*Mniotilta varia*
black-backed woodpecker	*Picoides arcticus*
black-billed magpie	*Pica pica*

Common Name	*Scientific Name*
black-capped chickadee	*Parus atricapillus*
black-throated green warbler	*Dendroica virens*
blackburnian warbler	*Dendroica fusca*
blackpoll warbler	*Dendroica striata*
blue-winged teal	*Anas discors*
boreal chickadee	*Parus hudsonicus*
boreal owl	*Aegolius funereus*
brown creeper	*Certhia americana*
brown-headed cowbird	*Molothrus ater*
bufflehead	*Bucephalus albeola*
Canada goose	*Branta canadensis*
Canada warbler	*Wilsonia canadensis*
canvasback	*Aythya valisineria*
Cape May warbler	*Dendroica tigrina*
cedar waxwing	*Bombycilla cedrorum*
chestnut-sided warbler	*Dendroica pensylvania*
chipping sparrow	*Spizella passerina*
clay-colored sparrow	*Spizella pallida*
common goldeneye	*Bucephala clangula*
common loon	*Gavia immer*
common raven	*Corvus corax*
common snipe	*Gallinago gallinago*
common yellowthroat	*Geothlypis trichas*
Connecticut warbler	*Oporonis agilis*
dark-eyed junco	*Junco hyemalis*
downy woodpecker	*Picoides pubescens*
evening grosbeak	*Coccothraustes vespertinus*
gadwall	*Anas strepera*
golden-crowned kinglet	*Regulus satrapa*
gray jay	*Perisoreus canadensis*
great blue heron	*Ardea herodias*
great gray owl	*Strix nebulosa*
great-horned owl	*Bubo virginianus*
greater yellowlegs	*Tringa melanoleuca*
green-winged teal	*Anas crecca*
hairy woodpecker	*Picoides villosus*
hermit thrush	*Catharus guttatus*
house wren	*Troglodytes aedon*
killdeer	*Charadrius vociferus*
least flycatcher	*Empidonax minimus*
LeConte's sparrow	*Ammodramus leconteii*
lesser scaup	*Aythya affinis*
lesser yellowlegs	*Tringa flavipes*
Lincoln's sparrow	*Melospiza lincolnii*
long-eared owl	*Asio otus*
magnolia warbler	*Dendroica magnolia*

Common Name	*Scientific Name*
mallard	*Anas platyrhynchos*
mourning warbler	*Oporornis philadelphia*
northern flicker	*Colaptes auratus*
northern harrier	*Circus cyaneus*
northern hawk owl	*Surnia ulula*
northern pintail	*Anas acuta*
northern shoveler	*Anas clypeata*
northern waterthrush	*Seiurus noveboracensis*
olive-sided flycatcher	*Contopus borealis*
orange-crowned warbler	*Vermivora celeta*
osprey	*Pandion haliaetus*
ovenbird	*Seiurus aurocapillus*
palm warbler	*Dendroica palmarum*
peregrine falcon	*Falco peregrinus*
Philadelphia vireo	*Vireo philadelphicus*
pileated woodpecker	*Dryocopus pileatus*
pine siskin	*Carduelis pinus*
red-breasted nuthatch	*Sitta canadensis*
red-eyed vireo	*Vireo olivaceus*
red-necked grebe	*Podiceps grisegena*
red-tailed hawk	*Buteo jamaicensis*
red-winged blackbird	*Agelaius phoeniceus*
redhead	*Aythya americana*
ring-necked duck	*Aythya collaris*
rose-breasted grosbeak	*Pheucticus ludovicianus*
Ross' goose	*Chen rossii*
ruby-crowned kinglet	*Regulus calendula*
ruffed grouse	*Bonasa umbellus*
sandhill crane	*Grus canadensis*
screech owl	*Otus kennicottii*
sharp-shinned hawk	*Accipiter striatus*
sharp-tailed grouse	*Tympanuchus phasianellus*
short-eared owl	*Asio flemmeus*
snow goose	*Chen caerulescens*
solitary sandpiper	*Tringa solitaria*
solitary vireo	*Vireo solitarius*
song sparrow	*Melospiza melodia*
spruce grouse	*Dendragapus canadensis*
Swainson's thrush	*Catharus ustulatus*
swamp sparrow	*Melospiza georgiana*
Tennessee warbler	*Vermivora peregrina*
three-toed woodpecker	*Picoides tridactylus*
western grebe	*Aechmophorus occidentalis*
western tanager	*Piranga ludoviciana*
western wood-pewee	*Contopus sordidulus*
white-throated sparrow	*Zonotrichia albicollis*

Common Name	*Scientific Name*
white-winged crossbill	*Loxia leucoptera*
willow ptarmigan	*Lagopus lagopus*
Wilson's warbler	*Wilsonia pusilla*
winter wren	*Troglodytes troglodytes*
yellow warbler	*Dendroica petechia*
yellow-bellied flycatcher	*Empidonax flaviventris*
yellow-bellied sapsucker	*Sphyrapicus varius*
yellow-rumped warbler	*Dendroica coronata*
MAMMALS	
beaver	*Castor canadensis*
black bear	*Ursus americanus*
buffalo	*Bison bison*
Canada lynx	*Lynx canadensis*
coyote	*Canis latrans*
deer mouse	*Peromyscus maniculatus*
elk	*Cervus elaphus*
ermine	*Mustela erminea*
fisher	*Martes pennanti*
gray wolf	*Canis lupus*
least weasel	*Mustela nivalis*
marten	*Martes americana*
meadow vole	*Microtus pennsylvanicus*
mink	*Mustela vison*
moose	*Alces alces*
mule deer	*Odocoileus hemionus*
muskrat	*Ondatra zibethicus*
porcupine	*Erethizon dorsatum*
red fox	*Vulpes vulpes*
red squirrel	*Tamiasciurus hudsonicus*
red-backed vole	*Clethrionomys gapperi*
river otter	*Lutra canadensis*
snowshoe hare	*Lepus americanus*
striped skunk	*Mephitis mephitis*
water shrew	*Sorex palustris*
white-tailed deer	*Odocoileus virginianus*
wolverine	*Gulo gulo*
woodland caribou	*Rangifer tarandus*

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APPENDICES

A INTRODUCTION

This document provides the following information, pertaining to Suncor's Project Millennium Application , April 1998:

- Project update, and new data and analysis with respect to SO_2 Dispersion Analysis, Ozone Modelling Analysis, Particulates and Aerosols, and Human Health
- Response to EUB requests for supplemental information
- Response to AEP requests for supplemental information
- Table of Errata for Project Millennium Application, April 1998
- Appendices which contain information regarding Suncor's coke management plan, Pond 1 reclamation schedule, field review of forestry resources in the Project Millennium development, and resubmitted items.

Suncor appreciates the detailed and comprehensive review afforded the Project, as evidenced by the reviewer comments and information requests. Suncor has made every effort to answer each question directly and as completely as practical.

This document may contain some abbreviations or acronyms that are not familiar to the reader. Please refer to the List of Abbreviations provided in Volume 1 of the Project Millennium Application.

The supplemental information requests provided herein follow the outline provided by EUB and AEP respectively. Requests for information are indicated in bold text; responses are in normal text.

B NEW INFORMATION

This section provides an update of Project Millennium as well as revised SO_2 dispersion modelling analyses, ozone modelling analyses, revised particulate and aerosols analyses, and additional health analyses.

B1 PROJECT UPDATE

The following information provides a brief description of the significant changes to the project description as provided in the Project Millennium Application, April 1998.

Sulphur Degas Facility

The Millennium Upgrader facility will now degas all sulphur produced at Suncor's oil sands operation. The overall sulphur balance will not change, however the potential of fugitive H_2S emissions from transport vehicles will be reduced. Odour potential when pouring sulphur onto the emergency sulphur pad will be also be reduced. As a result of degassing the sulphur the range of potential customers will be wider which will reduce the risk inherent in a single-customer transaction.

All sulphur will be degassed to <10-PPM H_2S content. The technology selected is the D'GAASS process (licensed by Goar Allison & Associates, Houston). The degassing takes place at pressure, which minimizes vessel size, capital cost and plot space requirements. No increase in SO_2 emissions is expected, as the H_2S stripped from the sulphur will be routed to the front end of the SRUs for recovery. Suncor is the first large-scale commercial facility to implement this process, and therefore there is some technical risk that may make the process uneconomical. While Suncor feels that this system is feasible and will make reasonable attempts to make it work, if it is uneconomical it may have to be discontinued.

Suncor requests that the Sulphur degas facility be added to the list of proposed upgrading units in Volume 1, Table C3-4 of the Project Millennium Application.

Sulphur Storage

The Millennium sulphur complex will construct a new sulphur storage tank, emergency storage, and loading facilities that will meet all Suncor sulphur handling requirements. Existing facilities will be demolished. The original plan was to upgrade base plant sulphur handling facilities to accommodate Project Millennium. There will be no impact on emissions.

Coke Quenching and Cutting Water

The Millennium facility will no longer use recycled stripped sour water for coke quenching and cutting operations. As a result, considerable capital expenditure will be avoided and the risk of contamination of water will be reduced.

Recycled utility water will now be used for quenching and cutting. The overall water balance remains the same, however individual stream flows will change accordingly.

Process Control Room

The new Upgrader process control room will now be an integrated facility so that the base plant and Project Millennium upgrading operations will be controlled from a central facility. This is expected to enhance coordination between the two upgrading units and improve performance of the combination. The location is proposed to be south of the Upgrader Operations Building.

Sour Water Feed Preparation Tank

This tank will now be located north of the north tank farm and west of the existing camp facility (rather than adjacent to the existing base plant tank).

Third Party Power Generation

Suncor has been negotiating for third party power generation. While there is no signed agreement as yet, and a concrete commitment cannot be made at this time, Suncor is providing the following preliminary information as to intent.

The major change resulting from third party power generation would be the export of up to 200 MW to the Alberta power grid over and beyond plant requirements of 220 MW.

This would be accomplished by installing:

- two 115 MW gas turbine generators, each equipped with a heat recovery steam generator
- two steam turbine generators totaling about 100 MW
- associated feedwater and aerator facilities

As a result, CO_2 and NO_x emissions would increase locally, offset by a reduction in the usage of Suncor's less efficient Plant 35 boiler. Provincially, there would be a reduction of both emissions because the power exports to the grid would back off equivalent coal generated power that produces higher emissions. The exact amounts will be quantified when the configuration is finalized and agreement is reached.

Natural Gas Liquids Facility

Suncor recently announced plans to recover natural gas liquids and olefins with Novagas Canada Ltd. By the end of 1999, this project is proposed to recover approximately 10,000 bpd, with the intent to recover more liquids as Suncor's oil sands production increases.

Both Suncor and Novagas Canada Ltd. are currently continuing with the normal business due diligence engineering and financial review necessary to finalize this business relationship. Suncor expects this project to proceed and has shown its commitment to the project by submitting the Suncor Oil Sands Pipe Line substance change application to the EUB for approval to ship higher vapour pressure products.

B2 REVISED SO_2 DISPERSION MODELLING ANALYSES

B2.1 Introduction

The latest estimates of emissions in the oil sands region are presented in the key reference report, "Technical Reference for Meteorology, Emissions and Ambient Air Quality in the Athabasca Oil Sands Region" (Golder and Conor-Pacific 1998). These revised emission estimates have been utilized to determine the impact on the predicted SO_2 concentrations for the Millennium and CEA emissions scenarios. In combination with these new estimates, corrections have been made to the stack height of the new Millennium sulphur plant thermal oxidizer and to the volumetric gas flow rate in the continuous flare stack (19F-1).

B2.2 Model Approach And Limitations

The Industrial Source Complex Short Term Model, Version 3 (ISCST3) is a steady-state Gaussian plume model, recommended by the U.S. EPA for evaluating pollutant releases from a wide variety of sources associated with industrial source complexes. This model can account for: building downwash; area, line and volume sources; plume rise as a function of downwind distance; separation of point sources; and limited terrain adjustment. Local hourly meteorological data are required by the ISCST3 model.

The ISC3BE dispersion model, developed by BOVAR Environmental, is a modified version of the original ISCST3 model. The modifications made to the original model code were undertaken to enable the model to yield maximum predictions during the daylight hours and to predict similar numbers of exceedances as observed at the local monitoring stations (Conor Pacific, 1998). Although the tuning done to the ISC3BE model has not been subjected to the same rigorous independent review as the original code, the changes are designed to yield model predictions which correspond to the observations made at sampling locations along the Athabasca River valley. This model has been extensively used in previous air assessments in the oil sands region.

Dispersion models employ simplifying assumptions to describe the random processes associated with atmospheric motions and turbulence. These simplifying processes limit the capability of a model to replicate individual events. A model's predictive capability and strength lies in the capability to predict an average for a given set of meteorological conditions. Other factors that limit the capability of a model to predict values that match observations are limitations in the input data and information used by the model. For example, the modelling does not account for the hour-by-hour emission rates in the source strength and exit characteristics (such as temperature and velocity). The models do not replicate the special flow patterns and reduced dispersion within the Athabasca River valley, although the ISC3BE model has been tuned in an attempt to account for some of these effects.

Notwithstanding these limitations, the data used by the models and for the model evaluation did undergo a review in the key reference report (Appendix III) and were found to be sufficient for the modelling application. Specifically, the model predictions show good agreement with observations, both in terms of magnitude and diurnal trends.

B2.3 Project Millennium

B2.3.1 Emissions

The Project Millennium expansion will increase Suncor's overall production rate and change overall air emissions. Important air emissions and their potential changes to ambient air quality as a result of this project are summarized below.

Table B2-1 Summary of Project Millennium Emissions in the Athabasca Oil Sands Region

	Emission Rates (t/cd)					
	SO_2	NO_x	CO	PM	VOC	TRS
Suncor	70.2	67.7	**12.9**	**3.8**	**233**	2.7
Syncrude	209.0	44.4	**53.6**	5.4	**39.4**	2.3
Other Industries	3.9	8.7	27.1	0.9	**4.9**	**0.01**
Transportation and Residential	0.2	1.37	6.5	1.5	2.95	n/a
Total	**283.3**	**122.2**	**100**	**11.6**	**280**	**5.0**

n/a data not available

Note: The updated values in the above table represent the latest estimates of emissions as detailed in Technical Reference for Meteorology, Emissions and Ambient Air Quality in the Athabasca Oil Sands Region (Golder and Conor Pacific 1998).

The specific sources that comprise Suncor's predicted Project Millennium emissions are shown below in Table B2-2.

Table B2-2 Summary of Suncor Project Millennium Emissions

Source	Emission [t/cd]					
	SO_2	NO_x	CO	PM[(a)]	VOC	TRS
Project Millennium						
Powerhouse stack	14.0	2.9	**1.67**	0.2	0.008	n/a
FGD stack	18.7	29.7	**0.69**	**2.6**	0.2	n/a
Millennium mine boilers / GTGs	1.1	4.1	0.3	0.1	0.01	-
Sulphur incinerator	12.3	0.064	3.4	0.038	0.06	n/a
Tail gas treatment unit	8.7	0.029	3.8	0.04	0.2	n/a
Upgrading furnace stacks	4.7	3.8	1.4	0.5	**0.06**	-
Flaring - continuous and acid gas	10.6	0.191	0.2	0.01	0.041	0.011
Mine fleet	0.08	26.9	1.4	0.3	0.8	-
Fixed Plant Fugitive	-	-	-	-	**23.3**	**0.15**
Tailings ponds	-	-	-	-	200.2	**2.4**
Mine surface[(b)]	-	-	-	-	15.3	**0.05**
Total	**70.2**	**67.7**	**12.9**	**3.8**	**233**	**2.7**

n/a data not available
- not a source of this emission
(a) Assumed as PM_{10}.
(b) Estimated based on Syncrude data.

B2.3.2 SO_2 Predicted Concentrations

The predicted maximum hourly, daily and annual ground level ambient SO_2 concentrations resulting from emissions of Project Millennium and all approved industrial sources and residential emissions in the oil sands region were estimated using the ISC3BE model. Emission rates used were the calendar day (cd) for annual GLC predictions and stream day (sd) for hourly and daily GLC predictions. Four years of observed meteorological measurements from the Suncor Mannix station (75 m level) were used in the modelling. These models provide an efficient means of estimating the predicted ambient SO_2 concentrations from all sources and provides an indication where maximum concentrations could occur.

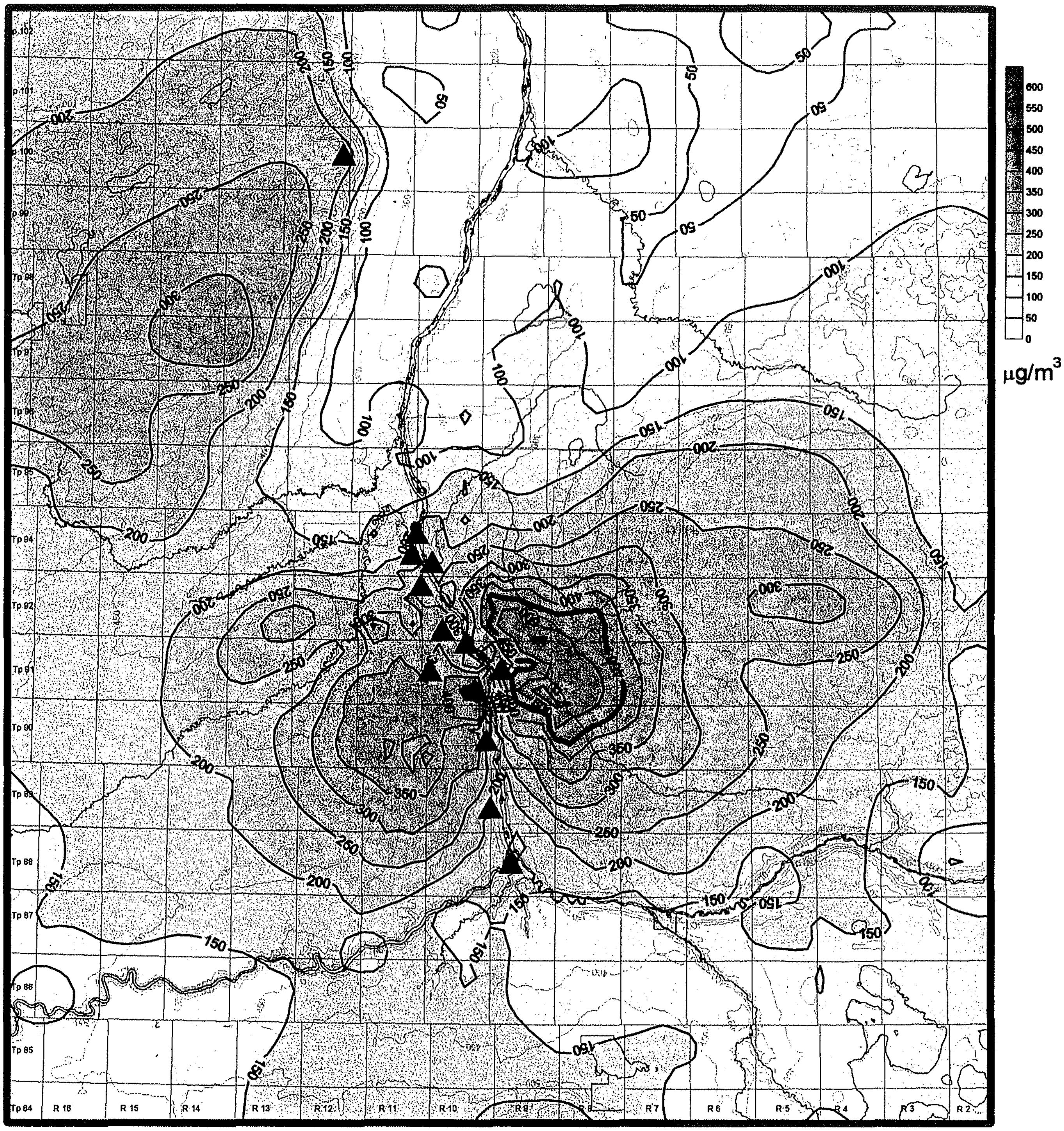
The modelling results, which are summarized in Table B2-3, indicate that the increased incinerator stack height, the adjusted flare stack (19F-1) gas flowrate, and the modified SO_2 emissions will result in reduced ground level concentrations and projected numbers of exceedances of the Alberta guidelines.

Table B2-3 Maximum Observed Ground Level Concentrations of SO_2 for Project Millennium Sources

Source	Hourly[b]	Daily[b]	Annual[b]
Project Millennium - ISC3BE			
Maximum SO_2 Concentration (μg/m³)	596	199	74.2
Maximum Number of Exceedances[a]	2	6	1
SO_2, Alberta Guideline (μg/m³)	450	150	30
SO_2, Federal Acceptable (μg/m³)	900	300	60

(a) Exceeds SO_2 Alberta Guideline. Normalized for a 12-month period.
(b) Based on Stream day emission rates for hourly and daily; Calendar day for annual.

Figure B3-2 Predicted Millennium SO_2 Maximum Hourly Average Ground Level Concentrations in the RSA Using the ISC3BE Model



Sources	SO_2 [t/sd]
Suncor	
Powerhouse	1.2
FGD	19.7
Incinerator	10.2
Flaring	1.3
Tail Gas Treatment Unit	5.2
Other Sources, Suncor	5.9
Syncrude (total)	209
Other Emissions (total)	4
TOTAL	256.5

Model Description	
Development	Project Millennium
Model	ISC3BE (7BG)
SO_2 Guideline [µg/m^3]	450
Maximum [µg/m^3]	596
Exceedences / Year [#]	2

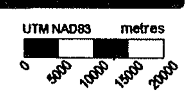


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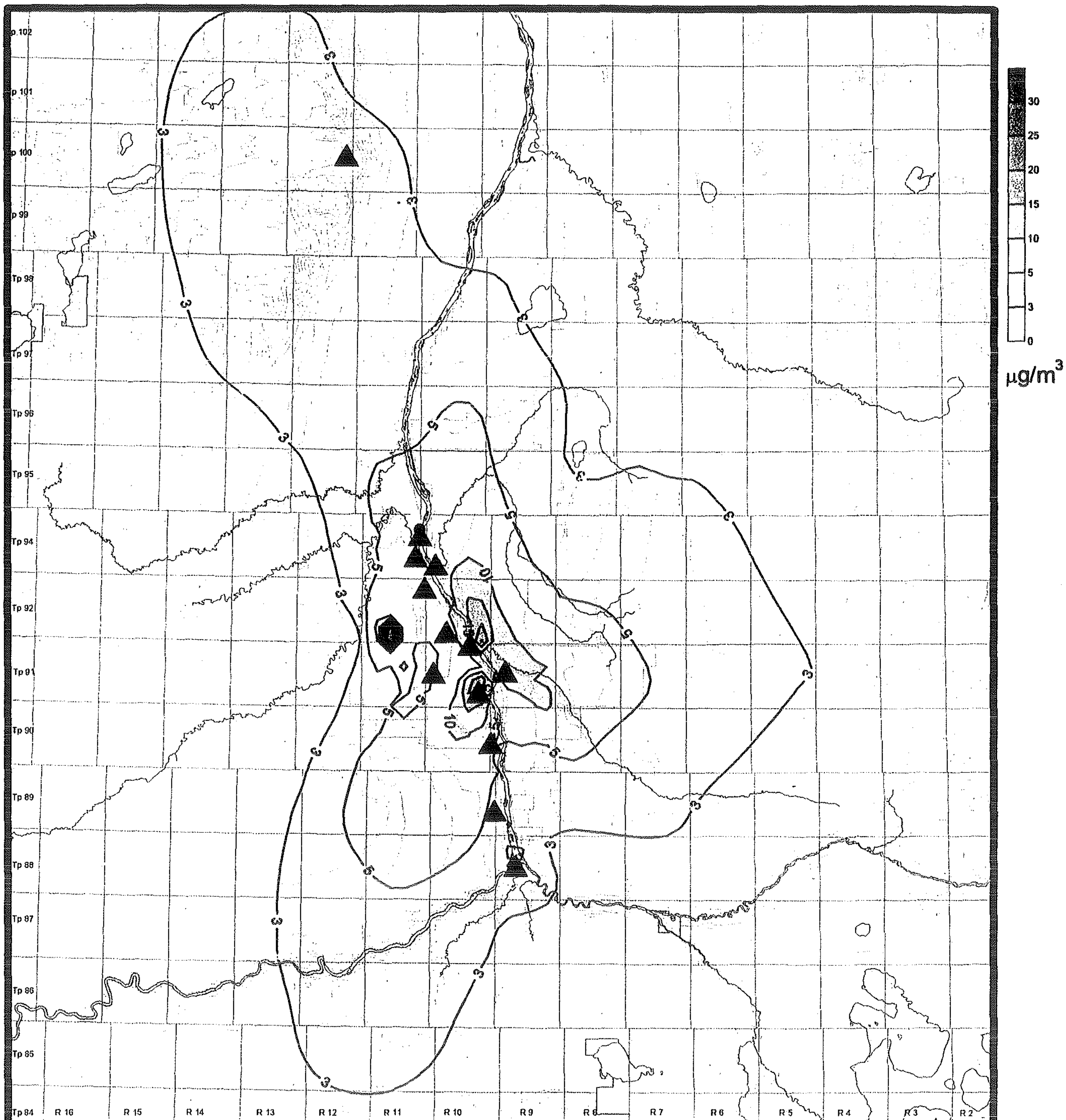
Figure B3-4 Predicted Millennium SO_2 Maximum Average Ground Level Concentrations in the RSA Using the ISC3BE Model



Sources	SO_2 [t/cd]
Suncor	
Powerhouse	14
FGD	18.7
Incinerator	12.3
Flaring	10.6
Tail Gas Treatment Unit	8.7
Other Sources, Suncor	5.9
Syncrude (total)	209
Other Emissions (total)	4
TOTAL	283.2

Model Description	
Development	Project Millennium
Model	ISC3BE (7BG)
SO_2 Guideline [µg/m³]	30
Maximum [µg/m³]	74
Exceedences / Year [#]	1

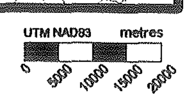
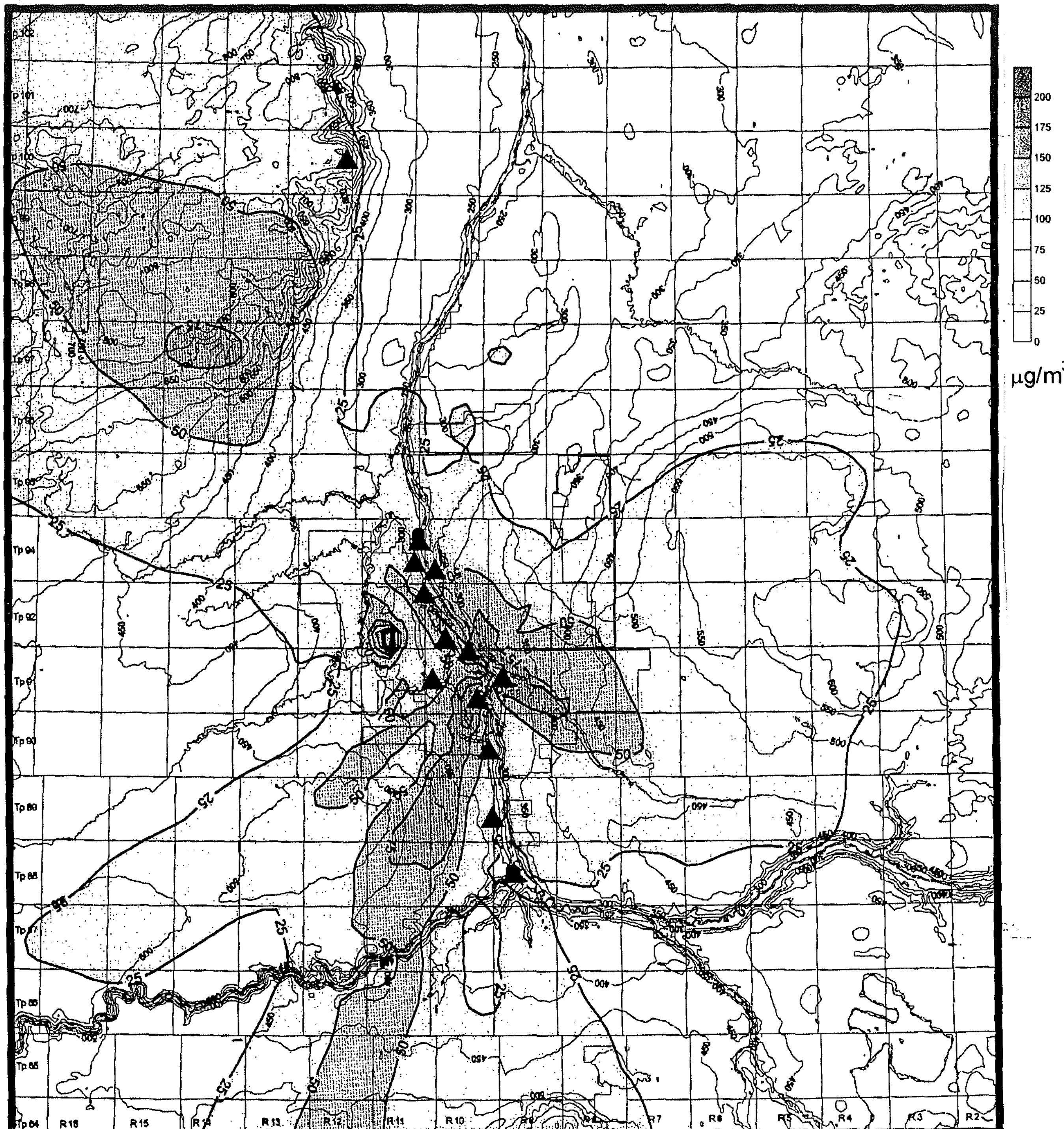
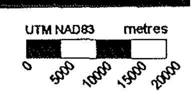


Figure B3-3 Predicted Millennium SO_2 Maximum Daily Average Ground Level Concentrations in the RSA Using the ISC3BE Model





Sources	SO_2 [t/sd]
Suncor	
Powerhouse	1.2
FGD	19.7
Incinerator	10.2
Flaring	1.3
Tail Gas Treatment Unit	5.2
Other Sources, Suncor	5.9
Syncrude (total)	209
Other Emissions (total)	4
TOTAL	256.5

Model Description	
Development	Project Millennium
Model	ISC3BE (7BG)
SO_2 Guideline [µg/m³]	150
Maximum [µg/m³]	199
Exceedences / Year [#]	6

B2.4 Cumulative Effects Assessment

B2.4.1 Emissions - Summary Of CEA Emissions

Table B2-4 summarizes the air emission estimates used in the CEA from Suncor, Syncrude, other industries, and transportation and residential sources in the oil sands region. The level of confidence in the data are high for the existing, approved and Project Millennium developments. Assumptions have been made in the air emission data for the planned developments and therefore the level of confidence for this data is lower.

Table B2-4 Summary of Estimated CEA Emissions in the Athabasca Oil Sands Region

Source	Emission Rates (t/cd)					
	SO_2	NO_x	CO	PM_{10}	VOC	TRS
Suncor	70.2	67.7	12.9	3.8	233.0	2.7
Syncrude	201.0	63.9	84.5	10.4	45.2	3.58
Other Industries	24.09	88.1	50.5	5.3	35.7	0.24
Transportation and Residential	0.299	2.206	9.89	2.33	4.34	-
Total	296.0	222.0	158.0	21.8	318.0	6.5

Note: The updated values in the above table represent the latest estimates of emissions as detailed in Technical Reference for Meteorology, Emissions and Ambient Air Quality in the Athabasca Oil Sands Region (Golder and Conor Pacific 1998).

B2.4.2 SO_2 Predicted Concentrations

The predicted maximum hourly, daily and annual ground level ambient SO_2 concentrations resulting from emissions of Project Millennium, all approved industrial sources, all disclosed new industrial developments and residential emissions in the oil sands region were estimated using the ISC3BE model. Emission rates used were the calendar day (cd) for annual GLC predictions and stream day (sd) for hourly and daily GLC predictions. Four years of observed meteorological measurements from the Suncor Mannix station (75 m level) were used in the modelling. These models provide an efficient means of estimating the predicted ambient SO_2 concentrations from all sources and provides an indication where maximum concentrations could occur.

The modelling results, which are summarized in Table B2-5, indicate that the increased incinerator stack height, the adjusted flare stack (19F-1) gas flowrate, and the modified

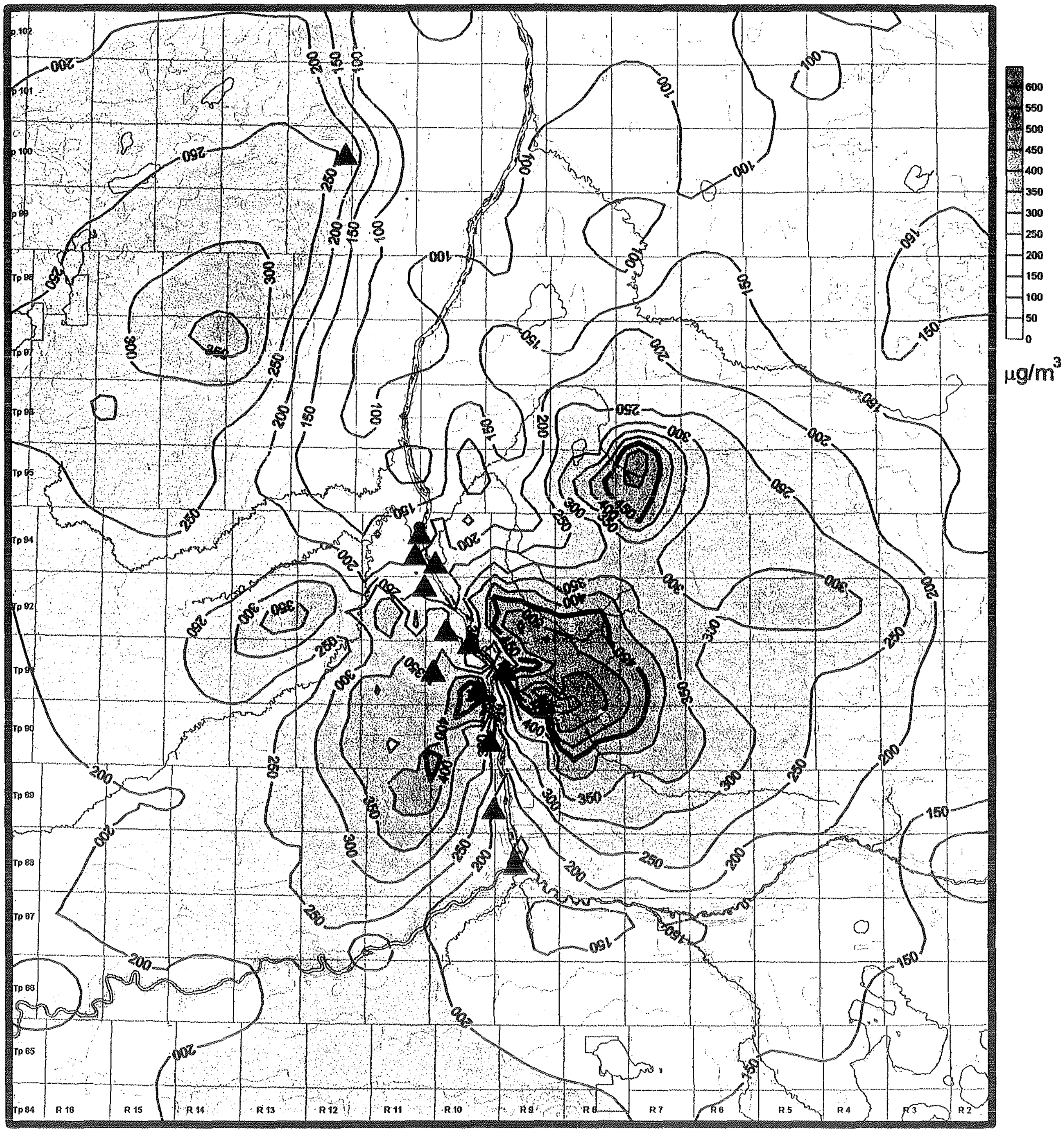
SO_2 emissions will result in reduced ground level concentrations and projected numbers of exceedances of the Alberta guidelines.

Table B2-5 Maximum Observed Ground Level Concentrations of SO_2 for Project Millennium Sources

Source	Hourly[(b)]	Daily[(b)]	Annual[(b)]
Project Millennium - ISC3BE			
Maximum SO_2 Concentration (μg/m³)	667	170	42.1
Maximum Number of Exceedances[(a)]	2	1	1
SO_2, Alberta Guideline (μg/m³)	450	150	30
SO_2, Federal Acceptable (μg/m³)	900	300	60

(a) Exceeds SO_2 Alberta Guideline. Normalized for a 12-month period.
(b) Based on Stream day emission rates for hourly and daily; Calendar day for annual.

Figure B4-2 Predicted CEA SO_2 Maximum Hourly Average Ground Level Concentrations in the RSA Using the ISC3BE Model



Sources	SO_2 [t/sd]
Suncor	
Powerhouse	1.2
FGD	19.7
Incinerator	10.2
Flaring	1.3
Tail Gas Treatment Unit	5.2
Other Sources, Suncor	5.9
Syncrude (total)	201
Other Emissions (total)	4
Other Proposed Emissions (total)	19.8
TOTAL	268.3

Model Description	
Development	CEA
Model	ISC3BE (78G)
SO_2 Guideline [µg/m^3]	450
Maximum [µg/m^3]	667
Exceedences / Year [#]	3

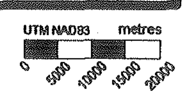
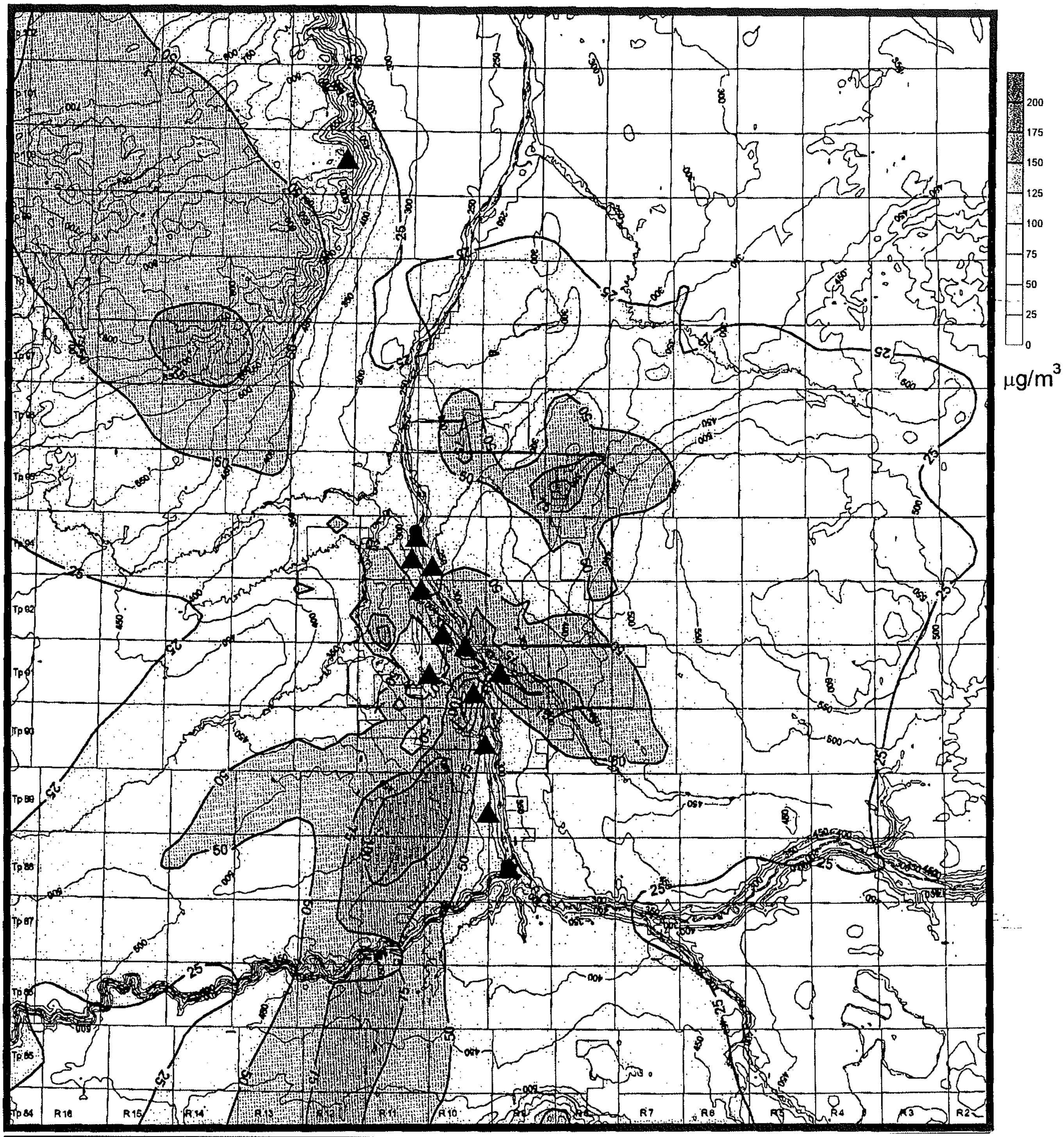


Figure B4-3 Predicted CEA SO_2 Maximum Daily Average Ground Level Concentrations in the RSA Using the ISC3BE Model



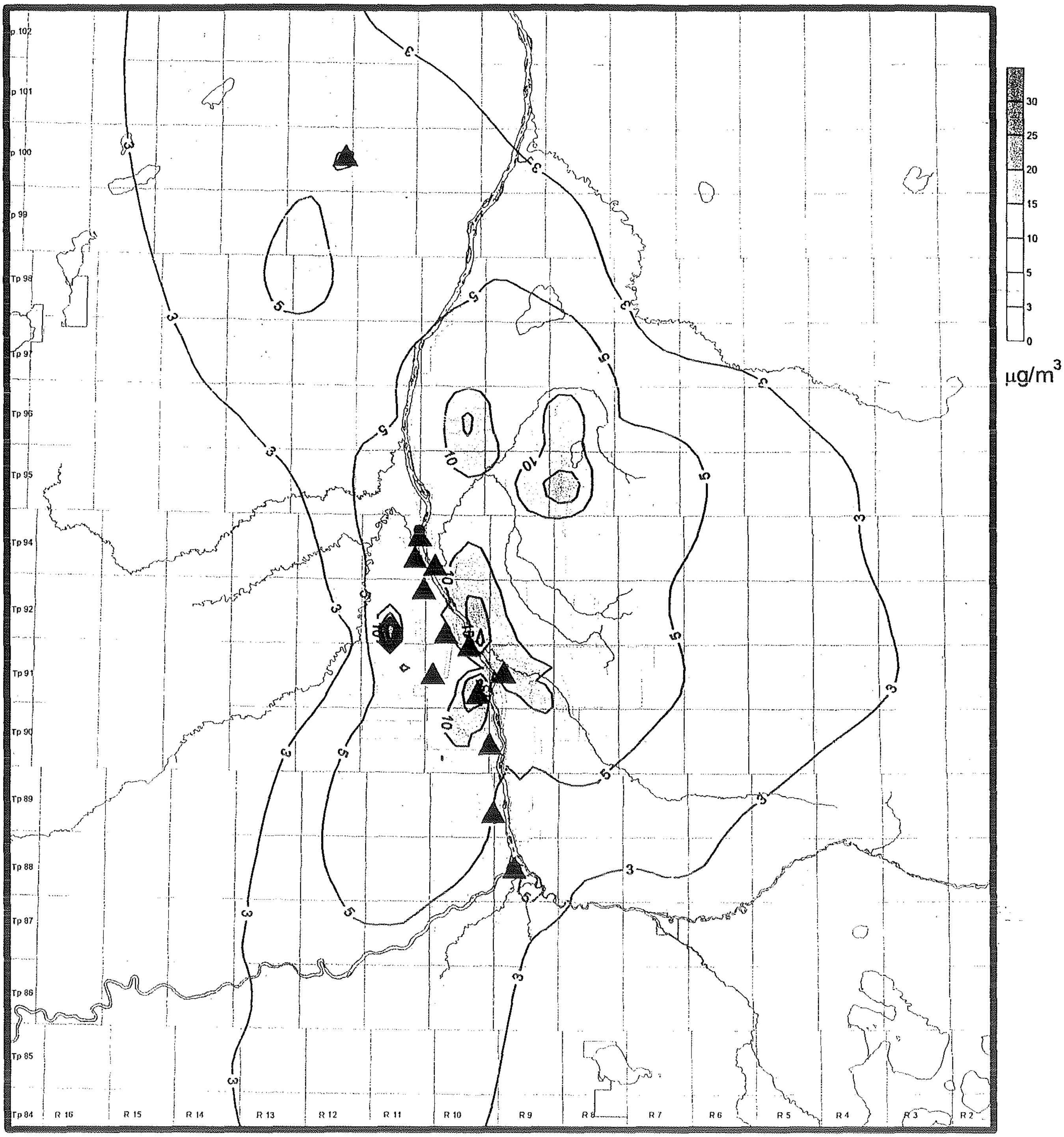
Sources	SO_2 [t/sd]
Suncor	
Powerhouse	1.2
FGD	19.7
Incinerator	10.2
Flaring	1.3
Tail Gas Treatment Unit	5.2
Other Sources, Suncor	5.9
Syncrude (total)	201
Other Emissions (total)	4
Other Proposed Emissions (total)	19.8
TOTAL	268.3

Model Description	
Development	CEA
Model	ISC3BE (7BG)
SO_2 Guideline [µg/m^3]	150
Maximum [µg/m^3]	170
Exceedences / Year [#]	<1

07/03/98 09:53:30

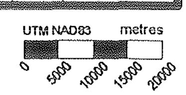
r:/1997/2200/972-2205/8600/8660/8664/ISCBE/figs/SO2CD_4a.srf

Figure B4-4 Predicted CEA SO_2 Maximum Average Ground Level Concentrations in the RSA Using the ISC3BE Model



Sources	SO_2 [t/cd]
Suncor	
Powerhouse	14
FGD	18.7
Incinerator	12.3
Flaring	10.6
Tail Gas Treatment Unit	8.7
Other Sources, Suncor	5.9
Syncrude (total)	201
Other Emissions (total)	4
Other Proposed Emissions (total)	19.8
TOTAL	295

Model Description	
Development	CEA
Model	ISC3BE (7BG)
SO_2 Guideline [µg/m³]	30
Maximum [µg/m³]	42
Exceedences / Year [#]	1



B3 OZONE MODELLING ANALYSES

B3.1 Introduction

The following section on ozone is summarized from the information recently presented in the Shell Muskeg River Mine Project Supplemental Information submitted to the Alberta Energy and Utilities Board and Alberta Environmental Protection in June 1998 (Shell 1998). This ozone modelling work was the result of collaboration among Suncor Energy Inc., Syncrude Canada Ltd. and Shell Canada Limited. Additional information on the oil sands region ozone modelling can be found in the Shell supplemental document.

The formation of tropospheric (i.e., ground level) ozone (O_3) can result from the reaction of precursor NO_x and VOC emissions. The Canadian Council of Ministers of the Environment (CCME 1990) developed a management plan for NO_x and VOC which identified that high ground level ozone concentrations in Canada were most severe in:

- the Lower Fraser Valley (British Columbia)
- the Windsor - Quebec corridor (Ontario and Quebec)
- the southern Atlantic Region (New Brunswick and Nova Scotia)

Although the CCME (1990) management plan does not identify Alberta as having a potential ozone problem, this issue was identified as a concern in the oil sands region. The regional issue of ground level ozone is being addressed through a separate Working Group, which identified the CALGRID model as the most appropriate tool for simulating the ground level ozone in the oil sands region. The Working Group retained EARTH TECH to conduct the ground level ozone analysis in the oil sands region.

The CALGRID dispersion model was selected to simulate the ozone forming potential within the RSA for both the Baseline Case (representing all approved emission sources) and the CEA emissions scenario.

B3.2 Baseline Observations

Ambient ozone concentrations are observed at a limited number of stations. Specifically, ozone is monitored continuously at Fort McMurray and recent short-term ozone measurements have been collected at the Syncrude North Mine and at Koch Canada's (formerly Solv-ex) background monitoring sites. Additional historical data are also available from the AOSERP program for the period March 1977 to April 1980 when ozone was measured at Birch Mountain and Bitumount.

Ozone statistics for Fort McMurray based on observations from 1990 to 1997 indicate that the Alberta hourly O_3 guideline concentration of 160 $\mu g/m^3$ was last exceeded in June

1993. Since then, the maximum hourly values have typically been in the 113 to 150 μg/m^3 range. The maximum 8-hour average concentration is in the 107 to 155 μg/m^3 range. These latter maximums are less than the new U.S. EPA 8-hour standard of 157 μg/m^3. While exceedances of the hourly guidelines are relatively infrequent, exceedances of the daily guideline (50 μg/m^3) occur on average about 110 days per year. Exceedances of the daily guidelines have been observed 50 to 90% of the time in rural Alberta areas compared to 10 to 40% of the time in urban areas (Angle and Sandhu 1989).

Ambient ozone concentrations observed at the AOSERP sites (Birch Mountain and Bitumount), Syncrude North Mine and the Koch background sites can be summarized as follows:

- The AOSERP monitoring results indicate greater ozone values when compared to those observed from 1990 to 1996 at the other sites.
- The higher values occur during periods when anthropogenic NO_x emissions were lower. These values may be attributable to higher natural background values at the higher elevation AOSERP locations.
- The North Mine ozone values are much lower because of the close proximity to NO_x sources. Therefore, the ozone concentrations are reduced as a result of scavenging by NO.
- The Koch ozone values are consistent with those observed in Fort McMurray.

For the purpose of comparison, the maximum one-hour average zone concentrations observed at two remote sites in Alberta are 238 μg/m^3 (Fortress Mountain [1985 to 1987]) and 133 μg/m^3 (Hightower Ridge [1996]). The average ozone concentrations at these two sites are 84 μg/m^3 at Fortress Mountain and 74 μg/m^3 at Hightower Ridge.

The values observed in Fort McMurray are consistent with observations from northern latitudes. For example, the observed maximum hourly average O_3 concentrations at other northern locations are as follows:

- Norway, 107 to 224 μg/^{m3} (Pederson and Lefohn 1994)
- Finland, 115 to 154 μg/^{m3} (Laurila and Lattila 1994)
- Northern U.K., 107 to 209 μg/^{m3} (Bower et al. 1994)

Various reasons have been proposed for the high rural ozone values, ranging from troposphere and stratosphere interactions (Angle and Sandhu 1986; Davies and Schepback 1994) to long-range transport of photochemical ozone precursors (Legge and Krupa 1990; Pederson and Lefohn 1994).

B3.3 Baseline Predictions

Individual hydrocarbon species have differing capability to react in the atmosphere and contribute to the formation of ground level ozone. Updates of the VOC emission estimates for the RSA were developed on the basis of the most recent information from Syncrude and Suncor and grouped according to photochemical production potential.

The CALGRID model was designed to evaluate photochemical ozone forming potential for specific episodes. The ozone forming potential in the RSA was evaluated using two periods:

1. A five-day period in the spring was selected when ambient ozone concentrations tend to be the greatest (May 1 to May 5, 1994). During this period, ambient O_3 concentrations exceeded 130μg/m^3 on five of the six days; temperatures exceeded 20°C on two of the six days; net radiation exceeded 400 W/m^2 on all six days and wind speeds were in the 1.4 to 5.5 m/s range. The highest ozone concentrations were associated with the two windiest days.

2. A six-day period in the summer was selected when photochemical production is expected to be the greatest due to warm temperatures and high solar radiation (July 25 to 30, 1994). During this period, peak ambient O_3 concentrations were about 60μg/m^3 on two of the days, about 90 μg/m^3 on three of the days and were in excess of 130 μg/m^3 on one day. Ambient temperatures exceeded 30°C on one of the six days, and exceeded 25°C on the other days. Peak net radiation values were about 500 W/m^2 on three of the days and about 350 W/m^2 on the other three days. Wind speeds were typically in the 1.4 to 2.8 m/s range.

Prior to running CALGRID, the CALMET pre-processor model was used to produce the two and three-dimensional meteorological and geographical data required by the model. Maximum hourly average O_3 concentrations associated with the following cases were calculated:

1. **Biogenic Case.** All anthropogenic sources of NO_x and VOC are set to zero. The BEIS (Biogenic Emission Inventory System) model was used to estimate biogenic emissions based on the RSA vegetation type and ambient temperatures.

2. **Existing Case**. Anthropogenic RSA sources of NO_x and VOC are based on the existing case emissions (about 1997). This case includes associated biogenic emissions.

3. **Future-year Base Case**. Anthropogenic RSA sources of NO_x and VOC are based on a Future-year Base case (about 2002). This case assumes that the approved Suncor and Syncrude plant expansions and the Syncrude Aurora North Mine (one train) have

been implemented. This case includes associated biogenic emissions. This emission scenario closely corresponds to the Baseline Scenario presented in the Project Millennium EIA.

The Future-year Base Case fugitive VOC emissions were modified to account for varying ambient temperatures and wind speeds during the respective periods. The following were noted with respect to the precursor NO_x and VOC emissions (Shell 1998):

- Biogenic NO_x emissions are much smaller than the Existing and Future-year Base Case NO_x emissions.
- During the spring period, biogenic VOC emissions are comparable to the Existing and Future-year Base Case VOC emissions.
- During the summer period, biogenic VOC emissions are much greater than the Existing and Future-year Base VOC emissions.

Predictions of maximum one-hour average ozone concentrations ($\mu g/m^3$) in the RSA are presented in Table B3-1 for each day of the simulation. The results indicate the following:

- Maximum O_3 concentrations associated with the Biogenic Case are typically 122 and 118 $\mu g/m^3$ for the spring and summer periods, respectively.
- The Existing Case NO_x and VOC precursor emissions (Spring Period) increase the maximum values to 129 $\mu g/m^3$ (an increase of 7 $\mu g/m^3$ or 6% over the Biogenic case).
- The existing Case NO_x and VOC precursor emissions (Summer Period) increase the maximum values to 161 $\mu g/m^3$ (an increase of 43 $\mu g/m^3$ or 36% over the Biogenic case).
- The Future-year Base Case NO_x and VOC precursor emissions (Spring Period) increase the maximum value to 130 $\mu g/m^3$. This is an increase of 1 $\mu g/m^3$ (about 1%) over the Existing Case.
- The Future-year Base Case NO_x and VOC precursor emissions (Summer Period) increase the maximum values to 173 $\mu g/m^3$. This is an increase of 12 $\mu g/m^3$ (about 7%) over the Existing Case.
- Hourly exceedances in the RSA are predicted to occur on 3 of the 6 summer period days for the Existing Case and on 4 of 6 summer period days for the Future-year Base Case. No exceedances are predicted to occur for the spring period days.

Table B3-1 Summary of O_3 Predictions in the Athabasca Oil Sands Region

Biogenic and Future Year Base Cases

	Maximum 1-hour Ozone [μg/m³]	
	Biogenic Case	**Future Year Base Case**
Spring		
May 1	125	133
May 2	125	125
May 3	113	123
May 4	125	127
May 5	121	142
Average	**122**	**130**
Summer		
July 25	127	195
July 26	115	160
July 27	115	139
July 28	113	203
July 29	117	178
July 30	119	166
Average	**118**	**173**

The 1-hour Alberta Ambient Air Quality Guideline and the Federal Acceptable Objective for O_3 are both 160 μg/m³.

B3.4 Cumulative Effects Assessment (CEA) Predictions

Emissions associated with the RDR Case (Shell 1998) are greater than those associated with the CEA scenario presented in the EIA. Therefore, the predicted 1-hour ozone concentrations presented in Table B3-2 represent conservative estimates of the ozone forming potential for the CEA case. The predicted maximum 1-hour O_3 concentrations in Table B3-2 indicate that:

- Maximum values are associated with the warmer summer period.
- Average incremental O_3 increase of 3 μg/m³ is associated with the summer period (3% increase).
- An average incremental O_3 increase of 16 μg/m³ is associated with the summer period (9% increase).
- The maximum values are predicted to exceed the 160 μg/m³ guideline.

Table B3-2 Summary of Baseline O_3 Predictions in the Athabasca Oil Sands Region Including the CEA Case

	Maximum 1-hour Ozone [μg/m³]		
	Biogenic Case	**Future Year Base Case**	**CEA Case**
Spring			
May 1	125	133	140
May 2	125	125	125
May 3	113	123	131
May 4	125	127	129
May 5	121	142	146
Average	**122**	**130**	**134**
Summer			
July 25	127	195	207
July 26	115	160	174
July 27	115	139	154
July 28	113	203	**217**
July 29	117	178	193
July 30	119	166	187
Average	**118**	**173**	**189**

The 1-hour Alberta Ambient Air Quality Guideline and the Federal Acceptable Objective for O_3 are both 160 μg/m³.

B3.5 Conclusions Regarding O_3 Modelling In The Athabasca Oil Sands Region

The above evaluation indicates that increased emissions in the oil sands region can result in increases to ambient 1-hour ground level ozone concentrations. To date, the CALGRID modelling evaluation has not evaluated the expected impact on elevated 24-hour ozone concentrations. These maximums may not be highest during the same periods as the maximum 1-hour results.

B3.6 References

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B4 REVISED PARTICULATE AND AEROSOLS ANALYSES

B4.1 INTRODUCTION

The latest estimates of emissions in the oil sands region are presented in the Technical Reference for Meteorology, Emissions and Ambient Air Quality in the Athabasca Oil Sands Region (Golder and Conor-Pacific 1998). These revised emission estimates have been utilized to determine the ambient particulate, aerosol, metal and PAH concentrations resulting from the Baseline, Millennium and CEA emissions scenarios.

In addition to refining the primary PM_{10} particulate concentrations presented in the EIA, this analysis includes a summary of the modelled secondary aerosols as well as estimates of the primary and secondary $PM_{2.5}$ concentrations. Secondary aerosols represent particles which are formed in the atmosphere as a result of chemical reactions among airborne chemicals. In the case of the oil sands region, the key secondary aerosols resulting from industrial activities are the sulphates and nitrates formed from the SO_2 and NO_x emissions in the region.

For completeness, this evaluation includes a refined analysis of the airborne concentrations of metals and PAH compounds resulting from industrial emissions, and an analysis of the resultant depositions of these compounds. These data have been incorporated into the Additional Human Health Analyses presented in Section B5 (New Information) of this supplemental submission.

B4.2 MODEL APPROACH AND LIMITATIONS

The analysis of primary particulate concentrations and depositions were conducted using the ISC3BE dispersion model developed by BOVAR Environmental that is a modified version of the original ISC3ST model. The Industrial Source Complex Short Term Model, Version 3 (ISCST3) is a steady-state Gaussian plume model, recommended by the U.S. EPA for evaluating pollutant releases from a wide variety of sources associated with industrial source complexes. This model can account for: building downwash; area, line and volume sources; plume rise as a function of downwind distance; separation of point sources; and limited terrain adjustment.

The modifications made to the original model code were undertaken to enable the model to yield maximum predictions during the daylight hours and to predict similar numbers of exceedances as observed at the local monitoring stations (Conor Pacific 1998). Although the tuning done to the ISC3BE model has not been subjected to the same rigorous independent review as the original code, the changes are designed to yield model predictions which correspond to the observations made at sampling locations along the Athabasca River valley. This model has been extensively used in previous air assessments in the oil sands region.

Dispersion models employ simplifying assumptions to describe the random processes associated with atmospheric motions and turbulence. These simplifying processes limit the capability of a model to replicate individual events. A model's predictive capability and strength lies in the capability to predict an average for a given set of meteorological conditions. Other factors that limit the capability of a model to predict values that match observations are limitations in the input data and information used by the model. For example, the modelling does not account for the hour-by-hour emission rates in the source strength and exit characteristics (such as temperature and velocity). The models do not replicate the special flow patterns and reduced dispersion within the Athabasca River valley, although the ISC3BE model has been tuned in an attempt to account for some of these effects.

Notwithstanding these limitations, the data used by the models and for an evaluation of the model was reviewed in Appendix III of Vol. 2D of the EIA, and were found to be sufficient for the modelling application. Specifically, the model predictions show good agreement with observations, both in terms of magnitude and diurnal trends.

One of the limitations of the ISC3BE model is that it cannot explicitly address the chemical transformations required to simulate acidic deposition or secondary aerosol formation. To effectively simulate these chemical processes it was necessary to employ the CALPUFF dispersion model.

CALPUFF is a multi-layer, multi-species non-steady-state puff dispersion model which can simulate the effects of time and space-varying meteorological conditions on pollutant transport, transformation, and removal. CALPUFF can use the three dimensional meteorological fields developed by CALMET or similar models, or simple, single station winds in a format consistent with the meteorological files used to drive the ISC3BE model. The use of single station wind files do not allow CALPUFF to take advantage of its capabilities to treat spatially-variable meteorological fields. However, all of the information required for the generation of the three dimensional meteorological fields required with the full implementation of CALPUFF were not readily available at the time of the assessment. For this reason, CALPUFF was run in the "steady-state" mode, using the meteorological data collected at the Suncor Mannix station (75m level).

B4.3 BASELINE CONDITIONS

B4.3.1 Emissions

The baseline emissions scenario includes the contribution from oil sands mining, extraction and upgrading facilities in the Athabasca oil sands region as well as emissions from other sources, including other industrial operations, transportation and community sources. This section summarizes the Baseline projects as defined in Table A2-11 of Vol. 2A of the EIA.

A summary of the emissions from Suncor, Syncrude, other industries, transportation and residential sources in the oil sands region is provided in Table B4-1. While the results in the table indicate the two oil sands operations are the major sources of emissions to the atmosphere, there are other smaller sources that can also influence air quality. This is especially true for those smaller sources which originate from the communities. The particulate emissions in the table have been adjusted to correspond to the best estimates of PM_{10} emissions available.

Table B4-1 Summary of Estimated Baseline Emissions in the Athabasca Oil Sands Region

Source	Emission Rates (t/cd)					
	SO_2	NO_x	CO	PM[(a)]	VOC	TRS
Suncor	65.3	47.7	7.6	3.4	130.2	1.5
Syncrude	209.0	44.4	53.6	5.4	39.4	2.3
Other Industries	3.9	8.7	27.1	0.9	4.9	0.01
Transportation and Residential	0.2	1.37	6.5	1.5	2.95	-
Total	**278.4**	**102.17**	**94.8**	**11.2**	**172**	**3.81**

- Not a source of this emission.
(a) Assumed as PM_{10}.
n/d no data

Note: The updated values in the above table represent the latest estimates of emissions as detailed in Technical Reference for Meteorology, Emissions and Ambient Air Quality in the Athabasca Oil Sands Region (Golder and Conor Pacific 1998).

The airborne concentrations of PM_{10} are typically referred to as the inhalable fraction and corresponds to those particles which can enter the human lungs. The PM_{10} fraction of the particles includes material over a wide range of sizes, but can reasonably be described as those particles having a mass mean diameter less than 10 μm. Within this PM10 fraction is a subset of particles which are small enough to infiltrate deep into the respiratory tract. These respirable particles are usually designated as $PM_{2.5}$, which includes those particles having a mass mean diameter less than 2.5 μm.

Concern regarding the $PM_{2.5}$ fraction of the airborne PM_{10} has started to get increasing attention from regulators and the public. Unfortunately, detailed information regarding actual $PM_{2.5}$ emissions to the atmosphere is limited in comparison to the information on PM_{10}. For the purposes of this evaluation, the airborne primary $PM_{2.5}$ concentrations have been derived from the predicted PM_{10} levels using available emission relationships as demonstrated in the following table. The overall relationships shown in Table B4-2 have been applied to all modelled primary PM_{10} concentrations.

Table B4-2 Summary of Baseline Particle Relationships

Source	Emissions [t/cd]		
	PM_{10}	$PM_{2.5}/PM_{10}$	$PM_{2.5}$
Suncor FGD[(a)]	2.73	99%	2.70
Syncrude Main Stack[(a)]	3.6	80%	2.88
Mine Fleet[(b)]	1.9	48%	0.9
Total	**8.23**	**78%**	**6.48**

(a) Based on stack monitoring results
(b) Based on emission relationships listed in Table 3-61 "Technical Reference for the Meteorology, Emissions and Ambient Air Quality in the Athabasca Oil Sands Region".

The key emission sources in the region for heavy metals and PAH compounds are the mine fleets, the Suncor FGD stack and the Syncrude main stack. Emissions of heavy metals and PAH compounds from each of these sources were derived from source specific speciation information gathered from emissions testing results (in the case of the FGD and Syncrude main stack) or from literature (in the case of the mine fleet). These speciation data were based on total PM emissions from each of these sources. The modelling methodology used to determine both the concentration and deposition of these compounds were similar. For each source, the airborne concentrations and resultant depositions of the total PM were determined. The individual speciations listed in Tables B4-3 and B4-4 were then applied to determine the contributions from each source. Finally, the contributions from each of the sources was then summed to determine the overall concentrations or depositions of the species of interest.

Table B4-3 Heavy Metal Speciations

Parameters	Average Fraction of Total PM Emissions		
	Suncor FGD	Syncrude Main Stack	Mine Fleet
Antimony	0.0010%	0.0009%	0%
Arsenic	0.0017%	0.0014%	0%
Aluminum	0.1270%	0.2299%	0%
Barium	0.0172%	0.0126%	0%
Beryllium	0.0002%	0.0002%	0%
Cadmium	0.0002%	0.0006%	0%
Calcium	0.1089%	0.3105%	0%
Chromium	0.0737%	0.0920%	0%
Cobalt	0.0037%	0.0053%	0%
Copper	0.0062%	0.0091%	0%
Iron	0.5324%	1.1444%	0%
Lead	0.0118%	0.0081%	0%
Magnesium	0.0499%	0.0494%	0%
Manganese	0.0320%	0.0294%	0%
Mercury	0.0002%	0.0002%	0%
Molybdenum	0.0148%	0.0164%	0%
Nickel	0.1095%	0.1612%	0%
Phosphorus	0.1149%	0.0169%	0%
Selenium	0.0662%	0.0027%	0%
Silicon	0.5445%	3.1338%	0%
Silver	0.0009%	0.0026%	0%
Sodium	1.3309%	1.1941%	0%
Tin	0.0118%	0.0090%	0%
Titanium	0.0163%	0.0215%	0%
Vanadium	0.0584%	0.0617%	0%
Zirconium	0.0118%	0.0090%	0%
Zinc	0.0218%	0.8160%	0%

Table B4-4 PAH Speciations

Parameter	Fraction of Total PM Emissions		
	Suncor FGD	Syncrude Main Stack	Mine Fleet
Acenaphthene	2.057E-07	8.451E-08	4.106E-05
Acenaphylene	1.301E-07	1.383E-05	8.109E-05
Anthracene	6.140E-07	1.268E-07	1.223E-05
1,2-Benzathracene	2.117E-07	1.831E-07	-
Benzo(b & j)fluoranthene	1.579E-06	5.211E-07	-
Benzo(k)fluoranthene	1.815E-07	2.394E-07	1.106E-06
Benzo(a)fluorene	2.329E-07	8.451E-08	2.650E-06
Benzo(b)fluorene	1.210E-07	8.451E-08	-
Benzo(g, h, i)perylene	2.208E-07	2.676E-07	2.513E-06
Benzo(a)pyrene	1.815E-07	1.408E-07	1.159E-06
Benzo(e)pyrene	1.210E-07	8.451E-08	1.643E-07
Camphene	4.083E-07	8.451E-08	-
Carbazole	2.117E-07	8.451E-08	-
1 -Chloronaphthalene	1.815E-07	9.859E-08	-
2-Chloronaphthalene	1.815E-07	3.239E-07	-
Chrysene	2.964E-07	5.634E-07	8.158E-06
Dibenz(a, j)acridine	1.815E-07	1.831E-07	-
Dibenz(a, h)acridine	1.815E-07	8.451E-08	-
Dibenz(a, h)anthracene	1.815E-07	9.859E-08	3.044E-06
Dibenzothiophene	7.320E-07	5.473E-05	1.746E-07
7,12-dimethylbenz(a)anthracene	1.815E-07	8.451E-08	-
1, 6-Dinitropyrene	1.815E-07	8.451E-08	-
1, 8-Dinitropyrene	1.815E-07	8.451E-08	-
Fluoranthene	1.594E-06	8.592E-07	2.927E-05
Fluorene	1.116E-06	8.451E-08	1.123E-04
Ideno(l, 2, 3-cd)pyrene	1.815E-07	2.817E-07	-
Indole	4.235E-07	8.451E-08	-
1 -Methylnaphthalene	1.903E-06	1.363E-05	-
2-Methylnaphthalene	2.710E-06	1.148E-05	-
Naphthalene	1.406E-05	1.980E-04	1.142E-03
Nitro-pyrene	2.722E-07	8.451E-08	-
Perylene	1.210E-07	8.451E-08	2.054E-08
Phenanthrene	6.803E-06	1.841E-05	3.302E-04
Pyrene	9.800E-07	1.944E-06	2.307E-05
Retene	2.117E-06	1.070E-06	-

- = no data

B4.3.2 Predicted Concentrations of Primary and Secondary Particulates

The predicted maximum daily and annual ground level concentrations of primary and secondary PM_{10} at each of the communities in the oil sands region are presented in Table B4-5. Table B4-6 presents a summary of the primary and secondary $PM_{2.5}$ fraction of the airborne PM_{10}. A discussion of the effects on human health in the region from the PM_{10} and $PM_{2.5}$ concentrations has been included in Section B5 (New Information) of this submission.

Table B4-5 Predicted Ground Level Concentrations of Primary and Secondary PM_{10} for the Baseline Emissions

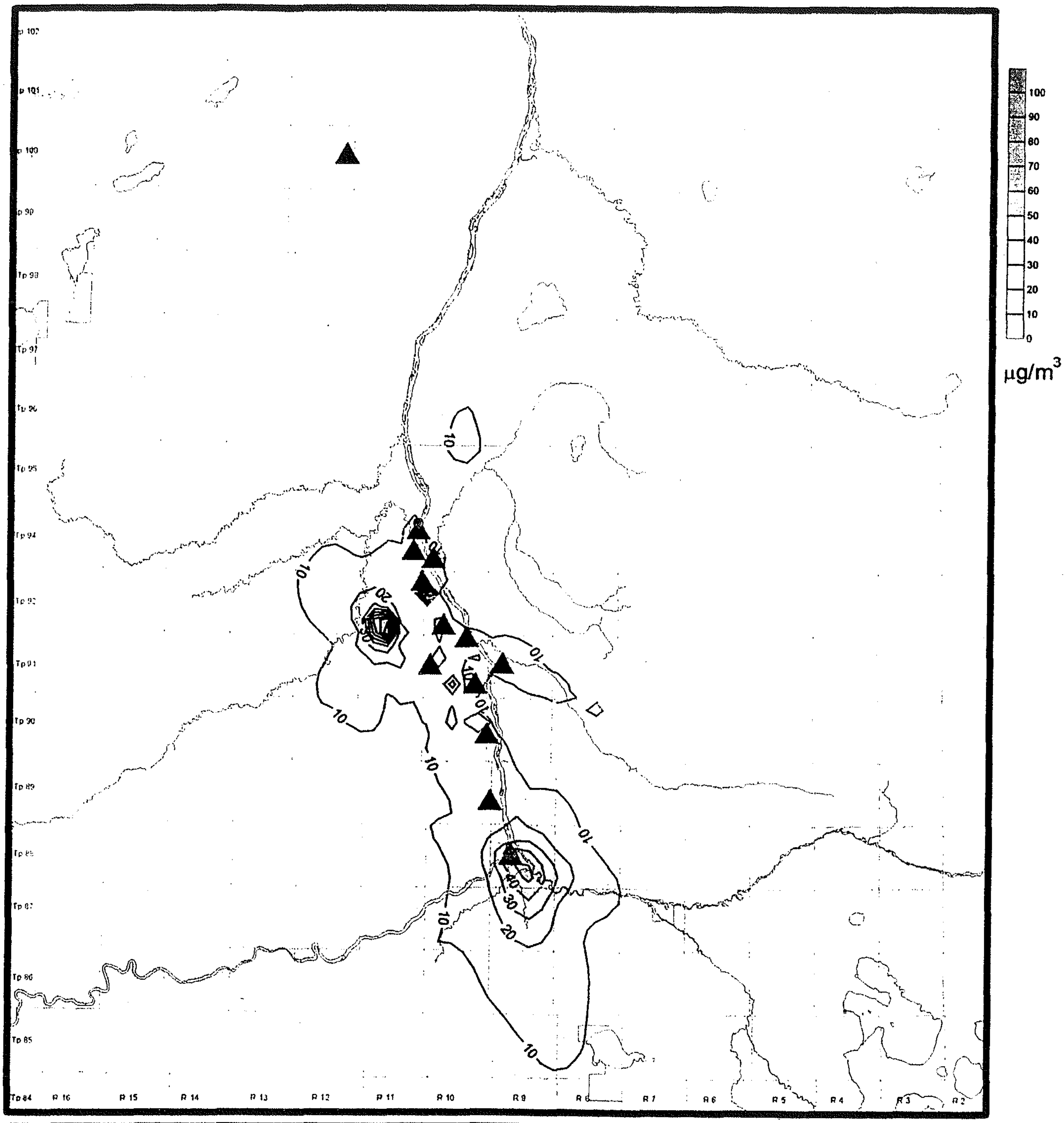
	Maximum Daily Concentration				Average Annual Concentration			
Location	Lower Camp	Fort McMurray	Fort McKay	Fort Chipewyan	Lower Camp	Fort McMurray	Fort McKay	Fort Chipewyan
Secondary PM_{10} [$\mu g/m^3$]								
Sulphate	0.7	0.5	0.7	0.5	0.1	0.1	0.1	0.0
Nitrate	4.0	3.3	3.2	0.2	0.7	0.3	0.6	0.0
Total Secondary PM_{10}	4.7	3.8	3.9	0.7	0.8	0.3	0.6	0.1
Primary PM_{10} [$\mu g/m^3$]	16.5	58.8	12.7	1.6	3.2	8.3	1.6	0.1
Total PM_{10} [$\mu g/m^3$]	21.2	62.6	16.6	2.3	3.9	8.6	2.2	0.2

Table B4-6 Predicted Ground Level Concentrations of Primary and Secondary $PM_{2.5}$ for the Baseline Emissions

	Maximum Daily Concentration				Average Annual Concentration			
Location	Lower Camp	Fort McMurray	Fort McKay	Fort Chipewyan	Lower Camp	Fort McMurray	Fort McKay	Fort Chipewyan
Secondary $PM_{2.5}$ [$\mu g/m^3$]								
Sulphate	0.7	0.5	0.7	0.5	0.1	0.1	0.1	0.0
Nitrate	4.0	3.3	3.2	0.2	0.7	0.3	0.6	0.0
Total Secondary $PM_{2.5}$	4.7	3.8	3.9	0.7	0.8	0.3	0.6	0.1
Primary $PM_{2.5}$ [$\mu g/m^3$]	12.9	45.9	9.9	1.3	2.5	6.4	1.2	0.1
Total $PM_{2.5}$ [$\mu g/m^3$]	17.6	49.6	13.8	2.0	3.2	6.8	1.8	0.2

The predicted baseline maximum daily and annual average primary PM_{10} concentrations are presented in Figures B2-27 and B2-28, respectively. These new figures correspond to the same numbered figures in the original EIA document (Vol. 2A).

Figure B2-27 Predicted Baseline PM_{10} Maximum Daily Average Ground Level Concentrations in the RSA



Sources	PM [t/cd]
Suncor	
FGD	2.74
Powerhouse	0.24
Incinerator	0.03
Lease 86/17 Mine Fleet	0.05
Steepbank Mine Fleet	0.05
Other Sources, Suncor	0.23
Syncrude (total)	5.6
Other Emissions (total)	2.2
TOTAL	11.1

Model Description	
Development	Baseline
Model	ISC3BE
PM_{10} Guideline [µg/m³]	50
Maximum [µg/m³]	132
Exceedences / Year [#]	95

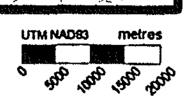
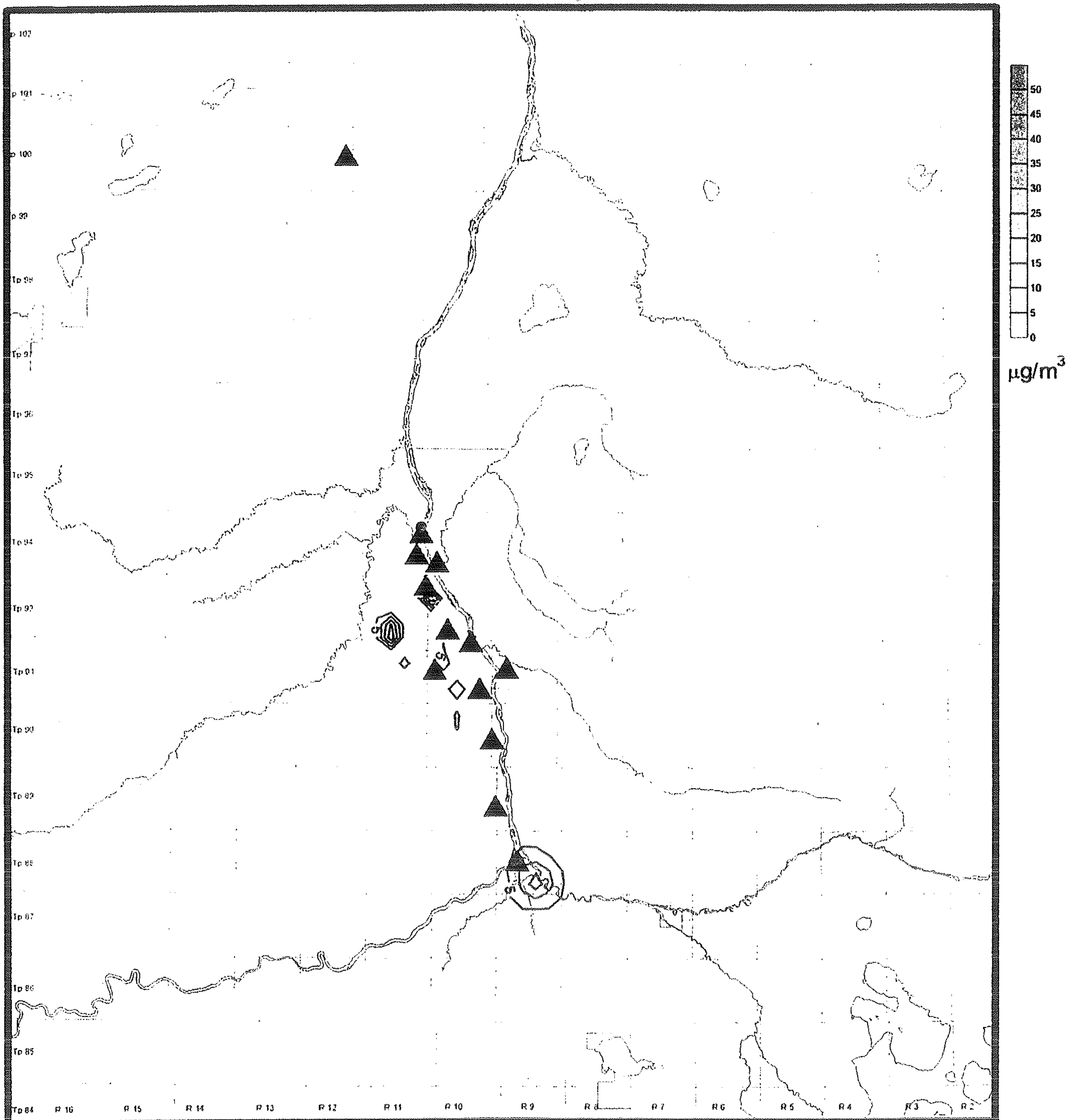
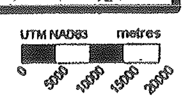


Figure B2-28 Predicted Baseline PM_{10} Annual Average Ground Level Concentrations in the RSA



Sources	PM [t/cd]
Suncor	
FGD	2.74
Powerhouse	0.24
Incinerator	0.03
Lease 86/17 Mine Fleet	0.05
Steepbank Mine Fleet	0.05
Other Sources, Suncor	0.23
Syncrude (total)	5.6
Other Emissions (total)	2.2
TOTAL	11.1

Model Description	
Development	Baseline
Model	ISC3BE
PM_{10} Guideline [µg/m³]	50
Maximum [µg/m³]	41.6
Exceedences / Year [#]	0



B4.3.3 Predicted Concentrations and Deposition Rates of Metals and PAH Compounds

The predicted maximum daily and annual ground level concentrations of heavy metals and PAH compounds resulting from the Baseline releases from the Suncor FGD, the Syncrude main stack and the mine fleets are summarized in Tables B4-7 and B4-8. In a similar manner, the annual deposition rates of the metals and PAH compounds are summarized in Tables B4-9 and B4-10, respectively.

Table B4-7 Average Predicted Ground Level Concentrations of Heavy Metals at Selected Sites for Baseline Emissions

	Maximum Daily Ground Level Concentration					Average Annual Ground Level Concentration			
Location	Ontario AAQC, Daily [ng/m³]	Lower Camp	Fort McMurray	Fort McKay	Fort Chipewyan	Lower Camp	Fort McMurray	Fort McKay	Fort Chipewyan
Heavy Metals [μg/m³]									
Antimony	—	1.01E-04	7.26E-06	2.60E-05	2.39E-06	4.73E-06	3.34E-07	2.11E-06	1.02E-07
Arsenic	3.00E+03	1.58E-04	1.16E-05	4.09E-05	3.79E-06	7.53E-06	5.35E-07	3.31E-06	1.63E-07
Aluminum	—	1.96E-02	1.16E-03	5.16E-03	4.07E-04	7.75E-04	4.90E-05	4.12E-04	1.62E-05
Barium	1.00E+05	1.54E-03	1.16E-04	3.96E-04	3.77E-05	7.54E-05	5.43E-06	3.22E-05	1.63E-06
Beryllium	0.00E+00	1.92E-05	1.33E-06	4.99E-06	4.44E-07	8.74E-07	6.05E-08	4.03E-07	1.87E-08
Cadmium	2.00E+04	4.52E-05	2.44E-06	1.20E-05	8.88E-07	1.66E-06	9.92E-08	9.52E-07	3.43E-08
Calcium	—	2.36E-02	1.24E-03	6.29E-03	4.55E-04	8.47E-04	4.94E-05	4.98E-04	1.74E-05
Chromium	1.50E+04	8.87E-03	5.80E-04	2.32E-03	1.97E-04	3.83E-04	2.57E-05	1.86E-04	8.15E-06
Cobalt	1.00E+03	4.88E-04	3.07E-05	1.28E-04	1.06E-05	2.04E-05	1.34E-06	1.02E-05	4.31E-07
Copper	5.00E+05	8.25E-04	5.17E-05	2.17E-04	1.78E-05	3.44E-05	2.25E-06	1.73E-05	7.25E-07
Iron	—	9.30E-02	5.24E-03	2.46E-02	1.87E-03	3.54E-03	2.17E-04	1.96E-03	7.35E-05
Lead	0.00E+00	1.02E-03	7.83E-05	2.61E-04	2.53E-05	5.06E-05	3.68E-06	2.12E-05	1.10E-06
Magnesium	—	5.22E-03	3.65E-04	1.36E-03	1.21E-04	2.39E-04	1.66E-05	1.09E-04	5.12E-06
Manganese	—	3.21E-03	2.29E-04	8.32E-04	7.55E-05	1.49E-04	1.05E-05	6.72E-05	3.21E-06
Mercury	2.00E+04	2.24E-05	1.50E-06	5.85E-06	5.07E-07	9.90E-07	6.73E-08	4.71E-07	2.11E-08
Molybdenum	1.20E+06	1.66E-03	1.12E-04	4.32E-04	3.77E-05	7.37E-05	5.03E-06	3.48E-05	1.57E-06
Nickel	2.00E+04	1.47E-02	9.16E-04	3.84E-03	3.16E-04	6.09E-04	3.98E-05	3.08E-04	1.28E-05
Phosphorus	—	6.18E-03	6.29E-04	1.53E-03	1.88E-04	3.94E-04	3.18E-05	1.28E-04	8.83E-06
Selenium	1.00E+05	3.14E-03	3.47E-04	7.69E-04	1.02E-04	2.16E-04	1.79E-05	6.50E-05	4.87E-06
Silicon	—	2.14E-01	9.63E-03	5.74E-02	3.77E-03	6.77E-03	3.51E-04	4.51E-03	1.35E-04
Silver	1.00E+04	2.00E-04	1.04E-05	5.32E-05	3.84E-06	7.13E-06	4.15E-07	4.21E-06	1.46E-07
Sodium	—	1.32E-01	9.46E-03	3.42E-02	3.12E-03	6.17E-03	4.34E-04	2.76E-03	1.33E-04
Tin	1.00E+05	1.07E-03	8.03E-05	2.76E-04	2.61E-05	5.21E-05	3.74E-06	2.24E-05	1.13E-06
Titanium	—	2.03E-03	1.31E-04	5.32E-04	4.47E-05	8.67E-05	5.77E-06	4.26E-05	1.84E-06
Vanadium	2.00E+04	6.35E-03	4.35E-04	1.65E-03	1.46E-04	2.86E-04	1.96E-05	1.33E-04	6.11E-06
Zirconium	—	1.07E-03	8.03E-05	2.76E-04	2.61E-05	5.21E-05	3.74E-06	2.24E-05	1.13E-06
Zinc	1.20E+06	5.03E-02	1.89E-03	1.36E-02	8.01E-04	1.38E-03	5.93E-05	1.06E-03	2.65E-05

OAAQC: Ontario Ambient Air Quality Criteria, Ontario Ministry of the Environment 1994' Summary of Point of Impingement Standards, Ambient Air Quality Criteria (AAQC), and Approvals Screening Levels

Table B4-8 Average Predicted Ground Level Concentrations of PAHs at Selected Sites for Baseline Emissions

Location	Maximum Daily Ground Level Concentration				Average Annual Ground Level Concentration			
	Lower Camp	Fort McMurray	Fort McKay	Fort Chipewyan	Lower Camp	Fort McMurray	Fort McKay	Fort Chipewyan
PAHs [μg/m³]								
Acenaphthene	9.87E-04	9.12E-05	1.75E-04	1.24E-05	1.84E-01	4.42E-03	2.27E-02	9.22E-04
Acenaphylene	2.03E-03	1.83E-04	3.68E-04	2.57E-05	3.66E-01	8.82E-03	4.66E-02	1.86E-03
Anthracene	2.97E-04	2.75E-05	5.30E-05	3.79E-06	5.51E-02	1.33E-03	6.83E-03	2.79E-04
1,2-Benzathracene	2.06E-06	1.49E-07	5.32E-07	4.89E-08	9.70E-05	6.85E-06	4.31E-05	2.09E-06
Benzo(b & j)fiuoranthene	1.02E-05	9.27E-07	2.58E-06	2.86E-07	5.88E-04	4.56E-05	2.13E-04	1.30E-05
Benzo(k)fluoranthene	2.88E-05	2.60E-06	5.30E-06	3.83E-07	5.06E-03	1.25E-04	6.58E-04	2.68E-05
Benzo(a)fluorene	6.51E-05	6.02E-06	1.17E-05	8.41E-07	1.20E-02	2.92E-04	1.50E-03	6.13E-05
Benzo(b)fluorene	1.05E-06	8.08E-08	2.71E-07	2.61E-08	5.22E-05	3.78E-06	2.20E-05	1.13E-06
Benzo(g, h, i)perylene	6.29E-05	5.75E-06	1.14E-05	8.15E-07	1.14E-02	2.78E-04	1.44E-03	5.87E-05
Benzo(a)pyrene	2.95E-05	2.70E-06	5.37E-06	3.90E-07	5.28E-03	1.31E-04	6.75E-04	2.77E-05
Benzo(e)pyrene	5.00E-06	4.45E-07	9.71E-07	7.56E-08	7.89E-04	2.15E-05	1.13E-04	4.82E-06
Camphene	2.34E-06	2.29E-07	5.85E-07	6.91E-08	1.44E-04	1.15E-05	4.87E-05	3.21E-06
Carbazole	1.46E-06	1.28E-07	3.70E-07	3.97E-08	8.12E-05	6.21E-06	3.05E-05	1.79E-06
1 -Chloronaphthalene	1.41E-06	1.15E-07	3.60E-07	3.65E-08	7.38E-05	5.49E-06	2.94E-05	1.61E-06
2-Chloronaphthalene	2.77E-06	1.64E-07	7.30E-07	5.77E-08	1.10E-04	6.97E-06	5.83E-05	2.30E-06
Chrysene	2.01E-04	1.84E-05	3.60E-05	2.55E-06	3.68E-02	8.89E-04	4.61E-03	1.87E-04
Dibenz(a, j)acridine	1.92E-06	1.33E-07	4.99E-07	4.44E-08	8.74E-05	6.05E-06	4.03E-05	1.87E-06
Dibenz(a, h)acridine	1.32E-06	1.12E-07	3.37E-07	3.51E-08	7.15E-05	5.40E-06	2.76E-05	1.57E-06
Dibenz(a, h anthracene	7.45E-05	6.87E-06	1.33E-05	9.53E-07	1.37E-02	3.33E-04	1.71E-03	6.98E-05
Dibenzothiophene	3.38E-04	1.27E-05	9.14E-05	5.31E-06	9.81E-03	3.97E-04	7.16E-03	1.77E-04
7,12-dimethylbenz(a)anthracene	1.32E-06	1.12E-07	3.37E-07	3.51E-08	7.15E-05	5.40E-06	2.76E-05	1.57E-06
1, 6-Dinitropyrene	1.32E-06	1.12E-07	3.37E-07	3.51E-08	7.15E-05	5.40E-06	2.76E-05	1.57E-06
1, 8-Dinitropyrene	1.32E-06	1.12E-07	3.37E-07	3.51E-08	7.15E-05	5.40E-06	2.76E-05	1.57E-06
Fluoranthene	7.15E-04	6.60E-05	1.28E-04	9.14E-06	1.32E-01	3.20E-03	1.64E-02	6.70E-04
Fluorene	2.70E-03	2.50E-04	4.80E-04	3.40E-05	5.04E-01	1.21E-02	6.22E-02	2.53E-03
Ideno(l, 2, 3-cd)pyrene	2.52E-06	1.55E-07	6.61E-07	5.37E-08	1.03E-04	6.69E-06	5.29E-05	2.17E-06
Indole	2.41E-06	2.37E-07	6.02E-07	7.14E-08	1.49E-04	1.19E-05	5.01E-05	3.32E-06
1 -Methylnaphthalene	9.09E-05	3.95E-06	2.45E-05	1.57E-06	2.80E-03	1.40E-04	1.92E-03	5.55E-05
2-Methylnaphthalene	8.15E-05	3.90E-06	2.18E-05	1.49E-06	2.71E-03	1.48E-04	1.72E-03	5.47E-05
Naphthalene	2.87E-02	2.58E-03	5.21E-03	3.65E-04	5.16E+00	1.25E-01	6.57E-01	2.63E-02
Nitro-pyrene	1.73E-06	1.59E-07	4.36E-07	4.87E-08	1.01E-04	7.82E-06	3.61E-05	2.23E-06
Perylene	1.55E-06	1.26E-07	3.59E-07	3.23E-08	1.44E-04	5.99E-06	3.34E-05	1.59E-06
Phenanthrene	8.07E-03	7.40E-04	1.44E-03	1.02E-04	1.49E+00	3.58E-02	1.85E-01	7.51E-03
Pyrene	5.70E-04	5.21E-05	1.03E-04	7.28E-06	1.04E-01	2.52E-03	1.31E-02	5.30E-04
Retene	1.60E-05	1.32E-06	4.07E-06	4.18E-07	8.48E-04	6.35E-05	3.33E-04	1.86E-05
Nitrobenzanthrone	1.59E-04	1.47E-05	2.82E-05	1.99E-06	2.96E-02	7.11E-04	3.65E-03	1.48E-04

Table B4-9 Average Predicted Deposition of Heavy Metals at Selected Sites as for Baseline Emissions

Location	Average Annual Deposition			
	Lower Camp	Fort McMurray	Fort McKay	Fort Chipewyan
Heavy Metals [ng/m^2]				
Antimony	2.14E-02	2.31E-04	6.26E-03	1.02E-05
Arsenic	3.38E-02	3.59E-04	9.61E-03	1.60E-05
Aluminum	3.80E+00	5.01E-02	1.57E+00	2.03E-03
Barium	3.34E-01	3.42E-03	8.83E-02	1.55E-04
Beryllium	4.01E-03	4.51E-05	1.27E-03	1.95E-06
Cadmium	8.47E-03	1.20E-04	3.92E-03	4.72E-06
Calcium	4.37E+00	6.36E-02	2.11E+00	2.48E-03
Chromium	1.80E+00	2.15E-02	6.33E-01	9.08E-04
Cobalt	9.75E-02	1.21E-03	3.64E-02	5.01E-05
Copper	1.64E-01	2.05E-03	6.21E-02	8.49E-05
Iron	1.77E+01	2.43E-01	7.79E+00	9.67E-03
Lead	2.23E-01	2.23E-03	5.65E-02	1.02E-04
Magnesium	1.09E+00	1.22E-02	3.41E-01	5.30E-04
Manganese	6.78E-01	7.41E-03	2.04E-01	3.25E-04
Mercury	4.61E-03	5.38E-05	1.55E-03	2.29E-06
Molybdenum	3.42E-01	3.95E-03	1.13E-01	1.69E-04
Nickel	2.92E+00	3.65E-02	1.10E+00	1.51E-03
Phosphorus	1.57E+00	1.05E-02	1.37E-01	5.93E-04
Selenium	8.35E-01	4.77E-03	3.21E-02	2.96E-04
Silicon	3.74E+01	6.06E-01	2.11E+01	2.27E-02
Silver	3.69E-02	5.39E-04	1.79E-02	2.09E-05
Sodium	2.79E+01	3.04E-01	8.29E+00	1.34E-02
Tin	2.32E-01	2.39E-03	6.25E-02	1.08E-04
Titanium	4.10E-01	4.97E-03	1.48E-01	2.08E-04
Vanadium	1.32E+00	1.50E-02	4.26E-01	6.46E-04
Zirconium	2.32E-01	2.39E-03	6.25E-02	1.08E-04
Zinc	8.27E+00	1.50E-01	5.48E+00	5.40E-03

Table B4-10 Average Predicted Deposition of PAHs at Selected Sites for Baseline Emissions

Location	Average Annual Deposition			
	Lower Camp	Fort McMurray	Fort McKay	Fort Chipewyan
PAHs [ng/m^2]				
Acenaphthene	2.81E-02	1.60E-04	1.00E-03	1.82E-05
Acenaphylene	6.86E-02	5.63E-04	1.11E-02	4.47E-05
Anthracene	9.16E-03	5.30E-05	3.78E-04	5.72E-06
1,2-Benzathracene	4.38E-04	4.70E-06	1.27E-04	2.08E-07
Benzo(b & j)fluoranthene	2.44E-03	1.97E-05	3.82E-04	1.00E-06
Benzo(k)fluoranthene	1.21E-03	9.76E-06	1.90E-04	7.18E-07
Benzo(a)fluorene	2.16E-03	1.32E-05	1.22E-04	1.32E-06
Benzo(b)fluorene	2.30E-04	2.32E-06	5.92E-05	1.06E-07
Benzo(g, h, i)perylene	2.23E-03	1.59E-05	2.42E-04	1.37E-06
Benzo(a)pyrene	1.14E-03	8.17E-06	1.25E-04	6.78E-07
Benzo(e)pyrene	3.42E-04	2.95E-06	6.30E-05	1.78E-07
Camphene	5.81E-04	4.17E-06	6.52E-05	2.26E-07
Carbazole	3.41E-04	2.91E-06	6.11E-05	1.44E-07
1 -Chloronaphthalene	3.18E-04	2.97E-06	6.99E-05	1.40E-07
2-Chloronaphthalene	5.39E-04	7.08E-06	2.21E-04	2.87E-07
Chrysene	6.44E-03	4.33E-05	5.71E-04	4.08E-06
Dibenz(a, j)acridine	4.01E-04	4.51E-06	1.27E-04	1.95E-07
Dibenz(a, h)acridine	3.04E-04	2.71E-06	6.05E-05	1.31E-07
Dibenz(a, h anthracene	2.38E-03	1.46E-05	1.40E-04	1.48E-06
Dibenzothiophene	5.47E-02	1.00E-03	3.67E-02	3.60E-05
7,12-dimethylbenz(a)anthracene	3.04E-04	2.71E-06	6.05E-05	1.31E-07
1, 6-Dinitropyrene	3.04E-04	2.71E-06	6.05E-05	1.31E-07
1, 8-Dinitropyrene	3.04E-04	2.71E-06	6.05E-05	1.31E-07
Fluoranthene	2.26E-02	1.38E-04	1.28E-03	1.41E-05
Fluorene	7.75E-02	4.38E-04	2.65E-03	5.00E-05
Ideno(l, 2, 3-cd)pyrene	4.98E-04	6.31E-06	1.93E-04	2.59E-07
Indole	5.99E-04	4.27E-06	6.55E-05	2.33E-07
1 -Methylnaphthalene	1.57E-02	2.61E-04	9.19E-03	9.66E-06
2-Methylnaphthalene	1.46E-02	2.27E-04	7.76E-03	8.60E-06
Naphthalene	9.85E-01	8.06E-03	1.59E-01	6.37E-04
Nitro-pyrene	4.15E-04	3.30E-06	6.23E-05	1.69E-07
Perylene	2.44E-04	2.40E-06	5.97E-05	1.15E-07
Phenanthrene	2.50E-01	1.64E-03	2.00E-02	1.60E-04
Pyrene	1.87E-02	1.30E-04	1.85E-03	1.18E-05
Retene	3.63E-03	3.32E-05	7.62E-04	1.59E-06

B4.4 PROJECT MILLENNIUM

B4.4.1 Emissions

The summary of estimated air emissions from Project Millennium and approved projects as well as other industrial emissions, combined with the transportation and residential sources are included in Table B4-11.

Table B4-11 Summary of Project Millennium Estimated Emissions in the Athabasca Oil Sands Region

Source	Emission Rates (t/cd)					
	SO_2	NO_x	CO	PM [(a)]	VOC	TRS
Suncor	70.2	67.7	12.9	3.8	233	2.7
Syncrude	209.0	44.4	53.6	5.4	39.4	2.3
Other Industries	3.9	8.7	27.1	0.9	4.9	0.01
Transportation and Residential	0.2	1.37	6.5	1.5	2.95	n/a
Total	**283.3**	**122.2**	**100**	**11.6**	**280**	**5.01**

(a) Assumed as PM_{10}.

The airborne concentrations of PM_{10} are typically referred to as the inhalable fraction and corresponds to those particles which can enter the human lungs. The PM_{10} fraction of the particles includes material over a wide range of sizes, but can reasonably be described as those particles having a mass mean diameter less than 10 µm. Within this PM10 fraction is a subset of particles which are small enough to infiltrate deep into the respiratory tract. These respirable particles are usually designated as $PM_{2.5}$, which includes those particles having a mass mean diameter less than 2.5 µm.

Concern regarding the $PM_{2.5}$ fraction of the airborne PM_{10} has started to get increasing attention from regulators and the public. Unfortunately, solid information regarding actual $PM_{2.5}$ emissions to the atmosphere is limited in comparison to the information on PM_{10}. For the purposes of this evaluation, the airborne primary $PM_{2.5}$ concentrations have been derived from the predicted PM_{10} levels using available emission relationships as demonstrated in the following table. The overall relationships, as shown in Table B4-12, have been applied to all modelled primary PM_{10} concentrations.

Table B4-12 Summary of Millennium Particle Relationships

Source	Emissions [t/cd]		
	PM_{10}	$PM_{2.5}/PM_{10}$	$PM_{2.5}$
Suncor FGD[(a)]	2.6	99%	2.57
Syncrude Main Stack[(a)]	3.6	80%	2.88
Mine Fleet[(b)]	2.4	54%	1.3
Total	**8.6**	**78%**	**6.75**

(a) Based on stack monitoring results

(b) Based on emission relationships listed in Table 3-61 "Technical Reference for the Meteorology, Emissions and Ambient Air Quality in the Athabasca Oil Sands Region".

The key emission sources in the region for heavy metals and PAH compounds are the mine fleets, the Suncor FGD stack and the Syncrude main stack. Emissions of heavy metals and PAH compounds from each of these sources were derived from source specific speciation information gathered from emissions testing results (in the case of the FGD and Syncrude main stack) or from literature (in the case of the mine fleet). These speciation data were based on total PM emissions from each of these sources. The modelling methodology used to determine both the concentration and deposition of these compounds were similar. For each source, the airborne concentrations and resultant depositions of the total PM were determined. These individual speciations were then applied to determine the contribution of each source. Finally, the contributions from each of the sources was then summed to determine the overall concentrations or depositions of the species of interest.

B4.4.2 Predicted Concentrations of Primary and Secondary Particulates

The predicted maximum daily and annual ground level concentrations of primary and secondary PM_{10} at each of the communities in the oil sands region are presented in Table B4-13. Table B4-14 presents a summary of the primary and secondary $PM_{2.5}$ fraction of the airborne PM_{10}. A discussion of the effects on human health in the region from the PM_{10} and $PM_{2.5}$ concentrations has been included in Section B5 (New Information) of this submission.

Table B4-13 Predicted Ground Level Concentrations of Primary and Secondary PM_{10} for the Millennium Emissions

	Maximum Daily Concentration				Average Annual Concentration			
Location	Lower Camp	Fort McMurray	Fort McKay	Fort Chipewyan	Lower Camp	Fort McMurray	Fort McKay	Fort Chipewyan
Secondary PM_{10} [$\mu g/m^3$]								
Sulphate	0.8	0.7	0.8	0.5	0.1	0.1	0.1	0.0
Nitrate	4.5	4.8	3.7	0.4	0.7	0.5	0.6	0.0
Total Secondary PM_{10}	5.3	5.5	4.5	0.9	0.8	0.6	0.7	0.1
Primary PM_{10} [$\mu g/m^3$]	13.2	58.8	12.4	1.9	2.5	8.4	1.7	0.1
Total PM_{10} [$\mu g/m^3$]	18.5	64.3	16.9	2.8	3.3	8.9	2.4	0.2

Table B4-14 Predicted Ground Level Concentrations of Primary and Secondary $PM_{2.5}$ for the Millennium Emissions

	Maximum Daily Concentration				Average Annual Concentration			
Location	Lower Camp	Fort McMurray	Fort McKay	Fort Chipewyan	Lower Camp	Fort McMurray	Fort McKay	Fort Chipewyan
Secondary $PM_{2.5}$ [$\mu g/m^3$]								
Sulphate	0.8	0.7	0.8	0.5	0.1	0.1	0.1	0.0
Nitrate	4.5	4.8	3.7	0.4	0.7	0.5	0.6	0.0
Total Secondary $PM_{2.5}$	5.3	5.5	4.5	0.9	0.8	0.6	0.7	0.1
Primary $PM_{2.5}$ [$\mu g/m^3$]	10.3	45.9	9.7	1.5	2.0	6.5	1.3	0.1
Total $PM_{2.5}$ [$\mu g/m^3$]	15.6	51.4	14.2	2.4	2.8	7.1	2.0	0.2

The predicted maximum daily and annual average primary PM_{10} concentrations resulting from the Project Millennium emissions in the oil sands region are presented graphically in Figures B3-17 and B3-18, respectively. These Figures correspond to the same numbered Figures in the original EIA document (Vol. 2A).

B4.4.3 Predicted Concentrations and Deposition Rates of Metals and PAH Compounds

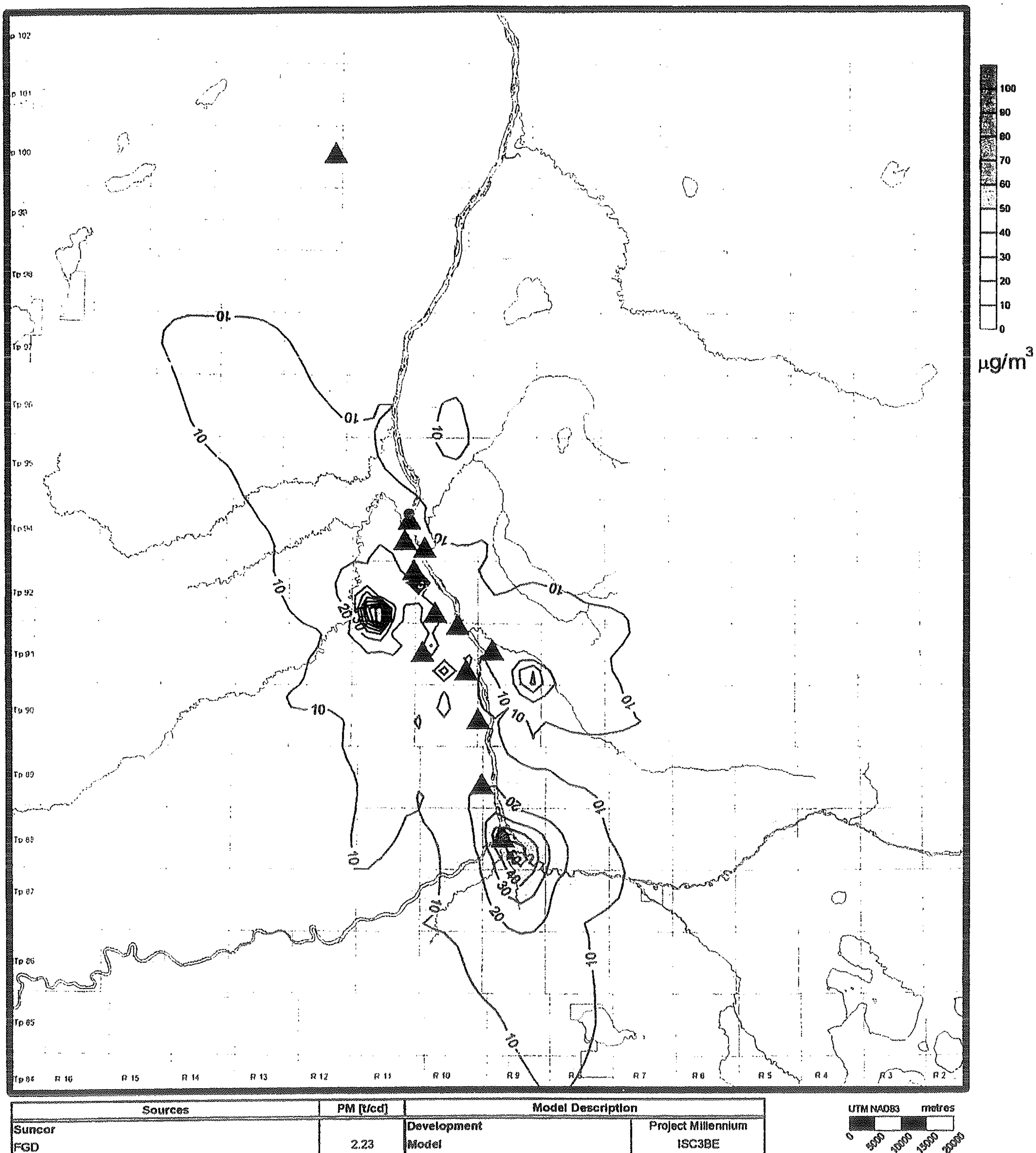
The predicted maximum daily and annual ground level concentrations of heavy metals and PAH compounds resulting from the Millennium emissions for the Suncor FGD, the Syncrude main stack and the mine fleets are summarized in Tables B4-15 and B4-16. In a similar manner, the annual deposition rates of the metals and PAH compounds are summarized in Tables B4-17 and B4-18, respectively.

Table B4-15 Average Predicted Ground Level Concentrations of Heavy Metals at Selected Sites for Millennium Emissions

Location	Maximum Daily Ground Level Concentration					Average Annual Ground Level Concentration			
	Ontario AAQC, Daily [ng/m^3]	Lower Camp	Fort McMurray	Fort McKay	Fort Chipewyan	Lower Camp	Fort McMurray	Fort McKay	Fort Chipewyan
Heavy Metals [μg/m^3]									
Antimony	—	9.54E-05	6.72E-06	2.50E-05	2.25E-06	4.35E-06	3.05E-07	2.01E-06	9.49E-08
Arsenic	3.00E+03	1.50E-04	1.07E-05	3.91E-05	3.56E-06	6.91E-06	4.88E-07	3.15E-06	1.51E-07
Aluminum	—	1.89E-02	1.09E-03	5.03E-03	3.89E-04	7.27E-04	4.55E-05	3.99E-04	1.54E-05
Barium	1.00E+05	1.45E-03	1.07E-04	3.78E-04	3.54E-05	6.89E-05	4.95E-06	3.05E-05	1.52E-06
Beryllium	0.00E+00	1.83E-05	1.24E-06	4.80E-06	4.19E-07	8.06E-07	5.54E-08	3.85E-07	1.75E-08
Cadmium	2.00E+04	4.40E-05	2.32E-06	1.18E-05	8.56E-07	1.58E-06	9.28E-08	9.29E-07	3.27E-08
Calcium	—	2.31E-02	1.18E-03	6.17E-03	4.40E-04	8.06E-04	4.64E-05	4.87E-04	1.66E-05
Chromium	1.50E+04	8.49E-03	5.42E-04	2.24E-03	1.87E-04	3.56E-04	2.37E-05	1.79E-04	7.64E-06
Cobalt	1.00E+03	4.69E-04	2.88E-05	1.24E-04	1.01E-05	1.90E-05	1.24E-06	9.88E-06	4.06E-07
Copper	5.00E+05	7.94E-04	4.84E-05	2.10E-04	1.70E-05	3.20E-05	2.08E-06	1.67E-05	6.83E-07
Iron	—	9.03E-02	4.96E-03	2.41E-02	1.80E-03	3.34E-03	2.02E-04	1.90E-03	6.99E-05
Lead	0.00E+00	9.56E-04	7.22E-05	2.49E-04	2.36E-05	4.62E-05	3.35E-06	2.01E-05	1.02E-06
Magnesium	—	4.97E-03	3.39E-04	1.30E-03	1.14E-04	2.20E-04	1.52E-05	1.05E-04	4.78E-06
Manganese	—	3.05E-03	2.12E-04	7.98E-04	7.11E-05	1.37E-04	9.57E-06	6.41E-05	2.99E-06
Mercury	2.00E+04	2.14E-05	1.40E-06	5.64E-06	4.80E-07	9.16E-07	6.18E-08	4.51E-07	1.98E-08
Molybdenum	1.20E+06	1.58E-03	1.04E-04	4.16E-04	3.56E-05	6.82E-05	4.62E-06	3.33E-05	1.47E-06
Nickel	2.00E+04	1.41E-02	8.58E-04	3.73E-03	3.01E-04	5.68E-04	3.68E-05	2.97E-04	1.21E-05
Phosphorus	—	5.59E-03	5.69E-04	1.41E-03	1.72E-04	3.51E-04	2.86E-05	1.17E-04	8.05E-06
Selenium	1.00E+05	2.80E-03	3.13E-04	7.00E-04	9.27E-05	1.91E-04	1.60E-05	5.85E-05	4.42E-06
Silicon	—	2.11E-01	9.35E-03	5.68E-02	3.69E-03	6.57E-03	3.36E-04	4.46E-03	1.32E-04
Silver	1.00E+04	1.95E-04	9.94E-06	5.22E-05	3.71E-06	6.79E-06	3.90E-07	4.12E-06	1.40E-07
Sodium	—	1.25E-01	8.76E-03	3.28E-02	2.94E-03	5.67E-03	3.97E-04	2.63E-03	1.24E-04
Tin	1.00E+05	1.01E-03	7.41E-05	2.64E-04	2.45E-05	4.76E-05	3.41E-06	2.12E-05	1.05E-06
Titanium	—	1.95E-03	1.22E-04	5.14E-04	4.25E-05	8.06E-05	5.32E-06	4.10E-05	1.73E-06
Vanadium	2.00E+04	6.05E-03	4.05E-04	1.59E-03	1.38E-04	2.64E-04	1.80E-05	1.27E-04	5.71E-06
Zirconium	—	1.01E-03	7.41E-05	2.64E-04	2.45E-05	4.76E-05	3.41E-06	2.12E-05	1.05E-06
Zinc	1.20E+06	5.02E-02	1.88E-03	1.36E-02	7.98E-04	1.37E-03	5.87E-05	1.06E-03	2.64E-05

OAAQC: Ontario Ambient Air Quality Criteria, Ontario Ministry of the Environment 1994, Summary of Point of Impingement Standards, Ambient Air Quality Criteria (AAQC), and Approvals Screening Levels

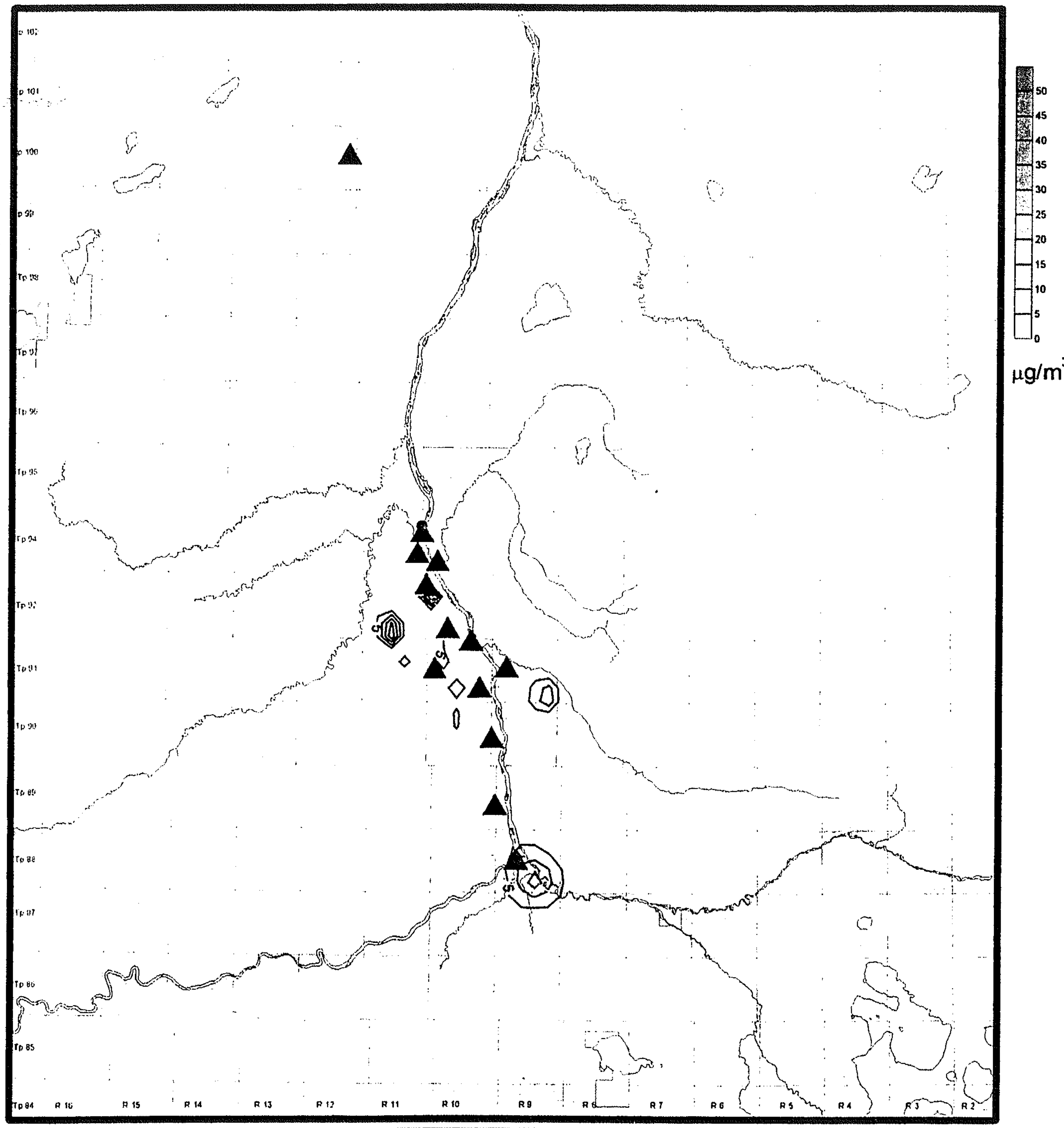
Figure B3-17 Predicted Millennium PM_{10} Maximum Daily Average Ground Level Concentrations in the RSA



Sources	PM [t/cd]
Suncor	
FGD	2.23
Powerhouse	0.24
Incinerator	0.038
Tail Gas Treatment Unit	0.042
Millennium Mine Fleet	0.3
Other Sources, Suncor	0.65
Syncrude (total)	5.6
Other Emissions (total)	2.2
TOTAL	11.3

Model Description	
Development	Project Millennium
Model	ISC3BE
PM_{10} Guideline [µg/m³]	50
Maximum [µg/m³]	132
Exceedences / Year [#]	95

Figure B3-18 Predicted Millennium PM_{10} Annual Average Ground Level Concentrations in the RSA



Sources	PM [t/cd]
Suncor	
FGD	2.23
Powerhouse	0.24
Incinerator	0.038
Tail Gas Treatment Unit	0.042
Millennium Mine Fleet	0.3
Other Sources, Suncor	0.65
Syncrude (total)	5.6
Other Emissions (total)	2.2
TOTAL	11.3

Model Description	
Development	Project Millennium
Model	ISC3BE
PM_{10} Guideline [µg/m³]	50
Maximum [µg/m³]	41.6
Exceedences / Year [#]	0

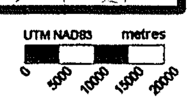


Table B4-16 Average Predicted Ground Level Concentrations of PAHs at Selected Sites for Millennium Emissions

Location	Maximum Daily Ground Level Concentration				Average Annual Ground Level Concentration			
	Lower Camp	Fort McMurray	Fort McKay	Fort Chipewyan	Lower Camp	Fort McMurray	Fort McKay	Fort Chipewyan
PAHs [μg/m³]								
Acenaphthene	1.84E-04	2.52E-04	1.75E-04	1.69E-05	2.25E-02	1.25E-02	2.25E-02	1.42E-03
Acenaphylene	4.45E-04	5.00E-04	3.69E-04	3.46E-05	4.65E-02	2.48E-02	4.61E-02	2.84E-03
Anthracene	5.76E-05	7.53E-05	5.30E-05	5.11E-06	6.87E-03	3.74E-03	6.75E-03	4.26E-04
1,2-Benzathracene	1.95E-06	1.38E-07	5.10E-07	4.60E-08	8.91E-05	6.26E-06	4.10E-05	1.95E-06
Benzo(b & j)fluoranthene	9.43E-06	8.44E-07	2.42E-06	2.64E-07	5.29E-04	4.12E-05	1.98E-04	1.19E-05
Benzo(k)fluoranthene	7.09E-06	6.92E-06	5.29E-06	5.01E-07	6.93E-04	3.43E-04	6.50E-04	4.00E-05
Benzo(a)fluorene	1.32E-05	1.64E-05	1.17E-05	1.13E-06	1.53E-03	8.13E-04	1.48E-03	9.30E-05
Benzo(b)fluorene	9.92E-07	7.44E-08	2.58E-07	2.44E-08	4.77E-05	3.45E-06	2.08E-05	1.05E-06
Benzo(g, h, i)perylene	1.37E-05	1.56E-05	1.14E-05	1.09E-06	1.48E-03	7.72E-04	1.43E-03	8.88E-05
Benzo(a)pyrene	6.73E-06	7.23E-06	5.35E-06	5.14E-07	7.06E-04	3.58E-04	6.66E-04	4.15E-05
Benzo(e)pyrene	1.72E-06	1.08E-06	9.59E-07	9.18E-08	1.37E-04	5.35E-05	1.11E-04	6.71E-06
Camphene	2.14E-06	2.07E-07	5.42E-07	6.35E-08	1.29E-04	1.03E-05	4.47E-05	2.93E-06
Carbazole	1.35E-06	1.16E-07	3.48E-07	3.68E-08	7.32E-05	5.62E-06	2.84E-05	1.65E-06
1 -Chloronaphthalene	1.32E-06	1.05E-07	3.41E-07	3.40E-08	6.70E-05	4.99E-06	2.77E-05	1.49E-06
2-Chloronaphthalene	2.68E-06	1.55E-07	7.11E-07	5.52E-08	1.03E-04	6.46E-06	5.65E-05	2.18E-06
Chrysene	4.09E-05	5.03E-05	3.60E-05	3.44E-06	4.63E-03	2.49E-03	4.55E-03	2.85E-04
Dibenz(a, j)acridine	1.83E-06	1.24E-07	4.80E-07	4.19E-08	8.06E-05	5.54E-06	3.85E-05	1.75E-06
Dibenz(a, h)acridine	1.23E-06	1.02E-07	3.18E-07	3.27E-08	6.47E-05	4.89E-06	2.59E-05	1.45E-06
Dibenz(a, h anthracene	1.49E-05	1.88E-05	1.33E-05	1.28E-06	1.73E-03	9.32E-04	1.69E-03	1.06E-04
Dibenzothiophene	3.34E-04	1.33E-05	9.13E-05	5.32E-06	9.10E-03	4.30E-04	7.15E-03	1.78E-04
7,12-dimethylbenz(a)anthracene	1.23E-06	1.02E-07	3.18E-07	3.27E-08	6.47E-05	4.89E-06	2.59E-05	1.45E-06
1, 6-Dinitropyrene	1.23E-06	1.02E-07	3.18E-07	3.27E-08	6.47E-05	4.89E-06	2.59E-05	1.45E-06
1, 8-Dinitropyrene	1.23E-06	1.02E-07	3.18E-07	3.27E-08	6.47E-05	4.89E-06	2.59E-05	1.45E-06
Fluoranthene	1.42E-04	1.80E-04	1.28E-04	1.23E-05	1.66E-02	8.96E-03	1.62E-02	1.02E-03
Fluorene	5.05E-04	6.90E-04	4.80E-04	4.63E-05	6.16E-02	3.42E-02	6.15E-02	3.88E-03
Ideno(l, 2, 3-cd)pyrene	2.42E-06	1.45E-07	6.42E-07	5.12E-08	9.64E-05	6.19E-06	5.11E-05	2.05E-06
Indole	2.20E-06	2.14E-07	5.57E-07	6.56E-08	1.33E-04	1.07E-05	4.60E-05	3.03E-06
1 -Methylnaphthalene	8.99E-05	3.85E-06	2.43E-05	1.54E-06	2.73E-03	1.35E-04	1.90E-03	5.42E-05
2-Methylnaphthalene	8.01E-05	3.76E-06	2.15E-05	1.45E-06	2.61E-03	1.40E-04	1.69E-03	5.29E-05
Naphthalene	6.33E-03	7.05E-03	5.21E-03	4.89E-04	6.59E-01	3.49E-01	6.50E-01	4.00E-02
Nitro-pyrene	1.59E-06	1.44E-07	4.08E-07	4.50E-08	9.03E-05	7.06E-06	3.34E-05	2.04E-06
Perylene	1.08E-06	2.00E-07	3.46E-07	3.28E-08	5.89E-05	9.70E-06	3.21E-05	1.76E-06
Phenanthrene	1.61E-03	2.03E-03	1.44E-03	1.38E-04	1.85E-01	1.01E-01	1.83E-01	1.15E-02
Pyrene	1.18E-04	1.42E-04	1.02E-04	9.78E-06	1.32E-02	7.06E-03	1.29E-02	8.07E-04
Retene	1.49E-05	1.21E-06	3.85E-06	3.89E-07	7.69E-04	5.76E-05	3.13E-04	1.71E-05
Nitrobenzanthrone	2.94E-05	4.05E-05	2.82E-05	2.71E-06	3.61E-03	2.01E-03	3.61E-03	2.28E-04

Table B4-17 Average Predicted Deposition of Heavy Metals at Selected Sites for Millennium Emissions

	Average Annual Deposition			
Location	Lower Camp	Fort McMurray	Fort McKay	Fort Chipewyan
Heavy Metals [ng/m^2]				
Antimony	2.00E-02	2.24E-04	6.24E-03	9.77E-06
Arsenic	3.16E-02	3.49E-04	9.58E-03	1.53E-05
Aluminum	3.63E+00	4.93E-02	1.57E+00	1.98E-03
Barium	3.11E-01	3.31E-03	8.80E-02	1.48E-04
Beryllium	3.76E-03	4.40E-05	1.26E-03	1.88E-06
Cadmium	8.16E-03	1.19E-04	3.92E-03	4.63E-06
Calcium	4.23E+00	6.30E-02	2.10E+00	2.43E-03
Chromium	1.70E+00	2.11E-02	6.32E-01	8.78E-04
Cobalt	9.24E-02	1.19E-03	3.63E-02	4.87E-05
Copper	1.56E-01	2.01E-03	6.19E-02	8.24E-05
Iron	1.70E+01	2.40E-01	7.78E+00	9.46E-03
Lead	2.07E-01	2.16E-03	5.63E-02	9.72E-05
Magnesium	1.03E+00	1.19E-02	3.41E-01	5.10E-04
Manganese	6.35E-01	7.22E-03	2.03E-01	3.12E-04
Mercury	4.34E-03	5.26E-05	1.55E-03	2.21E-06
Molybdenum	3.22E-01	3.86E-03	1.13E-01	1.63E-04
Nickel	2.77E+00	3.58E-02	1.10E+00	1.46E-03
Phosphorus	1.41E+00	9.79E-03	1.35E-01	5.47E-04
Selenium	7.45E-01	4.37E-03	3.08E-02	2.69E-04
Silicon	3.66E+01	6.03E-01	2.11E+01	2.24E-02
Silver	3.57E-02	5.33E-04	1.78E-02	2.06E-05
Sodium	2.61E+01	2.95E-01	8.26E+00	1.28E-02
Tin	2.16E-01	2.32E-03	6.23E-02	1.03E-04
Titanium	3.88E-01	4.87E-03	1.47E-01	2.02E-04
Vanadium	1.24E+00	1.47E-02	4.25E-01	6.23E-04
Zirconium	2.16E-01	2.32E-03	6.23E-02	1.03E-04
Zinc	8.24E+00	1.50E-01	5.48E+00	5.39E-03

Table B4-18 Average Predicted Deposition of PAHs at Selected Sites for Millennium Emissions

Location	Average Annual Deposition			
	Lower Camp	Fort McMurray	Fort McKay	Fort Chipewyan
PAHs [ng/m^2]				
Acenaphthene	1.48E-03	5.95E-04	9.34E-04	2.72E-05
Acenaphylene	1.60E-02	1.42E-03	1.10E-02	6.26E-05
Anthracene	1.14E-03	1.82E-04	3.57E-04	8.39E-06
1,2-Benzathracene	4.09E-04	4.57E-06	1.27E-04	1.99E-07
Benzo(b & j)fiuoranthene	2.22E-03	1.87E-05	3.80E-04	9.39E-07
Benzo(k)fluoranthene	4.63E-04	2.14E-05	1.88E-04	9.54E-07
Benzo(a)fluorene	4.11E-04	4.11E-05	1.17E-04	1.89E-06
Benzo(b)fluorene	2.14E-04	2.25E-06	5.90E-05	1.01E-07
Benzo(g, h, i)perylene	5.73E-04	4.24E-05	2.37E-04	1.92E-06
Benzo(a)pyrene	3.68E-04	2.04E-05	1.23E-04	9.26E-07
Benzo(e)pyrene	2.19E-04	4.62E-06	6.25E-05	2.09E-07
Camphene	5.25E-04	3.93E-06	6.44E-05	2.10E-07
Carbazole	3.12E-04	2.78E-06	6.07E-05	1.35E-07
1 -Chloronaphthalene	2.93E-04	2.86E-06	6.96E-05	1.33E-07
2-Chloronaphthalene	5.15E-04	6.97E-06	2.21E-04	2.80E-07
Chrysene	1.11E-03	1.30E-04	5.57E-04	5.86E-06
Dibenz(a, j)acridine	3.76E-04	4.40E-06	1.26E-04	1.88E-07
Dibenz(a, h)acridine	2.80E-04	2.60E-06	6.01E-05	1.24E-07
Dibenz(a, h anthracene	3.80E-04	4.68E-05	1.34E-04	2.14E-06
Dibenzothiophene	5.45E-02	1.00E-03	3.67E-02	3.60E-05
7,12-dimethylbenz(a)anthracene	2.80E-04	2.60E-06	6.01E-05	1.24E-07
1, 6-Dinitropyrene	2.80E-04	2.60E-06	6.01E-05	1.24E-07
1, 8-Dinitropyrene	2.80E-04	2.60E-06	6.01E-05	1.24E-07
Fluoranthene	3.40E-03	4.47E-04	1.23E-03	2.05E-05
Fluorene	4.49E-03	1.63E-03	2.47E-03	7.46E-05
Ideno(l, 2, 3-cd)pyrene	4.73E-04	6.20E-06	1.92E-04	2.52E-07
Indole	5.42E-04	4.01E-06	6.47E-05	2.16E-07
1 -Methylnaphthalene	1.54E-02	2.60E-04	9.18E-03	9.58E-06
2-Methylnaphthalene	1.42E-02	2.25E-04	7.75E-03	8.49E-06
Naphthalene	2.42E-01	2.02E-02	1.57E-01	8.88E-04
Nitro-pyrene	3.78E-04	3.13E-06	6.18E-05	1.58E-07
Perylene	2.15E-04	2.54E-06	5.94E-05	1.14E-07
Phenanthrene	3.48E-02	5.14E-03	1.95E-02	2.32E-04
Pyrene	3.63E-03	3.74E-04	1.81E-03	1.69E-05
Retene	3.35E-03	3.19E-05	7.58E-04	1.50E-06

B4.5 CUMULATIVE EFFECTS ASSESSMENT (CEA)

B4.5.1 Emissions

The summary of the air emissions from Project Millennium, including the approved Syncrude and other industrial emissions, combined with the transportation and residential sources are included in Table B4-19. The key difference between the Millennium and CEA scenarios is the inclusion of disclosed developments in the region. The ones incorporated in the analysis have been outlined in section B4.1.2.5 (Vol. 2A). Table B4-19 summarizes the sources of air emissions considered in the CEA.

Table B4-19 Summary of Estimated CEA Emissions in the Athabasca Oil Sands Region

Source	Emission Rates (t/cd)					
	SO_2	NO_x	CO	PM_{10}	VOC	TRS
Suncor	70.2	67.7	12.9	3.8	233.0	2.7
Syncrude	201.0	63.9	84.5	10.4	45.2	3.58
Other Industries	24.09	88.1	50.5	5.3	35.7	0.24
Transportation and Residential	0.299	2.206	9.89	2.33	4.34	-
Total	296.0	222.0	158.0	21.8	318.0	6.5

Note: The updated values in the above table represent the latest estimates of emissions as detailed in Technical Reference for Meteorology, Emissions and Ambient Air Quality in the Athabasca Oil Sands Region (Golder and Conor Pacific 1998).

The airborne concentrations of PM_{10} are typically referred to as the inhalable fraction and corresponds to those particles which can enter the human lungs. The PM_{10} fraction of the particles includes material over a wide range of sizes, but can reasonably be described as those particles having a mass mean diameter less than 10 μm. Within this PM_{10} fraction is a subset of particles which are small enough to infiltrate deep into the respiratory tract. These respirable particles are usually designated as $PM_{2.5}$, which includes those particles having a mass mean diameter less than 2.5 μm.

Concern regarding the $PM_{2.5}$ fraction of the airborne PM_{10} has started to get increasing attention from regulators and the public. Unfortunately, solid information regarding actual $PM_{2.5}$ emissions to the atmosphere is limited in comparison to the information on PM_{10}. For the purposes of this evaluation, the airborne primary $PM_{2.5}$ concentrations have been derived from the predicted PM_{10} levels using available emission relationships as shown in Table B4-20. The overall relationship derived have been applied to all modelled primary PM_{10} concentrations.

Table B4-20 Summary of Millennium Particle Relationships

	Emissions [t/cd]		
	PM_{10}	$PM_{2.5}/PM_{10}$	$PM_{2.5}$
Suncor FGD[(a)]	2.6	99%	2.57
Syncrude Main Stack[(a)]	4.3	80%	3.44
Mine Fleet[(b)]	3.0	83%	2.5
Total	**8.6**	**86%**	**8.51**

(a) Based on stack monitoring results
(b) Based on emission relationships listed in Table 3-61 "Technical Reference for the Meteorology, Emissions and Ambient Air Quality in the Athabasca Oil Sands Region".

The key emission sources in the region for heavy metals and PAH compounds are the mine fleets, the Suncor FGD stack and the Syncrude main stack. Emissions of heavy metals and PAH compounds from each of these sources were derived from source specific speciation information gathered from emissions testing results (in the case of the FGD and Syncrude main stack) or from literature (in the case of the mine fleet). These speciation data were based on total PM emissions from each of these sources. The modelling methodology used to determine both the concentration and deposition of these compounds were similar. For each source, the airborne concentrations and resultant depositions of the total PM were determined. These individual speciations were then applied to determine the contribution of each source. Finally, the contributions from each of the sources was then summed to determine the overall concentrations or depositions of the species of interest.

B4.5.2 Predicted Concentrations of Primary and Secondary Particulates

The predicted maximum daily and annual ground level concentrations of primary and secondary PM_{10} at each of the communities in the oil sands region are presented in Table B4-21. Table B4-22 presents a summary of the primary and secondary $PM_{2.5}$ fraction of the airborne PM_{10}. A discussion of the effects on human health in the region from the PM_{10} and $PM_{2.5}$ concentrations has been included in Section B5 (New Information) of this submission.

Table B4-21 Predicted Ground Level Concentrations of Primary and Secondary PM_{10} for CEA Emissions

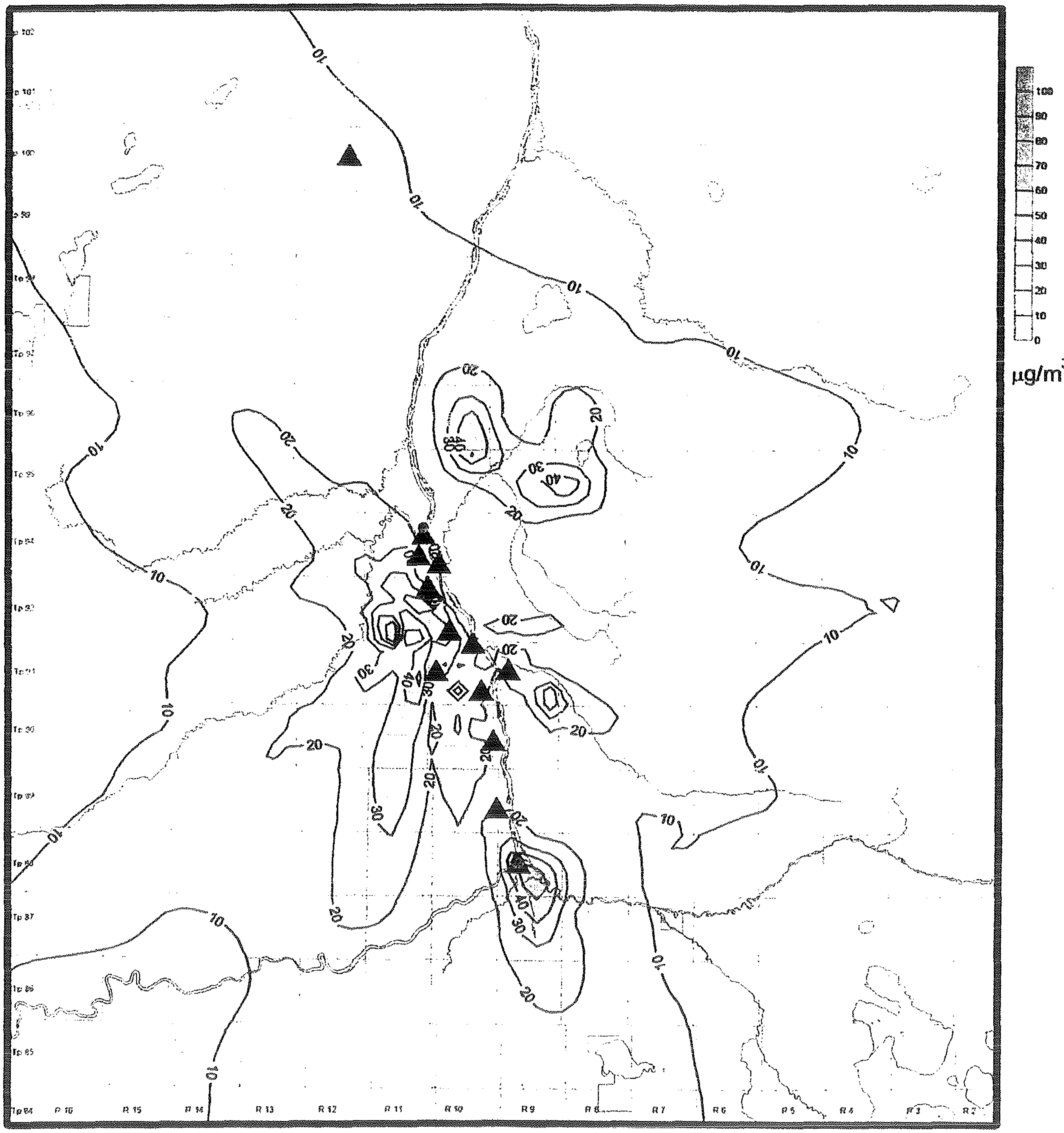
	Maximum Daily Concentration				Average Annual Concentration			
Location	Lower Camp	Fort McMurray	Fort McKay	Fort Chipewyan	Lower Camp	Fort McMurray	Fort McKay	Fort Chipewyan
Secondary PM_{10} [$\mu g/m^3$]								
Sulphate	0.8	0.7	0.9	0.5	0.1	0.1	0.1	0.0
Nitrate	7.9	6.3	8.0	0.6	1.3	0.7	1.5	0.1
Total Secondary PM_{10}	8.7	7.0	8.9	1.1	1.4	0.8	1.6	0.1
Primary PM_{10} [$\mu g/m^3$]	23.0	58.8	17.3	3.4	3.6	8.7	2.9	0.3
Total PM_{10} [$\mu g/m^3$]	31.7	65.9	26.2	4.5	5.1	9.5	4.5	0.4

Table B4-22 Predicted Ground Level Concentrations of Primary and Secondary $PM_{2.5}$ for CEA Emissions

Location	Maximum Daily Concentration				Average Annual Concentration			
	Lower Camp	Fort McMurray	Fort McKay	Fort Chipewyan	Lower Camp	Fort McMurray	Fort McKay	Fort Chipewyan
Secondary $PM_{2.5}$ [$\mu g/m^3$]								
Sulphate	0.8	0.7	0.9	0.5	0.1	0.1	0.1	0.0
Nitrate	7.9	6.3	8.0	0.6	1.3	0.7	1.5	0.1
Total Secondary $PM_{2.5}$	8.7	7.0	8.9	1.1	1.4	0.8	1.6	0.1
Primary $PM_{2.5}$ [$\mu g/m^3$]	17.9	45.9	13.5	2.6	2.8	6.8	2.3	0.2
Total $PM_{2.5}$ [$\mu g/m^3$]	26.7	52.9	22.4	3.7	4.3	7.6	3.9	0.3

The predicted maximum daily and annual average primary PM_{10} concentrations resulting from the CEA emissions in the oil sands region are presented graphically in Figures B2-27 and B2-28, respectively. These Figures correspond to the same numbered Figures in the original EIA document (Vol. 2A).

Figure B4-17 Predicted CEA PM_{10} Maximum Daily Average Ground Level Concentrations in the RSA



Sources	PM [t/cd]
Suncor	
FGD	2.23
Powerhouse	0.24
Incinerator	0.038
Tail Gas Treatment Unit	0.042
Millennium Mine Fleet	0.3
Other Sources, Suncor	0.65
Syncrude (total)	11.4
Other Emissions (total)	2.1
Other Proposed Emissions (total)	2.6
TOTAL	19.6

Model Description	
Development	CEA
Model	ISC3BE
PM_{10} Guideline [µg/m³]	50
Maximum [µg/m³]	134
Exceedences / Year [#]	85

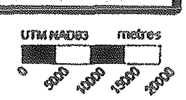
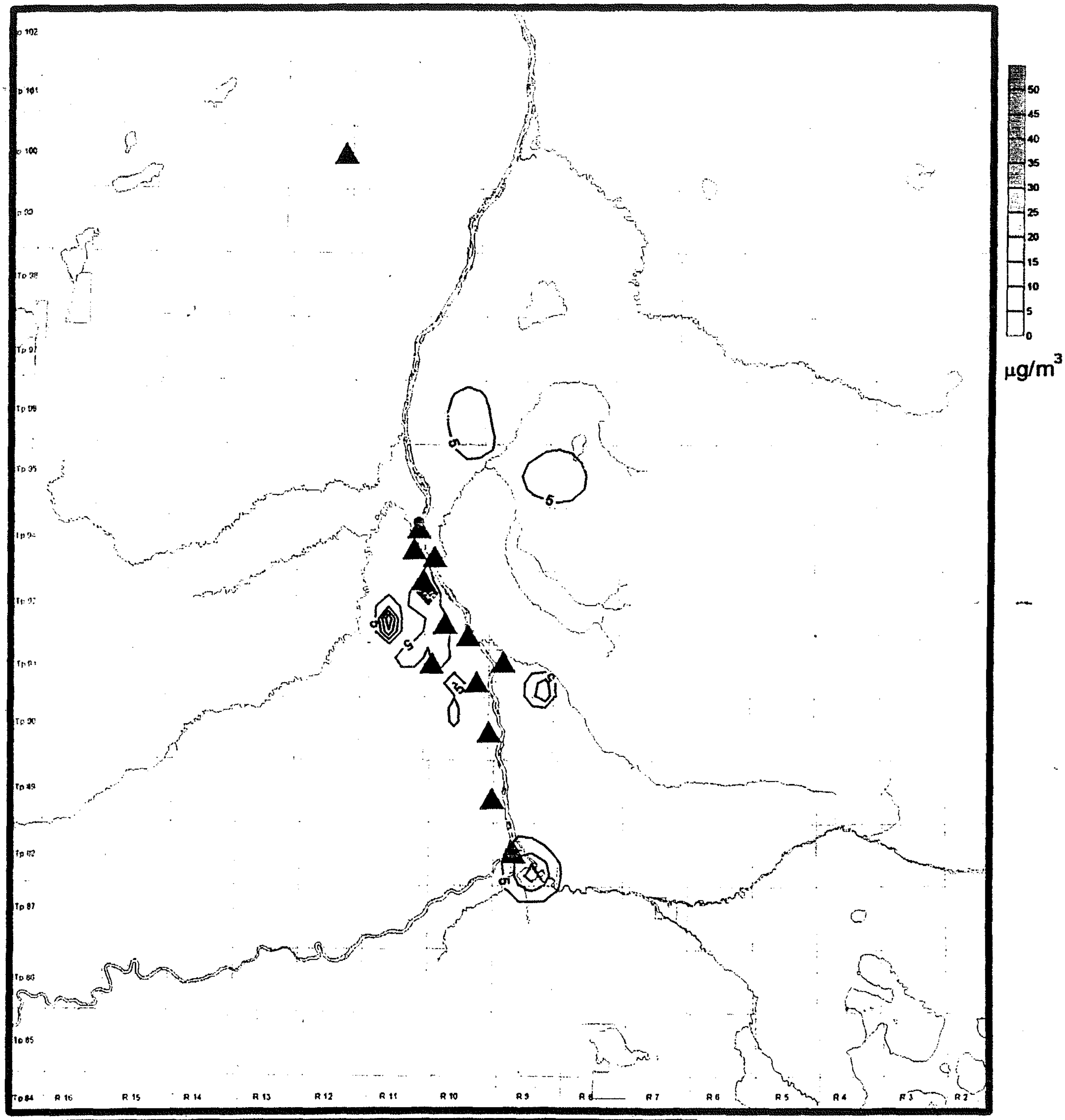
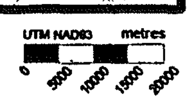


Figure B4-18 Predicted CEA PM_{10} Annual Average Ground Level Concentrations in the RSA





Sources	PM [t/cd]
Suncor	
FGD	2.23
Powerhouse	0.24
Incinerator	0.038
Tail Gas Treatment Unit	0.042
Millennium Mine Fleet	0.3
Other Sources, Suncor	0.65
Syncrude (total)	11.4
Other Emissions (total)	2.1
Other Proposed Emissions (total)	2.6
TOTAL	19.6

Model Description	
Development	CEA
Model	ISC3BE
PM_{10} Guideline [µg/m³]	50
Maximum [µg/m³]	37.3
Exceedences / Year [#]	0

B4.5.3 Predicted Concentrations and Deposition Rates of Metals and PAH Compounds

The predicted maximum daily and annual ground level concentrations of heavy metals and PAH compounds resulting from the CEA scenario are summarized in Tables B4-23 and B4-24. In a similar manner, the annual deposition rates of the metals and PAH compounds are summarized in Tables B4-25 and B4-26, respectively.

Table B3-23 Average Predicted Ground Level Concentrations of Heavy Metals at Selected Sites for CEA Emissions

	Maximum Daily Ground Level Concentration					Average Annual Ground Level Concentration			
Location	Ontario AAQC, Daily [ng/m³]	Lower Camp	Fort McMurray	Fort McKay	Fort Chipewyan	Lower Camp	Fort McMurray	Fort McKay	Fort Chipewyan
Heavy Metals [μg/m³]									
Antimony	—	1.24E-04	1.36E-05	4.10E-05	4.88E-06	8.51E-06	6.23E-07	4.28E-06	2.34E-07
Arsenic	3.00E+03	1.93E-04	2.13E-05	6.36E-05	7.60E-06	1.33E-05	9.76E-07	6.62E-06	3.64E-07
Aluminum	—	2.61E-02	2.85E-03	9.12E-03	1.06E-03	1.79E-03	1.27E-04	9.79E-04	5.08E-05
Barium	1.00E+05	1.84E-03	2.04E-04	6.02E-04	7.23E-05	1.27E-04	9.41E-06	6.23E-05	3.46E-06
Beryllium	0.00E+00	2.40E-05	2.64E-06	8.05E-06	9.55E-07	1.65E-06	1.20E-07	8.46E-07	4.57E-08
Cadmium	2.00E+04	6.21E-05	6.74E-06	2.20E-05	2.54E-06	4.24E-06	2.97E-07	2.38E-06	1.22E-07
Calcium	—	3.28E-02	3.56E-03	1.17E-02	1.35E-03	2.24E-03	1.56E-04	1.27E-03	6.45E-05
Chromium	1.50E+04	1.14E-02	1.25E-03	3.88E-03	4.56E-04	7.81E-04	5.62E-05	4.11E-04	2.18E-05
Cobalt	1.00E+03	6.35E-04	6.94E-05	2.18E-04	2.56E-05	4.35E-05	3.11E-06	2.33E-05	1.22E-06
Copper	5.00E+05	1.08E-03	1.18E-04	3.71E-04	4.34E-05	7.39E-05	5.27E-06	3.95E-05	2.08E-06
Iron	—	1.26E-01	1.37E-02	4.44E-02	5.15E-03	8.63E-03	6.06E-04	4.79E-03	2.46E-04
Lead	0.00E+00	1.21E-03	1.34E-04	3.92E-04	4.72E-05	8.34E-05	6.19E-06	4.04E-05	2.26E-06
Magnesium	—	6.51E-03	7.16E-04	2.18E-03	2.59E-04	4.48E-04	3.26E-05	2.29E-04	1.24E-05
Manganese	—	3.96E-03	4.37E-04	1.32E-03	1.57E-04	2.73E-04	1.99E-05	1.38E-04	7.52E-06
Mercury	2.00E+04	2.85E-05	3.13E-06	9.65E-06	1.14E-06	1.96E-06	1.41E-07	1.02E-06	5.45E-08
Molybdenum	1.20E+06	2.10E-03	2.30E-04	7.08E-04	8.36E-05	1.44E-04	1.04E-05	7.47E-05	4.00E-06
Nickel	2.00E+04	1.91E-02	2.09E-03	6.59E-03	7.72E-04	1.31E-03	9.37E-05	7.03E-04	3.69E-05
Phosphorus	—	6.12E-03	6.98E-04	1.71E-03	2.22E-04	4.29E-04	3.46E-05	1.60E-04	1.07E-05
Selenium	1.00E+05	2.89E-03	3.33E-04	7.48E-04	1.01E-04	2.04E-04	1.70E-05	6.54E-05	4.84E-06
Silicon	—	3.09E-01	3.33E-02	1.13E-01	1.29E-02	2.10E-02	1.44E-03	1.24E-02	6.14E-04
Silver	1.00E+04	2.78E-04	3.01E-05	9.90E-05	1.14E-05	1.90E-05	1.32E-06	1.08E-05	5.46E-07
Sodium	—	1.62E-01	1.79E-02	5.40E-02	6.43E-03	1.12E-02	8.18E-04	5.64E-03	3.08E-04
Tin	1.00E+05	1.29E-03	1.43E-04	4.23E-04	5.07E-05	8.90E-05	6.57E-06	4.38E-05	2.43E-06
Titanium	—	2.62E-03	2.87E-04	8.96E-04	1.05E-04	1.80E-04	1.29E-05	9.52E-05	5.04E-06
Vanadium	2.00E+04	7.98E-03	8.77E-04	2.69E-03	3.18E-04	5.49E-04	3.98E-05	2.83E-04	1.52E-05
Zirconium	—	1.29E-03	1.43E-04	4.23E-04	5.07E-05	8.90E-05	6.57E-06	4.38E-05	2.43E-06
Zinc	1.20E+06	7.57E-02	8.12E-03	2.81E-02	3.18E-03	5.14E-03	3.47E-04	3.12E-03	1.52E-04

OAAQC: Ontario Ambient Air Quality Criteria, Ontario Ministry of the Environment 1994, Summary of Point of Impingement Standards, Ambient Air Quality Criteria (AAQC), and Approvals Screening Levels

Table B3-24 Average Predicted Ground Level Concentrations of PAHs at Selected Sites for CEA Emissions

Location	Maximum Daily Ground Level Concentration				Average Annual Ground Level Concentration			
	Lower Camp	Fort McMurray	Fort McKay	Fort Chipewyan	Lower Camp	Fort McMurray	Fort McKay	Fort Chipewyan
PAHs [μg/m³]								
Acenaphthene	4.33E-04	2.99E-04	3.17E-04	4.29E-05	5.42E-02	1.89E-02	5.30E-02	3.65E-03
Acenaphylene	9.80E-04	6.03E-04	6.72E-04	9.01E-05	1.16E-01	3.79E-02	1.10E-01	7.47E-03
Anthracene	1.32E-04	8.93E-05	9.53E-05	1.29E-05	1.64E-02	5.64E-03	1.59E-02	1.09E-03
1,2-Benzathracene	2.52E-06	2.78E-07	8.35E-07	9.96E-08	1.74E-04	1.27E-05	8.71E-05	4.77E-06
Benzo(b & j)fiuoranthene	1.11E-05	1.24E-06	3.34E-06	4.16E-07	7.69E-04	5.96E-05	3.29E-04	2.00E-05
Benzo(k)fluoranthene	1.46E-05	8.36E-06	9.52E-06	1.27E-06	1.66E-03	5.23E-04	1.53E-03	1.04E-04
Benzo(a)fluorene	2.96E-05	1.94E-05	2.09E-05	2.83E-06	3.61E-03	1.23E-03	3.47E-03	2.39E-04
Benzo(b)fluorene	1.26E-06	1.39E-07	4.09E-07	4.91E-08	8.67E-05	6.43E-06	4.21E-05	2.35E-06
Benzo(g, h, i)perylene	2.98E-05	1.86E-05	2.05E-05	2.76E-06	3.54E-03	1.17E-03	3.36E-03	2.30E-04
Benzo(a)pyrene	1.42E-05	8.65E-06	9.60E-06	1.29E-06	1.67E-03	5.43E-04	1.56E-03	1.07E-04
Benzo(e)pyrene	2.98E-06	1.33E-06	1.67E-06	2.21E-07	3.03E-04	8.20E-05	2.54E-04	1.70E-05
Camphene	2.40E-06	2.72E-07	6.93E-07	8.82E-08	1.68E-04	1.33E-05	6.60E-05	4.24E-06
Carbazole	1.62E-06	1.81E-07	4.98E-07	6.15E-08	1.12E-04	8.60E-06	4.97E-05	2.95E-06
1 -Chloronaphthalene	1.63E-06	1.81E-07	5.16E-07	6.28E-08	1.13E-04	8.47E-06	5.25E-05	3.01E-06
2-Chloronaphthalene	3.69E-06	4.02E-07	1.29E-06	1.50E-07	2.53E-04	1.79E-05	1.38E-04	7.17E-06
Chrysene	9.22E-05	6.00E-05	6.51E-05	8.78E-06	1.12E-02	3.78E-03	1.08E-02	7.38E-04
Dibenz(a, j)acridine	2.40E-06	2.64E-07	8.05E-07	9.55E-08	1.65E-04	1.20E-05	8.46E-05	4.57E-06
Dibenz(a, h)acridine	1.50E-06	1.67E-07	4.68E-07	5.74E-08	1.04E-04	7.88E-06	4.72E-05	2.75E-06
Dibenz(a, h anthracene	3.36E-05	2.23E-05	2.40E-05	3.24E-06	4.13E-03	1.41E-03	3.98E-03	2.74E-04
Dibenzothiophene	5.07E-04	5.54E-05	1.89E-04	2.14E-05	3.45E-02	2.39E-03	2.11E-02	1.03E-03
7,12-dimethylbenz(a)anthracene	1.50E-06	1.67E-07	4.68E-07	5.74E-08	1.04E-04	7.88E-06	4.72E-05	2.75E-06
1, 6-Dinitropyrene	1.50E-06	1.67E-07	4.68E-07	5.74E-08	1.04E-04	7.88E-06	4.72E-05	2.75E-06
1, 8-Dinitropyrene	1.50E-06	1.67E-07	4.68E-07	5.74E-08	1.04E-04	7.88E-06	4.72E-05	2.75E-06
Fluoranthene	3.22E-04	2.14E-04	2.30E-04	3.11E-05	3.96E-02	1.35E-02	3.82E-02	2.63E-03
Fluorene	1.19E-03	8.17E-04	8.67E-04	1.18E-04	1.48E-01	5.17E-02	1.45E-01	1.00E-02
Ideno(l, 2, 3-cd)pyrene	3.31E-06	3.61E-07	1.14E-06	1.34E-07	2.27E-04	1.61E-05	1.22E-04	6.39E-06
Indole	2.46E-06	2.79E-07	7.07E-07	9.03E-08	1.72E-04	1.37E-05	6.73E-05	4.33E-06
1 -Methylnaphthalene	1.33E-04	1.43E-05	4.85E-05	5.53E-06	9.03E-03	6.16E-04	5.34E-03	2.64E-04
2-Methylnaphthalene	1.16E-04	1.25E-05	4.19E-05	4.81E-06	7.91E-03	5.45E-04	4.59E-03	2.30E-04
Naphthalene	1.39E-02	8.50E-03	9.49E-03	1.27E-03	1.63E+00	5.33E-01	1.55E+00	1.05E-01
Nitro-pyrene	1.86E-06	2.09E-07	5.58E-07	6.97E-08	1.29E-04	1.00E-05	5.47E-05	3.34E-06
Perylene	1.47E-06	2.88E-07	5.67E-07	7.06E-08	1.14E-04	1.59E-05	6.86E-05	4.18E-06
Phenanthrene	3.67E-03	2.42E-03	2.61E-03	3.53E-04	4.49E-01	1.53E-01	4.33E-01	2.97E-02
Pyrene	2.64E-04	1.70E-04	1.85E-04	2.50E-05	3.19E-02	1.07E-02	3.06E-02	2.09E-03
Retene	1.82E-05	2.03E-06	5.75E-06	7.02E-07	1.26E-03	9.54E-05	5.82E-04	3.36E-05
Nitrobenzanthrone	6.95E-05	4.80E-05	5.09E-05	6.90E-06	8.71E-03	3.04E-03	8.52E-03	5.88E-04

Table B3-25 Average Predicted Deposition of Heavy Metals at Selected Sites for CEA Emissions

Location	Average Annual Deposition			
	Lower Camp	Fort McMurray	Fort McKay	Fort Chipewyan
Heavy Metals [ng/m^2]				
Antimony	3.87E-02	3.86E-04	8.25E-03	1.67E-05
Arsenic	6.03E-02	5.97E-04	1.26E-02	2.59E-05
Aluminum	8.41E+00	9.06E-02	2.08E+00	3.75E-03
Barium	5.73E-01	5.58E-03	1.16E-01	2.45E-04
Beryllium	7.57E-03	7.69E-05	1.67E-03	3.29E-06
Cadmium	2.02E-02	2.22E-04	5.20E-03	9.07E-06
Calcium	1.07E+01	1.19E-01	2.79E+00	4.82E-03
Chromium	3.61E+00	3.76E-02	8.36E-01	1.59E-03
Cobalt	2.03E-01	2.14E-03	4.81E-02	8.95E-05
Copper	3.44E-01	3.64E-03	8.21E-02	1.52E-04
Iron	4.08E+01	4.45E-01	1.03E+01	1.83E-02
Lead	3.74E-01	3.60E-03	7.42E-02	1.59E-04
Magnesium	2.05E+00	2.08E-02	4.50E-01	8.90E-04
Manganese	1.24E+00	1.25E-02	2.68E-01	5.38E-04
Mercury	9.02E-03	9.30E-05	2.05E-03	3.95E-06
Molybdenum	6.63E-01	6.81E-03	1.50E-01	2.90E-04
Nickel	6.12E+00	6.47E-02	1.46E+00	2.71E-03
Phosphorus	1.76E+00	1.28E-02	1.73E-01	6.77E-04
Selenium	8.02E-01	4.86E-03	3.69E-02	2.91E-04
Silicon	1.02E+02	1.17E+00	2.81E+01	4.66E-02
Silver	9.04E-02	1.01E-03	2.37E-02	4.08E-05
Sodium	5.10E+01	5.10E-01	1.09E+01	2.20E-02
Tin	4.02E-01	3.93E-03	8.23E-02	1.72E-04
Titanium	8.35E-01	8.73E-03	1.95E-01	3.67E-04
Vanadium	2.52E+00	2.57E-02	5.62E-01	1.10E-03
Zirconium	4.02E-01	3.93E-03	8.23E-02	1.72E-04
Zinc	2.52E+01	2.97E-01	7.30E+00	1.17E-02

Table B3-26 Average Predicted Deposition of PAHs at Selected Sites for CEA Emissions

Location	Average Annual Deposition			
	Lower Camp	Fort McMurray	Fort McKay	Fort Chipewyan
PAHs [ng/m^2]				
Acenaphthene	3.28E-03	8.11E-04	2.22E-03	7.12E-05
Acenaphylene	4.80E-02	2.10E-03	1.66E-02	1.60E-04
Anthracene	1.89E-03	2.49E-04	7.62E-04	2.16E-05
1,2-Benzathracene	7.90E-04	7.86E-06	1.68E-04	3.40E-07
Benzo(b & j)fluoranthene	3.31E-03	2.81E-05	4.95E-04	1.34E-06
Benzo(k)fluoranthene	1.00E-03	3.15E-05	2.75E-04	2.32E-06
Benzo(a)fluorene	6.91E-04	5.65E-05	2.18E-04	4.79E-06
Benzo(b)fluorene	3.90E-04	3.76E-06	7.78E-05	1.66E-07
Benzo(g, h, i)perylene	1.23E-03	6.04E-05	3.74E-04	4.81E-06
Benzo(a)pyrene	7.07E-04	2.90E-05	1.90E-04	2.27E-06
Benzo(e)pyrene	4.01E-04	7.00E-06	8.64E-05	4.50E-07
Camphene	7.01E-04	5.44E-06	8.32E-05	2.75E-07
Carbazole	4.88E-04	4.29E-06	7.95E-05	2.00E-07
1 -Chloronaphthalene	4.98E-04	4.63E-06	9.15E-05	2.09E-07
2-Chloronaphthalene	1.19E-03	1.28E-05	2.93E-04	5.29E-07
Chrysene	2.60E-03	1.83E-04	9.34E-04	1.50E-05
Dibenz(a, j)acridine	7.57E-04	7.69E-06	1.67E-04	3.29E-07
Dibenz(a, h)acridine	4.55E-04	4.12E-06	7.89E-05	1.89E-07
Dibenz(a, h anthracene	7.06E-04	6.45E-05	2.50E-04	5.47E-06
Dibenzothiophene	1.68E-01	1.99E-03	4.89E-02	7.83E-05
7,12-dimethylbenz(a)anthracene	4.55E-04	4.12E-06	7.89E-05	1.89E-07
1, 6-Dinitropyrene	4.55E-04	4.12E-06	7.89E-05	1.89E-07
1, 8-Dinitropyrene	4.55E-04	4.12E-06	7.89E-05	1.89E-07
Fluoranthene	6.35E-03	6.16E-04	2.32E-03	5.25E-05
Fluorene	9.12E-03	2.22E-03	5.95E-03	1.95E-04
Ideno(l, 2, 3-cd)pyrene	1.06E-03	1.13E-05	2.55E-04	4.69E-07
Indole	7.18E-04	5.53E-06	8.35E-05	2.81E-07
1 -Methylnaphthalene	4.38E-02	5.05E-04	1.22E-02	2.01E-05
2-Methylnaphthalene	3.81E-02	4.31E-04	1.03E-02	1.73E-05
Naphthalene	6.99E-01	2.97E-02	2.37E-01	2.26E-03
Nitro-pyrene	5.54E-04	4.65E-06	8.07E-05	2.23E-07
Perylene	3.91E-04	4.17E-06	7.89E-05	2.02E-07
Phenanthrene	8.62E-02	7.20E-03	3.38E-02	6.00E-04
Pyrene	8.58E-03	5.30E-04	2.96E-03	4.30E-05
Retene	5.57E-03	5.11E-05	9.96E-04	2.32E-06

B4.6 REFERENCES

Conor Pacific. 1998. Draft Model Selection and Evaluation Appendix. Prepared for Syncrude Canada Ltd., as part of the Project 21 EIA.

Golder Associates Ltd. and Conor Pacific Environmental Technologies Inc. 1998. Technical Reference for Meteorology, Emissions and Ambient Air Quality in the Oil Sands Region. Report for Suncor Energy Inc., Oil Sands. Fort McMurray, Alberta.

B5 ADDITIONAL HUMAN HEALTH ANALYSES

This report provides a human health evaluation of airborne emissions of metals, PAHs and particulates. This information was not previously presented in the Project Millennium Application, since results of the stack survey analysis and associated air dispersion modelling were not available. This report is divided into two main sections, each of which provides additional information associated with a particular key question. Section B4.1 provides additional information with respect to key question HH-2 (inhalation of airborne chemicals) and is divided into two subsections: metals and PAHs, and particulate matter. Section B5.2 provides additional information for key questions HH-3 (ingestion of plants and game animals exposed to airborne metal and PAH emissions) and W-2.

B5.1 Additional Information For Key Question HH-2: Health Effects Associated With Airborne Emissions

The additional information provided in this section addresses additional aspects of Key Question HH-2 and corresponding sections of the baseline and cumulative effects assessments of the Project Millennium Application (Volume 2C, Sections F1.2.2, F1.3.2, and F1.4, Step 2):

What Impacts Will Chemicals in Operational Air Emissions From Project Millennium Have on Human Health?

The potential for impacts to human health as a result of direct inhalation of metals, PAHs, PM_{10} and $PM_{2.5}$ are addressed in the following sections. This information is based on results of recent stack survey analyses conducted by Suncor Energy Inc. and Syncrude Canada Ltd. and the results of air quality modelling for metals, PAHs, PM_{10} and $PM_{2.5}$ presented in the Air Quality component of the Project Millennium EIA, Section B. In addition to the above analyses, further air quality modelling was conducted to address diesel exhaust emissions from the vehicle fleet. Refer to Section B4 (New Information) of this supplemental report "Revised Particulate and Aerosols Analyses" for details on air quality modelling for metals, PAHs and PM_{10}.

B5.2 Metals And PAHs

B5.2.1 Objective

To evaluate the potential for impacts to human health as a result of inhalation of metals and PAHs released from stack and vehicle fleet emissions.

B5.2.2 Methods

Airborne concentrations of metals and PAHs were predicted using dispersion modelling, according to the method described in Section B3 of the Project Millennium Application. The major sources of airborne metals include emissions from stack and fugitive plant sources.

Sources of airborne PAHs include stack emissions and vehicle fleet emissions. Annual average metal and PAH air concentrations for Fort McKay, the closest residential community to the Project, along with Fort McMurray and Fort Chipewyan were evaluated. Additionally, two locations in close proximity to the Suncor Plant Site, known as "Lower Camp" and "Mannix", were also included for consideration of people such as hunters/trappers who may spend extended periods of time closer to the site and experience air quality different from the communities noted above.

In response to recent publications concerning 3-nitrobenzanthrone and associated stakeholder interests, this substance was added to the evaluation. Airborne concentrations of 3-nitrobenzanthrone were estimated from diesel fleet particulate concentrations based on the diesel exhaust particle emission rate of 6.61 μg/g particle reported by Enya et al. (1997) for diesel engines at 80% loading.

The annual average air concentrations were then used in exposure modelling to determine the estimated daily intake of these chemicals by local residents. Refer to Section B4 (New Information) of this report "Revised Particulates and Aerosols Analyses" for tables of airborne metal and PAH concentrations. For a description of the generic methodology used in the risk assessment and an explanation of terms, please refer to F1.1.4 of the Project Millennium Application.

B5.2.2.1 Metals

Annual average air concentrations, predicted for the closest community (i.e., Fort McKay) and the worst case monitoring station (i.e., Lower Camp), were screened against risk based concentrations (RBC), consistent with the screening procedures described in the main submission. Predicted metal concentrations for the baseline, Project and CEA scenarios were less than the RBCs, indicating that airborne concentrations of metals are acceptable from a human health perspective. On inspection of the predicted airborne concentrations of metals, these chemicals were several orders of magnitude less than RBCs, suggesting that these substances, individually or additively, would not present a health concern. Appendix 1 contains the metals screening tables for comparison of predicted air concentrations and RBCs (CEA scenario).

B5.2.2.2 PAHs

Individual PAHs were not screened against RBCs since this would not account for the potential additive effects of PAH mixtures. Rather, PAHs were separated into carcinogenic and non-carcinogenic members, and then grouped according to similarities in physical, chemical and toxicological properties. Potential impacts to human health were then evaluated for each of these chemical groups.

Non-Carcinogenic PAHs

For non-carcinogenic chemicals, potential residential exposure was estimated for children of age 5-11 years, a lifestage at which the greatest exposure via inhalation (per unit body mass) occurs (Health Canada 1994). Residential exposure was also estimated for adults. In addition, since people may be exposed to airborne chemicals while carrying out activities in areas near the

Project site (e.g., hunting/trapping, gathering plants), maximum predicted concentrations at the Lower Camp and Mannix air stations were also evaluated in the risk assessment. For this assessment, a hunter/trapper was assumed to live temporarily at a location adjacent to the Project Millennium boundaries for 6 months per year. No differentiation was made between indoor and outdoor air concentrations.

Daily intake rates were estimated for chemical groups (i.e. chemical mixtures) where possible. Non-carcinogenic PAHs were assembled into PAH groups with similar physical, chemical and toxicological characteristics. Chemical groupings and toxicity reference values are listed in Table B5-1.

Surrogate species within each group were selected to represent the toxicity of the entire group, assuming additivity. In all cases, the surrogate species was the most toxic known member of the group, or a substance for which sufficient toxicity data were available to represent the group. Exposure ratios were then calculated by dividing the estimated daily intake for all chemicals within the group by the reference dose (RfD) for the surrogate chemical. For some chemicals (i.e., camphene, retene, dibenzothiophene and indole), there is insufficient toxicity information to derive an RfD. However, there is no evidence of carcinogenicity associated with these chemicals. Therefore, these chemicals were grouped and evaluated with respect to the RfD for the most toxic non-carcinogenic PAH (i.e., pyrene).

Table B5-1 Chemical Grouping for PAHs and Associated Toxicity Reference Values

Non-carcinogenic PAH Groups	Chemicals within group	RfD [(a)] (mg/kg/d)	
Naphthalene Group	**napthalene**	0.04	
	1-methyl naphthalene		
	2-methly naphthalene		
	acenaphthene		
	acenaphthylene		
	1-chloronaphthalene		
	2-chloronaphthalene		
Fluorene/Fluoranthene Group	**fluorene**	0.04	
	fluoranthene		
	phenanthrene		
	anthracene		
Acridine Group	dibenz(a,j)**acridine**	0.04	
	dibenz(a,h)acridine		
Pyrene	**pyrene**	0.03	
	dibenzothiophene		
	indole		
	camphene		
	retene		
Carcinogenic PAH Groups	**Chemicals within group**	**RsD[(b)]/Slope Factor[(c)] (mg/kg/d)**	**Toxic Equivalency Factor (TEF) [(d)]**
Benzo(a)pyrene Group	**benzo(a)pyrene**	0.0000014/7.3	1
	benzo(k) fluoranthene		0.1
	benzo(a)fluorene		0.1
	benzo(b)fluorene		0.1
	benzo(b&j)fluoranthene		0.1
	benzo(e)pyrene		1
	1,2-benzanthracene		0.1
	7,12-dimethyl benz(a)anthracene		0.1
	1,6-dinitropyrene		1 [(e)]
	1,8-dinitropyrene		1 [(e)]
	nitro-pyrene		1 [(e)]
	benzo(g,h,i)perylene		1 [(e)]
	carbazole		0.004
	chrysene		0.01
	dibenzo(a,h)anthracene		1
	3-nitrobenzanthrone		1 [(e)]
	perylene		1 [(e)]
	indeno(1,2,3-cd)pyrene		0.01

(a) RfD: reference dose; units (mg/kg/day).
(b) RsD: risk-specific dose at a risk of 1:100,000; units (mg/kg/day).
(c) Slope factor: the rate of change in frequency of cancer per unit change in exposure, used to derive RsD.
(d) TEF: toxic equivalency factor; indicates the relative toxicity of each chemical to benzo(a)pyrene, the most toxic member of the group.
(e) TEF conservatively assumed to be 1 due to insufficient toxicity data.
Bolded chemicals are surrogates for the group.

Carcinogenic PAHs

For carcinogenic PAHs, the toxicity of each PAH was evaluated relative to the most toxic member of the group, benzo(a)pyrene using established toxic equivalency factors (TEFs; Table 4-1). The total benzo(a)pyrene toxic equivalent air concentration was then used in exposure modelling to determine the estimated daily intake of carcinogenic PAHs for composite receptors (i.e., exposed from birth to 70 years of age) and adult hunters/trappers (i.e., exposed for 50 years near the Suncor Plant Site). The estimated daily intakes were then compared to the risk-specific dose (RsD) for benzo(a)pyrene to calculate ERs for the carcinogenic PAH group. This conservative approach ensures that exposure to the entire mixture of PAHs is accounted for in the evaluation of human health risks. For some chemicals (i.e., nitropyrenes, benzo(g,h,i)perylene, perylene and 3-nitrobenzanthrone) there is insufficient toxicity information to determine an accurate TEF. Therefore, the TEFs for these chemicals were conservatively assumed to be 1, or equivalent to benzo(a)pyrene.

In addition to the exposure ratio, calculations were made to quantify the incremental lifetime cancer risk (ILCR) for this group of chemicals. The ILCR for each location was calculated by multiplying the estimated daily intake of carcinogenic PAHs by the slope factor for benzo(a)pyrene.

The ICLR indicates the potential risk of cancer above background that is associated with exposure to airborne carcinogenic PAHs.

B5.2.3 Results

Results of the analyses and the corresponding exposure ratios for the concerned locations are presented in Tables B4-2 to B4-4. It should be noted that predicted air concentrations of PAHs and associated ER values for the Project Millennium scenario are lower than those for the baseline scenario, due to changes in the location of mine activities and emission sources.

Exposure ratios for non-carcinogenic PAHs are significantly less than one and therefore the risk to human health is considered to be negligible. Exposure ratios for carcinogenic PAHs are also significantly less than one, and therefore are considered to be acceptable. The incremental lifetime cancer risk (ILCR) associated with exposure to the predicted levels of carcinogens for each location represents an increased frequency of cancer above background in the order of 10^{-7} to 10^{-10} (i.e., 10^{-7} represents a 1 in 10 million risk; 10^{-10} represents a 1 in 10 billion risk). In light of the degree of conservatism used in the assessment, the calculated risk is considered to be negligible.

Table B5-2 Baseline Exposure Ratios and ILCRs for Inhalation of PAHs

Receptor	Chemical	Fort McKay	Fort McMurray	Fort Chipewyan	Mannix	Lower Camp
Non-Carcinogenic PAHs		**ER [(a)]**	**ER [(a)]**	**ER [(a)]**	**ER [(b)]**	**ER [(b)]**
Child	naphthalene group	7.30E-07	1.38E-07	2.92E-08	n/a	n/a
	fluorene/fluoranthene group	2.71E-07	5.25E-08	1.10E-08	n/a	n/a
	acridine group	6.79E-11	1.14E-11	3.44E-12	n/a	n/a
	pyrene	3.06E-07	4.45E-08	1.08E-08	n/a	n/a
Adult	naphthalene group	7.30E-07	1.38E-07	2.92E-08	4.27E-06	2.34E-05
	fluorene/fluoranthene group	2.71E-07	5.25E-08	1.10E-08	1.61E-06	8.92E-06
	acridine group	6.79E-11	1.14E-11	3.44E-12	5.83E-10	6.51E-10
	pyrene	2.26E-07	3.29E-08	8.01E-09	6.28E-07	1.43E-07
Carcinogenic PAHs		**ER [(a)]**	**ER [(a)]**	**ER [(a)]**	**ER [(b)]**	**ER [(b)]**
Composite	Benzo(a)pyrene Group	9.15E-05	8.06E-05	1.09E-05	2.58E-02	7.59E-02
		ICLR [(c)]	**ICLR [(c)]**	**ICLR [(c)]**	**ICLR [(c)]**	**ICLR [(c)]**
		9.35E-10	8.23E-10	1.11E-10	4.33E-08	1.27E-07

[(a)] represents residential scenario (daily exposure for 7 years-child and 50 years-adult and 70 years-composite).
[(b)] represents hunter/trapper scenario (exposure for 6 months per year for 50 years near Suncor Plant Site).
[(c)] represents the increased frequency of cancer above background for the exposure concentration.
N/A = Not Applicable.

Table B5-3 Millennium Exposure ratios and ILCRs for inhalation of PAHs

Receptor	Chemical	Fort McKay	Fort McMurray	Fort Chipewyan	Mannix	Lower Camp
Non-Carcinogenic PAHs		**ER [(a)]**	**ER [(a)]**	**ER [(a)]**	**ER [(b)]**	**ER [(b)]**
Child	naphthalene group	7.23E-07	3.87E-07	4.44E-08	n/a	n/a
	fluorene/fluoranthene group	2.68E-07	1.48E-07	1.68E-08	n/a	n/a
	acridine group	6.43E-11	1.04E-11	3.20E-12	n/a	n/a
	pyrene	3.04E-07	1.12E-07	1.49E-08	n/a	n/a
Adult	naphthalene group	7.23E-07	3.87E-07	4.44E-08	6.89E-07	7.33E-07
	fluorene/fluoranthene group	2.68E-07	1.48E-07	1.68E-08	2.57E-07	2.70E-07
	acridine group	6.43E-11	1.04E-11	3.20E-12	1.28E-10	1.45E-10
	pyrene	2.24E-07	8.29E-08	1.10E-08	1.06E-07	1.27E-07
Carcinogenic PAHs		**ER [(a)]**	**ER [(a)]**	**ER [(a)]**	**ER [(b)]**	**ER [(b)]**
Composite	Benzo(a)pyrene Group	9.35E-05	1.06E-04	1.61E-05	5.73E-03	7.39E-03
		ICLR [(c)]	**ICLR [(c)]**	**ICLR [(c)]**	**ICLR [(c)]**	**ICLR [(c)]**
		9.55E-10	1.08E-09	1.65E-10	9.60E-09	1.24E-08

[(a)] represents residential scenario (daily exposure for 7 years-child and 50 years-adult and 70 years-composite).
[(b)] represents hunter/trapper scenario (exposure for 6 months per year for 50 years near Suncor Plant Site).
[(c)] represents the increased frequency of cancer above background for the exposure concentration.
N/A = Not Applicable.

Table B5-5 CEA Exposure Ratios and ILCR for Inhalation of PAHs

Receptor	Chemical	Fort McKay	Fort McMurray	Fort Chipewyan	Mannix	Lower Camp
Non-Carcinogenic PAHs		**ER [(a)]**	**ER [(a)]**	**ER [(a)]**	**ER [(b)]**	**ER [(b)]**
Child	naphthalene group	1.91E-05	6.57E-06	1.30E-06	n/a	n/a
	fluorene/fluoranthene group	7.03E-06	2.48E-06	4.83E-07	n/a	n/a
	acridine group	1.46E-09	2.21E-10	8.13E-11	n/a	n/a
	pyrene	7.76E-07	1.96E-07	4.69E-08	n/a	n/a
Adult	naphthalene group	1.41E-05	4.86E-06	9.60E-07	5.76E-06	7.45E-06
	fluorene/fluoranthene group	5.19E-06	1.84E-06	3.57E-07	2.12E-06	2.68E-06
	acridine group	1.08E-09	1.63E-10	6.01E-11	7.40E-10	1.10E-09
	pyrene	5.73E-07	1.45E-07	3.47E-08	2.35E-07	3.71E-07
Carcinogenic PAHs		**ER [(a)]**	**ER [(a)]**	**ER [(a)]**	**ER [(b)]**	**ER [(b)]**
Composite	Benzo(a)pyrene Group	2.26E-04	2.15E-04	4.52E-05	1.23E-02	1.43E-02
		ICLR [(c)]	**ICLR [(c)]**	**ICLR [(c)]**	**ICLR [(c)]**	**ICLR [(c)]**
		2.31E-09	2.20E-09	4.62E-10	2.06E-08	2.39E-08

[(a)] represents residential scenario (daily exposure for 7 years-child and 50 years-adult and 70 years-composite).
[(b)] represents hunter/trapper scenario (exposure for 6 months per year for 50 years near Suncor Plant Site).
[(c)] represents the increased frequency of cancer above background for the exposure concentration.
N/A = Not Applicable.

B5.2.4 Residual Impact Classification and Environmental Consequence

Residual impacts were classified according to the methodology presented in Sections A2 and F1.1.4.4 of the Project Millennium Application. Based on the results of the risk assessment concerning air concentrations of metals and PAHs, impacts to human health are not predicted to occur as a result of the Project. The magnitude of impact and resultant environmental consequence are rated as negligible.

B5.2.5 Modelling Assumptions and Uncertainty

The modelling of human exposure and performing the risk assessment introduces a degree of uncertainty. Every effort was made to offset the uncertainty associated with toxicological data and air dispersion modelling by making use of conservative assumptions as outlined below:

- maximum predicted ambient air exposure concentrations were derived from conservative air dispersion modelling methods;
- exposure assumes people reside in the communities for their entire lives and hunters/trappers live for 6 months per year directly adjacent to the Suncor Plant Site;
- where exposure assessment involves summation of concentrations across a group of chemicals, a conservative surrogate toxicity reference value was used;
- exposure parameter values for human receptors represent reasonable maximum exposure values (i.e., worst case but within the realm of reality); and
- PAHs were assessed additively as mixtures, rather than individual chemicals.

Collectively, these assumptions weigh heavily towards exposure ratios that over-estimate the true risk that is likely to be manifested by the Project.

The main area of uncertainty associated with this analysis is the uncertainty inherent with estimated fugitive emissions and air dispersion modelling that manifest as uncertainty in the predicted exposure concentrations.

B5.3 Particulate Matter (PM_{10})

B5.3.1 Objective

- To evaluate the potential for impacts to human health as a result of inhalation of PM_{10} released from stack and vehicle fleet emissions.

B5.3.2 Air Quality Modelling

Refer to Section B4 (New Information) of this report "Revised Particulates and Aerosols Analyses" for a discussion of air quality modelling methodology. Predicted concentrations of PM_{10} and $PM_{2.5}$ are presented in Tables B4-5, B4-6, B4-13, B4-14, B4-21 and B4-22 of Section B4 (New Information) of this submission..

B5.3.3 Health Assessment

With respect to health effects of particulate emissions, there remains significant controversy in the scientific community (e.g., annual meeting of the Society of Toxicologists, Seattle, Washington, March, 1998) concerning the reference levels for health effects of PM_{10} and $PM_{2.5}$ and appropriate guidelines. Health Canada has recently withdrawn the draft "air quality objectives" for PM_{10} that were issued last fall (based solely on risk considerations), and they are not planning to reissue new objectives for $PM_{10/2.5}$. Instead, the PM issue will be addressed under the "new" national harmonization strategy called "Canada Wide Standards" (CWS). These new objectives will take into account not only the risk of health effects, but also the costs and practicality/feasibility of achieving the standards, based on in-house analyses and stakeholder input. The CWS objectives for PM are not anticipated until the fall of 1999.

Other guidelines for PM_{10} and $PM_{2.5}$ are listed in Table B5-5. The predicted PM_{10} and $PM_{2.5}$ concentrations are less than these guidelines in the communities of Fort McKay and Fort Chipewyan, but are marginally greater than PM_{10} and $PM_{2.5}$ guidelines in Fort McMurray. The high levels of PM_{10} and $PM_{2.5}$ in Fort McMurray are due mainly to urban particulate emissions, rather than the oil sands particulate emissions.

Table B5-5 Summary of Applicable Guidelines for PM_{10}

PM Size Range	Averaging Time	Guideline (µg/m³)	Agency
PM_{10}	24 hr	50	BC Environment 1995
PM_{10}	24 hr annual	150 50	U.S. EPA 1997
$PM_{2.5}$	24 hr annual	50 15	U.S. EPA 1997

B5.3.4 Residual Impact Classification and Environmental Consequence

Residual impacts were classified according to the methodology presented in Section A2 of the Project Millennium Application. Since PM_{10} concentrations in the communities of Fort McKay, and Fort Chipewyan are less than BC Environment and US EPA guidelines, the magnitude of impact and resultant environmental consequence are rated as negligible for these communities. Although PM_{10} and $PM_{2.5}$ concentrations at Fort McMurray exceed guidelines, these high concentrations are a result of urban particulate emissions, and therefore the magnitude of impact and resultant environmental consequence as a result of oil sands emissions, is rated as low for Fort McMurray. Further evaluation of particulate matter levels should be conducted when Canadian guidelines are established.

B5.3.5 Modelling Assumptions and Uncertainty

Refer to Section B4 (New Information) of this report "Revised Particulates and Aerosols Analyses" for a discussion of modelling assumptions and uncertainty associated with particulate matter predictions.

B5.4 Additional Information For Key Question Hh-3 And W-2: Human And Wildlife Health Effects Associated With Deposition Of Metals And Pahs

The additional information provided in this section addresses additional aspects of Key Questions HH-3 and W-2 and corresponding sections of the cumulative effects assessment of the Project Millennium Application (Volume 2C, Sections F1.3.3 and F1.4, Step 3; Volume 2B, Sections D5.2.7 and D6.5.6):

HH-3: What Impacts Will Consumption of Local Plants and Game Animals Exposed to Operational Water Releases and Air Emissions From Project Millennium Have on Human Health?

W-2: What Impacts Will Chemicals in Operational Air and Water Releases From Project Millennium Have on Wildlife Health?

Metals and PAHs in air emissions from the Project may deposit directly onto plant surfaces, or they may deposit onto soils and be taken up by plant roots. Subsequent ingestion of these plants by local residents or wildlife may be an important route of exposure to these chemicals. The information presented in the Project Millennium Application was based on the results of baseline vegetation samples collected in August, 1997. This section presents the results of deposition modelling of predicted air emissions from Project Millennium and the combined developments. It provides an evaluation of the potential for impacts to human health from ingestion of these plants. This deposition modelling is based on results of recent stack survey analyses conducted by Suncor Inc. and Syncrude Canada Ltd. and the results of air quality modelling for metals and PAHs presented in Section B4 (New Information) of this report "Revised Particulates and Aerosols Analyses". Air quality modelling predictions are based on stack emissions and diesel exhaust emissions from the vehicle fleet.

B5.4.1 Ingestion of Metals and PAHs Deposited onto Soils and Plants

B5.4.2 Objectives

- To determine the amount of airborne metals and PAHs accumulated in plants via direct deposition onto plant surfaces and deposition onto soils followed by root uptake; and
- To evaluate the potential for impacts to human health as a result of ingestion of plants, which have accumulated metals and PAHs deposited from stack and vehicle fleet emissions.

B5.4.3 Methods

B5.4.3.1 Metals and PAHs

Incremental contributions of metals and PAHs from airborne deposition to tissue concentrations in berries, leaves and roots were predicted for two locations. Fort McKay was selected as the closest residential community and Lower Camp was selected as a worst case location in close proximity to the plant site. The risk assessment model for berries and leaves considered deposition onto the soil followed by root uptake plus deposition directly onto the plant surface. For roots, only uptake from soil was considered. Deposition onto plant surfaces was calculated by consideration of the chemical deposition rate and approximate plant surface available to which chemicals may adhere (Equation 1). Direct deposition onto plant surfaces was assumed to occur throughout the growing season (i.e., 3 months per year).

$$PC_d = D \times CF1 \times CF2 \times CF3 \times DT \times R / (K \times S \times Y) \quad \textbf{Equation 1}$$

where:

PC_d = Plant Concentration from Deposition (mg/kg dry wt)
D = Deposition rate (g/ha/yr)
CF1 = Conversion Factor for hectares to square meters (ha/m^2)
CF2 = Conversion Factor for grams to milligrams (mg/g)
CF3 = Conversion Factor for wet weight to dry weight
DT = Deposition Time (3 months/year)
R = Intercept fraction; represents portion of chemical deposition intercepted by plants (0.027 berries, 0.15 leaves; Baes et al. 1984, based on intercepts for cherries and leafy vegetables, respectively)

K = Natural weathering rate of chemical removal from the plant surface (ln(2)/14 days; Baes et al. 1984)
S = Growing season (3 months/yr)
Y = Crop Yield (1 kg/m^2 berries; 3 kg/m^2 leaves; Baes et al. 1984)

Uptake by roots was calculated by first converting the soil deposition rates into soil concentrations (Equation 2) and then applying bioconcentration factors (BCF) to determine the plant tissue concentration (Equation 3). Deposition onto soils was assumed to occur throughout the operational phase of the Project (i.e., 30 years), with no loss due to weathering and degradation. All chemicals deposited onto soils were assumed to mix within the top 15 cm of soil and remain available for plant uptake.

SC = D x CF1 x CF2 x DT/(SD x BD) Equation 2

where:

SC = Soil Concentration (mg/kg dry wt)
D = Deposition rate (g/ha/yr)
CF1 = Conversion Factor for hectares to square meters (ha/m^2)
CF2 = Conversion Factor for grams to milligrams (mg/g)
DT = Deposition Time (30 years)
SD = Soil Depth (0.15 m)
BD = Bulk Density (1600 kg/m^3)

PC_r = SC x BCF Equation 3

where:

PC_r = Plant Concentration from Roots (mg/kg dry)
SC = Soil Concentration as calculated above
BCF = Bioconcentration Factor (unitless)

BCFs were calculated for metals, based on the relationship between chemical concentrations in blueberries/Labrador tea leaves/cattail roots and corresponding soil samples analyzed in the August 1997 vegetation sampling program. The maximum site-specific BCF for each metal was conservatively used as the BCF in equation 3. These BCFs were determined to be more conservative and site-specific than literature-derived BCFs. In some instances, however, literature-reported BCFs (Efroymson 1996) were used where there was insufficient data to derive site-specific BCFs.

Since PAHs were not detected in the majority of plant and soil samples collected in August 1997, site-specific BCFs for PAHs could not be derived. Rather, BCFs for PAHs in plants were calculated based on the octanol-water partition coefficients (Kow) according to Equation 4 (Travis and Arms 1988):

log BCF = 1.588 - 0.578 (log Kow) Equation 4

Total plant tissue concentration (PC_T) is then equal to the sum of chemical concentrations in plants from direct deposition and root uptake (Equation 5).

$$PC_T = PC_d + PC_r \qquad \textbf{Equation 5}$$

B5.4.4 Results

B5.4.4.1 Metals

Results of deposition analyses and associated plant tissue concentrations predicted for the locations of interest are listed in Tables B4-8 to B4-10.

Table B5-8 Predicted Increase in Metal Concentrations for Berries

Chemical	Baseline		Millennium		CEA		1997	% Increase	
	Ft. McKay Increase in Berry Conc [a] mg/kg	Lower Camp Increase in Berry Conc [a] mg/kg	Ft. McKay Increase in Berry Conc [a] mg/kg	Lower Camp Increase in Berry Conc [a] mg/kg	Ft. McKay Increase in Berry Conc [a] mg/kg	Lower Camp Increase in Berry Conc [a] mg/kg	Suncor and Shell Leases Max Baseline Blueberry Conc [b] mg/kg	Fort McKay mg/kg	Lower Camp mg/kg
antimony	7.09E-06	2.42E-05	7.07E-06	2.26E-05	9.34E-06	4.39E-05	nd (0.04)	<dl	<dl
arsenic	8.72E-06	3.07E-05	8.69E-06	2.87E-05	1.15E-05	5.47E-05	nd (0.2)	<dl	<dl
aluminum	1.29E-03	3.12E-03	1.28E-03	2.98E-03	1.70E-03	6.90E-03	40	0.0043	0.017
barium	1.69E-04	6.38E-04	1.68E-04	5.93E-04	2.22E-04	1.09E-03	15.5	0.0014	0.0071
beryllium	1.20E-06	3.79E-06	1.19E-06	3.56E-06	1.58E-06	7.15E-06	nd (0.2)	<dl	<dl
cadmium	7.53E-06	1.63E-05	7.52E-06	1.57E-05	9.99E-06	3.87E-05	0.09	0.011	0.043
chromium	2.25E-03	4.68E-03	6.76E-04	1.82E-03	8.95E-04	3.87E-03	nd (0.2)	<dl	<dl
cobalt	2.89E-05	7.75E-05	2.89E-05	7.35E-05	3.83E-05	1.61E-04	nd (0.08)	<dl	<dl
copper	1.74E-04	4.62E-04	1.74E-04	4.38E-04	2.30E-04	9.67E-04	4.6	0.0050	0.021
lead	4.85E-05	1.91E-04	4.83E-05	1.77E-04	6.36E-05	3.21E-04	0.3	0.021	0.11
mercury	1.78E-06	5.28E-06	1.77E-06	4.97E-06	2.35E-06	1.03E-05	0.02	0.012	0.052
molybdenum	1.16E-04	3.49E-04	1.15E-04	3.28E-04	1.53E-04	6.76E-04	0.11	0.14	0.61
nickel	1.22E-03	3.23E-03	1.22E-03	3.07E-03	1.62E-03	6.78E-03	0.66	0.25	1.02
selenium	3.31E-05	8.62E-04	3.19E-05	7.69E-04	3.81E-05	8.28E-04	nd (0.2)	<dl	<dl
silver	1.69E-05	3.49E-05	1.69E-05	3.37E-05	2.24E-05	8.54E-05	nd (1)	<dl	<dl
vanadium	5.09E-04	1.57E-03	5.08E-04	1.48E-03	6.72E-04	3.01E-03	nd (0.08)	<dl	<dl
zinc	2.24E-02	3.39E-02	2.24E-02	3.37E-02	2.99E-02	1.03E-01	11	0.27	0.94

[a] represents predicted increase in concentration in berries resulting from uptake by roots and deposition onto plant surfaces.
[b] results of baseline blueberry samples collected in August, 1997.
nd = not detected (detection limit in brackets).
<d = predicted concentration remains less than detection limit.

Table B5-9 Predicted Increase in Metal Concentrations for Leaves

Chemical	Baseline		Millennium		CEA		1997	% Increase	
	Ft. McKay Increase in Leaf Conc [(a)] mg/kg	Lower Camp Increase in Leaf Conc [(a)] mg/kg	Ft. McKay Increase in Leaf Conc [(a)] mg/kg	Lower Camp Increase in Leaf Conc [(a)] mg/kg	Ft. McKay Increase in Leaf Conc [(a)] mg/kg	Lower Camp Increase in Leaf Conc [(a)] mg/kg	Suncor and Shell Leases Max Baseline Lab Tea Conc [(b)] mg/kg	Fort McKay mg/kg	Lower Camp mg/kg
antimony	1.11E-05	3.80E-05	1.11E-05	3.55E-05	1.47E-05	6.88E-05	0.68	0.0022	0.010
arsenic	1.49E-05	5.25E-05	1.49E-05	4.90E-05	1.96E-05	9.36E-05	nd (0.2)	<dl	<dl
aluminum	2.30E-03	5.58E-03	2.30E-03	5.32E-03	3.05E-03	1.23E-02	35	0.0087	0.035
barium	2.26E-04	8.53E-04	2.25E-04	7.93E-04	2.97E-04	1.46E-03	120	0.00025	0.0012
beryllium	2.01E-06	6.38E-06	2.01E-06	5.99E-06	2.66E-06	1.20E-05	nd (0.2)	<dl	<dl
cadmium	1.01E-05	2.17E-05	1.01E-05	2.09E-05	1.33E-05	5.17E-05	0.09	0.015	0.057
chromium	3.61E-03	7.50E-03	1.08E-03	2.92E-03	1.43E-03	6.20E-03	0.4	0.90	1.9
cobalt	5.24E-05	1.40E-04	5.23E-05	1.33E-04	6.94E-05	2.92E-04	0.31	0.022	0.094
copper	2.14E-04	5.68E-04	2.14E-04	5.39E-04	2.83E-04	1.19E-03	74	0.00038	0.0016
lead	8.49E-05	3.35E-04	8.46E-05	3.11E-04	1.12E-04	5.63E-04	2.9	0.0038	0.019
mercury	2.78E-06	8.25E-06	2.77E-06	7.77E-06	3.67E-06	1.62E-05	0.05	0.0073	0.032
molybdenum	1.89E-04	5.69E-04	1.88E-04	5.36E-04	2.49E-04	1.10E-03	0.12	0.21	0.92
nickel	1.94E-03	5.11E-03	1.93E-03	4.85E-03	2.56E-03	1.07E-02	6.92	0.037	0.15
selenium	5.38E-05	1.40E-03	5.18E-05	1.25E-03	6.20E-05	1.34E-03	nd (0.2)	<dl	<dl
silver	2.84E-05	5.87E-05	2.84E-05	5.67E-05	3.77E-05	1.44E-04	nd (1)	<dl	<dl
vanadium	7.84E-04	2.42E-03	7.82E-04	2.28E-03	1.03E-03	4.64E-03	0.15	0.69	3.1
zinc	2.60E-02	3.92E-02	2.60E-02	3.91E-02	3.46E-02	1.19E-01	54.5	0.063	0.22

[(a)] represents predicted increase in concentration in leaves resulting from uptake by roots and deposition onto plant surfaces.
[(b)] results of baseline Labrador tea leaf samples collected in August, 1997.
nd = not detected (detection limit in brackets).
<dl = predicted concentration remains less than detection limit.

Table B5-10 Predicted Increase in Metal Concentrations for Roots

Chemical	Baseline		Millennium		CEA		1997	% Increase	
	Ft. McKay Increase in Root Conc [(a)] mg/kg	Lower Camp Increase in Root Conc [(a)] mg/kg	Ft. McKay Increase in Root Conc [(a)] mg/kg	Lower Camp Increase in Root Conc [(a)] mg/kg	Ft. McKay Increase in Root Conc [(a)] mg/kg	Lower Camp Increase in Root Conc [(a)] mg/kg	Suncor and Shell Leases Max Baseline Cattail Conc [(b)] mg/kg	Fort McKay mg/kg	Lower Camp mg/kg
antimony	2.35E-06	8.02E-06	2.34E-06	7.50E-06	3.09E-06	1.45E-05	nd (0.04)	<dl	<dl
arsenic	3.84E-06	1.35E-05	3.83E-06	1.26E-05	5.06E-06	2.41E-05	1.1	0.0005	0.0022
aluminum	5.88E-04	1.43E-03	5.87E-04	1.36E-03	7.79E-04	3.15E-03	693	0.00015	0.00046
barium	2.62E-04	9.90E-04	2.61E-04	9.21E-04	3.44E-04	1.70E-03	47.3	0.0007	0.0036
beryllium	6.33E-07	2.00E-06	6.31E-07	1.88E-06	8.35E-07	3.78E-06	nd (0.2)	<dl	<dl
cadmium	5.47E-05	1.18E-04	5.46E-05	1.14E-04	7.25E-05	2.81E-04	0.034	0.21	0.83
chromium	1.76E-03	3.66E-03	5.29E-04	1.43E-03	7.00E-04	3.03E-03	1.2	0.15	0.31
cobalt	5.46E-06	1.46E-05	5.45E-06	1.39E-05	7.22E-06	3.04E-05	5.24	0.0002	0.00058
copper	2.96E-04	7.83E-04	2.95E-04	7.43E-04	3.91E-04	1.64E-03	14.4	0.0027	0.011
lead	3.67E-05	1.45E-04	3.66E-05	1.34E-04	4.82E-05	2.43E-04	2.5	0.0019	0.0097
mercury	1.84E-06	5.47E-06	1.84E-06	5.16E-06	2.44E-06	1.07E-05	0.07	0.0035	0.015
molybdenum	1.20E-04	3.63E-04	1.20E-04	3.42E-04	1.59E-04	7.04E-04	1.7	0.0093	0.041
nickel	2.15E-03	5.69E-03	2.15E-03	5.40E-03	2.85E-03	1.19E-02	10.9	0.026	0.11
selenium	2.40E-05	6.26E-04	2.31E-05	5.59E-04	2.77E-05	6.01E-04	0.7	0.004	0.089
silver	1.09E-05	2.26E-05	1.09E-05	2.19E-05	1.45E-05	5.54E-05	nd (1)	<dl	<dl
vanadium	4.47E-04	1.38E-03	4.46E-04	1.30E-03	5.90E-04	2.65E-03	7.16	0.0082	0.037
zinc	4.90E-02	7.40E-02	4.90E-02	7.38E-02	6.53E-02	2.26E-01	59.2	0.11	0.38

(a) represents predicted increase in concentration in roots resulting from uptake from soil.
(b) results of baseline cattail root samples collected in August, 1997.
nd = not detected (detection limit in brackets).
<dl = predicted concentration remains less than detection limit.

The predicted increase in plant tissue metal concentrations as a result of airborne chemical deposition is negligible in comparison to metal concentrations previously measured in blueberries, Labrador tea leaves and cattail roots in August 1997. Furthermore, metals which were not detected in plant tissue samples in August 1997 are predicted to remain at levels below the limit of detection.

B5.4.4.2 PAHs

Results of deposition analyses and associated plant tissue concentrations predicted for the locations of interest are listed in Tables B5-11 to B5-13.

Table B5-11 Predicted Increase in PAH Concentrations for Berries

Chemical	Baseline		Millennium		CEA	
	Ft. McKay Increase in Berry Conc [(a)] mg/kg	Lower Camp Increase in Berry Conc [(a)] mg/kg	Ft. McKay Increase in Berry Conc [(a)] mg/kg	Lower Camp Increase in Berry Conc [(a)] mg/kg	Ft. McKay Increase in Berry Conc [(a)] mg/kg	Lower Camp Increase in Berry Conc [(a)] mg/kg
Acenaphthene	3.09E-06	8.68E-05	2.57E-04	4.06E-04	6.84E-06	2.50E-06
Acenaphylene	3.69E-05	2.27E-04	3.03E-03	4.41E-03	5.50E-05	6.94E-06
Anthracene	7.20E-07	1.75E-05	9.77E-05	3.12E-04	1.45E-06	4.74E-07
1,2-Benzathracene	1.24E-07	4.26E-07	3.46E-05	1.12E-04	1.63E-07	7.65E-09
Benzo(b & j)fiuoranthene	3.31E-07	2.11E-06	1.04E-04	6.06E-04	4.29E-07	2.43E-08
Benzo(k)fluoranthene	1.58E-07	1.00E-06	5.12E-05	1.26E-04	2.29E-07	2.62E-08
Benzo(a)fluorene	1.06E-07	1.88E-06	3.20E-05	1.12E-04	1.89E-07	4.91E-08
Benzo(b)fluorene	5.15E-08	2.00E-07	1.61E-05	5.84E-05	6.77E-08	3.27E-09
Benzo(g, h, i)perylene	1.93E-07	1.78E-06	6.47E-05	1.56E-04	2.98E-07	4.82E-08
Benzo(a)pyrene	1.10E-07	1.01E-06	3.35E-05	1.00E-04	1.68E-07	2.56E-08
Benzo(e)pyrene	5.08E-08	2.75E-07	1.70E-05	5.97E-05	6.96E-08	5.64E-09
Camphene	5.20E-08	4.63E-07	1.76E-05	1.43E-04	6.64E-08	4.34E-09
Carbazole	4.17E-07	2.33E-06	1.69E-05	8.71E-05	5.43E-07	2.93E-08
1 -Chloronaphthalene	4.55E-07	2.07E-06	1.94E-05	8.17E-05	5.96E-07	3.01E-08
2-Chloronaphthalene	1.44E-06	3.51E-06	6.15E-05	1.43E-04	1.91E-06	8.33E-08
Chrysene	5.55E-07	6.26E-06	1.52E-04	3.02E-04	9.08E-07	1.78E-07
Dibenz(a, j)acridine	1.08E-07	3.41E-07	3.45E-05	1.03E-04	1.42E-07	6.54E-09
Dibenz(a, h)acridine	5.14E-08	2.59E-07	1.64E-05	7.63E-05	6.71E-08	3.50E-09
Dibenz(a, h)anthracene	1.16E-07	1.97E-06	3.66E-05	1.04E-04	2.07E-07	5.35E-08
Dibenzothiophene	3.12E-05	4.65E-05	1.00E-02	1.49E-02	4.16E-05	1.69E-06
7,12-dimethylbenz(a)anthracene	5.23E-08	2.63E-07	1.64E-05	7.63E-05	6.83E-08	3.56E-09
1, 6-Dinitropyrene	5.14E-08	2.59E-07	1.64E-05	7.63E-05	6.71E-08	3.50E-09
1, 8-Dinitropyrene	5.14E-08	2.59E-07	1.64E-05	7.63E-05	6.71E-08	3.50E-09
Fluoranthene	1.57E-06	2.78E-05	3.36E-04	9.30E-04	2.85E-06	7.57E-07
Fluorene	6.80E-06	1.99E-04	6.77E-04	1.23E-03	1.53E-05	5.69E-06
Ideno(l, 2, 3-cd)pyrene	2.63E-07	6.79E-07	5.26E-05	1.29E-04	3.48E-07	1.54E-08
Indole	4.07E-07	3.73E-06	1.80E-05	1.51E-04	5.19E-07	3.44E-08
1-Methylnaphthalene	3.24E-05	5.53E-05	2.53E-03	4.25E-03	4.31E-05	1.78E-06
2-Methylnaphthalene	2.44E-05	4.59E-05	2.13E-03	3.91E-03	3.25E-05	1.36E-06
Naphthalene	1.04E-03	6.41E-03	4.38E-02	6.74E-02	1.54E-03	1.93E-04
Nitro-pyrene	8.51E-08	5.66E-07	1.69E-05	1.03E-04	1.10E-07	6.34E-09
Perylene	5.36E-08	2.19E-07	1.62E-05	5.86E-05	7.08E-08	3.74E-09
Phenanthrene	4.12E-05	5.13E-04	5.34E-03	9.55E-03	6.94E-05	1.48E-05
Pyrene	2.53E-06	2.56E-05	4.96E-04	9.91E-04	4.03E-06	7.23E-07
Retene	1.57E-06	7.46E-06	2.08E-04	9.17E-04	2.05E-06	1.05E-07

(a) represents predicted increase in concentration in berries resulting from uptake by roots and deposition onto plant surfaces.
Note: PAHs were not detected in blueberry samples collected in August, 1997.

Table B5-12 Predicted Increase in PAH Concentrations for Leaves

Chemical	Baseline		Millennium		CEA		1997
	Fort McKay Increase in Leaf Conc [(a)] mg/kg	Lower Camp Increase in Leaf Conc [(a)] mg/kg	Fort McKay Increase in Leaf Conc [(a)] mg/kg	Lower Camp Increase in Leaf Conc [(a)] mg/kg	Fort McKay Increase in Leaf Conc [(a)] mg/kg	Lower Camp Increase in Leaf Conc [(a)] mg/kg	Max Baseline Measured Laborador Tea Conc mg/kg
Acenaphthene	3.73E-06	1.05E-04	3.48E-06	5.51E-06	8.27E-06	1.22E-05	nd
Acenaphylene	4.41E-05	2.72E-04	4.36E-05	6.34E-05	6.57E-05	1.90E-04	nd
Anthracene	9.64E-07	2.34E-05	9.11E-07	2.91E-06	1.94E-06	4.82E-06	0.04
1,2-Benzathracene	2.06E-07	7.08E-07	2.05E-07	6.62E-07	2.71E-07	1.28E-06	nd
Benzo(b & j)fiuoranthene	5.78E-07	3.68E-06	5.74E-07	3.36E-06	7.49E-07	5.00E-06	nd
Benzo(k)fluoranthene	2.80E-07	1.78E-06	2.77E-07	6.85E-07	4.06E-07	1.48E-06	nd
Benzo(a)fluorene	1.85E-07	3.27E-06	1.78E-07	6.22E-07	3.30E-07	1.05E-06	nd
Benzo(b)fluorene	8.97E-08	3.49E-07	8.94E-08	3.24E-07	1.18E-07	5.90E-07	nd
Benzo(g, h, i)perylene	3.49E-07	3.22E-06	3.42E-07	8.28E-07	5.40E-07	1.77E-06	nd
Benzo(a)pyrene	1.91E-07	1.75E-06	1.87E-07	5.63E-07	2.90E-07	1.08E-06	nd
Benzo(e)pyrene	9.14E-08	4.96E-07	9.07E-08	3.17E-07	1.25E-07	5.82E-07	nd
Camphene	9.40E-08	8.38E-07	9.30E-08	7.58E-07	1.20E-07	1.01E-06	nd
Carbazole	4.57E-07	2.55E-06	4.54E-07	2.33E-06	5.94E-07	3.65E-06	nd
1-Chloronaphthalene	5.01E-07	2.28E-06	4.98E-07	2.10E-06	6.55E-07	3.57E-06	nd
2-Chloronaphthalene	1.58E-06	3.86E-06	1.58E-06	3.68E-06	2.10E-06	8.50E-06	nd
Chrysene	9.24E-07	1.04E-05	9.01E-07	1.79E-06	1.51E-06	4.21E-06	nd
Dibenz(a, j)acridine	1.89E-07	6.00E-07	1.89E-07	5.63E-07	2.50E-07	1.13E-06	nd
Dibenz(a, h)acridine	9.04E-08	4.55E-07	8.99E-08	4.18E-07	1.18E-07	6.81E-07	nd
Dibenz(a, h)anthracene	2.06E-07	3.51E-06	1.98E-07	5.61E-07	3.69E-07	1.04E-06	nd
Dibenzothiophene	5.50E-05	8.18E-05	5.50E-05	8.15E-05	7.32E-05	2.52E-04	nd
7,12-dimethylbenz(a)anthracene	9.13E-08	4.60E-07	9.08E-08	4.22E-07	1.19E-07	6.88E-07	nd
1, 6-Dinitropyrene	9.04E-08	4.55E-07	8.99E-08	4.18E-07	1.18E-07	6.81E-07	nd
1, 8-Dinitropyrene	9.04E-08	4.55E-07	8.99E-08	4.18E-07	1.18E-07	6.81E-07	nd
Fluoranthene	2.40E-06	4.24E-05	2.30E-06	6.38E-06	4.35E-06	1.19E-05	nd
Fluorene	8.51E-06	2.49E-04	7.92E-06	1.44E-05	1.91E-05	2.93E-05	nd
Ideno(l, 2, 3-cd)pyrene	3.88E-07	1.00E-06	3.87E-07	9.51E-07	5.13E-07	2.13E-06	nd
Indole	4.49E-07	4.11E-06	4.44E-07	3.72E-06	5.73E-07	4.92E-06	nd
1-Methylnaphthalene	3.83E-05	6.55E-05	3.83E-05	6.44E-05	5.10E-05	1.83E-04	0.14
2-Methylnaphthalene	2.94E-05	5.53E-05	2.94E-05	5.39E-05	3.91E-05	1.44E-04	nd
Naphthalene	1.14E-03	7.05E-03	1.13E-03	1.73E-03	1.69E-03	5.00E-03	0.15
Nitro-pyrene	1.25E-07	8.34E-07	1.24E-07	7.60E-07	1.62E-07	1.11E-06	nd
Perylene	9.21E-08	3.77E-07	9.17E-08	3.31E-07	1.22E-07	6.04E-07	nd
Phenanthrene	5.41E-05	6.75E-04	5.27E-05	9.41E-05	9.12E-05	2.33E-04	0.04
Pyrene	3.72E-06	3.76E-05	3.65E-06	7.29E-06	5.94E-06	1.72E-05	nd
Retene	2.06E-06	9.81E-06	2.05E-06	9.03E-06	2.69E-06	1.50E-05	nd

[(a)] represents predicted increase in concentration in leaves resulting from uptake by roots and deposition onto plant surfaces.
nd= not detected.

Table B5-13 Predicted Increase in PAH Concentrations for Roots

Chemical	Baseline		Millennium		CEA	
	Fort McKay Increase in Root Conc [(a)] mg/kg	Lower Camp Increase in Root Conc [(a)] mg/kg	Ft. McKay Increase in Root Conc [(a)] mg/kg	Lower Camp Increase in Root Conc [(a)] mg/kg	Ft. McKay Increase in Root Conc [(a)] mg/kg	Lower Camp Increase in Root Conc [(a)] mg/kg
Acenaphthene	2.33E-06	6.55E-05	2.17E-06	3.44E-06	5.16E-06	7.63E-06
Acenaphylene	2.85E-05	1.75E-04	2.81E-05	4.10E-05	4.24E-05	1.23E-04
Anthracene	4.34E-07	1.05E-05	4.10E-07	1.31E-06	8.76E-07	2.17E-06
1,2-Benzathracene	2.74E-08	9.42E-08	2.73E-08	8.80E-08	3.60E-08	1.70E-07
Benzo(b & j)fiuoranthene	4.17E-08	2.66E-07	4.14E-08	2.42E-07	5.40E-08	3.61E-07
Benzo(k)fluoranthene	1.43E-08	9.06E-08	1.41E-08	3.48E-08	2.07E-08	7.55E-08
Benzo(a)fluorene	1.37E-08	2.42E-07	1.32E-08	4.60E-08	2.44E-08	7.75E-08
Benzo(b)fluorene	6.63E-09	2.58E-08	6.61E-09	2.40E-08	8.71E-09	4.36E-08
Benzo(g, h, i)perylene	9.71E-09	8.98E-08	9.53E-09	2.31E-08	1.50E-08	4.94E-08
Benzo(a)pyrene	1.58E-08	1.45E-07	1.55E-08	4.65E-08	2.39E-08	8.92E-08
Benzo(e)pyrene	3.05E-09	1.66E-08	3.03E-09	1.06E-08	4.18E-09	1.94E-08
Camphene	2.62E-09	2.34E-08	2.59E-09	2.11E-08	3.35E-09	2.82E-08
Carbazole	3.71E-07	2.07E-06	3.69E-07	1.90E-06	4.83E-07	2.96E-06
1-Chloronaphthalene	4.02E-07	1.83E-06	4.01E-07	1.69E-06	5.27E-07	2.87E-06
2-Chloronaphthalene	1.27E-06	3.10E-06	1.27E-06	2.96E-06	1.69E-06	6.84E-06
Chrysene	1.23E-07	1.38E-06	1.20E-07	2.38E-07	2.01E-07	5.59E-07
Dibenz(a, j)acridine	1.17E-08	3.72E-08	1.17E-08	3.49E-08	1.55E-08	7.01E-08
Dibenz(a, h)acridine	5.60E-09	2.82E-08	5.57E-09	2.59E-08	7.32E-09	4.22E-08
Dibenz(a, h)anthracene	1.01E-08	1.72E-07	9.70E-09	2.74E-08	1.81E-08	5.09E-08
Dibenzothiophene	3.41E-06	5.07E-06	3.40E-06	5.05E-06	4.53E-06	1.56E-05
7,12-dimethylbenz(a)anthracene	6.51E-09	3.27E-08	6.47E-09	3.01E-08	8.50E-09	4.90E-08
1, 6-Dinitropyrene	5.60E-09	2.82E-08	5.57E-09	2.59E-08	7.32E-09	4.22E-08
1, 8-Dinitropyrene	5.60E-09	2.82E-08	5.57E-09	2.59E-08	7.32E-09	4.22E-08
Fluoranthene	6.03E-07	1.07E-05	5.80E-07	1.61E-06	1.09E-06	2.99E-06
Fluorene	4.79E-06	1.40E-04	4.46E-06	8.13E-06	1.08E-05	1.65E-05
Ideno(l, 2, 3-cd)pyrene	1.17E-07	3.02E-07	1.17E-07	2.87E-07	1.55E-07	6.43E-07
Indole	3.57E-07	3.27E-06	3.53E-07	2.96E-06	4.56E-07	3.92E-06
1-Methylnaphthalene	2.54E-05	4.35E-05	2.54E-05	4.27E-05	3.38E-05	1.21E-04
2-Methylnaphthalene	1.86E-05	3.48E-05	1.85E-05	3.40E-05	2.47E-05	9.10E-05
Naphthalene	9.17E-04	5.67E-03	9.06E-04	1.39E-03	1.36E-03	4.02E-03
Nitro-pyrene	3.79E-08	2.52E-07	3.76E-08	2.30E-07	4.90E-08	3.36E-07
Perylene	8.38E-09	3.43E-08	8.35E-09	3.01E-08	1.11E-08	5.49E-08
Phenanthrene	2.60E-05	3.24E-04	2.53E-05	4.52E-05	4.38E-05	1.12E-04
Pyrene	1.12E-06	1.14E-05	1.10E-06	2.20E-06	1.80E-06	5.21E-06
Retene	9.88E-07	4.71E-06	9.83E-07	4.34E-06	1.29E-06	7.22E-06

[(a)] represents predicted increase in concentration in berries resulting from uptake by roots and deposition onto plant surfaces.
Note: PAHs were not detected in cattail root samples collected in August 1997.

The predicted plant tissue PAH concentrations as a result of airborne deposition are much less than analytical detection limits and therefore are considered negligible. PAHs were not detected in the 1997 vegetation sampling program, with the exception of a few Labrador tea samples which had measurable levels of naphthalene, methyl-naphthalene and phenanthrene/anthracene, as noted in Table B5-12. The predicted increases for these chemicals are negligible.

In summary, predicted future plant tissue concentrations of metals and PAHs as a result of airborne deposition are negligible in comparison to levels observed in plant tissue in 1997. A baseline risk assessment of ingestion of these 1997 concentrations was previously presented in Section F1.2.4 of the Project Millennium Application. No impacts to human or wildlife health were predicted in the baseline assessment. Since predicted future increases are negligible, no impacts to human or wildlife health are predicted from consumption of these plants during operation and following closure of Project Millennium and the combined developments (i.e. CEA scenario).

B5.4.5 Residual Impact Classification and Environmental Consequence

Residual impacts were classified according to the methodology presented in Sections A2 and F1.1.4.4 of the Project Millennium Application. The magnitude of impact and resultant environmental consequence are rated as negligible.

B5.4.6 Modelling Assumptions and Uncertainty

The following conservative assumptions were used in this assessment:

- 30 years of cumulative deposition to soil was assumed, with no loss due to weathering or degradation;
- all chemicals were assumed to mix within the top 15 cm of soil;
- plant uptake by direct deposition assumed no degradation and no washing of berries and leaves, except for natural weathering removal; and
- maximum site-specific BCFs were used for metals.

The main area of uncertainty associated with this analysis is the uncertainty inherent with air dispersion modelling.

B5.5 References

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APPENDIX 1

Table 1 Comparison of Airborne Metal Concentrations at Fort McKay for the CEA Scenario to Risk-Based Concentrations for Human Health

Chemical	Air Concentrations At Fort McKay CEA [µg/m³]	RBC for [b] Air Inhalation (RBC) [µg/m³]	Comments
INORGANICS			
Antimony	4.28E-06	0.15	Does not exceed
Arsenic	6.62E-06	0.00041 [e]	Does not exceed
Aluminum	9.79E-04	0.37	Does not exceed
Barium	6.23E-05	0.052	Does not exceed
Beryllium	8.46E-07	0.00075 [e]	Does not exceed
Cadmium	2.38E-06	0.00099 [e]	Does not exceed
Calcium	1.27E-03	[c]	Does not exceed
Chromium (III)	4.11E-04	370	Does not exceed
Chromium (VI) [d]	4.25E-05	0.00015 [e]	Does not exceed
Cobalt	2.33E-05	22	Does not exceed
Copper	3.95E-05	15	Does not exceed
Iron	4.79E-03	110	Does not exceed
Lead	4.04E-05	1.3	Does not exceed
Magnesium	2.29E-04	[c]	Does not exceed
Manganese	1.38E-04	0.0052	Does not exceed
Mercury	1.02E-06	0.031	Does not exceed
Molybdenum	7.47E-05	1.8	Does not exceed
Nickel	7.03E-04	7.3	Does not exceed
Phosphorous	1.60E-04	0.0073	Does not exceed
Selenium	6.54E-05	1.8	Does not exceed
Silicon	1.24E-02	[c]	Does not exceed
Silver	1.08E-05	1.8	Does not exceed
Sodium	5.64E-03	[c]	Does not exceed
Tin	4.38E-05	220	Does not exceed
Titanium	9.52E-05	3.1	Does not exceed
Vanadium	2.83E-04	2.6	Does not exceed
Zirconium	4.38E-05	[c]	Does not exceed
Zinc	3.12E-03	110	Does not exceed

(a) CEA Annual Average Heavy Metal Concentrations ug/m³.

(b) Risk-Based Concentrations from EPA Region III Risk-Based Concentrations (Smith 1997) based on adult exposure and a target hazard quotient of 0.1 (non-carcinogens). child and adult exposure and an acceptable risk level of 1 x 10^{-6} (carcinogens) since applied to undiluted air concentrations at the stack.

(c) These metals were not evaluated in the risk assessment, since they are essential nutrients and/or they are non-toxic.

(d) Chromium (VI) was conservatively assumed to comprise 10% of total chromium emissions (CEPA 1993).

(e) RBC based on carcinogenic effects.

Table 2 Comparison of Airborne Metal Concentrations at Lower Camp for the CEA Scenario to Risk-Based Concentrations for Human Health

Chemical	Air Concentrations At Lower Camp CEA [μg/m³]	RBC for [b] Air Inhalation (RBC) [μg/m³]	Comments
INORGANICS			
Antimony	8.51E-06	0.15	Does not exceed
Arsenic	1.33E-05	0.00041 [e]	Does not exceed
Aluminum	1.79E-03	0.37	Does not exceed
Barium	1.27E-04	0.052	Does not exceed
Beryllium	1.65E-06	0.00075 [e]	Does not exceed
Cadmium	4.24E-06	0.00099 [e]	Does not exceed
Calcium	2.24E-03	[c]	Does not exceed
Chromium (III)	7.81E-04	370	Does not exceed
Chromium (VI) [d]	6.66E-05	0.00015 [e]	Does not exceed
Cobalt	4.35E-05	22	Does not exceed
Copper	7.39E-05	15	Does not exceed
Iron	8.63E-03	110	Does not exceed
Lead	8.34E-05	1.3	Does not exceed
Magnesium	4.48E-04	[c]	Does not exceed
Manganese	2.73E-04	0.0052	Does not exceed
Mercury	1.96E-06	0.031	Does not exceed
Molybdenum	1.44E-04	1.8	Does not exceed
Nickel	1.31E-03	7.3	Does not exceed
Phosphorous	4.29E-04	0.0073	Does not exceed
Selenium	2.04E-04	1.8	Does not exceed
Silicon	2.10E-02	[c]	Does not exceed
Silver	1.90E-05	1.8	Does not exceed
Sodium	1.12E-02	[c]	Does not exceed
Tin	8.90E-05	220	Does not exceed
Titanium	1.80E-04	3.1	Does not exceed
Vanadium	5.49E-04	2.6	Does not exceed
Zirconium	8.90E-05	[c]	Does not exceed
Zinc	5.14E-03	110	Does not exceed

[a] CEA Annual Average Heavy Metal Concentrations ug/m³.

[b] Risk-Based Concentrations from EPA Region III Risk-Based Concentrations (Smith 1997) based on adult exposure and a target hazard quotient of 0.1 (non-carcinogens).
child and adult exposure and an acceptable risk level of 1 x 10^{-6} (carcinogens) since applied to undiluted air concentrations at the stack.

[c] These metals were not evaluated in the risk assessment, since they are essential nutrients and/or they are non-toxic.

[d] Chromium (VI) was conservatively assumed to comprise 10% of total chromium emissions (CEPA 1993).

[e] RBC based on carcinogenic effects.

C. EUB SUPPLEMENTAL INFORMATION RESPONSE

1. **Provide an update on the project that includes any additional information that Suncor may have on the following:**

a) **public consultation and outstanding issues,**

Response:
Suncor's public consultation on specific projects continues through each phase of project development, including post-commissioning. As well, non-project consultation is ongoing on general matters. Currently, detailed reviews of the Application by the Oil Sands Environmental Coalition (OSEC) and Fort McKay Industrial Relations Corporation are being addressed. A detailed review is expected from the Athabasca Chipewyan First Nations. These groups have relationship Memorandums of Understanding in place or pending. The objective of this phase of consultation is to arrive at a "Consensus Agreement" by the end of September prior to the EUB decision on the need for hearing. These groups and others have submitted Statements of Concern to AEP regarding the Application. Suncor is addressing these as part of consultation activities. In addition to the Consensus Agreements with above groups, Suncor is seeking formal support of other stakeholders. For example, the Regional Municipality of Wood Buffalo Council approved a letter of support for Project Millennium.

The outstanding issues are varied and in some cases will require long-term solutions. For example, acidifying emissions effects will require further scientific research and monitoring to determine acceptable levels. Discussions with stakeholders relate to understanding uncertainties and future needs. Understanding cumulative effects and managing within environmental objectives is a major area of discussion and Suncor expects this to be an ongoing consultation. The other area of emphasis is socio-economic impact where Suncor is involved with the Regional Infrastructure Working Group. As well, Suncor is continuing its initiatives with regional and local communities, specifically in the area of employment and business development.

b) **the Federal comprehensive study,**

Response:
The Comprehensive Study Report, as required under the Canadian Environmental Assessment Act, is being authored by the Department of Fisheries and Oceans and is in final draft stages. As per schedule it is expected to be issued by the CEAA in early August for public notification.

c) **the regional co- generation plant,**

Response:
At present the third party power option appears promising, but to date no commercial arrangement has been completed. Should this option proceed, the major change from the application would be a significant increase in power generation capability to allow export of up to 200 MW to the power grid over and above the plantsite requirement of 220 MW average. This would be accomplished by:

- Upgrading the 2 gas turbogenerators from 85 MW to 115 MW each. The associated heat recovery steam generators would remain as single pressure (5450 kPa) but increase slightly in capacity from 8.7 million kg/d to 9.8 million kg/d with higher (67 m) exhaust stacks.

- Adding two steam turbine generators (TG-3 at 60 MW and TG-4 tentatively at 40 MW) for higher efficiency and full co-generation capability condensing against waste heat recovered from the upgrader, to provide heat to the extraction process.

d) **the froth deaerator which requires no steam,**

Response:
The field test work has just been completed and data analysis is currently underway. Results of the test work have not been quantified, but preliminary indications are positive.

e) **the low-temperature raw bitumen pipeline, and**

Response:
Suncor has completed field testing of a static deaerator and small diameter froth pipeline testing. Test work has just been completed and data analysis is underway. Preliminary results are positive.

f) **the status of the Natural Gas Liquids Facility.**

Response:
Suncor recently announced plans to recover natural gas liquids and olefins with Novagas Canada Ltd. By the end of 1999, this project is proposed to recover approximately 10 000 bpd, with the intent to recover more liquids as Suncor's oil sands production increases.

Both Suncor and Novagas Canada Ltd. are currently continuing with due diligence, engineering and financial review necessary to finalize this business relationship. Suncor expects this project to proceed and has shown its commitment to the project by submitting the Suncor Oil Sands Pipe Line substance change application to the EUB for approval to ship higher vapour pressure products.

2. **Suncor stated it has held discussions with each party regarding timely access to exercise their interests. These discussions are not listed in Section A3, public consultation program. Describe discussions with these groups. (C2.4, page 50)**

Response:
Suncor has had several discussions with gravel operators. Plans have been shared and both parties have agreed to cooperate and respect each others rights. Access agreements are being developed to permit gravel removal. Gravel is expected to be removed well in advance of Suncor's overburden removal.

Suncor has been meeting with Northlands Forest Products and Alberta Pacific Forest Industries to resolve a number of issues relating to the removal of the existing forest stands prior to development and the potential adverse effects of the proposed activities. The issues being addressed include access interruptions, salvage of the valued timber supplies, Timber Damage Assessment, impact to Annual Operating Plans, development of new access, harvesting stand layout, and a number of lesser issues. Several helicopter trips have been taken with Alberta Pacific Forest Industries and Northlands Forest Products, with the inclusion of Alberta Land and Forest Service (LFS).

It is Suncor's intent to include Northlands Forest Products, Alberta Pacific Forest Industries participants and the LFS personnel in timber salvage decisions. As such, the LFS members from the Waterways District have been present at most of the meetings with the industry representatives.

Discussions have been held with Birch Mountain Resources. Both parties have shared concepts as to how exploration and development of mineral rights underlying the oil sands might occur, and have agreed to respect each others rights in the mining area.

3. **What would be the impact to the Millennium project if the regulatory process was more complex and took longer that anticipated? (C6, page 171)**

Response:
Project Millennium is a very significant component of Suncor Energy Inc. strategic plan to improve its long-term profitability and to keep its production costs competitive. A key benefit from Project Millennium will be the reduction of cash operating costs to \$10/bbl to \$11/bbl, which will reduce vulnerability to low world oil prices and improve profitability.

Additionally, significant economic benefits accrue to the Region, Alberta and Canada from the Project.

Any material delay in the proposed project schedule will reduce the economic benefit from the Project to Suncor. Suncor would also be concerned that a delay in schedule would cause the market window of opportunity to be missed, especially in light of the investment activity in Venezuelan heavy oil targeted at United States markets. A delay of the socio-economic benefits would also follow, which would have an adverse impact on business and community confidence in the Region.

Regulatory approval by the first quarter 1999 is important to Suncor - so that the 1999 spring and summer construction period can be taken advantage of, in order to meet the planned startup date. Even a slight delay will drive up construction costs through forcing more winter construction.

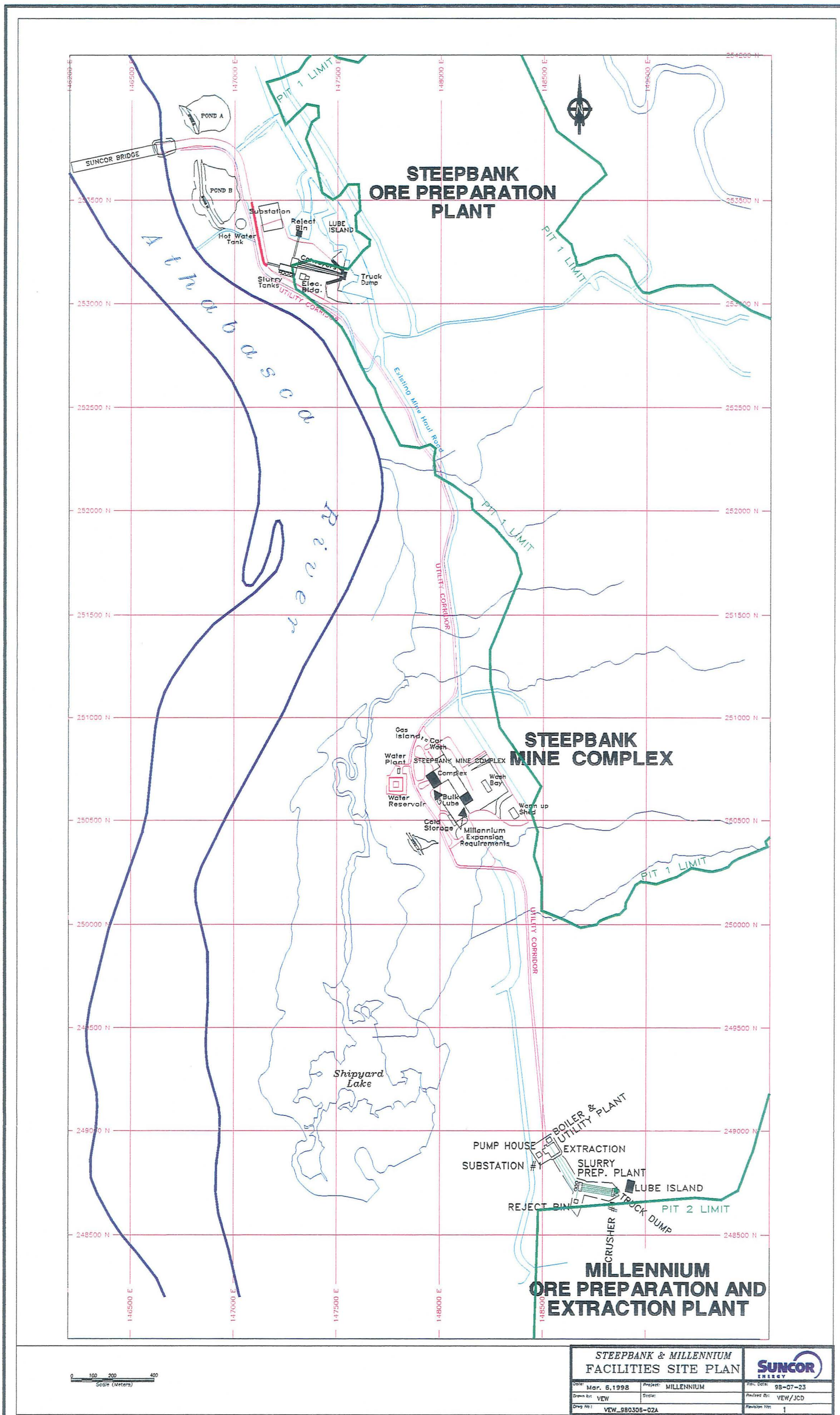
4. **Provide a drawing of the plant area on the west side of the river, and the two new extraction areas on the east side of the river, showing**

a) **the existing infrastructure and the additional infrastructure required for the Milennium Project, and**

b) **all required installations north of the pit 2 mine opening location.**

Response:
A figure illustrating the infrastructure and facilities on the east side of the Athabasca River follows attached. There are no changes to the Steepbank Ore Preparation Plant site. Additions to the shop area are indicated and the new Millennium site is shown.

More detailed plot plans, as requested, for the installations on the west side of the river are being provided to the EUB under separate cover. The general locations of plant facilities remains the same as provided in the Application.



STEEPBANK ORE PREPARATION PLANT
STEEPBANK MINE COMPLEX
MILLENNIUM ORE PREPARATION AND EXTRACTION PLANT
PIT 1 LIMIT
PIT 2 LIMIT
Athabasca River
Shipyard Lake
SUNCOR BRIDGE
POND A
POND B
Substation
Reject Bin
LUBE ISLAND
Hot Water Tank
Slurry Tanks
Elec. Bldg.
Truck Dump
UTILITY CORRIDOR
Existing Mine Haul Road
Gas Island
Car Wash
Water Plant
STEEPBANK MINE COMPLEX
Complex
Wash Bay
Water Reservoir
Bulk Lube
Wash up Shed
Cold Storage
Millennium Expansion Requirements
BOILER & UTILITY PLANT
PUMP HOUSE
EXTRACTION
SUBSTATION #1
SLURRY PREP. PLANT
LUBE ISLAND
REJECT BIN
TRUCK DUMP
CRUSHER
0 100 200 400
Scale (Meters)
STEEPBANK & MILLENNIUM
FACILITIES SITE PLAN
SUNCOR ENERGY
Date: Mar. 6,1998
Project: MILLENNIUM
Drawn by: VEW
Scale:
Dwg No: VEW_980306-02A
Rev. Date: 98-07-23
Revised By: VEW/JCD
Revision No: 1

5. **Suncor stated that it is considering further opportunities for enhancement of the bitumen production process including working on a design-basis test program to be concluded in mid-1998. Provide a summary of the program and results. (C2.5, page 99)**

Response:
The froth treatment hydrocyclone field test is just beginning due delays in commissioning the IPS unit. Results of the Design Basis Testing program are expected late Q3 1998.

The hydrocyclones are being tested as a potential replacement for scroll (first stage) centrifuges. If the hydrocyclones are proven to be a viable replacement they will have the advantage of lower capital and operating costs as well as significantly reduced power consumption. They have the potential to provide second stage (Westfalia) feed which is similar to current Westfalia feed in terms of total BS&W content. If this is demonstrated in the test work, then current centrifuge performance, in terms of hydrocarbon recovery and product quality, could be expected for Millennium operations.

Oil Sands Rights

6. **Suncor shows in figure B1-1 that the east portion of lease 25 is owned by Unocal. Based on the information provided in Section C2.2, it appears that the outline for Pit 2 and the "E Dump Potential" cross the boundary that is shown to divide lease 25. Describe what access/rights Suncor has to the east (Unocal) portion of lease 25.**

Response:
Suncor holds the the east portion of Lease 25 in trust. This means that Suncor is registered on the title but has no rights of access. Suncor is proceeding to resolve the issue of access/rights with Unocal in the area of the boundary that is shown to divide Lease 25.

7. **It would appear that the extreme SE corner of the proposed Pit 2 extends into an area identified as "Not Owned" (not leased?). What steps will Suncor take to obtain the rights to oil sands in this area?**

Response:
About 5.5 ha of Pit 2 is presently planned to overlap onto lands not currently held by Suncor. In addition, a further perimeter zone will be required external to the pit itself. This will be about 450 m long with a width still to be determined. Upon final confirmation of the pit limits, Suncor will lease the lands required to ensure surface rights for the pit limit (including the perimeter zone).

Geology

8. **Provide updated figures based on the new geological model (once 1997/98 data is included) for "Net Cost Contours" (figure C2.2-16), and "Total Volume/Net Recovered Barrels Contours" (figure C2.2-18). Based on the updated geological model , provide updated estimates of the oil sand resources affected by the construction of the external tailings pond, and the rehandle volumes that will required to mine to the pit limit indicated by the $10/bbl net cost contour. For the affected resource (ie the oil sand within the net cost contour defined pit which lies either directly beneath the pond or within the offsets required for geotechnical stability), give the ore tonnage, average grade, number of recoverable barrels of bitumen, the TV/NRB ratio for the resource, the extraction recovery used to calculate TV/NRB, overburden tonnage, interburden tonnage, and required volume of rehandled sand and starter dyke.**

Response:
The drilling data for the 1997/98 drilling program have been submitted (including non-licenced holes). The new geological model utilizing this data is still under development. Suncor expects to provide the information requested by mid-September.

9. **In Section C2.2, pg 16 it is stated that "a drilling density of 7 to 10 drillholes/km^2 is normally required for a feasibility study and a density of 30 to 40/km^2 is needed to facilitate five-year mine planning". Pit 2 drilling density is presently at 3.3 drillholes/km^2.**

a) **Why does Suncor believe the drill density level is acceptable for this stage in the process when information re - ore characteristics and procesibility is limited? (c2.2, page 16).**

Response:
Suncor believes that there is sufficient definition of the East Bank ore body with the conclusion of the 1996/97 drilling program to define ore processing requirements and to proceed with project decisions. Each successive drilling campaign has served to confirm the lateral continuity of the ore body. The 1997/98 drilling program, which adds approximately 130 holes, focused on pit limits and waste structure location.

b) **What is the accuracy of Figure C2.2-15?**

Response:
Figure C2.2-15 will be resubmitted with the revised geologic model by mid-September. The figure understates the grade (as a result of manual adjustment of the west pit limit based on geophysical logs).

c) **How confident is Suncor that the selected location and footprint size of proposed pit**

and infrastructure (external tailings pond, plantsite and dumps) will not change significantly upon further drilling and/or more detailed design work?

Response:
Suncor remains confident (based on preliminary assessment of 1997/98 drilling) that the referred to site locations will not change significantly. This will be confirmed with the geologic model to be submitted by mid-September.

d) **Suncor estimates that Pit 2 has an average ore grade of 11.7 wt% bitumen. How confident is Suncor that the estimated average ore grade will not drop significantly upon further drilling? What range of grades does Suncor believe would represent the best and worse cases for average grade? Discuss impacts to the operation if the grade does vary significantly from the 11.7% currently estimated.**

Response:
From the preponderance of evidence, Suncor expects that the average pit grade will be very nearly 11.7%. The impact to operations, should the grade vary, is a speculative question. Suncor would work to meet the challenge as it presents itself.

e) **Explain how Suncor can achieve an extraction recovery of 92.5 %. At what average grades does Suncor believe the commitment to 92.5% overall extraction recovery is valid? (Pg C2-31)**

Response:
Suncor is committed to achieve 92.5% recovery on average within the range of ore grades that are foreseen. Overall recovery factor is a function of pit definition, ore preparation, primary and secondary recovery. Within this system, Suncor has sufficient ability to assure 92.5% recovery.

10. **Provide the following maps to illustrate the distribution of Pleistocene deposits on the MILENNIUM Leases (No. 19 and 25):**

a) **isopach of the Pleistocene deposits or a structure contour map of the top of the McMurray**

b) **isopach of sediments that are glacial fluvial in origin**

The maps should illustrate drillhole control with CPA-ID and respective thickness intersected.

Response:
The requested maps are being provided to the EUB under separate cover.

11 **It is stated, in Section C2.2, Pg 18, that "deep, glacially-derived channels have not been encountered in the east bank exploration areas". Notwithstanding this statement, and in view of published opinions that the Pleistocene channel scours outcropping along the cliffs of the Steepbank river possibly extend south into the east bank leases opposite the Suncor site, it appears that their presence is still possible given the low density of drilling. As a Pleistocene meltwater channel could result in the removal of significant quantities of oilsand and could be a significant aquifer source, comment on the risks associated with the presence of an as-yet undetected channel. What effect would an undetected channel have with respect to alternate locations for infrastructure (external tailings pond, plant etc.).**

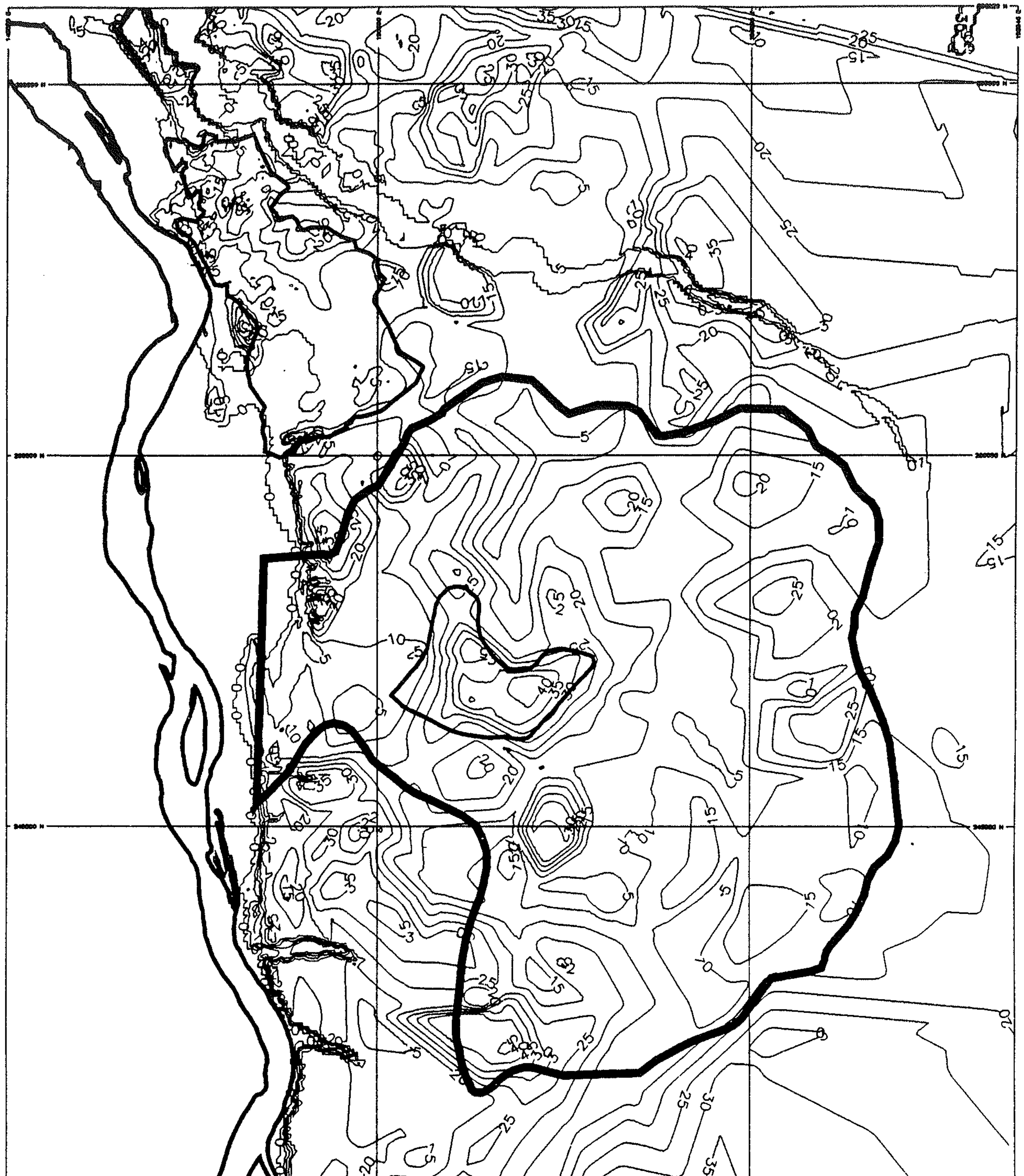
Response:
With additional drilling, the configuration of the Pleistocene and Holocene deposits is becoming clearer. In the 1997/98 drilling program, significant thicknesses of presumed glacio-fluvial sands and gravels have been intersected.

Coarse grained, unconsolidated sediments provide competent foundation conditions. Therefore the discovery of undetected glacio-fluvial channels would not impact plans for plant locations.

However, a glacio-fluvial channel would require careful consideration during detailed design of tailings ponds. The presence of sands and gravels below a dyke could be mitigated by constructing a low permeability plug, an upstream blanket or curtain wall, excavation of the channel and replacement with low permeability materials, or realignment of the dyke.

12. **Provide a contour map showing total interburden thickness for the Pit 2 and Pit 1 areas.**

Response:
An interburden isopach is provided on the following page.



INTERBURDEN ISOPACH

0 500 1000 2000
Scale (Meters)

PROJECT MILLENNIUM

SUNCOR ENERGY

Date:	July 24.1998	Project:	MILLENNIUM	Rev. Date:	98-07-24
Drawn by:	DAH	Scale:	1:30000	Revised By:	DAH
Drwg No.:	s_interiso8x10.plt			Revision No:	0

13. **Provide a plan view indicating the lateral distribution, thickness and quantity of coal encountered to date in Suncor's drilling programs. What characteristics of the coal have been determined to date? Does Suncor plan to recover the coal as a marketable product?**
(Pg C2-22)

Response:
The coal encountered to date is of very poor quality, averaging 4480 BTU/lb on an as received basis and 5700 BTU/lb on an air dried basis. The coal seams are interbedded with clay lenses and are discontinuous. Suncor's conclusion is that there is no economic value to this coal. An isopach is not being provided because the coal has been encountered only sporadically and an isopach would be meaningless.

14. **In volume 1, page C2-10 Suncor indicates that approximately 90 billion barrels of bitumen (10% of 900 billion) is recoverable from the Lower Cretaceous McMurray Formation by surface mining methods. What is the basis of this estimate?**

Response:
The source of the estimate was : Outtrim, C. P. and Evans, R.G., "Alberta Oil Sands and their Evaluation", Heavy Oil Symposium, 28th Ann. Tech. Mtg., Petroleum Society, CIM.

Cut-off Grade

15. **The ore cut-off grade as discussed on page C2.2-39 in volume 1 indicates that Suncor is using a cut-off grade of 7 weight percent bitumen for the Steepbank pits. However, in some recent discussions Suncor has indicated that a cut-off grade of 8 weight percent bitumen is being used for the Steepbank pits. Define "cut-off grade" as used in the discussion on page C2.2. Provide an example of a drill hole in which the use of 7% versus 8% as cut-off grade would change the composited ore/waste zones according to Suncor's methodology. Show the sample grades and composited grades and the ore/waste zones according to Suncor's definitions. What cut-off grade is being used in Pit 1?**

Response:
Suncor confirms that the cut-off grade is 7% for the East Bank Mining Area(Pit 1 and Pit 2). Suncor believes that its modelling routine reflects the ore body and uses procedures that give similar results to EUB methods. Compositing routines have been discussed with the EUB and Suncor is prepared to discuss them further.

16. **Describe the analysis completed to determine that processing oil sand in the 6%-7% range is not profitable. Discuss the validity of the cut-off grade analysis in light of the low density of drilling in the Pit 2 area. What are the estimated impacts on tailings handling plans associated with incorporation of the oil sand grading 6%-**

7% in the plant feed? What extraction recovery was used to determine the recoverable bitumen in the 6-7% grade ore?

Response:
The appropriate cut-off grade for an ore body is determined on the basis of an economic assessment which considers:

- volume of overburden removed
- volume of material processed in the extraction plant
- volume of bitumen recovered
- volume of tailings placed

The analysis for the East Bank Mining Area concluded that ore in the 6% to 7% range, with its inherent lower recovery and higher tailings generation (sand and fines), was not profitable. The predicted extraction recovery for ore in the 6% to 7% range was much less than 70% and well below the target 92.5% recovery.

Pit Limit/Pit Design

17. **Suncor stated that there is over 77 million bbls of recoverable bitumen under the proposed tailings pond but that area would be cleared and ore recovered at the end of mine life. Considering the amount of material to be moved and processing cost, what does the ore have to be worth to make recovery of this ore economic? (C2.4, page 68)**

Response:
The cost of material to be rehandled is recognized as part of the project economics. The chosen location of the external tailings pond is considered to be optimal and Suncor is committed to the rehandle cost.

18. **In order to clarify exactly what is being proposed for the out-of-pit tailings pond, provide six west-east cross sections of the area which cover at least 147000E to 152000E (coordinate system as in figure C2.4-12 - drawing number VEW-980307-12). The cross sections should be located at approximately the following northings: 242800N, 243800N, 244800N, 245800N, 246800N, and 247800N. Features shown on the sections should include: the Athabasca River, topography, top of clearwater, bottom of clearwater, top of oil sand, top of ore, bottom of ore, designed final pit wall, the area evaluated to quote "resources affected", waste island limits; and the tailings structure including internal beach slopes, approximate cell/beach boundary, overburden starter dyke, approximate yearly construction limits, rehandled portion of tailings, CT boundary, the insitu plug, and the pond infill material. If available, show the oil sand grades or ore/waste zones in the area affected by the tailings structure. (If necessary for clarity, the information can be split into two sections of the same scale which can be overlain to show features of interest.)**

Response:
The cross-sections with most of the requested information thereon are being provided under separate cover to the EUB. Suncor however, cannot provide ore quality on cross-sections from its modelling program. In addition, the requested computer-modelled details on overburden starter dyke, internal beach slopes, CT boundary and annual construction limits are not available until the final dyke design. This level of detail is not required at the current stage of decison making and therefore is not developed at this stage.

Suncor's planning at this stage is based on generalized parameters that have proved to be successful in its operations over the years. For example: the overburden starter dyke will be constructed to a minimum height allowing sand dyke construction to commence. Beach slope angles of about 15H:1V are used with annual dyke rise of 20 m.

19. **What is the relationship used to get the net cost contour? Why was a net cost contour of $10/bbl used to define the pit in the Millennium application versus a $6.50/bbl net cost contour in the Steepbank application? What does "bbl" in the denominator represent - bitumen in place, recovered bitumen, or synthetic crude?**

Response:
The pit limit was established at the economic limit and confirmed by the TV/BIP and TV/NRB methods. The improved economics of Project Millennium result in an expanded pit as compared to Steepbank.

The denominator (i.e., in $10/bbl) represents recoverable barrels of bitumen.

20. **Figures C2.2-16, C2.2-17, and C2.2-17 show the outline proposed for pit 2 versus net cost, TV/BIP, and TV/NRB contours respectively. Over most of the pit the outline follows the contours quite closely. However, in three areas: the southwest corner of the pit (in the area of pond 8A); the north side of the waste island; and under the northeast dump (immediately east of the dump area proposed in the Steepbank application) the pit limit does not follow the contours. Why does the pit outline deviate from the contours in these areas?**

Response:
With respect to the southwest corner of Pit 2 and the north side of the waste island: the pit outline was adjusted on the basis of then available interpretations of geophysical logs. The pit boundary in these locations will be confirmed with the new geologic model to be submitted by mid-September.

In the area of the northeast dump: the ore zones that have been excluded are in the configuration of two peninsulas, both of which appeared uneconomic when pit-wall effects are considered. The pit boundaries in this area will also be confirmed by the new geologic model to be submitted by mid-September.

21. **For determination of the TV/NRB contours, how was net recoverable bitumen determined? Was a recovery of 92.5% assumed for all grade ranges? If different grade ranges were assumed to have different recoveries provide the equation used to calculate the recoveries.**

Response:
For determination of the TV/NRB contours the net recoverable barrels of bitumen are based on a recovery equation which considers bitumen and fines content in ore (not a constant 92.5% recovery).

The equation that is used is the "Modified Syncrude Equation (MSE Base)" :

MSE Base % recovery = (1.004*((32.6*BIT **0.4263 + 119*FINT**(-0.1213)) - 91)) + 4

Where:
BIT is bitumen content from core data
FINT is fines content from core data using toluene wash methods
FIN is fines content from core data using water wash methods
FINT = FIN*0.8763 + 0.5159

If the calculated recovery from MSE Base is less than 88%, the calculated recovery is modified as follows:

Recovery (<88) % = MSE Base + 2 - (7* (88- MSE Base)/18)

If the MSE Base calculated recovery is above 94.5% , the calculated recovery is truncated at 94.5%.

22. **Table C2.4-1 in volume 1 indicates that a safety berm will be left on every second ore bench. Is it Suncor's intention to create mining faces 30m high (2-15m benches) in oil sand? If so, does Suncor have operating experience with 30m high oil sand faces in the truck/shovel operation or is this a new design feature developed specifically for the new mine? What slope is anticipated for the active bench faces in oil sand? Describe methods to be used to stabilize the (rich) ore zones in warm summer weather when the ore has a tendency to flow; and to prevent stability problems with the evolution of natural gas from the rich ore face. How will these events be accommodated with the proposed design and what measures will be taken to prevent subsequent failure of overburden material above the ore zone, should instability of the ore face develop.**

Response:
The parameters for pit wall and bench geometry shown on Table C2.4-1 are identical to those approved for the Steepbank mine and are intended for conceptual planning purposes. Suncor is not presently planning significantly different mining techniques

than presently used on Lease 86/17. Using these techniques, active bench faces in oil sand typically range from 60° to 70°. Mining excavations of 30 m high oil sand faces are very infrequent and would not be planned without careful consideration of pit wall stability. The perimeter pitwalls in the oil sand will be dug as steep as possible in order to maximize ore recovery consistent with the mine plan, overburden stripping, and safety, following procedures Suncor has used successfully for over 30 years of operation.

Typically oil sand slopes will remain stable through infilling with tailings or overburden, however, depending on local conditions such as very high bitumen content or geotechnical defects such as dipping clay seams, there are several modes off pit slope retrogression which, while not prevalent, can cause significant pit slope retrogression. From a safety perspective, the time period of greatest concern is the winter when deep frost penetration can create an overhang situation and the potential for frozen blocks falling and threatening operators and equipment. These potential failure modes will be assessed during design, and detailed pit wall designs will be developed based on present experience plus additional experience gained as mining proceeds in Pit 1 and Pit 2.

If potential adverse conditions are encountered, slopes must be flattened. This can be done by flattening the mined slope, which is not desirable as the local overburden to stripping ratio is increased. Alternatively, if problems are encountered with the bottom bench, it is possible to extract the ore and use buttresses of overburden.

Mining Mass Balance

23. **Volume 1, table C2.4-3 shows the overburden disposal schedule for different discard sites. Extensive changes to schedule since the Steepbank application prevent extrapolation of the material balance given in that application for current use. Provide a revised table which includes the current overburden/interburden/reject disposal schedule for the remainder of the discard sites on the east side of the Athabasca River. Does the "Pond NE" heading represent the NE Dump in the table? If not, define Pond NE and include the NE dump in the table.**

Response:
The requested table is provided on the following page. Pond NE represents NE Dump in the table in the Application.

TABLE C2.4-3 - OVERBURDEN DISPOSAL SCHEDULE - MTONNES (Revised)

YEAR	PIT 1					PIT 2																GRAND TOTAL
	DYKE 10	POND 7	DUMP N	DUMP NE	TOTAL PIT 1	DYKE 11a	DYKE 11B	DYKE 11	DYKE 11C	DYKE 12	DYKE 14	DYKE 15	DYKE 16	DUMP SW	DUMP NE	POND 8	POND 9	POND 10	POND 11	POND 12	TOTAL PIT 2	
1997			6.0		6.0																	6.0
1998	6.9		10.0		16.9																	16.9
1999	13.7	10.3			24.0																	24.0
2000	13.8	11.3			25.1	10.0								11.0							21.0	46.1
2001	19.8	16.2			36.0	8.6								19.3							27.9	63.9
2002	32.5	26.6			59.1	9.4	9.4	7.5						12.6							38.9	98.0
2003	36.3	13.7		16.0	66.0	9.4	9.4	27.1						21.3							67.2	133.2
2004	34.7	13.7		14.7	63.1	3.8		37.5						0.1		19.4					60.8	123.9
2005	14.9	12.2			27.1	3.7		48.8	12.3					0.1		30.4					95.3	122.4
2006						3.7		39.2	37.3	18.7				22.6		56.8					178.3	178.3
2007								39.2	46.7	9.3				0.0	34.4	92.3					221.9	221.9
2008											9.3				41.9		163.7				214.9	214.9
2009											18.6						158.7				177.3	177.3
2010											37.2						172.5				209.7	209.7
2011											46.6						152.1				198.7	198.7
2012											46.6						156.8				203.4	203.4
2013											48.5	37.3						103.5			189.3	189.3
2014												74.5						124.0			198.5	198.5
2015												74.5						171.7			246.2	246.2
2016												74.6						162.9			237.5	237.5
2017												74.6						127.2			201.8	201.8
2018												74.6						119.8			194.4	194.4
2019												74.6						196.6			271.2	271.2
2020												55.9	18.6						165.2		239.7	239.7
2021													65.3						128.3		193.6	193.6
2022													65.4						130.2		195.6	195.6
2023													65.4						130.2		195.6	195.6
2024													65.4						130.2		195.6	195.6
2025													65.4							131.0	196.4	196.4
2026													65.4							131.0	196.4	196.4
2027													65.4							131.0	196.4	196.4
2028																				196.4	196.4	196.4
2029																				196.4	196.4	196.4
2030																				196.4	196.4	196.4
2031																				196.4	196.4	196.4
2032																				196.4	196.4	196.4
2033																				16.0	16.0	16.0
	172.6	104.0	16.0	30.7	323.3	48.6	18.8	199.3	96.3	28.0	206.8	540.6	476.3	87.0	76.3	198.9	803.8	1005.7	684.1	1391.0	5861.5	6184.8

REJECTS WILL BE DISTRIBUTED TO OPEN PITS OR PONDS THAT HAVE AVAILABLE SPACE

24. **Volume 1, table C2.2-2 seems to have some errors in units. It appears that Suncor will be mining 54.5 billion tonnes of waste and 4.8 trillion tonnes of ore. Provide a corrected table. Include expected reject volumes for the Steepbank hydrotransport facility and the Millennium extraction plant.**

Response:
The corrected table is on the following page.

Table C2.4-2 Materials Handling Schedule - Mtonnes (Revised)

Year	Total Waste				Ore				Rejects
	L86/17	Pit 1	Pit 2	Total	L86/17	Pit 1	Pit 2	Total	
1998	22	23	0	45	59	7	0	67	1
1999	15	24	0	39	46	47	0	93	2
2000	7	25	21	54	49	46	0	94	2
2001	4	36	28	68	30	60	15	105	2
2002		59	39	98		96	53	149	3
2003		66	67	133		89	54	144	3
2004		63	61	124		87	54	141	3
2005		27	95	123		45	93	137	3
2006			178	178			134	134	3
2007			222	222			138	138	3
2008			215	215			142	142	3
2009			177	177			134	134	3
2010			210	210			143	143	3
2011			199	199			143	143	3
2012			203	203			142	142	3
2013			189	189			136	136	3
2014			198	198			142	142	3
2015			246	246			142	142	3
2016			238	238			136	136	3
2017			202	202			133	133	3
2018			194	194			140	140	3
2019			271	271			140	140	3
2020			240	240			144	144	3
2021			194	194			132	132	3
2022			196	196			137	137	3
2023			196	196			137	137	3
2024			196	196			138	138	3
2025			196	196			133	133	3
2026			196	196			140	140	3
2027			196	196			139	139	3
2028			196	196			145	145	3
2029			196	196			143	143	3
2030			196	196			150	150	3
2031			196	196			146	146	3
2032			196	196			147	147	3
2033			16	16			82	82	2
Totals	48	323	5862	6233	184	477	4128	4788	95

Overburden Dumps

25. **It appears from the figures provided in volume 1, section C2 that the NE dump will overlie a considerable amount of mineable oil sand as defined by the $10 net cost contour. Based on the updated geological model which includes 1997/98 drilling data, provide estimates of the oil sand resources affected by the construction of the northeast dump. For the affected resource (i.e. the oil sand within the net cost contour/river set-back defined pit which lies either directly beneath the dump or within the offsets required for geotechnical stability), give the ore tonnage, average grade, recoverable barrels of bitumen, the TV/NRB ratio for the resource, the extraction recovery used to calculate TV/NRB, overburden tonnage, and interburden tonnage. What options have been evaluated which would avoid burial of the resources evaluated? What are the benefits and difficulties associated with those options?**

Response:
Based on the current geologic model, the area identified under the NE Dump does contain ore that could be termed economic. It was excluded from the pit limit in the Application because of pit slope effects. The reserves in this area will be confirmed by the geologic model to be submitted by mid-September. Dump configuration and placement schedule will be optimized with the objective of minimizing the sterilization of economic ore.

26. **While it is recognized that a request for a complete engineered design for the dump would be premature at this time, there is sufficient geological information available to provide an indication of the suitability of the proposed dump location. Provide one longitudinal section through the dump with end points approximately corresponding to the coordinates (149490E, 252100N) to (155700E, 250750N). Additionally, provide five north-south cross sections of the dump area which cover at least 253000N to 249500N (coordinate system as in figure C2.4-12 - drawing number VEW-980307-12). The cross sections should be located at approximately the following eastings : 151000E, 152000E, 153000E, 154000E, and 155000E. Features shown on the sections should include: the Steepbank River, topography, top of clearwater, bottom of clearwater, top of oil sands, top of ore, bottom of ore, designed final pit wall, the area evaluated to quote "resources affected", and the outline of the dump corresponding to the dump capacity used in the mining mass balance. If available, show the oil sand grades or ore/waste zones in the area affected by the tailings structure. (If necessary for clarity, the information can be split into two sections of the same scale which can be overlain to show features of interest.)**

Response:
The requested sections are being provided to the EUB under separate cover. Suncor cannot supply the oil sand grade on the sections as requested due to limitations of its modelling program.

27. **Suncor indicates in volume 1, page C2.4-73, that slopes for external dumps will vary between 6H:1V and 3H:1V. For the northeast dump, which slopes were used to determine the dump capacity given in the mining mass balance?**

Response:
Slopes used were 3H:1V.

In-Pit Dyke Design

28. **Suncor indicates in volume 1, page C2.4-73, that unsupported slopes for in-pit dykes will vary between 6H:1V and 3H:1V. Which slopes were used to determine the construction volume requirements given in the mining mass balance?**

Response:
The slopes that were used to determine the construction volume requirements for the in-pit dykes provided in the mining mass balance were 3H:1V. (These slopes are in fact supported by in pond overburden dumps, the volumes of which are also included in the mass balance.)

In-situ Plug Configuration

29. **Provide a cross section of the in-situ plug of ore that will be left at the northwest end of the end-pit lake. Based on the most up to date geological model, describe the configuration of the plug in terms of the length, width, height, slopes, grade, and total volume of ore and recoverable bitumen.**

Response:
The plug is 400 m long (distance between pit walls) at the base and is 490 m thick at the base. The height of the plug is 50 m base of ore to top of ore. The 1 000 000 bbls loss of recoverable bitumen is based on a pit planning-slope of 45 degrees in ore. The requested cross-section is being provided to the EUB under separate cover.

Mine Opening Location

30. **It appears that the inability to create in-pit pond space quickly enough to avoid an external tailings pond is due, in part, to the decision to begin mining in Pit 2 prior to completion of mining in Pit 1 as was proposed in the Steepbank application. Has Suncor evaluated the option of supplying ore to the Millennium extraction plant in the early years of operation from Pit 1 instead of Pit 2? If so, what are the benefits and difficulties associated with this option?**

Response:
The external tailings pond is required to support the Millennium Extraction plant with recycle water. At the time of the Millennium Extraction plant start-up, there is insufficient space in Pit 1 to provide this capability. Suncor is evaluating the potential to accelerate the completion of Pit 1, which may reduce the size of the external tailings

pond. It is in Suncor's interest to reduce the size of the external tailings pond as much as possible to reduce operating and reclamation cost.

Plant Site Location

31. **Provide a more detailed comparison of the advantages and disadvantages of the North and Centre plant site locations discussed in volume 1, pages C2.3-46/47.**

Response:
A significant motivation to locate the Millennium Extraction plant as proposed (North location) rather than on the waste island (centre location), was the reduction of initial capital in an amount exceeding $30 million. This is important to Suncor because of the impact on project financing and project economics.

Table 1 Comparison between North and Centre Plant Locations

	North Location	Centre Location
Initial Capital Cost	Over $30 million lower	
Operating Cost		
Early life	Lower	
Remaining Life		Slightly lower
Environmental Disturbance		Significantly earlier
Resource Sterilization	None	Some potential
Haul Distance		Longer uphill haul in early years
NO_X Emissions		Higher due to uphill haul in early years

32. **If the Centre plant site was used from the beginning of the Millennium operation would NO_X emissions be significantly reduced due to lower overall haul distances?**

Response:
Suncor does not believe that NO_X emissions would be significantly reduced because the Centre plant site would require a significant uphill haul (albeit shorter) for the early portion of the mine-life (hence an increase in fuel consuption).

33. **Volume 1, page C2.5-112, Suncor indicates that two of the principle areas of power consumption in the extraction plant are tailings transport to the tailings pond and interplant pipelines. What is the approximate breakdown of the power consumption for these two activities? How would the breakdown change if the plant was constructed in the Centre plant location from the beginning of operation to reduce the distance to pond 8A?**

Response:
The power consumption of Millennium Extraction plant tailings transport and interplant

pipelines is about 24 MW and 9 MW respectively. If the plant were located at the Centre location, the breakdown would be about 17 MW and 12 MW respectively

Tailings Pond Need and Location

34. **It appears that opportunities for earlier reclamation of Pond 1 might be available if Millennium tailings plans placed more emphasis on this objective. Discuss whether such opportunities exist and if so how they might be incorporated into the Millennium tailings plans.**

Response:
Pond 1 reclamation schedule is driven by the need to manage recycle water quality to maintain bitumen recovery and the availability of sand for CT placement in the west-side ponds. This is discussed in more detail in the Pond 1 reclamation schedule provided in the appendices.

Use of MFT from Pond 1 for CT in the Millennium Extraction plant tailings was considered, however, this was determined to be uneconomic (see response 37)

35. **The proposed Millennium project requires that an external tailings pond be constructed on the east side of the Athabasca River but for the Steepbank application no such pond was required. Explain in detail the differences between the two projects that result in the conclusion that an external tailings pond is now required. What factors and ranking determined the selection of the proposed site of the external tailings pond? What consideration was given to the proximity of the site to the Athabasca River?**

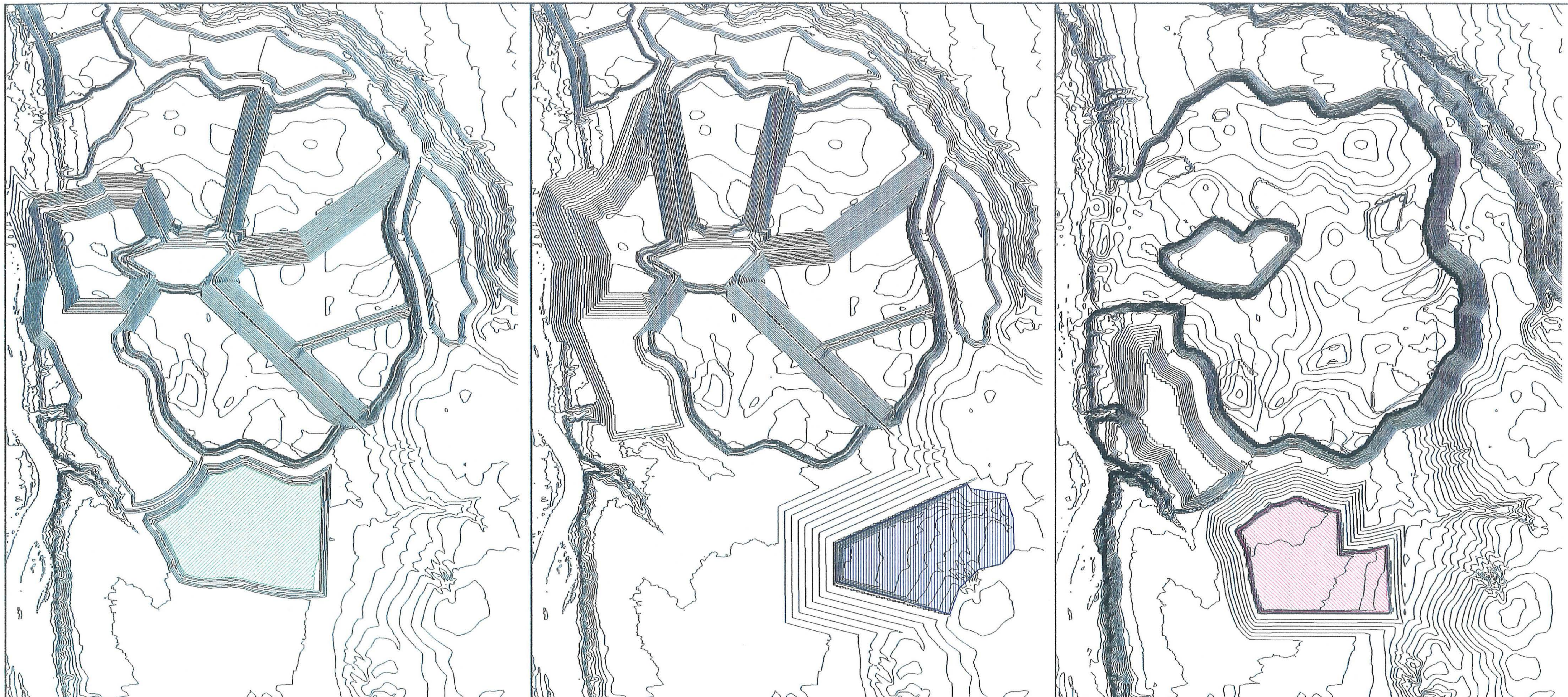
Response:
The Millennium Extraction plant requires a pond for recycle water. Because there is in insufficient internal space, the pond has to be external. The Steepbank project did not require the construction of a second extraction plant and utilized the Base plant facilities.

There were three primary criteria considered in the selection of the location of the external tailings pond: minimum environmental impact, minimum impact on the ore body, and minimum cost (capital and operating). These three factors were ranked relatively equal in importance.

The toe of the pond was located more than 300 m from the Athabasca River, with shallow construction slopes. The selected site is viewed as environmentally superior to the alternatives.

36. **Some alternative tailings pond scenarios are mentioned in volume 1, page C2.4-69. Provide a map which shows the conceptual layout of these locations.**

Response:
The requested map is provide on the following page.



TAILINGS POND OPTIONS

PROJECT MILLENNIUM

SUNCOR ENERGY

Date:	July 24,1998	Project:	MILLENNIUM	Rev. Date:	98-07-24
Drawn by:	HGK	Scale:	NTS	Revised By:	HGK
Drwg No.:	QUESTION38_HK			Revision No:	0

37. **In volume 1, page C2.4-69, Suncor indicates that one reason an external tailings pond is required on the east side of the river is to enable the creation of an inventory of MFT which will later be used to create CT. What work would be required to transfer MFT from the west side of the river to alleviate this problem? What would be the major cost items associated with such a transfer? What benefits and difficulties would such a transfer cause within the material handling plans?**

Response:
Transferring MFT from the west side to the east bank would involve:

- development of a containment pond on the east side for CT.
- construction of a pumping stations and pipelines for both gypsum and MFT
- additional operating cost

The total capital and operating cost over a initial 7 year period would be in excess of $45 million. The external tailings pond is also required for recycle water for the Millennium Extraction plant.

In addition to the cost, the logistics of MFT transfer would add complexity to tailings operation. Year-round long distance transfer of MFT could prove to be impractcal.

38. **Would a delay of the Millennium expansion remove the requirement for an external tailings pond? If so, what length of delay would be required and what would be the resulting impacts to Suncor and to the ultimate resource recovery in the proposed project area?**

Response:
This is a speculative question. The external tailings pond is required to support the Millennium Extraction plant. A project delay to create internal pond storage would be of significant duration and is not contemplated. Adherence to the proposed schedule is important to Suncor to reduce vulnerability to low oil prices and to capture the market window of opportunity, especially in light of the investment activity in Venezuelan heavy oil targeted at United States markets. The schedule is similarly important to the Region and to Alberta to capture the socio-economic benefits.

Design of Tailings Pond

39. **Discuss the key operational issues related to construction of the external tailings pond including foundation conditions, pre-loading requirements, rate of rise limitations, percentage of coarse tails stream required for cell construction, and anticipated internal beach slopes. Discuss the operational flexibility of the construction schedule with regards to ensuring sufficient storage capacity for sand, fine tails, and recycle water within the limitations imposed by rate of rise and maximum cell construction volumes.**

Response:
The information requested will be provided in detail in the final design. With respect to the key issues referred to:

- foundation conditions: a geotechnical drilling program is planned for 1998/99 drilling season
- preloading requirements: these will depend on the above results
- rate of rise limitations: the dyke will be constructed using established procedures developed by Suncor over 30 years. The maximum rate of rise is typically 20 m/construction season
- percentage of coarse tails stream required for cell construction: approximately 25% to 30%
- internal beach slope: 15H:1V
- operating flexibility: this is optimized on an annual basis with due regard to geotechnical security, availability of pond space and sand.

40. **It appears that significant consolidation will continue in the CT ponds on lease 86/17 for many years after mining is discontinued. How will ponding be minimized so that continued dyke maintenance can be avoided ? The Steepbank application indicated that Ponds 5 & 6 would be topped up with sand after sufficient CT consolidation had ocurred but sand will now be unavailable for this purpose. How will this impact the reclamation of Ponds 5 & 6?**

Response:
Sand will be placed in piles or hummocks that are higher than the nominal final elevation to both control drainage and compensate for CT consolidation. Some degree of ponding to form wet lands is desirable.

41. **Is it proper to use the seepage from Tar Island Dyke (TID) as representative of seepage of the new tailings pond given that TID seepage is decoupled from the pond contents and seepage from pond 8A will not be decoupled (according to the model).**

Response:
Finite element seepage modeling was used as a conceptual planning tool and is considered a conservative order of magnitude estimate for seepage that may occur from Pond 8A. Actual seepage from ponds is likely to be reduced by factors such as "blinding off" of the pond bottom by bitumen and fine tails, and experience gained from Pond 1 is valuable in understanding the general impact of such factors. Geotechnical and groundwater monitoring data is reviewed on an ongoing basis to improve understanding of the groundwater flow patterns around tailings ponds.

Tailings Material Balance

42. **Provide a graph which shows the settlement of fine tails with time. What is the model used to predict fine tails production? In volume 1, page C2.4-70, Suncor**

indicates that a total of 450 Mm^3 of fine tails will be generated during the life of the project. Is this thin fine tails, mature fine tails, or a combination of the two?

Response:
The model assumes fine tails reporting to the external pond settle to 30% solids by weight within one year. The 450 Mm^3 of MFT generated over the life of the operation is based on this 30% factor. The tailings referred to are mature fine tailings.

43. **Suncor notes in volume 1, page 2.2-31 that "Fines data is a relatively new addition to the east bank database and is insufficient to generate an accurate fines model". How did Suncor determine that the external tailings pond will provide sufficient storage for MFT and thin fine tails in the absence of an accurate fines model? What fines content was assumed for estimation of the volume of storage required for fine tails containment?**

Response:
The best information available at the time of developing the conceptual plans was used to establish the required pond size. Fines in Pit 2 are estimated at 15.4%, but range from 12.0% to over 20%. The higher fines occur in the first 10 years of mine-life. The fines data bank (to be submitted with the geologic model in mid-September) has improved substantially with the 1997/98 drilling data.

44. **Suncor noted that at Millennium rates, gypsum storage requirements would decrease or be eliminated depending on the gypsum dosage used for CT. Does this mean that production rates would be restricted by the amount of gypsum available to make CT? If excess gypsum was produced, what is the plan in providing sufficient storage within the tailings system? (F 2, page 7)**

Response:
Production rates will not be restricted by a lack of gypsum. If absolutely necessary, gypsum can be purchased.

Present studies indicate that when CT starts up on the east bank in 2007, all gypsum produced will be incorporated into CT. If excess gypsum materializes, it can be sold, stockpiled, or a combination of both. The relatively small volume of gypsum involved will not present a storage problem in the mine. Excess gypsum will continue to be incorporated into Pond 4 on Lease 86 until 2007.

45. **Provide an annual tailings material volume balance for all ponds and dykes included in the integrated reclamation plan. Include coke storage requirements where appropriate.**

Response:
A summary of the tailings plan is provided in the following tables, showing the placement of CT on a pond by pond basis. Additional information, if required, is available at Suncor's offices.

SUNCOR OS LONG RANGE TAILINGS PLAN - MILLENNIUM SUMMARY

			TAILINGS SAND					CT DISTRIBUTION - UNCONSOLIDATED BY POND					
YEAR	OILSAND KTONNES	COKE MTONNES	BEACH MCM	DYKE MCM	MFT NEW MCM	MFT USED MCM	SAND TO FINES RATIO	8 MCM	9 MCM	10 MCM	11 MCM	12 MCM	TOTAL MCM
2001	15.3		1.7	5.0	4.4		NA						0.0
2002	53.3		19.6	5.0	12.7		NA						0.0
2003	54.2		19.7	5.0	14.8		NA						0.0
2004	53.9		17.7	7.0	13.7		NA						0.0
2005	68.5		24.8	7.0	15.7		NA						0.0
2006	66.8		24.7	7.0	11.7		NA						0.0
2007	68.9		17.5		11.0	-7.4	5.0	29.4					29.4
2008	71.0		1.7		12.1	-15.3	5.0	60.5					60.5
2009	66.9		1.6		13.2	-14.2	5.0	56.1					56.1
2010	71.4		1.7		12.4	-11.2	6.0	55.2					55.2
2011	71.4		1.7		12.1	-11.2	6.0	55.3					55.3
2012	71.2		1.8		9.9	-9.7	6.5	53.7					53.7
2013	135.8	2.1	3.4		15.5	-18.8	6.5	0.0	103.6				103.6
2014	142.1	2.1	3.6		14.0	-19.8	6.5	0.0	109.4				109.4
2015	142.0	2.1	3.5		21.6	-19.3	6.5	0.0	106.5				106.5
2016	136.3	2.1	3.3		23.5	-18.2	6.5	0.0	100.7				100.7
2017	132.6	2.1	3.3		18.4	-18.1	6.5	0.0	99.8				99.8
2018	140.4	2.1	3.5		11.7	-19.7	6.5	0.0	54.4	54.4			108.8
2019	139.9	2.1	3.5		12.1	-19.6	6.5	0.0		108.3			108.3
2020	143.8	2.1	3.6		12.2	-20.3	6.5	0.0		111.8			111.8
2021	131.7	2.1	3.3		9.2	-18.6	6.5	0.0		102.4			102.4
2022	137.2	2.1	3.4		15.7	-18.9	6.5	104.5		0.0			104.5
2023	137.5	2.1	3.4		15.0	-19.0	6.5			26.3	78.8		105.1
2024	138.2	2.1	3.3		25.3	-18.5	6.5				101.8		101.8
2025	133.4	2.1	3.3		19.5	-18.1	6.5				100.1		100.1
2026	139.5	2.1	3.4		22.1	-16.2	7.0				100.5		100.5
2027	139.3	2.1	3.4		24.8	-16.0	7.0				99.4		99.4
2028	144.7	2.1	3.6		15.0	-17.3	7.0				107.6		107.6
2029	143.4	2.1	3.7		11.6	-17.4	7.0				108.2		108.2
2030	150.0	2.1	3.8		12.2	-18.2	7.0				113.3		113.3
2031	145.9	2.1	3.7		11.8	-17.7	7.0				109.9		109.9
2032	147.5	2.1	3.8		12.2	-10.0	7.0					100.0	100.0
2033	82.3	2.1	3.7		11.8	-5.0	7.0					50.0	50.0
TOTAL	3616.1	44.1	207.8	36.0	478.9	-433.9		414.6	574.3	403.1	919.6	150.0	2461.6

SUNCOR OS LONG RANGE TAILINGS PLAN - PLANT 3 ON LEASE 86/17

YEAR	OILSAND MTONNES LEASE 86/17	STEEPBANK TO PLANT 3	COKE MTONNES	SAND DYKE CONSTRUCTION 7 MCM	8 MCM	9 EAST MCM	TOTAL MCM	POND 1 INFILLIING BEACH/CT MCM	MFT NEW MCM	MFT CONSUMED MCM	SAND TO FINES RATIO	CT DISTRIBUTION - UNCONSOLIDATED BY POND 1 MCM	5 MCM	6 MCM	7 MCM	TOTAL MCM
1998	59.2	7.5	0.6		5.4	0.8	6.1		8.8	-15.1	3.5		38.1			38.1
1999	45.9	47.1	0.7	0.8	5.4	3.1	9.2		8.8	-23.5	3.5		59.4			59.4
2000	48.6	45.9	1.0		4.6	4.6	9.2		15.7	-23.8	3.5		60.1			60.1
2001	30.0	59.7	0.9		3.1	3.1	6.1		14.0	-26.4	3.5		66.7			66.7
2002		95.5	2.1			3.1	3.1		20.8	-30.1	3.5		0.0	76.0		76.0
2003		89.3	2.1			2.7	2.7		19.6	-27.5	3.5		0.0	69.6		69.6
2004		86.9	2.1						22.0	-25.9	3.5		0.0	65.4		65.4
2005		68.5	2.1					2.3	15.4	-18.0	3.5		0.0	0.0	45.6	45.6
2006		67.0	2.1					4.6	13.9	-20.4	3.5	2.3	0.0	0.0	49.1	49.1
2007		69.0	2.1					4.6	10.6	-18.5	4.0	2.3	0.0	0.0	50.3	50.3
2008		71.0	2.1					3.8	11.5	-19.0	4.0	1.5	0.0	0.0	52.5	52.5
2009		67.0	2.1					2.3	11.4	-17.8	4.0		0.0	0.0	50.5	50.5
2010		71.5	2.1					3.1	14.2	-18.2	4.0		51.9	0.0	0.0	51.9
2011		71.5	2.1						12.4	-20.6	4.0		29.3	0.0	29.3	58.5
2012		71.0	2.1						12.0	-20.5	4.0			43.7	14.6	58.3
TOTALS	183.7	988.4	26.2	0.8	18.4	17.2	36.3	20.6	211.4	-325.3		6.1	305.5	254.7	291.9	852.1

46. **In support of the application to amend the integrated reclamation plan, provide a table which summarizes the differences between the Steepbank application reclamation plan and that proposed in the Millennium application. Include descriptions of the changes to all major features (eg. ponds) included in the plan including reclamation dates, elevations, and proposed final land uses.**

Response:
The table below provides a comparison of elevations and estimated time for completion of tailings pond capping activities. The opportunity does exist to reclaim some portions of the pond before capping is complete, but most revegetation and performance monitoring of pond surface areas will occur after capping is complete. The Steepbank application did not provide specific times for activities after 2020, as continued mining in Pit 2 was foreseen. No fundamental difference exist in end-land use between the Steepbank and Millennium plans. Both focus on forestry land use with potential for wild-life.

The elevation increase for Pond 5 is required regardless of the Millennium application to handle the decrease in elevation for Pond 6, to accommodate additional production generated by current production rates, and because CT operations were slower to meet performance targets than assumed in the tailings plan used for the Steepbank application.

Major Structures - Comparison between Steepbank and Project Millennium Applications

Structure	Elevation		Capping complete	
	Steepbank Application	Millennium Application	Steepbank Application	Millennium Application
Pond 1	322	322	2010	2010
Pond 2/3	363	363	post 2020	2033
Pond 4	322	363 (coke and oversize only)	post 2020 (gypsum recycle pond)	2007[2] (gypsum recycle pond)
Pond 5	322	335	2020	2012
Pond 6	308	302	2020	2012
Pond 7	327	335	2020	2033
Pond 8	304[1]	365	post 2020	2033

1 Pond not complete in Steepbank plan as further mining was anticipated
2 Assumes no requirement for excess gypsum storage

With respect to out-of-pit waste storage, the significant change has been the removal the Steepbank West Dump, which was in the river valley and encroached on Shipyard Lake. With this change, the number of external dumps are reduced from four (referred to as North, South, East, and West dumps in the Steepbank Application) to three (referred to as North, Northeast, and Southwest dumps in the Project Millennium Application).

47. **A large percentage of the littoral zone within the end-pit lake will be created by constructing fill structures approximately 100m thick. It appears that the creation**

of appropriate water depths for littoral zone will be very sensitive to the total consolidation of the massive fills. It would seem likely that this consolidation will be non-linear and will be most rapid as the wetting front from the fluid in pond 12 passes through the fill, with continued less rapid settlement thereafter. Since a substantial amount of settlement may occur after mining is completed, it would be difficult to do remedial work to ensure creation of the littoral zone as desired. Does Suncor agree that these are issues and if so how will the issues be addressed? What is the anticipated settlement for these structures? How confident is Suncor that the settlements will be predictable to the accuracy required?

Response:

Suncor agrees that settlement of fills underlying the littoral zone must be carefully considered during design and construction. Suncor will consider wetting-induced consolidations when designing the dykes bordering Pond 12. Wetting induced settlement can be reduced by compacting cohesive fills at moisture contents above optimum, or by using granular fill such as tailings sand. (In cohesive fills, the improved settlement behavior must be balanced against increased construction pore pressures.) Calculations of settlement potential will be performed during detailed design of the dykes bordering Pond 12, and material selection and placement specifications will include consideration of settlement impacts of the littoral zone.

Suncor is committed to creating an end pit lake committee to work towards the definition of the design basis for end pit lakes, as well as to establish objectives for creation of a viable aquatic ecosystem in the lake. The committee will consider issues around construction of the end pit lake shoreline areas, establishment of littoral zone areas, input requirements for tailings, expected volumes of waters to enter the lake system, and requirements, if any, for infilling with additional waters to ensure filling of the system within an acceptable timeframe. Another part of the efforts of the committee will be to define the types of studies required to further understanding about oil sands end pit lakes

48. **In volume 1, page B2-17, Suncor indicates that "the current plan is to reduce the existing inventory of fine tailings by 2020 to 25Mm^3 (the ongoing volume required for the CT process). This plan requires a SFR of about 3.5:1." In a previous submission to the Board Suncor made the following statement regarding sand to fines ratio: *"It is clearly the selection of the sand to fines ratio in the CT mixture which prevents more rapid removal of MFT from Pond 1. The reason for selecting the specific ratio of 4:1 is that lower ratios (incorporation of a higher concentration of clay minerals) leads to very long term surface settlements of the final CT deposit which threaten the reclamation to a dry state".* What information has Suncor acquired since October 1996 which leads to the conclusion that the current planned sand to fines ratio of 3.5:1 will not threaten the long term reclamation to a dry state?**

Response:
The sand to fines ratio of 3.5 is for Lease 86/17 ponds and Pond 7 only, and is required regardless of Millennium approval in order to manage the mudline in Pond 2/3 while achieving target date to complete infilling of Pond 1 by 2010. A SFR of 4 to 5 and higher is planned for Ponds associated with the Millennium pit.

Calculations performed for Suncor by Agra Engineering and Environmental indicate that about 3 metres of settlement would occur in Pond 6 after the year 2033, when no further operations are presently planned or approved on Suncor leases. This settlement magnitude is within the range considered feasible for passive management leading to reclamation certification. Furthermore, preliminary evidence from field tests of CT which have been performed since 1996 suggest consolidation is more rapid than indicated from laboratory tests (as is often the case in geotechnical predictions of settlement rates). Suncor will monitor consolidation of CT ponds, and would have the option of remedial measures such as surcharging or installing wick drains if performance did not meet expectations.

Geotechnical

49. **What is the minimum offset necessary between the toe of the Tailings Pond dyke and the crest of Pit 2 to ensure geotechnical stability of the Tailings Pond and to provide for contingency action should movement occur.**

Response:
The offset required between the toe of the Tailings Pond dyke and the crest of Pit 2 depends on the foundation conditions and the design approach adopted for the dyke. The required offset is reduced when foundation conditions are favorable or when conservative design assumptions are adopted. During detailed dyke design, Suncor will evaluate foundation conditions and evaluate a combination of dyke designs and offsets that result in acceptably low risk levels. The design selected will be developed by Suncor's consultants with input from Suncor's internal review board and then submitted to AEP Dam Safety Branch for review and approval. Suncor believes that there is sufficient design flexibility to avoid sterilization of ore.

50. **What is the minimum offset between the toe of the NE Dump and the Steepbank River to provide adequate room for remedial action without entering the 100 metres environmental protection zones, should foundation geotechnical problems occur.**

Response:
As for response No. 49, the offset depends on foundation conditions and the design approach adopted for the waste dump. The design selected will be developed by Suncor's consultants with input from Suncor's internal review board and then submitted to the AEUB for review and approval. Again, Suncor believes that there is sufficient

design flexibility to avoid sterilization of ore.

Environmental

51. **Section E2.0 of the Steepbank Mine Application describes the impact assessment approach chosen for that application. The impact assessment approach for Project Millennium differs. In particular, for the terrestrial resources, the Steepbank application defines low impacts as less than 5 percent of the biophysical resource base while Project Millennium defines low impact as less than 10 percent change in terrestrial resource. Why have the impact assessments changed between the two applications? Describe the effects to Project Millennium if the Steepbank definition of low impact was used for the Millennium Project.**

Response:
The change in the impact assessment approach was made based on the use of information from Suter (1993) in his document Ecological Risk Assessment. Suter notes that a 20% threshold is useful in assessing the magnitude of impacts for populations where change is difficult to detect due to: 1) natural variability in natural populations, 2) lack of precision in currently available abundance estimate techniques, and 3) lack of unlimited funding to investigate population sizes. Thus a change in abundance of less than 20% may be within the normal range in population size for the species of concern, or may not be detectable given current techniques or information. For Project Millennium a change >20% was rated as high, 10 to 20% was rated as moderate, >1<10 was rated as low and <1 was rated as negligible.

When examining the data for changes in the local and regional study areas for most terrestrial components, the changes are typically well above 10% or well below 5%. Therefore, the relative change between the Steepbank Mine and Project Millennium terrestrial rating systems would not change the predicted impact ratings.

52. **Re - Vegetation**

a) **Volume 2B Section 3.2.8.10 Table D3.2-21 Page D3-105 - Please provide the missing units of this table (e.g., hectares).**

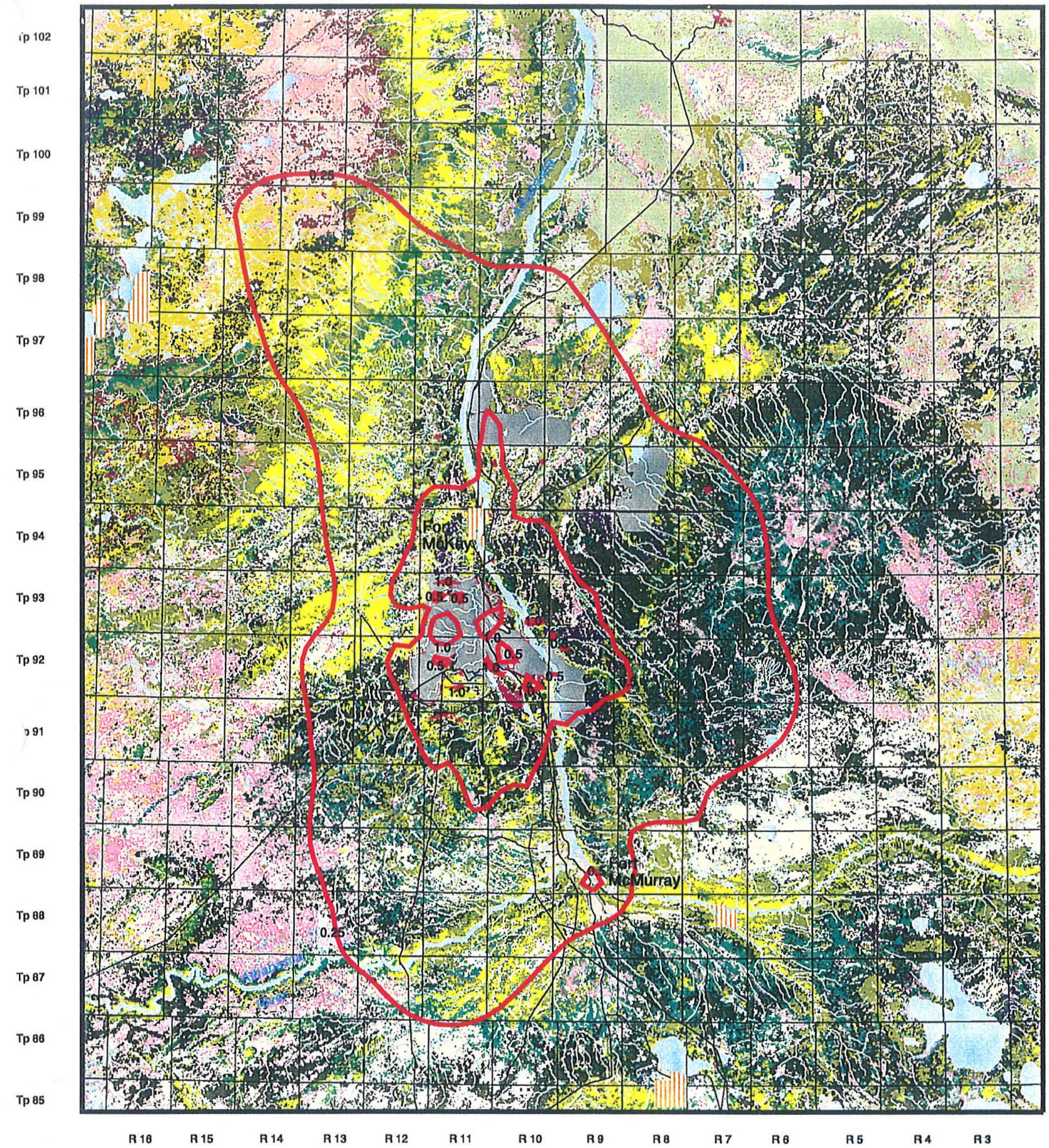
Response:
The missing units for Table D3.2-21 are hectares.

b) **Quantify the increase of area that will exceed the 0.25 keq/ha/a Critical Load as a result of the Millennium Project in terms of total area and as a percentage of the local and regional study areas.**

Response:
The total area exposed to PAI inputs above 0.25 keq/ha/a because of Project Millennium in the local study area (LSA) is 16,181 ha or 100%, while for the regional study area, it is 861,263 ha, or 35.5% of the area (see information in Table B3-20, Vol. 2A). (These percentages and those above (b) include all soil types. (The criterion of 0.25 keq/ha/a applies to sensitive soils and therefore the percentage of those soils would be more meaningful).

c) **The data from Table 3.2-21 relates the distribution of vegetation communities to PAI isopleths. Please reference the appropriate PAI and vegetation maps or figure numbers. Provide the PAI maps overlain on vegetation communities in order to graphically identify vegetation communities and patterns of acid deposition.**

Response:
Maps relating the distribution of vegetation communities to PAI isopleths are provided for both the Regional Study Area baseline and cumulative effects scenarios.



West of Fourth Meridian

SOURCES: Suncor, Syncrude, Petro-Canada, Golder, Alberta Research Council AOSERP (Report 122)

Scale 1:1,000,000

10 0 10 20 30 40

Kilometres

Map Projection: UTM 12
Datum: NAD 83

/data14/suncor/regional/9700/9740/arcview/alt2.apr

LEGEND

- PAI Isopleths (keq/ha/a)
- Regional Study Area
- Linear Disturbances
- Open Water
- Forestry
- Existing Open Pit Mines
- Other Disturbances
- Municipalities
- Indian Reserves

VEGETATION CLASSIFICATION

- Open Pine Lichen
- Mixed Deciduous (Aw Dom.)
- Mixedwood (Sw-Aw Dom.)
- Mixed Coniferous (Sw Dom.)
- Mixed Coniferous (Sw-PJ/Pl Dom.)
- Mixed Coniferous (PJ/Pl Dom.)
- Mixed Coniferous (Sb-Lt Dom.)
- Wet Closed Coniferous (Sb Dom.)
- Wet Open Coniferous (Sb Dom.)
- Pine Regeneration (Pine<2m)
- Shrubland
- Bog (Sphagnum Dom.)
- Bog (Shrub Dom.)
- Shrubby Fen
- Graminoid Fen
- Marsh Emergents
- Barren Ground / Bedrock Exposure
- Unclassified

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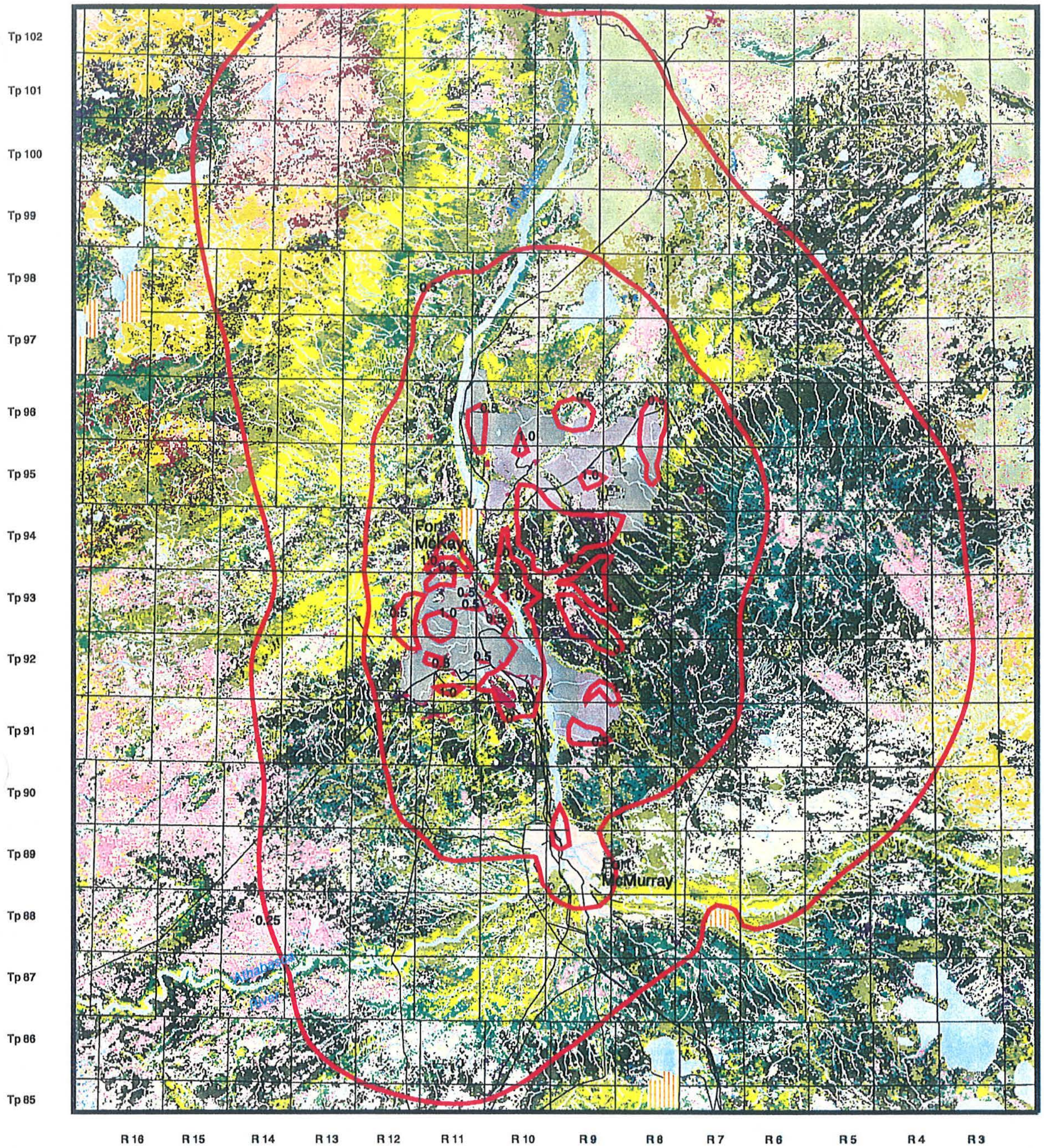
**REGIONAL STUDY AREA
RELATIVE VEGETATION COMMUNITIES
TO ACIDIFYING EMISSIONS
PAI BASELINE**

20 July 1998	Figure 1	PRODUCED BY: JS REVIEWED BY:



West of Fourth Meridian

SOURCES: Suncor, Syncrude, Petro-Canada, Mobil, Al-Pac, Golder, Alberta Research Council AOSERP (Report 122)

Scale 1:1,000,000

10 0 10 20 30 40

Kilometres

Map Projection: UTM 12
Datum: NAD 83

LEGEND

- PAI Isopleths ((keq/ha/a)
- Regional Study Area
- Linear Disturbances
- Open Water
- Forestry
- Existing Open Pit Mines
- Other Disturbances
- In-Situ
- Proposed Open Pit Mines
- Municipalities
- Indian Reserves

VEGETATION CLASSIFICATION

- Open Pine Lichen
- Mixed Deciduous (Aw Dom.)
- Mixedwood (Sw-Aw Dom.)
- Mixed Coniferous (Sw Dom.)
- Mixed Coniferous (Sw-Pj/Pl Dom.)
- Mixed Coniferous (Pj/Pl Dom.)
- Mixed Coniferous (Sb-Lt Dom.)
- Wet Closed Coniferous (Sb Dom.)
- Wet Open Coniferous (Sb Dom.)
- Pine Regeneration (Pine<2m)
- Shrubland
- Bog (Sphagnum Dom.)
- Bog (Shrub Dom.)
- Shrubby Fen
- Graminoid Fen
- Marsh Emergents
- Barren Ground / Bedrock Exposure
- Unclassified

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Taking Suncor into the 21st Century

REGIONAL STUDY AREA RELATIVE VEGETATION COMMUNITIES TO ACIDIFYING EMISSIONS PAI CUMULATIVE EFFECTS ASSESSMENT

20 July 1998	Figure 2	PRODUCED BY: K.K.Q. REVIEWED BY:

53. **Re Monitoring - Volume 2B Section D3.2.8.12 Page D3-106**

a) Describe in detail the monitoring program that might be implemented for assessing potential impacts of acid deposition upon vegetation. Identify the vegetation that will be monitored and the different soil types associated with this vegetation. What specific sites are recommended for the monitoring program? What duration of monitoring is expected for the program?

Response:
Suncor is participating in the Wood Buffalo Environmental Association (WBEA) Terrestrial Environmental Effect Monitoring program (TEEM) that has been established as part of the association's efforts to understand potential effects of air emissions on regional vegetation. Suncor will continue to support this program, as well as to actively participate in the enhancement of the program as agreed upon by the participants in the TEEM program.

The current vegetation monitoring program is an integrated effort focused on jack pine and aspen forests. The study involves investigations of the vegetation and soils at the selected research sites. The vegetation types currently under investigation as well as the sample sites, were selected by the TEEM program committee. Monitoring will continue as it adds value.

b) Identify measurement criteria that might be used in vegetation monitoring for the combined effects of acid deposition (e.g., PAI) as well as specific SO_2, NOx and ground level ozone effects upon wetland and terrestrial vegetation.

Response:
Suncor will continue to work as an active member of the regional airshed monitoring plan for the Wood Buffalo Zone, through involvement in the terrestrial Environmental Effects Monitoring initiative to develop and assess measurement criteria for regional air emission impacts to vegetation and wetlands.

c) Should residual effects to vegetation from impaired air quality become evident during monitoring, what mitigative measures will Suncor propose in the EIA to address this issue?

Response:
Potential impacts to vegetation from air emissions are best mitigated by reducing air emissions. Suncor has already substantially reduced emissions from its operations. Volume 1, section F3.1 describes Project Millennium emission reduction and strategies for further opportunities. If further mitigation is required, Suncor will pursue reduction opportunities in the context of regional emissions.

d) **Volume 2B Section D3.2.7.3 page - D3-80-84 - It is unclear whether rare plant data was assembled in the course of sampling representative vegetation plots for ELC ecosite classification or if independent sampling procedures for rare plants were adopted within the 1997 field studies? Page D3-5 states that a rare plant survey form was employed but does not state that a survey of rare plants was undertaken in 1997 for the Millennium study area. Identify methods used in the field sampling program for rare plants. Discuss the assumptions used in rating the impacts to rare plants as "low". What evidence is there that in reclaiming 11,245 ha of plant communities, rare plants can be established with such high success ratios?**

Response:
Specific rare plant studies were completed for Project Millennium. However, because of the requirement to link rare plants with specific ecosites, the studies were not done without investigation of representative vegetation plots for the ELC analysis. The methodology employed for the rare plant followed the guidelines of the Alberta Natural Heritage Information Centre, who were consulted about the study area and the proposed survey plans.

The assumptions used in rating the impacts to rare plants as low included the fact that the occurrence of the rare plants was estimated based on the results of field surveys and known associations of rare plants within specific ecosites. The rare plant potentials were determined and these areas were assessed against the development area. The net result was that the project would have a low impact on rare plants in the development area.

The establishment of rare plants in reclamation areas is a function of the creation of suitable habitat conditions as well as the creation of certain starter ecosite types. Suncor's plan includes development of types of ecosites that commonly include certain types of rare plants. Suncor's confidence in its ability to establish ecosites which will include rare plants is based on its successful development of reclamation habitats on its current operational area.

Additional details on the Project Millennium rare plant surveys and assessment are provided in the 1998 Golder report on "Terrestrial Vegetation Baseline for Project Millennium".

e) **The EIA identifies a lack of statistical significance for representative vegetation sampling data (e.g., page D3-33) in relation to rare/traditional plants. What is the statistical significance of vegetation data uses in the analyses of i) wildlife habitat units and ii) baseline diversity.**

Response:
The vegetation for the Project Millennium local study area (LSA) as well as the regional

study area (RSA) was initially defined based on satellite imagery. The predicted vegetation types were further defined through use of aerial photography. Field surveys were conducted to ground-truth predictions and confirm identified vegetation communities, as well as to further define ecosite variations in the area. The collected vegetation data was thorough enough to confirm the ecosites types predicted from the satellite imagery as well as aerial photography. Therefore statistical validation was not necessary.

The information collected during field operations were used to fine-tune predictions for the satellite image. This is necessary as it is impossible to cover all of the RSA in enough detail on the ground to enable completion of regional habitat modelling. The fine-tuned satellite image was then used for the HSI modelling to predict current and possible future wildlife usage as well as to predict diversity of vegetation under baseline and reclamation conditions in the LSA and RSA.

f) Volume 2B Section D3.2.7.3 page - D3-86 - What evidence is there for assuming that traditional plant populations will re-establish on reclaimed landscapes to pre-development conditions?

Response:
Plants used traditionally are integral members of regional ecosites. The traditional plants that are members of the ecosites planned for the Suncor reclamation program are expected to return to the reclamation area, just as other plant within those ecosites will return. Ecosites are the result of landscape, soil and moisture conditions. The plants of the different ecosites are found with the ecosite phases because of their preference for certain conditions. If the reclamation activities provide those conditions, then the plants are likely to return.

54. Re - Air Quality

a) Tables B4-13 and B4-14 for hourly and daily TRS concentrations respectively contain the same data. This should be corrected.

Response:
The predicted TRS concentrations in Tables B4-13 (maximum hourly TRS concentrations, Vol. 2A, p. B4-40) and B4-14 (maximum daily TRS concentrations, Vol. 2A, p. B4-44) were incorrect. The maximum hourly concentrations were repeated in both tables. These numbers have been corrected in the revised version of Section B4 which accompanies these responses in the appendices.

b) Suncor should identify how sensitive soils and water bodies might be monitored within the RSA for acidification effects. What are the conceptual alternatives for mitigating excessive PAI if adverse effects are detected by

monitoring?

Response:
Suncor is an active participant in the Terrestrial Environmental Effects Monitoring Program (TEEM) of the Wood Buffalo Environmental Association (WBEA) along with other stakeholders in the oil sands region. The overall objective of the TEEM program is to answer the question "Are air emissions having, or have they had, long-term adverse effects on the ecosystem and traditional resources in the area?". To address this question, ten jack pine (Pinus banksiana Lamp.) and ten trembling aspen (Populus tremuloides Minchx.) biomonitoring locations were selected across the oil sands region for evaluation of the long-term consequences of the acid deposition in the region to soils and species known to be sensitive to acidic deposition. Five of the jack pine and five of the aspen biomonitoring locations are positioned in areas considered to be potentially exposed to high levels of acidic deposition while the remaining five jack pine and five aspen biomonitoring locations are positioned in areas considered to potentially exposed to low levels of acidic deposition. Both jack pine and aspen trees are known to be sensitive to acid-forming emissions.

The matter of acidification of sensitive surface waters is being addressed by the Regional Aquatics Monitoring Program (RAMP).

Mitigation has been discussed in previous responses and in Volume 1 of the Application.

c) **Total reduced sulphur emissions are predicted to increase by 80% (Section B3.1.1.1, page B3-6) and ground level concentrations are predicted to exceed odour thresholds in populated areas (Table B4-14, page B4-46). Provide an explanation of the sources of TRS emissions including biogenic sources in the tailings ponds (e.g., list TRS point sources, sources of TRS in related emissions, assumed biogenic mechanisms). Explain alternatives that could be implemented to reduce TRS emissions from the Suncor operation to at least baseline levels and what impact such controls would have on the Millennium Project.**

Response:
Sources of TRS in tailings ponds relate to the materials input to the pond as well as the actions of microbial populations that live in the pond. Sulphurous compounds may have entered Tailings Pond 1 in previous years as constituents of the sour water system and unrecovered diluent in secondary extraction tailings. While the sour water system has been upgraded in recent years and routed through the naphtha recovery unit, some sulphurous compounds may still enter with pumpout waters from the slop tanks. Also, even though diluent quality and naphtha recovery has improved, sulphurous compounds could enter from this source.

Suncor has initiated an investigation into Pond 1 emissions and other opportunities to reduce VOCs. These are described in subsequent responses.

d) **Information used to assess ambient air quality in Section B3.2 appears to be based on normal operating conditions. Discuss emergency or upset conditions that may have the potential to cause significant short duration (one hour to several days) increases in SO_2, $H2_2$ or other emissions? Based on the predicted ground level concentrations of such upset conditions, what are the implications for operations staff and the public? What control measures are planned to minimize harmful emissions resulting from upset conditions?**

Response:
The Millennium Upgrader has been designed to operate independently from the existing plant, to minimize or eliminate common causes of upset conditions. Both Upgrader plants will be operated from a central control facility, to allow operations staff to enhance communications and collaboratively resolve problems in a particular unit. Hazard reviews and detailed Hazard and Operability studies have been and will be conducted on all systems before construction begins to optimize the design of control systems, which will minimize upset conditions. In addition, the Millennium Upgrader has been designed to allow continuous operation when the Base Upgrader is shut down (and vice versa).

Operator staffing and training is planned to commence 24 to 18 months prior to commissioning to ensure employees are prepared to both commission and operate the plant. Where similar technology to the existing Upgrading plant has been utilized, the design has incorporated changes to resolve issues identified over years of operation. The flare system is designed for smokeless operation and combustion of all hydrocarbon and sulphur compounds emitted during upset conditions.

These proactive measures notwithstanding, during upset conditions, higher than average 1-hour concentrations of SO_2 can be expected to occur in the immediate vicinity of the facility. Due to local nature of the impacts during upset conditions, significant impacts to the health of people in the communities of Fort McKay, Fort McMurray and Fort Chipewyan are not expected. With respect to worker health, Suncor will comply with occupational health and safety guidelines and ensure use of proper personal protective equipment for members of its workforce exposed to chemical emissions.

e) **Section C2.5, page B118 indicates that Suncor will be implementing measures to reduce diluent losses while Section B3.1.1.1, page B3-5 indicates that VOC emissions will increase by 85% based on data from current operations (e.g., worst case estimate). Explain most likely VOC emissions from the project based on results expected from implementing diluent recovery improvements. What additional measures could be undertaken to reduce VOC emissions and what would be the relative impact?**

Response:
The estimate of 85% increase in VOC emissions is a worst case scenario which assumes maximum VOC emissions for Millennium operations and does not take into account any of the initiatives to reduce VOC emissions. The estimate is based on the current worst case scenario prorated to Millennium operations. Further work will be done to confirm and monitor VOC emissions for current operations. This data will be required to better predict Millennium VOC emissions.

Based on current operating experience and design simulation work, Suncor believes the following estimate of froth treatment and NRU performance for Millennium operations to be reasonable although not confirmed at this time:

- Froth treatment diluent recovery 97.5 - 98%
- NRU recovery (excluding heart cut diluent) 76 -79%
- NRU recovery (including NRU improvement of 5 - 8% with heart cut diluent) 81% – 87%
- IPS D/B ratio of 0.5 to 0.55 wt/wt

Completion of current and planned performance testing programs, as well as completion of detailed engineering work will help to verify the above performance criteria. If the above plant performance is realized for Millennium operations, then the upside potential for diluent recovery is that recovery could be in the range of 99.5% to 99.7%. Reductions in VOC emissions would be realized through improvements in hydocarbon recovery.

Based on current operating performance, Suncor has demonstrated diluent recovery which meets or exceeds minimum requirements of 99.3%.

f) **Suncor is proposing an 8% increase in SO_2 emissions and a 42% increase in NOx emissions (Section B3.1.1.1) which, with other new projects discussed in the cumulative impact assessment, will contribute to a 111% increase in the area predicted to be impacted by potential acid emissions in excess of the 0.25 keq/ha/a interim critical load for sensitive soils (Table B4-14, page B4-45). Explain alternatives that would enable Suncor to reduce further increases in acidifying emissions (SO_2 and NOx) and discuss the feasibility of implementing the measures.**

Response:
There is still a great deal of uncertainty regarding the background PAI and applicability of the interim critical loading targets to ecosystems. Suncor recognizes the uncertainties associated with quantification of environmental effects associated with acidifying emissions in the oil sands region. Through the WBEA, Suncor is committed to enhancing the current level of activity associated with monitoring of environmental effects associated with acidifying emissions, as well as to decreasing uncertainties associated with background values.

SO_2 and NO_X reduction strategy have been discussed in previous responses and in Volume 1 of the Application.

g) **Section D1, figure D1-4 indicates that 3.5 t/cd and 0.7 t/cd sulphur will be emitted through the acid gas flare and HC flare stacks respectively. Explain the basis for the sulphur emissions from flares. If routine flaring of sour or acid gas is planned (e.g., for other than emergency flaring due to equipment outages), explain alternatives for recovering related sulphur and justification for the planned approach. Do the sour or acid gas flares have the potential to contribute to TRS emissions and if so what controls or features will be implemented to minimize such emissions?**

Response:
Sulphur emissions from acid gas flaring occur as a result of emergency conditions. Calendar-day emissions were estimated based on 0.3% of acid gas produced directed to the flare, which is a reasonable estimate for EIA modeling purposes based on Suncor's operational experience. SO_2 emission from hydrocarbon flaring from residual gas in excess of that recovered in the base plant Flare Gas Recovery Unit, and from gas flared when the base plant Flare Gas Recovery Unit is out of service. Suncor has implemented a number of measures to eliminate the occurrences of upset conditions and to minimize their duration should they occur.

One of the key purposes of the sour or sour-acid flares is to ensure that the TRS compounds in the gas stream (in particular H_2S) are converted to sulphur dioxide as part of the flaring process. In a flare operating at peak efficiency, all of the TRS compounds would be converted to SO_2. A recent study on flare gas compositions (Strosher 1996) looked at sour gas flares associated with oilfield battery flare tests. Although not directly comparable with the emergency flare stack at the Suncor facility, this report does give an indication that flare test stacks are capable of a combustion efficiency in excess of 82%. The efficiency at the Suncor facility is likely to be higher due to the addition of hydrogen gas to ensure high efficiencies.

Reference
Strosher, M. 1996. Investigation of Flare Gas Emissions in Alberta. Final report to Environment Canada Conservation and Protection the Alberta Energy and Utilities Board and the Canadian Association of Petroleum Producers. November 1996.

h) **Volume 2A Section B2.2.4, Figure B2-22 - In reference to the areal extent of lands exceeding 0.5 keq/ha/a a discrepancy exists with the data in Table B2 18. Figure B2-22 shows approximately 10 townships inside the 0.5 isopleth. This represents approximately 100,000 ha rather than the value of 11,543 ha contained in Table B2-18. Please confirm the correct value and modify any text in this section containing errors.**

Response:
The areal extent of lands which have a predicted PAI in excess of 0.5 keq/ha/y is wrongly given in Table B2-18 as 11,543 ha (vol. 2A, p. B2-50). The correct number of hectares predicted to have Baseline PAI values above 0.5 keq/ha/y is 115,430 ha. This value was provided for information purposes, since there is only one interim critical loading level which has been adopted, the 0.25 keq/ha/y for the most sensitive soils.

i) **Volume 2A Section B2.2.2 page B2-28 – Predicted $S0_2$ exceedances (daily and annual AAAQG) within the mine pit area are associated with fleet operations. Clarify the net contribution of mine fleet vehicles to SO_2 modelling results.**

Response:
Suncor has not modelled all individual sources for respective contribution to ground level concentrations of SO_2. But, based on model dynamics and output, it appears that the mine pit is a likely source of SO_2 causing exceedences in or near the pit. Modelling emissions from a mobile source has its limitations. It must be stressed that these are longer term concentrations (i.E. daily and annual) and that the combination of meteorology and terrain (i.e. poor dispersion from low source) are the influencing factors for the modelled result. Monitoring data is limited and this cannot be validated.

j) **Volume 2A Section B2.2.3 page B2-35 – Ambient air quality has been modelled using NOx emission factors from equipment manufacturers and the U.S EPA in addition to data from the Suncor Mannix station.**

i) **Does Suncor have any in-pit monitoring for NOx?**

ii) **Could this data be used to establish baseline conditions and an impact assessment?**

iii) **What plans does Suncor have with respect pit monitoring data of NOx.**

Response:
Ambient concentrations of NO_2 for the Baseline case were calculated using the ISC3BE and CALPUFF dispersion models coupled with meteorological data gathered at the Suncor Mannix station (75m level). The NO_x emissions data used as inputs to the dispersion modelling were summarized in Table B2-2 (Vol. 2A, p. B2-4). As noted at the top of the next page in the report (Vol. 2A, p. B2-5) these emission data were based on a combination of actual stack survey data, emissions supplied by the equipment designers and suppliers and U.S. EPA emission factors.

In the case of the ISC3BE predictions, the model was used to calculate ambient NO_x concentrations which were then converted to NO_2 using an empirical relationship derived in the oil sands region (Vol. 2A, p. B2-35). This approach was previously discussed with AEP and Environment Canada personnel (10 March 1998 in the AEP offices in Edmonton). The basis for this empirical relationship was the NO_X and NO_2 data collected during an 8.5 month period adjacent to the Syncrude north mine. No such monitoring program had been conducted adjacent to the Suncor active mine areas, however, the results would be expected to be similar due to the similarities in equipment.

No in-pit NO_X or NO_2 monitoring data were available from either the Suncor or Syncrude operations. Data of this type, if it were available, would be of little value in determining the baseline conditions in the region.

Ambient NO_2 and NO_X data in the oil sands region are limited to the historic data collected in Fort McMurray and the data collected adjacent to the active Syncrude mine area. The new monitoring stations commissioned in the region will provide a more complete picture of the ambient NO_2 and NO_X concentrations in the region which can then be utilized to enhance the understanding of the NO_2/NO_X chemistry in the region. These monitoring results are expected to be available near the end of 1998.

k) **Section B3.2.11 pages B3-50 and 51 - Predicted impacts for annual SO_2 and NOx concentrations have been identified as high in magnitude. Areas of predicted SO_2 and NOx exceedances and locations of highest concentrations were associated with Syncrude and Suncor lease areas (e.g., development areas). The local impact was rated as moderate or "not significant" based on occurrences of lesser concentrations (e.g., Ft. MacKay) within the regional study area. Justify the moderate impact rating within the Millennium "development area" and discuss implications of this rating in terms of potential impacts to**

i) **the 40% undisturbed vegetation remnants of the local study area and**

ii) **progressive reclamation that will occur within the "development area".**

Response:
The impact analyses for annual SO_2 and NO_2 concentrations are presented in Section B3.2.11 (Vol. 2A, p. B3-47 to 51). The magnitude of the impact for the annual concentrations was designated as high since the maximum values were predicted to exceed both the Alberta Ambient Air Quality Guidelines as well as the Federal Acceptable objective. For the annual concentrations of both contaminants, the overall rating of environmental consequence for air quality was determined to be moderate. This was due largely to the local extent and reversible nature of the impact.

When considering whether the moderate environmental consequence equates into a significant impact it was necessary to look at the spatial area over which the impacts could occur. As is clearly shown in Figures B3-4 (predicted annual SO_2 concentrations, Vol. 2A, p. B3-12) and Figure B3-10 (predicted annual NO_2 concentrations, Vol. 2A, p. B3-20), the areas where the annual air quality objectives are predicted to be exceeded are concurrent with the active mining areas. No exceedances of the annual objectives were predicted to occur outside the lease area. Therefore, it is expected that vegetation and reclamation sites and adjacent remnants in the LSA would not be affected. Over 20 years of reclamation monitoring supports this prediction.

55. **Suncor stated that it has recently identified a significant increase in emissions from its Tar Island tailings pond (Pond 1). The emissions from Pond 1 were attributed to methane and VOCs associated with unrecovered bitumen and naphtha diluent lost to secondary tailings. Suncor stated it is committed to investigate tailings pond losses thoroughly in order to develop an action plan by first quarter of 1999. (A4, page 42)**

a) Describe what investigations are to be completed.

Response:

There are two phases to the investigative program. Phase 1 work includes:

- thorough definition of the main operating modes that affect diluent discharge to the tailings pond
- review of plant data for selected examples of these modes
- creating an improved conceptual model for the key phenomena that influence VOC emissions from the tailings pond
- sampling and analysis of the Pond 1 water/sludge column and selected streams
- definition of a recommended sampling and analysis campaign for the latter half of the summer

Phase 2 includes the assessment and recommendations of actions that reduce emissions based on the learnings achieved in Phase 1. Phase 2 will likely include follow-up measurement and monitoring to verify Phase 1 learnings and refine the information.

b) What are some of the possible plans Suncor envisages to reduce emissions?

Response:

Initiatives being pursued by Suncor to understand and reduce VOC emissions include:

- improve the model for predicting the behaviour of diluent hydrocarbons sent to tailings ponds, including an understanding of the variability in the field data collected to date
- identify whether existing, accumulated hydrocarbon (including bitumen) in Pond 1 contributes significantly to emissions
- use of a modified diluent (heart cut diluent) with a narrower boiling point range to enable increased recovery of the diluent in the NRU as well as reduce the benzene content of diluent.

- improve mixing of NRU tails with BFRT tailings to reduce VOC emission immediately from tailings pipe discharge
  Other initiatives have addressed:
- Plant 16 operation: the feed and product streams were analyzed for hydrocarbon distribution between the water and mineral components. Theoretical simulations of the column operation have also been completed.
- The feasibility of recovering bitumen from Plant 4 and Plant 16 tailings: this was piloted, however limited success was achieved.

c) **Are emissions due to diluent quality changes or increased volume losses due to the increased production rates? (A4, page 42)**

Response:
The emissions from Suncor Pond 1 are a result of the unrecovered hydrocarbons input to the pond. Based on Suncor's current conceptual model of pond emission mechanisms, which is based on interpretation of the measured field data and known mass transfer principles, Suncor expects that the majority of the Pond 1 emissions are resultant from the lighter hydrocarbon fractions consistent with the unrecovered diluent present in naphtha recovery unit tailings.

Suncor is uncertain about the cause of the recently measured increase pond emissions. This is the subject of further investigation. Increased production is expected to result in increased emissions.

Although Suncor expects that overall diluent recovery will be in the range of the stewardship target of 99.5%, consistent with current performance, the increase in production associated with Project Millennium will result in increased diluent input to tailings and hence associated increases in emissions.

Diluent quality changes are expected to minimize this increase as described in a subsequent response.

56. **The Millennium application included the construction of a new NRU. What information does Suncor have that the new NRU would reduce emissions. Is a higher recovery expected? Would the new NRU have the flexibility to accommodate the change(s) required?**

Response:
Suncor's continuous improvement initiatives over the years has increased NRU recovery from 64% as measured in the 1989 audit to 76% as measured in the most recent 1997 audit. Current operating data verifies the 1997 audit findings. Reliability of the NRU has been maintained through continuous improvement and redesign / modification and is currently high with an on-stream factor > 95%.

Studies that Suncor has completed clearly show that the existing NRU column would be satisfactory (although marginal) at PEP rates, but would not provide the needed recovery at Millennium rates. These studies also clearly show that it is not economically feasible to modify the single stage NRU tower to increase diluent recovery above existing performance.

The new NRU is expected to provide performance at Millennium rates consistent with historical performance of the existing NRU.

57. **Suncor noted that Project Millennium "would improve the diluent character and thus reduce VOC unit emissions".**

a) What is the contingency plan if VOCs are not reduced ?

Response:
Should this event occur, Suncor will continue to evaluate the most effective measure to control diluent losses and to mitigate their potential impact on people and environment consistent with our policies and procedures. See also response 55b.

b) What reduction in VOCs would be expected if make up diluent is reformulated to have a narrower boiling range with reduced light and heavy ends and benzene as indicated in Table C 2.1-2?

Response:
Suncor proposes to introduce a reformulated "heart cut" diluent with Project Millennium. This diluent will be the sole source for make-up in the Suncor operation. The heart cut diluent would have a narrower boiling range (200°F to 400°F) as compared to the current diluent (175°F to 450°F). The narrower boiling range of the heart cut diluent is more within the recovery range of the NRU (425°F to 450°F).

This will result in the following benefits:

- The increased initial boiling point of the heart cut diluent will result in a benzene reduction of approximately 80% as compared with the current diluent. Therefore benzene emissions from the pond tailings pond are expected to be reduced by a similar amount.
- An increase in total diluent recovery of 5% to 8% because of higher overall volatility.

c) Provide the volatility or distillation curve for the reformulated diluent.

Response :
The distillation data for the reformulated "heart cut" diluent proposed Project Millennium follow.

Distillation Data for Proposed Heart Cut Diluent

Liquid Volume (%)	True Boiling Point at 760 mm Hg (°F)	ASTM D86 at 760mm Hg (°F)
1	167.89	216.64
5	192.31	232.26
10	209.56	243.29
30	245.87	258.31
50	280.93	279.62
70	315.43	306.68
90	357.23	340.37
95	374.83	361.57
98	403.02	395.55

d) **Has Suncor considered hydrotreating the diluent? What would be the impact on recovery and VOC emissions if the diluent were to be hydrotreated?**

Response:
Hydrotreated diluent would provide little or no improvement in diluent recovery over heart cut diluent - which will be formulated to more nearly match the performance capability of the NRU and with reduced benzene content. Hydrotreated diluent does have the potential to reduce the emission of sulphurous compounds (which can cause odours) from pond emissions. However, odour incidents have been substantially reduced with the NRU, the VRU, the reduction of fugitive emissions plant-wide and improvements in plant reliability. Suncor has concluded that there is insufficient justification to support an investment in incremental hydrogen and hydrotreating capacity to provide hydrotreated diluent.

e) **With the new NRU, and the present one used as a back-up which would be at considerably lower rates, what is the uptime for the combined NRUs? Would feed rates be reduced if only the new NRU were down for maintenance outage and not an upgrading train? (A3, page 34)**

Response:
The combined NRU uptime is expected to be 98.6% based on the following:

- the stand alone uptime of the "New" NRU is expected to be 98.5% (10 days every two years planned maintenance, excluding unplanned maintenance).
- the existing NRU has a YTD on-line factor of 97.74%.
- switchover time for each maintenance occurrence of approximately 3 days.
- an allowance for unplanned maintenance of 4 days per year.

Suncor believes based on experience and improvement in NRU tower reliability that the reliability of the new NRU tower can be maintained to prevent the suggested event.

Should this event occur, Suncor will evaluate the most effective measure to control diluent losses and to mitigate their potential impact on the environment. Suncor will evaluate all options including reduced production rates and act diligently consistent with our business and environmental practices.

58. **When will the assessment be completed and provided to address stack particulate and associated PAHs and metals in response to stakeholder concerns?(A4, page 48)**

Response:
The assessment has been included in Section B4 of this submission.

59. **When will the results be provided in the area of naphthenic acids and toxicity that is to be added to the overall health risk assessment database?(A4, page 48)**

Response:
The study results on naphthenic acid toxicity will be available in September 1998.

60. **When will the fish health and tainting study be completed to evaluate potential impacts on fish of CT release waters? What parameters or components in the water would be monitored? (E4, page 47)**

Response:
The fish tainting study will be conducted with other oil sands operators beginning in the third quarter 1998 and extending over a two to three year period. This extended period is required to ensure that representative CT water is being tested. Whole CT effluent will be used in the study and the water chemistry will be characterized. No specific parameters are being monitored initially.

61. **In the interest of minimizing NOx emissions from the mine equipment fleet, could the diesel fuel quality be modified to reduce emissions? If so, discuss the feasibility of producing a modified diesel fuel.**

Response:
Suncor is participating in an industry-wide initiative to consider improvements in emissions from mobile equipment. Suncor will make its air emission priorities known to competitive suppliers and will expect them to provide the latest feasible technology for emission control. At this point, Suncor does not have a specific control technology in mind.

Diesel fuels with poor ignition qualities, high boiling ranges high viscosity, and high levels of carbon residue, water and sediment tend to promote engine misfiring, low fuel economy, engine deposits, rough operation, smoke and odour emissions. Compared to the CGSB Standard, the Millennium diesel fuel will have a higher ignition quality by

exceeding the 40 minimum cetane number and <0.05% sulphur content. The diesel fuel distillation range will also be lower resulting in lower values of carbon residue, water and sediment, and ash compared to the CGSB standard
The Millennium Diesel Hydrotreater Unit has been designed to produce a diesel fuel that will comply with the National Standard of Canada for Automotive Diesel Fuels - Canadian General Standards Board CGSB-3.6-M88. This is a general industry diesel fuel quality standard across Canada.

62. Re - Groundwater

a) **Volume 2A Section C2.2.2.2 page c2-26 - The hydraulic conductivity of CT is several orders of magnitude less than the aquifer and aquitard material it will replace. Discuss this condition in relation to the modelling of impacts to groundwater recharge/discharge and flow patterns.**

Response:
A conservative approach was used in modelling. The hydraulic conductivity of CT is known to be low and is reported by AGRA (1996) as 1×10^{-9} m/s as referenced in the EIA. This is two to four orders of magnitude less than the natural materials it will replace, including the clay tills in the area. The impacts are discussed in paragraph 5, page C2-26 with regard to recharge and flow. Suncor anticipates that resultant seepage will be lower than modelled.

b) **Volume 2A Section C2.2.2.2 page C2-28 - What is the basis for estimating the negligible impact on groundwater and surface water quality when the EIA acknowledges adequate data on the chemistry of CT is not yet available?**

Response:
Suncor has acknowledged that chemistry data for CT is limited because of the short period of time that a commercial process has been operational. Suncor is currently continuing to collect data on CT chemistry as part of its commercial trial. Additionally, information is being collected by Syncrude Canada during its composite tailings trials. The available information is synthesized in the report "1997 Synthesis of Environmental Information on Consolidated/Composite Tailings (CT) - (Golder 1998).

Comparison of available commercial trial data with experimental data collected from bench and field scale trials of CT provides some confidence in the expected chemistry for CT waters. When comparing the quality of CT waters, as reclamation waters in the closure scenario, with the quality of groundwaters found in the Project Millennium area, the results indicate that the inorganic chemistry is relatively benign with respect to the potential impacts to surface waters. The organic loading in CT reclamation waters is similar to that of the area groundwaters (as shown in Vol. 2A, Table C2.2-6).

The assessment of potential impacts of CT reclamation waters on surface water systems is detailed in the water quality evaluations completed for the end pit lake (Vol. 2A Section C3.2.9). The assessment concluded that the environmental consequences of the addition of CT waters to the end pit lake was low. However, the uncertainties around the end pit lake were acknowledged. Suncor has committed to establishment of an End Pit Lake Working Group to aid in definition of the design basis for the end pit lake, as well as to evaluate the development of a viable aquatic ecosystem in the lake. Part of the information that will be considered by such a committee is new confirmatory or contradictory information on the chemistry of CT reclamation waters.

c) **Pages 68-69 of the Klohn-Crippen (1998) hydrogeology report reference two equations that were used to estimate the groundwater capture zones of creeks. Why was this method chosen? These types of situations are typically modelled, which easily allows a sensitivity analysis to be performed.**

Response:
Modelling was considered, however, there is insufficient information available in the immediate area of the creeks to calibrate an electronic model. Therefore, estimates were calculated using fundamental flow equations.

d) **With reference to these same equations, the term Lo (distance from maximum to zero drawdown) cannot be accurately determined with the currently available data. Why were the stated values of Lo chosen, and what effect does variance of this value have on the conclusions reached at the end of this section?**

Response:
These estimates were made based on material type and expected hydraulic conductivity of the known geologic materials. The estimates given are reasonable for the material type and known physical conditions. More rigorous modelling may be conducted as part of detailed design.

63. **Re - Noise Assessment**

Confirm that a Noise Impact Assessment has been conducted with respect to the proposed Millennium Project and that the assessment indicates compliance with EUB Noise Directive ID94-4.

Response:
Noise levels for Project Millennium have not been formally modelled according to the EUB Noise Directive ID94-4. However, the qualitative assessment presented in the Project Millennium Application is based on the noise impact assessment conducted for

the Aurora Mine, which followed the EUB Noise Directive ID94-4. It is assumed that noise levels from Project Millennium will be lower in Fort McKay than noise levels from the Aurora Mine, due to the increased distance of the Millennium site from Fort McKay. Therefore, noise levels will be in compliance with the EUB Noise Directive ID94-4.

64. Re - Soils and Terrain

a) **Volume 2B Section D2.2.6 page D2-30 -Terrain and soil unit impacts have been stated as "negligible" based on their spatial context in the regional study area. This method of comparing surface area disturbances between a local study area and much larger sized regional study area to rate impacts has no ecosystem basis. Discuss the appropriateness of using a regional study area that is 99.6 times larger in size than the local study area for nearly all environmental parameters, if the significance of local impacts is consistently rated as negligible (e.g., pg. D2-30 and D2-38).**

Response:
The selection of the regional study area (RSA) was made with input from regulators and stakeholders. Consistency in the size of the RSA is important if one wants to be able to look at the potential effects of the project in the region on various ecosystem components. While the size may be large when used to compare direct physical changes to soils or terrain, it is appropriate for use in evaluating potential impacts of acidifying emissions on regional soils.

b) **Volume 2B Section D5.2.6.1 Table D5.2-4 page D5-77 and Table D5.2-8 page D5-120 - The text on page D5-119 states that the magnitude of impact from site clearing is expected to be high for most key indicator resources in terms of habitat loss. However the environmental consequence is rated as moderate. It appears that the small geographic extent and reversibility of impacts contributed to the moderate consequence rating. Discuss the biological rationale of using the local to regional study area ratios of habitat units given the disproportionate size of the regional study area.**

Response:
Suncor recognizes that the impact of an open pit oil sands mining operation on the area to be developed is severe, with removal of vegetation, soils, overburden and oil sands. The EIA examined the area to be directly impacted and looked for environmental features that are unique, either to the immediate area or the RSA. When comparing the areas of soils and terrain to be removed through the Suncor east bank mining area with the types of soils and terrain in the oil sands region, it is evident that they are in fact relatively common. The rating of moderate recognizes that removal of the soil and terrain units, although eventually replaced by reclamation materials, is of some consequence.

c) **Volume 2B Section D3.1.2.2 page - D3-5 - and Section D2.2.7.1 page D2-32 - Fen and bog soils have been rated as Class 5 Non-Productive within the assessment of soil quality/capability, based on forest ecosystem productivity. What methods could Suncor adopt in the EIA to incorporate both forest productivity values and wetland productivity values in assessing impacts to soil quality?**

Response:
Suncor recognizes that the land capability rating system employed in oil sands EIAs focuses on creation of forest systems. As such, it is recognized that areas not necessarily optimal for forests may, in fact, be highly productive areas for other ecosystem habitat types (e.g., wetlands). The value of wetlands is understood by Suncor. Wetlands are a critical component of Suncor's reclamation and closure plan.

Suncor is currently a member of the Oil Sands Wetlands Working Group, a multi-disciplinary stakeholder group comprised of industry, regulatory, consulting and academic groups. This group is working to define the types of wetlands that are commonly disturbed trough oil sands development, as well as the types that could be constructed as part of oil sands reclamation efforts. The inherent values of the original and reclamation wetlands is one of the considerations of this working group.

65. **Within the EIA Suncor has identified past and present environmental research programs (e.g., Regional Aquatics Monitoring Program, Wood Buffalo Environmental Association). Other research and monitoring needs specific to Project Millennium and the oil sands region have been noted in a various chapters of the EIA (e.g., effects of acidification upon soils and vegetation, chronic effects of napthenic acids, CT chemistry). Provide a listing of the environmental research and monitoring commitments Suncor is prepared to undertake concerning Project Millennium. What is Suncor's suggested implementation strategy with respect to industry wide or regional research and/or monitoring involving multiple operators?**

Response:
Many current and future research and monitoring programs are associated with Project Millennium and the base plant operation. Source monitoring by Suncor will continue as described in the Application as required by the approval or otherwise. Ambient monitoring will generally be done in cooperation with the regional operators and stakeholder involvement. Effects monitoring will also be done on a cooperative basis. Suncor's vision for the region is multi-stakeholder management of all environmental monitoring, funded by industry through cost-sharing formulae. Research management and funding will be dependent on the nature of the issues. The following is a list of initiatives identified in the Application which are commitments at this time or under consideration:

- participation in the Air Monitoring System operated by Wood Buffalo Environmental Association (includes recent ozone modelling initiative).
- participation in Terrestrial Environmental Effects Committee
- participation in Alberta Oil Sands Community Exposure and Health Effects Assessment Program
- monitoring of site groundwater and surface drainage (including east bank creeks and mine drainage for additional parameters such as dissolved oxygen, temperature, benthics, metals and PAHs)
- monitoring of Shipyard lake
- participation in Regional Aquatics monitoring Program
- monitoring of spring acid pulse through cooperative arrangement (proposed)
- research program in cooperation with regional operators on end pit lakes (proposed)
- monitoring of fisheries habitat to verify No Net Loss Plan
- completion of fish health study
- continued monitoring of reclamation soil and vegetation
- soil acidification monitoring through TEEM (under consideration)
- development of field-scale CT reclamation demonstration
- continued work on Oil Sands Terrestrial Vegetation and Wetlands Reclamation Committees
- monitoring of wildlife utilization of reclaimed land
- monitoring of bird and wildlife interaction with tailings ponds
- further research into toxicity of naphthenic acids

66. **Volume 2B, page D5-37, table D5.1-9 give bird numbers recovered from ponds. Why are many more birds recovered from Pond 1 than the other ponds?**

Response:
Recoveries of birds from Pond 1 are higher than other ponds because of its location relative to the Athabasca River. The avifauna research completed by Suncor in the 1970s and 1980s showed that the frequency of sightings were much higher over Pond 1 compared with other ponds. This is because birds, especially waterfowl, often follow the river valley as they migrate through the area.

Extraction

67. **For ore preparation at the Steepbank Mine, it appears Suncor would condition ore in rotary breakers, deliver it to wet storage surge tanks in parallel which "dampens irregularities in ore delivery and enables the downstream hydrotransport operations to operate at steady-state rates" and pump the slurry using hydrotransport to the Extraction Plant.**

a) **What if the ore is over conditioned, can the wet storage surge tanks be bypassed?**

b) **If bypassed, can the hydrotransport system be operated at steady-state and still maintain the density required?**

c) **Has Suncor considered as an alternative, wet storage surge capacity near the existing Extraction Plant?(B2, page 10)**

Response: (a/b/c)
Suncor does not believe, as a result of its test data, that ore would be over-conditioned with the rotary breaker and wet storage as proposed. Suncor expects that the ore preparation stage has sufficient flexibility to optimize ore conditioning. The suggested remedies are all possibilities.

68. **How would Suncor control the calcium and magnesium concentrations in the CT release water for the life of the project since more and more CT release water would be generated for the same amount of clay-rich cyclone overflow stream? (B2, page 16)**

Response:
Calcium and magnesium are input to the pond water system via gypsum used in the recipe for consolidated tailings. It is sourced from the flue gas desulphurization unit. Calcium is removed by adsorption on clay in tailings from ore that is currently being processed, and during open water months by precipitation as calcium carbonate. Adsorption on clay surfaces is by far the most important sink. Magnesium is removed solely by adsorption on clay surfaces. Calcium and magnesium concentrations in pond water will be managed by appropriate control of the source and sink streams.

69. **Suncor noted that the diluent recovery (used in the bitumen extraction process) is to be not less than 99.3%, with a stewardship target of 99.5%.**

a) **The diluent recovery in the current operation is 15% greater than the recovery proposed for the Millennium project. How was the Millennium diluent recovery determined? What service factors were assumed on both the existing and new larger unit? (F3, page 23)**

Response:
Overall diluent recovery for current operations YTD has been 99.5%. Diluent recovery is calculated using the Extraction Recovery Calculation which is used to calculate the hydrocarbon recoveries reported on the monthly on the S23 report. The NRU recovery YTD is 80.3% as calculated with the Extraction Recovery Calculation. The YTD service factor for the existing NRU is 97.74%. The service factor for the Millennium NRU, including the existing column as a standby unit for half-plant operation, is expected to be 98.5% as per a previous response.

b) **Why is a lower diluent recovery requested for the Millennium project than the current operations when it appears that with reformulated diluent and lower D/B ratio recovery should improve? (C2.1, page 7)**

Response:
Suncor is motivated to continually improve diluent recovery from its operation as this makes good business sense and reduces emissions to the environment. Suncor does not see the merit in continuously raising the prescribed recovery level at which enforcement actions might apply. The proposed recovery level of 99.3% is equal to the existing regulatory limit, and one that Suncor is confident it can deliver. The stewardship target of 99.5% reflects Suncor's motivation to recover more diluent to reduce economic loss and environmental impact.

70. a) **Describe the work completed and the results to confirm that a decrease in D/B ratio from 0.86 v/v at present to 0.74 v/v using IPS units at Millennium production levels is feasible with the reformulated diluent?**

Response:
Suncor does not expect that D/B ratio will be affected significantly by the reformulated diluent because the heart cut of the diluent will remain essentially the same in composition., and therefore diluting performance will remain essentially the same. The small loss of front boiling material is not significant.

b) **What if the D/B ratio can not be lowered to that expected, how would the diluent lost per barrel of bitumen "decrease by 10%" for the Millennium operation relative to current practice?(C 2.5, page 119)**

Response:
The absolute loss of diluent to the plant 4 tailings system is insensitive to the overall D/B ratio. The only diluent losses to the froth treatment system tailings are those from the Centrifuge/Cyclone combination, which are controlled to the current constant D/B ratio (with makeup diluent) to achieve optimum performance. All other diluent is recovered to diluted bitumen product.

71. **Has Suncor considered alternative low energy extraction processes (e.g. the Low Energy Extraction Process)? If the LEE process was considered why was it not selected when it could provide benefits such as lower energy consumption and the reduction of CO2 emissions? If it was considered why is it not a viable option? Clarify whether Suncor will continue to consider lower separation circuit temperatures in the future, and indicate what the difference in carbon dioxide emission rates (ie. tonnes per day) would be if a low temperature extraction process**

(eg. 25 Degrees) were found to be feasible rather than the warm water process (50 Degrees) that Suncor is currently proposing.

Response:
The strategy being pursed for energy conservation at Suncor's oil sands plant is believed to be appropriate given the configuration of the integrated plant. Suncor found it economically optimal to use upgrading waste heat in combination with a hot water storage tank and steam generation to provide extraction process heat. Additionally, highly efficient co-generation utilizing gas turbine generators with associated heat recovery steam generators and steam turbine generators is proposed to produce electric power, some of which would be available to the Alberta electric power grid. Electric power generation in the region is much needed for further oil sands development. Low temperature technology (such as LEEP) was considered, but for these reasons was not selected.

With respect to CO_2 emissions utilizing a low temperature process, any benefits would be offset by a need to import electric power. Suncor's analysis indicates that, including import power generation, total CO_2 emissions for the two technologies are virtually identical.

72. **What testing has Suncor completed on the two-stage classifying cyclone circuit? What is the potential benefits of the using this type of equipment? (C2.5, page 103)**

Response:
The Millennium froth treatment process will be confirmed once the Design Basis Testing (DBT) Froth Treatment Hydrocyclone testing is completed. The test work has is just underway and is expected to be completed mid September 1998.

The hydrocyclones are being tested as a potential replacement for scroll (first stage) centrifuges. If the hydrocyclones are proven to be a viable replacement for the scroll centrifuges they will have the advantage of lower capital and operating costs as well as significantly reduced power consumption. They also have the potential to provide second stage (Westfalia) feed which is similar to current Westfalia feed in terms of total BS&W content. If this is demonstrated in the test work, then current centrifuge performance, in terms of hydrocarbon recovery, and product quality, could be expected for Millennium operations.

73. a) **Historically, tertiary recovery floatation cells do not work effectively with high fines bitumen. What evidence does Suncor have that indicates improved recovery with this equipment when processing high fines material?**

Response:

Based on operating experience, the secondary flotation cells make a significant contribution, eg 40%, to Plant 3 recovery when high fines ore is being processed. Therefore, the feed to the tertiary cells should not be substantially changed when processing high fines ore, and tertiary cell performance is not adversely affected by high fines ore.

b) **What options does Suncor have if bitumen losses due to high fines can not be counteracted by using tertiary recovery floatation cells in the separation circuit?(C 2.5, page 115)**

Response:

Options include a revised blending strategy in the mine plan, selective variation in the water/ore ratio throughout the separation circuit, deliberate and intrusive air addition strategies, and a lowering of the volumetric throughput.

74. **What affect does diluent quality (such as specific gravity, type of hydrocarbon components, amount of water and solids, and emulsions) have on the quantity of diluent lost to the tailings pond? (C 2.5, page 118)**

Response:

Qualitatively, high quality consistent diluent enhances the froth treatment process which results in reduced hydrocarbon losses and improved product quality. The specific gravity should be relatively low so that when blended with bitumen the combined diluted bitumen density is lower than water and mineral density, so that gravity separation is readily achieved thus minimizing losses. The diluent distillation should be within the recovery capability of the NRU. In general terms, diluent BS&W and emulsions have a negative effect on the froth treatment process and thus contribute to increased losses.

Suncor will continue to manage the quality of internal process streams to enhance processing and achieve recovery objectives.

75. a) **What testing has been completed or is planned on bitumen recovery from the hydrocyclone overflow? Summarize the results? What parameters may affect the recovery ?**

Response:

A pilot program was completed in 1996. The principal parameters affecting recovery are residence time in the flotation cells and bitumen content in the feed stream; recovery increases with both parameters. Over the range of test conditions, recoveries of up to 80% were achieved.

Performance testing on the commercial unit has recently been initiated.

b) **Suncor noted that bitumen recovery from MFT is not economical. When was the most current evaluation done? (C2.5, page 119)**

Response:
The evaluation was completed in 1995/96. A small test unit was designed to facilitate gravity separation and simultaneous heating/transport of bitumen-rich fluid recovered from the fine tailings. The latter was necessary owing to the extreme intractability of ambient temperature bitumen-rich fluid. It was achieved by introducing a layer of hot water at the interface between the source fine tailings and the recovered bitumen-rich fluid. This resulted in a mixture diluted with the hot water and was no longer suited to the manufacture of consolidated tailings.

76. **Has Suncor considered alternative froth treatment process such as paraffinic solvent? If this was not considered, why not? If it was considered why is it not a viable option?**

Response:
Suncor participated in the 1996 CONRAD program devoted to:

- definition of the potential for paraffinic solvents
- the resolution of problems identified in earlier work.

Suncor has considered alternative froth treatment process including paraffinic solvent. Suncor did not pursue the paraffinic diluent process because preliminary pilot test results were disappointing and did not meet original expectations. Based on Suncor's understanding of the potential commercial application of the technology, it is was not considered viable for Project Millennium considering Suncor's overall business objectives

77. **It is understood that Pond 2/3 would be used for lean froth treatment tailings and recycle water till the end of project life.**

a) **Why is this size of pond required for these purposes?**

Response:
Presently Pond 2/3 is the heart of the base plant (Plant 3 tailings plan). It acts as a recycle pond, MFT accumulation and thickening pond, cyclone overflow pond, and CT water mixing pond. Until 2012, it is also used as an overflow pond for the BRFT tailings. Post 2012 it will continue to be used for Plant 4 tailings. The present plan utilizes Pond 2/3 because the infrastructure is in place to do so, and all other ponds on the east side are in-filled with oversize, coke or CT. Note that the open area of Pond 2/3 is progressively reduced with time.

b) How would pond 2/3 be reclaimed at the end of the project since there will be no sand/overburden available?

Response:
Near the end of operations, all mature fine tailings will be removed from Pond 2/3 to the end pit lake. The pond will then be infilled by a combination of dozing in the dykes and pumping sand, as required, from the east bank. Soil amendment in inventory on the west side will be used for reclamation.

c) Why leave pond 2/3 open so long?

Response:
Opportunities are being investigated to optimize the tailings plan, for example, turning Pond 7 into the recycle pond for both the Base plant and the Millennium Extraction plant. This could allow Suncor to accelerate the reclamation of Pond 2/3, however, this solution would entail additional capital cost and tailings re-handling which may not be justifiable.

78. The following requests are related to the extraction plant site selection. (C2.3.3 - page 46)

a) It appears that the major benefit of the north location is cost, provide a detailed economic analysis for the life of the project including capital, operating costs and discount rates for the two plant site options.

Response:
A significant motivation to locate the Millennium Extraction plant as proposed, rather than on the waste island, was the reduction of initial capital in an amount exceeding $30 million. This is important to Suncor because of the impact on project financing and project economics. With the rationale of a significant reduction of capital, a detailed economic analysis was not carried out, nor was it required to make the decision.

b) Suncor stated that one reason the north location was preferred was that it limits the area disturbed for facilities, yet in the year 2012 a new plant location would be required and a new area disturbed, explain the benefit to limited the disturbed area at this time.

Response:
Should the Extraction plant tentatively proposed for the centre location be constructed there, it is acknowledged that there would be no net reduction in environmental disturbance. Nevertheless, the disturbance would be delayed significantly. That is in keeping with Suncor's desire to minimize the disturbance to reclamation time-span.

c) **Suncor stated that the north location provides an initial energy savings and commensurate environmental advantages because a portion of the haul route would be downhill yet the centre location results in the lowest overall haul distance and costs. Explain this statement.**

Response:
The centre plant requires a significant uphill haul (albeit, shorter) for the early portion of the mine life. Therefore, the north location provides an initial energy savings over the centre plant.

Upgrading

79. **Suncor has provided a description of its technology selection considerations which are summarized in Table C3-2 - Comparison of Upgrading Technology Alternatives and Table C3-3 - Hydrotreater Technology Alternatives. The following request more detail to provide a better understanding of the results of Suncor's alternative review process.**

a) **Re - Table C3-2, page 132**

i) **Provide the economics analysis used to determine capital and operating cost for each option. Include discount rates and any assumptions made in the analysis.**

Response:
In early 1996 Suncor, as part of their strategic development process, initiated a study to determine options for expanding its oil sands facilities beyond the Fixed Plant Expansion scheduled to come on stream in 1998. The Upgrading portion included a review of different options for bitumen upgrading that compared the capability of delayed coking with hydrogen addition process schemes to meet the sales and marketing objectives for Suncor.

Based on this review, Suncor learned that delayed coking has the majority of heavy oil processing capacity in the world. As of 1996, 136 delayed coking units accounted for 3.23 million barrels per day of processing capacity. This far exceeded the 8 fluid cokers at 0.37 million barrels per day capacity and the 5 flexi-cokers at 0.165 million barrels per day capacity. The hydrogen addition ebulating bed technology consists of 9 units with 0.34 million barrels per day capacity, and there are only 2 small Slurry Phase units with 0.009 million barrels per day capacity. From the industry search it is clear that the world still relies on delayed coking to upgrade heavy oil.

The 1996 study was completed to review the economics of delayed coking relative to the hydrogen addition process and conventional gas oil hydrocracking. The study used yield data and cost information from previous joint industry studies, Suncor's Fixed Plant

Expansion (DRU2 and Vacuum Unit), and the existing hydrocracker at the Suncor Energy Refinery in Sarnia Ontario.

The study calculated capital costs and operating costs which were input into company economic models. The risks and probabilities of success were evaluated for each technology and delayed coking was chosen as the optimum for Suncor considering market factors, financial capacity, economic return and risk. The study showed a 50% higher capital cost and a 250% higher operating cost per incremental barrel for a high conversion hydrogen addition process as compared to delayed coking.

ii) Explain what is meant by "operating complexity" for each option.

Response:
"Operating complexity" is defined by the level of technical knowledge required and availability of this knowledge, the operating pressure, the use of exotic and expensive metallurgy, the utilization of catalyst and reaction kinetics and acquired operating expertise.

Generally, catalytic processes that are at high pressure (greater than 1500 psig) with moving beds, are considered to have high operating complexity. These processes require a high level of technical expertise to operate and are much less forgiving with respect to process or operating upsets. As well, ramp-up to full production takes from 6 months to a 1 year longer due to the "learning curve" and operating upsets tend to be larger, riskier (high pressure hydrogen and hydrocarbon) with much greater downtime.

Delayed coking and fluid coking have relatively low operating pressure (less than 50 psig) and do not involve catalyst. The fluid coking unit does circulate hot coke and is less forgiving to operating upsets than delayed coking. With more than one set of delayed cokers on one fractionator, operating upsets are typically limited to one drum or one set of drums and can usually be corrected within one operating cycle. This allows the operator to minimize downtime and maximize throughput to allow greater returns than higher complexity units.

iii) For each option considered provide hydrogen consumption, and coke/resid make. For the liquid produced identify product quality by sulphur content, gravity and heating value.

Response:
There is no question that the higher pressure hydrogen addition process will use more hydrogen, have higher liquid yields and make less coke. Based on our analysis of our markets, the entire product slate for Suncor's customers does not require full upgrading to fully hydrotreated products. The qualities of products produced from each process configuration are different and the economics are based on confidential internal

evaluations of what the market will pay as a premium for these products. Pricing has to be based on the predictions for crude and products at least 5 years into the future, when the project is built, and also the subsequent 10 to 15 years depending on the economic model used.

iv) Provide a comparison of energy efficiencies for each option.

Response:
The high level at which the preliminary study was done did not look at energy efficiency. It is clear however that hydrogen addition processes are significantly more energy intense than delayed coking processes. Managing its greenhouse gas emissions is important to Suncor and throughout the engineering stages of the selected case, energy efficiency was considered and incorporated into the design.

v) Provide an estimate of SO_2 and CO_2 emissions for each option considered.

Response:
SO_2 was not part of the original study since it was assumed that in all cases a very high sulphur recovery was required, and this would not impact the economics. CO_2 was assumed to be higher in any hydrogen addition process that used bitumen feed compared to selective hydrotreating of intermediate products. CO2 generation from the production of hydrogen is minimized through optimization of hydrotreating to produce desired products, and the use of the steam/methane reforming process to make hydrogen.

vi) Provide the risk analysis for each option.

Response:
Suncor considered risk factors including probability of successful start-up, technical learning curve, expertise requirements and word-wide knowledge-base, operating complexity and flexibility, and impact of catastrophic failure. This analysis revealed that delayed coking continues to be the work horse of heavy oil upgrading industry.

Suncor has 30 years of operating experience with delayed coking. This enables Suncor to participate in development of the design to eliminate safety issues and problem areas identified over the years thereby ensuring a safe and efficient start-up and effective ramp up to name plate throughputs. From a risk management perspective, the delayed coking process runs at a lower pressure, is technically simpler and is much more forgiving of process upsets than hydrogen addition. Selection of delayed coking enables Suncor to finance a very large capital project (compared to its company asset value) with a high probability of success and assurance that the design specification will deliver the economic returns once complete.

vii) **Because fluid coking has higher conversion, operates at lower operating pressures and the technology is understood compared to some other technologies, describe in detail why fluid coking is not a viable alternative.**

Response:
To determine if Suncor should switch to fluid coking from delayed coking, an independent industry study was used to compare the economics. When a flue gas desulphurization plant is added to the capital of a fluid coker project to make the two technologies environmentally equal, the economics favour delayed coking by approximately 5%. The 5% difference is within the accuracy of the numbers which means it becomes a decision based on operating experience and technical expertise. Delayed coking has demonstrated much longer run lenghts (5 or more years versus 2 years) between maintenance turnarounds than fluid coking - an important economic advantage. For Suncor, delayed coking is the obvious choice.

viii) **Describe Suncor's reasons as to why combined technologies such as delayed coking and LC Fining were not considered. If technology combinations are feasible, describe the benefits and drawbacks of the most likely combination(s) of technologies.**

Response:
Based on Suncor studies, cases in which bitumen is upgraded by one process, and then hydrogen is carefully and selectively added to intermediate products, indicated reduced capital and operating costs. Configurations in which both, the hydrogen addition process with separate hydrotreating, and some type of coking process, are utilized, usually indicate higher capital and operating cost. An example, the LC Fining process, operates at 1600 psig to 1800 psig, requiring a high pressure unit that utilizes high cost catalyst and hydrogen. Minimizing the unit pressure or the size of high pressure units also minimizes capital cost and usually minimizes the operating complexity and impact of catastrophic failure.

b) Re - Table C3.3, page 133

i) **Provide the economics analysis used to determine capital and operating cost for each option, include discount rates and any assumptions made in the analysis.**

ii) **Explain what is meant by "operating complexity" for each option.**

Response:
Having selected delayed coking as the primary Upgrading technology, the range of hydro-treating options is narrowed to that provided by several licensors. The selections among licensors is based on world-wide experience and units in operation, technology

advancements, capital and operating cost. Suncor made its selection based on these parameters.

The alternatives listed in Table C3-3 are combined primary upgrading/hydrotreating options and ae not hydrotreating options once delayed coking is selected.

iii) Provide the liquid yield for each option.

Response:
Hydrotreating yield gain is a function of catalyst used and severity of operation rather than the particular liscensed technology. The hydrotreating operation is dictated by the desired quality of product for the target market (which also affects yield)

iv) For each option considered provide hydrogen consumption. For the liquid produced identify product quality by sulphur content, gravity and heating value.

Response:
Based on Suncor's analysis of its markets, the entire product slate for Suncor's customers does not require full upgrading to fully hydrotreated products. The qualities of products produced from each process configuration is different and the economics are based on confidential internal evaluations of what the market will pay as a premium for these products. Pricing has to be based on the predictions for crude and products at least 5 years into the future, when the project is built, and also the subsequent 10 to 15 years depending on the economic model used.

v) Provide a comparison of energy efficiencies for each option.

Response:
The feasibility review level at which the preliminary study was done did not look at energy efficiency. Managing its greenhouse gas emissions is important to Suncor and throughout the engineering stages of the selected case, energy efficiency was considered and incorporated into the design.

vi) Provide SO_2 and CO_2 emissions for each option considered.

Response:
The feasibility review level at which the preliminary study was done did not include SO_2 since it was assumed that in all cases a very high sulphur recovery was required, and this would not impact the economics. CO_2 differences between the various technologies were assumed not economically significant and not included. CO_2 generation from the production of hydrogen is minimized through optimization of hydrotreating to produce desired products, and the use of the steam/methane reforming

process to make hydrogen.

80. a) **In the current options the liquid yield from the Unifiner is less than 100%? Would the proposed Millennium project have a higher liquid yield?**

Response:
The proposed Millennium Upgrader will have a hydrotreating yield gain in excess of 100% - to provide appropriate product for the target market

b) **Could modifications be made to improve liquid yield and at what cost?**

Response:
Suncor is currently studying opportunities in the existing hydrotreating options to change the product state (and thereby affect yield)

81. **Suncor states a number of objectives used to scope new upgrading facilities. How were these objectives prioritized? What weighting factors were used in the evaluation? (C3, page 128)**

Response:
Suncor did not prioritize the objectives, as the intent was to meet all of the objectives to the maximum extent economically feasible.

82. **Explain why minimization of coke production is not an objective in Table C2.1-2.**

Response:
The minimization of coke production is not an objective of Bitumen Production (because it does not produce coke).

Suncor also has a product yield objective as listed in Table C3-1 to "optimize liquid volume and other product yield". Suncor would be concerned that if the upgrading objective was narrowed as to be specific as "minimize coke production" as this could inappropriately skew the result away from an optimized product yield solution.

83. **The proposed liquid yield with PEP is 82% but in the Millennium project the liquid yield would be reduced.**

a) **Explain why the reduction is necessary and what could be done to increase the liquid yield.**

Response:
Suncor's overall yield has recently increased due to the additional processing step of a vacuum unit prior to the coker, added in the Fixed Plant Expansion. Suncor has the ability to add a similar unit after Project Millennium at some later date.

b) **If a VDU were installed, would the liquid yield increase?(D 1, page 3, Figure D 1-1)**

Response:
The yield would be expected to increase similar to that expected with Suncor's Fixed Plant Expansion, 82% gross.

c) **Provide an economic analysis to install the modifications needed to increase liquid yield to PEP volumes.**

Response:
Suncor has examined the potential to add a vacuum distillation unit to the Millennium Upgrader to increase liquid yield to FPE levels. Although provision has been incorporated into the Upgrader design for space for a future vacuum unit, the additional capital cost is not within Suncor's range for consideration in Project Millennium initial construction. Suncor will further evaluate this based on captial availability and market timing.

d) **Justify why it is acceptable to reduce liquid yield for a plant expansion. (Table A-1, page 20)**

Response:
The appropriate business decision, whether expanding an existing facility or building a greenfield project, is to ensure the business can successfully capitalize the project, produce and sell a marketable product sustainably with the chosen technology. The business must be able to reach the optimized economic solution for its capacity to attract capital both, for the initial capital for construction, and the on-going operating funds. It must also be able to build into the business decision proper risk assessment of the potential outcomes such as start-up duration, technology learning curve, increased operations and maintenance skills and costs, potential failure modes including associated downtime and costs, impact on the environment, etc.

Suncor optimized Project Millennium considering product value, and volume, along with all those business perspectives that must be considered for fiscal due diligence. Suncor reached an economic optimum that resulted in delayed coking being selected as the primary upgrading technology for Project Millennium. This technology has a proven yield on bitumen at Suncor of 81.2% gross. This yield is consistent with that achieved by Suncor's base plant cokers processing bitumen feed.

Suncor's overall yield has recently increased due to the additional processing step of a vacuum unit prior to the coker, added in the Fixed Plant Expansion. Suncor has the ability to add a similar unit after Project Millennium at some later date.

84. **Suncor stated that byproducts such as coke and sulphur would be stored in a manner that enables recovery at a later date. Describe in detail Suncor's long term coke and sulphur storage plans. Include the Coke Storage submissions (required by the Steepbank Approval # 8101, conditions 4 & 5) as part of the Millennium application.**

Response:
The management plan for coke and gypsum is described in detail in Volume 1, Section F2.4. The coke storage plan required by the Steepbank Approval #8101 is attached in the Appendices.

The long term plan is to sell and ship Sulphur product as soon as it is produced. Sulphur storage facilities (sulphur pits and storage tank) are designed to smooth out unit operations. For emergencies, an emergency pad will be used (when trucks cannot reach the site, or when sulphur is not on-specification such as during start-up or under upset conditions).

85. **Suncor stated it would maintain a sulphur recovery of 98.0% based on acid gas produced, by modifying SRU #1 to enable it to use oxygen enrichment. Are any other modifications required to maintain a consistent 98% recovery? (B3, page 35)**

Response:
The primary purpose of installing oxygen enrichment on a sulphur plant is to increase the capacity by replacing inert gases present in combustion air with oxygen. Suncor will only do this if capacity increases are necessary. Suncor plans to add catalyst in the SUPERCLAUS™ converter to help bring residence time within the optimum range for the best sulphur recovery possible for the higher PEP throughput.

Once the Millennium Upgrader is in operation, some of the gases from the base plant will be rerouted to the new higher recovery system. Another benefit of rerouting some gases to the Millennium facility is that it will off-load the existing SUPERCLAUS™ converter and allow for further increased residence time for the conversion reaction to occur within the catalyst beds. It is Suncor's belief that it will be able to operate within the regulatory requirement of 98.0% recovery.

86. **Provide the results of the study to evaluate the costs and benefits of increased sulphur plant capacity? (C3, page 134)**

Response:
Return on investment and net present value estimates were made using capital cost estimates versus production losses for various sulphur plant capacities. Suncor reviewed the costs and benefits for different scenarios and chose to increase the Millennium sulphur plant capacity by about 100% of that required to process Millennium gas streams, thereby enabling off-loading of the existing sulphur plant. The TGTU and TOU sizes were increased accordingly.

87. **Would sulphur degassing be installed for sulphur from SRU #1 and #2? (C3, page 146)**

Response:
All sulphur produced in the both the base plant and Millennium Upgrader will be degassed.

88. **Amine acid gas would be fed to both SRUs, while SWAG would be processed in only one train at a time. What happens to SWAG when one train is down? Would it be processed in the other new train or can it be diverted to SRU #1 or #2? (C3, page 150)**

Response:
The only interconnection between the base plant and Millennium Sulphur Plants is the amine acid gas line from the base plant to the Millennium sulphur complex. When one Millennium sulphur train is down, the sour water acid gas will be processed in the Millennium sulphur train that is on-line.

89. a) **How many days of sulphur storage capacity is there at Millennium production rates?**

Response:
Project Millennium design includes two undegassed sulphur pits each at 100 t (five hour storage; 0.5 hour surge) and one 1200 t degassed sulphur storage tank (approximately one day site production).

b) **Does Suncor have any intention to block sulphur with the increase to Millennium production rates? (C3, page 152)**

Response:
There is no intention to block sulphur at this time. A sulphur blocking facility is not included in the Millennium design.

c) **What is the market for the Millennium sulphur?**

Response:
Suncor expects to continue to market all sulphur as it is being produced. Detailed market plans are proprietary. The end use for sulphur is primarily for fertilizer production.

90. a) **Since all makeup diluent would be supplied from the new GRU, resulting in reduced emissions, what happens when this Upgrading train is down for extended periods such as during a maintenance shutdown and makeup is required? (Table C 3-1, page 129)**

Response:
When the Millennium GRU is down, makeup diluent can be provided from the base plant GRU if necessary. The facility exists to stockpile makeup diluent from the Millennium GRU in advance of an outage, however tankage conditions existing at the time will determine the extent to which this is feasible. Detailed turnaround plans have not yet been fully developed.

b) **Why can't the present makeup diluent be reformulated? What modifications would be required in the GRU to produce a diluent with fewer light and heavy ends and reduced benzene?**

Response:
Significant modifications would be required to the existing GRU to have the capability to reformulate the diluent, including larger heat exchangers and condensers, and tower revamp/replacement. The Millennium GRU will produce all makeup diluent for the site.

91. **The market factors section C1.4, page 3 indicates that diluents are required to blend with bitumen for pipeline transportation yet the product slate does not indicate diluent as a product. Would Suncor be producing diluent for sale?**

Response:
Suncor is proposing to optimize its product slate to market conditions. Suncor has experience producing diluent and has the capabilities to become a significant supplier of diluent to heavy oil producers in the Athabasca region should that market opportunity develop. Transportation diluent is contemplated to be available for sale (assuming there are no higher value alternatives at the time).

92. **The following questions relate to Figure D 1-1, page 3.**

a) **Why did Stream #15 increase? It seems to contradict the statement in Section C 3, page 153 of "there would be no new continuous flaring from the**

Millennium plant". Is this excess fuel gas from 10 FI-31?

Response:
The Millennium Upgrader contains no units continuously routed to flare. The increase in flaring is the expected hydrocarbon flared, on an annual basis, due to emergency flaring based on Suncor's operating experience. This is not excess fuel gas flaring. The quantity of emergency flaring is assumed to increase proportionally with production rates.

b) **Diesel fuel has tripled. Is this correct?**

Response:
Diesel consumption is based largely on truck hours which will increase due to nearly tripling total volume moved. This includes increased ore production and overburden removal with a higher stripping ratio.

c) **What is the expected density of the reformulated diluent for Millennium - 2002 rates?**

Response:
The expected recovered diluent specific gravity prior to Millennium is 0.759, and for Millennium is 0.763

d) **For FPE-1998, stream #6 has 0.13 x 103 m3 diluent lost and assuming a density of 0.77 t/m3, this calculates to 100t/d. It was understood for FPE that Suncor committed to losses not greater than 90t/d. Explain.**

Response:
The increase in forecast diluent losses as presented in the material balances is due to the higher volume of bitumen planned for processing under the revised FPE-1988 case. This increase in bitumen is due to a change in the forecast yields of the Upgrader which is now based on an operating case rather than process engineering models. The diluent losses in the FPE-1998 balances were calculated assuming a diluent recovery of 99.3%. The absolute value for diluent losses for the FPE-1998 case is therefore forecast at 95 t/cd (which assumed a specific gravity for diluent of 0.759).
Suncor is committed to maximize the recovery of diluent, meeting or exceeding the operating criteria of 99.3%. To achieve an absolute diluent loss of 90 t/cd at the reforecast FPE-1998 rates would require an overall diluent recovery of 99.34%, this is attainable based on recent operating performance.

93. **The following questions relate to Figure D 1-3, page 5.**

a) **Explain why stream # 14 minus #15 does not equal #16.**

Response:
This is corrected in the errata

b) **Does stream #16 include a volume expected to fill end-pit lake?**

Response:
No, it does not.

c) **How was stream #16 determined (average over life of project assuming CT, end-pit lake, FT remaining, MFT production rates)?**

Response:
In the material balances stream No. 16 (pond water accumulation) was calculated on a point-in- time basis representing the year 2001. A more detailed life-time water balance, which will include the external tailings pond and end pit lake, will be available by mid-September.

d) **River water intake, stream #1, shows a decrease from FPE of 74,808 m3 /cd to 51,911 m3 /cd for Millennium-2002 and yet an increase is being requested. Explain**

Response:
Suncor has requested an increase in net retention of water from the Athabasca River, where net retention is the difference between intake and discharge. With Project Millennium, Suncor is decreasing both intake and discharge, however the difference between the two will increase.

94. **Explain why for stream #5, at Millennium-2002 rates, "SULPHUR TO ACID GAS FLARE" of 3.5 t/d is disproportional compared to the flare rate of 1.9 t/d for PEP rates. (Figure D 1-4, page 6)**

Response:
The three cases (FPE, PEP and Millennium) cannot be compared with ratios because the product slate and therefore the quantity of sulphur requiring further processing in the Sulphur Complex for each case is different. It is assumed that the emergency flaring scenarios will be similar to the existing requirements (0.3%), and that Suncor will be able to manage within emission limits.

95. **The following relate to Figure D 1-5, page 7.**

a) **Confirm that the energy intensity factors are correct.**

Response:

Corrected in errata. Figure D1-5 Energy Intensity Factors table: numers in first row of table should read 0.79, 0.78, and 0.69 respectively; heading for last row should read GJ/M^3 OF CRUDE PRODUCED FOR SALE.

b) **Provide an energy efficiency for Fixed Plant, PEP and Millennium. Energy efficiency enables a comparison with other facilities including that submitted in the FPE Application. Since the oil sands processed, yields, and energy efficiency and calculated energy intensity have changed from FPE Application, revised energy inputs are required to assess the improvements.**

Response:

The following table presents the requested calculation. Note that the energy efficiency as determined here for FPE is lower than the energy efficiency previously calculated, for the following reasons:

- The previous FPE calculation was made for the planned Suncor facilities in the year 2001. This included flare gas recovery (which will be installed in 1999), and turbogenerator 3 (which will now be part of Project Millennium or as third party power).
- The upgrader yields used in the previous FPE calculation was based on process engineering models, whereas this calculation is based on measured plant performance using the expected yield increase with the vacuum unit.

Table 1 Overall Energy Efficiency

Case	105 000 bbl/cd	130 0000 bbl/cd	210 000 bbl/cd
Input (1000 GJ/cd)			
Bitumen	908.0	1121.7	1894.3
Natural Gas	17.1	31.1	43.5
Electric Power Import	5.3	0	0
Total	930.4	1152.8	1937.8
Output (1000 GJ/cd)			
SCO Product	384.0	435.5	774.1
Distillate Product	217.8	309.7	475.9
Sulphur	5.0	5.8	10.7
Coke to Stockpile	58.9	83.1	203.2
Total	665.7	834.1	1463.9
Overall Energy Efficiency (%)	71.6	72.4	75.5

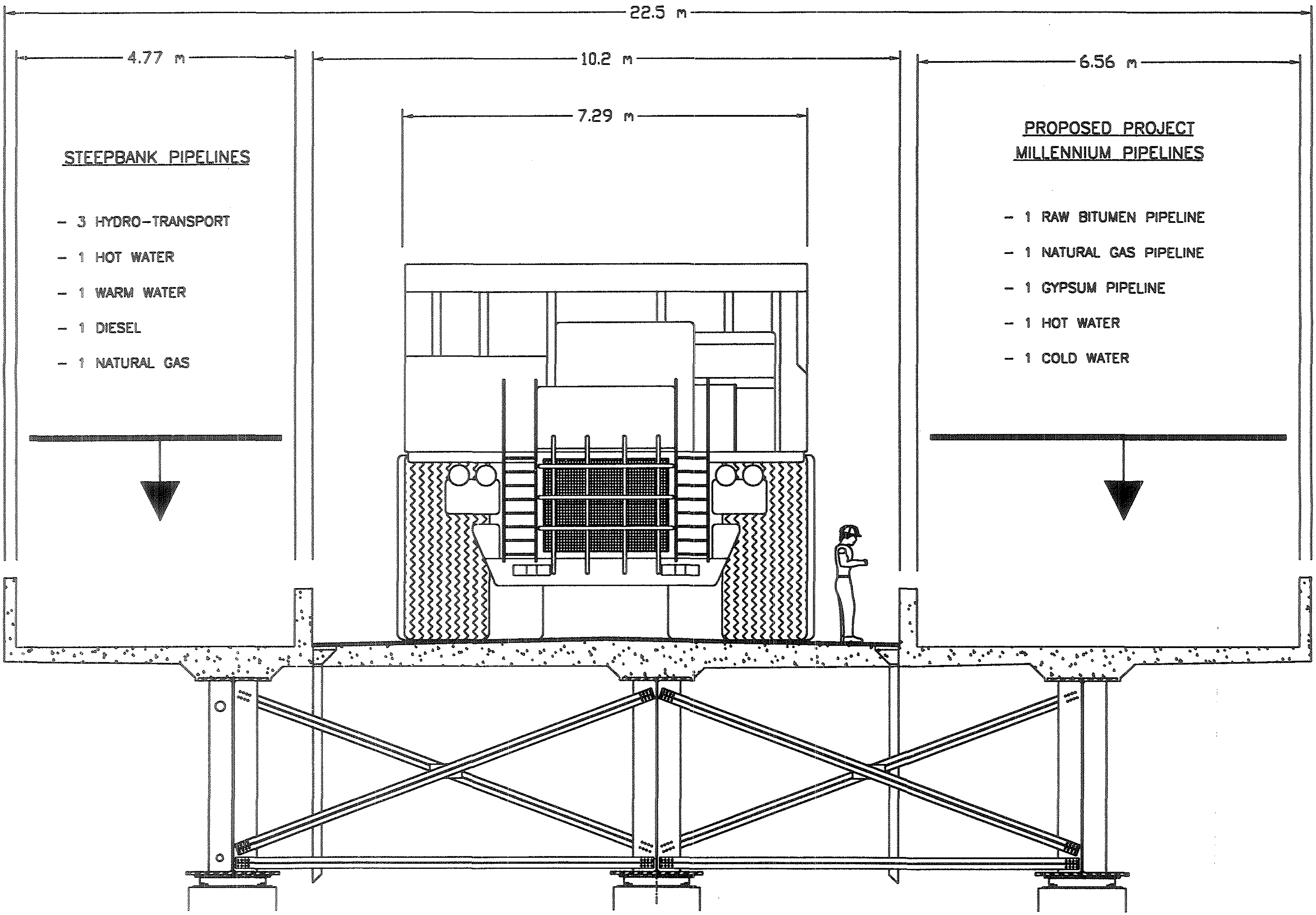
Table 2 Net heating Value of Streams

Component	Lower Heating Value	Units
Bitumen	40.408	GJ/m^3
Natural Gas	0.033	GJ/m^3
SCO Product	36.054	GJ/m^3
Distillate Product	36.054	GJ/m^3
Coke	34.933	GJ/t
Sulphur	9.26	GJ/m^3
Electric Power	10.286	GJ/MWh

Infrastructure

96. **Figure C4.0-5 of the Steepbank Mine Application shows the configuration of the pipelines on the Athabasca River Bridge. Update this information showing any additional pipelines that will be required for Project Millennium and the material to be transported in each line. Describe the ability of the bridge to handle any additional pipelines.**

Reponse:
The requested schematic is presented on the following page. There is sufficient ability to handle all contemplated pipeline needs


22.5 m
4.77 m
10.2 m
6.56 m
7.29 m
STEEPBANK PIPELINES
- 3 HYDRO-TRANSPORT
- 1 HOT WATER
- 1 WARM WATER
- 1 DIESEL
- 1 NATURAL GAS
PROPOSED PROJECT
MILLENNIUM PIPELINES
- 1 RAW BITUMEN PIPELINE
- 1 NATURAL GAS PIPELINE
- 1 GYPSUM PIPELINE
- 1 HOT WATER
- 1 COLD WATER

97. **Suncor stated in the Steepbank Mine Project, Supplemental Information Response that there would be holding space on both sides of the (Athabasca River) bridge for draining any of the lines across the bridge. With the additional lines crossing the bridge does this commitment hold true? Describe the plans Suncor has to control a substance release from the pipelines on the bridge or near the river.(C2.4 page 49)**

Response:
Yes, the commitment to provide sufficient holding space on both sides of the bridge to drain any of the lines continues. Because of the design of the bridge deck (with pipeline troughs) and the collection systems at both ends of the bridge, a leak would be contained within the system.

98. **Suncor stated that raw bitumen or froth would be transported from the Millennium plant by pipeline to the existing Base Plant for clean up. (C2.4 page 49)**

a) **Is there only one pipeline required?**

Response:
Yes, there will only be one pipeline.

b) **Explain the technology Suncor would use to transport the bitumen.**

Response:
The intent is to capitalize on the annular flow phenomenon which results in the formation of an annulus of water at the pipe wall, thereby reducing the friction loss associated with raw bitumen transport.

c) **Confirm Suncor is not planning any froth clean up on the east side of the Athabasca river.**

Response:
Suncor intends only to deaerate froth on the east side of the Athabasca River.

d) **How would hot raw bitumen that is pumped to the interstage bitumen tank be measured?**

Reponse:
This issue will be considered and assessed during subsequent detail engineering study and design.

e) **What would be the effect pumped froth has on Base Plant froth treatment performance such as product quality and recovery?**

Response:
Suncor anticipates neither benefits nor adverse effects on Base plant operations.

f) **What testing has been done on froth pumping by Suncor or others? (C2.5, page 103)**

Response:
Suncor routinely pumps hot deareated froth between process units in its existing operations. Suncor has pumped deareated froth (i.e., raw bitumen) at various temperatures through a short 2 inch diameter test loop. Suncor plans to embark on a test program utilizing a larger diameter test line.

99. **What is Suncor's understanding of the stage of development of other solid tailings management alternatives such as thickeners? (C2.4, page 71). What benefits would thickeners provide in the terms of tailings impoundment and environmental impacts? Has Suncor done any work in this area? If not, does Suncor plan to do any work in this area?**

Response:
During the last two years, Suncor has moved to commercial operation of its CT technology which facilitates reclamation of most of its disturbed lands to a solid state supporting full revegetation. Suncor has continued to investigate enhancements as well as alternatives to its CT technology as part of the feasibility study for the Millennium Project. Based on these studies, Suncor has concluded that CT is the best solid tailings management method that is technically and economically viable at this time. Although other technologies such as paste or thickeners show promise, they are not sufficiently developed. Suncor will support further research through CONRAD. Suncor was a founding partner in CONRAD, which has sponsored much of the research and development work on alternative tailings technologies.

The proposed benefits of alternative technologies may include reduced inventory requirement for MFT, increased recovery of heat from process water, and perhaps more rapid reclamation or improved groundwater chemistry, although the latter benefits are uncertain. Suncor will continue to participate in research and development initiatives leading to pilot scale testing of some of these alternatives in order to continue to improve its economic, environmental and reclamation performance.

Clarification

1. **Define Energy Intensity.**

Response:
Energy intensity can be defined as the magnitude of the usable heat or power consumed per volume of resource mined or product produced.

Pursuant to discussions with the EUB and Suncor Oil Sands defines three measures of site-wide energy intensity:

- total energy consumed in gigajoules (GJ) divided by the mass of oil sands mined in tonnes
- total energy consumed in gigajoules (GJ) divided by the volume of bitumen produced in cubic metres (m3)
- total energy consumed in gigajoules (GJ) divided by the volume of net salable products in cubic meters (m3)

The conversion of "energy consumed" is determined using lower heating values.

2. **Regarding C2.3 - page 41 - Table C2.3-1:**

- Pit 2 WT% bitumen is given as 11.5% but in other parts of the application it is given as 11.7%. Why the change in this table?

Response:
Suncor believes that the average grade in Pit 1 and Pit 2 combined will be 11.7%. (The value of 11.5% was derived by manually adjusting the geologic model on the basis of geophysical logs and understates the average grade.)

- Why does it take a shorter time to mine the north body than pit one even though the north ore body is larger?

Response:
Table C2.3 -1 should read 12 years for Pit 1.

3. **It is noted that in approximately 2012, "additional primary extraction capacity will be installed in the area of the Steepbank Mine. Over its thirty - year life....". Does this mean Suncor is seeking approval until 2042 ? Yet on page 16 of this same section, end of mine life of about 2035 is stated. Explain. (A2, page 10)**

Response:
Suncor is seeking approval for the mine life, until about 2035.

4. **Describe what is required in converting the scroll mechanism and feed arrangement in the remaining nine Bird centrifuges to increase capacity to handle PEP rates? (B2, page 8)**

Response:
The feed system and scrolls are changed out during unit rebuilds

5. **In Figure B2-1 PEP Extraction Process, why is there no flow into Secondary Flotation? (B2, page 9)**

Response:
A flow stream from the separation cell middlings into secondary floatation should be indicated.

6. **Clarify the high-pressure steam at 5450 kPa is produced by the three coke-fired boilers and steam at 2900 kPa is produced from a 1981 gas-fired unit. It seems to be reversed in the application. (B4, page 43)**

Response:
The four boilers referred to produce both 5450 kPa and 2900 kPa steam

7. **What is the boiler efficiency of the upgraded coke-fired Boilers No. 2 and 3? (B4, page 46)**

Response:
Boiler No. 2, which was upgraded in 1997, is now operating at 85% overall efficiency with approximately 40% reduction in NO_X emissions. Boiler No. 3 upgrade is currently in progress and is expected to be returned to service in September.

8. **In point number 3, the separation temperature for the present extraction plant of 86 ^{o} C appears in error. (C 2.5, page 115)**

Response:
The separation circuit temperature should read 68^{o}C.

9. **There is an error in the coke production of 40kt/d for the FPE case.(F2, page 8)**

Response:
The number should read 4.0 kt/d.

10. **Arrow for Stream #9 is the wrong direction. (Figure D1-1)**

Response:
Corrected in errata.

11. **Arrows for streams #1,#14 and #15 are going the wrong direction. (Figure D 1-4, page 6)**

Response:
Corrected in errata.

12. **Re - "…. the fiscal capacity of the municipality may expand by 190% or more……Taken together, the almost doubling of the fiscal capacity and the 30% population increase…." (first and third sentences under Cumulative Case, Vol. 2c, page F2-47). Should this be read as a 90% (or more) increase in fiscal capacity?**

Response:
The phrase "may expand by 190 % or more" should read: may nearly double.

13. **What is the capacity of the existing NRU unit?**

Response:
The hydraulic capacity of the NRU under normal operating conditions is about 7000 bbl per hour.

14. **It is noted that the design liquid yield to be a minimum of 81.2% gross yet 81.7% is used throughout the application. Explain.**

Response:
The 81.2% yield is for the Millennium Upgrader stand-alone. All material balances were calculated for the combined operation in which the blended yield would be 81.7%.

15. **Suncor stated that the hydrotransport of ore from the Centre plant location to the Base Extraction Plant would be beyond practical limits for hydrotransport. Explain Suncor's reasons behind this statement (technical or economic). (C2.4, page 66)**

Response:
This statement was made in context of explaining the need for additional extraction capacity in the east bank mining area post 2012. From a technical perspective Suncor has knowledge that effective conditioning in the temperature range of 50°C to 55°C can

be achieved at a hydrotransport distance of 2.5 km. Suncor does not possess data on the effects on ore conditioning at a distance of 11 km (the distance from the Centre plant location to the Base Plant), but would have a significant concern about over-conditioning of ore. From an economic perspective, transporting ore to the Base plant a distance of 11 km and returning tailings about the same distance introduces undue cost and operational risks.

16. **The year-end 2025 drawing (VEW-980307-11) shows that pond 8A will be affected by the advancing pit wall sometime prior to 2025 but pond 12 will not be ready to accept the fluids to be drained from pond 8A at that time. Explain what will happen to allow this to occur.**

Response:
The plan is to build an interim pond within Pond 12 to contain the fluids from Pond 8A to enable rehandle and subsequent mining of the ore.

17. **In volume 2B, page D4-40, Suncor indicates that littoral zone will comprise 20% of the lake volume. Should this be 20% of the lake surface area?**

Response:
The littoral zone is 20% of the lake area, not lake volume.

18. **Volume 1, table C2.4-7 gives a summary of geotechnical criteria. In the table entry for dump slopes with a weak clearwater foundation, define the term (D/H<0.25).**

Response:
D is the depth of the weak (Clearwater) layer below the toe of the dump
H is the height of the dump

19. **Several figures have been requested in the preceeding questions. Of these, two copies of the figures listed below are needed in a large scale (eg. 1:30 000) for EUB staff review:**
- Isopach of total interburden thickness for pit 1 and pit 2.
- Isopach of the Pleistocene deposits or a structure contour map of the top of McMurray
with drillhole control illustrated.
- Isopach of sediments that are glacial fluvial in origin with drillhole control illustrated.
- Cross sections in the out-of-pit tailings and NE Dump areas.
- Updated TV/BIP and TV/NRB contour maps.
- A drawing of the facilities which will be required on the east side of the Athabasca river.

Response:
The requested figures are being provided to the EUB under separate cover.

**20. In order to assist EUB staff review of the application, please submit a DXF file in UTM 6
degree, NAD27 coordinates, which contains the following information: Pit outlines, dump crests and toes, dyke crests and toes, surface facilities, rivers, creeks, and topography surrounding the project area.**

Response:
The requested information in electronic format is being provided to the EUB under separate cover.

D AEP SUPPLEMENTAL INFORMATION RESPONSE

1.0 AIR QUALITY AND NOISE

Assessment Approach

1.1 **Scientific uncertainty is discussed in the section on approach used for the EIA. (*Vol. 2A, p. A2-31*) Clarify how a level of uncertainty identified as "making a prediction of the impact problematic" (*Vol. 2A, p. A2-31*) is used in deriving an environmental consequence for an EIA issue/question. Please discuss the proposals for study or investigation that will be undertaken to reduce the level of uncertainty from a "problematic" level.**

Response:
The matter of scientific uncertainty with respect to deriving an environmental consequence or consequences for an EIA issue/question is driven by the amount of available information, knowledge and understanding of the EIA issue/question. In an "ideal" world the level of scientific uncertainty progressively decreases as information, knowledge and understanding increases. Inherent within an EIA issue/question is a conceptual and/or mathematical model which attempts to frame cause/effect relationships in a way which meaningfully reflects conditions in the field. The main problem, however, is that a conceptual and/or mathematical model is simply a representation of our current knowledge and understanding and as such the output is an estimation. It becomes "problematic" to derive an environmental consequence to an EIA issue/question when the "estimation" must be made with insufficient information and/or it is discovered that the conceptual and/or mathematical model does not adequately frame the EIA issue/question. The above is a problem common to all scientific investigations whether they be theoretical or applied and is particularly the case with environmental issues due to their inherent complexity. Suncor recognizes the need to reduce scientific uncertainty with respect to making impact predictions and will take appropriate steps in the "problematic" areas. These follow-up commitments are stated throughout this Supplemental Information Response.

1.2 **Reversibility is listed as one of the impact description criteria for Project Millennium. (*Vol. 2A, p. A2-27, Table A2-8*) Please clarify the definition of the "reversibility" criterion used in deriving the environmental consequence rating for the EIA questions addressed by Suncor. In particular, describe the time frame during which an impacted receptor identified effect is expected to recover to the natural or intended final state.**

Response:
The concept of reversibility/irreversibility relates to the capacity or lack of capacity of a receptor to respond to an environmental perturbation. The response of the receptor is said to be "reversible" if the receptor returns to its original condition after perturbation or the response is said to be "irreversible" if the receptor does not return to its original condition after perturbation. There are two related key elements. One is the type and magnitude of the perturbation and the other is time. Time is a critical factor. Simply put, an extreme perturbation will require more time for recovery than a minor perturbation and will require different environmental management approaches. The time required is thus a function of the nature of the perturbation. Reclamation, for example, is the environmental management response after open pit mining of bitumen has been completed. The time required to achieve a stable sustainable ecosystem is variable but is in the range of decades. In this sense "reclamation" reflects reversibility of an extreme perturbation by receptor replacement to reestablish natural conditions.

Irreversible impacts relate to events for which neither planned mitigation nor time will allow a change back to the conditions prior to the impact. An example related to fisheries habitat is the planned removal of Leggett and Wood creeks. The impact to fish habitat directly associated with these streams is irreversible because the streams are being removed as part of the mining operation. The effect of this removal can only be compensated for environmentally through creation of new fish habitat in another area, a plan which is detailed in Suncor's "No Net Loss" plan.

1.3 **Suncor has presented a concise description of the difficulties in assessing responses of vegetation to exposure to multiple stresses. (*Vol. 2B, p. D3-101*) Does Suncor have any suggestions regarding how to overcome the difficulties associated with assessing possible effects on a receptor exposed to multiple stresses (e.g., SO_2, O_3. and NO_x, in combination with natural stresses such as heat, drought, insect infestation, etc.)? Is this component of a cumulative effects assessment being addressed in the industry-stakeholder cumulative effects assessment initiative?**

Response:
It is a well-documented fact that in the ambient environment that vegetation is exposed to an array of natural stresses that interact with air pollution stresses. Most of the research on this issue, however, has been carried out under controlled conditions in the field using open-top chambers and in the laboratory/greenhouse using various types of controlled environment chambers. While limited research has been carried out under natural field conditions, this is an evolving area of scientific research in North America and Europe. Suncor recognizes the evolving nature of this area of science and will follow these developments carefully for their applicability in the Oil Sands region particularly as they relate to the industry-stakeholder cumulative effects assessment initiative. Please reference Vol. 2B, pp. F1-19, 20 and 21 for a detailed discussion of this issue.

Emissions

1.4 **Information about the proposed sulphur recovery technology and tail gas treating technology is provided in the application. (*Vol. 1, p. C3-134 and 151*) Please clarify the following:**

a) **With respect to the two 100% sulphur recovery trains for the Millennium Upgrader, (*Vol. 1, p. C3-134*) please confirm that each train will be able to handle all of the flow (i.e., no operating scenarios that would require flaring of acid gas or sour water acid gas in order to maintain production levels).**

Response:
Each of the Millennium sulphur trains is designed to process all sour gases generated as a result of the Millennium operation. During planned maintenance, when a single Millennium sulphur train is available for service, all Millennium-produced amine acid gas and sour water acid gas can be processed in the on-line sulphur train and the base plant acid gas will be routed to the SRU #1 and #2 for processing. Flaring of acid gas during startup, shutdown, upset or emergency conditions will continue to take place to protect personnel and equipment.

b) **Has the specific commercial technology for the Tail Gas Treating Unit 2 been selected, and is it a proven technology for services similar to the Suncor Upgrader?**

Response:
Technology selection has been completed. A hydrogenation/amine process, licensed by Bechtel will be used in the Millennium Tail Gas Treating Unit (TGTU). This or similar technology is currently in use in gas plants and refineries across the country/world. (The Husky Upgrader in Lloydminster uses a similar process, licensed by Shell.) Suncor's Oilsands operation is unique in that over 50% of the gas processed in the SRU is a result of a delayed coking process, so the technology has been proven for services similar but not identical to Suncor's.

c) **Will the Millennium Upgrader be designed and operated in a manner such that the tail gas from Sulphur Recovery Units 3 and 4 will always be directed to the Tail Gas Treating Unit? If it is possible that the Tail Gas Treating Unit could sometimes be bypassed, please clarify the expected frequency and duration of such events, the resultant sulphur dioxide (SO_2) emissions, and the effect on predicted ambient SO_2 concentrations during such a scenario.**

Response:
During normal operation, the tail gas from SRU 3 and SRU 4 will be directed to the TGTU to minimize emissions. During abnormal or upset conditions there is the potential to form extremely corrosive conditions in the TGTU equipment, which would quickly result in serious damage requiring extensive downtime to repair. Because of this

possibility, the TGTU will be automatically bypassed during upsets, and the tail gas will be routed directly to the Thermal Oxidizer unit (TOU).

The expected TGTU on-line time is a minimum of 95%. This factor has been used in material balances to determine calendar day and stream day emissions for use in dispersion modelling. Duration and frequency of TGTU bypass events are not possible to predict, however both the duration and frequency should gradually be reduced over time as operating experience is gained. During upset conditions, Suncor will manage its operation to ensure SO_2 and overall sulphur emissions meet regulatory limits.

For TGTU bypass events expected to last longer than a few minutes, the base plant acid gas will be rerouted back to SRU #1 and #2 for processing. Such action maximizes sulphur recovery until TGTU is back on line because sulphur recovery would be better in the SRU1/2 and SUPERCLAUS TM tail gas treatment combination than with SRU 3/4 only.

d) **Will the sulphur recovery complex for the Millennium project be integrated with the existing Base plant sulphur recovery system in order to reduce the frequency and duration of any flaring events (e.g., sour water acid gas flaring) and scenarios of reduced sulphur recovery (e.g., SUPERCLAUS bypass) that might otherwise occur with the Base plant units?**

Response:
The sulphur recovery complexes are partially integrated. Approximately 50% of the base plant amine acid gas, under normal operations, will be routed to the Millennium sulphur complex for processing. Therefore, the impact (i.e., SO_2 emissions) of upsets in the base plant SRU (such as SUPERCLAUS TM bypasses or SRU trips) will be reduced by nearly one half, as there will be less gas being processed.

The incidence of flaring should be slightly reduced. Improved performance of the base plant SRUs due to extended catalyst life is expected. Because the units will be processing less gas there will be fewer upsets of the magnitude which would result in SRU trips.

During planned maintenance of one of the base plant SRUs, there will be sufficient capacity in the on-line train to process half of the amine acid gas and all of the sour water acid gas produced in the base plant, while the remainder of the amine acid gas is routed to the Millennium sulphur complex. Flaring of sour water acid gas due to upset or emergency conditions is not expected to be reduced by the degree of integration with the Millennium Plant.

e) **A 106 m stack is noted for the Thermal Oxidizer Unit 2. (*Vol. 1, p. C3-151*) Please clarify how/why this stack height was selected.**

Response:
The preliminary stack height was selected on the basis of licenser design experience and dispersion modelling. The final stack height will be determined during the detailed design phase.

1.5 **Suncor has indicated that a detailed analysis is being conducted to evaluate the costs and benefits of increased sulphur plant capacity. (*Vol. 1, p. C3-134*) Please advise us of the outcome of the analysis and comment on the following:**

a) **Has Suncor considered the options of either:**

i) **sizing the Tail Gas Treatment Unit 2 sufficiently large to accommodate all of the tail gas from the Project Millennium sulphur recovery units (SRU 3 and 4) and the Base plant units (SRU 1 and 2), or**

ii) **sizing the entire new Millennium sulphur recovery complex of a size that would eliminate the need for the existing sulphur recovery complex, and eliminate the associated emissions.**

Response:
The analysis resulted in a decision to increase the size of the Millennium SRUs from two at 75% Millennium capacity to two at 100% Millennium capacity. The TGTU and TOU sizes were also increased. The increase in cost is estimated at approximately $29 million. This includes the cost of processing approximately 50% of the base plant acid gas in the Millennium sulphur complex.

Tail gas from the existing SUPERCLAUS^{TM} unit cannot be processed in the Millennium TGTU as the oxygen content of the tail gas would degrade the amine in the TGTU. Tail gas from the base plant SRUs because of the low exit pressure, would require a sour gas blower and large piping to reach the Millennium sulphur complex. Capital, operating and maintenance costs would increase significantly in comparison to the selected option to reroute acid gas. In addition, with one large TGTU processing all tail gas, bypass events would result in greater emissions and TGTU operating problems would adversely impact both the base plant and the Millennium operations and production rates.

This option was briefly evaluated, however the capital costs were very high. Sizing the Millennium SRUs, TGTU and TOU to accommodate about 50% of the base plant acid gas was found to be the optimal balance between reduced emissions, increased capital cost and increased operating complexity.

b) **If the emissions from the existing sulphur recovery complex were completely eliminated (i.e., eliminate the existing incinerator stack emissions), please comment on the expected effect on:**

i) **Suncor's total SO_2 emissions,**

ii) **predicted ambient SO_2 concentrations (such as those provided in *Vol. 2A, p. B4-8, Figure B4-2*), and**

iii) **predicted acid deposition.**

Response:
This is a speculative question. The emissions from the existing sulphur recovery complex could, for example be eliminated by transferring all acid gas to an appropriate Millennium complex sized for that case. Two limiting factors are, current best sulphur recovery is 99.9% (when operating), and capital cost. If one large unit were built, on line recovery would be excellent, but poor when off-line. Increased recovery could be achieved by installing a number of smaller units with excess capacity to process gas when other units are down - at high capital cost. Detailed analysis was not performed on the base plant zero emission case, as there are no immediate plans to cease operations of this plant. Suncor's analysis based on capital cost, reliability, production and emission control resulted in a decision to size the Millennium complex to handle approximately half of the base plant amine acid gas.

Dispersion modelling was not conducted on all alternative emission profiles. In general, the ambient SO_2 concentrations would be lower than the analyzed case.

Detailed analysis was not completed for all alternative emission profiles.

1.6 **Indicate whether Suncor has considered treating the residual tail gas from the sulphur recovery units in the existing flue gas desulphurization (FGD) plant and if this is not feasible please, briefly discuss why.**

Response:
This option has been evaluated, and found to have similar drawbacks to the alternative of routing base plant tail gas to the Millennium plant Sulphur complex. Long, large diameter lines, blower reliability, safety issues with piping and blowing sour gas from Upgrading to and through the Energy Services plant, lower recovery and up-time of FGD compared to TGTU recovery were all factors in eliminating further consideration of this option.

1.7 **Suncor has indicated that sulphur from Sulphur Recovery Units 3 and 4 and Tail Gas Treating Unit 2 will be degassed. (*Vol. 1, p. C3-151*) Please describe the benefits that the sulphur degassing will provide and clarify whether the sulphur from the existing Base plant sulphur recovery unit will also be degassed.**

Response:
The Millennium Upgrader facility will now degas all sulphur produced at Suncor's Oilsands operation. The overall sulphur balance will not change. However, the potential of fugitive H_2S emissions from transport vehicles will be reduced. Odour potential when pouring sulphur onto the emergency sulphur pad will be also be reduced. As a

result of degassing the sulphur, the range of potential customers will be wider which will reduce the risk inherent in a single-customer transaction.

All sulphur will be degassed to <10-PPM H_2S content. The technology selected is the D'GAASS process (licensed by Goar Allison & Associates, Houston). The degassing takes place at pressure, which minimizes vessel size, capital cost and plot space requirements. No increase in SO_2 emissions is expected, as the H_2S stripped from the sulphur will be routed to the front end of the SRUs for recovery. Suncor is the first large-scale commercial facility to implement this process, and therefore there is some technical risk that may make the process uneconomical. While Suncor feels that this system is feasible and will make reasonable attempts to make it work, if it is uneconomical it may have to be discontinued.

1.8 **An air quality impact mitigative measure that Suncor will be undertaking is the installation of a flare gas recovery project, whereby gas streams that are currently being flared on a continuous basis will be recompressed for treatment and use. (*Vol. 2A, p. B5-1*) Please clarify the following:**

a) The current status of this undertaking.

Response:
The Flare Gas Recovery System as proposed is now advancing into the detailed engineering design stage. The project cost to gather the identified streams is quite high. An alternate process configuration (used by others) that has the potential to reduce cost, increase reliability, reduce complexity and utilize existing equipment is under active consideration, with a plant trial planned for July. Actual gas produced from the new DRU and Vacuum Unit is now available for design purposes and the blowers installed in Plant 25 are being evaluated for their applicability to handle off-gas from two sources.

b) Has this expected reduction in SO_2 emissions been considered in the requested approval limit of 79 t/day on a 365-day rolling average basis? (*Vol. 1, p. F3-16*)

Response:
Yes, it has.

1.9 **It appears that 1.3 t/sd of SO_2 from flaring at the Suncor plant was used in modelling for predicting the maximum hourly ambient SO_2 concentrations in the future (*Vol. 2A, p. B4-8, Figure B4-2*) and that 10.6 t/cd of SO_2 from flaring was used in modelling for predicting annual ambient SO_2 concentrations. (*Vol. 2A, p. B4-10, Figure B4-4*) Is the difference in the flaring emissions between these two scenarios the expected amount of non-continuous flaring (i.e., 9.3 t/cd), or is Suncor targeting a lower value for non-continuous flaring emissions?**

Response:
Suncor is targeting to minimize all flaring to the extent economically feasible while continuing to comply with all regulated limits. Modeling was done on cases developed to reasonably estimate future emissions. For hourly ambient SO_2 concentrations the model was based on the normal operating case, with all pollution control equipment in operation at design rates (i.e.: a **Stream Day**). For the annual ambient SO_2 concentrations the model was based on emissions from an expected amount of abnormal operation, such as emergency flaring, and includes equipment downtime for planned and unplanned maintenance (i.e.: a **Calendar Day**) on an annual basis. Therefore, the difference between the two flaring estimates does not represent Suncor's estimate for continuous flaring. Suncor is estimating continuous flaring to be much lower at 3.5 t/cd for the Millennium case (which is after the implementation of flare gas recovery).

1.10 **Suncor has discussed smaller SO_2 emission sources, and the affect of including these smaller sources in model predictions. (*Vol. 2A, p. B2-4*) Please clarify the following matters related to the smaller SO_2 emission sources:**

a) It is stated that the contribution of smaller emission sources to the overall SO_2 ground level concentrations is significant within 20 km of the fixed plant and represents more than a third of the hourly Alberta Ambient Air Quality Guideline exceedances. (*Vol. 2A, p. B2-4*) Is the basis for this statement the model predictions or actual air monitoring statistics?

Response:
The statement regarding the proportion of the Alberta Ambient Air Quality Guideline exceedances (*Vol. 2, p. B2-4*) was based on the results of comparative dispersion modelling. It is practical using a dispersion model to eliminate the contribution from a particular source (i.e., the low level smaller SO_2 sources) by deleting it from the dispersion modelling input files. It is not possible to look at the ambient monitoring results and make the same distinction.

b) Does the Project Millennium design include any features to reduce mercaptans and other sulphur compounds in fuel gas, to either reduce the SO_2 emissions that occur on a continuous basis, or to reduce intermittent scenarios of increased SO_2 emissions from these sources?

Response:
The Millennium Gas Recovery Unit (GRU) is designed to recover a higher percentage of butane (C4) material, and therefore the amount of C4 and heavier mercaptans sent to the fuel gas system is expected to be lower than currently observed in the base plant, and the resulting SO_2 emissions should be lower.

In addition, Suncor is currently evaluating the technical and commercial feasibility of allowing the recovery of light hydrocarbons from its fuel gas stream (Novagas Canada Ltd. natural gas liquids plant). Should this project proceed, the SO_2 emissions resulting from burning fuel gas in fired heaters will be further reduced.

1.11 **On page 79 of the *Technical Reference for the Meteorology, Emissions and Ambient Air Quality in the Athabasca Oil Sands Region* it is indicated that under upset conditions, the operation of the flue gas desulphurization (FGD) bypass or hydrocarbon flaring can result in significant SO_2 emission on a short term basis (a few hours for flaring or a few days for the FGD operation, depending on the nature of the upset). Please summarize the actions that Suncor is taking to reduce the possibility of these upset conditions occurring, and to manage emissions during such events.**

Response:
Emergency flaring protects equipment and personnel from harm during process upsets. Flaring represents a loss of hydrocarbon products otherwise available for sale. Every effort is made at the engineering stage to minimize hydrocarbon losses through proper equipment and control system design. Operational systems in place to minimize upset conditions include computer control systems, operator training, preventive maintenance programs, incident reporting, investigation and follow-up.

Suncor has worked to reduce the possibility of an upset condition in the FGD, with the result that the unit has remained on-line continuously since September 1997. This was achieved by modifications to achieve more even flow distribution and to reduce plugging tendencies. In addition, plans are to combust natural gas (which has lower sulphur content) rather than liquid fuel in the coke-fired boilers during FGD downtime.

1.12 **On page 67 of the *Technical Reference for the Meteorology, Emissions and Ambient Air Quality in the Athabasca Oil Sands Region* a footnote under Table 3-17 indicates that the new Suncor Gas Turbine Generators will each have separate bypass stacks which would be operated intermittently. Please discuss why the bypasses are necessary, and the type of emissions that would occur.**

Response:
The design of the new gas turbine generators has since been modified to eliminate separate bypass stacks.

1.13 **With respect to the summary of stack and emission parameters associated with the Suncor FGD stack which are provided in Table 3-18 of the *Technical Reference for the Meteorology, Emissions and Ambient Air Quality in the Athabasca Oil Sands Region*, please clarify the following:**

a) **Why is the expected exit temperature expected to be 49°C under the Baseline and Millennium scenarios, while it is 59°C under the existing scenario?**

Response:
The expected exit temperature is 59°C.

b) **Clarify the expected SO_2 removal efficiency of the flue gas desulphurization (FGD) plant that would result in the predicted SO_2 emissions that are listed for the Baseline and Millennium scenarios (i.e., the SO_2 removal efficiency appears to be less that the 95% design figure that is noted elsewhere, such as in *Vol. 2A, p. B2-2*).**

Response:
The original design of the FGD plant was for three coke fired boilers at 800 000 lb/hr load to achieve 95% SO_2 removal of 6% sulphur in coke containing 13 200 BTU/lb. With the increased energy needs and driven by a lack of capability in the Alberta electric power grid, Suncor will increase firing of the three main coke-fired boilers to 1 000 000 lbs/hr each. With this increased loading of the FGD process, a slight decrease in SO_2 removal efficiency to 94% is anticipated.

1.14 **In Section F3.1.2 of the application, Suncor is requesting an increase to some of the sulphur dioxide emission limits that are presently stipulated in Environmental Protection and Enhancement Act (EPEA) Approval No. 94-01-00, in order to accommodate the Project Millennium. (*Vol. 1, p. F3-11*) With regards to the requested site-wide SO_2 limit of 79 t/day on a 365-day rolling average, and the performance target value of 71 t/day per calendar year, please provide further details on the following:**

a) **the projected emissions from each source (or category of sources) that form the basis for the request, and**

Response:
The projected emissions from each source (or category of sources) that form the basis for the requested site-wide SO2 limit of 79 t/day on a 365-day rolling average, and the performance target value of 71 t/day per calendar ,year are described in Table B3-1 provided in Volume 2 Section B3-4.

Source	SO2 Emission (t/cd)
Energy Services	
FGD stack - FGD on-line	18.7
coker gas firing in Millennium boilers/ GTGs	1.1
Powerhouse stack (includes FGD off-line)	14.0
Upgrading	
existing incinerator	12.3
Millennium incinerator	8.7
coker gas firing in heaters	4.7
existing plant continuous flaring	3.6
emergency acid gas flaring	7.0
Mine Fleet	0.08
Total	70.2

Note this does not account for any unplanned hydrocarbon flaring events nor technology performance issues thereby explaining Suncor's request for a compliance limit of 79 tonne/d.

b) a general description of how emissions from each source (or category of sources) will either be measured or calculated to determine compliance with the limit.

Response:
These emissions sources (or category of sources) will be measured or calculated by meters and process engineering judgment to determine compliance with the limit. Both sulphur plant incinerators will have continuous stack emissions monitors (CSEMs). Both the old powerhouse and FGD stacks have CSEMs. Both gas turbine generators will have CSEMs. The new furnace stacks will be estimated based on sound engineering judgement, these will be equipped will facilities for stack measurements. Acid gas and hydrocarbon flaring will be determined as per the approved methodology consistent with today.

1.15 Please comment on how the requested site-wide SO_2 emission limits values compare/relate to the sulphur losses that are shown in Figure D1-4, which describes the sulphur balance calendar day rates. (*Vol. 1, p. D1-6*)

Response:
The relationship between the requested site-wide SO_2 emission limits values and the sulphur losses that are shown in Figure D1-4, is that Figure D1-4 describes the sulphur balance under normal operations calendar day rates. Suncor's definition of normal operations emissions includes sulphur emissions from all sources except when the flue gas desulphurization plant is off-line.

1.16 **Alberta Environmental Protection typically stipulates hourly and daily sulphur dioxide emission limits for sulphur recovery plants. Please advise us whether at this time Suncor would like to comment on potential emission limits for the new stack that will be associated with the sulphur recovery complex for the Millennium project.**

Response:
The new stack would require hourly and daily limits for SO_2 as per past practice. Suncor will initiate this when more detailed engineering is completed and during the drafting of the amendment to the Environmental Operating Approval.

1.17 **Please clarify whether some mine shovels will be powered by diesel engines and others by electric power. Cable shovels and hydraulic shovels are both listed in Table C2.4-6. (*Vol. 1, p. C2-77*) Briefly discuss the reasons for selecting each type of shovel, and the environmental significance from an air emissions standpoint.**

Response:
The mining operation requires the use of both types of shovels. The primary unit for overburden removal and ore mining is a large electric shovel Efficient operating practice dictates the need for smaller and more mobile diesel powered units for cleanup, selective mining and miscellaneous work. (An example of this type (23 m^3) would be a Demag 455 rated at 1680 kW (2250 HP) and with a fuel-consumption rating of 280 litres per gross operating hour.) Either type of shovel ultimately results in air emissions - the decision to use one or the other is driven by operating needs.

1.18 **Suncor has stated it will initiate discussions with mining equipment suppliers to make low NO_x a priority in their design. (*Vol. 2A, p. B3-5*) It is further indicated that mine fleet vehicles with state of the art emission control technology will be used. (*Vol. 2A, p. B5-1*) Does Suncor have a specific air emission control technology in mind? Confirm whether it is Suncor's intent to determine the availability of diesel engine designs and other types of engines with reduced air emissions, and to incorporate criteria for reduced air emissions into the selection process for new equipment, and into engine replacement and rebuilding procedures for existing equipment during mine operations.**

Response:
Suncor is participating in an industry-wide initiative to consider improvements in emissions from mobile equipment. Suncor will make its air emission priorities known to competitive suppliers and will expect them to provide the latest feasible technology for emission control. At this point, Suncor does not have a specific control technology in mind.

1.19 **On page 91 of the *Technical Reference for the Meteorology, Emissions and Ambient Air Quality in the Athabasca Oil Sands Region* it is indicated that the emission factors applied to the diesel emissions are based on a composite of emission factors obtained from a number of different sources. Please comment on the expected level of accuracy of the emission factors, considering that Suncor and Syncrude produce their diesel, and considering other site specific factors (e.g. physical environment) that may apply.**

Response:
The emission factors used by Suncor to estimate mine fleet vehicle emissions were obtained from specification sheets provided by the engine manufacturers (Caterpillar and Detroit Diesel). Emission factors were provided for each size of engine and were expressed as a mass emission per engine operating hour. Although these manufacturer supplied estimates are based on engine dynamometer tests performed under "laboratory" conditions using a specified diesel fuel, Suncor feels that they nevertheless provide a good first order estimate for vehicle emissions from the mine fleet operating out in the field and running on Suncor manufactured diesel fuel.

1.20 **Upon reviewing the predicted mine fleet emission rates in Table B3-1 as compared to Table B2-3 (*Vol. 2A, p. B3-6 and p. B2-6*), there appears to be a significant difference in the ratio of predicted NO_X to CO emissions between the Suncor estimate *(Table B3-1)* and the Syncrude estimate *(Table B2-6)*. Is this difference largely due to differences in the selected emission factors, or are there other likely reasons for this difference? If the difference is largely due to emission factors, we note that the NO_X to CO ratio is larger in the Suncor estimate, and wonder whether there is a possibility that either the CO prediction is perhaps too low or the NO_X prediction perhaps too high?**

Response:
It is uncertain why the NOx to CO ratio differs so much between the estimates provided by Suncor and those supplied by Syncrude (SCL). However, it is likely that the difference can be attributed to using different emission factors as opposed to any operational differences in equipment or fuel. The methods used by Suncor to arrive at the mine fleet emission estimates have been described in the previous response. Until Suncor understands how the SCL estimates in Table B2-3 were derived, Suncor is unable to comment on the possibility of the figures in the Project Millennium application either overestimating NOx or underestimating CO.

1.21 **Does Suncor presently have a program to monitor and minimize emissions from mine mobile sources? If such a program does not presently exist, please indicate the plans that Suncor is considering to address this issue and the type of monitoring that may be done if such a program is implemented.**

Response:
Suncor does not currently have a program to monitor emissions from mobile sources. Suncor does have a strategy to minimize NO_X emissions from mobile equipment (as part of a site-wide strategy) through minimizing energy (fuel) consumption, maintenance of units for highest efficiency and invoking best practical engine technology. Suncor is participating in an industry group to review the state of technology with regards to emissions. As a subsequent phase, Suncor will consider monitoring mobile emissions in collaboration with industry and AEP, should such monitoring add value.

1.22 **Upon reviewing the estimated fugitive emissions from tailings ponds that are presented in the *Technical Reference for the Meteorology, Emissions and Ambient Air Quality in the Athabasca Oil Sands Region*, there is a large difference in estimated nonmethane hydrocarbons (C2+) emissions for the Suncor Pond I *(Table 3-68, p 112)* as compared to the Syncrude Mildred Lake Settling Basin. *(Table 3-66, p 110)* Discuss possible reasons for these differences.**

Response:
The differences in emission rates may be due to one or some combination of the following:

- Inaccurate measurement or calculation of emission rates. This would include items such as detection limits, experimental error or fundamental assumptions.
- The type of diluent used in the separate operating plants.
- The differences in operation of the two ponds. Specifically, Pond 1 has a lower through flow than the Syncrude Lake Settling basin and is also much smaller in area.
- Physical differences between the two ponds. This may be due in part to the operational history of each pond - as well as the size of each pond.

Pond 1 is unique within the Suncor pond system, as such, it would not be unreasonable to expect differences between the behavior of Pond 1 and the Mildred Lake Settling Basin.

1.23 **Suncor has indicated that volatile organic compound (VOC) estimates in Table F3-3 in the application (*Vol. 1, p. F3-22*) reflect conservative assumptions and that to define a worst-case scenario it has been assumed that all the diluent sent to the ponds does vaporize. It is further indicated that Suncor is committed to improve its understanding of pond emissions of VOC's, in order to understand the pond emission phenomena and to take appropriate mitigative actions. Suncor has**

initiated a task force to understand and establish an action plan for this issue. (*Vol. 1, p. F3-22*) Please provide further details about the make-up of this task force, and when an action plan is expected to be established.

Response:
The task force is composed of Suncor technical staff from Environmental, Upgrading and Extraction areas and led by Extraction process engineering.

Suncor's action plan to investigate and understand pond emissions is intended to:

- identify alternative means to mitigate the loss of diluent hydrocarbons to the atmosphere
- improve the model for predicting the behaviour of diluent hydrocarbons sent to tailings ponds, including an understanding of the variability in the field data collected to date
- identify whether existing, accumulated hydrocarbon (including bitumen) in Pond 1 contributes significantly to emissions.

There are two phases to the program. Phase 1 work includes:

- thorough definition of the main operating modes that affect diluent discharge to the tailings pond
- review of plant data for selected examples of these modes
- creating an improved conceptual model for the key phenomena that influence VOC emissions from the tailings pond
- sampling and analysis of the Pond 1 water/sludge column and selected streams
- definition of a recommended sampling and analysis campaign for the latter half of the summer

Phase 2 work will be the assessment and recommendation of options that reduce emissions based on learnings achieved in Phase 1. Phase 2 will also likely include more follow-up measurement and monitoring to verify Phase 1 learnings and/or refine the information

1.24 **Suncor has stated that total reduced sulphur (TRS) emissions from pond 2/3 have been assumed to scale up with production levels from Baseline production levels. This likely over-estimates TRS emissions since TRS from the ponds is believed to be a biogenic emission. (*Vol. 1, p. B3-6*) Please provide further details on why Suncor believes that the TRS emissions are biogenic in nature. Also, clarify what studies or investigations Suncor is doing, or will be doing, to reduce uncertainty about biological activity in the tailing ponds that may be causing emissions.**

Response:

This statement is not entirely correct. Suncor believes that diluent contains enough TRS to warrant the assumption that TRS emissions increase linearly with diluent loss rate. Also, biogenic emission values are likely increasing from baseline levels. The investigative program to address the entire issue, including the biological component is described in 1.23 above.

1.25 **It is stated that the results in Table B3-12 (*Vol. 2A, p. B3-42*) and Table B3-13 (*Vol. 2A, p. B3-46*) indicate that the predicted concentrations of total reduced sulphur (TRS) compounds could potentially lead to the detection of odours, originating from the development in the oil sands area, by sensitive individuals. (*Vol. 2A, p. B3-46*) Discuss any mitigation plans that Suncor has developed for odour controls in case the frequency and magnitude of odour events does increase.**

Response:
TRS compounds are one suite of compounds that could cause odour complaints. Main sources include Pond 1, extraction operations associated with diluent, fugitive emissions from Upgrading operations and upset conditions (flares).

Suncor has reduced the potential for these sources to cause odour complaints over the past few years with such improvements as the Vapour Recovery Unit, diluent quality control, and Naphtha Recovery Unit efficiency.

Further improvements include diluent modifications, leak detection program in Upgrading, and improved reliability and reduction of continuous flaring. The program for investigating VOC emissions from Pond 1 and evaluating controls has been described in other responses.

1.26 **As part of Project Millennium, Suncor has stated that it will undertake modification of the diluent (e.g., narrower boiling range, and less benzene and light ends) for use in secondary extraction to improve recovery in the naphtha recovery unit (NRU) and reduce volatile organic compound (VOC) emissions from diluent. Please provide further details about when this modification is expected to be completed, and the anticipated degree of effect that it will have on VOC emissions and potentially odorous emissions.**

Response:
Suncor proposes to introduce a reformulated "heart cut" diluent with Project Millennium. The heart cut diluent would have a narrower boiling range (200°F to 400°F) as compared to the current diluent (175°F to 450°F). The narrower boiling range of the heart cut diluent is more within the recovery range of the NRU (425°F to 450°F).

This will result in the following benefits:

- The increased initial boiling point of the heart cut diluent will result in a benzene reduction of approximately 80% as compared with the current diluent. Therefore benzene emissions from the pond tailings pond are expected to be reduced by a similar amount.
- An increase in total diluent recovery of 5% to 8% because of higher overall volatility.

This modification to diluent quality will be implemented as part of the Millennium Upgrader.

1.27 **Suncor has indicated that it will be installing a new larger vacuum column and upgrading the overhead circuit in the naphtha recovery unit (NRU) to handle the new production rates. (*Vol. 2A, p. B5-1*) It is further indicated that the existing NRU tower will be utilized when the new tower is down for planned maintenance. (*Vol. 1, p. B2-13*) Will the existing tower also be utilized as a backup/contingency during unplanned outages of the new tower? Will production rates be reduced to accommodate the smaller existing NRU tower, or will diluent recovery efficiency be sacrificed during such time periods? If production is not going to be reduced, has Suncor considered installing full redundancy in the NRU system at the Millennium production rates (e.g., two units that could each handle full flow), or any other contingencies to prevent odour incidents (such as the May 1998 incident) from occurring during such time periods?**

Response:
Suncor believes based on experience and improvement in NRU tower reliability that the reliability of the new NRU tower can be maintained to prevent the suggested event. Should this event occur, Suncor will evaluate the most effective measure to control diluent losses and to mitigate their potential impact on the environment. Suncor will evaluate all options including reduced production rates and act diligently consistent with our business and environmental practices.

1.28 **Sour water recovered through the upgrading process is treated in a sour water stripper. (*Vol. 1, p. B3-31*) It is our understanding that the sour water stripper bottoms are normally sent to the naphtha recovery unit (NRU) for further processing. Please clarify whether any contingencies will be provided for handling this material when the NRU is down in order to prevent odour incidents.**

Response:

Suncor has no contingency for handling the stripped sour water stream during NRU outages. However, stripped sour water efficiency and reliability have improved, such that Suncor is confident that this stream does not cause off-site odour problems. Any upsets within the sour water stripper during NRU outages will be addressed through mormal control procedures

1.29 **Please advise us whether Suncor has considered the feasibility of installing some type of vapour control systems downstream from the naphtha recovery unit (NRU), or modifying operational practices, in order to further reduce volatile organic compound (VOC) and odorous emissions from the ponds. For example, has any research been done on the potential feasibility and effectiveness of installing facilities to collect vapours from the discharge pipe, or to cool this tailings stream prior to discharge, or to discharge this stream at a point below the water surface, in order to reduce pond emissions?**

Response:
Suncor has considered some of these options. For example, pilot work was conducted to evaluate the feasibility of recovering hydrocarbon from the plant 4 tailings stream, with limited success. With regard to temperature, the new process being proposed that mixes Plant 16 tailings with the Bitumen Recovery from Tailings (BRFT) overflow will have a reduced temperature, thereby lowering volatilization potential. Suncor has also considered below surface tailings discharge and has concluded that operational issues such as sand build-up, especially in the winter, make this option impractical.

Diesel Fuel

1.30 **Suncor has indicated that the Diesel Hydrotreater Unit 1 will result in an improved product quality that should result in lower NO_X and particulate emissions (from internal and external customer equipment) using this fuel. (*Vol. 1, p. C3-144*) Please comment on how the quality of this fuel, from an air emissions standpoint, compares to diesel fuel commercially sold in North America. Also, clarify whether Suncor is manufacturing the diesel to a recognized set of established specifications.**

Response:
The Millennium Diesel Hydrotreater Unit has been designed to produce a diesel fuel that will comply with the National Standard of Canada for Automotive Diesel Fuels - Canadian General Standards Board CGSB-3.6-M88. This is a general industry diesel fuel quality standard across Canada.

Diesel fuels with poor ignition qualities, high boiling ranges, high viscosity, and high levels of carbon residue, water and sediment tend to promote engine misfiring, low fuel economy, engine deposits, rough operation, smoke and odour emissions. Compared to the CGSB Standard, the Millennium diesel fuel will have a higher ignition quality by exceeding the 40 minimum cetane number and <0.05% sulphur content. The diesel fuel distillation range will also be lower resulting in lower values of carbon residue, water and sediment, and ash compared to the CGSB standard.

1.31 **It is indicated that Suncor is currently participating in a Canadian Oil Sands Network for Research and Development (CONRAD) research project on diesel emissions from oil sands-derived feed stocks. (*Vol. 1, p. C3-155*) Please indicate when results from the research project may become available and how they might be used.**

Response:
The study is a CONRAD project in conjunction with several other companies. The engine emissions from diesel fuel are being studied with respect to NO_X , particulate matter and aromatics. By comparing oil sands derived diesel fuel with conventional oil derived diesel fuel, the industry will be able to determine if there are any differences and/or areas of either concern or benefit with respect to the different feedstocks. The

data from this study will allow industry to act in a knowledgeable manner to deal with related environmental issues. The study is expected to be completed in late 1998.

Vapour Recovery Unit

1.33 **Suncor indicates that the existing Vapour Recovery Unit (VRU) will be used to recover and treat vapours resulting from additional froth treatment facilities, and additional tankage, if installed. (*Vol. 1, p. C3-55*) It is our understanding that the existing VRU was designed with three stages of recovery, but that the third stage has not been operational. Is Suncor planning to enhance or modify the VRU as part of the Project Millennium? Will any backup or contingencies be available for time periods when the VRU is down, and if not, could a potential for odours exist during such time periods?**

Response:
The VRU is now operational and is capturing about 94% of the vapours from the sources it serves. Plans are in place to improve the recovery further. Based on the current projections of vapour emissions at Project Millennium rates, the current VRU has sufficient capacity for the increased load. If it is determined that the increased flows will exceed the capacity of the current unit, Suncor will install the necessary equipment to ensure these emissions are collected. With respect to the downtimes, Suncor does not have any contingencies, as justified by the high service factor.

Air Quality Modelling

1.34 **Suncor states that four years of observed meteorological measurement from the Suncor Mannix Station (75m level) were used in the modelling. (*Vol. 2A, p. B3-7*) However, some figures for predicted maximum hourly and daily SO_2 concentration contain a note that indicates that the results are based on a one year simulation (i.e., *Figures B3-2, B3-3, B4-2 and B4-3*) while others do not contain such a note. (i.e., *Figures B2-7 and B2-8*) Please clarify the duration of the meteorological time-series that were used in the modelling for predicting SO_2 concentrations in the Baseline Setting, *(Vol. 2A, Section B2)* the Project Impact Assessment *(Vol. 2A. Section B3)* and the Cumulative Effects Assessment. *(Vol. 2A, Section B4)* If the time-series are not all identical, the applicable SO_2 concentration modelling should be redone with a four year time series, so that baseline SO_2 contours can be properly compared to the future scenarios.**

Response:
The intent was to use a full four years of meteorological data from the Suncor Mannix Station (75m) level in the dispersion modelling. Most of the dispersion modelling

results do correspond to this four year period. However, to have sufficient time to incorporate refined emission estimates in the assessment document, it was necessary to run the Project Millennium and Cumulative Effects Assessment SO_2 modelling runs with only a one year data set. Dispersion modelling runs for the full four year period have been completed and the results are incorporated into the additional information on SO_2 modelling included in this submission (see Section B2).

1.35 **With regards to Table III-12 in Appendix III, Suncor has noted that the ISCBE model maximum ground level concentration predictions are 80% of the observed extreme sulphur dioxide concentrations at the ambient monitoring locations. (*Vol. 2D, p. III-26*) It is noted that the emission rates for the model predictions were based on stream day rates that do not necessarily reflect hourly fluctuations in production levels or unpredictable upset conditions, yet these variations may be captured in the ambient monitoring data. (*Vol. 2D, p. III-21*) Please provide further discussion and/or information on what the maximum ground level concentrations of sulphur dioxide may be if the plants are emitting at their maximum licensed emission rates, or if an upset condition exists.**

Response:
Variation in flows is, by necessity, a normal part of Suncor's operation. Suncor's operating approval recognized this reality with annual, daily and hourly emission limits. It is these hour to hour fluctuations that typically result in differences between the modelled maximum concentrations and the maximums observed at the monitoring stations. Nevertheless, the calendar-day emission rates used for modelling have been estimated allowing for upset conditions resulting in increased gas flaring.

During upset conditions, higher than average 1-hour concentrations of SO_2 can be expected to occur in the immediate vicinity of the facility. Suncor has implemented a number of measures to eliminate the occurrences of upset conditions or to minimize their duration should they occur. In addition, the Millennium Upgrader has been designed to allow operational continuation when the Base Upgrader is shut down, and vice versa.

Since the plant is not expected to run in the "upset" mode for any significant duration of time, dispersion modelling of these high instantaneous rates has not been done.

1.36 **Suncor has noted that the methodology for predicting potential acid input (PAI) on a regional scale using the CALPUFF model has only been applied in a limited number of cases and the experience of applying and interpreting the model predictions is undergoing development. (*Vol. 2A, p. B2-51*) What type of further work does Suncor anticipate being conducted in this regard, and who would likely participate in the work?**

Response:
Suncor recognizes the uncertainties associated with quantification of environmental effects associated with acidifying emissions in the oil sands

region. Suncor was one of the founding members of the Regional Air Quality Coordinating Committee and is currently actively involved in the efforts of the Wood Buffalo Air Monitoring Zone monitoring programs.

Suncor is committed to enhancing the current level of activity associated with monitoring of environmental effects associated with acidifying emissions, as well as to decreasing uncertainties associated with background values. Activities that will be sponsored by Suncor, in cooperation with other members of the Wood Buffalo Environmental Association may include:

- completion of a regional assessment of forest resources to monitor for effects associated with acidic deposition; and
- resampling of waters from lakes in the oil sands regional study area that were identified as moderately or highly sensitive to acidic deposition following sampling by Saffran and Trew (1996).

The resolution of issues associated with effects of acidifying emissions may include:

- collection of additional monitoring information;
- collaboration with other regional developers and independent researcher to includd consideration of information from other studies to assess effects of acidifying emissions;
- comparison of identified effects with predictions made in the EIA;
- identification of additional studies required to quantify effects; and
- identification of additional mitigation options to reduce emissions, if required

Reference:

Saffran K.A. and D.O. Trew. 1996. Sensitivity of Alberta lakes to acidifying deposition: an update of sensitivity maps with emphasis on 109 northern lakes. Water Sciences Branch. Water Management Division, Alberta Environmental Protection. July 1996.

1.37 **Upon reviewing Table 3-58 in the *Technical Reference for the Meteorology, Emissions and Ambient Air Quality in the Athabasca Oil Sands Region* it appears that the highway and residential sources were modelled as area sources, as were the mine pits. Please explain why this source type was chosen. Also, please provide further information about references and/or calculation methods for emissions from these sources.**

Response:
The caption in Table 3-58 of the "Technical Reference for the Meteorology, Emissions and Ambient Air Quality in the Athabasca Oil Sands Region" is misleading in that it suggests these sources were modelled as pits. The

dispersion modelling analysis was actually performed with these sources represented as area sources. Each of the area sources were modelled using the widths, lengths, areas and rotation angles listed in Table 3-58. The sources were also given an initial vertical term to account for the relative source heights. The following table provides additional information about the modelling source characteristics.

Modelled Source Characteristics for Highway and Residential Sources

Parameter	Highway	Fort. McKay	Fort. McMurray
UTM location North	462,507	468,100	476,008
UTM location East	6,331,720	6,337,400	6,282,130
East-West Width [km]	0.030	0.5	5.0
North-South Width [km]	28	0.5	5.0
Area [km^2]	0.84	0.25	25
Rotation Angle [°]	78	0	0
Initial Vertical Dispersion [m]	3	7	15

1.38 **Upon reviewing Table III-8 it appears that CALPUFF predicts NO_X concentrations near the mine pits which are lower than the ISC3BE prediction. (*Vol. 2D, p. III-43*) However, predicted NO_2 concentrations appear to be much higher by the CALPUFF model than those predicted by ISC3BE. (*Figures B2-16 through B2-21*) Suncor has provided discussion on the NO_X to NO_2 conversion methods that each model uses. Please provide a comparison of the two methods, as well as any supporting rationale to choose one method for use in modelling in this region.**

Response:
The NO_2 concentrations presented in the EIA do not represent the direct dispersion of emitted pollutants. The predictions are the result of chemical transformations being applied to the modelled NO_X concentrations. In the case of the ISC3BE predictions, the model was used to calculate ambient NO_X concentrations which were then converted to NO_2 using an empirical relationship derived in the oil sands region (Vol. 2A, p. B2-35). This approach was previously discussed with AEP and Environment Canada personnel (10 March 1998 in the AEP offices in Edmonton). The CALPUFF model performs a similar conversion internally using algorithms derived from the US EPA MESOPUFF dispersion model. The MESOPUFF algorithms were developed to simulate the chemical transformations which occur at medium to long-range distances (i.e., greater than 10 km) from large sources of emissions. The predictions of NO_2 made using the CALPUFF model are not consistent with the current observational data available in the oil sands region.

Ambient NO_2 and NO_X data in the oil sands region are limited to the historic data collected in Fort McMurray and the data collected adjacent to the active

Syncrude mine area. The new monitoring stations commissioned in the region will provide a more complete picture of the ambient NO2 and NOx concentrations which can then be utilized to enhance the understanding of the NO_2/NO_X chemistry in the region. These monitoring results are expected to be available near the end of 1998.

1.39 **Volatile organic compound (VOC) predicted concentrations at Baseline conditions are discussed. (*Vol. 2A, p. B2-66*) Please discuss how predicted VOC concentrations compare to observed ambient data, or if such a comparison is not possible, please explain why and indicate what Suncor is doing to address this data gap.**

Response:
There have been no continuous measurements of VOCs within the oil sands region that can be compared to predicted concentrations. The new monitoring stations commissioned in the region will provide a more complete picture of the ambient VOC concentrations in the region. These can then be utilized to improve the understanding of the ambient VOC emissions, dispersion and concentrations in the region. These monitoring results are expected to be available near the end of 1998.

Limited total hydrocarbon (THC) data are available from the historic monitoring stations operated in the region ("Technical Reference for the Meteorology, Emissions and Ambient Air Quality in the Athabasca Oil Sands Region", Section 4.10, p. 177-189). These data indicate that the observed THC concentrations are significantly lower than the VOC concentrations predicted in the modelling analysis.

Predicted Ambient Air Quality

1.40 **With regards to the project impact analysis for air quality, Suncor has discussed the predicted impacts of hourly and daily sulphur dioxide (SO_2) emissions and concentrations, and has derived the environmental consequence of these impacts to be "Low". (*Vol. 2A, p. B3-49*) Please clarify whether exceedances of the Alberta 1-hour and daily SO_2 guidelines are expected to occur outside the development areas, and the magnitude and aerial extent of these exceedances. Confirm the "Low" rating for the Environmental Consequence of these exceedances, clarify how this rating was determined, and discuss if a "Moderate" environmental consequence would be more appropriate if exceedances are predicted beyond the development area.**

Response:
A limited region adjacent to the development areas was predicted to have exceedances of the Alberta 1-hour and daily SO_2 guidelines. The total area predicted to exceed the hourly SO_2 guideline of 450 $\mu g/m^3$ is 28,162 ha. While some of the impacted zone is outside the development area of 35,284 ha, the concentrations were all below the Federal Acceptable SO_2 objective, and therefore were considered to have a moderate impact magnitude. These exceedances were however, short-term in duration, of a moderate frequency, regional in geographic extent and reversible. Consideration of all of these conditions resulted in the low environmental consequence.

1.41 **Suncor has discussed predicted NO_x and NO_2 concentrations in the Cumulative Effects section in the Air Quality assessment. With respect to predicted NO_2 values by CALPUFF, clarify what is meant by "calibration of chemical conversion rates to the oil sands region". (*Vol. 2A, p. B4-13*) Is this chemical conversion calibration an issue that is being addressed in the regional industry ozone monitoring/modelling initiative, or is this a separate issue? Is there any relationship between the chemical conversion calibration and ground-truthing of CALPUFF and/or CALGRID predictions of ozone levels?**

Response:
The NO_2 concentrations presented in the EIA do not represent the direct dispersion of emitted pollutants. The predictions are the result of chemical transformations being applied to the modelled NO_x concentrations.

In the case of the ISC3BE predictions, the model was used to calculate ambient NO_x concentrations which were then converted to NO_2 using an empirical relationship derived in the oil sands region (Vol. 2A, p. B2-35). This approach was previously discussed with AEP and Environment Canada personnel (10 March 1998 in the AEP offices in Edmonton).

The CALPUFF model performs a similar conversion internally using algorithms derived from the US EPA MESOPUFF dispersion model. The MESOPUFF algorithms were developed to simulate the chemical transformations which occur at medium to long-range distances (i.e., greater than 10 km) from large sources of emissions. The predictions of NO_2 made using the CALPUFF model are not consistent with the current observational data available in the oil sands region. Therefore, calibration of the chemical conversion rates in CALPUFF to the oil sands region is a similar exercise to what was done in developing the power-law equation used as a post processing step with the ISC3BE model to relate NO_x to NO_2. Field measurements from the new air monitoring stations would be used to perform this calibration and to enhance the understanding of the NO_2/NO_x chemistry in the region. These monitoring results are expected to be available near the end of 1998.

It has not yet been decided if this calibration work should be undertaken by the new ozone committee formed within the Wood Buffalo Environmental Association. The matter will certainly be discussed by that group prior to proceeding.

1.42 **Given that in the project impact assessment (*Vol. 2A, Section B3*) the maximum predicted sulphur dioxide (SO_2) concentrations (hourly, daily, and annual) are in excess of the Alberta Ambient Air Quality Guidelines, discuss any potentially viable actions that Suncor has considered, or is presently considering, to further reduce SO_2 emissions such that exceedances of the provincial guidelines may be avoided.**

Response:
To further reduce SO_2 emissions Suncor will examine cost effective measures to further increase FGD reliability and SO_2 recovery. Additionally, Suncor plans to convert the coke-fired boiler backup-combustion-system from gas oil and kerosene to natural gas in 1999.

1.43 **Given that some of the maximum predicted nitrogen dioxide (NO_2) concentrations (daily, annual) in the project impact assessment (*Vol. 2A, Section B3*) are in excess of the guideline levels, discuss any potentially viable actions that Suncor has considered, or is presently considering, to further reduce emissions of NO_x such that exceedances of provincial and federal guidelines for NO_2 may be avoided.**

Response:
To minimize NO_x emissions, Suncor plans to install highly efficient natural gas turbine generators, waste heat recovery steam generators and steam turbine generators in a full co-generation arrangement. For the existing coke-fired boilers, modifications to expand capacity and install overfired air equipment for NO_x control are progressing. The most recent such modification to Boiler No. 2, completed in late 1997, successfully reduced NO_x emissions by about 40% during initial testing, well above the anticipated 20% reduction. Boiler No. 3 modifications are underway and Boiler No. 1 modifications are planned for completion in 1999.

Acid Deposition

1.44 **With regard to the discussion of total potential acid input, please note that the summary of the information in Fox et al (paper in press) appears to be**

incorrect. (*Vol. 2A, p. B2-17*) Please clarify Suncor's suggestion that acid deposition should be more closely monitored in the south than in the north, given the emissions of acidifying substances in the province relative to receptor sensitivities.

Response:
The discussion on Potential Acid Input (PAI) in the EIA (vol. 2A, pB2-17) contains a simplified summary of the information referenced from Fox et al. (paper in press). Although the document has not been yet been published, it was Suncor's understanding that the paper had been submitted for publication to the Air and Water Management Association. The document provides a summary of valuable information regarding RELAD modelling results which are useful for discussion purposes.

The basis of the emissions data used in the RELAD modelling summarized in the Fox et al. paper was "The 1990 National Criteria Pollutant Inventory" (The National Emission Inventory and Projection Task Group). As noted in the EIA (Vol. 2A, pB2-17) there were significantly higher emissions of SO_2 and less emissions of NO_x in the oil sands region in 1990 than is currently projected.

One of the conclusions drawn in the paper from the RELAD modelling results was that "... on a regional scale, effects of urbanization, power generation and transportation increases may overwhelm effects due to expansion in the Oil Sands region". The document goes on to indicate that "... for Alberta the southeastern parts of the province and potentially the province of Saskatchewan to the east are the regions that need to be more carefully monitored for potential acidification effects". Suncor has supported, and continues to support the efforts in enhanced air quality and acidification deposition monitoring in the oil sands region independent of the efforts that Fox et al. suggest are required for other parts of the province.

1.45 **Uncertainty regarding the amount of background potential acid input (PAI) is described and discussed by Suncor. (*Vol. 2A, p. B3-22*) Included in this discussion is the potential for "double-counting of PAI". What studies, investigations, or other activities is Suncor willing to initiate in order to address the uncertainty regarding background PAI and how would this be applied in reducing uncertainty identified in the EIA?**

Response:
Please refer to the response to Question AEP 1.36.

1.46 **In the Air Quality Conclusion it is indicated that the predicted potential acid input (PAI) exceeds the interim critical loading for sensitive soils over**

an area of 861,263 hectares. (*Vol. 2A, p. B5-5*) What is the area outside of the development area that will be subjected to a predicted PAI greater than the interim critical load (>0.25 keq H^+ ha^{-1} yr^{-1})? Of this area, what area is considered to be occupied by sensitive mineral and organic soils and aquatic systems?

Response:

Section D2.2.8 provides a complete discussion of the impacts of acidifying emissions on the soils within the regional study area (RSA).

Within the RSA, the soils have been rated for sensitivity to acidifying emissions, using a low, moderate and high classification system. Sixty-one percent of the RSA (1,419,124 ha) has low sensitivity, 586,044 ha or 24% has moderate sensitivity, and 525,441 ha or 22% has high sensitivity (Table D2.2-22).

The total area for the Project Millennium scenario to be subjected to a predicted PAI greater than the interim critical load of 0.25 keq H^+/ha/yr is 861,263 ha, of which 825,979 ha are outside the Suncor/Syncrude development areas of 35,284 ha (from Table A2-13). As noted in Table D2.2-25, the application of the interim critical load to sensitive ecosystems showed that for high sensitivity soils, Project Millennium will potentially affect 33,024 ha over and above baseline emissions; for moderately sensitive soils, the Project will affect an additional 27,755 ha above baseline; and for low sensitivity soils, the Project will affect approximately 115,713 ha more than baseline conditions.

1.47 **It is indicated that aluminium levels in excess of freshwater guideline levels have been observed in McLean Creek and the source of the aluminium is identified as natural. (*Vol. 2A, p. C3-40*) Comment on whether acid deposition to the McLean Creek watershed (basin) could increase aluminium solubilization in the basin, thus increasing the amount of aluminium found in creek water and ultimately in the receiving water body (Athabasca River)? Is this possible for other creeks in the area, which also contain apparently high levels of aluminium due to natural sources?**

Response:

Since lowering of pH increases the solubility of metals, acid pulses may contribute to aluminum loads to receiving rivers. Because a large number of streams are located within the area where an increase in acid deposition was predicted, there is no reason to assume that McLean Creek would be the only stream that may be affected by acidification.

Because metal solubility is related to pH, once stream waters carrying elevated aluminum levels mix with large volumes of well-buffered receiving rivers, one may expect that aluminum solubility will decline to correspond to the level in the receiving river (i.e., dissolved aluminum would precipitate or adsorb to particles). Therefore, the concentration of the toxic (i.e., dissolved) form of aluminum would not increase appreciably.

A large increase in the aluminum load of the Athabasca River is unlikely from tributary loads in the event of episodic acidification, because only a small proportion (16%) of the flow of the Athabasca River originates from the RSA (Shell 1998; Section F4) and any additional aluminum loading during spring pulses would be restricted to a short period of time.

Reference:

Shell Canada Limited. 1998. Application for approval of the Muskeg River Mine Project. Volume 4. Submitted to Alberta Energy and Utilities Board and Alberta Environmental Protection.

1.48 **A discussion of acid sensitive lakes is provided in Volume 2, Section C. (*Vol. 2A, p. C-63*) It should be noted that more lakes may be found to be acid sensitive in this region, as many small lakes in the region have yet to be sampled. Of the lakes sampled to date, 10 have been determined to be acid-sensitive. Please discuss the ratio of acid-sensitive lakes to the total number of sampled lakes, the estimated total number of lakes in the area and whether it is possible to estimate the potential total number of acid sensitive lakes present in the region. Discuss the type of sampling program that would be required to more clearly define the total number and geographic distribution of sensitive lakes in the region and the role that Suncor would anticipate having in developing and implementing any such program.**

Response:

It is acknowledged that the number of lakes known to be acid sensitive probably represent only a certain proportion of the total number of sensitive lakes. Using the sensitivity map based on total alkalinity (Saffran and Trew 1996), 11 of the 24 lakes sampled in the RSA are moderately to highly sensitive to acidification (sensitive lakes were defined as those with total alkalinity $\leq$20 mg/L; actual total number of lakes sampled might be slightly different because some appear on the border of the RSA). This, however, does not imply that nearly half of the lakes in the RSA are sensitive to acidification, because the available data may include a greater proportion of sensitive lakes than the actual proportion. For example, based on the sensitivity map, it appears that more lakes were sampled in the Birch and Muskeg Mountain uplands, which represent areas with sensitive lakes, than in other areas.

An extensive sampling program would be required to more clearly define the amount and distribution of acid sensitive lakes in the region. Such a sampling program would have to select lakes representative of natural subregions to arrive at unbiased results at a reasonable expenditure of resources.

Reference:

Saffran, K.A., and D.O. Trew. 1996. Sensitivity of Alberta lakes to acidifying deposition: an update of sensitivity maps with emphasis on 109 northern lakes. Water Sciences Branch, Water Management Division, Alberta Environmental Protection.

1.49 **Further to the discussion of acid sensitive lakes, (*Vol. 2A, p. C-63*) it should be noted that although less sensitive lakes may be more abundant in the region, the sensitive ones could represent rare habitats with uniquely adapted flora and fauna. Where are the sensitive lakes within the study region located in relation to the predicted acid deposition contours? What would be the environmental significance of altering these lakes?**

Response:
At the present there is no information to suggest that lakes with lower buffering capacity may represent rare habitats with unique flora and fauna. Baseline studies of sensitive lakes would be necessary to evaluate this question.

Known acid sensitive lakes are located in the Birch and Muskeg Mountain uplands, which fall outside of the highest PAI deposition contours.

The effects of acidification on aquatic life are detrimental. Reduction of pH below 6 typically causes a reduction in the number of fish species, with progressive reduction to zero (local extinction of fish) at approximately 4.7 pH units (Beggs and Gunn 1986). A similar reduction in the species richness of benthic invertebrate and plankton communities occurs in acidified lakes. Acidification can also cause shifts in community structure, such as dominance of biological communities by a few, tolerant species.

Reference:

Beggs, G.L., and J.M. Gunn. 1986. Response of lake trout (*Salvelinus namaycush*) and brook trout (*S. fontinalis*) to surface water acidification in Ontario. Water, Air and Soil Pollution 30: 711-717.

1.50 **The residual impact classification of acidifying emissions from Project Millennium on regional water bodies is discussed in the EIA. (*Vol. 2A, p. C3-65*) The environmental consequence of acid deposition on of both lakes and streams is rated as Low". It could be argued that although the chemical effect may be transitory or reversible, the biological consequences of acidifying emissions on the aquatic environment may not be (e.g., if episodic acidification resulted in a fish kill). Discuss the biological effects, and their**

magnitude and reversibility, that may occur as a consequence of a potential acidification of lakes or streams. Please discuss whether the classification of the environmental consequence as "Low" is still appropriate if biological effects are considered, along with the level of uncertainty associated with this environmental effect, or whether another classification such as "moderate" or "undetermined" may be more appropriate.

Response:
The environmental consequence of the potential impact caused by acidifying emissions was designated as low because results of the impact analysis suggested that large-scale acidification of lakes or streams is unlikely in the RSA. It is acknowledged that, on the scale of an individual sensitive lake, acidification may cause severe effects; however, the scale of the analysis was regional, which necessitated a broader approach.

The scientific literature on the effects of acidification on lakes, streams and wetlands in Canada was most recently summarized by Jeffries (1997), building on information summarized by NRCC (1980) and RMCC (1990). Based on the information summarized by these authors, the effects of acidification on benthic invertebrates and plankton are reversible upon recovery of pH. Recovery of fish populations in lakes with improving pH is also possible, but is dependent upon a number of factors (e.g., severity of acidification, degree of reduction in fish population size, availability of source population for recolonization).

As noted in the EIA, there is a high degree of uncertainty regarding predictions of impacts on water quality and aquatic life due to acidifying emissions, and there is sufficient reason for concern over the potential effects of acidifying emissions in the oil sands region. Suncor is committed to pursue further studies to enhance the predictive capability for effects of acidifying emissions by participating in regional efforts to address this issue.

References:

Jeffries, D.S. 1997. 1997 Canadian acid rain assessment (Volume 3) - The effects on Canada's lakes, rivers and wetlands. Environment Canada.

National Research Council Canada (NRCC). 1980. Acidification in the Canadian aquatic environment: scientific criteria for assessing the effects of acidic deposition on aquatic ecosystems. NRCC Publication No. 18475. 369 pp.

Research and Monitoring Coordinating Committee (RMCC). 1990. The 1990 Canadian long-range transport of air pollutants and acid deposition assessment report: Part 4 - aquatic effects. Federal/Provincial Research and Monitoring Coordinating Committee, Ottawa, Ontario, 151 pp.

1.51 **Suncor states that uncertainties associated with the soil sensitivity ratings, as well as the fact that the PAI results are generated by model simulations leads to a high level of scientific uncertainty about the predicted impact of acidifying emissions on regional soils. Therefore, the environmental consequence for the impact of acidifying emissions on soils has been rated as undetermined. *(Vol. 2B, p. D2-57)* Does this statement imply that the buffering capacity of reclamation soils (i.e. engineered soils) to acidifying emissions is also undetermined? Please discuss acidifying emissions with regard to potential impact to reclamation soils and the associated vegetative growth in the LSA.**

Response:
The buffering capacity of reclamation soils is currently evaluated as a component of the annual conservation and reclamation (C&R) program completed by Suncor in compliance with its AEPEA Approval. Within the annual C&R reports, Suncor provides information on reclamation area soils and their development. Information collected in 1996 indicated that reclamation area soils had average pH values of 7.3. These values imply that the reclamation soils are well buffered from acidic deposition. Suncor will continue to monitor its reclamation soils to allow detection of indications of acidification.

1.52 **It is indicated that the impacts of acidic deposition on aquatic and terrestrial ecosystems are difficult to predict because the effects are exceedingly complex, subtle and long-term. (*Vol. 2B, p. D2-46*) For sensitive soils in the high acidification deposition areas, where impacts could be measured, is it possible to determine what impact to tree growth may have occurred to date, and to discuss the effects to aquatic and terrestrial ecosystems? What mitigation will be done to prevent future impacts to forest resources?**

Response:
The capability to predict impacts of acidic deposition on aquatic and terrestrial ecosystems is driven by two elements. One is the level of fundamental understanding of the processes that hold aquatic ecosystems together and how they respond to different levels of natural and anthropogenic perturbation. The second relates to the need to verify the "reality" of the predicted PAI model outputs. The first can be addressed using the scientific literature to the extent that it exists. To apply this knowledge to assess potential effects, however, requires the evaluation of the correct locations. Suncor is participating in the terrestrial environmental effects monitoring (TEEM) program in an attempt to provide information that will allow this question to be answered. Suncor's strategy to reduce acid forming emissions (SO2 and Nox) is described in Vol. 1, p. F3.

1.53 **Suncor states that "field verification of soil sensitivities has not been completed" with respect to soil sensitivity to acid input. (*Vol. 2B, p. 6-33*) What studies or investigations is Suncor prepared to undertake either independently or collaboratively with regional stakeholders, to address this uncertainty?**

Response:
Field verification of soil sensitivities for the oil sands region have been initiated on a couple of fronts. Suncor, as a member of the Terrestrial Environmental Effects Monitoring (TEEM) program is involved in the assessment of soils and aspen and jack pine forests. Additionally, Syncrude Canada recently completed a study in cooperation with various research groups to evaluate the sensitivity of some regional soils. The results of that study are now available from Syncrude.

Suncor will continue to participate within the TEEM to assess the sensitivity of regional soils to acidic inputs, as well as to assess the potential effects of acidifying emissions on regional ecosystems.

1.54 **As indicated in Table G2.1-1 the impact of project emissions on deposition of acid-forming compounds is evaluated in the water quality, soils and terrestrial, and vegetation and wetlands sections, and environmental consequence ratings have been assigned in each section. (*Vol. 2C, p. G-10*) Is it possible to develop an overall environmental consequence rating for deposition of acid forming compounds? An overall rating would recognize the fact that soils, water and vegetation are all interrelated parts of the ecosystem, rather than completely separate from each other.**

Response:
Ideally, it is possible to develop an overall environmental consequence rating for the deposition of acid forming compounds. Practically, given the current state of knowledge, it is unrealistic to rate overall environmental consequence. The reason is the lack of fundamental knowledge and understanding of the interrelationships of processes within various ecosystems much less the interrelationships of processes between and among ecosystems.

1.55 **With regards to long-range movement of air contaminates, please discuss what percentage of total emissions of acidifying compounds are deposited outside of the regional study area. What amount/extent of such deposition will be due to the Millennium Project?**

Response:
A discussion of long range modelling results relating to Potential Acid Input was presented in the EIA (Vol.2A, p. B2-17). Suncor has not conducted long range modelling of Project Millennium and cumulative emissions from the region. Suncor believes this is outside of the Terms of Reference. The models used for the EIA are designed for near and medium range transport. Suncor's position is that long range modelling of acidifying emissions must be based on a larger

geographic area (i.e. Alberta) and that the larger stakeholder community must be involved. Suncor is willing to discuss any such initiatives with AEP.

Nitrogen Deposition

1.56 **Discuss the potential for increased growth and/or succession in nitrogen-deficient ecosystems that are predicted to receive increased nitrogen deposition. Given that phosphorus levels appear to be sufficient to support growth (phosphorus levels are above guideline levels; *Vol. 2B, p. C3-3*), other nutrients such as nitrogen appear to be the factor limiting growth. Please discuss whether the total Kjeldahl nitrogen and total ammonia data presented in Tables C3.1-2, C3.1-6, C3.1-8, C3.1-9, C3.1-11 are indicative of watershed nitrogen deficiency.**

Response:
The statement on phosphorus in Vol. 2A, C3-3 is specific to the Athabasca River water quality. Water quality concentrations for nutrients cannot be related to vegetation productivity in the river basin. There are many variables and pathways that ultimately determine plant growth rate, most of which are related to soils and species.

The values provided for concentrations of TKN and total ammonia are also not suitable for making predictions regarding nitrogen deficiency because they, as with phosphorus, reflect conditions in the full watershed areas, and they do not differentiate between bioavailable and non-bioavailable forms.

Particulates

1.57 **Discuss the potential for fine particulate formation ($PM_{2.5}$) as a consequence of emissions of sulphur and nitrogen containing chemical species. Describe the area in which fine particles ($PM_{2.5}$) may be elevated relative to background, and the concentrations of fine particles ($PM_{2.5}$) in this area. Discuss the environmental and health consequences which may result from these levels of fine particles ($PM_{2.5}$).**

Response:
The emissions of sulphur and nitrogen containing emissions will result in the formation of secondary aerosols in the oil sands region. These compounds will also result in increased PM_{10} and $PM_{2.5}$ concentrations. An evaluation of the primary and secondary aerosol concentrations in the region are discussed more fully in the additional information accompanying this package (see Section B4).

Ground-level Ozone

1.58 **Suncor indicates that research is ongoing to determine the most appropriate tools to predict ozone concentrations. (*Vol. 2B, p. B3-3*) Please provide an update on the status of this research, discuss intentions and timelines regarding any future research and, if available, submit the results of any new modelling that has been conducted.**

Response:
The regional issue of ground level ozone is being addressed through a separate Working Group, which identified the CALGRID model as the most appropriate tool for simulating
the ground level ozone in the oil sands region. The Working Group retained EARTH TECH to conduct the ground level ozone analysis in the oil sands region. (Note: at a recent meeting of the Wood Buffalo Environmental Association, it was decided to form an ozone committee that will manage any further work on ozone. AEP is represented on this committee.)

The CALGRID dispersion model was used to simulate the ozone forming potential within the RSA for both the Baseline Case (representing all approved emission sources) the CEA emissions scenario. The modelling was done for two episodes, namely:

- for a five day spell between May 1 and May 5, 1994 selected to represent the spring period. During this period, the peak ozone concentrations were greater than 130 $\mu g/m^3$ on most days; and
- for six days from July 25 to July 30, 1994 which was representative of the summer period. Peak ozone concentrations were above 130 $\mu g/m^3$ on one day only.

The CALMET pre-processor program was utilized by EARTH TECH to develop a 3 dimensional meteorological and geographical data file for these episodes. Detailed emissions inventories describing the magnitude, fluctuation and chemical composition of the man-made and natural emissions of ozone precursor chemicals were also developed for the same two episodes.

The preliminary modelling results indicate that during the spring, maximum hourly ozone concentrations are expected to increase by 3% under the CEA scenario, compared to the Baseline Case during the spring. During the summer, the CEA emissions would result in a 9% increase in the maximum hourly ozone concentration. A more complete discussion of the CALGRID modelling results has been included in the additional information accompanying this package (section B3).

Monitoring

1.59 **Suncor has indicated that air quality monitoring programs will include continued participation in the Terrestrial Environmental Effects Monitoring (TEEM) committee of the Wood Buffalo Environmental Association to evaluate changes in vegetation and soils resulting from air emissions. (*Vol. 2C, p. G-17*) With regard to acid deposition, for each of the cases (baseline, Millennium, CEA) the following information and analyses are requested from Suncor:**

a) **Include on the maps which display the CALPUFF deposition predictions the location of each of the accepted and established jack pine sites (10 in total);**

b) **Include on the same maps the location of the proposed aspen monitoring sites (16 in total);**

c) **For each site, determine the potential acid impact (PAI) predicted by CALPUFF;**

d) **For each site, determine the predicted proportion of the deposition of each of sulphur and nitrogen and assess whether deposition at each site is dominated by one form or the other;**

e) **Assess the suitability of each jack pine site in the determination of acid deposition amounts and effects;**

f) **Provide an opinion as to the suitability of each aspen candidate site for inclusion in the TEEM program.**

g) **Assess the suitability of the TEEM acid deposition monitoring program to address the needs for future monitoring.**

Response:
Maps are provided on the following pages showing the location of jack pine and aspen monitoring sites as well as the PAI predictions for the Baseline, Project Millennium and CEA scenarios. Details on the exact locations of the sites are provided below.

Jack Pine Locations: (H = high; L = low)

SITE	Latitude	Longitude	SITE	Latitude	Longitude
PH1	57°21'56"	111°25'52"	PL1	56°32'24"	112°16'29"
PH2	56°54'34'	111°32'19"	PL6	57°39'44"	111°10'02"
PH4	57°07'18"	111°25'18"	PL7	57°53'24"	111°26'08"
PH6	57°20'03"	111°45'26"	PL8	56°42'14"	109°55'35"
PH7	57°25'38"	111°34'31"	PL9	57°32'28"	111°05'29"

Aspen locations: (H = high; L = low)

SITE	Latitude	Longitude	SITE	Latitude	Longitude
AH2	57°11'52"	111°43'34"	AL2	56°16'05"	111°00'22"
AH5	57°25'59"	111°23'03"	AL4	57°25'01"	110°55'54"
AH6	57°26'06"	111°43'19"	AL5	57°54'33"	111°32'26"
AH7	56°49'51"	111°46'15"	AL7	56°41'19"	112°34'34"
AH8	57°02'57"	111°13'54"	AL8	57°06'36"	112°02'37"

The predicted PAI, sulphur-based deposition and nitrogen based deposition at each of these stations are summarized in the following three tables for the Baseline, Millennium and CEA cases, respectively.

Summary of CALPUFF Deposition Prediction for the Baseline Emissions Case

Station	Distance km [a]	Direction [a]	PAI keq/ha/y	Sulphur keq/ha/y	Nitrogen keq/ha/y	Proportion of Deposition
Jack Pine Sites (H = high; L = low)						
PH1	36.9	N	0.41	0.11	0.21	Sulphur deposition dominates
PH2	11.0	SSW	0.71	0.32	0.29	Sulphur deposition dominates
PH4	13.1	NNE	0.56	0.18	0.27	Nitrogen deposition dominates
PH6	40.6	NNW	0.36	0.13	0.13	Nitrogen deposition dominates
PH7	48.6	N	0.33	0.08	0.14	Nitrogen deposition dominates
PL1	67.8	SW	0.20	0.06	0.03	Sulphur deposition dominates
PL6	80.7	NNE	0.16	0.04	0.02	
PL7	97.1	N	0.17	0.05	0.03	Nitrogen deposition dominates
PL8	86.5	ESE	0.14	0.02	0.01	
PL9	62.1	NNE	0.18	0.05	0.04	
Aspen Sites (H = high; L = low)						
AH2	24.4	NW	0.63	0.20	0.33	Nitrogen deposition dominates
AH5	48.2	N	0.30	0.09	0.11	Nitrogen deposition dominates
AH6	51.0	NNW	0.30	0.09	0.11	Nitrogen deposition dominates
AH7	26.2	SW	0.46	0.19	0.17	Sulphur deposition dominates
AH8	14.6	ENE	0.44	0.16	0.18	Nitrogen deposition dominates
AL2	85.4	SSE	0.14	0.03	0.01	
AL4	57.9	NE	0.19	0.05	0.04	
AL5	97.3	N	0.18	0.05	0.03	Nitrogen deposition dominates
AL7	72.2	WSW	0.14	0.03	0.02	
AL8	34.3	WNW	0.23	0.05	0.09	Nitrogen deposition dominates

(a) Distance/direction from Suncor fixed plant area.

Summary of CALPUFF Deposition Prediction for the Project Millennium Emissions Case

Station	Distance km [(a)]	Direction [(a)]	PAI keq/ha/y	Sulphur keq/ha/y	Nitrogen keq/ha/y	Proportion of Deposition
Jack Pine Sites (H = high; L = low)						
PH1	36.9	N	0.47	0.12	0.25	Nitrogen deposition dominates
PH2	11.0	SSW	0.86	0.39	0.37	Sulphur deposition dominates
PH4	13.1	NNE	0.71	0.23	0.38	Nitrogen deposition dominates
PH6	40.6	NNW	0.39	0.14	0.15	
PH7	48.6	N	0.36	0.09	0.17	Nitrogen deposition dominates
PL1	67.8	SW	0.20	0.07	0.04	Sulphur deposition dominates
PL6	80.7	NNE	0.17	0.04	0.03	
PL7	97.1	N	0.18	0.05	0.03	Sulphur deposition dominates
PL8	86.5	ESE	0.15	0.02	0.02	
PL9	62.1	NNE	0.20	0.05	0.05	
Aspen Sites (H = high; L = low)						
AH2	24.4	NW	0.69	0.22	0.37	Nitrogen deposition dominates
AH5	48.2	N	0.34	0.10	0.14	Nitrogen deposition dominates
AH6	51.0	NNW	0.33	0.10	0.13	Nitrogen deposition dominates
AH7	26.2	SW	0.52	0.21	0.21	
AH8	14.6	ENE	0.73	0.20	0.43	Nitrogen deposition dominates
AL2	85.4	SSE	0.14	0.03	0.02	
AL4	57.9	NE	0.21	0.06	0.05	
AL5	97.3	N	0.19	0.05	0.03	Sulphur deposition dominates
AL7	72.2	WSW	0.15	0.03	0.02	
AL8	34.3	WNW	0.26	0.05	0.11	Nitrogen deposition dominates

(a) Distance/direction from Suncor fixed plant area.

Summary of CALPUFF Deposition Prediction for the CEA Emissions Case

Station	Distance km [(a)]	Direction [(a)]	PAI keq/ha/y	Sulphur keq/ha/y	Nitrogen keq/ha/y	Proportion of Deposition
Jack Pine Sites (H = high; L = low)						
PH1	36.9	N	0.43	0.22	0.11	Sulphur deposition dominates
PH2	11.0	SSW	0.94	0.38	0.46	Nitrogen deposition dominates
PH4	13.1	NNE	0.45	0.29	0.06	Sulphur deposition dominates
PH6	40.6	NNW	0.54	0.15	0.28	Nitrogen deposition dominates
PH7	48.6	N	0.76	0.13	0.52	Nitrogen deposition dominates
PL1	67.8	SW	0.22	0.06	0.06	
PL6	80.7	NNE	0.26	0.06	0.10	Nitrogen deposition dominates
PL7	97.1	N	0.25	0.06	0.09	Nitrogen deposition dominates
PL8	86.5	ESE	0.17	0.03	0.04	
PL9	62.1	NNE	0.36	0.08	0.18	Nitrogen deposition dominates
Aspen Sites (H = high; L = low)						
AH2	24.4	NW	0.90	0.23	0.57	Nitrogen deposition dominates
AH5	48.2	N	0.86	0.16	0.60	Nitrogen deposition dominates
AH6	51.0	NNW	0.51	0.12	0.29	Nitrogen deposition dominates
AH7	26.2	SW	0.58	0.21	0.27	Nitrogen deposition dominates
AH8	14.6	ENE	1.00	0.25	0.65	Nitrogen deposition dominates
AL2	85.4	SSE	0.18	0.03	0.05	Nitrogen deposition dominates
AL4	57.9	NE	0.37	0.08	0.18	Nitrogen deposition dominates
AL5	97.3	N	0.26	0.06	0.10	Nitrogen deposition dominates
AL7	72.2	WSW	0.16	0.03	0.03	
AL8	34.3	WNW	0.31	0.06	0.15	Nitrogen deposition dominates

(a) Distance/direction from Suncor fixed plant area.

The suitability of each site in determination of acid deposition amounts and effects is the subject of the TEEM efforts. Based on the PAI levels for each site,

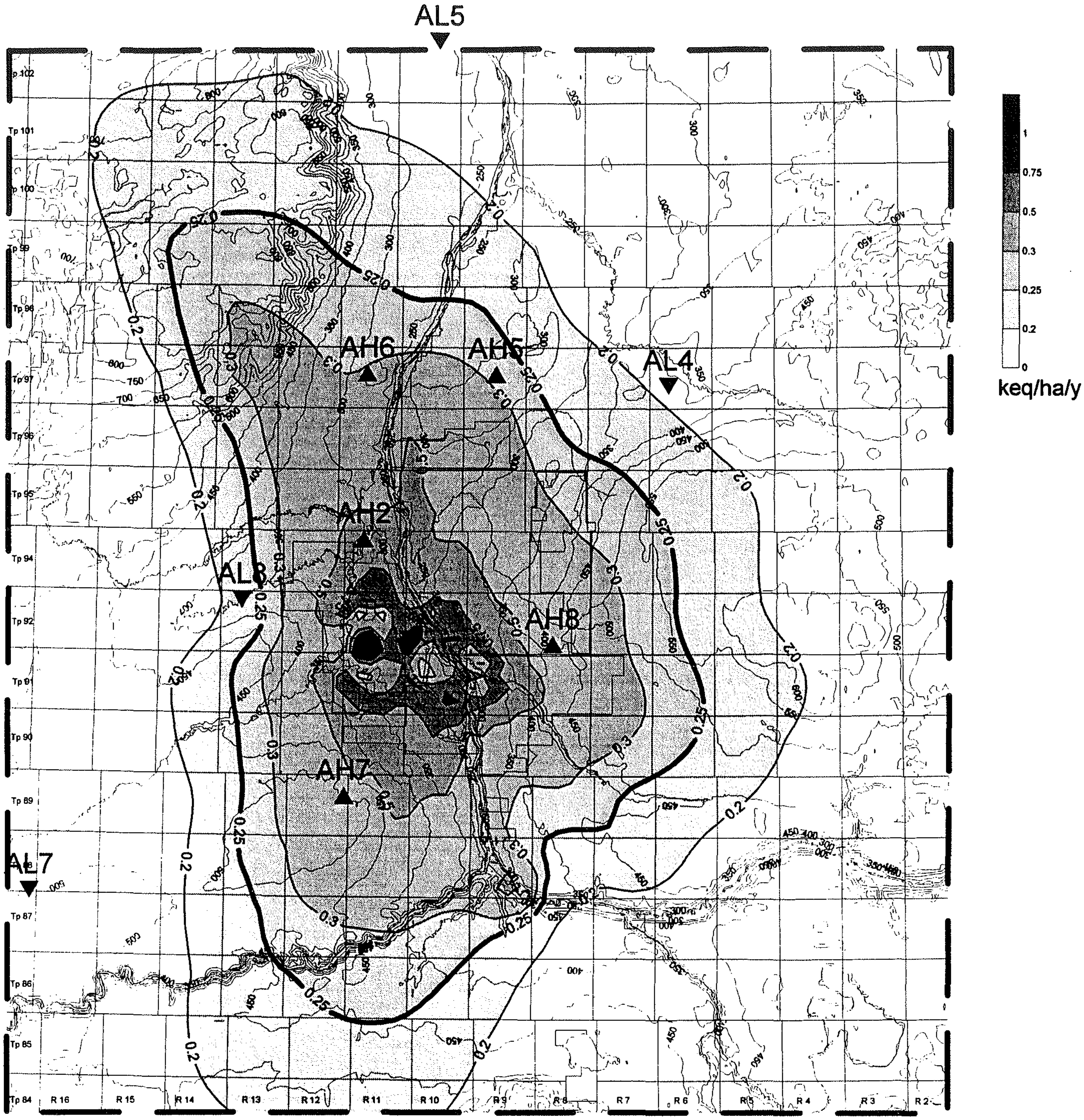
as shown in the above tables, the sites are suitable for relative high and low deposition areas. Details on
the results of the first year of assessment are provided in the draft project reports (Conor 1997, Conor and Landcare 1997).
The suitability of each of the candidate aspen sites is discussed in detail in the report "Environmental Effects of Oil Sand Plant Emissions in Northeastern Alberta, Regional Effects of Acidifying Emissions, 1997 Annual Report - Aspen Site Selection" (Conor and Landcare 1997).

Suncor supports the efforts of the Wood Buffalo Environmental Association and its TEEM program to assess the impacts of acidifying emissions in the oil sands region. As a participant in the program, Suncor believes that the assessment of the suitability of the monitoring program is best completed by the TEEM program members rather than by a single member of the group.

References:

Conor Pacific Environmental. 1997. Examination of Jack Pine Plots near Fort McMurray, Alberta. Prepared for Environmental Effects Subcommittee of the Southern Wood Buffalo Regional Air Quality Coordinating Committee. December 1997.

Conor Pacific Environmental and Landcare Research & Consulting Inc. 1997. Environmental Effects of oil sand plant emissions in northeastern Alberta, Regional Effects of Acidifying Emissions, 1997 Annual Report - Aspen Site Selection. Prepared for Environmental Effects Subcommittee of the Southern Wood Buffalo Regional Air Quality Coordinating Committee.



AL2

Sources	SO_2 [t/cd]	NO_x [t/cd]
Suncor		
Powerhouse	13.1	3.9
FGD	18	29.8
Incinerator	18.8	0.1
Flaring	12.6	0.1
Other Sources, Suncor	2.8	13.8
Syncrude (total)	209	44.4
Other Emissions (total)	4.1	10.1
TOTAL	278.4	102.2

Model Predictions	
Development	Baseline
Model	CALPUFF
Critical Loading [keq/ha/y]	0.25
Maximum [keq/ha/y]	24.6

UTM NAD83 metres
0 5000 10000 15000 20000

LEGEND

▲ AH =Aspen (High)

▼ AL = Aspen (Low)

TEEM Tree Sites on Predicted Baseline Potential Acid Input (PAI) Isopleths

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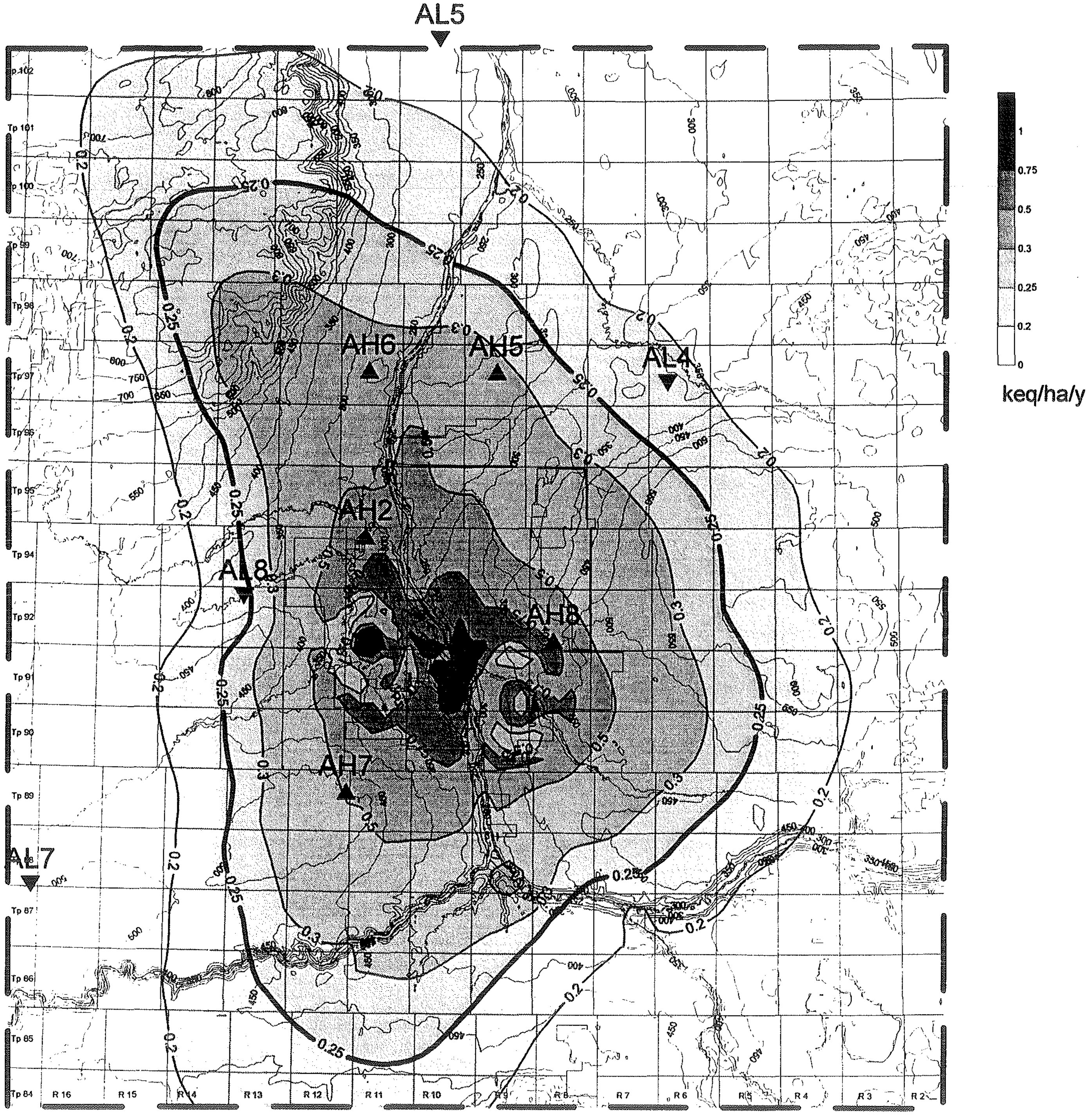

Sources	SO_2 [t/cd]	NO_x [t/cd]
Suncor		
Powerhouse	14	2.9
FGD	18.7	29.7
Incinerator	12.3	0.064
Flaring	10.6	0.191
Tail Gas Treatment Unit	6.4	0.03
Other Sources, Suncor	5.9	34.8
Syncrude (total)	209	44.4
Other Emissions (total)	4.2	10.1
TOTAL	281.1	122.185

Model Predictions	
Development	Project Millennium
Model	CALPUFF
Critical Loading [keq/ha/y]	0.25
Maximum [keq/ha/y]	24.7

LEGEND

▲ AH =Aspen (High)

▼ AL = Aspen (Low)

TEEM Tree Sites on Predicted Millennium Potential Acid Input (PAI) Isopleths

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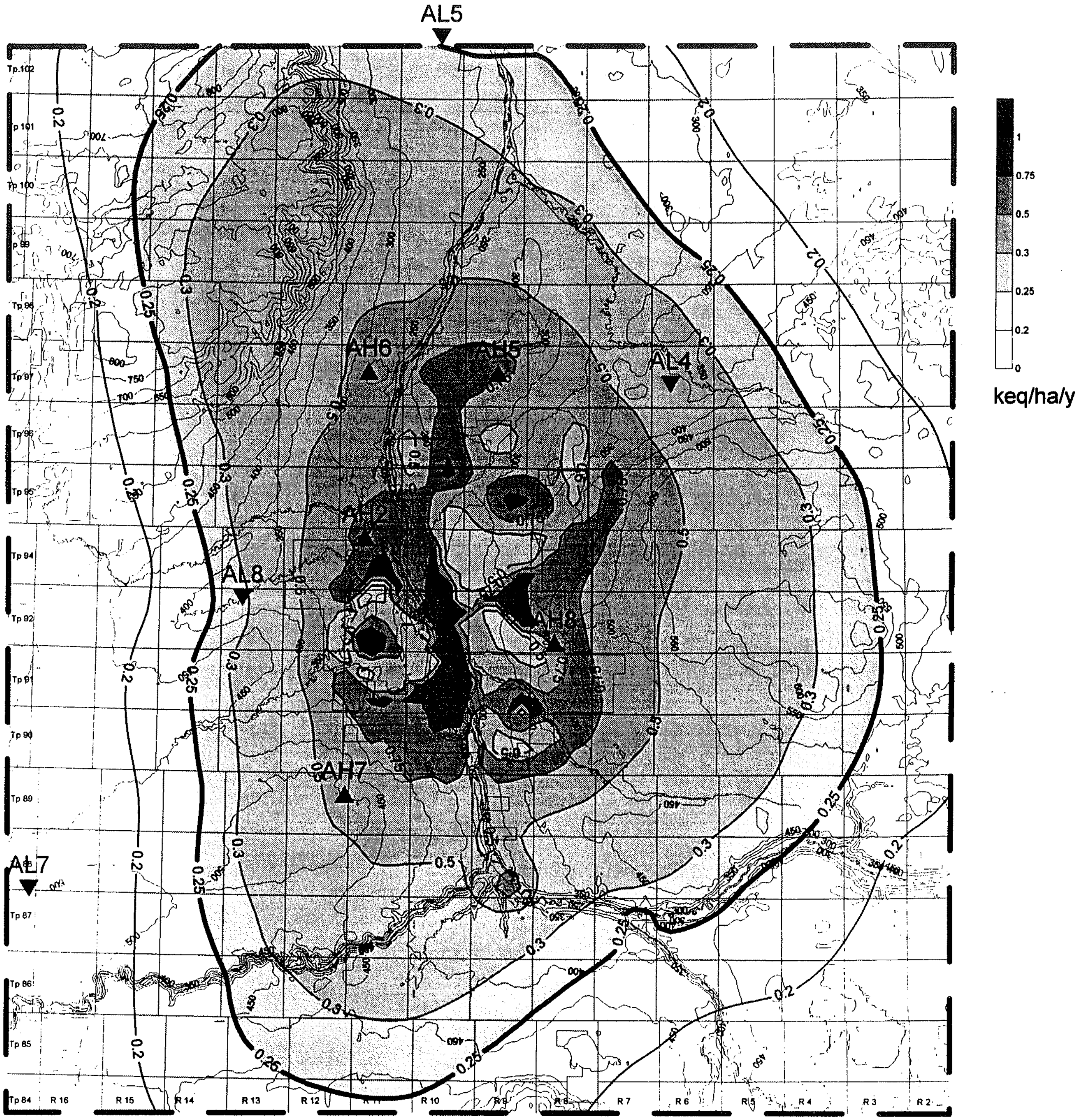
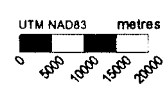


Sources	SO_2 [t/cd]	NO_x [t/cd]
Suncor		
Powerhouse	14	2.9
FGD	18.7	29.7
Incinerator	12.3	0.06
Flaring	10.6	0.19
Tail Gas Treatment Unit	6.4	0.03
Other Sources, Suncor	5.9	34.8
Syncrude (total)	199	63.9
Other Emissions (total)	4.2	10.9
Other Proposed Emissions (total)	18.8	60.9
TOTAL	289.9	203.4

Model Predictions	
Development	CEA
Model	CALPUFF
Critical Loading [keq/ha/y]	0.25
Maximum [keq/ha/y]	24.5



LEGEND

▲ AH =Aspen (High)

▼ AL = Aspen (Low)

TEEM Tree Sites on the Predicted CEA Potential Acid Input (PAI) Isopleths

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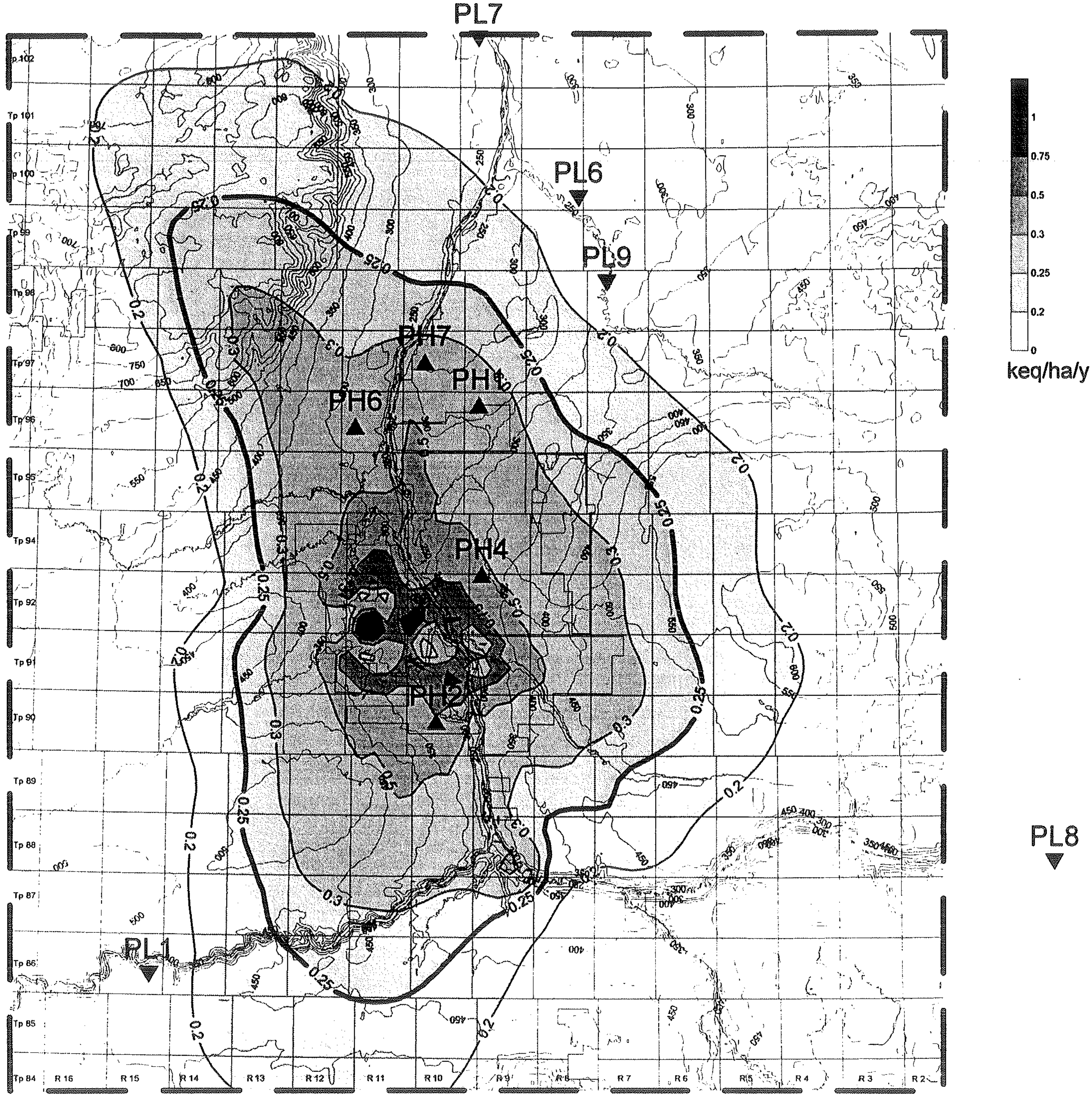


Sources	SO_2 [t/cd]	NO_x [t/cd]
Suncor		
Powerhouse	13.1	3.9
FGD	18	29.8
Incinerator	18.8	0.1
Flaring	12.6	0.1
Other Sources, Suncor	2.8	13.8
Syncrude (total)	209	44.4
Other Emissions (total)	4.1	10.1
TOTAL	278.4	102.2

Model Predictions	
Development	Baseline
Model	CALPUFF
Critical Loading [keq/ha/y]	0.25
Maximum [keq/ha/y]	24.6

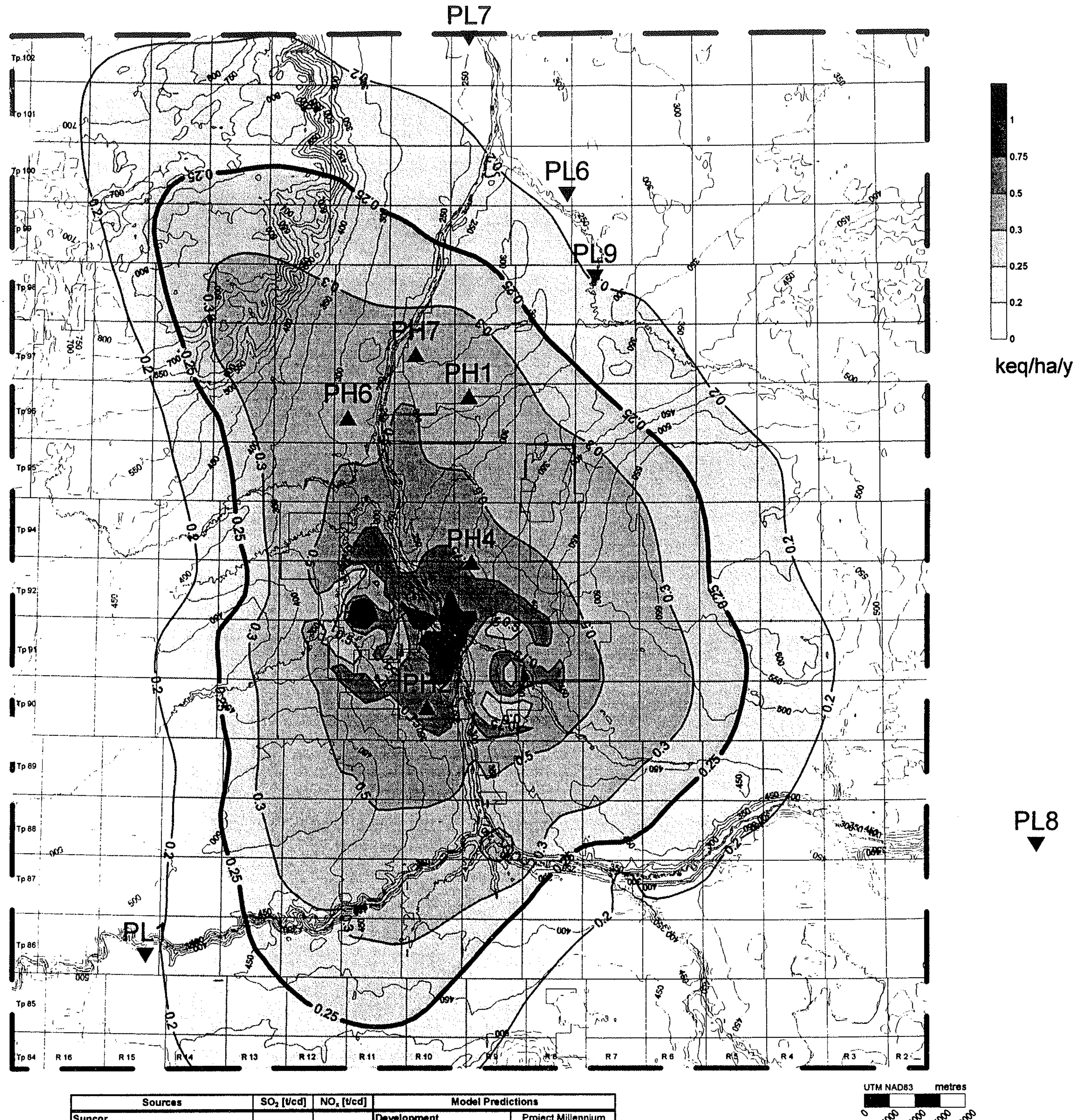
UTM NAD83 metres
0 5000 10000 15000 20000

LEGEND

▲ PH = Jack Pine (High)

▼ PL = Jack Pine (Low)

TEEM Tree Sites on Predicted Baseline Potential Acid Input (PAI) Isopleths



Sources	SO_2 [t/cd]	NO_x [t/cd]
Suncor		
Powerhouse	14	2.9
FGD	18.7	29.7
Incinerator	12.3	0.064
Flaring	10.6	0.191
Tail Gas Treatment Unit	6.4	0.03
Other Sources, Suncor	5.9	34.8
Syncrude (total)	209	44.4
Other Emissions (total)	4.2	10.1
TOTAL	281.1	122.185

Model Predictions	
Development	Project Millennium
Model	CALPUFF
Critical Loading [keq/ha/y]	0.25
Maximum [keq/ha/y]	24.7

LEGEND

▲ PH = Jack Pine (High)

▼ PL = Jack Pine (Low)

TEEM Tree Sites on Predicted Millennium Potential Acid Input (PAI) Isopleths

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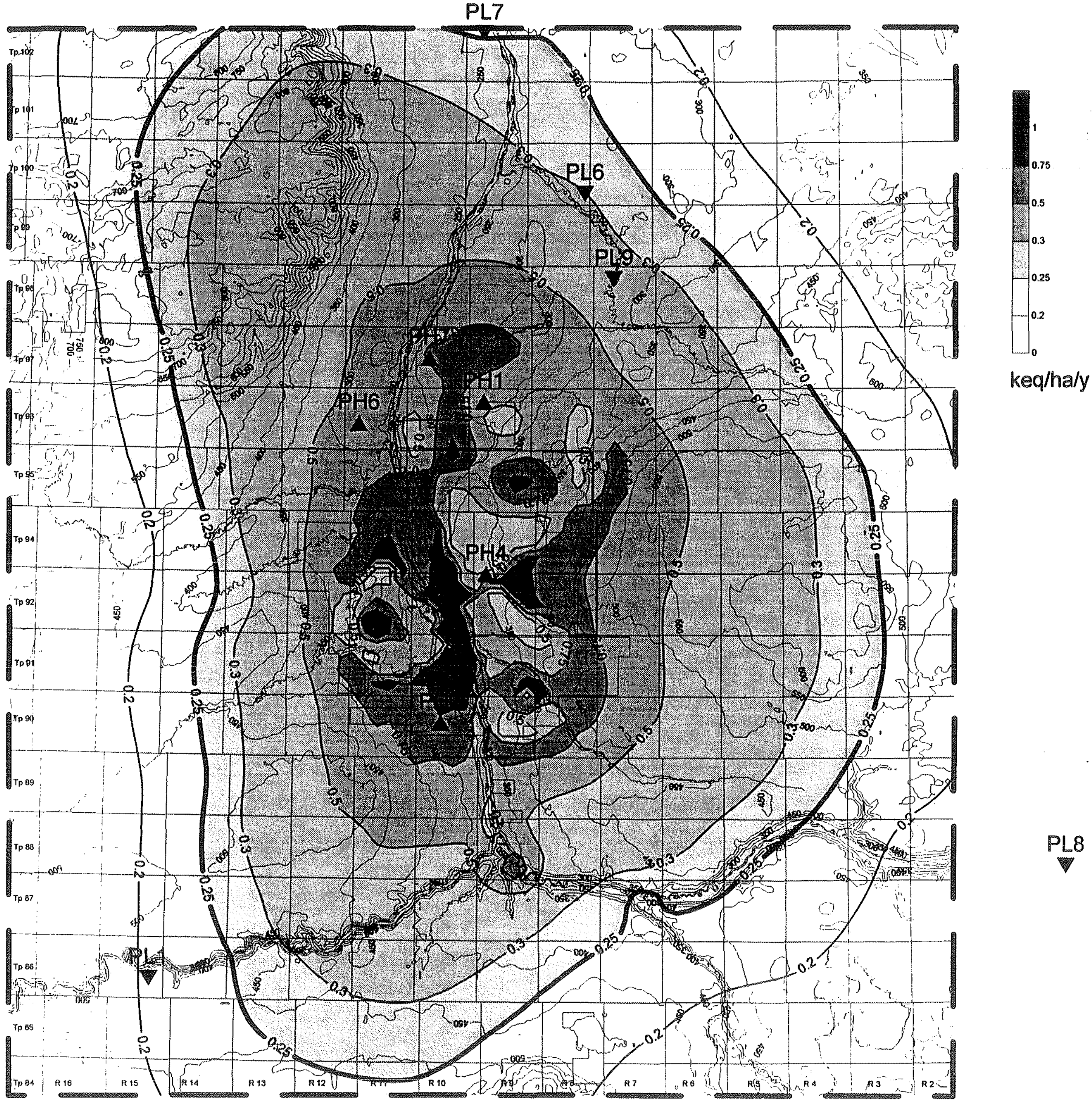


Sources	SO_2 [t/cd]	NO_x [t/cd]
Suncor		
Powerhouse	14	2.9
FGD	18.7	29.7
Incinerator	12.3	0.06
Flaring	10.6	0.19
Tail Gas Treatment Unit	6.4	0.03
Other Sources, Suncor	5.9	34.8
Syncrude (total)	199	63.9
Other Emissions (total)	4.2	10.9
Other Proposed Emissions (total)	18.8	60.9
TOTAL	289.9	203.4

Model Predictions	
Development	CEA
Model	CALPUFF
Critical Loading [keq/ha/y]	0.25
Maximum [keq/ha/y]	24.5

LEGEND

▲ PH = Jack Pine (High)

▼ PL = Jack Pine (Low)

TEEM Tree Sites on the Predicted CEA Potential Acid Input (PAI) Isopleths

1.60 **Suncor suggests the need for an "early warning" monitoring system for the detection of effects related to acid deposition. (*Vol. 2B, p. D3-106*) The Terrestrial Environmental Effects Monitoring committee is currently considering the establishment of an early warning monitoring system as part of the regional monitoring program. Please clarify Suncor's level of support for such a system, and indicate the level of support that Suncor is prepared to make to ensure that an early warning system is established in the region.**

Response:
It is Suncor's expectation that the TEEM programs would be reassessed on the basis of recent project EIAs. As stated in the application, Suncor supports the concept of developing an "early warning" monitoring system for the detection of effects related to acid deposition. Suncor will work with the other members of TEEM to set up such a program. Consideration could be given to looking at indicators such as nutrient deficiency (i.e. the loss of magnesium in sensitive species such as mosses and lichens) and invasion of sphagnum mosses into poor fens (i.e. percent cover in poor fens by sphagnum mosses).

1.61 **Suncor has generally discussed further air quality monitoring programs that will be undertaken. (*Vol. 2C, p. G-17*) Additional clarification would be helpful in this regard, such as the following:**

a) **List and discuss all air quality monitoring activities and initiatives that Suncor is proposing to conduct independently of other stakeholder activities.**

Response:
Suncor will continue to perform on-site emission surveys on an ongoing basis to better understand and quantify its emissions. This will help to ensure that an accurate and up to date emission inventory is available to be used, among other things, as an input to predictive air dispersion models. Suncor is also committed to continuing the Pond Emissions study that is currently underway to better understand the mechanisms associated with this phenomenon.

b) **List and discuss all air quality monitoring activities that Suncor is proposing to conduct collaboratively with other stakeholders. Include in this discussion the role that Suncor anticipates taking in each of the programs being developed and implemented by the Wood Buffalo Environmental Association (WBEA) and it's committees. Discuss any changes that arise from Millennium Project activities, and how Suncor will initiate and work with stakeholders to implement these changes. Please clarify whether the study of metal accumulation in plant tissues discussed in *(Vol. 2B,***

***p. D5-141)* is a study of potential negative effects on wildlife health, or whether this is the same study being developed by the Terrestrial Environmental Effects Monitoring committee and the Ft. McKay community for the examination of potential human health effects (the "Traditional Resource Use" study).**

Response:
The Wood Buffalo Environmental Association (WBEA) will continue to be the vehicle through which Suncor performs ambient air quality monitoring. Suncor intends to maintain its position of leadership within this organization. It is Suncor's belief that with the recent upgrade to the ambient air monitoring network, the region is well poised for monitoring the effects of not only Project Millennium, but all of the other proposed oil sands growth projects. Further initiatives under WBEA include the recently formed ozone committee.

The study of metal accumulation referred to was a Suncor initiative and not related to TEEM or Fort McKay studies.

2.0 GEOLOGY, TERRAIN, AND SOILS

Granular Material

2.1 **Suncor states that the availability of suitable granular materials for construction will be determined from the results of ongoing drilling. *(Vol. 1, p. C2-77)* The Isopach Map of Surficial Sand and Gravel, shows significant sand and gravel deposits within the development footprint. *(Vol. 2A, p. C2-13)* Please provide any existing information regarding granular resource quality and management strategies to identify the resource and the impact of development on them.**

Response:
Suncor will develop a detailed gravel management plan designed to protect the interests of Alberta with respect to the value of the gravel resources.

The management plan will include the following key elements:

- Identification of gravel reserves: gravel deposits will be delineated by surface drilling and test pits, as required, in advance of overburden stripping. Reserves will be quantified and include an assessment of quality.

- Removal of gravel resource: gravel deposits that are deemed to be significant will be excavated for stockpiling and/or use. The determination of significant will be based on deposit volume, quality and thickness.

- Royalties for the resource will be paid under the terms for the Mineral Surface Lease.

- Suncor will work cooperatively with other interested parties to maximize recovery of quality gravel deposits.

2.2 **Suncor is aware that several gravel operators have applied for surface rights dispositions in the proposed development area.** ***(Vol. 1, p. C2-50)*** **Please provide results of consultation with the operators. Discuss the proposed mitigation regarding the impact to those affected by Suncor's development.**

Response:
Suncor has had several discussions with gravel operators. Plans have been shared and both parties have agreed to cooperate and respect each others rights. Access agreements are being developed to permit gravel removal. Gravel is expected to be removed well in advance of Suncor's overburden removal.

3.0 VEGETATION AND RESOURCES

3.1 **Suncor indicates that de-watering will lower groundwater levels in the surficial aquifer within 300 meters of the mine area.** ***(Vol. 2B, p. D3-63)*** **Please demonstrate that the de-watering impact will not exceed 300 m for all types or range of wetlands, including fens. Discuss the distance from the mine footprint that a fen or shallow fen could possibly be affected. Figure D2.2-6 shows the LSA Closure Terrain Classification.** ***(Vol. 2B, p. D2-26)*** **Discuss the probability of wetland types presently adjacent the proposed development area surviving as the same type of wetland in the closure landscape. Discuss the type of vegetation community that would be created if the wetland types are drained. Also, discuss any possible mitigation to prevent the elimination of adjacent fens by the project.**

Response:
The radius of dewatering of the surficial aquifer is not dependent on the type of surface landform including wetlands. The 300 m distance assumes the surficial aquifer is fully drained at the pit boundary.

The fate of wetlands communities impacted by surficial aquifer dewatering is one of the subjects of discussion by the Oil Sands Wetlands Working Committee. Because of the uncertainties associated with wetlands dewatering due to aquifer dewatering, Suncor is considering a plan for monitoring in collaboration with the above committee during operations.

In the closure period, the adjacent wetlands would remain except for the portions that are directly connected to the surficial aquifer within the 300 m distance. This would only occur on the southeast portion of the end pit lake.

3.2 **Suncor suggests that both Class 3 and 4 areas may contain highly productive wetlands systems or grassland areas suitable for raising range animals. As a result, these can be considered for use other than the production of commercial forest stands under a different management regime. *(Vol. 1, p. E1-6)* Please discuss how the landscape classification system would rate wetlands. Also include a discussion on the suitability of wetlands for range animals.**

Response:
The "Land Capability Classification for Forest Ecosystems in the Oilsands Region" would rate wetlands as class 5. The wetlands would have no potential for developing a commercial forest stand because of an excessively high water table. This classification system used in the EIA and the reclamation planning is focused on forest ecosystems. Currently, a Wetlands Working Committee, of which Alberta Environmental Protection is a member, is considering a system to detail classification and reclamation of wetlands systems. The report from this committee is expected later in 1998.

The inclusion of meadows or grassy areas within the forest context, replicate the existing brush or open areas found in the parklands regions. Such openings would likely become treed with time, but form a valued wildlife foraging area during the interim. During historical periods such openings would have been used by such species as the bison. Suncor did not intend that the reader would consider wetlands as areas suitable for range animals. While it is recognized that bison require availability of some types of wetlands systems for important food sources, Suncor does not intend to include bison ranching or cattle ranching as part of the end use objectives for the lease.

3.3 **Suncor indicates that when combined with the littoral zones around these open areas, the final landscape should be a substantial benefit to many types of waterfowl, other waterbirds and aquatic mammals. *(Vol. 2B, p. E4-23)* Please discuss the wetland habitat types that will be included in the Suncor wetland areas and the bird species targeted. Are there other wetland types that are suitable for other wildlife which could be incorporated into the wetland types?**

Response:
As indicated in Figure E2 in the Closure Plan Assessment, the following wetlands habitat types will be developed:

- shrubby deciduous swamps;
- open water; and
- constructed wetlands (consisting of shrubby or graminoid marshes).

These wetlands community types will provide habitat for dabbling ducks and beavers which were both chosen as KIRs. For further clarification, habitat requirements for dabbling ducks and beavers were described in the baseline wildlife report (Golder 1998) and Section D.5.1.2. As well, other bird species (i.e., breeding birds) associated with various wetlands and riparian community types were listed in Section D5.1.2.7 and in the wildlife baseline report (Golder 1998).

It is expected that the plant community types adjacent to the various drainages will develop into riparian shrub communities, providing additional habitat. These initial ecosite phases consist mainly of dogwood and balsam poplar (e1, e2, e3; see Figure E-2). Wildlife species likely to be found in these habitat types were listed in the wildlife baseline report (Golder 1998) and throughout Section D.5.1.2.

Literature Cited

Golder Associates (Golder). 1998. Wildlife Baseline Conditions for Project Millennium. Prepared for Suncor Energy Inc., Fort McMurray, Alberta by Golder, Calgary, Alberta

3.4 **Suncor states that a wetland type, riparian shrub complex, which is dominated by willow and river alder, is included within the Local Study Area (LSA) and does not fit into the Alberta Wetland Inventory (AWI) classification. *(Vol. 2B, p. D3-35) The Terrestrial Vegetation Baseline Study* states that riparian wetland areas occupy a unique position in the landscape and life of the boreal forest. Their importance far exceeds that implied by their relatively small area. *(p.5)* Please describe the species and vegetation types important to wildlife that are not listed in the table, such as, within wetlands and riparian areas.**

Response:
Riparian shrub complexes consist of a mosaic of vegetation communities that include shrubby swamps (SONS), shrubby marshes (MONS), dogwood balsam poplar-aspen (e1) and dogwood balsam poplar white spruce (e2). Vegetation species typical of these riparian wetlands and ecosite phases are provided in Table D3.1-17 and Table D3.1-18.

Vegetation species within riparian shrub complexes which are important to wildlife are species specific. Moose, for example, forage on plant species that occur within the ecosite phases and wetlands listed above. Plant species not listed in the Table D3.1-17 and Table D3.1-18, but which are included as forage species for moose include pin cherry, high-bush cranberry, clematis and dwarf birch (Stelfox 1993). However, moose are opportunistic in that they forage on the available food sources and would not avoid a habitat if it did not include all forage species.

Reference:

Stelfox, J.B. 1993. Hoofed Mammals of Alberta. Lone Pine Publishing. Edmonton, Alberta. 242 p.

3.5 **Suncor states that peatlands, fens and bogs may be particularly sensitive to acid forming emissions (SO_2 and NO_x). According to the Air Impact Section (B3), critical loads will exceed 0.25 Keq/ha/a for sensitive ecosystems and 0.50 Keq/ha/a for moderately sensitive soils. Therefore, there is a valid linkage between air quality and terrestrial vegetation and wetlands.** ***(Vol. 2B, p. D3-63)*** **Additionally, key caribou habitat ranges called Dunkirk, Steepbank and Audet fall within the acidification zones.** ***(Vol. 2B, p. D2-51, Figure 2.2-11)***

a) **Figure D2.2-11 provides a map illustrating the relative soil sensitivities to acidifying emissions, as well as, contours of predicted potential acid input (cumulative effects) for the regional study area.** ***(Vol. 2B, p. D2-51)*** **Comment on the growth reduction which has occurred (if any) and/or the elimination of lichen that has occurred to date or will occur by date 2025 due to acidic emissions. Please discuss the likely impact to the critical caribou range due to acid deposition and other air emission effects.**

Response:

Suncor recognizes the uncertainties associated with quantification of environmental effects associated with acidifying emissions in the oil sands region. Suncor is committed to enhancing the current level of activity associated with monitoring of environmental effects associated with acidifying emissions. The TEEM program will assist oil sands developers and stakeholders in assessing the potential effects of the developments on the ecosystem, including possible impacts to lichens. Activities that will be considered by Suncor, in cooperation with other members of the Wood Buffalo Environmental Association will include:

- completion of a regional assessment of forest resources to monitor for effects associated with acidic deposition; and

- resampling of waters from lakes in the oil sands regional study area that were identified as moderately or highly sensitive to acidic deposition in the Saffran and Trew report (1996).

The resolution of issues associated with effects of acidifying emissions will include:

- collection of additional monitoring information;
- collaboration with other regional developers and independent researcher to include consideration of information from other studies to assess effects of acidifying emissions;
- comparison of identified effects with predictions made in the EIA;
- identification of additional studies required to quantify effects; and
- identification of additional mitigation options to reduce emissions, if required.

Reference:

K.A. Saffran and D.O. Trew. 1996. Sensitivity of Alberta lakes to acidifying deposition: an update of sensitivity maps with emphasis on 109 northern lakes. Water Sciences Branch. Water Management Division, Alberta Environmental Protection. July 1996.

b) **Please clarify which year this figure represents. The critical loading for sensitive ecosystems is discussed as 0.25 Keq/ha/a. Does the range of loading for this category go from 0.25 to 0.17 Keq/ha/a? If this is so, please provide 10 copies of a map that show the 0.17 Keq/ha/a isopleth predicted for now and up to 2025.**

Response:
In the air quality evaluation, Potential Acidic Input (PAI) were predicted to exceed 0.25 keq/ha/y and 0.50 keq/ha/y during each of the Baseline (Vol. 2A, Figure B2-22, p. B2-52), Project Millennium (Vol. 2A, Figure B3-12, p. B3-23) and the CEA (Vol. 2A, Figure B412, p. B4-22) emission scenarios. PAI levels of 0.25 keq/ha/y have been adopted as interim critical loads for highly sensitive soils (Target Loading Subgroup 1996). The areal extents above 0.25 keq/ha/y varies from scenario to scenario with changes in the levels of SO_2 and NO_X emitted. To date, no critical PAI loads have been established for terrestrial vegetation or wetlands.

The isopleths in Figure D2.2-11 represent the annual Potential Acidic Input (PAI) during any year when all of the CEA emission sources are fully operational. The actual year that this represents is difficult to pinpoint since the schedule of the proposed developments in the oil sands regions are subject to a number of external market influences. However, it is possible to gain an appreciation for the changes to be expected in the annual PAI in the region by comparing the Baseline (Vol. 2B, Figure D2.2-19, p. D2-50) to the CEA (Vol. 2B, Figure D2.2-11, p. D2-51) predictions. Differences in the PAI reflect the increased impacts resulting as additional developments are brought into operation.

The Target Loading Subgroup (1996) suggested that a critical acidic input loading of 0.25 keq/ha/y be adopted as an interim guideline to protect the most sensitive soils. Therefore, at PAI levels above 0.25 keq/ha/y there is a potential to effect the most sensitive soils. No interim guideline was adopted for soils with lesser sensitivities. The interim guideline value was based on suggested guidelines by the World Health Organization (WHO 1994). The WHO report suggests several critical loading ranges, designed to protect varying percentages of the ecosystems. The lowest critical loading category ranges from 0 to 0.25 keq/ha/y, with a median value of 0.17 keq/ha/y. This range was designed to protect 99.2% of the ecosystems evaluated by WHO. Critical loadings ranging from 0.25 to 0.50 keq/ha/y (this range had a median value of 0.414 keq/ha/y) would protect approximately 96.2% of the ecosystems evaluated.

Reference:

Target Loading Subgroup. 1996. Final report of the target loadingsubgroup on critical and target loading in Alberta. Final Report to CASA SO_2 Management Project Team.

World Health Organization (WHO). 1994. Updating and revision of the air quality guidelines for Europe. Report on WHO Working Group on Ecotoxic Effects. Copenhagen, Denmark. p. 22.

4.0 WILDLIFE

Assessment

4.1 **Suncor indicates that there were no surveys of diurnal, stick nesting raptors and that the owl surveys were conducted in very poor survey conditions (snow storms and high winds) and not within the Local Study Area (LSA).** ***(Vol. 2B, Section D5; Section 4.0 Methods in Wildlife Baseline Conditions for Project Millennium)*** **Please clarify that the survey efforts were sufficient to establish baseline conditions and assess impacts for raptors within the LSA; including all raptors on the AEP yellow list (great grey owl, bald eagle, barred owl, boreal owl, broad-winged hawk, northern goshawk, northern harrier).**

Response:
A survey for diurnal raptors was conducted concurrently with the aerial waterfowl survey (See Section 4.5.1 in the Golder 1998 Wildlife Baseline Report). As well, field crews were vigilant for all signs of raptors when conducting other surveys (e.g., browse-pellet counts, breeding birds, winter track counts) and when traveling to and from survey locations. These survey efforts were deemed to be sufficient to establish baseline conditions and assess impacts

for bald eagles, broad-winged hawks, great gray owls, northern goshawks, and northern harriers.

Owl surveys were used to identify the presence of boreal owls and great gray owls (e.g. both of these species were surveyed for using the call-playback tapes). According to Semenchuk (1992), all breeding evidence of barred owls is south of Lesser Slave Lake. Thus, the call-playback tapes did not include this species.

Owl surveys were not conducted in very poor survey conditions (e.g. snow storms and high winds). On the first survey night, winds were light and the temperature was above -10 °C. Conditions were less optimum on the second night, with snowfall ranging from light to moderately heavy, and occasional wind gusts.

Owl surveys were not conducted within the LSA. However, surveys were conducted immediately north of the LSA. Owl abundance and distribution from the survey location was determined to be similar to that within the LSA, as the vegetation community types were similar.

Literature Cited:

Semenchuk, G.P., ed. 1992. The Atlas of Breeding Birds of Alberta. Federation of Alberta Naturalists, Edmonton, Alberta.

Golder Associates Ltd. (Golder). 1998. Wildlife Baseline Conditions for Project Millennium. Prepared for Suncor Energy Inc., Fort McMurray, Alberta by Golder, Calgary, Alberta.

4.2 **Suncor states that the Biodiversity Habitat Modelling used in the application measures species richness as a function of area but not a function of type.** ***(Vol. 2B, p. D5-28)*** **Please discuss the possibility of Suncor refining the biodiversity habitat model by incorporating a measure of species assemblage uniqueness to measure species richness as a function of type and not only area.**

Response:
In the Biodiversity Habitat Modelling section, species richness was measured as a function of area rather than type. This addresses the question of how the different habitat richness classes sum up in terms of habitat units (area times richness index). However, this method does not address the need to maintain unique examples of each species assemblage in the post-development and closure scenarios. In the richness index calculations, the potential exists to completely remove some habitat types, yet still maintain high richness habitat units by replacing these with other habitat types.

To address this issue, the model would have to be refined to incorporate a measure of assemblage uniqueness. This would involve quantifying the uniqueness of the broad habitat groups, perhaps based on species lists for each habitat type. This, in itself, is a difficult task as the original model was based on a review of the literature of broad habitat preferences of wildlife species, not actual data from the study site. As well, the new model would have to account for species which are unique to each habitat type, species which are unique to two habitat types, etc. A similarity index could be used to compare how each habitat type differed in terms of species assemblages. From this, the total number of species present at each development stage could be modeled and compared with baseline conditions. In the end, however, this would have to be related back to the areas of habitat change in each of the broad habitat groups.

The main limitation appears to be the determination of an adequate species list for each habitat type within the study area. While a literature review gives a general idea of the potential of an area or a habitat to provide habitat for a particular species, it is difficult to determine which species are actually present. Likewise, the field surveys to adequately complete this task would be monumental. A more realistic approach may involve a closer examination of the species lists for each habitat type, both pre-disturbance and following closure. This would give an idea of which species might be lost from the area. However, this approach may not adequately address the movement to the area by other species.

4.3 **The Habitat Suitability Index (HSI) model verification results are presented in a key reference report on HSI modelling for Project Millennium.** ***(Vol. 2B, p. D5-63)*** **The report states that an important step in the HSI modelling process is the verification of models with field data. Spearman rank correlation analysis was used to examine the association between observed relative abundance and predicted habitat suitability for six of the 12 Key Indicator Resources (KIRs). The association was statistically significant ($p<0.05$) for only one of the KIRs, and the r^2 values were very low (ranging from 0.04-0.47) for the other five. It is further stated that the remaining six KIRs were not compared statistically because of very small sample sizes. Considering the inconclusive results, please discuss the validity of the confidence levels placed in the predictions of habitat units lost and gained for wildlife KIRs in the Project.**

Response:
As stated, model verification is an important step in the HSI modelling process (p 6, Golder 1998). However, this step rarely occurs within environmental assessments and has not been used in previous HSI modelling for oil sands developments in the RSA. Suncor, through its consultant, took a believed first step in model verification by using field data from the baseline wildlife surveys to verify the models. It should be stressed that this was a preliminary step as the field programs were developed to provide information on baseline conditions, not to verify models. However, the rationale was that some verification was better than none and that the baseline wildlife data could be used to see if there

were any broad relationships between the HSI values and KIR observations in the field.

Although sample sizes were small, there were enough data to examine six of the twelve HSI models. None of the results showed a negative association between relative abundance and predicted habitat suitability, and certainly there were no significant deviations between model predictions and field data. Thus, Suncor is confident that the models currently provide the best tool to predict habitat units lost and gained for wildlife KIRs in the Project area. Future work is required for all EIAs to better verify and modify the existing models. The aim of all of the major oil sands developers should be to improve on the HSI models and modelling process, including model verification, where possible. This type of project would best be managed by a regional oil sands development committee outside of any single EIA.

Reference

Golder Associates. 1998. Wildlife Habitat Suitability Index Modelling for Project Millennium. Prepared for Suncor Energy Inc., Fort McMurray, Alberta.

4.4 **Table D5.2-8 provides a summary of wildlife residual impacts and degrees of concern. *(Vol. 2B, p. D5-120)* In the last section of the table, "changes in habitat due to reclamation", the direction is "positive" for several of the wildlife Key Indicator Resources (KIRs). However, the "reversibility" column indicates that all of the impacts, both positive and negative, are reversible. Please provide an explanation for this apparent contradiction.**

Response:
Replacement of vegetation communities due to closure will result in habitat gains for several of the KIR species. However, for some of the KIR species, habitat losses will occur. Suncor conservatively labelled these changes as "reversible" as closure goals may change over time (e.g., the focus on wildlife habitat may change in 30 years) or reclamation techniques may improve to allow reclamation of previously unreclaimable habitats (e.g., patterned fens). The "irreversible" category was only used where there was no potential for reversing or altering the situation (e.g., removal of a nuisance bear).

4.5 **Suncor states that an end pit lake and numerous small wetlands are proposed for closure, which will have a net positive effect on wildlife. *(Vol. 2B, p. D5-98)* This statement may be true for some waterfowl and perhaps several other Key Indicator Resources (KIRs). For many other wildlife**

species, however, particularly those preferring peatland ecotypes, the net effect could potentially be negative. Please provide the evidence and a confidence level that there will be a net positive benefit to area wildlife.

Response:
The use of the term "net" was an error. However, as discussed in the response to question 3.3, the reclamation of various wetlands types will have a positive effect on a variety of wildlife species, including dabbling ducks, beaver, moose, various breeding birds, and amphibians. Suncor recognizes the fact that peatland ecotypes cannot be reclaimed, and the loss of these habitats will have a negative effect on the wildlife species found in those areas.

4.6 **Suncor indicates that closure landscapes will not include specific corridor considerations, but will allow free range of wildlife species throughout the area. The *Wildlife Baseline Report* states that moose move perpendicular to the valley and that riparian areas are the primary movement corridor. *(Vol. 1, p. E3-41)* Please discuss if riparian areas will be designed to accommodate this habitat requirement.**

Response:
The drainage systems developed as part of the closure landscape for Project Millennium will include design consideration to enhance riparian areas as wildlife habitat areas. Such considerations could include additions of level areas beside the drainage areas where willows and alder could be planted to improve the habitat for moose.

4.7 **Suncor indicates that the optimum width for wildlife corridors is 500 meters, as suggested in the literature. Suncor further indicates that it is recognized that corridors can be narrower in places and still be effective for wildlife movements. *(Vol. 2B, p. D5-101)* Please explain why Suncor believes corridors narrower than 500 meters can still be effective for wildlife movements.**

Response:
Much has been written about different corridor widths for different target species, however, none of these recommendations have been derived from empirical evidence (Pace 1991). Suggested widths have ranged from 5 m for small mammals (Lapolla and Barrett 1993) to 6.4 km for large mammals (Csuti 1991). Harris and Aitkens (1991) suggested that corridors of 10 to 30 m were adequate for movement of individuals, while movements of species required 30 to 1,000 m. Pace (1991) recommended a tiered approach to corridor widths, with three levels of increasing width: 15 to 61 m wide riparian corridors; 400 to 1,600 m riparian and ridge corridors; and 1600+ corridors.

Within the Bow Valley Corridor, the Three Sisters EIA (UMA 1991) recommended a minimum width of 350 m for primary corridors and 187 m for secondary corridors, based on elk requirements for secure habitat and hiding cover (Thomas 1979). Following a review of the EIA, the NRCB (1992) recommended that corridors be a minimum of 350 m wide, except in very unusual circumstances. These recommendations were based on corridors that were well-defined by topography (e.g., ravines). Smaller corridor widths may be effective in the Suncor study area where the terrain is relatively flat and wildlife have more movement options.

Ultimately, corridor width should be determined by many factors, including the length of the corridor, the topography and vegetation of the corridor, the wildlife species of interest, and adjacent human activities (Beier and Loe 1992).

Sources:

Beier, P. and S. Loe. 1992. A Checklist for Evaluating Impacts to Wildlife Movement Corridors. Wildlife Society Bulletin. 20(4):434-440.

Csuti, B. 1991. Conservation Corridors: Countering Habitat Fragmentation (Introduction). Pp. 81-90. In: Landscape Linkages and Biodiversity. W.E. Hudson, Defenders of Wildlife (ed.), Island Press, Washington D.C.

Harris, L.D. and K. Aitkens. 1991. Faunal Movement Corridors in Florida. Pp. 117-134. In: Landscape Linkages and Biodiversity. W.E. Hudson, Defenders of Wildlife (ed.), Island Press, Washington D.C.

Lapolla, V.N. and G.W. Barrett. 1993. Effects of Corridor Width and Presence on the Population Dynamics of the Meadow Vole (Microtus pennsylvanicus). Landscape Ecology. 8:25-37.

NRCB. 1992. Application to Construct a Recreational and Tourism Project in the Town of Canmore, Alberta. Decision Report Application #9103 - Three Sisters Golf Resorts Inc.

Pace, F. 1991. The Klamath Corridors: Preserving Biodiversity in the Klamath National Forest. In: Landscape Linkages and Biodiversity. W.E. Hudson, Defenders of Wildlife (ed.), Island Press, Washington D.C.

Thomas, J.W. (ed.). 1979. Wildlife Habitats in Managed Forest: the Blue Mountains of Oregon and Washington. US Dept. of Agriculture. Agriculture Handbook No. 553.

UMA Engineering. 1991. Environmental Impact Assessment Report for the Three Sisters Golf Resorts Inc. Destination Resort, Canmore, Alberta. Vol. II.

4.8 Suncor states that they will time activities to avoid critical seasons for wildlife (i.e., mid-March to late July) to reduce the impacts of sensory disturbance on wildlife. ***(Vol. 2B, p. D5-105)*** **Please clarify that this is a**

feasible mitigation strategy. Explain what Suncor means by 'time activities' and identify which operations this would involve.

Response:
The proposed mitigation focusses on the completion of certain operations that involve major disruptions to existing habitat (e.g., land clearing) during critical wildlife periods. It was not meant to imply that all operations would cease during the period mid-March to late July. As Alberta Environmental Protection is aware, operations at the Suncor mine and fixed plant area operate continuously throughout the year.

5.0 WATER

Dam and Dyke Safety

5.1 **Suncor indicates that if there is weak Clearwater Formation in the foundation, the recommended dyke slope is 10:1 with a possible 200 m wide berm. *(Vol. 1, p. C2-78, Table C2.4-7)* The slope for the west side of Pond 8A is given as 8:1. Would flattening the slope and adding a berm to account for Clearwater Shale cut into the setback distances from the river? Would the setback meet the recommendations outlined in the *Fort McMurray-Athabasca Subregional Integrated Resource Plan (IRP)*?**

Response:
The assessment of the impacts of Project Millennium on water quality evaluated all potential inputs from oil sands materials into surface and groundwater sources. Inputs considered included seepage waters from landforms including sand storage areas and CT deposits, as well as discharges from the end pit lake. The assessment completed in the water quality section of the EIA showed that water quality will be protected (i.e., that there is no adverse impact).

Suncor, as part of its continuous improvement activities will continue to explore ways to reduce the potential for waters from its operation to impact other water systems. Additionally, through participation in the RAMP program, Suncor is actively monitoring the receiving environment areas to verify that predictions made in the EIA are accurate(i.e., that water quality is protected).

5.2 **McLean Creek is actively eroding and has a steep valley. *(Vol.2B, p. E9)* Was the McLean Creek taken into account in the evaluation of the stability of the dyke at the south side of Pond 8A?**

Response:
The present designs are conceptual and provide a considerable setback from the McLean Creek valley. A detailed geotechnical investigation and design program

will be conducted that will include consideration of the McLean Creek valley. The report will be submitted for review and approval of the AEP Dam Safety Branch. Additionally, as part of the Suncor "no net loss" plan for fisheries habitat and its work to ensure the stability of McLean Creek under the expected increase in flows, Suncor will be working to stabilize the McLean Creek area (please also refer to the response to Question AEP 5.24).

5.3 **Suncor states that the toes of the slopes will be set back a minimum 100 m from the Athabasca River and McLean Creek (Pond 8A).** ***(Vol. 2B, p. E-10)*** **Will the setback from McLean Creek be reduced if the dyke has to be flatter?**

Response:
It is possible that the setback from the creek would be reduced if dyke slopes established in detailed design are flatter than 8:1 and stability analyses show that a reduced setback is shown to be stable. Optimization studies are continuing to minimize the size of the external tailings pond. A reduction in required storage space would decrease the likelihood that the setback would be reduced.

5.4 **Suncor states that the dykes along the Athabasca River represent a reconstruction of the existing embankment at angles that are typically less than or equal to the current slope. As a result, it is likely that a stable configuration can be achieved.** ***(Vol. 2B, p. E-19)*** **This would be the case if the pore pressures in the dykes were as low as the pore pressures in the natural slopes. Does Suncor expect the pore pressures in the dykes to be that low?**

Response:
Pore pressure effects will be fully considered in detailed geotechnical design for the dykes. All structures in this area will be designed to acceptable standards.

Water Quality/Quantity

5.5 **Suncor states that pipelines will extend from the Millennium Extraction plant to the Base plant and will cross the Suncor Bridge.** ***(Vol.1, p.C2- 125)*** **Spill containment and mitigation practises outlined in the Steepbank Mine application will apply for these lines. Please discuss spill containment for high-pressure pipelines. How will an upward projected leak be contained on the bridge? What design measures will prevent a leak to the Athabasca River from the bridge?**

Response:
The design of the proposed lines was approved for the Steepbank Project. Suncor has designed the lines to minimize the potential of an upward projected leak with welded rather than flanged joints. Pressure alarms on the pipeline will automatically shut down a line in the event of a leak. As well, the lines are subject to continual visual checks by bridge traffic and will be routinely inspected by non-destructive test methods. The bridge deck is designed with continuous pipeline troughs with containment systems at both ends.

5.6 **Mitigation to prevent possible sediment loading of the Steepbank River includes a mining setback of at least 100 m from the escarpment. *(Vol. 2A, p. C4-41)* Clarify why Suncor considers the 100m setback to be sufficient to prevent sediment from reaching the river.**

Response:
The 100 m setback is for the full mine development area. Dyke structures will be setback more than 100 m from the river. Drainage ditches will be constructed to divert runoff away from the Steepbank River to sediment control structures from which the water is directed to the Athabasca River. Discharge will be monitored and controlled to comply with presently approved water quality standards. The Suncor setup of setback and drainage ditches are adequate to prevent sediment from reaching the river.

5.7 **Suncor states that the NE Dump footprint encroaches into the Steepbank River valley and runoff could enter the valley. *(Vol. 2A, p. C2-53)* Clarify the potential sedimentation of the Steepbank River. Please discuss options for mitigating the impact, including relocating the dump away from the valley.**

Response:
Suncor does not expect sediments to enter the Steepbank River from any of its east bank mining areas. Control systems, including drainage ditches and berms will be used to ensure runoff from areas is collected and channeled to sedimentation ponds developed as part of the mine plan.

5.8 **Discharge of muskeg water will be quite high initially during dewatering of the mine site. Does Suncor plan continual monitoring of the receiving streams to see if a problem is starting to occur? Discuss the locations of monitoring stations. Discuss how quickly Suncor would respond to a low oxygen problem, and how.**

Response
Suncor intends to monitor all streams in the East Bank Mining Area that flow into the Athabasca River. These streams will have sedimentation control. With respect to muskeg water, the parameters to be monitored will be determined with AEP for the approval conditions. Procedural details such as sampling sites and frequency will be determined at that time. The control system will be designed to respond to low oxygen conditions.

5.9 **Some of aspects of the project which could potentially affect surface water and groundwater qualities include tailings sand seepage, consolidated tailings (CT) flux and End Pit Lake outflow. *(Vol. 2A, p. C3-20 – C3-21)* Further reduction of effluent from these sources and/or improvement of water quality at the sources may required to minimize or eliminate the impact of these aspects. Has Suncor plans to pursue this matter in the near future?**

Response:
The assessment of the impacts of Project Millennium on water quality evaluated all potential inputs from oil sands materials into surface and groundwater sources. Inputs considered include seepage waters from landforms, including sand storage areas and CT deposits, as well as discharges from the EPL. The assessment completed in the water quality section of the EIA showed that water quality will be protected (i.e., that there is no adverse impact).

Suncor, as part of their continuous improvement activities will continue to explore ways to reduce the potential for waters from their operation to impact other water systems. Additionally, through participation in the RAMP program, Suncor is actively monitoring the receiving environment areas to verify that predictions made in the EIA are accurate (i.e., that water quality is protected).

5.10 **The *Hydrology Baseline Report* indicates that within the Local Study Area (LSA), Unnamed Creek, Creek 2, Leggett Creek, Wood Creek and McLean Creek are deeply incised into the Athabasca escarpment and tend to flow year-round. *(p. 3)* Winter data is necessary to understand baseline conditions during which surface water flows are typically at their lowest annual rates. No water quality data is provided for winter conditions in these creeks. Please clarify why this data was not presented.**

Response:
There is no winter water quality data for Leggett, McLean or Wood creeks. Winter flows have been monitored. As illustrated in Figure 1 (hydrographs), these are intermittent streams which generally have zero flow in winter.

5.11 **Suncor states that limited data are presently available on the concentrations of dissolved metals as a proportion of total metals in the study area.** ***(Vol. 2A, p. C3-16)*** **Additional data will be useful in better evaluating the effects of dissolved metals, which are more readily available to biota, in small streams and during different seasons.**

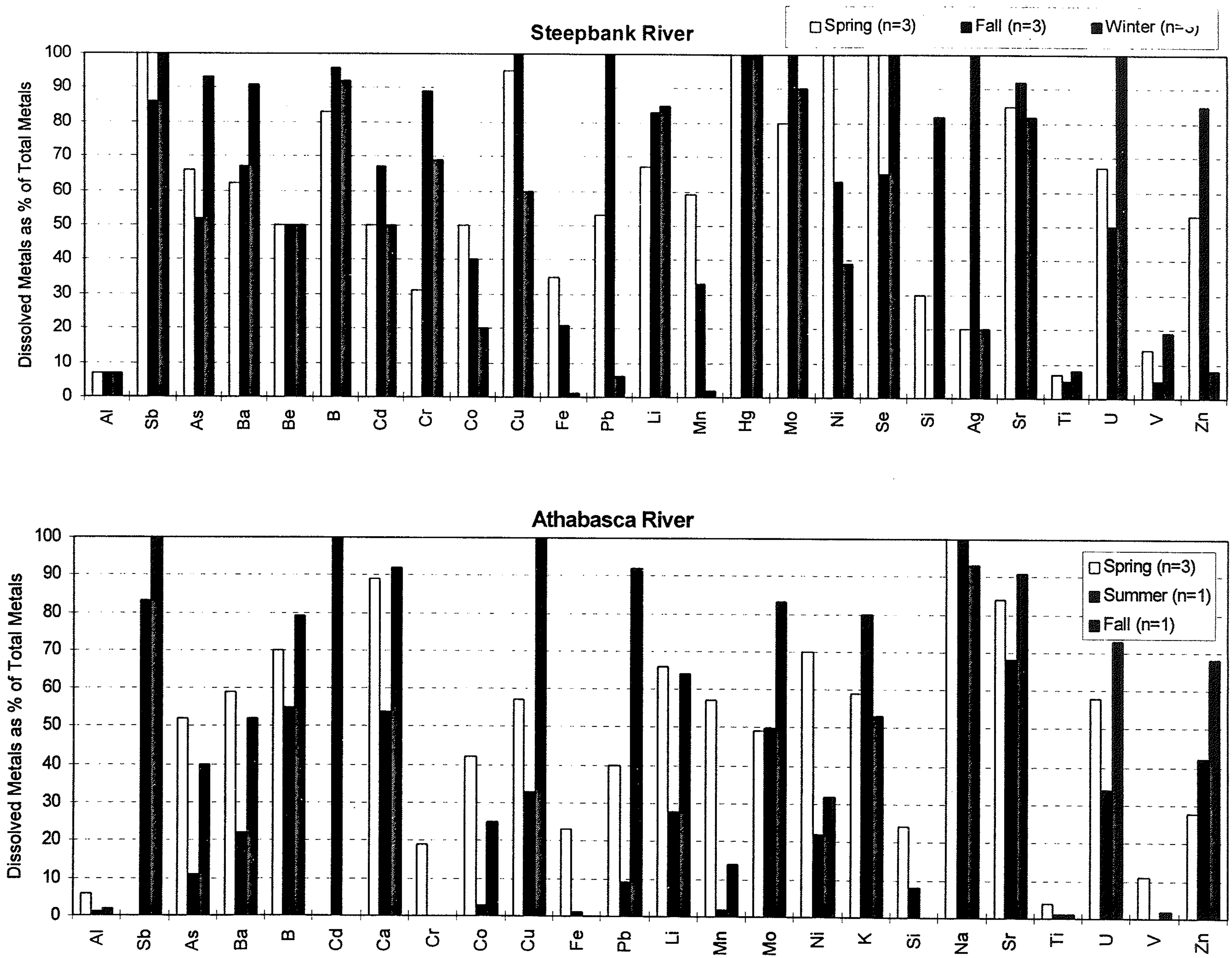
Clarify whether data is available for winter in the Athabasca River and summer in the Steepbank River. Indicate whether Suncor intends to collect additional and more comprehensive data on dissolved and total metals in surface waters for all seasons and for smaller waterbodies.

Response:
Data for the Athabasca and Steepbank Rivers is presented in Vol. 2A, table C3.1-10. However, this data is based on a limited number of samples and therefore, seasonal water quality data (including total and dissolved metals) will be collected in the Muskeg, Steepbank, Tar and Ells Rivers as Part of RAMP. In addition, Suncor will collect seasonal water quality data in McLean Creek which will include conventional parameters, major ions, nutrients, dissolved and total metals, and PAHs using ultra-low detection levels.

5.12 **Cobalt does not appear to follow the suggested pattern of low dissolved concentration relative to total concentration shown by aluminium, titanium and vanadium.** ***(Vol. 2A, p. C3-16, Table C3.1-10)*** **Please provide a graph of the data to show patterns and gaps in the entire data set that are less apparent in Table C3.1-10.**

Response:
The comment is acknowledged regarding cobalt; the percentage of total cobalt made up of the dissolved form falls in the moderate range.

Bar graphs of the data presented in Table C3.1-10 are provided in the following figure.



Dissolved Metals - Steepbank and Athabasca Rivers

5.13 **Clearing and muskeg and overburden dewatering are discussed under Key Questions SHH-1 and SHH-2.** ***(Vol. 2A, p. C2-24)*** **Do the changes in flows represented in Key Question SHH-3 include those impacts, or are they merely the incremental impacts from changes to drainage boundaries and land disturbances?**

Response:
Yes, the changes in flows represented in key question SHH-3 are related to surface drainage alterations. Key questions SHH-1 and SHH-2 are related to groundwater impacts.

5.14 **With respect to impacts on surface water, are muskeg and overburden dewatering flows expected to occur in winter? What is the effect on existing winter flows?** ***(Vol. 2A, p. C2-34)***

Response:
Whether muskeg drainage is expected to take place over the winter months is dependent on detailed operating plans. Based on current practice at the Steepbank Mine, it is anticipated that there will be flows during the winter from muskeg and overburden drainage. However, these flows may not be released from the active mine area.

Muskeg and overburden dewatering flows were assumed to occur year round, as indicated in Appendix V, Section V-1.3.5. Winter flows in McLean Creek may, as a result, be higher than baseline conditions. Winter water quality in McLean Creek was assessed assuming no natural flow; all water within the channel originated from the mine site. The results of this assessment are discussed in Section C3.2.5.2 and in Table C3.2-7.

5.15 **Suncor expects large volumes of muskeg drainage water to enter surface waters during mine dewatering. Water quality data from 4 samples of muskeg drainage collected in 1997 at Syncrude Aurora mine and 1978 data from Muskeg River and Jackpine Creek are compared to data from three streams at the Millennium mine site.** ***(Vol. 2A, p. C3-16-19)*** **Does Suncor plan to collect additional data specifically from the Millennium mine site to better evaluate the water quality of muskeg drainage and to predict the effects on surface waters? Describe the levels of polycyclic aromatic hydrocarbons (PAHs) found in small streams, Shipyard Lake and in muskeg drainage.** ***(Vol. 2A, Tables C3.1-8, C3.1-9 and C3.1-11)***

Response:
Suncor intends to collect additional seasonal data on muskeg drainage waters by sampling sedimentation ponds. There is insufficient water quality data available to evaluate seasonal fluctuations in muskeg drainage chemistry. Water samples collected from Wood, McLean and Leggett Creeks, Shipyard Lake and Muskeg

drainage areas have never been analyzed for PAHs. As a result, PAH concentrations in these waters are not known. However, PAHs have never been detected in surface waters that have been analyzed for these substances.

Suncor is committed to examining PAH concentrations in Wood, McLean and Leggett creeks, Shipyard Lake and Muskeg drainage areas.

5.16 **Biochemical oxygen demand measured in 4 samples of muskeg drainage from the Aurora mine show a range of levels (<0.05, 6.1, 6.7 and 8 mg/L).** ***(Vol. 2A, p. C3-52)*** **Data for nutrients (ammonia and total phosphorus) show greater concentrations in muskeg drainage than in local streams.** ***(Vol. 2A, p. C3-19, Table C3.1-11)*** **Dewatering drainage will contain different proportions of muskeg and overburden waters and thus, will have variable water quality.**

Are more comprehensive data (larger number of samples and from different areas) available to show the natural range of biochemical oxygen demand expected from dewatering activities in the Millennium mine? Are there seasonal differences between the biochemical oxygen demand levels and other general water quality characteristics in muskeg drainage and overburden water, especially during winter when surface water flows are at their lowest levels?

Response:
Data on muskeg and overburden drainage at Suncor is limited to the licensed mine drainage streams on Lease 86/17 with only a few monitored parameters. As per commitments in other responses, Suncor will commence expanded monitoring of these streams for the east bank mining area.

5.17 **Suncor states that if monitoring of dissolved oxygen (DO) in muskeg drainage shows problems, levels of organic material will be controlled using sedimentation ponds.** ***(Vol. 2A, p. C3-53 and C3-69)*** **Clarify how this will be done. Could a problem be identified rapidly enough to allow mitigation? Discuss whether sedimentation ponds will successfully reduce quantities of organic material. Describe how DO and biochemical oxygen demand will be monitored in the sedimentation ponds and receiving streams.**

Response:
Organic material associated with particulate matter can be settled out in the ponds. Other mitigation options to maintain DO levels will be pursued once more water quality data is available.

5.18 **The water quality modelling predicted exceedances of various metals and benzo(a)anthracene polycyclic aromatic hydrocarbons (PAHs) in the Athabasca River, McLean Creek and Shipyard Lake. *(Vol. 2A, p.C3-34-43)* Describe the metals used in the modelling, in particular, those metals known to be found in waters affected by oil sands mining and muskeg drainage. Has Suncor considered the potential accumulation of metals in aquatic sediments, biota and food webs?**

Response:
Metals included in the water quality assessment are listed in Appendix V, Table V-6. They include metals known to be found in waters affected by oil sands mining and muskeg drainage. Since exceedances are due to natural background levels and because a large amount of the metals are typically in the non-bioavailable particulate form, it is not likely that accumulation will occur beyond that which may currently take place. Additional seasonal metals monitoring will be done to verify this as part of RAMP. Suncor's proposed fish health study will examine metal and PAH concentrations in fish tissues to assess the bioaccumulation potential of these substances.

5.19 **Recent data collected by Golder Associates has shown a 2 to 3-fold increase in total polycyclic aromatic hydrocarbons (PAHs) in sediments in the Athabasca River below the oil sands area, in contrast to a site between Fort McMurray and Suncor's current operations. *(Vol. 2A, p. C3-6 and 55)* Discuss the implications for this increase in PAHs. Outline the baseline concentrations used for modelling PAHs in McLean Creek. *(Vol. 2D, Tables V-11 and V-12)* Elaborate on why recoverable hydrocarbons were at 9 mg/L in Wood Creek during summer, in contrast to concentrations of <1 mg/L in all other samples from Wood, McLean and Legget creeks. *(Vol. 2A, p. C3-14, Table C3.1-8)***

Response:
The increase in sediment PAHs below the oil sands area has only been observed in 1997. Previous data collected during the NRBS (during the early 1990s) has not shown the same trend, therefore it should be verified with further sampling before conclusions can be formulated regarding its significance. Sediment sampling will continue during RAMP, which will also include an expanded sediment program. Therefore, the data required to confirm the increase below the oil sands area will be collected as part of long-term monitoring.

Baseline concentrations of PAHs in McLean Creek were assumed to be zero, based on the hydrophobic properties of PAHs and the fact that, to date, PAHs have not been detected at measurable concentrations in natural surface waters in the oil sands area using conventional detection limits.

There is no known reason for the higher measured level of recoverable hydrocarbons in Wood Creek relative to other streams. However, it is possible that sediments in Wood Creek contain more oil sands than those in the other streams.

Suncor has considered the potential bioaccumulation of PAHs in fish in the local study area. See p. C4-59 to C4-62. Baseline information on tissue levels of PAHs in benthic invertebrates is also available (Golder 1996). Further information on the potential for bioaccumulation of PAHs in fish will be obtained through follow-up studies on the effects of CT water on fish health (p. C4-55 and C4-56). The fish health studies will include tissue analyses for PAHs.

Reference

Golder Associates Ltd. 1996. Aquatic baseline report for the Athabasca, Steepbank and Muskeg Rivers in the Vicinity of the Steepbank and Aurora Mines. Final Report for Suncor Inc., Oil Sands Group. 164 p. + Appendices.

5.20 **Suncor indicates that the effectiveness of sedimentation ponds to control contaminants (predicted by modelling to be at high levels) will be assessed.** ***(Vol. 2A, p. C3-46)*** **Please provide the following information:**

a) **Sedimentation ponds that will be monitored.**

b) **The discharge locations for these ponds.**

c) **Monitoring parameters and frequencies.**

Response:

The mine drainage plan prescribed in Volume 1, Section C2.4.3 illustrates the various sedimentation ponds. Some of these ponds handle mine pit drainage which is diverted to the tailings process. Others collect muskeg and overburden drainage which all eventually discharge to the Athabasca River. The main sedimentation ponds conceptual locations are also shown on the drainage plans presented in volume 2A, Figures C2.2-5 and C2.2-8 through 11.

Details with respect to a monitoring program will be finalized with AEP with the drafting of the Amendment to the Environmental Operating Approval for Project Millennium.

5.21 **Suncor suggests that if changes in water quality caused by water releases from the Project are detected, the retention time of sedimentation ponds and wetlands will be increased. What is Suncor's plan to accomplish this, especially if a large volume of water or long time period is required? Discuss how and when the water quality parameters will be monitored.**

Response:
The statement is made based on current projections indicating that an impact would not occur and that if an impact were to be anticipated, it would likely not be of a magnitude that significant increases in volumes would be required. The water quality parameters to be measured could include BOD, DO, acute and chronic toxicity, temperature, TSS and pH on a routine basis and PAHs and dissolved and total metals less frequently, both in the ponds and in the receiving streams.

The structures will be designed to appropriate standards for retention times. This will be done in consultation with AEP.

Closure Planning/Landscape Design

5.22 **Suncor has provided a reclamation drainage plan. *(Vol. 2A, p. C2-34)* However, there are no maps or figures which delineate the post-reclamation drainage boundaries or tabulate the drainage areas of the major water features (such as Shipyard Lake, McLean Creek, Wood Creek, and the end pit lake). Please provide 10 copies of maps and figures comparing the pre- and post-reclamation basin boundaries and the associated drainage areas.**

Response:
Volume 1, Section C2.4.3 has a series of figures illustrating pre-development, operational, and future drainage areas.

McLean Creek

5.23 **Please describe how the average annual flows for McLean Creek were derived. The inflows value from the undisturbed areas of Leggett and Wood Creeks do not seem to be consistent with the various time steps. *(Vol. 2A, p. C2-41, Table C2.2-9)***

Response:
There will be two drainage systems for surface runoff. They are:

- An interception drainage system to collect runoff from undisturbed and cleared areas, muskeg drainage and groundwater from shallow aquifers.

Water from this system will be discharged to environment via watercourses in the project area.

- A mine drainage system to collect runoff from mined, stripped and developed areas as well as groundwater from the Basal Aquifer. Water from this system will be used in process or, it is excess to process needs, treated before being released.

The flows shown on Table C2.2-9 are natural runoff to the watercourses plus flows from the interception drainage system.

The annual runoff to the watercourses in the Local Study Area (Shipyard Lake, Unnamed Creek, Leggett Creek, Wood Creek and McLean Creek) was estimated for each time step using the following approach:

1. An interception drainage system was developed using natural topography to minimize the runoff from outside the mine footprint that could not be captured by the interception drainage system and had to be diverted to mine drainage.
2. Using maps provided by Golder Associates, areas were estimated for undisturbed and cleared portions of the basins draining to each watercourse as well as for the dumps and reclamation materials stockpile, where appropriate. It was assumed that runoff from the latter two items would, with some settlement, be suitable for release to the environment.
3. Annual runoff volumes and flows were calculated using the net runoff depths given on Table C2.2-7 for each type of surface.
4. Estimated additional flows due to muskeg drainage and groundwater discharge from surficial aquifer dewatering were then added to arrive at the values shown on Table C2.2-9. It was assumed that the muskeg would be drained over a two year period.

5.24 **Starting during construction, both mean annual and mean daily flows in McLean Creek will increase substantially.** ***(Vol. 2A, p. C2-35)*** **The 1:100 flood event would now be expected to occur once every five to ten years. Please clarify:**

a) the expected impacts to McLean Creek.

b) the measures Suncor intends to take to prevent excessive erosion and to protect the existing streambed, habitat and morphology of the creek ,and at what stage of mine development.

c) whether Suncor would armour the creek before a serious problem.

d) how Suncor will do the instream work.

e) Suncor's plan to gain access to the creek with equipment and materials without causing considerable damage to the watershed.

Response:
Suncor believes the impacts to McLean Creek will be positive in the long term. As detailed in the EIA, water flows in McLean Creek will increase. Additionally, as discussed in the Suncor Project Millennium conceptual "no net loss" plan (Golder 1998), McLean Creek has been indicated as one area where fisheries habitat can be enhanced in compensation for losses in Leggett and Wood creeks.

Based on the changes in the hydrological regime of McLean Creek, modifications to the channel and stream banks will be made to accommodate the increased flows such that the resulting channel is dynamically stable. Dynamically stable channels have achieved a balance between their ability to move water and sediment and will, therefore, be able to function within their floodplains without excessive erosion.

The concepts outlined in OMNR (1994) and FISRWG (1998) are suggested for the design of the new channel and its features. These measures will ensure that the new channel is capable of conveying the increased flows. The channel features (e.g., size, shape, meander pattern, slope, banks) will be developed to accommodate the modified hydrology and sediment load.

Specific bank treatment measures such as rip rap; bank shaping and planting; brush mattresses; log rootwad and boulder revetments will be incorporated into the channel design at the reach level where necessary.

The measures outlined will be used to preserve or enhance fish habitat in McLean Creek. Mitigation of habitat impacts in McLean Creek are also described in the Project Millennium conceptual "no net loss" plan (Golder 1998).

Suncor will undertake work on and within McLean Creek to ensure that fish habitat is protected or enhanced, not destroyed. Therefore, planning for the work to be completed will include consultation with Alberta Fish and Wildlife personnel as well as personnel from the Department of Fisheries and Oceans on the best methods to achieve the desired outcomes in the creek.

Detailed plans for the completion of the work on McLean Creek will be finalized following approval of Project Millennium. As noted above, consultation with regulatory agencies will be included in development and finalization of the plans. Access to McLean Creek will be required on a routine basis for the purposes of the creek monitoring that Suncor has proposed. Therefore, it is expected that some form of roadway will be required to access the area. This access plan will be included in the overall plan for habitat enhancement in McLean Creek.

References:

Federal Interagency Stream Restoration Working Group. 1998. Stream Corridor Restoration: Principles, Processes and Practice.

Ontario Ministry of Natural Resources. 1994. Natural Channel Systems: An Approach to Management and Design. 101 p. + Appendices.

Golder Associates Ltd. 1998. Project Millennium Conceptual Plan for "No Net Loss" of Fish Habitat. Prepared for Suncor Energy Inc., Oil Sands.

5.25 **McLean Creek is characterized by unstable and undercut banks. *(Vol. 2A, p. C4-16)* Increased flows may accentuate or aggravate this problem. Clarify if Suncor intends to implement the habitat improvement/protection program before directing any flows towards this creek. How will Suncor protect McLean Creek from habitat loss?**

Response:
Modification of McLean Creek to allow it to handle the predicted increased flows will be completed prior to its use for the increased flows. Please refer to the response to Question 5.24 for a discussion on protection and enhancement of fisheries habitat.

5.26 **Dewatering of the mine site will produce large volumes of surface drainage. Flow in McLean Creek is predicted to increase 3-fold, beginning during mine construction. *(Vol. 2A, p. C3-52)* Sport fish (young-of-the-year arctic grayling) were found downstream of the escarpment in McLean Creek indicating rearing habitat and spring spawning in this section of the stream. *(Golder Associates.1998. Suncor Project Millennium – 1997. Fall Fisheries Investigations)* Mean open-water flow was used in the model for McLean Creek. *(Vol. 2A, C3-25)***

Can estimated or known annual 7Q10 values be used for the modelling of water quality parameters in McLean Creek during winter? In particular, discuss the effects changes in water quality, such as decreased dilution of contaminants and low dissolved oxygen during winter will have on fish and other aquatic organisms, in McLean Creek. Will the habitat of aquatic organisms be restored or enhanced to mitigate the potential effects of high discharge?

Response:
As described in Section C3.2.5.2, McLean Creek is an intermittent stream which can experience no flow conditions in winter. To be conservative, winter water quality in McLean Creek was assessed assuming that background flows were equal to zero, and the only flows in the creek were a result of natural basal and surficial aquifer seepage and Project releases. The results of the assessment for water quality impacts for McLean Creek are discussed in Section C3.2.5 of

Volume 2A. The predicted impacts to McLean Creek were classified as negligible to low in magnitude, longterm in duration, moderate in frequency, local in geographic extent and irreversible. The mitigation is discussed in response 5.24. Because of the low level of uncertainty associated with predicting this impact, Suncor is confident that these mitigation measures will be effective

Shipyard Lake

5.27 **Suncor proposes to divert runoff from the northeast overburden dump and reclamation materials stockpile to Shipyard Lake via the interception drainage system. *(Vol. 2A, p. C2-48)* What is the anticipated quality of the water draining from the dump and the reclamation stockpile? Will it increase nutrient and metal loadings into Shipyard Lake?**

Response:
As discussed in Appendix V, Section V-1.3.6, reduced surface water flows to Shipyard Lake could be supplemented by pumping 0.1 m^3/s of Athabasca River water into the lake from 2020 to 2033. Lake levels will not change over the life of the mine, since inflows into Shipyard Lake will continually exceed evaporative losses. As such, the lake will always produce an outflow to the Athabasca River. Water quality in Shipyard Lake is discussed in Section C3.2.5.2 and Table C3.2-8, as well as in Appendix V, Table V-13.

The referenced information indicates that runoff from the NE Dump and Reclamation materials Stockpile will be directed to Shipyard Creek, and not Shipyard Lake as indicated in the question. Shipyard Creek is the outlet channel connecting Shipyard Lake to the Athabasca River. As such, discharging runoff from the reclaimed dump and stockpile to the creek should not affect water quality in Shipyard Lake.

Runoff from the reclaimed dump and stockpile were assigned water chemistry equivalent to median annual water quality in McLean, Wood and Leggett creeks. These flows were accounted for in the Shipyard Lake modelling. Therefore the potential for these waters to influence Shipyard Lake water quality was assessed in Section C3.2. The results of this assessment are summarized in Table C3.2-8 and discussed in greater detail in Section C3.2.5.2.

5.28 Water into Shipyard Lake will originate from Ponds 7, 9, and the north half of 10, the northeast overburden dump and some non-mined areas. *(Vol. 2B, p. E-29)* Similarly, the water quality from the dump is anticipated to be of acceptable quality assuming that it is not detrimentally impacted by Clearwater materials. Please discuss how Suncor will prevent Shipyard Lake from receiving poor quality water contaminated by Clearwater material.

Response:
As the stream in question will discharge to the Athabasca River, it will flow through a control system meeting specified requirements of the AEP operating approval.

5.29 **During the early stages of mining, Suncor will divert natural runoff and muskeg drainage water from the upland areas into Shipyard Lake.** ***(Vol. 2A, p. C4-43)*** **Discuss whether this will increase the chances of further lowering oxygen levels in Shipyard Lake (increased biochemical oxygen demand), especially during the winter. Clarify whether Suncor anticipates any flow into Shipyard Lake in the winter.**

Response:
Suncor has committed to maintain Shipyard lake in its natural state to the extent possible. Oxygen would be maintained at appropriate levels by controlling input streams (e.g., sedimentation ponds). Winter flows are minimal or non-existent naturally and this would be the intent of the proposed drainage plan.

5.30 **Impacts on flows to Shipyard Lake are rated as "negligible".** ***(Vol. 2A, p. C2-52)*** **Flows in Unnamed Creek are expected to be reduced by as much as 2/3. Is this rating based on the mitigation Suncor intends to implement? In terms of frequency, volumes and duration, discuss how Suncor will supplement Shipyard Lake inflows such that the character of the wetland is maintained. For example, would a continuous baseflow be supplied to replace the predicted losses, or would periodic flooding be employed to mimic peak storm events or Athabasca River flooding, or is some other method envisioned?**

Response:
The rating presumed the mitigation measures to be in place. The timing and amount of diversions from the Athabasca River will be based on what ongoing studies indicate are required to maintain the present aquatic ecosystem in Shipyard Lake. This may vary from maintaining water levels in the wetlands complex through maintaining existing flows from the local drainage basin to mimicking overflows to the Athabasca River.

5.31 **Suncor predicts post-reclamation landscape surface inflows to Shipyard Lake to be approximately equal to pre-development conditions.** ***(Vol. 2B, p. E-25)*** **Clarify the long-term contingencies if flows are either too high or too low, or if the consolidated tailings (CT) discharge water quality is**

acceptable. Indicate whether the End Pit Lake would be available at the time of these initial CT releases to receive this water. ***(Vol. 2A, p. C3-47)***

Response:
The flow balances were based on the best available information. Water from CT during the active consolidation process is recycled to extraction tailings system and is not released to the environment. Contingencies for the post operations period include continuing treatment if necessary as outlined in the Suncor Steepbank Mine Application.

The end pit lake is not in existence during the early life of the mine. Water from the CT consolidation begins with Pond 7 and will be recycled into the extraction process. This water is not released to the environment. Once full reclamation of CT deposits is completed, the end pit lake will be available for receipt of runoff waters from CT deposit areas.

5.32 **After 2015, the area of the mine contributing flow to Shipyard Lake will be mined out and runoff will be diverted to the End Pit Lake, resulting in reduced mean annual flows to Shipyard Lake.** ***(Vol. 2A, p. C2-48)*** **Suncor indicates that it might use water from the Athabasca River to maintain the water balance of the lake. Indicate whether Suncor intends for the water withdrawn from the Athabasca River to be included in their current withdrawal permit, or whether this is in addition to their current allocation.**

Response:
After 2015 the area of the mine contributing flow to Shipyard Lake will be mined out and runoff will be diverted to the in-pit lake resulting in reduced mean annual flows to Shipyard Lake. Water from the Athabasca River may be used to maintain the water balance of this lake.

If required, make-up water required for Shipyard Lake can likely be covered within our current withdrawal permit. Preliminary estimates suggest that on an annual basis, the make-up volume required is in the order of 50-100 l/s. However, data from Shipyard Creek, the outlet from Shipyard Lake, (Figure 36, Hydrology Baseline Report) show a wide range of flows. Suncor is carrying out on-going monitoring (e.g. RAMP) to determine what the effect of the flow variability is on the Shipyard Lake eosystem. In addition, Suncor is still evaluating the potential for using water from sources already part of an allocation which will reduce or eliminate the need for water from the Athabasca River.

Hydrogeology

5.33 **Ground water flows horizontally towards Shipyard Lake and the Steepbank River.** ***(Vol. 2A, p. C2-16)*** **The mine site will intercept flows into these water bodies. What impact will the interception of this ground water have on summer and winter flows on the Steepbank River and Shipyard Lake?**

Response:
This question is addressed in Volume 2A, Section C2.2.2 in the response to Key Question SHH-1. The discharges from each aquifer are discussed. Based on the evaluation criteria, the impacts to flow are negligible to both Steepbank River and Shipyard Lake.

5.34 **Suncor indicates that the range of concentrations of naphthenic acids measured in the consolidated tailings (CT) porewater (62-94 mg/L) is slightly higher than in the bedrock aquifers (8-57 mg/L).** ***(Vol. 2A. p. C2-28)*** **Please explain Suncor's use of the term "slightly higher".**

Response:
The concentrations of naphthenic acids in CT porewaters ranges from 62 to 94 mg/L, while that in bedrock aquifer groundwaters ranges from 8 to 57 mg/L. The statement that one was slightly higher than the other was focused on the difference between the upper end of concentrations for the aquifer and the lower end for the porewater (i.e., 57 versus 62).

5.35 **Suncor proposes to use interceptor ditches, which is similar to Tar Island Dyke, to prevent seepage from Pond 8A from entering the Athabasca River.** ***(Vol. 2A, p. C2-31)*** **How much confidence does Suncor have with the efficiency of these ditches? Will the interceptor ditch collect seepage coming out of the bottom of the pit? Describe the effect this seepage will have on Athabasca River water quality if it goes beyond the interceptor ditches.**

Response:
Interceptor ditches are very effective in controlling seepage through dyke structures, but will not intercept foundation seepage. Based on the low permeability of CT deposits and experience with existing tailings ponds, seepage quantities from the pond bottom will be extremely small. During detailed design, measures will be implemented to control drainage water from cell construction through the foundation, which is the primary source of seepage reaching the Athabasca River from Tar Island Dyke (TID). It is anticipated that seepage quantities from Pond 8A will be less than or equal to flows from TID. Monitoring to assess potential impacts related to TID seepage have shown no impact on aquatic life or water quality in the Athabasca River.

5.36 **Figure C2.2-9 shows the drainage plan for the year 2018. How far will Ponds 8 and 8A be from the Athabasca River? *(Vol. 2A, p. C2-45)* Is there any possibility for this to become a similar situation to Tar Island Dyke?**

Response:
The minimum distance between the surface of Pond 8 (which is already approved in the Steepbank Mine Plan) and the Athabasca River is about 1 km. The surface of Pond 8A will be about 1.5 km from the Athabasca River. The dykes for Ponds 8 and 8A will be constructed on Tertiary sediments with a minimum 300 m setback between the downstream dyke toe and the Athabasca River valley, while Tar Island Dyke was constructed in the river valley on Holocene alluvial sediments. Ponds 8 and 8A will be constructed to modern standards identical to any other current Suncor pond, using over 30 years of experience gained in seepage and reclamation issues since Tar Island Dyke was designed.

5.37 **Suncor considers the impact on Leggett Creek to be of low severity and short term. *(Vol. 2A, p. C2-55)* Given that Leggett Creek will be eliminated by the Project, clarify Suncor's rationale for "low" level impact.**

Response:
The statements referenced are from a section of the EIA that is focused specifically on Key Question SHH-4, which deals with sediment concentrations and channel regimes in receiving streams. Since there will be no be flow in Leggett Creek, the impact should be the same as the flow impacts, i.e., high severity, local in extent and long-term. The impact on the Athabasca River is negligible. This impact on Leggett Creek remains the same as described for the approved Steepbank Mine.

5.38 **Suncor discusses bedrock acquifers and groundwater flows in the unclaimed landscape. Clarify the anticipated elevation of the hydraulic head. If the hydraulic head approximates the elevation of the reclaimed surface, discuss the potential impact on vegetation.**

Response:
The bedrock (Basal Aquifer and possibly the Devonian bedrock) is a confined system. Therefore, although the head is at surface, the actual water does not reach the surface since the flow direction is vertically downward or horizontal.

End Pit Lake

5.39 **There is uncertainty regarding the future configuration of the End Pit Lake (EPL). Does the uncertainty regarding the EPL have implications for the Millennium project operation? For example, would early alterations to the mining plan be necessary if it were desirable to produce a different configuration in the end pit to mitigate projected problems in the EPL?**

Response:
The design details for the end pit lake (e.g., shape, configuration, contents, littoral zones, end use, access control) will all be determined at an appropriate time towards the end mine-life. The uncertainty regarding these design details does not have any implications for the mine plan early on. The end pit lake does not drive the mine sequence, rather it is the result of mining the ore body and can be configured as required at the appropriate time

5.40 **The End Pit Lake (EPL) will consist of two lakes linked by a wetland. Outflow from one lake containing mature fine tails (MFT) and consolidated tailings (CT) materials will flow through the wetland to the second lake. Since the lakes have different design features, types and quantities of tailings and waters, clarify why modelling was based on one lake rather than two.**

Response:
Modelling the end pit lake as a single body was a conservative approach, since the beneficial effects of the interconnecting wetland were ignored. Organics and other compounds would degrade much faster than shown in the EIA if the interconnecting wetland had been included in the end pit lake model. Therefore, at this early stage of assessment and considering the worst case nature of the model, it will not provide additional value to model the lakes separately.

5.41 **Modelling for the End Pit Lake (EPL) assumes complete mixing. Thermal stratification is an important physical characteristic that will likely affect various water quality parameters including concentration of dissolved oxygen (DO), metals, polycyclic aromatic hydrocarbons (PAHs), hydrogen sulphide (H_2S), ammonia (NH_3) and phosphorous (P) levels that are of concern in the EPL. Clarify whether Suncor plans to improve the model so it can use specific design criteria such as lake depth and area, wind fetch to predict if thermal stratification will occur. Can other lakes be used as an analogue to determine if thermal stratification will occur in the EPL? Does Suncor have any plan to model the EPL using the assumption of thermal stratification to determine the effects of various contaminants that might accumulate in the hypolimnion? Would the modelling include winter conditions?**

Response:
Fine Tailings Fundamentals Consortium (1995) reported on work done in support of the Syncrude Base Mine Lake application in 1993. The rheological properties of mature fine tailings in terms of its ability to establish a well stratified system were reported. This work also indicated that, based on laboratory investigations and historical wind records, there is a very low probability of occurrence of storm or convective thermal mixing events capable of generating velocities required to suspend the fine tails under the planned water capped depths. A capping depth of 5 m was reported as being sufficient to prevent resuspension during a one in one hundred year storm for a lake with a fetch of 4 km.

The end pit lake is expected to be thermally stratified at least some of the time during the summer months. Stratification is a feature common to all deep lakes in Alberta. More sophisticated water quality modelling will be pursued to attempt to predict how substances may be affected by thermal stratification and subsequent full mixing and to determine the effect of seasonality on substance concentrations. This modelling will be initiated consistent with the formation of the end pit lake committee discussed below.

5.42 **In the event future monitoring indicates that water quality in the End Pit Lake (EPL) is unsuitable and that human and wildlife access to the EPL must be limited, discuss Suncor's mitigation strategy.** ***(Vol. 2C, p. F1-74)***

Response:
Suncor will consider mitigation measures in its research strategy that would limit human or wildlife access to the end pit lake should that be a concern.

5.43 **Figure C.2.4-12 shows that Pond 12 will be an End Pit Lake (EPL), which will fill with surface runoff and CT release water.** ***(Vol. 1, p. C2-71)*** **Discuss the potential for saline or brackish water from groundwater or watersand deposits to contribute to Pond 12 filling.**

Response:
The end pit lake elevation is higher than the head of the Basal Aquifer. Therefore, these units will not discharge into the end pit lake. This is shown by the negative numbers (i.e., outflow from the lake to the groundwater) in the end pit lake water balance presented in Table C2.2-12 (Section 2.2.3).

5.44 **Discuss Suncor's research strategy to ensure that the End Pit Lake is a self-sustaining ecosystem. Discuss the research that will be conducted and provide a work schedule.**

Response:
Suncor understands that there are many uncertainties associated with the end pit lake, but believes that it can be designed and operated to achieve the desired end result of a viable, productive, self-sustaining lake with a non-toxic outflow at all times. The key to achieving this goal is proactive planning, research and monitoring. Suncor is committed to participating with other regional operators and regulators to achieve this goal. This regional approach will be used not only to continually fine-tune design and operational parameters, but to assess the overall feasibility of the end pit lake concept, to ensure a viable plan is available for reclamation.

Suncor believes it will be necessary to form a dedicated, multi-stakeholder committee to ensure that the knowledge gained on end pit lakes over the ensuing decades is consistent with that required to ensure that they are viable reclamation features at closure. Suncor is committed to this endeavor.

Some of the elements of the monitoring plan may include:

- continued toxicological and chemical (naphthenic acids, BOD, PAHs, salts, metals [dissolved and total]) characterization of contributing streams; and
- acquisition of vertical profiles for temperature and chemicals (DO, salts, toxicity, BOD, naphthenic acids, PAHs, metals [dissolved and total]) from Base Mine Lake and analogue lakes

The frequency of sampling would be defined based on end pit lake committee recommendations and modelling needs. Monitoring of the end pit lake once it is developed and filling would be based on knowledge gained from the initial work described above. It is expected that monitoring would begin very early during end pit lake filling to verify predicted results and enable contingency options to be pursued at optimal junctures.

5.45 **Suncor will contour shoreline areas to enhance future potential for use of the lake as a recreational area. *(Vol. 1, p. E3-39)* Please describe how the backshore design could be incorporated to accommodate more intensive recreational use potentially attracted to the End Pit Lake (i.e., beach use, day use, camping, boating).**

Response:
The intensive planning for development of recreation properties around the end pit lake is premature. This portion of the mine development will not occur until after the year 2025. Therefore, Suncor is taking a pragmatic approach by not including within the closure plan the intensive recreational use of reclaimed areas around the end pit lake. During design and construction of the lake

following 2025, some features enhancements may be considered to allow the Government of Alberta the opportunity to initiate insensitive recreational activities following reclamation and certification. What those features are and how they are included in the landscape design will be a result of stakeholder consultation.

Prior to the construction of the end pit lake, Suncor will establish a research program and will cooperate with regional stakeholders in any common programs.

5.46 **Suncor states that the capability to support forestry and wildlife indicates that re-established ecosystems are diverse and will provide the opportunities for traditional land use and recreational use. *(Vol. 1, p. E3-39)* Suncor goes on to say that reclamation to a diverse upland habitat with good wildlife potential and much higher recreational attractiveness will change all land uses and recreational uses. Discuss if this has been taken into account in the final landscape design. Also stated in the application is "inherent within the design of reclamation areas suitable for wildlife habitat is the development of areas with the potential for recreational use". *(Vol. 1, p. E3-41)* Please discuss the possibility of re-design, considering the entire range of potential recreational uses (i.e., camping, beaches, and extensive trail riding, ATV use, picnicking). In particular, discuss those recreational uses which will be attracted to the End Pit Lake.**

Response:
It is Suncor's intent that its reclaimed lands should provide areas usable for commercial forestry as well as for wildlife habitat. The primary recreational goal associated with Suncor's current closure plan is wildlife observation. Ultimate decisions on the end land use of the reclaimed Project Millennium area will be based on the input from stakeholders. Suncor is committed to discuss end land use desires of the region with traditional land users as well as other stakeholders.

Modifications to the final landscape design can be over the life of the project. Based on the input of the regional stakeholders, Suncor will develop final landscape designs as the project progresses.

In keeping with the predisturbence recreational activities existing within the development area, these same recreational opportunities are projected for the post reclamation landforms. These are both passive in nature. At this stage of development, Suncor has not determined details for the recreation use option. Detailed recreation options will only be included through stakeholder input and interest at a time when the end pit lake is closer to being a reality.

6.0 AQUATIC RESOURCES

6.1 **Several studies have documented effects on the fish in the lower Athabasca River, such as induction of liver enzymes and delays in sexual maturation in fish. Discuss Suncor's plans to conduct similar studies to determine whether this trend is continuing or increasing in magnitude.**

Response:
There is ample evidence of mixed function oxidase (MFO) induction in fish in the oil sands area, indicating exposure to a combination of natural conditions and industrial discharges (Lockhart and Metner 1996, Golder 1996).

However, there is insufficient evidence of fish health effects in the Athabasca River. Lockhart and Metner (1996) found indications that the frequency of immature burbot collected in the lower Athabasca River in NRBS studies is lower than expected. However, this finding has not been confirmed (Lockhart and Metner 1996). In fish health studies for the Steepbank Mine, effects have been noted compared to reference data, but sample sizes were low and/or reference data were from a different year (Golder 1996).

Suncor, along with other oil sands operators, is funding two fish health studies: fish health parameters will be measured in fish collected as part of the RAMP program and the health of fish exposed to CT waters will be assessed in the laboratory. See pages C4-55 to C4-56 in the EIA for more details on the laboratory fish health study.

The fisheries program of RAMP includes collection of fish population parameters (e.g., length-frequency, length-at-age) from Athabasca River walleye, goldeye, lake whitefish and longnose sucker. Fish will be sampled in the oil sands area and from a reference site (if a suitable site can be found). Currently, a suitable reference area is being sought.

Fish health parameters including liver somatic index (LSI), gonadal somatic index (GSI), fecundity, gross and histopathology and age-to-maturity will also be measured in a subsample of fish collected as part of the RAMP program. Sample size will be based a balance between collecting useful information on fish health and the number of fish mortalities.

Field fish health information will be used in conjunction with results of NRBS studies (Brown et al. 1996, Lockhart and Metner 19996), PERD studies and previous (HydroQual 1996a, 1996b) and future laboratory studies to provide a weight-of-evidence approach to determining impacts on fish populations and fish health.

References:

Brown, S.B., R.E. Evans and L. Vandenbyllaardt. 1996. Analysis for circulating gonadal sex steroids and gonad morphology in fish: Peace, Athabasca and Slave River Basins, September to December, 1994.

HydroQual Laboratories Ltd. 1996a. Laboratory studies on trophic level effects and fish health effects of Suncor Tar Island Dyke Wastewater. Report for Suncor Inc., Oil Sands Group, Calgary, Alberta

HydroQual Laboratories Ltd. 1996b. Laboratory tests of trophic level effects and fish health effects and tainting potential of Suncor Refinery Effluent. Report for Suncor Inc., Oil Sands Group, Calgary, Alberta.

Golder Associates Ltd. 1996. Athabasca River water releases impact assessment. Prepared for Suncor Inc. Oil Sands Group.

Lockhart, W. L. and D.A. Metner. 1996. Analysis of liver mixed-function oxygenase in fish, Peace, Athabasca and Slave river basins, September to December, 1994. Northern River Basins Study Project Report No. 132. 53 pp.

6.2 **Suncor will mitigate temperature changes to prevent impacts on fish habitats. *(Vol. 2A, p. C4-46)* If a temperature problem is discovered, how fast does Suncor expect to be able to respond? Discuss the monitoring sites Suncor intends to develop in terms of location, number and timing.**

Response:
The monitoring program for McLean Creek is yet to be developed with respect to temperature and other parameters. Baseline temperature data will be collected as well as through the operationg phases of the mine. If a temperature problem is discovered, Suncor will make the appropriate adjustments to the drainage system. At this stage of planning, the monitoring and mitigation details have not been developed.

6.3 **Suncor estimates seepage rates into Wood and Leggett Creeks to be 10L/s after closure. *(Vol. 2B, p. E28)* Please elaborate on any adverse effects on the water quality of these streams, especially at the mouth of the stream where sport fish are currently found.**

Response:
This is primarily a water quality and fisheries issue. The 10 L/s is a post closure flow estimate. Releases to the former Wood and Leggett creek channels would not be done if water quality is not acceptable.

The upper and middle portions of Wood and Leggett Creek catchment basins will be either eliminated or rerouted early in the Project. Hence, the lower portions of these creeks will essentially be dewatered except for the small amount of seepage (10 L/s) which will occur in the dry creek bed. Since the creeks will not be utilized by fish once they are dewatered effects on water quality and subsequently on sport fish would not occur. Note that the seepage from Leggett and Wood Creeks were accounted for in the Athabasca River water quality modelling.

6.4 **The following questions are based on the report entitled *Golder Associates. 1998. Report on 1997 Synthesis of Environmental Information On Consolidated/Composite Tailings (CT)*:**

a) **The report acknowledges that most chemistry data are for inorganic compounds. Data for organic chemistry and toxicity levels of consolidated tailings (CT) waters and solids are limited and cover a wide range of "process recipes". Discuss how Suncor will address this data gap in current, proposed and planned research and monitoring. Provide an outline of more recent or proposed work and a schedule.**

Response:
Suncor will continue research into the application of the CT technology to the closure planning. Organic and toxicity data collection are included in the various programs which have been described in Volume 1, Section E5.2.

b) **The presentation of concentrations including detection limits in Tables 1 to 5 is difficult to follow. For example, concentrations for arsenic are shown as < 20 and 0.05 ppm in Table 1 and < DL and 0.02 mg/L in Table 5. Please clarify.**

Response:
The concentrations presented in Tables 1 to 5 differ from table to table (and by parameters) due to the fact that there were different sources (i.e., Syncrude versus Suncor), study scales and matrices for the CT samples (i.e., solids versus release water). Detection limits, and as a result some concentrations, varied due to CT sample collection and analysis dates (i.e., 1993 versus 1997), and laboratories (i.e., Chemex, ETL, ASL and Syncrude Lab) used for analysis at that time. As a result, the observed variation for both concentrations and detection limits were likely due to some combination of these factors.

c) **Tables 1 and 3 show high concentrations of ammonia (NH_3) in CT solids and CT release water in bench, field and commercial scale trials of Suncor , but Table 4 shows relatively low concentrations of NH_3 in CT release water for Syncrude trials. Please explain the contrasting results between CT materials from Syncrude and Suncor trials. Will these NH_3 levels reduce over time? Clarify whether these concentrations are likely to be toxic to aquatic organisms, and will they affect bioremediation in wetlands.**

Response:
For modelling purposes, CT release waters were assumed to have an ammonia concentration of 6.3 mg/L (Appendix V, Table V-1).

At Suncor, the primary source of ammonia is stripped sour water from the Upgrader.

In addition, as CT release water ages ammonia will decrease due to various physical, chemical and biological processes that will occur in both lake or wetlands scenarios. The significant processes are assumed to be biological uptake (e.g., algae) adsorption/sedimentation (i.e., all lead to accumulation in sediments), microbial transformation by nitrification (ammonia to nitrate) and denitrification (nitrate to nitrous oxide/dinitrogen) and ammonia volatilization to the atmosphere.

Ammonia toxicity varies with temperature and pH because there is an equilibrium between un-ionized (NH_3) ammonia and ionized (NH_4^+) ammonia. Un-ionized ammonia is the toxic fraction and increases with increasing temperature and pH and the toxicity of un-ionized ammonia also varies with temperature and pH. The federal guidelines for total ammonia for the protection of aquatic life reflect both these variations (CCME 1987). For example, at temperature of 10-15°C and pH of 7-7.5 the guideline is 2.2 mg/L and at higher temperature of 20°C and pH of 8 this guideline is reduced to 0.93 mg/L.

The total ammonia concentrations observed in the CT release water often exceed these guidelines. However, with storage over time or wetlands treatment ammonia in oil sands process affected waters has decreased from the 5-15 mg/L to < 1-2 mg/L and simultaneously acute toxicity to rainbow trout was removed (e.g., EVS 1995). Since one of the assumed major pathways is nitrification/denitrification which consumes approximately 4.6 g oxygen for every 1 g of ammonia oxidized, high concentrations of ammonia have been hypothesized to inhibit other microbial transformations (e.g., degradation of naphthenic acids). It is hypothesized that once ammonia is reduced below a threshold level, then other microbial processes can proceed more readily. The combination of open water wetlands (e.g., ~ 2 m deep) and highly vegetated wetlands (e.g., < 1m deep) enhance overall wetlands treatment by first removing the ammonia and then allowing other processes to proceed.

Dr. Margo Moore of Simon Fraser University is presently investigating naphthenic acid degradation in the laboratory. Samples from different wetlands have exhibited different degradation rates (Schley, Pinto and Moore 1998) and she is currently examining the effects of different resources (e.g., oxygen, phosphorus) on degradation. This information will provide a better understanding of naphthenic acid degradation and therefore what affect elevated levels of ammonia may have on reducing the overall toxicity of CT release water in either lakes or wetlands.

Gaps in organic and toxicity data will be addressed in part, by follow-up fish health studies that Suncor is planning using CT water. As described on pages C4-55 and C4-56 the planned studies include toxicity testing on representative species of major aquatic trophic levels. These studies will be conducted using the same water as the fish are exposed to in the fish health portion of the study. The study will also include chemical characterization of the water.

References:

Canadian Council of Ministers of the Environment (CCME). 1987. Canadian water quality guidelines. Prepared by the Task Force on Water Quality Guidelines of the CCME. Environment Canada, Ottawa, ON.

EVS Consultants (EVS). 1995. Constructed wetlands for the treatment of oil sands wastewater: Technical Report #4. Prepared for Suncor Inc., Oil Sands Group by EVS Consultants, North Vancouver, BC. 369 pp. + appendices.

Schley, P., L. Pinto and Margo Moore. 1998. Biodegradation of naphthenic acids in sediments receiving oil sands wastewater. Prepared for Suncor Energy Inc., Oil Sands by Simon Fraser University, Burnaby, BC. 41 pp.

d) Table 1 shows high concentrations of several metals in CT solids from bench, field and commercial scale trials. However, concentrations of most of these metals were not measured in the CT release water *(Table 3)*. In earlier studies, nickel and vanadium were of concern in oil sands mining. Please explain why these metals were not measured in CT release water. Clarify whether Suncor plans to monitor these metals the future. Will more consistent data (complete set of metals and same metals in different media) be collected in current and future studies?

Response:
The data presented in Tables 1 to 5 of the CT report (Golder Associates. 1998. 1997 Synthesis of environmental information on consolidated/composite tailings [CT]) were for illustrating and comparing representative CT solid and release chemistry between Suncor and Syncrude at different study scales (i.e., bench, field and commercial scale). Detailed listing of available CT chemistry data is provided in Appendix II of the CT report.

For modelling purposes, CT release waters were assumed to have nickel and vanadium concentrations of 0.03 mg/L and 0.17 mg/L, respectively (EIA Appendix V, Table V-1). Table IIA of the CT report lists the CT solid chemistry for nickel in the range of 14.4 µg/g (Syncrude bench trial); 1.2 µg/g (Suncor field trial) and 10.8 µg/g (Suncor commercial). The vanadium concentrations (from Table II-A) for the selected CT solids were 23.7 µg/g (Syncrude bench), 4.43 µg/g (Suncor field) and 19.6 µg/g (Suncor commercial trial).

e) **It is difficult to make comparisons and identification of potential relationships between CT solids and CT release waters when organic compounds were not consistently measured. *(Tables 2, 6 and 7)* Clarify whether the same polycyclic aromatic hydrocarbons (PAHs) and other organic compounds, known to be associated with oil sands mining will be measured in CT solids and CT release water to evaluate relationships between these media.**

Response:
As discussed above, the data are presented in Tables 1 to 5 of the CT report (Golder Associates, 1998. 1997). Synthesis of environmental information on consolidated/composite tailings (CT) were for illustrating and comparing representative CT solids and release water chemistry between Suncor and Syncrude at different study scales (i.e., bench, field and commercial scale). Detailed listing of available organic CT chemistry data is provided in Appendix II (II-A, II-B.2, II-C.1 and II-D.1) of the CT report.

Ongoing analysis of a suite of parameters will continue in the various research programs on CT technology. Bolth solids and release water components are included in these programs

f) **The toxicity data are difficult to interpret because of changes in the CT materials being tested and lack of sufficient information in the tables. In the sections for different scales of toxicity trials *(p. 15-16)*, it is suggested that toxicity was reduced over time. Please clarify the time frame suggested here. Also, indicate how the environmental conditions and test substances are comparable in these evaluations.**

Response:
The available information is preliminary and is insufficient to provide a period over which toxicity of CT water is reduced by a certain amount or proportion. The reductions in toxicity described on pages 15 and 16 were observed over different periods, ranging from 10 weeks (bench-scale trials) to about a year (field-scale trials). These reductions were noted in toxicity tests using the same test organisms in repeated samples taken from the same batch of CT water. However, there are uncertainties, such as storage conditions, which were not

consistent among trials. Nevertheless, because reductions in toxicity were observed in a number of independent trials, there is sufficient weight of evidence to suggest that they are real.

g) **Clarify whether Suncor can summarize the toxicity data for CT release water to provide an evaluation of the potential effects on the End Pit Lake and other receiving water bodies. For example, is CT release water expected to affect the productivity (e.g., algae and other biota) and food webs of receiving waters?**

Response:
As suggested by the reviewer, the toxicity data collected for CT waters were used to assess potential effects of CT release waters on water quality in receiving waters and the end pit lake. Representative toxicity test results were converted to acute and chronic Toxic Units (TU), which were then used as input data in the water quality models. The predicted TU in receiving waters were compared with the applicable water quality guidelines. Results of the TU modelling are presented in Section C3.2.

The analysis did not extend to assessing productivity and food web effects. Effects are being addressed in various studies such as the fish health and tainting study and the wetlands research.

6.5 **The current information from wetlands research on the treatment of consolidated tailings (CT) shows that a minimum of 30 days retention time is required to reduce acute toxicity to rainbow trout, and that acute toxicity to organisms was reduced.** ***(Vol. 2B, p. E-27)*** **Clarify:**

a) **the retention time anticipated in the current plan for the Millennium mine.**

Response:
The wetlands around the tailings structures were assumed to have retention times of one year.

b) **the retention time required for the reduction of chronic toxicity for organisms tested.**

Response:
Suncor has an ongoing research program to evaluate the efficiency of constructed wetlands for treatment of oil sands wastewaters. This research is conducted as part of CONRAD, and is partially reviewed in Volume 1, section E5.2.6. Acute toxicity and chronic toxicity were assumed to degrade at 0.77/yr and 1.67/yr, respectively. Data are available that demonstrate the reduction of ammonia and total extractable hydrocarbons/naphthenic acids (EVS 1994, 1995

and 1996), which are considered the primary toxicants. As examples, toxicity to *Ceriodaphnia dubia* was reduced in constructed wetlands receiving CT release water; however, complete removal was not observed at the retention times tested (i.e., 10 d and 36 d; EVS 1996). In previous studies focusing on dyke drainage, improvement in *Ceriodaphnia* reproduction was observed at the retention times tested (i.e., 18 d; EVS 1995).

c) **whether data is available to demonstrate the efficiency of constructed wetlands to change and reduce various water quality parameters associated with oil sands mining that are of concern.**

Response:
Information on the research completed by Suncor and its research partners on the efficacy of constructed wetlands is available as part of the CONRAD environmental information. Specific CONRAD information is available from the Alberta Department of Energy, secretariat for CONRAD.

d) **what is available to examine the potential bioaccumulation of contaminants in wetlands.**

Response:
Bioaccumulation has been assessed where some metals were considered to be of potential risk (EVS 1994 and 1995; included as reports to CONRAD). Current research at the Suncor wetlands research facility includes collection and archiving of chironomids for tissue residue analysis by Dr. Jan Ciborowski of the University of Windsor; assessments using mallard ducklings by Dr. Leah Bendell-Young of Simon Fraser University; and assessment of tree swallows by Dr. Judit Smits of the University of Saskatchewan and Mark Wayland of the Canadian Wildlife Service.

e) **what research and monitoring is currently being conducted or planned to evaluate the efficiency of wetlands that will be used in the Millennium mine.**

Response:
Suncor is actively researching the use of wetlands as components of the reclamation landscape. Suncor provides Alberta Environmental Protection with a summary of the yearly research in its annual C&R report. Additionally, the on-going and planned research associated with the CT reclamation demonstration, which includes application of wetlands, is described in detail in Volume 1, section E5.2.5. Suncor is also an active participant in the Wetlands Working Group, which will be identifying research requirements to help understand the development and use of wetlands as part of oil sands mine closure plans.

References:

EVS Environment Consultant (EVS). 1994. Constructed wetlands for the treatment of oil sands wastewater: Technical Report #3. Prepared for Suncor Inc. - OSG by EVS Consultants Ltd. 222 pp. + appendices.

EVS Environment Consultant (EVS). 1995. Constructed wetlands for the treatment of oil sands wastewater: Technical Report #4. Prepared for Suncor Inc. - OSG by EVS Consultants Ltd. 386 pp. + appendices.

EVS Environment Consultant (EVS). 1996. Constructed wetlands for the treatment of oil sands wastewater: Technical Report #5. Prepared for Suncor Inc. - OSG by EVS Environment Consultants. 236 pp. + appendices.

7.0 RECLAMATION/CLOSURE

Closure Planning/Landscape Design

7.1 **Suncor states that three types of landforms will be designed and constructed to specification during the course of mining operations at the east bank mining area. The design slopes shown on Figure C2.4-13 were used in defining the mine plan for this application. *(Vol. 1, p. C2-71 and 72)* Suncor shows their overburden dumps and dykes to be constructed in stepped lifts to achieve 3:1 final slopes. *(Figure C2.3-13)* There appears to be some contradiction to Suncor's intent to create landscapes, topography and slopes in the reclaimed landscape that are similar to the pre-disturbance situation (as recommended by the *Fort McMurray-Athabasca Subregional Integrated Resource Plan (IRP)*) rather than strictly engineered structures. Please clarify the above statements.**

Response:
The design slopes in Figure C.2.3-13 are conceptual. Detailed designs for earth structures will consider the relative merits of berms (stepped slopes). Berms will not be employed unless necessary, and Suncor has eliminated berms from the North West Dump of the Steepbank mine.

In some cases, berms may be required to provide access for mining or dyke monitoring operations.

One significant uncertainty is the influence of berms on erosion control. Although berms are conventionally considered a positive feature in reducing sheet flow runoff velocities, experience indicates that berms tend to pond water that accentuates gully initiation when the local storage capacity is exceeded. The trials underway at the North West dump may assist in a practical resolution of this factor. While Suncor is prepared to take a certain level of operational risk in eliminating berms for the North West dump (and potentially having to subsequently correct adverse performance) in order to seek a more visually pleasing landform, future performance may require re-consideration of this decision.

a) **Suncor will conduct field demonstrations of landform grading to develop natural appearing structures subject to overall landform stability and integrity.** ***(Vol. 1, p. E3-20)*** **Discuss potential opportunities to incorporate these techniques on undisturbed or newly disturbed areas regulated under the current Steepbank Mine approval. Describe how Suncor will ensure that landform designs are similar to the natural landscapes of the area and are aesthetically acceptable to the stakeholders. Also, describe Suncor's management guidelines that would indicate that landform grading is not feasible if not intended to be used.**

Response:
Landform grading is defined as replication of irregular shapes of natural slopes, and includes varying slope gradients and non-linearity in plan view. Suncor will implement landform grading where feasible for the remainder of Steepbank mine, subject to technical constraints on earth structure stability and economic constraints. However, landform grading can result in an impact that has both an economic cost and a requirement for additional external waste storage. Furthermore, dyke integrity is paramount. Thus, the degree that natural landscapes are replicated will vary depending on these constraints.

On Lease 86/17, the long term landscape is fixed, and moreover in many places already supports substantial vegetation covers. Thus it is not presently considered economically feasible to modify existing Lease 86/17 structures to incorporated landform grading. The prospects for landform grading on existing structures within the Lease 86/17 mine are limited to the ultimate slopes of Dyke 9 and to some extent Dyke 8 and other slopes where it is planned to place a zone of tailings sand downslope of the planned retention
structures. Suncor will evaluate the economics and technical feasibility of landform grading during detailed design.

When considering the requirement for aesthetically pleasing reclamation, one stated objective of landform grading is to replicate the natural view as much as possible or desirable. However, a more fundamental objective is to not draw obvious attention to the former mining activities. Thus, a camouflage approach will be employed where constraints reduce the acceptability of landform grading.

From a practical perspective the essential feature of the natural slopes along the river is one of highly variable, locally rugged topography with rapidly changing slopes and vegetation patterns. This natural terrain cannot be safely replicated in the looser geologically unconsolidated mine overburdens and tailings sands. A much more gentle and smooth landscape is required. Therefore a practical application of landform grading is camouflage - disguising from the viewer that there has been historically a major use of the land.

The major consideration in developing an aesthetically pleasing landform is the viewers perspective. The most frequent stakeholder with an aesthetic concern is a river borne traveler or secondly, a highway traveler. With the exception of Tar Island Dyke, the views offered on the river are quite constrained by the buffer strip of vegetation, and the river width. When close to the near bank, the buffer strip limit lines of sight. When further from the bank, individual details become obscured and one of the most noticeable elements is the sky-line. In the natural setting the sky-line is typically flat, broken only by steeply incised gullies. This same flat skyline will tend to be replicated by the reclaimed structures. Constructing steeply incised gullies is not acceptable because the gullies usually create a wide range of slope failure types. However some more gradual slopes will be built in. Suncor has considered placing an infrequent or random appearing mound on the skyline and this could be undertaken if it was considered pleasing.

A major element of "un-naturalness" of the TID structure when seen from the river today is the stepped slope (see also question 7.3.). When reclamation is complete, a high tree belt along the toe will limit views of TID to the upper portions of the slope to only at a distance. Nevertheless, Suncor intends to experiment with the elimination of the stepped appearance for new structures, and work is underway on this concept for the North West dump on the Steepbank Lease.

Another element of the artificiality induced by mining operations is the presence of long continuous slopes. This can be broken up by contour grading in which the toe of the structure is moved in or out such that the slopes are curvilinear in plan.

b) Suncor indicates that vegetation buffers and setbacks from the Athabasca River will minimize the visual impact of the mine during operations. With removal of facilities from the river valley in 2033, Suncor notes that the most notable long-term visual impact will be provided by the bridge and existing plant on the west-side of the river. (*Vol. 1, p. A4-45*) Please describe how Suncor will construct the new structures and infrastructure developments on the west side of the Athabasca River consistent with the values outlined in the *Fort McMurray-Athabasca Subregional Integrated Resource Plan (IRP)*.

Describe how the structures and infrastructure will be designed to blend in with the valley. Discuss the potential for developing visual buffers along the river.

Response:
With respect to the remaining mine activity on Lease 86/17, Pond 6 and Dyke 9 would not be considered as part of the valley structure and furthermore not visible from the Athabasca River.

With respect to new fixed plant facilities on the west bank, Suncor has no special design plans to blend these structures with natural landscapes nor provide visual buffers. This will be considered during decommissioning stages

c) **Suncor will continue with the mitigating measures identified in the Steepbank EIA including contouring (including introducing surface irregularities) dyke and overburden storage areas where possible.** ***(Vol. 1, p. A4-45)*** **Please discuss reasons why contouring would not be possible.**

Response:
Contouring earth storage structures may not be possible:

- where non-linear physical layout would reduce confidence in the stability of the structure
- where economic costs are significant
- where significant reductions in waste storage volumes result from contouring and have an important impact on tailings plans

The use of berms (stepped slopes) is dictated primarily by operational requirements. Current Suncor design philosophy is to eliminate berms where practical.

7.2 **Suncor is committed to fulfilling the objectives of the *Fort McMurray-Athabasca Subregional Integrated Resource Plan* (AEP 1996 a) for wildlife, erosion, floodplain, recreation and tourism and ecological resource development.** ***(Vol. 1, p. E3-31)*** **Guideline Number 5 for the Athabasca-Clearwater Resource Management Area suggests that "The Athabasca River valley ecosystem and its resources and values will be protected and adverse impacts of development minimized. Exploration and development of oils sand resources will be considered only if the proponent can demonstrate that a satisfactory level of mitigation of the adverse impacts of development on the resources and values identified below can be achieved:" With respect to this guideline, please clarify the following:**

Response:
The premise of Suncor's application is that Suncor has displayed a satisfactory level of mitigation of the adverse impacts of development on the resources and values identified within the EIA.

a) **"Wildlife - valley vegetation, riparian habitat, habitat diversity." Please discuss how the vegetation communities that Suncor will establish will be consistent with pre-development valley vegetation. Include in the discussion how the vegetation types will provide habitat diversity. Compare the number, distribution and sizes of vegetation types within the Athabasca Valley pre- and post-disturbance.**

Response:
The Athabasca River Valley has been delineated as the Athabasca Floodplain macroterrain unit (Figure D4.1-1). The ecosite phases occurring within the floodplain or river valley are listed in Table D4.2-1. Approximately 32 ha will be cleared by Project Millennium and 148 ha will be cleared by the Steepbank Mine. The dominant ecosites and wetland types include low bush cranberry (d), dogwood (e), shrubby swamps and shrubby marsh (Figure D4.1-2). Approximately 32 ha will be cleared by Project Millennium and 148 ha will be cleared by the Steepbank Mine (Figure D4.2-3). Table D4.2-2 shows the distribution of ecosite phases and wetland types (ELC) pre and post development. All of the ELC types will remain in relatively the same proportions except wooded fens (FTNN) which will be permanently removed from the river valley. Overall, the number of ELC patches will be reduced from 140 to 102 (Table D4.2-17). The size of the ELC patches is shown in Table D4.2-19. The mean patch size will increase from 4 ha (pre-development) to 7 ha (post-development). However, the range (minimum-maximum) patch size will not change.

Overall, the magnitude of impact to the Athabasca River Valley is considered low for both direct losses to ELC (Table D4.2-14) and diversity (Table D4.2-21).

b) **"Erosion - sensitive soils and drainage patterns from erosion or disturbance, and water sedimentation." Please discuss how water runoff structured will satisfy this requirement and provide an estimate of the distance of surface water flow before being intercepted by an ephemeral draw or watercourse.**

Response:
The detailed engineering design for the Project Millennium reclaimed dyke areas is still to be completed. Suncor has committed to developing drainage systems that function such that erosion levels are within the range expected for natural areas in the oil sands region. Therefore, the drainage systems associated with dyke structures (i.e., the closure valley escarpment areas) will be designed such

that surface water flows are controlled from a sediment pickup and transport point of view.

c) **"Ecological - unique physical valley characteristics, rare flora and fauna, critical ecological functions." Please discuss what the unique physical valley characteristics are and explain how the rare flora and fauna will be protected. Please identify critical ecological functions and how Suncor will attempt to replace them.**

Response:
Unique physical valley characteristics as identified by Westworth (1990) include fluvial meander scars and fans; wildlife habitat, diverse vegetation communities, and diversity of landforms. In addition, the valley supports rare flora, old growth forests and riparian wetlands. The valley or floodplain functions as a movement corridor for wildlife and attenuates flooding.

Suncor has developed a viable east bank mining area plan which balances the Alberta Energy and Utility Board's requirement to maximize effective recovery of the oil sands resources while adhering to the intent of the IRP. As such, Suncor has planned to position as few operational facilities and areas within the Athabasca River valley as is possible. As part of the closure plan, Suncor will reclaim developed areas of the valley to pre-development ecosite phases and wetlands. Areas not required for development will be protected through limitations to access. This includes the wildlife corridor area Suncor left between its operation and the Athabasca River. Additionally, undisturbed riparian wetlands such as Shipyard Lake will be monitored for changes in vegetation, hydrology and fish habitat as part of the Regional Aquatic Monitoring Program (RAMP).

Interpretation of the question of critical ecological functions requires focusing on the Athabasca River in general or on the specific area in question. Critical or crucial ecological functions within a small, specific area may be defined very broadly because all ecological changes within a small area can have an impact on the ecology of that area. Suncor believes the intent of the statement in the IRP is to focus on ecological functions critical to the protection of the Athabasca River valley. With the later focus in mind, no ecological function within the Project Millennium area is critical to the ongoing existence of the Athabasca River valley. Suncor, through its reclamation of development areas through replacement of ecosystems, will re-establish ecological functions within the development area.

Reference:

Westworth, D.A. and Associates Ltd. 1990. Significant natural features of the eastern boreal forest region of Alberta. Technical Report. Report for Alberta Forestry, Lands and Wildlife. Edmonton, Alberta. 147 p. + maps.

d) **"Traditional Uses- important traditional areas for First Nations Peoples." Please discuss areas important to First Nations Peoples. Describe the measures Suncor will use to re-establish the plants shown in the *Terrestrial Vegetation Baseline Report (Table 20, p. 62)* that lists plant species important to Native peoples.**

Response:
Suncor has provided details on the types of ecosites that are planned for development on its reclaimed areas. Many of these ecosites include species of plants that are important to Traditional Land Users. Suncor believes that through establishment of suitable landforms, soils and drainage systems, that the traditionally used plants can be expected to develop as do the other plant species typically found within the target ecosites.

7.3 **Suncor states that they will satisfy the *Fort McMurray-Athabasca Subregional Integrated Resource Plan (IRP)* guidelines for Athabasca River Valley development. *(Vol. 1, p. A4-46)* Additionally, "Forest types currently in pre-development areas, as well as types that will develop on reclaimed Suncor lease areas, are determined by parent materials, topography and drainage of the area." *(Vol.1, p. E2-13)***

a) **Please discuss how Suncor will re-establish native ecosystems with similar ecosite phases and range of plant species consistent with the Athabasca River Valley as recommended in the IRP. Considering that only one type of soil is proposed for reclamation, outline proposed research to substantiate that these species can be successfully re-established and sustained. Clarify the type of soils, chemistry tolerances and moisture regimes these plants normally inhabit.**

Response:
The statement that Suncor will be using one soil type in the reclamation of the river valley and other reclamation areas is incorrect. The reclamation work completed on Lease 86/17 has proven that there can be a tremendous variation in the vegetation response from the soils being used. To assume that all muskeg soil, all underlying soil, or all reclamation soil is homogeneous would ignore the diversity found in nature.

To add to this diversity, the seed bank in one specific area of the muskeg soil is not likely to be representative of all the muskeg soil. Just as there is a variety of ecosystems in the river valley, so there is variety in the muskeg soil being used for reclamation, the landforms being reclaimed, the subsoil parameters, and the moisture regimes.

The current revegetation approach at Suncor has shown that the rate of establishment of natural vegetation is correlated with higher organic matter content in the surface reclaimed soil. The recent Land Capability Classification for Forest Ecosystems in the Oil Sands Region also supports this approach as a viable method of restoring forest capability. In addition, there are several factors in addition to soil type that influence development of ecosystems. Suncor believes that as a result of the range in landforms that will be created in the reclaimed landscape, including a variety of subsoil materials (i.e., tailings sand, CT, several types of overburden), drainage conditions, and slope and aspect, there is opportunity to replace diverse, sustainable ecosystems that are representative of the pre-development ecosystem diversity.

These and soil characteristics have been described in previous documents related to the Steepbank Mine Application. Experience from Suncor's reclamation program demonstrates these plants can inhabit a wide range of soil types, chemistry tolerances and moisture regimes.

b) **Please discuss the variety of native parent materials and topsoils that Suncor will use to provide a basis for re-establishment of native ecosystems. Include a description of the research Suncor will conduct or has conducted to demonstrate that ecosystems consistent with the Athabasca Valley can be established and will be sustainable. Examine the possibility that commercial forests and a range of native ecosystems within the Athabasca River Valley prove not to be sustainable on reclamation soils. Discuss what alternative reclamation techniques could be implemented.**

Response:
Suncor uses a combination of muskeg soil as well as mineral soil reclamation materials. Both these soils include muskeg and mineral materials at varying rates. Suncor has demonstrated the success of its reclamation program using these soil materials on Lease 86/17. Suncor also has noted that it will employ guidelines listed in the document "Guidelines for Reclamation of Terrestrial Vegetation in the Oil Sands Region". Suncor has provided a listing of the types of reclamation research it conducts, both in Section E4 of Volume 1, as well as in its annual conservation and reclamation reports.

Suncor actively monitors its reclamation areas on a yearly basis. The results of this monitoring are used to adapt the reclamation program as required.

c) **Suncor states that the IRP guidelines are to restore forest capability equivalent to pre-development levels. Similarly, the Oil Sands End Land Use Committee goals are to achieve equal or better capability. *(Vol. 2B, p. E- 36)* Please discuss how these goals will be achieved within the Athabasca Valley, where there presently exists a**

dominance of Land Capability (LC) Class 2 soils, without restoring this particular LC Class 2 soil type.

Response:
The soil capability classes are affected primarily by the moisture regime. An increased water availability can elevate a soil from a class 3 into a class 2. Too much water, however, can cause a lowering of a soil class from a class 3 to a class 5. Class 3 soils are the ones most often found on the better drained sites that still have a good water holding capacity and are capable of supporting a productive forest cover.

The reclamation method used by Suncor prescribes an average depth of 20 cm muskeg soil placed on the reclamation sites. This results in a class 3 soil capability rating assuming a neutral effect from moisture. An increase in the available moisture due to slope position or higher water table found in the river valley can increase the capability by one class thus elevating the site to a class 2. In addition, though the plan is to place a 20 cm muskeg soil layer on the surface, this depth can range between 10 cm minimum to pockets with more than 100 cm. This variability is a function of the materials handling method which includes woody material and stumps with the soil along with frozen lumps. When the soil spreading occurs, the depths are usually variable and allow for increased capability for portions of an area while other portions will have a lower capability. This soil depth and material quality difference illustrates another variability that can occur in the reclamation process.

Therefore, even though the dominant capability after reclamation is class 3, there will be variability ranging into class 2 at a micro-scale level.

7.4 **Suncor states that reclaimed lands will be maintenance free, thereby qualifying for reclamation certification. *(Vol. 2B, p. E-3)* Suncor suggests that problems do occur regionally with gully erosion down the 3:1 stepped slopes. *(Vol. 2B, p. C2-72, Figure C2.4-13)* Please describe how these structures will transmit water runoff to watercourses without creation of erosion and discuss the options Suncor will use to resolve this potential problem.**

Response:
Erosion is a natural process, occurring on undisturbed slopes as well as on reclaimed slopes. The design goal is not to eliminate erosion, but to limit the impacts of erosion of mature reclaimed slopes to levels similar to that found for undisturbed slopes.

Most water from the reclamation structures is transmitted by sheet flow. Vegetation cover is an effective control for erosion by sheet flow. However, where the topography concentrates the sheet flow, additional protection will be provided. Requirements for additional protection are typically identified during initial stages of reclamation when an erosion channel develops. Mitigative work is initiated to protect the area from additional erosion. One of the most effective techniques has been to enhance the drainage channel to make it permanent. The channel bed is lined with clay, armored with rock, and a top dressing of muskeg soil is placed. The site is then vegetated with native grasses, along with willow and poplar cuttings inserted to provide additional support. This channel protection technique, though costly, does provide the erosion resistance necessary to protect slopes from excessive erosion until vegetation becomes well established. Once this has occurred, the erosion rate is consistent with landforms found in the region.

7.5 **Suncor states that it is possible that some shallow skin failures will be observed on the slopes of the dyke areas or the disposal areas. For this plan, it is assumed that an observational approach will be appropriate and that specific design issues can be addressed as they arise. *(Vol. 2B, p. E-20)* Discuss the variables that may lead to shallow skin failures and options to prevent their occurrence. Discuss the potential consequences to the Closure Plan (reclamation) objectives of a large scale occurrence of these failures. Discuss any regional studies that would be applicable to this problem.**

Response:
Shallow skin failures are very much a part of any natural sloping. The natural healing ability of the reclaimed landscape reduces impact of shallow failures. The design goal is to limit the impacts to levels comparable to undisturbed areas.

Skin flows or shallow detachment failures are usually encountered in poorly drained clay or bitumen rich soils. The failures can occur when highly saturated conditions develop on natural or reclaimed slopes and are often exacerbated by heavy rains during a spring thaw, when the soil lower within the slope is still frozen. The skin flow mode is also more likely when the vegetation on a slope is locally and temporarily lost, due to heavy forest fires, wind throw of tree and root mass, or after logging activities. Vegetation plays an important role in controlling the likelihood and frequency of such movements both due to the mechanical effects imparted by a well developed root structure and the control exerted on the pore pressure regime within the root mass by evaporation/transpiration effects.

One mitigative measure is to flatten slopes; however, this is often economically not practical given the constraints of the mine plan and the regulatory pressure to minimize external footprints of waste disposal structures. Therefore various impacts must be balanced. Another mitigative measure is to compact the reclamation layer well, but this is incompatible with the requirement to get a viable vegetative cover. Finally, it is possible to avoid placing the most troublesome soils immediately subjacent to the final slopes. In summary, slope angles and compaction effort for the surface cover can be adjusted only within a limited range, but weak soils can be limited near the slope surface. This will be at least partially achieved because materials with Sodium Adsorption Ratio above 12 will not be placed within the top 1 m of fill. Mitigation of shallow failures will be considered further during detailed landform design.

Regional studies of natural events might be of general interest, but are of less value in overburden fills. Suncor has many years of operational experience with all soils types except Clearwater dominated material. Experience at Syncrude will be considered as part of final design.

7.6 **According to Suncor, maintenance-free reclamation means that routine maintenance activities are not required, except for circumstances where future human activities lead to re-disturbance of areas. *(Vol.1, p. E1-1)* Please clarify whether the closure landscape will be able to recover from disturbance to the same degree as the pre-disturbance lands. Also, discuss which human activities could lead to degradation of the designed landscape.**

Response:
There are unavoidable differences between the pre-disturbance and post-certification mined landforms. It is inevitable that looser and more homogenous materials within the reclaimed landscapes are more susceptible to erosion than the original geologically consolidated nature of the pre-disturbance land, especially elements of the Clearwater and McMurray formations. At the same time, the productive capability of the land has been enhanced by the soil covers used or planned and the local drainage provided in the reclamation plans. Performance to date indicates that the recovery will be different but acceptable. Performance of reclaimed landscapes will be monitored on an on-going basis to confirm this indication.

Human activities that could lead to degradation of reclaimed landscapes include industrial activities on adjacent leases, logging on slopes, heavy grazing by cattle or other commercial ungulate herds, and heavy recreational use by wheeled or tracked vehicles.

7.7 **Suncor indicates that future large-scale demonstrations and monitoring of fully reclaimed areas will comprise the basis for reclamation certification. *(Vol. 1, p. E1-4)* One of the objectives of Suncor's Closure Plan is to achieve phased certification of its reclaimed area. *(Vol. 1, p. E3-14)* Please provide a schedule and describe the areas that Suncor will be applying for certification.**

Response:
At this time a meaningful schedule for phased certification cannot be established. Suncor intends to review plans and issues with the appropriate regulatory groups and other stakeholders to define the logical elements of a phased schedule. A better understanding of the performance of the CT deposits

is also required to establish the schedule. This understanding will be gained over the next few years as the behaviour of CT test sites and Pond 5 CT deposits is studied.

One requirement for phased certification is logical physical boundaries, and this requires further consideration before establishing schedules. End land use is also a factor. For areas where commercial forest development has been defined as the end use, fourteen years are required to prove the areas are producing a tree crop of a sufficient size and density to meet the LFS standards. Areas defined as primarily wildlife habitat can be certified at a much earlier stage.

Suncor made a previous commitment within the Steepbank Mine Application to develop a closure plan for the Tar Island Pond area. This lease segment may be the first area ready for closure. Depending on CT performance, Pond 5 may be available shortly thereafter. Other segments might include the waste areas lying to the west of Pond 2/3, and the North West Dump for the Steepbank Mine

7.8 **Suncor indicates that following mine closure, new Ecological Land Classification (ELC) units will replace those lost. Upland vegetation communities will pre-dominate the new landscape replacing the previously existing wetlands. These vegetation communities were selected based on: landforms, soil drainage, slope and aspect following the methodologies recommended in the *Draft Guidelines for Reclamation of Terrestrial Vegetation in the Alberta Oil Sands Region* (Oil Sands Vegetation Reclamation Committee 1997). *(Vol. 2B, p. D5-117 and p. E-33-34)* The Draft Guidelines propose methodologies for establishment of ecosite phases of primary importance to commercial timber harvesting. The guidelines do not address ecosite phases of lower value to commercial timber harvesting such as Black Spruce, Tamarack, and wetland types such as Willow and Alder riparian types, sedge fens or deciduous swamps.**

a) Please describe the measures Suncor could take to replace vegetation community types appropriate to wetland locations.

Response:
Suncor has included such wetlands as shrubby deciduous swamps, constructed wetlands and open water as part of the final reclaimed landscape (Section E3.2). In addition, the dogwood ecosites (E1, E2 and E3) adjacent to the drainages (Figure E-2) are typical of naturally occurring riparian communities observed in the LSA (Figure D4.1-2). Sequential reclamation planning will allow for the re-establishment of wetlands types at multi-serial stages, thereby increasing the overall diversity of these wetlands types.

Suncor is currently working with the Wetlands Working Committee to determine which wetlands types the constructed wetlands will closely emulate. For example, it is speculated (Halsey pers. communication; June 19, 1998) that the constructed wetlands will likely resemble shrubby marsh wetlands or shrubby swamp wetlands. Suncor is continuing to conduct research on wetlands ecosystems to determine reclamation design. An adaptive management approach will be applied by Suncor to their current closure plan based on the recommendations of the Wetlands Working Committee and the results of their ongoing research.

b) **This section lists five primary ecosite phase types targeted for the closure landscape.** ***(Vol. 1, p. E3-31 and 32)*** **The** ***Terrestrial Vegetation Baseline Report*** **lists 16 ecosite phases within the LSA.** ***(Table 3, p.16)*** **Please discuss Suncor's philosophy of establishing a diverse range of vegetation types and wildlife habitat. Examine the possibility of other species that could be added to the original choice of five communities to enhance these values. Discuss why some of the original species such as Black Spruce, and Tamarack were excluded from the species mix. Also, examine other species that would be important to wildlife.**

Response:
The philosophy of establishing a diverse range of wildlife types and habitat is based on an understanding of early successional phases in the development of forest ecology. The reclamation design provides for the suitable conditions that will promote succession to the desired end points.

The vegetation species identified in the reclamation prescription are those that are usually associated with these early successional phases. Other species can be expected to invade the reclamation sites from adjacent areas as well as regenerate from soil amendments. The reason species such as Tamarack and Black Spruce were excluded is because most reclamation sites have a drier moisture regime, not conducive to these species. These species are expected to be established in wetter areas through natural processes.

Species for wildlife habitat has been considered in the reclamation design through the same philosophy.

7.9 **Suncor states that site preparation for oil sands mining involves several steps: clearing vegetation; draining muskeg and overburden aquifers; removing and storing muskeg and overburden; and depressurizing the basal aquifer located in parts of the mine area.** ***(Vol. 1, p. B2-6)*** **Provide a summary table of the lands to be disturbed or utilized (approximate areas) for all development activities on an annual basis for the first 10 years and for subsequent milestone events as depicted in Figures C2.4-1 to C2.4-12.** ***(Vol. 1, p. C2-54 - 65)***

Response:
A table of annual disturbance is shown below. This table is based on Section B, Figures 2.4-1 to 2.4-12, and Section E, Figures E5-1 to E5-12, with the phases of disturbance including tree clearing followed by muskeg stripping and then by mining activities. The mining activities included in the table are only those beyond the pit limits, the external tailings pond and the dump areas. The direct mining activities of oil sands mining, overburden removal and in pit tailings disposal remain shown descriptively in Figures 2.4-1 to 2.4-12. The comments address key milestone events. The disturbances indicated on the table are not additive due to them overlapping each other.

TABLE 1 Annual Disturbance for the East Bank Mine Area

YEAR	TREE CLEARING (ha)	MUSKEG STRIPPING (ha)	OUT OF PIT TAILINGS (ha)	NE - DUMP (ha)	EAST - DUMP (ha)	COMMENTS
2000	2,715.7	139.9	159.7	162.2	-	
2001	-	78.4	114.3	-	-	
2002	-	46.8	385.4	96.3	-	
2003	-	157.3	486.0	54.2	-	External tailings begins to rise
2004	-	174.5		192.6	-	
2005	1,155.2	336.7			-	In pit tailings start in Pit 1 - 7a
2006	-	223.9			-	In pit tailings start in Pit 1 - 7b
2007	-	168.5			-	
2012	1,783.1	976.0			403.3	In pit tailings start in Pit 2 - 8
2018	-	820.4				In pit tailings start in Pit 2 - 9&10
2025	1,300.4	929.0				In pit tailings start in Pit 2 - 11
2032	-	874.0				Completion of mining and reclamation

Constructed Ponds/Wetlands

7.10 **Suncor states that wetlands will be constructed in three areas as part of the closure landscape; as linear features around the perimeter of the development as the drainage ditches evolve into wetlands.** ***(Vol. 2B, p. E-16)*** **This evolution will result in drainage, which is similar to existing wetlands drainage in the area. Clarify whether the perimeter or diversion ditches will be designed as watercourses or riparian areas, or both. Please provide a conceptual watercourse design that could be used for perimeter ditches that have the potential to be riparian areas or watercourses in the closure landscape. Show how riparian areas could be incorporated into the design.**

Discuss the potential range of vegetation that would be suitable for these permanent riparian channel areas and discuss the opportunities to design these vegetation systems for enhancing wildlife habitat and travel corridors. Provide 10 copies of a map showing the perimeter ditches that have this potential.

Response:

Perimeter or diversion ditches will be designed as watercourses with the capability to enhance them into riparian areas in the future. The intent of these ditches during operations is to ensure water is channeled effectively into systems that either feed to recycle systems or into sedimentation ponds prior to release to receiving streams. Design features will be considered to allow enhancement of these areas into riparian habitats under reclamation conditions. Creation of riparian habitats during operational periods would create possible increases in wildlife equipment interactions, something Suncor does not wish to occur.

Operational watercourse designs will be provided as part of the detailed engineering information being prepared for Project Millennium.

Types of vegetation suitable for permanent riparian areas will be based on those types typically found in boreal forest riparian areas. Examples of the vegetation types would include willow and alder. Additional considerations for selection of reclamation vegetation types for riparian areas would be based on the plant types used by wildlife species expected to frequent the riparian areas.

Final details on the closure drainage system will be developed by Suncor as the mine planning progresses. The conceptual closure plan presented in the EIA shows some of the expected drainage systems, many of which have the capability to become riparian areas. Closure drawing E-3 (Volume 2B) shows the proposed drainage systems, all of which have sections with the potential to become riparian areas.

7.11 **As part of a discussion on tailings disposal and pond management, Suncor notes that an external pond is required on the east side of the Athabasca River, in part, to create an inventory of mature fine tails (MFT).** ***(Vol. 1, p. C2- 69)*** **Please describe how this plan is consistent with the plan for reclamation of Pond 1 (Tar Island Dyke) as outlined in the Steepbank Mine application to AEP dated June, 1996.**

Clarify the implications of the Millennium application on the reclamation strategy and schedule set out in the current Steepbank Mine approval.

Response

There is no relationship between the two ponds. The external tailings pond handles tailings and recycle water from the Millennium Extraction plant. Pond 1 handles certain tailings from the Base Extraction plant. The alternative of transferring MFT from the west side to the east bank was evaluated and rejected on the basis of high capital and operating costs.

CT Landforms

7.12 **Suncor indicates that the drainage system for the reclaimed CT deposits has been designed to be robust and self healing. *(Vol. 2B, p. E4-27)* Please clarify if these drainage systems will be designed to have riparian areas associated with them. Provide a conceptual channel design and describe the research to determine the vegetation species associated with them.**

Response:
The CT drainage systems, as noted in Section E4.4.2, will be designed to be robust and self-healing, but there is uncertainty of the impacts of CT settlement on drainage. As described in Section E5 (pg. 68) of Volume 1 of the Application, Suncor is undertaking a CT reclamation demonstration. This demonstration is designed in part to help Suncor define the drainage systems for the CT deposits. Channel design for CT drainage systems will be developed based, in part, on the results of the demonstration project. In addition, as discussed in that section on page 72, Suncor has an active research program underway to evaluate the suitability of reclamation plant species for the CT deposit areas.

7.13 **It is indicated in the application that the release of reclamation drainage water from CT landforms will result in the discharge of water with elevated levels of salinity and other chemicals from both surface and groundwater sources. *(Vol. 2B, p. D-35)* Describe the native plant species, which could be used to colonize these saline wetlands.**

Response:
The majority of previous research, available in the scientific literature, on the effects of salinity on biota has focused on agricultural plant species and to some extent freshwater organisms (e.g., *Ceriodaphnia dubia*, fathead minnow). In both cases, sulphate has not necessarily been the focus of study. Some impacts of sulphate on either survival or growth have been observed. To aquatic organisms, such as *Ceriodaphnia dubia*, sulphate was the least toxic of the five (i.e., $K^+ > HCO_3 > MG^{++} > Cl^- > SO_4^-$) of seven (i.e., K^+, HCO_3, MG^{++}, Cl^-, SO_4^-, Na^+, Ca^+) ions tested that showed some toxic effect, while sodium and calcium did not appear to be toxic to the test species (Mount and Gulley 1992). To agricultural plants, such as wild potatoes, 20 mM (or ~19,000 mg

SO_4/L) of sodium sulphate significantly reduced survival and growth (Bilski et al. 1988).

Plants vary greatly in their tolerance to salts such as sodium sulphate. Some species are sensitive to saline stress and have a narrow tolerance range to salt concentrations in the environment, while other species are salt-tolerant and can effectively regulate salt intake by increasing internal osmotic pressure, thus preventing dehydration. Some examples of wetlands species tolerant of moderate salinity (2-15 mS/cm) include *Scolochloa festucacea*, *Eleocharis palustris*, sea mil-wort (*Gaux martima*), water parsnip (*Sium suave*), hard-stemmed bulrush (*Scirpus lacustris*), common reeds (*Phragmmites* sp.), red goosefoot (*Chenopodium rubrum*) among others (NWWG 1988).

In 1995, a wetland with elevated sulphate (1,130 mg SO_4/L) and high conductivity (2.3 mS/cm) was located adjacent to Crane Lake on Suncor Lease 86 (EVS 1996). A vegetation survey was conducted here in 1996 and the sulphate (1,400 mg/L) was again elevated (Golder 1997a). The predominant habitat types were open water, shallow shore marsh, shrub/scrub and meadow marsh. The area contained a variety of floating and emergent plants. The most common floating plants included coontail, water-milfoil, Fries' pondweed and water smartweed. The emergent macrophyte, common great bulrush, dominated water deeper than 1 m, while in shallower areas the most common emergent macrophytes were common cattail and creeping spike-rush. In very shallow areas or saturated soils the most common species include marsh reed grass, sedge, rush and common horsetail. In the marsh meadow habitat, the dominant forbs include marsh cinquefoil and white waterbuttercup. A full species list, for 1996, in the High Sulphate Wetland are provided in Table 1. This wetland was surveyed again in 1997 where again both sulphate (1,500 mg/L) and conductivity (2.7 mS/cm) were elevated. This site will also be surveyed in 1998. However, 1997 and 1998 data are currently not available.

Other saline wetlands in the region are being considered for monitoring (e.g., La Saline Lake as part of RAMP). However, this lake has a different ion composition and is dominated by sodium and chloride whereas future reclamation wetlands are expected to be dominated by sulphate and sodium. Different ion compositions will have different stress or toxic effects due to difference in the properties of each ion as well as countervailing properties exhibited by some cations on toxic effects of some anions (Mount and Gulley 1992). CT release water in Pond 5 typically has conductivity of 2.3 mS/cm and sulphate, sodium, chloride and calcium concentrations of 654 mg/L, 441 mg/L, 52 mg/L and 87 mg/L, respectively (Golder 1997b). While this is somewhat lower than expected future concentrations, the ratios are similar to the High Sulphate Wetlands noted above, but quite different from La Saline Lake where the conductivity is 4.57 mS/cm and sulphate, sodium, chloride and calcium concentrations of 38 mg/L, 762 mg/L, 1,230 mg/L and 140 mg/L, respectively (Golder 1997c). The ion composition of Pond 5 compared with the High Sulphate wetlands is very similar, while sulphate concentrations are lower and chloride concentrations are higher in La Saline Lake.

Vegetation that will be expected to establish in reclamation wetlands with elevated sulphate concentrations are those observed in the High Sulphate Wetlands. As the reclamation wetlands become established it is expected that other species may also colonize these sites. At present, Suncor is studying the wetlands plant (established and transplanted) survival in a wetland that did not previously receive CT release waters. In addition, Suncor is planning a larger scale CT Demonstration of both terrestrial and wetlands ecosystems to assess vegetation success as well as the success of other biota. This new information will be used to further understand what species should be selected for reclamation as well as what species will voluntarily colonize saline wetlands with elevated sulphate concentrations.

Table 1. Species List For Wetlands Plants Located In The High Sulphate Wetland, 1996

Common Name	Genus Species
Forbs	
Common Yarrow	*Achillea millefolium*
Many Flowered Yarrow	*Achillea sibirica*
Showy Aster	*Aster conspicuus*
Purple-Stemmed Aster	*Aster puniceus*
Harebell	*Campanula rotundifolia*
Fireweed	*Epilobium angustifolium*
Purple-leaved Willowherb	*Epilobium glandulosum*
Wild Strawberry	*Fragaria virginiana*
Purple Peavine	*Lathyrus venosus*
White Sweet Clover	*Melilotus alba*
Grass of Parnassus	*Pamassia palustris*
Sow Thistle	*Sonchus arvensis*
Dandelion	*Taraxacum officinale*
Vetch	*Vicia americana*
Violet spp.	*Viola spp.*
Aquatic Species	
Sedge spp.I	*Carex spp. I*
Sedge spp.II	*Carex spp. II*
Sedge spp.III	*Carex spp. III*
Sedge spp.IV	*Carex spp. IV*
Coontail	*Ceratophyllum demersum*
Spike Rush	*Eleocharis palustris*
Horsetail	*Equisetum arvense*
Horsetail	*Equisetum hyemale*
Mare's Tail	*Hippuris vulgaris*
Wire Rush	*Juncus balticus*
Rush spp.	*Juncus spp.*
Rush spp. II	*Juncus spp. II*
Common Duckweed	*Lemna minor*
Water Milfoil	*Myriophyllum spicatum*
Three-leaved Pondweed	*Potamogeton filiformis*
Common Great Bull Rush	*Scirpus lacustris ssp. validus*
Sparganium	*Sparganium angustifolium*
Giant Bur-Reed	*Sparganium eurycarpum*
Cattail	*Typha latifolia*
Common Bladderwort	*Utricularia vulgaris*
Grasses	
Northern Wheat Grass	*Agropyron dasystachyum*
Slender Wheat Grass	*Agropyron trachycaulum*
Rough Hair Grass	*Agrostis scabra*
Smooth Brome	*Bromis inermis*
Blue-Joint	*Calamagrostis canadensis*
Tufted Hair Grass	*Deschampsia ceaspitosa*
Foxtail Barley	*Hordeum jubatum*
Kentucky Bluegrass	*Poa pratensis*
Trees and Shrubs	
White Spruce	*Picea glauca*
Balsam Poplar	*Populus balsamifera*
Trembling Aspen	*Populus tremuloidies*
Beaked Willow	*Salix bebbiana*
Sandbar Willow	*Salix exigua*
Grey-leaved Willow	*Salix glauca*
Mushrooms	
	Mushroom spp.

References Cited

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Mount, D.R. and D.D. Gulley. 1992. Development of salinity/toxicity relationship to predict acute toxicity of saline waters to freshwater organisms. Final Report. Prepared for Gas Research Institute, Environment and Safety Research Department. October 1992.

EVS Environment Consultants (EVS). 1996. Suncor Lease 86. Baseline Aquatic Monitoring. Prepared for Suncor Inc., Oil Sands Group by EVS, North Vancouver, BC. 18 pp. + tables, figures and appendices.

Golder Associates Ltd. (Golder). 1997a. Field scale trials to assess effects of consolidated tails release water on plants and wetlands ecology. Prepared for Suncor Energy Inc., Oil Sands by Golder, Calgary, AB. 78 pp. + tables, figures and appendices.

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Golder Associates Ltd. (Golder). 1997c. A limnological survey of Suncor's Pond 5 East. Prepared for Suncor Energy Inc., Oil Sands by Golder, Calgary, AB. 15 pp. + tables, figures and appendices.

National Wetlands Working Group (NWWG). 1988. Wetlands of Canada. Ecological land classification series, No. 24. Sustainable Development Branch, Environment Canada, Ottawa, ON, and Polyscience Publications Inc., Montreal, Quebec. 452 pp.

Reclamation Process

7.14 **Suncor states that re-vegetation of disturbed areas will restore the potential to achieve regional diversity and vegetation community types but it will take some time for vegetation communities to mature.** ***(Vol. 1, p. A4-45)*** **With respect to diversity and equivalent capability, describe how the vegetation community maturation will be affected as a result of the proposed homogeneous reclamation soil.**

Response:
Suncor followed the guidelines detailed in "Guidelines for Reclamation to Forest Vegetation in the Alberta Oil Sands Region" to determine the appropriate ecosite phases for each of the reclaimed landforms. As indicated previously in this response, there is a considerable variability in reclamation soils. Diversity is not

solely a function of soil cover but rather the interaction of soil, landform composition, slope, aspect, climate and drainage conditions. The guidelines considered these factors in setting out the ecosite phases and species compositions for designated reclamation locations and soil reclamation material. In addition, reclamation will be phased over the life of the project to allow for multi-aged stands, which will increase structural diversity at the community level. Suncor will continue to participate in, and seek guidance from the Oil Sands Vegetation Reclamation Committee and will continue its adaptive management approach for their reclamation planning.

Suncor currently monitors the progress of plant species, soils and vegetation communities re-establishment on their reclamation areas. Several years of monitoring are required to verify the medium and long-term sustainability of landscape similarities. Suncor will establish research test plots to monitor the re-establishment of targeted plant species, soils and vegetation communities on reclamation soils. Suncor will also continue to participate in research on test plots to monitor if targeted plant ecosite phase species, soils, vegetation communities will re-establish on reclamation soils.

7.15 **Suncor states that approximately 22 million BCM are indicated as the volume of organic soil reclamation material surplus.** ***(Vol. 1, p. E5- 49)*** **At an average applied depth of 0.2 m this represents an ability to reclaim approximately 11,000 additional hectares (about 43 square miles). Please comment upon the planned use for this surplus material.**

Response:
A portion of the surplus muskeg soil material remain available following the mining operation as muskeg piles blended into the landscape. Repairs of areas as a result of erosion or operational impacts will use a portion of the surplus. Once the mine plan has been optimized, the potential may develop for the placement of increased depths on portions of the reclamation areas, thus increasing the soil capability from a class 3 to a class 2. These opportunities will be based on haulage economics.

7.16 **Figure E3-7 indicates that in the reclaimed land, a large proportion of Class 5 Forest Capability land has changed to Class 3.** ***(Vol. 1, p. E3-30)*** **The same information indicates an apparent loss of nearly all of the Class 2 land which has changed to Class 3. Considering that Class 2 has a greater productive capability for commercial forested land, than Class 3 clarify why Suncor does not propose to restore Class 2 soils in the reclamation landscape. Discuss any factors that might limit the land to Class 3.**

Response:
In the Millennium Application, Suncor took a conservative approach and generalized the effects of the reclamation soil application by making the assumption that 20 cm of muskeg soils would be applied evenly throughout the

site. As indicated earlier in this response, there a number of factors that will cause considerable variability in the soil capability. These are soil depth, quality, moisture regime, and site effects. These factors can cause a reclamation site to be up graded to a class 2 or better or downgraded. Please refer to "Land Capability Classification for Forest Ecosystems in the Oil Sands Region" for more detail on these effects.

Suncor cannot specifically identify areas where class 2 soils will develop on the micro-scale level because the mine and reclamation plan is at a conceptual stage.

7.17 **Suncor states that on the order of 1000 ha of Class 2 soils will be reclaimed as Class 3, – a negative change, but "low" in magnitude.** ***(Vol. 2B, p. D2-37)*** **Suncor also indicates that there is a significant percentage of the Class 2 soils that exist within the Athabasca Valley prior to disturbance.** ***(Vol. 2B, p. D2-34, Figure D2.2-7)*** **The figure** ***Closure Land Capability for Forest Ecosystems*** **shows Class 3 soils placed across the closure landscape.** ***(Vol. 2B, p. D2-35, Figure D2.2-8)*** **The naturally occurring soils will not be restored at closure, but will be replaced by a uniform land capability Class 3 reclamation soil mix that is approximately 60% peat and 40% mineral in composition:**

a) **Clarify how this soil salvage and replacement plan protects the Valley's resources and ecological functions as discussed in the** ***Athabasca-Clearwater Sub Regional Integrated Resource Plan (IRP), Athabasca-Clearwater Resource Management Area, Guideline 5, p. 30.*** **With reference to the values outlined in the guidelines, please discuss why the loss of 1000 ha of landscape capability Class 2 is "low" in magnitude and environmental consequence.** ***(Vol. 2B, p. D2-37, Table D2.2-11)***

Response:
Soil is only one variable in re-establishing the ecological values of the IRP. The variablility in reconcstructed soil has been discussed in previous responses. Other variables include: drainage, parent material, topography and source of biota. All these variables work together to eventually evolve a reclaimed site to IRP variables.

The loss of 1000 ha of Class 2 capability was less than 10% of the LSA and was therefore judged as low in magnitude according to the impact classification system.

b) **In the table** ***Residual Impacts and Environmental Consequences Due to Soil Unit Changes in the LSA*****, reclaimed soil capabilities 1, 2, and 4 are shown as 'not applicable'.** ***(Vol. 2B, p. D2-27)*** **Please explain why the loss of these soil capabilities is 'not applicable'. Also,**

discuss why pre-disturbance soils are not compared to reclamation soil capabilities.

Response:
No soils were reclaimed to capability classes 1, 2 or 4, therefore there were no impacts determined to the three classes. All impacts, residual impacts and environmental consequences were evaluated for the naturally occurring soils under the broad categories of Disturbed Soils (organic or mineral dominant) except for reclaimed class 3, which was the reclamation goal.

The changes to pre-disturbance and closure land capabilities are outlined in Table D2.2-10, while the impacts, residual impacts and environmental consequences associated with these changes are evaluated in Table D2.2-11. These two tables provide a comparison of pre-disturbance and closure soils with respect to land capabilities.

c) **Suncor states that replacement of Class 5 lands with Class 3 lands should be interpreted as a positive, qualitative alteration to land capability for forest ecosystems in the Regional Study Area (RSA).** ***(Vol. 2B, p. D6-14)*** **Please explain how the loss of ecosystems available only in Class 5 lands could present a positive qualitative alteration. Also, discuss whether this argument explains the near total loss of Class 1 and 2 land, which is also replaced by Class 3.**

Response:
The current Suncor environmental operating approval requires the return of lands to primarily a forestry end land use. With commercial forestry as one of the main end land use objectives, the increase in Class 3 areas at the expense of Class 5 was determined to be positive. As set out in Table D2.2-10, at closure there will remain approximately 3,300 ha of undisturbed Class 5 land in a mostly contiguous area to the south of the development footprint. This, over time, will permit the invasion of communities found in these areas into suitable habitats which will evolve over time as the reclaimed landscape matures.

Under the Cumulative Effects Assessment scenario, which considers regional developments, Class 1 lands will experience a loss of 106 ha, or 22% of the total 465 ha regional area of this class (refer to Table D6-6). Class 2 lands will experience a loss of 4,680 ha, or 1.1% of the total 439,060 ha regional area of this class. Therefore, neither of these classes should be considered as experiencing near total loss.

d) **Suncor indicates that reconstructed soil is a mixture capable of sustaining an initial erosion controlling plant cover. The reconstructed soil is also**

designed to be capable of supporting vegetation species found in adjacent forest communities. ***(Vol. 1, p. E3-26)*** **Please provide a list of vegetation species in adjacent forest communities and a species list for the reclamation target ecosite phases that Suncor will re-establish. Compare the range in species types for both the adjacent communities and the reclamation target ecosite phases.**

Response:

Refer to Volume 2b, Section D3.1.2.4 and the Terrestrial Vegetation Baseline (Section 3.2.2) for a discussion of the vegetation species found in each Ecosite phase. In addition, Table D3.1-3 (Section D3.1.2.4) discusses the vegetation species which make up 50% or more of the Ecosites surveyed.

Regarding the species list for the reclamation target ecosite phases that Suncor will re-establish, refer to Section D3.2.7 for a discussion on Reclamation and Closure. In particular, refer to Table D3.2-4 for a summary of the target Ecosite phases and their corresponding tree and shrub species.

The vegetation species for the reclamation target Ecosite phases have been designed to be compatible with the original plant community tree and shrub species. As the vegetation becomes established on the reclaimed ecosites, successional processes, in combination with micro-site variations, will allow for multi-aged vegetation stand development, with a corresponding diversity of species. The vegetation species selected should contribute to the attainment of the end land use goal for the site. The vegetation species selected for the reclamation target Ecosite phases are native species, consequently there should be no introduced species planted and/or seeded within the reclaimed site.

e) **Suncor indicates that unless a significant advantage can be demonstrated, mineral soils are not normally salvaged because they are difficult to salvage with the types of equipment used in the oil sands environment.** ***(Vol. 1, p. E3-27 and E5-49)*** **Please clarify the parameters that Suncor believes would have to be met to qualify as a 'significant advantage' (i.e., minimum depth, minimum salvage area, and so on). Provide a comparison of the quality of the subsoil mineral material salvaged during muskeg overstripping with the subsoil underlying the mineral topsoil. Provide estimates of total mineral soil volume and potential salvageable mineral soil volumes. Discuss why the appropriate reclamation equipment would not be available for mineral soil salvage. Discuss how Suncor will meet their Steepbank Mine approval conditions if mineral soils are not salvaged and used in the reclamation process.**

Response:

Significant advantage in relation to the shallow soil study would be an increase by 25% of native woody stemmed species not normally planted by Suncor. In addition, significant advantage would be considered to be a productive increase (tree growth) in excess of 25% from the shallow soil plots when compared to the deeper soil plots. Either advantage would be worth the extra effort and cost of salvaging shallower mineral soils.

There are two types of mineral topsoil located an the Steepbank Mine escarpment area. The properties are described in the Soil and Terrain baseline Report for Project Millennium (page 8).
RB2 soils are found on +16% slopes therefore are prone to downslope movement, as a result both parent materials and textures are quite variable - generally these are classified as regosols or soils with little/no profile development. Parent material ranges from sandy loam textured fluvial to sandy clay loam textured till, frequently both overlie residual tar sand within a metre of the surface. Typically profiles are deeper at the base of the slope and shallower near crests due to the instability. RB3 soils are found in the upper and slope crest location so are a bit more stable, hence the soils are more developed and classified as brunisols. Parent materials are similar in range to those for RB2. Evaluation of the physical and chemical characteristics of the C horizons for both RB soils indicate reclamation suitability would be Fair, limited principally by the coarse textures (see Table 8, p. 32 in Baseline Report).

Organic soils of the McLelland and Muskeg series (shallow variants have 40-120 cm of organics over mineral) are underlain primarily by till (sandy clay loam in texture) with minor areas of fluvial (sandy loam) and lacustrine (loam-silt loam) deposits. Slopes for both series are typically less than 0.5%. Evaluation of the chemical and physical characteristics of the C horizons for both series indicate reclamation suitabilities would generally be rated Good, although in some cases the structure may reduce this to Fair (see Table 8, p. 32 as above).

As discussed on pages 34 & 35 of the Millennium Soil & Terrain Baseline Report, only Kinosis and Steepbank series were evaluated as being suitable for reclamation placement (i.e. rated Good using the Criteria in Table 7, p. 31 of the Report) and then only as upper subsoil. Within the East Bank Mining Area (9281 ha) approximately 3599 ha are mineral soils of which the Kinosis and Steepbank series comprise 2089 ha. Salvaging the upper 0.5 metre of the profile would yield roughly the following: **(Note that since the BC to C horizon boundary for both the Kinosis and Steepbank series varies between 30 and 60 cm below the surface it is highly likely that salvage would incorporate some amount of the less desireable C horizon material and further downgrade the rating the material.)**

Soil Series	**Area (ha)**	**Average Depth, m.**	**Volume*, m^3**
Kinosis	1143	0.5	5,715,000
Steepbank	946	0.5	4,730,000
Total	2089	n/a	10,445,000

* values do not include potential shrink or swell of material

Actual volumes to be salvaged will be dependent on results of the soil study and the area on the escarpment that could eventually be developed (i.e., 20% of escarpment area). Mineral topsoil is being salvaged and the supply for the above commitment will be met.

7.18 **"Slash and deadfall will be incorporated into soil amendment materials used in Suncor's reclamation program because they provide a number of benefits."** ***(Vol. 1, p. E3-37)*** **Clarify what debris will be burnt versus what could be incorporated into the reclamation soils, or on the surface of reclaimed areas. Please discuss the method(s) Suncor will use to incorporate slash and deadfall into the reclamation program. Discuss Suncor's strategies to deal with these options.**

Response:
Suncor is working with the regional logging operators to ensure all economically viable trees are salvaged. It is Suncor's intent to salvage the timber resource that has value to the logging industry. However, Suncor does not plan to have uneconomical small dimension wood salvaged.

This means that uneconomical small wood diameter stands of aspen, poplar, spruce, and pine will not be logged, but consistent with the practices within the province, disposed of by burning. The intent will be to pile the woody debris in the summer or early fall in order to allow the wood to dry with the brush; disposal by burning occurring during the winter months. This process is expected to result in a lessening of the particulate release from the clearing operation.

Most of the woody debris left after logging on the shallow mineral soils will be removed or disposed of by burning. Roots, stumps and residual wood debris will be taken with the soil. On the deeper muskeg soil pockets, the trees, stumps and roots are included with the reclamation soil only if the volume does not exceed 25% of the soil material. This additional woody component is viewed by Suncor as adding to the diversity of the soil. Excessive amounts of woody debris included in the soil adversely affect reclamation performance.

7.19 **Figure E3-7 shows the relative area of soil capabilities in the east mine pre-development and post reclamation areas. As part of this application, Suncor is requesting that the return of land capability approval requirements be changed to reflect the fact that "... a different composition of pre-disturbance land capabilities...now exist".** ***(Vol. 1, p. F4-45)*** **To further illustrate and clarify Suncor's reclamation strategy, please summarize the results of Figure E3-7 with the current requirements of the Steepbank Mine Approval. Compare these results with the changes in land capability, which Suncor is proposing and with Table 6 of the** ***Soil and***

Terrain Baseline Report (p. 26). **Include proportional distribution and aerial extent.**

Response:

Table of Land Capability Classes for Forest Ecosystems

Land Capability Classes	Table 6 of the Soil and Terrain Baseline		Steepbank Mine Approval[1]		Changes to the Steepbank Mine Approval (Section F4.2) [2]		Forest Capability Classes (Figure E3-7)	
	ha	%	ha	%	ha	%	ha	%
1	465	3	150	2	108	1	16	0.1
2	3,437	21	1,700	27	879	7	146	0.9
3	1,675	10	1,500	25	7,989	65	12,155	75.2
4	1,907	12	1,750	28	1,458	12	1,665	10.3
5	8,698	54	1,100	18	1,849	15	2,201	13.6
Total	16,181	100	6,850	100	12,510	100	16,181	100

(1) Includes 650 ha classified as infrastructure. The land capability classes are based on draft of Leskiw (1995) land capability classification.
(2) Includes 230 ha classified as infrastructure.

7.20 **Suncor indicates "land capability classes are a function of slope, aspect, drainage, depth of amendment, and climate."** ***(Vol.1, p. E5-64)*** **Clarify whether the soil factors (i.e., hydrological, soil chemistry, nutrient exchange) are important to the range of species for all ecosite phases accurately reflected in the Soil Capability Classes.**

Response:
Suncor followed the recommendations detailed in the Guidelines for Reclamation to Terrestrial Vegetation (1998) to determine the appropriate ecosite phases on the reclaimed landforms. This guide considers soil factors in prescribing the range of species for the ecosite phases.

7.21 **Suncor indicates that "under the land use goal, the plant species selected should meet the needs of commercial forestry and wildlife habitat (moose habitat). Food and cover for the wildlife species (moose) anticipated on the site must be addressed in plant species selection".** ***(Vol. 2B, p. D-71)***

a) **Describe how the land use goals and revegetation plans satisfy the EIA objectives to supply equivalent carrying capacity for moose and a wide range of wildlife identified by the Key Indicator Resources (KIRs) chosen by Suncor. Describe how the revegetation plan will fulfil the** ***Fort McMurray-Athabasca Subregional Integrated Resource***

Plan (IRP) **guidelines to replace diverse habitats, characteristic valley vegetation and landforms.**

Response:
AEP requires that plant species composition be compatible with the original plant communities, a neighboring community, or other reasonable land management objective (Gerling et al. 1996). The plant species selected for reclamation contribute to the attainment of the land use goal for the site. Site conditions such as topography, drainage and soil materials also influence the selection of compatible revegetation species. Plant species have been selected to meet the needs of commercial forestry and wildlife habitat (moose habitat).

Thirteen community types have been selected for establishment on reclaimed landscapes after closure. These communities include the following, of which eight are particularly suitable for moose habitat (low-bush cranberry Aw (d1) to shrubs, inclusive).

- blueberry Pj-Aw (b1)
- blueberry Aw(Bw) (b2)
- blueberry Aw-Sw (b3)
- low-bush cranberry Aw (d1)
- low-bush cranberry Aw-Sw (d2)
- low-bush cranberry Sw (d3)
- dogwood Pb-Aw (e1)
- dogwood Pb-Sw (e2)
- dogwood Sw (e3)
- shrubby swamp (SONS)
- shrubland
- Constructed Wetlands
- Open Water

Table D3.2-4 (Vol. 2B, Section D, Reclamation and Closure) presents a list of tree and shrub species that should be planted to achieve the corresponding vegetation community types (i.e., target ecosite phase).

The reclamation landscapes selected should all support moose populations to varying degrees. These would include early successional communities that support browse species and mature mixedwood or conifer communities that provide winter shelter. Tree and shrub species that will support moose include alder, aspen, balsam poplar, white birch, buffalo-berry, low-bush cranberry, dogwood, raspberry, rose, Saskatoon and Labrador tea (Stelfox 1993). These tree and shrub species listed are some of the common forages used by moose as food. They are also the vegetation species selected to establish vegetation communities on reclaimed landscapes. Consequently, the vegetation species selected fulfill IRP guidelines and should create suitable habitat for moose. The reclamation monitoring program will regularly assess the status of forage and browse species and utilization of reclaimed ecosites by wildlife.

Reference:

Gerling, H.S., M.G. Willoughby, A. Schoepf, K.E. Tannas and C.A. Tannas. 1996. A guide to using native plants on disturbed lands. Alberta Agriculture, Food and Rural Development and Alberta Environmental Protection. Publishing Branch. Edmonton, Alberta. 247 p.

Stelfox, J.B. 1993. Hoofed Mammals of Alberta. Lone Pine Publishing. Edmonton, Alberta. 242 p.

b) **Suncor makes reference to two main goals of the closure landscape "commercial forestry and moose habitat". Suncor also indicates that moose are an important wildlife species and that reclamation landscapes will be selected that support moose populations. Discuss Suncor's rationale in primarily selecting moose over other wildlife species that may be found in the area. Please provide the ranking of the other 11 KIRs evaluated in the study area.**

Response:
Suncor focused on moose as one of the main goals of closure landscape because moose were identified as a key objective in the "Fort McMurray-Athabasca Oil Sands Subregional Integrated Resource Plan" (AEP 1996). The Suncor study area mainly occurred in the Mildred-Kearl Lake Resource Management Area (RMA) and the Athabasca-Clearwater RMA.

The main wildlife objectives for the Mildred-Kearl Lakes RMA are (see p. 38):

- "To maintain moose habitat and to rebuild wintering moose population to a least 430 animals from the present population of approximately 360."
- "To maintain, or to replace at another site(s), the waterfowl and fisheries habitat of Kearl Lake."

The main wildlife objectives for the Athabasca-Clearwater RMA (see p. 33) are:

- "To maintain the limited waterfowl habitat found in this RMA."
- "To maintain and enhance moose habitat to support at least 225 wintering moose, up from the current population of approximately 100."

The closure planning process ensured that habitat for all KIR species was reclaimed, where possible. However, various limitations in the reclamation processes and current technology make it impossible to reclaim all of the lost habitats (e.g., patterned fens). The exercise of ranking KIR species for the purpose of reclaiming different habitats is a difficult one. Obviously, each KIR species was chosen for different reasons (from economic value to importance in the food chain), and these values cannot be ranked. Thus, the approach was to identify which habitats could be feasibly reclaimed and then examine how well these habitats met the needs of the various KIR species. This approach allowed the reclamation of habitat primarily for moose and for other KIR species, as well.

Source:

Alberta Environmental Protection (AEP). 1996. Fort McMurray-Athabasca Oil Sands Subregional Integrated Resource Plan. AEP, Edmonton, Alberta.

Reclamation Monitoring and Research

7.22 **Suncor indicates that permanent, midslope transects provide the location for routine annual soil sampling and vegetation monitoring.** ***(Vol. 1, p. E4-43, 44)*** **Please discuss how upper slope erosion and lower slope sedimentation will be monitored using permanent midslope transects.**

Response:
There have been no obvious differences noted in the vegetation on upper and lower slope positions except for the very narrow band (e.g., 1 to 2 m) adjacent to active berm roads. The purpose of the monitoring program is to monitor soil and vegetation development. Erosion monitoring is a visual observation which is acted upon accordingly.

The original design basis for the sampling position was the anticipated top-slope erosion and down-slope sedimentation. If this were to occur, then mid-slope sampling would provide most meaningful results in early stages of reclamation.

Lower soil sampling is conducted the first year following reclamation, then on a five year period. The following parameters are monitored:

- pH (Sat. Paste)
- Conductivity (Sat. Paste)
- Sodium Adsorption Ratio
- Soluble Cations
    - Calcium
    - Magnesium
    - Potassium
    - Sodium
- Saturation
- Plant Available Nutrients
    - Nitrate-Nitrogen
    - Phosphate-Phosphorous
    - Potassium

Sulphate-Sulphur
- Total Nutrients
  Organic Carbon
  Nitrogen
  Phosphorous
  Sulphur
- Cation Exchange Capacity
- Oil & Grease (Gravimetric)
- Thickness
- Bulk Density
- Texture Classification
  Sand
  Silt
  Clay

7.23 **A monitoring program as outlined in the Terms of Reference is required to demonstrate a commitment to effort, methodologies, and frequency of such monitoring into the post-mine future.** ***(Vol. 1, Section E4; Reclamation and Monitoring Research)*** **Provide more detail regarding the overall proposed monitoring program following reclamation. Include wetlands, End Pit Lake, water quality, biodiversity, productivity, nutrient availability, aquatic plants, invertebrates and vertebrates.**

Response:
The monitoring program to be established during the reclamation finalization period (2033 to 2043) will include a terrestrial element to assess development of soils and vegetation communities, as well as invasion of the developing habitats by wildlife species. In addition, the monitoring program will include an aquatic component to evaluate the development of wetlands, drainage systems and the end pit lake, both from a physical as well as biological point of view.

The design of the end-of-reclamation monitoring program will be based on the reclamation monitoring completed as part of Suncor's operations. Decisions on the final design of the end-of-reclamation program will be finalized by Suncor in conjunction with the regulatory agencies and regional stakeholders.

7.24 **Suncor states that successful reclamation requires that ecosystems which become re-established on the surface of consolidated tailings (CT) deposits should be healthy and sustainable.** ***(Vol. 1, p. E5-72)*** **Suncor also indicated that development of a stable surface on CT deposits has not been demonstrated;** ***(Vol. 1, p. E5-69)*** **and that the impact of CT water on reclamation plant communities is unclear.** ***(Vol. 2, p. D3-90)*** **Please clarify the apparent discrepancy in the stability of CT deposits.**

Response:
While development of a stable surface on CT deposits has not been demonstrated in an operating pond, this statement was not intended to imply that there is no evidence to support the likelihood of such stabilization or that a successful demonstration was unlikely in the future. Several methods that are likely to be successful have been identified and described in the application, and industry experience with prototype deposits has been positive. Suncor will be testing surface stabilization methods in the CT Test Pond currently under construction, and is confident that surface stabilization will be economically achieved.

7.25 **Suncor indicates that "the performance of reclaimed areas must be predicted well into the future. Predictions of performance are based on:** ***(Vol. 1, E4-43)***

-Extrapolation of data from research project and pilot tests

-Results of monitoring programs on reclaimed areas

-Input of current experience in the oil sands and other northern regions.

-Elements considered for performance prediction includes:

-Landform performance

-Impact of chemical constituents of the landscape

-Ecosystems sustainability"

Discuss these statements in the context of the monitoring objectives set out in the ***Draft Guidelines for Reclamation to Forest Vegetation in the Alberta Oil Sands Region.*** **Describe the monitoring Suncor will undertake as per the** ***Draft Guidelines for Reclamation to Forest Vegetation in the Alberta Oil Sands Region. (Section 6, Monitoring Programs).***

Response:
All the performance factors listed in the question are now incorporated into Suncor's overall reclamation Monitoring program. Suncor will follow the referenced guidelines. Suncor's existing monitoring program is described in Volume 1, Section E4.

7.26 **Suncor indicates that a demonstration area has been set up on the north slope of the Horse Shoe Substation on Lease 86/17 to determine the benefits of salvaging shallow deposits of topsoil.** ***(Vol.1, p. E5-48)*** **The Steepbank approval required the salvage and use of mineral soils to facilitate** ***Fort McMurray-Athabasca Subregional Integrated Resource Plan (IRP)***

requirements of developing ecosystems consistent with those of the Athabasca River Valley.

a) **Please provide a list of the ecosite phase vegetation community and a list of species, which Suncor expects to inhabit the experimental sites. Please discuss factors involved in the mineral and peat soil salvage such as timing between tree clearing, soil salvage, and soil placement. Also discuss whether the overburden placed on site is consistent with the source location. Discuss the probable reasons why woody species such as Aspen did not regenerate. Include in the discussion any other potential experiments that may be conducted to enhance the successful re-establishment of vegetation on salvaged mineral soils.**

Response:
The ecosite phases that occurred on mineral soils in the pre-developed landscape are listed in the Table D4.2-2 to Table D4.2-6. The targeted ecosite phases, for example, will include low bush cranberry aspen (d1), low bush cranberry aspen-white spruce (d2), dogwood aspen(e1), and dogwood white spruce (e3).

The regeneration of deciduous vegetation from soils and transferred seedbank is subject to many variables including source of materials, placement location, aspect, and moisture regime. During the 27 years of applying reclamation practices in conjunction with an extensive amount of research, Suncor's observation is that after initial management inputs, reclamation is taken over by natural processes. The reclamation program has been effective in allowing this evolution to occur unhindered, thus making the sites more in tune with the ecosystems found in the region.

Both aspen and poplars as well as an assortment of other deciduous species are included as a part of the current tree planting prescription. Therefore, these species are being planted in areas where they should be found in nature. The results are too preliminary to understand why certain woody species did not regenerate. However, further monitoring will assist in determining the effectiveness of this method.

At this time, Suncor does not have any specific plans for mineral soil research with the exception of monitoring of operational areas where these soils have been placed.

b) **Suncor's demonstration area indicates that native plant regrowth on salvaged shallow mineral soil has been limited to herbaceous plants, and is in contrast with the regrowth on muskeg from a deeper source.** ***(Vol. 1, p.***

E5-48-49) **Please describe the ways in which the regrowth on the muskeg differs from the shallow mineral soil.**

Response:
A summary of the vegetation cover for the four subplots in each plot located on the study site is shown in Table 1. The most noteworthy difference between the two experimental areas is the dominance of the seeded barley in the Thick Organic (Peat) source material plot which provided over 50% cover compared to the Thin Organic (Mineral) source material plot where seeded barley contributed less than 10% cover. Herbaceous invading species, especially sweet clover and sow thistle, were much more abundant in the Thin Organic source plot providing over 46% cover compared to the Thick Organic source plot where these species accounted for less than 10% cover. Trees and shrubs provided negligible (<1%) cover in both plots. Total cover was nearly the same averaging 60% cover for the Thick Organic source and 55% for the Thin Organic source.

The average vegetation height was 52 cm for the Thick organic source, slightly higher than the 37 cm average for the Thin Organic source. This difference is due to the relatively tall growth habit of the seeded barley which dominated the Thick Organic source compared to most of the herbaceous invading species that dominated the Thin Organic source plot.

These results should be considered preliminary. Based on monitoring results in other areas of the Suncor Lease, it is common that native tree and shrub growth is not apparent until two or three growing seasons. As well, herbaceous species often invade very quickly after the initial seeded barley dies off.

This study will continue during 1998 with some minor enhancements. An alternate area set up on tailings sand can be used as an indicator of performance potential with an alternate substrate. Information from this alternate location can be used to validate the results from the overburden shallow soil study area.

The initial assessment is surprising as the experiment has not produced the expected results. However, the experiment may serve to illustrate the tremendous variability that can be encountered in nature. Past reclamation has already brought to light this variability as areas develop into a variety of ecosystems across the site.

Table 1

Mean Percentage Vegetation Cover and Height in August 1997 on the Shallow Soil Experiment Plots

Cover Type	Thick Organic Source	Thin Organic Source
Native Vascular Invaders:		
Sow Thistle	5.8	10.9
Fireweed	2.5	0.0
Hawksbeard	0.2	3.4
Dandelion	0.0	1.4
Smartweed	0.0	0.4
Lamb's Quarters	0.0	0.5
Strawberry Blite	0.0	0.3
Corydalis	0.1	0.1
Herbaceous Cinquefoil	0.0	1.2
Horsetail	0.0	0.2
Subtotal	8.5	18.4
Agronomic Invaders:		
Barley (seeded)	51.3	8.6
Grasses	0.1	4.6
Red Clover	0.0	5.1
Sweet Clover	0.3	18.2
Subtotal	51.7	36.5
Shrubs and Trees:		
Spruce (planted)	0.1	0.0
Pine (planted)	0.1	0.0
Subtotal	0.2	0.0
Total Vegetation Cover	60.2	54.9
Height (cm)	52.0	37.0

Note: Data are the mean of 4 plots per treatment and 10 quadrates per plot.

7.27 **Suncor indicates that "the aim is to provide a revegetation community mix, which will develop into a seamless blend on the reclaimed landscape. This requires selecting pre-development vegetation communities as benchmarks."** ***(Vol. 1. p. E5-64)*** **Please define the type of landscape or vegetation community that constitutes a seamless blend. Also, discuss the variables and their use in landscape and vegetation community development. Clarify why Suncor uses the term the establishment of benchmark "reclamation" plant communities rather than the establishment of benchmark "native" plant communities. Include a discussion on possible establishment of control benchmark native communities in offsite undisturbed native ecosystems, and how they will serve as surrogate targets for the reclamation ecosite.**

Response:
Suncor believes its reclamation program, which focuses on the use of native plant species, is designed to allow the plant communities in reclamation areas to blend into similar plant communities where they exist adjacent to the reclamation areas. Fundamentally Suncor is saying that the closure scenario will show that plant communities on reclamation areas can just as likely be found in nearby undeveloped areas, i.e., they fit seamlessly into the mosaic of boreal forest habitats. The term "reclamation" is not intended to replace the commitment to native species.

Suncor has included the use of control sites within its existing reclamation monitoring program. Suncor will work cooperatively with Alberta Environmental Protection and other oil sands developers to define the need for control site establishment. Suncor does believe that the ecosite targets for the reclamation program have been well defined, both by scientists focused on the various types of ecosites within the boreal forest, as well as by the Oil Sands Reclamation Committee.

Biodiversity

7.28 **Suncor indicates that species richness and diversity indices were not calculated for field data because only a few of the ecosite phases were represented by a sufficient number of plots to allow meaningful statistical comparisons.** ***(Vol. 2B, p. D3- 44)***

Suncor also states that it is recognized that it is not possible to conduct a complete listing of all indigenous species present. ***(Vol. 2B, p. E-33)***

a) **Please provide further baseline data on species richness and diversity and present a more complete listing of species in each of the ecosite phases that will be disturbed by the mine development. This effort should be designed to improve on the sample size of plots, and allow meaningful comparisons of species richness and**

diversity indices. Please provide a schedule for the collection of this information.

Response:
Suncor believes that the level of assessment on biodiversity is within the Terms of Reference of the EIA. Suncor has no current plans to complete any additional surveys of terrestrial vegetation on the Project Millennium area.

b) **In Suncor's application, "diversity is assessed for plant species by two main indices: species richness and species diversity (Shannon Index)."** ***(Vol. 2B, p. D3-54)*** **Discuss the accuracy and validity of the diversity measurements for species richness and species diversity. Please adjust the appropriate sections that use species richness and diversity if surveys find additional, or amended, information is warranted.**

Response:
The ecosite phases represented in the LSA but not surveyed include:

- lichen jack pine (a1);
- Labrador tea - mesic jack pine-black spruce (c1);
- Labrador tea- subhygric black spruce-jack pine (g1);
- Labrador tea black spruce-white spruce (h1);
- black spruce-tamarack (Sb-Lt); and
- shrub.

Labrador tea - mesic jack pine-black spruce (c1), Labrador tea- subhygric black spruce-jack pine (g1), Labrador tea/horsetail black spruce-white spruce (h1), and black spruce-tamarack (Sb-Lt) occupy small upland areas bordering wooded fens. It is predicted that these ecosite phases would support the same species composition as wooded fens.

The shrub class is restricted to cutblocks or disturbed upland areas. The lichen jack pine (a1) is restricted to one isolated stand on the Athabasca River escarpment that is not representative of the dominant ecosites in the LSA. In addition, lichen jack pine (a1), Labrador tea - mesic jack pine-black spruce (c1), and Labrador tea- subhygric black spruce-jack pine (g1), collectively occupy only 3 ha of the LSA.

7.29 **Suncor states that undeveloped areas will provide refugia for native plants. These refugia areas will be maintained to enhance recolonization of the reclamation areas with native species. Table D4.2-13 shows the reclaimed Ecological Land Classification (ELC) units associated with this macroterrain unit.** ***(Vol. 2B, p. D4-41)*** **The remainder of Section C2 up to Figure C2.4.23** ***(Vol. 2B, p. C2-92)*** **shows complete disturbance and reclamation of this area. Discuss whether some of the activities that**

encroach on the non-mined area could be relocated to allow the retention of some undeveloped ground in the middle of the mine. Also include a discussion on how Suncor could ensure these lands remain through to closure. Table D4.2-13 shows an area of 943 ha of undeveloped area. ***(Vol. 2B, p. D4-39)*** **Please provide 10 copies of a map showing locations of the undeveloped land set aside as refugia.**

Response:
Unique physical valley characteristics as identified by Westworth (1990) include fluvial meander scars and fans; wildlife habitat, diverse vegetation communities, and diversity of landforms. In addition, the valley supports rare flora, old growth forests and riparian wetlands. The valley or floodplain functions as a movement corridor for wildlife and attenuates flooding. Suncor will reclaim disturbed area of the valley to pre-development ecosite phases and wetlands. Undisturbed riparian wetlands such as Shipyard Lake will be monitored for changes in vegetation, hydrology and fish habitat as part of the Regional Aquatic Monitoring Program (RAMP).

7.30 **Suncor indicates that species richness for reptiles and amphibians is calculated to decrease 23% for the closure landscape when compared to the predevelopment conditions. A decrease of 13% is calculated for bird species richness. This is reflective principally due to the decrease in fen and other wetland areas.** ***(Vol. 2B, p. E-35)*** **Please discuss if some of this decrease in amphibian and bird diversity might be mitigated by maintaining water levels in bogs and fens immediately adjacent the mine site.**

Response:
Species richness for reptiles, amphibians and birds will decrease in the closure landscape, primarily due to the decrease in fen and other wetlands habitats in the development footprint. It is assumed that the bogs and fens adjacent to the development area are as suitable for amphibian and birds following closure as they were before development.

7.31 **"Within the LSA, 6 rare plants have been identified in wetlands, which include bogs, fens, swamps and marsh."** ***(Vol. 2B, Table D3.1-27)*** **"Riparian areas, which were also surveyed, provide considerably more unique microhabitats for rare plants."** ***(Vol. 2B, p. D3-49)*** **Two rare plants have been identified as being directly impacted by development. Turned Sedge was identified in a dogwood ecosite (e1).**

This community will be used over much of the consolidated tailings (CT) backfilled mine cell reclamation unit as shown on Figure E-2 and thus there will be an increase in habitat for this plant after closure. ***(Vol. 2B, p. E-33)*** **The provincially rare small water lily (S1G5T5) is documented within**

Shipyard Lake *(Terrestrial Vegetation Baseline, p. 46, Table 15)*. Please discuss Suncor's rare plant protection strategy and the locations where these rare plants could be protected. The reclaimed ecosite phase el is promoted as being potential habitat for Turned Sedge. Discuss the chemistry and hydrological factors important to the Turned Sedge, and whether the species is tolerant to the chemistry and hydrological changes in the reclaimed habitat.

Response:
Suncor will avoid known locations or ecosites with a high potential to support rare species where it is possible to do so. Protection of natural areas within the lease, such as Shipyard Lake and portions of the floodplain of the Athabasca River, known to support rare plants, will be avoided.

Turned sedge was identified in a Dogwood Ecosite (e1) along the Athabasca River. Prairie cord grass was identified in a shrubby swamp along the Athabasca River. In addition, small-water lily was identified in Shipyard Lake and in the lake at the end of McLean Creek. These sites are not being disturbed by Suncor. These are locations where these rare plants have been identified and consequently, will be avoided.

In referring to Moss (1983) Flora of Alberta, turned sedge is found in swampy woods and wet meadows. It prefers sites that are wet and would not be tolerant of drought conditions. Turned sedge does not tolerate saline soils. Reclamation of Ecosite Phase e1 will allow a variety of micro site conditions to develop which could support its colonization and re-establishment.

7.32 **Suncor states that it has been demonstrated that the impact of development on rare plants is expected to be "low" since only one rare plant was identified in a fen environment which will not exist on the closure landscape. *(Vol. 2B, p. E-35)* Please comment on the apparent contradiction in Table D3.1-27 that shows 6 rare plants were identified in LSA wetlands. *(Vol. 2B, p. D3-50)* Also comment on the statistical level of confidence of the assessment, considering that not all vegetation types were sampled.**

Response:
The statement that one rare plant was identified is in error. Table D3.1-27 and the Terrestrial Vegetation Baseline (Section 3.3) identify that 6 rare plants were recorded in LSA wetlands during the 1995 and 1997 field surveys in total. The rare plant field survey methodology was addressed in the Terrestrial Vegetation Baseline Report (Section 3.3).

The rare plant survey utilized the Alberta Native Plant Council Guidelines for Rare Plant Surveys (1997).

The rare plant survey was undertaken to determine the presence and location of all rare plant species, and botanically significant plant assemblages on the survey site. A rare plant survey can confirm the presence of rare species on a site, but it cannot rule out the existence of rare species on a site (ANPC 1997). The size of the project area and inaccessibility to some sites, precluded a detailed survey of the entire area. Therefore, searches were concentrated on high potential habitats while still sampling each plant community represented in the LSA.

There are times when even the best plant survey would not reveal a rare plant that exists on a site. The relative abundance of any species can vary annually. Some species have the ability to withstand stresses, such as drought, by storing seed for extended periods. Thus, in unfavorable seasons, some rare species may not be apparent at all. Because of these uncertainties, it is fair to say that the intent of this rare plant survey was to determine rare plant habitat potential and the presence of rare plants.

7.33 **Suncor states that the reclaimed terrain units present a positive alteration in that the variety of genetic materials upon closure will be greater than pre-disturbance, leading to an overall increase in potential ecosystem variability. *(Vol. 2B, p. D2-28)* This statement appears to contradict the overall EIA information provided. Terrestrial vegetation types go from 16 *(Vol. 2B, p. D3-9, Table D3.1-2)* to 12 in the Reclamation Closure Landscape *(Vol. 2B, p. D3-66, Table D3.2-2)*, and Wetland vegetation types go from 12 *(Vol. 2B, p. D3-66, Table D3.1-17)* and riparian type from the preceding paragraph to 8 in the reclamation closure landscapes. *(Vol. 2B, p. D3-66, Table D3.2-2)* Please provide a list of the maximum, minimum, mean, range, and distribution of vegetation polygon sizes in the pre and post disturbance landscapes. Discuss and contrast the apparent differences. Discuss whether there are any other terrestrial or aquatic ecotypes that could be replaced or conserved.**

Response:

A discussion of the range (maximum-minimum) and mean polygon sizes is presented in Section D3.2.5. When patch size at the baseline is compared to patch size at closure, there is an increase in average patch size. For example, the blueberry Aw(Bw) ecosite phase average patch size for the baseline is 27 ha, whereas at closure the average patch size is 77 ha. This increase in average patch size can be observed in the low-bush cranberry (d1, d2, and d3) and dogwood (e1, e2 and e3) ecosites. The Project development will also result in reductions of average patch size.

A reduction in patch size ranges may potentially equate to a temporary loss in diversity. Reductions in patch size range are recorded in ecosite phases lichen Pj (a1), Labrador tea-mesic Pj-Sb (c1) and Labrador tea-subhygric Sb-Pj (g1). However, these ecosite phases comprise less than 1% (3 ha) of the LSA.

The mean, minimum and maximum patch size for wetland patches within the LSA is presented in Table D3.2-26. The mean patch size will increase within the

Baseline from 1 to 2 ha, to 1 to 19 ha after closure. For some wetland classes, the average patch size will increase, for example, wooded fens (FTNN/FFNN) and coniferous swamps (STNN/SFNN). However, for others the maximum patch size will decrease as a result of Project development. In the baseline, for example, the maximum patch size for wooded fens (FTNN) is 4,667 ha, however, after closure the maximum patch size is 1,200 ha. Maximum patch size decreases for all wetland classes. Wetland classes not affected by Project development are the wooded bogs (BTNN/BFNN).

Suncor will continue to participate and follow the recommendations detailed in the Guidelines for Reclamation to Terrestrial Vegetation (1998) and the Wetlands Working Committee on determining the appropriate ecotypes to reclaim.

7.34 **Table D3.2-25, compares pre and post disturbance patch sizes *(Vol. 2B, p. D3-111)*. Mean and maximum closure patch sizes have increased considerably in the closure landscape. Discuss the likely impact on vegetation diversity and wildlife carrying capacity. Include in the discussion measures or strategies that Suncor could include in their reclamation procedures to reduce the mean and maximum patch size. Also provide in the discussion, wildlife visual resources or other objectives Suncor may be targeting with larger patch sizes.**

Response:
Concerns regarding patch size were addressed earlier in the discussion for response 7.33. Refer to Volume 2B, Section D3.2.5 for a discussion of the range (maximum-minimum) and mean polygon or patch sizes.

7.35 **Table D3.3-1 shows the changes in terrestrial vegetation patch size to be low in magnitude and reversible *(Vol. 2B, p. D3-115)*. Please discuss how modifications to patch size are achieved through the evolutionary process of a maturing landscape when the subsoil and topsoil are homogeneous and hydrological factors are at an equilibrium state.**

Response:
Please refer to response 7.3a for a more detailed answer to this question. In addition, hydrological factors are not expected to be at an equilibrium due to the gradient of the reclaimed structures. Seep zones and dryer areas will be evident following reclamation.

8.0 LAND USE

Traditional Land Use and Resource Use

8.1 **Suncor indicates it will consult with aboriginal groups, to design a closure plan that accommodates traditional land uses *(Vol. 1, p. A4-50)*. Table D3.1-16 identifies plant species important to aboriginal peoples that have been gathered in the project area. *(Vol. 2B, p. D-34)* Please identify the traditional species that Suncor intends to re-establish on reclaimed lands. Identify the portions of the reclaimed lands that Suncor will reclaim with the traditional species mix. Discuss the consultation with the Aboriginal groups and their views on traditional uses in the reclaimed landscape.**

Response:
As indicated in section E15.4, detailed planning of the topography and vegetation communities that will characterize the reclaimed landscape has not been completed to-date. It is Suncor's intent to consult with aboriginal communities during the planning process according to the provisions of the existing Memoranda of Understanding with the communities of Fort McKay and Fort Chipewyan. Input into end land uses from aboriginal communities can also be obtained through Suncor's participation in the multi-stakeholder initiatives currently underway in the region. The specific views of these communities relating to desirable plant species will be considered in planning the reclaimed landscape.

In the view of the Fort McKay elders, reclaimed lands may not be the same as pre-development, and traditional and other uses are uncertain to them. They expressed a desire to participate in the planning, research and monitoring of the reclamation program. Suncor is currently considering a process for Fort McKay involvement in the reclamation program.

8.2 **Table D3.3-1 shows that the impact of the development on traditional use plants to be "low" in magnitude, reversibility, and of low consequence *(Vol. 2B, p. D3-115)*. Please discuss whether this reflects an agreement with the aboriginal groups on an reclaimed landscape that has incorporated plant species important to them. Provide a schedule for the restoration of plant species important to aboriginal groups.**

Response:
The impact rating for the development on traditional land use does not reflect a specific agreement with the aboriginal people, but rather a comparison of those species listed by aboriginal peoples as important for traditional land use with those species predicted to be components of the closure habitats.

It is not possible to provide a schedule for the return of traditionally-important species other than to reiterate the expected reclamation and closure schedule.

Plants used traditionally are integral members of regional ecosite phases. The traditional plants that are members of the ecosite phases planned for the Suncor reclamation program are expected to return to the reclamation area, just as other plants within those ecosite phases will return. Ecosites are the result of landscape, soil and moisture conditions. The plants of the different ecosites are found with the ecosite phases because of their preference for certain conditions. If the reclamation activities provide those conditions, then the plants are likely to return.

Environmental Management

8.3 **Suncor states that they seldom use pesticides on the plantsite.** ***(Vol. 1, p. F5-48)*** **Please provide a list of the chemicals that have been used in the past and would be used in the future. Indicate the application standards that would be used when applying the pesticides.**

Response:
In the past, Suncor has used pesticides to control rodents and insects in the camp facility and also to control weeds in selected locations around plantsite. Suncor's approach to the responsible use of pesticides is to try and avoid their use in the first place. If this is not possible, then products that do not require a licensed applicator (and hence are less potent and less likely to result in adverse impacts beyond their target area) are considered. As a last resort, Suncor will use products that are controlled under the Pest Control Products Act and that require licensed applicators. Suncor does not have any licensed applicators on staff and would rely on a company that is so qualified to do this work on their behalf. The selected contractor would then use application standards appropriate to the task at hand.

Forest Resources

8.4 **Table A3-1 shows the range of consultation with groups interested or affected by the Suncor Millennium Project.** ***(Vol. 1, p. A3-29)*** **Northlands and Alpac Forest Industries are absent from this listing. Please provide the results of the consultation with forest harvesting companies regarding mitigation of the projected impact to their Annual Allowable Cut (AAC).**

Response:
Suncor has been meeting with Northlands Forest Products and Alberta Pacific Forest Industries to resolve a number of issues relating to the removal of the existing forest stands prior to development and the potential adverse effects of the proposed activities. The issues being addressed include access interruptions, salvage of the valued timber supplies, Timber Damage Assessment, impact to

Annual Operating Plans, development of new access, harvesting stand layout, and a number of lesser issues. Several helicopter trips have been taken with Alberta Pacific Forest Industries and Northlands Forest Products, with the inclusion of Alberta Land and Forest Service (LFS).

It is Suncor's intent to include Nothlands Forest Products, Alberta Pacific Forest Industries participants and the LFS personnel in the decision making process. As such, the LFS members from the Waterways District have been present at most of the meetings with the industry representatives.

Impact on the AAC has not yet been quantified. This information should be determined from the Alberta Vegetation Inventory information covering the Project Millennium area provided to Northlands Forest Products and Alberta Pacific Forest Industries for their assessment.

8.5 **A summary of the existing and predicted annual cuts for the closure is provided in Table E-3.** ***(Vol. 2B, p. E-37 & 38)*** **Please describe the commercial forest Annual Allowable Cut (AAC) by area and species for the pre and post disturbance area. Provide 10 copies of a map showing the areas considered for each of the species identifying the areas deleted as required due to slope, watercourses and lakes with recreation potential. Please clarify the estimated AAC in the closure landscape and how it was determined. Please discuss the loss of AAC, by species, per annum for disturbed areas until equivalent areas, by species, of regenerated stands have been established. Provide a schedule for a return of productive forest.**

a) **Determine the impact of development on these uses and identify possible mitigation strategies. Describe the impact to the AAC for the local study area and the associated regional study area for each commercial species. Include such variables as the area to be harvested, volumes salvageable, and the change in wood flow both for the short term and the long term. Describe the areas to be reclaimed for commercial forestry, the site productivity anticipated and the rate of return of the land to a commercial forest landbase having a productive capability equivalent to the predisturbance condition.**

Response:
A breakdown of AAC is usually completed by the forest industry as part of their operations. With the withdrawal of the lands granted through the Mineral Surface Lease, the developer compensates the Forest Management Agreement (FMA) holder for the timber values of the area being cleared through the Timber Damage Assessment process. As such this request should be directed to the FMA holder following removal of the lands from their AAC landbase calculation. Suncor is not in a position to assess the AAC potential for any forest harvesting operation and feels that this question is not relevant to the approval process.

The reclamation plan illustrating the time of the reforestation activities has been included in the C&R section of the application. These drawings serve to illustrate the incremental return and the temporal projections associated with the alteration of the land base values to those of a commercial forest ecosystem. Suncor supports the inclusion of these areas into the landbase calculations for AAC immediately following reclamation and planting. Although there is a monitoring period prior to requesting certification of these areas, this should not negate but enhance the values of the lands as this work provides a higher level of assurance that the reforestation standards are being met.

b) Suncor indicates that slash and deadfall will be incorporated into soil amendment materials used in Suncor's reclamation program because they provide a number of benefits. ***(Vol. 1, p. E3-37)*** **Please discuss whether Suncor will salvage all trees that the forest industry is willing to utilize.**

Response:
As previously stated in response 7.18, Suncor will attempt to salvage a certain portion of the slash and deadfall in the soil handling process. Other material (not salvaged by forestry operators) will be burned.

c) Provide an assessment of impact to forest resources by industrial users, including the following:

- **i) Identify commercial and non-commercial coniferous, deciduous and mixedwood landbases;**
- **ii) Volume and area estimates by strata (cover group);**
- **iii) An estimate of the growing stock that will be lost;**
- **iv) Estimate of timber volumes that will be salvaged ; and**
- **v) A reforestation or reclamation plan to return equivalent areas, by species and productivity.**

Response:
Suncor has completed a field review of the AVI potential of the Project. A report prepared by Timberline Forest Inventory Consultants is included in the Appendices

8.6 **Suncor states that the approval holder shall return disturbed land east of the Athabasca to a re-vegetated condition compatible with the surrounding area, including forest ecosystem on 78% of the disturbed land, containing an equivalent pre-disturbance area of commercial forest having equivalent**

productivity as determined by site indices outline in the Alberta Vegetation Inventory (AVI) standards manual. ***(Vol. 1, p. F4-46)*** **Please clarify Suncor's interpretation of the requirement of the Suncor Steepbank approval. Verify whether this area include lands listed as disturbed, or potentially productive such as existing cutblocks, or old airstrips.** ***(Forestry Baseline Report, p.11 and Table 4-footnote A)***

Response:
The statement means that Suncor will return the area to a state where 78% of the total development area is a forest ecosystem, while 22% is primarily an aquatic ecosystem and other areas considered as non-forest ecosystems. Suncor expects to return a minimum of 65% of the total development area to a commercial forest state (as per the conditions in the current approval for the Steepbank Mine).

8.7 **Suncor indicates that stands situated on steep slopes where slope would preclude harvesting (harvesting requirement of slopes > 30%) were not included. As all rough broken soils (RB2 soils) are found on slopes greater than 16%, all polygons with RB2 type soils were removed from the database. (The GIS database indicated that all RB2 polygons were on escarpment slopes)** ***(Table 2, p. 9, Forestry Baseline Report)*** **Please clarify the guideline source that requires slopes >30% or >16% on RB2 soils not be logged.**

Response:
The guidelines for harvesting operations consider slopes of greater than 30% to be adverse requiring specialized equipment to remove the trees safely without undue damage to the environment.

Petroleum Coke

8.8 **Suncor indicates that it intends to complete a full assessment of the long-term coke handling requirements by August 1998.** ***(Vol. 1, p. F2-8)*** **This is a rquirement of the Steepbank Approval. Please confirm that Suncor intends to fulfil this requirement as a response to this letter.**

Response:
The coke management plan is provided in the appendices to this submission.

Engineered Structures

8.9 **Suncor's current closure plan includes one engineered structure to take the flow of Ponds 7, 9 and the north half of 10 along with the northeast dump down the Athabasca escarpment to Shipyard Lake. The design of this structure will be based on hydrologic principles taking into account the maximum probable flood. *(Vol. 2B, p. E-38)* Please discuss why Suncor chose a structure which requires long-term maintenance. This will be a permanent structure that will require some long-term maintenance. *(Vol. 2B, p. E-38)* Provide a discussion on how this approach is consistent with Suncor's' philosophy of establishing a maintenance free closure landscape suitable for reclamation certification. Include in the discussion how Suncor will obtain certification if the lands require long-term maintenance.**

Response:
Suncor's present assessment is that providing for long term maintenance of this structure is much more cost-effective than constructing a drainage channel that will not require long-term maintenance. However, Suncor will continue to explore options for maintenance free drainage structures with the required flow capacity, and would select this option if economically justifiable.

Cumulative Effects/Regional

8.10 **The Regional Study Area (RSA) for this project is 24,286 km^2. This is more than twice the size of the RSA used in the previous oil sands mine EIA project (10,395km^2).**

a) **Please provide the rationale for having a much larger RSA for assessing impacts to terrestrial resources. Include a justification of the percent loss of habitat (ecosystem disturbance significance) as a result of the size of the RSA. *(Vol. 2B, p. D5-77, Table D5.2-4)***

Response:
Suncor participated with the regulators in discussions on the regional study area (RSA) during various workshops held during the completion of the EIA. Feedback on the possible RSA for the project focused on concerns associated with determining potential effects of acidifying emissions. Therefore, most reviewers recommended including as large a terrestrial RSA as possible to ensure that potential effects on soils, vegetation and water could be identified.

Suncor selected the RSA boundary based on:

- confidence in the predictions of the air models; and
- available information on soils and vegetation.

When discussing impacts to terrestrial resources for the RSA, values for the RSA baseline are provided as well as impacts directly associated with Project Millennium and impacts associated with the CEA developments.

In the discussions of wildlife, comparisons are made for the local study area (LSA) and RSA primarily because most of the species are wide-ranging, traveling well beyond the limits of the LSA. The intent was not to dilute the impact of habitat loss within the LSA, but to put the loss in perspective with a generic RSA, as selected based on the considerations discussed above.

b) **Having chosen that area, the current boundary incorporates significant portions of major terrestrial ecosystems other than the Central Mixedwood SubRegion in which the Local Study Area (LSA) is located. (i.e., Sub-Arctic, Boreal highlands, Peace River Lowlands and the Athabasca Plain). Please discuss if the RSA boundary was selected using an ecosystem-based approach. Consider the following criteria: airshed, watershed, and terrestrial features.**

Response:
The rationale for selecting the terrestrial RSA was based on the geographic extent of potential acidification. Because the selection of the RSA was bsed on the airshed, watershed and terrestrial features would become secondary.

c) **The RSA intersects two major natural regions (Boreal Forest, Canadian Shield) and five SubRegions, each of which is identified as a distinct ecosystem. What is being referred to as the corresponding ecosite phases for each of the three Ecological Areas represented in the RSA are also presented in Table D6-11. *(Vol. 2B, p. D6-20)* Explain the classification used and the discrepancy in terminology used.**

Response:
The RSA classification system was based on an amalgamation of ecosite phases. Beckingham and Archibald (1996) define an ecosite phase according to the Ecological Area in which it occurs. Ecological Areas, as defined by Beckingham and Archibald, are comparable to Subregions. For example, the Boreal Mixedwood Ecological Area includes the Central Mixedwood, Dry Mixedwood, Wetland Mixedwood and Peace River Lowlands natural Subregions.

8.11 **"The impact predictions for wildlife are based on a habitat assessment approach. The EIA assessed habitat removed during the project development, and the habitat replaced by reclamation following mine**

closure. This type of assessment approach can simplify the impacts to wildlife by assuming that displaced species will simply move elsewhere during operations and return again after closure of the project". *(Vol. 2B, p. D5-1)* This may be true for some species, but other less adaptable species will not be as fortunate to find optimal habitat. Disturbance due to the overall operations of the project could potentially result in a significant impact to some wildlife populations, through the lost of reproductive potential over the project life. Please provide a re-assessment of impacts to wildlife populations by quantifying the cumulative effects of reduced reproductive potential and recruitment into regional populations.

Response:
The requested assessment through quantification of the cumulative effects of reduced reproductive potential and recruitment into regional populations assumes that information on the reproduction and populations of wildlife species in the region is known. Suncor is not aware of any such information on a regional basis. Suncor would be willing to work with Alberta Environmental Protection Fish and Wildlife Services through the Oil Sands Regional Cumulative Effects Working Group to explore the options for resolving this question. Suncor would welcome Fish and Wildlife's active participation in the working group.

9.0 PUBLIC HEALTH

9.1 **Suncor states that for the purpose of modelling, all PM was assumed to be PM_{10}." *(Vol. 2A, p. B3-30, p.B4-28)* Please explain the rationale for omitting an analysis of the impacts of $PM_{2.5}$ and the potential for secondary particulate generation and its subsequent effects on human health.**

Response:
The air quality assessment included the contribution of secondary aerosols in the evaluation of acidic deposition. The contribution of these aerosols was not included in the PM_{10} isopleth figures presented in the EIA. Suncor has now completed an evaluation of the secondary aerosol concentrations in the RSA and assessed the results from a human health perspective. This new information is provided in Sections B4 and B5 of this submission.

In the EIA, comparison to guideline values for particulate matter focused on the TSP (particles with a mass mean diameter less than 50 μm) and PM_{10} (particles with a mass mean diameter less than 10 μm) components. No $PM_{2.5}$ guidelines from Canadian jurisdictions are available for comparison. Section B4 estimated $PM_{2.5}$ concentrations from the PM_{10} figures since PM_{10} includes the $PM_{2.5}$ fraction as a component.

With respect to the health effects of particulate emissions, there remains significant controversy in the scientific community (e.g., annual meeting of the Society of Toxicologists, Seattle, Washington, March, 1998) concerning the reference levels for health effects of PM_{10} and $PM_{2.5}$ and appropriate guidelines. Health Canada has recently withdrawn the draft "air quality objectives" for $PM_{10}/PM_{2.5}$ that were issued last fall (based solely on risk considerations) and they are not planning to reissue new objectives for $PM_{10}/PM_{2.5}$. Instead, the PM issue will be addressed under the "new" national harmonization strategy called "Canada Wide Standards" (CWS). These new objectives will take into account not only the risk of health effects, but also the costs and practicality/feasibility of achieving the standards, based on in-house analyses and stakeholder input. The CWS objectives for PM are not anticipated until the fall of 1999.

9.2 **Suncor is committed to improve its understanding of pond emissions of volatile organic compounds (VOCs) *(Vol.1, p. F3-22, Table F3-4)* and Suncor represents about 70% of the VOC total emisions. *(Vol. 2A, pB4-36)* Explain.**

a) **the VOC emission estimates from the tailings pond.**

Response:
Suncor has relied on a number of sources of information to estimate the VOC emissions from its tailings ponds. Field measurements collected over a number of years in combination with theoretical mass transfer calculations are the basis upon which Suncor has built its estimates. Nevertheless, there are still issues with respect to the pond emissions that Suncor does not completely understand. These uncertainties will be the subject of recently commissioned pond studies. Volume 1, Section F of the Application provides more detail on this subject.

b) **what processes are unique to Suncor's operation that result in these high expected emission rates.**

Response
The fact that Suncor uses diluent in its extraction process and stores tailings in large tailings ponds is the fundamental reason that Suncor has VOC emissions to the atmosphere from the ponds. At the present time, Suncor is estimating higher pond emissions than is Syncrude. Possible reasons for this difference have been previously summarized in the response 1.22.

c) **what is being emitted and what are the potential human health impacts,**

Response:
The VOCs being emitted include: C2-C12 alkanes/alkenes; cycloalkanes, benzene, C6-C8 aromatics, aldehydes, ketones and reduced sulphur compounds.

The potential human health impacts are evaluated in Sections F1.2.2.2 (Baseline), F1.3.2 (Millennium) and F1.4, Step 2 (CEA) of the Project Millennium Application. No impacts to human health were predicted for residents of the communities of Fort McKay, Fort McMurray or Fort Chipewyan for Baseline, Millennium and CEA scenarios. In addition to evaluating these communities, an additional conservative exposure scenario was evaluated, involving a hypothetical hunter/trapper living 6 months per year adjacent to the Suncor fenceline for 50 years. Air concentrations from the Lower Camp receptor location were used in this scenario. Chemical exposures in this latter scenario were higher than those for the communities. However, despite the increased exposure, exposure ratio (ER) values remained less than 1 for non-carcinogenic chemicals and were marginally greater than 1 for benzene (i.e., 1.2 to 1.5). Due to the compounded conservative assumptions used in this assessment, impacts to human health are predicted to be negligible.

9.3 **Suncor states that they are committed to providing a safe and healthy work environment for employees, contractors and others who may be affected by its operations.** ***(Vol. 1, p.B6-56)*** **Will the higher NO_X and VOC emissions from Suncor's proposed operations have an impact on ozone generation? What might the human health impacts be on the local population and on those members of the workforce in and around the truck and shovel operations in the mining pit (i.e. exposure to high ozone, NO_X and VOC's)?**

Response:
The higher NOx and VOC emissions from Suncor's proposed operations may have an impact on ozone generation under specific meteorological conditions. Although the hourly Alberta Ambient Air Quality Guideline for ozone is rarely exceeded in Fort McMurray, the 8 hour guideline is exceeded more often. Based on preliminary ozone modelling results, ozone generation during certain meteorological conditions is expected to increase by 3% in the spring and 9% in the summer for the CEA scenario as compared to the Baseline case scenario. A more complete discussion has been provided in the additional information submitted with this package (Section B3).

The EIA has shown that the health of people in the communities of Fort McKay, Fort McMurray and Fort Chipewyan are not expected to be affected by VOCs or NOx. Since the one hour air quality guideline for ozone has not historically been exceeded in Fort McMurray, it is not expected that the health of residents will be affected. With respect to worker health, Suncor will comply with occupational health and safety guidelines and ensure use of proper personal protective equipment for members of its workforce exposed to chemical emissions.

9.4 **Suncor states that a recent assessment was initiated to address stack particulates and associated polycyclic aromatic hydrocarbons (PAHs) and metals in response to stakeholder concerns, *(Vol. 1, p. A4-48)* and that information respecting particulate emissions and associated PAHs and metals will be available when their analysis is complete. *(Vol. 2C: p. F1-30; p. F1-55)* Please clarify Suncor's analysis of (PAHs) and metals.**

a) **Did the analysis of total PAHs include the vapor phase and particulate phase? Compare with the observation data from Environment Canada and apply this analysis to human health risk assessment.**

b) **Provide a human health risk assessment analysis for metals based on Suncor's predicted metals emissions and the observed metals data from Environment Canada.**

Response:
Predicted metal and PAH concentrations as a result of stack and vehicle fleet emissions were evaluated with respect to human health from direct inhalation and from deposition onto soils and plants and uptake through the food chain. The methodology and results of these analyses are provided in Section B5, "Additional Human Health Analysis" of this submission.. Briefly, no impacts to human health were predicted via direct inhalation or ingestion of plants which have accumulated metals and PAHs from deposition. This finding is a direct result of the low particulate, metal and PAH emissions predicted to be emitted from the Suncor and Syncrude stacks. These stacks are equipped with sophisticated pollution control technology to capture the majority of particulate and vapour phase emissions.

The analysis of PAHs included particulate phase emissions from stack emissions and diesel exhaust emissions. However, given the sampling methodology used in the stack survey analysis, it is assumed that all vapour phase PAHs would have been condensed and included with particulate phase PAHs in the sampling device. Thus, it is assumed that both vapour and particulate phase PAHs were accounted for in dispersion modelling, based on the stack survey speciation of emissions.

The predicted metal and PAH data have not been compared with observed metals and PAH data from Environment Canada. Due to the significant changes in pollution control technology undertaken by Suncor and Syncrude over the past few years, it is unlikely that historical data would accurately reflect current and future emission rates.

9.5 **Suncor anticipates odour problems related to mercaptans. *(Vol. 2A, p. B4-40, Table B4-13)* Please discuss Suncor's proposed plans for validating their conclusion that Total Reduced Sulphur (TRSs) may continue to be an occasional odour problem, however, the impact is not deemed to be**

"significant". ***(Vol. 2A, p. B4-47)*** **Please define what is a "significant" impact. What impact would act as a trigger requiring a response from Suncor to address the impact, and what would be that response?**

Response:
Suncor has participated in a series of specialized studies to characterize odourous emissions associated with oil sands activities. These studies have included ambient THC and TRS monitoring, odour calculations, odour sensory studies, dispersion modelling studies and odour complaint and incident tracking studies. A review of odour complaint information collected in the area from 1993 to 1997 indicates a significant decrease in odour complaints/incidents over this period of time. Refer to Table B2-14 on page B2-18 of the revised air quality component for Project Millennium and Section 4.13 of the "Technical Reference for the Meteorology, Emissions and Ambient Air Quality in the Athabasca Oil Sands Region" (Golder 1998) for more details.

Maximum hourly and daily estimates of TRS concentrations in the communities of Fort McKay, Fort McMurray and Fort Chipewyan were reported in Section B of the Project Millennium Application for Baseline, Millennium and CEA scenarios. These estimates are maximum concentrations and do not reflect the typical odour level.

Because odours are difficult to measure, triggering mechanisms could be community complaints or exceedences of monitored parameters such as H_2S. Significance is judgmental and is based on severity and frequency of these incidents. Suncor responds to any such incidents as part of the emergency response procedure. The type of action is based on results of investigation.

9.6 **Suncor states that work is progressing in the area of napthenic acids and particulates to add further knowledge to the health risk assessment database.** ***(Vol. 1, p. A4-37)*** **In addition, one of the guiding principles of Suncor's Health, Safety, and Loss Control policy is prevention, which states that Suncor will implement risk-based programs designed to anticipate, prevent, and mitigate harm to health or safety.** ***(Vol. 1, p. B6-56)*** **Suncor also states that results of particulate analysis...were not received in time for inclusion in this EIA.** ***(Vol. 2C, p. F1-59)*****, and air quality remains a paramount issue that requires regular monitoring.** ***(Vol. 2C, p. F1-63)*** **What monitoring plans are in place to address the issue of data/knowledge gaps as it relates to emission rates and human health impacts? What management plans are in place to address this issue? Is it possible to engage the Wood Buffalo Environmental Association in overseeing a modelling work-group that would address emissions monitoring, emission data modelling and emissions impact assessment?**

Response
Suncor has the following plans for monitoring to address the issue of data/knowledge gaps as they relate to emission rates and human health impacts:

Suncor reports its emissions on a regular basis for the purposes of both, internal and external stewardship. Management systems are in place to ensure that such emission reporting takes place.

Suncor is committed to ongoing monitoring of its emission sources so that an accurate and up to date emissions inventory can be maintained. As part of the Project Millennium design, Suncor shall ensure that all new stacks are provided with the required sampling points so that future stack surveys can be easily and accurately performed.

The Wood Buffalo Environmental Association is already actively involved in air monitoring in the region. Nevertheless, there could be an opportunity for the association to oversee a modelling working group that would address source emissions measurement, dispersion modelling, and correlation of those model results with actual air station monitoring data.

9.7 **Suncor states work is also progressing in the area of napthenic acids and toxicity, *(Vol. 1, p. A4-48)* and that the mouse mononucleus test has been selected for use. In addition, Suncor is also providing financial support for academic research concerning the toxicity of napthenic acids at the University of Saskatchewan. *(Vol. 2C, p. F1-19)* What coordination will exist between oil sands producers to address the issues related to napthenic acids? Explain why mice are the species of choice in addressing toxicity. Explain the nature of the research being conducted at the University of Saskatchewan.**

Response:
CONRAD will be the main coordination body for such research. Specifically, napthenic acids research is being cordinated through CEATAG. (A recent report issued by CEATAG in June, 1998, entitled "Naphthenic Acids Background Information Discussion Report" provides an excellent overview of this subject).

The mouse micronucleus assay is a standard test for evaluating genotoxicity of chemicals in mammals. This in-vivo exposure, combined with this animal model are considered to be ideal to provide additional insight respecting potential genotoxicity of CT water constituents in mammalian systems. The assay is being conducted according to a protocol standardized by the Organization for Economic Cooperation and Development (OECD), by which Canada abides, and which uses mice as the standard animal model.

The University of Saskatchewan study is a Ph.D. research project focused on naphthenic acid mammalian toxicity. The study will involve exposure of small rodents to naphthenic acids in drinking water. This will be used to determine gastro-intestinal absorption, tissue distribution, lipid compartmentalization and clearance patterns of the parent chemicals. If possible, metabolites will be identified. The naphthenic acids to be utilized will be isolated from Syncrude tailings pond waters. Both fresh and aged water samples will be used. A reference, technical grade standard and/or constituent acid compound will be used as a control.

Toxicity assessments will include lethality, enzyme induction, immunological induction, endocrine status, behavioural changes, reproductive toxicity and developmental toxicity.

9.8 **"A variety of plants in the LSA are used for medicinal, spiritual and consumptive purposes. High, moderate or low were assigned to each species based on the number of times a species was occurred within a specific region of the traditional land use maps"** ***(Golder 1996). (Vol. 2B, p. D3-84)*** **Please clarify the use of "importance" to select traditional use plants and then the subsequent description of the process as using abundance (i.e., "times a species was occurred") as the qualifier. Importance and abundance are not synonymous. Clarification is required.**

Response:
As noted in the referenced section, the ranking of importance was taken from literature prepared by the Fort McKay First Nations. The ranking indicates the Fort McKay First Nations assessment of the importance of specific species to their peoples. The abundance ranking simply provides a reference to the number of times a specific species was noted as occurring within a specific region of the traditional land use maps.

9.9 **In response to the uncertainties and concerns articulated by stakeholders respecting air deposition of airborne chemicals onto vegetation, Suncor undertook a stack survey to collect information respecting particulate matter, organic chemicals and metals. Information from this study will be used to model the deposition of air contaminants onto vegetation and then interpret this in the context of potential exposure for humans consuming plants from this area. However, the results of the stack survey were not received in time to be incorporated into this section at the time of submission.** ***(Vol. 2C, p. F1-64)*** **If available, please present the results and discuss them in the context of direct effects on human health. Discuss the indirect effects of accumulation of toxic substances in plants and animals, and subsequent consumption of plants and animals by area residents. If the results are unavailable at this time, provide a schedule for their submission.**

Response:
Predicted metal and PAH concentrations as a result of stack and vehicle fleet emissions were evaluated with respect to human health from direct inhalation and from deposition onto soils and plants and uptake through the food chain.

The methodology and results of these analyses are provided in the attached Section B5,"Additional Human Health Analyses". Briefly, no impacts to human health were predicted via direct inhalation or ingestion of plants which have accumulated metals and PAHs from deposition. Due to the negligible predicted increase in metal and PAH concentrations of plant tissues due to oil sands air emissions, significant accumulation in game animals from ingestion of plants and soils is not expected.

9.10 **Suncor states that five composite samples of each species (composed of berries, leaves or roots from three different plants) were collected from each test area and from control areas *(Vol. 2C, p. F1-35)*. How does the assessment of blueberry, Labrador tea, and cat tail root plants relate to the use of other plant species for spiritual and medicinal purposes?**

Response:
These plant species were selected primarily due to their use as sources of food for local aboriginal communities. Edible parts of these plants (berries, leaves and roots) were analyzed for chemical concentrations to determine potential exposures to local residents. It was not practical to sample all traditional plant species used for food, spiritual or medicinal purposes; however, analysis of the selected species provides some indication of the magnitude of accumulation of metals and PAHs in other berries, leaves and roots which are used for these purposes. Our initial sampling protocols specifically called for inclusion of ratroot as a component of medicinal plants used by local aboriginal communities. However, no ratroot plants were observed during the sampling program. Thus, cattail was collected and regarded as a surrogate for ratroot.

9.11 **What is the potential metal accumulation for fungi(i.e. mushrooms) harvested in the area as a food source, and what impact does this hold for humans?**

Response:
As noted in the response to Question 9.10, it was not practical to sample all traditional plant species used for food, spiritual or medicinal purposes in the August 1997 vegetation sampling program; however, analysis of the selected species provides some indication of the magnitude of likely accumulation of metals and PAHs in mushrooms. It may be valuable to sample edible mushrooms (i.e., puffballs) in future studies of this nature.

9.12 **The selection of blueberries, Labrador Tea leaves, and cat tail root is termed "representative of public and scientific values"*(Vol. 2B, p. D5-62)*. However, it appears that only public values were considered as there is no presentation of scientific literature that validates these selections. Please**

provide the scientific rationale that supports the selection of blueberries, Labrador Tea leaves and cat tail root. Does the scientific literature suggest other species and tissues should be included in a study such as this, and if so, what will Suncor do to ensure that these additional species will be included in future studies in the region?

Response:
The statement in Vol. 2B, page D5-62, refers to the selection of key indicator wildlife species (KIRs) for the wildlife impact assessment. It was not meant to apply to selection of plant species for the vegetation sampling program. The purpose of the vegetation sampling study was to provide edible plant tissue concentration data for the human health risk assessment.

The selection of plant species was based primarily on consideration of public values, since the goal of the vegetation sampling program was to gain an understanding of the magnitude of chemical exposure people are likely to incur from consumption of edible plants collected from areas within the zone of deposition of airborne chemical emissions from the oil sands region. The purpose of the study was not to select plants that are necessarily significant or insignificant accumulators of metals, but rather to select plant species that people eat. However, plant species were selected to include different edible parts of plants (fruit, leaves and roots), since several scientific studies have reported significantly different concentrations of metals in different parts of plants (typically root>stem>leaf>fruit; Bagatto and Shorthouse 1991, Sheppard 1991). Thus, these species were selected using a combination of public values and scientific knowledge.

References:

Bagatto, G. and J.D. Shorthouse. 1991. Accumulation of copper and nickel in plant tissues and an insect gall of low-bush blueberry, *Vaccinium angustifolium*, near an ore smelter at Sudbury, Ontario, Canada. Can J Bot 69: 1483-1490.

Sheppard, S.C. 1991. A field and literature survey, with interpretation of elemental concentrations in blueberry (*Vaccinium angustifolium*). Can J Bot 69: 63-77.

9.13 **The study which investigates metal concentrations in blueberry, Labrador tea and cat tail root was developed in consultation with regional stakeholders. However, Suncor states *(Vol. 2B, p. D5-55)* that the experimental design used to address this issue was not rigorous (limited replicates and power of experimental design). There are other Traditional Resource Use initiatives presently underway in the Wood Buffalo region that focus on contamination of plants and animals harvested for consumption. Describe the specific steps that Suncor will undertake to ensure that a proper, rigorous study design is to be employed in future**

studies to provide the data necessary to answer the questions regarding consumption of local plants and animals.

Response:
While the vegetation sampling program employed a limited number of samples, the data generated from this sampling program do provide an indication of the range of chemical concentrations likely to be found in edible portions of plants in the oil sands region. Because of the uncertainty associated with a small number of samples, the maximum chemical concentrations observed in these samples were used in the human health and wildlife health risk assessments to conservatively evaluate potential exposures due to consumption of plants. This vegetation sampling program was designed to provide adequate data for a screening level human health risk assessment; it was not designed to be a rigorous study on metal and PAH accumulation in plants..

9.14 **Suncor collected soil and/or *Sphagnum* samples from the base of blueberry, Labrador tea, and cat tail plants sampled for metal analysis *(Vol. 2C, p. F1-35)*. Suncor did this sampling in order to determine if there were accumulations of metals in the soil that could help explain metal accumulation, if any, in the sampled plant tissues *(Vol. 2D, p. VI-180)*. The results of the soil/*Sphagnum* sample analysis are not presented in the EIA, nor is an assessment of the metal content of the soils relative to the vegetation data presented. The conclusion reached later in the section *(Vol. 2C, p. F1-65)* is therefore incomplete, since the soil part of the bioaccumulation pathway (soil → plants → animals → humans) is missing. Please provide this data, and interpret and discuss the results in the context of the study.**

Response:
Tables 1 to 3 present the geometric means of soil, sphagnum and sediment samples collected at the base of blueberry, Labrador tea and cattail plants. For most metals, concentrations in soil and sphagnum samples collected from the Suncor Lease 25 site are not significantly elevated in comparison to control samples. Some chemicals (i.e., aluminum, calcium, manganese, phosphorus and sulphur) appear to be elevated in soil and sphagnum samples collected from the Suncor Lease 25 site in comparison to control samples (Tables 1 and 2). Sediment concentrations of boron, calcium, iron, phosphorus, potassium, sodium, sulphur, vanadium and zinc appear to be elevated in samples collected from Suncor Lease 25 in comparison to control samples (Table 3). PAHs were generally not detected in soil, sphagnum and sediment samples, with the exception of a few samples with low concentrations.

Site-specific bioconcentration factors (BCFs) for metals were calculated where sufficient data were available. Mean site-specific BCFs appear to be within the range of values reported in the literature. (Table 4).

Table 1 Mean Chemical Concentrations in Soil and Sphagnum Samples Collected at the Base of Blueberry Plants (mg/kg)

Chemical	Control Areas (Soil; n=3)	Muskeg River Mine Site (Soil; n=5)	Suncor Lease 25 (soil; n=1)	Suncor Lease 25 (sphagnum; n=1)
Aluminum	n/a	n/a	1280	79
Antimony	n/a	n/a	<0.04	0.05
Arsenic	n/a	n/a	0.7	<0.2
Barium	61.2	87.4	162	23.3
Beryllium	n/a	n/a	<0.2	<0.2
Boron	n/a	n/a	3	4
Cadmium	n/a	n/a	0.13	0.09
Calcium	563.3	1344.2	3520	4570
Chromium	13.1	6.0	1.6	0.3
Cobalt	3	2.1	2.4	0.42
Copper	7.8	7.9	4.2	3.5
Iron	6708.5	6013.2	3710	254
Lead	7.5	5.9	4.2	0.5
Magnesium	863.6	462.6	397	11030
Manganese	42.5	295.3	1630	415
Mercury	0.04	0.04	0.05	0.05
Molybdenum	n/a	n/a	1.37	0.18
Nickel	2.9	3.6	77	9.5
Phosphorus	n/a	n/a	265	1040
Potassium	1003.3	634.6	282	5040
Selenium	n/a	n/a	<0.2	<0.2
Silver	n/a	n/a	<1	<1
Sodium	112.5		19	36
Strontium	13.8	12.9	11.7	10.1
Sulphur	165.2	241.1	497	1150
Thallium	n/a	n/a	<0.04	<0.04
Tin	n/a	n/a	<0.1	0.3
Vanadium	22.5	12.7	20.7	1.6
Zinc	22.1	17.8	25	20
PAHs[a]				
naphthalene	<0.01	<0.01	<0.01	0.03
methyl naphthalene	<0.01	<0.01	<0.01	0.05
phenanthrene/ anthracene	<0.01	0.01	<0.01	0.04

a naphthalenes were detected in 1 of 1 sphagnum samples from Suncor Lease 25; phenanthrene/anthracene was detected in 1 of 1 sphagnum samples from Suncor Lease 25 and I of 5 soil samples from Muskeg River Mine site; all other PAHs were not detected.

n/a not analyzed

Table 2 Mean Chemical Concentrations in Soil and Sphagnum Samples Collected at the Base of Labrador Tea Plants (mg/kg)

Chemical	Control Areas (Soil; n=2)	Control Areas (Sphagnum; n=3)	Muskeg River Mine Site (Soil; n=4)	Muskeg River Mine Site (Sphagnum; n=1)	Suncor Lease 25 (Sphagnum; n=5)
Aluminum	n/a	52.1	n/a	108	155
Antimony	n/a	n/a	n/a	0.06	0.04
Arsenic	n/a	n/a	n/a	<0.2	0.2
Barium	44.6	15.8	78.7	28.3	31.1
Beryllium	<1	<0.2	<1	<0.2	<0.2
Boron	n/a	3.1	n/a	3	6.7
Cadmium	<0.5	0.09	<0.5	<0.08	0.1
Calcium	472	2223	1168	4700	6016
Chromium	9.1	0.24	5.8	<0.5	0.4
Cobalt	<1	0.18	1.8	0.21	0.37
Copper	5.2	7.4	8.1	2.8	3.2
Iron	3369	121.8	5844	635	444.5
Lead	5	0.65	5	0.9	0.63
Magnesium	458.1	639.5	449.9	605	1065
Manganese	26.3	267.7	208	450	231.3
Mercury	0.056	0.043	0.039	0.04	0.06
Molybdenum	<1	0.11	<1	<0.4	0.33
Nickel	2.3	3	3.5	3.2	3.3
Phosphorus	n/a	567	n/a	1210	748
Potassium	689	3316	606	2490	3797
Selenium	n/a	<0.2	n/a	<0.2	<0.2
Silver	<1	<1	<1	<0.08	<1
Sodium	111	43.6	<100	12	43.6
Strontium	12.3	5.4	12.7	8.3	15
Sulphur	137	674	232	741	1224
Thallium	<1	<0.04	<1	<0.04	<0.04
Tin	<5	<0.1	<5	<0.08	<0.1
Vanadium	14.7	0.38	12.6	1.23	3.17
Zinc	21.8	33.1	17.7	18	27.6
PAHs[a]					
naphthalene	<0.01	<0.01	<0.01	<0.01	0.08
methyl naphthalene	<0.01	<0.01	<0.01	<0.01	0.07
phenanthrene/ anthracene	<0.01	<0.01	<0.01	0.01	0.06

a naphthalenes were detected in 1 of 5 sphagnum samples from Suncor Lease 25; phenanthrene/anthracene was detected in 1 of 5 sphagnum samples from Suncor Lease 25 and I of 4 soil samples from Muskeg River Mine site; all other PAHs were not detected.

n/a not analyzed

Table 3 Mean Chemical Concentrations in Sediment Samples Collected at the Base of Cattail Plants (mg/kg)

Chemical	Control Areas (n=5)	Muskeg River Mine Site (n=5)	Suncor Lease 25 (n=5)
Aluminum	2581	n/a	2298
Antimony	0.17	n/a	<0.04
Arsenic	1.9	n/a	2.3
Barium	102.8	79.8	101.1
Beryllium	0.6	<1	<0.2
Boron	9.6	n/a	23
Cadmium	0.36	<0.5	0.27
Calcium	8603	17407	11248
Chromium	4.4	16.7	6.9
Cobalt	5.7	5.6	5.0
Copper	5.2	15	7.4
Iron	5347	19530	11248
Lead	4.9	9.1	5.6
Magnesium	2090	3825	2224
Manganese	386	370	463
Mercury	0.1	0.08	0.09
Molybdenum	1	1	0.87
Nickel	7	14.4	9.8
Phosphorus	653	n/a	1256
Potassium	453.8	1369	1043
Selenium	0.26	n/a	0.44
Silver	<1	<1	<1
Sodium	102	213	246
Strontium	40	44	56
Sulphur	1638	3590	2312
Thallium	0.06	<1	0.04
Tin	0.19	<5	0.1
Vanadium	9.7	22.1	24.3
Zinc	38	45	423
PAHs[a]			
phenanthrene/anthracene	<0.01	0.02; 0.04	<0.01
pyrene	<0.01	0.01;0.02	0.03
benzo[a]anthracene/chrysene	<0.01	0.03;0.03	0.06
benzo[a]pyrene	<0.01	0.02;0.01	<0.01

a phenanthrene/anthracene, pyrene, benzo[a]anthracene/chrysene and benzo[a]pyrene were detected in 2 of 5 sediment samples from Muskeg River Mine site; pyrene and benzo[a]anthracene/chrysene were detected in 1 of 5 sediment samples from Suncor Lease 25; all other PAHs were not detected.

n/a not analyzed

Table 4 Calculated Bioconcentration Factors (BCFs) from Soil/Sediment to Berries/Leaves/Roots (mg/kg)

Chemical	Average Calculated BCF (Berries)	Average Calculated BCF (Lab Tea)	Average Calculated BCF (Cattail)	Range of Literature BCF for Soil to Plants[a]
arsenic	nc	nc	0.38	0.001-0.230
aluminum	0.013	nc	0.063	0.004-0.115
barium	0.19	1.6	0.22	0.007-0.628
chromium	nc	nc	0.093	0.001-0.528
cobalt	nc	0.097	0.24	0.001-0.040
copper	0.38	0.59	0.47	0.001-0.864
lead	nc	0.04	0.17	0-0.228
mercury	0.37	0.64	0.46	0.005-0.9
molybdenum	0.073	nc	0.78	0.001-0.25
nickel	0.16	1.1	0.32	0.001-0.327
selenium	nc	nc	1.3	0.009-1.20
vanadium	nc	nc	0.036	0.006-0.151
zinc	0.17	0.80	2.2	0.004-1.5

[a] Minimum and maximum BCF selected from literature references (Efroymson 1996; Baes 1984)
nc = not calculated due to insufficient data

9.15 **Suncor mentions their participation in activities relating to air quality and human health a number of times in the document. For example, Suncor states that they will further quantify and characterize existing emissions, assess environmental and human health impacts, determine cause of emissions, and evaluate control options *(Vol. 1, p. A4-42)* and that they will continue to participate in the Fort McMurray regional health study and the aquatics and air effects monitoring programs in the region. *(Vol. 1, p. A4-48)* Suncor also states that they will continue to participate in the Alberta Oilsands Community Exposure and Health Effects Assessment Program *(Vol. 2A, p. B5-10,)* as well as, continue to participate in regional assessment programs of air quality. *(Vol. 2C, p. F1-59)* Furthermore, Suncor states that the linkage between air quality and human health remains a paramount issue that requires regular monitoring, *(Vol. 2C, p. F1-63)* and that Suncor will continue to participate in regional studies related to ecological and human health, such as....and the Wood Buffalo Environmental Association. *(Vol. 2C, p. F1-100)***

Discuss what commitments Suncor is prepared to make respecting ongoing activities that will further develop and define the relationship between regional air quality and human health issues. Would Suncor be willing to help underwrite the cost of continuing the work started by the Alberta Oilsands Community Exposure and Health Effects Assessment Program?

Response:
Suncor will continue to participate in the Alberta Oil Sands Community Exposure and Health Effects Assessment Program through to study completion. This is a critical piece of work that will provide much needed information about the link between emissions in the oil sands region and human health. Suncor is prepared to discuss the outcomes from this study and in that context would consider supporting any recommended follow-up work provided there is a demonstrated need.

10.0 ERRATA

10.1 **Table D3.2-2 shows a range of wetland types *Vol. 2B, Table D3.2-2, pg. 66).* Does this table include wetland types surrounded by mine the development or does it also include wetland types within the LSA but outside the development area that would be eliminated or severely modified due to Surficial and groundwater drainage by the development? Adjust the figures if this observation is correct. In Table *D3.2-2* eight wetland types are listed that will be establish in the reclaimed landscape and in pages *Vol. 2B, Section D, pgs.73 & 74)* Suncor lists 3 wetland types. Please clarify the discrepancy.**

Response:
The wetlands type listed are those that will be lost to mine development. Refer to Impact Analysis (Section D3.2.7.2) Direct Losses/Alterations to Wetlands Resources. In Table D3.2-2, there should be three wetlands types listed, not eight. The three wetlands types being reclaimed are those listed in pages 73 and 74(Vol. 2B, Section D Analysis of Replacement of Plant Communities), which are Shrubby swamp (SONS), Constructed wetlands and Open water. The eight listed in Table D3.2-2 as reclaimed landscapes is an error.

10.2 **Vol. 2B, Section D3.1.3.5, Table D3.1-25, p D3-25**
Clarify the standard deviation provided for the stand ages by wetland classes.

Response:
Refer to Section D3.1.3.4 (Wetlands Species Richness, Diversity, Cover and Tree Measurements. Standard deviation is obtained as follows: (1) square the

deviation of a value from the mean, (2) sum the squares, (3) divide by N and (4) take the square root of the quotient from (3).

Table D3.1-25 is based upon stand age since disturbance and is used to determine the mean, minimum, maximum, standard deviation and the age class distribution of all the existing stands within the LSA. These values can then be compared to the existing stands.

10.3 D6.3 Terrestrial Vegetation and Wetlands (page D6-20)
Table D6-10 is repeated, Table D6-11 is missing.

Response:
Section D6 was reissued as part of the Errata.

10.4 Volume 2b, Section D6

Some of the subsections are repeated on pages within this section. Subsections D6.6.1 and D6.6.2 are missing.

Response:
Section D6 was reissued as part of the Errata.

10.5 The area of the LSA is 16,181 hectares. The east bank mining area on overall development footprint comprises 57% of the LSA (9,223 ha,) *(Vol, 2B, D1.5.1, p D1-9)* However, proposed changes to 12.3.1 in the approval *(Vol. 1, F4.2, p 45)* state the total area as 12,510 ha. Clarify this discrepancy.

Response:
The total value discussed in Section F4.2 represents the total Suncor operation, not just the east bank mining area.

10.6 Soil and Terrain Baseline pg. 30. There appears to be text missing from the previous page (p 25). Clarify the lack of continuity from page 25 to 30.

Response:

The first word on p.30 should be last word in the final sentence on page 25. (i.e., nutrient retention properties.)

10.7 **Vol. 2B, p. D3-111, D3-112**

Clarify the baseline mean patch size in Table D3.2-25 and Table D3.2-26.

Response:
Refer to (Section D3.2.9.5) Patch Size in Terrestrial Vegetation and Wetlands Resources for response. Table D3.2-25 shows the mean, minimum and maximum patch size for the baseline vegetation, while Table D3.2-26 (mean, minimum and maximum patch size)is for the wetlands resources within the LSA.

The mean patch size for terrestrial vegetation within the baseline is between 1 and 27, however, some of the ecosite phase patch sizes are less than 1 ha. For closure, the mean patch size will be between 2 and 77 ha. For some ecosite phase types, there will be an increase in patch size. For example, the low-bush cranberry (d1, d2 and d3) and dogwood (e1, e2 and e3) ecosites.

10.8 **The values listed in Figure E3-7 (Vol. 1, Section E3, pg. 70), Table D2.1-5 (Vol. 2B, Section D2, pg. 8), Table D6-6 (Vol. 2B, Section D, pg. 14) and Table E-2 (Vol. 2B, Section E, pg. 36) do not indicate the same area (ha) values for Capability Classes 1 through 5. Clarify this discrepancy.**

Response:
Figure E3-7 refers only to the forest capability on the development footprint of the east bank mining area. Tables D2.1-5 and E-2 refer to the forest capability for the Project Millennium local study area. Table D6-6 only refers to Project Millennium's incremental contribution to forest capability under the cumulative effects scenario.

10.9 **In addition, the ratio of commercial to non-commercial forest on the side of the Athabasca River..." should be corrected to read " In addition, the ratio of commercial to non-commercial forest on the <u>east</u> side of the Athabasca River..."*(Volume 1, Section F4.2, (pg. 45))*.**

Response:
Change incorporated into the Errata.

10.10 **The table in the application; Pre-Development and Closure Forest Capability Classes for Soils in the Project Millennium LSA (Vol. 2B, P. D2-**

33, Table D2.2-9), shows 8 ha of disturbed lands in the closure landscape, and footnote (b) indicates that all disturbed lands were assumed to be permanently non-productive for forestry. Provide all explanation for this assumption.

Response:
Disturbed lands are those for which a final end land use has not been specified. These areas are likely minor infrastructure still in place at closure and, therefore, the conservative assumption was made to designate them as 'Disturbed - Class 5" to differentiate them from "Muskeg or McLelland Series - Class 5". they are non-productive for commercial forestry because they are occupied by other land uses.

10.11 **For Water Rights licensing, Suncor will be required to have flood inundation, flood action, and emergency preparedness plans for notification and action in the event of a dyke failure.**

Response:
Suncor has provision for notifying downstream communities on the Athabasca River of emergency incidents through the environmental monitoring and reporting procedure.

10.12 **The impact and strategies for discharges into McLean Creek are not presented in E4.4.4 as indicated in *Vol. 2B, p.E31.***

Response:
The information is contained in Volume 2B, Section E4.4..5

10.13 **Figure 2.4-15, River Set-Back Cross-Sections, (*Vol. 1, p. C2-76*) is too small a scale for Dam Safety approval purposes. Please provide a larger and more detailed cross figure (5 copies) as well as the proposed maximum height of the dykes for the external tailings pond.**

Response:
The requested figures are being provided to AEP under separate cover.

10.14 **Table E2-3 shows a total of 1952 ha of Class 1 and 2 soils and 2100 ha of Class 3 soil capability. *(Vol. 1, p. E2-11)* There appears to be some conflict with the Forestry Baseline Study, Table 4, p. 12, which shows 9477 ha of commercially viable forestlands. Please clarify the apparent contradiction of productivity capabilities.**

Response:

The baseline areas for the study were completed on the LSA, which totals 16, 181 ha. Of this total, approximately 6 500 ha are outside the project development footprint. considering the development area for the east bank mining area (i.e., Steepbank and Millennium), the total is about 9 500 ha. This is the total LSA minus the undisturbed or buffer area of about 6500 ha. That is one reason why the capability areas in the EIA are less than the forest productivity rations in the forestry baseline.

Land capability and forest productivity are two distinct rating systems. Forest productivity is a measure of what is there, while land capability is an estimate of the potential to support commercial forest species. Since commercial species in this sense usually mean white spruce, the assumption is made that only classes 1, 2, and 3 are viable; however, other tree species that are useful commercially can be found in other areas. There are inherent systemic differences between the two approaches so there is little chance that the results would be close to the same.

ADDITIONAL SUPPLEMENTAL INFORMATION RESPONSE
Alberta Environmental Protection
September 25, 1998

PROPOSED PROJECT MILLENNIUM

1. AIR QUALITY

1.1. Please provide a table on the modeling to clarify how the models were run (i.e., options selected).

RESPONSE:

Tables 1.1-1 and 1.1-2 summarize the dispersion modeling options used in the Project Millennium analysis.

Table 1.1-1 ISC3BE Dispersion Model Control Codes

Control Option	ISC3BE Model Options	Explanations
Model Options Card (MODELOPT)	MSGPRO RURAL NOCMPL	MSGPRO specifies non-default options for missing data processing. RURAL dispersion parameters will be used. NOCMPL triggers the specific complex terrain model options coded by Conor Pacific.
Elevated Terrain Flag (TERRHGTS)	ELEV	The terrain heights required for each receptor.
Anemometer Height (ANEMHGHT)	75 metres	Input meteorological data derived from Mannix @ 75 m.
Wind Speed Categories (WINDCATS)	1.54 3.09 5.14 8.23 10.80	Default ISC wind speed categories.
Stability Specific Temperature Profiles (DTHETADZ)	A 6*0.00 B 6*0.00 C 6*0.00 D 6*0.00 E 6*0.051 F 6*0.054	These particular temperature profiles were derived from the actual 4 years of meteorological data observed.
Stability Specific Wind Speed Profiles (WINDPROF)	A 6*0.28 B 6*0.28 C 6*0.30 D 6*0.44 E 6*0.59 F 6*0.46	These particular wind speed profile values were derived from the actual 4 years of meteorological data observed.

Table 1.1-2 CALPUFF Dispersion Model Control Codes

Control Option	CALPUFF Model Options	Explanations
Number of Chemical Species (NSPEC)	6 - SO_2, SO_4, NO, NO_2, HNO_3, NO_3	The required chemical species to calculate PAI.
Number of Chemical Species Emitted (NSE)	3 - SO_2, NO, NO_2 *(NO_2=5%*NO_x)*	Estimated NO/NO_2 split, based on stack testing results.
Meteorological Data Format (METFM)	ISC ASCII Format	Mannix Station @ 75 m.
Vertical Distribution used in the near field (MGAUSS)	Gaussian	
Terrain Adjustment Method (MCTADJ)	Partial Plume Path Adjustment	Similar to ISC3BE.
Subgrid-scale Complex Terrain Flag (MCTSG)	No	Only applicable with full 3-D meteorological file.
Near-field Puffs Modelled as Elongated (MSLUG)	No	Time-intensive, minimum wind speed in meteorological file set to 1 m/s.
Transitional Plume Rise Modeled (MTRANS)	Yes	
Stack Tip Downwash (MTIP)	Yes	
Effects on Plume Rise of Vertical Wind Shear (MSHEAR)	No	Single layer of meteorological data.
Puff Splitting Allowed (MSPLIT)	No	No calms modeled, single layer of meteorological data.
Chemical Mechanism Flag (MCHEM)	3 - RIVAD/ARM3	
Wet Removal (MWET)	Yes	Needed for PAI calculations.
Dry Deposition (MDRY)	Yes	Needed for PAI calculations.
Method Used to Compute Dispersion Coefficients (MDISP)	4 - Rural PG dispersion Coefficients using MESOPUFF 2 equations	Improved estimates beyond 10 km.
Sigma-v\Sigma-theta, Sigma-w Measurements (MTURBVW)	No	Only used for special dispersion scenarios.
Back-up Method used to Compute Dispersion when Measured Turbulence Data are Missing (MDISP2)	4 - Rural PG dispersion Coefficients using MESOPUFF 2 equations	Improved estimates beyond 10 km.
Pasquil-Gifford Sigma-y, z Adjustment for Roughness (MROUGH)	No	Non-uniform roughness over region.
Partial Plume Penetration of Elevated Inversion (MPARTL)	No	Single layer of meteorological data.
PDF used for Dispersion under Convective Conditions (MPDF)	No	Only applicable with CTDM plus algorithms *(i.e., 3-D meteorological data)*.
Test Options Specified to see if they Conform to Regulatory Values (MREG)	No	

1.2. Please clarify the contribution of various emission sources to ground level concentrations of SO_2 for the events where ambient exceedences are predicted (e.g., 3 hours of ambient hourly SO_2 exceedences that were predicted). Please provide considerations on how these might be eliminated (e.g., modification to proposed sulphur recovery plant design).

RESPONSE:

Tables 1.2-1, 1.2-2 and 1.2-3 show all receptor locations where the model has predicted SO_2 exceedences of the guideline. They also provide the relative contributions towards the predicted exceedences for the Project Millennium and CEA emission modeling results presented in section "B2 – Revised SO_2 Dispersion Modeling Analyses" of the Supplemental Information provided to AEP and AEUB.

The Tables list the receptor location, the annual number of exceedences predicted at the receptor, the maximum 1-hour (24-hour) concentration predicted, and the average contribution (averaged over all of the hours/days in excess of the guideline) from the specific source categories in question. As there were no receptors with one or more daily exceedences under the CEA scenario, no table is presented.

The data shows that the receptors with the greatest number of hourly exceedences of the SO2 guideline are generally those that are closest to the plant site. For these receptor locations (which are all near the Suncor plantsite) as much as 90% of the concentration resulting in exceedences originates from Suncor emission sources. Relative contributions indicate that the "other Suncor sources" are the largest contributor to these exceedences. The new TGTU contributes approximately 10% to the exceedences and the flare contribution is even less at around 8 or 9%.

These "other Suncor sources" consist of the Powerhouse and FGD stacks, the mine fleet and the Upgrading furnace stacks. Modeling results with removal of mercaptans from fuel gas (this assumes the Suncor-Novagas Canada Ltd. natural gas liquids extraction project is approved and operating) predict no hourly exceedences confirming that the low level furnace stacks are a significant contributor to predicted exceedences. (Figure will be forwarded by John Gulley, of Golder Associates under separate cover)

The same general trends seen in Table 1.2-1 also apply to Tables 1.2-2 and 1.2-3.

Table 1.2-1 Source Contributions to the Hourly Exceeding SO_2 Concentrations for the Project Millennium Emission Scenario (Determined using the ISC3BE Dispersion Model)

Distance from Powerhouse [km]	Direction from Powerhouse	Annual # >460μg/m³	Maximum from All Sources	Incinerator Contribution	Flare Contribution	New TGTU Contribution	Other Suncor Sources Contribution
4.2	S	3	553.5	15.5%	8.0%	8.0%	60.6%
4.5	S	2	490.7	15.7%	9.2%	7.9%	58.9%
3.5	S	2	502.9	11.2%	7.9%	6.7%	67.9%
11.5	ESE	2	582.1	24.9%	6.3%	10.2%	34.0%
10.7	E	2	583.1	22.2%	7.3%	12.7%	36.0%
11.8	ESE	2	560.4	26.0%	6.6%	10.8%	33.1%
3.8	SSW	2	475.8	12.7%	10.0%	7.0%	65.7%

6.4	NE	2	520.3	21.7%	9.9%	8.1%	49.6%
6.1	ENE	2	493.2	19.9%	10.0%	7.8%	50.9%
7.9	NE	2	526.8	23.0%	9.0%	9.5%	45.4%
8.0	NE	2	531.0	23.6%	9.1%	9.3%	44.0%
9.3	NE	2	524.2	23.9%	8.3%	10.4%	42.4%
10.2	ESE	2	543.9	24.5%	7.6%	10.3%	38.7%
9.3	ESE	2	557.4	23.4%	7.5%	9.9%	39.3%
8.9	ENE	2	535.5	22.9%	7.6%	10.0%	42.0%
9.7	E	2	566.7	22.2%	8.0%	11.4%	39.6%
13.8	ESE	2	572.1	26.0%	5.7%	11.5%	30.2%
2.5	S	2	458.0	5.2%	7.4%	4.5%	77.8%
5.8	NE	2	519.2	19.7%	10.0%	7.8%	52.8%
6.6	ESE	2	505.4	22.0%	9.1%	8.2%	48.2%
6.6	ENE	2	517.5	22.2%	9.8%	7.9%	48.8%
8.6	NE	2	468.8	20.2%	7.8%	11.8%	46.6%
8.8	ESE	2	533.5	21.9%	9.0%	11.6%	41.8%
8.4	ENE	2	543.8	23.4%	8.6%	9.5%	43.3%
9.3	ENE	2	538.7	24.5%	7.9%	9.8%	40.3%
11.6	SE	2	517.8	25.7%	6.7%	9.7%	36.2%
10.6	ENE	2	546.5	23.9%	7.7%	11.3%	39.3%
12.4	ESE	2	541.0	24.3%	7.1%	11.7%	34.9%
11.5	ENE	2	472.7	25.5%	7.4%	10.9%	36.2%
11.7	E	2	520.1	22.3%	6.7%	13.0%	34.6%
4.7	SSW	1	471.8	16.7%	10.1%	7.9%	57.3%
6.1	NNE	1	501.7	19.9%	9.2%	8.7%	53.6%
6.6	NNE	1	529.5	21.4%	9.5%	8.8%	49.2%
7.4	NNE	1	517.6	20.3%	8.2%	10.3%	49.5%
8.0	NE	1	514.4	20.9%	8.2%	10.8%	47.2%
6.1	ESE	1	536.9	20.9%	9.1%	7.9%	48.7%
7.2	NE	1	506.5	18.6%	8.6%	10.7%	50.2%
9.4	NE	1	545.3	23.4%	8.5%	10.9%	41.1%
10.2	ENE	1	506.8	24.6%	8.0%	10.9%	40.1%
11.0	ESE	1	526.1	23.5%	7.8%	11.8%	37.5%
10.9	ENE	1	484.9	24.1%	7.4%	11.9%	37.9%
13.3	ESE	1	551.6	24.5%	6.3%	13.2%	31.1%
12.8	ESE	1	595.8	26.3%	5.5%	11.0%	30.4%
15.7	ESE	1	494.8	25.8%	5.6%	11.5%	29.3%
18.5	E	1	519.3	24.9%	4.4%	12.1%	22.9%
8.8	NNE	1	518.1	21.7%	7.8%	10.8%	45.0%
5.6	E	1	514.6	19.7%	10.6%	7.2%	52.5%
9.4	NE	1	524.8	23.3%	8.2%	10.9%	42.7%
8.0	SE	1	516.3	24.3%	7.7%	8.4%	42.9%
7.0	ENE	1	524.4	19.8%	9.0%	8.8%	47.0%
8.3	ESE	1	526.1	23.5%	8.3%	9.5%	42.2%
10.7	NE	1	494.0	24.7%	8.2%	11.0%	39.5%
9.7	ENE	1	520.7	19.9%	7.9%	13.9%	44.0%
10.6	ESE	1	566.5	25.2%	7.2%	10.4%	36.6%
9.9	ESE	1	570.3	26.1%	7.0%	8.8%	37.5%
9.9	ENE	1	523.3	23.6%	7.3%	10.6%	40.2%
10.2	ENE	1	561.9	23.2%	7.4%	10.3%	38.0%
16.3	SE	1	494.2	27.0%	5.2%	12.9%	27.3%
11.6	E	1	485.9	26.0%	6.0%	10.2%	33.8%
11.6	E	1	565.2	24.4%	6.9%	12.4%	35.1%
11.7	E	1	555.6	26.5%	7.1%	11.3%	33.8%

Table 1.2-2 Source Contributions to the Daily Exceeding SO_2 Concentrations for the Project Millennium Emission Scenario (Determined using the ISC3BE Dispersion Model)

Distance from Powerhouse [km]	Direction from Powerhouse	Annual # >150 µg/m³	Maximum from All Sources	Incinerator Contribution	Flare Contribution	New TGTU Contribution	Other Suncor Sources Contribution
15.5	WNW	6	196.4	0.4%	0.3%	0.2%	1.2%
15.1	WNW	3	193.4	0.6%	0.5%	0.2%	2.0%
14.2	WNW	2	184.4	0.0%	0.0%	0.0%	0.0%
14.9	WNW	2	199.0	0.1%	0.1%	0.0%	0.3%
13.9	WNW	1	168.9	0.2%	0.0%	0.0%	0.2%

Table 1.2-3 Source Contributions to the Hourly Exceeding SO_2 Concentrations for the CEA Emission Scenario (Determined using the ISC3BE Dispersion Model)

Distance from Powerhouse [km]	Direction from Powerhouse	Annual # >450 µg/m³	Maximum from All Sources	Incinerator Contribution	Flare Contribution	New TGTU Contribution	Other Suncor Sources Contribution
14.9	WNW	4	553.6	15.6%	8.2%	8.0%	60.2%
15.1	WNW	3	530.4	10.7%	8.2%	6.5%	60.6%
15.5	WNW	3	495.0	16.0%	7.5%	8.4%	49.4%
13.9	WNW	3	502.7	11.5%	8.8%	6.7%	66.4%
14.2	WNW	2	492.9	15.6%	9.1%	7.9%	58.5%
14.5	WNW	2	582.8	21.8%	6.2%	6.8%	37.5%
3.8	SSW	2	585.7	22.1%	5.6%	8.4%	32.0%
3.5	S	2	599.2	21.6%	7.0%	12.4%	35.2%
2.5	S	2	623.7	21.4%	5.1%	11.0%	27.1%
14.9	WNW	2	573.3	24.9%	6.4%	10.6%	32.4%
15.1	WNW	2	492.3	22.9%	5.1%	10.7%	26.5%
15.5	WNW	2	484.1	18.2%	7.8%	8.6%	45.3%
13.9	WNW	2	576.8	18.8%	8.0%	7.5%	43.0%
14.2	WNW	2	599.0	19.9%	7.5%	9.7%	36.8%
14.5	WNW	2	617.0	21.6%	6.6%	9.0%	34.3%
3.8	SSW	2	607.3	21.1%	6.8%	9.2%	36.3%
3.5	S	2	617.9	21.5%	5.9%	9.9%	30.8%
2.5	S	2	638.2	22.7%	5.7%	9.3%	31.0%
14.9	WNW	2	659.3	22.4%	4.9%	9.9%	26.4%
15.1	WNW	2	510.2	14.9%	8.7%	7.4%	53.9%
15.5	WNW	2	460.0	5.2%	7.5%	4.5%	77.3%
13.9	WNW	2	512.4	22.0%	10.1%	8.3%	50.4%
14.2	WNW	2	592.6	19.7%	7.7%	6.6%	44.4%
14.5	WNW	2	519.9	23.3%	9.1%	9.6%	46.0%
3.8	SSW	2	524.3	23.9%	9.2%	9.4%	44.5%
3.5	S	2	518.1	24.2%	8.4%	10.5%	42.9%
2.5	S	2	592.8	20.0%	6.8%	10.7%	33.5%
14.9	WNW	2	626.9	22.9%	5.9%	8.4%	33.2%
15.1	WNW	2	593.8	19.6%	6.8%	10.5%	34.6%
15.5	WNW	2	572.6	22.0%	7.9%	11.3%	39.3%
13.9	WNW	2	561.5	22.5%	5.1%	8.3%	29.3%
14.2	WNW	2	667.5	23.5%	4.7%	9.3%	27.2%
14.5	WNW	2	573.8	22.3%	4.9%	10.0%	25.6%
3.8	SSW	2	529.3	13.9%	10.3%	7.9%	49.0%
3.5	S	2	572.8	17.9%	8.7%	9.9%	40.5%
2.5	S	2	537.7	23.7%	8.7%	9.6%	43.8%

14.9	WNW	2	620.4	19.9%	7.2%	10.6%	35.5%
15.1	WNW	2	530.6	22.5%	7.8%	10.4%	42.8%
15.5	WNW	2	533.3	24.7%	8.0%	9.9%	40.7%
13.9	WNW	2	541.6	24.1%	7.8%	11.4%	39.7%
14.2	WNW	2	468.7	25.7%	7.5%	11.0%	36.6%
14.5	WNW	2	556.1	21.4%	6.0%	10.1%	30.5%
3.8	SSW	2	545.1	21.7%	6.5%	12.7%	33.6%
3.5	S	2	552.3	22.4%	4.0%	11.3%	21.0%
2.5	S	2	557.6	0.0%	0.0%	0.0%	0.0%
14.9	WNW	1	463.9	22.1%	4.6%	10.8%	25.2%
15.1	WNW	1	506.8	23.7%	5.0%	11.0%	26.5%
15.5	WNW	1	476.5	22.0%	5.3%	10.6%	28.0%
13.9	WNW	1	474.8	19.5%	7.9%	8.8%	42.4%
14.2	WNW	1	510.4	19.9%	10.4%	8.0%	53.6%
14.5	WNW	1	521.4	21.7%	9.6%	8.9%	50.0%
3.8	SSW	1	510.4	20.6%	8.3%	10.4%	50.2%
3.5	S	1	507.6	21.1%	8.4%	10.9%	47.9%
2.5	S	1	485.5	22.6%	10.5%	6.7%	50.1%
14.9	WNW	1	509.9	23.3%	10.3%	7.7%	48.9%
15.1	WNW	1	499.6	18.8%	8.7%	10.8%	50.9%
15.5	WNW	1	547.4	22.5%	5.7%	7.0%	34.7%
13.9	WNW	1	580.3	21.4%	7.2%	8.3%	38.5%
14.2	WNW	1	539.6	23.6%	8.6%	11.0%	41.6%
14.5	WNW	1	501.7	24.9%	8.1%	11.0%	40.5%
3.8	SSW	1	650.0	21.4%	6.4%	11.2%	30.5%
3.5	S	1	480.8	24.3%	7.5%	12.0%	38.2%
2.5	S	1	540.3	24.8%	4.6%	11.3%	24.4%
14.9	WNW	1	570.4	24.5%	4.8%	12.1%	26.1%
15.1	WNW	1	569.8	22.6%	4.3%	8.5%	25.0%
15.5	WNW	1	493.4	23.3%	4.8%	10.8%	25.2%
13.9	WNW	1	481.7	14.7%	8.5%	7.8%	54.4%
14.2	WNW	1	473.5	5.3%	7.5%	5.2%	72.2%
14.5	WNW	1	511.8	22.0%	7.9%	10.9%	45.6%
3.8	SSW	1	470.6	21.8%	8.4%	9.6%	45.9%
3.5	S	1	506.5	20.0%	10.8%	7.4%	53.4%
2.5	S	1	518.7	23.6%	8.3%	11.0%	43.2%
14.9	WNW	1	488.2	22.7%	7.9%	10.3%	41.9%
15.1	WNW	1	495.7	19.2%	8.5%	7.9%	44.1%
15.5	WNW	1	518.1	20.0%	9.1%	8.9%	47.7%
13.9	WNW	1	477.3	23.3%	7.5%	10.6%	38.8%
14.2	WNW	1	488.8	24.9%	8.3%	11.1%	39.9%
14.5	WNW	1	585.4	25.7%	6.9%	8.7%	36.9%
3.8	SSW	1	518.3	23.8%	7.3%	10.7%	40.6%
3.5	S	1	557.2	23.4%	7.5%	10.4%	38.4%
2.5	S	1	621.4	21.7%	6.0%	10.1%	31.4%
14.9	WNW	1	482.2	26.1%	6.0%	10.3%	34.0%
15.1	WNW	1	581.0	24.5%	6.9%	12.5%	35.3%
15.5	WNW	1	551.5	26.7%	7.2%	11.4%	34.1%
13.9	WNW	1	545.7	21.1%	3.6%	10.2%	19.6%

1.3. Regarding the handling of non-steady state emissions of SO_2 (e.g., FGD bypass, bypass of sulphur recovery unit tail gas scrubber, flaring), what precautions will be taken to prevent these situations from arising (e.g., design features) and how will these situations be handled if they occur?

RESPONSE:

Suncor, in its application and previous supplemental submission, has described how Project Millennium has been designed and will be operated to minimize the frequency of upset conditions (eg. Supplemental EUB #54.d). Suncor has a proven track record of continuing to decrease the frequency and duration of upset conditions and will continuously strive to improve .

Nevertheless, to better understand the potential impacts of such upsets, an evaluation of a number of upset scenarios was done. These were:

- the Flue Gas Desulphurization (FGD) system going down; and
- the Tail Gas Treatment Unit (TGTU) system going down

The emission characteristics for each of these release scenarios have been summarized in the following Table 1.3-1. Tables 1.3-2 and 1.3-3 summarize the results of the upset dispersion modeling analysis for the FGD going down and the TGTU unit going down. When the FGD is down the emissions occur through the powerhouse stack. In the case of the TGTU, the emission estimates were derived from the design engineering firm for the project (Bantrel) based on the worst case scenario of emissions from a by-pass of the TGTU concurrent with the end of the catalyst cycle for SRU#3 and SRU#4.

It should be noted that the TGTU down scenario has not assumed that acid gas will be routed through SRU #1 and SRU #2. This would be the normal operating practice although there will be a short period of time when emissions would be as per the TGTU down scenario prior to the gas being swung over to the Base Plant. Thus, the TGTU down scenario that has been modeled represents a worst case short term condition.

Table 1.3-1 Upset Modeling Emission Sources

	Emission Source Characteristics	
	FGD (Powerhouse during upset conditions)	TGTU
Typical Condition		
Stack Height [m]	137.2	106.7
Stack Diameter [m]	7.01	1.83
Temperature [°C]	59	399
Exit Velocity [m/s]	13.12	30.5
SO_2 [t/sd]	19.7	5.2
Upset Conditions		
Stack Height [m]	106.7	106.7
Stack Diameter [m]	5.79	1.83
Temperature [°C]	193	399
Exit Velocity [m/s]	30.5	30.5
SO_2 [t/sd]	259	81.7[a]

[a] Based on the engineering emission calculations

Table 1.3-2 Summary of the Likely Number of Hourly SO_2 Exceedences Resulting from Upsets of the FGD System (Determined using the ISC3BE Dispersion Model)

Station	Likelihood of Exceeding During an Upset	Likelihood of a FGD Upset	Likelihood of an Exceedence Occurring	Likely Number of Hours > 450 μg/m³
Mannix	0.02%	5.00%	0.0011%	0.10
Lower Camp	0.01%	5.00%	0.0004%	0.04
Fina	0.03%	5.00%	0.0014%	0.13
Poplar Creek	0.00%	5.00%	0.0000%	0
Athabasca Bridge	0.00%	5.00%	0.0000%	0
AQS1 (Mine South)	0.01%	5.00%	0.0003%	0.03
AQS2 (Fort McMurray)	0.00%	5.00%	0.0000%	0
AQS3 (Mildred Lake)	0.00%	5.00%	0.0001%	0.01
AQS4 (Tailings North)	0.00%	5.00%	0.0000%	0
AQS5 (Tailings East)	0.00%	5.00%	0.0000%	0
Fort McMurray	0.00%	5.00%	0.0000%	0
Fort McKay	0.00%	5.00%	0.0000%	0
Birch Mountain	0.00%	5.00%	0.0000%	0
Maximum of All Receptor Locations	0.53%	5.00%	0.0267%	2.34

Table 1.3-3 Summary of the Likely Number of Hourly SO_2 Exceedences Resulting from Upsets of the TGTU System (Determined using the ISC3BE Dispersion Model)

Station	Likelihood of Exceeding During an Upset	Likelihood of a TGTU Upset	Likelihood of an Exceedence Occurring	Likely Number of Hours > 450 μg/m³
Mannix	0.18%	4.50%	0.0081%	0.71
Lower Camp	0.14%	4.50%	0.0063%	0.55
Fina	0.08%	4.50%	0.0036%	0.32
Poplar Creek	0.00%	4.50%	0.0000%	0
Athabasca Bridge	0.00%	4.50%	0.0000%	0
AQS1 (Mine South)	0.02%	4.50%	0.0008%	0.07
AQS2 (Fort McMurray)	0.00%	4.50%	0.0000%	0
AQS3 (Mildred Lake)	0.05%	4.50%	0.0021%	0.18
AQS4 (Tailings North)	0.00%	4.50%	0.0000%	0
AQS5 (Tailings East)	0.00%	4.50%	0.0000%	0
Fort McMurray	0.00%	4.50%	0.0000%	0
Fort McKay	0.00%	4.50%	0.0000%	0
Birch Mountain	0.00%	4.50%	0.0000%	0
Maximum of All Receptor Locations	0.66%	4.50%	0.0297%	2.60

1.4. **Response to Questions 1.38 and 1.41:** SUNCOR completed NO_2 modeling for both the ISC3BE model and the CALPUFF model in the EIA. In the ISC3BE model, total NO_x was modeled, and resulting concentrations were converted to NO_2 using an Ambient-Ratio method that was derived from local monitoring data. In the CALPUFF model, it is our current understanding that the modeled NO_x used the MESOPUFFII chemical transformation scheme to convert NO_x concentrations into NO_2.

RESPONSE:
The actual CALPUFF dispersion modeling analyses performed for the Project Millennium EIA were done to achieve predictions of PAI. The CALPUFF model was most suitable for this as it facilitated the calculation of the chemical transformations, wet deposition and dry deposition elements of all of the constituents required to calculate PAI. As part of these calculations, concentrations of SO_2 and NO_2 were predicted as interim results. For information purposes, the CALPUFF outputs of NO_2 and SO_2 were presented in the EIA document.

The algorithm used for the CALPUFF modeling was the RIVAD/ARM methodology available in version 5 of CALPUFF. When this algorithm is selected, the user is required to input explicit emissions of both NO and NO_2. The model will take these values and perform the applicable chemistry to determine the concentrations and deposition of all of the nitrogen species considered (i.e., NO, NO_2, NO_3^-, HNO_3). No emissions of NO_x, nor NO_x-to-NO_2 conversion are used with the RIVAD/ARM scheme.

a) During discussions with Suncor on August 24, 1998, the CALPUFF NO_2 modeling results were dismissed in favour of ISC3BE results due to CALPUFF's overestimation of ground-level NO_2 concentrations in the near field. After further study, it is now AEP's understanding that CALPUFF can also use the Ambient Ratio method option in conjunction with the MESOPUFF scheme to allow the user to apply a typical measured ambient ratio of NO_2/NO_x to scale the predicted NO_2 concentrations.

RESPONSE:
In the latest version of the CALPUFF model, the user has the option to select either the RIVAD/ARM, the MESOPUFFII or Ambient Ratio schemes for performing the appropriate chemical transformations. Given that the intent of the modeling was first-and-foremost to establish the PAI, Golder chose to apply the RIVAD/ARM3 chemistry. As a component of this scheme, explicit emissions, concentrations and depositions of both NO and NO_2 are determined. The selection of the MESOPUFFII and Ambient Ratio schemes may have addressed the nitrogen chemistry more directly. However, this was not the purpose for which CALPUFF was used in the EIA. It was used primarily for the determination of acidic deposition.

In order to have a higher degree of confidence in assessing the modeled NO_2 levels to complete our decision making, please clarify the following:

a) After applying the MESOPUFFII scheme, how much NO_x was assumed to be NO_2?

b) An explanation to why SUNCOR deems the chemistry in the CALPUFF model is suitable for Nitrate Deposition, but not for NO_2 prediction.

c) An explanation as to why the NO_2 ground-level concentrations modeled using CALPUFF were not calculated with either the same power law ratio used during ISC3BE modeling or with the RIVAD/ARM3 scheme.

d) Please provide a table showing the top ten concentrations of NO_2 predicted with CALPUFF using the (1) Mesopuff Scheme, (2) the Ambient-Ratio method, and the (3) RIVAD/ARM3 scheme.

RESPONSE:
The selected approach for predicting NO2 concentrations was to use the ISC3BE NOx predictions, and then convert them to NO2 using the empirical relationship developed in the region and discussed in the EIA document (Vol. 2A, p. B2-35). This approach was previously discussed with AEP and Environment Canada personnel (10 March 1998 in the AEP offices in Edmonton). Suncor is confident that the concentrations detailed in the EIA are valid and representative, and sufficient information has been provided for EIA completeness for regulatory decision.

1.5. B4. Revised Particulate and Aerosol Analysis

Please explain why emission rates and maximum ground-level concentrations of PM_{10} increase from the Millennium to the CEA case, but the daily number of exceedences decreases from 95 to 85?

RESPONSE:
The dispersion model used to simulate the airborne concentrations in the RSA (i.e., ISC3BE) has physical limitations on the number of emission sources that can be evaluated. In the case of the Cumulative Effects Assessment (CEA) emission scenario, it was necessary to combine several of the emission sources at the Suncor and Syncrude facilities to satisfy the physical limitations of the model. Combining emission sources had the effect of reducing peak concentrations predicted from some point sources in the active development area. The maximum concentrations in these areas are fundamentally the same, but the number of times that exceedences are predicted is reduced. This reduction in exceedences is largely the result of consolidating the smaller emission sources.

1.6. **Pages B2-51, B3-24 and B4-21, Revised Application**: Potential Acidic Input (PAI) and Nitrate maximum values for all three scenarios (Baseline, Millennium and CEA) seem to be a great deal larger than originally predicted, but the plotted concentration isopleths do not change. Why do the PAI and deposition maximum values differ from those initially presented in the EIA?

RESPONSE:
The computer algorithm used to extract the maximum PAI values presented in the EIA from the actual CALPUFF dispersion model outputs was in error in the manner in which the single maximum values were identified. These erroneous maximum values were corrected in our previous Supplemental submission. The isopleth figures of Baseline, Millennium and CEA predictions of PAI did not change as a result of this error and did not need to be corrected.

1.7. The PAI predicted in the original EIA submission showed a maximum of 1.66 keq $H^+ ha^{-1} yr^{-1}$. This section (B4) was revised and resubmitted; maximum PAI is now predicted to be 24.5 keq $H^+ ha^{-1} yr^{-1}$. This increase is largely due to new estimates of nitrate deposition. Were there errors in the model runs that led to the original submission, has the modeling changed, or have emission predictions changed?

RESPONSE:
As noted above, the difference in the PAI, Nitrate and Sulphate numbers presented in the original and revised EIA submissions were the result of an error in the manner in which the maximum values were extracted from the CALPUFF dispersion modeling outputs. There were no errors in the emission estimates or CALPUFF dispersion modeling runs used to generate the isopleth plots and affected areas presented in the EIA.

1.8. Prediction of acid deposition using CALPUFF suggests that deposition in excess of the interim critical load for sensitive systems will occur outside the RSA (Figure B4-12 page B4-22 in the re-submitted Section B). It is also important to know the maximum PAI that occurs outside of the development area. Is it the same as the maximum predicted PAI for within the development area (22 to 25 keq $H^+ ha^{-1} yr^{-1}$), or is it substantially less?

RESPONSE:
A review of the isopleth plot of PAI predicted with the CEA emissions (Figure B4-12 page B4-22 in the re-submitted Section B) indicates that the 0.25 keq $H^+ ha^{-1} yr^{-1}$ contour line does extend beyond the bounds of the regional study area (RSA). A review of this figure indicates that the maximum PAI outside of the study area would be between 0.3 keq $H^+ ha^{-1} yr^{-1}$ and 0.25 keq $H^+ ha^{-1} yr^{-1}$. The maximum predicted PAI values are typically in the immediate vicinity of the modelled mining areas, where elevated emissions of NO_x and SO_2 are present close to the ground. In the modeling analysis conducted as part of the Project Millennium EIA, no

exclusionary zone was considered (i.e., the active development area) in which the PAI values were not determined. Therefore, it is difficult to estimate the exact values of PAI that would occur if the values within this region were omitted.

1.9. Another area that requires clarification is ambient monitoring commitments. For example, although Suncor was asked to discuss the role it anticipates for itself in monitoring acid sensitive lakes (Q1.48), this question was not specifically answered. Suncor does suggest earlier that sampling of previously identified sensitive lakes may be done in co-operation with other members of WBEA (Q1.36).

a) Will this sampling program include sampling of potentially sensitive water bodies (i.e. those draining/situated in areas with acid sensitive soils)?

RESPONSE:
Suncor has committed to working with the other members of the WBEA to develop and participate in a cooperative program to assess Regional Study Area (RSA) lakes identified in the Saffran and Trew (1996) report as being moderately or highly sensitive to acidic deposition. Eleven such lakes were identified in the report. The locations of these lakes have been placed onto a figure of the RSA that shows the relative soil sensitivities to acidifying emissions (Figure will be forwarded by John Gulley, of Golder Associates under separate cover). A review of the locations of the Saffran and Trew lakes shows them to be located in soils with low, moderate and high sensitivities to acidifying emissions.

Reference: Saffran, K.A. and D.O. Trew. 1996. Sensitivity of Alberta lakes to acidifying deposition: an update of sensitivity maps with emphasis on 109 northern lakes. Water Sciences Branch. Water Management Division, Alberta Environmental Protection. July 1996.

b) As well, will acid-solubilized metals be included on the variable list?

RESPONSE:
The list of parameters to be considered during the proposed sampling program will be determined by the WBEA participants in the program. As Alberta Environmental Protection is a member of the WBEA, they will be able to suggest relevant variables for the sampling program, as well as to participate actively in the sampling program.

1.10 MITIGATIVE OPPORTUNITIES

Suncor should discuss alternatives it would pursue to reduce its contribution of PAI, zone precursors, or other emissions responsible for potential future adverse ecological effects, if future monitoring indicated reductions are needed. This information is requested in order to understand what mitigation measures are possible, and to have appropriate commitments from project proponents to act, if necessary to correct unacceptable environmental impact.

RESPONSE:

Suncor has made the commitment to work with other regional developers on effective strategies to reduce emissions responsible for PAI and ground level ozone should monitoring indicate adverse environmental effects. Decisions on the specifics of the mitigation and which sources would most effectively result in a reduction of the specific concern will be determined through a cooperative effort, consistent with the intent of the multi-stakeholder Oil Sands Cumulative Effects Initiative.

Listed below for information are some of the possible types of mitigation that may be used to reduce specific air emissions. This is a general listing and does not indicate specific mitigation options recommended by Suncor.

Oxides of Nitrogen

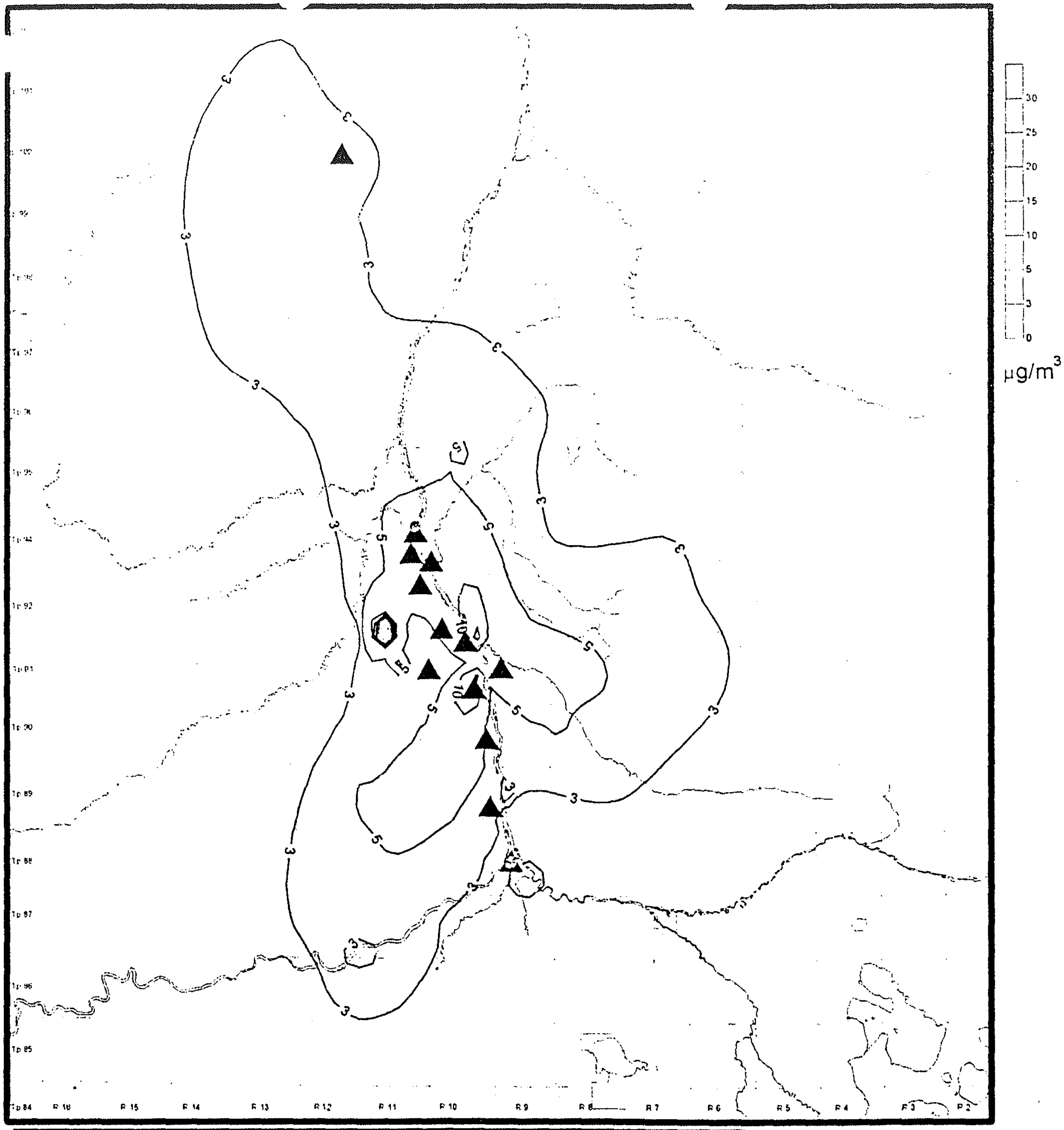
Two basic routes are available for control of the formation of oxides of nitrogen. These include combustion modification and flue gas treatment. Combustion modifications include methods to inhibit the thermal and fuel NO_x formation. This may be done by either advanced (low NO_x) burner design or by flue gas recirculation. For mine trucks, low NO_x engine technology is being pursued, as well as larger more energy efficient trucks Flue gas treatment generally consists of either catalytic reduction, or other processes such as activated carbon, copper oxide, or electron beam processes.

Sulphur Dioxide

Methodologies to reduce sulphur dioxide (SO_2) are well documented and are also applied by operational oil sands companies. Flue gas desulphurization is employed or proposed for operation by the industry. In addition, sulphur plants with tail gas clean-up technology are also employed and proposed to maximize sulphur recovery. As well, Suncor is examining removal of mercaptans from fuel gas, as part of the Suncor-Novagas Canada Ltd. natural gas liquids extraction project to reduce the SO_2 emitted from low level furnace stacks

Volatile Organic Compounds

Control of volatile organic carbons by the oil sands industry relates primarily to fugitive emission control. Opportunities for fugitive emission control includes improvements in management of diluents used in secondary extraction; improvement in pipe, valve and tank leakage control; and modifications to the diluent make-up.



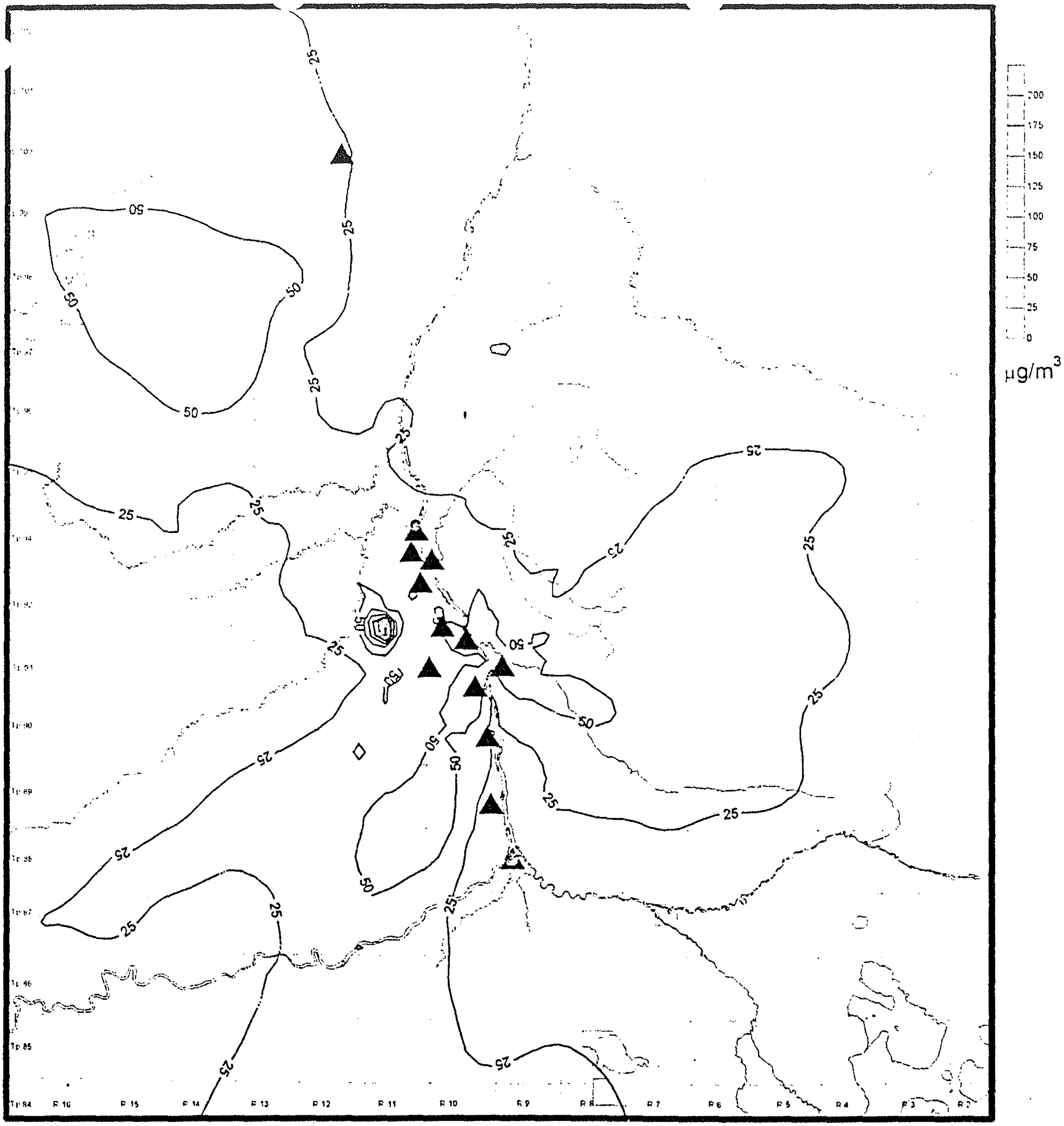
Sources	SO_2 [t/cd]
Suncor	
Powerhouse	14
FGD	18.7
Incinerator	12.3
Flaring	10.6
Tail Gas Treatment Unit	8.7
Other Sources, Suncor	0.08
Syncrude (total)	209
Other Emissions (total)	4
TOTAL	277

Model Description	
Development	Project Millennium
Model	ISC3BE (7BG)
SO_2 Guideline [µg/m³]	30
Maximum [µg/m³]	74
Exceedences / Year [#]	1

Figure B3-4x Predicted Millennium SO_2 Annual Average Ground Level Concentrations in the RSA using the ISCBE Model. With no mercaptans in fuel gas.

Project Millennium
Taking Suncor into the 21st Century

SUNCOR ENERGY

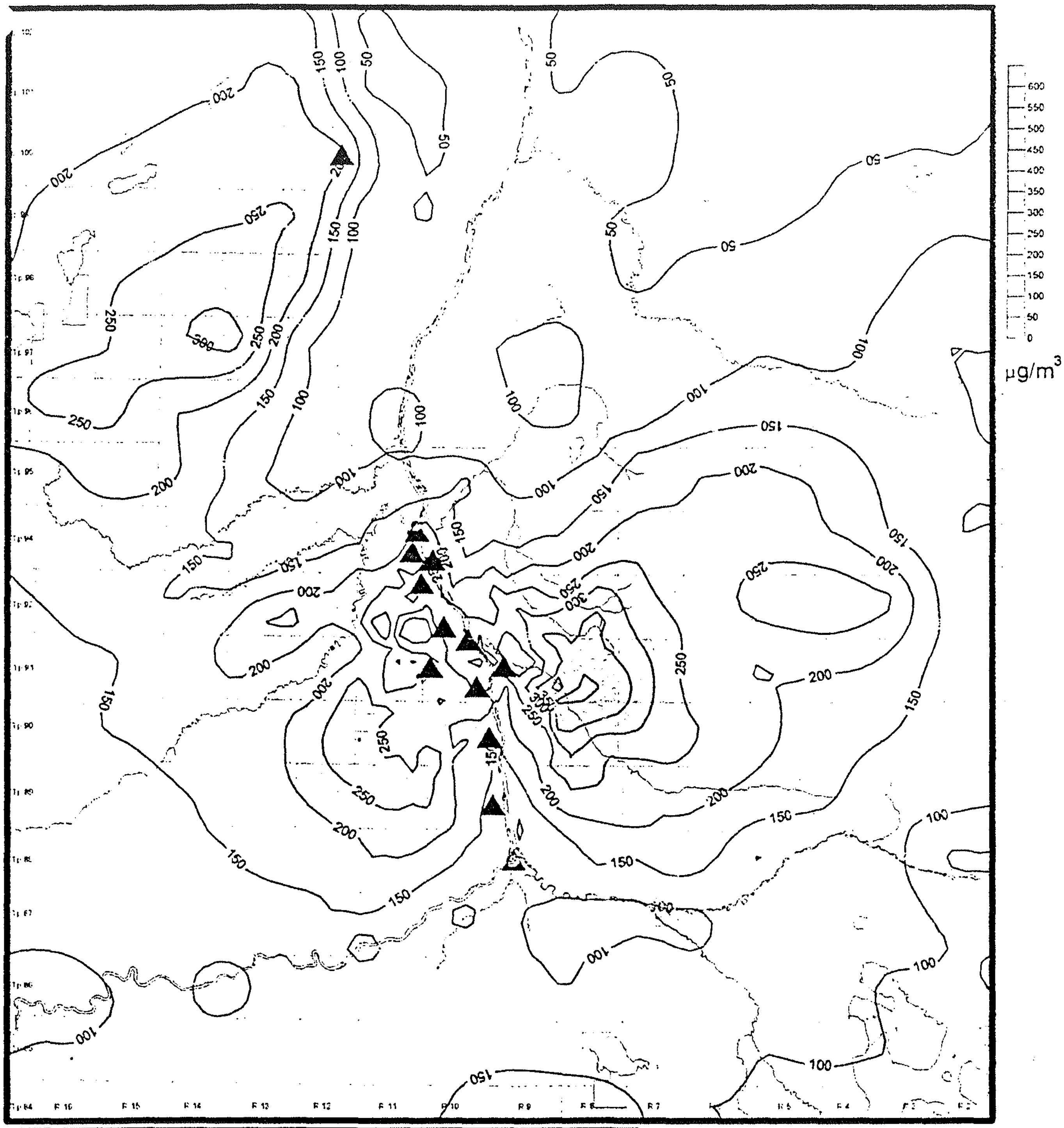


UTM NAD83 metres
0 5000 10000 15000 20000

Sources	SO_2 [t/sd]
Suncor	
Powerhouse	1.2
FGD	19.7
Incinerator	10.2
Flaring	1.3
Tail Gas Treatment Unit	5.2
Other Sources, Suncor	0.08
Syncrude (total)	209
Other Emissions (total)	4
TOTAL	250.7

Model Description	
Development	Project Millennium
Model	ISC3BE (7BG)
SO_2 Guideline [µg/m³]	150
Maximum [µg/m³]	198
Exceedences / Year [#]	6

Figure B3-3x Predicted Millennium SO_2 Maximum Daily Average Ground Level Concentrations in the RSA using the ISCBE Model With no mercaptans in the fuel gas.

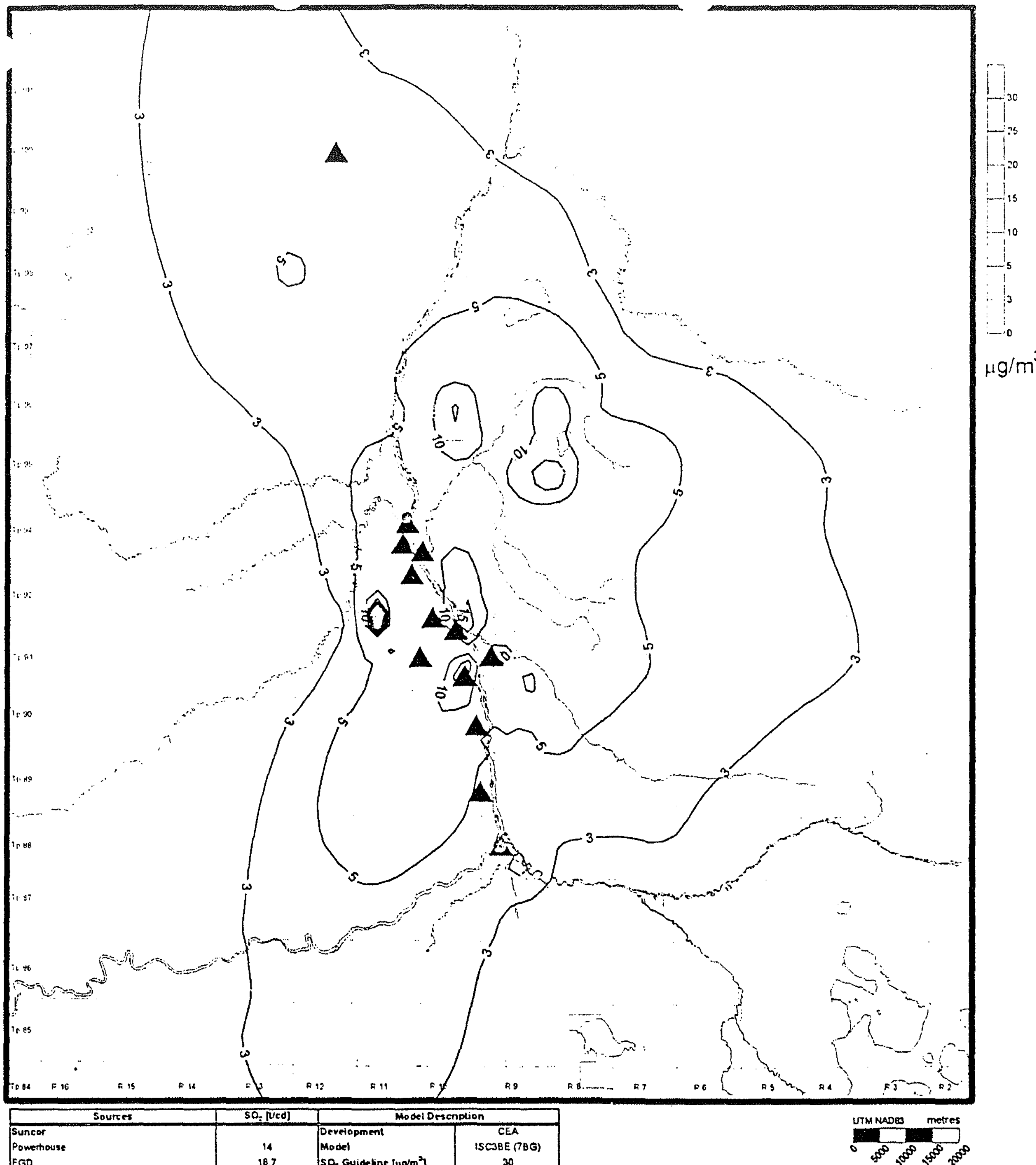


Sources	SO_2 [t/sd]
Suncor	
Powerhouse	1.2
FGD	19.7
Incinerator	10.2
Flaring	1.3
Tail Gas Treatment Unit	5.2
Other Sources, Suncor	0.08
Syncrude (total)	209
Other Emissions (total)	4
TOTAL	250.7

Model Description	
Development	Project Millennium
Model	ISC3BE (7BG)
SO_2 Guideline [µg/m³]	450
Maximum [µg/m³]	421
Exceedences / Year [#]	0

UTM NAD83 metres 0 5000 10000 15000 20000

Figure B3-2x Predicted Millennium SO_2 Maximum Hourly Average Ground Level Concentrations in the RSA using the ISCBE Model. With no mercaptans in fuel gas.



Sources	SO_2 [t/cd]
Suncor	
Powerhouse	14
FGD	18.7
Incinerator	12.3
Flaring	10.6
Tail Gas Treatment Unit	8.7
Other Sources, Suncor	0.08
Syncrude (total)	201
Other Emissions (total)	4
Other Proposed Emissions (total)	18.8
TOTAL	289

Model Description	
Development	CEA
Model	ISC3BE (7BG)
SO_2 Guideline [µg/m³]	30
Maximum [µg/m³]	41
Exceedences / Year [#]	1

Figure B4-4x Predicted CEA SO_2 Annual Average Ground Level Concentrations in the RSA using the ISC3BE Model. With no mercaptans in fuel gas.

Project Millennium
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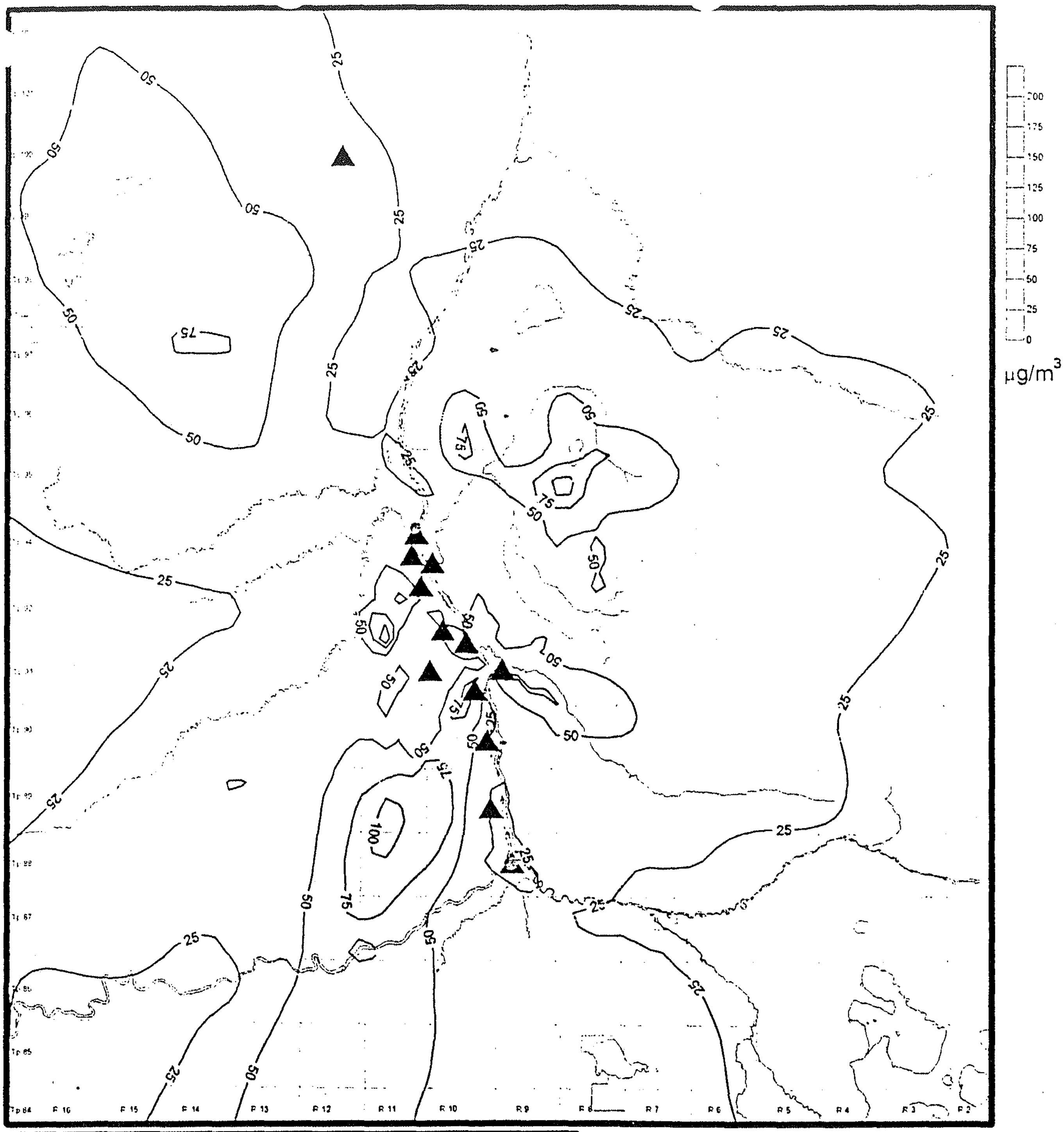


Sources	SO_2 [t/sd]
Suncor	
Powerhouse	1.2
FGD	19.7
Incinerator	10.2
Flaring	1.3
Tail Gas Treatment Unit	5.2
Other Sources, Suncor	0.08
Syncrude (total)	201
Other Emissions (total)	4
Other Proposed Emissions (total)	19.8
TOTAL	262.5

Model Description	
Development	CEA
Model	ISC3BE (7BG)
SO_2 Guideline [µg/m³]	150
Maximum [µg/m³]	128
Exceedences / Year [#]	0

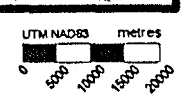
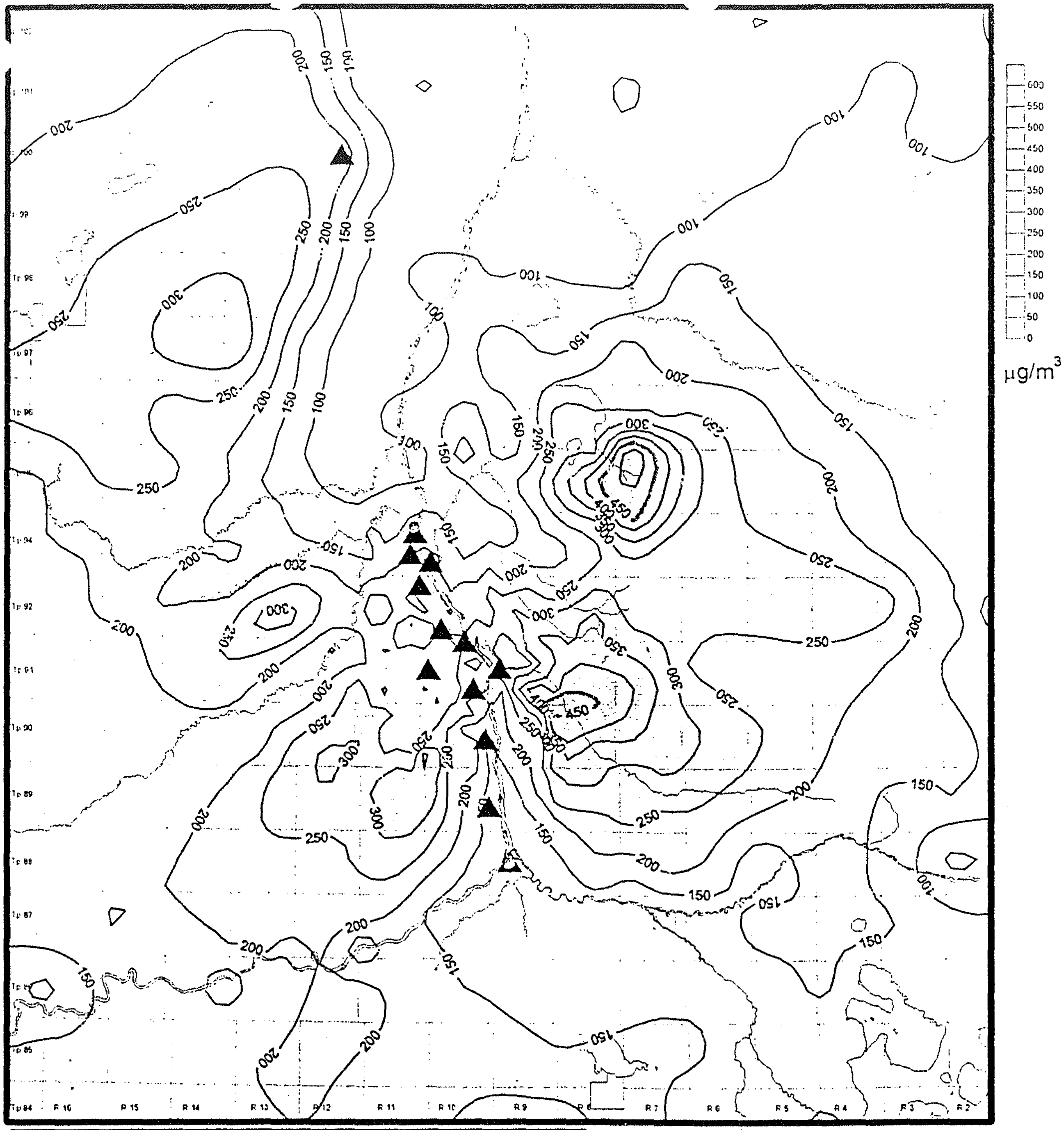


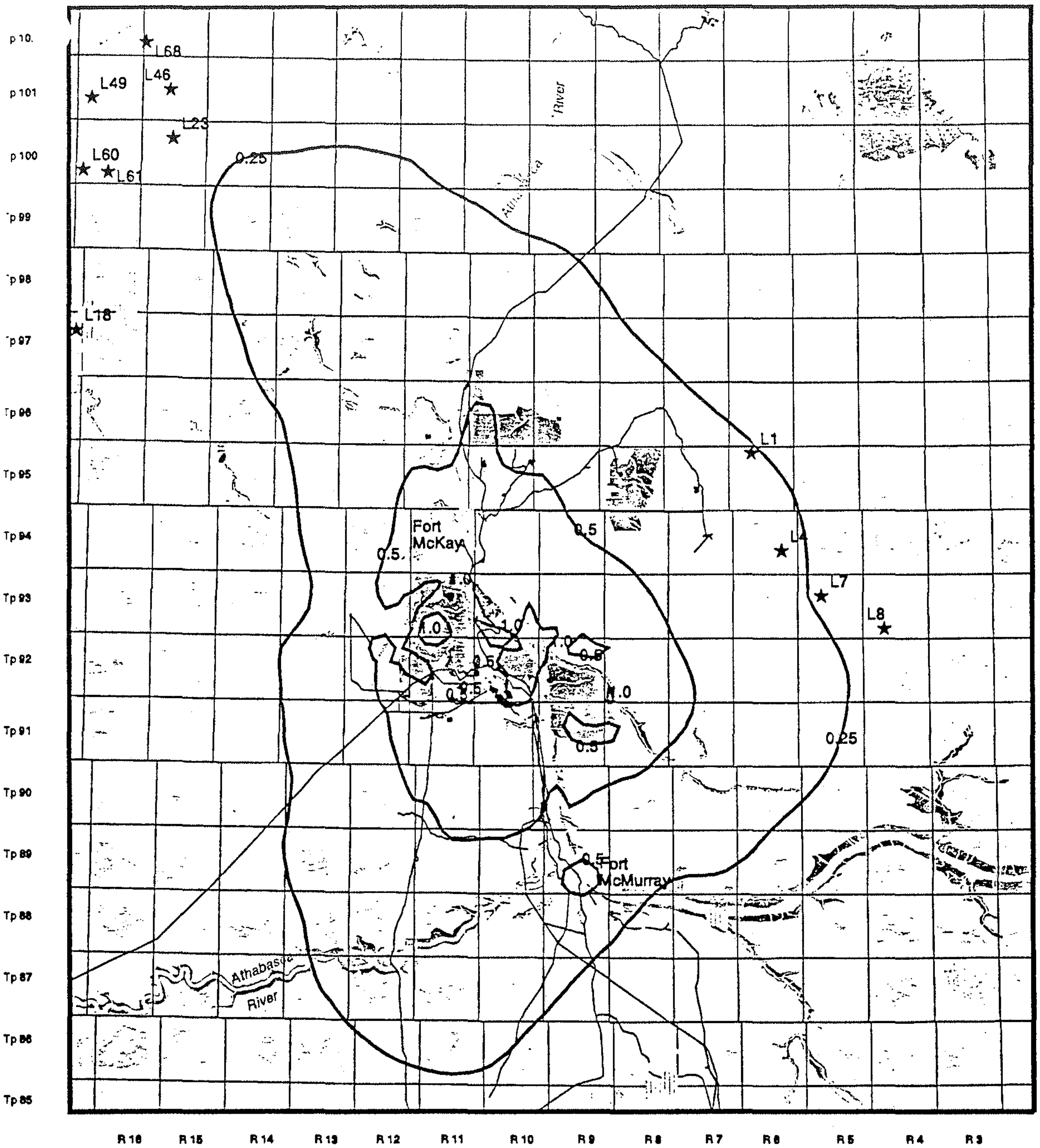
Figure B4-3x Predicted CEA SO_2 Maximum Daily Average Ground Level Concentrations in the RSA using the ISC3BE Model. With no mercaptans in fuel gas.

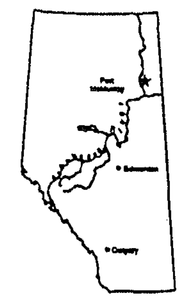


Sources	SO_2 [t/sd]
Suncor	
Powerhouse	1.2
FGD	19.7
Incinerator	10.2
Flaring	1.3
Tail Gas Treatment Unit	5.2
Other Sources, Suncor	0.08
Syncrude (total)	201
Other Emissions (total)	4
Other Proposed Emissions (total)	19.8
TOTAL	262.5

Model Description	
Development	CEA
Model	ISC3BE (7BG)
SO_2 Guideline [µg/m³]	450
Maximum [µg/m³]	557
Exceedences / Year [#]	1

Figure B4-2x Predicted CEA SO_2 Maximum Hourly Average Ground Level Concentrations in the RSA using the ISC3BE Model. With no mercaptans in fuel gas.





West of Fourth Meridian

SOURCES: Suncor, Syncrude, Petro-Canada, Mobil, Al-Pac, Golder, Alberta Research Council, AOSERP (Report 122)

Scale 1:1,000,000

10 0 10 20 30 40

Kilometres

Map Projection: UTM 12
Datum: NAD 83

LEGEND

- Lakes Rated for Sensitivity to Acidifying Deposition
- PAI Isopleths (keq/ha/a)
- Regional Study Area
- Linear Disturbances
- Open Water
- Existing Open Pit Mines
- Other Disturbances
- Municipalities
- Proposed Open Pit Mines
- In-Situ
- Indian Reserves

SOIL SENSITIVITY

- Low
- Moderate
- High
- Variable

N

SUNCOR ENERGY | Project Millennium

REGIONAL STUDY AREA RELATIVE SOIL SENSITIVITIES TO ACIDIFYING EMISSIONS PAI IMPACT ASSESSMENT

24 Sept. 1998	Figure	PRODUCED BY: K.O., J.H. REVIEWED BY:

Project Millennium Application

Section C : EUB Supplemental Information Response
Deferred Items from August 6 Submission

Question 8. **Provide updated figures based on the new geological model (once 1997/98 data is included) for "Net Cost Contours" (figure C2.2-16), and "Total Volume/Net Recovered Barrels Contours" (figure C2.2-18). Based on the updated geological model , provide updated estimates of the oil sand resources affected by the construction of the external tailings pond, and the rehandle volumes that will required to mine to the pit limit indicated by the $10/bbl net cost contour. For the affected resource (ie the oil sand within the net cost contour defined pit which lies either directly beneath the pond or within the offsets required for geotechnical stability), give the ore tonnage, average grade, number of recoverable barrels of bitumen, the TV/NRB ratio for the resource, the extraction recovery used to calculate TV/NRB, overburden tonnage, interburden tonnage, and required volume of rehandled sand and starter dyke.**

Response: The geological model has been revised based on the 1998 drilling information. Revised figures for the Net Cost Contours and the Total Volume/Net Recovered Barrels Contour are attached.

Based on the new model, the mining pit limits have shifted to the west in the area under the proposed external tailings pond. As a result of this shift the pond design has been reconfigured to extend the pond to the south-east to minimize any increase of resource affected by the pond location. Ongoing mine planning work to look for enhancements to the mine plan has also confirmed the opportunity to reduce the operational life (and consequently size) of this pond by approximately 2 years.

The resource beneath the external pond is characterized as follows:

- 68 million barrels of recoverable bitumen
- 102 million tonnes of oilsand averaging 11.6% bitumen and 16.1% fines
- insitu overburden of 90 million tonnes, interburden 27.5 million tonnes
- the predicted recovery of this resource is 91.1%
- calculated TV/NRB ratio of 1.6 excluding rehandle
- the estimated rehandle of placed overburden and tailings to recover this resource is 12.5 million m^3

Figures 1 and 2 illustrate the reconfigured tailings pond size and location before and after rehandle.

The geotechnical design assumptions for the external pond used in this plan are:

- 12H:1V slope on the east side (pit side) of the pond for construction of starter dyke and tailings placement
- 6H:1V excavation slope in the constructed dyke section
- 50 meter offset to the mining crest
- 3H:1V excavation slope in the overburden section (for thicknesses less than 50 meters), with allowance for slope buttresses
- 1H:1V oilsand slope with appropriate berms

Suncor believes that these design parameters will allow for the successful recovery of the affected resource. In the event that these assumptions are later found to require adjustment and a substantial increase in cost would be incurred then Suncor is prepared to examine other alternatives, including the substitution of an otherwise uneconomical area for mining to replace the equivalent value of resource.

9. **In Section C2.2, pg 16 it is stated that "a drilling density of 7 to 10 drillholes/km^2 is normally required for a feasibility study and a density of 30 to 40/km^2 is needed to facilitate five-year mine planning". Pit 2 drilling density is presently at 3.3 drillholes/km^2.**

c) **How confident is Suncor that the selected location and footprint size of proposed pit and infrastructure (external tailings pond, plantsite and dumps) will not change significantly upon further drilling and/or more detailed design work?**

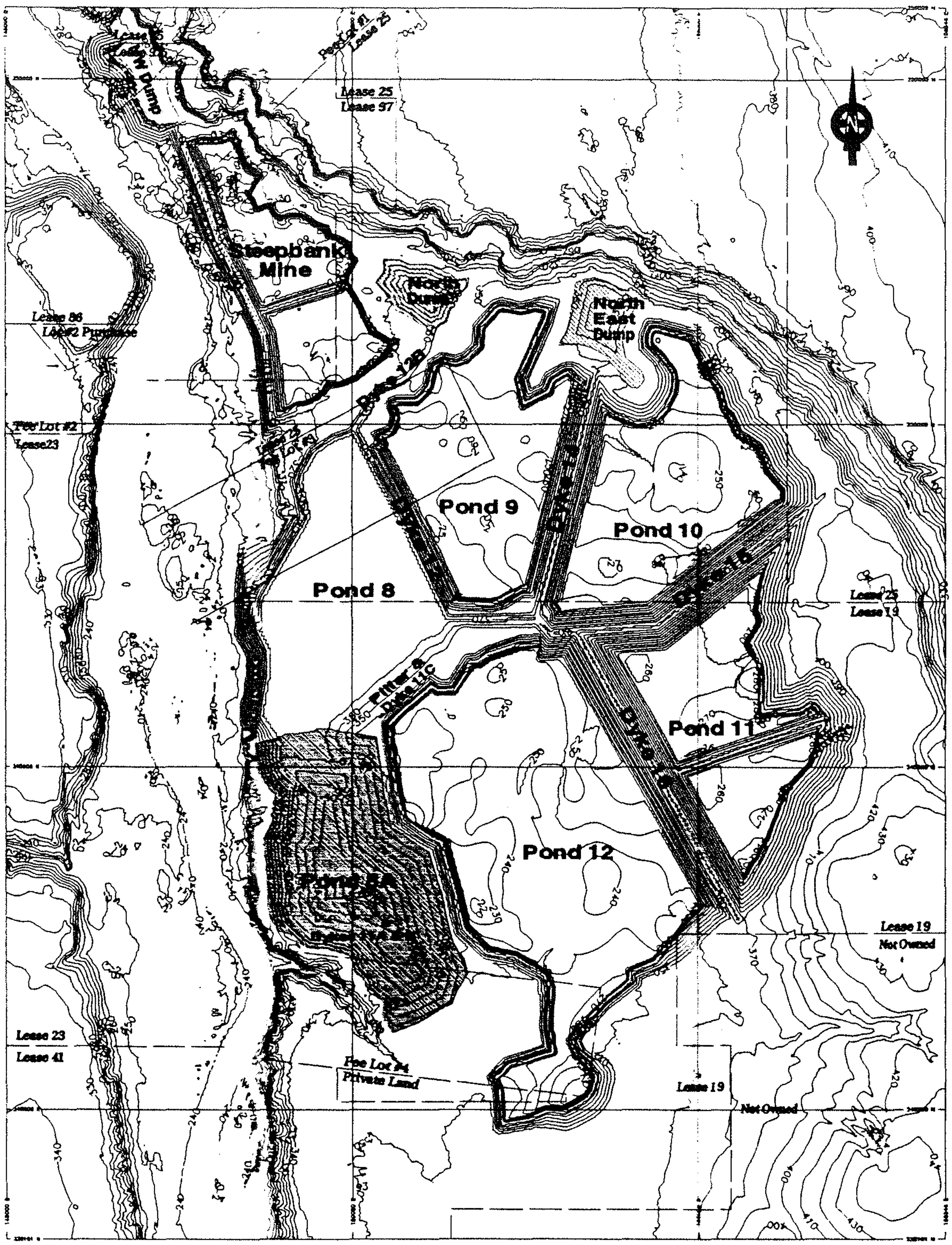
Response: As confirmed with the 1998 drilling program the location and footprint size of the proposed infrastructure have not changed significantly with the addition of further drilling. Suncor remains confident that the proposed infrastructure sites will not change significantly with increased drilling. Additional holes will be added to the drilling database in areas where the potential for resource sterilization exists. This re-examination of the infrastructure detailed site location will continue up to the time when the construction begins. Potential holes have been identified for the 1998/1999 drilling program to further refine the design and site considerations.

20. **Figures C2.2-16, C2.2-17, and C2.2-17 show the outline proposed for pit 2 versus net cost, TV/BIP, and TV/NRB contours respectively. Over most of the pit the outline follows the contours quite closely. However, in three areas: the southwest corner of the pit (in the area of pond 8A); the north side of the waste island; and under the northeast dump (immediately east of the dump area proposed in the Steepbank application) the pit limit does not follow the contours. Why does the pit outline deviate from the contours in these areas?**

Response: The pit outline has been revised based on the geology model containing the 1998 drilling information. In the three areas identified the pit outline now follows the cost contour closely. As was discussed previously, the deviations were based on geological interpretations, which were subsequently not confirmed by the model.

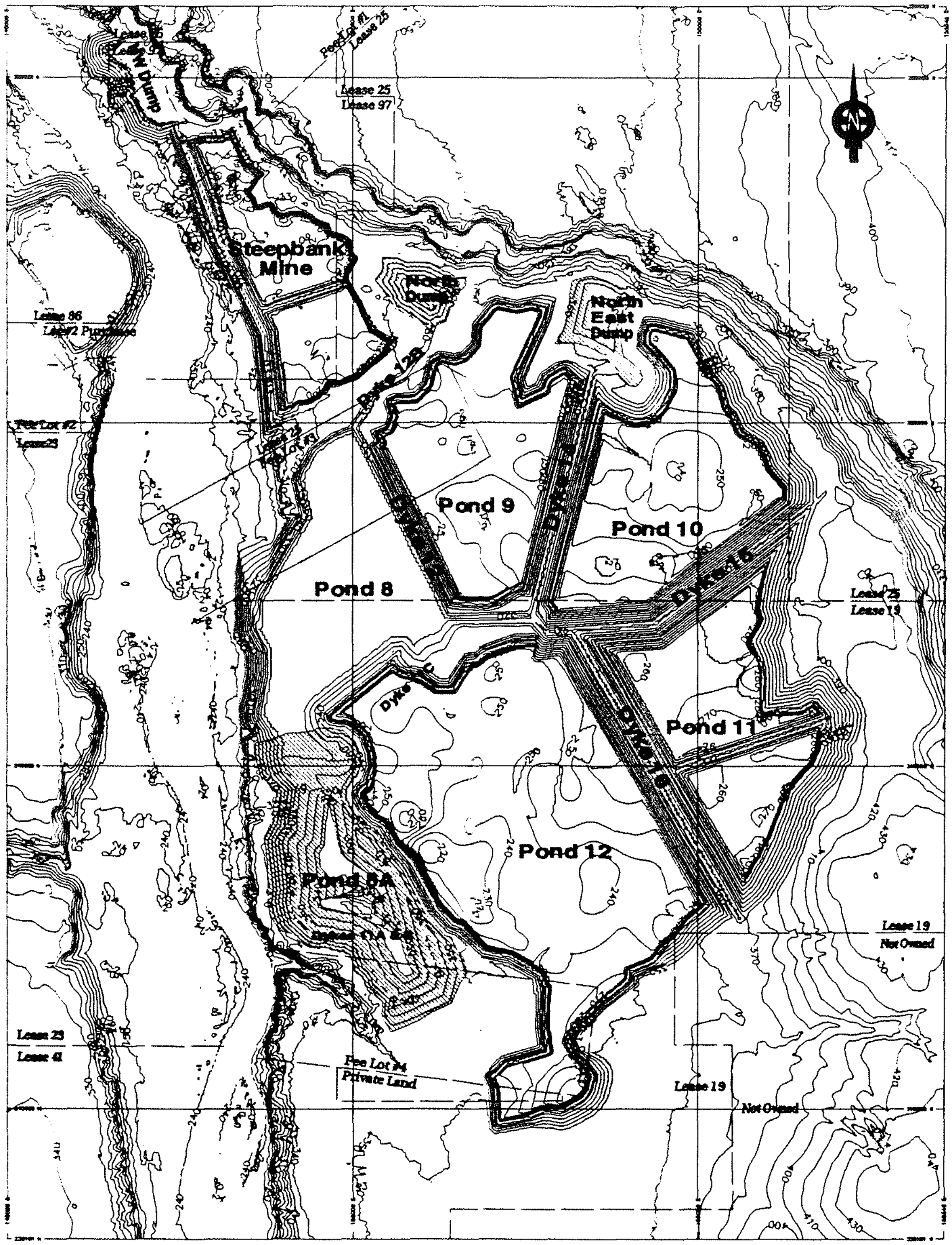
25. **It appears from the figures provided in volume 1, section C2 that the NE dump will overlie a considerable amount of mineable oil sand as defined by the $10 net cost contour. Based on the updated geological model which includes 1997/98 drilling data, provide estimates of the oil sand resources affected by the construction of the northeast dump. For the affected resource (i.e. the oil sand within the net cost contour/river set-back defined pit which lies either directly beneath the dump or within the offsets required for geotechnical stability), give the ore tonnage, average grade, recoverable barrels of bitumen, the TV/NRB ratio for the resource, the extraction recovery used to calculate TV/NRB, overburden tonnage, and interburden tonnage. What options have been evaluated which would avoid burial of the resources evaluated? What are the benefits and difficulties associated with those options?**

Response: The pit limit has been revised to include these areas into the mining sequence. There is no mineable oil sand identified under the revised overburden dump locations.



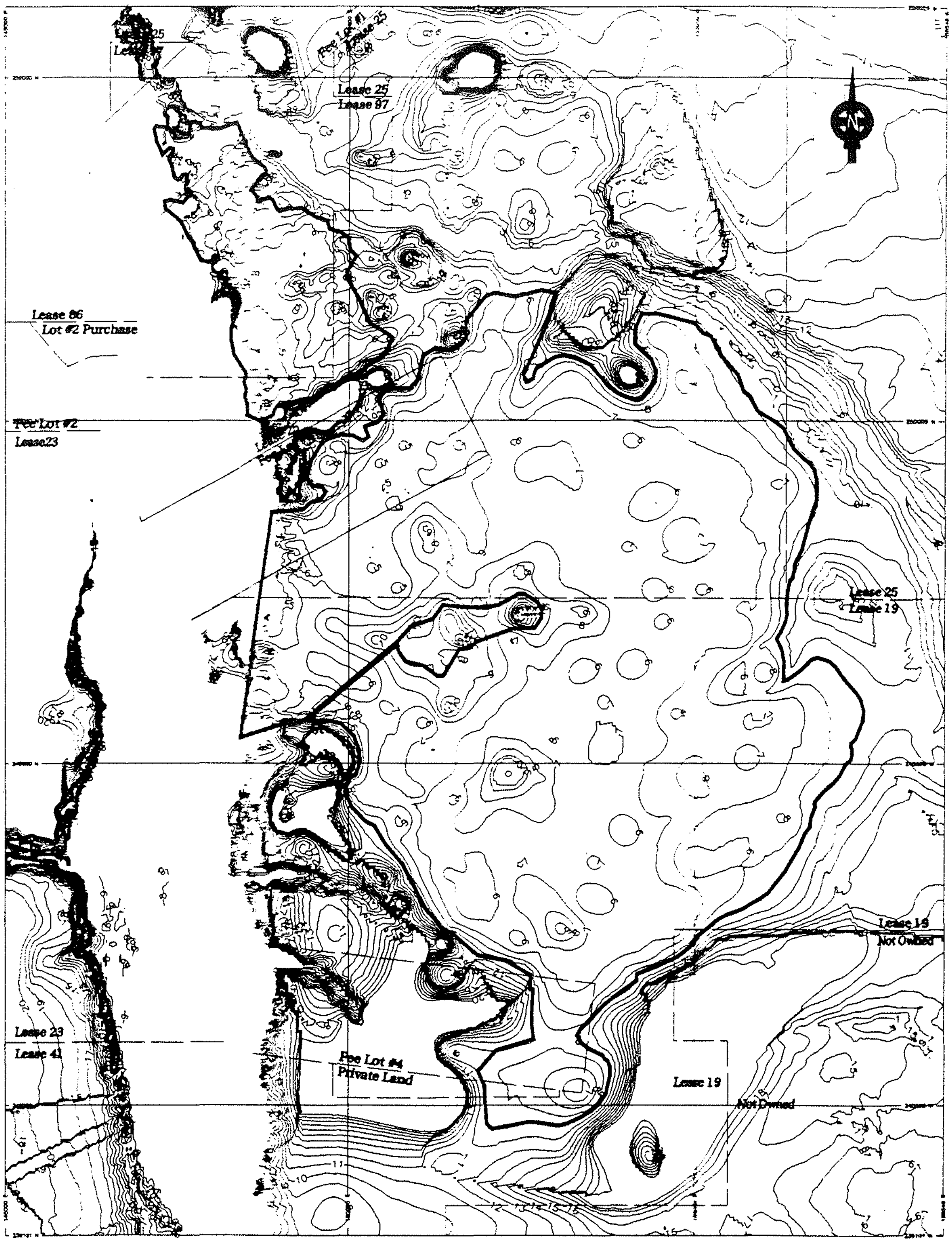
Mine Surface Before Rehandle	Project Millennium	SUNCOR ENERGY
Scale (Meters) 0 500 1000 2000	Date: Sep 30/98; Project: MILLENNIUM	Rev. Date: 98-09-30
	Drawn by: DAH; Scale: 1:30000	Revised By: DAH
	Drwg No.: a_mine.plt	Revision No.: 0

FIGURE 1



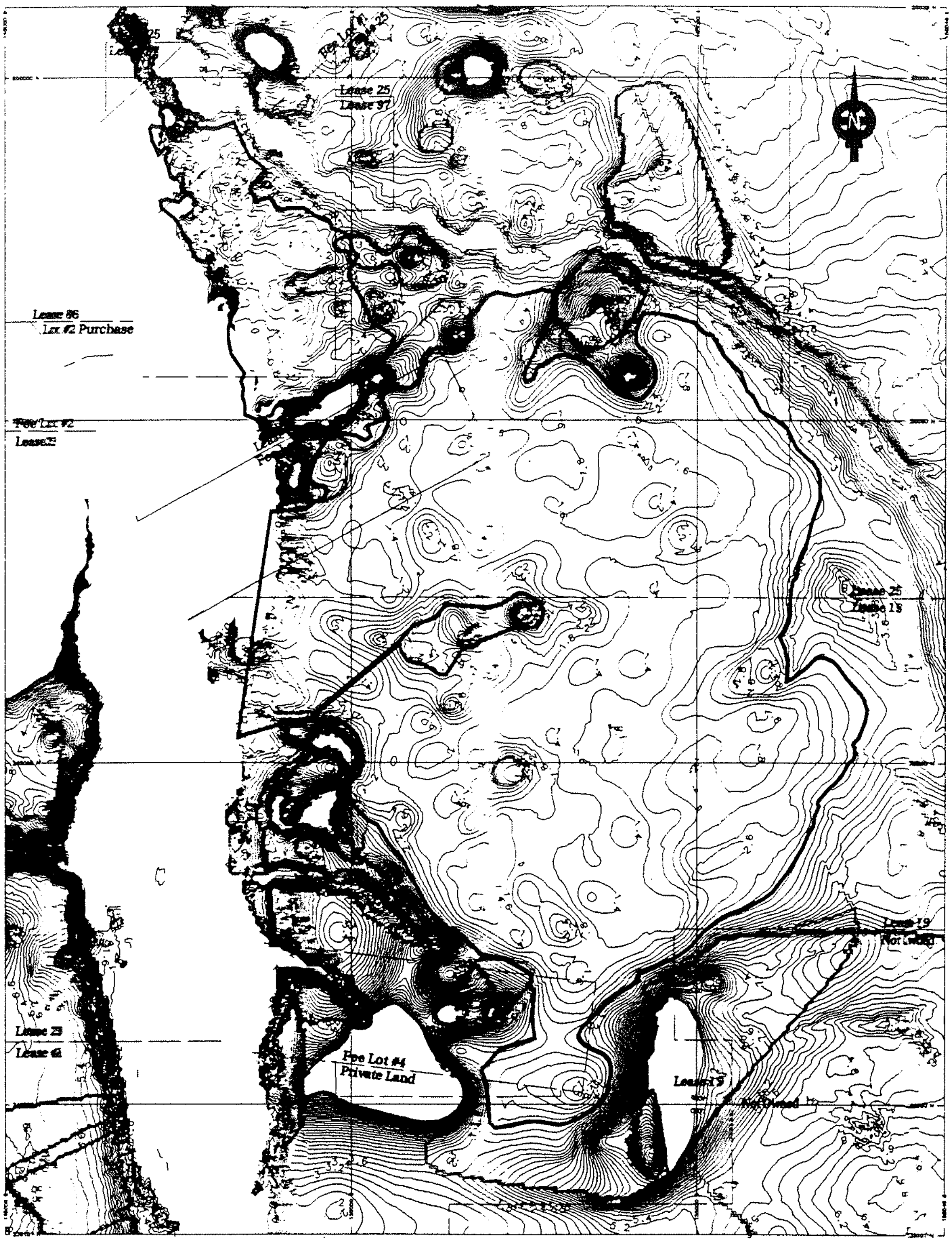
End of Mine	Project Millennium	SUNCOR ENERGY
Scale (Meters) 0 500 1000 2000	Date: Sep 30/98 · Project: MILLENNIUM	Rev. Date: 98-09-30
	Drawn by: DAH · Scale: 1:30000	Revised By: DAH
	Dwg No.: a_mine.plt	Revision No: 0

FIGURE 2



Economic Ratio 0 500 1000 2000 Scale (Meters) *dollars per barrel recovered*	*Project Millennium*		SUNCOR ENERGY
	Date Sep 30/98	Project MILLENNIUM	Rev Date 98-09-30
	Drawn by DAH	Scale 1:30000	Revised By DAH
	Drwg No. a_ratio_eco.zl*		Revision No 0

FIGURE C2.2-16 REVISED



Total Volume / Recovered Barrel

0 500 1000 2000
Scale (meters)

cubic meters per barrel

Project Millennium

Date:	Sep 30/98	Project:	MILLENNIUM	Rev. Date:	98-11-30
Drawn By:	DAH	Scale:	1:30000	Revised By:	DAH
Drwg No.:	a_ratio_bitr.plt			Revision No.:	3

FIGURE C2.2-18 REVISED

SUNCOR ENERGY

ENVIRONMENTAL [illegible] DIVISION

NOV 10 1998

OIL SANDS

Suncor Energy Inc.
Oil Sands
P.O. Box 4001
Fort McMurray, Alberta T9H 3E3
Website: www.suncor.com

November 6, 1998

ATT: Mr. Ralph Dyer
Senior Approvals Coordinator
Land Reclamation Division
Alberta Environmental Protection
3rd Floor, Oxbridge Place
9820 – 106 Street
Edmonton AB T5K 2J6

ATT: Mr. Dave Henderson
Resources Division
Mine Development Group
Alberta Energy and Utilities Board
640 – 5 Avenue SW
Calgary AB T2P 3G4

Dear Messrs. Dyer and Henderson

We are continuing our consultations with stakeholders on Project Millennium. As a result of discussions with Fort McKay Industry Relations Corp. and the Athabasca Chipewyan First Nation, we have completed a reassessment of air emission compounds associated with VOC's. Because of a different approach using a more realistic method, as determined through our consultation, the results show less of an impact on air quality at different locations off-site.

This report is attached for your information. Please contact me for further information or discussion on this.

Yours truly

SUNCOR ENERGY INC., OIL SANDS

K Hobbs

for Don Klym
Manager, Regulatory Affairs
Sustainable Development

DK/klh

Attachment

Cc Tony Punko (without attachment)
Ken Shipley (without attachment)

\\osg05s\hobbsk\millennium\supplemental trs dyer_henderson nov 6 98 ltr.doc

REVISED TOTAL REDUCED SULPHUR COMPOUND ANALYSES

1. INTRODUCTION

As part of the Project Millennium Environmental Impact Assessment, evaluations of the expected concentrations of the Total Reduced Sulphur (TRS) Compounds, Hydrogen Sulphide (H_2S) and Mercaptans were presented. The predictions of these compounds were based on the dispersion modelling conducted on the VOC emissions in the region, and then scaled based on the relative magnitudes of the TRS, H_2S and Mercaptans emissions compared to the VOC releases. This assessment approach was conservative in that it assumed that all of the VOC emission sources released TRS at a rate proportional to the regional totals.

Based on Suncor's ongoing stakeholder consultation on Project Millennium and base operations, a refined analysis of the reduced TRS emissions has been undertaken to give a more realistic estimate of the expected concentrations in the regional communities. This refined analysis was undertaken using the actual TRS emission sources. The resultant TRS concentrations were speciated to yield H_2S and Mercaptan concentrations. This information provides the results of the revised reduced sulphur analysis.

2. MODEL APPROACH AND LIMITATIONS

The analysis of reduced sulphur emissions was conducted using the ISC3BE dispersion model developed by BOVAR Environmental. The modifications made to the original ISC3 model code were undertaken to enable the model to yield maximum predicted concentrations and numbers of exceedances that were similar to those observed at the local monitoring stations (Conor Pacific, 1998). Although the tuning done to the ISC3BE model has not been subjected to the same rigorous independent review as the original code, the changes are designed to yield model predictions which correspond to the observations made at sampling locations along the Athabasca River valley. This model has been used extensively in previous air assessments in the oil sands region.

Dispersion models employ simplifying assumptions to describe the random processes associated with atmospheric motions and turbulence. These simplifying processes limit the capability of a model to replicate individual events. A model's predictive capability and strength lies in it's capability to predict an average for a given set of meteorological conditions. Other factors that limit the capability of a model to predict values that match observations are limitations in the input data. For example, the modelling does not account for the hour-by-hour emission rates in the source strength and exit characteristics (such as temperature and velocity). The available dispersion models cannot fully replicate the special flow patterns and reduced dispersion within the Athabasca River valley, although the ISC3BE model has been tuned in an attempt to account for some of these effects.

3. BASELINE CONDITIONS

3.1. Emissions

The baseline emissions scenario includes the contribution from oil sands mining, extraction and upgrading facilities in the Athabasca oil sands region, as well as emissions from other sources, including industrial operations, transportation and residential sources. This section summarizes the Baseline projects as defined in Table A2-11 of Vol. 2A of the EIA.

A summary of the emissions from Suncor, Syncrude, other industries, transportation and residential sources in the oil sands region is provided in Table 1. While the results in the table indicate the two oil sands operations are the major sources of emissions to the atmosphere, there are other sources that can also influence air quality. This is especially true for smaller sources originating in the communities of Fort McMurray and Fort McKay. The TRS, H_2S and Mercaptan emissions in the table correspond to the best estimates of emissions available.

Table 1 Summary of Estimated Baseline Total Reduced Sulphur Emissions in the Athabasca Oil Sands Region

Source	Emission Rates (t/cd)		
	TRS	H_2S[(a)]	Mercaptans[(a)]
Suncor	1.5	0.11	0.0041
Syncrude	2.3	0.16	0.0062
Other Industries	0.01	0.0007	0.0000
Transportation and Residential	-	-	-
Total	**3.8**	**0.27**	**0.0097**

- Not a source of this emission.
(a) Estimated emissions based on fugitive emissions surveys at the various oil sand facilities.
Note: The updated values in the above table represent the latest estimates of emissions as detailed in Technical Reference for Meteorology, Emissions and Ambient Air Quality in the Athabasca Oil Sands Region (Golder and Conor Pacific 1998).

3.2. Predicted Sulphur Compound Concentrations

The predicted maximum hourly, daily and annual ground level concentrations of TRS compounds, H_2S and Mercaptans at each of the communities in the oil sands region are presented in Table 2. A summary of the frequencies and relative magnitudes of the total reduced sulphur compound concentrations are presented in Appendix 1 of this supplement.

Table 2 Predicted Ground Level Concentrations of Total Reduced Sulphur Compounds from the Baseline Emissions

Location	1-Hour Maximum [μg/m³]			Daily Maximum [μg/m³]			Annual Average [μg/m³]		
	Fort McMurray	Fort McKay	Fort Chipewyan	Fort McMurray	Fort McKay	Fort Chipewyan	Fort McMurray	Fort McKay	Fort Chipewyan
Total Reduced Sulphur (TRS)	70.98	85.94	23.12	6.28	15.20	1.43	0.26	0.98	0.06
Hydrogen Sulphide (H_2S)	4.97	6.02	1.62	0.44	1.06	0.10	0.02	0.07	0.004
Mercaptans	0.1916	0.2320	0.0624	0.0169	0.0410	0.0039	0.0007	0.0026	0.0002

4. PROJECT MILLENNIUM

4.1. Emissions

The summary of estimated air emissions from Project Millennium and approved projects as well as other industrial emissions, combined with the transportation and residential sources are included in Table 3. The TRS, H_2S and Mercaptan emissions in the table correspond to the best estimates of emissions available.

Table 3 Summary of Estimated Project Millennium Total Reduced Sulphur Emissions in the Athabasca Oil Sands Region

Source	Emission Rates (t/cd)		
	TRS	H_2S[(a)]	Mercaptans[(a)]
Suncor	2.7	0.19	0.0065
Syncrude	2.3	0.16	0.0062
Other Industries	0.01	0.0007	0.0000
Transportation and Residential	-	-	-
Total	**5.01**	**0.35**	**0.0120**

\- Not a source of this emission.
(a) Estimated emissions based on fugitive emissions surveys at the various oil sand facilities.
Note: The updated values in the above table represent the latest estimates of emissions as detailed in Technical Reference for Meteorology, Emissions and Ambient Air Quality in the Athabasca Oil Sands Region (Golder and Conor Pacific 1998).

4.2. Predicted Sulphur Compound Concentrations

The predicted maximum hourly, daily and annual ground level concentrations of TRS compounds, H_2S and Mercaptans at each of the communities in the oil sands region under the Project Millennium conditions are presented in Table 4. A summary of the frequencies and relative magnitudes of the total reduced sulphur compound concentrations are presented in Appendix 1 of this supplement.

Table 4 Predicted Ground Level Concentrations of Total Reduced Sulphur Compounds from the Project Millennium Emissions

Location	1-Hour Maximum [µg/m³]			Daily Maximum [µg/m³]			Annual Average [µg/m³]		
	Fort McMurray	Fort McKay	Fort Chipewyan	Fort McMurray	Fort McKay	Fort Chipewyan	Fort McMurray	Fort McKay	Fort Chipewyan
Total Reduced Sulphur (TRS)	137.02	165.56	43.63	11.98	29.00	2.65	0.48	1.65	0.14
Hydrogen Sulphide (H_2S)	9.59	11.59	3.05	0.84	2.03	0.19	0.03	0.11	0.01
Mercaptans	0.3699	0.4470	0.1178	0.0323	0.0783	0.0072	0.0013	0.0044	0.0004

5. CEA CONDITIONS

5.1. Emissions

The summary of the air emissions from Project Millennium, including the approved Syncrude and other industrial emissions, combined with the transportation and residential sources are included in Table 5. The key difference between the Millennium and CEA scenarios is the inclusion of planned developments in the region. The ones incorporated into the analysis have been outlined in section B4.1.2.5 (Vol. 2A). Table B4-19 summarizes the sources of air emissions considered in the CEA. The TRS, H_2S and Mercaptan emissions in the table correspond to the best available estimates of emissions.

Table 5 Summary of Estimated CEA Total Reduced Sulphur Emissions in the Athabasca Oil Sands Region

Source	Emission Rates (t/cd)		
	TRS	H_2S[(a)]	Mercaptans[(a)]
Suncor	2.7	0.19	0.0065
Syncrude	3.5	0.25	0.0084
Other Industries	0.09	0.0063	0.0002
Transportation and Residential	-	-	-
Total	**6.29**	**0.44**	**0.0151**

\- Not a source of this emission.
(a) Estimated emissions based on fugitive emissions surveys at the various oil sand facilities.
Note: The updated values in the above table represent the latest estimates of emissions as detailed in Technical Reference for Meteorology, Emissions and Ambient Air Quality in the Athabasca Oil Sands Region (Golder and Conor Pacific 1998).

5.2. Predicted Sulphur Compound Concentrations

The predictions of the maximum hourly, daily and annual ground level concentrations of TRS compunds, H_2S and Mercaptans at each of the communities in the oil sands region, under the CEA emission conditions, are presented in Table 6. A summary of the frequencies and relative magnitudes of the total reduced sulphur compound concentrations are presented in Appendix 1 of this report.

Table 6 Predicted Ground Level Concentrations of Total Reduced Sulphur Compounds from the CEA Emissions

Location	1-Hour Maximum [μg/m³]			1-Hour Maximum [μg/m³]			1-Hour Maximum [μg/m³]		
	Fort McMurray	Fort McKay	Fort Chipewyan	Fort McMurray	Fort McKay	Fort Chipewyan	Fort McMurray	Fort McKay	Fort Chipewyan
Total Reduced Sulphur (TRS)	137.14	165.34	45.06	12.39	28.97	2.75	0.52	1.76	0.12
Hydrogen Sulphide (H_2S)	9.60	11.57	3.15	0.87	2.03	0.19	0.04	0.12	0.01
Mercaptans	0.3703	0.4464	0.1217	0.0335	0.0782	0.0074	0.0014	0.0048	0.0003

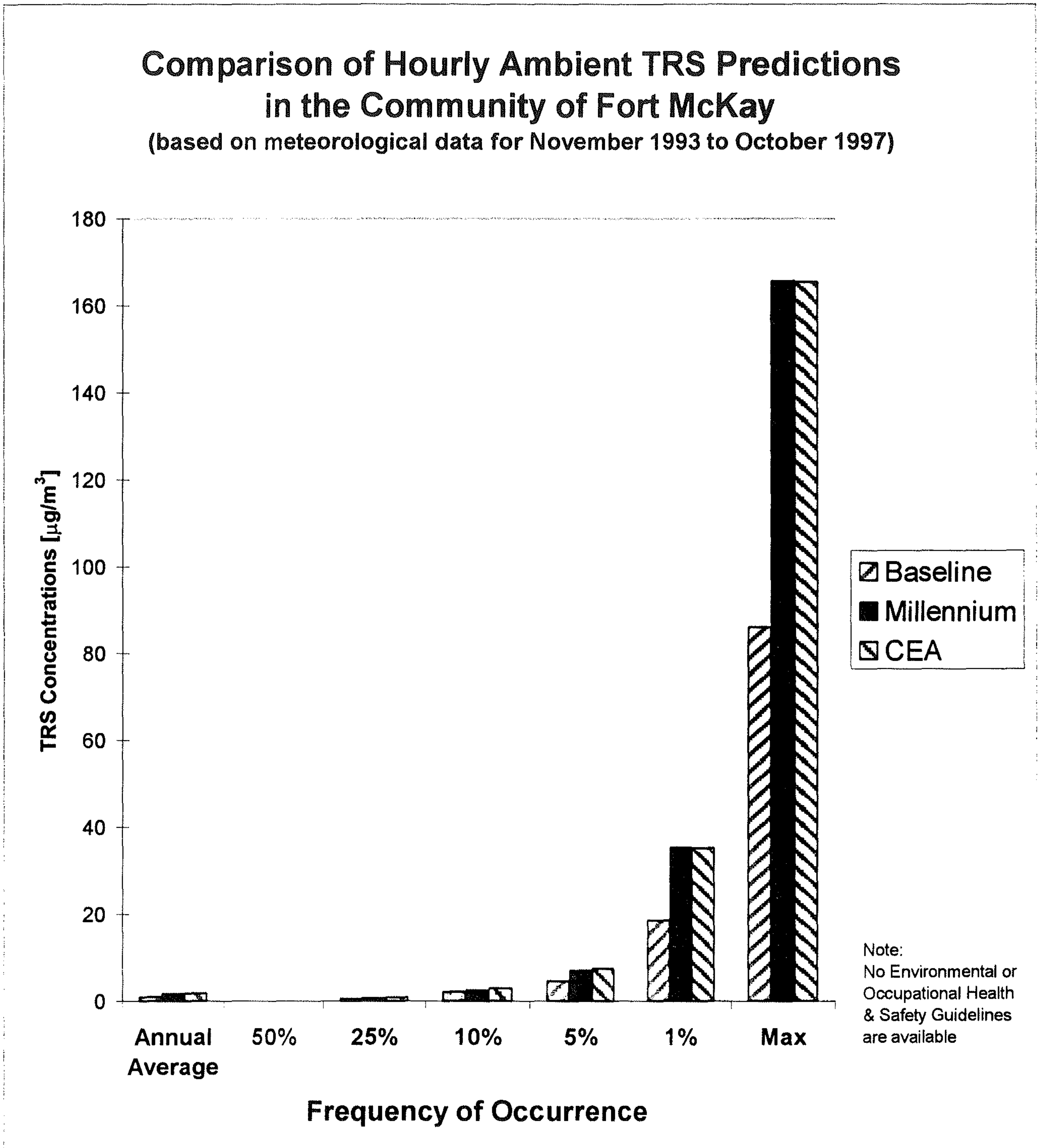
6. REFERENCES

Conor Pacific. 1998. Draft Model Selection and Evaluation Appendix. Prepared for Syncrude Canada Ltd., as part of the environmental impact assessment currently underway.

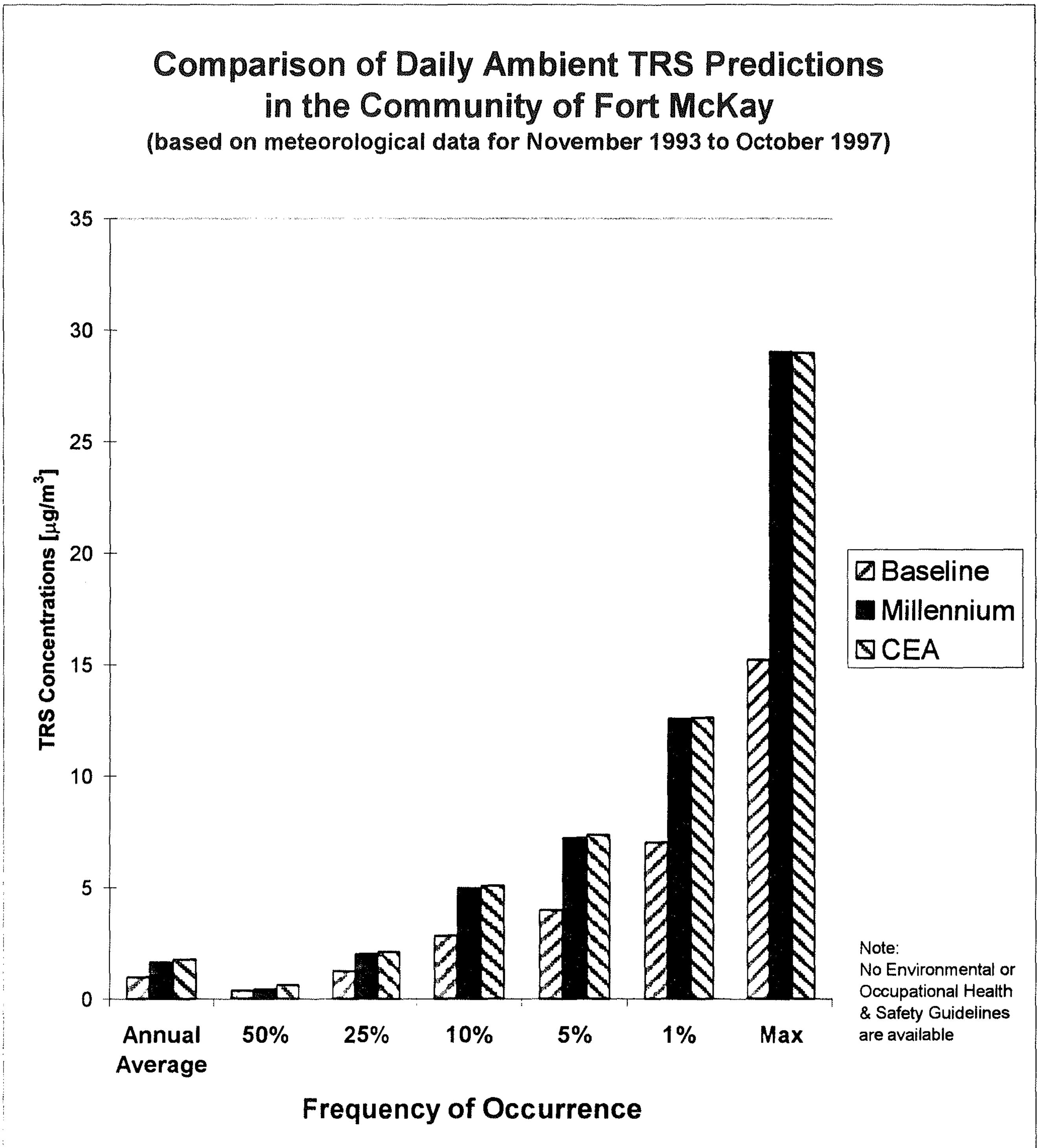
Golder Associates Ltd. and Conor Pacific Environmental Technologies Inc. 1998. Technical Reference for Meteorology, Emissions and Ambient Air Quality in the Oil Sands Region. Report for Suncor Energy Inc., Oil Sands. Fort McMurray, Alberta.

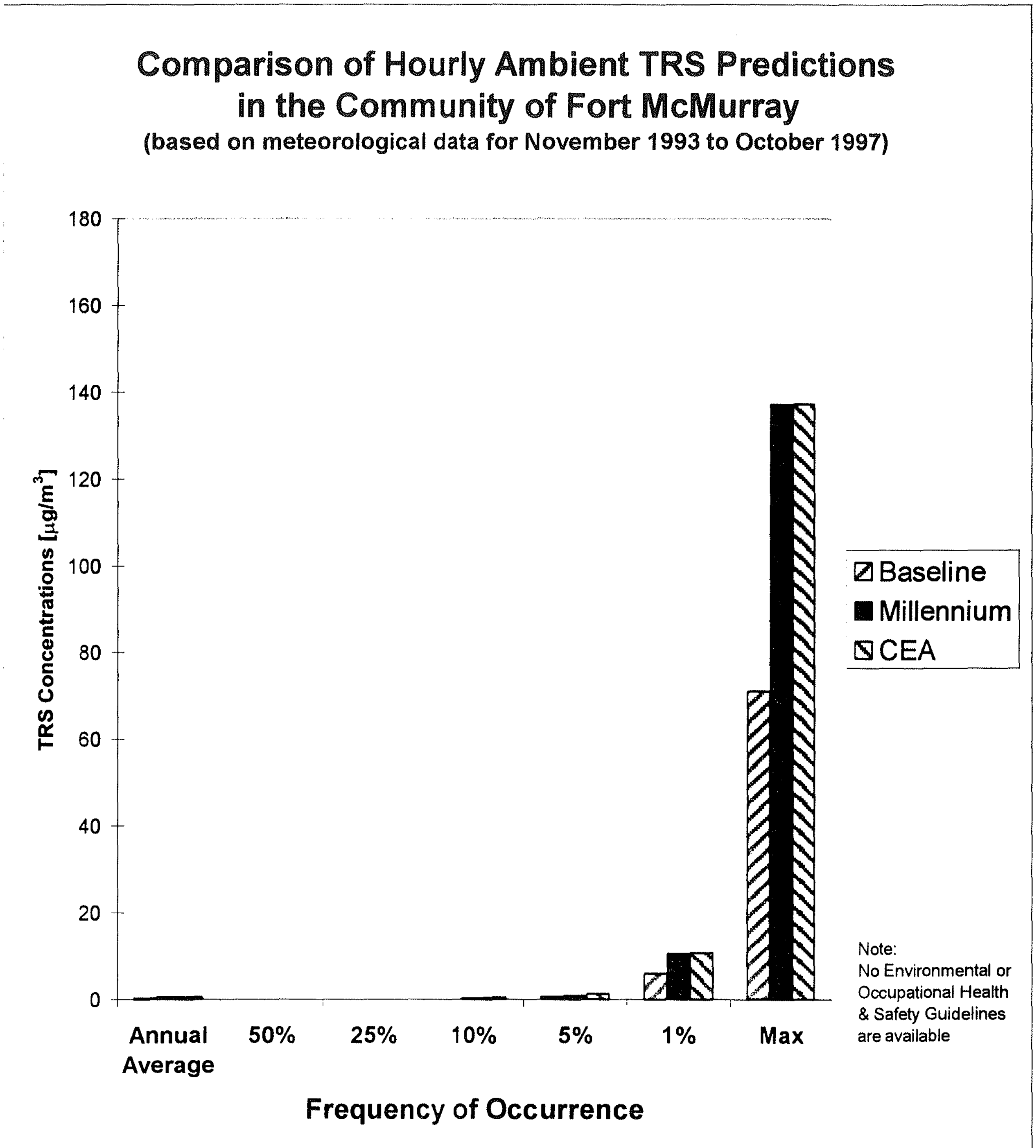
APPENDIX 1

SUMMARIES OF THE FREQUENCIES AND RELATIVE MAGNITURE OF TOTAL REDUCED SULPHUR COMPOUND CONCENTRATIONS IN FORT MCMURRAY, FORT MCKAY AND FORT CHIPEWYAN



Comparison of Hourly Ambient TRS Predictions in the Community of Fort McKay
(based on meteorological data for November 1993 to October 1997)
TRS Concentrations [µg/m3]
180
160
140
120
100
80
60
40
20
0
Annual Average
50%
25%
10%
5%
1%
Max
Frequency of Occurrence
Baseline
Millennium
CEA
Note:
No Environmental or Occupational Health & Safety Guidelines are available

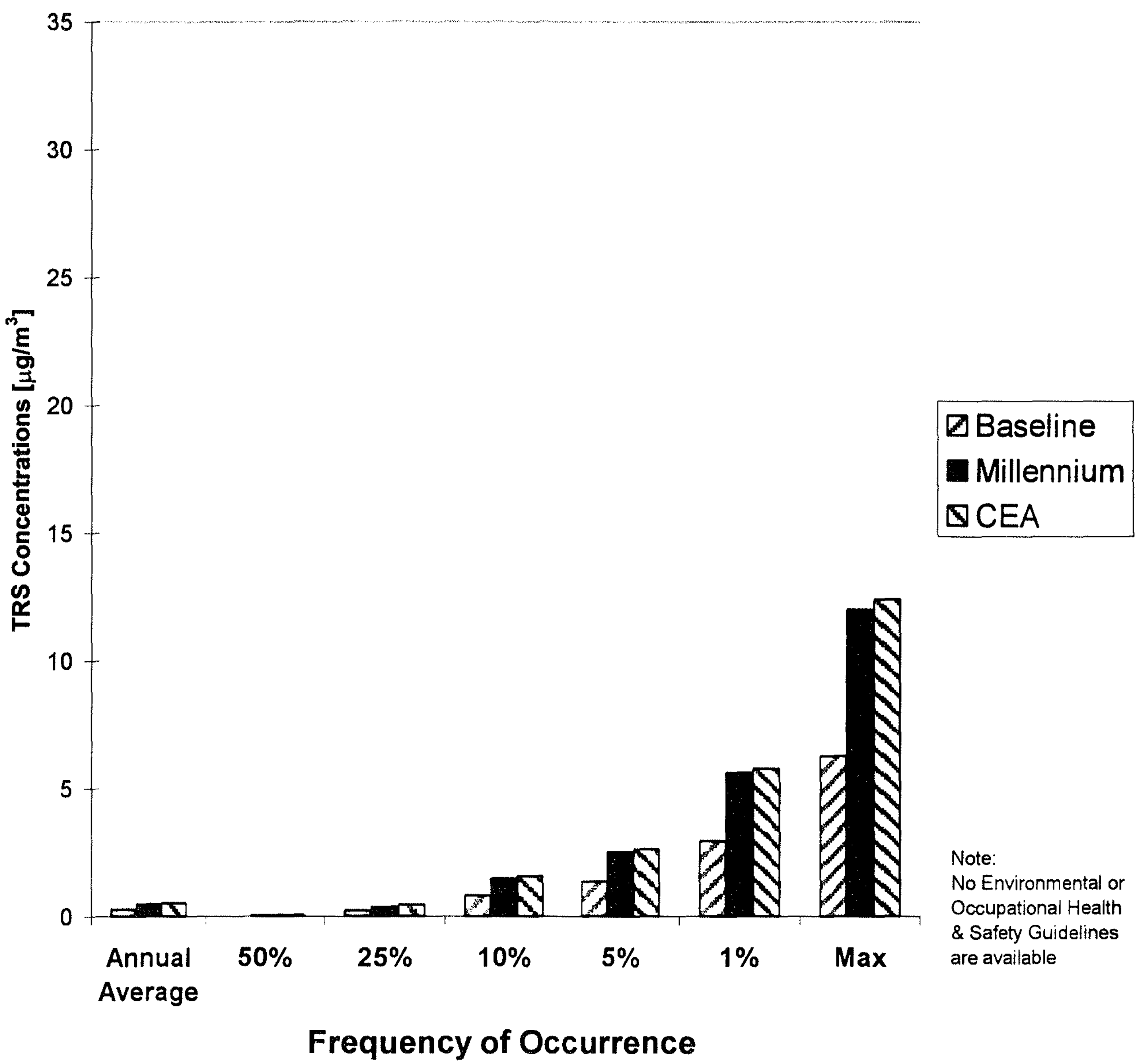

Comparison of Daily Ambient TRS Predictions
in the Community of Fort McKay
(based on meteorological data for November 1993 to October 1997)
35
30
25
20
15
10
5
0
TRS Concentrations [μg/m3]
Annual Average
50%
25%
10%
5%
1%
Max
Frequency of Occurrence
Baseline
Millennium
CEA
Note:
No Environmental or Occupational Health & Safety Guidelines are available



Comparison of Hourly Ambient TRS Predictions in the Community of Fort McMurray
(based on meteorological data for November 1993 to October 1997)
180
160
140
120
100
80
60
40
20
0
TRS Concentrations [µg/m3]
Baseline
Millennium
CEA
Note:
No Environmental or Occupational Health & Safety Guidelines are available
Annual Average
50%
25%
10%
5%
1%
Max
Frequency of Occurrence

Comparison of Daily Ambient TRS Predictions in the Community of Fort McMurray

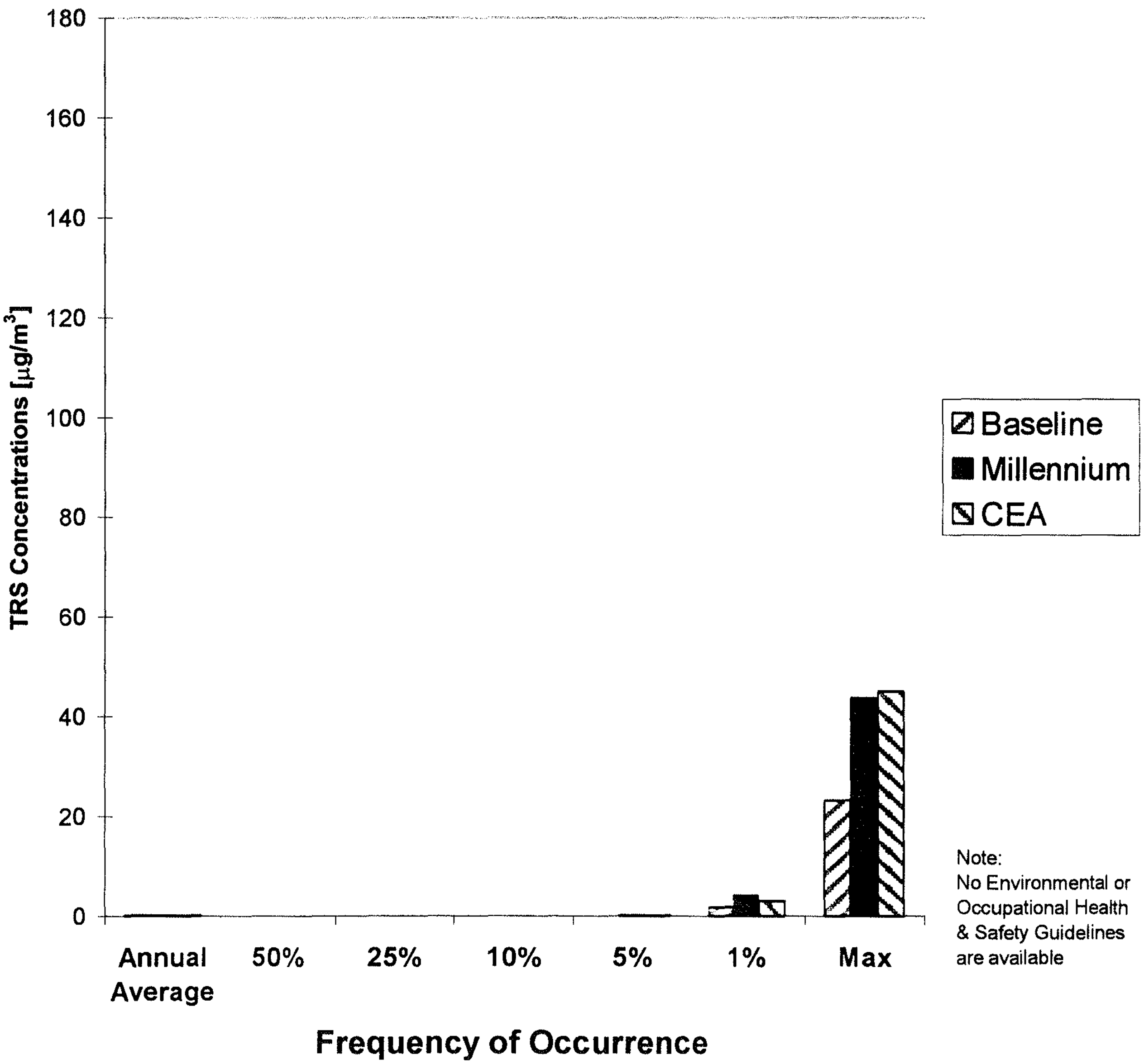
(based on meteorological data for November 1993 to October 1997)



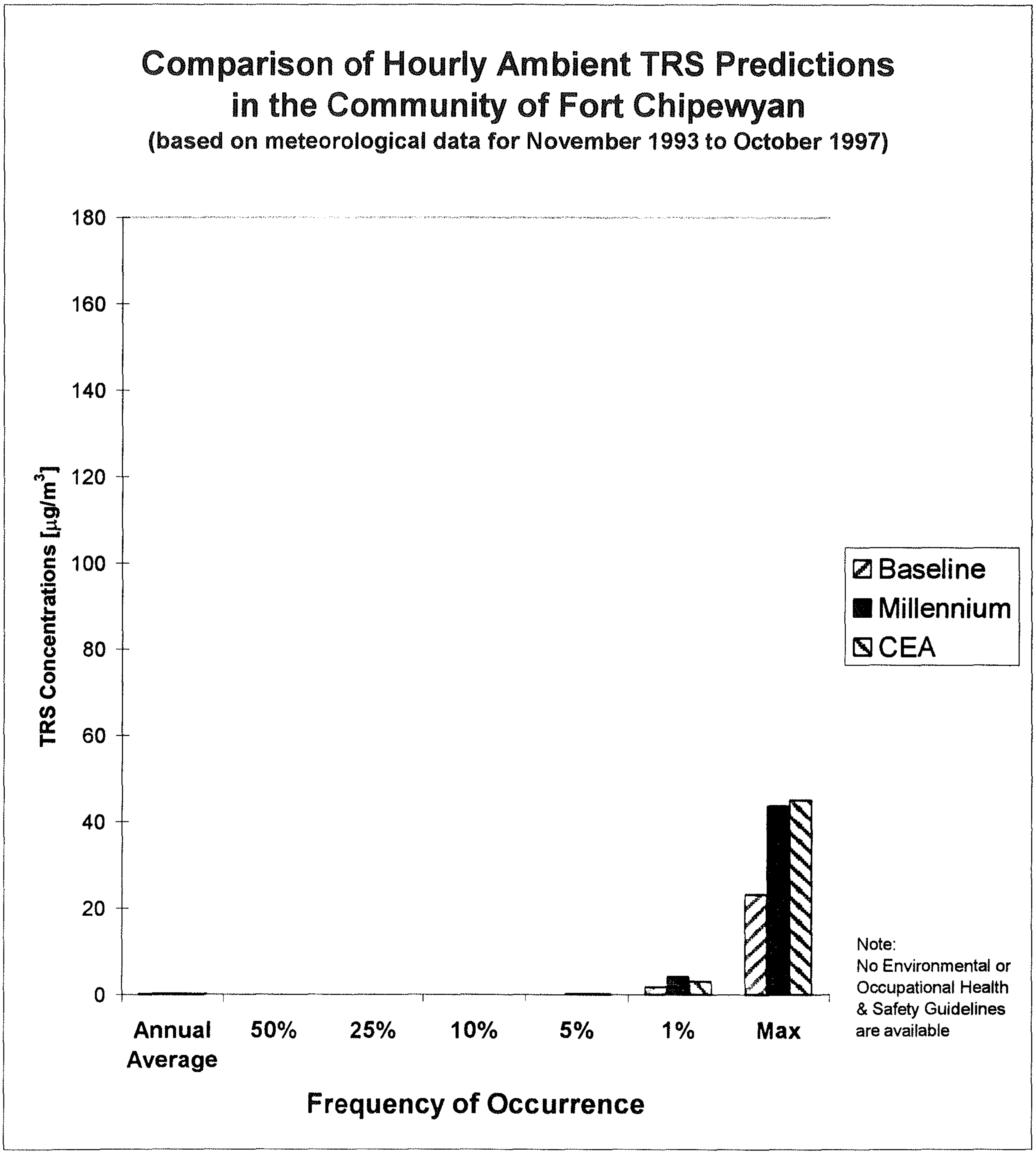
Note:
No Environmental or Occupational Health & Safety Guidelines are available

Comparison of Hourly Ambient TRS Predictions in the Community of Fort Chipewyan

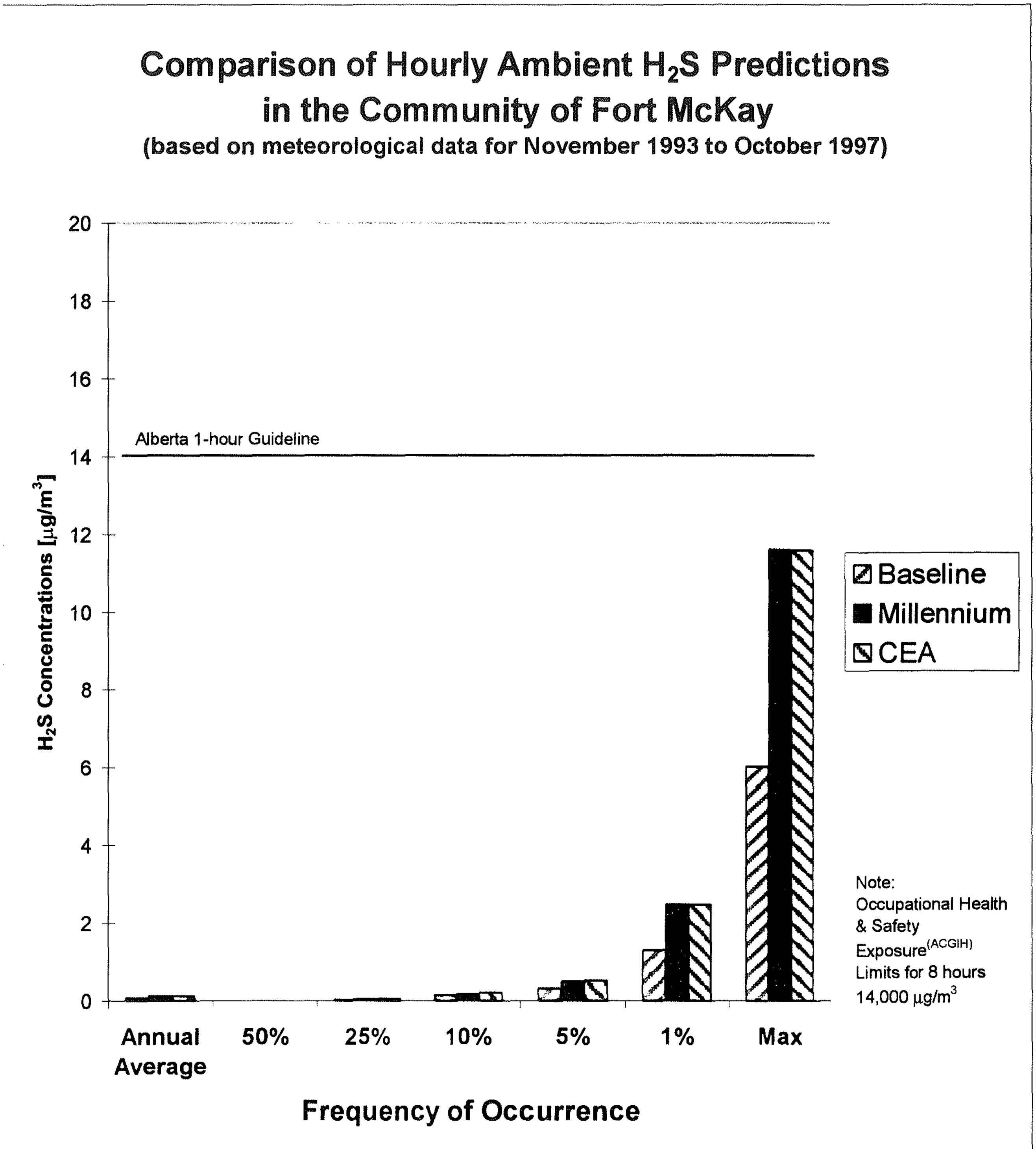
(based on meteorological data for November 1993 to October 1997)



Note:
No Environmental or Occupational Health & Safety Guidelines are available

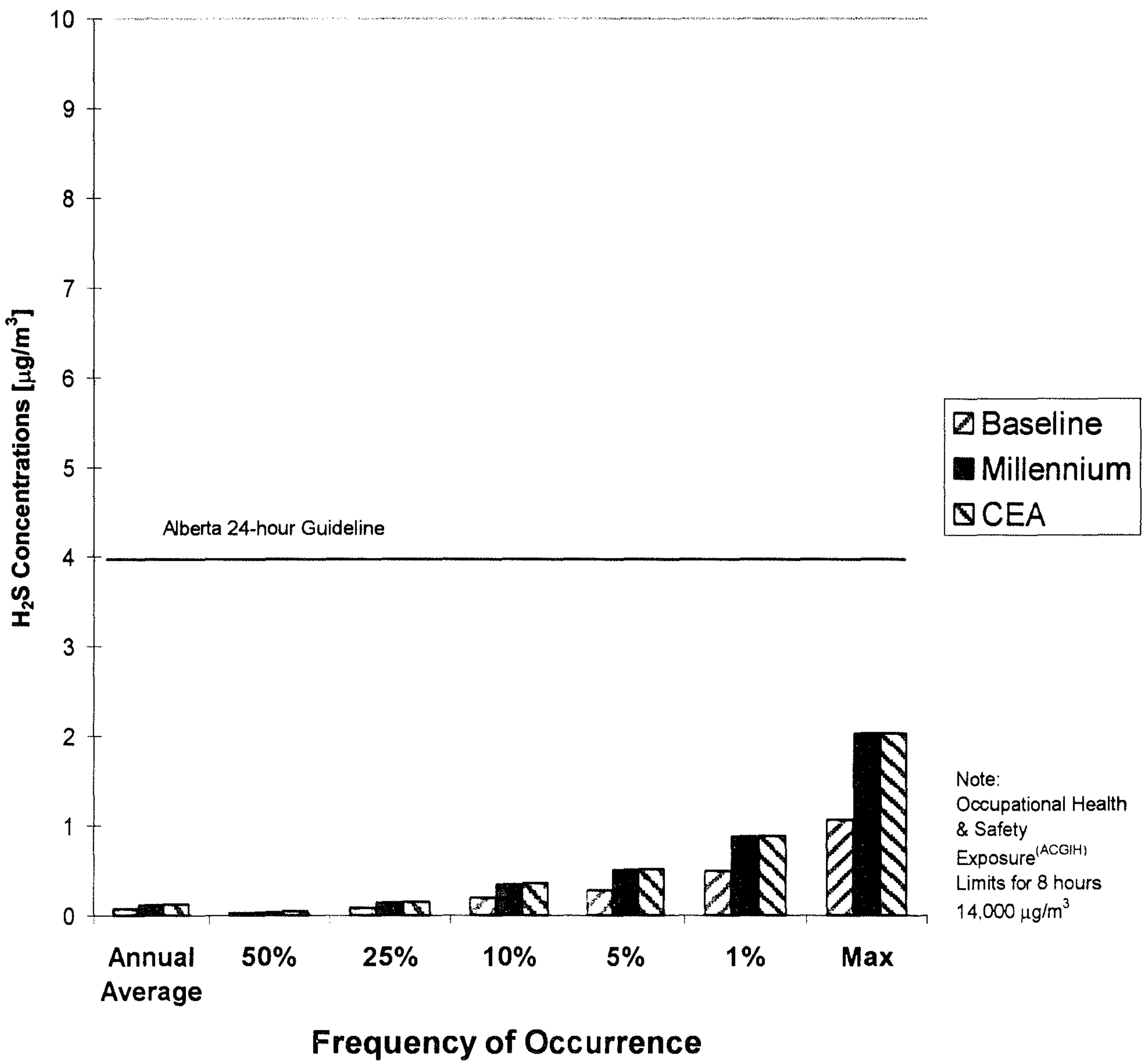


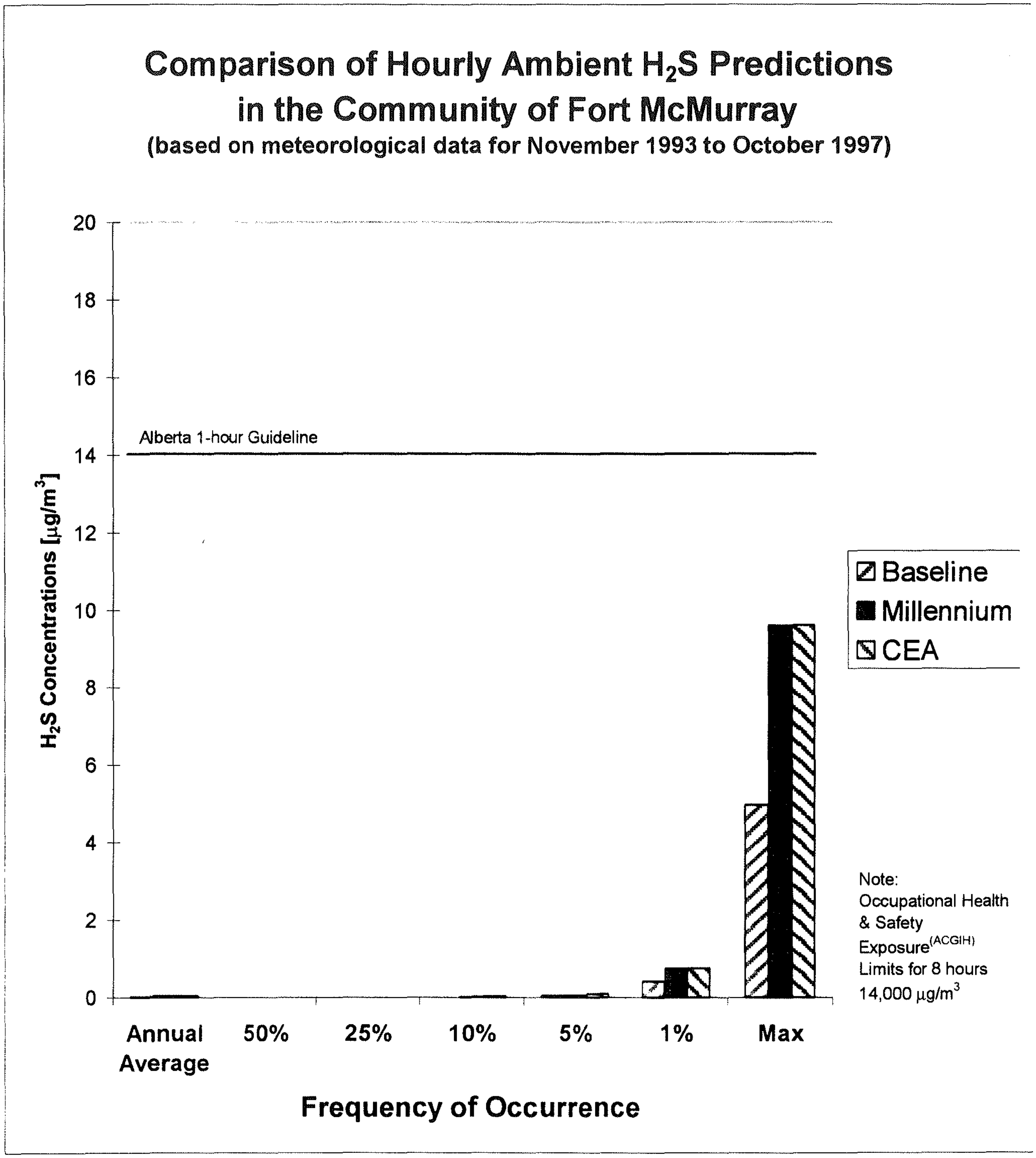
Comparison of Hourly Ambient TRS Predictions
in the Community of Fort Chipewyan
(based on meteorological data for November 1993 to October 1997)
180
160
140
120
100
80
60
40
20
0
TRS Concentrations [µg/m³]
Baseline
Millennium
CEA
Note:
No Environmental or
Occupational Health
& Safety Guidelines
are available
Annual Average
50%
25%
10%
5%
1%
Max
Frequency of Occurrence


Comparison of Hourly Ambient H2S Predictions
in the Community of Fort McKay
(based on meteorological data for November 1993 to October 1997)
20
18
16
14
12
10
8
6
4
2
0
Alberta 1-hour Guideline
H2S Concentrations [µg/m3]
Baseline
Millennium
CEA
Note:
Occupational Health
& Safety
Exposure(ACGIH)
Limits for 8 hours
14,000 µg/m3
Annual Average
50%
25%
10%
5%
1%
Max
Frequency of Occurrence

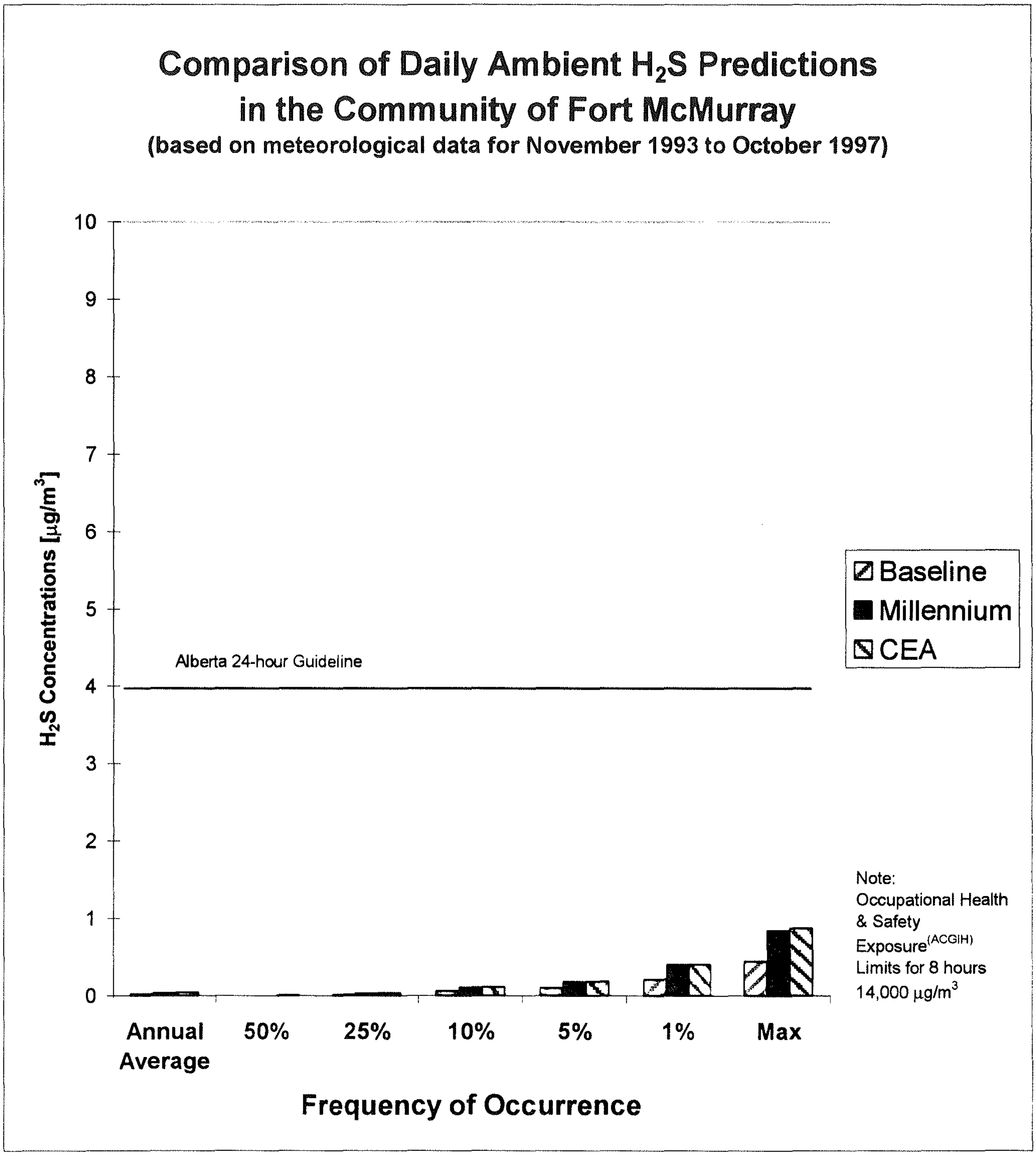
Comparison of Daily Ambient H_2S Predictions in the Community of Fort McKay

(based on meteorological data for November 1993 to October 1997)

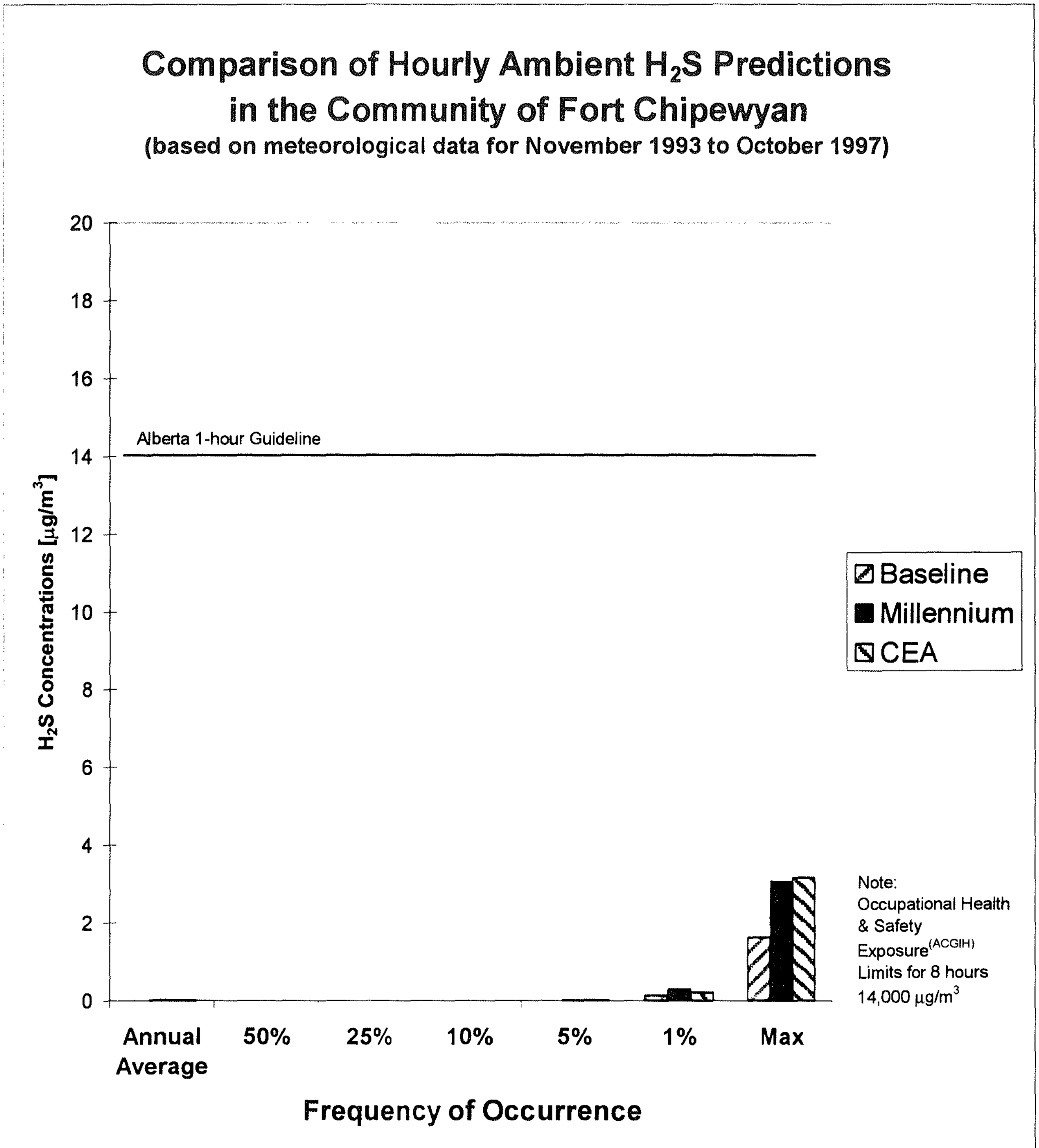


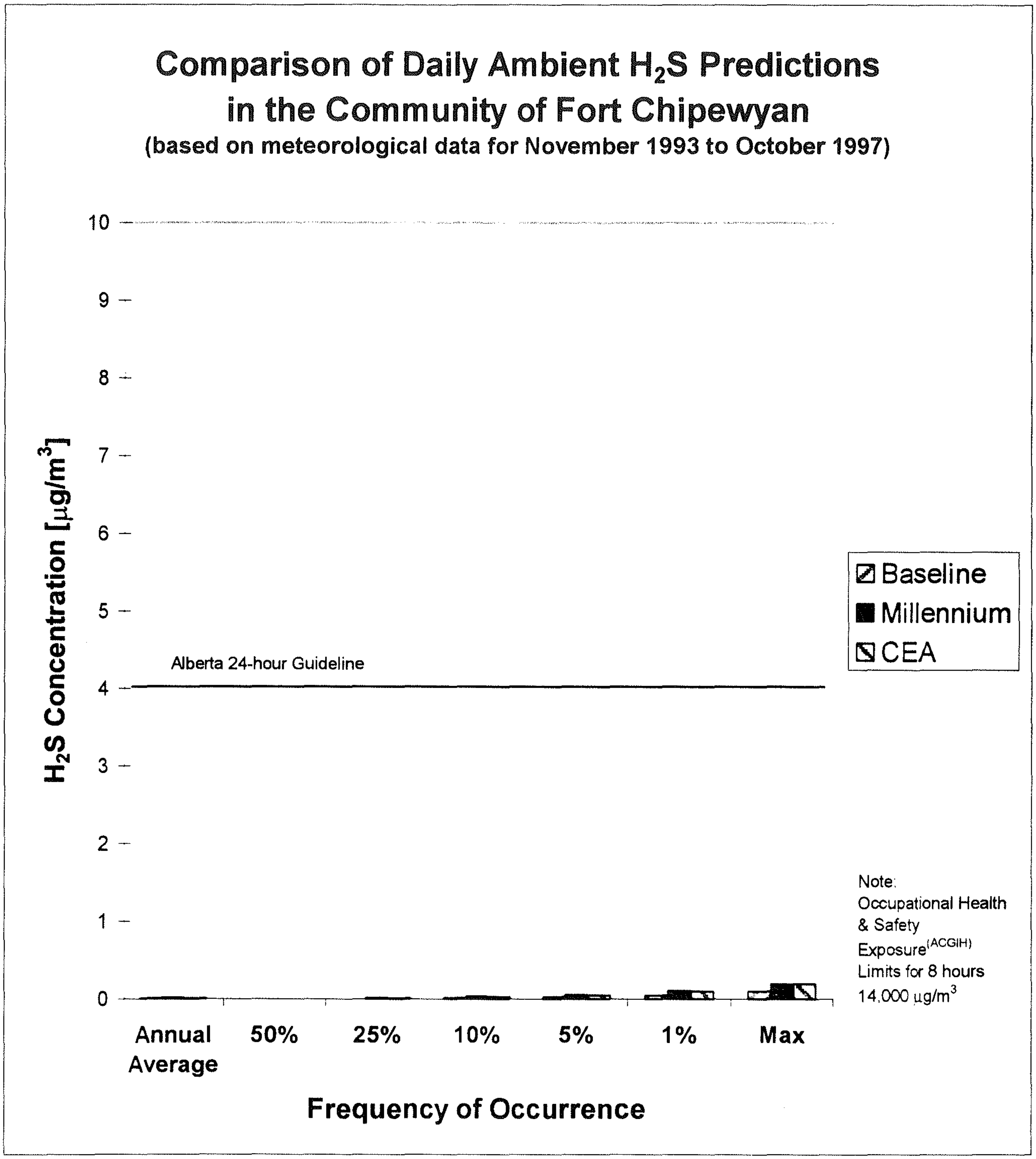


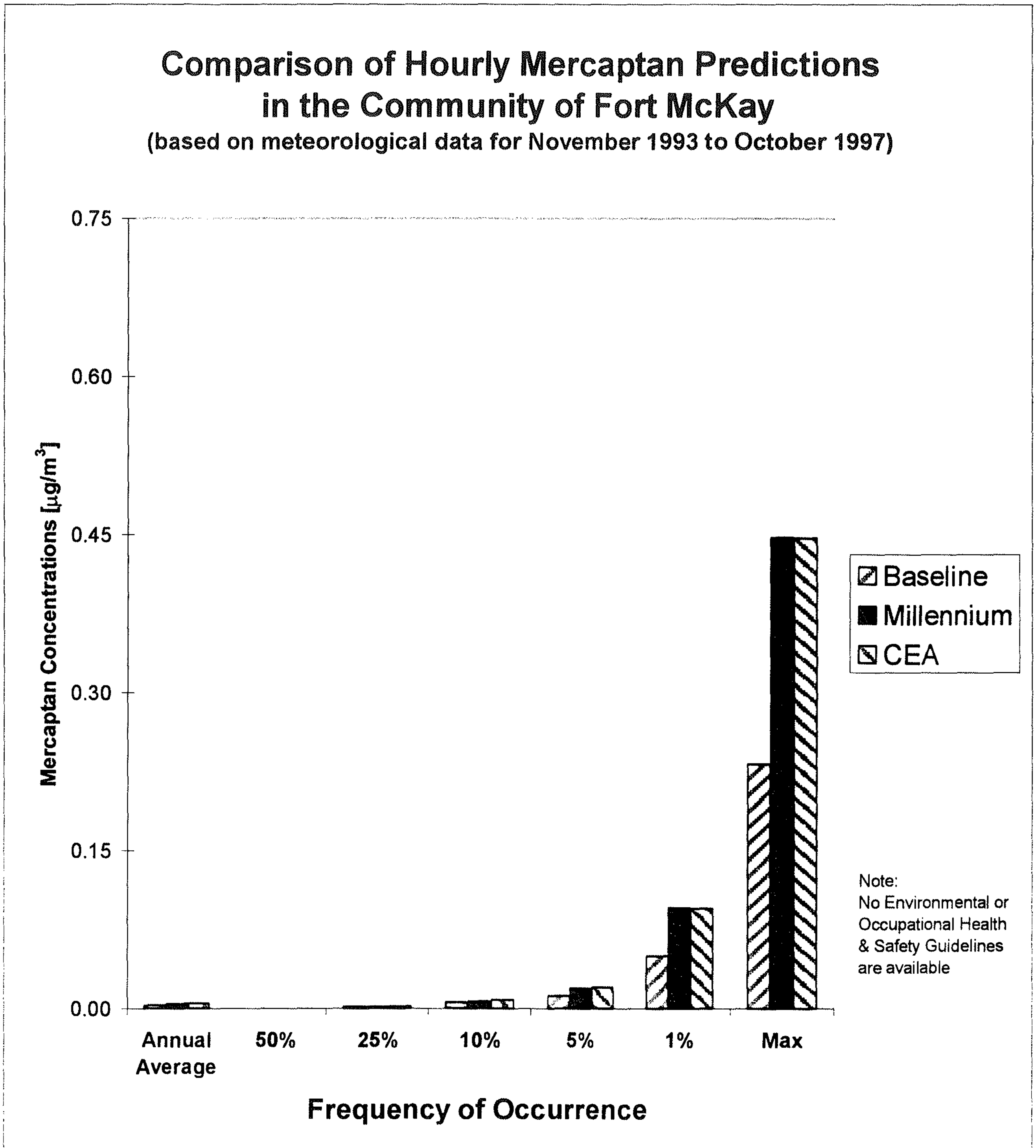
Comparison of Hourly Ambient H_2S Predictions
in the Community of Fort McMurray
(based on meteorological data for November 1993 to October 1997)
20
18
16
14
12
10
8
6
4
2
0
Alberta 1-hour Guideline
H_2S Concentrations [μg/m³]
Baseline
Millennium
CEA
Note:
Occupational Health
& Safety
Exposure(ACGIH)
Limits for 8 hours
14,000 μg/m³
Annual Average
50%
25%
10%
5%
1%
Max
Frequency of Occurrence

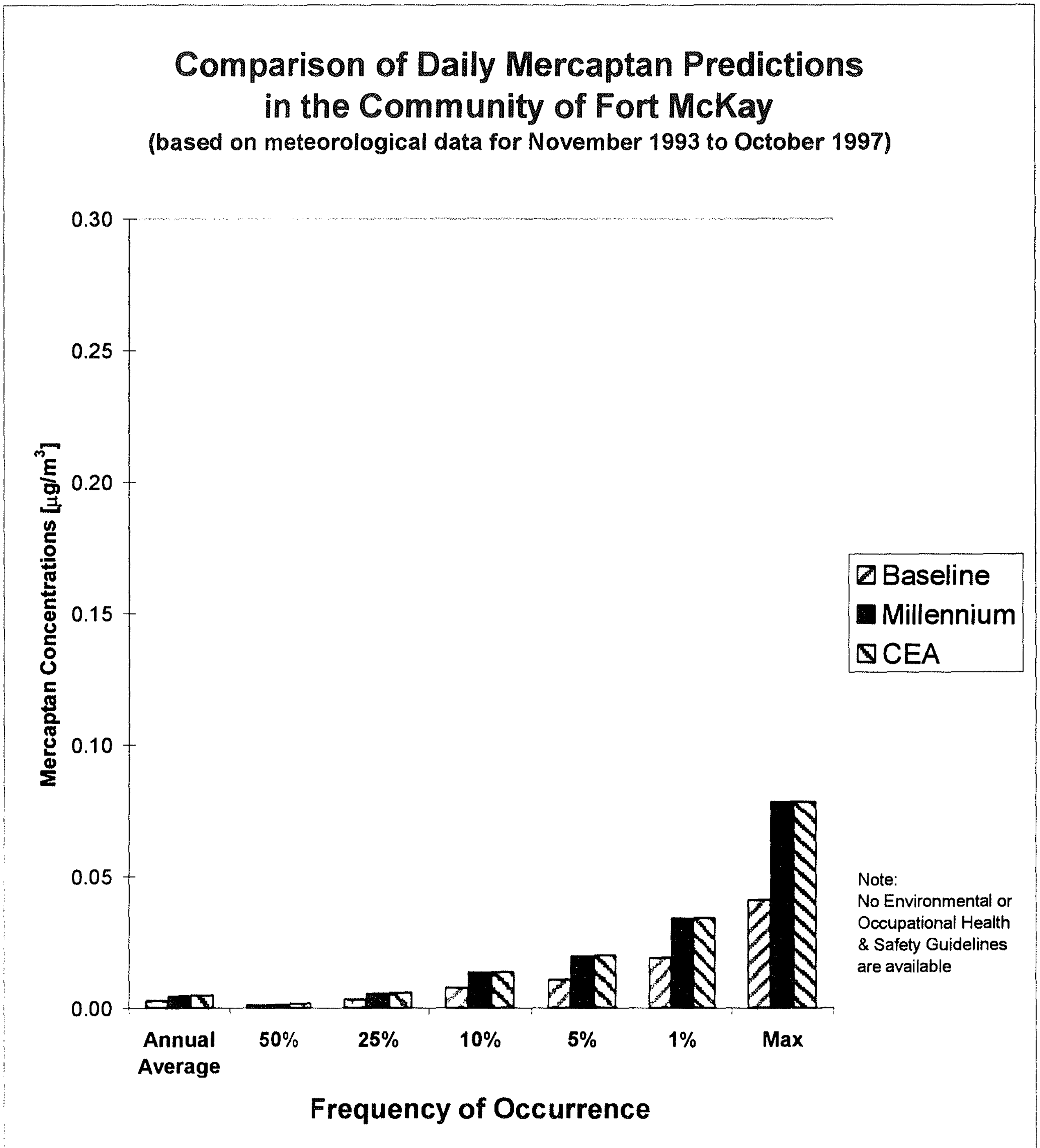


Comparison of Daily Ambient H2S Predictions
in the Community of Fort McMurray
(based on meteorological data for November 1993 to October 1997)
10
9
8
7
6
5
4
3
2
1
0
H2S Concentrations [µg/m3]
Alberta 24-hour Guideline
Baseline
Millennium
CEA
Note:
Occupational Health
& Safety
Exposure(ACGIH)
Limits for 8 hours
14,000 µg/m3
Annual Average
50%
25%
10%
5%
1%
Max
Frequency of Occurrence

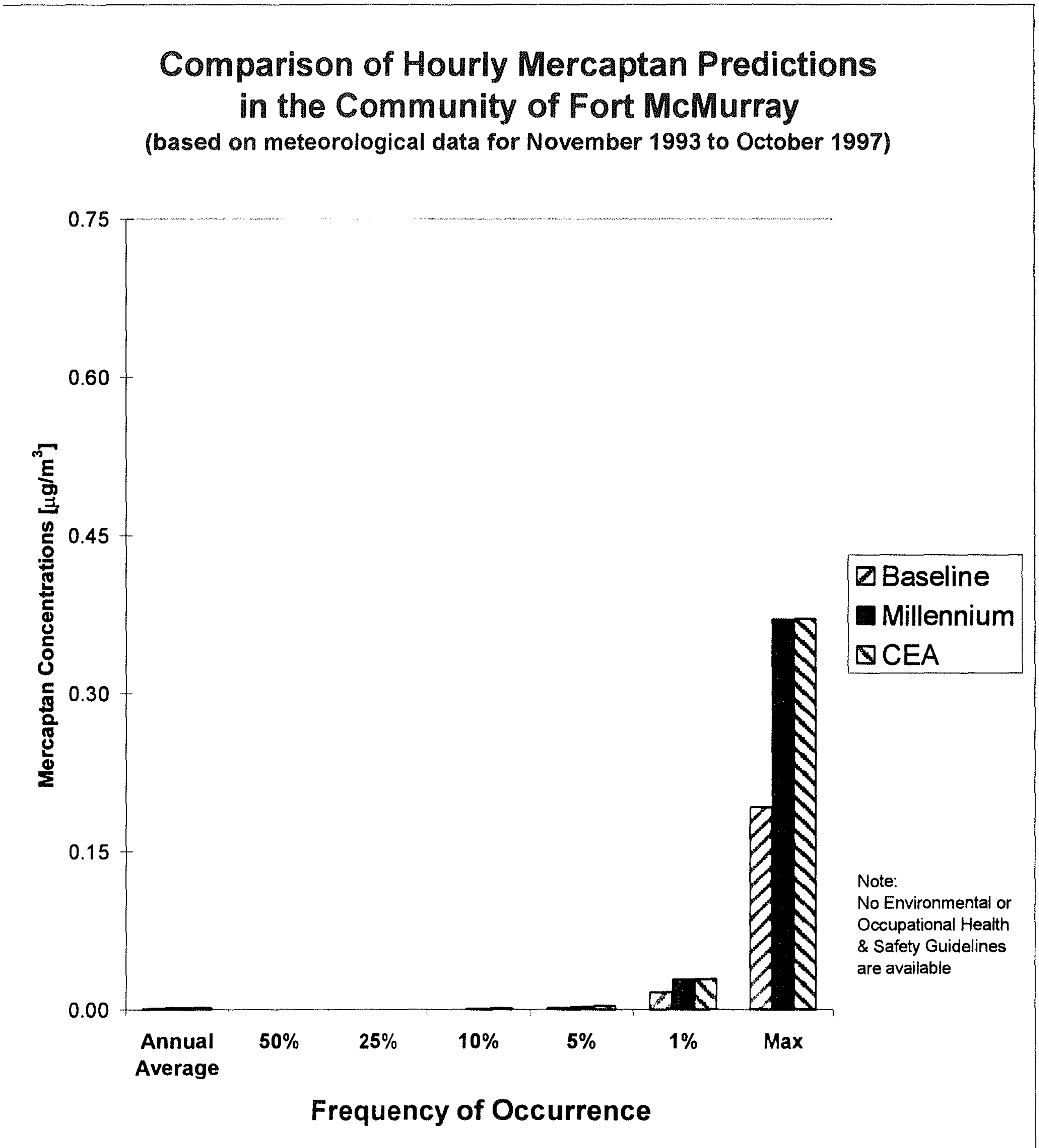

Comparison of Hourly Ambient H2S Predictions
in the Community of Fort Chipewyan
(based on meteorological data for November 1993 to October 1997)
20
18
16
14
12
10
8
6
4
2
0
Alberta 1-hour Guideline
H2S Concentrations [µg/m3]
Baseline
Millennium
CEA
Note:
Occupational Health
& Safety
Exposure(ACGIH)
Limits for 8 hours
14,000 µg/m3
Annual
Average
50%
25%
10%
5%
1%
Max
Frequency of Occurrence


Comparison of Daily Ambient H2S Predictions
in the Community of Fort Chipewyan
(based on meteorological data for November 1993 to October 1997)
H2S Concentration [µg/m3]
10
9
8
7
6
5
4
3
2
1
0
Alberta 24-hour Guideline
Baseline
Millennium
CEA
Note:
Occupational Health & Safety Exposure(ACGIH) Limits for 8 hours 14,000 µg/m3
Annual Average
50%
25%
10%
5%
1%
Max
Frequency of Occurrence

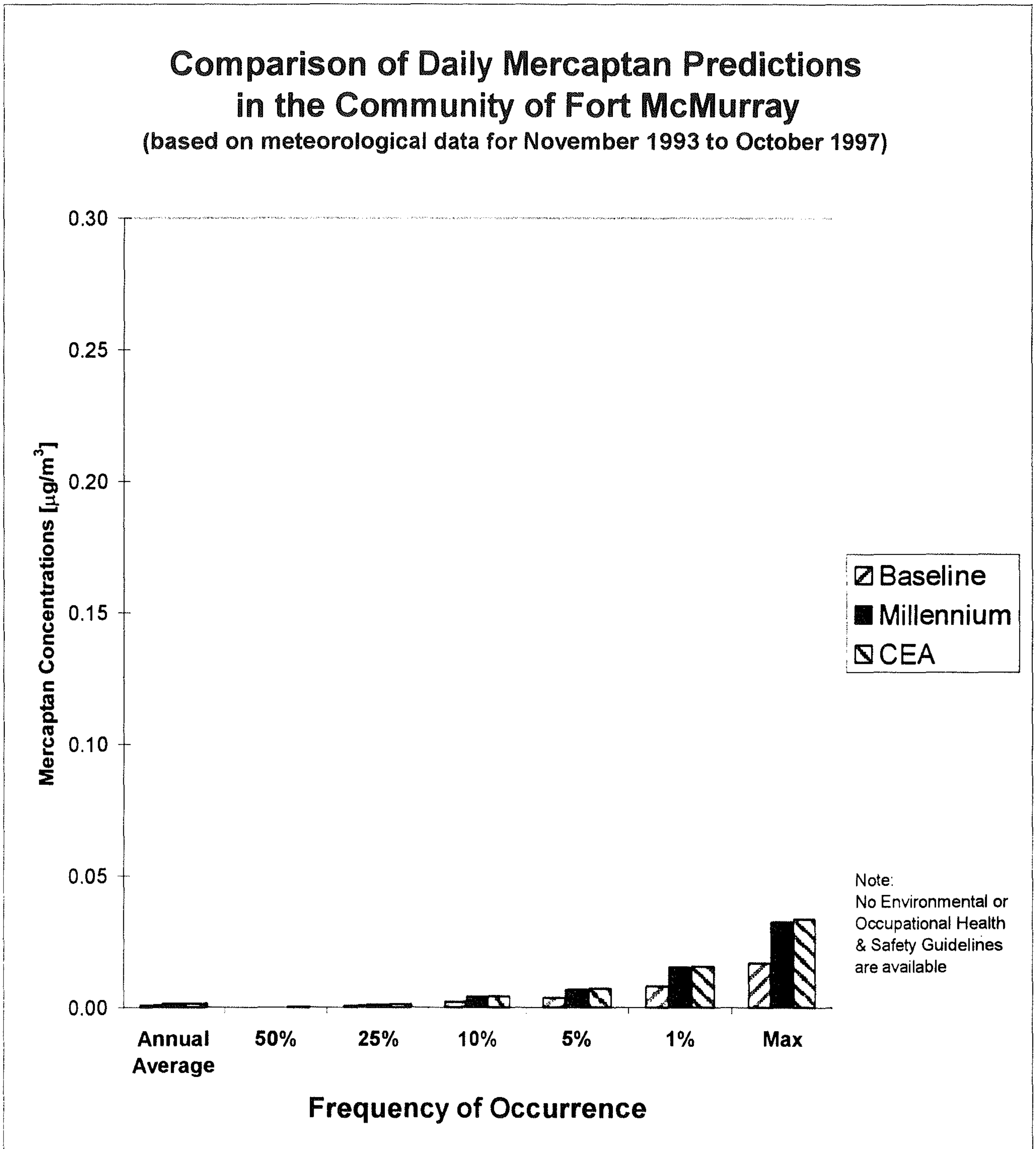

Comparison of Hourly Mercaptan Predictions
in the Community of Fort McKay
(based on meteorological data for November 1993 to October 1997)
0.75
0.60
0.45
0.30
0.15
0.00
Mercaptan Concentrations [μg/m3]
Baseline
Millennium
CEA
Note:
No Environmental or Occupational Health & Safety Guidelines are available
Annual Average
50%
25%
10%
5%
1%
Max
Frequency of Occurrence

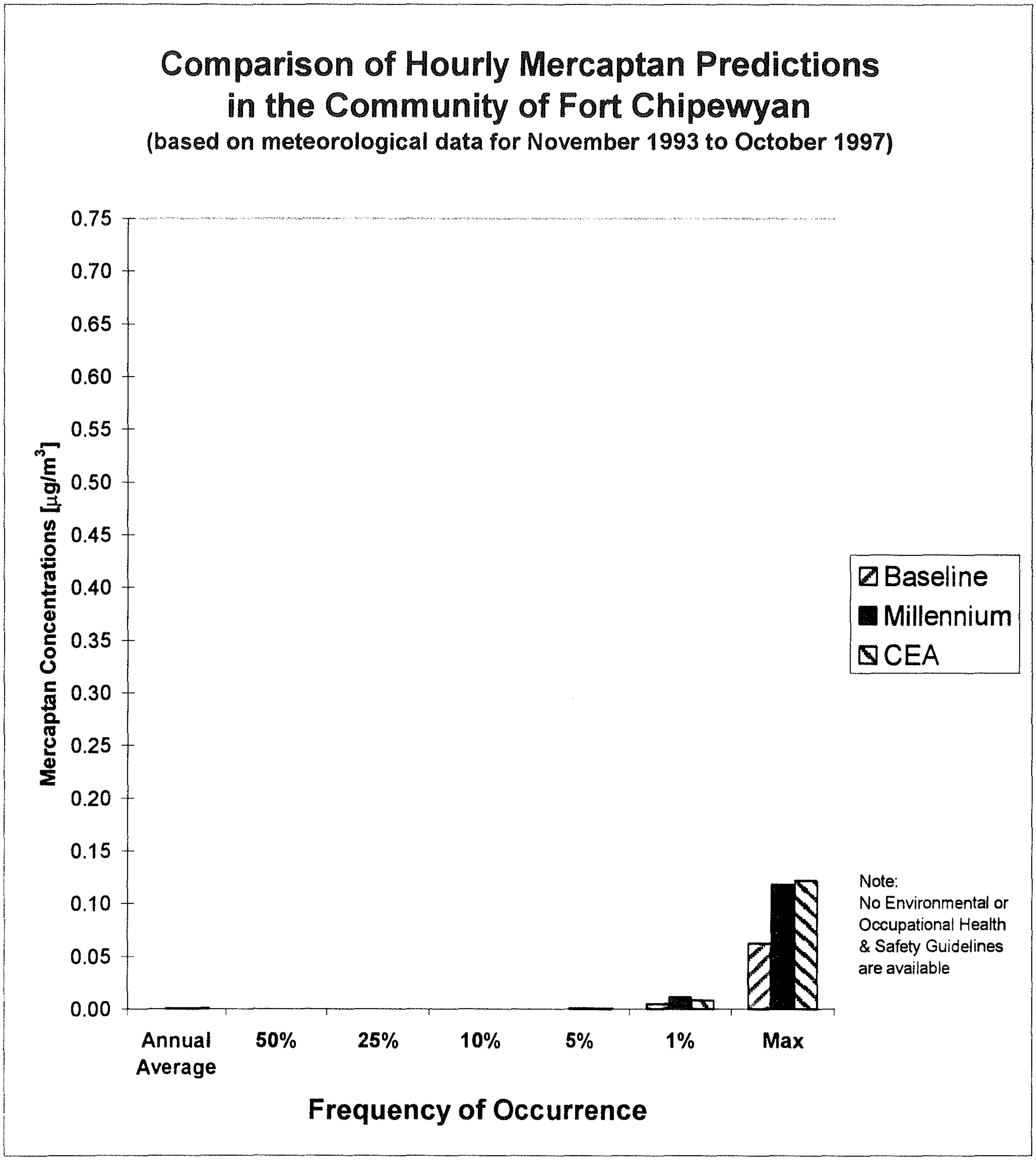


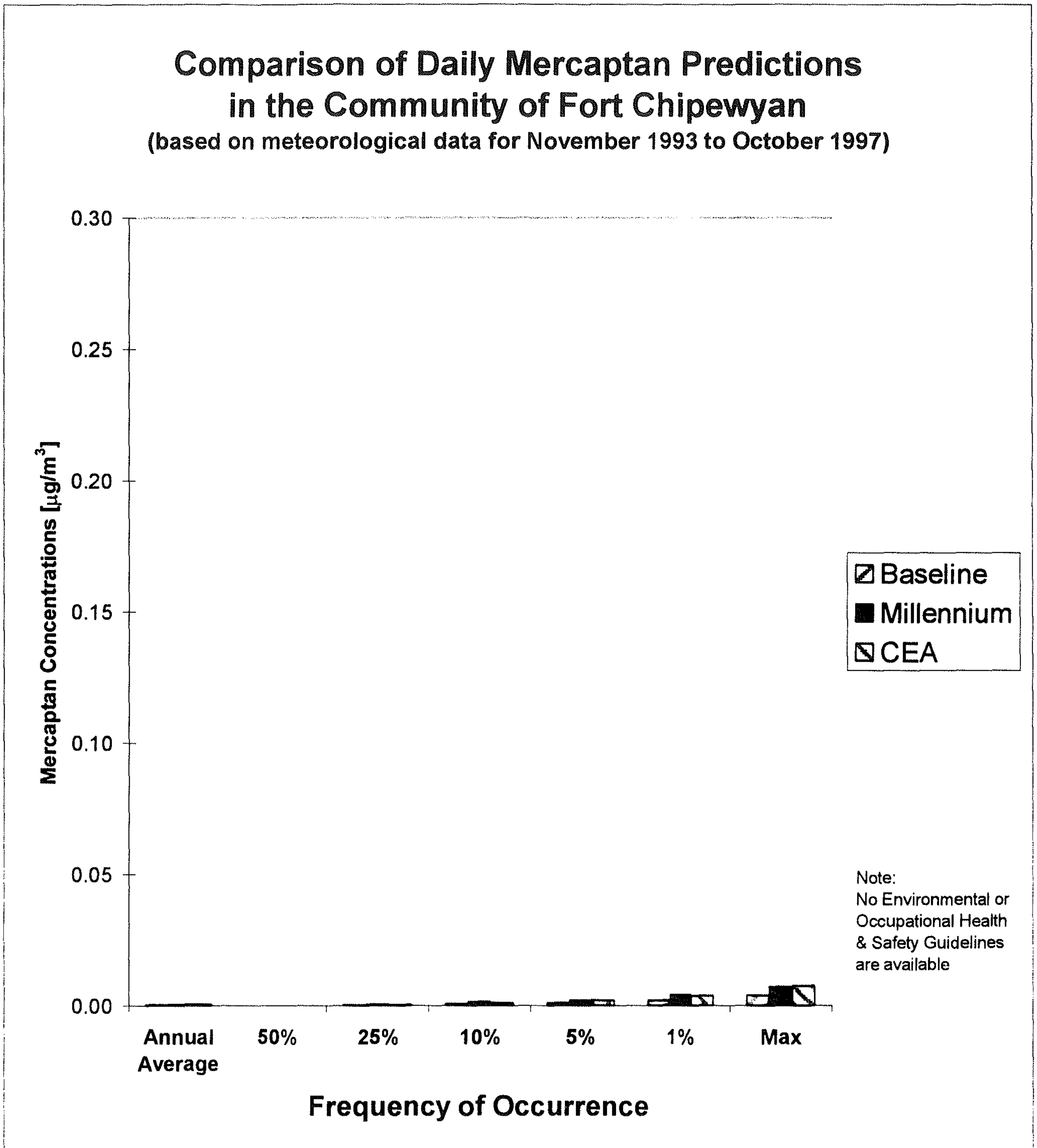
Comparison of Daily Mercaptan Predictions
in the Community of Fort McKay
(based on meteorological data for November 1993 to October 1997)
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Mercaptan Concentrations [µg/m3]
Baseline
Millennium
CEA
Note:
No Environmental or
Occupational Health
& Safety Guidelines
are available
Annual
Average
50%
25%
10%
5%
1%
Max
Frequency of Occurrence



Comparison of Hourly Mercaptan Predictions
in the Community of Fort McMurray
(based on meteorological data for November 1993 to October 1997)
0.75
0.60
0.45
0.30
0.15
0.00
Mercaptan Concentrations [μg/m³]
Annual Average
50%
25%
10%
5%
1%
Max
Frequency of Occurrence
Baseline
Millennium
CEA
Note:
No Environmental or Occupational Health & Safety Guidelines are available


Comparison of Daily Mercaptan Predictions
in the Community of Fort McMurray
(based on meteorological data for November 1993 to October 1997)
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Mercaptan Concentrations [µg/m³]
Annual Average
50%
25%
10%
5%
1%
Max
Frequency of Occurrence
Baseline
Millennium
CEA
Note:
No Environmental or Occupational Health & Safety Guidelines are available


Comparison of Hourly Mercaptan Predictions
in the Community of Fort Chipewyan
(based on meteorological data for November 1993 to October 1997)
Mercaptan Concentrations [µg/m3]
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Annual Average
50%
25%
10%
5%
1%
Max
Frequency of Occurrence
Baseline
Millennium
CEA
Note:
No Environmental or Occupational Health & Safety Guidelines are available



Comparison of Daily Mercaptan Predictions
in the Community of Fort Chipewyan
(based on meteorological data for November 1993 to October 1997)
Mercaptan Concentrations [µg/m³]
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Annual Average
50%
25%
10%
5%
1%
Max
Frequency of Occurrence
Baseline
Millennium
CEA
Note:
No Environmental or Occupational Health & Safety Guidelines are available

E ERRATA

INTRODUCTION

The Table of Errata that follows is abridged to include only those errors and omissions which would compromise the meaning or accuracy of the content of the Project Millennium Application. Minor spelling, punctuation and formatting errors have not been included for the sake of brevity.

Four sections, the contents of which were impacted by air quality modeling are re-submitted (see list after Table of Errata). The original version of these sections reflected modeling of the then best-available air emissions data. Subsequent changes to the data and re-modeling resulted in numerous changes to these sections (the original modeling over-estimated the air quality impacts). For the convenience of the reviewer changes from the original version are highlighted.

TABLE OF ERRATA

Table E2 Project Millennium Application Errata

<table>
<tr><th>Vol.</th><th>Section</th><th>Page/Table</th><th>Item</th></tr>
<tr><td>1</td><td>Section D</td><td>Figure D1-2</td><td>Reverse arrow direction for stream 9.</td></tr>
<tr><td></td><td></td><td>Figure D1-2</td><td>Reverse arrow direction for stream 9.</td></tr>
<tr><td></td><td></td><td>Figure D1-2</td><td>Stream 14 numbers should read 84,443 instead of 78,993 and 147, 456 instead of 142,006.</td></tr>
<tr><td></td><td></td><td>Figure D1-4</td><td>Reverse arrow direction for streams 1, 2, 14 and 15 and between "MINING" and "PRIMARY AND SECONDARY EXTRACTION" boxes.</td></tr>
<tr><td></td><td></td><td>Figure D1-5</td><td>Energy Intensity Factors table: numers in first row of table should read 0.79, 0.78, and 0.69 respectively; heading for last row should read GJ/M^3 OF CRUDE PRODUCED.</td></tr>
<tr><td></td><td>Section E3</td><td>Figure E3-1</td><td>Title should be: Key Components of the Closure Plan.</td></tr>
<tr><td></td><td></td><td>Figure E3-2</td><td>Legend changed and one lake color changed. Figure E3-2 is resubmitted.</td></tr>
<tr><td></td><td>Section E3</td><td>Page E3-42</td><td>Last paragraph, first sentence should read "Establishment of productive habitats on reclaimed areas will be assisted by planting a mixture of native woody-stemmed plant species."</td></tr>
<tr><td></td><td></td><td>References</td><td>Reference citation for Tailings Sand (Figure E3-5) and Overburden (Figure E3-6) missed. Draft guidelines for terrestrial vegetation in the Oil Sands Region (Oil Sands Vegetation Reclamation Committee 1998).</td></tr>
<tr><td></td><td>Section F4</td><td>Page 45</td><td>Third paragraph, last sentence should be corrected to read "In addition, the ratio of commercial to non-commercial forest on the east side of the Athabasca River..."</td></tr>
<tr><td></td><td>Section F4</td><td>Page 45</td><td>"In addition, the ration of commercial to non-commercial forest on the side of the Athabasca River...." should be corrected to read "In addition, the ration of commercial to non-commercial forest on the east side of the Athabasca River...."</td></tr>
<tr><td>2A</td><td>Section A2</td><td>Table A2-13</td><td>Development Area column should be replaced with the following:
<table>
<tr><th>Development</th><th>Development Area (ha)</th></tr>
<tr><td>Suncor Lease 86/17</td><td>2,877</td></tr>
<tr><td>Syncrude Mildred Lake</td><td>18,782</td></tr>
<tr><td>Steepbank Mine/Fixed Plant Expansion</td><td>3,776</td></tr>
<tr><td>Aurora Mine (four trains)</td><td>15,171</td></tr>
<tr><td>SOLV-EX</td><td>2,088</td></tr>
<tr><td>Northstar Energy</td><td>22</td></tr>
<tr><td>Suncor Project Millennium</td><td>5,644</td></tr>
</table></td></tr>
<tr><td></td><td>Section B1</td><td>Page B1-4</td><td>Omit last bullet within the list.</td></tr>
<tr><td></td><td></td><td>Page B1-8</td><td>Second paragraph , first, fifth and last sentences should read Chipewyan rather than Cree</td></tr>
<tr><td></td><td></td><td>Table B1-1</td><td>Alberta Guidelines PM$_{2.5}$ 24-Hour and Annual should be superscript (j).</td></tr>
<tr><td></td><td></td><td></td><td>There should be no values for the Federal Objectives, both Acceptable and Tolerable for PM$_{10}$ Annual Guidelines.</td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
</table>

Vol.	Section	Page/Table	Item
			Changes to footnotes should be: (g) BC and Ontario 24 hour PM_{10} - 50 µg/m^3. (h) U.S. EPA 24 hour PM_{10} - 150 µg/m^3, Annual PM_{10} - 50 µg/m^3. (i) $PM_{2.5}$ - particulate matter emissions with particle diameter less than 2.5 µm. (j) U.S. EPA 24 hour $PM_{2.5}$ - 65 µg/m^3, Annual $PM_{2.5}$ - 15 µg/m^3.
		Page B1-5	Second paragraph, first sentence should read "...Athabasca Chipewyan First Nations..." not "...Athabasca Cree First Nations...".
		Page B1-8	Within the first paragraph, second, fifth and last sentences should read "...Athabasca Chipewyan First Nations..." not "...Athabasca Cree First Nations...".
	Section B2		Re-submitted Section B2.
	Section B3		Re-submitted Section B3.
	Section B4		Re-submitted Section B4.
	Section B5	Page B5-10	Second, third and fourth bullets should read as: • The maximum predicted PAI of 24.7 keq/ha/y occurs in the development area, in the immediate vicinity of the open pit mines. • The maximum predicted sulphate deposition rate of 1.98 keq/ha/y is predicted to occur in the active plant area. • The highest predicted nitrate deposition rate of 23.6 keq/ha/y is predicted to occur in the development area, adjacent to the open pit mines.
	Section C2	Table C2.1-2	"Node" should be changed to "Drainage Basin".
		Page C2-8	Last paragraph in Section C2.1.4 should be: "The three small basins..."
		Table C2.1-5	Table should read as:

Node	Return Interval			
	5 Years	10 Years	50 Years	100 Years
Athabasca River	114.0	102.0	83.5	76.5
Steepbank River	0.190	0.135	0.031	0
Shipyard Lake	0	0	0	0
Shipyard Creek	0	0	0	0
Unnamed Creek	0	0	0	0
Leggett Creek	0	0	0	0
Wood Creek	0	0	0	0
McLean Creek	0	0	0	0
Athabasca A	0	0	0	0
Athabasca B	0	0	0	0
Athabasca C	0	0	0	0

Vol.	Section	Page/Table	Item
		Table C2.2-10	Surface Water Impact Assessment. 1:100 year mean daily maximum discharge for the Steepbank River is 131 m3/s, not 113m3/s (ref. Hydrology Baseline Report).
		Table C2.2-11	Surface Water Impact Assessment. Mean daily low flow values for the Steepbank River have been given in L/s, not m3 as indicated/
		Table C2.2-12	"Bedrock Outflow" should be: "Bedrock Inflow" and the Mean Annual flow should be: "1", not "-1".
	Section C4	Page C4-9	Paragraph 4, last sentence, reference should be "*(Golder 1996a)*".
		Page C4-36	Fifth paragraph, last sentence should read: "...found in Section C4.1.6."

Vol.	Section	Page/Table	Item
		Page C4-41	First paragraph, last sentence should read: "Mining at the north end of Pit 1, in the area of Pond 7a, could also cause an increase in sediment loading in the Steepbank River (Figure C1-1)."
		Page C4-42	Fourth paragraph, last sentence should read: "...(Table C2.2-8)..."
		Page C4-43	First line should read: "...(Table C2.2-8)..."
		Page C4-46	First paragraph, third sentence should read: "...mitigation will be employed to prevent impacts to fish habitat in McLean Creek (Section C3.2.6.6)."
		Page C4-46	Fifth paragraph, first sentence should read: "...no changes in channel regime are expected in these waterbodies (Key Question WQ-4, Section C2.2.4.2)."
		Page C4-54	First paragraph, first sentence should read: "...and fish habitat key question (C4.2.5)."
		Page C4-58	Second paragraph, second sentence should read: "...habitat is attained (Section C4.2.5.2)."
		Page C4-58	Sixth paragraph should read: "...monitoring section of Section C4.2.6.5."
		Table C4.2-6	Table footnote should read: "(1) < indicates less than detection limit."
		Page C4-65	Second paragraph, first and second sentences should refer to Section C3.2.9. Last sentence should read: "...potential diversity of aquatic macrophytes (Section C3.2.9)."
		Page C4-65	Fifth paragraph, last sentence should read: "...follow-up studies identified in Sections C4.2.6.4 and C4.2.8.4 will provide information..."
		Page C4-67	First bullet should read: "avoidance of habitat impacts in the Athabasca River, in part by ensuring a minimum setback above the 1-in-100 year ice-flood level;".
		Page C4-72	First bullet should read: "evaluation of compensation options, and habitat design and construction to determine viable options for habitat compensation;" Following bullets should read: • monitoring of existing and created/enhanced habitat to ensure that mitigation is working and the "No Net Loss" objective is achieved; • monitoring of benthic invertebrates in conjunction with water quality monitoring, to assess the effects on aquatic resources from the end pit lake discharge; • completion of a fish health laboratory study on CT water using trophic level toxicity testing and chemical analyses of CT water to confirm: – no acute or chronic effects on fish,...

<table>
<tr><th>Vol.</th><th>Section</th><th>Page/Table</th><th>Item</th></tr>
<tr><td></td><td>Section C5</td><td>Page C5-11</td><td>Section C5.4.1 is missing the following information:

FCEA-3: What impacts will Project Millennium and the combined developments have on fish abundance?

FCEA-4: Will changes to fish tissue quality will results from Project Millennium and combined developments?

Generally, the key questions that were posed in the impact assessment section apply to the CEA for fisheries and fish habitat, with one exception. Key Question (F-5), that relates to the viability of Project Millennium's</td></tr>
<tr><td>2B</td><td>Section D2</td><td>Table D2.1-6</td><td>Table corrected to read:
<table>
<tr><th>Soil Series</th><th>Area (ha)</th><th>Average Depth (m)</th><th>Volume [a] m^3</th></tr>
<tr><td>McLelland</td><td>1,531</td><td>1.51</td><td>23,115,000</td></tr>
<tr><td>shMcLelland</td><td>3,037</td><td>0.80</td><td>24,300,000</td></tr>
<tr><td>Muskeg</td><td>316</td><td>1.55</td><td>4,904,000</td></tr>
<tr><td>shMuskeg</td><td>3,672</td><td>0.65</td><td>23,863,000</td></tr>
<tr><td>TOTAL</td><td>8,556</td><td>1.13</td><td>76,181,800</td></tr>
</table></td></tr>
<tr><td></td><td></td><td>Table D2.1-7</td><td>Table corrected to read:
<table>
<tr><th>Soil Series</th><th>Area (ha)</th><th>Average Depth (m)</th><th>Volume [a] m^3</th></tr>
<tr><td>Kinosis</td><td>759</td><td>0.5</td><td>3,795,000</td></tr>
<tr><td>Steepbank</td><td>357</td><td>0.5</td><td>1,785,000</td></tr>
<tr><td>TOTAL</td><td>1,116</td><td>n/a</td><td>5,580,000</td></tr>
</table></td></tr>
<tr><td></td><td></td><td>Section D2.1.6.2</td><td>Should be replaced with:
Mineral Soils
None of the mineral soils in the LSA are recommended for direct placement as reclamation material due primarily to textural limitations. It is suggested that the present practice of overstripping the organic deposits to incorporate some of the underlying mineral subsoils is the most practical approach.

The medium to coarse textured mineral soils of the Kinosis and Steepbank series have very shallow A and B horizons, on average 15 and 20 cm respectively. The upper 0.5 m of the profile for both series is suitable for placement as upper subsoil (i.e., as a cap beneath the reclamation topsoil mix). Table D2.1-7 presents data on the approximate amounts of these materials available within the project development footprint (as per Table D2.1-6, these data exclude the areas under the overburden and muskeg storage areas and the tailings pond).</td></tr>
<tr><td></td><td></td><td>Page D2-30</td><td>Change to Table D2.2-5. Livock and Fort soil series are the same (i.e., all may be classed as Livock).</td></tr>
<tr><td></td><td></td><td>Page D2-38</td><td>Change last column in Table D2.2-12 to read:
<table>
<tr><th>Change ha/%RSA</th></tr>
<tr><td>-122/<0.1</td></tr>
<tr><td>-1,010/<0.1</td></tr>
<tr><td>+5,895/0.2</td></tr>
<tr><td>-302/2</td></tr>
<tr><td>-5,379/<0.1</td></tr>
<tr><td>-918/<0.1</td></tr>
<tr><td>0/0</td></tr>
<tr><td>0/0</td></tr>
</table></td></tr>
</table>

Vol.	Section	Page/Table	Item
		Table D2.2-20	Within the Sensitivity Rating Column, Moderate [a] should be changed to Moderate*.
		Table D2.2-22	Delete superscript in heading "Area, ha [a]".
	Section D3	Page D3-22	First paragraph, last two sentences should be replaced with: A picture of a black spruce-jack pine ecosite phase is shown in Figure D3.1-16. This picture was taken from a Labrador tea black spruce-jack pine ecosite phase in the Muskeg River Mine Project (Golder 1997o).
			In the first sentence of the last paragraph, "biodiversity" should be changed to "diversity".
		Page D3-26	Second sentence should read as "The b1 and b3 blueberry ecosite phases and the d1 and d2 low-bush cranberry ecosite phases have the highest mean among ecosite phases surveyed."
			Sixth sentence should read as "The lowest mean diversity in the tree layer is in b2, e1 and e3."
			Last paragraph, last sentence should read "The dogwood ecosites (e1, e2 and e3) have a higher percentage of single layered structured stands, whereas the low-bush cranberry ecosites (d1, d2 and d3) have higher percentage of multilayered structured stands.
		Page D3-28	Last paragraph, second sentence should read as "The Labrador tea black spruce-jack pine ecosite phase (g1) and Labrador tea/horsetail Sw-Sb (h1) ecosite phase have the minimum mean height.
		Table D3.1-17	Addition to Percent column: (see table below)
		Page D3-38	Last paragraph, second sentence should read "They can be dominated by shrubs (FONS), grasses (FONG), wooded (FTNN) and forested (FFNN) fens. The remaining text of the paragraph should be introduced as a new paragraph with the title **Open Fens (FONS and FONG)**.
		Page D3-40	Paragraph title should read "Wooded and Forested Fens (FTNN, FFNN)".
		Page D3-44	Last paragraph should read as: Table D3.1-20 provides an indication of relative species richness among wetlands classes, as indicated by the mean and range of numbers of species. The highest number of total species found in each wetland site are in the wooded (FTNN) and forested (FFNN) fen and the shrubby fen (FONS) (Table D3.1-20). The lowest number of total species found in each wetland site are in the graminoid marsh (MONG). The highest number of species in the shrub layer are in the forested fen (FFNN) and the wooded fen (FTNN); in the herb layer it is in the marsh (MONS) and shrubby fen (FONS). Total shrub species are high among wetlands surveyed. Total tree species are low among wetlands surveyed, particularly among graminoid fens (FONG), marshes (MONG/MONS) and shrubby swamps (SONS).
		Page D3-45	First paragraph, first sentence should read "Table D3.1-21 gives the mean and range of species diversity values for individual plots surveyed within the wetlands classes.
		Page D3-45	First paragraph, first sentence should read "Table D3.1-21 gives the mean and range of species diversity values for individual plots surveyed within the wetlands classes.
			Fourth sentence should read "The highest mean diversity in the shrub layer is in the SONS (shrubby swamp) wetlands class, and the lowest mean diversity are in the FONG (graminoid fen) and MONG (graminoid marsh) wetlands classes.

Table D3.1-17 addition:

Wetlands Type	Percent
Total Wetlands	62
Non-Wetlands	36
Existing Disturbances and Water	2
Total Area	100

<table>
<tr><th>Vol.</th><th>Section</th><th>Page/Table</th><th>Item</th></tr>
<tr><td></td><td></td><td>Table D3.1-22</td><td>Table should read as:
<table>
<tr><th>Wetlands Class</th><th>Multilayered Stand Percentage</th><th>Single Layer Stand Percentage</th></tr>
<tr><td>BFNN</td><td>0.0</td><td>100.0</td></tr>
<tr><td>BTNN</td><td>0.0</td><td>100.0</td></tr>
<tr><td>FFNN</td><td>13.0</td><td>87.0</td></tr>
<tr><td>FONG</td><td>0.0</td><td>100.0</td></tr>
<tr><td>FONS</td><td>0.0</td><td>100.0</td></tr>
<tr><td>FTNN</td><td>39.0</td><td>61.0</td></tr>
<tr><td>MONG</td><td>0.0</td><td>100.0</td></tr>
<tr><td>MONS</td><td>1.8</td><td>98.2</td></tr>
<tr><td>SFNN</td><td>8.3</td><td>91.7</td></tr>
<tr><td>SONS</td><td>0.0</td><td>100.0</td></tr>
<tr><td>STNN</td><td>52.1</td><td>47.9</td></tr>
<tr><td>WONN</td><td>0.0</td><td>100.0</td></tr>
</table></td></tr>
<tr><td></td><td></td><td>Page D3-47</td><td>Last paragraph, second last sentence should read as “The maximum height of standing trees was found in the wooded fen (FTNN) and coniferous swamp (STNN) wetlands classes.</td></tr>
<tr><td></td><td></td><td>Table D3.2-1</td><td>The value of 5,956 ha for Terrestrial Vegetation in the Pre-development LSA should be 5,856 ha.</td></tr>
<tr><td></td><td></td><td>Page D3-64</td><td>Second last paragraph, first sentence should read “Terrestrial ecosite phases occupy 5,856 ha or 36% of the LSA (Table D3.2.1).”</td></tr>
<tr><td></td><td></td><td>Table D3.2-3</td><td>LSA column should read as (bolded numbers are the corrections):
<table>
<tr><th>Level Code</th><th>LSA (ha)</th></tr>
<tr><td>Shallow Open Water (W)</td><td>15</td></tr>
<tr><td>Marsh (M)</td><td>107</td></tr>
<tr><td></td><td>211</td></tr>
<tr><td>Subtotal</td><td>333</td></tr>
<tr><td>Swamps (S)</td><td>1,359</td></tr>
<tr><td></td><td>687</td></tr>
<tr><td></td><td>161</td></tr>
<tr><td>Subtotal</td><td>2,207</td></tr>
<tr><td></td><td>426</td></tr>
<tr><td></td><td>4</td></tr>
<tr><td></td><td>6,012</td></tr>
<tr><td></td><td>966</td></tr>
<tr><td>Subtotal</td><td>7,407</td></tr>
<tr><td>Bogs (B)</td><td>20</td></tr>
<tr><td></td><td>26</td></tr>
<tr><td>Subtotal</td><td>46</td></tr>
<tr><td>Total Wetlands</td><td>9,994</td></tr>
<tr><td>Terrestrial Vegetation</td><td>5,856</td></tr>
<tr><td>Lakes</td><td>26</td></tr>
<tr><td>Rivers</td><td>79</td></tr>
<tr><td>Existing Disturbances</td><td>226</td></tr>
<tr><td>Total</td><td>16,181</td></tr>
</table></td></tr>
<tr><td></td><td></td><td>Page D3-75</td><td>The last sentence in the third paragraph should be deleted.</td></tr>
<tr><td></td><td></td><td>Page D3-76</td><td>Second paragraph, sixth sentence should read “...would have removed...” as well as “east bank mining areas” should be “east bank mining area”.</td></tr>
<tr><td></td><td></td><td>Page D3-80</td><td>Third paragraph should read “...it occurs at the fringe of its range, or for some other reason, exists in low numbers...”</td></tr>
<tr><td></td><td></td><td>Page D3-98</td><td>First paragraph should read “ of the plant at Sudbury,...”</td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
</table>

Vol.	Section	Page/Table	Item
	Section D5	Page D5-12	Third paragraph, second last sentence should read "...study area were 0.31 tracks/km-track day..." instead of "...study area were 22.8 tracks/km-track day..."
			Fourth paragraph, last sentence should read "In a 1997 study, coyotes were recorded at a track density of 0.24 tracks/km-track day in January (Golder 1997s).
		Page D5-13	Third paragraph, third sentence should read, "...densities up to 0.59 tracks/km-track day...", versus "...densities up to 37.4 tracks/km-track day".
			Third paragraph, fourth sentence should read, "...recorded as a track density of 0.29 tracks/km-track day..." ,versus "...recorded as a track density of 22.2 tracks/km-track day...".
			Fourth paragraph, third sentence should read, "...densities of up to 0.44 tracks/km-track day..." and "...surveys and up to 1.16 tracks/km-track day...", versus "...densities of up to 18.3 tracks/km-track day..." and "...surveys and up to 181.1 tracks/km-track day...".
			Fifth paragraph, last sentence should read "Weasels were recorded at up to 0.71 tracks/km-track day in the 1997 Seepbank River surveys, and up to 0.80 tracks/km-track day in the Lease 29 uplands area (Golder 1997s)."
		Page D5-14	First paragraph, last sentence should read "...densities up to 0.05 tracks/km-track day...", versus "...densities up to 2.5 tracks/km-track day...".
			Fourth paragraph, last sentence should read "The 1997 track count survey indicated that coyotes preferred disturbed areas (3.95 tracks/km-track day) and wooded fens (0.03 tracks/km-track day) and wooded bogs (0.14 tracks/km-track day) Golder 1997s).
		Page D5-15	First paragraph, last two sentences should read "In the 1997 Upland Lease 29 study, fisher tracks were found in low-bush cranberry Aw-Sw (d2), wooded fens (Ftnn) and wooded bogs (Btnn) (Golder 1997s). Martens avoided low-bush cranberry (d1, d2 and d3); lichen jackpine (a1); shrubland (shrub); and shallow open water (Wonn).
			Second paragraph, last sentence should read "In this study, weasels preferred wooded bogs (Btnn)."
		Page D5-16	Fourth paragraph, second last sentence should read "...at a density of 0.59 tracks/km-track day...", versus "...at a density of 10.47 tracks/km-track day...".
		Page D5-18	Third paragraph, last sentence should read "...estimates of up to 15.98 tracks/km-track day...", versus "...estimates of up to 22.4 tracks/km-track day...".
			last paragraph, last sentence should read "...densities of up to 9.86 tracks/km-track day...", versus "...densities of up to 1,671 tracks/km-track day...".
		Page D5-19	Second paragraph, second last sentence should read "...low-bush cranberry-aspen poplar -white spruce (d2)."
			Third paragraph, last sentence should read "In the 1997 study, red squirrels preferred low-bush cranberry aspen poplar-white spruce (d2) and avoided lichen-jackpine (a1), Labrador tea/horsetail-white spruce-black spruce (h1) and wooded fens (Ftnn), wooded bogs (Btnn) and shrubland (shrub) (Golder 1997s)."
		Page D5-35	First paragraph, should read "...that the LSA contains..."
		Page D5-52	Within the Residual Impact Classification table, the High rating should be ER>20.
	Section D6		Re-submitted Section D6.
	Section E	Figure E-1	Change to figure. Replacement submitted.
2C	Section F1	Table F1.1-3	Within the Chemical column, last row, "aromatiicx(b)" should read as "aromatics(g) ".
		Table F1.2-1	C9-C12 Aliphatics(e) for Fort McMurray should be 0.019.
		Table F1.2-2	For Shipyard Lake in 1997, vanadium should be 0.0000005, beryllium should be 0.001 and Total Carcinogens should be 0.008.
		Table F1.2-3	For the Athabasca River Far Future, the Total Carcinogens should be 4.8.
		Page F1-62	The Frequency within the Impact table should be High.
		Page F1-65	The Frequency within the Impact table should be High.
		Page F1-71	The Frequency within the Impact table should be High.

Vol.	Section	Page/Table	Item
		Table F1.5-1	The Magnitude for HH-2, HH-3, HH-4 and CHH-1 should all be Low.
	Section F3	Page F3-69	First paragraph, seventh sentence should reference Section F3.4.7.
		Page F3-70	Third paragraph should reference Section F3.4.4.
		Page F3-83	Second paragraph should reference Section F3.4.7.
		Page F3-85	Fourth paragraph should reference Section F3.4.7.
2D	Appendix III	Table III-2	Fort McMurray and Fort McKay should be deleted from the table.
	Appendix V	Page V-16	Page V-16 should include the following: The regulatory guidelines used in the impact assessment for toxicity receiving environment were TUa≤0.3 and TUc≤1 (AEP 1995d). guidelines were developed by the USEPA based on a large set of effluent toxicity data. The guideline values correspond to the approx values of the NOEC for acute and chronic endpoints. Hence, predicte values below the guidelines indicate the absence of toxicity. **V.1.5 Water Quality Modelling Results** **V.1.5.1 Athabasca River** Tables V-6 to V-10 summarize projected water quality in the Atha River during mean open-water and annual 7Q10 flows. **V.1.5.2 McLean Creek** Tables V-11 and V-12 summarize projected water quality in McLean during annual average and low flow conditions. **V.1.5.3 Shipyard Lake** Table V-13 summarizes projected average annual water quality in Shi Lake.
	Appendix VI	Table VI.1-41	Baseline Water Exposure Column should also include barium and molybdenum.
			Baseline Air Exposure Column should also include C2-C8 aliphatics, C9-C12 aliphatics, C6-C8 aromatics, C9-C12 aromatics and benzene.
			Baseline Plant Exposure should also include boron, cadmium and nickel.
		Table VI.1-52	HH-2 Air Exposure (Operation) Column should include C2-C8 aliphatics, C9-C12 aliphatics, C6-C8 aromatics, C9-C12 aromatics and benzene.
		Section VI.4.3	Note: Text bullets #1 to 6 do not necessarily apply to the assessment of air quality impacts, as currently presented in F. The supplemental information for the human health assessment of air quality issues will reflect the methodology provided here.
		Section VI.5.1.1	Cobalt - The last sentence of the second paragraph should include a receptor-specific NOAEL of 3.0 for the water shrew.
			Manganese - A NOAEL of 977 mg/kg/day was used in the analysis for killdeer, based on adverse effects on growth and behaviour in Japanese quail (Laskey and Edens 1985).

Vol.	Section	Page/Table	Item
The following Ierrata is for a key reference report Wildlife Baseline Conditions For Project Millennium. April 1998. By: Golder Associates for Suncor Energy Inc., Oil Sands			
	Abstract		Second, third and fourth paragraphs should be replaced with the following: Winter track count and early summer browse/pellet group count surveys in that the relative abundance of moose and deer was low compared to other a northern Alberta. Within vegetation communities, no difference in habitat use be detected, but at the landscape level, ungulates utilized riparian areas signifi more than escarpment and upland communities. Preferred browse material (e. osier dogwood, willow) was relatively uncommon, a condition which ma caused limited use of this area by moose. Winter track count data suggested that the relative abundance of most of the furbearers (e.g., wolves, coyotes, wolverines, and lynx) was low in the Local Area (LSA). Red squirrels preferred low-bush cranberry-aspen poplar- white (d2) over lichen-jack pine (a1), Labrador tea/horsetail-white spruce-black (h1), wooded fens (FTNN) and wooded bogs (BTNN). At the landscape squirrels avoided upland areas. Snowshoe hares preferred low-bush cranberry poplar-white spruce (d2). Hares avoided lichen-jack pine (a1), low-bush cra white spruce (d3) and aspen poplar (d1) and wooded bogs (BTNN). landscape level, snowshoe hares preferred upland habitats. Tracks were detected for wolves, coyotes, fishers, marten, weasels and mink wolf tracks were recorded and a habitat preference for wolves could determined. Wolves did show a preference for upland areas and a escarpment. Coyotes preferred disturbed areas (CIU), wooded fens (FTN wooded bogs (BTNN). Coyotes and red foxes did not show a landscape pref Martens avoided low-bush cranberry (d1, d2, d3) and lichen jackpine (a1), fishers showed no preference or avoidance. Weasels avoided low-bush cra (d1, d2, d3); lichen jackpine (a1); riparian shrubland (shrub); and open, s water (WONN). Martens preferred escarpment areas, fishers preferred upland and weasels avoided escarpment areas. Mink were not recorded duri Steepbank River survey. In the Upland Lease 29 survey, mink preferred ri shrubland (shrub). Mink were also observed on Shipyard Lake. No rive tracks were observed. Lynx tracks were only observed during the Steepbank surveys. Lynx tracks were found in riparian areas.
	Executive Summary		Third and fourth paragraphs should be replaced with the following: Winter track count data suggest that the relative abundance of most of the larger furbearers (e.g., coyotes, lynx, wolves, wolverines) was low in the study area. Red squirrels preferred low-bush cranberry-aspen poplar- white spruce (d2) over lichen-jack pine (a1), Labrador tea/horsetail-white spruce-black spruce (h1), wooded fens (FTNN) and wooded bogs (BTNN). At the landscape level, squirrels avoided upland areas. Snowshoe hares preferred low-bush cranberry-aspen poplar-white spruce (d2). Hares avoided lichen-jack pine (a1), low-bush cranberry-white spruce (d3) and aspen poplar (d1) and wooded bogs (BTNN). At the landscape level, snowshoe hares preferred upland habitats. Tracks were detected for wolves, coyotes, fishers, marten, weasels and mink. Few wolf tracks were recorded and a habitat preference for wolves could not be determined. Wolves did show a preference for upland areas and avoided escarpment. Coyotes preferred disturbed areas (CIU), wooded fens (FTNN) and wooded bogs (BTNN). Coyotes and red foxes did not show a landscape preference. Martens avoided low-bush cranberry (d1, d2, d3) and lichen jackpine (a1), while fishers showed no preference or avoidance. Weasels avoided low-bush cranberry (d1, d2, d3); lichen jackpine (a1); riparian shrubland (shrub); and open, shallow water (WONN). Martens preferred escarpment areas, fishers preferred upland areas, and weasels avoided escarpment areas.

Vol.	Section	Page/Table	Item
			Mink were not recorded during the Steepbank River survey. In the Upland Lease 29 survey, mink preferred riparian shrubland (shrub). Mink were also observed on Shipyard Lake. No river otter tracks were observed. Lynx tracks were only observed during the Steepbank River surveys. Lynx tracks were found in riparian areas. Fifth paragraph, second sentence should read as "...for grouse species in the Upland Lease 29 study area were 0.99 tracks/km-track day..." versus "...for grouse species in the Upland Lease 29 study area were 45.88 tracks/km-track day...".
	Section 4.3.1	Page 15	First paragraph, third sentence in Field Methods should read as "...at altitudes of approximately 50 m above...".
	Section 5.1.1.2	Page 27	Second paragraph, last sentence should read as "...(1.16 tracks/km-track day)." versus "...(0.35 tracks/km-track day)."
	Section 5.1.1.4	Page 29	Fourth sentence should read as "Winter track counts for this study indicated that moose use riparian areas and avoid upland and escarpment areas at certain times of the year."
	Section 5.2.1.1	Page 31	First paragraph, last sentence should read as "Winter track counts for this study recorded 0.06 tracks/km-track day in January and 0.03 tracks/km-track day in February for coyotes (Golder 1997a)."
	Section 5.2.1.1	Page 32	First paragraph, second last sentence should read as "...for the month of March were 0.31 tracks/km-track day..." versus "...for the month of March were 0.31 tracks/km-track day...".
	Section 5.2.1.2	Page 32	First paragraph, last sentence should read "The 1997 winter track count survey indicated that coyote tracks were most often detected in disturbed areas (CIU) (3.95 tracks/km-track day), wooded fens (FTNN) (0.03 tracks/km-track day) and wooded bogs (BTNN) (0.14 tracks/km-track day)."
	Section 5.2.2.1	Page 34	First paragraph, second last sentence should read "...fisher track density was recorded at 0.59 tracks/km-track day...".
	Section 5.2.2.1	Page 34	Second and third paragraphs should read as: Westworth (1979) classified martens as scarce in the Lease 17 area. Recently, We Brusnyk and Associates (1996c) reported that track densities for the Lease 12, 13 and were 0.15 tracks/km-track-day, suggesting a possible resurgence of martens in the area. were recorded at densities of 0.36, 0.35 and 0.44 tracks/km-track day in January, Febru March of the Steepbank River surveys. In the Upland Lease 29 surveys, marten densiti recorded at 0.38 tracks/km-track day in January and 1.16 tracks/km-track day in February 1997a). These high numbers may be indicative of the continued resurgence of marten. Weasels are the most common carnivores in the oil sands area. Ermines are considered a and least weasels uncommon, although the inability to distinguish the species based o makes this speculative. Combined track densities for the two species were 1.14 tracks/k day for the Lease 88 and 89 areas, and 1.22 tracks/km-track-day for the Lease 12, 13 and (Westworth, Brusnyk and Associates 1996c). A track density of 1.12 tracks/km-track-recorded in 1997 in the Shell Lease 13 area (Golder 1998a). Weasels were recorded tracks/km-track day in January and 0.48 tracks/km-track day in February for the Steepban surveys. No weasel tracks were recorded in March during that survey. In the Upland L surveys, weasel tracks were recorded at 0.80 and 0.78 tracks/km-track day in Janu February, respectively.
	Section 5.2.2.2	Page 34	Second paragraph should read as: Martens and fishers are thought to prefer middle to late stage coniferous forests (Busk Ruggiero 1994, Powell and Zielinski 1994). Inventory work on Lease 12, 13 and 34 (We Brusnyk and Associates 1996c) showed that fisher tracks were found in greatest frequ riparian balsam poplar forest. In the Upland Lease 29 study area, fisher tracks were found bush cranberry-aspen poplar-white spruce (d2), wooded fens (FTNN) and wooded bogs (Chi-square analysis suggested that martens avoid low-bush cranberry (d1, D2, D3), jackpine (a1) and shrubland (shrub).
	Section 5.2.2.2	Page 35	Last paragraph, second last sentence should read as "In the Upland Lease 29 surveys, weasels preferred wooded bogs (BTNN) and avoided low-bush cranberry (d1, d2, d3), lichen jackpine (a1), riparian shrubland (shrub), and open shallow water (WONN) in January.
	Section 5.2.2.4	Page 35	First paragraph, second sentence should read as "...weasels avoided escarpment and preferred riparian areas..."

Vol.	Section	Page/Table	Item
	Section 5.2.2.4	**Page 35**	First paragraph, fifth and sixth sentences should read as "Fishers preferred upland areas in February..." and " ...showed no preference in January or March." respectively.
	Section 5.2.3.1	**Page 36**	First paragraph, second last sentence should read as "...were recorded as at density of 0.02 and -0.05 tracks/km-track day...".
	Section 5.2.3.3	**Page 36**	First paragraph first sentence should read "Lynx tracks were recorded in riparian areas during February Steepbank River surveys."
	Section 5.3.2.1	**Page 40**	Second paragraph, second last sentence should read as "...mink were recorded at a density on 0.59 tracks/km-track day."
	Section 5.4.2.1	**Page 42**	First paragraph, last sentence should read as "....and this study produced estimates of 15.98 tracks/km-track day."
	Section 5.4.2.1	**Page 43**	First paragraph, last sentence should read as "...densities of up to 9.86 tracks/km-track day were recorded...".
	Section 5.4.2.2	**Page 43**	First paragraph, last sentence should read "For the current study, hares were found to prefer low-bush cranberry-aspen poplar-white spruce (d2) and to avoid lichen-jackpine (a1), low-bush cranberry-white spruce (d3), low-bush cranberry-aspen poplar (d1), wooded fens (FTNN), wooded bogs (BTNN), shrublands (Shrub) and shallow, open water (WONN).
	Section 5.4.2.2	**Page 43**	Second paragraph, last sentence should read "In this study, red squirrels were found to prefer low-bush cranberry-aspen poplar-white spruce (d2) and to avoid lichen-jackpine (a1), Labrador tea/horsetail-white spruce-black spruce (h1), lichen jackpine (a1), Labrador tea/horsetail-white spruce-black spruce (h1), wooded fens (FTNN) and wooded bogs (BTNN).
	Section 5.4.2.4	**Page 44**	Second last sentence should end with "...and riparian areas."
	Section 5.6.1.1	**Page 47**	Last two sentences should read as "Up to 0.30 tracks/km-track day were recorded during the Steepbank River surveys. Up to 0.99 tracks/km-track day were recorded in the Upland Lease 29 surveys.

RE-SUBMITTED ITEMS

The following are re-submitted (in a separate attachment):

- Volume 1, Figure E3-2
- Volume 2B, Figure E-1
- Volume 2A, Section B2
- Volume 2A, Section B3
- Volume 2A, Section B4
- Volume 2B, Section D6

APPENDIX I

Materials Handling Constraints on Pond 1 Reclamation

Materials Handling Constraints on Pond 1 Reclamation

Prepared by R. Sisson, Ph.D, P.Eng.
Manager, Tailings Engineering
June 30, 1998

SUNCOR ENERGY

The Alberta Energy and Utilities Board (AEUB) Approval No. 8101, Clause 6 requires that Suncor submit a report that describes the material handling and the need to defer the Reclamation of Pond 1 past 2002. This report has been prepared to meet that requirement.

Background

Pond 1 (Suncor's original tailings pond) commenced operation in 1967. The pond is currently receiving only a small tailings stream from the Extraction centrifuge plant and periodic flows from the Upgrader. At its deepest point it contains a deposit (about 30 m deep) of exceptionally viscous mature fine tailings and less than 2 m of recycle water. As the fine tailings currently in the pond will not settle to form a soil-like material for hundreds of years, these materials will be removed and replaced with stable infill. Pond 1 will thus be transformed into a stable, trafficable and revegetated landform.

Prior to implementation of Consolidated Tails, it was planned to pump fine tailings from Pond 1 to Pond 5, Pond 6, or both. This pumping operation could be conducted relatively independently of the rest of the tailings operation, and the target date to begin revegetation of the infilled Pond 1 was 2002. However, the conversion to the Consolidated Tailings reclamation process required delaying this target date for reclamation of Pond 1 until 2010. The constraints and opportunities that have guided development of the reclamation schedule for Tar Island Pond are presented in this document.

Suncor Tailings Plan

The tailings plan described in this report was developed for the ore feed to Plant 3 using production schedules developed for Lease 86/17 and Steepbank Pit 1 at the rates for the Production Enhancement Phase (PEP). The oilsand and bitumen production rates associated with this program are presented on Table 1. Suncor continues to optimize resource recovery with this plan subject to economic and operating constraints, but the target date for Pond 1 remains fixed. The proposed Millennium Project does not change the rates of ore feed to Plant 3 and thus will not change the reclamation plan for Pond 1 described in this report.

Tailings Operation Overview

Figure 1 shows a schematic diagram of the tailings process at Suncor. Tailings from the extraction plant are cycloned to provide sand with sufficient density to produce CT. In addition to use in CT, the sand underflow from the cyclones is used in cell construction for sand sections of tailings pond dykes. During upset periods, relatively small amounts of cyclone underflow are deposited in tailings ponds as beach material.

CT is produced by mixing cyclone underflow with gypsum from the Flue Gas Desulpherization plan and with mature fine tails from either Pond 2/3 or Pond 1. The CT is then pumped to the active CT deposition pond, which is currently Pond 5 as shown in the diagram. CT release water is pumped back to Pond 2/3, where it is stored for recycle

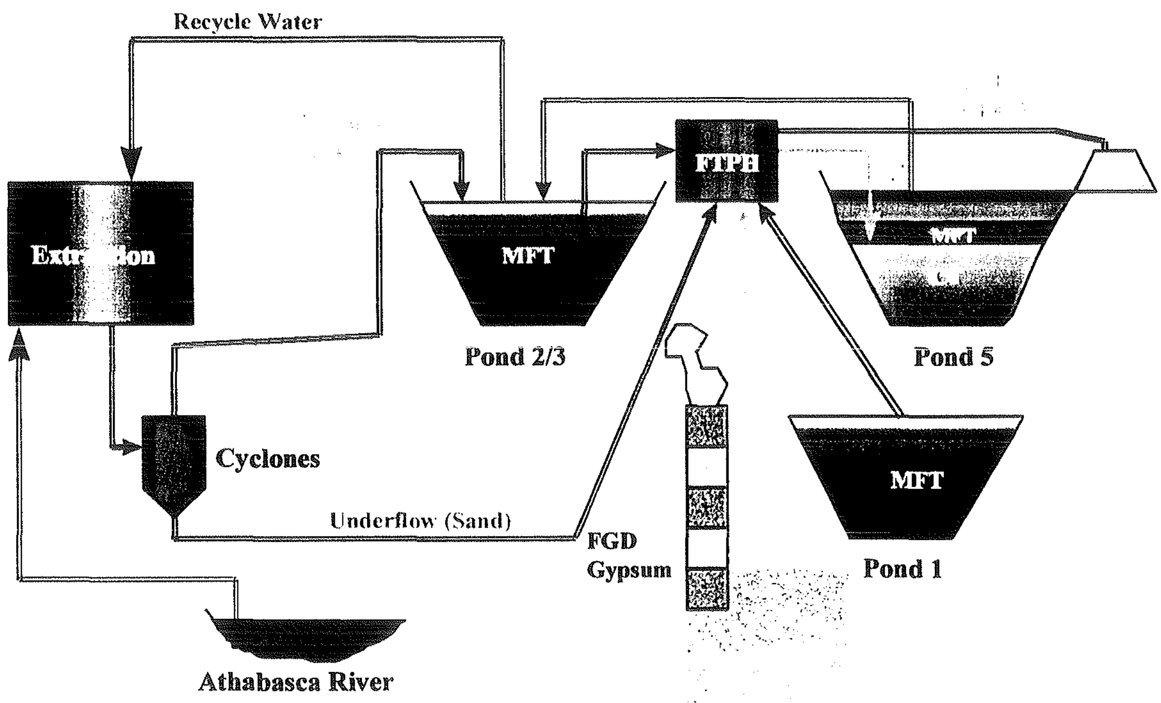


Figure 1 Suncor CT Tailings Process

use in the extraction process.

Pond 2/3 receives the cyclone overflow. Sand contained in the cyclone overflow typically forms below-water beach deposits near the discharge points. The fine tailings which are the predominant constituent of cyclone overflow are deposited further from shore in Pond 2/3 where they dewater for future use in CT. Pond 2/3 is currently at its maximum operating water level. The fine tailings mudline has risen to an elevation such that for the next few years thickened fine tailings must be removed from the pond and incorporated in CT at a rate at least equal to the accumulation of fresh fine tailings to prevent a reduction in the quality of recycle water required for bitumen recovery in Extraction operations.

Tailings Plan Objectives

The goals of tailings planning efforts are to provide safe, cost-effective tailings storage without restricting bitumen production, while constructing stable landscapes that meet reclamation requirements of Suncor's stakeholders. Key objectives in achieving these goals are to:

- Control the mudline in Pond 2/3 so that recycle water quality does not reduce extraction recovery.
- Provide a minimum of 6 month storage space contingency in active tailings ponds
- Control the sand to fines ratio of CT so that reclamation of CT ponds can occur within a reasonable time frame. Current planning is for a ratio of 3.5:1, the minimum considered acceptable.
- reduce the current 100 Mm^3 inventory of fine tailings contained in all the tailings ponds to a minimum working level of about 25 Mm^3 by 2020

Tailings Plan Constraints

Storage space limitations as well as requirements for dyke construction materials, reclamation scheduling, and recycle water quality requirements constrain the tailings plan as follows:

- suitable overburden dyke construction materials are in short supply on Lease 86/17, thus requiring construction of portions of Dykes 8 and 9 from tailings sand. (The dykes planned for construction on Steepbank Mine will utilize overburden except where filter zones are required for geotechnical integrity, which leaves up to 95% of sand available for CT once Lease 86/17 dyke construction is complete.)
- The amount of fine tailings that can removed from Ponds 1, 1A, and 2/3 is limited by the amount of sand available because CT is mixed to a specified sand /fines ratio.
- The operating priority must be to withdraw sufficient fine tails from Pond 2/3 for CT to control the mudline in Pond 2/3. Until the demand for sand to construct Lease 86/17 dykes declines, the opportunity to remove fine tails from Pond 1 without jeopardising the mudline in Pond 2/3 is limited. Eventually, more and more sand will become available for CT construction and removal of fine tailings from Pond 1 can accelerate. The distribution of sand usage to the year 2010 is shown in Figure 2.

Suncor Tailings Model

Modeling oil sand mine tailings ponds is complicated due to the behavior of the fines contained within the ore. Predicting storage required for solids is relatively straightforward based on mining quantities. However, the water contained within fine

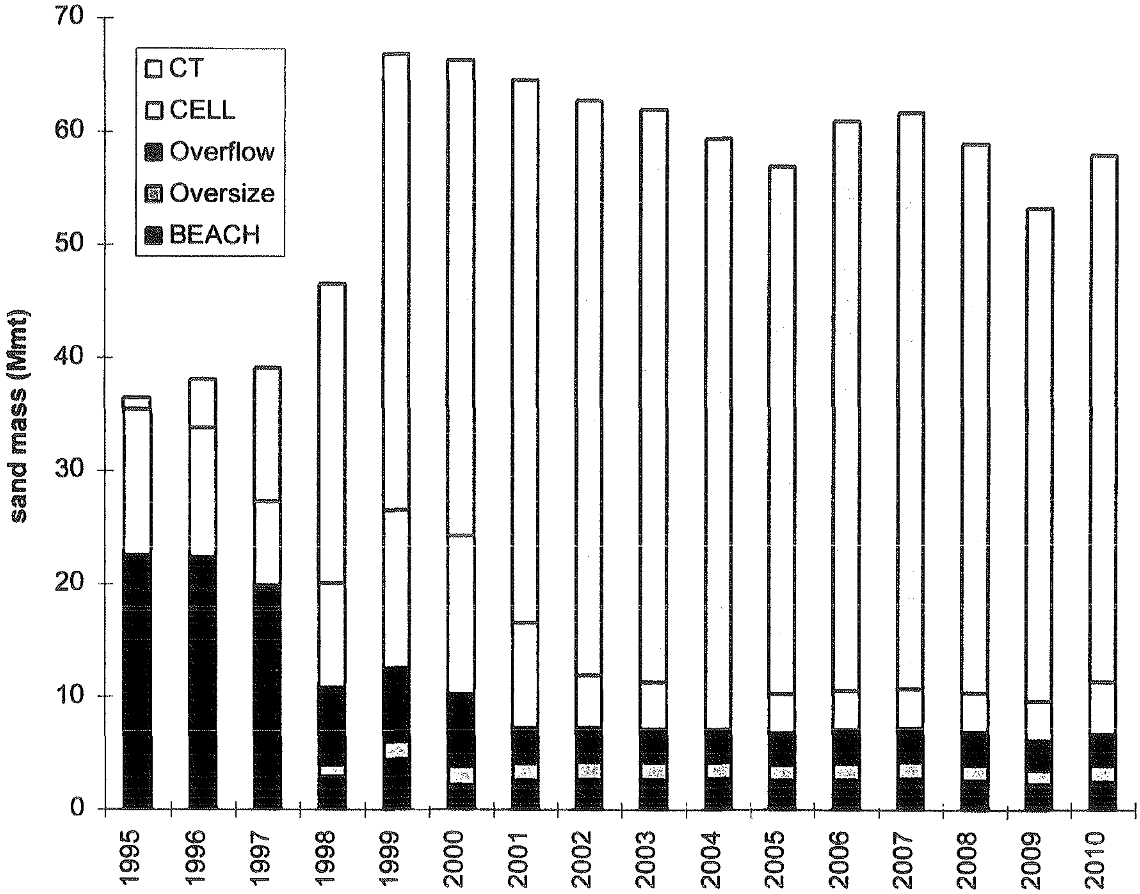


Figure 2 Sand Usage

tailings and CT significantly impacts the storage space required. This volume is governed by a combination of Stokian sedimentation, hindered settling processes, and non-linear soil settlement equations. Present models use simple empirical relationships to approximate the governing equations for these processes. Continual pond monitoring is thus required to check the accuracy of the simplifications and modify tailings pond operation as required when behavior varies from predictions.

Suncor has recently engaged Agra Earth & Environmental Engineering to review and modify the Suncor Tailings Planning Model. The flowchart developed to describe the model is shown schematically in Figure 3. Key input parameters for the model are attached on Sheet 1. By using similar input parameters are used in the models, the Agra work has been used to confirm the mass balances calculated by Suncor tailings planners.

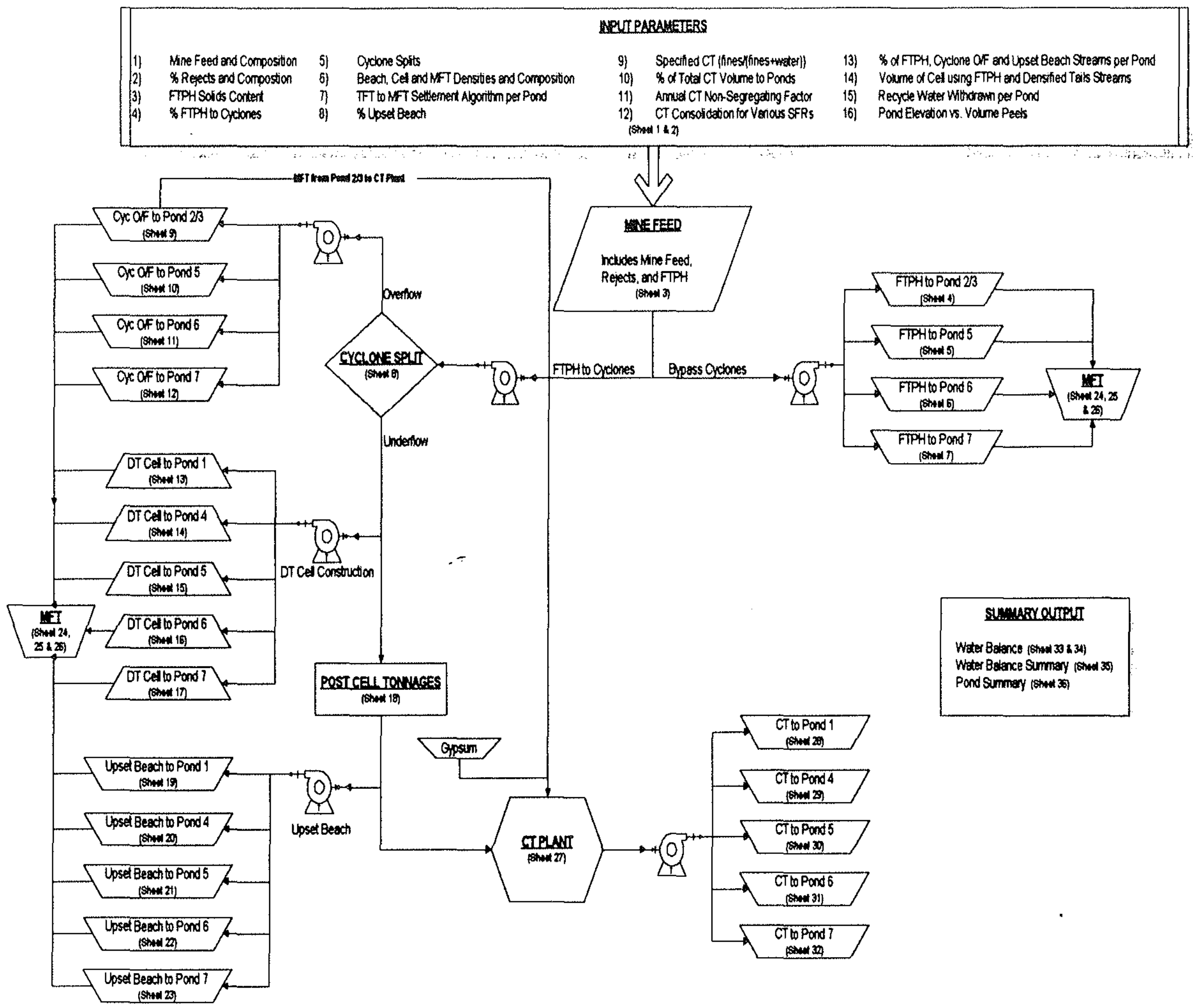


Figure 3 Tailings Model Flowchart

Tailings Material Handling

Using the tailings model subject to the operating constraints described above and pond capacities shown on Table 4, material balances for Ponds 1, 2/3, and 5 to 7 were developed as presented on Tables 5 through 9. Based on these material balances and the water balance presented on Table 3, pond elevation schedules for Pond 1 and Pond 2/3 were calculated as shown on Figures 4 and 5, respectively. The schedule for Pond 2/3 illustrates the mudline being drawn down until 1999. At that time, MFT withdrawal rates from Pond 1 are increased as shown on Figure 4, and thus the mudline and pond surface begins to rise in Pond 2/3. The predicted operating levels in Pond 2/3 are actually slightly above maximum allowed levels. Suncor would transfer relatively limited quantities of MFT from Pond 2/3 to Pond 6 if necessary to maintain allowable operating levels in Pond 2/3 while meeting the Pond 1 reclamation target date. MFT withdrawal from Pond 1 at rates faster than the plan would cause unacceptable rises in the Pond 2/3 mudline and surface level.

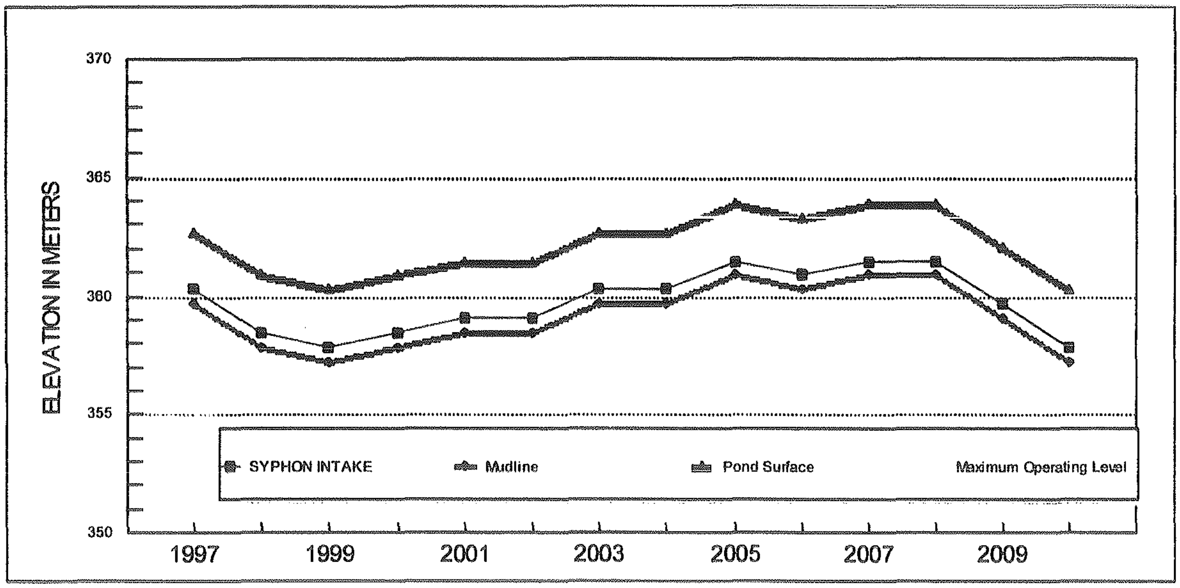


Figure 4 Pond 2/3 Rise Schedule

Pond 1 Seepage

In the 1995 Application for Renewal of Environmental Operating Approval and the 1996 Steepbank Mine Application, Suncor reported the results of seepage analyses of Tar Island Dyke. The results of those analyses showed:

1. The two main sources for seepage from the Tar Island dyke are:

   - precipitation infiltration through the dyke, and

   - downward seepage through a zone of coarse Plant 4 beach tailings.

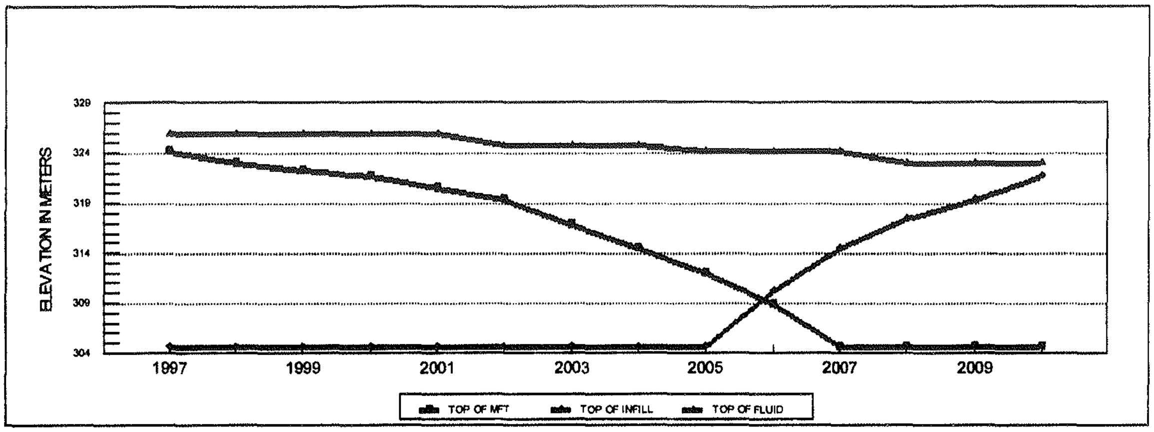


Figure 5 Pond 1 Rise Schedule

Seepage quantities directly from the pond are extremely small due to low permeability materials within the pond (fine tails) and the presence of bitumen and fines layers incorporated into the beach and dyke sands. The probable volume of foundation seepage entering the Athabasca River is about 1700 m^3/day.

2. Seepage conditions at the Tar Island dyke are not yet at steady state: the phreatic surface (internal saturated water level) is dropping 1 m to 1.6 m/y.

3. Under steady-state conditions (when the phreatic surface has dropped to approximately elevation 244 m ASL), there will be about 325 m^3/d to 650 m^3/d of seepage exiting the structure primarily due to infiltration. Steady-state conditions will not be reached for about a century.

Because fluids within the pond do not contribute significantly to the volume of seepage water, removal of the pond contents and infilling with CT will not impact seepage volumes or rates. Suncor continues to monitor the groundwater quality in TID as well as the elevation of the phreatic surface. In addition, Suncor also carries out extensive biomonitoring within the Athabasca river.

Conclusion

The 2002 target date for beginning Pond 1 revegation was based on cessation of mining by Suncor and long-term storage of fluid in Pond 5 and 6. The current plan for continued mining and solid landscape reclamation of Lease 86/17 using CT technology provides substantial benefits to Suncor and its stakeholders, but the earliest practical date to begin revegetation of Pond 1 is 2010. During that time, Suncor will

1. continue to assess pond monitoring results (e.g. Pond 2/3 mudline) to identify potential for accelerating Pond 1 reclamation, and

2. continue participation in industry research to improve tailings disposal techniques, and review the developments for potential application to accelerate Pond 1 reclamation.

3. continue discussion of planning assumptions and results, and will improve yearly mine plan reporting to the AEUB to include:

   - sand usage
   - contingency space available
   - pond surface and mudline profiles
   - a Pond 1 progress report

Table 1 Feed Composition

Year	Oilsand M[1] Tonnes[2]	Bitumen (kbbls per day)	Oversize M Tonnes	Sand M Tonnes	Fines		Water
					% Mineral	Tonnes	% Feed
1998	63.6	110.7	2.1	45.7	11.3%	6.4	3.5%
1999	92.1	156.5	3.1	65.4	12.5%	10.4	3.5%
2000	93.8	159.9	3.1	64.8	14.4%	12.3	3.5%
2001	91.4	157.9	3	63.1	14.2%	11.8	3.5%
2002	90.1	160	3	61.4	15.3%	12.6	3.5%
2003	89.5	160	3	60.6	15.6%	12.8	3.5%
2004	88.1	160	2.9	58.1	17.1%	14	3.5%
2005	86.6	153.9	2.9	56.6	17.7%	14.2	3.5%
2006	87.8	160	2.9	59.7	15.1%	12.1	3.5%
2007	89	159.8	3	60.2	15.4%	12.6	3.5%
2008	84.9	160	2.8	57.7	14.9%	11.6	3.5%
2009	76.3	154	2.5	52	14.1%	9.8	3.5%
2010	83.7	160	2.8	56.6	15.0%	11.5	3.5%

[1] M = million

[2] Suncor recently converted to metric units. The plan presented here was developed in the middle of the transition, and contains both metric and Imperial units. Of particular note, tonnes are metric while tons are imperial.

Table 2 Sand Usage

	Oversize M tons	Overflow M tons	Cell M tons	CT M tons	Upset Beach M tons	Total M tons
1998	1.2	7.5	10.2	29.2	3.2	51.4
1999	1.7	7.2	15.4	44.4	4.9	73.6
2000	1.8	7.1	15.4	46.3	2.4	73.0
2001	1.7	3.5	10.2	52.9	2.8	71.1
2002	1.7	3.4	5.1	56.0	2.9	69.1
2003	1.7	3.3	4.5	55.8	2.9	68.2
2004	1.6	3.2	0.0	57.6	3.0	65.5
2005	1.6	3.1	3.8	52.4	2.8	63.8
2006	1.6	3.3	3.8	55.5	2.9	67.2
2007	1.7	3.3	3.8	56.1	3.0	67.8
2008	1.6	3.2	3.8	53.5	2.8	64.9
2009	1.4	2.9	3.8	48.0	2.5	58.6
2010	1.6	3.1	5.1	51.3	2.7	63.8

Table 3 Water Balance

Year	Losses Total sinks MCY	Forecast Total CT Return MCY	Forecast Dyke Seeps Etc MCY	Total Inventory M Tons
1998	-31.8	15.3	2.3	52.3
1999	-49.7	20	2.3	46.6
2000	-55.9	22.2	2.3	37.5
2001	-55.7	26.7	2.3	32.3
2002	-58.7	30.5	2.3	27.8
2003	-59.2	31.2	2.3	23.5
2004	-62.9	39	2.3	22.7
2005	-62.3	36.7	2.3	24.9
2006	-56.9	35.4	2.3	30.5
2007	-58.5	35.3	2.3	34.7
2008	-54.4	33.6	2.3	40.9
2009	-47.1	31.4	2.3	51.5
2010	-53.7	34.2	2.3	58.8

Table 4 CT Pond Capacities

	Capacity (Mcy)	Max Operating Elevation (ft)
Pond 5	273	1110
Pond 6	210.9	990
Pond 7	584.8	1160.7

Table 5 Pond 1 Material Balance

Year	MFT Out MCM @ 40 % by wt	Beach/Cell Infill MCY	CT Infill MCM	Surface Elevation M	Top Of Infill Elevation M	MFT Elevation Elevation M
1998	-1	0	0	326.1	304.8	323.1
1999	-1	0	0	326.1	304.8	322.5
2000	-1	0	0	326.1	304.8	321.9
2001	-1.5	0	0	326.1	304.8	320.6
2002	-1.5	0	0	324.9	304.8	319.4
2003	-2.6	0	0	324.9	304.8	317
2004	-2.6	0	0	324.9	304.8	314.6
2005	-2.6	2.3	0	324.3	304.8	312.1
2006	-2.6	2.3	2.3	324.3	310.3	309.1
2007	-2.6	2.3	2.3	324.3	314.6	304.8
2008	-2.6	2.3	1.5	323.1	317.6	304.8
2009	0	2.3	0	323.1	319.4	304.8
2010	0	3.1	0	323.1	321.9	304.8

Table 6 Pond 2/3 Material Balance

Year	Beach Below Water MCM	New Fine Tails MCM	Mature Fine Tails Consumed MCM	Elevation Fine Tails M	Elevation Top Of Fluid M
1998	4.7	7.9	-17.1	357.8	360.9
1999	4.5	14.6	-21.5	357.2	360.3
2000	4.4	20	-22.5	357.8	360.9
2001	2.2	19	-25.2	358.4	361.5
2002	2.1	21.6	-26.8	358.4	361.5
2003	2.1	22.3	-25.1	359.7	362.7
2004	2	26	-32.9	359.7	362.7
2005	1.9	27	-29.6	360.9	363.9
2006	2	20.6	-27.4	360.3	363.3
2007	2.1	21.8	-26.5	360.9	363.9
2008	2	19.5	-24	360.9	363.9
2009	1.8	15.8	-24.9	359.1	362.1
2010	1.9	19.6	-26.6	357.2	360.3

Table 7 Pond 5 Material Balance

Year	CT Slurry MCM	Water Released MCM	Water Returned MCM	MFT Reformed In P 5 MCM	MFT Back To P 2/3 MCM	Elevation CT M	Elevation Top Of Sludge M
1998	41.8	11.7	-15.3	6.1	0	274.3	280.4
1999	58.2	15.3	-19.1	6.3	0	292.6	301.8
2000	60.7	17	-19.1	4.9	0	307.8	317
2001	69.4	20.4	-15.3	3.8	-3.8	323.1	329.2
2002	0	1.8	-11.5	0	-3.8	323.1	329.2
2003	0	1.7	-3.8	0	-3.8	323.1	326.1
2004	0	1.7	0	0	-3.8	320	326.1
2005	0	1.7	0	0	-3.8	320	323.1
2006	0	1.7	0	0	-3.8	320	323.1
2007	0	1.7	0	0	-3.8	320	320
2008	0	1.6	0	0	-2.7	320	320
2009	0	1.6	0	0	0	320	320
2010	67.3	21.8	-15.3	0	0	332.2	332.2

Table 8 Pond 6 Material Balance

Year	Dump Overburden MCY	CT Slurry MCM	Water Released MCM	Water Returned MCM	Elevation CT M	Elevation Top Of Fill M
1998	2.8	0	0	0	259.1	259.1
1999	1.9	0	0	0	259.1	259.1
2000	1	0	0	0	259.1	259.1
2001	0	0	0	0	259.1	259.1
2002	0	73.5	21.6	-7.6	271.3	274.3
2003	0	73.2	22.1	-22.9	286.5	289.6
2004	0	82.3	28.1	-22.9	301.8	304.8
2005	0	18.7	7.9	-11.5	304.8	307.8
2006	0	0	1.9	0	301.8	307.8
2007	0	0	1.9	0	301.8	307.8
2008	0	0	1.8	-3.8	301.8	307.8
2009	0	0	1.8	-3.8	301.8	304.8
2010	0	0	1.8	-3.8	301.8	304.8

Table 9 Pond 7 Material Balance

Year	CT Slurry MCM	Water Released MCM	Water Returned MCM	Overburden Into pond MCM	CT Elevation M	Top of fill Elevation M
1998	0	0	0	7.8	0	0
1999	0	0	0	12.2	262.1	262.1
2000	0	0	0	16.9	268.2	268.2
2001	0	0	0	13.1	274.3	274.3
2002	0	0	0	2.3	274.3	274.3
2003	0	0	0	0.8	274.3	274.3
2004	0	0	0	23.5	280.4	280.4
2005	56.2	18.4	-22.9	23.5	295.7	295.7
2006	72.9	22.8	-30.6	0	307.8	310.9
2007	72.4	22.7	-30.6	0	317	323
2008	68.7	21.7	-30.6	0	326.1	332.2
2009	62.9	20.6	-30.6	0	335.2	338.3
2010	0	2.5	-30.6	0	335.2	338.3

Table 10 Overburden required for Dyke Construction

	Dyke 8 mcy	Dyke 9E mcy	Pond 6 mcy	Subtotal for Lease 86/17 mcy	Dyke 10 mcy	Dyke 11 mcy
1998	5	3.6	3.7	12.2	0	
1999	0	5.8	2.5	8.3	9.6	
2000	0	2.9	1.2	4.2	10	
2001	0	0	0	0	15	
2002	0	0	0	0	16	
2003	0	0	0	0	18	
2004	0	0	0	0	20	
2005	0	0	0	0	20	
2006					5	0
2007					0	19.6
2008					0	19.6
2009					0	26.2
2010					0	26.2

Table 11 Sand Required for Dyke Construction

	Dyke 7W	Dyke 8	Dyke 9E	Pond 1	Total
	mcy	mcy	mcy	mcy	mcy
1998		7	1	0	8
1999	1	7	4	0	12
2000		6	6	0	12
2001		4	4	0	8
2002			4	0	4
2003			3.5	0	3.5
2004			0	0	0
2005			0	3	3
2006				3	3
2007				3	3
2008				3	3
2009				3	3
2010				4	4

APPENDIX II

Long Term Coke Management Plan

SUNCOR
ENERGY

Suncor Energy Inc.
Long Term Coke Management Plan

Prepared by Suncor Mine Engineering

July 30, 1998

1.0 Summary

Suncor will meet the requirement to remove the existing coke stockpile by 2006 by:

- utilizing coke as boiler fuel, new production will not be added into the existing stockpile
- implementing a 5 year sales agreement for 1 million tonnes
- relocating portions of the stockpile, as needed, to allow for construction of Project Millennium facilities.

Suncor's Long Range Coke Management Plan is summarized as follows:

- Suncor will continue to utilize coke as boiler fuel as the first priority
- Coke sales are Suncor's preferred method of removing coke in excess of boiler requirements, but transportation and market restrictions limit rates to approximately 700,000 tonnes per year.
- In the short term, Pond 4 provides coke storage capacity for excess coke production until at least 2001 (approximately 6.5 million tonnes), with about 75% of the coke being recoverable.
- Excess coke is planned to be co-disposed with mine tailings. This could be implemented as early as 2000, or deferred until after the Pond 4 site is full.
- A small stockpile will be maintained at the present site to cover operational and sales contract needs.

Findings to support this plan, included in this report, are:

- At present no proven cost-effective options for recoverable coke storage exist after Pond 4 is full.
- The least cost option for coke that cannot be sold is slurry disposal with Consolidated Tailings (CT).
- Preliminary findings of studies suggest that co-disposal of CT and coke is technically feasible; more work is being undertaken to confirm the findings. These results will be communicated to AEP / AEUB by December 15, 1998.
- Suncor requires approval for an extension to Pond 4 stockpiling until 2001.
- Suncor requires approval for the co-disposal of coke with CT.

2.0 Background

As part of its current AEP Operating Approval 94-01-00 and AEUB Approval No. 8101, Suncor is required to submit:

1. a plan outlining the disposition of the existing coke stockpile
2. a plan outlining the disposition of all future coke production

This report presents Suncor's Long Term Coke Pile Management Plan which addresses both requirements.

3.0 Disposition of the Existing Coke Stockpile

Current Operations

Currently, a front end loader is used to transfer coke from piles below the coke drums to a 14 day stockpile. The coke is dewatered in this stockpile, draining water used in cutting coke from the drums so that moisture contents are below 8%, the maximum moisture content at which Utilities can operate efficiently. The dewatered coke is fed by the front end loader to a grizzly, crusher, and conveyor system that feeds the Utilities plant silo. Coke in excess of utilities requirements is loaded and hauled to long term stockpile.

Projected Production

The excess coke production is forecast to average at 0.9 million tonnes per year for Steepbank beginning in 2000, and 2.1 million tonnes per year for Millennium beginning in 2002.

The new vacuum tower, installed as part of the Fixed Plant Expansion, has recently become operational. This unit provides a number of production enhancements including increased product volumes and quality by removing salable products from the bitumen prior to coking. There is potential that the coke produced will change in character to shot coke and require a segregated storage area.

Storage Status

The status of existing coke storage at Suncor is as follows:

- Suncor's coke stockpile has nearly reached capacity, currently containing about 6 million tonnes of coke.
- Suncor began moving the current coke stockpile in 1997. To date, Suncor has removed about 195,000 tonnes of coke from the pile as part of a sales agreement with Sumitomo Corporation of Japan. Ube Ammonia, has been testing the coke for use in the production of ammonia. Recently Suncor has signed a 5 year sales agreement with Sumitomo for 1 million tonnes of coke over the time period.

- Suncor has obtained approval to place coke in Pond 4 and to use it for an associated ramp. Suncor is utilizing Pond 4 for shot coke storage. Ramp construction has begun, and plans are to place shot coke in Pond 4 until at least the end of 1999, and perhaps into the year 2001, subject to extension of the current regulatory approval which expires at the end of 1998
- Project Millennium construction plans require moving over 1 million tonnes of coke from the current stockpile location in 1999 to allow construction of the proposed upgrader, subject to regulatory approval
- Regulatory approval conditions require that the entire current stockpile is moved by June, 2006.
- With the third and final upgrade of Suncor's coke fired boiler completed next spring, Suncor will be consuming about 1 million tonnes of coke per year. This coke will be obtained from the existing stockpile, thus enabling Suncor to meet the requirement that the existing stockpile be moved by June, 2006.

Reclamation of existing Stockpile Site

Suncor's preliminary plans for the current stockpile area are:

- to maintain a smaller stockpile as a source for boiler fuel and sales. The size would be on the order of 1 to 2 million tonnes, providing six months to a year of storage for maximum anticipated sales and boiler feed rates. This storage site would meet the intent of AEUB Guide G-55.
- to use a portion of the area for laydown and facility requirements for the expanded upgrader and energy services sites
- and to reclaim remaining areas following Suncor's established reclamation practices, including the placement of soil amendment and reforestation to a suitable state

The configuration of the above uses within the current stockpile footprint have not detailed. A detailed plan can be provided once the finalization of the operational stockpile and facility needs has occurred.

4.0 Long Term Management Plan

Objectives

Economic objectives established in developing Suncor's tong term management plan are to maximize net present value to Suncor while utilizing the resource to the extent that it is feasible. Environmental objectives are to provide secure storage that reduces impacts of leachate, dusting, and fires to acceptably low levels. Any new coke stockpile will meet the intent of AEUB Guide G-55.

Alternatives

Alternatives considered for long term coke management include:

- Use as Boiler Fuel
- Sales
- Long term storage in stockpiles and cells
- Co-disposal of coke and CT

Boiler Fuel

Suncor's first priority for coke is to maximize its use as fuel for the coke fired boilers. With the third and final upgrade of Suncor's coke fired boiler completed next spring, Suncor will be consuming about 1 million tonnes of coke per year. This coke will be obtained from the existing stockpile, thus enabling Suncor to meet the requirement that the existing stockpile be moved by June, 2006.

As an option to increase the use of coke as boiler fuel Suncor evaluated a circulating, fluidized bed coke boiler to supply power for the proposed Millennium expansion project. The option was rejected because of high capital and operating costs, increased air emissions and solid waste, and inadequate plot space availability. Efforts to date have not been successful in identifying third parties that can economically use coke as fuel for local power generation. Thus, further use of coke in power generation for the Wood Buffalo region is not currently anticipated.

Sales

Suncor's preferred option for excess coke utilization is off-site sales. Recently, Suncor has been successful in developing a five year contract with Sumitomo Corporation of Japan. However, sales potential is limited by transportation constraints and an excess of fuel grade petroleum coke available in the world-wide market.

Presently, coke must be transported by truck through Fort McMurray to a rail head at Lynton. Assuming one truck-load every 30 minutes on a round-the-clock basis, transport volumes would be limited to about 700,000 tonnes per year. Thirty minute truck cycles place a heavy demand on infrastructure both at the plantsite and in the municipality.

Preliminary explorations of rail line extensions in the Fort McMurray area have not been promising. To be feasible rail transport would require an industry wide commitment to transportation of a wide range of commodities. Thus, increased transportation capability is unlikely in the immediate future and developing the capability is not fully in Suncor's control.

Figure 1 shows the cumulative volume of coke that will accumulate at Millennium production rates, assuming average sales rates of 700,000 tonnes per year. Clearly, with present transportation capabilities, Suncor can supply any reasonable sales from yearly coke production, and significant volumes of coke would have to be stockpiled. These coke

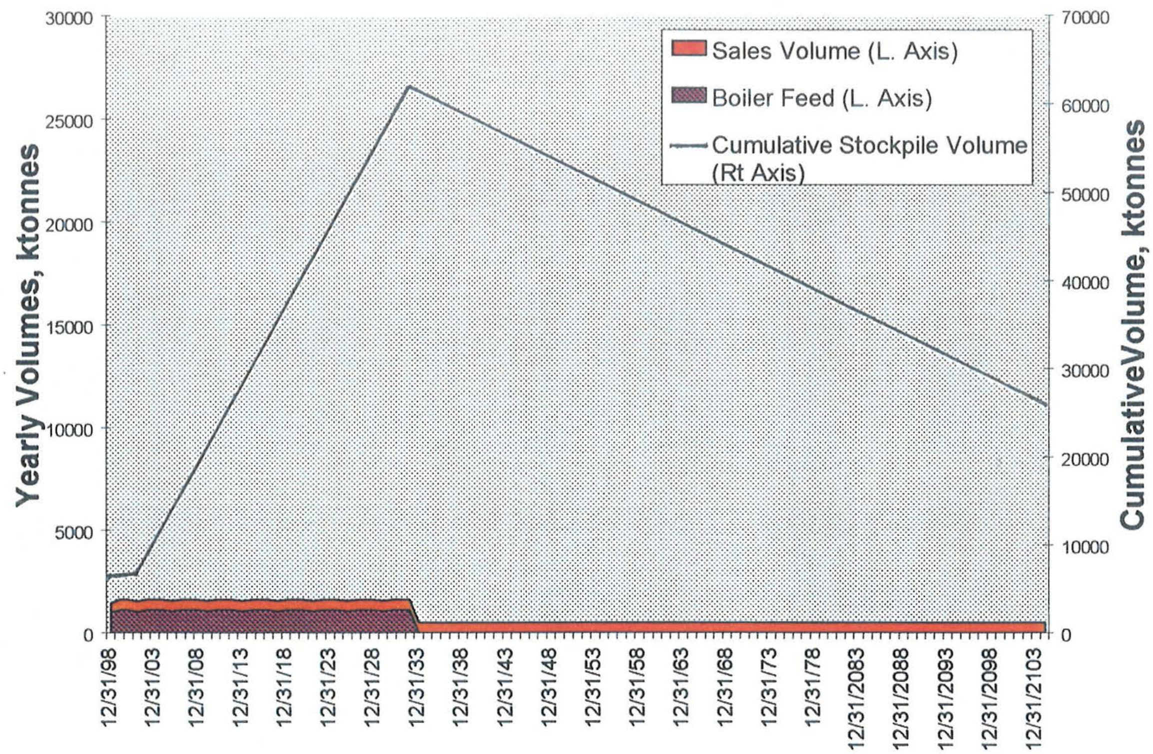


Figure 1 Coke Usage and Stockpile Requirements

stockpiles could not be sold until after upgrading operations are concluded, because present transportation system are inadequate even for current production rates.

Long Term Stockpiling

The option of a long term stockpile, for coke in excess of boiler fuel and sales, involves improving current practices to meet present day standards for stockpiles. To study this option, Suncor commissioned Kilborn Engineering Pacific Ltd. to perform a feasibility study examining various combinations of options for disposing of the existing stockpile and storing new excess coke that will be generated during continued operations.

Operations considered involved:

- trucking to pads constructed with low permeability leachate barriers and collection systems
- slurry to containment cells constructed with low permeability leachate barriers and to fluid retention standards
- slurry to the final tails pumphouse (FTPH) for co-disposal with other tailings streams

Cost comparison of the third option are discussed in this section of the report, while technical issues are addressed in the following section.

A significant constraint in developing a long term stockpile is the limited availability of land surface that does not conflict with tailings pond development or increase overall disturbance significantly. One such option that allowed substantial resource recovery was identified in Pond 4, and Suncor has submitted plans utilizing this space and has received approval to use this site until January 1, 1999. For the purposes of economic comparison, the next site considered for a land stockpile was south of Pond 2/3 in Lot 2. As will be seen, this option was not economically favourable partly because of the distance from the upgrader. In addition, visual impact, increased surface disturbance and potential ore sterilization issues would have to be addressed and competing requirements for the land area would have to be resolved.

Ignoring the practicalities of land availability, Kilborn compared the costs of slurry to cell and trucking to facilities that would allow future coke recovery with the cost of slurry disposal with the tailings stream. The results of the study on a unit cost basis (assuming Millennium rates) are summarized in table 2 below:

The conclusions supported by the figures in Table 2 are:

- operating costs for slurry transport were less than truck transport
- construction costs are significant for recoverable storage of coke
- disposal of coke with the tailings stream is the least cost alternative, (for coke in excess of practical sales volumes).

Table 1 Feasability Cost Estimate Summary

	Slurry to Cell	Truck to Pad	Slurry to FTPH
Capital Costs	$37M	$12.8M	$17.8M
Capital Costs per tonne	$1.21	$0.42	$0.58
Storage Facility Costs $/tonne	$6.11	$1.17	$0.10
Process Operating Costs (Crush, Screen & Pump) $/tonne	$1.11	$0.72	$0.60
Mobile Equipment Costs $/tonne	$0.56	$2.22	$0.47
Total Operating Cost per tonne produced	$7.78	$4.11	$1.17
Total Cost per year	$19078k	$10800k	$2869k

On the basis of this feasibility level study, the marginal cost of creating a recoverable stockpile of coke is estimated to exceed $2.50 per tonne. Because of transportation limitations, sales of this coke would not occur until after Suncor ceased upgrader operation, which would occur no earlier than 2033. The transportation limitation would still exist after upgrader operation ceases, so it would be decades later before the coke stockpile was exhausted. Thus, the sales proceeds would be received far in the future, while the marginal stockpile costs are incurred immediately on production. The required sales prices to offset the stockpiling cost (net present value of zero) has been computed using a rate of return of 11% for a range of annual coke sales rates and are shown on Table 3. The future value sales prices are substantially in excess of any reasonable expectation. Thus, Suncor does not consider that long term stockpiles for coke are economically justified.

Table 2 Economics of Stockpiling

Annual Coke Sales (ktonnes per year)	**1000**	**750**	**500**
Sales price in $/tonne required for Zero Net Present Value (based on $2.50 per tonne marginal cost for recoverable stockpile)	**$83**	**$130**	**$237**

Co-disposal of Coke with Consolidated Tailings

The least cost long term option, for coke that is generated in excess of boiler fuel and sales requirements, is to incorporate the coke in the CT slurry and dispose of the coke in tailings ponds. The coke would be slurried to the final tails pumphouse where it would be combined with Consolidated Tailings and then pumped to tailings ponds. The slurry medium would be fine tails from Pond 2/3, so no additional water would be added to dilute the CT mixture. The coke would comprise about 3% of the cyclone underflow used to make CT in the winter, and about 6% in the summer when about half of tailings sand is used for dyke cell construction. In terms of volume, there is no significant impact on the long range tailing plan.

Two specific technical issues that must be resolved before the plan can be implemented are:

1. Confirmation of impacts on the segregation boundary
2. Demonstration that leachate from the coke/CT mixture is acceptable

Suncor has commissioned the Canada Centre for Mineral and Energy Technology (CanMET) to study of coke effects on CT segregation. The tests are time-consuming, and final results are not yet available. Preliminary results are encouraging.

Suncor also commissioned Golder Associates to assemble existing coke leachate data and to provide a preliminary assessment of its environmental significance. Previously, all testing has been performed on coke alone, not coke in CT. A draft of the review indicates most of the materials bound with the solid coke appear to be non-leachable. Golder did recommend testing with more sensitive detection limits and including PAH and napthenic acid analyses. Suncor will be working with Golder to develop objectives and scope for further tests specifically on a CT and coke mixture.

Kilborn has proceeded to the preliminary detailed engineering phase in the design and construction process. The slurry plant will be constructed to allow flexibility in management options for coke. The plant includes screening and crushing operations that support sales, and would allow slurrying coke to containment cells if cost effective alternatives are identified in the future.

One proposed schedule would be for Suncor to construct the slurry plant in 1999, and begin operation in 2000. Alternatively, Suncor may prefer to accept higher operating costs associated with hauling coke to Pond 4, and defer capital costs for constructing the slurry plant in 2001, with operation commencing in 2002 when Pond 4 capacity is reached. A firm decision has not been reached on the timing of construction.

5.0 Conclusions

The preferred alternative for long term coke management is slurry disposal with CT. This would only apply to volumes in excess of sales and boiler fuel. Suncor therefore requests approval for the co-disposal for coke with CT. The resulting integrated management plan provides the best combination of economics, resource utilization, and environmental protection.

In the interim, while engineering, planning and construction of a slurry facility is undertaken, Suncor also requires approval for an extension to Pond 4 stockpiling until 2001.

Suncor proposes to prepare a supplement to this report describing the results of the technical studies and preliminary detailed designs underway, by December 15th, 1998.

APPENDIX III

Field Review of the AVI Inventory of Suncor's Millennium Project Development

FIELD REVIEW OF THE AVI INVENTORY OF SUNCOR'S MILLENNIUM PROJECT DEVELOPMENT

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July 9, 1998

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INTRODUCTION

The Millennium Project area is located in townships 91 and 92 w4th between the Athabasca and Steepbank rivers. Several creeks with large steep valleys; Leggat, Wood, and Mclean, run west into the Athabasca River. For the area to be cleared by the year 2000, volume estimates are approximately 140,000m^3 with a breakdown of 45,000m^3 of conifer and 96,000m^3 of deciduous. Within the year 2000 clearing area, several AVI stands are 16 - 19 meters tall and are quite marginal for a deciduous harvest operation. The goal of the field evaluation is to visit several of these marginal stands and assess their merchantability and their piece size i.e. trees/m^3.

METHODS

Suncor has recently had a new Alberta Vegetation Inventory (AVI) done on the Millennium Project area. The cover types from this inventory were used to determine the piece size for all stands to be cleared by the year 2000. These stands were joined with the Alpac growth and yield strata and the average piece size for the strata was assigned to the stand.

Piece size data from all marginal stands in the south area to be cleared was evaluated by doing a field visit into the marginal stand and assessing the actual merchantability and piece size of these stands. The stands were accessed by using a boat to travel along the Athabasca River and then to compass in from tie points along the river. On the first day an Alpac representative came along to assess the stands so that everyone was aware of the size of these stands.

ROADING

Exact road location was not looked at; however, stands that were looked at were all accessible during frozen conditions. The road accessing the timber between Mclean and Wood creeks will have to go partly outside of the year 2000 clearing area. This is to avoid the steep gully of Wood creek.

OPERABILITY

Within the Millennium Project area there are a number of major drainage channels that will pose a problem for harvesting. Because the area is to be mined later, there is more ground that can be accessed than if the normal ground rules were being followed. However, there is still several areas which are too steep or unstable to harvest and they will be left standing and dealt with at a later time. These inoperable areas will be determined later by Alberta Pacific once they choose the equipment that will be used to harvest this area.

MERCHANTABILITY AND PIECE SIZE

The field visit was focused on the south end of the Millennium Project in the area to be cleared by the year 2000. The new AVI inventory for this area identifies several stands which are in the 16 - 19 meter range which would normally be left for second pass, as well as several stands which are borderline merchantable, i.e. 50 m^3/ha. The following chart lists the stands which were visited and the calculated piece size from the Alpac strata.

POLY #	AVI LABEL	PIECE SIZE
1905	C21 AW10	4.54
1906	C16 AW10	9.09
26	C16 PJ8AW2	6.67
74	B18 AW9PB1	6.67
25	A20 AW8SW2	3.13
28	C19 AW9PB1	5.88
75	C21 AW10	4.35
23	C16 AW10	9.09
1896	C18 AW10	7.69
1897	B18 AW10	6.67
73	C22 AW9PB1	4.35
70	C20 AW9PB1	5.88

The first thing to note was that the majority of the stands that were checked were 1 - 2 meters taller than the map label. The 16 meter stands that were checked were actually closer to 18 meter, which would make them 6.5 trees/m^3 instead of 9 trees/m^3. As well, there were several A density deciduous stands in the area which contained a small non-merchantable conifer understory. The overstory for these stands was in the 3 - 5 trees/m^3; however, the spacing of them increases logging costs due to decreased efficiency of the equipment.

WOOD SIZE

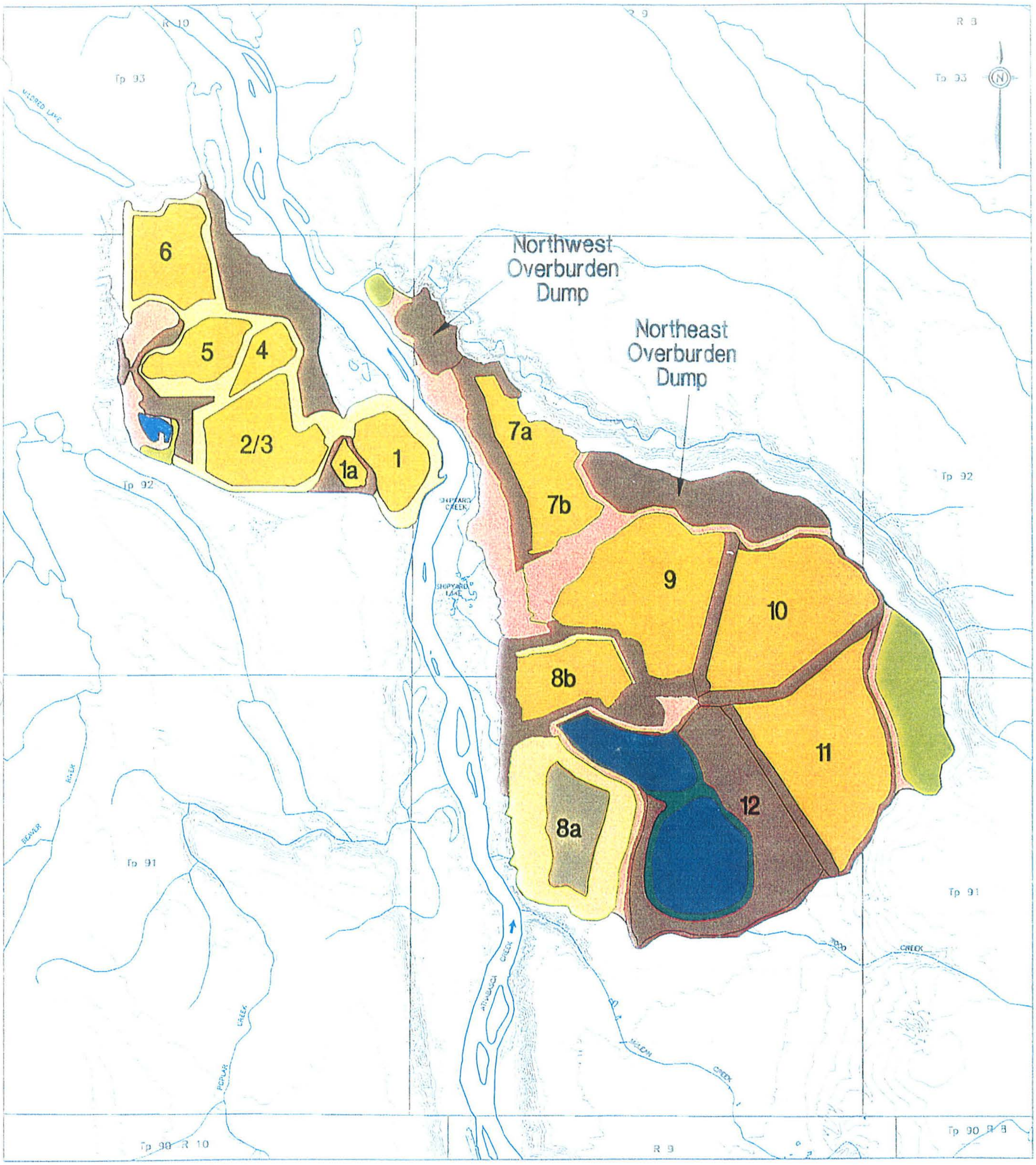
The piece size or trees/m^3 has a direct influence on the cost of harvesting the trees. The more trees that have to be handled to reach a targeted volume the longer the equipment cycle time to complete its task. The area in the Millennium

Project to be cleared by the year 2000 contains a mix of good sized deciduous timber along with several stands of below average wood. The majority of the 18 and 19 meter stands border between 5 and 7 trees/m3. However, due to the small scope of the field visit, exact numbers couldn't be obtained. One thing to note from the field visit is a few areas that, by the stand label, would have been costly to harvest due to a high piece size turned out to be smaller and therefor not economically harvestable at all. An example of this is the A density deciduous stands with a marginally merchantable conifer understory. The understory turned out to be quite small and therefor the only merchantable portion of the stand is the A density overstory which tend to have quite large diameters.

AVI POLYGON AND VOLUME SUMMARY

APPENDIX IV

Resubmitted Items



LEGEND

- OVERBURDEN
- TAILINGS SAND
- OVERBURDEN SAND MIX
- CONSOLIDATED TAILINGS
- END PIT LAKE
- LITTORAL ZONE
- UNMINED DEVELOPMENT AREA
- RECLAMATION MATERIALS STORAGE
- 7a POND NUMBER
- LAKE

REFERENCE
DIGITAL DATA SETS 74D AND 74E RESOURCE DATA DIVISION, ALBERTA ENVIRONMENTAL PROTECTION, 1997.
MINE PLAN SUPPLIED BY SUNCOR ENERGY, MAR 1998.
DATUM IS IN NAD83 UTM

0 2.5 5km
SCALE 1:125,000

SUNCOR ENERGY

Project Millennium
Taking Suncor into the 21st Century

CLOSURE LANDFORMS

09 Apr. 1998	Figure E-1	DRAWN BY: RFM

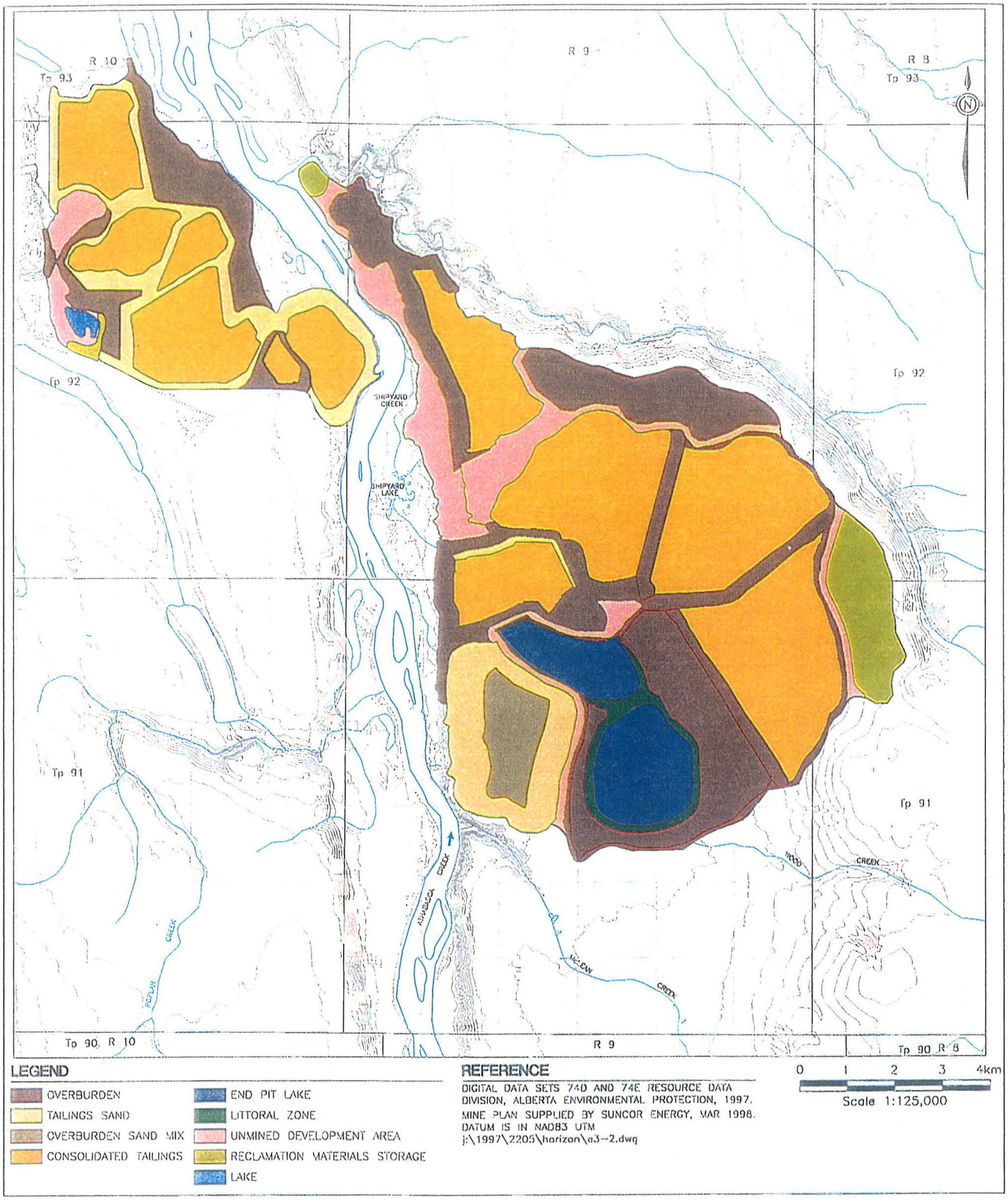


Figure E3-2 East Bank Mining Area Closure Landforms

B2 AIR QUALITY BASELINE/ENVIRONMENTAL SETTING

B2.1 CURRENT EMISSIONS AND BASELINE DATA

B2.1.1 Current Emissions

The operation of oil sands mining, extraction and upgrading facilities in the Athabasca oil sands region results in gaseous and particulate emissions from controlled and fugitive sources. Additional emissions to the airshed result from other sources, including other industrial operations, transportation and community sources. This section summarizes the Baseline projects as defined in Table A2-11.

Additional information on current emissions is provided in the EIA key reference report "Technical Reference for Meteorology, Emissions and Ambient Air Quality in the Oil Sands Region" (Golder and Conor Pacific 1998).

B2.1.1.1 Baseline Suncor Emissions

Emission sources from Suncor's operations are listed below. Included are sources from operating and approved facilities at the Suncor site. Sources are in all of Suncor's operating units: mining, extraction, upgrading and energy services.

- Continuous combustion sources include: the Flue Gas Desulphurization (FGD) stack that services three coke-fired boilers; the powerhouse stack that services five gas fired boilers and, if necessary, three coke-fired boilers; incinerator stack that services the sulphur recovery plant; upgrading secondary stacks that are either natural gas or refinery gas-fired; continuous flaring; and exhaust gases from the mine fleet that use diesel fuel;
- Intermittent combustion sources include two hydrocarbon flares, one acid gas flare and a hydrogen plant flare that are used for plant start-up, shut-down and upset conditions. The flare stacks are serviced by continuous pilots and are used for both planned and unplanned combustion of gas streams;
- Plant vents that service various storage tanks, process vessels and buildings. The vent gases typically contain hydrocarbon product which may also include reduced sulphur compounds;
- Fugitive particulate emissions result from surface disturbances that include mining activities, traffic, storage piles (e.g., coke) and tailings pond dykes; and

- Fugitive hydrocarbon emissions result from leaks in the upgrading area (i.e., valves, flanges, piping, rotating seals, drains) and from area sources (mine surfaces and tailings ponds).

The current operations employ a number of emission reduction technologies or practices. The major ones are summarized below:

- the Flue Gas Desulphurization (FGD) plant designed to remove 95% of SO_2 from the five gas coke fired boilers;
- a SuperClaus sulphur recovery plant designed to remove more than 98% of the sulphur in the acid gas prior to venting through the incinerator stack;
- a Naphtha Recovery Unit (NRU) recovers light hydrocarbons from Extraction Plant 4 tailings prior to discharge to Tailings Pond 1;
- electrostatic precipitators designed to remove 98% of particulate matter from flue gases generated during coke combustion in the power house;
- a Vapour Recovery Unit (VRU) recovers about 95% of the hydrocarbon and Total Reduced Sulphur (TRS) emission from Plant 4 vents, the NRU and the south tank farm vents;
- a sour water stripping system is used to strip H_2S from process water. The stripped H_2S is routed to the sulphur plant;
- improved operating procedures and equipment reliability has reduced the frequency of intermittent flaring;
- during times when the FGD unit is down, the Supplementary Emission Control (SEC) system can be used to control powerhouse SO_2 emissions;
- mine haul roads are sprayed with water in non-freezing conditions to reduce fugitive dust on dry, windy days; and
- tailings pond dykes are revegetated on the exterior slopes to reduce wind blown sand.

Table B2-1 provides a summary of the predicted emissions from Suncor's current and approved operations. The values are the sum of current and predicted emissions for the existing facility and the approved Fixed Plant Expansion and Steepbank Mine Projects. The emission sources have been grouped for ease of presentation. In developing the ambient air quality predictions (Section B2.2) the individual source emission rates and locations were modelled. The Volatile Organic Compounds (VOC) emissions are based on a VRU uptime of 90%. No estimates for surface generated particulate matter (PM_s) have been provided.

Table B2-1 Summary of Baseline (Current + Approved) Suncor Emissions

Source	Emission Rates (t/cd)					
	SO_2	NO_x	CO	PM[(a)]	VOC	TRS
Suncor						
Powerhouse Stack	13.1	3.9	**2.45**	0.2	0.008	n/a
FGD Stack	18.0	29.8	**0.69**	**2.8**	0.15	n/a
Sulphur Incinerator	18.8	0.1	2.9	0.03	0.051	n/a
Upgrading Furnaces	2.8	2.5	0.8	0.3	**0.038**	--
Flaring (Continuous and Acid Gas)	12.6	0.1	0.2	0.005	0.033	--
Mine Fleet	0.04	11.3	0.6	0.1	0.27	--
Fixed Plant Fugitive	-	-	-	-	**17.3**	**0.13**
Tailings Ponds	-	-	-	-	102.0	1.3
Mine Surface[(b)]	-	-	-	-	**5.6**	**0.035**
Total	**65.3**	**47.7**	**7.64**	**3.4**	**125**	**1.5**

n/a Data not available.
\- Not a source of this emission.
(a) Assumed as PM10.
(b) Estimated based on Syncrude data.

Note: The updated values in the above table represent the latest estimates of emissions as detailed in Technical Reference for Meteorology, Emissions and Ambient Air Quality in the Athabasca Oil Sands Region (Golder and Conor Pacific 1998). The dispersion modelling results presented in the figures were based on the original emission estimates (as tabulated at the bottom of each figure). All of the original estimates, save for PM, were higher than the latest estimates. Previous model results can be therefore considered conservative. PM has recently been remodeled using these higher estimates.

SO_2 Sources

The major approved sources of SO_2 emissions to the atmosphere are the powerhouse, FGD and incinerator stacks and three flares stacks. When the FGD process is on line, effluent gas from the three coke-fired boilers (powerhouse) is processed via the FGD plant and vented up the FGD stack. The FGD plant has been designed to be operational 95% of the time. When FGD is down, effluent gas from the three coke fired boilers is routed up the power house stack. In this configuration, SO_2 emission rates from the powerhouse stack approach 259 t/d. The "current" part of the baseline emissions are based on 1997, a year in which the FGD was still being commissioned and one of the coke fired boilers was down for an extended overhaul.

Suncor has spent considerable effort in understanding and reducing SO_2 emissions. Over the last few years Suncor has substantially reduced total SO_2 emissions with the installation of the FGD unit, improvements in the Upgrader sulphur plant and in overall operational reliability. This approach has initially been directed toward the major sources of SO_2. At the same time, Suncor has been identifying and quantifying smaller SO_2 sources. These include the flares and the upgrading furnace stacks. With success in reducing emissions from the largest sources, Suncor is now looking more closely at emissions from smaller sources. As a result, more accurate estimates of total SO_2 emissions from the facility have been acquired.

Table B2-2 provides a review of sulphur emissions from Suncor from 1994 to 1997. This time frame was selected to match available meteorological data for modelling purposes (see Section B2.2). Historically, Suncor's SO_2 emissions have been assessed based on the powerhouse and incinerator stacks. As Table B2-2 indicates, these two sources represented about 95%

of the overall Suncor SO_2 emissions. These two sources plus the main stack at Syncrude (emissions of 208 t/d) represented the major area sources and formed the basis for historical SO_2 modelling efforts. In 1997, the FGD unit was commissioned and SO_2 emissions are expected to be reduced from approximately 250 t/d in 1994 to 65 t/d for the baseline case from all sources and from approximately 240 t/d to 50 t/d from the historical main sources.

The focus in the air quality assessments for Suncor has historically been the large SO_2 emissions. In the last three years Suncor has implemented new SO_2 emission controls on its principal sources and has quantified all of its smaller SO_2 emission sources (i.e., smaller in terms of SO_2 mass emission rates). When these smaller sources are included in model predictions for the past four years of operation at Suncor, the effect of these smaller sources are masked by the larger principal sources. However, with the full implementation of FGD in 1997 and the subsequent reduction of SO_2 GLCs, the contribution of the smaller sources to GLCs becomes apparent. Their contribution to the overall SO_2 GLC is significant within 20 km of the fixed plant and represents more than a third of the 450 $\mu g/m^3$ hourly AAAQG exceedances. Whereas the Baseline AAAQG exceedances appear to result from increased emissions, they are in fact from existing historical sources, now made significant due to the large SO_2 emission reductions.

There are many industrial SO_2 emission sources in the oil sands region which contribute to GLCs over a large area around the Suncor facility within a radius of approximately 40 km. Within this area the contribution of the individual sources, large or small, result in an integrated GLC very near the SO_2 AAAQG. Therefore, a better understanding of the sources, subtle changes in emission rates, source exit characteristics (e.g., temperature and velocity), or modelling assumptions (e.g., plume rise, dispersion coefficients, or terrain influences) can result in dramatic changes in the number of predicted exceedences of the AAAQG. For example, a predicted 25 $\mu g/m^3$ increase for a maximum one hour average ambient level could result in a significant increase in exceedances. Hence, a regional perspective is required when addressing development, significant increases in SO_2 emission in the area and the distributed nature of the existing emissions in the area.

Table B2-2 Summary of Historical SO_2 Suncor Emissions

Source	Suncor Emission Rates (t/sd)				
	1994	1995	1996	1997	Baseline
Powerhouse stack	211	215	153	171	259 [(a)]
FGD stack	-	-	-	10.8	18.9
Sulphur Incinerator	31	16	18	19.4	19.1
Upgrading furnaces	2.6	2.9	3.0	3.1	3.1
Continuous flaring	7.8	8.7	9.1	9.3	7.3
Mine fleet	-	-	-	-	0.04
Total	252.4	242.6	183.1	213.6	48.4

- Not a source of this emission.
[(a)] Emissioin rate when FGD is not in operation.

NO_x Sources

The calculation of NO_x emissions was based on a combination of measured stack survey data, emissions supplied by equipment designers and suppliers, and U.S. EPA emission factors.

CO Sources

The CO emissions are based on emission factors. CO emissions are relatively small compared to NO_x or SO_2 emissions.

Particulate Matter (PM) Sources

Particulate matter (PM) emissions from the Powerhouse and FGD stacks, are based on stack survey measurements and are the major sources of PM emissions. All flue gas from the coke fired boilers passes through electrostatic precipitators designed to remove 98% of the PM. When FGD is on line, gases from the coke fired boilers are passed through the Jet Bubbling Reactor which acts as a wet scrubber and removes approximately 85% of the remaining particulate. Other sources of PM were estimated using appropriate emission factors.

VOC Sources

Total hydrocarbon emissions include methane and non-methane components. The latter are referred to as VOC (volatile organic compounds). The methane emission rates for the combustion sources, extraction plant, tank farms, and other vents were based on U.S. EPA emission factors. The VOC emission rates for the combustion sources, extraction plant, tank farms, upgrading facilities and other vents were also based on U.S. EPA emission factors. The emission rates from the tailings ponds were based on field characterization studies commissioned by Suncor in 1997.

TRS Sources

Reduced sulphur emissions include emissions of hydrogen sulphide (H_2S), carbonyl sulphide (COS), carbon disulphide (CS_2), mercaptans and thiophenes. The largest sources of TRS are the secondary extraction tailings ponds due to biogenic activity within the pond. A minor source of TRS is the Suncor fixed plant with the operation of the vapour recovery unit which is in operation 90% of the time. TRS is also a small component, exposed at oil sands. For the purposes of this assessment, TRS has been speciated with VOCs, implying that since VOCs have been assumed to scale with production rates, then TRS will also. This likely over estimates TRS because the dominant source of TRS is the Suncor tailings pond emissions which is believed to be biogenic in origin.

Greenhouse Gases

Greenhouse gases (GHG) include emissions of carbon dioxide (CO_2), methane (as equivalent CO_2) and NO_X (as equivalent CO_2). Overall GHG emissions for the Baseleine case are estimated at 13,350 CO_2 eq t/cd. Existing emissions for 1997 were 9,952 CO_2 eq t/cd.

B2.1.1.2 Baseline Syncrude Emissions

The other existing source of primary emissions in the region is Syncrude's Mildred Lake mining, extraction and upgrading operations. Table B2-3 provides an overview of their average emissions. The primary source of SO_2 emissions is the main stack, which services the CO boiler, the sulphur recovery plant and the sour water stripper. The THC/VOC and TRS emissions are based on updated estimates for the tailings settling pond (1992) and older estimates (1987) for the plant area. Given recent improvements in the plant operation, THC/VOC and TRS emissions from the plant area may be lower than those given in the table.

Table B2-3 Summary of Syncrude Baseline Emissions

Source	Emission Rates [a] (t/cd)					
	SO_2	NO_x	CO	PM[b]	VOC	TRS
Main Stack	208	10.9	45.0	3.6	0.002	0.00
Secondary Sources	0	14.0	3.4	1.2	0.14	0.00
Fugitive	0	0	0.0	0.0	5.4	1.9
Mine Fleet	1.0	19.5	5.2	0.6	0.9	0.00
Settling Basin (Fugitive)	-	-	-	-	26.5	0.36
Mine Surface (Fugitive)	-	-	-	-	**6.5**	**0.03**
Total	**209.0**	**44.4**	**53.6**	**5.4**	**39.4**	**2.3**

n/a Data not available.
\- Not a source of this emission.
(a) Data provide by Syncrude or Syncrude's consultants.
(b) Assumed as PM_{10}.

Note: The updated values in the above table represent the latest estimates of emissions as detailed in Technical Reference for Meteorology, Emissions and Ambient Air Quality in the Athabasca Oil Sands Region (Golder and Conor Pacific 1998). The dispersion modelling results presented in the figures were based on the original emission estimates (as tabulated at the bottom of each figure). All of the original estimates, save for PM, were higher than the latest estimates. Previous model results can be therefore considered conservative. PM has recently been remodeled using these higher estimates.

B2.1.1.3 Other Existing or Approved Development Emission Sources

Other existing or approved industrial sources in the Athabasca Oil Sands Region include the following:

- **Northstar Energy Dover SAGD.** The emission sources at the Northstar Energy Dover SAGD facility include a central utilities flare stack, a glycol heater, a mine heater and five steam generators;
- **Northland Forest Products.** The main source of air emissions from Northland Forest Products' lumber mill is the conical waste wood burner;
- **Fort McMurray Hospital.** The hospital incinerator operates on an intermittent basis;

- **Syncrude Aurora Mine.** The approved Aurora North and South mines will include four operating trains with an ultimate production rate of 431,000 b/d of bitumen. The emission sources include eight stacks when the project is fully developed. A number of emissions (CO, VOC, PM_{10}) were not identified in the Aurora application and these values are based on scaling emissions from the existing Mildred Lake sources; and
- **SOLV-EX.** SOLV-EX has approval for a combined bitumen and metal extraction plant located near Bitumount. The emission sources from the facility include a sulphur recovery plant and tail gas incinerator, the sulphuric acid plant, and various secondary sources (i.e., heaters, boilers, dryers and turbines).

Table B2-4 summarizes and compares the emissions from these industrial sources. The emission estimates are provided from a combination of existing approvals, existing operations, preliminary engineering design estimates and extrapolation of existing data. Emissions from these sources, however, are much smaller than those associated with the Suncor and Syncrude operations. The emissions for these sources, unlike the others, are expressed on a "stream day (s/d)" basis instead of a "calendar day (c/d)" basis.

Table B2-4 Summary of Baseline Emissions from Other Existing or Approved Industrial Projects

Source	Emission Rates - (t/cd)					
	SO_2	NO_x	CO	PM[a]	VOC	TRS
Other estimates						
Northstar - Dover SAGD	-	0.2	0.10	0.0	0.004	n/a
Northlands Forest Products	0.02	0.2	25.0	0.2	2.1	n/a
Fort McMurray Hospital	0.0005	0.001	0.006	0.003	-	-
Syncrude - Aurora[b]	0.3	7.6	1.8	**1.2**	**2.8**	**0.03**
SOLV-EX - Bitumount	3.6	0.7	0.2	0.40	0.02	n/a
Total	**3.9**	**8.7**	**27.1**	**1.8**	**4.9**	**0.03**

n/a Data not available.
\- Not a source of this emission.
(a) Assumed as PM_{10}.
(b) For one train only.

Note: The updated values in the above table represent the latest estimates of emissions as detailed in Technical Reference for Meteorology, Emissions and Ambient Air Quality in the Athabasca Oil Sands Region (Golder and Conor Pacific 1998). The dispersion modelling results presented in the figures were based on the original emission estimates (as tabulated at the bottom of each figure). All of the original estimates, save for PM, were higher than the latest estimates. Previous model results can be therefore considered conservative. PM has recently been remodeled using these higher estimates. Note that TRS has also gone up but not very significantly.

B2.1.1.4 Transportation and Residential Source Emissions

There are a number of non-industrial sources of NO_x, CO and CO_2 emissions in the Athabasca oil sands region that result from combustion sources. Specifically, these sources include the following:

- Highway 63 traffic (gasoline and diesel fueled vehicles);
- local community traffic (gasoline and diesel fueled vehicles);

- natural gas combustion for residential and commercial space heating, cooking and water heating;
- residential wood combustion (fireplace or wood stove); and
- natural sources.

The two primary communities are Fort McMurray and Fort McKay, with respective populations of 38,700 and 330. The number of occupied residences are 12,955 and 110, respectively. For the most part, natural gas is used as the primary heating source in both communities. Table B2-5 summarizes the emissions from these other sources.

Table B2-5 Summary of Baseline Emissions From Transportation and Residential Sources

Source	Emission Rates (t/cd)				
	SO_2	NO_x	CO	PM[a]	VOC[b]
Highway	0.05	0.35	1.19	0.32	0.21
Fort McMurray					
Traffic	0.136	0.900	3.408	0.919	1.415
Residential Natural Gas	0.002	0.099	0.137	0.017	0.038
Residential Wood	0.003	0.018	1.713	0.233	1.279
Fort McKay					
Traffic	<0.001	<0.001	0.005	<0.001	<0.001
Residential Natural Gas	<0.001	0.007	0.003	<0.001	0.001
Residential Wood	<0.001	<0.001	0.014	0.002	0.01
Total	**0.191**	**1.374**	**6.47**	**1.49**	**2.95**

(a) Assumed as PM_{10}.
(b) Assume THC equals VOC.

B2.1.1.5 Summary of Baseline Emissions

Table B2-6 summarizes the emissions from Suncor, Syncrude, other industries, transportation and residential sources in the oil sands region. While the results in the table indicate the two oil sands operations are the major sources of emissions to the atmosphere, there are other smaller sources that can also influence air quality. This is especially true for those smaller sources which originate from the communities.

Table B2-6 Summary of Baseline Emissions in the Athabasca Oil Sands Region

	Emission Rates (t/cd)					
	SO_2	NO_x	CO	PM[(a)]	VOC	TRS
Suncor	65.3	47.7	**7.6**	**3.4**	**125**	1.5
Syncrude	209.0	44.4	53.6	5.4	**39.4**	2.3
Other Industries	3.9	8.7	27.1	0.9	**4.9**	0.03
Transportation and Residential	0.2	1.37	6.5	1.5	2.95	-
Total	**278.4**	**102.17**	**94.8**	**11.2**	**172**	**3.8**

- Not a source of this emission.
(a) Assumed as PM_{10}.

Note: The updated values in the above table represent the latest estimates of emissions as detailed in Technical Reference for Meteorology, Emissions and Ambient Air Quality in the Athabasca Oil Sands Region (Golder and Conor Pacific 1998). The dispersion modelling results presented in the figures were based on the original emission estimates (as tabulated at the bottom of each figure). All of the original estimates, save for PM, were higher than the latest estimates. Previous model results can be therefore considered conservative. PM has recently been remodeled using these higher estimates. Note also that TRS has also gone up but not very significantly.

B2.1.2 Air Quality Baseline Observations

The ambient air quality monitoring program in the Athabasca oil sands region is comprised of continuous monitoring, passive monitoring, precipitation monitoring and specialized studies. Up until very recently, Suncor, Syncrude and Alberta Environmental Protection (AEP) collectively maintained 12 continuous ambient air quality stations and 76 passive monitoring stations. AEP and Environment Canada collectively maintain 8 precipitation monitoring stations in northern Alberta and Saskatchewan. These monitoring programs are further supplemented by short-term specialized studies that have focused on characterizing ambient hydrocarbon and reduced sulphur species concentrations, odours and deposition.

Additional information on air quality in the oil sands region is provided in the EIA key reference report "Technical Reference for Meteorology, Emissions and Ambient Air Quality in the Oil Sands Region" (Golder and Conor Pacific 1998).

B2.1.2.1 Continuous Monitoring Summary

Five years of continuous ambient air quality data (1993 to 1997) from the Suncor, Syncrude and Alberta Environmental Protection monitoring stations were summarized and compared to air quality guidelines (Figure B2-1 and Table B2-7).

Table B2-7 Summary of Parameters Currently Monitored on a Continuous Basis

Operation	Station	U	θ	SO_2	H_2S	NO_x	THC	O_3	CO
Suncor	Mannix (#2)	✓	✓	✓	✓	✗	✗	✗	✗
	Lower Camp (#4)	✓	✓	✓	✓	✗	✗	✗	✗
	Fina Airstrip (#5)	✓	✓	✓	✗	✗	✗	✗	✗
	Poplar Creek (#9)	✓	✓	✓	✓	✗	✓	✗	✗
	Athabasca (#10)	✓	✓	✓	✓	✗	✓	✗	✗
Syncrude	AQS1 (Mine South)	✓	✓	✓	✓	✗	✗	✗	✗
	AQS2 (Fort McMurray)	✓	✓	✓	✓	✗	✓	✗	✗
	AQS3 (Mildred Lake)	✓	✓	✓	✓	✗	✗	✗	✗
	AQS4 (Tailings North)	✓	✓	✓	✓	✓	✓	✗	✗
	AQS5 (Tailings East)	✓	✓	✓	✓	✗	✗	✗	✗
AEP	FMMU (Fort McMurray)	✓	✓	✓	✓	✓	✓	✓	✓
	FRMU (Fort McKay)	✓	✓	✓	✓	✗	✓	✗	✗

NOTE:
✓ = currently being monitored
✗ = not being monitored
U = wind speed
θ = wind direction
AEP = Alberta Environmental Protection
CO = carbon monoxide
H_2S = hydrogen sulphide
NO_x = oxides of nitrogen
THC= total hydrocarbons
O_3 = ozone
SO_2 = sulphur dioxide

Sulphur Dioxide (SO_2) Concentrations

Concentrations of SO_2 in excess of the federal acceptable objectives level of 0.34 ppm (900 μg/m^3) have been observed at four of the five Suncor stations in the five year review period. Since the beginning of 1996, readings greater than 0.34 ppm have occurred only at the Fina and Poplar Creek sites (Table B2-8).

While exceedances of the Alberta Guideline of 0.17 ppm (450 μg/m^3) have been observed at least once at all of the monitoring sites, these exceedances are most frequently observed at the Fina and Mannix stations and least frequently at the AQS5 (Syncrude Tailings East) and FMMU (Fort McMurray) stations (Table B2-9). The total number of exceedances has been decreasing since 1994 and in 1997 the overall network recorded the fewest exceedances in the five year study period.

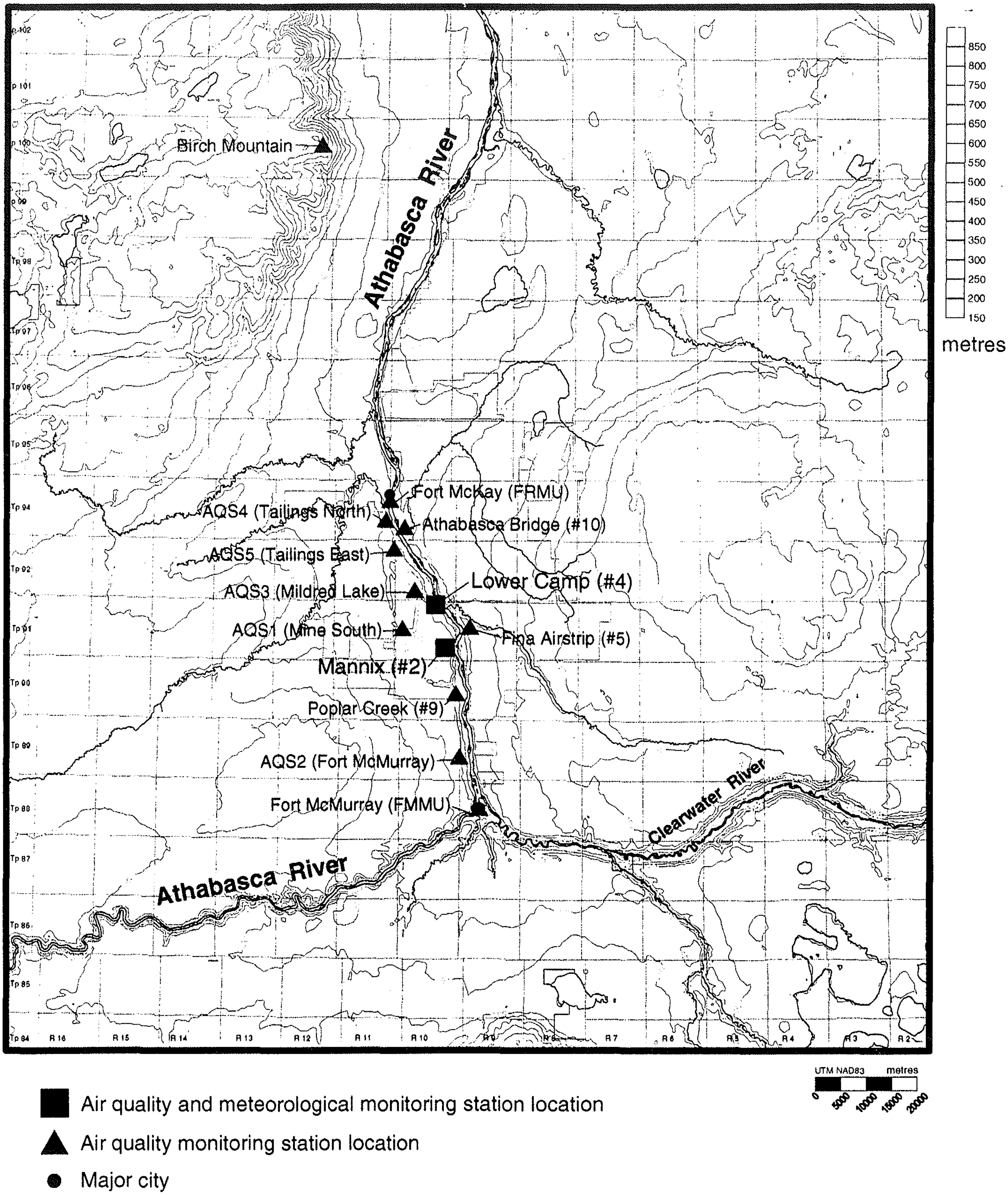


Figure B2-1 Locations of Continuous Air Quality Monitoring Stations

Table B2-8 Number of Hourly SO_2 Concentrations Greater Than 0.34 ppm (900 $\mu g/m^3$)

Station	1993	1994	1995	1996	1997	Total	Average
Mannix (#2)	0	3	13	0	0	16	3
Lower Camp (#4)	0	0	5	0	0	5	1.4
Fina (#5)	3	0	3	3	0	9	1.2
Poplar Creek (#9)	0	1	0	0	2	3	0.6
Athabasca (#10)	0	0	0	0	0	0	0
AQS1 (Mine South)	0	2	0	0	0	2	0.4
AQS2 (Fort McMurray)	0	0	0	0	0	0	0
AQS3 (Mildred Lake)	0	1	0	0	0	1	0.2
AQS4 (Tailing North)	0	0	0	0	0	0	0
AQS5 (Tailing East)	0	0	0	0	0	0	0
Fort McMurray (FMMU)	0	0	0	0	0	0	0
Fort McKay (FRMU)	0	0	0	0	0	0	0
Total	**3**	**7**	**21**	**3**	**2**	**36**	**7**

Table B2-9 Number of Hourly SO_2 Concentrations Greater Than 0.17 ppm (450 $\mu g/m^3$)

Station	1993	1994	1995	1996	1997	Total	Average
Mannix (#2)	9	21	20	10	1	61	12.2
Lower Camp (#4)	3	6	5	3	0	17	3.4
Fina (#5)	14	16	21	11	3	65	13.0
Poplar Creek (#9)	0	4	4	3	0	11	2.2
Athabasca (#10)	2	6	2	0	0	10	2.0
AQS1 (Mine South)	3	7	3	1	0	14	2.8
AQS2 (Fort McMurray)	0	5	6	0	0	11	2.2
AQS3 (Mildred Lake)	4	8	5	2	0	19	3.8
AQS4 (Tailing North)	0	3	3	2	0	8	1.6
AQS5 (Tailing East)	0	1	0	2	0	3	0.6
Fort McMurray (FMMU)	0	0	1	0	0	1	0.2
Fort McKay (FRMU)	1	2	2	0	0	5	1.0
Total	**36**	**79**	**72**	**34**	**4**	**225**	**45**

The ambient SO_2 concentrations observed at Suncor's monitoring stations have exceeded the daily Alberta guideline of 150 $\mu g/m^3$ (0.06 ppm) either once or twice per year except in 1997 when there were no exceedances. The average number of combined daily exceedances over the 1993 to 1997 period is 1.4 days per year.

Background annual values of SO_2 are expected to be in the 1 to 4 $\mu g/m^3$ range (summer and winter, respectively). This value is based on extrapolating measurements from Cree Lake, Saskatchewan and Vegreville, Alberta to the region. The compliance monitoring program conducted by

Suncor, Syncrude and AEP does not allow meaningful annual or background values to be calculated.

Hydrogen Sulphide (H_2S) Concentrations

Concentrations of H_2S in excess of the Alberta guideline of 0.10 ppm (14 μg/m^3) have been observed at all locations. The most frequent exceedances have been observed at the Mannix station (Table B2-10). Exceedances have been decreasing with 1997 measuring the lowest number in the five year period.

The H_2S concentrations above the Alberta Guideline were mainly observed during the summer months and the month of January.

Table B2-10 Number of Hourly H_2S Concentrations Greater Than 0.01 ppm (14 μg/m^3)

Station	1993	1994	1995	1996	1997	Total	Average
Mannix (#2)	24	42	10	16	6	98	19.6
Lower Camp (#4)	2	2	4	12	4	24	4.8
Poplar Creek (#9)	0	0	4	0	0	4	0.8
Athabasca (#10)	1	2	2	2	0	7	1.4
AQS1 (Mine South)	4	10	0	1	0	15	3.0
AQS2 (Fort McMurray)	3	13	0	0	0	16	3.2
AQS3 (Mildred Lake)	3	1	0	3	0	7	1.4
AQS4 (Tailing North)	5	6	2	0	0	13	2.6
AQS5 (Tailing East)	0	0	2	0	0	2	0.4
Fort McMurray (FMMU)	0	5	0	0	0	5	1.0
Fort McKay (FRMU)	0	0	2	1	0	3	0.6
Total	**42**	**81**	**26**	**35**	**10**	**194**	**39**

Oxides of Nitrogen (NO_x) Concentrations

The continuous monitoring for NO_x occurs at two stations within the region, AQS4 (Tailings North) and FMMU (Fort McMurray). The AQS4 station reports NO_x while the FMMU Station reports NO_x, NO and NO_2. The Alberta Guideline for NO_2 is 400 μg/m^3 (0.21 ppm).

A review of the NO_2/NO_x ratio indicated a dependence on the NO_x concentrations. For small NO_x concentrations (that is, less than 0.05 ppm), the NO_2 concentration is typically 55 to 75% of the NO_x value. For larger NO_x concentrations (that is, greater than 400 μg/m^3), the NO_2 concentration is typically 20% of the NO_x value.

Two hourly NO_x values at AQS4 were observed to exceed 400 μg/m^3 (0.21 ppm). Both of these readings occurred in 1993 and there have been no values or exceedance of the NO_2 guideline since 1993 at this location.

During the five year assessment period for the Fort McMurray station there has been, on a yearly average, four NO_x readings that have exceeded 400 μg/m^3 (0.21 ppm).

Ozone (O_3) Concentrations

Ozone concentrations are only measured at FMMU station in Fort McMurray. Exceedances of the hourly Alberta guideline of 160 μg/m^3 (0.08 ppm) are relatively infrequent during the five year review period and occurred only in 1993. There have been no exceedances since 1993. Exceedances of the daily Alberta guideline of 50 μg/m^3 (0.025 ppm) occur on average about 118 days per year (Table B2-11).

High ozone concentrations have been observed in rural areas of Alberta (Angle and Sandhu 1986, Peake and Fong 1990). Exceedances of the guideline occur more frequently in rural than in urban areas such as Calgary and Edmonton. Exceedances of the daily guidelines have been observed 50 to 90% of the time in rural Alberta areas compared with only 10 to 40% of the time in urban areas (Angle and Sandhu 1989).

Table B2-11 Summary of Hourly and Daily O_3 Concentrations Observed at Fort McMurray

Station	1993	1994	1995	1996	1997
Hourly Statistics					
Mean (ppb)	22	24	25	18	18
Median (ppb)	21	22	22	17	n/a
Maximum (ppb)	91	77	71	58	61
N ≥ 80 ppb (h/y)	4	0	0	0	0
Daily Statistics					
Mean (ppb)	22	24	23	18	18
Median (ppb)	21	23	22	17	n/a
Maximum (ppb)	54	58	68	44	n/a
N ≥ 25 (ppb) (d/y)	127	153	135	93	81

h/y = Hours per year.
d/y = Days per year.
n/a = not available

Carbon Monoxide (CO) Concentrations

Carbon monoxide concentrations are only measured at FMMU station in Fort McMurray. All observed CO one-hour average values have been within the Alberta guideline of 15,000 μg/m^3 (13 ppm).

Total Hydrocarbons (THC) Concentrations

Total hydrocarbons are measured at six locations. While median THC concentrations are typically in the 1.6 to 1.9 ppm range, maximum values in excess of 30 ppm have been reported in Athabasca River valley locations (that is, Poplar Creek and Athabasca) (Table B2-12). These values suggest channeling by the valley of emissions from low level fugitive hydrocarbon sources. Further along the valley, the maximum observed values were less, with a maximum observed value at Fort McMurray of 2,492 μg/m³ (3.8 ppm) and at Fort McKay of 5,442 μg/m³ (8.3 ppm).

Table B2-12 Median and Maximum THC Concentrations (ppm)

		Poplar Creek (#9)	Athabasca (#10)	AQS2 (Fort McMurray)	AQS4 (Tailings North)	Fort McMurray (FMMU)	Fort McKay (FRMU)
Median	1993	1.7	1.9	1.6	1.8	2.0	1.8
	1994	1.5	1.6	1.4	1.5	2.2	1.7
	1995	1.7	n/a[a]	1.6	1.7	2.0	1.6
	1996	1.7	n/a[a]	2.0	1.7	2.2	1.8
	1997	1.7	n/a[a]	n/a[a]	1.9	2.1	1.6
Maximum	1993	51.4	35.0	3.3	5.7	3.2	3.6
	1994	11.1	13.7	4.6	4.3	3.7	3.3
	1995	35.0	n/a[a]	6.1	14.6	3.2	8.3
	1996	35.0	n/a[a]	3.4	16.2	3.8	3.9
	1997	35.0	n/a[a]	n/a[a]	7.5	3.2	4.7

(a) No data.
n/a Data not available.`

Suncor conducts fugitive emission surveys each calendar year for compounds such as THC. A condition of the latest approval requires Suncor, commencing in 1997, to monitor fugitive volatile organic compounds (VOC) according with the Canadian Council of Ministers of Environment (CCME) fugitive VOC emission code. THC results during the five year assessment period are only available for 1993 and 1994 and maximum one minute values were 40,700 μg/m³ (62 ppm) and 55,700 μg/m³ (85 ppm) respectively. No VOC readings were available for review.

Non-methane hydrocarbons (NMHC) were measured at the SOLV-EX background site. On a monthly basis, the maximum values ranged from 3,500 μg/m³ (5.3 ppm) to 8,700 μg/m³ (13.3 ppm). However, in February and March 1997, the peak values were 47,750 (73 ppm) and 14,400 μg/m³ (22 ppm), respectively.

Particulates

Total suspended particulate matter (TSP or PM) is measured at AQS2 (Fort McMurray) and AQS4 (Tailings North). Only 1993 and 1994 data were available for review during the five year period. The annual geometric mean at both sites of between 9.4 and 16.6 μg/m³ is less than the 60 μg/m³

Alberta guideline. There has been one exceedance, at AQS4, of the daily guideline of 100 $\mu g/m^3$.

AEP commenced measurement of $PM_{2.5}$ in 1997 at the Fort McMurray site (FMMU). The maximum hourly observed value was 105.5 $\mu g/m^3$ and this reading exceeds the U.S. EPA 24-hour guideline of 65 $\mu g/m^3$. The annual average of 6.50 $\mu g/m^3$ is less than the U.S. EPA annual guideline of 15 $\mu g/m^3$.

B2.1.2.2 Passive Monitoring Summary

The locations of the passive samplers are biased on a north/south axis parallel to the Athabasca River valley. Maximum total sulphation and hydrogen sulphide values occur in the vicinity of each plant and in the river valley near Lower Camp.

A review of selected Suncor, Syncrude and AEP passive samplers for total sulphation and hydrogen sulphide that are closely located indicated biases that may be due to either the sampling approach and/or the analytical approach. Adjustment factors were applied to normalize the data prior to analysis.

B2.1.2.3 Summary of Acid Forming Compounds

Precipitation Chemistry and Wet Potential Acid Input (PAI_{wet})

The average acidity (pH) of the precipitation observed in Fort McMurray in the 1993 to 1996 period (1997 data not available) is 4.8. This is more acidic than other locations measured in northern Alberta or Saskatchewan (pH = 4.9 to 5.3).

The level of acidification (PAI_{wet}) caused by rain depends on a balance between the amount of acid forming compounds (e.g., SO_4^{-2}, NO_3^- and NH_4^+) and the available cations (e.g., Mg^{+2}, Ca^{+2} and K^+) in the precipitation. The measure of this acidification preferred by AEP is the PAI approach, which is calculated in the following manner:

$$PAI_{wet}=([SO_4^{-2}]+[NO_3^-]+[NH_4^+])-([Ca^{+2}]+[Mg^{+2}]+[K^+])$$

The PAI takes into account sulphur and nitrogen species and all values are in units of "keq/ha/y" (1 keq = 1 kmol H^+).

The annual average wet potential acidic input (PAI_{wet}) observed in Fort McMurray is 0.08 keq/ha/y. Regional data (Table B2-13) indicates a range of 0.00 to +0.09 keq/ha/y and an average background level of PAI_{wet} of 0.040 keq/ha/y.

Table B2-13 Annual Average Wet Potential Acidic Input Observed at Selected Precipitation Stations, keq/ha/y

Site	1993	1994	1995	1996	Average
Beaverlodge	0.05	0.09	0.07	0.06	0.07
Cold Lake	-	0.07	0.05	0.09	0.07
Fort Chipewyan	0.00	-	0.01	-	0.01
Fort Vermilion	0.02	0.03	0.00	-	0.02
High Prairie	0.03	-	-	-	0.03
Vegreville	-	0.11	0.05	0.10	0.09
Cree Lake	0.00	0.00	0.00	0.00	0.00
Snare Rapids	0.03	0.03	0.03	0.05	0.04
Average	**0.03**	**0.05**	**0.04**	**0.06**	**0.04**
Fort McMurray	0.08	0.06	0.10	0.09	0.08

Dry Deposition and Potential Acid Input (PAI_{dry})

The contribution of dry deposition mechanisms of acidification is calculated in a similar manner to that of wet deposition. The average concentration of acid forming compounds (e.g., SO_2, SO_4^{-2}, HNO_3, NO_3^- and NH_4^+) and the available cations (e.g., Mg^{+2}, Ca^{+2} and K^+) are converted into dry deposition rates by multiplying by an appropriate deposition velocity. The dry component of the PAI (in hydrogen equivalents) can be given by:

$$PAI_{dry}=([SO_2]+[SO_4^{-2}]+[HNO_3]+[NO_3^-]+[NH_4^+])-([Ca^{+2}]+[Mg^{+2}]+[K^+])$$

The calculation of the annual dry PAI required the estimation of dry deposition velocities (see the EIA key reference report "Technical Reference for Meteorology, Emissions and Ambient Air Quality in the Oil Sands Region" (Golder and Conor Pacific 1998). The estimated dry PAI contribution is 0.06 keq/ha/y.

Total Potential Acid Input (PAI)

The total PAI can be calculated for both the current measured conditions at Fort McMurray and the background air quality in the region. This is done by using the appropriate wet PAI and the dry PAI of 0.06 keq/ha/y.

The total current baseline PAI using the measured Fort McMurray data is 0.14 keq/ha/y. The total background PAI for the background air quality in the region is estimated at 0.10 keq/ha/y.

Alberta has selected an interim critical load of 0.25 keq/ha/y for highly sensitive soils following recent European experience. In order to evaluate this selection and compare it with other options, Alberta Environmental Protection and Environment Canada have developed a regional model based on 1990 provincial emission rates (Fox, McDonald and Cheng, Air and Waste Management 1998, in press). Their model results, based on 1990 emissions (i.e., significantly increased SO_2 emissions but reduced NO_x

emissions from present emission rates in the oil sands region) have found "on the regional scale, effects of urbanization, power generation and transportation increases may overwhelm effects due to expansion in the oil sands region". Their sensitivity assessment indicates that doubling NO_x emissions and halving the SO_2 emissions would not increase PAI above 0.25 keq/ha/y in the oil sands region. Based on the modelling results, Fox et al. have concluded that the southern part of the province be more closely monitored than the northeast oil sands region

B2.1.2.4 Odour Assessment Studies

A review of the odour complaint information, collected in response to the initiation of a regional odour response protocol, indicates a reduction of both the frequency and magnitude of odour incidents over the 1993 to 1997 period (Table B2-14).

Table B2-14 Oil Sands Odour Complaints Received by Alberta Environmental Protection 1993 - 1997

Year	Fort McMurray Complaints/Incidents	Fort McKay Complaints/Incidents
1993	263/116	22/18
1994	102/59	11/11
1995	62/40	19/9
1996	43/28	15/12
1997	13/10	4/4

B2.1.2.5 Conclusions

The operation of the Suncor and Syncrude oil sands facilities has resulted in changes to the quality of the air downwind of the facilities. The major changes are associated with the emissions of SO_2 from the main stacks and from fugitive total hydrocarbon and total reduced sulphur emissions from lower level sources.

The historical SO_2 emissions from the main stacks have resulted in ambient SO_2 ground level concentrations that are in excess of ambient guidelines. These exceedances occurred most frequently in the vicinity of the Suncor site. The wet sulphate deposition is higher than in other regions in northern Alberta or Saskatchewan.

Fugitive hydrocarbon and reduced sulphur compound emissions from the oil sands plant area and associated ponds have historically contributed to off-site odours. There has been a significant reduction in odour complaints suggesting that the recently instituted mitigation measures are reducing odour emission sources.

B2.1.3 Meteorology

Suncor currently maintains a network of five ambient air quality monitoring stations in the vicinity of their operation. In the summer of 1993, the meteorological instrumentation at the Lower Camp and Mannix stations was upgraded to meet the needs associated with the Supplemental Emission Control (SEC) program as well as those of a regional-based meteorological monitoring program. The objective of the enhanced meteorological monitoring program is to gain a better understanding of plume-level air flow and dispersion characteristics in the vicinity of the Fort McMurray oil sands operations.

Meteorological data collected at the Mannix site is summarized and is used to assess the local and regional air quality changes. The Mannix station is comprised of a communications tower that is instrumented at the 20, 45 and 75 m levels; this analysis uses the data from the 75 m level. Validated data are available for the period November 1993 to October 1997.

Meteorology plays a significant role in the transport and dispersion of gaseous emissions vented to the atmosphere. Specific meteorological parameters of concern for air quality modelling of ground level concentrations and deposition include: wind direction, wind speed, mixing height and atmospheric turbulence.

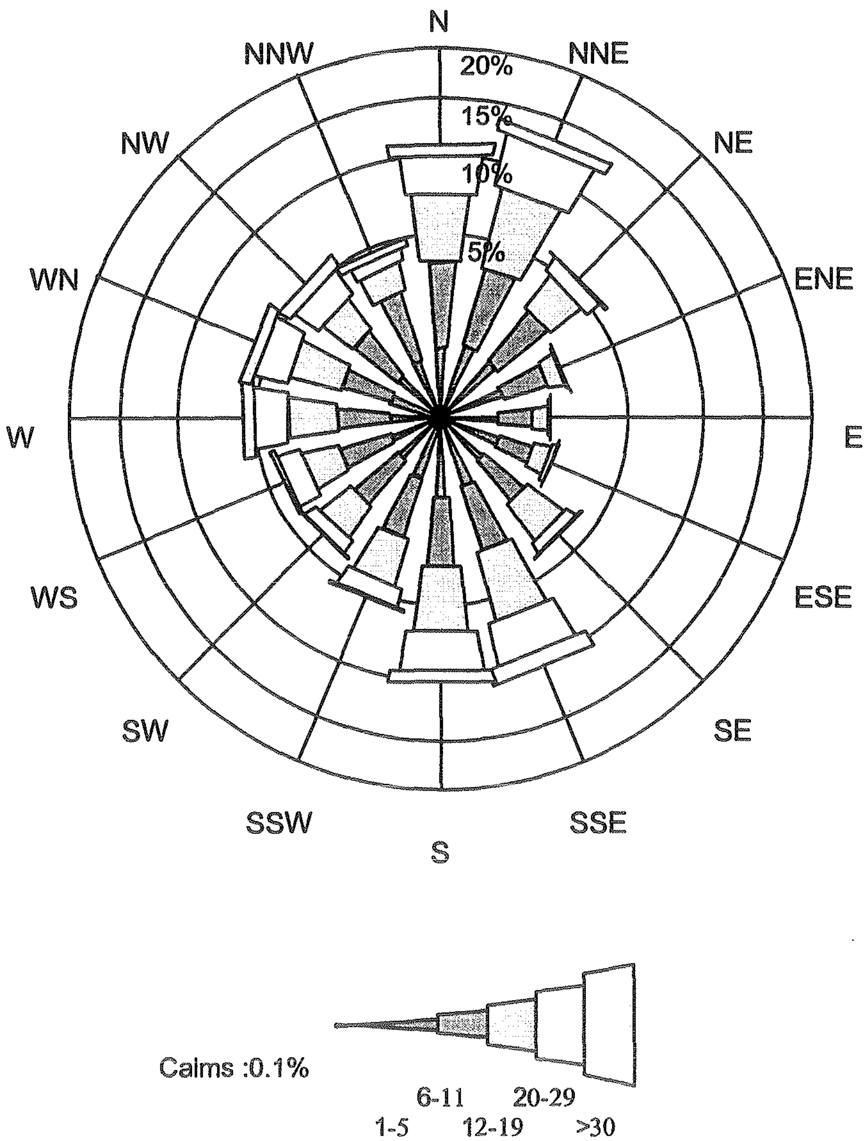
Additional information on meteorological data collected by the Suncor enhanced monitoring program is provided in the EIA key reference report "Technical Reference for Meteorology, Emissions and Ambient Air Quality in the Oil Sands Region" (Golder and Conor Pacific 1998).

B2.1.3.1 Wind Related Observations

Wind direction and speed data can be displayed by plotting the frequency distribution as a "windrose". The windrose is comprised of bars whose length indicates the frequency the wind blows from a given direction. Wind direction information is displayed for the 16 points of a compass. The windrose also indicates the frequency of wind speed for each of the 16 compass points. Five different wind speed summaries are displayed.

- **Wind Direction.** Wind directions tend to be either from the south (S) to south-southeast (SSE) sector or from the north (N) to north-northeast (NNE) sector (Figure B2-2). These two sectors represent the orientation of the Athabasca River Valley; and
- **Wind Speed.** The mean wind speed is 16.3 km/h. Wind speeds less than 11 km/h occur approximately 35% of the time. Mean wind speed is consistent throughout each season with summer having the lowest mean speed (15.6 km/h) and autumn having the highest mean speed (17.2 km/h).

Figure B2-2 Observed Wind Speeds and Directions at the Mannix Station (75 m Level)



B2.1.3.2 Atmospheric Stability Class Related Observations

Atmospheric stability can be viewed as a synonymous measure of the atmosphere's ability to disperse emissions. Atmospheric turbulence plays an important role in the dilution of a plume as it is transported by the wind. Turbulence can be generated by either thermal or mechanical mechanisms. Surface heating or cooling by radiation contributes to the generation or suppression of thermal turbulence, while high wind speeds contribute to the generation of mechanical turbulence.

The Pasquill-Gifford (PG) stability classification scheme is one classification of the atmosphere. The classification ranges from Unstable (Stability Classes A, B and C), Neutral (Stability Class D) to Stable (Stability Classes E and F). Unstable conditions are primarily associated with daytime heating conditions, which result in enhanced turbulence levels (enhanced dispersion). Stable conditions are associated primarily with nighttime cooling conditions, which result in suppressed turbulence levels (poorer dispersion). Neutral conditions are primarily associated with higher wind speeds or overcast conditions.

At the Mannix station the PG stability classes for the time period assessed indicates Neutral conditions 54.4 percent of the time, Stable conditions 23.6 percent of the time and Unstable conditions 21.8 percent of the time (Figure B2-3).

B2.1.3.3 Mixing Height Estimation

Mixing height is the depth of the atmospheric surface layer in which mixing of emissions occurs. In a well-mixed atmosphere, the temperature tends to decrease 1°C for every 100 m increase in height above the ground, which defines the norm. During the night, when the ground cools due to radiation heat loss, the temperature may increase above this norm with increasing height. This is referred to as a temperature inversion. The base of an inversion can be ground level or elevated.

The mean mixing height value at the Mannix station for the time period assessed is 650 m. There is a seasonally and monthly variation to the mixing height levels with the winter season having a lowest mixing height mean of 418 m and the summer having the highest mixing height mean of 884 m. Monthly mixing height means, maximums and minimums are presented in Figure B2-4.

Figure B2-3 Observed Pasquill-Gifford Stability Classifications

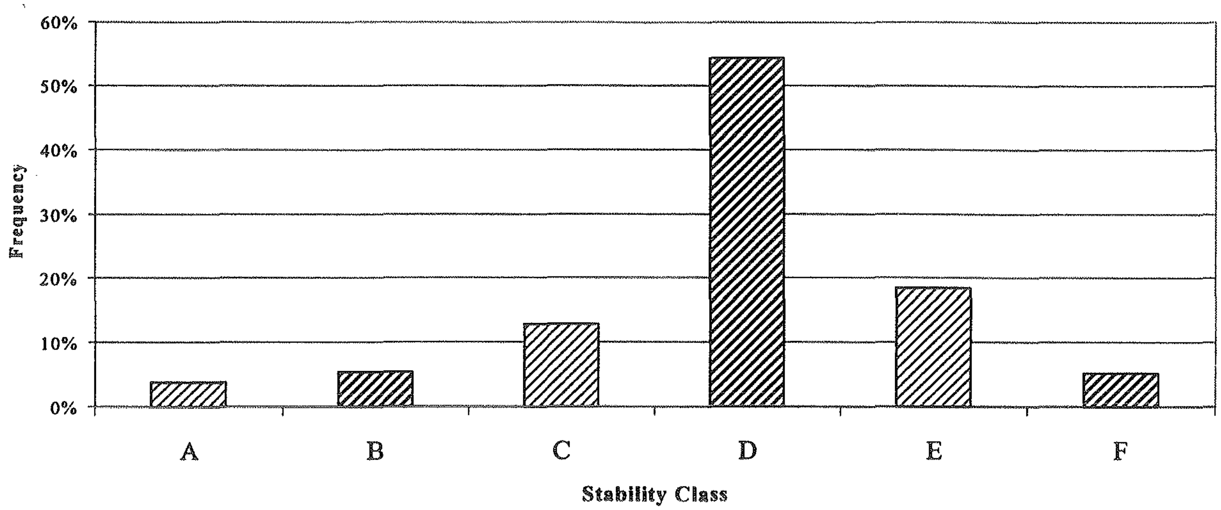
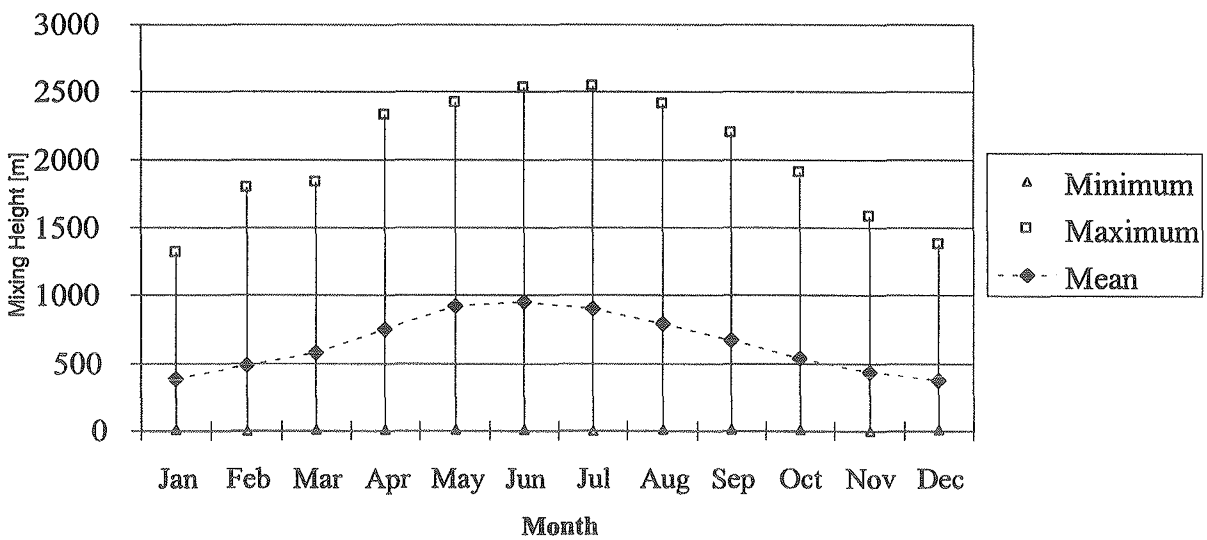


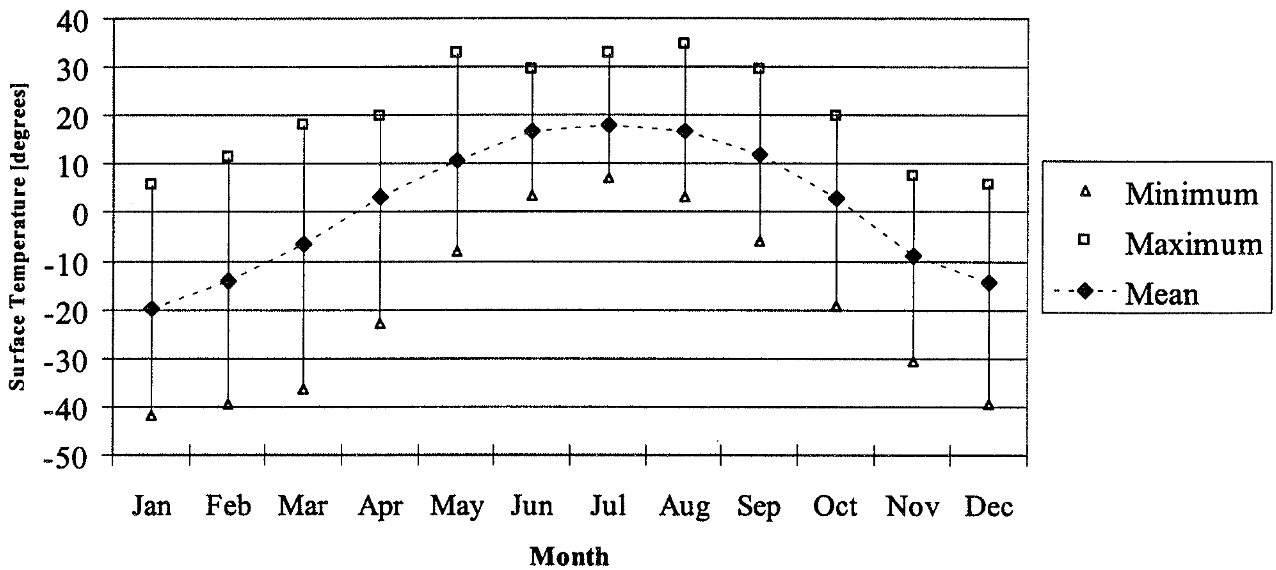
Figure B2-4 Summary of Monthly Mixing Heights Estimations



B2.1.3.4 Temperature Related Observations

Mean monthly surface temperatures at the Mannix station ranged from approximately -20°C in January to 18°C in July. Extreme temperatures (i.e., above 30°C and below -30°C) were observed in the months from May to September and November to March, respectively. The annual average temperature was approximately 0°C. Figure B2-5 summarizes the monthly temperatures during the assessment time period.

Figure B2-5 Summary of Observed Monthly Temperatures



B2.1.3.5 Precipitation

A review of the precipitation at the Mannix station for the assessment period indicates that approximately 60% of the precipitation falls in the summer months (June to August). In total, the mean precipitation was 455 mm/y.

B2.1.4 Topography

The path followed by a plume and the turbulence levels that result in the dilution of the plume can be affected by terrain features such as valleys and hills. The magnitude of the terrain effect is dependent on factors such as terrain elevation, the slope of the terrain feature, the relative height of the plume with respect to the terrain and the meteorological conditions.

Step-like terrain features can cause complex recirculating flow patterns in their immediate vicinity. A valley can generate its own air flow path independent of the regional winds above the valley. In some cases, the plume will flow either around or over hills or other dominant terrain features. In extreme cases, the plume may impinge directly on a hill in its path.

Figure B2-6 shows a map of the terrain on a regional scale. The dominant terrain features on a regional scale include:

- **The Athabasca River Valley, which has a general north-south orientation in the vicinity of the oil sands plants;**
- **The Clearwater River Valley, which has a general east-west orientation;**
- **The highest elevations are associated with the Birch Mountains, which are approximately 50 km to 75 km to the northwest of the Suncor plant area. These mountains reach an elevation of 820 masl;**
- **Muskeg Mountain is about 40 km to the east of the plant area. At a distance of 55 km, this mountain reaches an elevation of 665 masl;**
- **The Thickwood Hills are about 20 km to the southwest of the plant area. At a distance of 25 km, these hills rise to an elevation of 515 masl; and**
- **Stoney Mountain is about 60 km to the south of the plant area. At a distance of 65 km, this mountain rises to an elevation of 760 masl.**

For the purposes of comparison, the base elevation of the Suncor plant stacks is about 259 masl and the base elevation of the Syncrude plant stack is about 304 masl.

The roughness and smoothness of a vegetation canopy affect the wind speed and turbulence profiles. The oil sands area is located in the Boreal Forest Region which supports a variety of upland and lowland vegetation. The area is characterized by forest associations of white spruce, black spruce, jack pine, balsam fir, tamarack, aspen, balsam poplar and white birch.

Mature tree heights range from 10 m for black spruce in low-lying areas to 30 m for jack pine located on sandy soils. Mature white spruce and aspen

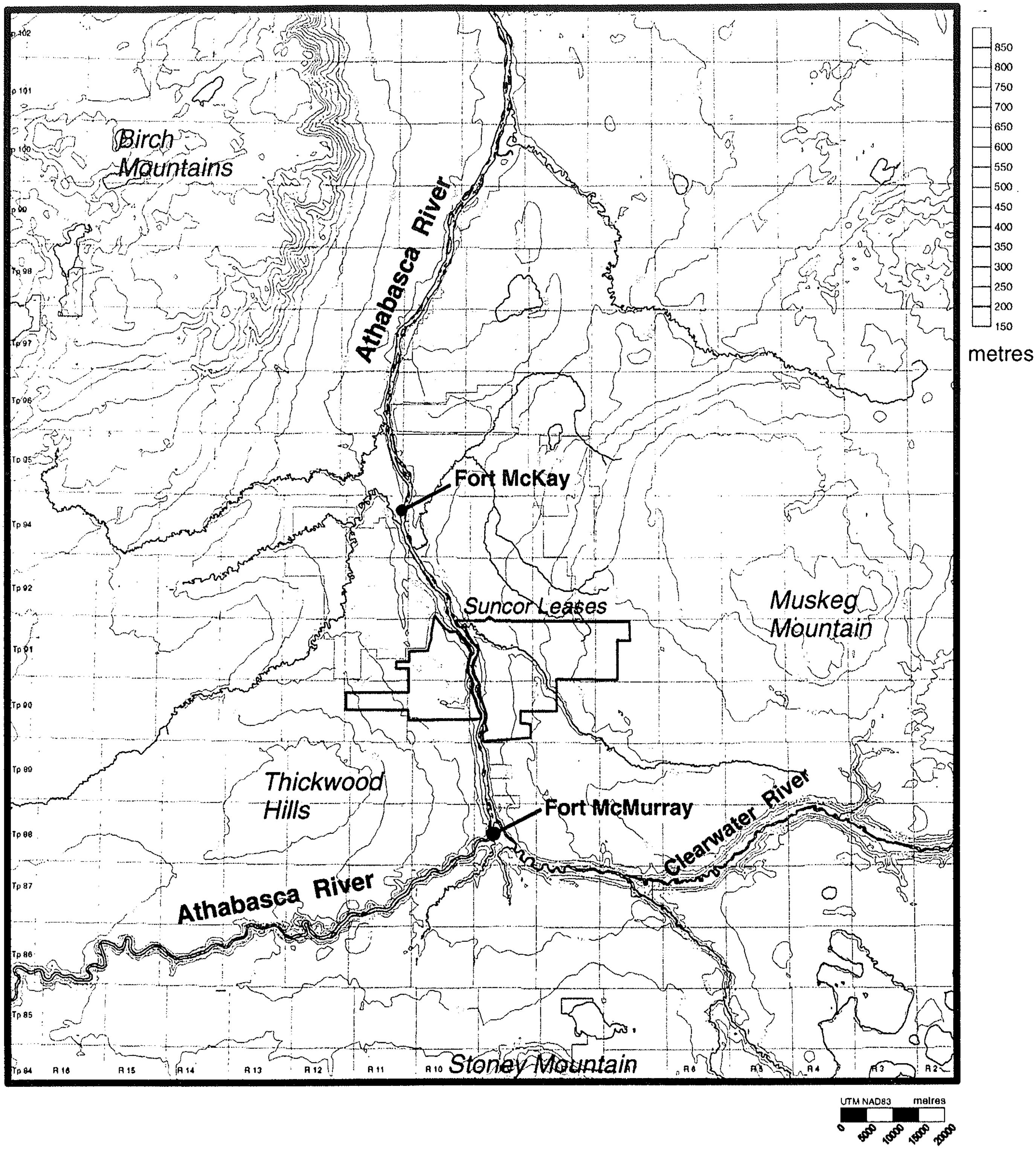


Figure B2-6 Terrain Over the RSA Used in the Air Quality Analysis

forest stands tend to be 25 and 15 m in height, respectively. Due to differing soil types and drainage patterns, the vegetation cover is non-uniform within the region.

B2.2 AMBIENT AIR QUALITY PREDICTIONS

B2.2.1 Model Approach and Limitations

The selection of an air quality model for use in evaluating the atmospheric emissions in the Athabasca oil sands region should be able to satisfy the following key conditions:

- evaluate the various source types present in the region;
- predict the necessary pollutant concentrations or deposition rates;
- have a technical basis which is scientifically sound, and is in keeping with the current understanding of the dispersion of contaminants in the atmosphere;
- have assumptions and formulations which are clearly set out, and have undergone rigorous independent scrutiny; and
- predictions made by the model should be consistent with local observations.

A series of dispersion models were considered for use in the assessment, ranging from the simpler SCREEN3 model (which requires minimal inputs to run), to the more elaborate CALPUFF and CALGRID models. Details of the model review are presented in Appendix III, Air Quality Modelling Documentation.

The SCREEN3 model is an easy-to-use Gaussian plume model that has built in meteorological conditions to aid in determining the worst case concentrations from individual sources. Due to the screening nature of the model, it is possible for SCREEN3 to significantly over predict the worst case concentrations under specific scenarios.

The Industrial Source Complex Short Term Model, Version 3 (ISCST3) is a steady-state Gaussian plume model, recommended by the USEPA for evaluating pollutant releases from a wide variety of sources associated with industrial source complexes. This model can account for: building downwash; area, line and volume sources; plume rise as a function of downwind distance; separation of point sources; and limited terrain adjustment. Local hourly meteorological data are required by the ISCST3 model.

The ISC3BE dispersion model is a modified version of the original ISCST3 model developed by BOVAR Environmental. The modifications made to the original model code were undertaken to enable the model to yield maximum predictions during the daylight hours and to predict similar numbers of exceedances as observed at the local monitoring stations (Conor Pacific, 1998). Although the tuning done to the ISC3BE model has not been subjected to the same rigorous independent review as the original code, the changes are designed to yield model predictions which correspond to the observations made at sampling locations along the Athabasca River valley. This model has been extensively used in previous air assessments in the oil sands region.

CALPUFF is a multi-layer, multi-species non-steady-state puff dispersion model which can simulate the effects of time- and space-varying meteorological conditions on pollutant transport, transformation, and removal. CALPUFF can use the three dimensional meteorological fields developed by CALMET or similar models, or simple, single station winds in a format consistent with the meteorological files used to drive the ISCST3 model. The use of single station wind files do not allow CALPUFF to take advantage of its capabilities to treat spatially-variable meteorological fields.

CALGRID is an Eulerian photochemical transport and dispersion model which includes modules for horizontal and vertical advection/diffusion, dry deposition, and a detailed photochemical mechanism. The full implementation of the CALPUFF modelling system, including a 3-dimensional wind field, a digital terrain model and more rigorous, hourly source and ambient air quality characterizations are required in order to run the CALGRID model. It is being considered for use in calculating ozone levels in the study area.

Dispersion models employ simplifying assumptions to describe the random processes associated with atmospheric motions and turbulence. These simplifying processes limit the capability of a model to replicate individual events. A model's predictive capability and strength lies in the capability to predict an average for a given set of meteorological conditions. Other factors that limit the capability of a model to predict values that match observations are limitations in the input data and information used by the model. The modelling does not account, for example, the hour-by-hour emission rates in the source strength and exit characteristics (such as temperature and velocity). The models do not replicate the special flow patterns and reduced dispersion within the Athabasca River valley, although the ISC3BE model has been tuned in an attempt to account for some of these effects.

Notwithstanding these limitations, the data used by the models and for the model evaluation did undergo a review in the key reference report (Appendix III) and were found to be sufficient for the modelling application. Specifically, the model predictions show good agreement with observations, both in terms of magnitude and diurnal trends.

Emission rates used in the tables in this report are presented as daily tonnes per calendar day (t/cd). All distances to readings are measured from the Suncor Incinerator Stack and are referred to as distances from Suncor.

B2.2.2 SO_2 Predicted Concentrations

There are numerous SO_2 emission sources associated with the baseline operations as summarized in Section B2.1 (e.g., Tables B2-1 to B2-6). The estimated total SO_2 emission rate in the oil sands region is 278.4 t/cd. Suncor emits an estimated 25% (65.3 t/cd) of the total SO_2 emissions to the atmosphere (Table B2-6). The major sources of SO_2 at Suncor are the Sulphur Incinerator stack (18.8 t/cd), the FGD stack (18.0 t/cd), the Powerhouse stack (13.1 t/cd) and continuous flaring (12.6 t/cd).

The predicted maximum hourly, daily and annual ground level ambient SO_2 concentrations resulting from emissions of all approved industrial sources and residential emissions in the oil sands region were estimated using the ISC3BE model. The CALPUFF model was used to address acidic deposition, hence annual SO_2 GLC are presented for comparison to the ISC3BE model. Emission rates used were the calendar day (total annual emissions divided by 365 days) for annual values and stream day (typical operating conditions which represent emissions for 95% of time) for hourly and daily values. Four years of observed meteorological measurements from the Suncor Mannix station (75 m level) were used in the modelling. These models provide an efficient means of estimating the predicted ambient SO_2 concentrations from all sources and provides an indication where maximum concentrations could occur.

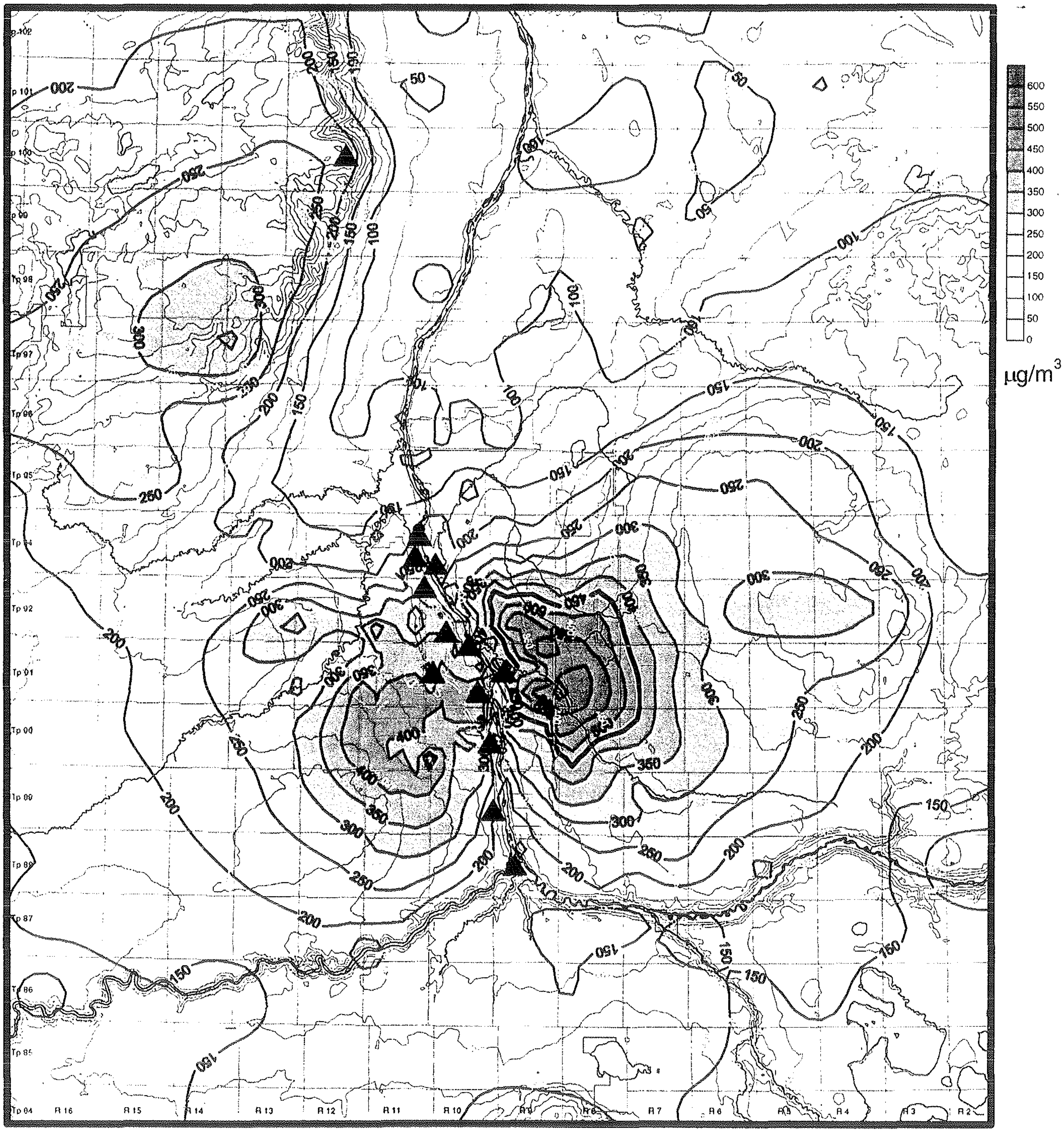
The modelling predictions for daily SO_2 emission rate cases are summarized in Table B2-15 for each model. The predicted ground level concentrations are mapped in Figures B2-7 to B2-12 and described below:

- Figures B2-7 show the maximum hourly average SO_2 ground level concentrations (GLC) associated with the Baseline operations for the ISC3BE model. An overall maximum hourly average SO_2 concentration, as determined by ISC3BE, of 648 $\mu g/m^3$ is predicted to occur at a location 13 km ESE of Suncor and is within the lease boundary (Figure B2-7). This maximum hourly average value exceeds the Alberta Ambient Air Quality Guideline (AAAQG) of 450 $\mu g/m^3$. The ISC3BE predictions indicate two areas that result in maximum hourly averages in excess of the AAAQG. A very small area, located SSW of Suncor and a large area located east of Suncor. The area ESE of Suncor encompasses approximately 33,310 ha of land of which about 90% are within the Suncor lease boundaries. The ISC3BE model predicts a maximum of 3 yearly exceedances of the Alberta hourly guideline. The location of the maximum number of exceedances is predicted to occur 12 km ESE of Suncor within the Suncor development area.

- Figure B2-8 shows the maximum daily average ground level SO_2 concentrations associated with Baseline operations for the ISC3BE model. An overall maximum daily average SO_2 concentration of 199 μg/m^3 is predicted to occur WNW of Suncor. This maximum average value exceeds the Alberta Guideline of 150 μg/m^3. In total, 358 ha are predicted to have the maximum average in excess of the Alberta daily guideline. The ISC3BE model predicts a maximum of 6 yearly exceedances of the Alberta daily guideline at a location 16 km WNW of Suncor.
- Figure B2-9 and Figure B2-10 show the annual average ground level concentration map for SO_2 for the ISC3BE and CALPUFF models, respectively. The maximum annual average concentration is 74 μg/m^3 and this predicted value is in excess of the AAAQG of 30 μg/m^3. The single area of high annual averages is WNW of the Suncor site and is approximately 356 ha in size. The corresponding values for the CALPUFF model indicate an overall maximum annual average SO_2 concentration of 79 μg/m^3, at the same location as predicted by the ISC3BE model (Figure B2-10). This maximum average value also exceeds the Alberta Guideline of 30 μg/m^3. The areal extent of the high annual average is 365 ha. There is good agreement between the two models particularly in relation to the areal extent of the predicted longer time averaged concentrations. The CALPUFF model suggests a slightly higher maximum value.

From the ISCBE model results, the location and areal extent of the maximum hourly GLC SO_2 concentration can be assessed. Figures B2-7 to B2-10 indicate that the predicted areas that exceed the daily and annual guidelines will occur WNW of Suncor; the area where the hourly guideline exceeds will occur mostly (90%) within the Suncor lease area. Repeating this analysis using the Federal Acceptable hourly and daily standards (900 μg/m^3 and 300 μg/m^3 respectively) indicates no predicted exceedances. However, there would remain an exceedance of the Federal annual value of 60 μg/m^3. The exceedence of the daily and annual guidelines is a result of the generalized characterization of the mine fleet (common to all developments) coupled with receptor points which happen to be located within the mine pit. These circumstances lead to unrealistically high long-term averages near the source, which have not been verified through monitoring data.

There are twelve air quality monitoring stations in the region which can be used to support the model predictions through direct observation of SO_2 air concentrations.



Sources	SO_2 [t/sd]
Suncor	
Powerhouse	0.3
FGD	18.9
Incinerator	19.1
Flaring	7.3
Other Sources, Suncor	3
Syncrude (total)	209
Other Emissions (total)	3.9
TOTAL	261.5

Model Description	
Development	Baseline
Model	ISC3BE (78G)
SO_2 Guideline [µg/m³]	450
Maximum [µg/m³]	648
Exceedences / Year [#]	3

UTM NAD83 metres
0 5000 10000 15000 20000

Figure B2-7 Predicted Baseline SO_2 Maximum Hourly Average Ground Level Concentrations in the RSA using the ISCBE Model

Table B2-15 Maximum Predicted Ground Level Concentrations of SO_2 for Baseline Sources

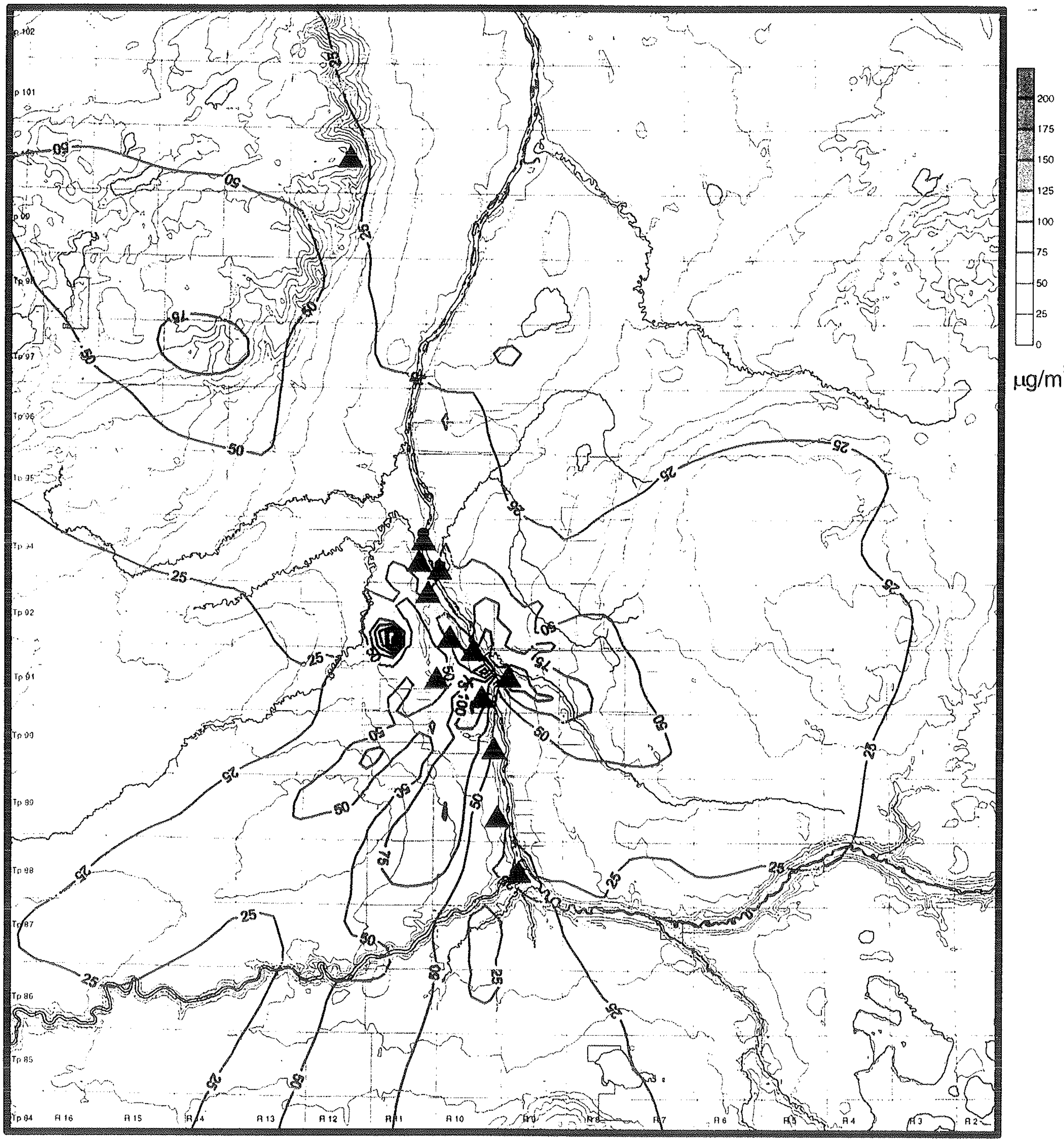
Source	Hourly	Daily	Annual
Baseline Condition - ISC3BE[b]			
Maximum SO_2 Concentration ($\mu g/m^3$)	648	199	74
Location of Maximum Concentration (km)	13 ESE	18 WNW	15 WNW
Maximum Number of Exceedances[a]	3	6	1
Location of Maximum Exceedances (km)	12 ESE	16 WNW	n/a
Baseline Condition - CALPUFF[c]			
Maximum SO_2 Concentration ($\mu g/m^3$)	n/m	n/m	79
Location of Maximum Concentration (km)	n/m	n/m	15 WNW
Maximum Number of Exceedances[a]	n/m	n/m	1
Location of Maximum Exceedances (km)	n/m	n/m	15-WNW
SO_2, Alberta Guideline ($\mu g/m^3$)	450	150	30
SO_2, Federal Acceptable ($\mu g/m^3$)	900	300	60

n/m Not modelled.
(a) Exceeds SO_2 Alberta Guideline. Normalized for a 12-month period.
(b) Based on Stream day emission rates for hourly and daily; Calendar day for annual.
(c) Based on Calendar day emission rates.

Table B2-16 summarizes the observed and predicted maximum hourly GLC and the number of times the AAAQG have been exceeded in the past 4 years. For comparison, the Baseline assessment scenario results have also been appended to the table.

The modelling for the actual 1994 to 1997 SO_2 historical review was based on SO_2 emission rates listed in Table B2-2. The SO_2 emission sources at Suncor include the Powerhouse, Incinerator, continuous flaring and upgrading furnace stacks (containing mercaptans). Emission rates for the principal sources were based on stack tests reported in Suncor annual reports and other rates were prorated based on 1997 production levels and emissions. The Syncrude main stack emission rates were assumed constant over the 4 year assessment based on 1997 rates. Two scenarios were presented for 1997 based on whether the FGD was operational during its commissioning phase. Table B2-16 reflects a "Powerhouse Case" (worst case) that assumes the Powerhouse was 100% operational over the year, and a "FGD Case" (best case) that assumes the FGD was 100% operational throughout the year. The actual 1997 performance is expected to fall between these two extreme cases.

A review of the data presented in Table B2-16 indicates that, in general, the observed maximum hourly concentrations at the monitoring stations is under-predicted by the ISC3BE model. However, the maximum concentration in the RSA predicted by the ISC3BE model exceeds the observed maxima except at the Lower Camp and Fina stations in 1996. In these cases the observed concentrations are approximately 30% greater than the overall predicted concentrations. On average the ISC3BE model maximum GLC predictions are 80% of the observed concentrations at the



Sources	SO_2 [t/sd]
Suncor	
Powerhouse	0.3
FGD	18.9
Incinerator	19.1
Flaring	7.3
Other Sources: Suncor	3
Syncrude (total)	209
Other Emissions (total)	3.9
TOTAL	261.5

Model Description	
Development	Baseline
Model	ISC3BE (7BG)
SO_2 Guideline [µg/m³]	150
Maximum [µg/m³]	199
Exceedences / Year [#]	6

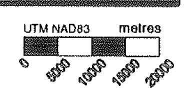
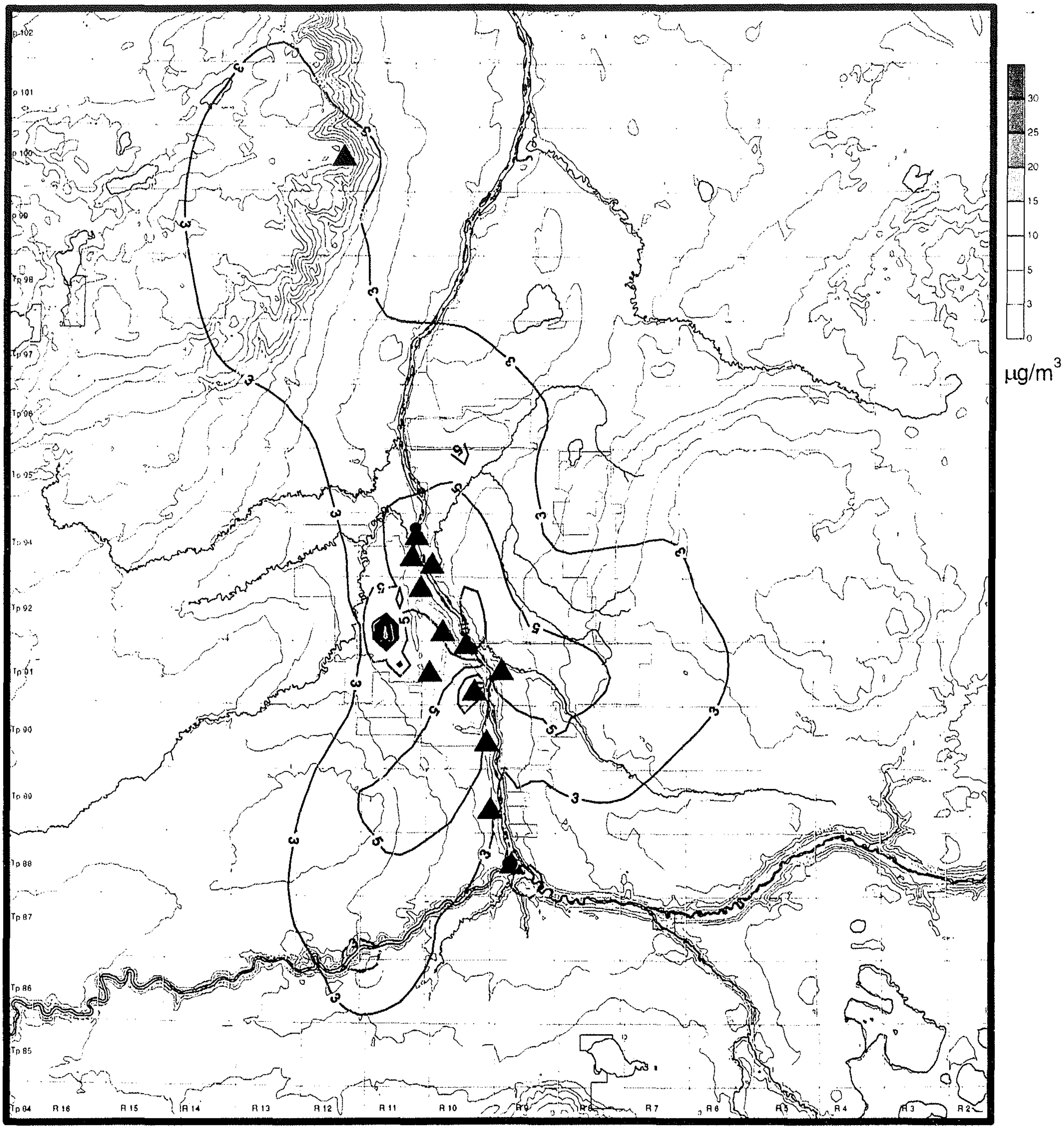


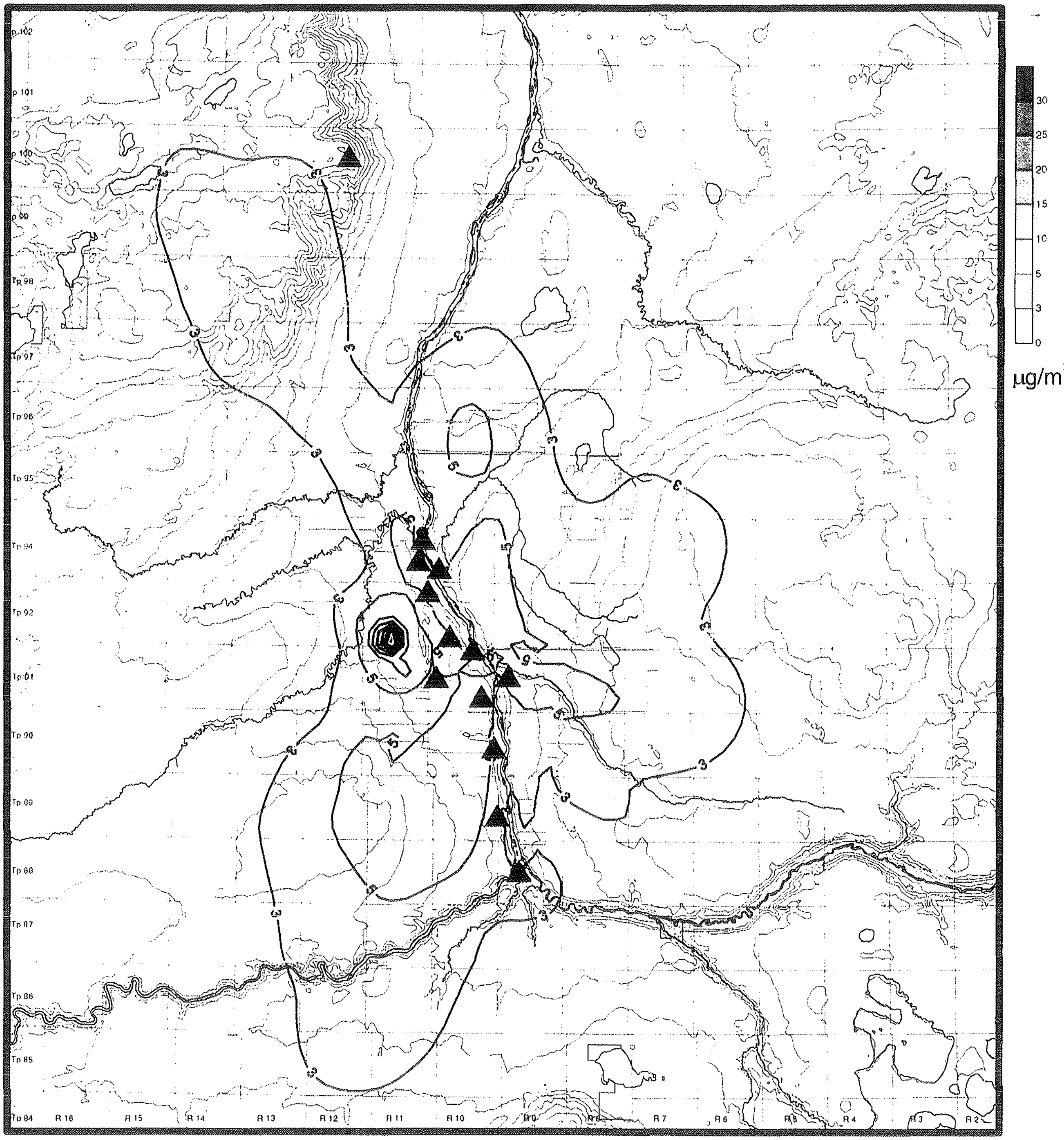
Figure B2-8 Predicted Baseline SO_2 Maximum Daily Average Ground Level Concentrations in the RSA using the ISCBE Model



Sources	SO_2 [t/cd]
Suncor	
Powerhouse	13.1
FGD	18
Incinerator	18.8
Flaring	12.6
Other Sources, Suncor	2.8
Syncrude (total)	209
Other Emissions (total)	3.9
TOTAL	278.2

Model Description	
Development	Baseline
Model	ISC3BE (7BG)
SO_2 Guideline [µg/m³]	30
Maximum [µg/m³]	74
Exceedences / Year [#]	1

Figure B2-9 Predicted Baseline SO_2 Maximum Annual Average Ground Level Concentrations in the RSA using the ISC3BE Model



Sources	SO_2 [t/cd]
Suncor	
Powerhouse	13.1
FGD	18
Incinerator	18.8
Flaring	12.6
Other Sources, Suncor	2.8
Syncrude (total)	209
Other Emissions (total)	3.9
TOTAL	278.2

Model Description	
Development	Baseline
Model	CALPUFF
SO_2 Guideline [µg/m³]	30
Maximum [µg/m³]	79
Exceedences / Year [#]	1

UTM NAD83 metres
0 5000 10000 15000 20000

Figure B2-10 Predicted Baseline SO_2 Maximum Annual Average Ground Level Concentrations in the RSA using the CALPUFF Model

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Table B2-16 Summary of Predicted and Observed Maximum Hourly Ground Level Concentrations of SO_2 From 1994 to 1997 Plus Baseline Sources Using ISC3BE Model

Source[(a)]		1994	1995	1996	1997[(c)]	Baseline
Maximum Predicted Concentration in RSA	Concentration (µg/m³) [(b)]	1441	1272	959	1057/343	582
	Concentration (µg/m³)	1642	1446	1246	1250/648	648
	Exceedances	80	43	32	49/2	3
Mannix Location	Predicted (µg/m³)	707	695	569	588/447	524
	Observed (µg/m³)	1101	1272	725	535	n/a
	Exceedances, Predicted	39	20	10	12/0	2
	Exceedances, Observed	21	20	10	1	n/a
Lower Camp Location	Predicted (µg/m³)	544	438	346	390/394	370
	Observed (µg/m³)	839	1363	1506	381	n/a
	Exceedances, Predicted	5	0	0	0	0
	Exceedances, Observed	6	5	3	0	n/a
Fina Location	Predicted (µg/m³)	558	482	450	487/309	405
	Observed (µg/m³)	736	1175	1583	630	n/a
	Exceedances, Predicted	22	4	1	4/0	0
	Exceedances, Observed	16	21	11	3	n/a
Poplar Creek Location	Predicted (µg/m³)	400	418	324	278/169	252
	Observed (µg/m³)	958	622	392	n/a	n/a
	Exceedances, Predicted	0	0	0	0	0
	Exceedances, Observed	4	4	3	0	n/a
Athabasca Bridge Location	Predicted (µg/m³)	489	431	249	333/226	248
	Observed (µg/m³)	802	630	450	392	n/a
	Exceedances, Predicted	1	0	0	0	0
	Exceedances, Observed	6	2	0	0	n/a
AQS1 Location	Predicted (µg/m³)	563	489	517	469/325	361
	Observed (µg/m³)	1,046	752	482	220	n/a
	Exceedances, Predicted	6	3	2	1/0	0
	Exceedances, Observed	7	3	1	0	n/a
AQS2 Location	Predicted (µg/m³)	526	488	424	352/169	243
	Observed (µg/m³)	545	625	418	289	n/a
	Exceedances, Predicted	3	2	0	0	0
	Exceedances, Observed	5	6	0	0	n/a
AQS3 Location	Predicted (µg/m³)	769	658	486	622/410	412
	Observed (µg/m³)	,072	675	559	442	n/a
	Exceedances, Predicted	12	16	3	5/0	0
	Exceedances, Observed	8	5	2	0	n/a
AQS4 Location	Predicted (µg/m³)	433	338	294	354/190	222
		686	651	728	315	n/a
	Exceedances, Predicted	0	0	0	0	0
	Exceedances, Observed	3	3	2	0	n/a
AQS5 Location	Predicted (µg/m³)	398	341	312	262/262	292
	Observed (µg/m³)	469	386	588	357	n/a
	Exceedances, Predicted	0	0	0	0	0
	Exceedances, Observed	1	0	2	0	n/a
Fort McMurray (FMMU) Location	Predicted (µg/m³)	396	368	253	227/138	199
	Observed (µg/m³)	400	455	257	177	n/a
	Exceedances, Predicted	0	0	0	0	0
	Exceedances, Observed	0	1	0	0	n/a
Fort McKay (FRMU) Location	Predicted (µg/m³)	416	357	193	313/191	201
	Observed (µg/m³)	649	611	394	296	n/a
	Exceedances, Predicted	0	0	0	0	0
	Exceedances, Observed	2	2	0	0	n/a
Alberta Ambient Air Quality Guideline (µg/m³)		**450**				
Federal Acceptable (µg/m³)		**900**				

n/a Data not available.
(a) Using all potential sources indicated in Table B2-2 unless noted differently.
(b) Based on Powerhouse, Incinerator and Syncrude Main Stack.
(c) Concentrations provided are for the Powerhouse case / FGD case.

monitoring locations. The emission rates for the model predictions in Table B2-16 are based on stream day rates. Stream day rates reflect typical operation rates for each piece of equipment. This does not necessarily reflect hourly fluctuations in production levels or unpredictable upset conditions. These emission variabilities may however be captured in the ambient monitoring data, hence the maximum observed concentrations at the monitoring stations could exceed the maximum hourly predicted concentrations.

The predicted maximum SO_2 ground level concentrations, assuming all emission sources for 1994 through 1997 are presented in Figures B2-13 to B2-17. Figure B2-11, representing the 1994 concentrations, indicates a significant amount of the RSA would have had maximum values in excess of the Alberta guideline of 450 $\mu g/m^3$. In 1995 (Figure B2-12) and 1996 (Figure B2-13) the areal extent of the readings in excess of the guideline are reduced substantially. These plots tend to show the effect of the SO_2 reduction activities implemented by Suncor. The two figures for 1997 (Figures B2-14 and B2-15) indicate the extremes for the operation depending on whether the boiler emissions are going through the FGD unit or directly through the Powerhouse stack.

B2.2.3 NO_2 Predicted Concentrations

There are numerous NO_x emission sources associated with the baseline operations as summarized in Section B2.1 (e.g., Tables B2-1 to B2-6). The estimated total NO_x emission rate in the oil sands region is 102.2 t/cd. Suncor emits an estimated total of 47.7 t/cd which is approximately 45% of the total (Table B2-5). The major sources of NO_x at Suncor are the FGD stack (29.8 t/cd) and the mine fleet (11.3 t/cd).

The predicted maximum hourly, daily and annual ground level ambient NO_x and NO_2 concentrations resulting from emissions of all approved industrial sources and residential emissions in the oil sands region were estimated using the ISC3BE and CALPUFF models. Four years of observed meteorological measurements from the Suncor Mannix station (75 m level) were used in the modelling. These models provide an efficient means of estimating the predicted ambient NO_x/NO_2 concentrations from all sources and provides an indication where maximum concentrations could occur.

The conversion of NO_x to NO_2 has been estimated using onsite NO_2/NO_x observations from fleet emissions adjacent to one of Syncrude's operational mine pits. Conor Pacific (1998) has analyzed these data sets and have conservatively estimated the ratio as

$$\frac{NO_2}{NO_x} = 0.1\, NO_x^{-0.608}$$

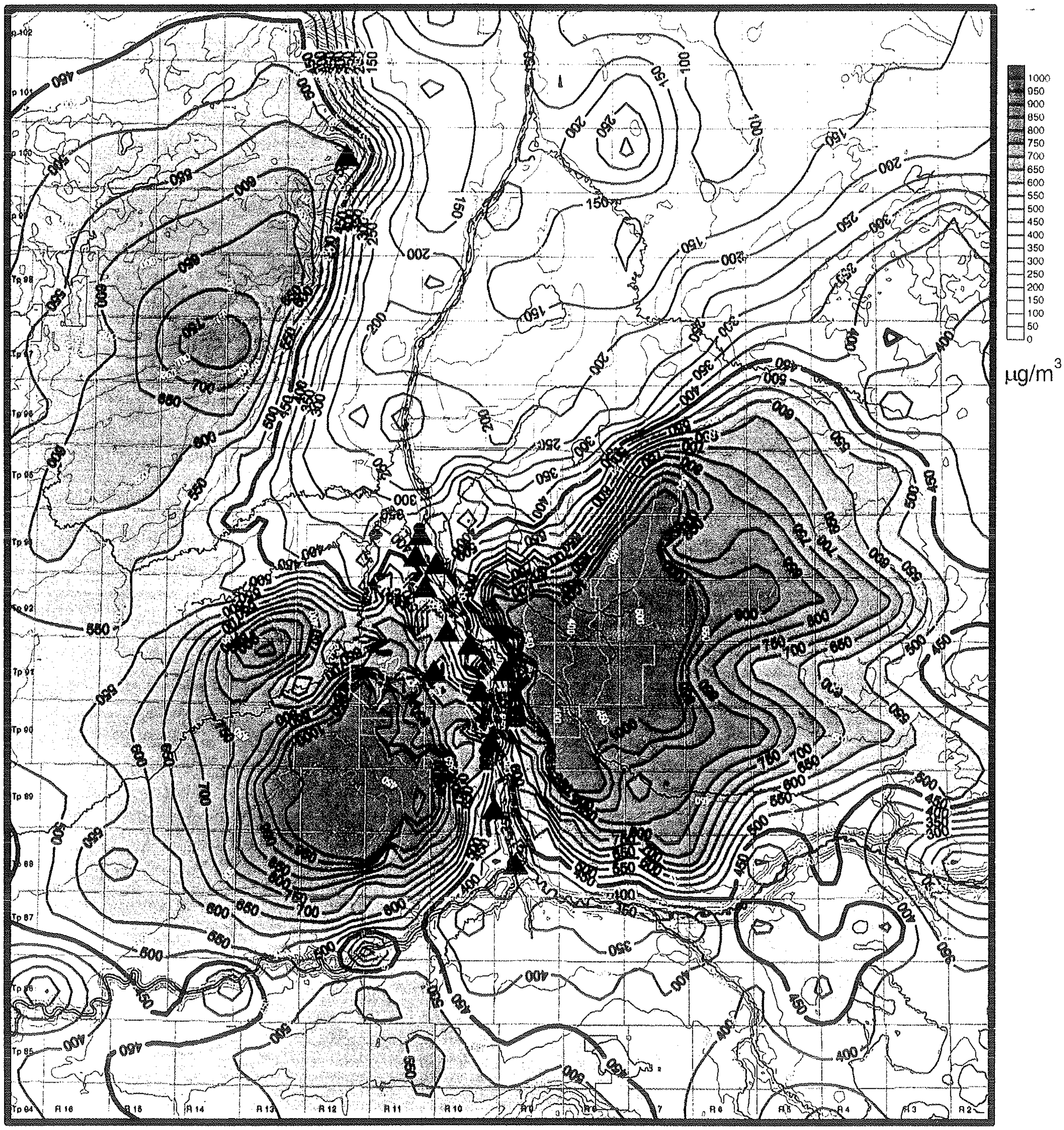
This equation is based on a power-law fit to the upper 99% of the NO_2/NO_x data (units are ppm). It has been applied to the averaged results as well as to the hourly predictions of NO_x made using the ISC3BE model. The application of this equation and the methodology had previously been discussed with AEP and Environment Canada during consultation meetings in the preparation of this EIA (10 March 1998 in AEP's office in Edmonton).

The CALPUFF dispersion model is able to account for chemical transformations, and therefore directly outputs estimated NO_2 concentrations. The formulations used in the model focus on the effect of photochemical reactions on the formulation of nitrates and other deposition chemicals. The estimates of ambient NO_2 assumes that the remaining nitrogen species are oxidized at a steady state. Near the mine pits, however, the formulation approach may not be able to deal with the excess quantity of NO_x, and will therefore tend to over predict the amount of NO_2 present.

The modelling predictions are summarized in Table B2-17 and predicted ground level concentrations are mapped in Figures B2-16 to B2-21.

Figures B2-16 and B2-17 show the maximum hourly average ground level NO_2 concentrations associated with Baseline operations for the ISC3BE and CALPUFF models. The overall maximum hourly average NO_2 concentration, as determined by ISC3BE, of 316 $\mu g/m^3$ is predicted to occur at a location 14 km WNW of Suncor. This maximum value is less than the Alberta Guideline of 400 $\mu g/m^3$ for ambient hourly average NO_2 concentrations. Comparison values for the CALPUFF model indicate an overall maximum hourly average NO_2 concentration of 1,305 $\mu g/m^3$, at a location 15 km WNW from the Suncor also in the Syncrude development area (Figure B2-17). This maximum average value is much greater than the hourly Alberta NO_2 Guideline of 400 $\mu g/m^3$. In total, approximately 64,000 ha are predicted to have the maximum average in excess of the guideline. The model predicts a maximum of 572 yearly exceedances of the hourly guideline. There is poor agreement between the two models at estimating maximum NO_2 concentrations. The CALPUFF model predicts much higher maximum average values and a large number of exceedances. The predictions of the two models become more comparable at greater distances from the sources.

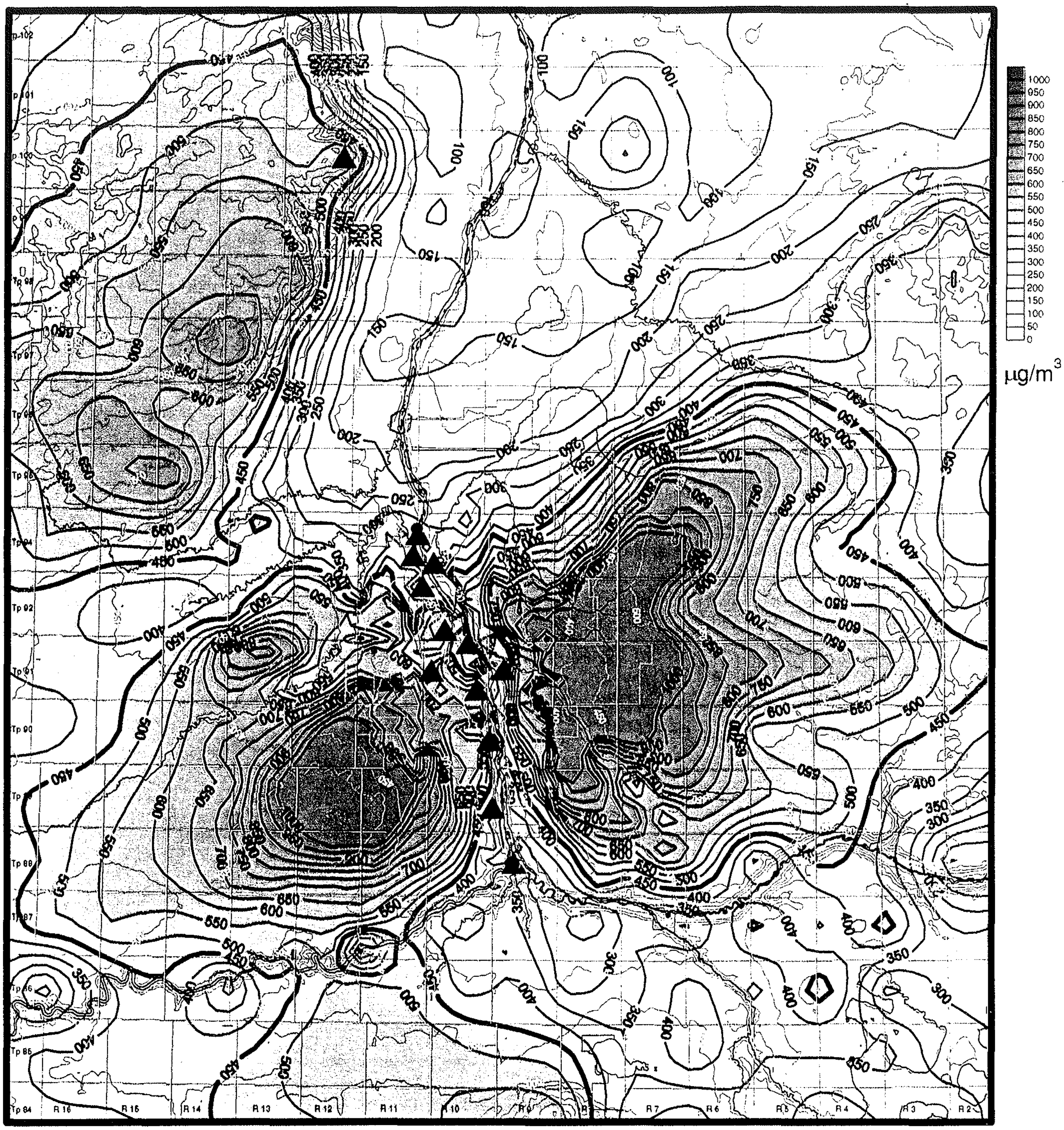
- Figures B2-18 and B2-19 shows the maximum daily average ground level NO_2 concentrations associated with Baseline operations for the ISC3BE and CALPUFF models. An overall maximum daily average NO_2 concentration, as determined by ISC3BE, of 259 $\mu g/m^3$ is predicted to occur 12 km WNW of Suncor. This maximum average value exceeds the daily AAAQG of 200 $\mu g/m^3$. The ISC3BE model predicts that there will be a maximum of 101 exceedances of the daily



Sources	SO_2 [t/sd]
Suncor	
Powerhouse	211
FGD	-
Incinerator	31
Flaring	8.3
Other Sources, Suncor	2.8
Syncrude (total)	208
Other Emissions (total)	-
TOTAL	461.1

Model Description	
Development	Baseline
Model	ISC3BE (7BG)
SO_2 Guideline [µg/m³]	450
Maximum [µg/m³]	1642
Exceedences / Year [#]	80

Figure B2-11 Predicted Historical SO_2 Maximum Hourly Average Ground Level Concentrations in the RSA for 1994



Sources	SO_2 [t/sd]
Suncor	
Powerhouse	215
FGD	-
Incinerator	16
Flaring	8.9
Other Sources, Suncor	3.0
Syncrude (total)	209
Other Emissions (total)	-
TOTAL	451.9

Model Description	
Development	Baseline
Model	ISC3BE (7BG)
SO_2 Guideline [µg/m^3]	450
Maximum [µg/m^3]	1446
Exceedences / Year [#]	43

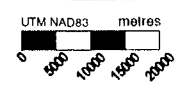
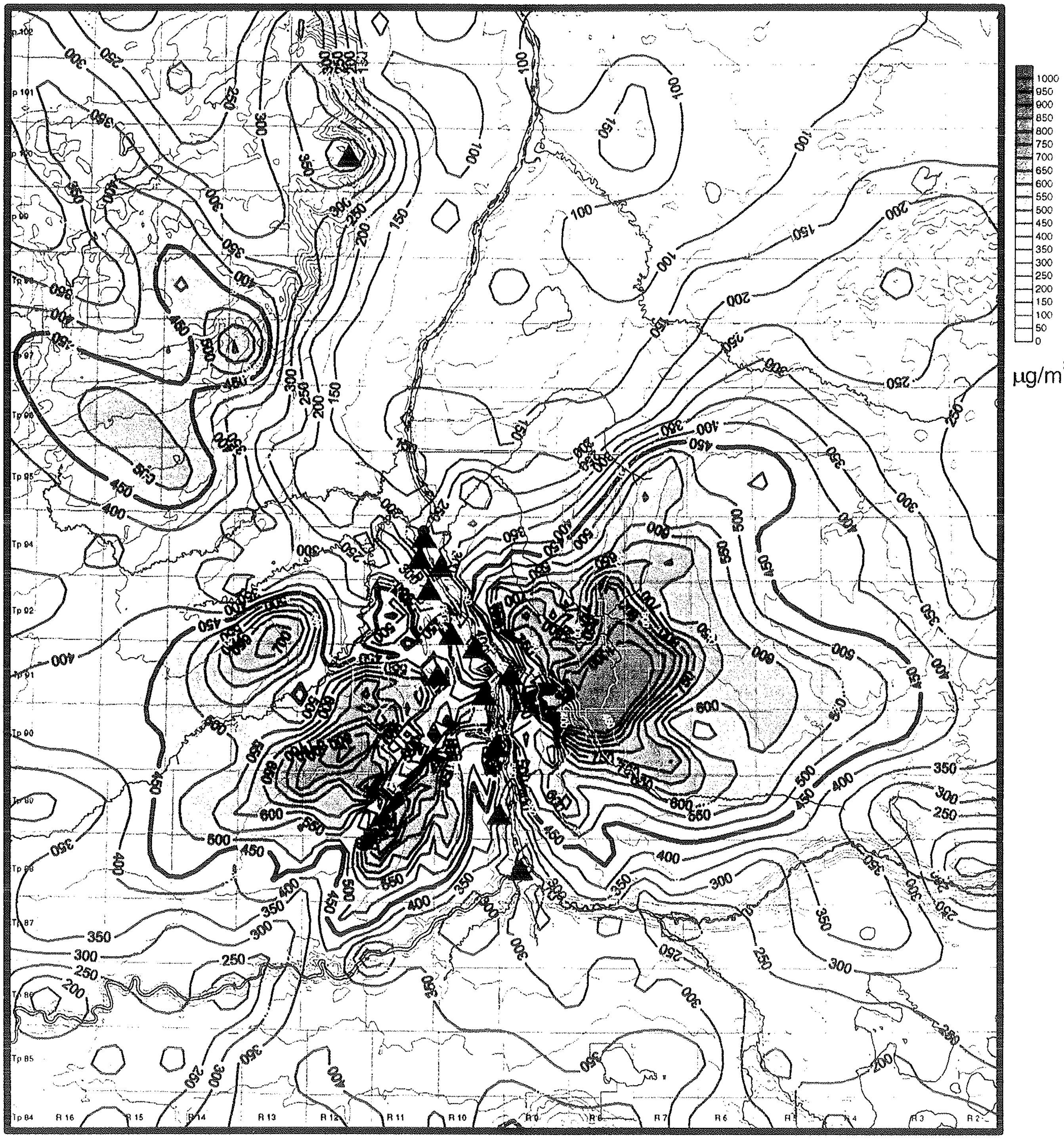


Figure B2-12 Predicted Historical SO_2 Maximum Hourly Average Ground Level Concentrations in the RSA for 1995

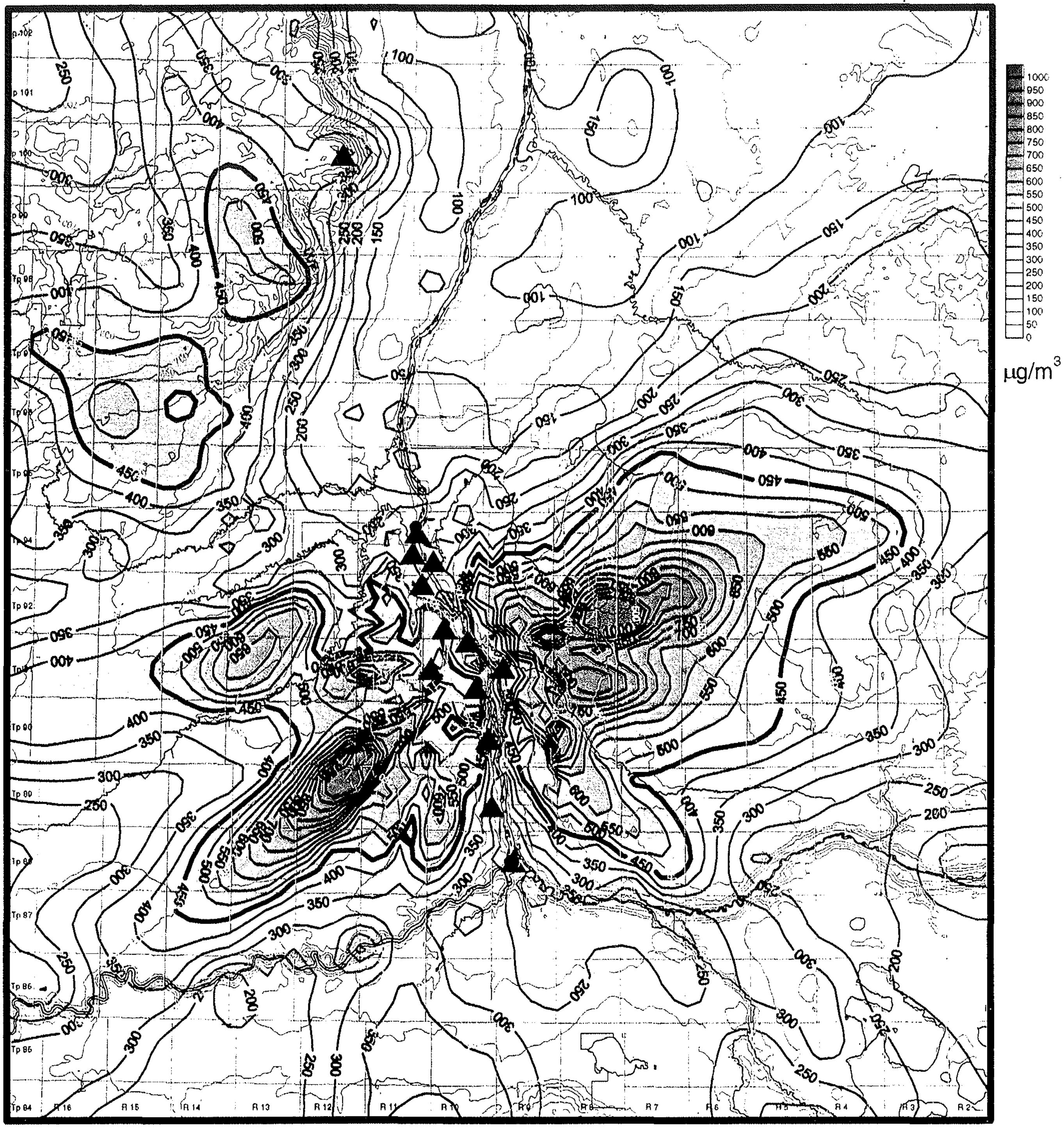


Sources	SO_2 [t/sd]
Suncor	
Powerhouse	153
FGD	-
Incinerator	18
Flaring	9.1
Other Sources, Suncor	3.0
Syncrude (total)	209
Other Emissions (total)	-
TOTAL	392.1

Model Description	
Development	Baseline
Model	ISC3BE (7BG)
SO_2 Guideline [µg/m^3]	450
Maximum [µg/m^3]	1246
Exceedences / Year [#]	32

UTM NAD83 metres
0 5000 10000 15000 20000

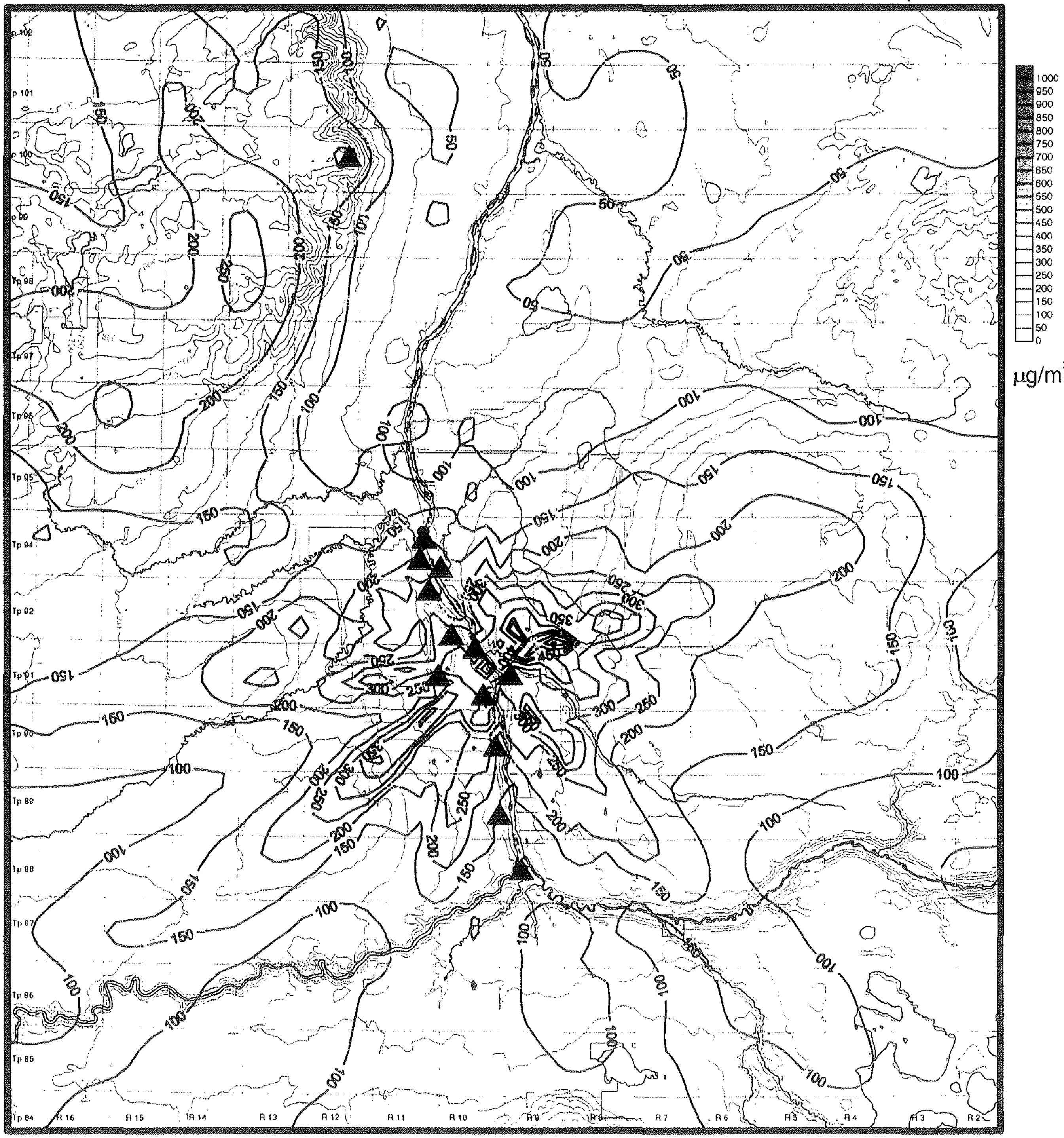
Figure B2-13 Predicted Historical SO_2 Maximum Hourly Average Ground Level Concentrations in the RSA for 1996



Sources	SO_2 [t/sd]
Suncor	
Powerhouse	171
FGD	-
Incinerator	19.1
Flaring	9.3
Other Sources, Suncor	3.1
Syncrude (total)	209
Other Emissions (total)	-
TOTAL	411.5

Model Description	
Development	1997 "Powerhouse"
Model	ISC3BE (7BG)
SO_2 Guideline [$\mu g/m^3$]	450
Maximum [$\mu g/m^3$]	1250
Exceedences / Year [#]	49

Figure B2-14 Predicted Historical SO_2 Maximum Hourly Average Ground Level Concentrations in the RSA for 1997 (assuming PH operational 100% of time with two boilers)



Sources	SO_2 [t/sd]
Suncor	
Powerhouse	-
FGD	10.8
Incinerator	19.1
Flaring	7.3
Other Sources, Suncor	3.1
Syncrude (total)	209
Other Emissions (total)	-
TOTAL	249.3

Model Description	
Development	1997 "FGD"
Model	ISC3BE (7BG)
SO_2 Guideline [µg/m^3]	450
Maximum [µg/m^3]	648
Exceedences / Year [#]	2

Figure B2-15 Predicted Historical SO_2 Maximum Hourly Average Ground Level Concentrations in the RSA for 1997 (assuming FGD operational 100% of time with two boilers)

Table B2-17 Maximum Predicted Ground Level Concentrations of NO_x and NO_2 for Baseline Sources

Source	Hourly	Daily	Annual
Baseline Condition - ISC3BE[b]			
Maximum NO_x Concentration ($\mu g/m^3$)	7,093	4,259	1,279
Maximum NO_2 Concentration ($\mu g/m^3$)	316	259	162
Location of Maximum Concentration (km)	14 WNW	12 WNW	13 WNW
Maximum Number of Exceedances[a]	0	101	1
Location of Maximum Exceedances (km)	0	n/a	n/a
Baseline Case CALPUFF[c]			
Maximum NO_2 Concentration ($\mu g/m^3$)	1,305	598	239
Location from Suncor incinerator stack (km)	15 WNW	15 WNW	15 WNW
Maximum Number of Exceedances[a]	572	83	1
Location of Maximum Exceedances (km)	15 WNW	15 WNW	n/a
NO_2, Alberta Guideline ($\mu g/m^3$)	400	200	60
NO_2, Federal Acceptable ($\mu g/m^3$)	400	200	100

(a) Exceeds NO_2 Alberta Guideline. Normalized for a 12-month period.
(b) Based on Stream day emission rates for hourly and daily; Calendar day for annual.
(c) Based on Calendar day emission rates.

guideline, all within the Syncrude Mine Pit. In total, about 825 ha are predicted to have a maximum average in excess of the guideline. Corresponding values for the CALPUFF model indicate an overall maximum daily average NO_2 concentration of 598 $\mu g/m^3$, at a location similar to the ISC3BE prediction. This maximum average value also exceeds the daily Alberta NO_2 Guideline of 200 $\mu g/m^3$. The predictions shown in Figure B2-19 indicate the three areas that result in maximum daily averages in excess of the guideline. The areas are all in or adjacent to the Syncrude and Suncor existing operations. In total, about 23,500 ha are predicted to have maximum average in excess of the guideline. The CALPUFF model predicts that there will be a maximum of 83 exceedances of the daily guideline on an annual basis for the Baseline case. There is poor agreement between the two models for predicting the maximum concentrations or the number of exceedances due to their respective chemistry assumptions to estimate NO_2.

- Figure B2-20 and B2-21 shows the maximum annual average ground level NO_2 concentrations associated with Project Millennium for the ISC3BE and CALPUFF models, respectively. The overall maximum annual average NO_2 concentration, as determined by ISC3BE, of 162 **$\mu g/m^3$** is predicted to occur in the same vicinity as the maximum hourly concentration. This annual average value exceeds the AAAQG of 60 **$\mu g/m^3$**. The predicted concentrations indicate three areas totaling 5,818 ha, all within the Suncor or Syncrude development areas, with maximum annual concentrations that are in excess of the annual guideline. Corresponding values for the CALPUFF model indicate an overall annual average NO_2 concentration of 239 $\mu g/m^3$, at the same location (Figure B.2-21). This maximum average value also exceeds the annual Alberta NO_2 Guideline of 60 $\mu g/m^3$. The predictions shown in Figure B.2-21 indicate three areas that result in annual averages in excess of the guideline. The areas are in or adjacent to the Suncor or Syncrude development areas. In total, approximately 4,000 ha are predicted to have a maximum average in excess of the guideline. There is better correlation between the two models for the annual results but the CALPUFF model continues to predict higher maximum values.

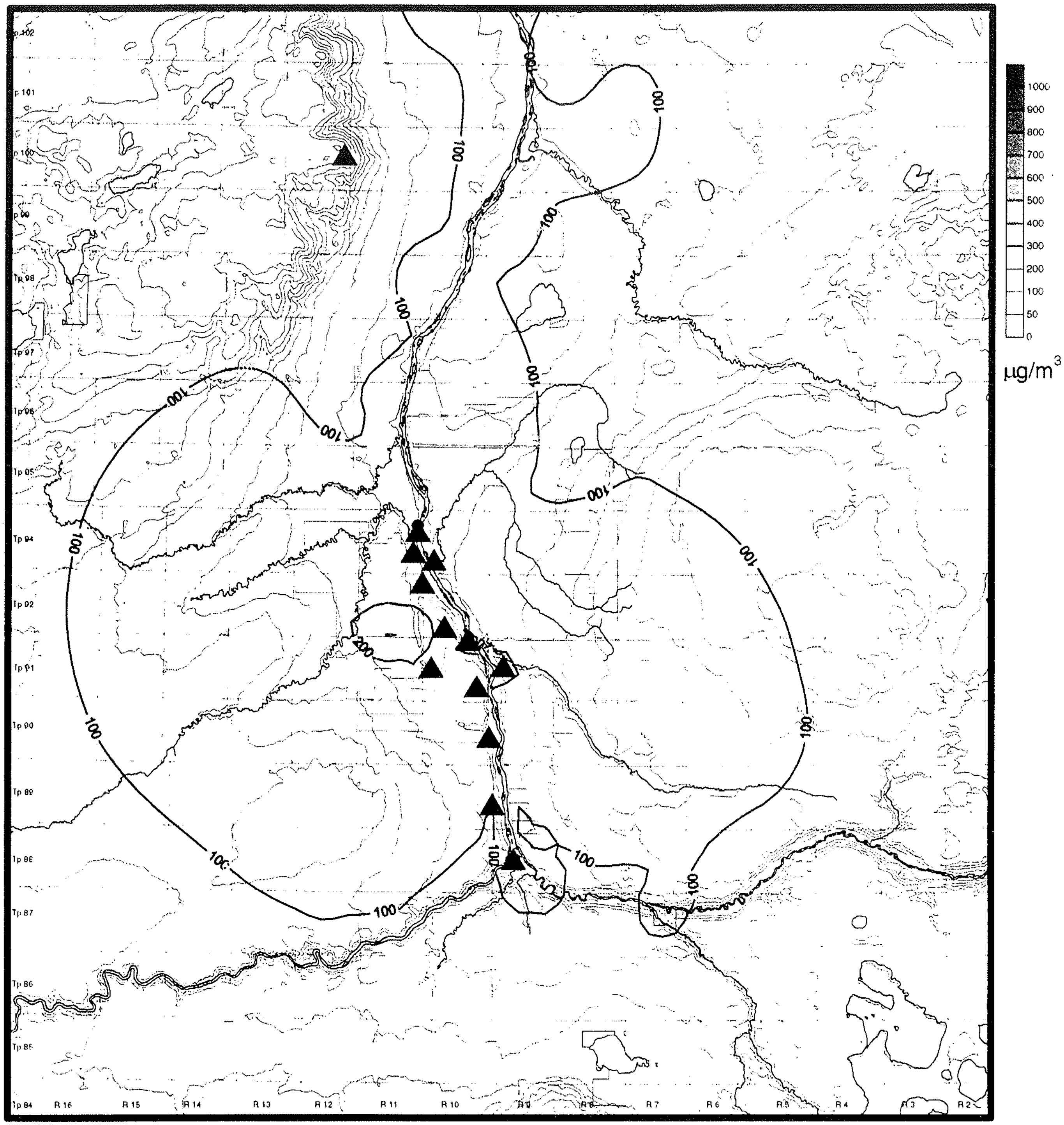
The modelling predictions indicate that the maximum NO_2 concentrations will tend to occur in or near the development areas. The principal contributors to these maximum values would be the mine fleet. The mine fleet emissions have been modelled as ground level sources with an areal extent matching the mine pit area. Because the fleet emissions are relatively large and are at ground level, there is a decreased opportunity for dispersion and dilution of their plumes as compared to a tall stack with a similar emission rate. It is this ground level characterization which produces the increase in the ground level low concentrations throughout a large portion of the RSA. This characterization is expected to be a conservative modelling assumption. Therefore, the largest concentrations and exceedances of the daily and annual average Guidelines are expected to be within the lease area boundaries. The ability to compare the model predictions to existing monitoring data are limited because only a few locations within the region measure NO_2.

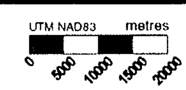
B2.2.4 Potential Acid Input (PAI) Predictions

Acidic deposition in the RSA results from the cumulative emissions of SO_2 and NO_x. The total estimated emissions of SO_2 and NO_x within the RSA (278.4 t/cd and 102.2 t/cd, respectively) are presented in Table B2.6. Suncor contributes about 30% of the combined SO_2 and NO_x emissions.

Potential Acid Input (PAI) is the preferred method for evaluating the overall effects of acid forming chemicals on the environment since it accounts for the acidifying effect of the sulphur and nitrogen species, as well as the neutralizing effect of available base cations. A discussion on the calculation methods for PAI is provided in Section B2.1.2.3.

PAI in the oil sands region was predicted using the CALPUFF model and four years of meteorological observations from the 75 m level at the Suncor Mannix station. The CALPUFF model is a good tool for estimating the PAI in the oil sands region as it takes into account the chemical transformations of the emitted SO_2 and NO_x and predicts wet (rain and snow scavenged) and dry (via an effective dry deposition velocity) deposition of SO_2, SO_4, NO, NO_2, NO_3^-, and HNO_3. These deposition rates are combined following the methodology in Section B2.1.2.3 to predict the PAI for the region.

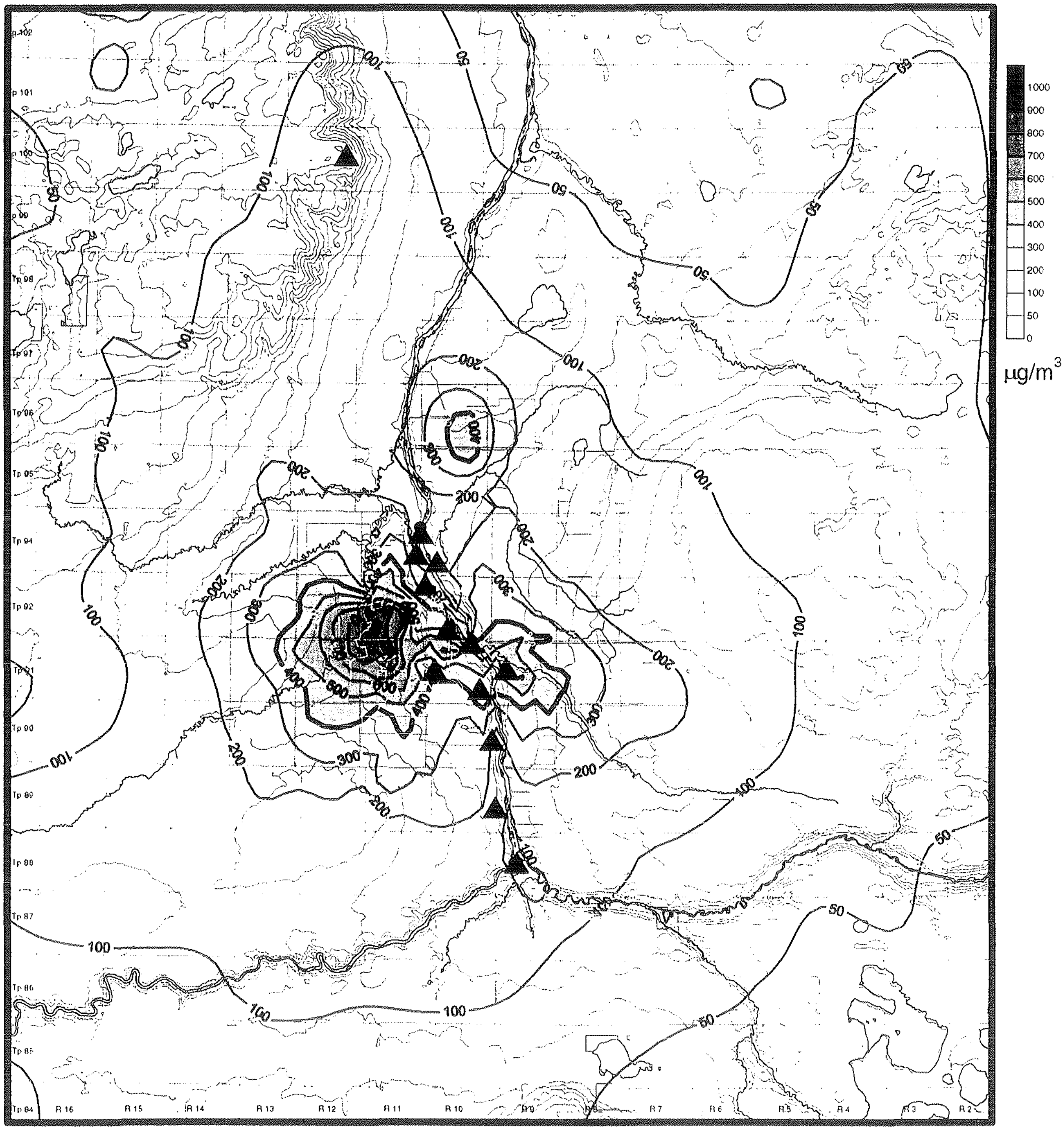




Sources	NO_2 [t/sd]
Suncor	
Powerhouse	2.8
FGD	30.9
Incinerator	0.1
Flaring	0.1
Other Sources, Suncor	13.9
Syncrude (total)	44.4
Other Emissions (total)	10.1
TOTAL	102.3

Model Description	
Development	Baseline
Model	ISC3BE (7BG)
NO_2 Guideline [µg/m³]	400
Maximum [µg/m³]	316
Exceedences / Year [#]	0

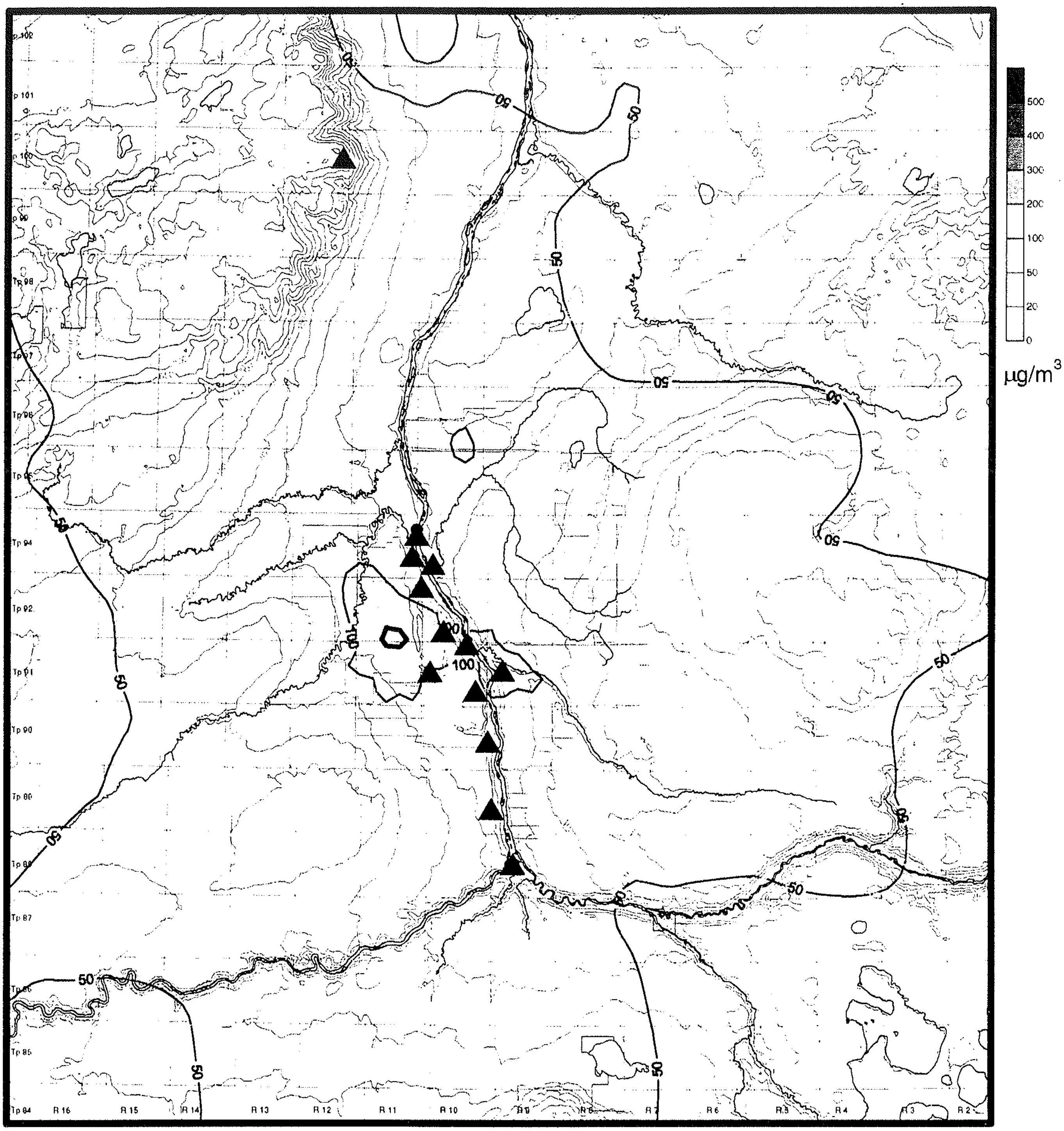
Figure B2-16 Predicted Baseline NO_2 Maximum Hourly Average Ground Level Concentrations in the RSA using the ISC3BE Model



Sources	NO_x [t/cd]
Suncor	
Powerhouse	2.8
FGD	30.9
Incinerator	0.1
Flaring	0.1
Other Sources, Suncor	13.9
Syncrude (total)	44.4
Other Emissions (total)	10.1
TOTAL	102.3

Model Description	
Development	Baseline
Model	CALPUFF
NO_2 Guideline [µg/m³]	400
Maximum [µg/m³]	1305
Exceedences / Year [#]	572

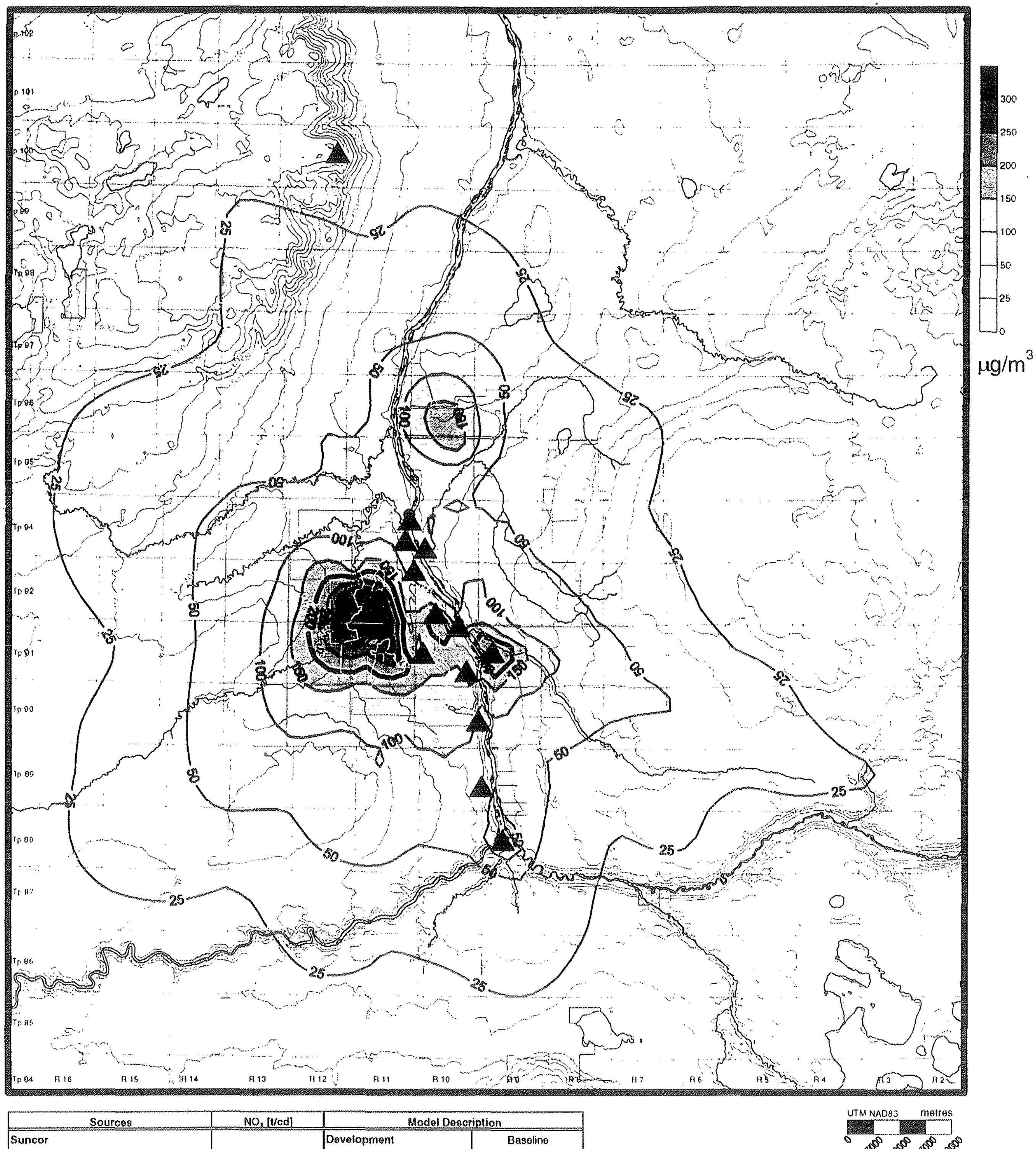
Figure B2-17 Predicted Baseline NO_2 Maximum Hourly Average Ground Level Concentrations in the RSA using the CALPUFF Model



Sources	NO2 [t/sd]
Suncor	
Powerhouse	2.8
FGD	30.9
Incinerator	0.1
Flaring	0.1
Other Sources, Suncor	13.9
Syncrude (total)	44.4
Other Emissions (total)	10.1
TOTAL	102.3

Model Description	
Development	Baseline
Model	ISC3BE (7BG)
NO_2 Guideline [µg/m³]	200
Maximum [µg/m³]	259
Exceedences / Year [#]	101

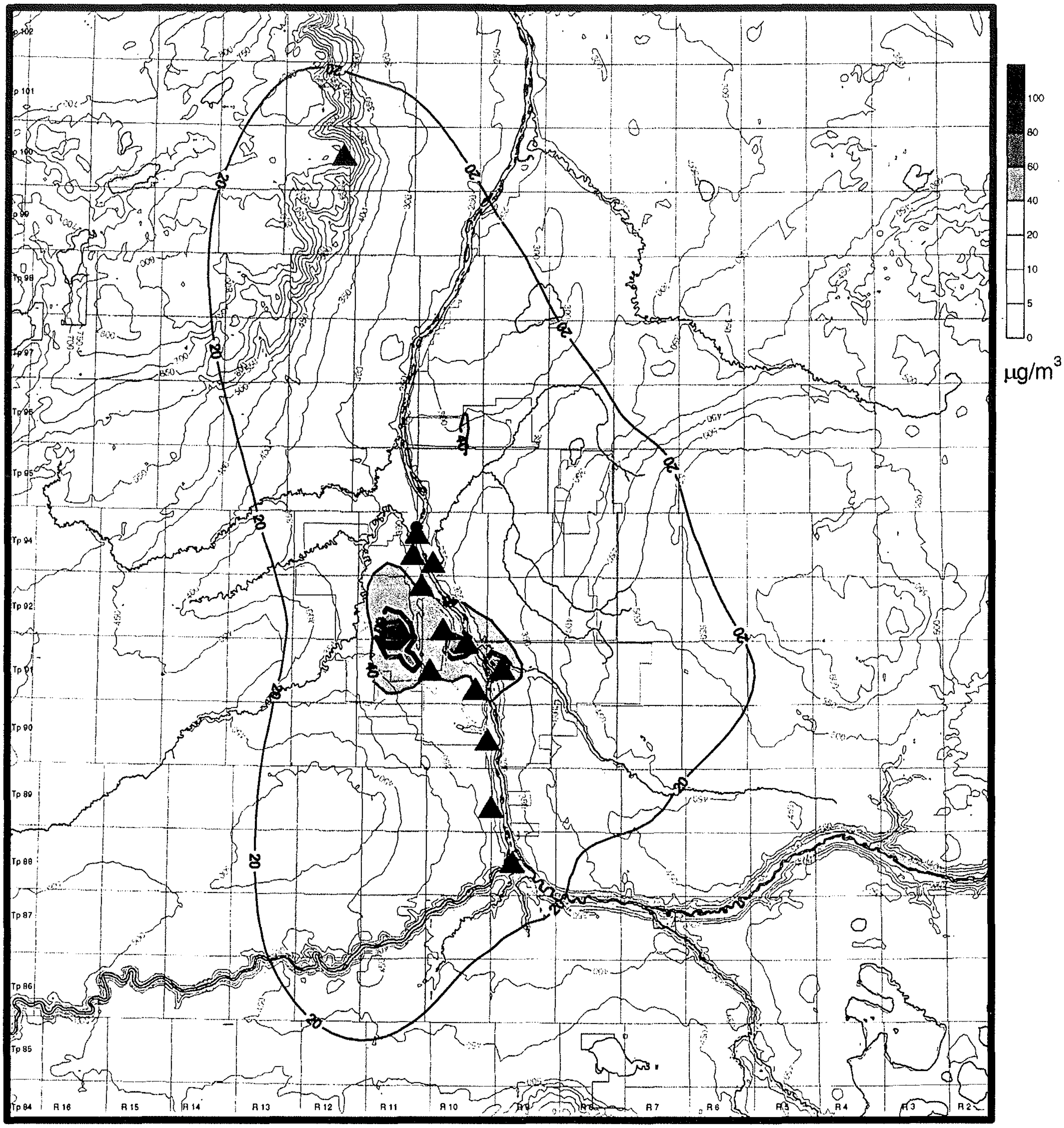
Figure B2-18 Predicted Baseline NO_2 Maximum Daily Average Ground Level Concentrations in the RSA using the ISC3BE Model



Sources	NO_x [t/cd]
Suncor	
Powerhouse	2.8
FGD	30.9
Incinerator	0.1
Flaring	0.1
Other Sources, Suncor	13.9
Syncrude (total)	44.4
Other Emissions (total)	10.1
TOTAL	102.3

Model Description	
Development	Baseline
Model	CALPUFF
NO_2 Guideline [µg/m³]	200
Maximum [µg/m³]	598
Exceedences / Year [#]	83

Figure B2-19 Predicted Baseline NO_2 Maximum Daily Average Ground-Level Concentrations in the RSA using the CALPUFF Model



Sources	NO_2 [t/cd]
Suncor	
Powerhouse	3.9
FGD	29.8
Incinerator	0.1
Flaring	0.1
Other Sources, Suncor	13.8
Syncrude (total)	44.4
Other Emissions (total)	10.1
TOTAL	102.2

Model Description	
Development	Baseline
Model	ISC3BE (7BG)
NO_2 Guideline [µg/m³]	60
Maximum [µg/m³]	162
Exceedences / Year [#]	1

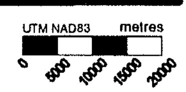
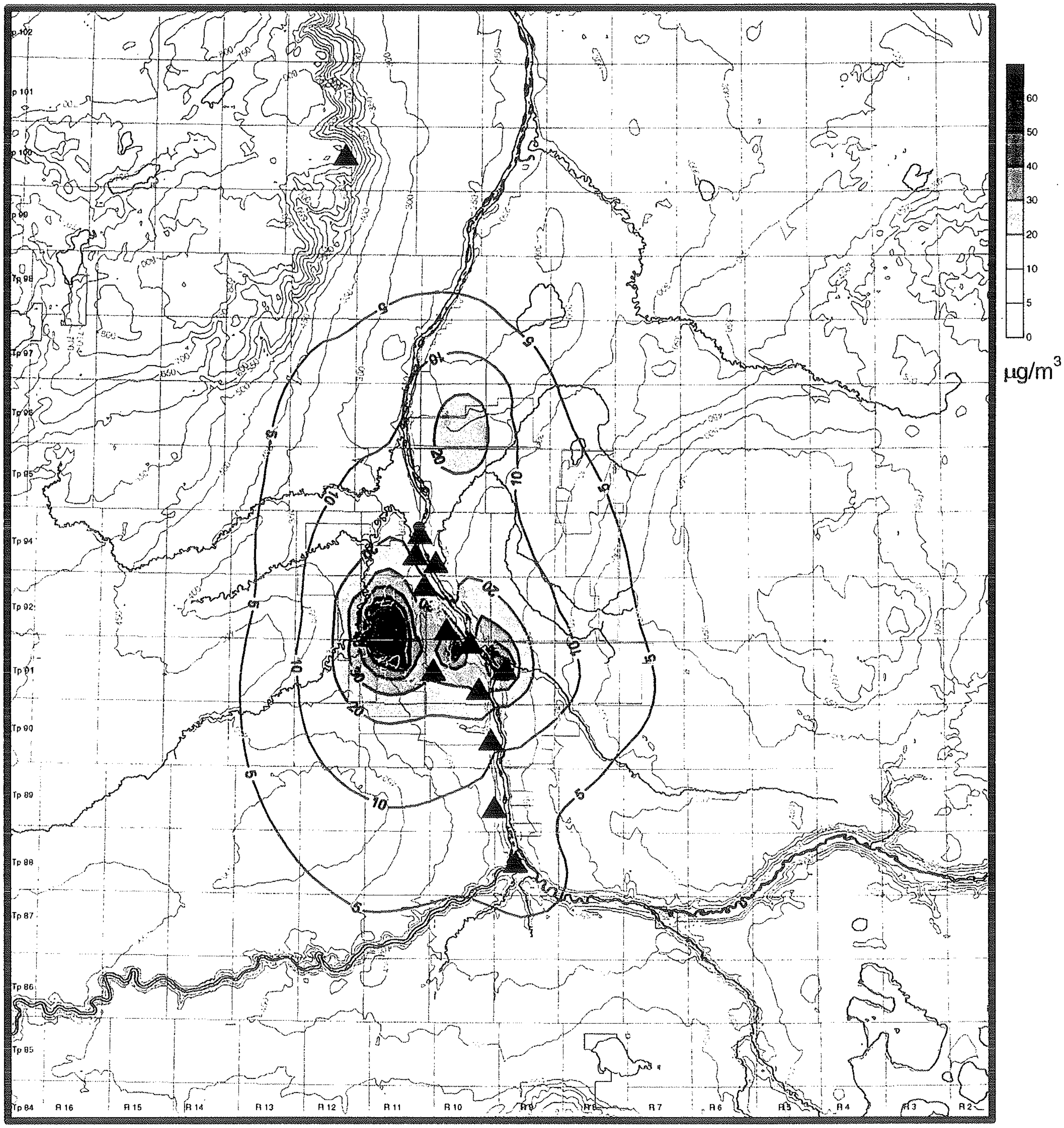
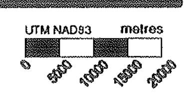


Figure B2-20 Predicted Baseline NO_2 Maxiimum Annual Average Ground Level Concentrations in the RSA using the ISC3BE Model





Sources	NO_x [t/cd]
Suncor	
Powerhouse	3.9
FGD	29.8
Incinerator	0.1
Flaring	0.1
Other Sources, Suncor	13.8
Syncrude (total)	44.4
Other Emissions (total)	10.1
TOTAL	102.2

Model Description	
Development	Baseline
Model	CALPUFF
NO_2 Guideline [$\mu g/m^3$]	60
Maximum [$\mu g/m^3$]	239
Exceedences / Year [#]	1

Figure B2-21 Predicted Baseline NO_2 Maximum Annual Average Ground Level Concentrations in the RSA using the CALPUFF Model

A background PAI of 0.1 keq/ha/y has been assumed for the region based on estimates of sulphur, nitrogen and base cation concentrations and depositions in the region surrounding the RSA. This background PAI may be conservatively high since it was derived from monitoring data at stations adjacent to the RSA. These data were used, as opposed to remote pristine arctic monitoring station data, to better reflect the local Alberta airshed. While these data may represent air flows entering the RSA, they may also reflect air leaving the RSA. Therefore a nominal amount of "double counting" may be assumed for the select background PAI.

The PAI predictions are summarized in Table B2-18 and shown graphically in Figure B2-24. The predicted PAI exceeds the 0.25 keq/ha/y Alberta interim critical load for sensitive soils over an area of 670,483 ha (27.6% of the RSA). The areal extent over which the PAI exceeds the critical loadings for less sensitive soils is significantly lower, namely: 11,543 ha (0.5% of the RSA) greater than 0.50 keq/ha/y; 3,206 ha (0.1% of the RSA) greater than 1.0 keq/ha/y; and 250 ha (0.01% of the RSA) greater than 1.5 keq/ha/y.

Table B2-18 Areal Extent For Predicted PAI Values

PAI Threshold (keq/ha/y)	AREA	
	(ha)	(%)[a]
0.25	670,483	27.6
0.50	11,543	0.5
1.0	3,206	0.1
1.5	250	0.01

[a] as % of the total RSA

The maximum deposition rates of the sulphur and nitrogen species were calculated as interim variables by the CALPUFF model. These are summarized in Table B2-19 and presented graphically in Figures B2-21 and B2-22. The maximum deposition rates of both nitrates and sulphates occur in the immediate vicinity of the active mine pits. This is the same area where the maximum overall PAI is predicted to occur, suggesting that the highest deposition and PAI values occur in the areas where there are sizable ground level releases of SO_2 and NO_x.

Table B2-19 Maximum Predicted Acid Forming Deposition

Parameter	Maximum [keq/ha/y]
PAI	**24.6**
Nitrate Deposition	**22.5**
Sulphate Deposition	**1.96**

The methodology for predicting PAI on a regional scale using CALPUFF has only been applied in a limited number of cases and the experience at applying and interpreting the model predictions is undergoing development.

Further, there is considerable uncertainty in the background PAI for the region ranging from approximately -0.5 to 0.25 keq/ha/y. For this reason, the PAI map presented in the Figure B2-20 should be regarded as providing an indication of relative spatial distributions and relative changes associated with differing emissions scenarios. This map should also be used in conjunction with the sulphate and nitrate deposition maps (Figures B2-24 and B2-22, respectively) as input in the evaluation of impacts to sensitive soil or vegetation, and in the design of any long-term monitoring programs deemed necessary in such evaluations.

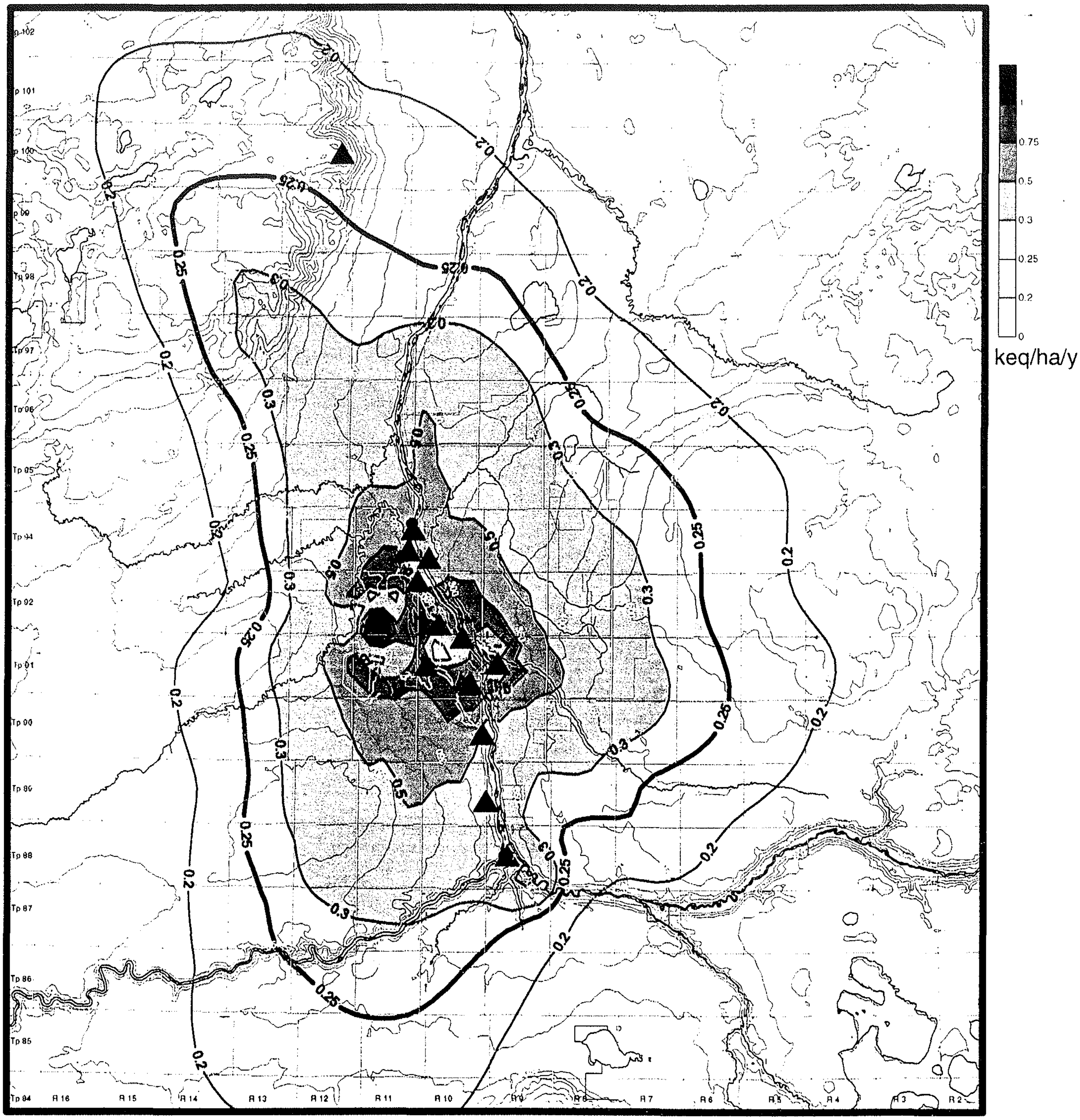
B2.2.5 CO Predicted Concentrations

The CO emission sources associated with the baseline operations are summarized in Section B2.1 (e.g., Tables B2-1 to B2-6). Total estimated CO emission rate for the baseline case is 120.7 t/cd. The major continuous source of CO emissions at Suncor is the FGD Stack (25.7 t/d) which represents about 21% of the total.

The predicted maximum hourly, daily and annual ground level ambient CO concentrations resulting from emissions of all approved industrial sources and residential emissions in the oil sands region were estimated using ISC3BE and meteorology measurements from the Mannix station. This model provides an efficient means of calculating the overall ambient CO concentration from all sources and provides an indication of where maximum concentrations could occur. The modelling predictions are summarized in Table B2-20 and predicted ground level concentrations are mapped in the figures described below:

- Figure B2-25 shows the maximum hourly average ground level CO concentrations associated with the Baseline operations. An overall maximum hourly average CO concentration of 5,561 $\mu g/m^3$ is predicted to occur at a location SSE of the Suncor. This maximum value is less than the hourly Alberta CO guideline of 15,000 $\mu g/m^3$
- Figure B2-26 shows the maximum 8-hour average ground level CO concentrations associated with the Baseline operations. The overall maximum 8-hour average CO concentration of 2,226 $\mu g/m^3$ is predicted to occur at a location SSE of Suncor. This 8-hour maximum value is less than the Alberta 8-hour guideline of 6,000 $\mu g/m^3$.

The modelling predicts that the maximum hourly and 8-hour CO concentrations will occur SSE of Suncor in or near Fort McMurray. The principal contributor to high values in the area of the existing developments



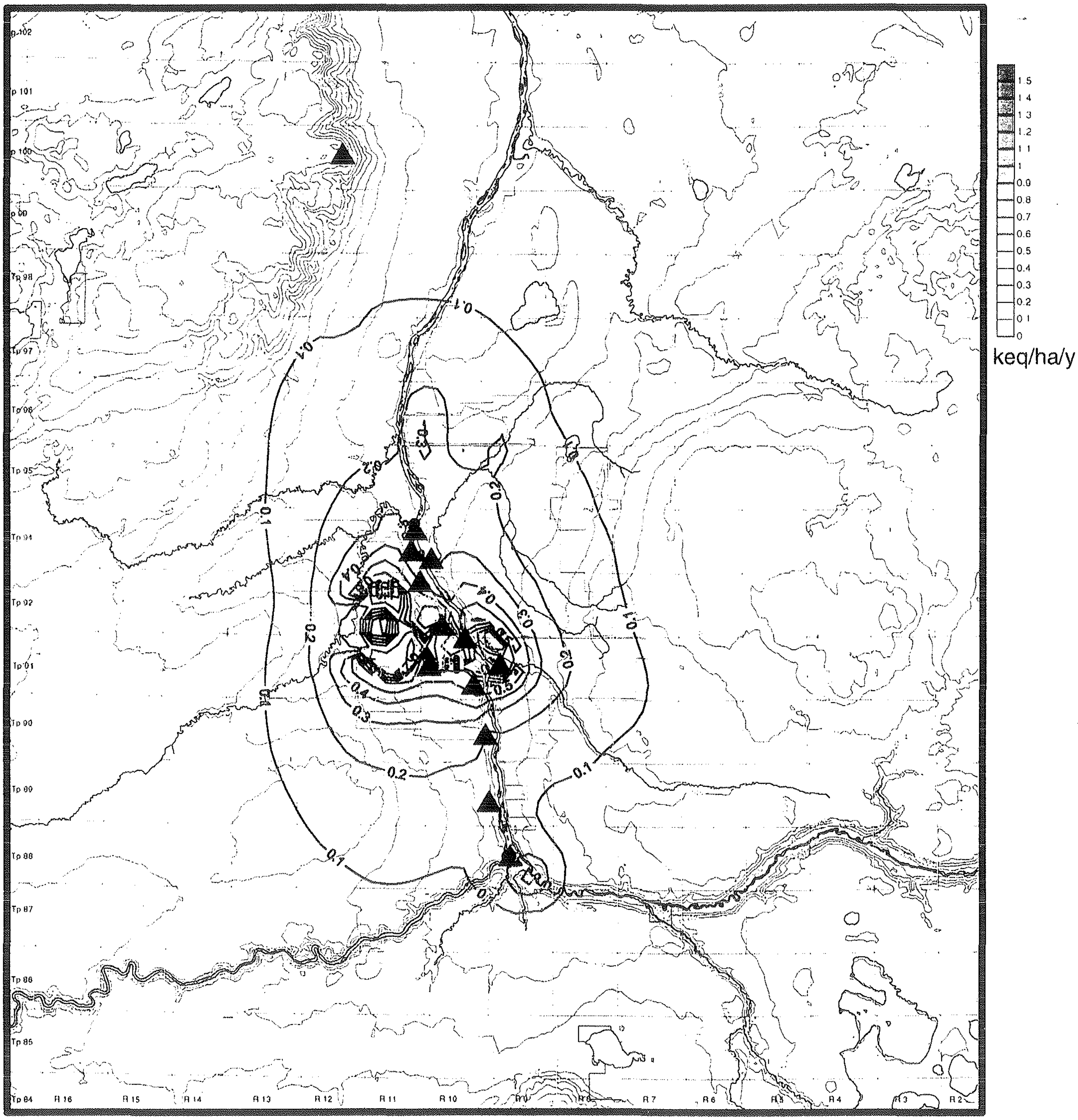
UTM NAD83 metres

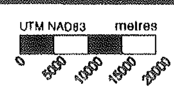
0 5000 10000 15000 20000

Sources	SO_2 [t/cd]	NO_x [t/cd]
Suncor		
Powerhouse	13.1	3.9
FGD	18	29.8
Incinerator	18.8	0.1
Flaring	12.6	0.1
Other Sources, Suncor	2.8	13.8
Syncrude (total)	209	44.4
Other Emissions (total)	4.1	10.1
TOTAL	278.4	102.2

Model Predictions	
Development	Baseline
Model	CALPUFF
Critical Loading [keq/ha/y]	0.25
Maximum [keq/ha/y]	24.6

Figure B2-22 Predicted Baseline Potential Acid Input (PAI) in the RSA using the CALPUFF Model

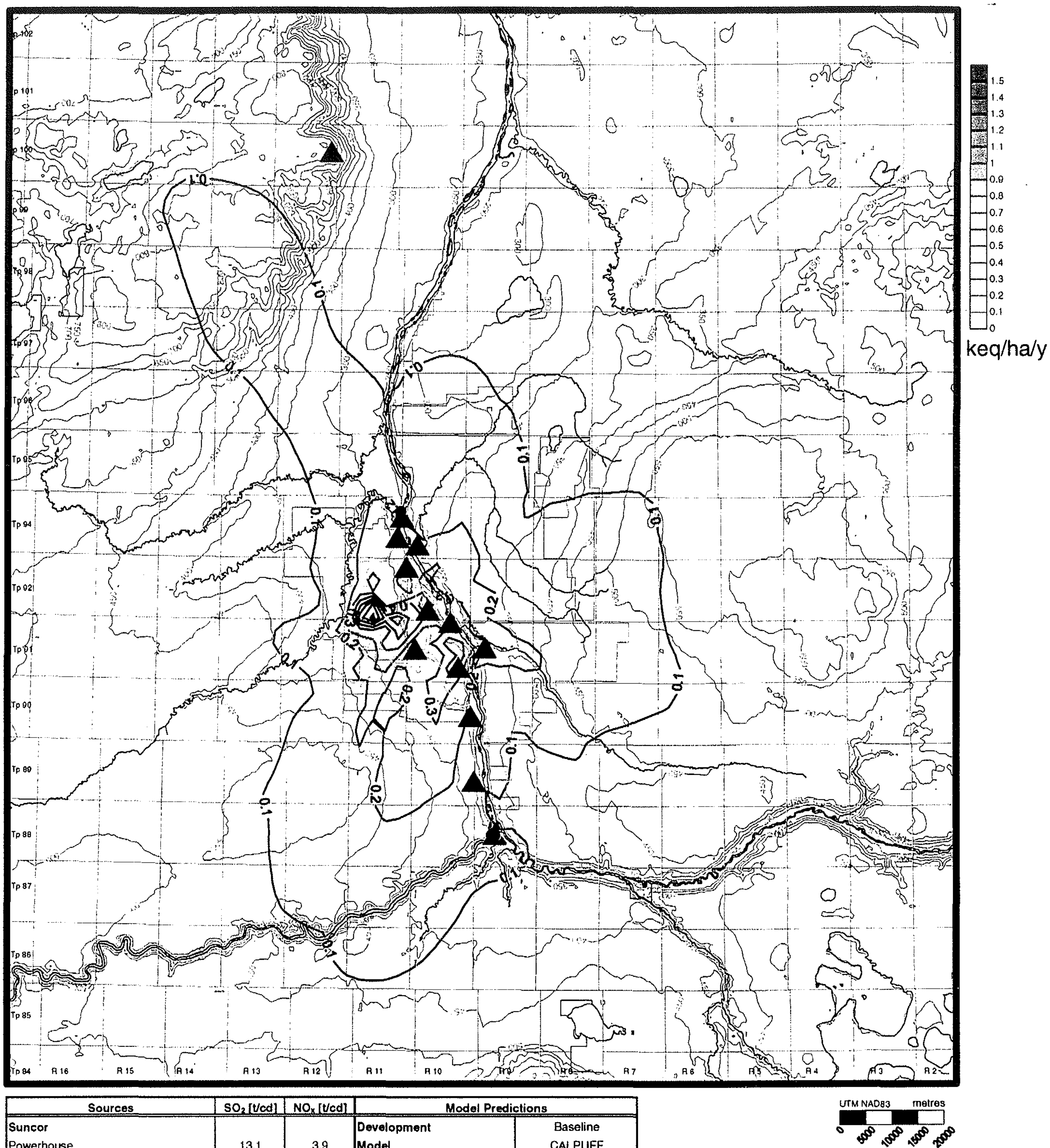




Sources	SO_2 [t/cd]	NO_x [t/cd]
Suncor		
Powerhouse	13.1	3.9
FGD	18	29.8
Incinerator	18.8	0.1
Flaring	12.6	0.1
Other Sources, Suncor	2.8	13.8
Syncrude (total)	209	44.4
Other Emissions (total)	4.1	10.1
TOTAL	278.4	102.2

Model Predictions	
Development	Baseline
Model	CALPUFF
Maximum [keq/ha/y]	22.5

Figure B2-23 Predicted Baseline Nitrate Equivalent Deposition in the RSA using the CALPUFF Model



Sources	SO_2 [t/cd]	NO_x [t/cd]
Suncor		
Powerhouse	13.1	3.9
FGD	18	29.8
Incinerator	18.8	0.1
Flaring	12.6	0.1
Other Sources, Suncor	2.8	13.8
Syncrude (total)	209	44.4
Other Emissions (total)	4.1	10.1
TOTAL	278.4	102.2

Model Predictions	
Development	Baseline
Model	CALPUFF
Maximum [keq/ha/y]	1.96

Figure B2-24 Predicted Baseline Sulphate Equivalent Deposition in the RSA using the CALPUFF Model

Table B2-20 Maximum Predicted Ground Level Concentrations of CO for Baseline Sources

Source	Hourly	8-Hour
Baseline Condition - Model ISC3BE		
Maximum CO Concentration (μg/m³)	5,561	2,226
Location of Maximum Concentration (km)	30 SSE	30 SSE
Maximum Number of Exceedances [(a)]	0	0
Location of Maximum Exceedances	n/a	n/a
CO, Alberta Guideline (μg/m³)	15,000	6,000

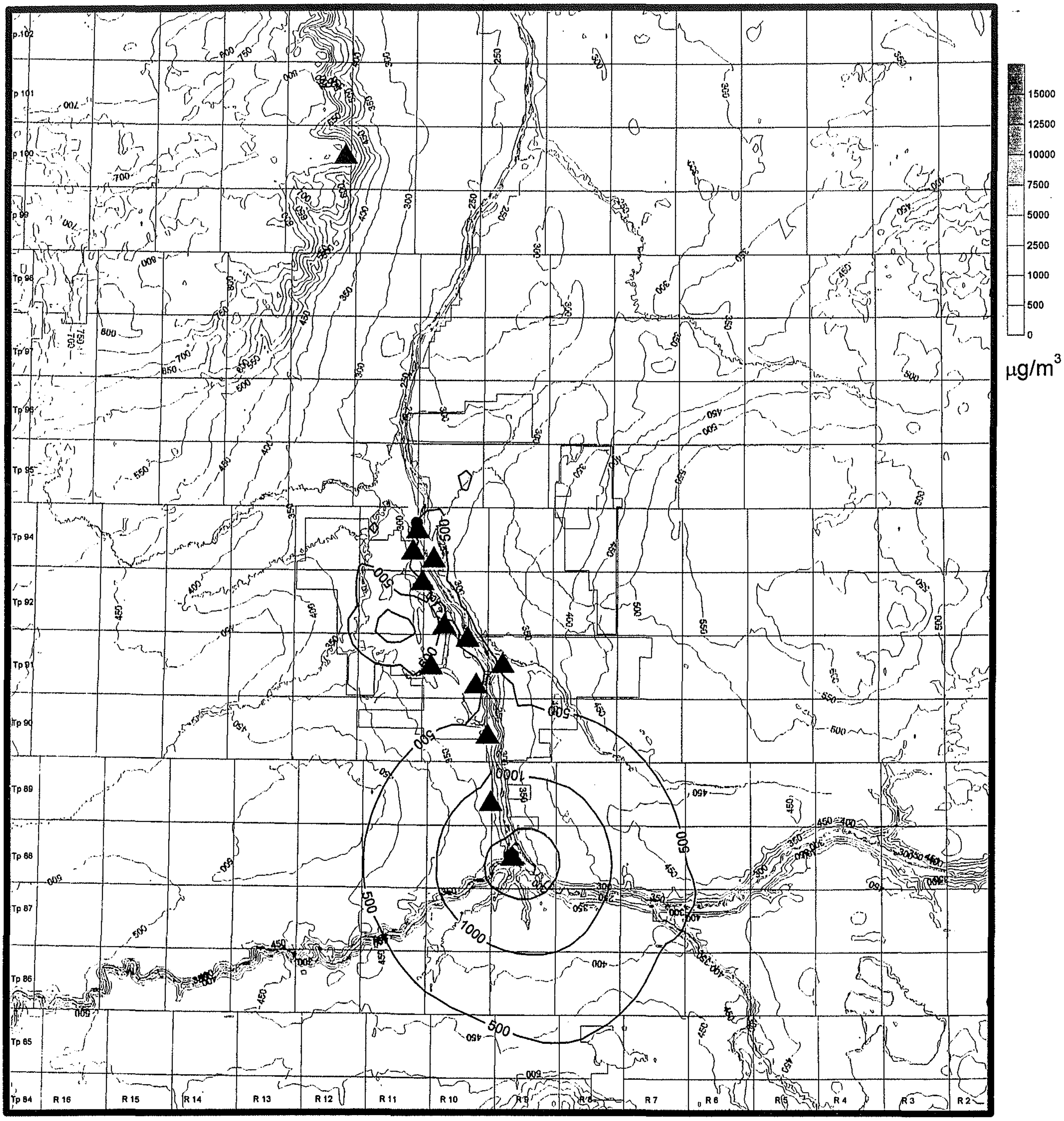
[(a)] Exceeds CO Alberta Guideline. Normalized for a 12-month period.

appears to be the mine fleet. The mine fleet emissions have been modelled as ground level sources with an areal extent matching the mine pit area. Because the fleet emissions are relatively large and at ground level, there is a decreased opportunity for dispersion and dilution of their plumes as compared to a tall stack with a similar emission rate. It is this ground level characterization which produces the increase in the ground level concentrations and this characterization is expected to be a conservative modelling assumption. The ability to compare the model predictions to monitoring data are limited because only one station within the region measures CO.

B2.2.6 Particulates

The ambient PM emission sources associated with the baseline operations are summarized in Section B2.1 (e.g., Tables B2-1 to B2-5). Total estimated PM emission rate for the baseline case is 9.5 t/cd. The major continuous source of particulate emissions from Suncor is the FGD Stack and it emits approximately 1.1 t/cd. In total Suncor emits approximately 20% of the PM. For the purpose of modelling, all PM was assumed to be PM_{10}. In addition to the PM emissions, metals and PAHs have been determined from stack sampling surveys collected by Syncrude. Based on the speciation completed for the stack sampling surveys, concentrations of metals and PAHs were estimated. These results are discussed in subsections following this section.

The predicted maximum daily and annual ground level ambient PM_{10} concentrations resulting from emissions of all approved industrial sources and residential emissions in the oil sands region were estimated using ISC3BE and meteorology measurements from the Mannix station. The modelling results are summarized in Table B2-21 which includes the PM_{10} predictions based on the source sampling results. Predicted PM_{10} ground level concentrations are mapped in the figures described below:



Sources	CO [t/sd]
Suncor	
Powerhouse	2.41
FGD	26.57
Incinerator	2.9
Flaring	0.2
Other Sources, Suncor	1.4
Syncrude (total)	53.6
Other Emissions (total)	33.57
TOTAL	120.65

Model Description	
Development	Baseline
Model	ISC3BE (7BG)
CO Guideline [µg/m³]	15000
Maximum [µg/m³]	5561
Exceedences / Year [#]	0

Figure B2-25 Predicted Baseline CO Maximum Hourly Average Ground Level Concentrations in the RSA

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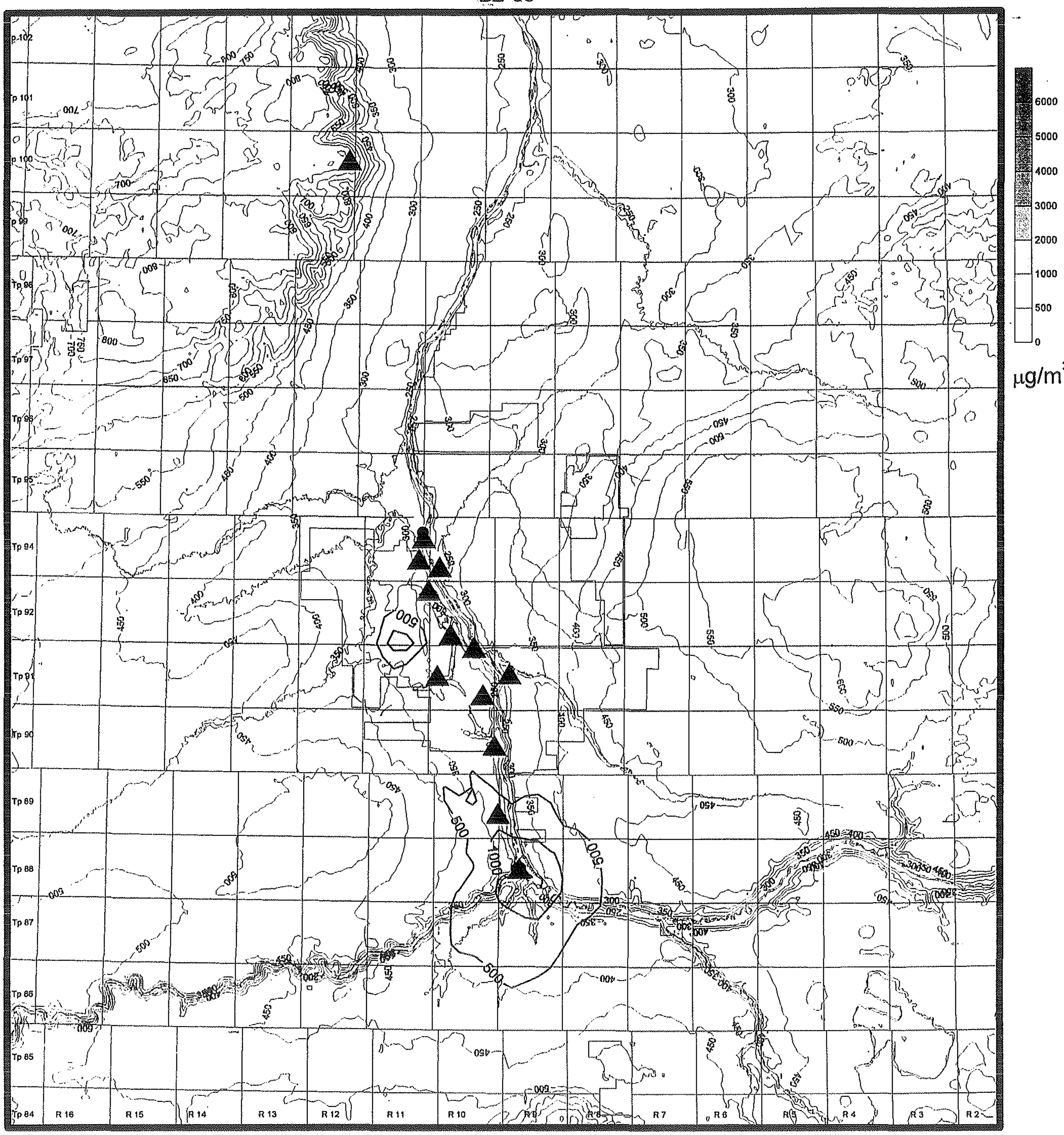


r:/1997/2200/972-2205/8600/8660/8662/ISCBE/FIGS/COCD_2P.srf

Sources	CO [t/sd]
Suncor	
Powerhouse	2.41
FGD	26.57
Incinerator	2.9
Flaring	0.2
Other Sources, Suncor	1.4
Syncrude (total)	53.6
Other Emissions (total)	33.57
TOTAL	120.65

Model Description	
Development	Baseline
Model	ISC3BE (7BG)
CO Guideline [µg/m³]	6000
Maximum [µg/m³]	2226
Exceedences / Year [#]	0

UTM NAD83 metres
0 5000 10000 15000 20000

Figure B2-26 Predicted Baseline CO Maximum 8-Hour Average Ground Level Concentrations in the RSA using the ISC3BE Model

- Figure B2-27 shows the maximum daily average ground level PM_{10} concentrations associated with the Baseline operations. The overall maximum daily average PM_{10} concentration of 113 µg/m^3 is predicted to occur at a location WNW of Suncor. This daily maximum average value exceeds the Alberta Guideline **for TSP** of 100 µg/m^3. The high readings and all the exceedances occur in a very small area within the existing development areas.
- Figure B2-28 shows the annual average ground level concentration contours for PM_{10}. The results show that the overall maximum annual concentration of 45.8 µg/m^3 is predicted to occur at the same location as the daily results.

Table B2-21 Maximum Predicted Ground Level Concentrations of PM_{10} for Baseline Sources

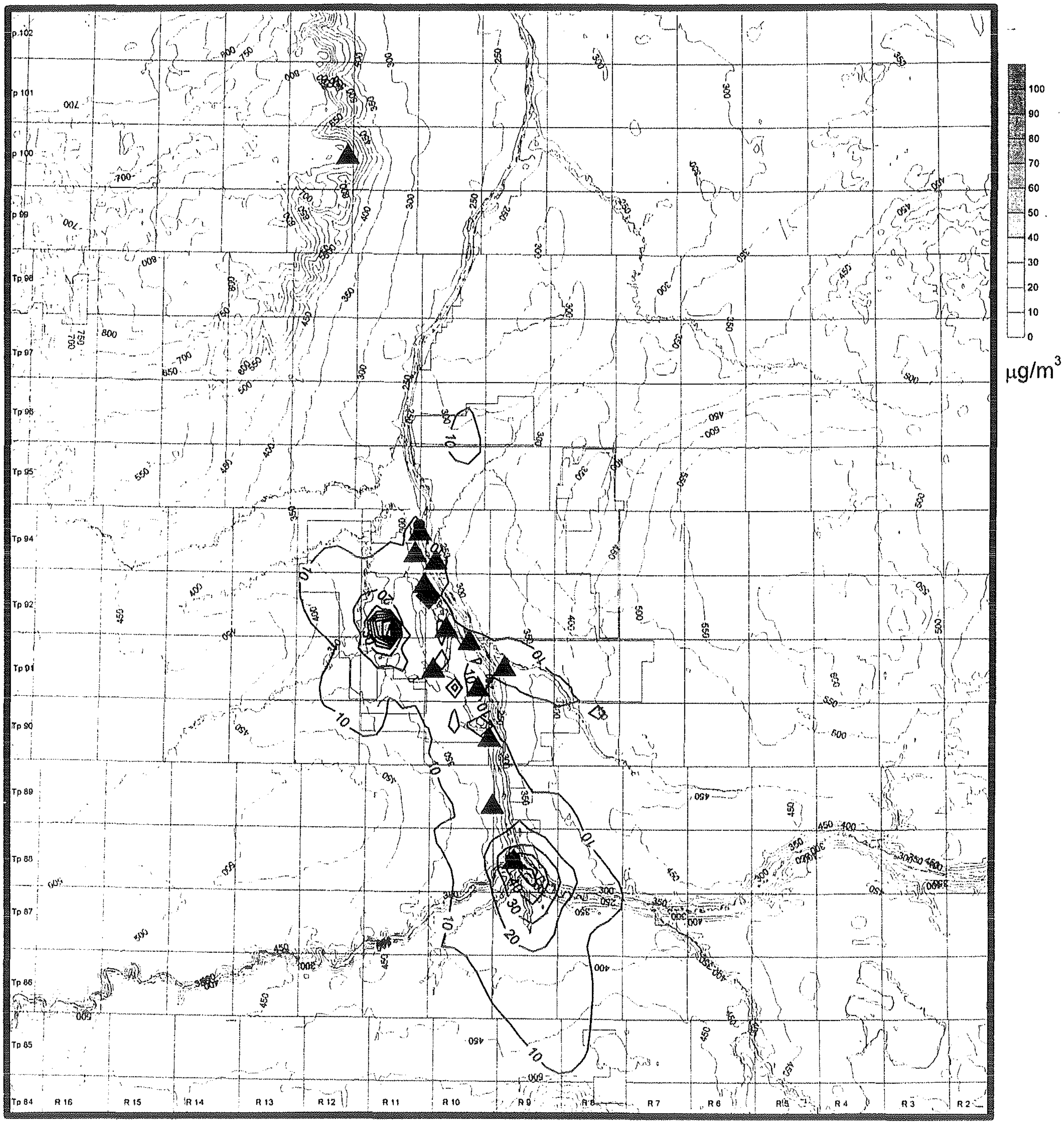
Source	Daily	Annual
Baseline Condition - Model ISC3BE		
Maximum PM_{10} Concentration (µg/m^3)	113	45.8
Location of Maximum Concentration (km)	WNW	WNW
Maximum Number of Exceedances	33	0
Location of Maximum Exceedances	n/a	n/a
TSP, Alberta Guideline (µg/m^3)	100	60

n/a data not available.

The modelling predicts high levels of PM_{10} in the development area and low levels in the rest of the RSA based on the existing emission sources.

The particulate emissions from the Suncor FGD and Syncrude Main stacks contain metals and PAH compounds. The ISC3BE was configured to predict particulates from these two stacks to determine ground level concentrations and deposition rates. Particulate size fraction, metal composition and PAH composition for the Suncor FGD stack emissions were based on a recent stack survey (March 1998). The survey results indicate that the size fraction of FGD emissions is predominantly in the $PM_{2.5}$ size range with a total emission rate of about 2.6 t/d. Information on the Syncrude Main stack emissions indicate a range of particulate sizes. These ranges are 40% $PM_{2.5}$, **50%** PM_{10} and **100%** PM_{50} (based on emissions information provided from Syncrude) with a total emission rate of about 7.1 t/d.

The predicted average annual ground level concentrations of total particulates from these two sources are shown in Figure B2-29. A summary of the predicted metals and PAHs concentrations derived from the total particulate air concentrations are listed in Tables B2-22 and B2-23, respectively for selected locations.

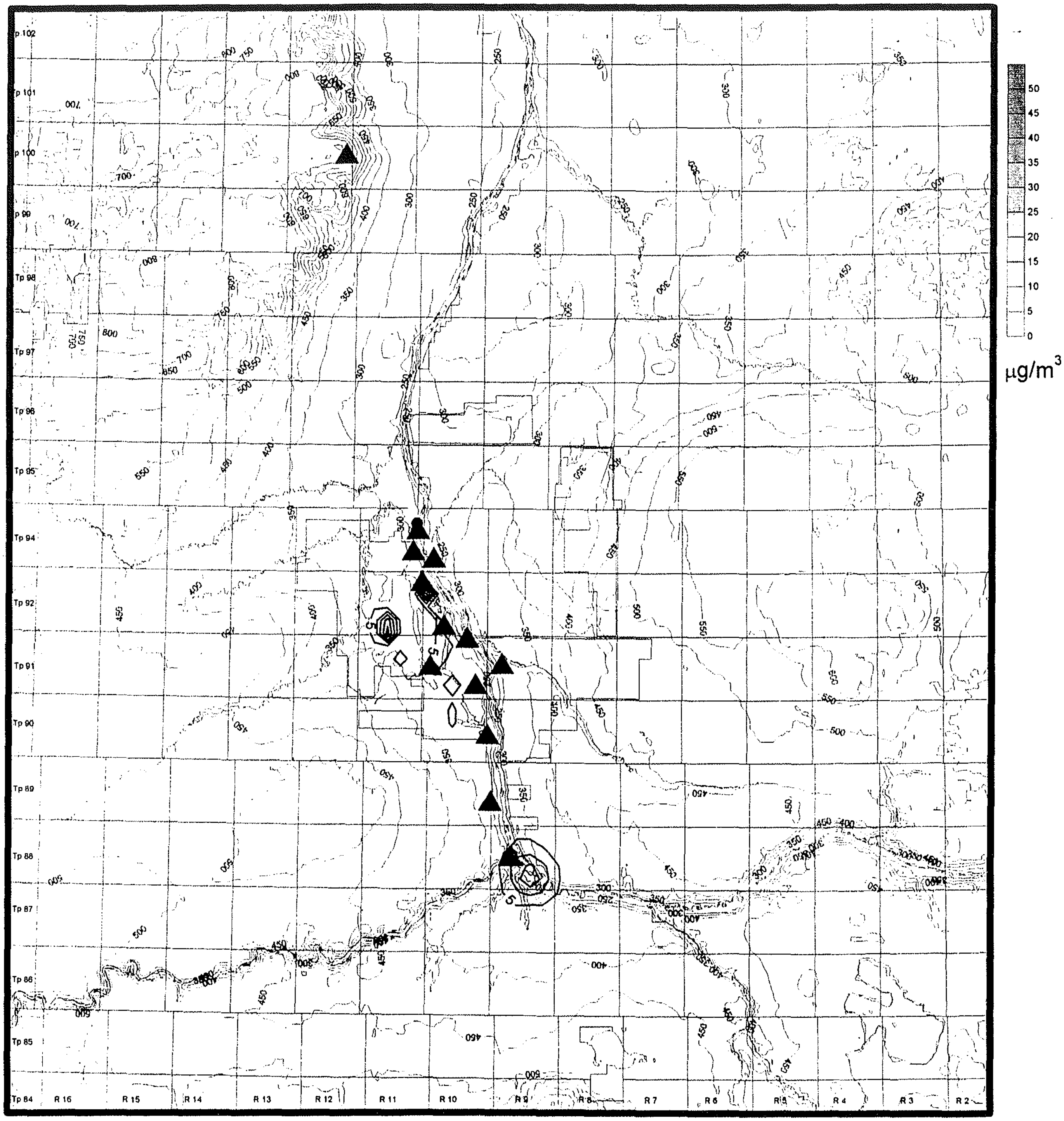


Sources	PM [t/cd]
Suncor	
FGD	1.10
Powerhouse	0.24
Incinerator	0.03
Lease 86/17 Mine Fleet	0.05
Steepbank Mine Fleet	0.05
Other Sources, Suncor	0.23
Syncrude (total)	5.6
Other Emissions (total)	2.2
TOTAL	9.5

Model Description	
Development	Baseline
Model	ISC3BE
PM_{10} Guideline [µg/m³]	50
Maximum [µg/m³]	113
Exceedences / Year [#]	33

UTM NAD83 metres
0 5000 10000 15000 20000

Figure B2-27 Predicted Baseline PM_{10} Maximum Daily Average Ground Level Concentrations in the RSA



Sources	PM [t/cd]
Suncor	
FGD	1.10
Powerhouse	0.24
Incinerator	0.03
Lease 86/17 Mine Fleet	0.05
Steepbank Mine Fleet	0.05
Other Sources, Suncor	0.23
Syncrude (total)	5.6
Other Emissions (total)	2.2
TOTAL	9.5

Model Description	
Development	Baseline
Model	ISC3BE
PM_{10} Guideline [µg/m³]	50
Maximum [µg/m³]	45.8
Exceedences / Year [#]	0

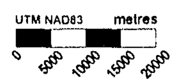
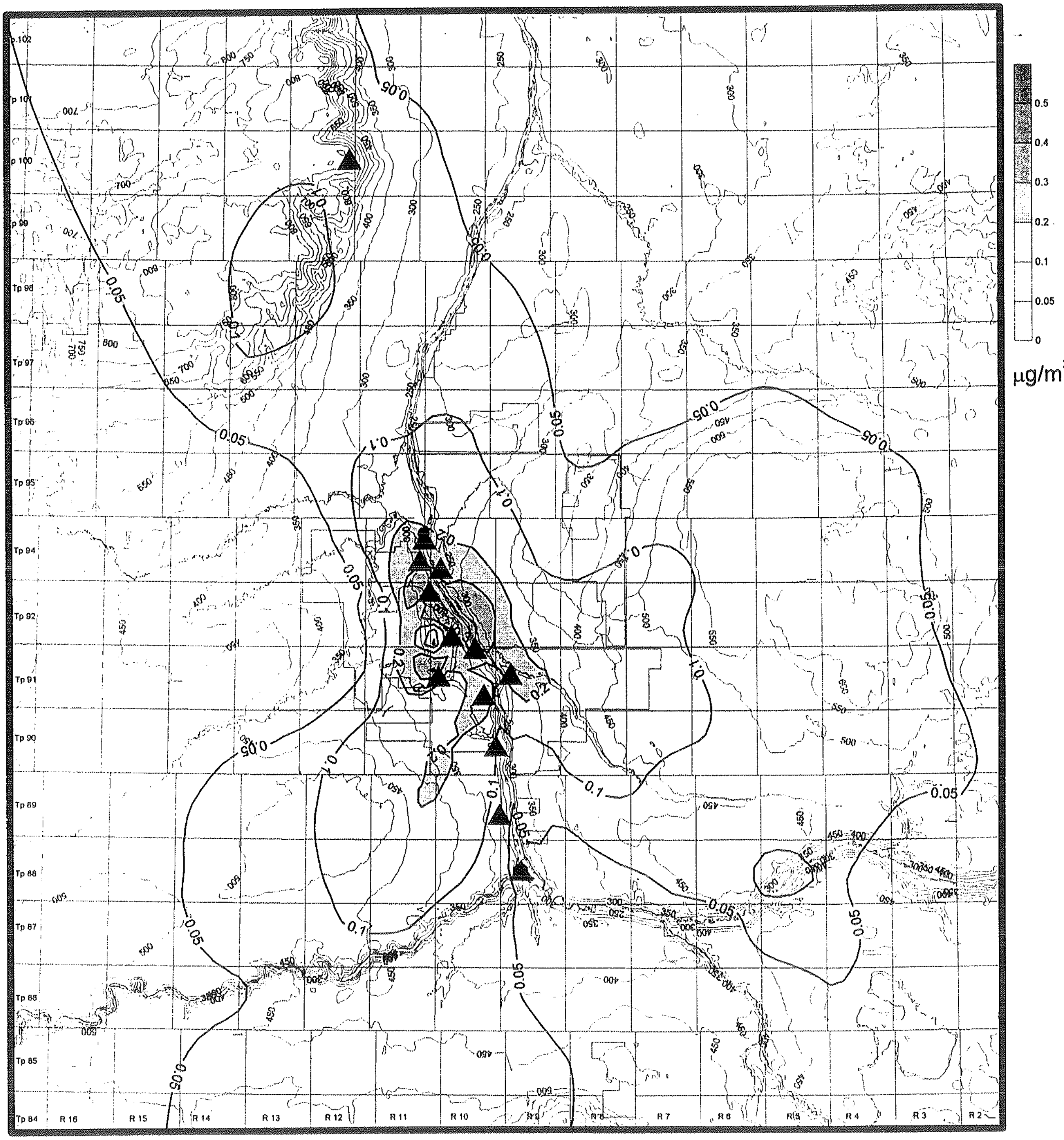


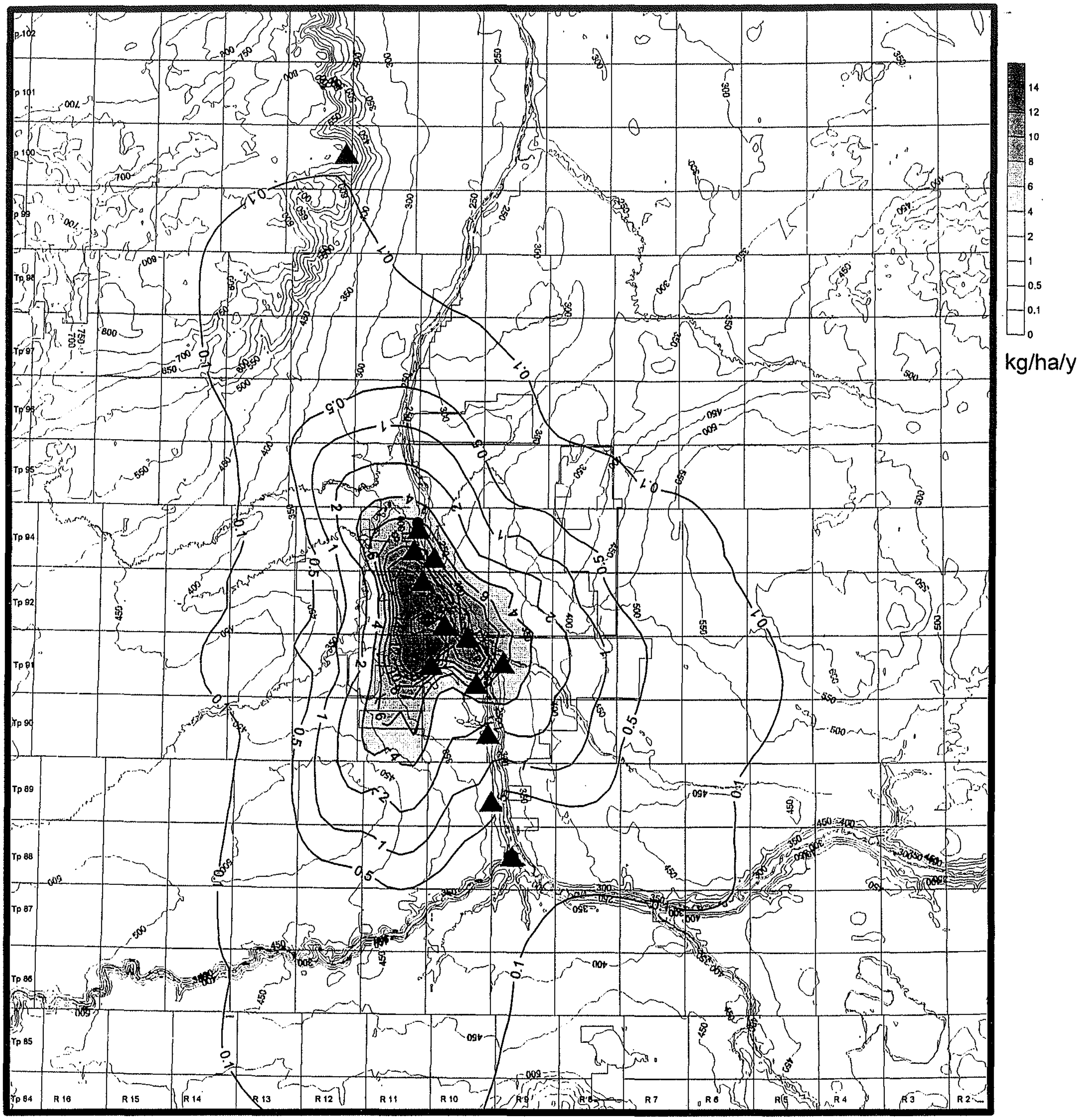
Figure B2-28 Predicted Baseline PM_{10} Annual Average Ground Level Concentrations in the RSA

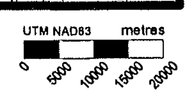


Sources	PM [t/cd]
Suncor	
FGD	2.9
Powerhouse	-
Incinerator	-
Lease 86/17 Mine Fleet	-
Steepbank Mine Fleet	-
Other Sources, Suncor	-
Syncrude Main Stack	7.1
Other Emissions (total)	-
TOTAL	10.0

Model Description	
Development	Baseline
Model	ISC3BE

Figure B2-29 Predicted Baseline Particulate Annual Average Ground Level Concentrations in the RSA from the operation of the Suncor FGD and Syncrude Main stacks





Sources	PM [t/cd]
Suncor	
FGD	2.9
Powerhouse	-
Incinerator	-
Lease 86/17 Mine Fleet	-
Steepbank Mine Fleet	-
Other Sources, Suncor	-
Syncrude Main Stack	7.1
Other Emissions (total)	-
TOTAL	10.0

Model Description	
Development	Baseline
Model	ISC3BE

Figure B2-30 Predicted Baseline Particulate Annual Average Deposition in the RSA from the operation of the Suncor FGD and Syncrude Main stacks

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Table B2-22 Average Ground Level Predicted Concentrations of Heavy Metals at Selected Sites as a Result of Emissions From Suncor FGD and Syncrude Main Stack

Location	Average Daily Ground Level Concentration					Average Annual Ground Level Concentration			
	Ontario AAQC, Daily [ng/m³]	Mannix	Fort McMurray	Fort McKay	Fort Chipewyan	Mannix	Fort McMurray	Fort McKay	Fort Chipewyan
Heavy Metals [ng/m³]									
Antimony	—	5.6E-02	8.4E-03	2.8E-02	2.8E-03	2.9E-03	3.6E-04	2.2E-03	1.2E-04
Arsenic	3.00E+03	8.9E-02	1.3E-02	4.4E-02	4.4E-03	4.6E-03	5.7E-04	3.5E-03	1.9E-04
Aluminum	—	9.2E+00	1.3E+00	5.4E+00	4.5E-01	4.8E-01	5.1E-02	4.3E-01	1.9E-02
Barium	1.00E+05	8.9E-01	1.3E-01	4.3E-01	4.4E-02	4.6E-02	5.8E-03	3.4E-02	1.9E-03
Beryllium	0.00E+00	1.0E-02	1.5E-03	5.3E-03	5.1E-04	5.4E-04	6.5E-05	4.2E-04	2.2E-05
Cadmium	2.00E+04	2.0E-02	2.7E-03	1.2E-02	9.7E-04	1.0E-03	1.0E-04	9.8E-04	3.9E-05
Chromium	1.50E+04	4.5E+00	6.6E-01	2.5E+00	2.2E-01	2.4E-01	2.7E-02	1.9E-01	9.5E-03
Cobalt	1.00E+03	2.4E-01	3.5E-02	1.4E-01	1.2E-02	1.3E-02	1.4E-03	1.1E-02	5.0E-04
Copper	5.00E+05	4.1E-01	5.8E-02	2.3E-01	2.0E-02	2.1E-02	2.4E-03	1.8E-02	8.4E-04
Iron	—	4.2E+01	5.8E+00	2.6E+01	2.1E+00	2.2E+00	2.3E-01	2.0E+00	8.3E-02
Lead	0.00E+00	6.0E-01	9.1E-02	2.8E-01	2.9E-02	3.1E-02	4.0E-03	2.3E-02	1.3E-03
Manganese	—	1.8E+00	2.6E-01	8.9E-01	8.7E-02	9.2E-02	1.1E-02	7.1E-02	3.8E-03
Mercury	2.00E+04	1.2E-02	1.7E-03	6.2E-03	5.8E-04	6.1E-04	7.2E-05	4.9E-04	2.5E-05
Molybdenum	1.20E+06	8.7E-01	1.3E-01	4.6E-01	4.3E-02	4.5E-02	5.4E-03	3.6E-02	1.8E-03
Nickel	2.00E+04	7.2E+00	1.0E+00	4.1E+00	3.5E-01	3.8E-01	4.2E-02	3.2E-01	1.5E-02
Selenium	1.00E+05	2.5E+00	4.2E-01	9.0E-01	1.3E-01	1.3E-01	2.0E-02	7.2E-02	6.0E-03
Silver	1.00E+04	8.5E-02	1.1E-02	5.5E-02	4.2E-03	4.4E-03	4.3E-04	4.3E-03	1.6E-04
Tin	1.00E+05	6.1E-01	9.3E-02	3.0E-01	3.0E-02	3.2E-02	4.0E-03	2.4E-02	1.3E-03
Titanium	—	1.0E+00	1.5E-01	5.6E-01	5.0E-02	5.3E-02	6.1E-03	4.4E-02	2.1E-03
Vanadium	2.00E+04	3.4E+00	5.0E-01	1.8E+00	1.7E-01	1.8E-01	2.1E-02	1.4E-01	7.1E-03
Zirconium	—	6.1E-01	9.3E-02	3.0E-01	3.0E-02	3.2E-02	4.0E-03	2.4E-02	1.3E-03
Zinc	1.20E+06	1.7E+01	1.9E+00	1.4E+01	8.1E-01	8.6E-01	5.6E-02	1.1E+00	2.7E-02

OAAQC: Ontario Ambient Air Quality Criteria
Ontario Ministry of the Environment 1994
Summary of Point of Impingement Standards, Ambient Air Quality Criteria (AAQC), and Approvals Screening Levels

Table B2-23 Average Ground Level Predicted Concentrations of PAHs at Selected Sites as a Result of Emissions From Suncor FGD and Syncrude Main Stack

Location	Average Daily Ground Level Concentration				Average Annual Ground Level Concentration			
	Mannix	Fort McMurray	Fort McKay	Fort Chipewyan	Mannix	Fort McMurray	Fort McKay	Fort Chipewyan
PAHs [ng/m^3]								
Acenaphthene	9.3E-04	1.5E-04	4.0E-04	4.6E-05	4.9E-05	6.6E-06	3.2E-05	2.1E-06
Acenaphylene	2.7E-02	3.1E-03	2.3E-02	1.3E-03	1.4E-03	8.8E-05	1.8E-03	4.4E-05
Anthracene	2.5E-03	4.1E-04	1.0E-03	1.3E-04	1.3E-04	1.9E-05	8.0E-05	5.9E-06
1,2-Benzathracene	1.1E-03	1.7E-04	5.7E-04	5.6E-05	6.0E-05	7.3E-06	4.5E-05	2.5E-06
Benzo(b & j)fluoranthene	6.9E-03	1.1E-03	2.9E-03	3.4E-04	3.6E-04	5.0E-05	2.3E-04	1.6E-05
Benzo(k)fluoranthene	1.1E-03	1.7E-04	6.3E-04	5.6E-05	5.9E-05	6.8E-06	4.9E-05	2.4E-06
Benzo(a)fluorene	1.0E-03	1.6E-04	4.4E-04	5.1E-05	5.4E-05	7.4E-06	3.5E-05	2.3E-06
Benzo(b)fluorene	6.2E-04	9.4E-05	2.9E-04	3.0E-05	3.2E-05	4.1E-06	2.3E-05	1.3E-06
Benzo(g, h, i)perylene	1.3E-03	2.0E-04	7.2E-04	6.6E-05	7.0E-05	8.1E-06	5.7E-05	2.8E-06
Benzo(a)pyrene	9.5E-04	1.4E-04	4.7E-04	4.7E-05	5.0E-05	6.2E-06	3.7E-05	2.1E-06
Benzo(e)pyrene	6.2E-04	9.4E-05	2.9E-04	3.0E-05	3.2E-05	4.1E-06	2.3E-05	1.3E-06
Camphene	1.7E-03	2.7E-04	6.7E-04	8.3E-05	8.8E-05	1.3E-05	5.3E-05	3.9E-06
Carbazole	9.5E-04	1.5E-04	4.1E-04	4.7E-05	5.0E-05	6.8E-06	3.3E-05	2.2E-06
1 -Chloronaphthalene	8.7E-04	1.3E-04	4.0E-04	4.3E-05	4.5E-05	5.9E-06	3.1E-05	1.9E-06
2-Chloronaphthalene	1.3E-03	1.8E-04	7.7E-04	6.4E-05	6.8E-05	7.3E-06	6.0E-05	2.6E-06
Chrysene	2.2E-03	3.1E-04	1.3E-03	1.1E-04	1.1E-04	1.2E-05	1.0E-04	4.4E-06
Dibenz(a, j)acridine	1.0E-03	1.5E-04	5.3E-04	5.1E-05	5.4E-05	6.5E-06	4.2E-05	2.2E-06
Dibenz(a, h)acridine	8.4E-04	1.3E-04	3.7E-04	4.2E-05	4.4E-05	5.9E-06	3.0E-05	1.9E-06
Dibenz(a, h anthracene	8.7E-04	1.3E-04	4.0E-04	4.3E-05	4.5E-05	5.9E-06	3.1E-05	1.9E-06
Dibenzothiophene	1.1E-01	1.2E-02	9.1E-02	5.3E-03	5.6E-03	3.5E-04	7.1E-03	1.8E-04
7,12-dimethylbenz(a)anthracene	8.4E-04	1.3E-04	3.7E-04	4.2E-05	4.4E-05	5.9E-06	3.0E-05	1.9E-06
1, 6-Dinitropyrene	8.4E-04	1.3E-04	3.7E-04	4.2E-05	4.4E-05	5.9E-06	3.0E-05	1.9E-06
1, 8-Dinitropyrene	8.4E-04	1.3E-04	3.7E-04	4.2E-05	4.4E-05	5.9E-06	3.0E-05	1.9E-06
Fluoranthene	7.6E-03	1.2E-03	3.5E-03	3.8E-04	4.0E-04	5.2E-05	2.8E-04	1.7E-05
Fluorene	4.3E-03	7.1E-04	1.6E-03	2.1E-04	2.3E-04	3.3E-05	1.3E-04	1.0E-05
Ideno(l, 2, 3-cd)pyrene	1.2E-03	1.7E-04	7.0E-04	6.0E-05	6.4E-05	7.1E-06	5.5E-05	2.5E-06
Indole	1.7E-03	2.8E-04	6.9E-04	8.6E-05	9.1E-05	1.3E-05	5.5E-05	4.0E-06
1 -Methylnaphthalene	3.4E-02	4.2E-03	2.5E-02	1.6E-03	1.7E-03	1.4E-04	1.9E-03	6.0E-05
2-Methylnaphthalene	3.2E-02	4.2E-03	2.2E-02	1.6E-03	1.7E-03	1.5E-04	1.8E-03	6.0E-05
Naphthalene	4.4E-01	5.2E-02	3.4E-01	2.1E-02	2.3E-02	1.6E-03	2.7E-02	7.4E-04
Nitro-pyrene	1.2E-03	1.9E-04	4.9E-04	5.8E-05	6.2E-05	8.5E-06	3.9E-05	2.7E-06
Perylene	6.2E-04	9.4E-05	2.9E-04	3.0E-05	3.2E-05	4.1E-06	2.3E-05	1.3E-06
Phenanthrene	6.1E-02	8.2E-03	3.9E-02	3.0E-03	3.2E-03	3.1E-04	3.1E-03	1.2E-04
Pyrene	7.4E-03	1.0E-03	4.5E-03	3.6E-04	3.9E-04	4.1E-05	3.5E-04	1.5E-05
Retene	1.0E-02	1.6E-03	4.5E-03	4.9E-04	5.2E-04	6.9E-05	3.6E-04	2.2E-05

The PM assessment from the Suncor FGD stack reflects the most recent stack survey data which included analysis of heavy metals, PAHs and particulate size fractions. This data has been included in the air quality section, but was not available in time for the writing of the health assessment in Section F.

B2.2.7 Fugitive Dust Discussion

The maximum predicted PM does not include contributions due to non-combustion sources nor natural background levels. Potential fugitive sources associated with the Suncor operation includes the coke piles, road dust, beaches, and sand dykes. It is Suncor's experience that the mining area, given the coarse nature of oil sands (bitumen and sand combination), is expected to produce minimal PM fugitive emissions. The existing reclamation activities will control fugitive particulate emissions from the sand dykes and beaches. Suncor's ongoing operations include particulate control programs for the coke piles and the haul roads. Overall, fugitive emissions are possible on an episodic basis but are managable with existing management systems.

B2.2.8 Volatile Organic Compounds Predicted Concentrations

The VOC emission sources associated with the baseline operations are summarized in Section B2.1 (e.g., Tables B2-1 to B2-6). Total estimated emission rates for the baseline case are 180 t/cd for VOC (Table B2-6). Suncor represents about 70% of the VOC total emissions. The major emission sources from Suncor are the Tailings Pond 1 and the mine surface areas (Table B2-1). Overall, tailings ponds and exposed mine surfaces emissions represent about 85% of the VOC emissions. Using the VOC runs and the unique fingerprint of each emission source, specific VOCs were further speciated from the modelling results.

The predicted annual average ground level ambient total VOC concentrations resulting from emissions of all approved industrial sources and residential emissions in the oil sands region were estimated using ISC3BE and meteorology measurements from the Mannix station. This model provides an efficient means of predicting the overall ambient VOC concentration and the speciated compounds from all sources.

The predicted total VOC annual average ground level concentrations are mapped in Figure B2-31. The results show that the overall maximum annual concentrations are expected to occur over the Suncor's Tailings Pond 1 (a secondary extraction tailings pond). Because source characterization simplifications are used to model large sources such as tailings ponds, which include annualized emission rates and homogeneous emissions over the ponds surfaces, maximum concentrations under worst case meteorology are likely over-estimated very close to the pond. The annual concentrations for selected receptors are listed in Table B2-24 and are put into perspective in the health discussion in Section F1.

Table B2-24 Maximum Predicted Annual Average Ground Level Concentrations of VOCs for Baseline Conditions at Selected Locations

	VOC Concentration [µg/m³]				
Species	Location of Maximum	Mannix	Fort McMurray	Fort McKay	Fort Chipewyan
Total VOCs					
Maximum concentration [µg/m³]	17,400	428	50	107	7
Speciated VOCs					
C2 to C4 alkanes and alkenes	252	6.2	0.7	1.6	0.10
C5 to C8 Alkanes and alkenes	6,565	162	18.9	40.4	2.7
C9 to C12 alkanes and alkenes [(a)]	6,508	160	18.8	40.0	2.6
Cyclohexane	1,467	36	4.2	9.0	0.6
Benzene	59	1.4	0.17	0.36	0.024
C6 to C8 non-benzene aromatics	898	22	2.6	5.5	0.4
Total aldehydes	24	0.6	0.069	0.147	0.010
Total ketones	7	0.2	0.019	0.040	0.003
Total Reduced Sulphur Compounds	378	9.3	1.1	2.3	0.2

[(a)] Unknown speciation are included in Group C9 to C12.

The large sources have been represented in the ISC3BE model using an area source characterization. Because sources such as tailings ponds are large and because their emissions originate at ground level, there is decreased opportunity for dispersion of their plume compared to an elevated source, such as a stack. Persistent low concentrations (i.e., not varying greatly with changes in meteorology compared to stack emissions) can be expected in the modelling results from these large area sources and is reflected in Figure B2-31 throughout a large portion of the RSA.

B2.2.9 TRS Predicted Concentration

The ambient TRS emission sources associated with the baseline operations are summarized in Section B2.1 (e.g., Tables B2-1 to B2-6). Total estimated TRS emission rate for the Baseline case is 3.8 t/cd. The major sources of TRS emissions from Suncor are the tailing ponds representing approximately 1.3 t/cd. In total, Suncor emits approximately 40% of the TRS.

The predicted maximum hourly, daily and annual ground level ambient TRS concentrations resulting from emissions of all approved industrial sources and residential emissions in the oil sands region were estimated using ISC3BE and meteorology measurements from the Mannix station. Selected results of the speciated reduced sulphide compounds are shown in Figure B2-32 and Figure B2-33 for the hourly and daily H_2S and in Figure B2-34 for hourly mercaptans. These TRS species were selected

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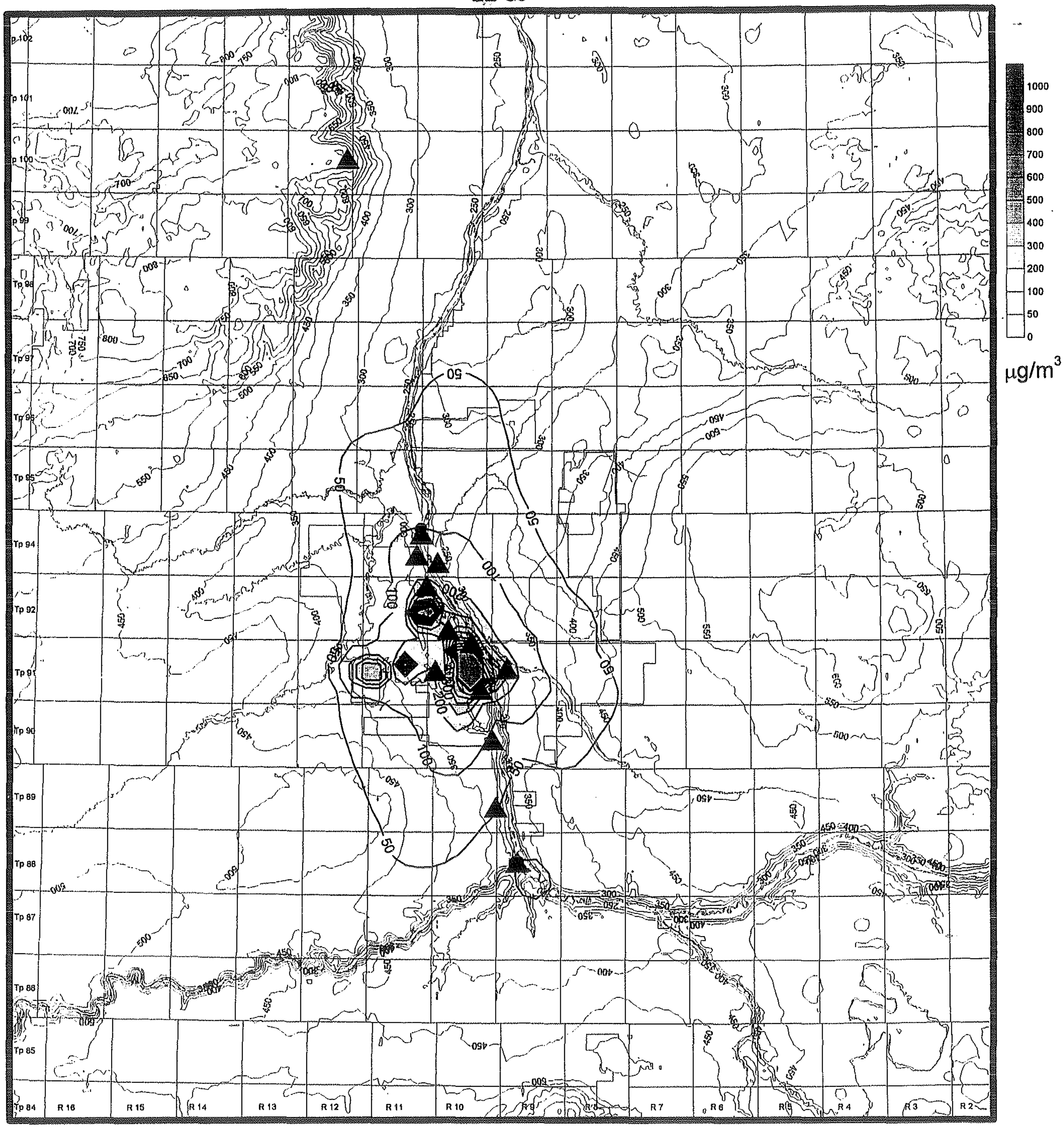

Sources	VOC [t/cd]
Suncor Plant	17.6
Syncrude Plant	5.4
Mine Fleets	1.7
Mine Faces	17.2
Tailings Ponds	128.6
TOTAL	170.5

Model Description	
Development	Baseline
Model	ISC3BE

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Figure B2-31 Predicted Baseline VOC Maximum Annual Average Ground Level Concentrations in the RSA

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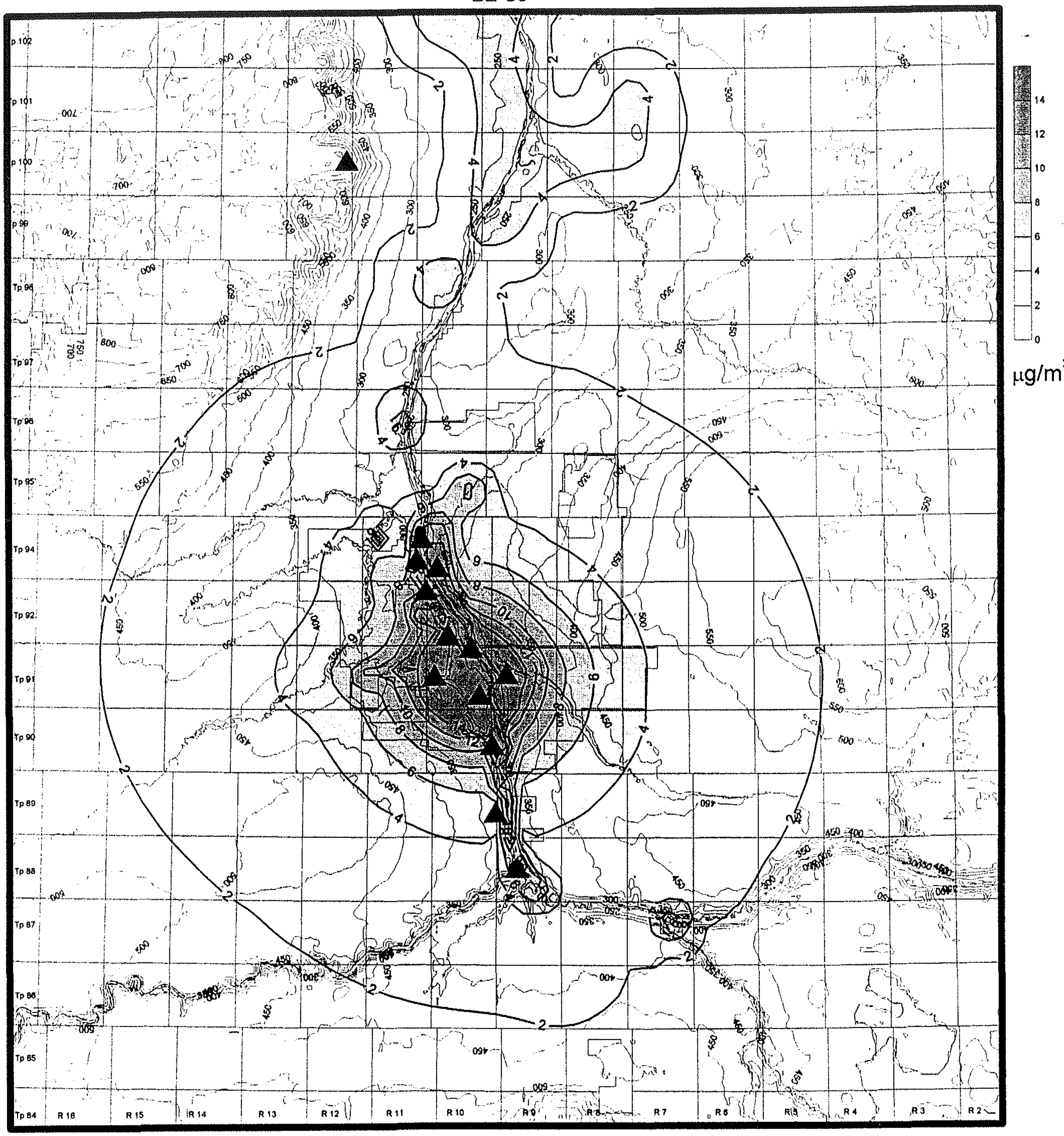
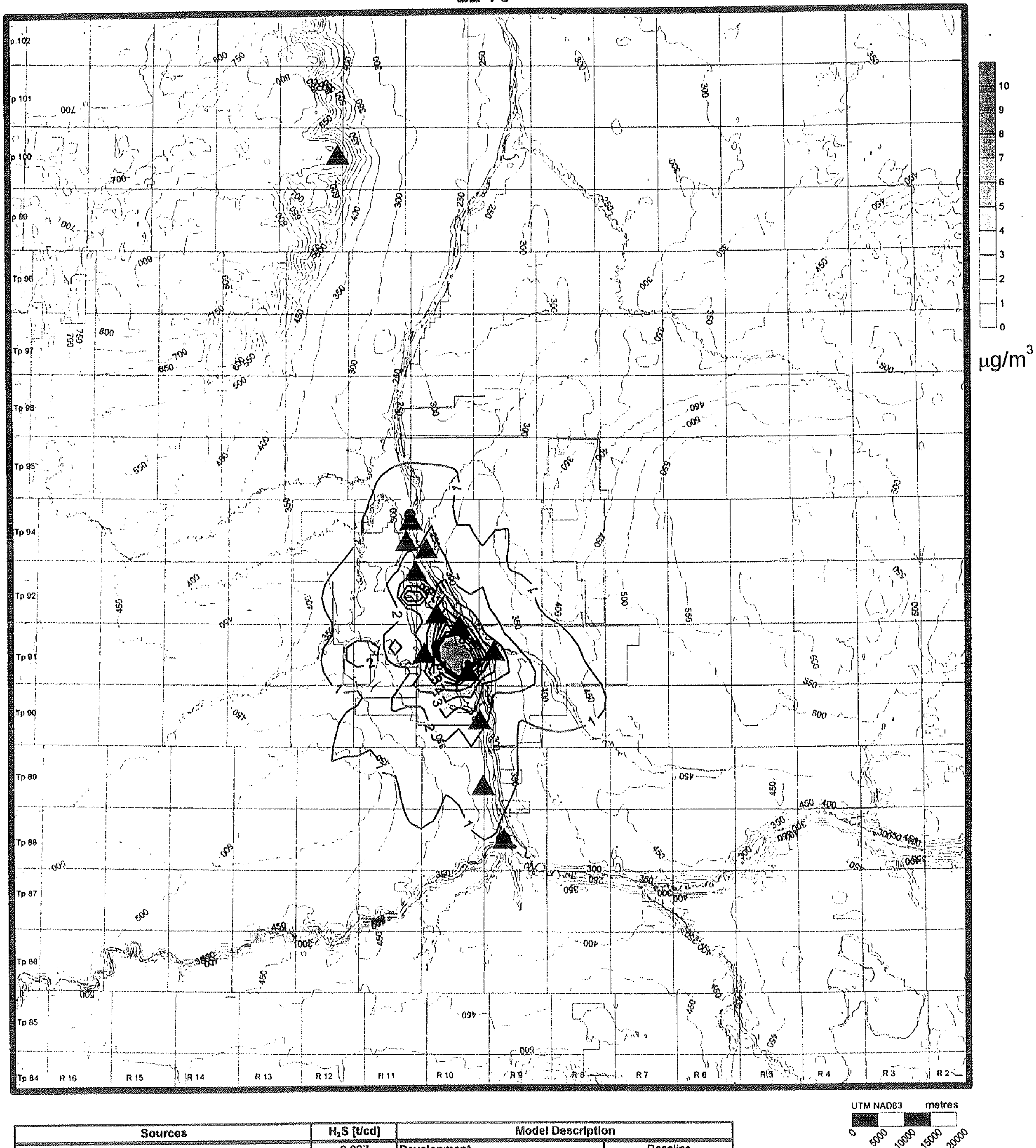


Sources	H_2S [t/cd]
Suncor Plant	0.027
Syncrude Plant	0.008
Mine Fleets	0.003
Mine Faces	0.026
Tailings Ponds	0.195
TOTAL	0.259

Model Description	
Development	Baseline
Model	ISC3BE

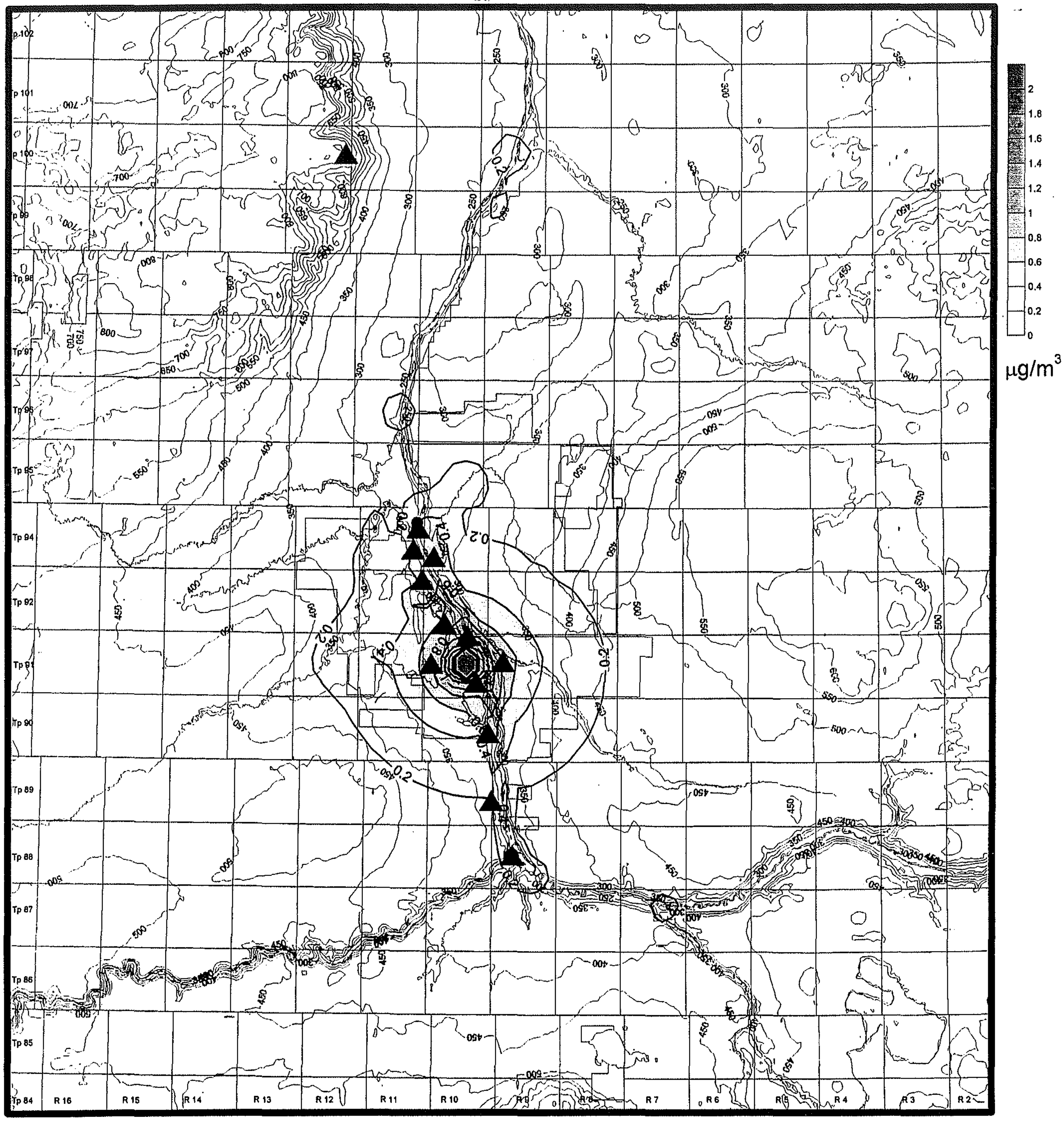
Figure B2-32 Predicted Baseline H_2S Maximum Hourly Average Ground Level Concentrations in the RSA



Sources	H_2S [t/cd]
Suncor Plant	0.027
Syncrude Plant	0.008
Mine Fleets	0.003
Mine Faces	0.026
Tailings Ponds	0.195
TOTAL	0.259

Model Description	
Development	Baseline
Model	ISC3BE

Figure B2-33 Predicted Baseline H_2S Maximum Daily Average Ground Level Concentrations in the RSA



Sources	Mercaptans [t/cd]
Suncor Plant	0.0010
Syncrude Plant	0.0003
Mine Fleets	0.0001
Mine Faces	0.0010
Tailings Ponds	0.0075
TOTAL	0.0100

Model Description	
Development	Baseline
Model	ISC3BE

Figure B2-34 Predicted Baseline Mercaptans Maximum Hourly Average Ground Level Concentrations in the RSA

because they have particularly low odour thresholds. Maximum hourly and daily concentrations at selected locations are listed in Table B2-24 and Table B2-25. Similar to the discussion in the VOC section above, the predicted maximum concentration occurs directly over a Suncor tailings pond and the predicted maximum concentration at that location is a result of the modelling simplifications.

Whereas the ISC3BE model was not configured to explicitly assess odours, the concentrations at the selected locations can be used to qualitatively assess the potential for odour detection at these locations. The results presented in the figures do not address the complexities of thorough odour assessment which would take into account concentration magnitude, duration above a threshold, frequency of exceeding various thresholds and receptor sensitivity. As a part of the ISC3BE development, the dispersion coefficients were adjusted for receptors within the Athabasca River valley such that limited mixing could occur under certain meteorological conditions. The result of this fine tuning can be seen in Figure B2-32 in the elevated H_2S concentrations within the Athabasca River valley.

The results in Table B2-25 and Table B2-26 indicate that the predicted concentrations could potentially lead to the detection of odours originating from the developments in the oil sands area for sensitive individuals.

Table B2-25 Maximum Predicted Hourly Concentrations of TRS at Selected Sites for Baseline Sources

	TRS Concentration [μg/m³]				
Species	**Location of Maximum**	**Mannix**	**Fort McMurray**	**Fort McKay**	**Fort Chipewyan**
Total Reduced Sulphur Compounds					
Maximum VOC concentration [μg/m³]	71,800	21,036	6,063	7,722	2,081
Maximum TRS concentration [μg/m³]	1,561	457	132	168	45
Speciated Compounds					
H_2S	109	31.9	9.2	11.7	3.2
COS	0	0	0	0	0
CS_2	0	0	0	0	0
Mercaptans	4.20	1.23	0.36	0.45	0.12
Thiophenes	563	165	48	61	16

Alberta H_2S hourly guideline - 15 μg/m³
Odour threshold for mercaptans is 0.04 to 2.0 μg/m³
Odour threshold for H_2S is 0.7 to 14 μg/m³

Table B2-26 Maximum Predicted Daily Concentrations of TRS at Selected Sites for Baseline Sources

	TRS Concentration [µg/m³]				
Species	Location of Maximum	Mannix	Fort McMurray	Fort McKay	Fort Chipewyan
Total Reduced Sulphur Compounds					
Maximum VOC concentration [µg/m³]	46,900	5,448	597	1,093	127
Maximum TRS concentration [µg/m³]	1,019	118	13	24	3
Speciated Compounds					
H_2S	71	8.3	0.9	1.7	0.2
COS	0	0	0	0	0
CS_2	0	0	0	0	0
Mercaptans	2.75	0.32	0.03	0.06	0.00
Thiophenes	367	43	5	9	0

Alberta H_2S **daily** guideline - **4** µg/m³

B3 AIR QUALITY

B3.1 PROPOSED EMISSIONS

Suncor's oil sands operations result in a number of air emissions from a variety of sources. This section describes and quantifies the changes in the air emissions as a result of Project Millennium. A detailed project description is provided in Section C, Volume I, of the application.

Air quality changes due to the emissions from Project Millennium will combine with emissions from existing sources in the RSA and with ambient conditions associated with air flow into the region. Air quality related issues associated with these emissions can be summarized as a series of key questions whose linkages are identified in Figure B3-1. The key questions are as follows:

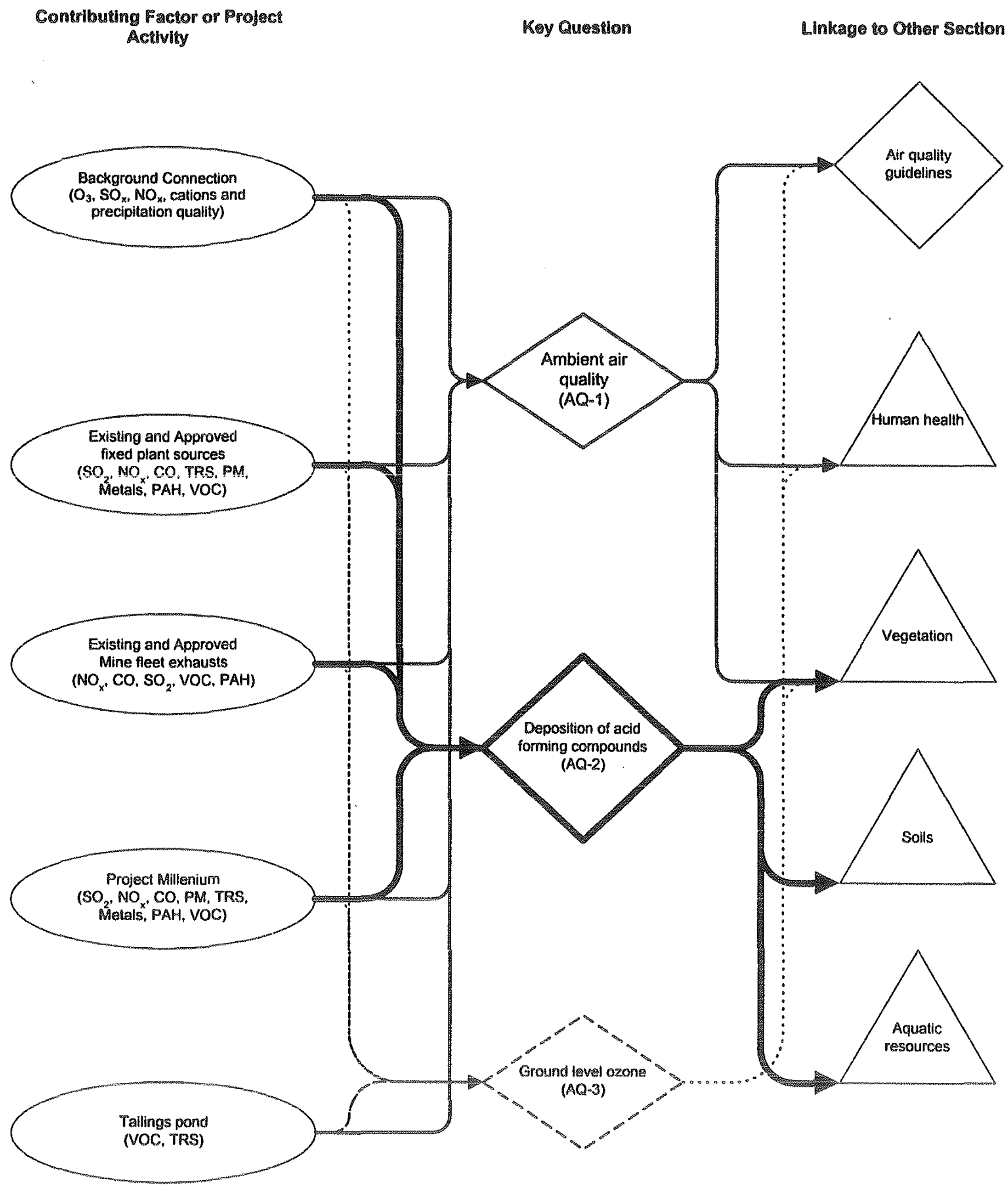
AQ-1 What impacts will air emissions from Project Millennium have on ambient air quality?

The potential for air emissions to have an impact on ambient air quality has been raised as a concern. To address this issue, predicted air quality concentrations were modelled using the ISC3BE air dispersion model. The selected parameters for air quality are SO_2, NO_2, CO, PM, VOC and TRS. The modelling results were compared to Alberta Ambient Air Quality Guidelines, Canadian Federal Air Quality Objectives or other guidelines to assist in the prediction of impacts. The linkage pathway for this key question is depicted by the narrow line in Figure B3-1.

AQ-2 What impacts will air emissions from Project Millennium have on the deposition of acid-forming compounds?

In the Project Millennium case, NO_x and SO_2 air emissions are considered the primary sources that result in the deposition of acid-forming compounds. The preferred method for evaluating the overall effects of these compounds is by determining the Potential Acid Input (PAI). This method takes into account the acidification effect of sulphur and nitrogen species as well as the neutralizing effect of available cations. Modelling of PAI was undertaken for the Project Millennium case using the CALPUFF model and the results presented in a manner that allowed for use in other components of the EIA. In particular the results were incorporated into determining impacts to Water Quality (C3), Soils (D2) and Vegetation and Wetlands (D3). The linkage pathway for this key question is depicted by the bolded line in Figure B3-1.

Figure B3-1 Air Quality Linkage Diagram for Project Millennium



AQ-3 What impacts will air emissions from Project Millennium have on concentrations of ground level ozone?

The evaluation of ground level ozone concentrations is complicated since ozone is not directly emitted from Project Millennium, but rather results from a series of chemical reactions in the atmosphere. Research is ongoing to determine the most appropriate tools to predict ozone concentrations. Until the research is completed in October 1998, predicted impacts this project will have on ozone levels is undetermined. The linkage pathway for this key question is depicted by the dotted line in Figure B3-1.

B3.1.1 Proposed Emissions

B3.1.1.1 Project Millennium

The Project Millennium expansion will increase Suncor's overall production rate and change overall air emissions. Important air emissions and their potential changes to ambient air quality as a result of this project are summarized below.

- **Sulphur Dioxide** (SO_2) emissions result from the combustion of petroleum coke and upgrading operations. These can acidify surrounding soils and water bodies and cause changes to ambient air quality.
- **Oxides of Nitrogen** (NO_x) emissions result from the mine fleet and combustion sources in Energy Services and Upgrading. These emissions can cause ambient air quality changes and deposition of acidifying emissions. They also can act as precursors for the photochemical production of ozone which may impact human health and vegetation.
- **Volatile Organic Compounds** (VOC) and other hydrocarbon emissions result from the tailings ponds mine fleet exhaust, the mine pit area, and upgrading and extraction operations. These emissions can cause ambient air quality changes, the photochemical production of ground level ozone and potential impact on human health.
- Fugitive emissions including **Total Reduced Sulphur** (TRS) and H_2S can result from the extraction and upgrading operations and tailings ponds. These have the potential to cause off-site odours.
- **Particulate Matter** (PM) emissions can result from site clearing, mining activities, combustion sources, and coke handling and storage. PM and associated polycyclic aromatic hydrocarbons (PAHs) can have adverse impacts on human health and aquatic life.

Proposed Emissions

An overall summary of the emissions from the baseline conditions and Project Millennium is provided in Table B3-1. This table summarizes the overall air emissions expected from the facility and includes data on SO_2, NO_X, CO, PM, VOC and TRS. Comments specific to each emission parameter accompany the table and include design mitigation inputs. The existing baseline emission data were provided in Table B2-1.

Table B3-1 Summary of Suncor Project Millennium Emissions

Source	Emission [t/cd]					
	SO_2	NO_x	CO	PM[(a)]	VOC	TRS
Project Millennium						
Powerhouse stack	14.0	2.9	**1.67**	0.2	0.008	n/a
FGD stack	18.7	29.7	**0.69**	**2.6**	0.2	n/a
Millennium mine boilers / GTGs [(c)]	1.1	4.1	0.3	0.1	0.01	-
Sulphur incinerator	12.3	0.064	3.4	0.038	0.06	n/a
Tail gas treatment unit	8.7	0.029	3.8	0.04	0.2	n/a
Upgrading furnace stacks	4.7	3.8	1.4	0.5	**0.06**	-
Flaring - continuous and acid gas	10.6	0.191	0.2	0.01	0.041	0.011
Mine fleet	0.08	26.9	1.4	0.3	0.8	-
Fixed Plant Fugitive	-	-	-	-	**23.3**	**0.15**
Tailings ponds	-	-	-	-	200.2	2.4
Mine surface[(b)]	-	-	-	-	15.3	**0.05**
Total	**70.2**	**67.7**	**12.9**	**3.8**	**233**	**2.7**

n/a data not available
\- not a source of this emission
(a) Assumed as PM_{10}.
(b) Estimated based on Syncrude data.
(c) Gas turbine generators.

Note: The updated values in the above table represent the latest estimates of emissions as detailed in Technical Reference for Meteorology, Emissions and Ambient Air Quality in the Athabasca Oil Sands Region (Golder and Conor Pacific 1998). The dispersion modelling results presented in the figures were based on the original emission estimates (as tabulated at the bottom of each figure). All of the original estimates, save for PM, were higher than the latest estimates. Previous model results can be therefore considered conservative. PM has recently been remodeled using these higher estimates.

SO_2 Sources

Project Millennium will result in very little change to overall SO_2 emissions when compared to the baseline conditions. As indicated in Table B3-1, the new total SO_2 emission rate is projected to be 70.2 t/cd. The major sources of SO_2 emissions to the atmosphere are the Powerhouse stack, the FDG stack, the incinerator and the continuous flare stacks.

Improved equipment, technology and operating procedures have resulted in this essentially no increase strategy. The existing sulphur plant achieves

98% recovery and the Project Millennium Upgrader sulphur plant is designed to achieve 99.7% recovery. There will be no new continuous flaring sources in the Project Millennium Upgrader. Continuous flare gas from the base plant will be recompressed for treatment and used in upgrading as part of Suncor's flare gas recovery project and will be completed in 1999 prior to Project Millennium start up.

NO_x Sources

The proposed project will result in approximately a 40 percent increase in total NO_x emissions from the baseline conditions of 47.7 t/cd to Project Millennium levels of 67.7 t/cd. The majority of the increase comes from the expansion of the mine fleet (75% of the increase) and, to a lesser degree, from the new Millennium Mine Boilers and Gas Turbine Generators. The calculation of NO_x emissions was based on a combination of emissions supplied by equipment designers and U.S. EPA emission factors.

Project Millennium will utilize the best technologies available considering capital costs, operating costs, fuel efficiency and emission performance. Suncor will initiate discussions with mining equipment suppliers to make low NO_x a priority in their design. With Millennium, Suncor expects to produce diesel with a higher cetane number than currently produced diesel. This is expected to have favourable impacts on mine vehicle fleet emissions.

CO Sources

The proposed project will result in approximately a 15% increase of the CO emissions from the baseline conditions of 33.5 t/cd to Project Millennium emissions of 38.6 t/cd. CO emissions are smaller when compared to the NO_x or SO_2 emissions. The major source of CO emissions to the atmosphere is the FGD stack.

Particulate Matter (PM_{10}) Sources

Project Millennium will result in about a 25% increase in PM emissions to the atmosphere. The major source of PM emissions will continue to be the FGD stack. PM controls on this unit include an electrostatic precipitator, that removes 98% of the particulate matter, and an additional 85% of the remainder is removed by the FGD wet scrubbing process.

VOC Sources

Project Millennium will result in approximately a 85% increase in total VOC emissions from the baseline conditions of 130.2 t/cd to emissions of 240.4 t/cd. The major source of VOC emissions to the atmosphere are the fugitive emissions generated from the tailings ponds. This source represents about 80% of the VOC emissions for Project Millennium. These emission rates are based on recent field data collection surveys completed by Suncor and a reinterpretation of historical results. The emission estimate provide for Project Millennium is based on this new data and is considered to be an upper limit or worst case estimate. Thus, the EIA has taken a conservative approach.

TRS Sources

Project Millennium will result in an approximately 80% increase in emission rates of TRS. The total emissions will increase from the baseline case of 1.523 t/cd to 2.73 t/cd. Similar to VOC emissions, the tailings ponds are the largest source of TRS from Project Millennium and represent about 90% of the emissions. TRS emissions from pond 2/3 have been assumed to scale with production levels from Baseline production levels. This likely over-estimates TRS emissions since TRS is believed to be a biogenic emission.

Greenhouse Gases

Greenhouse gases (GHG) include emissions of carbon dioxide (CO_2), methane (as equivalent CO_2) and NO_x (as equivalent CO_2). Overall GHG emissions for Project Millennium are estimated at 20,643 CO_2 eq t/cd. The majority, over 95%, is generated by direct emissions of CO_2.

B3.1.1.2 Syncrude Sources

The baseline section of this report (Section B2.1.1.2) summarizes the emissions from Syncrude. No additional sources of air emissions from Syncrude were considered in the Project Millennium impact assessment.

B3.1.1.3 Other Approved Development Industrial Sources

Air emissions from other approved developments were considered in the baseline section of this report (Section 2.1.13). No additional sources have been added to the Project Millennium case.

B3.1.1.4 Transportation and Residential Sources

No changes were made to the emission estimates from these sources as outlined in Section 2.1.1.4.

B3.1.1.5 Summary

The summary of the air emissions from Project Millennium, Syncrude, other industries, transportation and residential sources are included in Table B3-2.

Table B3-2 Summary of Project Millennium Emissions in the Athabasca Oil Sands Region

	Emission Rates (t/cd)					
	SO_2	NO_X	CO	PM_C	VOC	TRS
Suncor	70.2	67.7	**12.9**	**3.8**	**233**	2.7
Syncrude	209.0	44.4	**53.6**	5.4	**39.4**	2.3
Other Industries	3.9	8.7	27.1	0.9	**4.9**	**0.01**
Transportation and Residential	0.2	1.37	6.5	1.5	2.95	n/d
Total	**283.3**	**122.2**	**100**	**11.6**	**280**	**5.0**

n/d no data

Note: The updated values in the above table represent the latest estimates of emissions as detailed in Technical Reference for Meteorology, Emissions and Ambient Air Quality in the Athabasca Oil Sands Region (Golder and Conor Pacific 1998). The dispersion modelling results presented in the figures were based on the original emission estimates (as tabulated at the bottom of each figure). All of the original estimates, save for PM, were higher than the latest estimates. Previous model results can be therefore considered conservative. PM has recently been remodeled using these higher estimates.

B3.2 DISPERSION MODEL PREDICTIONS

B3.2.1 Model Approach and Limitations

Descriptions of the models used to determine the predicted ground level concentrations were discussed in Section B2.2.1. In assessing the results of Project Millennium the same models were used, in particular the ISC3BE and CALPUFF.

B3.2.2 SO_2 Predicted Concentrations

There are numerous SO_2 emission sources associated with the Project as summarized in Section B3.1.1 (Tables B3-1 and B3-2). The estimated total SO_2 emission rate in the oil sands region including the Project is 283.3 t/cd. Suncor will emit an estimated 25% (70.2 t/cd) of the total SO_2 emissions to the atmosphere (Table B3-2). The major sources of SO_2 at Suncor will be the FGD stack (18.7 t/cd), the Powerhouse stack (14.0 t/cd), the Sulphur Incinerator stack (12.3 t/cd) and continuous flaring (10.6 t/cd).

The predicted maximum hourly, daily and annual ground level ambient SO_2 concentrations resulting from emissions of Project Millennium and all approved industrial sources and residential emissions in the oil sands region were estimated using ISC3BE and CALPUFF models. Emission rates used were the calendar day (cd) for annual GLC predictions and stream day (sd) for hourly and daily GLC predictions. Four years of observed meteorological measurements from the Suncor Mannix station (75 m level) were used in the modelling. These models provide an efficient means of estimating the predicted ambient SO_2 concentrations from all sources and provides an indication where maximum concentrations could occur.

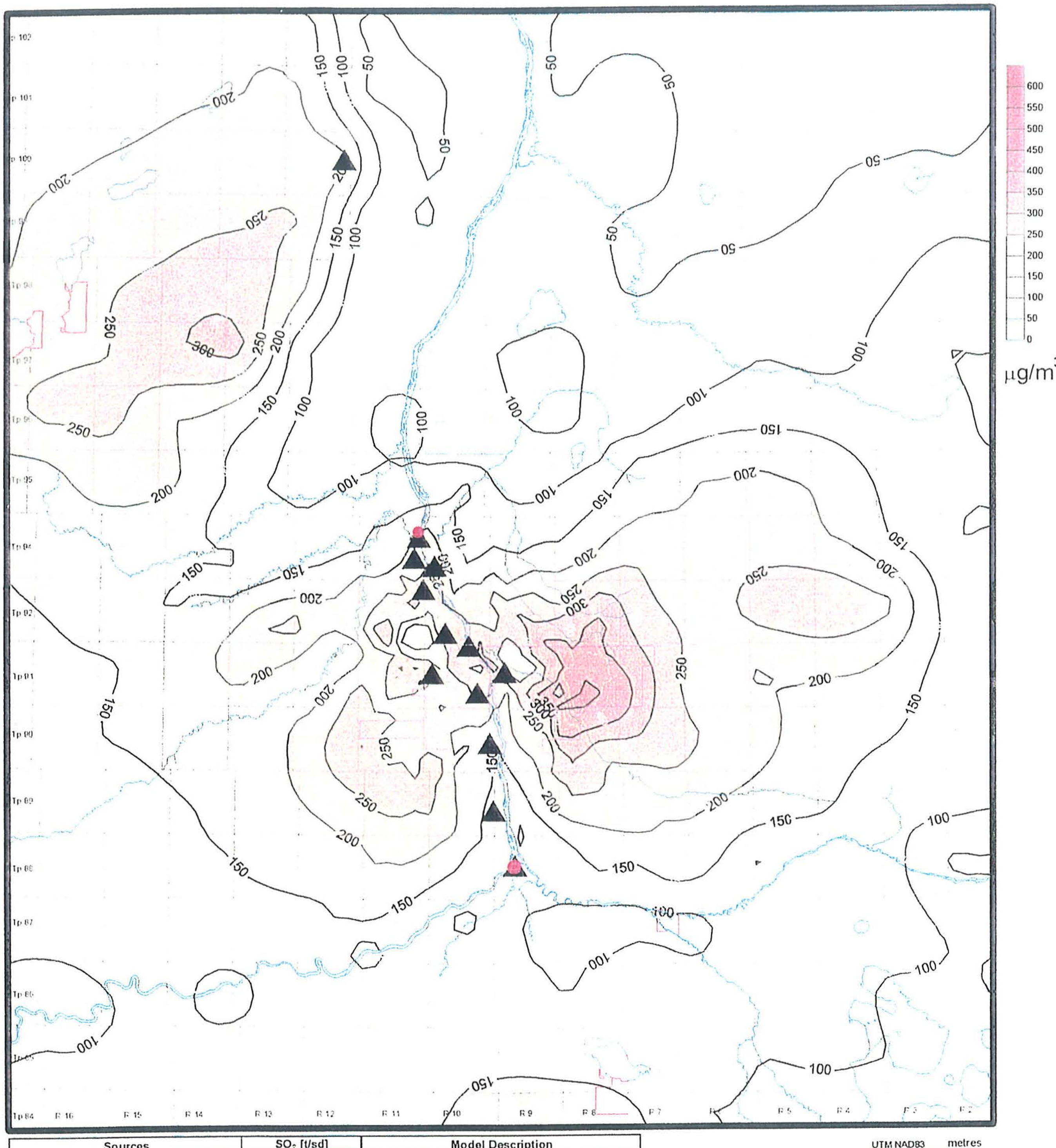
Table B3-3 Maximum Predicted Ground Level Concentrations of SO_2 for Project Millennium Sources

Source	Hourly[d]	Daily[d]	Annual
Project Millennium - ISC3BE[b]			
Maximum SO_2 Concentration (μg/m^3)	870	200	82
Location of Maximum Concentration (km)	4 S	2 SSW	15 WNW
Maximum Number of Exceedances[a]	49	9	1
Location of Maximum Exceedances (km)	2 S	16 WNW	n/a
Project Millennium - CALPUFF[c]			
Maximum SO_2 Concentration (μg/m^3)	n/a	n/a	80
Location of Maximum Concentration (km)	n/a	n/a	15 WNW
Maximum Number of Exceedances[a]	n/a	n/a	1
Location of Maximum Exceedances (km)	n/a	n/a	n/a
SO_2, Alberta Guideline (μg/m^3)	450	150	30
SO_2, Federal Acceptable (μg/m^3)	900	300	60

n/a = data not available
(a) Exceeds SO_2 Alberta Guideline. Normalized for a 12-month period.
(b) Based on Stream day emission rates for hourly and daily; Calendar day for annual.
(c) Based on Calendar day emission rates.
(d) Based on a single year of meteorological variation.

The modelling predictions for daily SO_2 emission rate cases are summarized in Table B3-3 for each model. The predicted ground level concentrations are mapped in Figures B3-2 to B3-5 and described below:

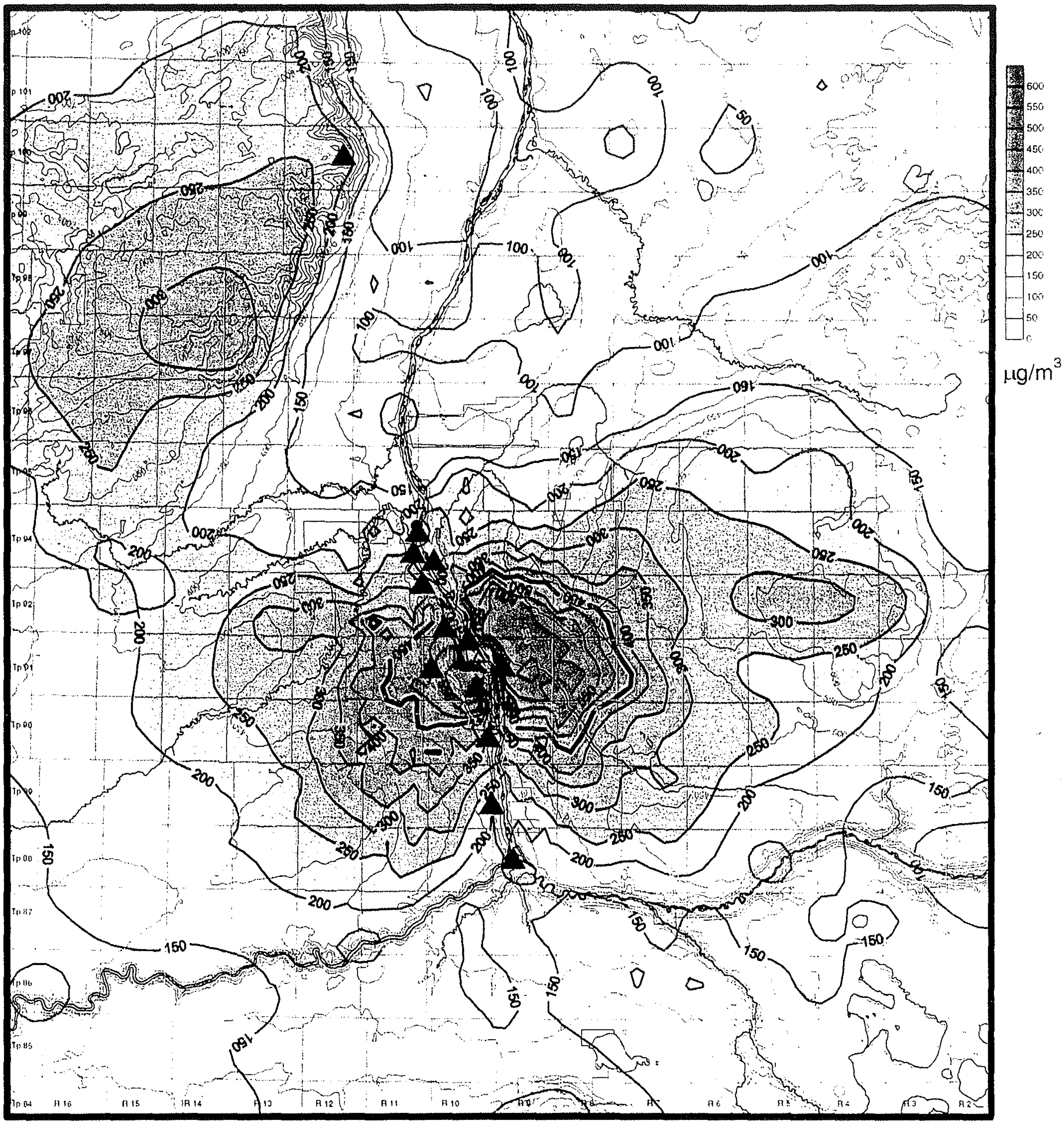
- Figure B3-2 shows the maximum hourly average ground level SO_2 concentrations associated with Project Millennium for the ISC3BE model. An overall maximum hourly average SO_2 concentration, as determined by ISC3BE, of 870 μg/m^3 is predicted to occur at a location 4 km south of Suncor within the facility boundary (Figure B3-2). This maximum average value exceeds the Alberta guideline of 450 μg/m^3. This model predicts two areas that result in maximum hourly averages in excess of the guideline. The areas are south and east of Suncor and include a total of 58,860 ha of land. Approximately 70% of this area is within Suncor's lease areas. The ISC3BE model predicts a maximum of 49 yearly exceedances of the hourly guideline.
- Figure B3-3 shows the maximum daily average ground level SO_2 concentrations associated with the Project Millennium for the ISC3BE model. The overall maximum daily average SO_2 concentration, as determined by ISC3BE, of 200 μg/m^3 is predicted to occur within the existing Suncor lease boundary. This maximum average value exceeds the daily Alberta guideline of 150 μg/m^3. The predictions shown in Figure B3-3 indicate a small area of 289 ha that will have a maximum



Sources	SO_2 [t/sd]
Suncor	
Powerhouse	1.2
FGD	19.7
Incinerator	10.2
Flaring	1.3
Tail Gas Treatment Unit	5.2
Other Sources, Suncor	0.08
Syncrude (total)	209
Other Emissions (total)	4
TOTAL	250.7

Model Description	
Development	Project Millennium
Model	ISC3BE (7BG)
SO_2 Guideline [$\mu g/m^3$]	450
Maximum [$\mu g/m^3$]	421
Exceedences / Year [#]	0

Figure B3-2x Predicted Millennium SO_2 Maximum Hourly Average Ground Level Concentrations in the RSA using the ISCBE Model. With no mercaptans in fuel gas.



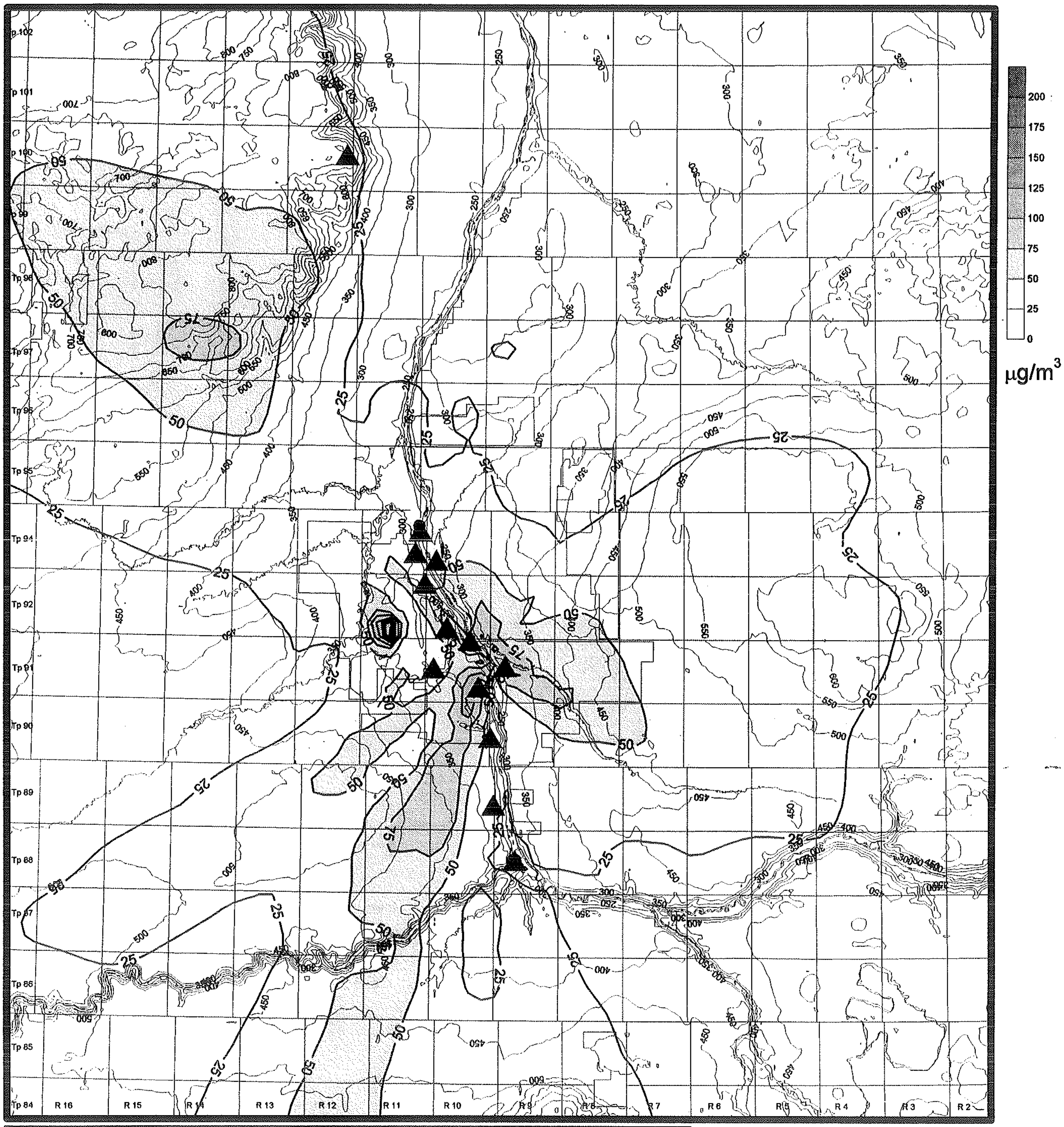
Sources	SO_2 [t/ed]
Suncor	
Powerhouse	1.2
FGD	19.7
Incinerator	10.2
Flaring	1.3
Tail Gas Treatment Unit	5.2
Other Sources, Suncor	6.2
Syncrude (total)	209
Other Emissions (total)	4.1
TOTAL	256.9

Model Description	
Development	Project Millennium
Model	ISC3BE (7BG)
SO_2 Guideline [µg/m³]	450
Maximum [µg/m³]	870
Exceedences / Year [#]	49

Note Results are base on a 1 year simulation

UTM NAD83 metres
0 5000 10000 15000 20000

Figure B3-2 Predicted Millennium SO_2 Maximum Hourly Average Ground Level Concentrations in the RSA using the ISCBE Model



Sources	SO₂ [t/sd]
Suncor	
Powerhouse	1.2
FGD	19.7
Incinerator	10.2
Flaring	1.3
Tail Gas Treatment Unit	5.2
Other Sources, Suncor	5.9
Syncrude (total)	209
Other Emissions (total)	4
TOTAL	256.5

Model Description	
Development	Project Millennium
Model	ISC3BE (7BG)
SO_2 Guideline [$\mu g/m^3$]	150
Maximum [$\mu g/m^3$]	199
Exceedences / Year [#]	6

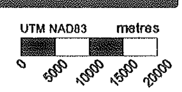


Figure B3-3 Predicted Millennium SO_2 Maximum Daily Average Ground Level Concentrations in the RSA using the ISCBE Model

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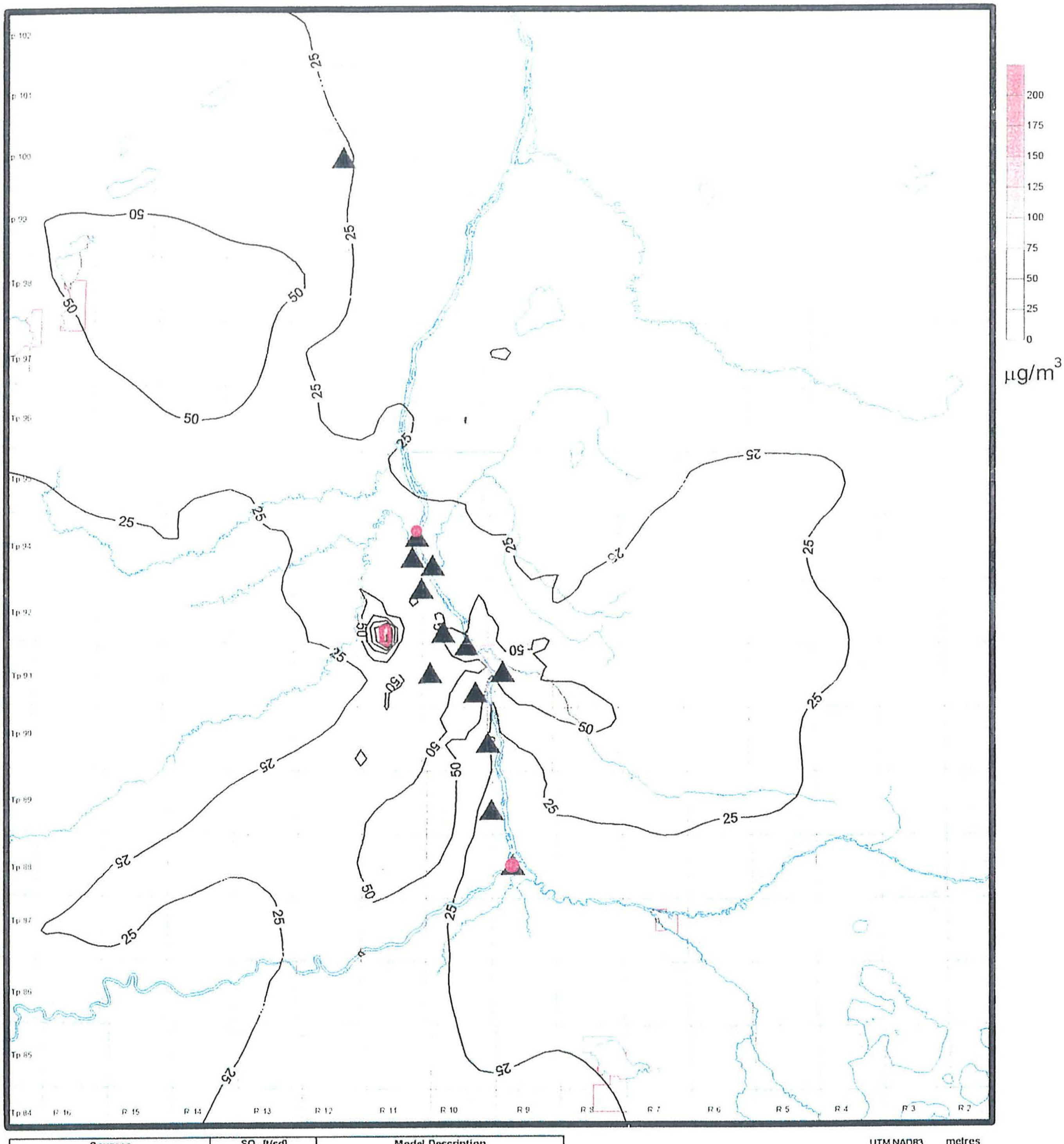
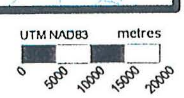




Sources	SO_2 [t/sd]
Suncor	
Powerhouse	1.2
FGD	19.7
Incinerator	10.2
Flaring	1.3
Tail Gas Treatment Unit	5.2
Other Sources, Suncor	0.08
Syncrude (total)	209
Other Emissions (total)	4
TOTAL	250.7

Model Description	
Development	Project Millennium
Model	ISC3BE (7BG)
SO_2 Guideline [µg/m³]	150
Maximum [µg/m³]	198
Exceedences / Year [#]	6

Figure B3-3x Predicted Millennium SO_2 Maximum Daily Average Ground Level Concentrations in the RSA using the ISCBE Model With no mercaptans in the fuel gas.

average in excess of the Guideline. The model predicts a maximum of 9 yearly exceedances of the guideline.

- Figures B3-4 and B3-5 show the annual average ground level concentration map for SO_2 for the ISC3BE model and CALPUFF model, respectively. The maximum annual average concentration, as determined by ISC3BE, is 82 $\mu g/m^3$ located in the current development area and covers an area of approximately 409 ha. The predicted concentrations are in excess of the annual Alberta guideline of 30 $\mu g/m^3$, with a predicted frequency of once per year.

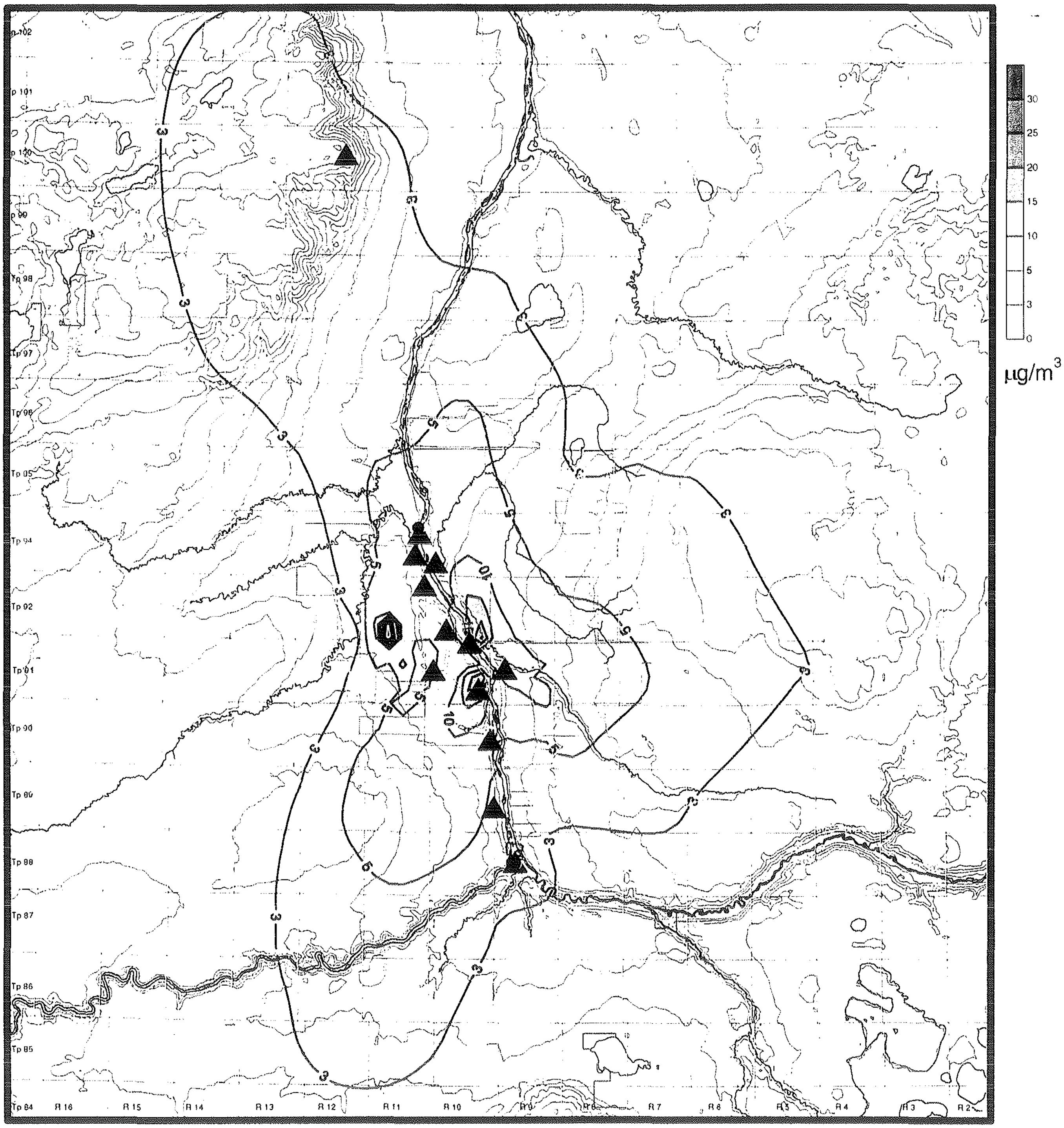
The ISC3BE modelling predictions indicate that the location and areal extent of the maximum hourly and daily SO_2 concentrations will tend to occur close to the existing operations and be are expected to be within the lease boundaries. The maximum annual averages will occur WNW of Suncor. Comparing this analysis to the Federal acceptable hourly and daily standards indicates no predicted exceedances. However, there would remain an exceedance of the Federal annual standard.

When a historical assessment approach is taken by considering only the major stack sources (i.e., Suncor FGD, Incinerator, Continuous flaring, new tail gas treatment unit and Syncrude main stack), the maximum hourly average GLC is predicted to be 503 μ/m^3. The predicted frequency of exceeding the AAAQG based on one year of meteorological variation is 6 times per year. These are the only sources of SO_2 that were included in previous assessments.

B3.2.3 NO_2 Predicted Concentrations

There are numerous NO_x emission sources associated with the Project as summarized in Section B3.1 (Table B3-1). The estimated total NO_x emission rate in the oil sands region including Project Millennium will be 122.2 t/cd (Table B3-2). Suncor will emit an estimated total of 67.7 t/cd which is approximately 55% of the total (Table B3-2). The major sources of NO_x at Suncor are the FGD stack (29.7 t/cd) and the mine fleet (26.9 t/cd).

The predicted maximum hourly, daily and annual ground level ambient NO_x concentrations resulting from emissions of Project Millennium and all approved industrial sources and residential emissions in the oil sands region were estimated using the ISC3BE and CALPUFF models. Four years of observed meteorological measurements from the Suncor Mannix station (75 m level) were used in the modelling. These models provide an efficient means of estimating the predicted ambient NO_x or NO_2 concentrations from all sources and provide an indication of where maximum concentrations could occur. The conversion of predicted NO_x to NO_2 has been estimated for ISC3BE results using the methodology described in Section B2.2.3.



Sources	SO_2 [t/cd]
Suncor	
Powerhouse	14
FGD	18.7
Incinerator	12.3
Flaring	10.6
Tail Gas Treatment Unit	6.4
Other Sources, Suncor	5.9
Syncrude (total)	209
Other Emissions (total)	4.1
TOTAL	281

Model Description	
Development	Project Millennium
Model	ISC3BE (7BG)
SO_2 Guideline [µg/m^3]	30
Maximum [µg/m^3]	82
Exceedances / Year [#]	1

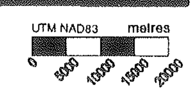


Figure B3-4 Predicted Millennium SO_2 Annual Average Ground Level Concentrations in the RSA using the ISCBE Model

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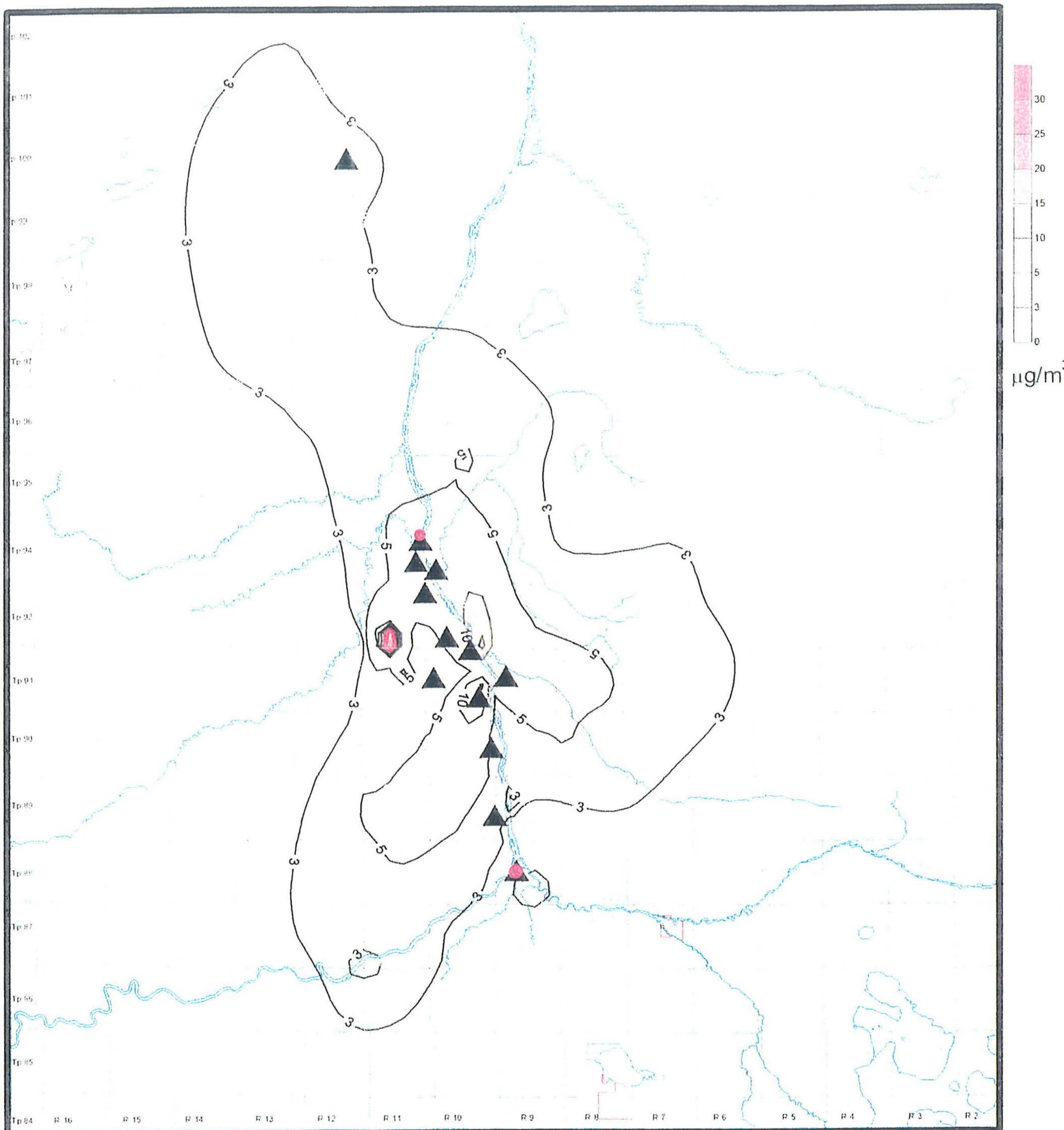

Sources	SO_2 [t/cd]
Suncor	
Powerhouse	14
FGD	18.7
Incinerator	12.3
Flaring	10.6
Tail Gas Treatment Unit	8.7
Other Sources, Suncor	0.08
Syncrude (total)	209
Other Emissions (total)	4
TOTAL	277

Model Description	
Development	Project Millennium
Model	ISC3BE (7BG)
SO_2 Guideline [µg/m³]	30
Maximum [µg/m³]	74
Exceedences / Year [#]	1

Figure B3-4x Predicted Millennium SO_2 Annual Average Ground Level Concentrations in the RSA using the ISCBE Model. With no mercaptans in fuel gas.

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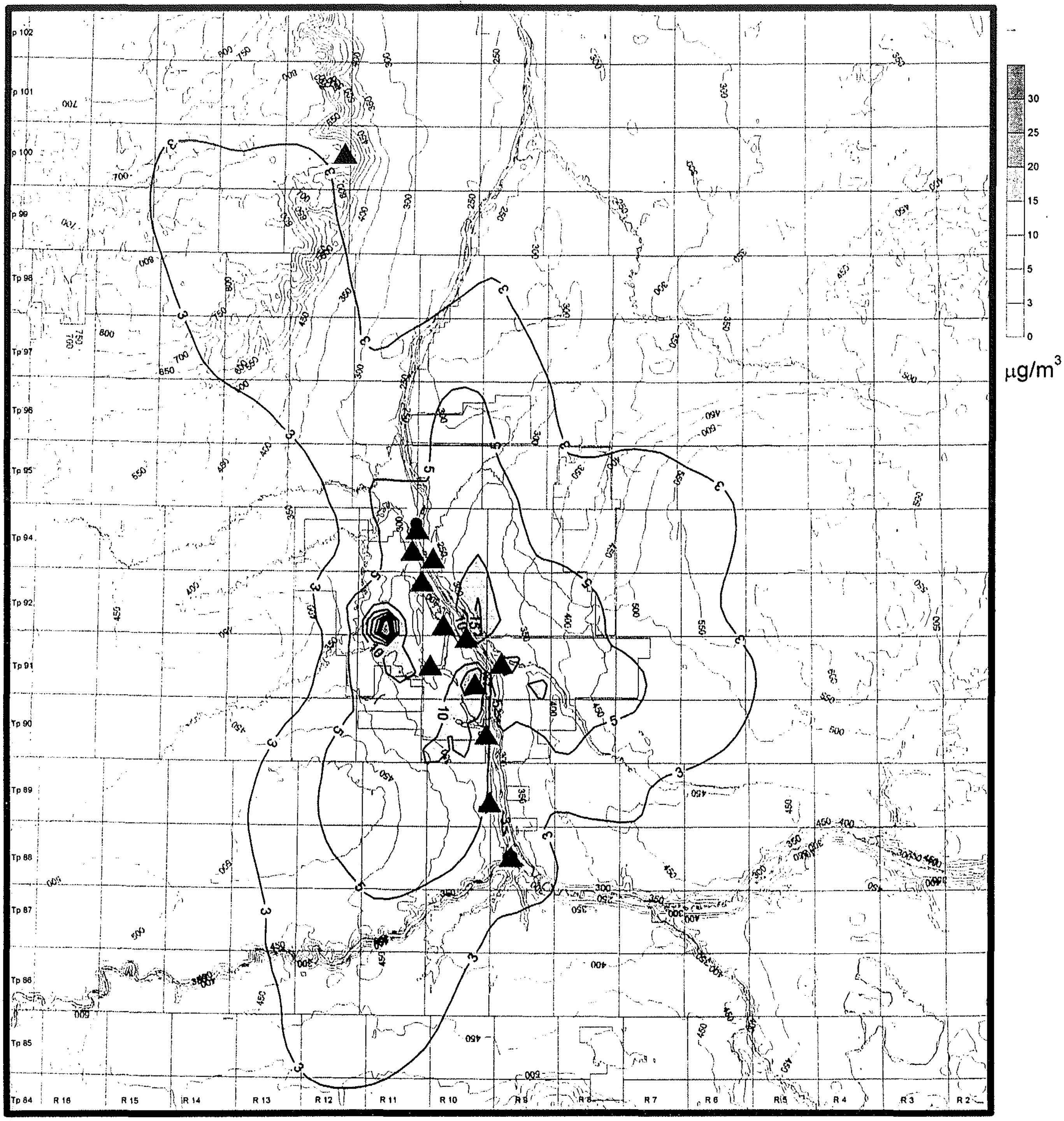
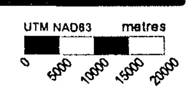




Sources	SO_2 [t/cd]
Suncor	
Powerhouse	14
FGD	18.7
Incinerator	12.3
Flaring	10.6
Tail Gas Treatment Unit	6.4
Other Sources, Suncor	5.9
Syncrude (total)	209
Other Emissions (total)	4.1
TOTAL	281

Model Description	
Development	Project Millennium
Model	CALPUFF
SO_2 Guideline [µg/m³]	30
Maximum [µg/m³]	80
Exceedences / Year [#]	1

Figure B3-5 Predicted Millennium SO_2 Maximum Annual Average Ground Level Concentrations in the RSA using the CALPUFF Model

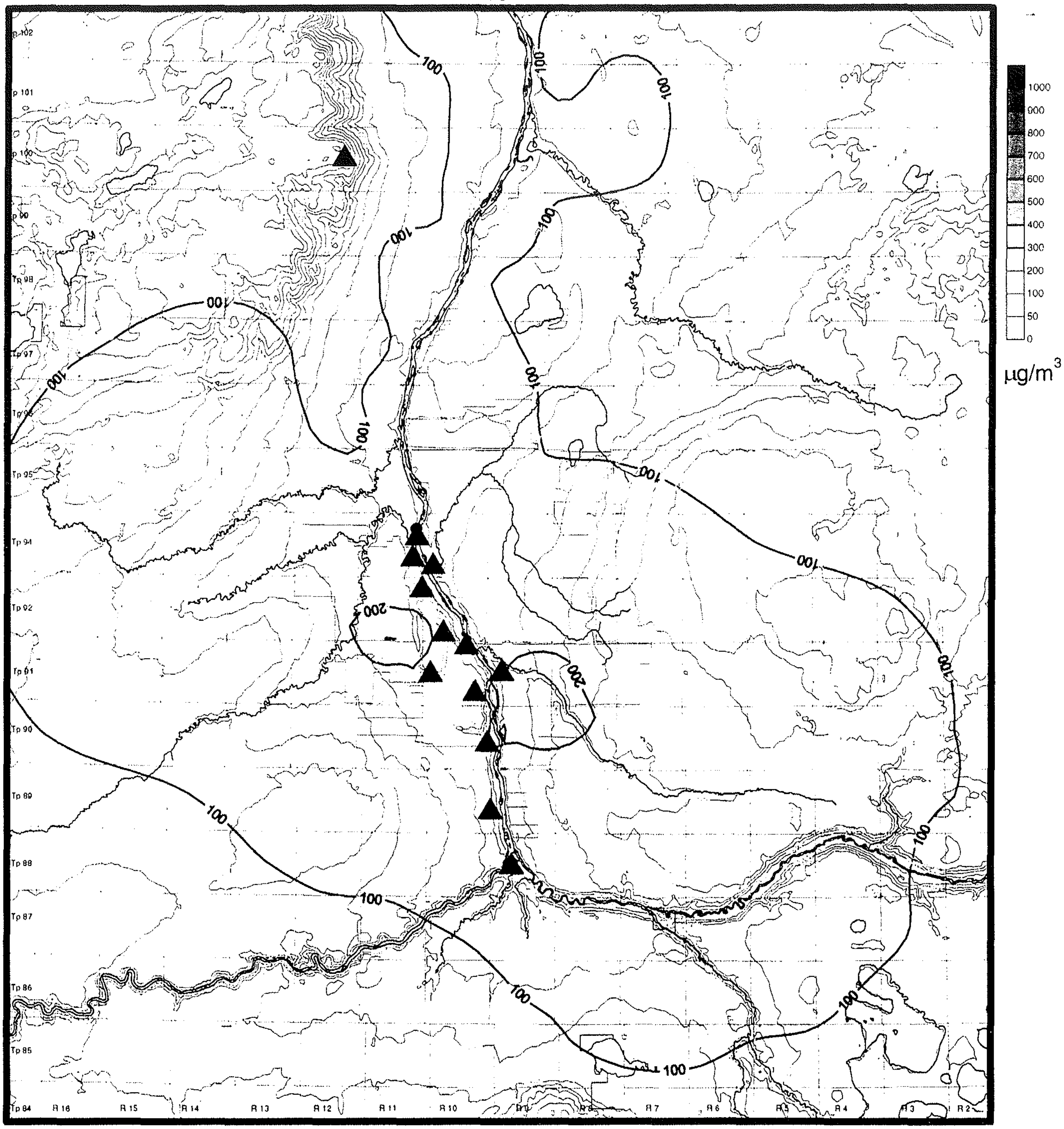
Table B3-4 Maximum Predicted Ground Level Concentrations of NO_x and NO_2 for Project Millennium Sources

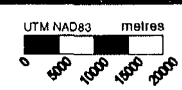
Source	Hourly	Daily	Annual
Project Millennium - ISC3BE(b)			
Maximum NO_x concentration ($\mu g/m^3$)	7288	4287	1282
Maximum NO_2 concentration ($\mu g/m^3$)	320	260	162
Location of maximum concentration (km)	14 WNW	14 WNW	11 ESE
Maximum number of exceedances(a)	0	101	1
Location of maximum exceedances (km)	0	n/a	n/a
Project Millennium CALPUFF(c)			
Maximum NO_2 concentration ($\mu g/m^3$)	1812	708	316
Location from Suncor incinerator stack (km)	11 ESE	11 ESE	11 ESE
Maximum number of exceedances(a)	936	103	1
Location of maximum exceedances (km)	11 ESE	11 ESE	n/a
NO_2, Alberta Guideline ($\mu g/m^3$)	400	200	60
NO_2, Federal Acceptable ($\mu g/m^3$)	400	200	100

(a) Exceeds NO_2 Alberta Guideline. Normalized for a 12-month period.
(b) Based on Stream day emission rates for hourly and daily; Calendar day for annual.
(c) Based on Calendar day emission rates.

The modelling predictions are summarized in Table B3-4 and predicted ground level concentrations are mapped in the figures described below:

- Figures B3-6 and B3-7 show the maximum hourly average ground level NO_2 concentrations associated with Project Millennium for the ISC3BE and CALPUFF models respectively. An overall maximum hourly average NO_2 concentration, as determined by ISC3BE, of 320 $\mu g/m^3$ is predicted to occur at a location 14 km WNW of Suncor (Figure B3-6). This maximum concentration is less than the Alberta Guideline of 400 μg/m3 for ambient hourly average NO_2 concentrations. Corresponding values for the CALPUFF model indicate an overall maximum hourly average NO_2 concentration of 1812 $\mu g/m^3$, at a location 11 km ESE of Suncor in the Suncor East Bank mining area (Figure B3-7). This maximum average value is much higher than the hourly NO_2 guideline of 400 $\mu g/m^3$. This model predicts a total of 114,543 ha may have maximum concentration in excess of the guideline and that a maximum of 936 exceedances may occur.
- Figures B3-8 and B3-9 show the maximum daily average ground level NO_2 concentrations associated with Project Millennium for the ISC3BE and CALPUFF models. An overall maximum daily average NO_2 concentration, as determined by ISC3BE, of 260 $\mu g/m^3$ is predicted to occur in the same vicinity as the maximum hourly concentration. This maximum average value exceeds the daily Alberta Guideline of 200 $\mu g/m^3$.

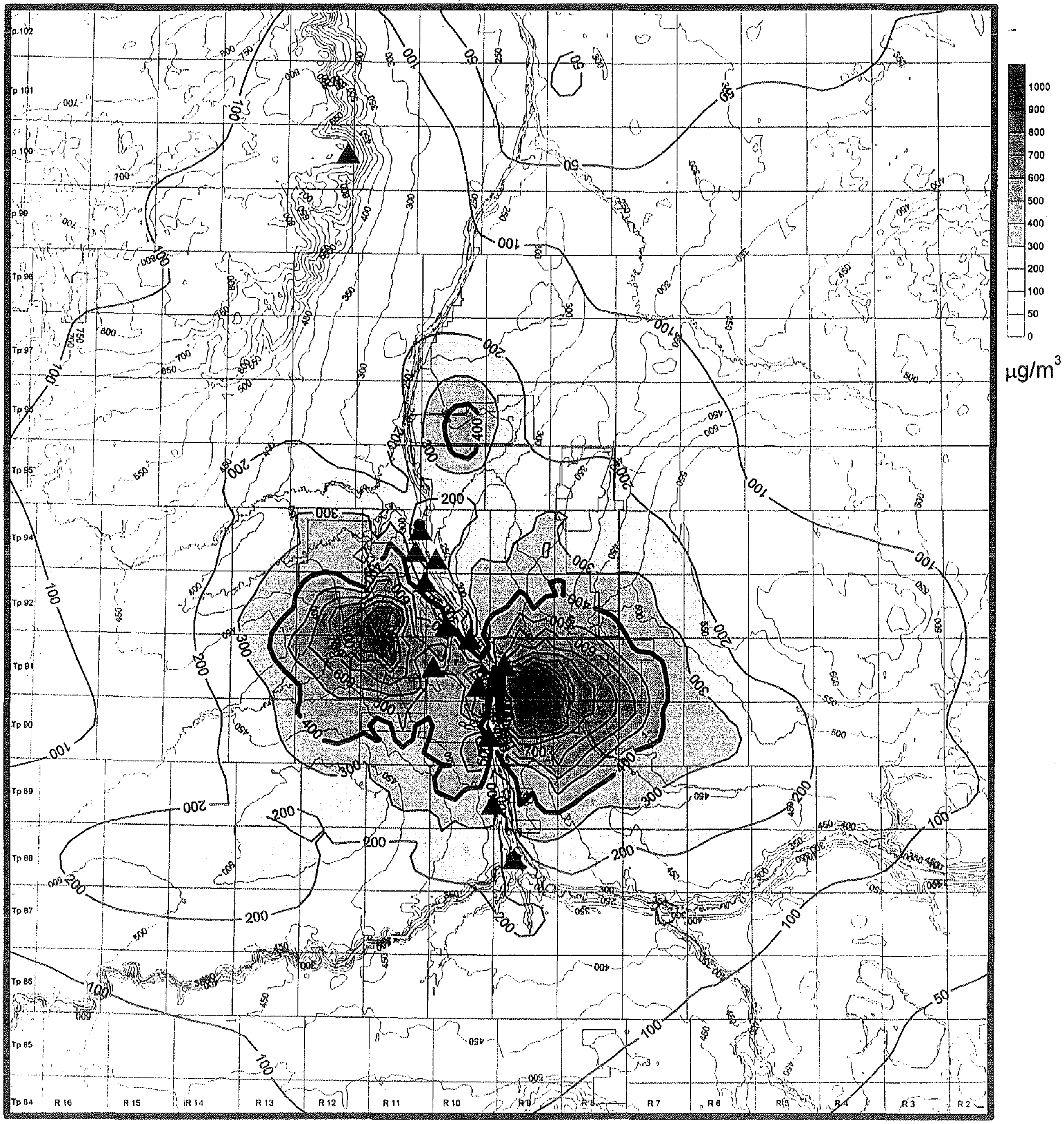




Sources	NO_2 [t/sd]
Suncor	
Powerhouse	3.5
FGD	32
Incinerator	0.07
Flaring	0.03
Tail Gas Treatment Unit	0.03
Other Sources, Suncor	34.8
Syncrude (total)	44.4
Other Emissions (total)	10.1
TOTAL	124.93

Model Description	
Development	Project Millennium
Model	ISC3BE (7BG)
NO_2 Guideline [µg/m³]	400
Maximum [µg/m³]	320
Exceedences / Year [#]	0

Figure B3-6 Predicted Millennium NO_2 Maximum Hourly Average Ground-Level Concentrations in the RSA using the ISC3BE Model

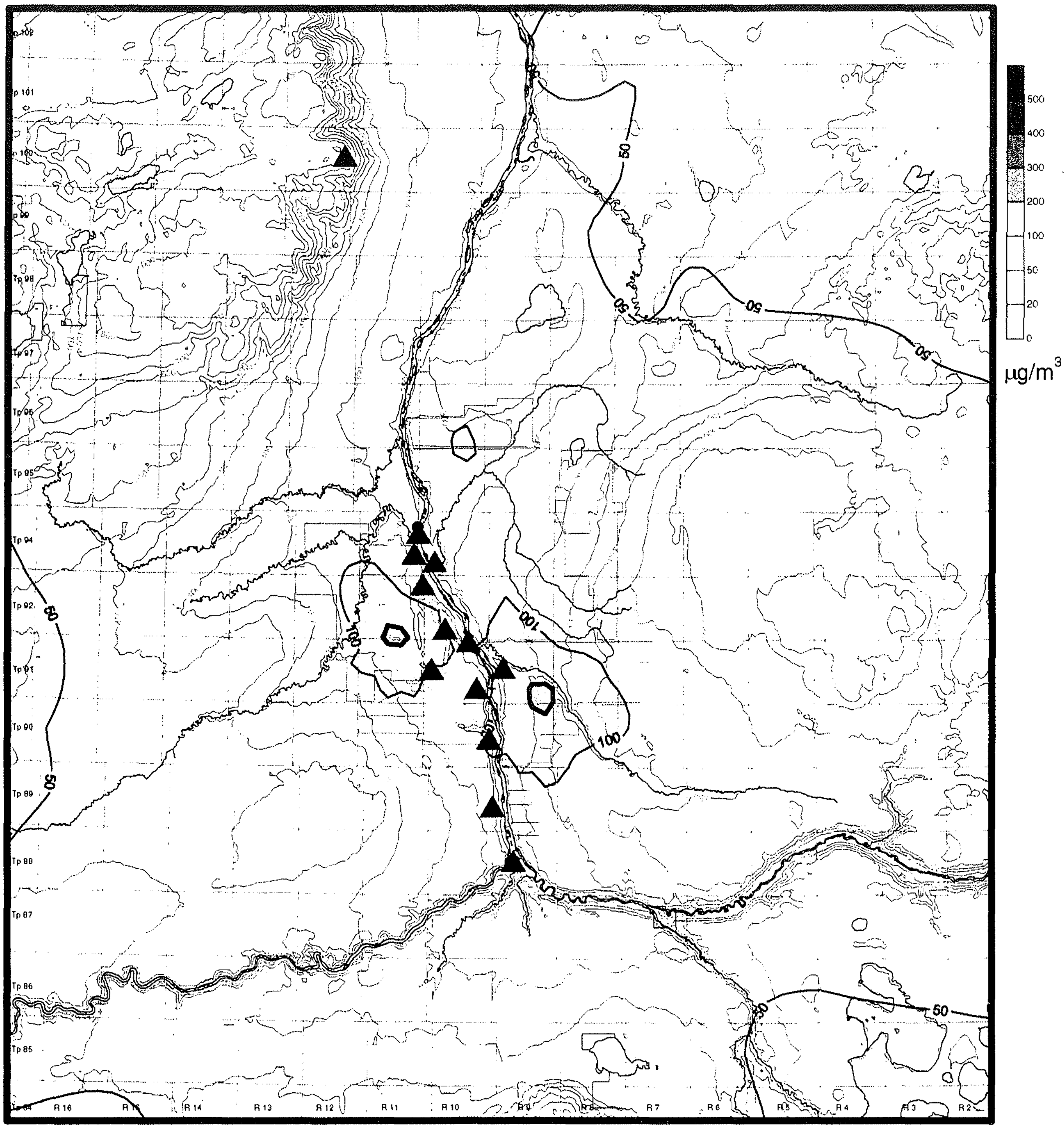


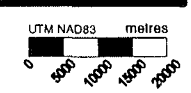
UTM NAD83 metres
0 5000 10000 15000 20000

Sources	NO_x [t/cd]
Suncor	
Powerhouse	3.5
FGD	32
Incinerator	0.07
Flaring	0.03
Tail Gas Treatment Unit	0.03
Other Sources, Suncor	35
Syncrude (total)	44.4
Other Emissions (total)	10.1
TOTAL	125.13

Model Description	
Development	Project Millennium
Model	CALPUFF
NO_2 Guideline [µg/m³]	400
Maximum [µg/m³]	1612
Exceedences / Year [#]	936

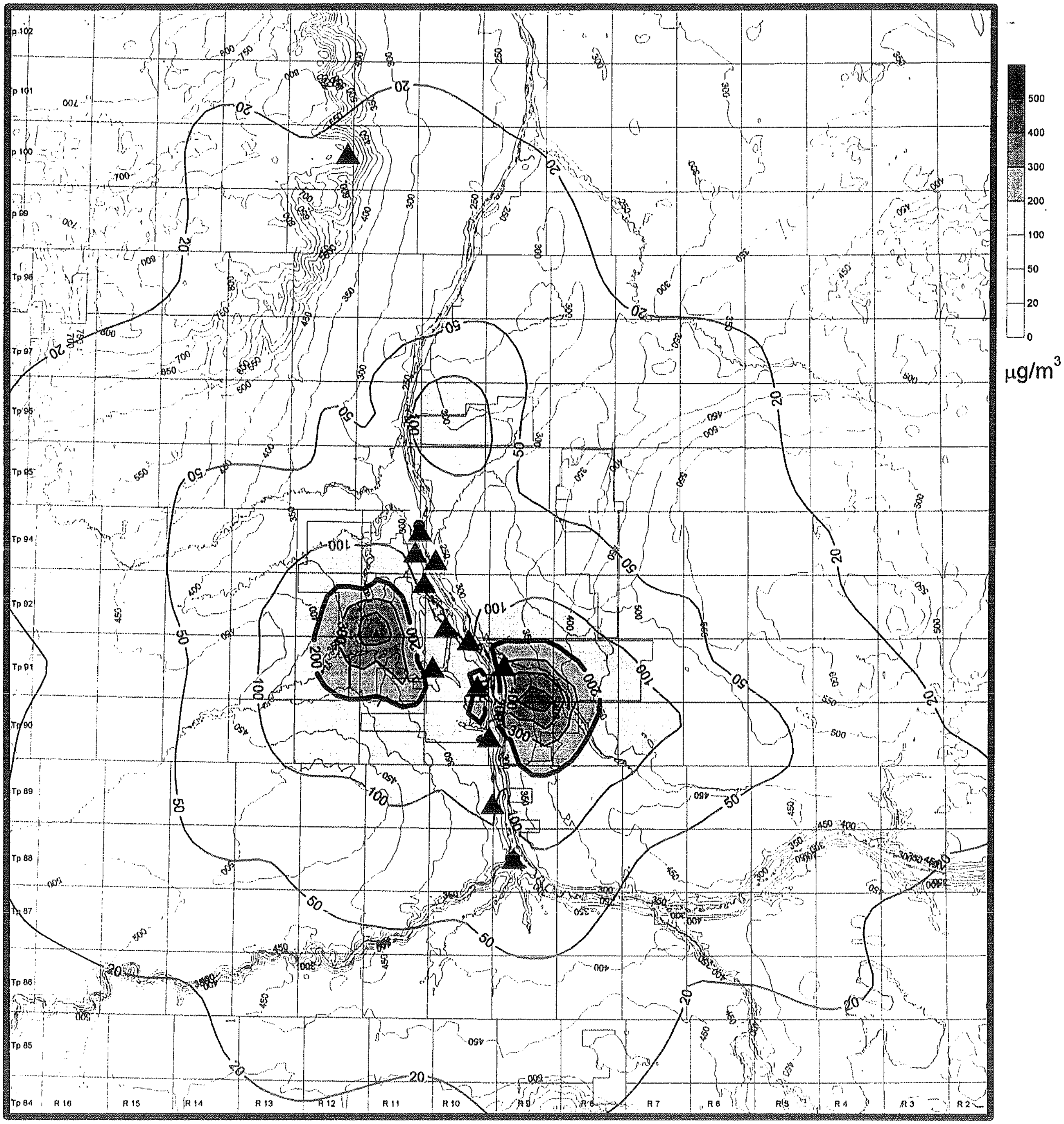
Figure B3-7 Predicted Millennium NO_2 Maximum Hourly Average Ground Level Concentrations in the RSA using the CALPUFF Model





Sources	NO_2 [t/sd]	Model Description	
Suncor		**Development**	Project Millennium
Powerhouse	3.5	**Model**	ISC3BE (7BG)
FGD	32	**NO_2 Guideline [μg/m³]**	200
Incinerator	0.07	**Maximum [μg/m³]**	260
Flaring	0.03	**Exceedences / Year [#]**	101
Tail Gas Treatment Unit	0.03		
Other Sources, Suncor	34.8		
Syncrude (total)	44.4		
Other Emissions (total)	10.1		
TOTAL	124.93		

Figure B3-8 Predicted Millennium NO_2 Maximum Daily Average Ground Level Concentrations in the RSA using the ISC3BE Model



Sources	NO_x [t/cd]
Suncor	
Powerhouse	3.5
FGD	32
Incinerator	0.07
Flaring	0.03
Tail Gas Treatment Unit	0.03
Other Sources, Suncor	35
Syncrude (total)	44.4
Other Emissions (total)	10.1
TOTAL	125.13

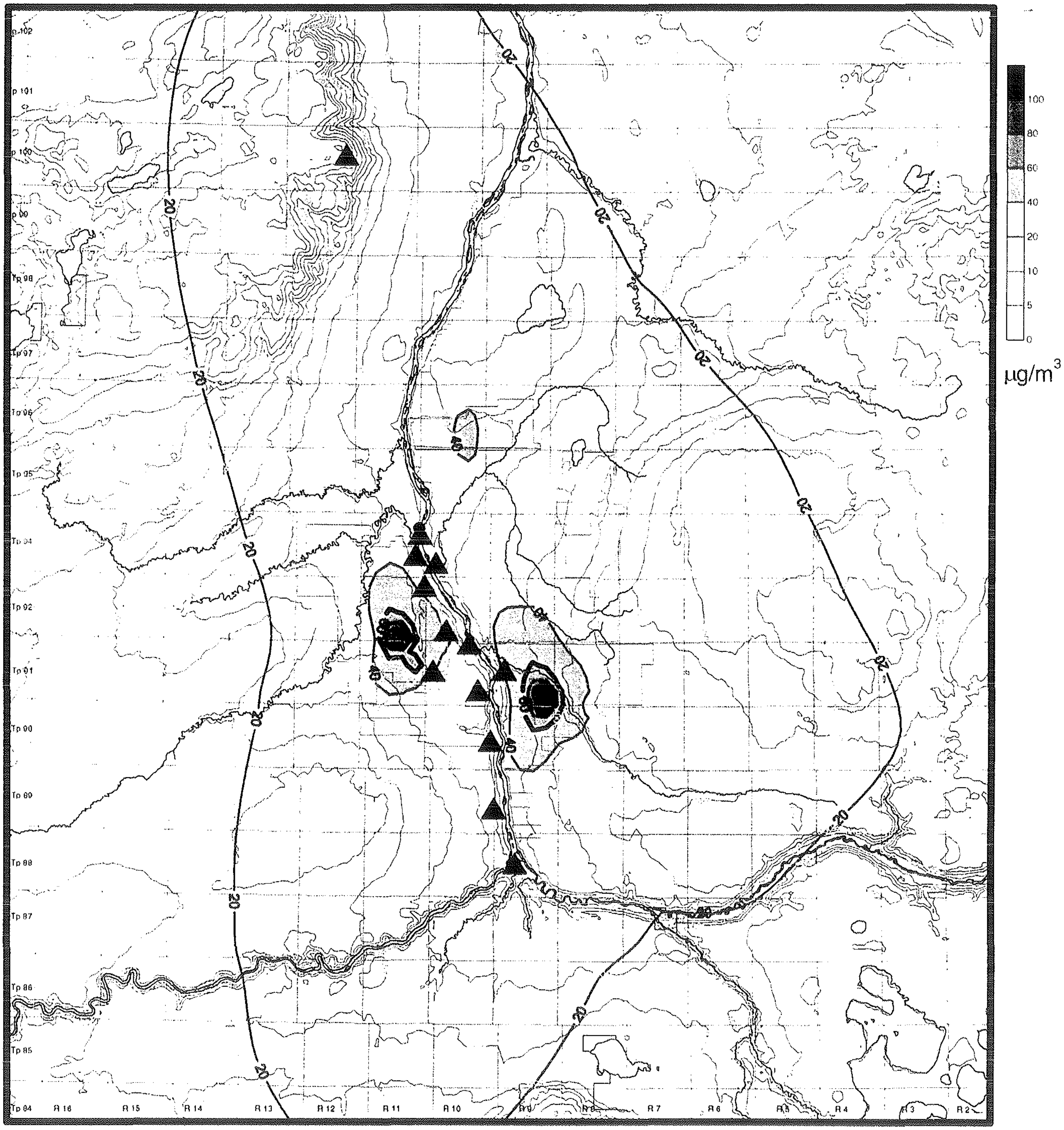
Model Description	
Development	Project Millennium
Model	ISC3BE (7BG)
NO_2 Guideline [µg/m³]	200
Maximum [µg/m³]	708
Exceedances / Year [#]	103

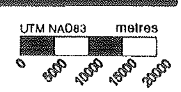
Figure B3-9 Predicted Millennium NO_2 Maximum Daily Average Ground Level Concentrations in the RSA using the CALPUFF Model

The predictions shown in Figure B3-8 indicate that two areas will result in maximum daily averages in excess of the guideline. The areas are within the Suncor and Syncrude development areas. In total, 2,185 ha are predicted to have maximum average concentrations in excess of the guideline. The ISC3BE model predicts 101 exceedances. Corresponding values for the CALPUFF model indicate an overall maximum hourly average NO_2 concentration of 708 $\mu g/m^3$, at a location 11 km ESE of Suncor in the East Bank mining area (Figure B3-9). The predictions shown in Figure B3-9 indicate two areas that result in maximum daily averages in excess of the Alberta Guideline. The areas are in or adjacent to the Suncor and Syncrude development areas. In total, 51,028 ha are predicted to have maximum average concentrations in excess of the guideline. The CALPUFF model predicts there may be 103 exceedances of the daily guideline on an annual bases for the Project Millennium case.

- Figures B3-10 and B3-11 show the annual average ground level NO_2 concentrations associated with Project Millennium for the ISC3BE and CALPUFF models. An overall maximum annual average NO_2 concentration, as determined by ISC3BE, of 162 $\mu g/m^3$ is predicted to occur at a location 11 km ESE of Suncor in the East Bank mining area (Figure B3-10). This annual average value exceeds the annual Alberta Guideline of 60 $\mu g/m^3$. The predictions shown in Figure B3-10 indicate two areas that result in annual averages in excess of the guideline. The areas are again within the Suncor and Syncrude development areas. In total, 8,343 ha are predicted to have maximum average concentrations in excess of the guideline. Corresponding values for the CALPUFF model indicate an overall maximum annual average NO_2 concentration of 316 $\mu g/m^3$, at a location 11 km ESE from Suncor in the East Bank mining area (Figure B3-11). The predictions shown in Figure B3-11 indicate the two areas that result in maximum annual averages in excess of the Alberta Guideline. The areas are also in or adjacent to Suncor and Syncrude development areas. In total, 14,623 ha are predicted to have maximum average concentrations in excess of the guideline.

- Overall, there is poor correlation between the two models. They both, however, predict the highest concentrations will occur within the Suncor and Syncrude development areas indicating that the ground level emissions from the mine fleets are a major source of NO_2. The ISC3BE model has been selected over the CALPUFF model results because the ISC3BE predictions have been validated based on a comparison to observed NO_x data adjacent to an active mine pit. Further the ISC3BE predicted NO_x concentrations have been converted to NO_2 based on an empirical relationship based on observed data at the same active mine pit. The same level of validation of CALPUFF's chemical transformation algorithms have not been performed for the Suncor site.





Sources	NO_2 [t/cd]
Suncor	
Powerhouse	2.9
FGD	29.7
Incinerator	0.064
Flaring	0.191
Tail Gas Treatment Unit	0.03
Other Sources, Suncor	34.8
Syncrude (total)	44.4
Other Emissions (total)	10.1
TOTAL	122.185

Model Description	
Development	Project Millennium
Model	ISC3BE (78G)
NO_2 Guideline [µg/m³]	60
Maximum [µg/m³]	161
Exceedences / Year [#]	1

Figure B3-10 Predicted Millennium NO_2 Maximum Annual Average Ground Level Concentrations in the RSA using the ISC3BE Model

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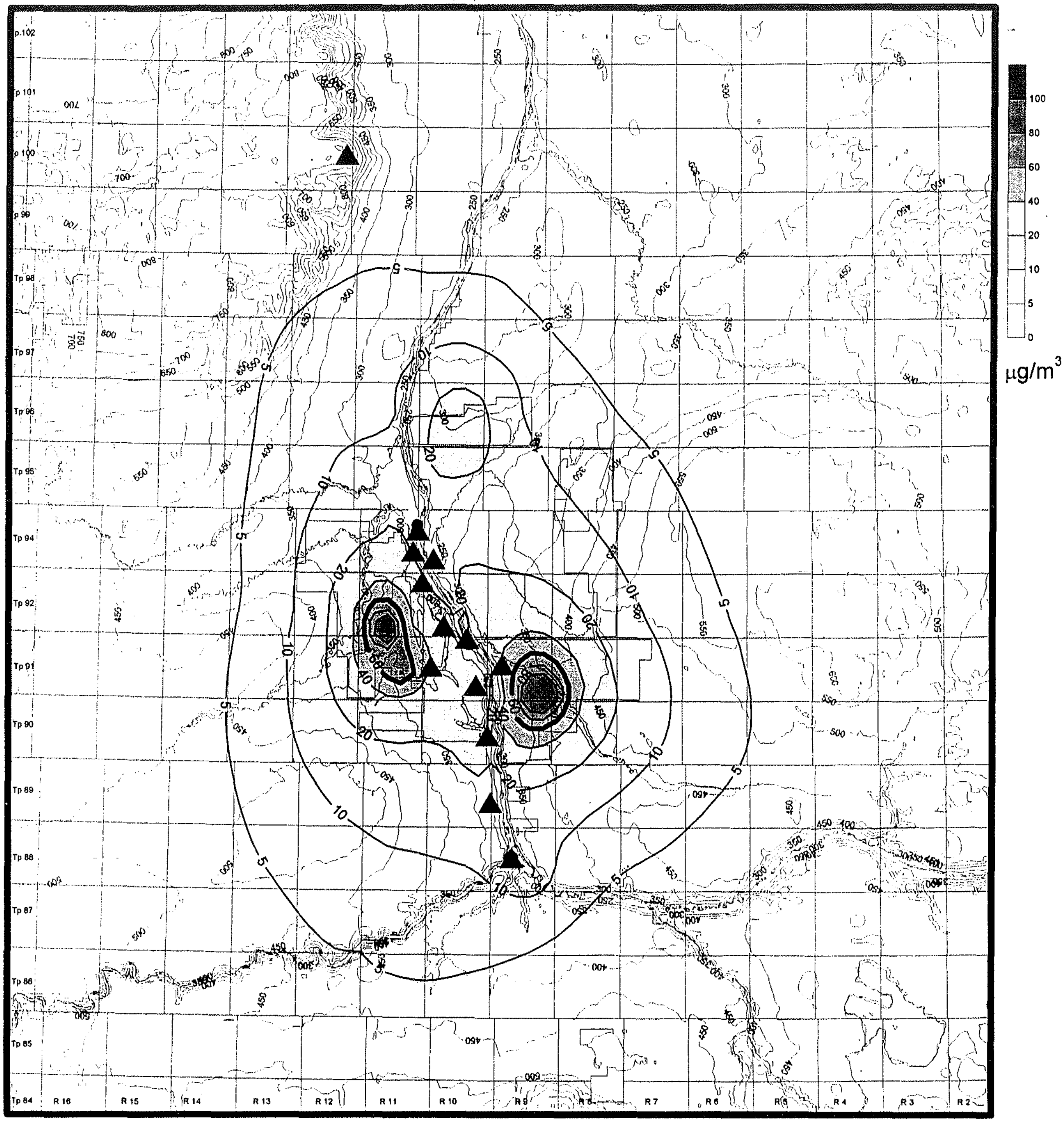

UTM NAD83 metres

0 5000 10000 15000 20000

Sources	NO_x [t/cd]
Suncor	
Powerhouse	2.9
FGD	29.7
Incinerator	0.064
Flaring	0.191
Tail Gas Treatment Unit	0.03
Other Sources, Suncor	34.8
Syncrude (total)	44.4
Other Emissions (total)	10.1
TOTAL	122.185

Model Description	
Development	Project Millennium
Model	CALPUFF
NO_2 Guideline [µg/m³]	60
Maximum [µg/m³]	316
Exceedences / Year [#]	1

Figure B3-11 Predicted Millennium NO_2 Maximum Annual Average Ground Level Concentrations in the RSA using the CALPUFF Model

r/1997/2200/972-2205/8600/8660/8663/CALPUFF/FIGS/M1_NO2_A.srf

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The large number of exceedances of the daily and annual guidelines have not been verified through on-site monitoring. While Syncrude has monitoring stations for NO_x data adjacent to one of its active mine pits, long-term average NO_2 concentrations are not yet available.

B3.2.4 Potential Acid Input (PAI) Predictions

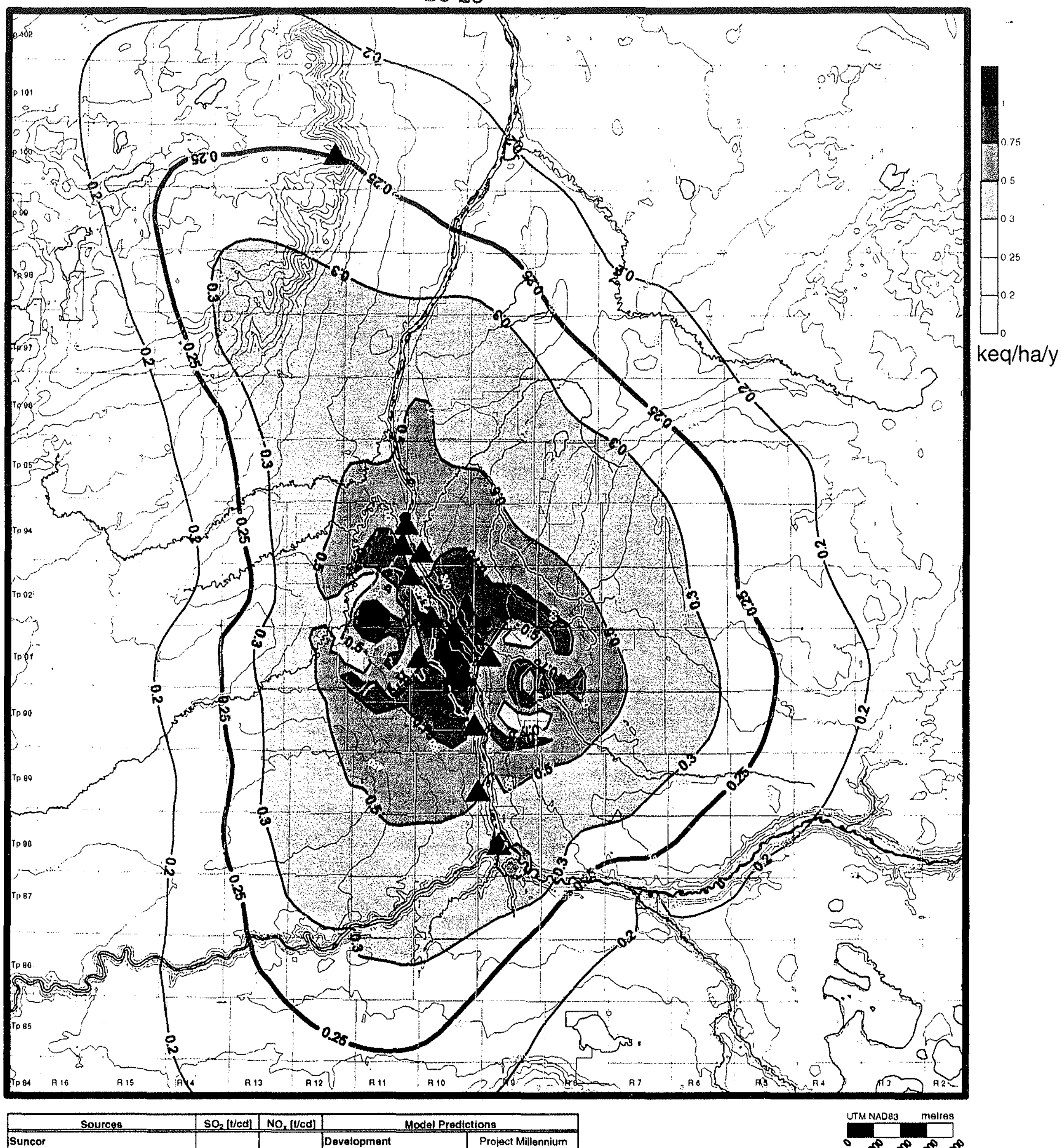
Acidic deposition in the RSA results from the cumulative emissions of SO_2 and NO_x. The total estimated emissions of SO_2 and NO_x (281 t/cd and 122.2 t/cd, respectively) from Project Millennium and all existing and approved developments within the RSA are presented in Table B3-2. Suncor contributes about 34% of the combined SO_2 and NO_x emissions.

PAI is the preferred method for evaluating the overall effects of acid forming chemicals on the environment since it accounts for the acidifying effect of the sulphur and nitrogen species, as well as the neutralizing effect of available base cations. A discussion on the calculation methods for PAI is provided in Section B1.4.2.

PAI in the oil sands region was predicted using the CALPUFF model and four years of meteorological observations from the 75 m level at the Suncor Mannix station. The CALPUFF model is a good tool for estimating the PAI in the oil sands region as it takes into account the chemical transformations of the emitted SO_2 and NO_x and predicts wet (rain and snow scavenged) and dry (via an effective dry deposition velocity) deposition of SO_2, SO_4^{2-}, NO, NO_2, NO_3^-, and HNO_3. These deposition rates are combined following the methodology in Section B1.4.2 to predict the PAI for the region.

A background PAI of 0.1 keq/ha/y has been assumed for the region based on estimates of sulphur and nitrogen and base cation concentrations and depositions in the region surrounding the RSA. This background PAI may be conservatively high, since it was derived from monitoring data at stations adjacent to the RSA. These data were used, as opposed to remote pristine arctic monitoring station data, to better reflect the local Alberta airshed. While these data may represent air flows entering the RSA, they may also reflect air leaving the RSA. Therefore, a nominal amount of "double-counting" may be assumed for the selected background PAI.

The PAI predictions are summarized in Table B3-5 and shown graphically in Figure B3-12. The predicted PAI exceeds the 0.25 keq/ha/y Alberta interim critical load for sensitive soils over an area of 861,263 ha (35.5% of the RSA). The areal extent over which the PAI exceeds the critical loading for less sensitive soils is lower, namely: 195,695 ha (8.1% of the RSA) greater than 0.50 keq/ha/y; 9,598 ha (0.4% of the RSA) greater than 1.0 keq/ha/y; and 317 ha (0.01% of the RSA) greater than 1.5 keq/ha/y.



Sources	SO_2 [t/cd]	NO_x [t/cd]
Suncor		
Powerhouse	14	2.9
FGD	18.7	29.7
Incinerator	12.3	0.064
Flaring	10.6	0.191
Tail Gas Treatment Unit	6.4	0.03
Other Sources, Suncor	5.9	34.8
Syncrude (total)	209	44.4
Other Emissions (total)	4.2	10.1
TOTAL	281.1	122.185

Model Predictions	
Development	Project Millennium
Model	CALPUFF
Critical Loading [keq/ha/y]	0.25
Maximum [keq/ha/y]	24.7

Figure B3-12 Predicted Millennium Potential Acid Input (PAI) in the RSA

Table B3-5 Areal Extent For Predicted PAI Values for Project Millennium

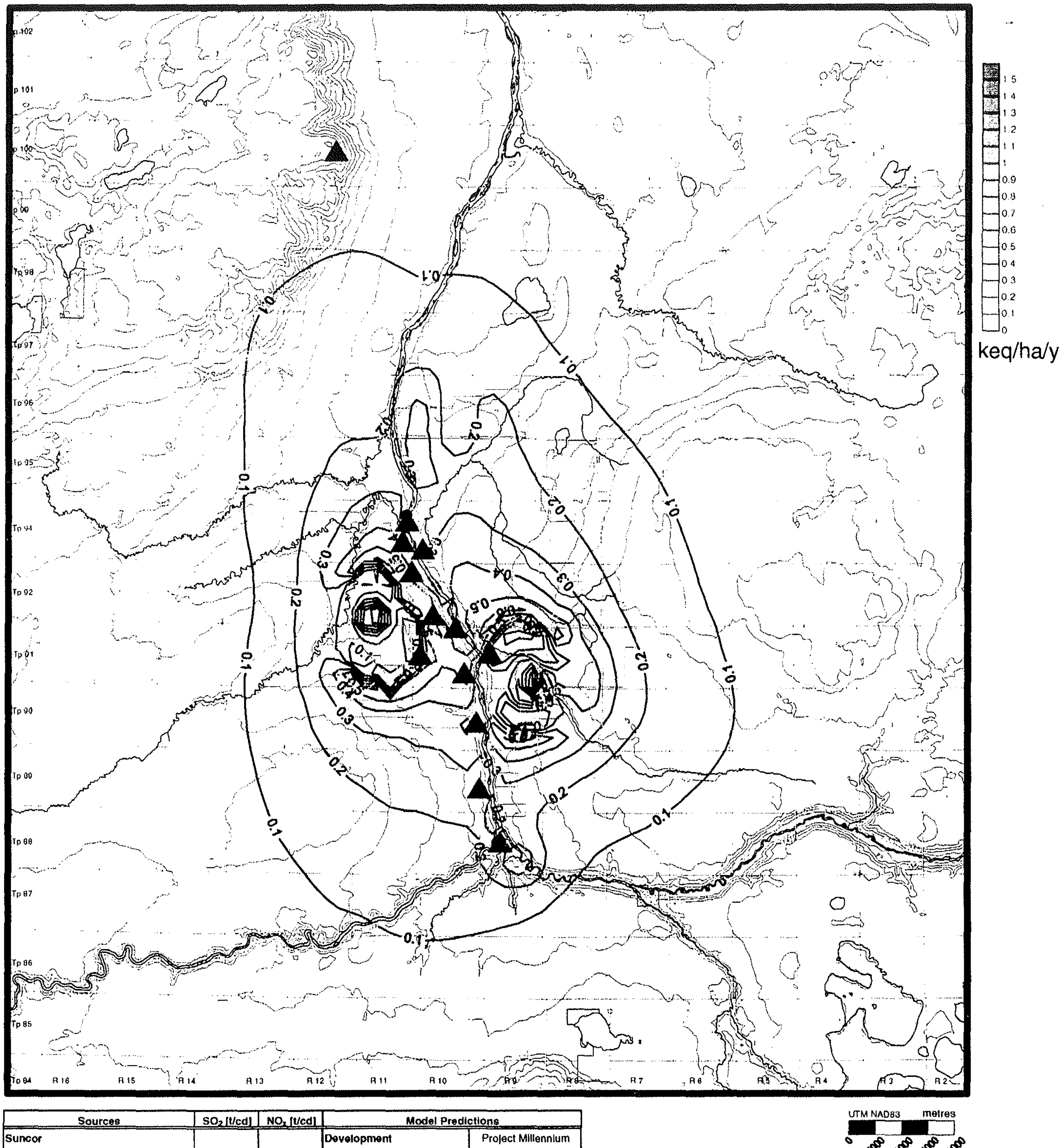
PAI Threshold	AREA	
(keq/ha/y)	(ha)	% of RSA
0.25	861,263	35.5
0.50	195,695	8.1
1.0	9,598	0.4
1.5	317	0.01

The maximum deposition rates of the sulphur and nitrogen species were calculated as interim variables by the CALPUFF model. These are summarized in Table B3-6 and presented graphically in Figures B3-12, B3-13 and B3-14. The maximum deposition rates of nitrates occur in the Suncor east bank mining area, the maximum sulphate deposition rates occur in the immediate vicinity of the Suncor operations, and the maximum overall PAI is predicted to occur in the Syncrude development area. These predicted results suggest the highest deposition and PAI values occur in areas where there are sizable ground level releases of SO_2 and NO_x.

Table B3-6 Maximum Predicted Acid Forming Deposition

Parameter	Maximum [keq/ha/y]
PAI	**24.7**
Nitrate Deposition	**23.6**
Sulphate Deposition	**1.98**

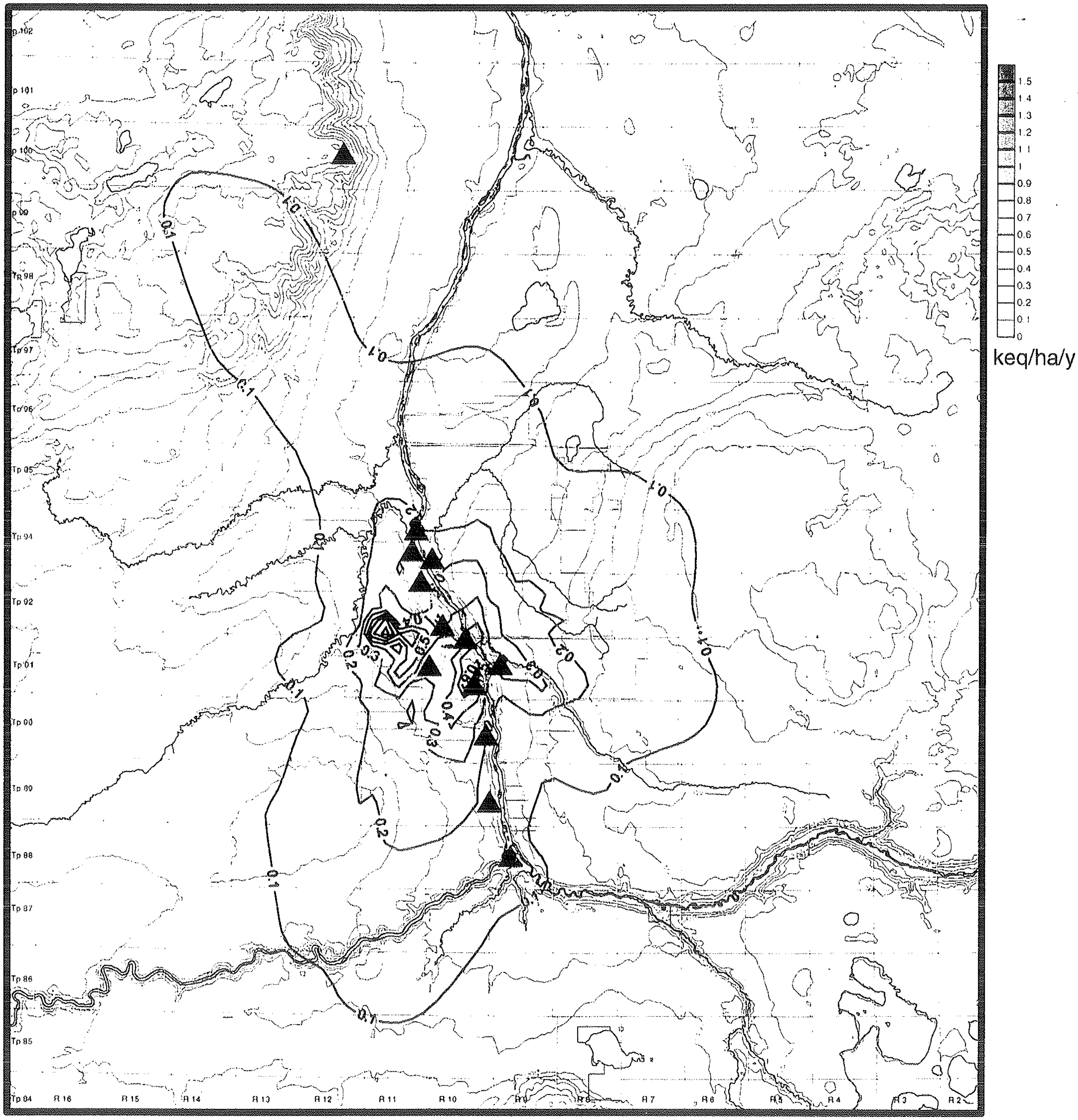
The methodology for predicting PAI on a regional scale using CALPUFF has only been applied in a limited number of cases and experience at applying and interpreting the model predictions is undergoing development. Further, there is considerable uncertainty in the background PAI for the region with estimates ranging from approximately -0.5 to 0.25 keq/ha/y. For this reason, the PAI map presented in Figure B3-12 should be regarded as providing an indication of relative spatial distributions and relative changes associated with differing emission scenarios. This map should also be used in conjunction with the sulphate and nitrate deposition maps (Figures B3-13 and B3-14, respectively) as input in the evaluation of impacts to sensitive soil or vegetation, and in the design of any long-term monitoring programs deemed necessary in such evaluations. This information is further assessed in the soils and terrain impact assessment (Section D2.2).



Sources	SO₂ [t/cd]	NO₂ [t/cd]
Suncor		
Powerhouse	14	2.9
FGD	18.7	29.7
Incinerator	12.3	0.064
Flaring	10.6	0.191
Tail Gas Treatment Unit	6.4	0.03
Other Sources, Suncor	5.9	34.8
Syncrude (total)	209	44.4
Other Emissions (total)	4.2	10.1
TOTAL	281.1	122.185

Model Predictions	
Development	Project Millennium
Model	CALPUFF
Maximum [keq/ha/y]	23.6

Figure B3-13 Predicted Millennium Nitrate Equivalent Deposition in the RSA using the CALPUFF Model



UTM NAD83 metres

0 5000 10000 15000 20000

Sources	SO_2 [t/cd]	NO_x [t/cd]
Suncor		
Powerhouse	14	2.9
FGD	18.7	29.7
Incinerator	12.3	0.064
Flaring	10.6	0.191
Tail Gas Treatment Unit	6.4	0.03
Other Sources, Suncor	5.9	34.8
Syncrude (total)	209	44.4
Other Emissions (total)	4.2	10.1
TOTAL	281.1	122.185

Model Predictions	
Development	Project Millennium
Model	CALPUFF
Maximum [keq/ha/y]	1.98

Figure B3-14 Predicted Millennium Sulphate Equivalent Deposition in the RSA using the CALPUFF Model

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B3.2.5 CO Predicted Concentrations

The CO emission sources associated with Project Millennium and other approved developments are summarized in Section B3.1 (e.g., Tables B3-1 and B3-2). Total estimated CO emission rate for this case is 125.8 t/cd. The total Suncor CO emissions are approximately 38.6 t/cd with the FDG stack (25.6 t/cd) being the major single continuous source.

The predicted maximum hourly and 8-hour ground level ambient CO concentrations resulting from emissions of Project Millennium and all approved industrial sources and residential emissions in the oil sands region were estimated using ISC3BE and meteorology measurements from the Mannix station. This model provides an efficient means of calculating the overall ambient CO concentration from all sources and provides an indication of where maximum concentrations could occur. The modelling predictions are summarized in Table B3-7 and predicted ground level concentrations are mapped in the figures described below:

- Figure B3-15 shows the maximum hourly average ground level CO concentrations associated with Project Millennium. An overall maximum hourly average CO concentration of 5,560 $\mu g/m^3$ is predicted to occur at a location SSE of the Suncor. This maximum value is less than the Alberta hourly CO guideline of 15,000 $\mu g/m^3$.
- Figure B3-16 shows the maximum daily average ground level CO concentrations associated with Project Millennium. The overall maximum 8-hour average CO concentration of 2,226 $\mu g/m^3$ is predicted to occur in Fort McMurray. This maximum 8-hour value is less than the Alberta 8-hour guideline of 6,000 $\mu g/m^3$.

| **Table B3-7 Maximum Predicted Ground Level Concentrations of CO for Project Millennium Sources**

Source	Hourly	8-Hour
Project Millennium - Model ISC3BE		
Maximum CO Concentration ($\mu g/m^3$)	5,560	2,226
Location of Maximum Concentration (km)	30 SSE	30 SSE
Maximum Number of Exceedances [a]	0	0
Location of Maximum Exceedances	n/a	n/a
CO, Alberta Guideline ($\mu g/m^3$)	15,000	6,000

[a] Exceeds CO Alberta Guideline. Normalized for a 12-month period.

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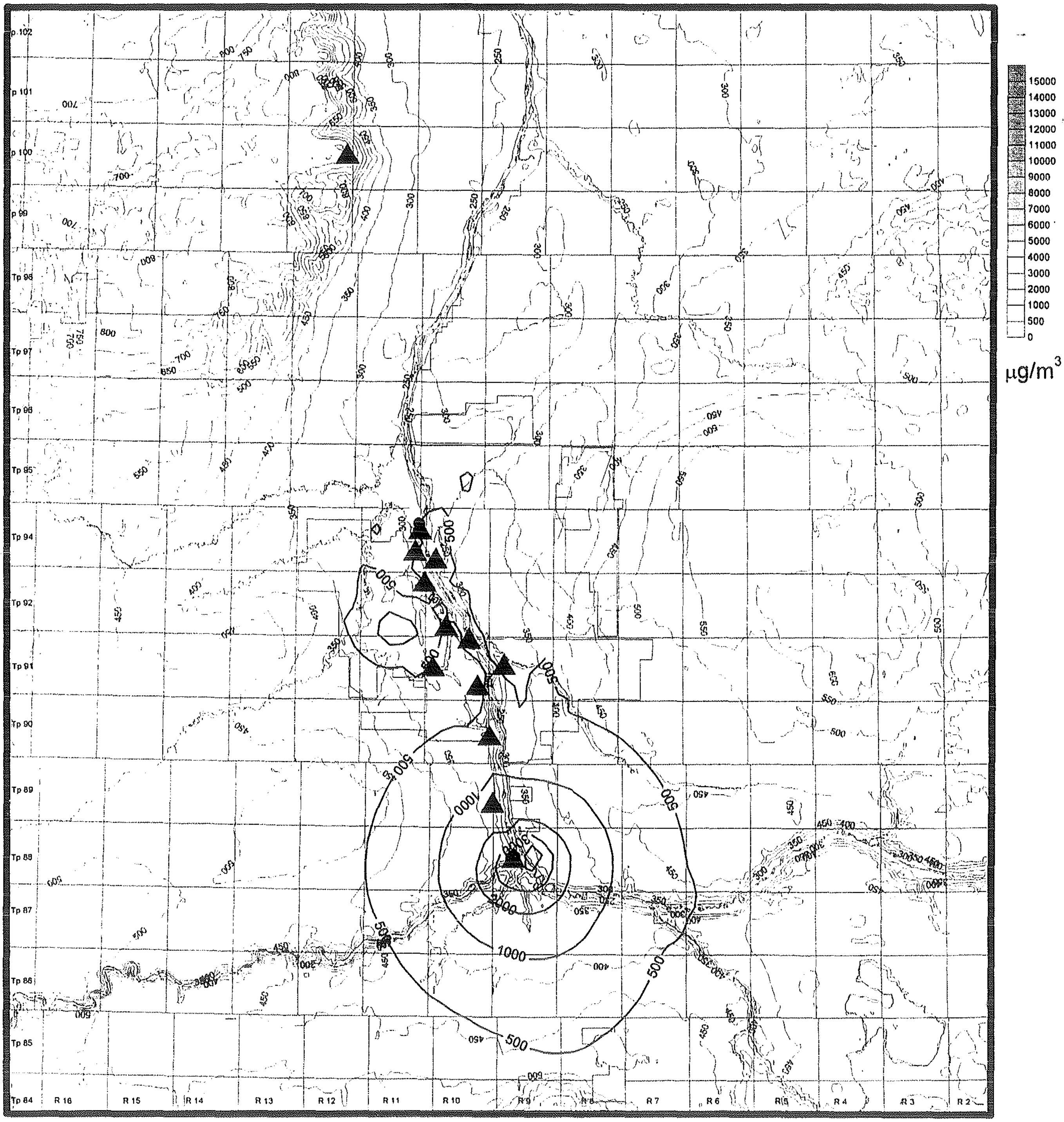
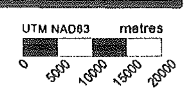


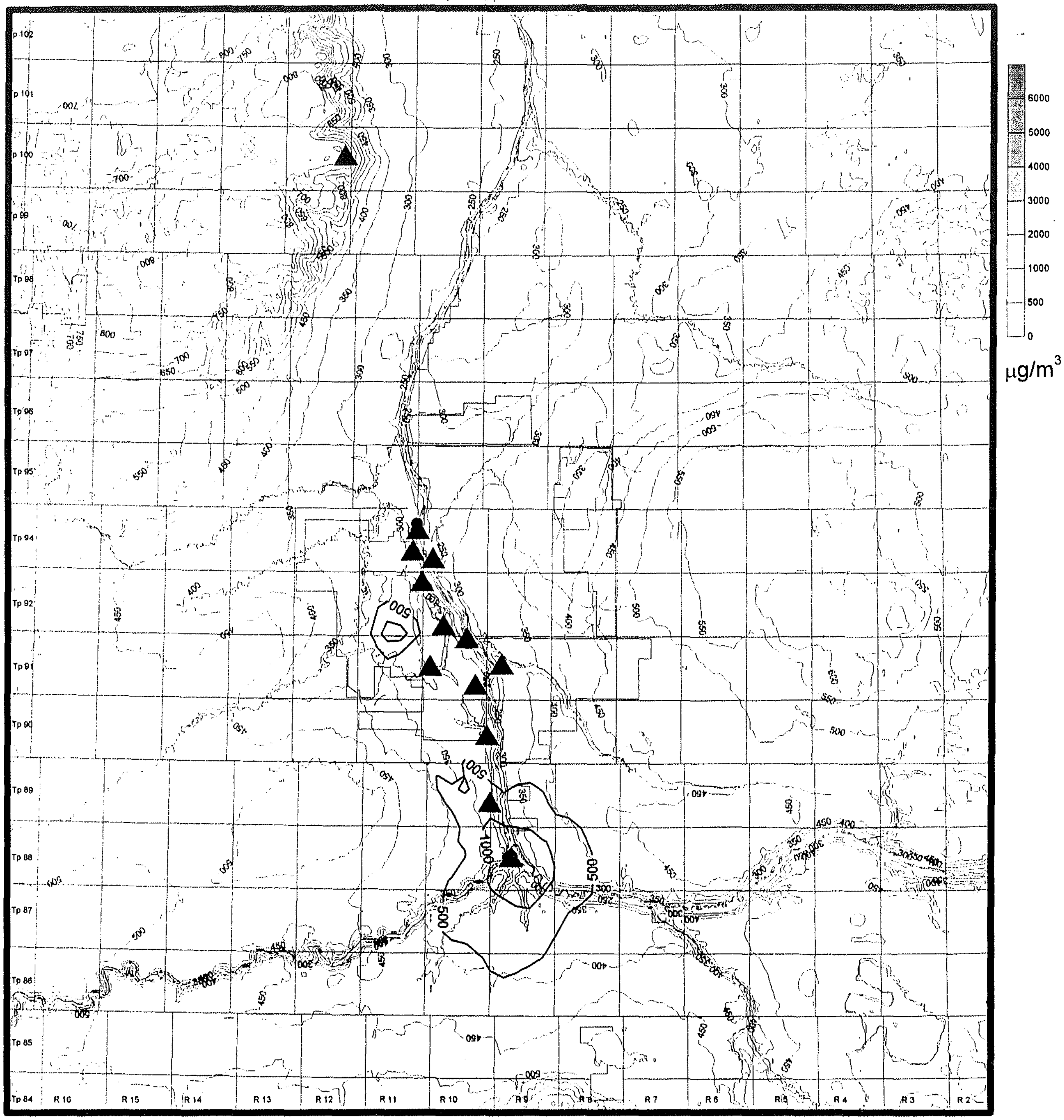


Sources	CO [t/sd]
Suncor	
Powerhouse	3.01
FGD	27.51
Incinerator	3.4
Flaring	0.01
Tail Gas Treatment Unit	3.8
Other Sources, Suncor	3.6
Syncrude (total)	53.61
Other Emissions (total)	33.6
TOTAL	128.54

Model Description	
Development	Project Millennium
Model	ISC3BE (7BG)
CO Guideline [µg/m³]	15000
Maximum [µg/m³]	5560
Exceedences / Year [#]	0

r:/1997/2200/972-2205/8600/8660/8663/ISC3BE/FIGS/COCD_2H.srf

Figure B3-15 Predicted Millennium CO Maximum Hourly Average Ground Level Concentrations in the RSA using the ISC3BE Model



Sources	CO [t/sd]
Suncor	
Powerhouse	3.01
FGD	27.51
Incinerator	3.4
Flaring	0.01
Tail Gas Treatment Unit	3.8
Other Sources, Suncor	3.6
Syncrude (total)	53.61
Other Emissions (total)	33.6
TOTAL	128.54

Model Description	
Development	Project Millennium
Model	ISC3BE (7BG)
CO Guideline [µg/m³]	6000
Maximum [µg/m³]	2226
Exceedences / Year [#]	0

UTM NAD83 metres
0 5000 10000 15000 20000

Figure B3-16 Predicted Millennium CO Maximum 8-Hour Average Ground Level Concentrations in the RSA using the ISC3BE Model

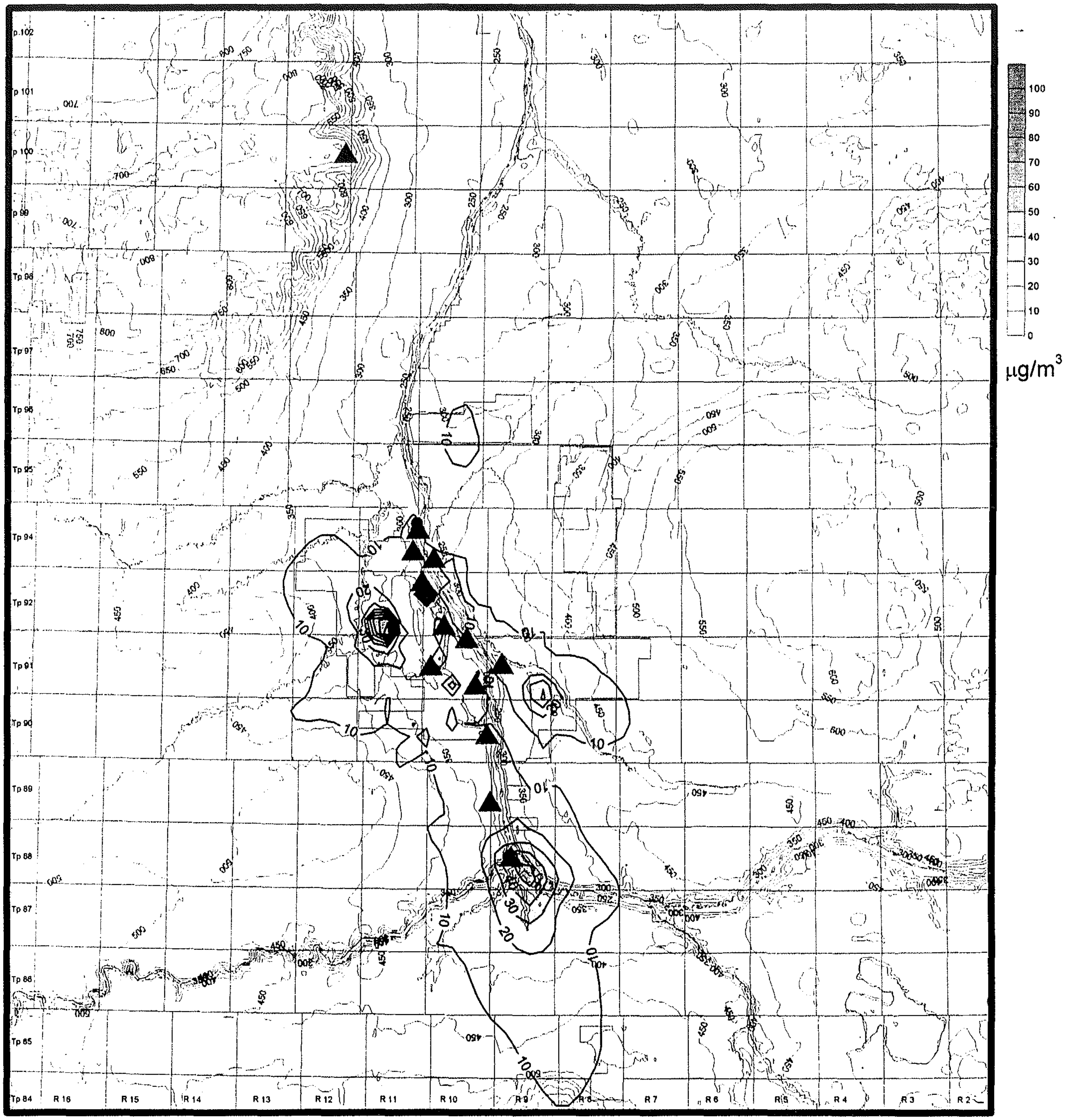
The modelling predicts that the maximum hourly and 8-hour CO concentrations will occur SSE of Suncor near Fort McMurray. The principal contribution to these elevated CO values are the releases from the conical burner operated by Northland Forest Products. The principal contributors to high values outside of Fort McMurray would be the mine fleet. The mine fleet and vehicle emissions have been modelled as a ground level area source. Because these emissions are relatively large and are at ground level, there is a decreased opportunity for dispersion and dilution of their plumes as compared to a tall stack with a similar emission rate. It is this source characterization which produces the increase in the ground level concentrations and this characterization is expected to be a conservative modelling assumption. The ability to compare the model predictions to monitoring data are limited because only one location within the region measures CO.

B3.2.6 Particulate Predicted Concentrations

The ambient PM emission sources associated with Project Millennium and other approved developments are summarized in Section B3.1 (e.g., Tables B3-1 and B3-2). Total estimated PM emission rate for all sources is 10.0 t/cd. The major continuous source of particulate emissions from Suncor is the FGD Stack and it emits approximately 1.0 t/cd. Suncor PM emissions account for approximately 22% of the PM in the RSA. For the purpose of modelling, all PM was assumed to be PM_{10}. In addition to the PM emissions, metals and PAHs have been determined from stack sampling surveys collected by Suncor and Syncrude. Based on the speciation completed for the stack sampling surveys, metals and PAHs were estimated. These results are discussed in subsections following this section.

The predicted maximum daily and annual ground level ambient PM_{10} concentrations resulting from emissions of Project Millennium and all approved industrial sources and residential emissions in the oil sands region were estimated using ISC3BE and meteorology measurements from the Mannix station. The modelling results are summarized in Table B3-8 which includes the PM_{10} results based on source sampling. Predicted PM ground level concentrations are mapped in the figures described below:

- Figure B3-17 shows the maximum daily average ground level PM concentrations associated with Project Millennium. The overall maximum daily average PM concentration is 113 $\mu g/m^3$ and is predicted to occur WNW of Suncor. All of the exceedances **of the Alberta TSP guideline of 100 $\mu g/m^3$** are predicted to occur in the existing development areas.
- Figure B3-18 shows the annual average ground level concentration contours for PM. The results show that the overall maximum annual concentration of 45.9 $\mu g/m^3$ is predicted to occur at the same location as the daily results.



Sources	PM [t/cd]
Suncor	
FGD	1.00
Powerhouse	0.24
Incinerator	0.038
Tail Gas Treatment Unit	0.042
Millennium Mine Fleet	0.3
Other Sources, Suncor	0.653
Syncrude (total)	5.6
Other Emissions (total)	2.2
TOTAL	10.073

Model Description	
Development	Project Millennium
Model	ISC3BE
PM$_{10}$ Guideline [µg/m³]	50
Maximum [µg/m³]	113
Exceedences / Year [#]	33

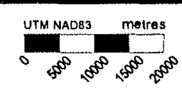
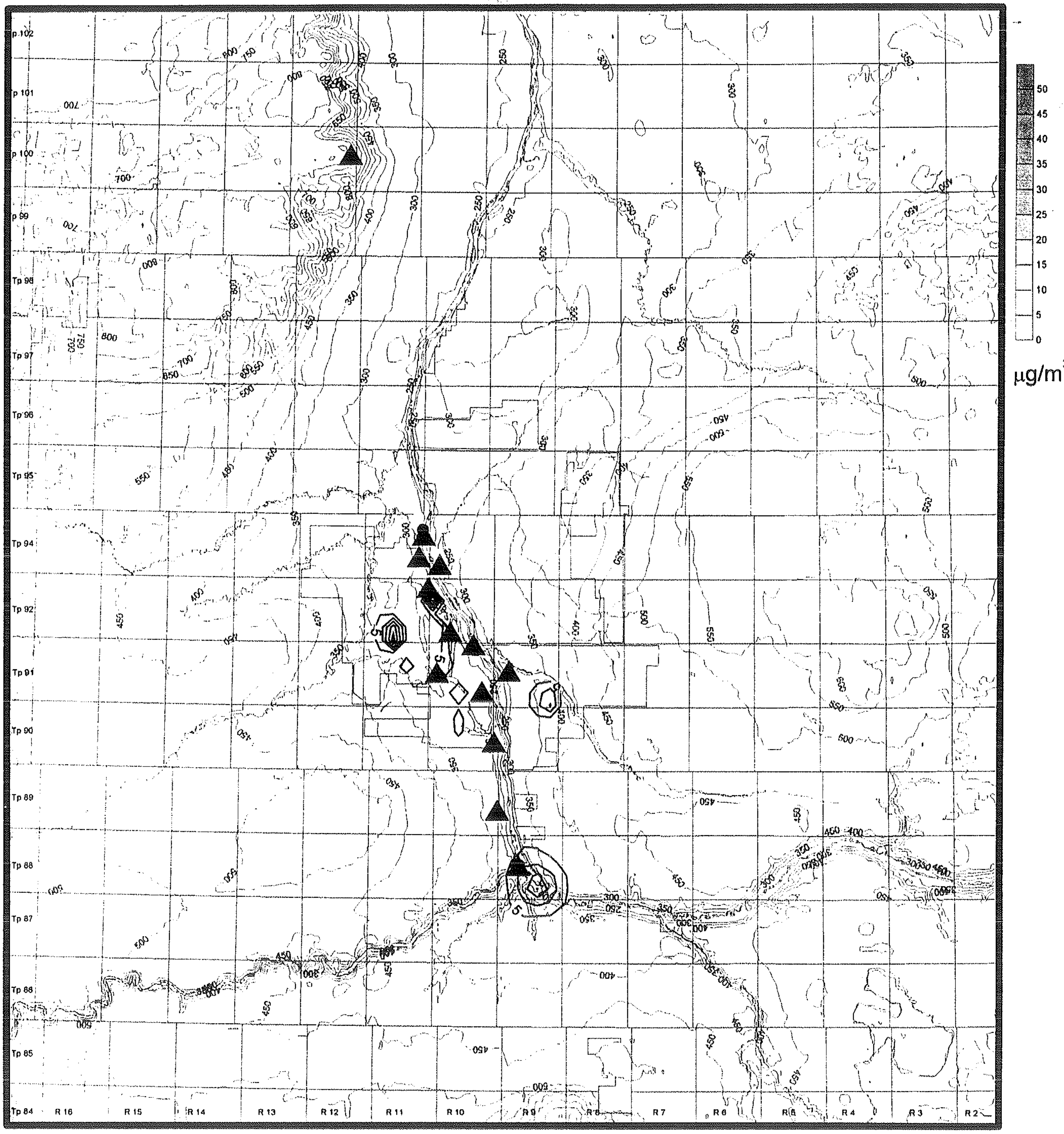
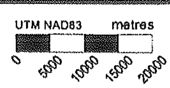


Figure B3-17 Predicted Millennium PM$_{10}$ Maximum Daily Average Ground Level Concentrations in the RSA





Sources	PM [t/cd]
Suncor	
FGD	1.00
Powerhouse	0.24
Incinerator	0.038
Tail Gas Treatment Unit	0.042
Millennium Mine Fleet	0.3
Other Sources, Suncor	0.653
Syncrude (total)	5.6
Other Emissions (total)	2.2
TOTAL	10.073

Model Description	
Development	Project Millennium
Model	ISC3BE
PM_{10} Guideline [µg/m³]	50
Maximum [µg/m³]	45.9
Exceedences / Year [#]	0

Figure B3-18 Predicted Millennium PM_{10} Maximum Annual Average Ground Level Concentrations in the RSA

| **Table B3-8 Maximum Predicted Ground Level Concentrations of PM_{10} for Millennium Sources**

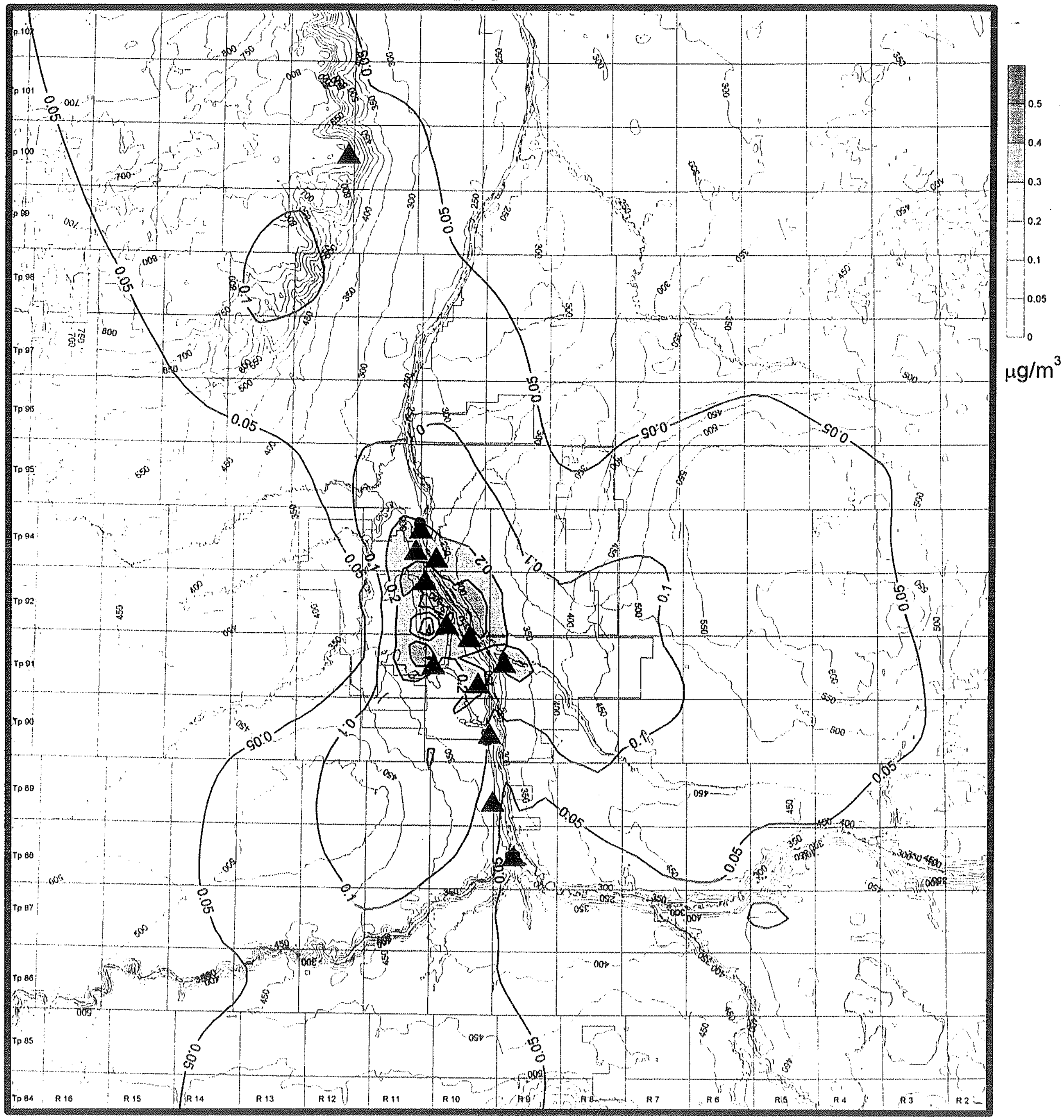
Source	Daily	Annual
Baseline Condition - Model ISC3BE		
Maximum PM_{10} Concentration (µg/m³)	113	45.9
Location of Maximum Concentration	WNW	WNW
Maximum Number of Exceedances	33	0
Location of Maximum Exceedances	WNW	n/a
TSP Alberta Guideline (µg/m³)	100	60

The particulate emissions from the Suncor FGD and Syncrude Main stacks contain metals and PAH compounds. The ISC3BE was configured to predict particulates from these two stacks to determine ground level concentrations and deposition rates. The FGD particulate emission rate was estimated for Project Millennium based on the expected operation of the coke fired boilers. The particulate size fraction, metal composition and PAH composition for the Suncor FGD stack emissions was assumed to remain the same as the Baseline case. The FGD emissions for Project Millennium were assumed predominantly to be in the $PM_{2.5}$ size range with a total emission rate of about 1.0 t/d. The Syncrude Main stack emissions were not changed from the Baseline case.

The predicted average daily and annual ground level concentrations of total particulates from these two sources are shown in Figure B3-19 and Figure B3-20. A summary of the predicted metal and PAH concentrations derived from the total particulate air concentrations are listed in Tables B3-9 and B3-10 for selected locations. This PM assessment from the Suncor FGD stack reflects the most recent stack survey data which has included analysis of heavy metals, PAHs and particulate size fractions. This data has been included in the air quality section but was not available in time for the writing of the health assessment in Section F1.

B3.2.7 Fugitive Dust Discussion

The maximum predicted PM does not include contributions due to non-combustion sources nor natural background levels. Potential fugitive sources associated with Project Millennium include an expanded mine area, new tailings pond areas and additional roads and truck traffic. These new or expanded activities could result in additional sources of fugitive dust emissions. It is Suncor's experience that the mining area, given the coarse nature of oil sands (bitumen and sand combination), is expected to produce minimal PM fugitive emissions. The existing reclamation activities control fugitive particulate emissions and the same management practice will be undertaken for Project Millennium. Overall, fugitive emissions are not expected to change from the existing situation with the development of Project Millennium.



Sources	PM [t/cd]
Suncor	
FGD	2.6
Powerhouse	-
Incinerator	-
Tail Gas Treatment Unit	-
Millennium Mine Fleet	-
Other Sources, Suncor	-
Syncrude Main Stack	7.1
Other Emissions (total)	-
TOTAL	9.7

Model Description	
Development	Project Millennium
Model	ISC3BE

Figure B3-19 Predicted Millennium Particulate Annual Average Ground Level Concentrations in the RSA from the operation of the Suncor and Syncrude main stacks

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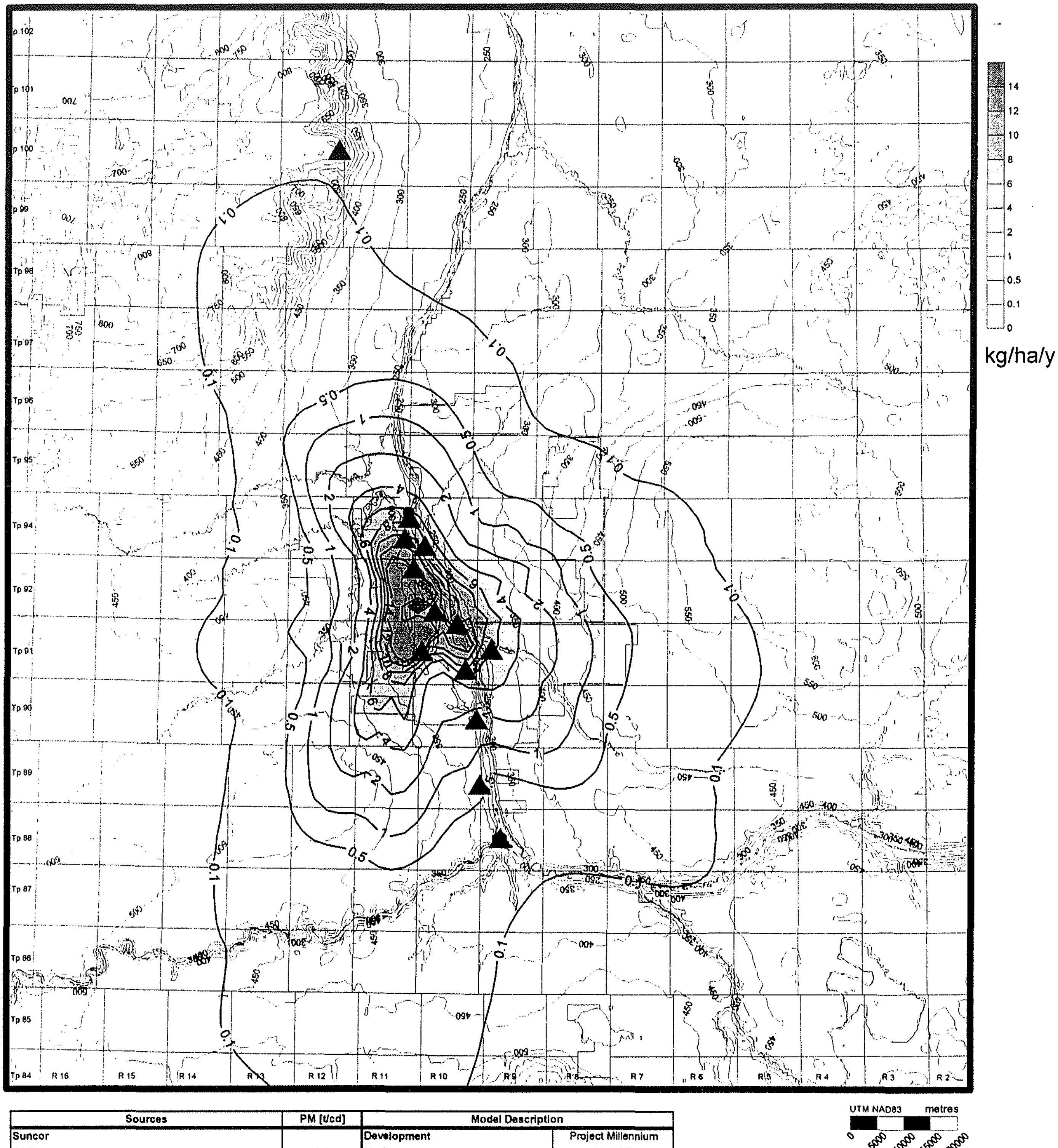

Sources	PM [t/cd]
Suncor	
FGD	2.6
Powerhouse	-
Incinerator	-
Tail Gas Treatment Unit	-
Millennium Mine Fleet	-
Other Sources, Suncor	-
Syncrude Main Stack	7.1
Other Emissions (total)	-
TOTAL	9.7

Model Description	
Development	Project Millennium
Model	ISC3BE

Figure B3-20 Predicted Millennium Particulate Annual Average Deposition in the RSA from the operation of the Suncor and Syncrude Main stacks

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Table B3-9 Average Ground Level Predicted Concentrations of Heavy Metals at Selected Sites as a Result of Emissions from Suncor FGD and Syncrude Main Stack

Location	Average Daily Ground Level Concentration					Average Annual Ground Level Concentration			
	Ontario AAQC, Daily [ng/m³]	Mannix	Fort McMurray	Fort McKay	Fort Chipewyan	Mannix	Fort McMurray	Fort McKay	Fort Chipewyan
Heavy Metals [ng/m³]									
Antimony	—	5.1E-02	7.7E-03	2.7E-02	2.6E-03	2.6E-03	3.2E-04	2.1E-03	1.1E-04
Arsenic	3.00E+03	8.1E-02	1.2E-02	4.2E-02	4.1E-03	4.2E-03	5.2E-04	3.3E-03	1.8E-04
Aluminum	—	8.6E+00	1.2E+00	5.3E+00	4.3E-01	4.4E-01	4.7E-02	4.1E-01	1.7E-02
Barium	1.00E+05	8.0E-01	1.2E-01	4.1E-01	4.1E-02	4.2E-02	5.3E-03	3.2E-02	1.8E-03
Beryllium	0.00E+00	9.4E-03	1.4E-03	5.1E-03	4.8E-04	4.9E-04	5.8E-05	4.0E-04	2.0E-05
Cadmium	2.00E+04	1.9E-02	2.5E-03	1.2E-02	9.3E-04	9.7E-04	9.5E-05	9.5E-04	3.7E-05
Chromium	1.50E+04	4.2E+00	6.1E-01	2.4E+00	2.1E-01	2.2E-01	2.5E-02	1.9E-01	8.8E-03
Cobalt	1.00E+03	2.2E-01	3.2E-02	1.3E-01	1.1E-02	1.2E-02	1.3E-03	1.0E-02	4.7E-04
Copper	5.00E+05	3.8E-01	5.4E-02	2.2E-01	1.9E-02	2.0E-02	2.2E-03	1.7E-02	7.8E-04
Iron	—	3.9E+01	5.5E+00	2.5E+01	2.0E+00	2.0E+00	2.1E-01	2.0E+00	7.9E-02
Lead	0.00E+00	5.4E-01	8.4E-02	2.7E-01	2.7E-02	2.8E-02	3.6E-03	2.1E-02	1.2E-03
Manganese	—	1.6E+00	2.4E-01	8.5E-01	8.1E-02	8.3E-02	1.0E-02	6.7E-02	3.5E-03
Mercury	2.00E+04	1.1E-02	1.6E-03	6.0E-03	5.4E-04	5.6E-04	6.5E-05	4.7E-04	2.3E-05
Molybdenum	1.20E+06	8.0E-01	1.2E-01	4.4E-01	4.0E-02	4.2E-02	4.9E-03	3.5E-02	1.7E-03
Nickel	2.00E+04	6.7E+00	9.6E-01	3.9E+00	3.4E-01	3.5E-01	3.8E-02	3.1E-01	1.4E-02
Selenium	1.00E+05	2.2E+00	3.8E-01	8.2E-01	1.1E-01	1.1E-01	1.7E-02	6.5E-02	5.4E-03
Silver	1.00E+04	8.0E-02	1.1E-02	5.4E-02	4.0E-03	4.2E-03	4.0E-04	4.2E-03	1.6E-04
Tin	1.00E+05	5.6E-01	8.5E-02	2.8E-01	2.8E-02	2.9E-02	3.6E-03	2.2E-02	1.2E-03
Titanium	—	9.5E-01	1.4E-01	5.4E-01	4.8E-02	4.9E-02	5.6E-03	4.3E-02	2.0E-03
Vanadium	2.00E+04	3.1E+00	4.6E-01	1.7E+00	1.6E-01	1.6E-01	1.9E-02	1.3E-01	6.6E-03
Zirconium	—	5.6E-01	8.5E-02	2.8E-01	2.8E-02	2.9E-02	3.6E-03	2.2E-02	1.2E-03
Zinc	1.20E+06	1.7E+01	1.9E+00	1.4E+01	8.0E-01	8.5E-01	5.5E-02	1.1E+00	2.7E-02

OAAQC: Ontario Ambient Air Quality Criteria
Ontario Ministry of the Environment 1994
Summary of Point of Impingement Standards, Ambient Air Quality Criteria (AAQC), and Approvals Screening Levels

Table B3-10 Average Ground Level Predicted Concentrations of PAHs at Selected Sites as a Result of Emissions from Suncor FGD and Syncrude Main Stack

	Average Daily Ground Level Concentration				Average Annual Ground Level Concentration			
Location	Mannix	Fort McMurray	Fort McKay	Fort Chipewyan	Mannix	Fort McMurray	Fort McKay	Fort Chipewyan
PAHs [ng/m^3]								
Acenaphthene	8.3E-04	1.3E-04	3.8E-04	4.3E-05	4.3E-05	5.9E-06	3.0E-05	1.9E-06
Acenaphylene	2.7E-02	3.1E-03	2.3E-02	1.3E-03	1.4E-03	8.7E-05	1.8E-03	4.4E-05
Anthracene	2.2E-03	3.7E-04	9.2E-04	1.2E-04	1.2E-04	1.7E-05	7.3E-05	5.4E-06
1,2-Benzathracene	1.0E-03	1.6E-04	5.5E-04	5.3E-05	5.4E-05	6.6E-06	4.3E-05	2.3E-06
Benzo(b & j)fluoranthene	6.1E-03	1.0E-03	2.7E-03	3.1E-04	3.2E-04	4.4E-05	2.1E-04	1.4E-05
Benzo(k)fluoranthene	1.1E-03	1.5E-04	6.0E-04	5.3E-05	5.5E-05	6.2E-06	4.8E-05	2.2E-06
Benzo(a)fluorene	9.2E-04	1.5E-04	4.1E-04	4.7E-05	4.8E-05	6.6E-06	3.2E-05	2.1E-06
Benzo(b)fluorene	5.5E-04	8.6E-05	2.8E-04	2.8E-05	2.9E-05	3.7E-06	2.2E-05	1.2E-06
Benzo(g, h, i)perylene	1.2E-03	1.8E-04	7.0E-04	6.2E-05	6.4E-05	7.4E-06	5.5E-05	2.6E-06
Benzo(a)pyrene	8.6E-04	1.3E-04	4.4E-04	4.4E-05	4.5E-05	5.6E-06	3.5E-05	1.9E-06
Benzo(e)pyrene	5.5E-04	8.6E-05	2.8E-04	2.8E-05	2.9E-05	3.7E-06	2.2E-05	1.2E-06
Camphene	1.5E-03	2.5E-04	6.1E-04	7.7E-05	7.8E-05	1.1E-05	4.9E-05	3.6E-06
Carbazole	8.5E-04	1.4E-04	3.9E-04	4.4E-05	4.4E-05	6.0E-06	3.0E-05	2.0E-06
1 -Chloronaphthalene	7.8E-04	1.2E-04	3.7E-04	4.0E-05	4.1E-05	5.3E-06	2.9E-05	1.8E-06
2-Chloronaphthalene	1.2E-03	1.7E-04	7.4E-04	6.1E-05	6.3E-05	6.7E-06	5.8E-05	2.5E-06
Chrysene	2.1E-03	2.9E-04	1.3E-03	1.0E-04	1.1E-04	1.1E-05	1.0E-04	4.2E-06
Dibenz(a, j)acridine	9.4E-04	1.4E-04	5.1E-04	4.8E-05	4.9E-05	5.8E-06	4.0E-05	2.0E-06
Dibenz(a, h)acridine	7.5E-04	1.2E-04	3.5E-04	3.8E-05	3.9E-05	5.2E-06	2.8E-05	1.7E-06
Dibenz(a, h)anthracene	7.8E-04	1.2E-04	3.7E-04	4.0E-05	4.1E-05	5.3E-06	2.9E-05	1.8E-06
Dibenzothiophene	1.1E-01	1.2E-02	9.1E-02	5.3E-03	5.6E-03	3.5E-04	7.1E-03	1.8E-04
7,12-dimethylbenz(a) anthracene	7.5E-04	1.2E-04	3.5E-04	3.8E-05	3.9E-05	5.2E-06	2.8E-05	1.7E-06
1, 6-Dinitropyrene	7.5E-04	1.2E-04	3.5E-04	3.8E-05	3.9E-05	5.2E-06	2.8E-05	1.7E-06
1, 8-Dinitropyrene	7.5E-04	1.2E-04	3.5E-04	3.8E-05	3.9E-05	5.2E-06	2.8E-05	1.7E-06
Fluoranthene	6.8E-03	1.1E-03	3.3E-03	3.5E-04	3.6E-04	4.7E-05	2.6E-04	1.6E-05
Fluorene	3.8E-03	6.4E-04	1.4E-03	2.0E-04	2.0E-04	3.0E-05	1.1E-04	9.3E-06
Ideno(l, 2, 3-cd)pyrene	1.1E-03	1.6E-04	6.7E-04	5.7E-05	5.9E-05	6.4E-06	5.3E-05	2.3E-06
Indole	1.5E-03	2.6E-04	6.3E-04	7.9E-05	8.0E-05	1.2E-05	5.0E-05	3.7E-06
1 -Methylnaphthalene	3.3E-02	4.0E-03	2.5E-02	1.6E-03	1.7E-03	1.3E-04	1.9E-03	5.8E-05
2-Methylnaphthalene	3.1E-02	4.0E-03	2.2E-02	1.5E-03	1.6E-03	1.4E-04	1.7E-03	5.8E-05
Naphthalene	4.3E-01	5.1E-02	3.4E-01	2.1E-02	2.2E-02	1.6E-03	2.7E-02	7.3E-04
Nitro-pyrene	1.0E-03	1.7E-04	4.6E-04	5.4E-05	5.5E-05	7.6E-06	3.6E-05	2.5E-06
Perylene	5.5E-04	8.6E-05	2.8E-04	2.8E-05	2.9E-05	3.7E-06	2.2E-05	1.2E-06
Phenanthrene	5.8E-02	7.8E-03	3.8E-02	2.9E-03	3.0E-03	2.9E-04	3.0E-03	1.1E-04
Pyrene	6.9E-03	9.7E-04	4.3E-03	3.5E-04	3.6E-04	3.7E-05	3.4E-04	1.4E-05
Retene	8.9E-03	1.4E-03	4.2E-03	4.6E-04	4.7E-04	6.2E-05	3.3E-04	2.0E-05

B3.2.8 Volatile Organic Compounds Predicted Concentrations

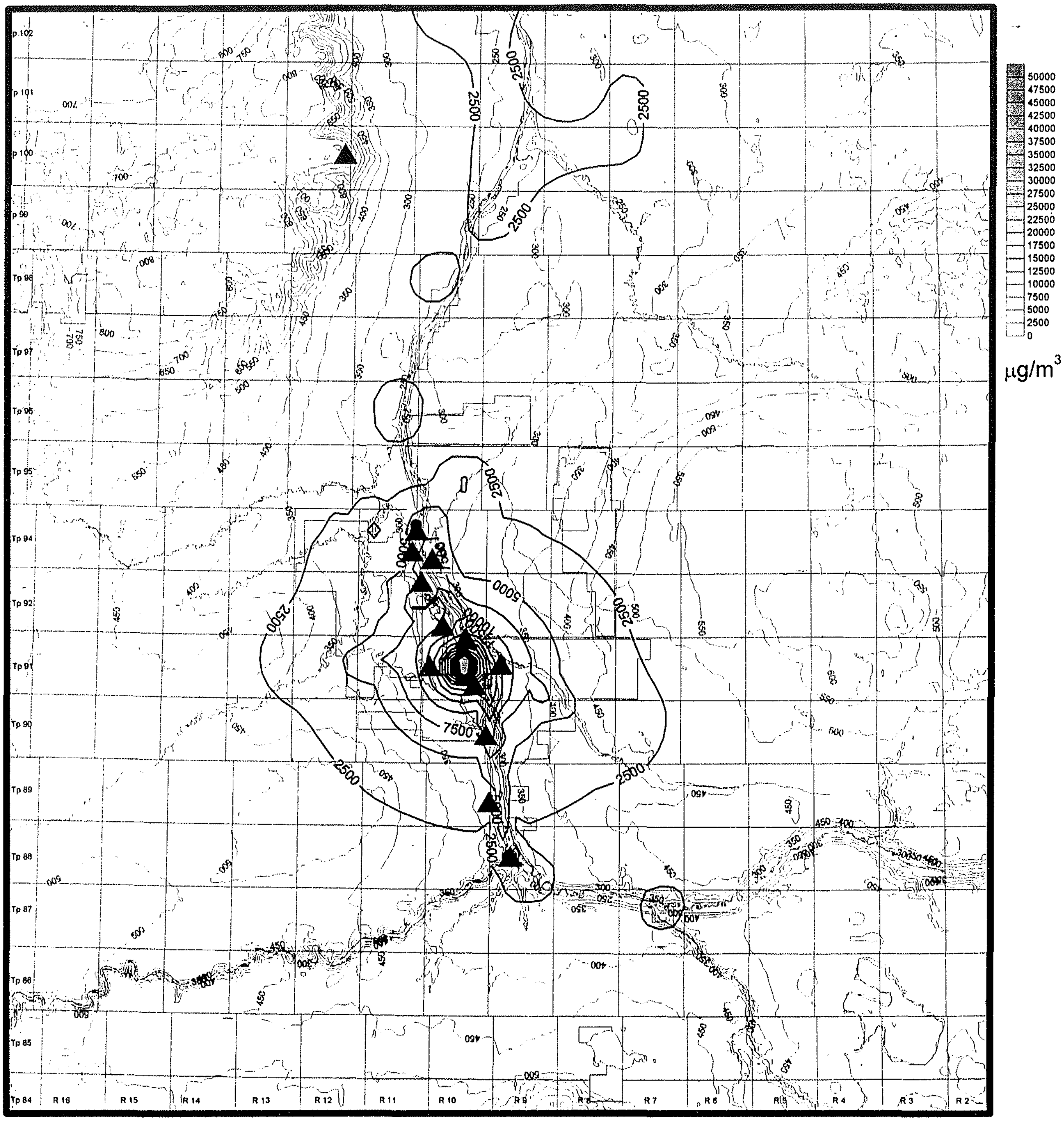
The VOC emission sources associated with Project Millennium and other approved developments are summarized in Section B3-1 (e.g., Tables B3-1 and B3-2). Total estimated emission rates for the Project Millennium case are 293 t/cd (Table B3-2). Suncor emissions account for approximately 80% of the VOC emissions in the RSA. The major VOC emissions sources from Suncor are the tailings pond (Pond 2/3) and the active mine surface areas (Table B3-1). Using the unique fingerprint of each emission source, specific VOCs were speciated from the modelling results based on an overall VOC speciation.

The predicted annual average ground level ambient total VOC concentrations resulting from emissions of Project Millennium and all approved industrial sources and residential emissions in the oil sands region were estimated using ISC3BE and meteorology measurements from Mannix station. This model provides an efficient means of predicting the overall ambient VOC concentration and the extrapolated compounds from all sources and provides an indication of where maximum concentrations could occur. The model also predicted values at specific locations (Fort McMurray, Fort McKay and Fort Chipewyan for use in the Health section (Section F1). The modelling predictions are summarized in Table B3-11.

Table B3-11 Maximum Predicted Annual Average Ground Level Concentrations of VOCs for Project Millennium Sources

	VOC Concentration [μg/m³]				
Fort McMurray	Maximum	Mannix	Fort McMurray	Fort McKay	Fort Chipewyan
Total VOCs					
Maximum concentration [μg/m³]	34000	796	76	163	12
Speciated VOCs					
C2 to C4 alkanes and alkenes	391	9.2	0.9	1.9	0.14
C5 to C8 Alkanes and alkenes	14831	347	33.2	71.1	5.1
C9 to C12 alkanes and alkenes [(a)]	10638	249	23.8	51.0	3.7
Cyclohexane	3441	81	7.7	16.5	1.2
Benzene	103	2.4	0.23	0.49	0.036
C6 to C8 non-benzene aromatics	1904	45	4.3	9.1	0.7
Total aldehydes	40	0.9	0.090	0.193	0.014
Total ketones	11	0.3	0.025	0.053	0.004
Total Reduced Sulphur Compounds	599	14.0	1.3	2.9	0.2

The predicted total VOC hourly, daily and annual average ground level concentrations are mapped in Figures B3-21, B3-22 and B3-23, respectively. The hourly and daily results show that the overall maximum concentrations are expected to occur over the Suncor Pond 2/3 (a secondary extraction tailings pond). Figure B3-23 shows that



UTM NAD83 metres
0 5000 10000 15000 20000

Sources	VOC [t/cd]
Suncor Plant	24.0
Syncrude Plant	5.4
Mine Fleets	2.4
Mine Faces	19.8
Tailings Ponds	226.8
TOTAL	278.4

Model Description	
Development	Project Millennium
Model	ISC3BE

Figure B3-21 Predicted Millennium VOC Maximum Hourly Average Ground Level Concentrations in the RSA

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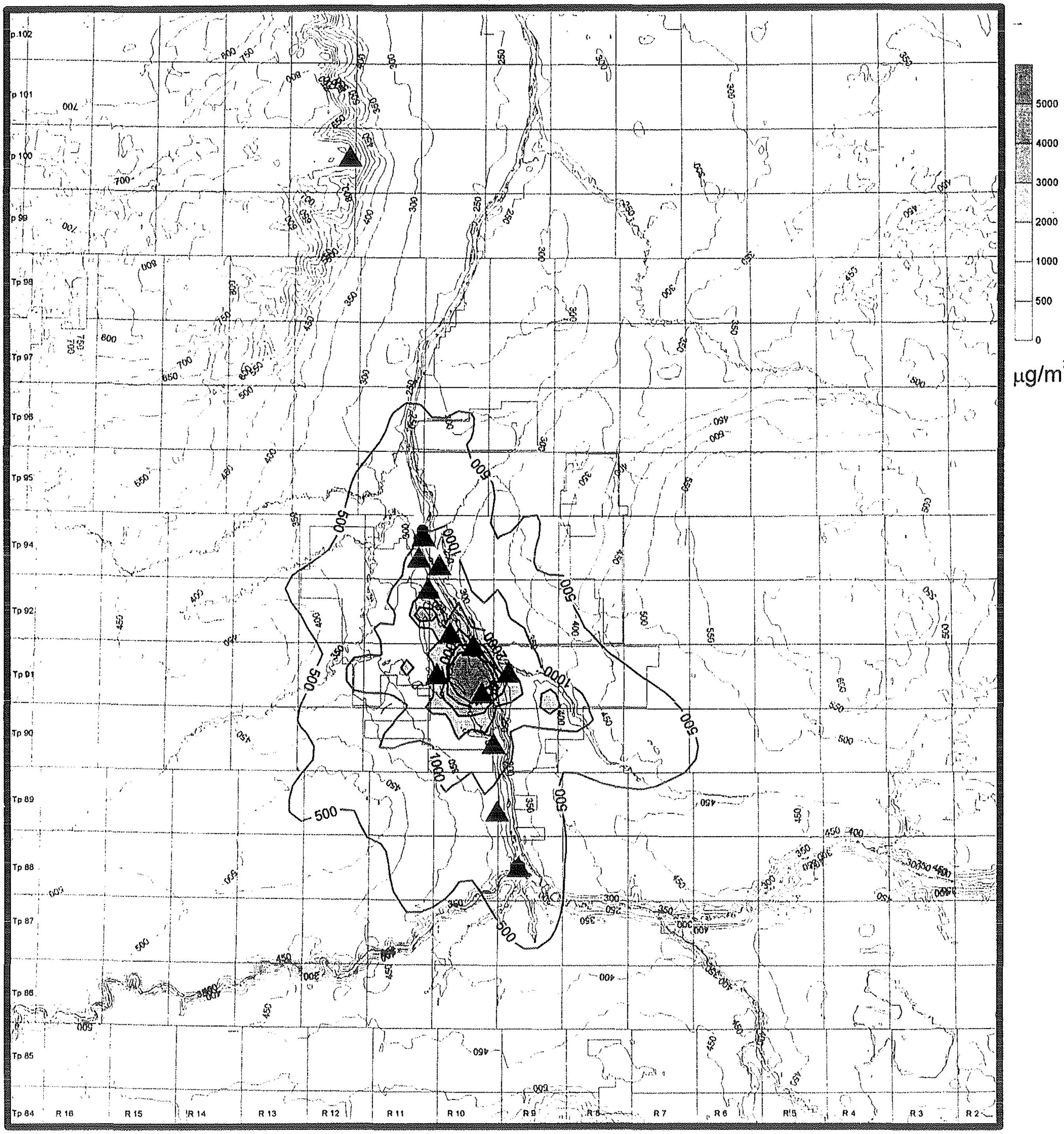
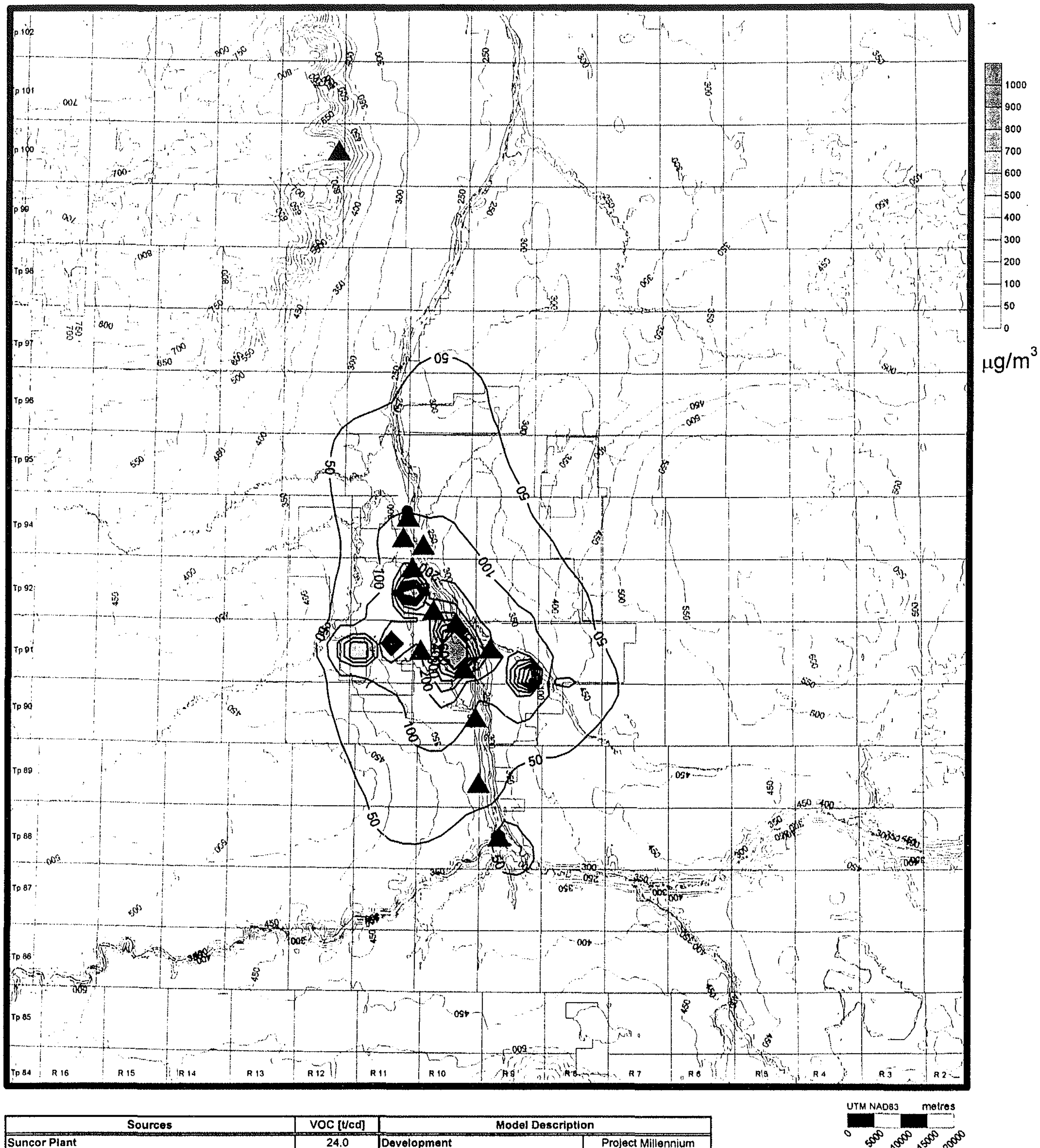


Sources	VOC [t/cd]
Suncor Plant	24.0
Syncrude Plant	5.4
Mine Fleets	2.4
Mine Faces	19.8
Tailings Ponds	226.8
TOTAL	278.4

Model Description	
Development	Project Millennium
Model	ISC3BE

Figure B3-22 Predicted Millennium VOC Maximum Daily Average Ground Level Concentrations in the RSA



Sources	VOC [t/cd]
Suncor Plant	24.0
Syncrude Plant	5.4
Mine Fleets	2.4
Mine Faces	19.8
Tailings Ponds	226.8
TOTAL	278.4

Model Description	
Development	Project Millennium
Model	ISC3BE

Figure B3-23 Predicted Millennium VOC Annual Average Ground Level Concentrations in the RSA

the annual high concentrations occur over the existing and proposed pond areas. Because source characterization simplifications are used to model large sources such as tailings ponds, which include annualized emission rates and homogeneous emissions over the pond's surfaces, maximum concentrations under worst-case meteorology are likely over-estimated very close to the pond. The annual concentrations for selected receptor locations are listed in Table B3-11 and are put into perspective in the health discussion in Section F1.

B3.2.9 TRS Predicted Concentration

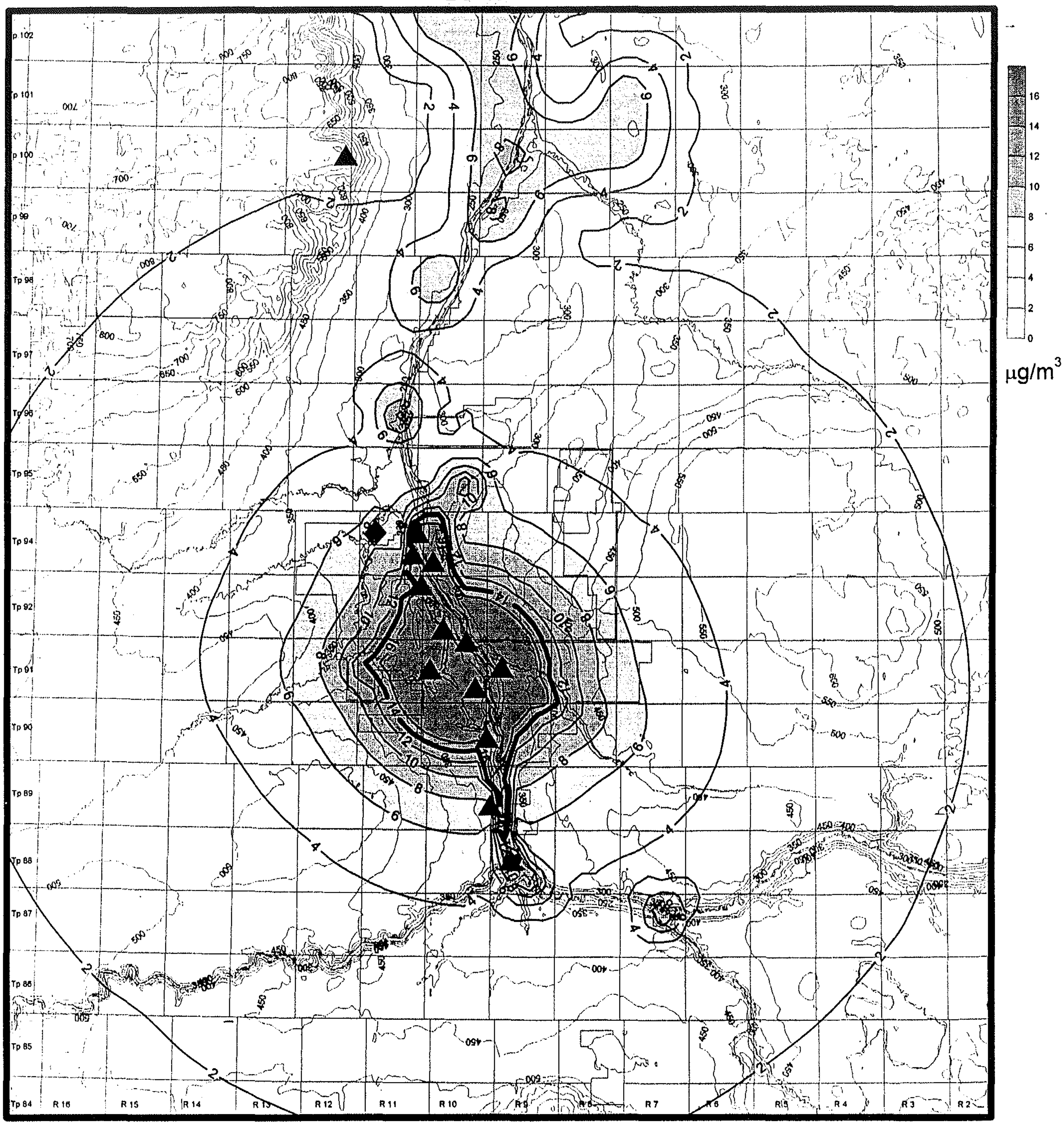
The ambient TRS emission sources associated with Project Millennium and other approved developments are summarized in Section B3.1 (e.g., Tables B3-1 and B3-2). Total estimated TRS emission rate for this case is 5.1 t/cd. The major sources of TRS emissions from Suncor are the tailing ponds and they emit approximately 2.5 t/cd or about 90% of Suncor's total. In total Suncor emits approximately 53% of the TRS. For the purposes of this assessment, TRS has been speciated with VOC emissions, implying that TRS emissions will increase in proportion to VOC emissions. This simplifying assumption over estimates TRS because the TRS emissions from the pond are believed to biogenic in origin.

Selected results of the speciated reduced sulphide compounds are shown in Figure B3-24 and Figure B3-25 for the hourly and daily H_2S and in Figure B3-26 for hourly mercaptans. These TRS species were selected because they have particularly low odour thresholds. Maximum hourly and daily concentrations at selected locations are listed in Table B3-12 and Table B3-13. Similar to the discussion in the VOC section above, the predicted maximum concentration occurs directly over a Suncor tailings pond and the predicted maximum concentration at that location is a result of the modelling simplifications.

Table B3-12 Maximum Predicted Hourly Concentrations of TRS at Selected Sites for Project Millennium Sources

	TRS Concentration [μg/m³]				
Species	Location of Maximum	Mannix	Fort McMurray	Fort McKay	Fort Chipewyan
Total Reduced Sulphur Compounds					
Maximum VOC concentration [μg/m³]	141000	39670	11056	13988	3684
Maximum TRS concentration [μg/m³]	2484	699	195	246	65
Speciated Compounds					
H_2S	180	50.5	14.1	17.8	4.69
COS	0	0	0	0	0
CS_2	0	0	0	0	0
Mercaptans	6.68	1.88	0.52	0.66	0.17
Thiophenes	892	251	70	89	23

Alberta H_2S **hourly** guideline - 15 μg/m³
Odour threshold for H_2S is 0.7 to 14 μg/m³
Odour threshold for mercaptans is 0.04 to 2.0 μg/m³



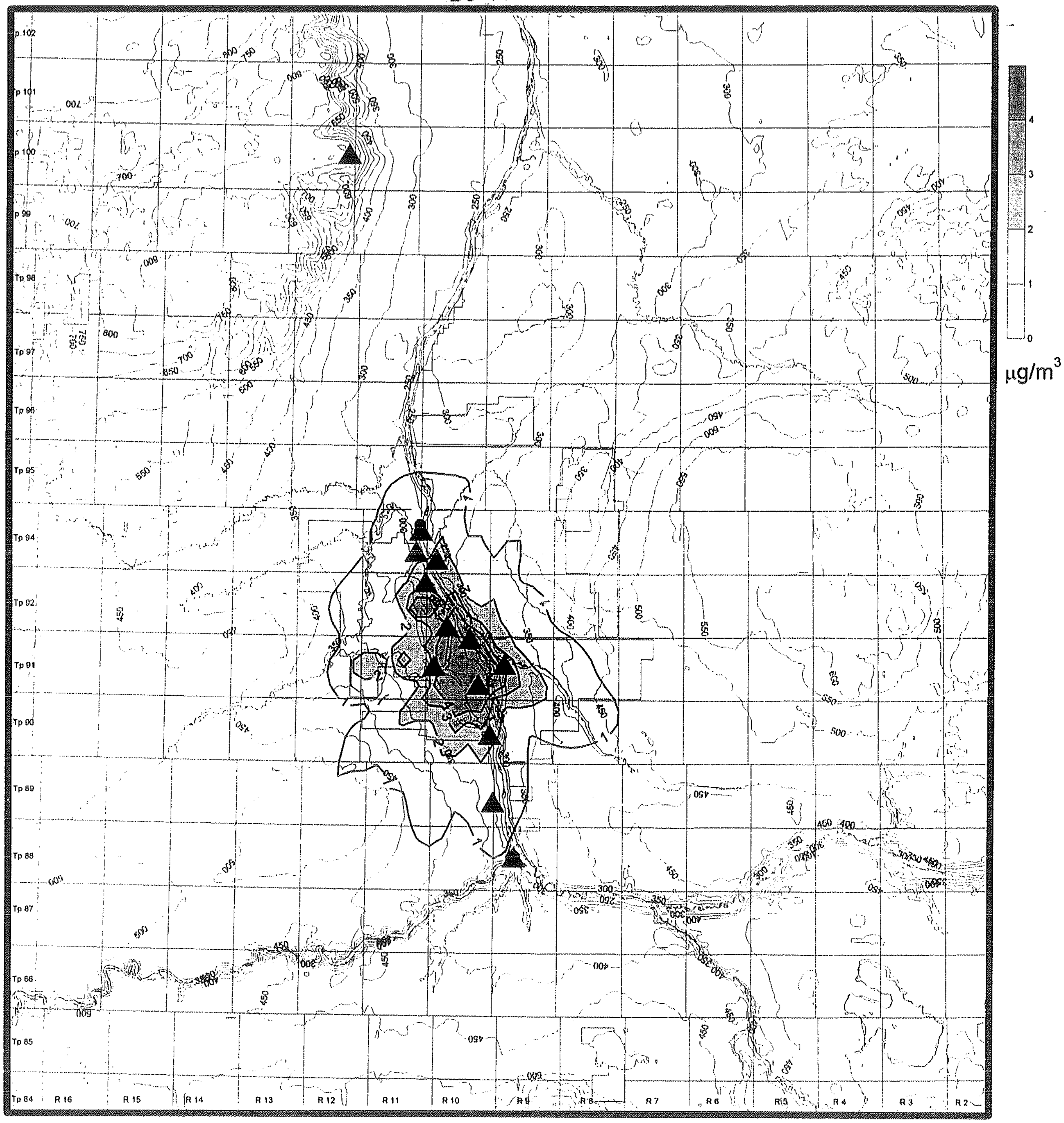
Sources	H_2S [t/cd]
Suncor Plant	0.031
Syncrude Plant	0.007
Mine Fleets	0.003
Mine Faces	0.025
Tailings Ponds	0.289
TOTAL	0.355

Model Description	
Development	Project Millennium
Model	ISC3BE

UTM NAD83 metres
0 5000 10000 15000 20000

r/1997/2200/972-2205/8600/8650/8663/SCBE/FIGS/H2Scd_4H.srf

Figure B3-24 Predicted Millennium H_2S Maximum Hourly Average Ground Level Concentrations in the RSA

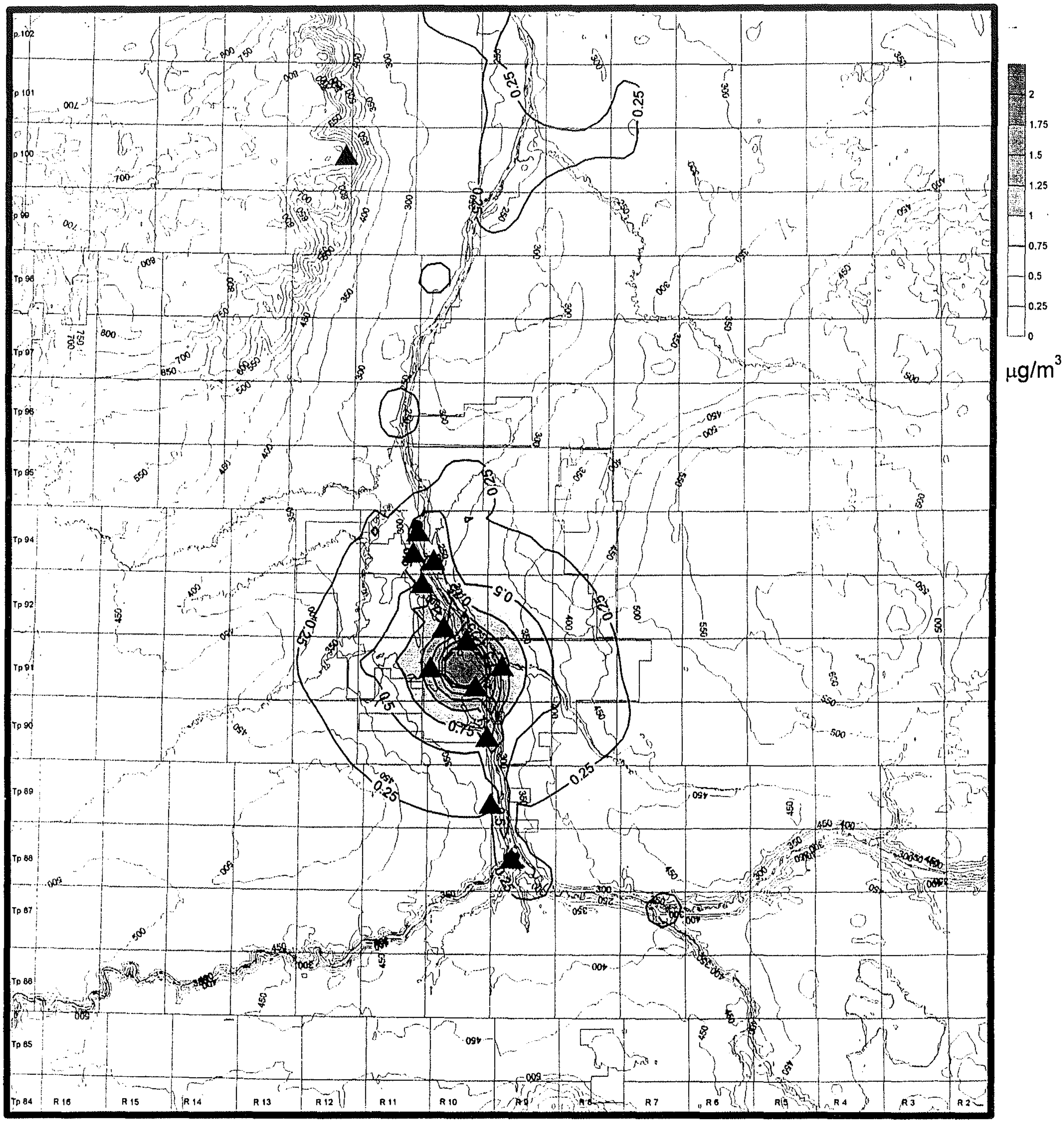


Sources	H_2S [t/cd]
Suncor Plant	0.031
Syncrude Plant	0.007
Mine Fleets	0.003
Mine Faces	0.025
Tailings Ponds	0.289
TOTAL	0.355

Model Description	
Development	Project Millennium
Model	ISC3BE

UTM NAD83 metres
0 5000 10000 15000 20000

Figure B3-25 Predicted Millennium H_2S Maximum Daily Average Ground Level Concentrations in the RSA



Sources	Mercaptans [t/cd]
Suncor Plant	0.0011
Syncrude Plant	0.0003
Mine Fleets	0.0001
Mine Faces	0.0009
Tailings Ponds	0.0107
TOTAL	0.0132

Model Description	
Development	Project Millennium
Model	ISC3BE

Figure B3-26 Predicted Millennium Mercaptans Maximum Hourly Average Ground Level Concentrations in the RSA

Table B3-13 Maximum Predicted Daily Concentrations of TRS at Selected Sites for Project Millennium Sources

Species	TRS Concentration [μg/m³]				
	Location of Maximum	Mannix	Fort McMurray	Fort McKay	Fort Chipewyan
Total Reduced Sulphur Compounds					
Maximum VOC concentration [μg/m³]	92000	10237	1013	1864	221
Maximum TRS concentration [μg/m³]	1621	180	18	33	4
Speciated Compounds					
H_2S	117	13.0	1.3	2.4	0.28
COS	0	0	0	0	0
CS_2	0	0	0	0	0
Mercaptans	4.36	0.49	0.05	0.09	0.01
Thiophenes	582	65	6	12	1

Alberta H_2S daily guideline - 4 μg/m³

Whereas the ISC3BE model was not configured to explicitly assess odours, the concentrations at the selected locations can be used to qualitatively assess the potential for odour detection at these locations. The results presented in the figures do not address the complexities of thorough odour assessment which would take into account concentration magnitude, duration above a threshold, frequency of exceeding various thresholds and receptor sensitivity. As a part of the ISC3BE development, the dispersion coefficients were adjusted for receptors within the Athabasca River valley such that limited mixing could occur under certain meteorological conditions. The result of this fine tuning can be seen in Figure B3-24 in the elevated H_2S concentrations within the Athabasca River valley.

The results in Table B3-12 and Table B3-13 indicate that the predicted concentrations could potentially lead to the detection of odours originating from the developments in the oil sands area for sensitive individuals.

B3.2.10 Noise

Heavy machinery and other on-site activities are likely to increase the background and peak noise levels during construction and throughout the operational phase of Project Millennium. Hence it is of interest to understand the scope and magnitude of the potential impacts arising from project related noise. Industrial noise level assessment are general conducted in reference to the nearest residence or community. If a residence is not close by, then a 1.5 km radius may be prescribed. The closest community that may be affected by the noise from Project Millennium are residents of Fort McKay. The local population for Fort McKay is approximately 360.

Noise may be generated from a variety of on-site activities, including engine noise from truck and shovel operations, extraction, on-site power generation, upgrading operations and increased traffic within the local communities. Currently, noise sources exist at the fixed plant and other mining operations at Suncor's Lease 86/17. Additionally, similar activities at the Syncrude Mildred Lake and Aurora Mine operations will also contribute to the ambient levels experienced in Fort McKay.

A detailed noise assessment was conducted by Syncrude (BOVAR 1996e) for the Aurora Mine that provides good insight to the present case. The Aurora Mine is located approximately 15 km northeast of Fort McKay. Project Millennium is located approximately 25 km southeast of Fort McKay. The Syncrude assessment was conducted on noise levels from hydraulic and electric shovels at the Mildred Lake North Mine, which had been established as the loudest noise source on-site. Assuming similar noise sources for Aurora, noise levels were estimated in Fort McKay assuming a theoretical noise attenuation due to distance, but ignored other attenuation effects such as meteorology, vegetation and barrier effects such as equipment operating below grade level. The noise levels estimated at Fort McKay suggested that the predicted noise due to the mine and background noise would meet the recommended day or night sound levels.

In the case of Project Millennium, the incremental contribution is expected to be less than that described above for other locations because of the increased distance from the Project noise sources to Fort McKay and therefore the greater opportunity for noise levels to attenuate. Also, as Suncor operations located west of the Athabasca River (i.e., closer to Fort McKay) are scaled back in the future, with gradual increased activity on the Millennium site (i.e., further from Fort McKay), one can expect the overall Suncor-derived noise levels to become less at Fort McKay.

B3.2.11 Impact Analyses

The air emissions from the project Millennium case have been described and quantified as a result of Project Millennium. The resulting air quality concentrations have been determined using appropriate models. This approach provides the foundation to determine the Project Millennium air impacts using the approach described in Section A2.1.8. The key questions identified at the beginning of this section can now be addressed.

AQ-1 What impacts will air emissions from Project Millennium have on ambient air quality?

The potential for air emissions to have an impact on ambient air quality has been raised as a concern from Project Millennium. To address this issue, predicted air quality concentrations were modelled using the ISC3BE air dispersion model. The select parameters for air quality are SO_2, NO_2, CO, PM, VOC and TRS. The modelling results were compared to Alberta Ambient Air Quality Guidelines, Canadian Federal Air Quality Objectives or other guidelines to assist in the prediction of impacts. The linkage pathway for this key question is depicted by the narrow line in Figure B3-1. Comparison of emissions and concentrations are presented in Table B3-14. A discussion of each parameter follows:

Table B3-14 Summary of Air Emissions for Project Millennium

Description	Baseline Case(a)	Project Millennium Case(a)	Comments
Suncor Process Information			
Capacity **[bbl/d]**	105,000	210,000	
Emission Rate of SO_2 [t/cd]	65.3	70.2	
Emission Rate of NO_x [t/cd]	47.7	67.7	
Emission Rate of CO [t/cd]	33.5	38.5	
Emission Rate of PM_{10} [t/cd]	1.7	2.2	
Emission Rate of VOC [t/cd]	130	240.4	
Emission Rate of TRS [t/cd]	1.5	2.73	
Predicted SO_2 Concentrations			
Hourly			
• Maximum average [$\mu g/m^3$]	648	870	Below Federal Acceptable
• Exceedance [number]	3	49	
• Areal extent [ha]	33,313	58,860	Approximately 70% in Lease Area
Daily			
• Maximum average [$\mu g/m^3$]	199	200	Below Federal Acceptable
• Exceedance [number]	6	9	
• Areal extent of exceedance [ha]	358	289	In Development Area
Annual			
• Maximum average [$\mu g/m^3$]	74	82	Above Federal Acceptable
• Exceedance [number]	1	1	
• Areal extent of exceedance [ha]	356	409	In Development Area
Predicted NO_2 Concentrations			
Hourly			
• Maximum average [$\mu g/m^3$]	316	320	Below Alberta Guideline
• Exceedance [number]	0	0	
• Areal extent of exceedance [ha]	0	0	
Daily			
• Maximum average [$\mu g/m^3$]	259	260	Above Federal Acceptable
• Exceedance [number]	n/a	101	
• Areal extent of exceedance [ha]	825	2,185	In Development Area
Annual			
• Maximum average [$\mu g/m^3$]	162	162	Above Federal Acceptable
• Exceedance [number]	1	1	
• Areal extent of exceedance [ha]	5,818	8,343	
Predicted CO Concentrations			
Hourly			
• Maximum average [$\mu g/m^3$]	5561	5560	Below Alberta Guideline
• Exceedance [number]	0	0	
• Areal extent of exceedance [ha]	0	0	
8-Hour			
• Maximum average [$\mu g/m^3$]	2226	2226	Below Alberta Guideline
• Exceedance [number]	n/a	n/a	

Description	Baseline Case[(a)]	Project Millennium Case[(a)]	Comments
• Areal extent of exceedance [ha]	n/a	n/a	
Predicted PM Concentrations			
Daily			
• Maximum average [$\mu g/m^3$]	113	113	
• Exceedance [number]	33	33	
• Areal extent of exceedance [ha]	n/a	n/a	
Annual			
• Maximum average [$\mu g/m^3$]	45.8	45.9	
• Exceedance [number]	0	0	
• Areal extent of exceedance [ha]	n/a	n/a	
Predicted VOC Concentrations			
Annual			
• Maximum average [$\mu g/m^3$]	50	76	**Fort McMurray**
• Maximum average [$\mu g/m^3$]	107	163	**Fort McKay**
• Exceedance [number]	n/a	n/a	
• Areal extent of exceedance [ha]	n/a	n/a	
Predicted TRS Concentrations			
Hourly			
• Maximum average H_2S [$\mu g/m^3$]	9.2	14.1	**Fort McMurray**
• Maximum average H_2S [$\mu g/m^3$]	11.7	17.8	**Fort McKay**
• Exceedance [number]	n/a	n/a	
• Areal extent of exceedance [ha]	n/a	n/a	
Daily			
• Maximum average H_2S [$\mu g/m^3$]	**0.9**	1.3	**Fort McMurray**
• Maximum average H_2S [$\mu g/m^3$]	**1.7**	2.4	**Fort McKay**
• Exceedance [number]	n/a	n/a	
• Areal extent of exceedance [ha]	n/a	n/a	

(a) All calculated values based on ISC3BE model unless otherwise noted.
(b) Calculations based on CALPUFF model

Sulphur Dioxide (SO_2)

The ISC3BE model was used to predict SO_2 concentrations resulting from the Project Millennium case. The model provides predicted maximum concentrations, areal extent of land above the Alberta guideline, number of exceedances and the location of the high readings. In comparing the results to historical levels, there has been a substantial decrease in concentrations as shown in Figures B2-11 to B2-15 and emissions (Table B2-2). Using the approach discussed in Section A2 and the analyses summarized in Table B3-15, the following impact predictions and environmental consequences have been derived for SO_2:

- The predicted impacts of hourly SO_2 emissions and concentrations on the air quality are classified as moderate in magnitude, short-term in duration, moderate in frequency, regional in geographic extent and reversible. The environmental consequence of these impacts is low.
- The predicted impacts of daily SO_2 emissions and concentrations on the air quality are classified as moderate in magnitude, short-term in

duration, moderate in frequency, local in geographic extent and reversible. The environmental consequence of these impacts is low.

- The predicted impacts of annual SO_2 emissions and concentrations on the air quality are classified as high in magnitude, mid-term in duration, high in frequency, local in geographic extent and reversible. The environmental consequence of these impacts is moderate.

Table B3-15 Residual Impact Classification for SO_2 Emissions on Ambient Air Quality

SO_2	Magnitude	Duration	Frequency	Geographic Extent	Reversibility	Environmental Consequence
Hourly	Moderate	Short-Term	Moderate	Regional	Reversible	Low
Daily	Moderate	Short-Term	Moderate	Local	Reversible	Low
Annually	High	Mid-Term	High	Local	Reversible	Moderate

Impacts to the annual SO_2 concentrations were assigned a moderate environmental consequence. However, the maximum annual concentration plus the areal extent are all within existing operations. Outside of the Suncor and Syncrude lease boundaries the maximum annual concentrations are predicted to be approximately 20 $\mu g/m^3$ and, therefore, below the annual Alberta guideline of 30 $\mu g/m^3$. The concentrations from Project Millennium at Fort McKay are predicted to be between 5 and 10 $\mu g/m^3$ and at Fort McMurray, less than 5 $\mu g/m^3$. Viewed in this context, it is predicted that there would be no exceedances outside of the lease areas and that the concentrations in the rest of the RSA will be low. Hence the environmental risk is considered to be low and, therefore, this impact is not significant.

Nitrogen Dioxide (NO_2)

The ISC3BE model was used to predict NO_2 concentrations resulting from the Project Millennium case. The model provides predicted maximum concentrations, areal extent of land above the Alberta Guideline, number of exceedances and the location of the high readings. Using the approach discussed in Section A2 and the analyses summarized in Table B3-16, the following impact predictions and environmental consequences have been derived for NO_2:

- The predicted impacts of hourly NO_2 concentrations on the air quality are classified as low in magnitude, short-term in duration, low in frequency, local in geographic extent and reversible. The environmental consequence of these impacts is low.
- The predicted impacts of daily NO_2 concentrations on the air quality are classified as high in magnitude, short-term in duration, moderate in

frequency, local in geographic extent and reversible. The environmental consequence of these impacts is moderate.

- The predicted impacts of annual NO_2 concentrations on the air quality are classified as high in magnitude, mid-term in duration, high in frequency, local in geographic extent and reversible. The environmental consequence of these impacts is moderate.

Table B3-13 Residual Impact Classification for NO_2 Emissions on Ambient Air Quality

NO_2	Magnitude	Duration	Frequency	Geographic Extent	Reversibility	Environmental Consequence
Hourly	Low	Short-Term	Low	Local	Reversible	Low
Daily	High	Short-Term	Moderate	Local	Reversible	Moderate
Annually	High	Mid-Term	High	Local	Reversible	Moderate

Impacts to the daily and annual NO_2 concentrations were assigned a moderate environmental consequence. The maximum daily concentration and the areal extent are all within a small area within the existing operations. There are no exceedances projected outside of the development areas. Daily concentrations are predicted to be well below 100 $\mu g/m^3$ at Fort McKay and Fort McMurray. The maximum annual concentration plus the areal extent are also centered in the existing operational area but occupy a larger area. There are no exceedances predicted outside the development areas. Annual concentrations at both Fort McKay and Fort McMurray are predicted to be between 20 and 40 $\mu g/m^3$. Viewed in this context of low concentrations outside the mine pits, the environmental consequence of the NO_2 emissions is rated as low and, therefore, this impact is not significant.

Carbon Monoxide (CO)

The ISC3BE model was used to predict CO concentrations resulting from the Project Millennium case. The model provides predicted maximum concentrations, areal extent of land above the Alberta guideline, number of exceedances and the location of the high readings. Using the approach discussed in Section A2 and summarized in Table B3-17, the following impact predictions and environmental consequences have been derived for CO:

- The predicted impacts of hourly CO emissions and concentrations on the air quality are classified as low in magnitude, short-term in duration, low in frequency, local in geographic extent and reversible. The environmental consequence of these impacts is low.
- The predicted impacts of 8-hour CO emissions and concentrations on the air quality are classified as low in magnitude, short-term in duration,

low in frequency, local in geographic extent and reversible. The environmental consequence of these impacts is low.

Table B3-17 Residual Impact Classification for CO Emissions on Ambient Air Quality

CO	Magnitude	Duration	Frequency	Geographic Extent	Reversibility	Environmental Consequence
Hourly	Low	Short-Term	Low	Local	Reversible	Low
8-Hour	Low	Short-Term	Low	Local	Reversible	Low

Particulate Matter (PM)

The ISC3BE model was used to predict PM concentrations resulting from the Project Millennium. The model provides predicted maximum concentrations, concentration contours and the location of the high readings. The results were compared to the Alberta suspended particulate guideline and the U.S. EPA PM_{10} guidelines. Using the approach discussed in Section A2 and summarized in Table B3-18, the following impact predictions and environmental consequences have been derived for PM:

- The predicted impacts of daily PM emissions and concentrations on the air quality are classified as moderate in magnitude, short-term in duration, moderate in frequency, local in geographic extent and reversible. The environmental consequence of these impacts is low.
- The predicted impacts of annual PM emissions and concentrations on the air quality are classified as low in magnitude, mid-term in duration, low in frequency, local in geographic extent and reversible. The environmental consequence of these impacts is low.

Table B3-18 Residual Impact Classification for PM Emissions on Ambient Air Quality

PM	Magnitude	Duration	Frequency	Geographic Extent	Reversibility	Environmental Consequence
Daily	Moderate	Short-Term	Moderate	Local	Reversible	Low
Annually	Low	Mid-Term	Low	Local	Reversible	Low

Volatile Organic Components (VOC)

The ISC3BE model was used to predict VOC concentrations resulting from the Project Millennium case. The model provides predicted maximum concentrations, concentration contours and the location of the high readings.

Using the unique fingerprint of each emission source, specific VOCs were speciated from the modelling results.

No impact predictions and environmental consequences have been established for VOCs (and the speciated VOCs) in the air section as VOCs are an input into the health section (F1).

Total Reduced Sulphur (TRS)

The ISC3BE model was used to predict TRS concentrations resulting from the Project Millennium case. The major source of TRS is the Suncor ponds. TRS emissions were conservatively assumed to increase in relation to the increase in VOCs for this assessment. It is more likely that the generation of TRSs result from biogenic activity in the pond thus and are expected to remain similar to the existing Baseline case. The ISC3BE model was used to predict maximum VOC concentrations, concentration contour maps, and the location of high readings. From these data, H_2S concentrations were speciated for the TRS assessment end point. There are Alberta guidelines for H_2S based on odour detection limits. Using the approach discussed in Section A2 and summarized in Table B3-19, the following impact predictions and environmental consequences have been derived for TRS:

- The predicted impacts of hourly TRS concentrations on the air quality are classified as high in magnitude, short-term in duration, moderate in frequency, regional in geographic extent and reversible. The environmental consequence of these impacts is moderate.
- The predicted impacts of daily TRS concentrations on the air quality are classified as high in magnitude, short-term in duration, moderate in frequency, local in geographic extent and reversible. The environmental consequence of these impacts is moderate.

Table B3-19 Residual Impact Classification for TRS Emissions on Ambient Air Quality

TRS	Magnitude	Duration	Frequency	Geographic Extent	Reversibility	Environmental Consequence
Hourly	High	Short-Term	Moderate	Regional	Reversible	Moderate
Daily	High	Short-Term	Moderate	Local	Reversible	Moderate

Impacts to the hourly and daily TRS concentrations were assigned a moderate environmental consequence. However, the conservative modelling assumptions are likely to over-estimate TRS because the TRS emissions from the pond are believed to be biogenic in nature and not a function of total VOC emission. It is more likely that there will not be an increase in TRS emissions from the existing Baseline rates. Although TRS may continue to be an occasional odour issue, odour abatement programs have been ongoing at both Suncor and Syncrude and there has been a decrease in complaints from over 275 to less than 20 per year. Hourly concentrations are predicted to be below the H_2S guideline for this component at both Fort McKay and Fort McMurray. The maximum daily concentrations of H_2S are centered in the existing operational area. There are no exceedances predicted outside the development areas. Daily concentrations of H_2S at both Fort McKay and Fort McMurray are predicted to be well below the Alberta guideline. Viewed in this context of low concentrations outside the existing operational areas and the potential of no net increase in emission rates, the environmental consequence of the TRS emissions is rated as low and, therefore, this impact is not significant.

AQ-2 What impacts will air emissions from Project Millennium have on the deposition of acid forming compounds?

The CALPUFF model was used for predicting the PAI resulting from the Project Millennium case. The CALPUFF model is a good tool for estimating the PAI in the oil sands region as it takes into account the chemical transformations of the emitted SO_2 and NO_x and predicts wet (rain and snow scavenged) and dry (via an effective dry deposition velocity) deposition of SO_2, SO_4, NO, NO_2, NO_3^-, and HNO_3. A background PAI of 0.1 keq/ha/y has been incorporated into the PAI presented numbers. This value was based on estimates of sulphur and nitrogen and base cation concentrations and depositions in the region surrounding the RSA. The linkage pathway for this key question is depicted by the bolded line in Figure B3-1. Comparisons of emissions and concentrations are presented in Table B3-20 and discussed below:

- The predicted PAI exceeds the Alberta interim critical loading for sensitive soils (0.25 keq/ha/y) over an area of 861,263 ha (35.5% of the RSA). The areal extents where the PAI exceeds the critical loadings being considered for less sensitive soils are: 195,695 ha (8.1% of the RSA) above 0.50 keq/ha/y; and 9,598 ha (0.4% of the RSA) above 1.0 keq/ha/y.
- The maximum predicted PAI of **24.7** keq /ha/y occurs in the development area, in the immediate vicinity of the open pit mines.
- The maximum predicted sulphate deposition rate of **1.98** keq/ha/y is predicted to occur in the active plant area.
- The highest predicted deposition rate of nitrates (**23.6** keq/ha/y) occurs in the development area, adjacent to the open pit mines.
- The maximum wet and dry deposition rates (including both the sulphate and nitrate species) are **0.77** and **24.5** keq/ha/y, respectively. These maximums occur in the vicinity of the active open pit mines.

Table B3-20 Summary of Deposition of Acid Forming Compounds for Project Millennium

	Baseline Case[a]	Project Millennium Case[a]	Comments
Suncor Process Information			
Capacity	105,000	210,000	
Emission Rate of SO_2 t/cd	65.3	67.9	
Emission Rate of NO_x t/cd	47.7	67.7	
Predicted PAI			
Areal extent > 0.25 keq/ha/y [ha]	670,483	861,263	
Areal extent > 0.50 keq/ha/y [ha]	11,543	195,695	
Areal extent > 1.0 keq/ha/y [ha]	3,206	9,598	In Development Area
Maximum average [keq/ha/y]	**24.6**	**24.7**	In Development Area
Predicted Acidic Deposition Rates			
Sulphate (wet + dry) Maximum average [keq/ha/y]	**1.96**	**1.98**	In Development Area
Nitrate (wet + dry) Maximum average [keq/ha/y]	**22.5**	**23.6**	In Development Area
Wet Deposition (sulphate + nitrate) Maximum average [keq/ha/y]	**0.77**	**0.77**	In Development Area
Dry Deposition (sulphate + nitrate) Maximum average [keq/ha/y]	**24.4**	**24.5**	In Development Area

(a) All calculated values based on CALPUFF model.

No impact predictions and environmental consequences have been established for PAI in the air section as PAI is an input into the water quality, soil and terrain, terrestrial vegetation and wetlands evaluations presented in Sections C3.2, D2.2 and D3.2, respectively.

AQ-3 What impacts will air emissions from Project Millennium have on concentrations of ground level ozone (O_3)?

The prediction of ground level ozone (O_3) concentrations is complex because ozone results from a series of chemical reactions in the atmosphere rather than being a direct emission. To simulate the formation of ozone, it is essential that the model developed considers all of the releases from natural or industrial activities combined with an accurate simulation of the meteorological conditions over the region. Compounding these difficulties is the fact that many of the emissions in the region can bring about a decline in the ozone as a result of chemical transformations. Therefore, only minor discrepancies in the emission values used can result in completely different predictions.

In order to address the regional issue of ground level ozone effectively, a separate Working Group has been established with industrial, technical and regulatory representatives to identify suitable methodologies to undertake the assessment and initiate a comprehensive evaluation. The Working Group has identified the CALGRID model as the most appropriate tool for achieving the said goals of simulating the ground level ozone in the oil sands region, and have retained EARTH TECH to conduct the analysis. The results of the CALGRID modelling are expected to provide improved estimates of the expected future ozone trends for the region. The current schedule for initial completion of the EARTH TECH study is in October 1998.

B4 AIR QUALITY CUMULATIVE EFFECTS ASSESSMENT

B4.1 EMISSION SOURCES AND BASELINE DATA

B4.1.1 Introduction

The Cumulative Effects Assessment (CEA) requires a review of all the existing and approved developments, Project Millennium and planned future developments. This section describes the air emission sources that are considered in developing the CEA. The data for the existing and approved operations are based on approved and operating conditions and are summarized in Section B2.1.1. The air emission data for Project Millennium are based on design and are summarized in Section B3.1. The air emission data for the planned developments are based on best estimates as provided by the proponents or have been estimated based on the existing Suncor and Syncrude operations. These emissions and resultant concentrations are summarized in this section of the report.

The objective of the cumulative air emissions impact analysis is to identify and analyze the potential combined effects associated with Project Millennium and other disclosed developments in the region. The air quality impact analysis focuses on determining changes to the chemical composition of the air and not on the effect these changes may have on receptors. Effects of air quality changes to aquatics, terrestrial ecosystems and human health are discussed in the Aquatics Section C, Terrestrial Resources Section D and the Human Health Section F1.

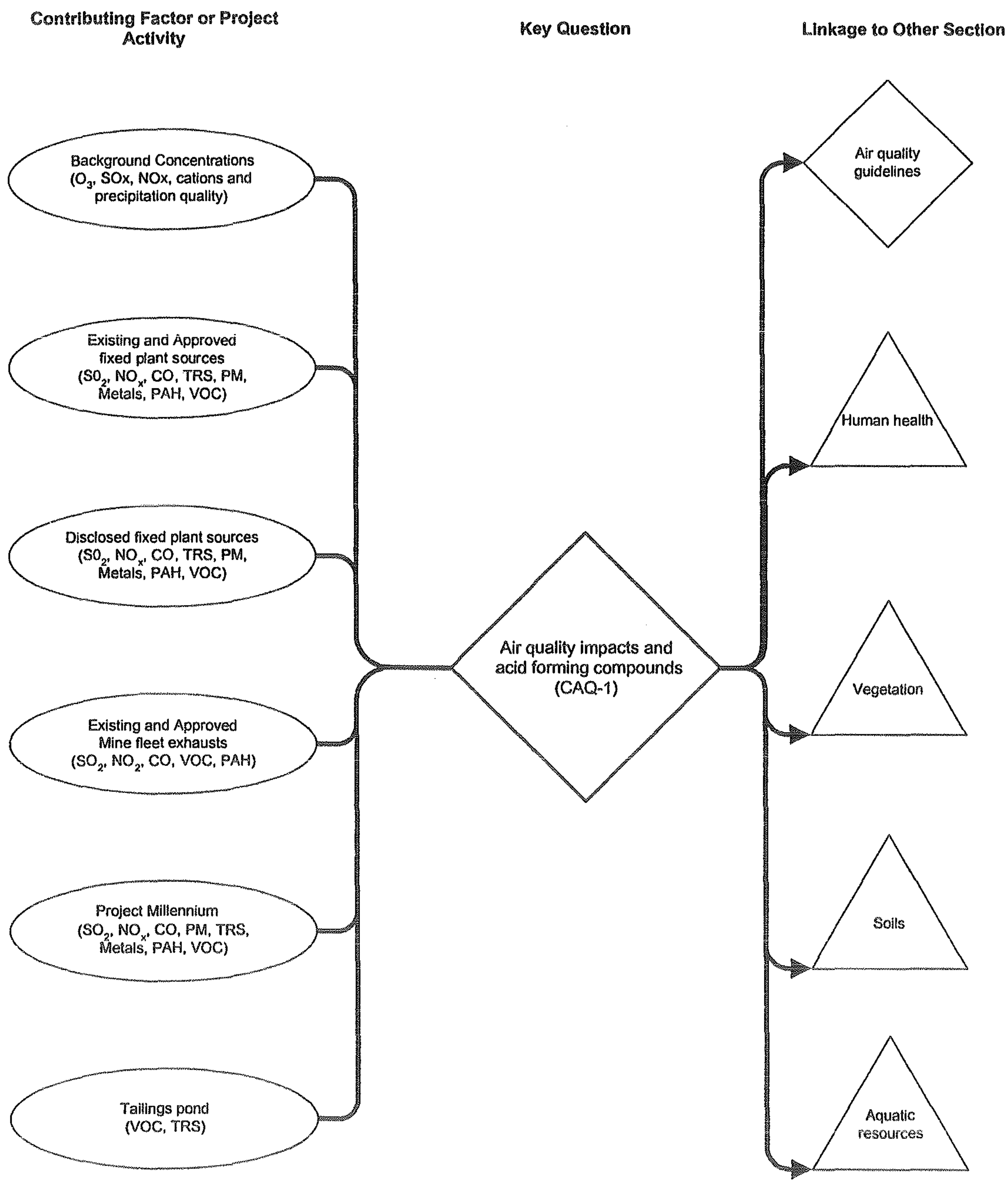
The following overall key question is addressed in this CEA:

CAQ-1: What impacts to ambient air quality and acidification of water, soils and vegetation will result from air emissions associated with Project Millennium and the combined developments?

The potential for air emissions from Project Millennium and combined developments to impact on ambient air quality and the acidification of water, soils and vegetation has been raised as a cumulative concern in the region. This issue was addressed in two stages. The first stage looked at the potential impacts on air quality by predicting air concentrations of SO_2, NO_2, CO, PM, VOC and TRS using the ISC3BE dispersion model. The model results were then compared to Alberta Ambient Air Quality Guidelines, Canadian Federal Air Quality Objectives or other guidelines to assist in the prediction of impacts. The potential for acidification of water, soils and vegetation was then addressed by using the CALPUFF dispersion model to determine the Potential Acid Input (PAI) resulting from the SO_2 and NO_x emitted by Project Millennium and the combined developments. The resulting PAI values were presented in a manner suitable for comparison to appropriate evaluation parameters. In particular the PAI results were incorporated into the Cumulative Aquatics (C6) and

Cumulative Terrestrial (D5) sections of this EIA. The linkage pathway for this key question is depicted in Figure B4-1.

Figure B4-1 Air Quality Linkage Diagram for the CEA



B4.1.2 Emission Projections

B4.1.2.1 Suncor

The Project Millennium section describes the total planned air emissions by Suncor at this time. No additional sources of air emissions were considered in the CEA.

B4.1.2.2 Syncrude

The baseline section of this report (Section B2.1) summarizes the existing and approved emissions from the Syncrude site. Project 21, the Mildred Lake Upgrader Expansion, is a new development project planned by Syncrude. The plan is to expand the existing upgrader to an overall capacity of 480,000 b/d. Predicted air emissions for the proposed upgrader were provided by Syncrude's. In completing the CEA for this project, the new air emissions from the Upgrader were combined with the existing and approved emissions. The resultant Syncrude air emissions are summarized in Table B4-2.

B4.1.2.3 Other Existing or Approved Developments

All air emissions from other approved developments were considered in the baseline section of this report (Section B2.1). No additional sources of air emissions from other existing or approved developments were considered in the CEA.

B4.1.2.4 Transportation and Residential Sources

Future changes were estimated for the air emissions from transportation and residential sources. Table B4-1 presents the estimated air emissions data for transportation and residential sources based on a Fort McMurray population of 49,500 in 2006. These data were used in the prediction of air quality for the CEA.

Table B4-1 Summary of Estimated CEA Emissions From Transportation and Residential Sources

	Emission (t/cd)				
Source	**SO_2**	**NO_x**	**CO**	**PM**	**VOC[(a)]**
Highway	0.07	0.54	**1.9**	0.50	0.33
Fort McMurray					
Traffic	0.222	1.473	**5.6**	1.504	2.314
Residential Natural Gas	0.003	0.162	**0.17**	0.022	0.049
Residential Wood	0.004	0.024	**2.2**	0.298	1.279
Fort McKay					
Traffic	<0.001	<0.001	**<0.001**	<0.001	<0.001
Residential Natural Gas	<0.001	0.007	**0.003**	<0.001	<0.001
Residential Wood	<0.001	0.000	**0.014**	0.002	0.01
Total	**0.299**	**2.206**	**9.9**	**2.33**	**4.34**

(a) assume THCs equals VOCs.

B4.1.2.5 Planned Developments

A number of additional developments are in the planning stage that could result in air emissions in the region. The planned projects are presented in Table A4-1 and the air emissions from these planned projects are summarized in Table B4-2 and discussed below.

- **Syncrude Project 21 Mildred Lake Upgrader Expansion.** Syncrude is developing plans to expand the existing upgrader to an overall capacity of 480,000 b/d. This is an expansion of 180,000 b/d and will result in increased air emissions. Predicted air emissions for the proposed upgrader were provided by Syncrude. The air emissions are combined with the existing and approved developments and summarized in Table B4-2.

- **Mobil Kearl Oil Sands Mine and Upgrader.** Mobil Oil proposes to develop the Kearl Oil Sands Mine project comprising of a 130,000 b/d mine and associated upgrader. The mine will be a truck and shovel operation. Air emissions from the proposed extraction plant and upgrader were provided by Mobil. Specifically, extraction emissions were scaled from the proposed Aurora North Mine plant on the basis of production and upgrader emissions were scaled from the proposed Syncrude 8-3 coker.

- **Shell Muskeg River Mine Project.** Shell Canada has submitted an Application and Environmental Impact Assessment for the development of the Muskeg River Mine Project located on the western portion of Lease 13 (Shell 1997). Shell also disclosed an interest in further development of Lease 13 East. The nominal bitumen production capacity of the proposed Muskeg River and Lease 13 East developments are 150,000 b/d and 200,000 b/d, respectively.

  The Muskeg River Mine plant will be serviced by six fired heaters and two boilers. No upgrader is planned for the site. The Lease 13 East plant emissions were scaled (for the fired heaters and boilers) from the Muskeg River Mine values on the basis of bitumen production.

- **Gulf Surmont.** Gulf Canada Resources Limited has disclosed an intent to operate a SAGD in-situ project with a bitumen production capacity of 100,000 b/d (Gulf 1997). The operation will consist of five sites, each with a production capacity of 20,000 b/d. Preliminary engineering indicate that each site will be serviced by four natural gas fired boilers. Each boiler was assumed to be serviced by a separate stack.

- **Petro-Canada MacKay River.** Petro-Canada proposes to develop the MacKay River SAGD in-situ project with an initial design production capacity of 20,000 b/d of bitumen. The preliminary design is for five boilers, each served by a separate stack.

- **JACOS Hangingstone.** The JACOS Hangingstone in-situ SAGD development has recently received approval for Phase I at 2,000 b/d and is scheduled to ramp up to 10,000 b/d by 2001. The estimated emissions from this development are based on information in the approved development application and scaled up where necessary to the ultimate production rate of 10,000 b/d.

- **Fee Lot 2 Development.** Suncor Energy Inc. is planning a number of developments on Fee Lot 2. At this time, it appears that such development will not significantly increase air emissions.

Table B4-2 Summary of Estimated CEA Air Emissions from Planned or Exisiting Developments

Source	Emission (t/cd)					
	SO_2	NO_x	CO	PM[a]	VOC[c]	TRS
Planned Developments						
Syncrude - **Application**						
Main Stack	188.0	14.8	55.2	4.3	0.003	0.000
8-3	**12.0**	3.5	13.5	2.9	0.002	0.000
Secondary Sources	0.0	26.4	7.8	2.6	0.3	0.000
Plant **(Fugitive)**	0.0	0.0	0.0	0.0	9.6	3.100
Mine Fleet **(Fugitive)**	1.0	19.2	**5.1**	**0.5**	0.9	0.000
Ponds (Fugitive)	-	-	-	-	22.2	0.399
Mine Surface (Fugitive)		-	-	-	12.2	**0.08**
Total Syncrude	**201.0**	**63.9**	**81.5**	**10.4**	**45.2**	**3.6**
Aurora North (4 trains)	**0.59**	**18.0**	**4.3**	**0.78**	**7.9**	**0.065**
Shell Muskeg River	**0.63**	**16.0**	**4.2**	**0.63**	**5.3**	**0.03**
Shell Lease 13 East	**0.84**	**21.0**	**5.6**	**0.83**	**5.5**	**0.03**
Mobil Kearl Oil Sands Mine	**18.0**	**13.0**	**2.9**	**0.6**	**4.3**	**0.025**
Petro-Canada McKay River	**0.0**	**1.4**	**0.69**	**0.086**	**0.024**	**0.0**
Koch (SOLV-EX)	**3.5**	**0.65**	**0.16**	**0.42**	**0.014**	**0.0**
Northstar UTF	**0.0**	**0.22**	**0.06**	**0.019**	**0.004**	**0.0**
Gulf Surmont	**0.0**	**0.68**	**3.5**	**0.43**	**0.12**	**0.0**
JACOS Hangingstone	**0.02**	**2.0**	**0.22**	**0.028**	**0.008**	**0.0**
Northlands Forest Products	**0.02**	**0.19**	**25.0**	**0.19**	**2.1**	**0.0**
Total (other)	**24.0**	**88.0**	**50.0**	**5.3**	**36.0**	**0.24**

n/a data not available.
- not a source of this emission.
(a) Assumed as PM_{10}.
(b) Estimate based on CAPP emission factor.
(c) Assume THCs equals VOCs.

Note: The updated values in the above table represent the latest estimates of emissions as detailed in Technical Reference for Meteorology, Emissions and Ambient Air Quality in the Athabasca Oil Sands Region (Golder and Conor Pacific 1998). The dispersion modelling results presented in the figures were based on the original emission estimates (as tabulated at the bottom of each figure). All of the original estimates were higher than the latest estimates, therefore model results are conservative.

B4.1.2.6 Summary of CEA Emissions

Table B4-3 summarizes the air emission estimates used in the CEA from Suncor, Syncrude, other industries, and transportation and residential sources in the oil sands region. The level of confidence in the data are high for the existing, approved and Project Millennium developments. Assumptions have been made in the air emission data for the planned developments and therefore the level of confidence for this data is lower.

Table B4-3 Summary of Estimated CEA Emissions in the Athabasca Oil Sands Region

Source	Emission Rates (t/cd)					
	SO_2	NO_x	CO	PM_{10}	VOC	TRS
Suncor	70.2	67.7	12.9	3.8	233.0	2.7
Syncrude	201.0	63.9	84.5	10.4	45.2	3.58
Other Industries	24.09	88.1	50.5	5.3	35.7	0.24
Transportation and Residential	0.299	2.206	9.89	2.33	4.34	-
Total	296.0	222.0	158.0	21.8	318.0	6.5

Note: The updated values in the above table represent the latest estimates of emissions as detailed in Technical Reference for Meteorology, Emissions and Ambient Air Quality in the Athabasca Oil Sands Region (Golder and Conor Pacific 1998). The dispersion modelling results presented in the figures were based on the original emission estimates (as tabulated at the bottom of each figure). All of the original estimates were higher than the latest estimates, therefore model results are conservative.

B4.2 PREDICTIONS

B4.2.1 Model Approach and Limitations

Descriptions of the models used to determine the predicted ground level concentrations were discussed in Section B2.2.1. In this CEA the same models were used, in particular the ISC3BE and CALPUFF, for determining predicted concentrations of air emissions.

B4.2.2 SO_2 Predicted Concentrations

The SO_2 emission sources associated with this CEA are summarized in Section B4.1 (Table B4-3). The estimated total SO_2 emission rate in the oil sands region for the CEA is 292.2 t/cd. Suncor will emit an estimated 24% (70.2 t/cd) of the total SO_2 emissions to the atmosphere.

The predicted maximum hourly, daily and annual ground level ambient SO_2 concentrations resulting from all emissions sources presented in Section 4.1 were estimated using the ISCBE model. Average annual ground level SO_2 concentrations were also estimated using the CALPUFF model. These models provide an efficient means of estimating the predicted ambient SO_2 concentrations from all sources and provides an indication where maximum concentrations could occur.

The modelling predictions for daily SO_2 emission rate cases are summarized in Table B4-4 for each model. The predicted ground level concentrations are mapped in Figures B4-2 to B4-5 and described below:

- Figure B4-2 shows the maximum hourly average SO_2 ground level concentrations (GLC) associated the CEA for the ISC3BE model. An overall maximum hourly average SO_2 concentration of 872 $\mu g/m^3$ is predicted to occur at a location 2 km south of Suncor within the existing facilities (Figure B4-2). This maximum average value exceeds the Alberta Ambient Air Quality Guideline (AAAQG) of 450 μg/m^3. This model predicts three areas that result in maximum hourly averages in excess of the AAAQG. The areas (54,269 ha) are located south and east of the Suncor (mainly within Suncor and Syncrude leases) and an area northwest of Suncor (near Mobil). The ISC3BE model predicts 50 yearly exceedances per year of the hourly AAAQG.

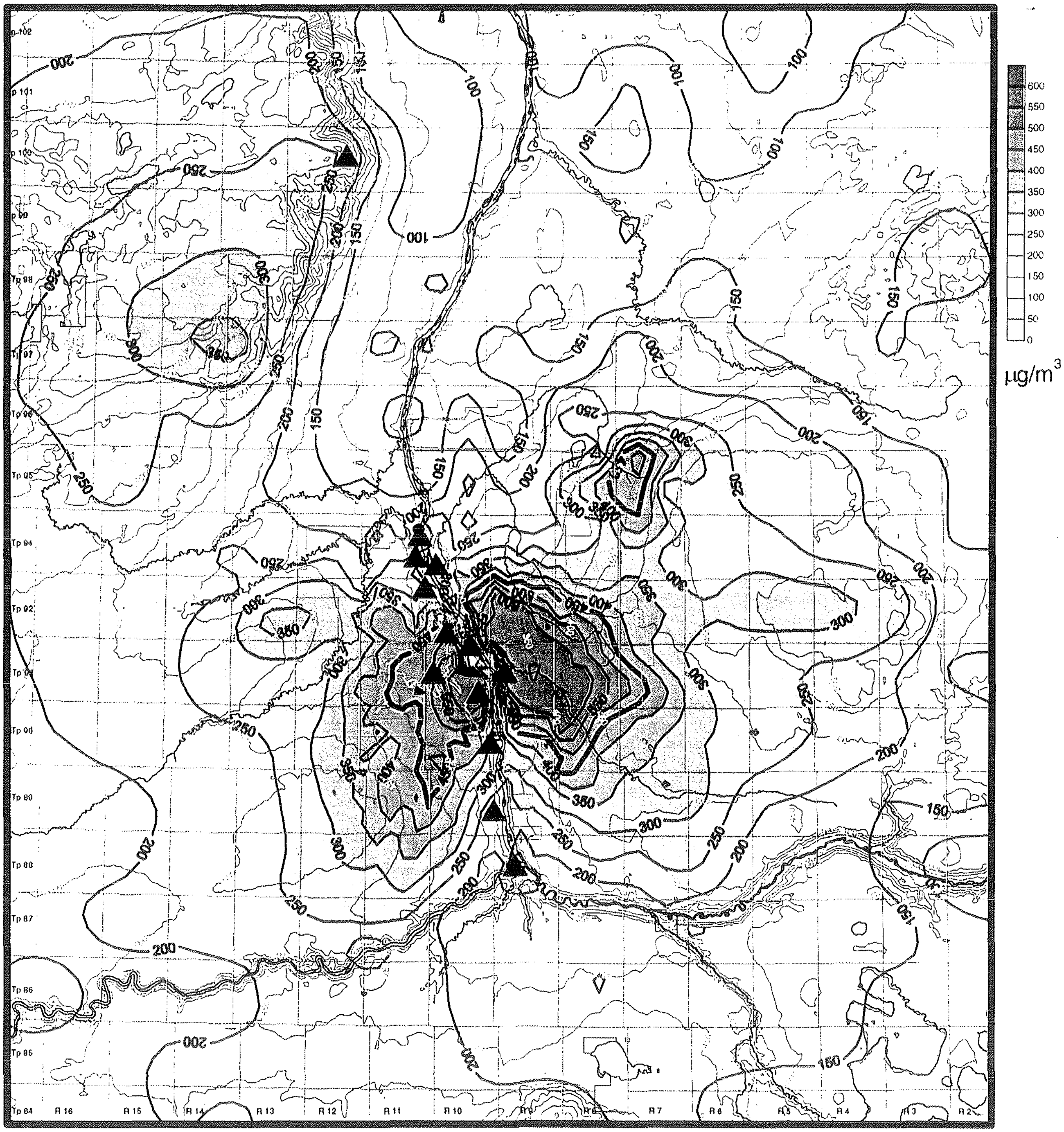
Figure B4-3 shows the maximum daily average SO_2 GLC associated with this CEA for the ISC3BE model. The overall maximum daily average SO_2 concentration of 188 μg/m^3 is predicted to occur very close to the Suncor plant and within the lease boundaries. This maximum average value exceeds the daily AAAQG of 150 μg/m^3. The predictions shown in Figure B4-3 indicate a small area of 270 ha that will have maximum average in excess of the Guideline. The model predicts one exceedance per year of the daily AAAQG guideline.

- Figures B4-4 and B4-5 show the annual average ground level concentration map for SO_2 for the ISC3BE and CALPUFF models, respectively. The maximum annual average concentration, as determined by ISC3BE, is 46.1 μg/m^3 located in the Syncrude development area and covering an area of approximately 540 ha. The predicted concentrations are in excess of the AAAQG of 30 μg/m^3.

Table B4-4 Maximum Predicted Ground Level Concentrations of SO_2 for CEA Sources

Source	Hourly	Daily	Annual
CEA - ISC3BE[(b)]			
Maximum SO_2 Concentration (μg/m^3)	872	188	46.1
Location of Maximum Concentration (km)	4 S	2 SSW	15 WNW
Maximum Number of Exceedances[(a)]	50	1	1
Location of Maximum Exceedances (km)	2 SSW	4-SSW	n/a
SO_2, Alberta Guideline (μg/m^3)	450	150	30
SO_2, Federal Acceptable (μg/m^3)	900	300	60

n/a data not available
(a) Exceeds SO_2 Alberta Guideline. Normalized for a 12-month period.
(b) Based on Stream day emission rates for hourly and daily; Calendar day for annual.
(c) Assume THCs equals VOCs.



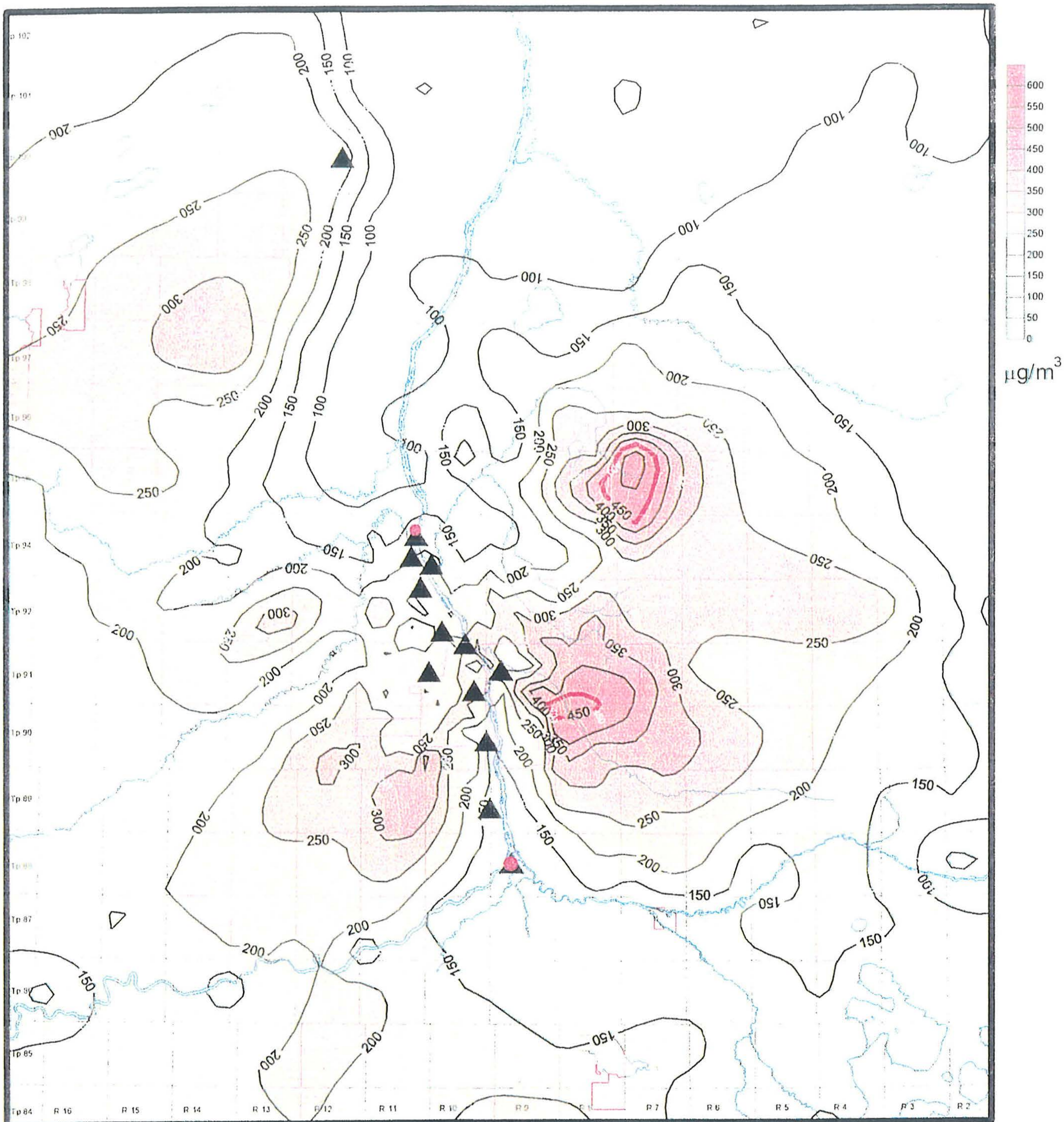
Sources	SO_2 [t/cd]
Suncor	
Powerhouse	1 2
FGD	19 7
Incinerator	10 2
Flaring	1 3
Tail Gas Treatment Unit	5 2
Other Sources Suncor	6 2
Syncrude (total)	109
Other Emissions (total)	4 2
Other Proposed Emissions (total)	18 8
TOTAL	265 8

Model Description	
Development	CEA
Model	ISC3BE (7BG)
SO_2 Guideline [µg/m³]	450
Maximum [µg/m³]	872
Exceedences / Year [#]	50

Note: Results are based on a 1 year simulation

UTM NAD83 metres
0 5000 10000 15000 20000

Figure B4-2 Predicted CEA SO_2 Maximum Hourly Average Ground Level Concentrations in the RSA using the ISC3BE Model

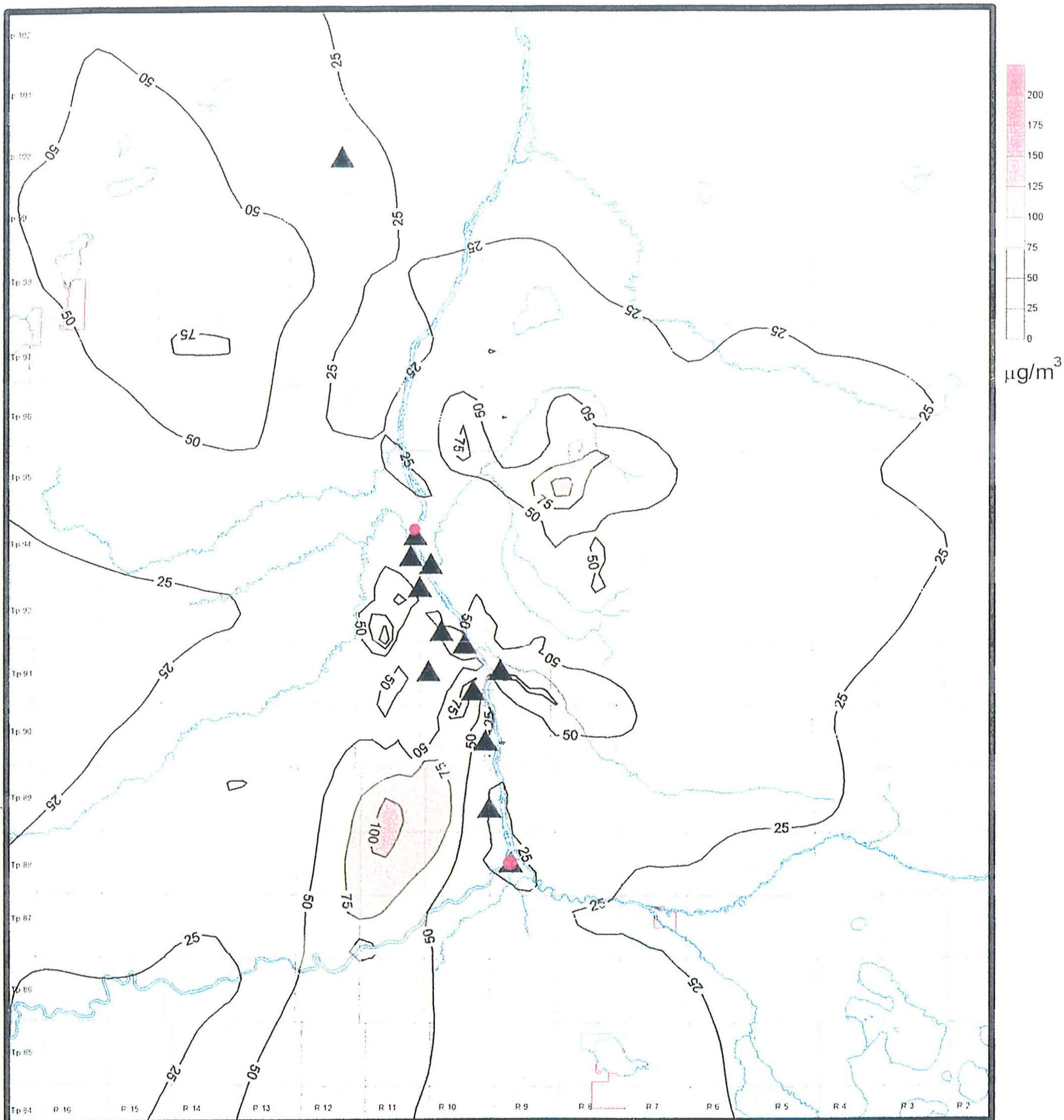


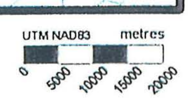
Sources	SO_2 [t/sd]
Suncor	
Powerhouse	1.2
FGD	19.7
Incinerator	10.2
Flaring	1.3
Tail Gas Treatment Unit	5.2
Other Sources, Suncor	0.08
Syncrude (total)	201
Other Emissions (total)	4
Other Proposed Emissions (total)	19.8
TOTAL	262.5

Model Description	
Development	CEA
Model	ISC3BE (7BG)
SO_2 Guideline [µg/m³]	450
Maximum [µg/m³]	557
Exceedences / Year [#]	1

UTM NAD83 metres
0 5000 10000 15000 20000

Figure B4-2x Predicted CEA SO_2 Maximum Hourly Average Ground Level Concentrations in the RSA using the ISC3BE Model. With no mercaptans in fuel gas.





Sources	SO_2 [t/sd]
Suncor	
Powerhouse	1.2
FGD	19.7
Incinerator	10.2
Flaring	1.3
Tail Gas Treatment Unit	5.2
Other Sources, Suncor	0.08
Syncrude (total)	201
Other Emissions (total)	4
Other Proposed Emissions (total)	19.8
TOTAL	262.5

Model Description	
Development	CEA
Model	ISC3BE (7BG)
SO_2 Guideline [µg/m³]	150
Maximum [µg/m³]	128
Exceedences / Year [#]	0

Figure B4-3x Predicted CEA SO_2 Maximum Daily Average Ground Level Concentrations in the RSA using the ISC3BE Model. With no mercaptans in fuel gas.

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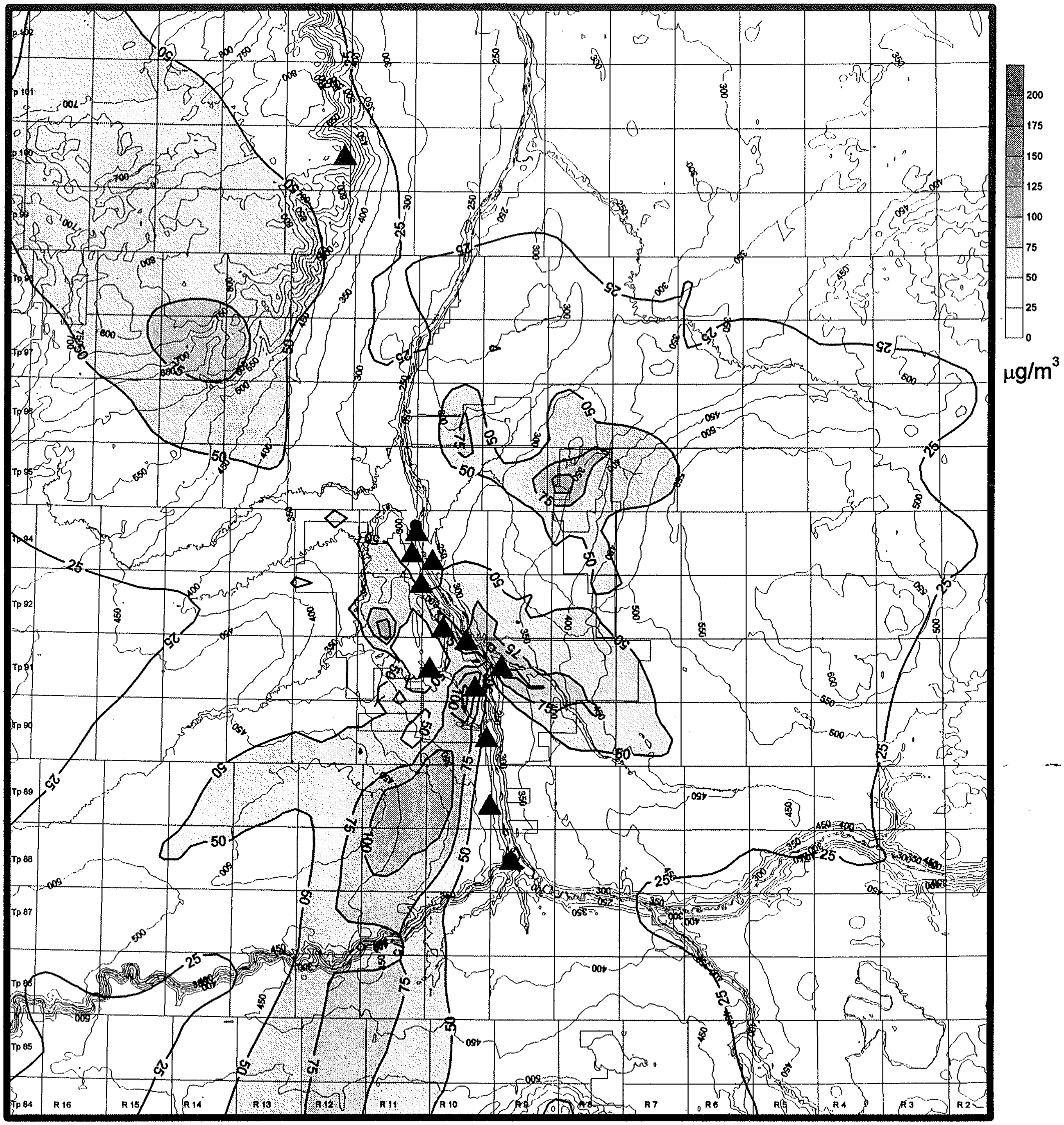

Sources	SO_2 [t/sd]
Suncor	
Powerhouse	1.2
FGD	19.7
Incinerator	10.2
Flaring	1.3
Tail Gas Treatment Unit	5.2
Other Sources, Suncor	5.9
Syncrude (total)	201
Other Emissions (total)	4
Other Proposed Emissions (total)	19.8
TOTAL	268.3

Model Description	
Development	CEA
Model	ISC3BE (7BG)
SO_2 Guideline [µg/m³]	150
Maximum [µg/m³]	170
Exceedences / Year [#]	<1

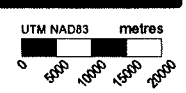

Figure B4-3 Predicted CEA SO_2 Maximum Daily Average Ground Level Concentrations in the RSA using the ISC3BE Model

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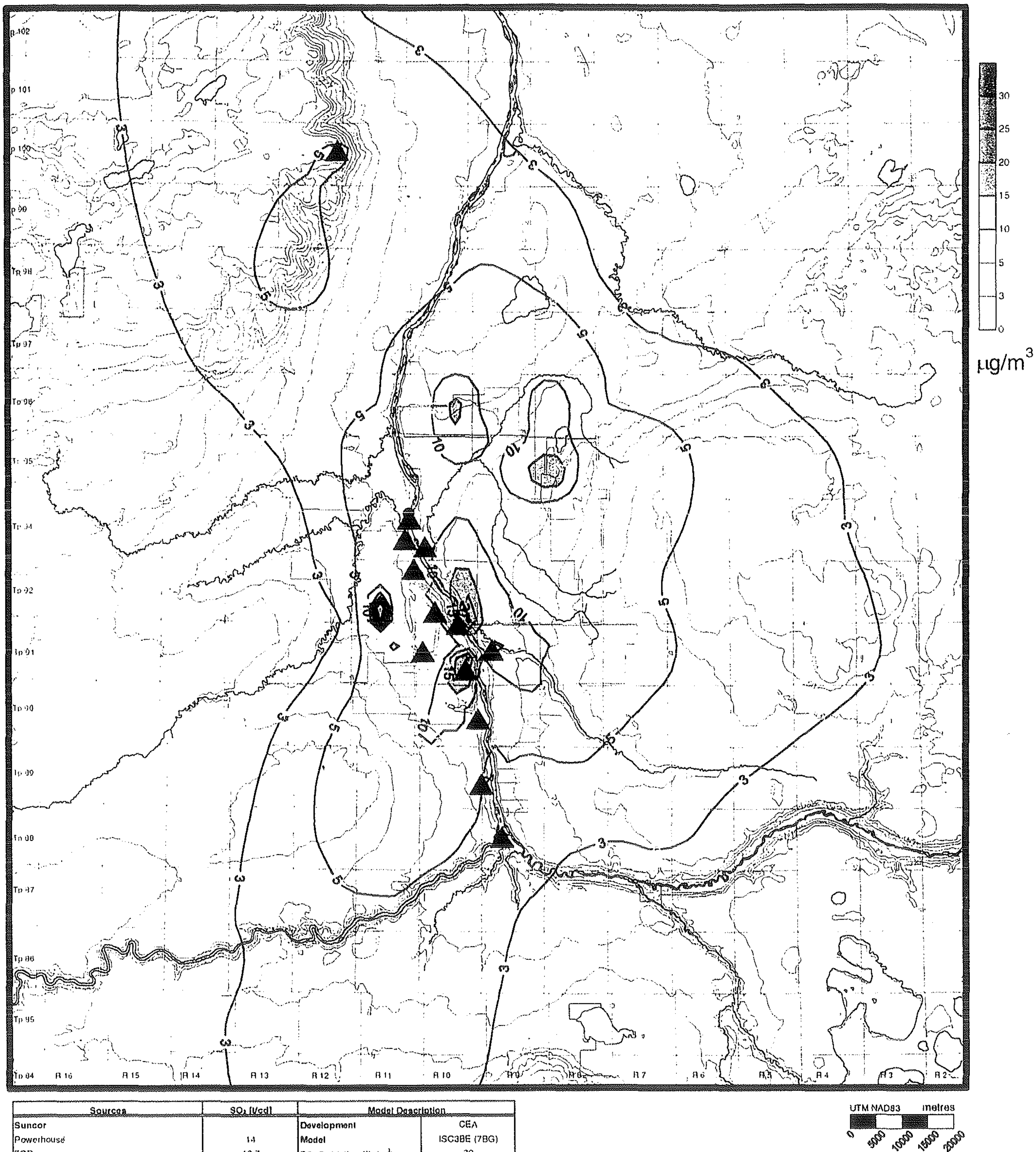
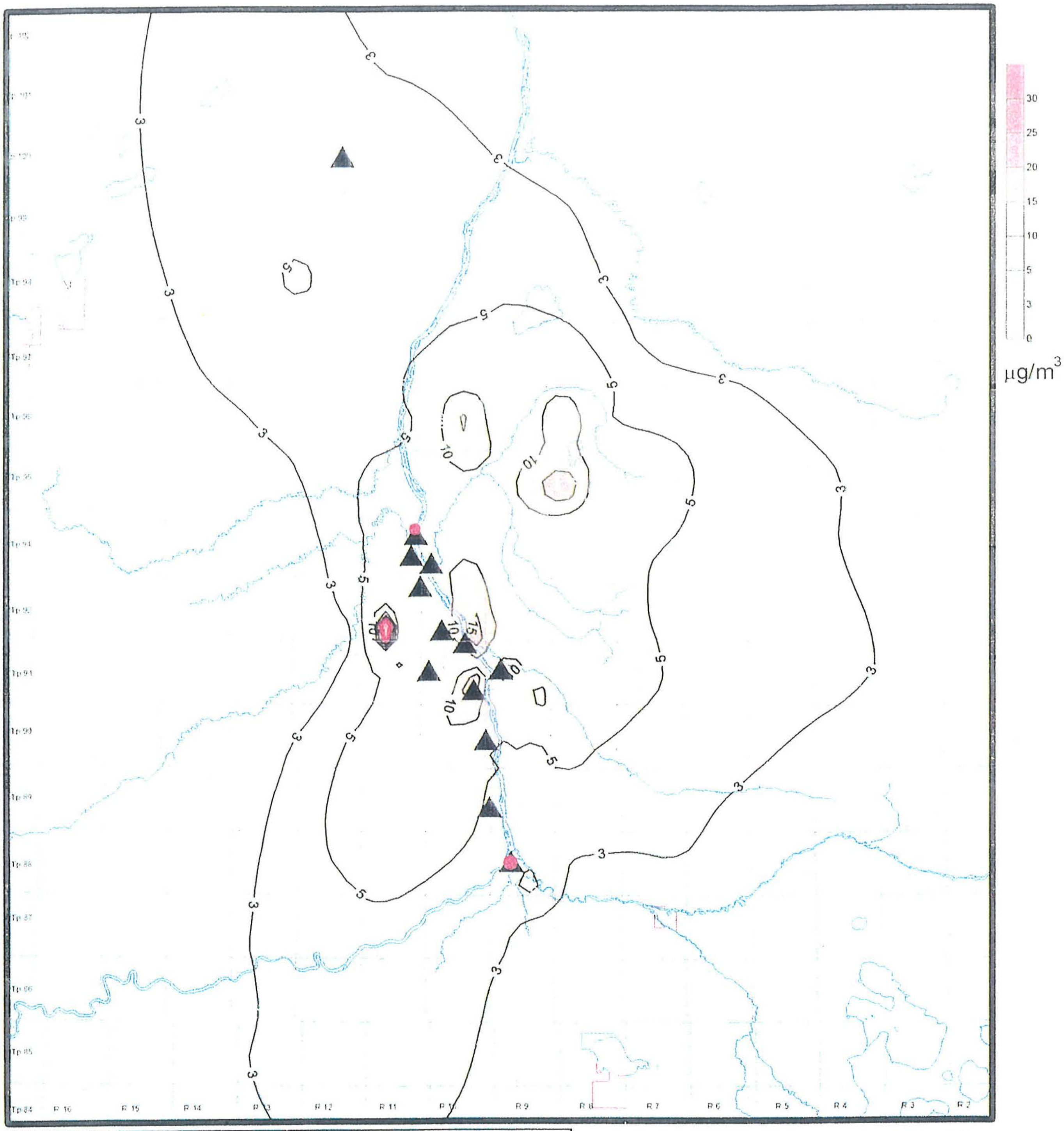


Sources	SO₂ [t/cd]
Suncor	
Powerhouse	14
FGD	18.7
Incinerator	12.3
Flaring	10.6
Tail Gas Treatment Unit	6.4
Other Sources, Suncor	5.9
Syncrude (total)	199
Other Emissions (total)	4.2
Other Proposed Emissions (total)	18.8
TOTAL	289.9

Model Description	
Development	CEA
Model	ISC3BE (7BG)
SO_2 Guideline [µg/m³]	30
Maximum [µg/m³]	46
Exceedences / Year [#]	1

Figure B4-4 Predicted CEA SO_2 Annual Average Ground Level Concentrations in the RSA using the ISC3BE Model



Sources	SO_2 [t/cd]
Suncor	
Powerhouse	14
FGD	18.7
Incinerator	12.3
Flaring	10.6
Tail Gas Treatment Unit	8.7
Other Sources, Suncor	0.08
Syncrude (total)	201
Other Emissions (total)	4
Other Proposed Emissions (total)	19.8
TOTAL	289

Model Description	
Development	CEA
Model	ISC3BE (7BG)
SO_2 Guideline [$\mu g/m^3$]	30
Maximum [$\mu g/m^3$]	41
Exceedences / Year [#]	1

Figure B4-4x Predicted CEA SO_2 Annual Average Ground Level Concentrations in the RSA using the ISC3BE Model. With no mercaptans in fuel gas.

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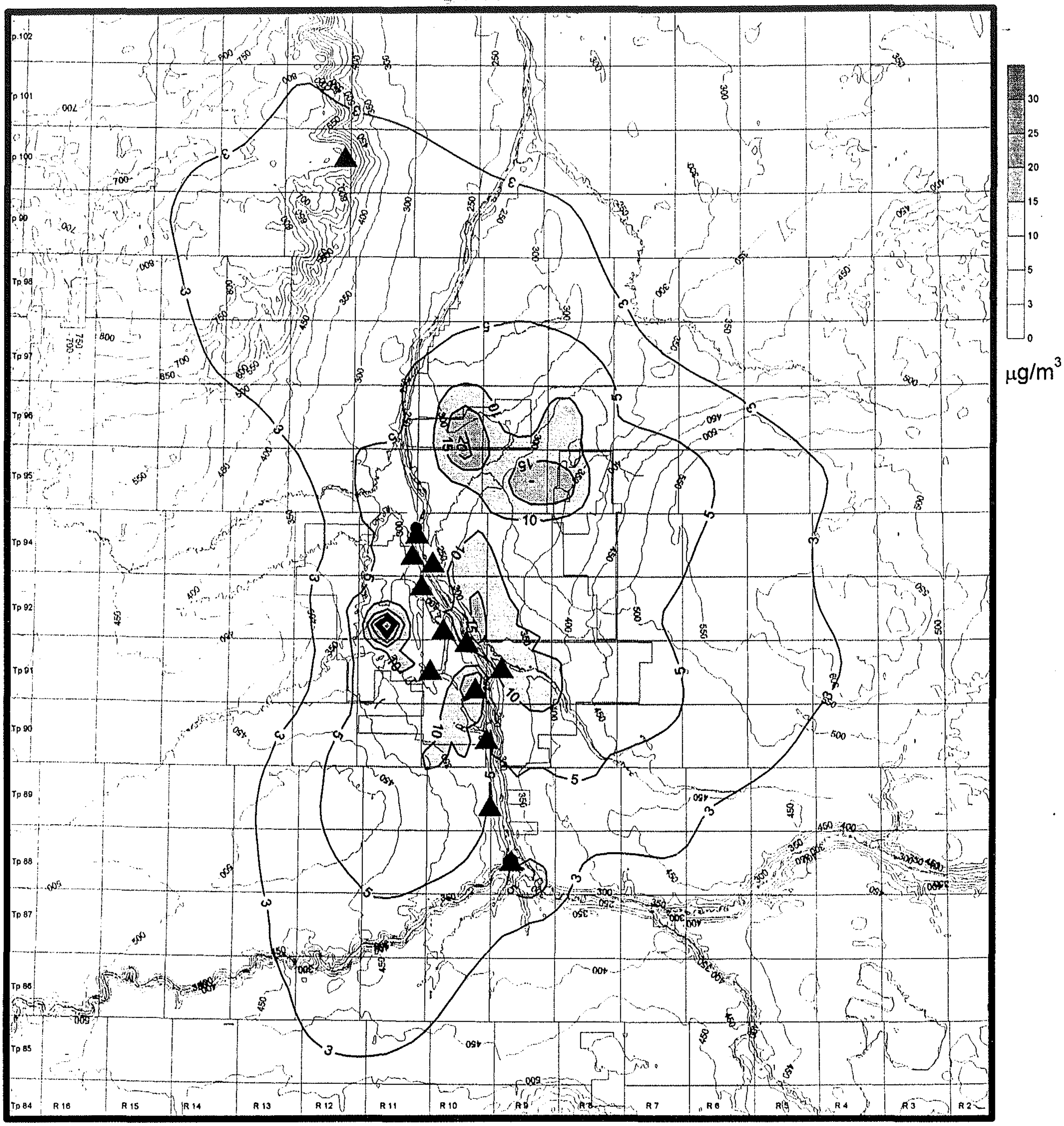
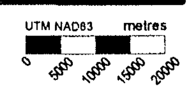




Sources	SO_2 [t/cd]
Suncor	
Powerhouse	14
FGD	18.7
Incinerator	12.3
Flaring	10.6
Tail Gas Treatment Unit	6.4
Other Sources, Suncor	5.9
Syncrude (total)	199
Other Emissions (total)	4.2
Other Proposed Emissions (total)	18.8
TOTAL	289.9

Model Description	
Development	CEA
Model	CALPUFF
SO_2 Guideline [µg/m³]	30
Maximum [µg/m³]	44
Exceedences / Year [#]	1

Figure B4-5 Predicted CEA SO_2 Annual Average Ground Level Concentrations in the RSA using the CALPUFF Model

Corresponding values for the CALPUFF model indicate an overall maximum annual average SO_2 concentration of 44.4 $\mu g/m^3$, at a location WNW of Suncor in Syncrude's development area (Figure B4-6). This model predicts a total of 382 ha that result in concentrations in excess of the AAAQG.

From the ISC3BE model results, the location and areal extent of the maximum hourly GLC SO_2 concentration can be assessed. Figures B4-2 to B4-4 indicate that the predicted areas that exceed the daily and annual guidelines will occur within the Suncor or Syncrude development areas; the area where the hourly guideline is exceeded will occur mostly within the Suncor lease area. Repeating this analysis using the Federal acceptable hourly, daily and annual standards (900 $\mu g/m^3$, 300 $\mu g/m^3$ and 60 $\mu g/m^3$ respectively) indicates no predicted exceedances. The exceedance of daily and annual AAAQG is a result of the generalized characteristics of the mine fleet emissions coupled with the receptor points which happen to be located within the mine pit. These circumstances lead to unrealistic, high long-term averages near the source which have not been verified through monitoring data.

B4.2.3 NO_x Predicted Concentrations

The NO_x emission sources associated with this CEA are summarized in Section B4.1. The estimated total NO_x emission rate for this CEA in the oil sands region is 203.4 t/cd. Suncor will emit an estimated total of 67.7 t/cd which is approximately 33% of the total (Table B4-3).

The predicted maximum hourly, daily and annual ground level ambient NO_x concentrations resulting from these emissions were estimated using ISC3BE and CALPUFF models. The conversion of NO_x to NO_2 has been estimated using the methodology described in Section B2.2.3.

The modelling predictions are summarized in Table B4-5 and predicted ground level concentrations are mapped in the figures described below.

| **Table B4-5 Maximum Predicted Ground Level Concentrations of NO_x and NO_2 for CEA Sources**

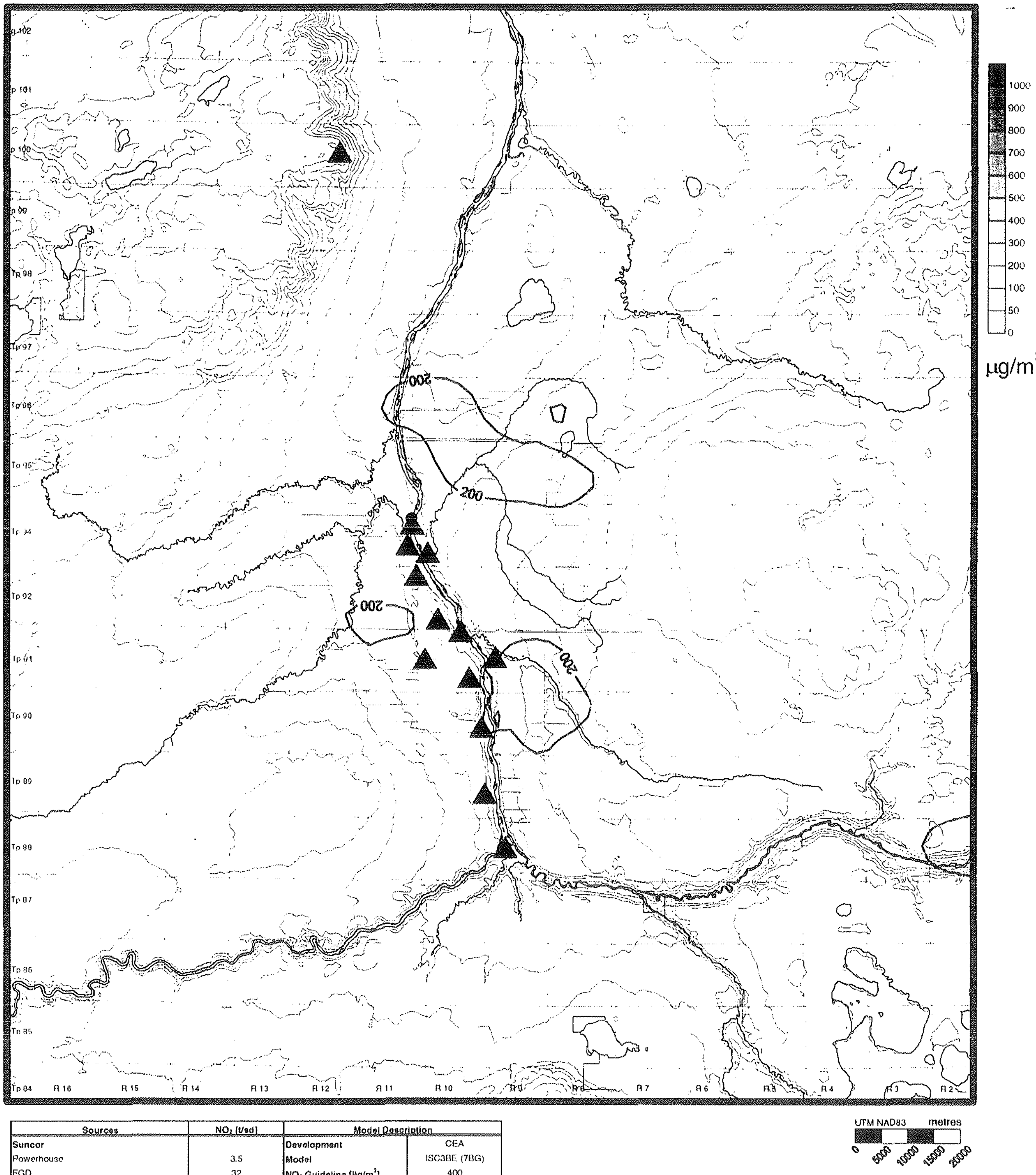
Source	Hourly	Daily	Annual
CEA - ISC3BE[(b)]			
Maximum NO_x Concentration ($\mu g/m^3$)	5,953	3,652	1296
Maximum NO_2 Concentration ($\mu g/m^3$)	295	244	163
Location of Maximum Concentration (km)	12 ESE	11 SE	11 ESE
Maximum Number of Exceedances[(a)]	0	81	1
Location of Maximum Exceedances (km)	0	n/a	n/a
CEA CALPUFF[(c)]			
Maximum NO_2 Concentration ($\mu g/m^3$)	1866	714	314
Location from Suncor incinerator stack (km)	11 ESE	11 ESE	11 ESE
Maximum Number of Exceedances[(a)]	2,449	274	1
Location of Maximum Exceedances (km)	11 ESE	11 ESE	n/a
NO_2, Alberta Guideline ($\mu g/m^3$)	400	200	60
NO_2, Federal Acceptable ($\mu g/m^3$)	400	200	100

(a) Exceeds NO_2 Alberta Guideline. Normalized for a 12-month period.
(b) Based on Stream day emission rates for hourly and daily; Calendar day for annual.
(c) Based on Calendar day emission rates.

- Figures B4-6 and B4-7 show the maximum hourly average ground level NO_2 concentrations associated for the CEA for the ISC3BE and CALPUFF models. An overall maximum hourly average NO_2 concentration, as determined by ISC3BE, of 295 $\mu g/m^3$ is predicted to occur at a location 12 km ESE of Suncor in the east bank mining area (Figure 4-7). This maximum value is less than the hourly AAAQG NO_2 of 400 $\mu g/m^3$.

  Corresponding values for the CALPUFF model indicate an overall maximum hourly average NO_2 concentration of 1866 $\mu g/m^3$, at a location 11 km ESE of Suncor in the east bank mining area (Figure B4-8). This maximum average value is much higher than the hourly Alberta NO_2 Guideline of 400 $\mu g/m^3$. This model predicts a total of 481,603 ha will have maximum concentrations in excess of the guideline. It also predicts a maximum of 2449 exceedances of the hourly guideline. The predicted NO_2 values by CALPUFF correlate to the observed NO_x concentrations recorded by Syncrude adjacent to their active mine pit. This would suggest that the chemistry conversion rates may require calibration for the oil sands region.

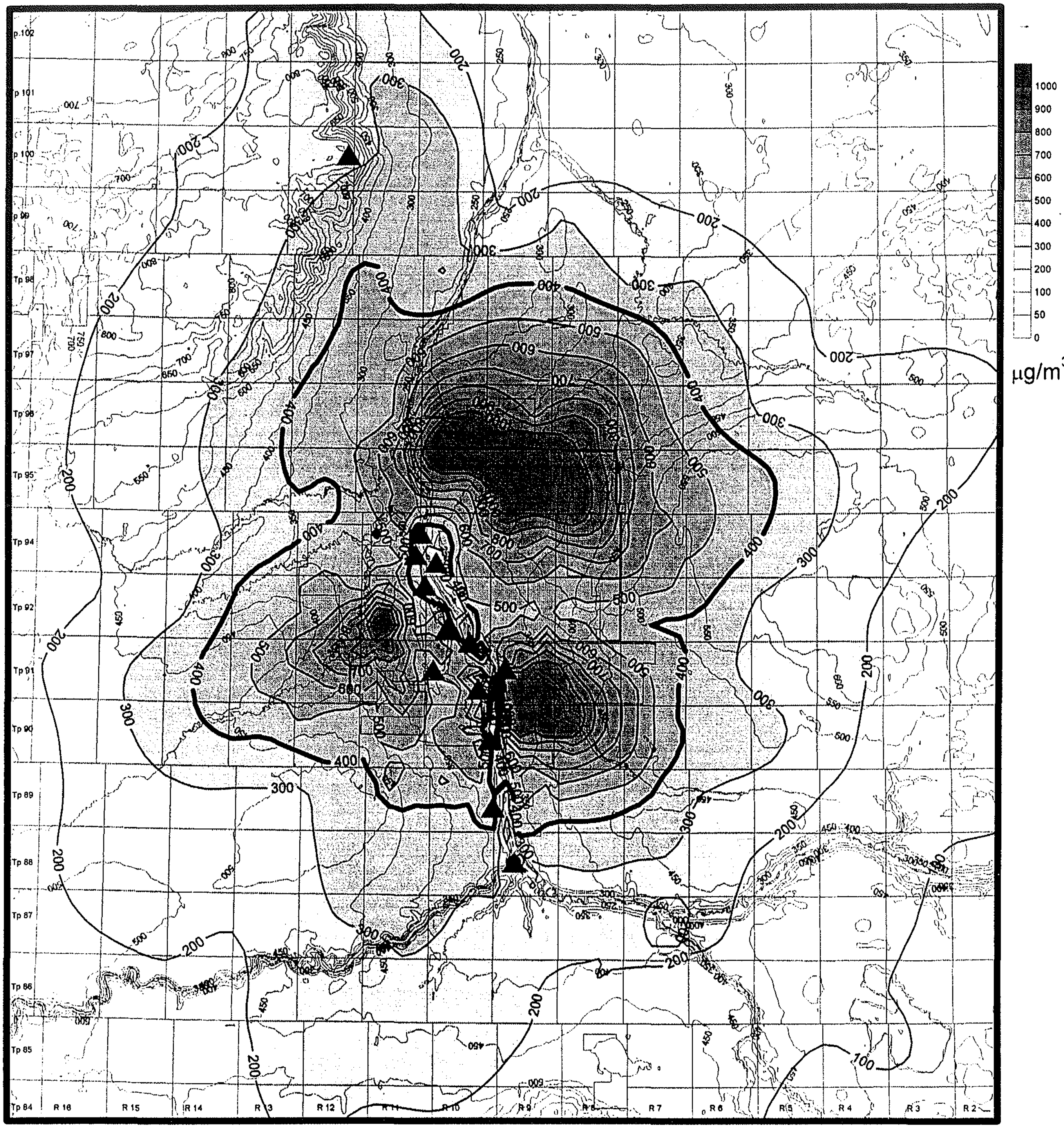
- Figures B4-8 and B4-9 show the maximum daily NO_2 average GLC associated with the CEA emissions for the ISC3BE and CALPUFF models. An overall maximum daily average NO_2 concentration, as determined by ISC3BE, of 244 $\mu g/m^3$ is predicted to occur in the same vicinity as the maximum hourly concentration (east bank mining area of Suncor). This maximum average value exceeds the daily Alberta Guideline of 200 $\mu g/m^3$. The predictions shown in Figure B4-9 indicate



Sources	NO_2 [t/sd]
Suncor	
Powerhouse	3.5
FGD	32
Incinerator	0.07
Flaring	0.03
Tail Gas Treatment Unit	0.03
Other Sources, Suncor	34.8
Syncrude (total)	63.9
Other Emissions (total)	10.1
Other Proposed Emissions (total)	60.9
TOTAL	205.33

Model Description	
Development	CEA
Model	ISC3BE (7BG)
NO_2 Guideline [µg/m³]	400
Maximum [µg/m³]	295
Exceedences / Year [#]	0

Figure B4-6 Predicted CEA NO_2 Maximum Hourly Average Ground Level Concentrations in the RSA using the ISC3BE Model



Sources	NO_x [t/cd]
Suncor	
Powerhouse	3.5
FGD	32
Incinerator	0.07
Flaring	0.03
Tail Gas Treatment Unit	0.03
Other Sources, Suncor	35
Syncrude (total)	63.9
Other Emissions (total)	10.9
Other Proposed Emissions (total)	60.9
TOTAL	206.33

Model Description	
Development	CEA
Model	CALPUFF
NO_2 Guideline [µg/m³]	400
Maximum [µg/m³]	1666
Exceedences / Year [#]	2449

Figure B4-7 Predicted CEA NO_2 Maximum Hourly Average Ground Level Concentrations in the RSA using the CALPUFF Model

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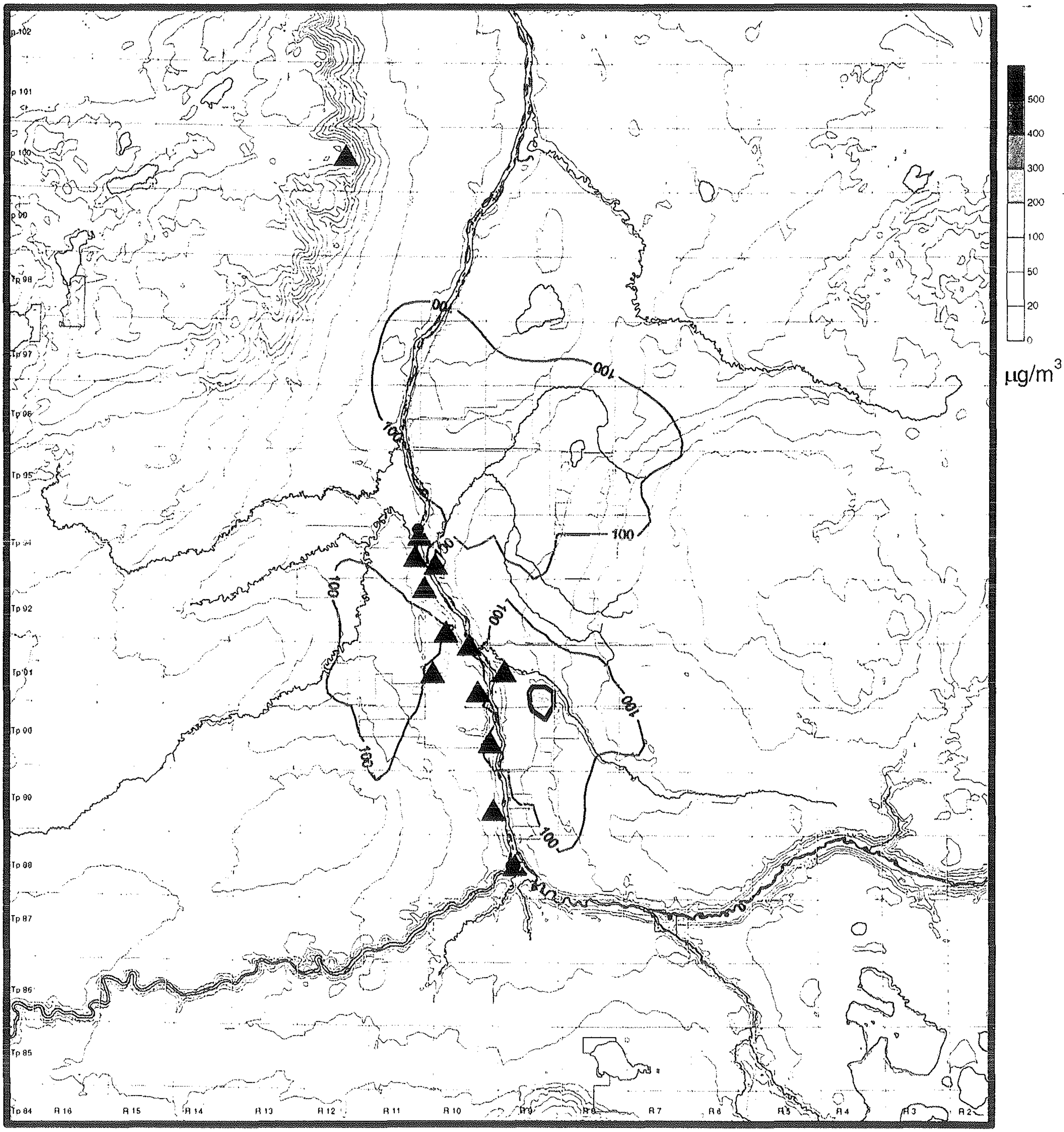

Sources	NO_x [t/sd]
Suncor	
Powerhouse	3.5
FGD	32
Incinerator	0.07
Flaring	0.03
Tail Gas Treatment Unit	0.03
Other Sources, Suncor	34.8
Syncrude (total)	63.0
Other Emissions (total)	10.1
Other Proposed Emissions (total)	60.9
TOTAL	205.33

Model Description	
Development	CEA
Model	ISC3BE (7BG)
NO_2 Guideline [µg/m³]	200
Maximum [µg/m³]	244
Exceedences / Year [#]	81

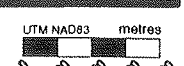

Figure B4-8 Predicted CEA NO_2 Maximum Daily Average Ground Level Concentrations in the RSA using the ISC3BE Model

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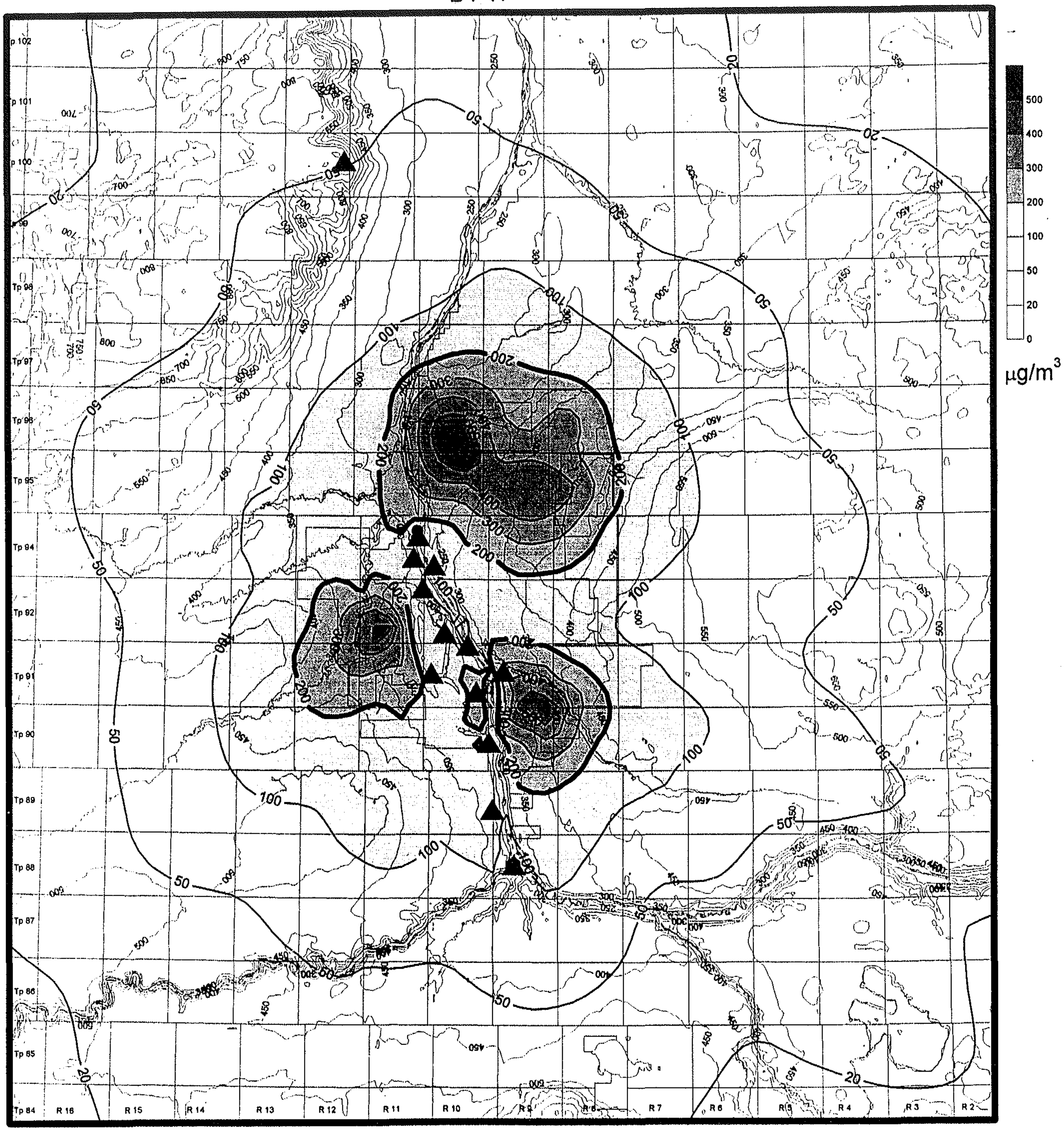
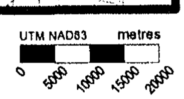




Sources	NO_2 [t/sd]
Suncor	
Powerhouse	3.5
FGD	32
Incinerator	0.07
Flaring	0.03
Tail Gas Treatment Unit	0.03
Other Sources, Suncor	34.8
Syncrude (total)	63.9
Other Emissions (total)	10.1
Other Proposed Emissions (total)	60.9
TOTAL	205.33

Model Description	
Development	CEA
Model	ISC3BE (7BG)
NO_2 Guideline [µg/m³]	200
Maximum [µg/m³]	244
Exceedences / Year [#]	61

Figure B4-9 Predicted CEA NO_2 Maximum Daily Average Ground Level Concentrations in the RSA using the CALPUFF Model

the area, 1,447 ha, of maximum daily average concentrations in excess of the guideline all fall within the east bank mining. In total, the model predicts that there will be a maximum of 81 exceedances of the daily guideline on an annual bases.

Comparison values for the CALPUFF model indicate an overall maximum daily average NO_2 concentration of 714 $\mu g/m^3$, at a location 11 km ESE of Suncor in the east bank mining area (Figure B4-10). The predictions shown in Figure B4-10 indicate three areas that result in maximum daily average concentrations in excess of the Alberta Guideline. The areas are the Suncor and Syncrude existing development areas and an area north of these two developments (in the area of Syncrude Aurora, Shell (Muskeg River and Lease 13), Mobil and Solv-Ex). In total, 158,886 ha are predicted to have maximum average concentrations in excess of the guideline. The CALPUFF model predicts there will be a maximum of 274 exceedances of the daily guideline on an annual bases.

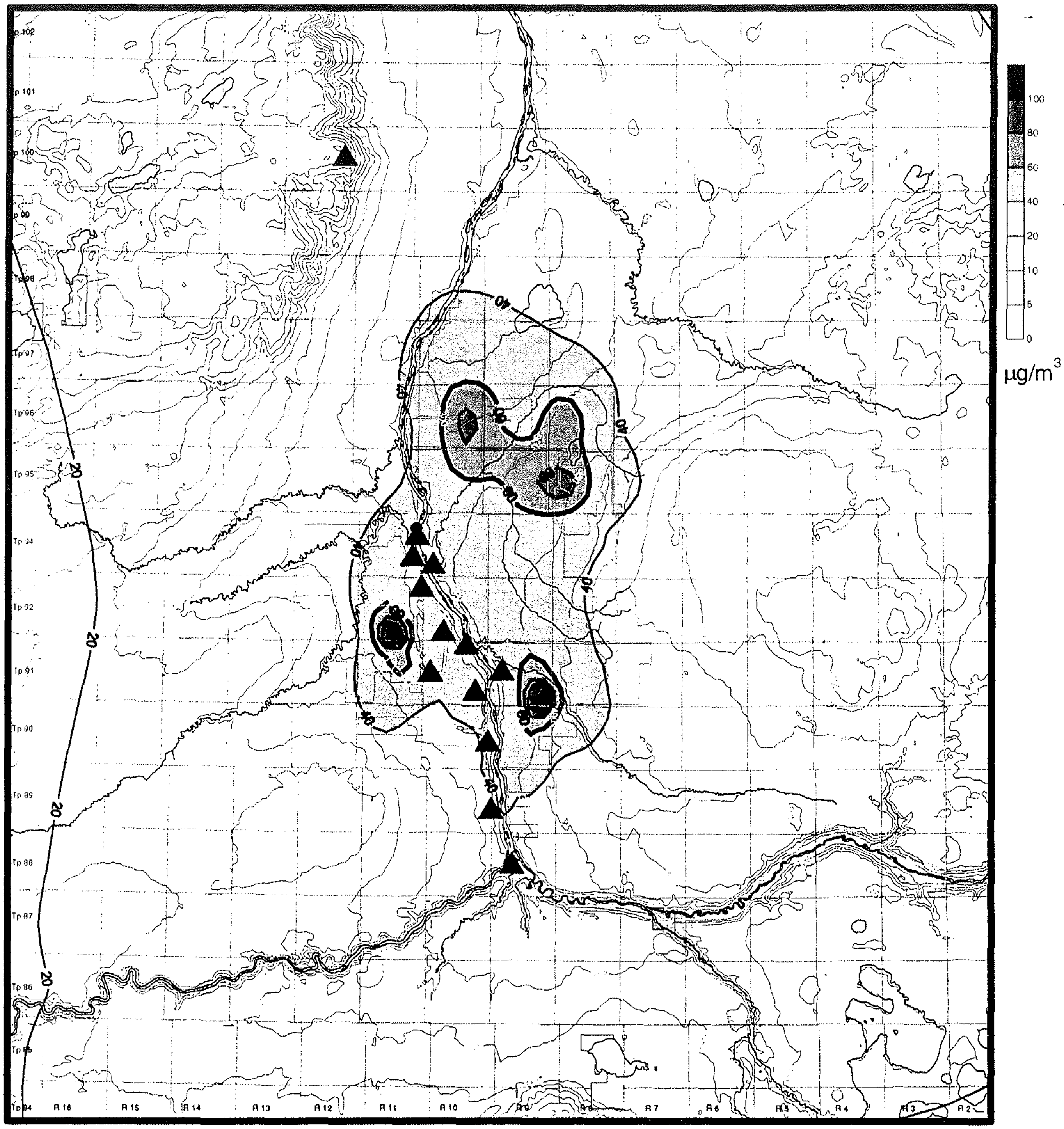
- Figures B4-10 and B4-11 show the annual average ground level NO_2 concentrations associated with the CEA emissions for the ISC3BE and CALPUFF models. The overall maximum annual average NO_2 concentration, as determined by ISC3BE, of 163 $\mu g/m^3$ is predicted to occur at in the east bank mining area of Suncor (Figure B4-12). This annual average value exceeds the Alberta guideline of 60 $\mu g/m^3$. The predictions shown in Figure B4-11 indicate the areas that result in annual averages in excess of the guideline and they are the areas in the Suncor and Syncrude development areas and an area north of the existing operations, near other proposed oil sands projects. In total, 38,624 ha are predicted to have maximum average concentrations in excess of the guideline.

  Comparison values for the CALPUFF model indicate an overall annual average NO_2 concentration of 314 $\mu g/m^3$, at a location 11 km ESE from Suncor in the east bank mining area (Figure B4-12). The predictions shown in Figure B4-12 indicate a similar pattern for the annual maximum concentrations as in the daily results. In total, 58,100 ha are predicted to have maximum average concentrations in excess of the guideline.

The modelling predictions using ISC3BE indicate that the maximum NO_2 concentrations will tend to occur in or near the development areas. The principal contributors to these maximum values would be the mine fleets.

B4.2.4 Potential Acid Input (PAI) Predictions

Acidic deposition in the RSA results from the cumulative emissions of SO_2 and NO_x. The total estimated emissions of SO_2 and NO_x (292.2 t/cd and 203.4 t/cd, respectively) for this CEA are presented in Table B4-3. Suncor contributes about 28% of the combined SO_2 and NO_x emissions.



Sources	NO_2 [t/cd]
Suncor	
Powerhouse	3.5
FGD	32
Incinerator	0.07
Flaring	0.03
Tail Gas Treatment Unit	0.03
Other Sources, Suncor	34.8
Syncrude (total)	63.9
Other Emissions (total)	10.1
Other Proposed Emissions (total)	60.9
TOTAL	205.33

Model Description	
Development	CEA
Model	ISC3BE (7BG)
NO_2 Guideline [µg/m³]	60
Maximum [µg/m³]	244
Exceedences / Year [#]	81

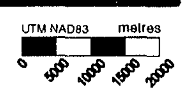
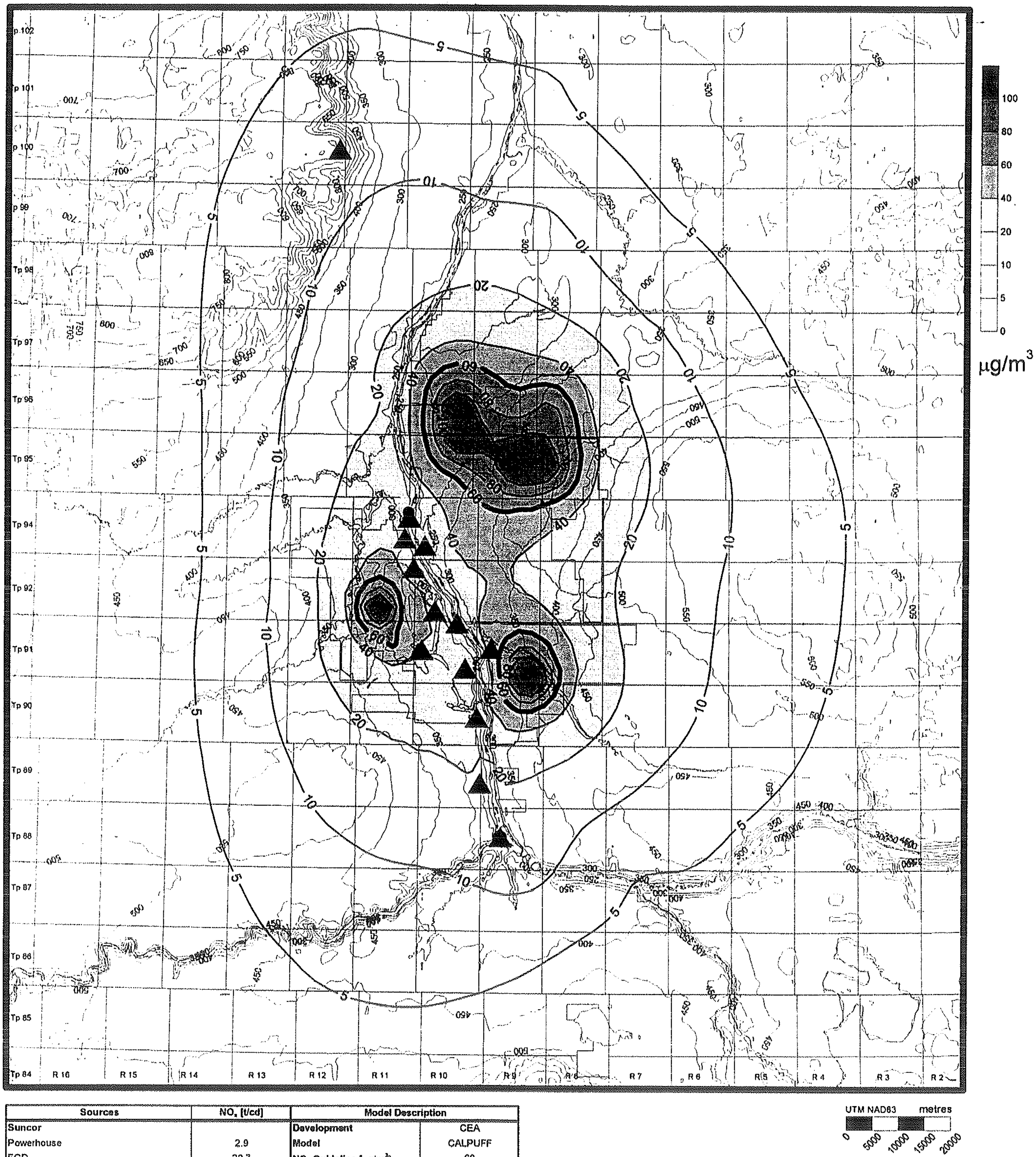


Figure B4-10 Predicted CEA NO_2 Annual Average Ground Level Concentrations in the RSA using the ISC3BE Model



Sources	NO_x [t/cd]
Suncor	
Powerhouse	2.9
FGD	29.7
Incinerator	0.064
Flaring	0.191
Tail Gas Treatment Unit	0.03
Other Sources, Suncor	34.8
Syncrude (total)	63.9
Other Emissions (total)	10.9
Other Proposed Emissions (total)	60.9
TOTAL	203.385

Model Description	
Development	CEA
Model	CALPUFF
NO_2 Guideline [µg/m³]	60
Maximum [µg/m³]	314
Exceedences / Year [#]	1

Figure B4-11 Predicted CEA NO_2 Annual Average Ground Level Concentrations in the RSA using the CALPUFF Model

PAI is the preferred method for evaluating the overall effects of acid forming chemicals on the environment since it accounts for the acidifying effect of the sulphur and nitrogen species, as well as the neutralizing effect of available base cations. A discussion on the calculation methods for PAI is provided in Section B1.4.2.

PAI in the oil sands region was predicted using the CALPUFF model. A background PAI of 0.1 keq/ha/y has been assumed for the region based on estimates of sulphur and nitrogen and base cation concentrations and depositions in the region surrounding the RSA. This background PAI may be conservatively high since the formulation of the background value uses monitoring data that may both reflect the air shed coming into the RSA as well as possibly being impacted by the air leaving the RSA.

The PAI predictions are summarized in Table B4-6 and shown graphically in Figure B4-12.

Table B4-6 Areal Extent For Predicted PAI Values for the CEA Sources

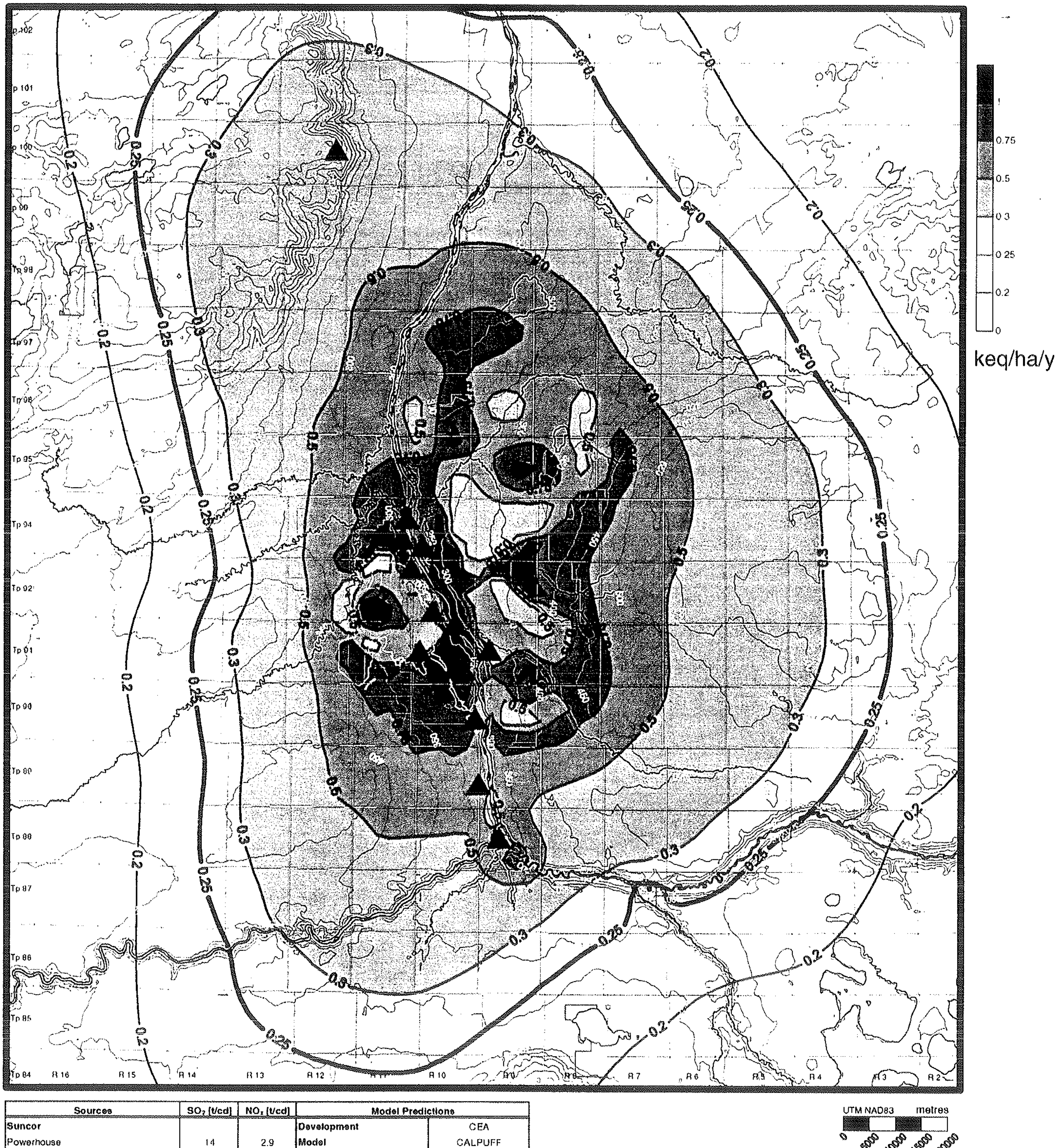
PAI Threshold (keq/ha/y)	Area (ha)	Area (%)[a]
0.25	1,417,300	58.4
0.50	420,086	17.3
1.0	20,430	0.8
1.5	13	<0.01

(a) as % of the total RSA.

The maximum deposition rates of the nitrogen and sulphur species were calculated as interim variables by the CALPUFF model. These are summarized in Table B4-7 and presented graphically in Figures B4-13 and B4-14. The maximum deposition rate of nitrates occur in the Suncor east bank mining area and the maximum sulphates and overall PAI occur in the immediate vicinity of the existing Suncor operations. These predicted results suggest that the highest deposition and PAI values occur in the areas where there are sizable ground level releases of SO_2 and NO_x.

Table B4-7 Maximum Predicted Acid Forming Deposition

Parameter	Maximum (keq/ha/y)
PAI	**24.5**
Nitrate Deposition	**24.0**
Sulphate Deposition	**1.21**



Sources	SO_2 [t/cd]	NO_x [t/cd]
Suncor		
Powerhouse	14	2.9
FGD	18.7	29.7
Incinerator	12.3	0.06
Flaring	10.6	0.19
Tail Gas Treatment Unit	6.4	0.03
Other Sources, Suncor	5.9	34.8
Syncrude (total)	199	63.9
Other Emissions (total)	4.2	10.9
Other Proposed Emissions (total)	18.8	60.9
TOTAL	289.9	203.4

Model Predictions	
Development	CEA
Model	CALPUFF
Critical Loading [keq/ha/y]	0.25
Maximum [keq/ha/y]	24.5

Figure B4-12 Predicted CEA Potential Acid Input (PAI) in the RSA

There is considerable uncertainty in the background PAI for the region, with estimates ranging from approximately -0.5 to 0.25 keq/ha/y. For this reason, the PAI map presented in Figure B4-12 should be regarded as providing an indication of relative spatial distributions and relative changes associated with this emission scenario. This map should also be used in conjunction with the nitrate and sulphate deposition maps (Figures B4-13 and B4-14, respectively) as input in the evaluation of impacts to sensitive soil or vegetation, and in the design of any long-term monitoring programs deemed necessary in such evaluations. This information is further assessed in soils Section D2.2.

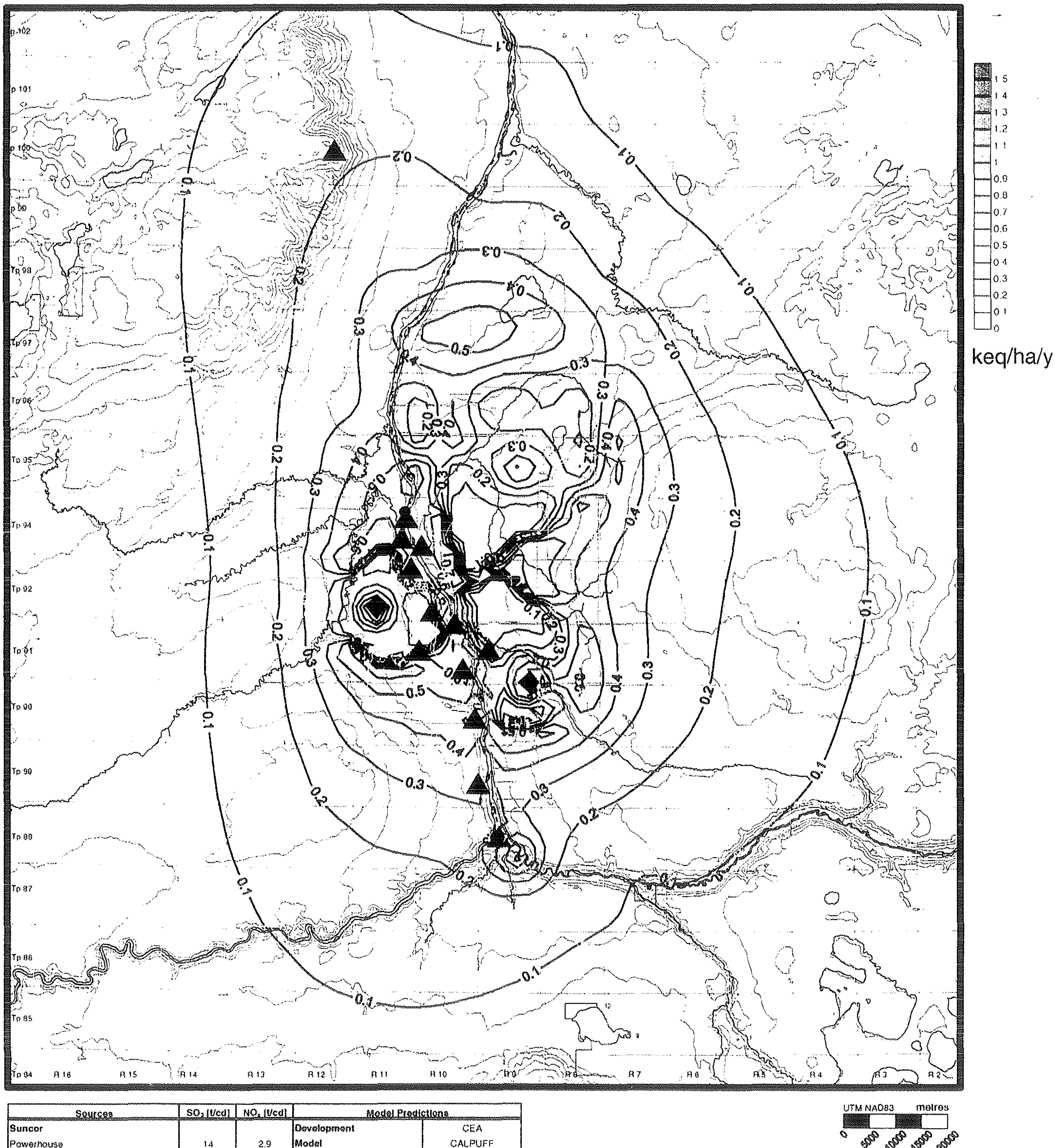
B4.2.5 CO Predicted Concentrations

The CO emission sources associated with this CEA are summarized in Section B4.1. Total estimated CO emission rate for this case is 173.9 t/cd. The total Suncor CO emissions are approximately 38.6 t/cd representing about 22% of the total.

The predicted maximum hourly and 8-hour ground level ambient CO concentrations resulting from these emissions were estimated using ISC3BE and meteorology measurements from the Mannix station. This model provides an efficient means of calculating the overall ambient CO concentration from all sources and provides an indication of where maximum concentrations could occur. The modelling predictions are summarized in Table B4-8 and predicted ground level concentrations are mapped in the figures described below:

- Figure B4-15 shows the maximum hourly average ground level CO concentration associated with the CEA case. An overall maximum hourly average CO concentration of 5,560 $\mu g/m^3$ is predicted to occur at a location SSE of the Suncor. This maximum value is less than the hourly Alberta CO guideline of 15,000 $\mu g/m^3$.
- Figure B4-16 shows the maximum 8-hour average ground level CO concentration associated with the CEA sources. The overall maximum daily average CO concentration of 2,228 $\mu g/m^3$ is predicted to also occur south of Suncor. This 8-hour maximum value is also less than the 8-hour guideline of 6,000 $\mu g/m^3$.

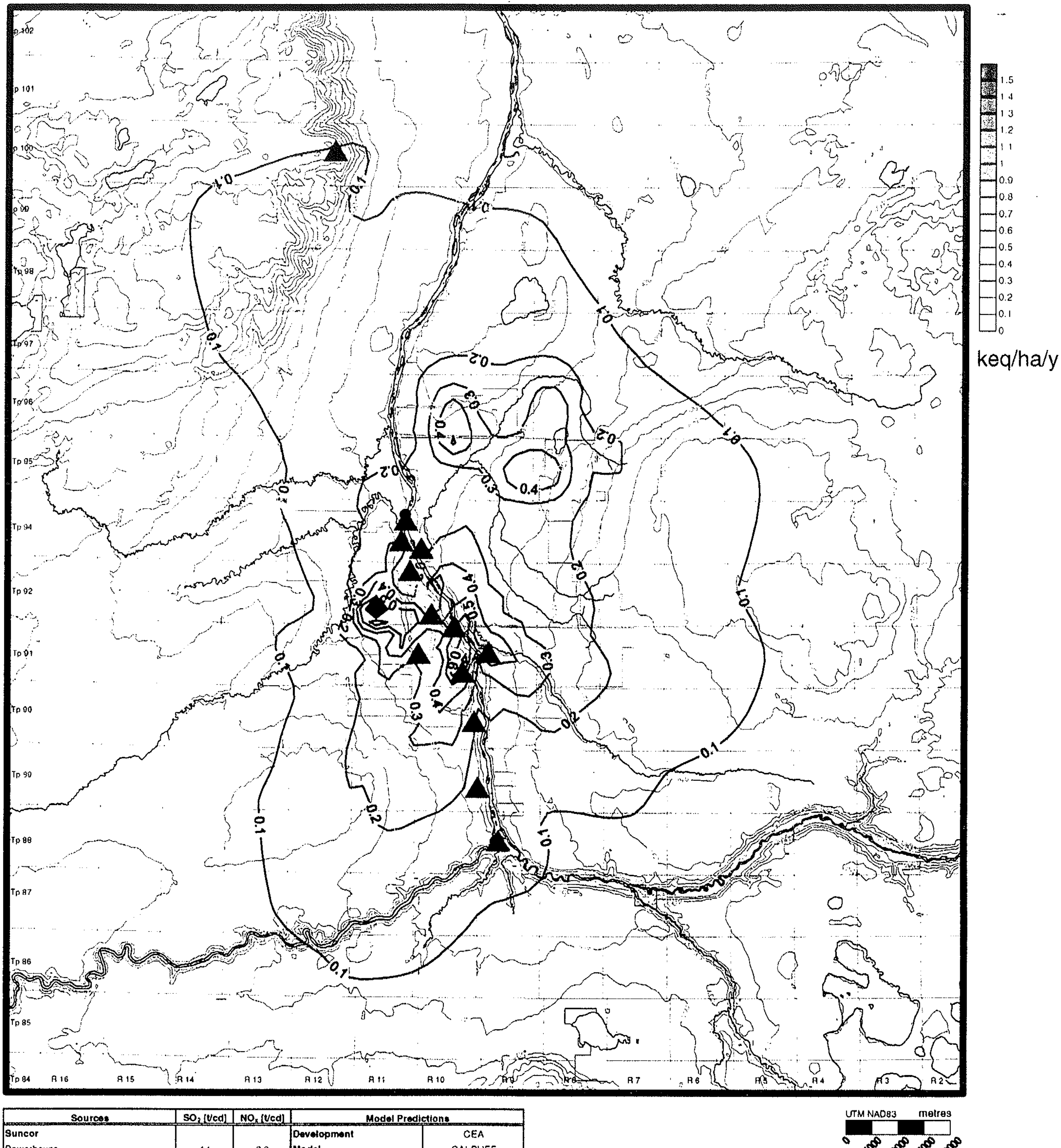
The modelling predicts that the maximum hourly and 8-hour CO concentrations will occur SSE of Suncor in or near Fort McMurray.



Sources	SO_2 (t/cd)	NO_x (t/cd)
Suncor		
Powerhouse	14	2.9
FGD	18.7	29.7
Incinerator	12.3	0.06
Flaring	10.6	0.19
Tail Gas Treatment Unit	6.4	0.03
Other Sources, Suncor	5.9	34.8
Syncrude (total)	199	63.9
Other Emissions (total)	4.2	10.9
Other Proposed Emissions (total)	18.8	60.9
TOTAL	289.9	203.4

Model Predictions	
Development	CEA
Model	CALPUFF
Maximum (keq/ha/y)	24

Figure B4-13 Predicted CEA Nitrate Equivalent Deposition in the RSA

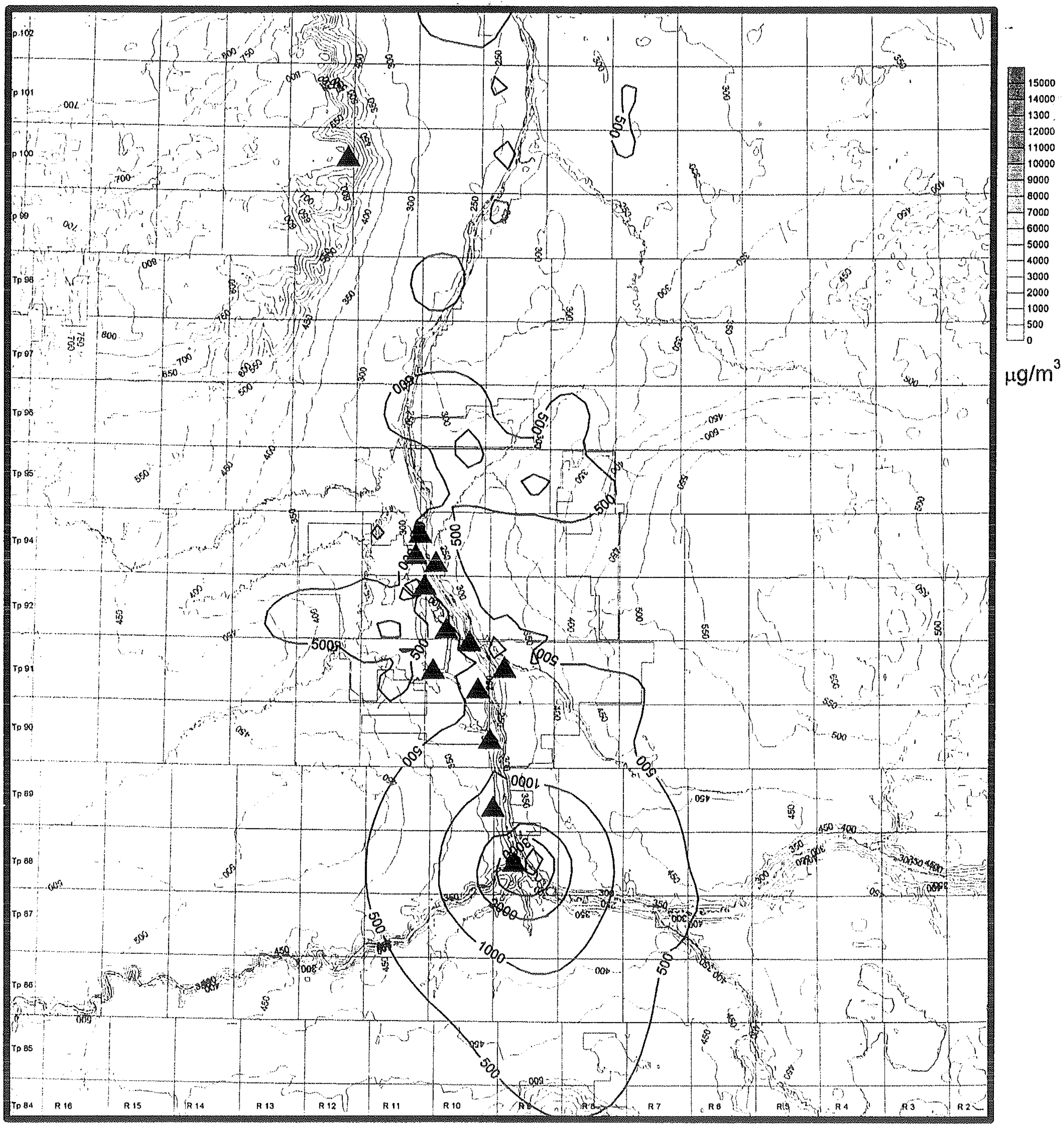


Sources	SO_2 [t/cd]	NO_x [t/cd]
Suncor		
Powerhouse	14	2.9
FGD	18.7	29.7
Incinerator	12.3	0.06
Flaring	10.6	0.19
Tail Gas Treatment Unit	6.4	0.03
Other Sources, Suncor	5.9	34.8
Syncrude (total)	199	63.9
Other Emissions (total)	4.2	10.9
Other Proposed Emissions (total)	18.8	60.9
TOTAL	289.9	203.4

Model Predictions	
Development	CEA
Model	CALPUFF
Maximum [keq/ha/y]	1.21

Figure B4-14 Predicted CEA Sulphate Equivalent Deposition in the RSA

04/20/98 16:12:25



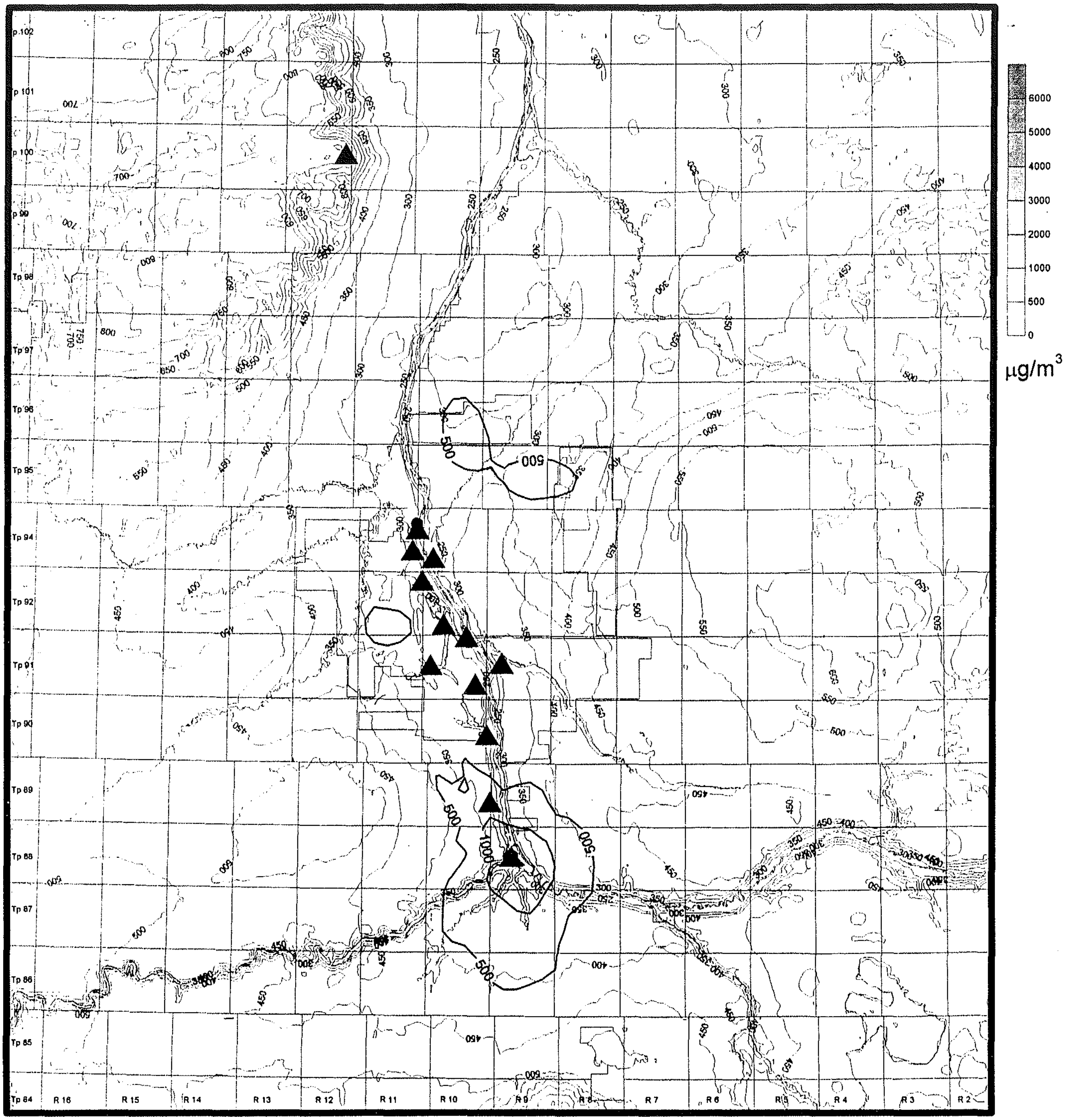
UTM NAD83 metres
0 5000 10000 15000 20000

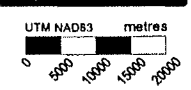
Sources	CO [t/sd]
Suncor	
Powerhouse	3.01
FGD	27.51
Incinerator	3.4
Flaring	0.01
Tail Gas Treatment Unit	3.8
Other Sources, Suncor	3.6
Syncrude (total)	81.5
Other Emissions (total)	36.9
Other Proposed Emissions (total)	16.9
TOTAL	176.6

Model Description	
Development	CEA
Model	ISC3BE (7BG)
CO Guideline [µg/m³]	15000
Maximum [µg/m³]	5560
Exceedances / Year [#]	0

Figure B4-15 Predicted CEA CO Maximum Hourly Average Ground Level Concentrations in the RSA

r:/1997/2200/972-2205/8600/8650/8664/SCBE/FIGS/COCD_2H.srf





Sources	CO [t/sd]
Suncor	
Powerhouse	3.01
FGD	27.51
Incinerator	3.4
Flaring	0.01
Tail Gas Treatment Unit	3.8
Other Sources, Suncor	3.6
Syncrude (total)	81.5
Other Emissions (total)	36.9
Other Proposed Emissions (total)	16.9
TOTAL	176.63

Model Description	
Development	CEA
Model	ISC3BE (7BG)
CO Guideline [µg/m³]	6000
Maximum [µg/m³]	2228
Exceedences / Year [#]	0

Figure B4-16 Predicted CEA CO Maximum 8-Hour Average Ground Level Concentrations in the RSA using the ISC3BE Model

Table B4-8 Maximum Predicted Ground Level Concentrations of CO for CEA Sources

Source	Hourly	Daily
CEA - Model ISC3BE		
Maximum CO Concentration (μg/m^3)	5,560	2,228
Location of Maximum Concentration (km)	30 SSE	30-SSE
Maximum Number of Exceedances [(a)]	0	0
Location of Maximum Exceedances	n/a	n/a
CO, Alberta Guideline (μg/m^3)	15,000	6,000

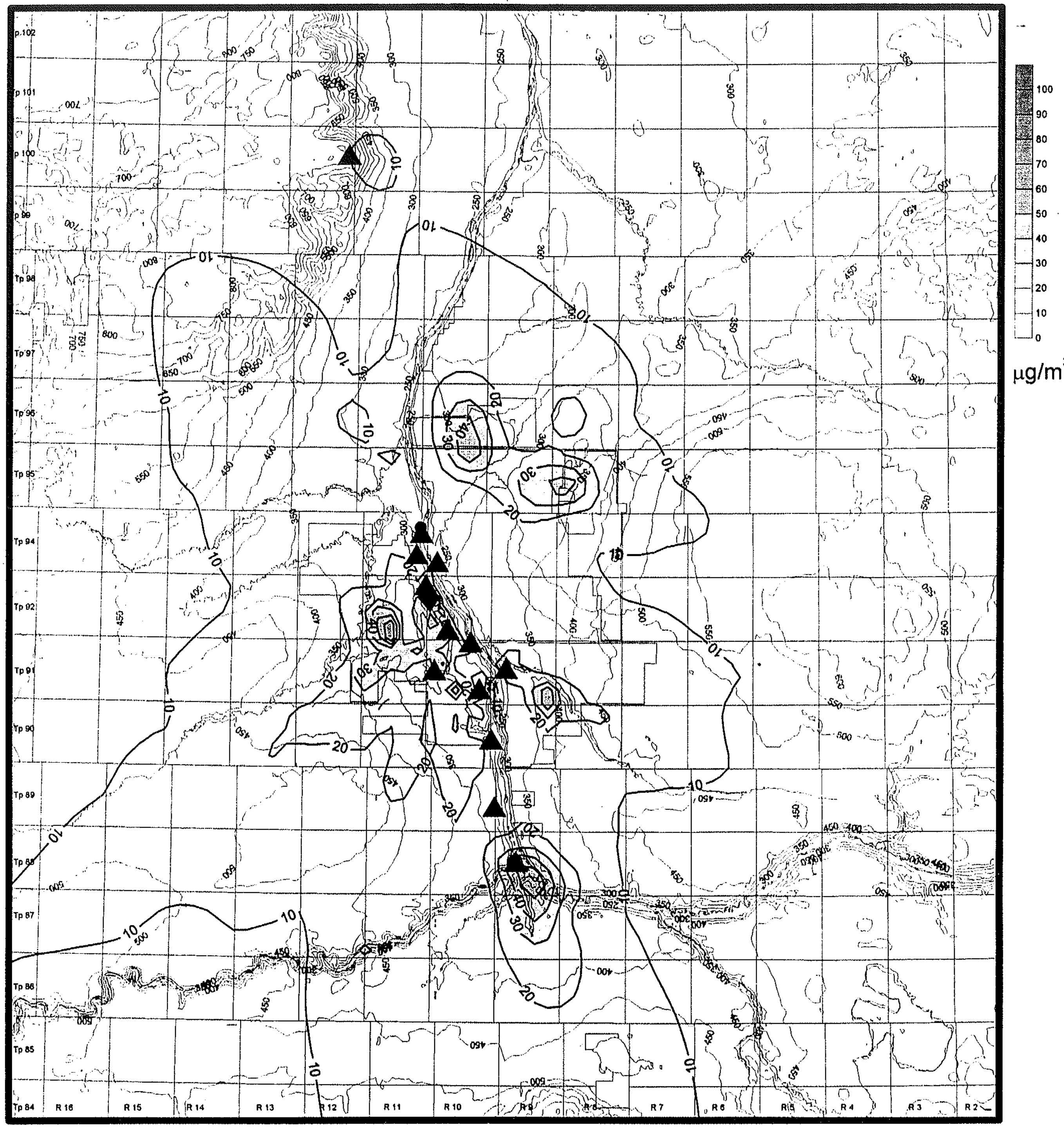
[(a)] Exceeds CO Alberta Guideline. Normalized for a 12-month period.

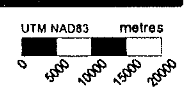
B4.2.6 Particulates

The ambient PM emission sources associated with this CEA are summarized in Section B4.1. The total estimated PM emission rate for this case is 18.3 t/cd. In total Suncor emits approximately 12% of the PM. For the purpose of modelling, all PM was assumed to be PM_{10}. In addition to the PM emissions, metals and PAHs have been determined from stack sampling surveys collected by Syncrude. Based on the speciation completed for the stack sampling surveys, concentrations of metals and PAHs have been estimated. These results are discussed in subsections following this section.

The predicted maximum daily and annual ground level ambient PM_{10} concentrations resulting from emissions used in the CEA were estimated using ISC3BE and meteorology measurements from the Mannix station. The modelling results are summarized in Table B4-9 which includes the PM_{10} predictions and selected metals and grouped PAH predictions estimated from the PM_{10} results and based on the source sampling results. Predicted PM_{10} ground level concentrations are mapped in the figures described below:

- Figure B4-17 shows the maximum daily average ground level PM_{10} concentrations associated with CEA emissions. The overall maximum daily average PM_{10} concentration of 116 μg/m^3 is predicted to occur at a location NW of Suncor. This daily maximum average value exceeds the Alberta **TSP** Guideline of 100 μg/m^3. The high readings occur in a very small area within the existing development areas.
- Figure B4-18 shows the annual average ground level concentration contours for PM_{10}. The results show that the overall maximum annual concentration of 39.2 μg/m^3 is predicted to occur at the same location as the daily results. This high annual average is less than the Alberta guideline of 60 μg/m^3 **for TSP**.



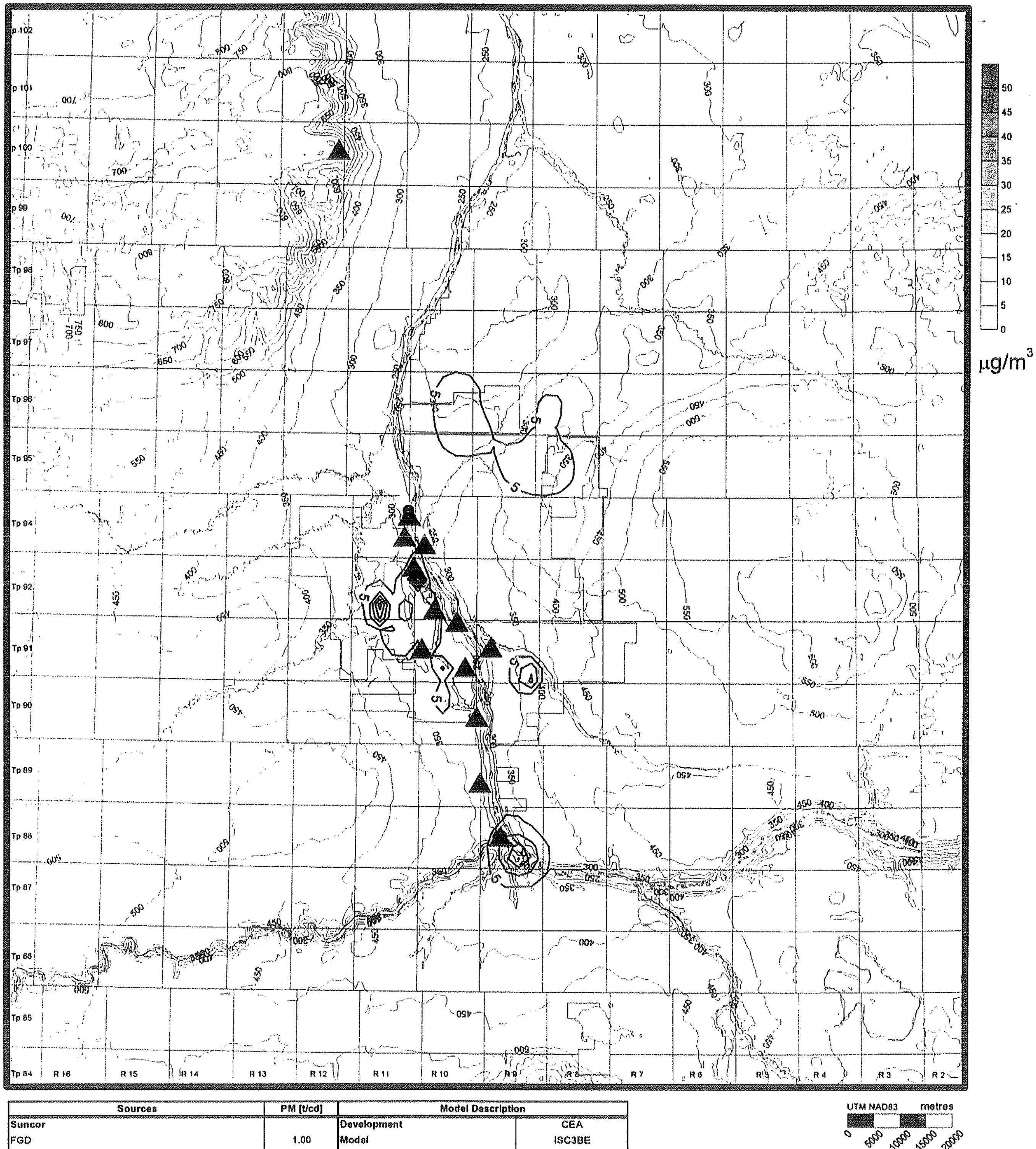


Sources	PM [t/cd]
Suncor	
FGD	1.00
Powerhouse	0.24
Incinerator	0.038
Tail Gas Treatment Unit	0.042
Millennium Mine Fleet	0.3
Other Sources, Suncor	0.653
Syncrude (total)	11.41
Other Emissions (total)	2.125
Other Proposed Emissions (total)	2.59
TOTAL	18.398

Model Description	
Development	CEA
Model	ISC3BE
PM_{10} Guideline [µg/m³]	50
Maximum [µg/m³]	116
Exceedences / Year [#]	25

Figure B4-17 Predicted CEA PM_{10} Maximum Daily Average Ground Level Concentrations in the RSA

r:/1997/2200/972-2205/8600/8660/8664/SCBE/FIGS/PMCD_3d.srf



Sources	PM [t/cd]
Suncor	
FGD	1.00
Powerhouse	0.24
Incinerator	0.036
Tail Gas Treatment Unit	0.042
Millennium Mine Fleet	0.3
Other Sources, Suncor	0.653
Syncrude (total)	11.41
Other Emissions (total)	2.125
Other Proposed Emissions (total)	2.59
TOTAL	18.398

Model Description	
Development	CEA
Model	ISC3BE
PM_{10} Guideline [µg/m³]	50
Maximum [µg/m³]	39
Exceedances / Year [#]	0

Figure B4-18 Predicted CEA PM_{10} Maximum Annual Average Ground Level Concentrations in the RSA

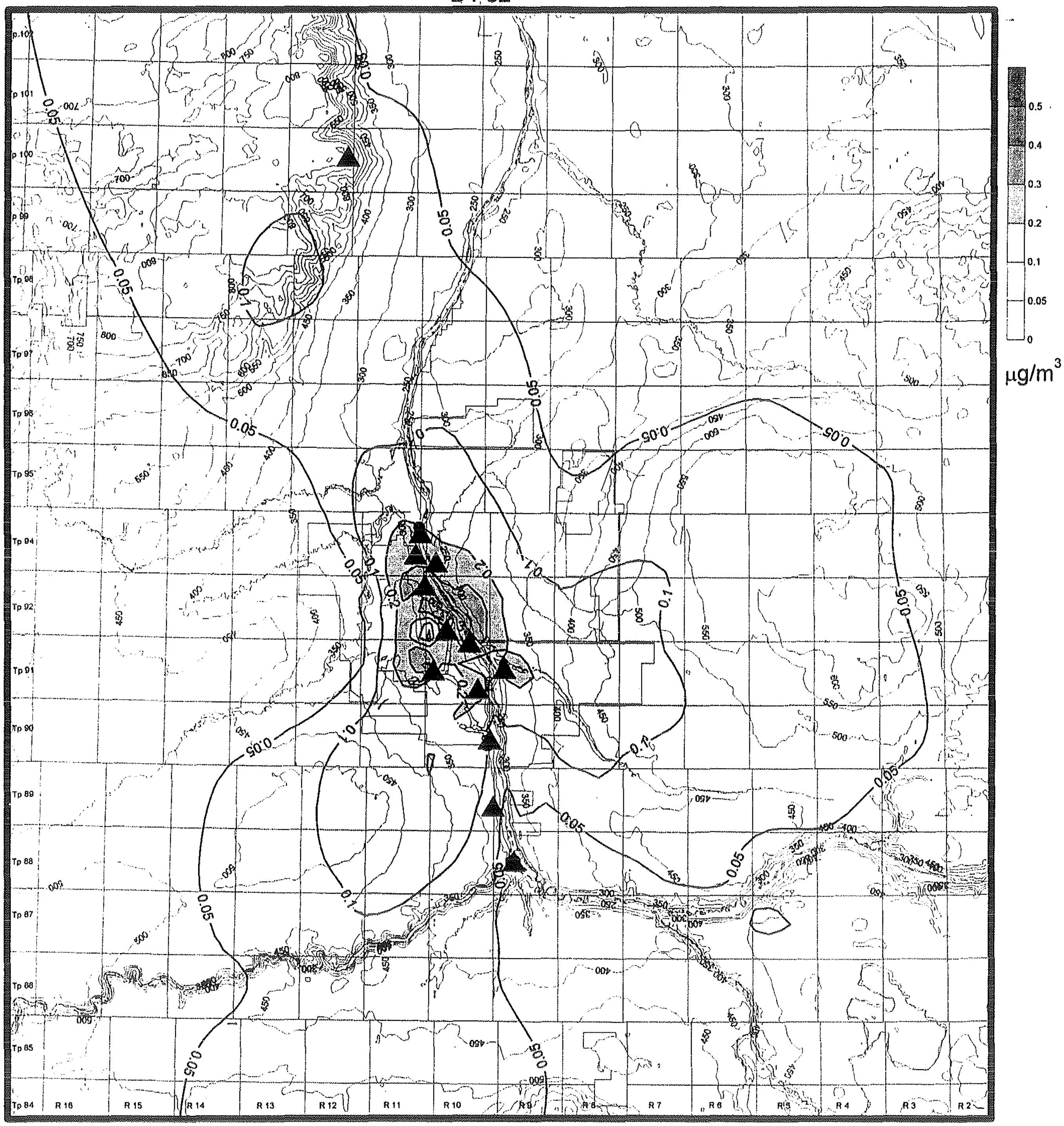
Table B4-9 Maximum Predicted Ground Level Concentrations of PM_{10} for Baseline Sources

Source	Daily	Annual
CEA - Model ISC3BE		
Maximum PM_{10} Concentration ($\mu g/m^3$)	116	39.2
Location of Maximum Concentration (km)	WNW	WNW
Maximum Number of Exceedances	n/a	0
Location of Maximum Exceedances	n/a	n/a
TSP, Alberta Guideline (µg/m3)	100	60

The modelling predicts high levels of PM_{10} in the development area and low levels in the rest of the RSA based on the CEA emission sources.

The particulate emissions from the Suncor FGD and Syncrude stacks contain metals and PAH compounds. The ISC3BE was configured to predict particulates from these two stacks plus the new stack at Syncrude as part of proposed Upgrader expansion to determine ground level concentrations and deposition rates. Particulate characteristics were based on stack surveys completed for the existing stacks.

The predicted average annual ground level concentrations of total particulates from these sources are shown in Figure B4-19. The predicted annual average deposition of total particulates from these sources are shown in Figure B4-20. A summary of the predicted metal and PAH concentrations derived from the total particulate air concentrations are listed in Tables B4-10 and B4-11 for selected locations. The PM assessment from the Suncor FGD stack reflects the most recent stack survey data which included analysis of heavy metals, PAHs, and particulate size fractions. This data has been included in the air quality section but was not available in time for inclusion in the health assessment in Section F1.



UTM NAD83 metres
0 5000 10000 15000 20000

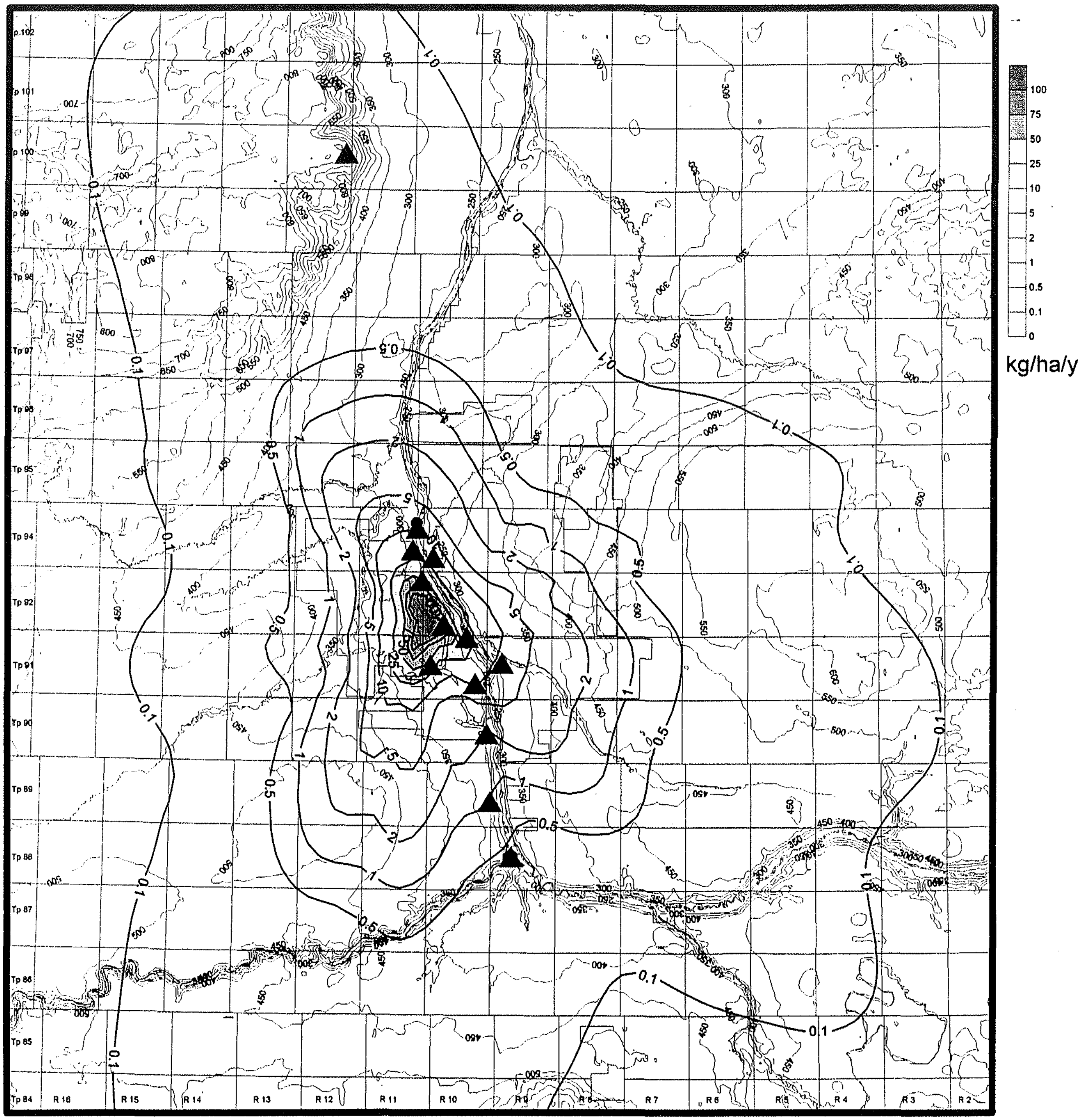
Sources	PM [t/cd]
Suncor	
FGD	2.60
Powerhouse	-
Incinerator	-
Tail Gas Treatment Unit	-
Millennium Mine Fleet	-
Other Sources, Suncor	-
Syncrude Main Stack	8.5
Syncrude New Stack	5.8
Other Emissions (total)	-
Other Proposed Emissions (total)	-
TOTAL	16.9

Model Description	
Development	CEA
Model	ISC3BE

Figure B4-19 Predicted CEA Particulate Annual Average Ground Level Concentrations in the RSA from the operation of the Suncor and Syncrude main stacks

Project Millennium
Taking Suncor into the 21st Century

SUNCOR ENERGY



Sources	PM (t/cd)
Suncor	
FGD	2.60
Powerhouse	-
Incinerator	-
Tail Gas Treatment Unit	-
Millennium Mine Fleet	-
Other Sources, Suncor	-
Syncrude Main Stack	8.5
Syncrude New Stack	5.8
Other Emissions (total)	-
Other Proposed Emissions (total)	-
TOTAL	16.9

Model Description	
Development	CEA
Model	ISC3BE

UTM NAD83 metres
0 5000 10000 15000 20000

Figure B4-20 Predicted CEA Particulate Annual Average Deposition in the RSA from the operation of the Suncor and Syncrude Main stacks

Table B4-10 Average Ground Level Predicted Concentrations of Heavy Metals at Selected Sites as a Result of Emissions From Suncor FGD and Syncrude Main Stack

Location	Average Daily Ground Level Concentration					Average Annual Ground Level Concentration			
	Ontario AAQC, Daily [ng/m^3]	Mannix	Fort McMurray	Fort McKay	Fort Chipewyan	Mannix	Fort McMurray	Fort McKay	Fort Chipewyan
Heavy Metals [ng/m^3]									
Antimony	—	7.0E-02	1.5E-02	4.3E-02	5.2E-03	4.4E-03	3.2E-04	2.1E-03	2.5E-04
Arsenic	3.00E+03	1.1E-01	2.3E-02	6.7E-02	8.1E-03	6.8E-03	5.2E-04	3.3E-03	3.9E-04
Aluminum	—	1.3E+01	3.0E+00	9.3E+00	1.1E+00	8.8E-01	4.7E-02	4.1E-01	5.2E-02
Barium	1.00E+05	1.1E+00	2.2E-01	6.3E-01	7.8E-02	6.6E-02	5.3E-03	3.2E-02	3.7E-03
Beryllium	0.00E+00	1.3E-02	2.8E-03	8.4E-03	1.0E-03	8.4E-04	5.8E-05	4.0E-04	4.8E-05
Cadmium	2.00E+04	3.1E-02	7.0E-03	2.2E-02	2.6E-03	2.1E-03	9.5E-05	9.5E-04	1.2E-04
Chromium	1.50E+04	6.1E+00	1.3E+00	4.0E+00	4.8E-01	3.9E-01	2.5E-02	1.9E-01	2.3E-02
Cobalt	1.00E+03	3.3E-01	7.3E-02	2.2E-01	2.7E-02	2.2E-02	1.3E-03	1.0E-02	1.3E-03
Copper	5.00E+05	5.7E-01	1.2E-01	3.8E-01	4.5E-02	3.7E-02	2.2E-03	1.7E-02	2.2E-03
Iron	—	6.3E+01	1.4E+01	4.5E+01	5.3E+00	4.2E+00	2.1E-01	2.0E+00	2.5E-01
Lead	0.00E+00	7.1E-01	1.5E-01	4.1E-01	5.1E-02	4.3E-02	3.6E-03	2.1E-02	2.4E-03
Manganese	—	2.2E+00	4.7E-01	1.4E+00	1.7E-01	1.4E-01	1.0E-02	6.7E-02	7.9E-03
Mercury	2.00E+04	1.5E-02	3.3E-03	1.0E-02	1.2E-03	9.9E-04	6.5E-05	4.7E-04	5.7E-05
Molybdenum	1.20E+06	1.1E+00	2.4E-01	7.3E-01	8.8E-02	7.3E-02	4.9E-03	3.5E-02	4.2E-03
Nickel	2.00E+04	1.0E+01	2.2E+00	6.8E+00	8.1E-01	6.5E-01	3.8E-02	3.1E-01	3.8E-02
Selenium	1.00E+05	2.2E+00	4.0E-01	8.7E-01	1.2E-01	1.2E-01	1.7E-02	6.5E-02	5.9E-03
Silver	1.00E+04	1.4E-01	3.1E-02	1.0E-01	1.2E-02	9.2E-03	4.0E-04	4.2E-03	5.5E-04
Tin	1.00E+05	7.4E-01	1.5E-01	4.4E-01	5.4E-02	4.6E-02	3.6E-03	2.2E-02	2.6E-03
Titanium	—	1.4E+00	3.0E-01	9.3E-01	1.1E-01	9.0E-02	5.6E-03	4.3E-02	5.2E-03
Vanadium	2.00E+04	4.4E+00	9.3E-01	2.8E+00	3.4E-01	2.8E-01	1.9E-02	1.3E-01	1.6E-02
Zirconium	—	7.4E-01	1.5E-01	4.4E-01	5.4E-02	4.6E-02	3.6E-03	2.2E-02	2.6E-03
Zinc	1.20E+06	3.4E+01	8.1E+00	2.8E+01	3.2E+00	2.4E+00	5.5E-02	1.1E+00	1.5E-01

OAAQC: Ontario Ambient Air Quality Criteria
Ontario Ministry of the Environment 1994
Summary of Point of Impingement Standards, Ambient Air Quality Criteria (AAQC), and Approvals Screening Levels

Table B4-11 Average Ground Level Predicted Concentrations of PAHs at Selected Sites as a Result of Emissions From Suncor FGD and Syncrude Main Stack

Location	Average Daily Ground Level Concentration				Average Annual Ground Level Concentration			
	Mannix	Fort McMurray	Fort McKay	Fort Chipewyan	Mannix	Fort McMurray	Fort McKay	Fort Chipewyan
PAHs [ng/m^3]								
Acenaphthene	1.0E-03	2.0E-04	5.3E-04	6.7E-05	4.3E-05	5.9E-06	3.0E-05	1.9E-06
Acenaphylene	5.6E-02	1.4E-02	4.7E-02	5.4E-03	1.4E-03	8.7E-05	1.8E-03	4.4E-05
Anthracene	2.5E-03	4.7E-04	1.1E-03	1.5E-04	1.2E-04	1.7E-05	7.3E-05	5.4E-06
1,2-Benzathracene	1.4E-03	3.0E-04	8.7E-04	1.1E-04	5.4E-05	6.6E-06	4.3E-05	2.3E-06
Benzo(b & j)fiuoranthene	7.2E-03	1.4E-03	3.6E-03	4.7E-04	3.2E-04	4.4E-05	2.1E-04	1.4E-05
Benzo(k)fluoranthene	1.6E-03	3.4E-04	1.0E-03	1.2E-04	5.5E-05	6.2E-06	4.8E-05	2.2E-06
Benzo(a)fluorene	1.1E-03	2.1E-04	5.6E-04	7.2E-05	4.8E-05	6.6E-06	3.2E-05	2.1E-06
Benzo(b)fluorene	7.3E-04	1.5E-04	4.3E-04	5.3E-05	2.9E-05	3.7E-06	2.2E-05	1.2E-06
Benzo(g, h, i)perylene	1.8E-03	3.9E-04	1.2E-03	1.4E-04	6.4E-05	7.4E-06	5.5E-05	2.6E-06
Benzo(a)pyrene	1.2E-03	2.4E-04	6.9E-04	8.5E-05	4.5E-05	5.6E-06	3.5E-05	1.9E-06
Benzo(e)pyrene	7.3E-04	1.5E-04	4.3E-04	5.3E-05	2.9E-05	3.7E-06	2.2E-05	1.2E-06
Camphene	1.7E-03	3.1E-04	7.7E-04	1.0E-04	7.8E-05	1.1E-05	4.9E-05	3.6E-06
Carbazole	1.0E-03	2.0E-04	5.4E-04	6.8E-05	4.4E-05	6.0E-06	3.0E-05	2.0E-06
1 -Chloronaphthalene	9.8E-04	2.0E-04	5.5E-04	6.9E-05	4.1E-05	5.3E-06	2.9E-05	1.8E-06
2-Chloronaphthalene	1.9E-03	4.2E-04	1.3E-03	1.6E-04	6.3E-05	6.7E-06	5.8E-05	2.5E-06
Chrysene	3.2E-03	7.2E-04	2.3E-03	2.7E-04	1.1E-04	1.1E-05	1.0E-04	4.2E-06
Dibenz(a, j)acridine	1.3E-03	2.8E-04	8.4E-04	1.0E-04	4.9E-05	5.8E-06	4.0E-05	2.0E-06
Dibenz(a, h)acridine	9.3E-04	1.8E-04	5.0E-04	6.3E-05	3.9E-05	5.2E-06	2.8E-05	1.7E-06
Dibenz(a, h anthracene	9.8E-04	2.0E-04	5.5E-04	6.9E-05	4.1E-05	5.3E-06	2.9E-05	1.8E-06
Dibenzothiophene	2.2E-01	5.4E-02	1.9E-01	2.1E-02	5.6E-03	3.5E-04	7.1E-03	1.8E-04
7,12-dimethylbenz(a)anthracene	9.3E-04	1.8E-04	5.0E-04	6.3E-05	3.9E-05	5.2E-06	2.8E-05	1.7E-06
1, 6-Dinitropyrene	9.3E-04	1.8E-04	5.0E-04	6.3E-05	3.9E-05	5.2E-06	2.8E-05	1.7E-06
1, 8-Dinitropyrene	9.3E-04	1.8E-04	5.0E-04	6.3E-05	3.9E-05	5.2E-06	2.8E-05	1.7E-06
Fluoranthene	8.6E-03	1.7E-03	4.8E-03	6.0E-04	3.6E-04	4.7E-05	2.6E-04	1.6E-05
Fluorene	3.9E-03	7.1E-04	1.6E-03	2.2E-04	2.0E-04	3.0E-05	1.1E-04	9.3E-06
Ideno(l, 2, 3-cd)pyrene	1.7E-03	3.8E-04	1.2E-03	1.4E-04	5.9E-05	6.4E-06	5.3E-05	2.3E-06
Indole	1.7E-03	3.2E-04	7.8E-04	1.0E-04	8.0E-05	1.2E-05	5.0E-05	3.7E-06
1 -Methylnaphthalene	6.1E-02	1.4E-02	4.9E-02	5.6E-03	1.7E-03	1.3E-04	1.9E-03	5.8E-05
2-Methylnaphthalene	5.5E-02	1.3E-02	4.2E-02	4.9E-03	1.6E-03	1.4E-04	1.7E-03	5.8E-05
Naphthalene	8.4E-01	2.0E-01	6.9E-01	7.9E-02	2.2E-02	1.6E-03	2.7E-02	7.3E-04
Nitro-pyrene	1.2E-03	2.4E-04	6.1E-04	7.8E-05	5.5E-05	7.6E-06	3.6E-05	2.5E-06
Perylene	7.3E-04	1.5E-04	4.3E-04	5.3E-05	2.9E-05	3.7E-06	2.2E-05	1.2E-06
Phenanthrene	9.6E-02	2.2E-02	7.1E-02	8.3E-03	3.0E-03	2.9E-04	3.0E-03	1.1E-04
Pyrene	1.1E-02	2.5E-03	7.8E-03	9.2E-04	3.6E-04	3.7E-05	3.4E-04	1.4E-05
Retene	1.1E-02	2.2E-03	6.1E-03	7.7E-04	4.7E-04	6.2E-05	3.3E-04	2.0E-05

B4.2.7 Fugitive Dust Discussion

The maximum predicted PM does not include contributions due to non-combustion sources nor natural background levels. Potential fugitive sources associated with all of the existing, planned and proposed projects include the mining operations, coke piles, road dust, beaches, and the physical reclamation activities. It is Suncor's experience that the mining area, given the coarse nature of oil sands (bitumen and sand combination), is expected to produce minimal PM fugitive emissions. The existing reclamation activities will control fugitive particulate emissions from the sand dykes and beaches. Overall, fugitive emissions are most likely an episodic issue and can be managed.

B4.2.8 Volatile Organic Compounds Predicted Concentrations

The VOC emission sources associated with the CEA case are summarized in Section B4.1. Total estimated emission rates for this case are 340 t/cd for VOC (Table B4-2). Suncor represents about 70% of the VOC total emissions. The predicted annual average ground level ambient total VOC concentrations resulting from emissions of all approved industrial sources and residential emissions in the oil sands region were estimated using ISC3BE and meteorology measurements from the Mannix station. Using these VOC runs and the unique fingerprint of each emission source, specific VOCs were further speciated from the modelling results. This model provides an efficient means of predicting the overall ambient VOC concentration and the speciated compounds from all sources.

The predicted total VOC hourly, daily and annual average ground level concentrations are mapped in Figures B4-21, B4-22 and B4-23 respectively. The results show that the overall maximum concentrations are expected to occur within the existing development areas and are associated with the tailings ponds. Because source characterization simplifications are used to model large sources such as tailings ponds, which include annualized emission rates and homogeneous emissions over the pond surfaces, maximum concentrations under worst case meteorology likely overestimates values very close to the pond. The annual concentrations for selected receptors are listed in Table B4-12 and are put into perspective in the health discussion in Section F1.

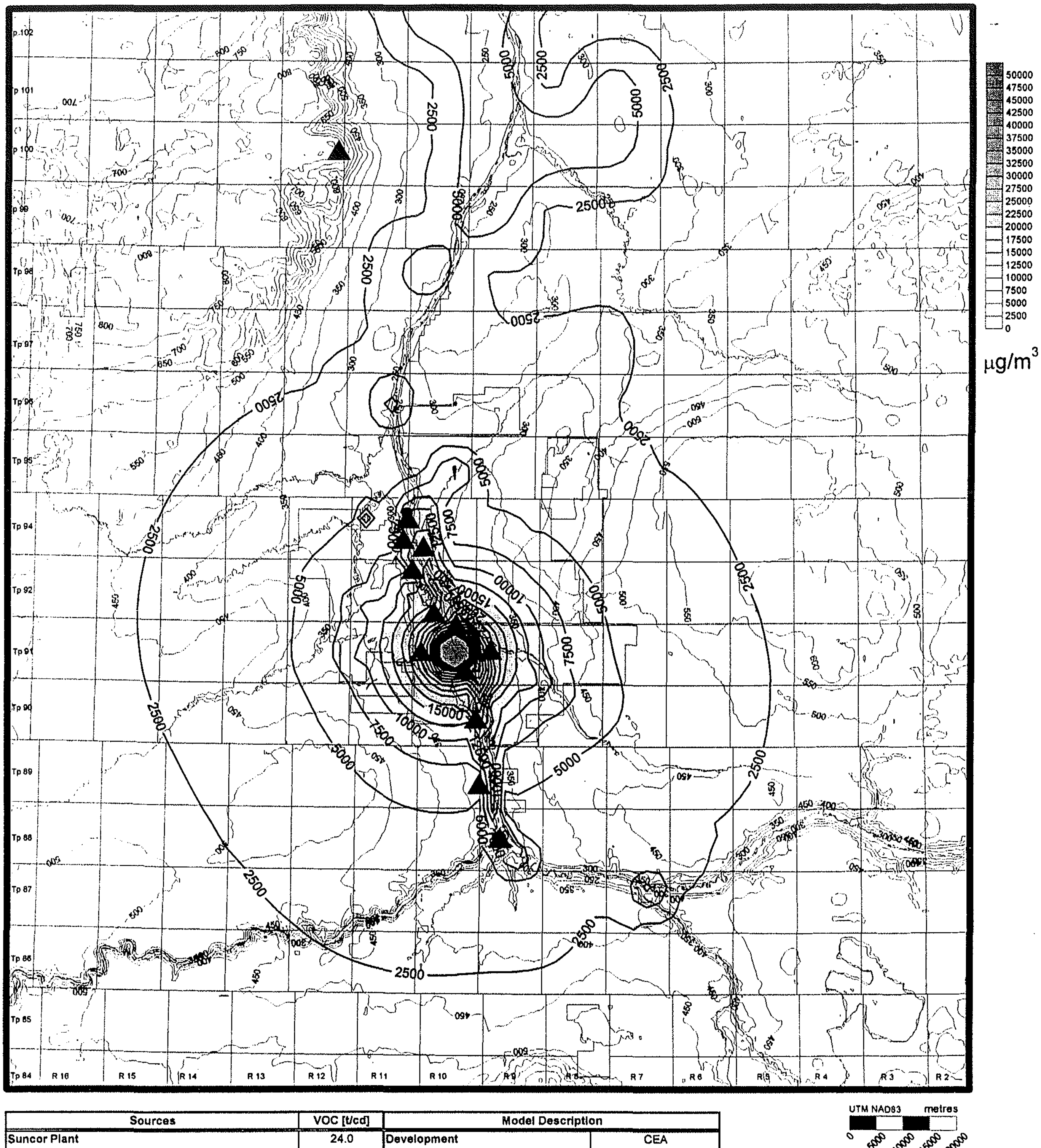
Table B4-12 Maximum Predicted Annual Average Ground Level Concentrations of VOCs for CEA at Selected Locations

	VOC Concentration [μg/m³]				
Species	Location of Maximum	Mannix	Fort McMurray	Fort McKay	Fort Chipewyan
Total VOCs					
Maximum concentration [μg/m³]	34100	811	85	190	16
Speciated VOCs					
C2 to C4 alkanes and alkenes	616	14.7	1.5	3.4	0.29
C5 to C8 Alkanes and alkenes	13029	310	32.5	72.5	6.0
C9 to C12 alkanes and alkenes [(a)]	13862	330	34.6	77.1	6.4
Cyclohexane	2894	69	7.2	16.1	1.3
Benzene	102	2.4	0.25	0.56	0.047
C6 to C8 non-benzene aromatics	1705	41	4.3	9.5	0.8
Total aldehydes	66	1.6	0.165	0.368	0.031
Total ketones	18	0.4	0.045	0.101	0.008
Total Reduced Sulphur Compounds	664	15.8	1.7	3.7	0.3

(a) Unknown speciation are included in group C9 to C12

B4.2.9 TRS Predicted Concentration

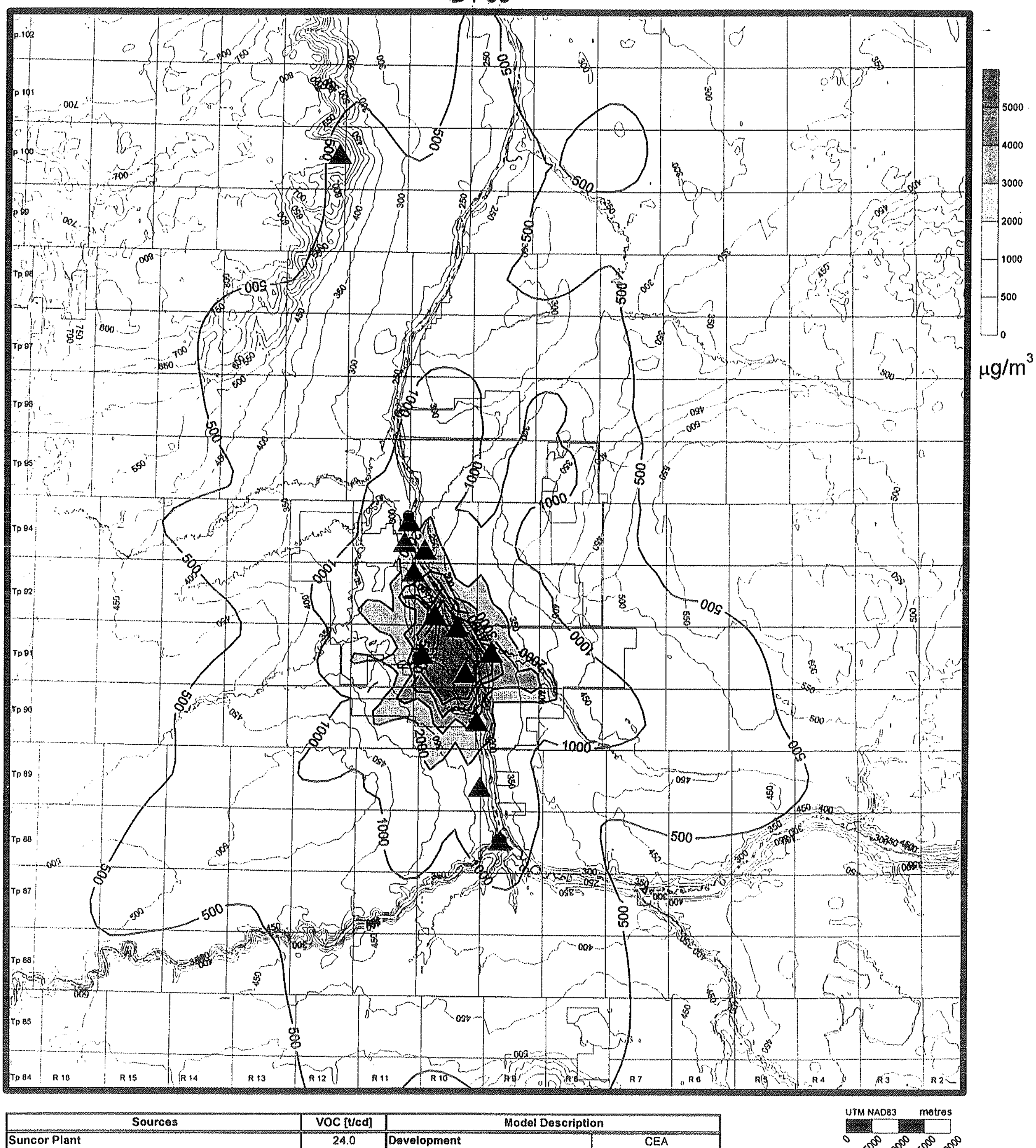
The ambient TRS emission sources associated with this case are summarized in Section B4.1. Total estimated TRS emission rate for the



Sources	VOC [t/cd]
Suncor Plant	24.0
Syncrude Plant	9.6
Mine Fleets	4.8
Mine Faces	50.8
Tailings Ponds	243.4
TOTAL	332.5

Model Description	
Development	CEA
Model	ISC3BE

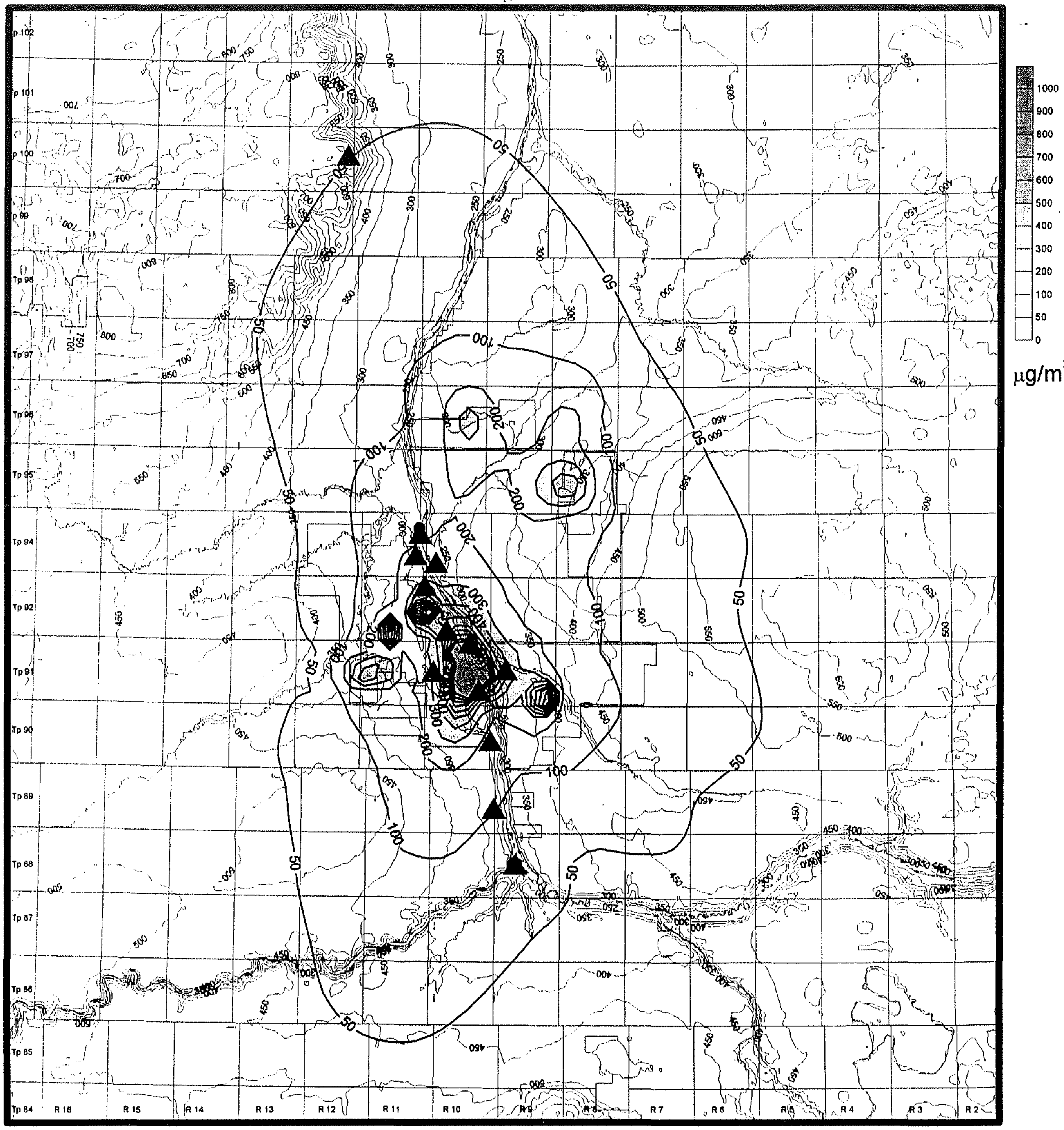
Figure B4-21 Predicted CEA VOC Maximum Hourly Average Ground Level Concentrations in the RSA



Sources	VOC [t/cd]
Suncor Plant	24.0
Syncrude Plant	9.6
Mine Fleets	4.8
Mine Faces	50.8
Tailings Ponds	243.4
TOTAL	332.5

Model Description	
Development	CEA
Model	ISC3BE

Figure B4-22 Predicted CEA VOC Maximum Daily Average Ground Level Concentrations in the RSA



UTM NAD83 metres

0 5000 10000 15000 20000

Sources	VOC [t/cd]
Suncor Plant	24.0
Syncrude Plant	9.6
Mine Fleets	4.8
Mine Faces	50.8
Tailings Ponds	243.4
TOTAL	332.5

Model Description	
Development	CEA
Model	ISC3BE

Figure B4-23 Predicted CEA VOC Annual Average Ground Level Concentrations in the RSA

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CEA case is 6.3 t/cd. Suncor emits about 2.7 t/cd of TRS mainly from the tailing ponds. In total Suncor emits approximately 43% of the TRS.

The predicted maximum, daily and annual ground level ambient TRS concentrations resulting from the CEA emissions were estimated using ISC3BE and meteorology measurements from the Mannix station. Selected results of the speciated reduced sulphur compounds are shown in Figure B4-24 and Figure B4-25 for the hourly and daily H_2S and in Figure B4-26 for hourly mercaptans. These TRS species were selected because they have particularly low odour thresholds. Maximum hourly and daily concentrations at selected locations are listed in Table B4-13 and Table B4-14.

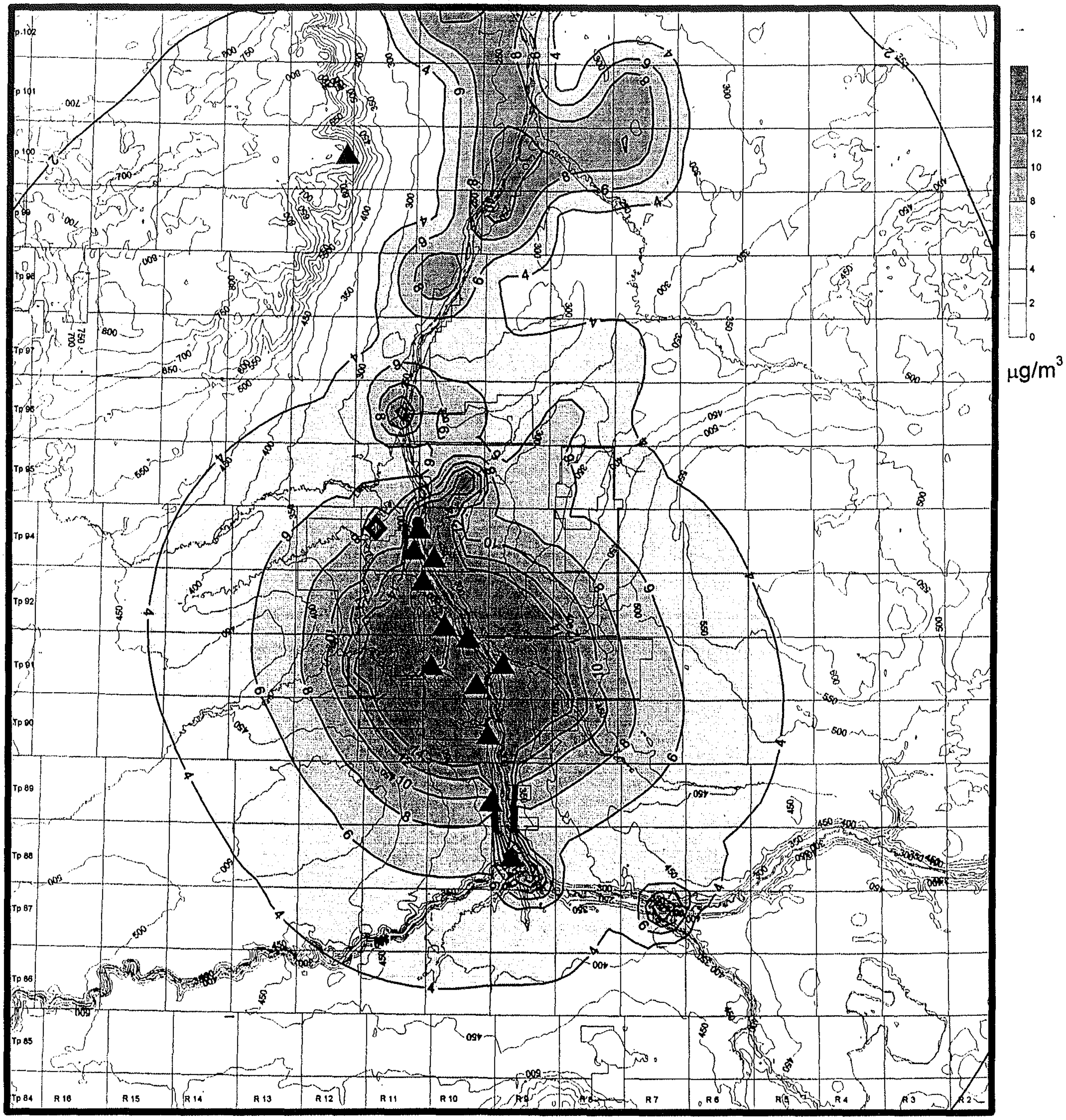
Whereas the ISC3BE model was not configured to explicitly assess odours, the concentrations at the selected locations can be used to qualitatively assess the potential for odour detection at these locations. The results presented in the figures do not address the complexities of thorough odour assessment which would take into account concentration, duration above a threshold, frequency of exceeding various thresholds and receptor sensitivity. As a part of the ISC3BE development, the dispersion coefficients were adjusted for receptors within the Athabasca River valley such that limited mixing could occur under certain meteorological conditions. The results of this fine tuning can be seen in Figure B4-24 in the elevated H_2S concentrations within the Athabasca River valley.

The results in Table B4-13 and Table B4-14 indicate that the predicted concentrations could potentially lead to the detection of odours originating from the developments in the oil sands area for sensitive individuals.

Table B4-13 Maximum Predicted Hourly Concentrations of TRS at Selected Sites for CEA Sources

	TRS Concentration [μg/m³]				
Species	Location of Maximum	Mannix	Fort McMurray	Fort McKay	Fort Chipewyan
Total Reduced Sulphur Compounds					
Maximum VOC concentration [μg/m³]	141000	39492	11057	13987	3989
Maximum TRS concentration [μg/m³]	2747	769	215	273	78
Speciated Compounds					
H_2S	221	62	17	22	6
COS	0	0	0	0	0
CS_2	0	0	0	0	0
Mercaptans	7.35	2.06	0.58	0.73	0.21
Thiophenes	977	274	77	97	28

Alberta H_2S hourly guideline - 4 μg/m³
Odour threshold for mercaptans is 0.04 to 2.0 μg/m³
Odour threshold for H_2S is 0.7 to 14 μg/m³



Sources	H_2S [t/cd]
Suncor Plant	0.038
Syncrude Plant	0.015
Mine Fleets	0.007
Mine Faces	0.080
Tailings Ponds	0.382
TOTAL	0.521

Model Description	
Development	CEA
Model	ISC3BE

Figure B4-24 Predicted CEA H_2S Maximum Hourly Average Ground Level Concentrations in the RSA

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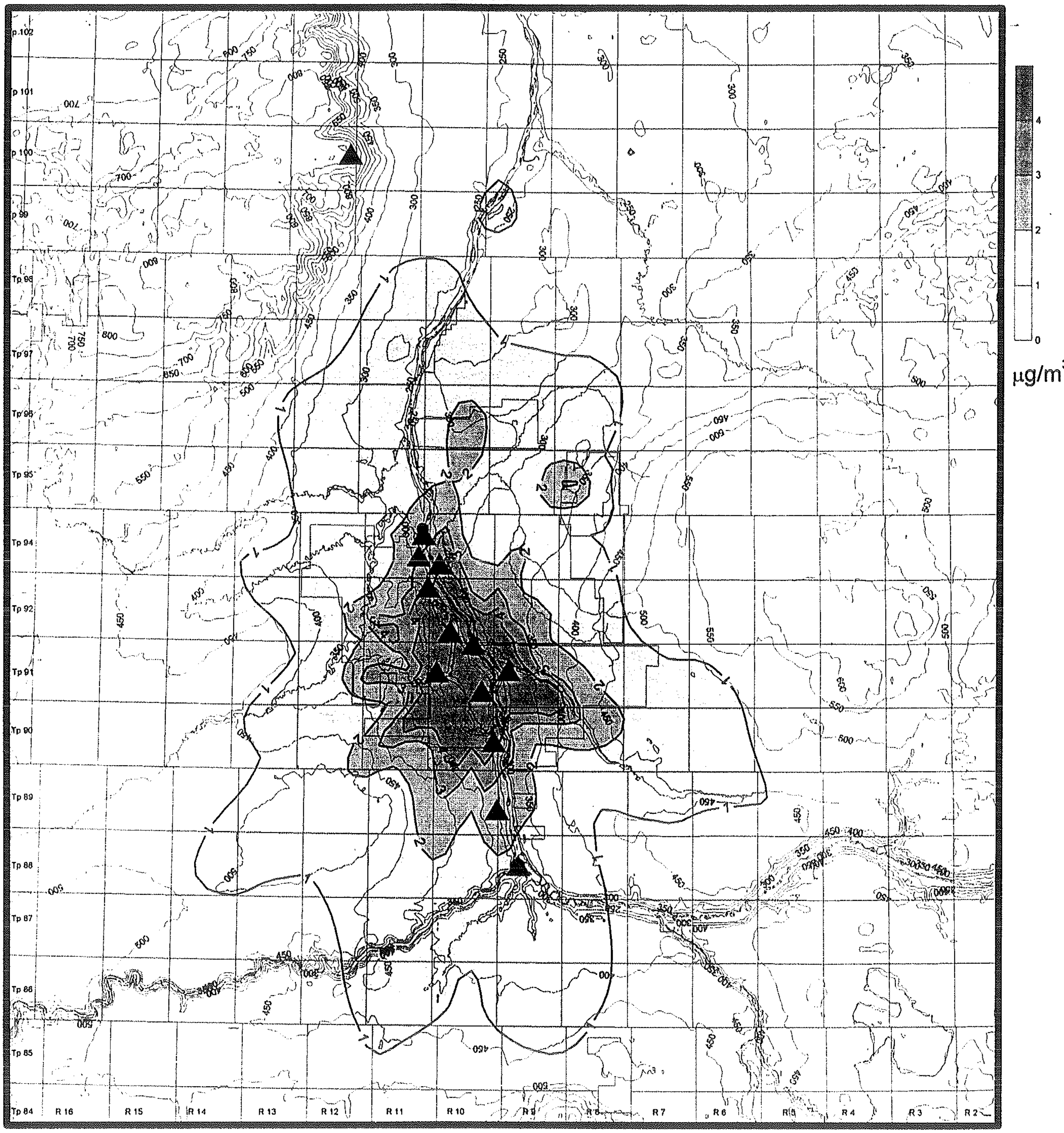

Sources	H_2S [t/cd]
Suncor Plant	0.038
Syncrude Plant	0.015
Mine Fleets	0.007
Mine Faces	0.080
Tailings Ponds	0.382
TOTAL	0.521

Model Description	
Development	CEA
Model	ISC3BE

Figure B4-25 Predicted CEA H_2S Maximum Daily Average Ground Level Concentrations in the RSA

Project Millennium
Taking Suncor into the 21st Century

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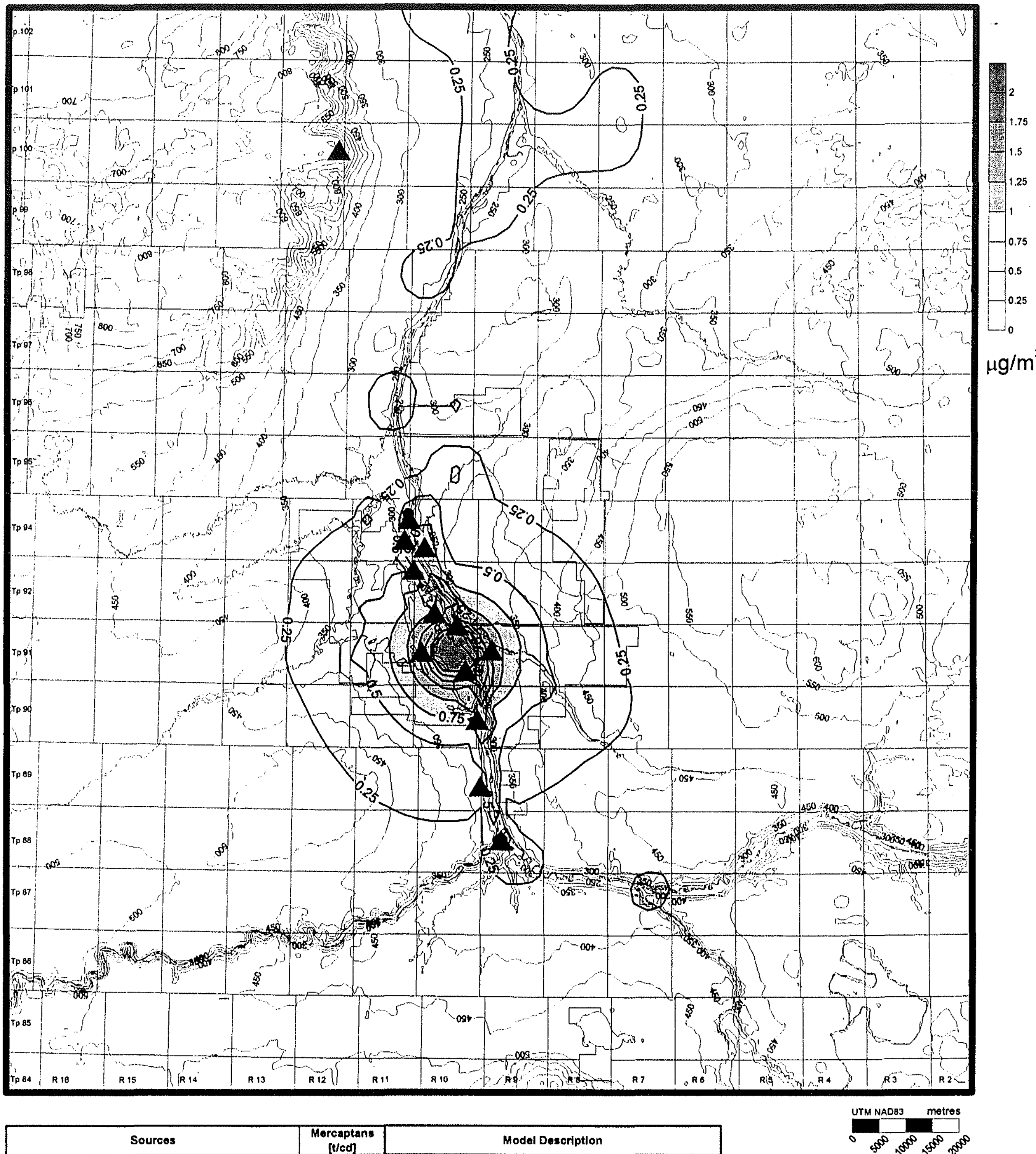


Sources	Mercaptans [t/cd]
Suncor Plant	0.0013
Syncrude Plant	0.0005
Mine Fleets	0.0002
Mine Faces	0.0026
Tailings Ponds	0.0127
TOTAL	0.0173

Model Description	
Development	CEA
Model	ISC3BE

Figure B4-26 Predicted CEA Mercaptans Maximum Hourly Average Ground Level Concentrations in the RSA

Table B4-14 Maximum Predicted Daily Concentrations of TRS at Selected Sites for CEA Sources

Species	TRS Concentration [μg/m³]				
	Location of Maximum	Mannix	Fort McMurray	Fort McKay	Fort Chipewyan
Total Reduced Sulphur Compounds					
Maximum VOC concentration [μg/m³]	92,000	10,341	1,124	1,828	243
Maximum TRS concentration [μg/m³]	1,792	201	22	36	5
Speciated Compounds					
H_2S	144	16	2	3	0
COS	0	0	0	0	0
CS_2	0	0	0	0	0
Mercaptans	4.79	0.54	0.06	0.10	0.01
Thiophenes	637	72	8	13	2

Alberta H_2S hourly guideline - 14 μg/m³
Odour threshold for mercaptans is 0.04 to 2.0 μg/m³
Odour threshold for H_2S is 0.7 to 14 μg/m³

B4.2.10 Noise

The closest community that may be affected by the noise from the existing and approved projects, Project Millennium and the proposed projects is Fort McKay. Noise may be generated from a variety of on-site activities, including engine noise from truck and shovel operations, extraction, on-site power generation, upgrading operations and increased traffic within the local communities. Currently, noise sources exist at the fixed plant and other mining operations at Suncor's Lease 86/17. Additionally, similar activities at the Syncrude Mildred Lake operation, as well as from the Aurora Mine and the planned Shell Muskeg River Mine and Lease 13 will also contribute to the ambient levels experienced in Fort McKay.

Comprehensive assessment of the anticipated noise levels in Fort McKay would need to consider the collective contribution of all mine operations, in addition to background. As the level of detailed information required to complete an assessment is not available, only general comments can be made. The modelling of all regional sources will be complex given the variability in noise emission of the equipment, the mobile nature of many of the noise sources, the effects of the mine pits and general terrain features in addition to the meteorological inputs. Mitigation, such as using natural or man made sound barriers and noise mufflers, is available should final operating plans predict high noise levels.

B4.2.11 Cumulative Impact Analyses

The air emissions from all of the CEA emission sources have been described and quantified as a result of Project Millennium. The resulting air quality concentrations have been determined using appropriate models. This approach provides the foundation to determine the potential cumulative air impacts using the approach described in Section A2.1.8. The key question identified at the beginning of this section can now be addressed.

CAQ-1: What impacts to ambient air quality and acidification of water, soils and vegetation will result from air emissions associated with Project Millennium and the combined developments?

The potential for air emissions from Project Millennium and combined developments to impact ambient air quality and the acidification of water, soils and vegetation has been raised as cumulative concern in the region. This issue was addressed in two stages. The first stage looked at the potential impacts on air quality by predicting air concentrations of SO_2, NO_2, CO, PM, VOC and TRS using the ISC3BE dispersion model. The model results were then compared to Alberta Ambient Air Quality Guidelines, Canadian Federal Air Quality Objectives or other guidelines to assist in the prediction of impacts. The potential for acidification of water, soils and vegetation was then addressed by using the CALPUFF dispersion model to determine the Potential Acid Input (PAI) resulting from the SO_2 and NO_x emitted by Project Millennium and the combined developments. The linkage pathway for this key question is depicted in Figure B4-1. Comparison of emissions and concentrations are presented in Table B4-15 and a discussion follows.

Table B4-15 Summary of Air Emissions for Project Millennium and the Combined Developments

	Baseline Case[a]	Project Millennium Case[a]	Cumulative Environmental Assessment[a]	Comments
Suncor Process Information				
Capacity **[bbl/d]**	105,000	210,000	210,000	
Emission Rate of SO_2 t/cd	65.3	70.2	70.2	
Emission Rate of NO_x t/cd	47.7	67.7	67.7	
Emission Rate of CO t/cd	33.5	38.5	38.5	
Emission Rate of PM t/cd	1.7	2.2	2.2	
Emission Rate of VOC t/cd	130	240.4	240.4	
Emission Rate of TRS t/cd	1.5	2.73	2.73	
Predicted SO_2 Concentrations				
Hourly				
• Maximum average (µg/m³)	648	870	872	Below Federal Acceptable
• Exceedance (number)	3	49	50	
• Areal extent (ha)	33,313	58,860	68,950	
Daily				
• Maximum average (µg/m³)	199	200	188	Below Federal Acceptable
• Exceedance (number)	6	9	1	
• Areal extent (ha)	358	289	neg	In Development Area
Annual				
• Maximum average (µg/m³)	74	82	47.5	Above Federal Acceptable
• Exceedance (number)	1	1	1	
• Areal extent (ha)	356	409	540	In Development Area

	Baseline Case[a]	Project Millennium Case[a]	Cumulative Environmental Assessment[a]	Comments
Predicted NO_2 Concentrations				
Hourly				
• Maximum average (µg/m³)	316	320	295	Below Alberta Guideline
• Exceedance (number)	0	0	0	
• Areal extent (ha)	0	0	0	
Daily				
• Maximum average (µg/m³)	259	260	244	Above Federal Acceptable
• Exceedance (number)	**101**	**101**	**81**	
• Areal extent (ha)	825	2,185	1,447	In Development Area
Annual				
• Maximum average (µg/m³)	162	162	163	Above Federal Acceptable
• Exceedance (number)	1	1		
• Areal extent (ha)	5,818	8,343	38,624	
Predicted PAI Concentrations				
• Areal extent if >0.25 keq/ha/y (ha)[b]	670,483	861,263	1,417,300	
• Areal extent if >0.50 keq/ha/y (ha)[b]	11,543	195,695	420,086	
• Areal extent if >1.0 keq/ha/y (ha)[b]	3,206	9,598	20,430	
• Areal extent if >1.5 keq/ha/y (ha)[b]	250	317	13	
Predicted CO Concentrations				
Hourly				
• Maximum average (µg/m³)	5,561	5,560	5,560	Below Alberta Guideline
• Exceedance (number)	0	0	0	
• Areal extent (ha)	0	0	0	
8-Hour				Below Alberta Guideline
• Maximum average (µg/m³)	1,160	1,169	928	
• Exceedance (number)	n/a	n/a	n/a	
• Areal extent (ha)	n/a	n/a	n/a	
Predicted PM Concentrations				
Daily				
• Maximum average (µg/m³)	115	113	116	
• Exceedance (number)	n/a	n/a	n/a	
• Areal extent (ha)	n/a	n/a	n/a	
Annual	45	45.9	39.2	
• Maximum average (µg/m³)				
• Exceedance (number)	n/a	n/a	n/a	
• Areal extent (ha)	n/a	n/a	n/a	
Predicted VOC Concentrations				
Annual				
• Maximum average (µg/m³)	50	76	85	**Fort McMurray**
• Maximum average (µg/m³)	107	163	190	**Fort McMcKay**
• Exceedance (number)	n/a	n/a	n/a	
• Areal extent (ha)	n/a	n/a	n/a	
Predicted TRS Concentrations				
Hourly				
• Maximum average H_2S (µg/m³)	**9.2**	**14.1**	17	**Fort McMurray**
• Maximum average H_2S (µg/m³)	**11.7**	**17.8**	22	**Fort McMcKay**
• Exceedance (number)	n/a	n/a	n/a	
• Areal extent (ha)	n/a	n/a	n/a	
Daily				
• Maximum average H_2S (µg/m³)	**0.9**	**1.3**		**Fort McMurray**
• Maximum average H_2S (µg/m³)	**1.7**	**2.4**		**Fort McMcKay**
• Exceedance (number)	n/a	n/a	n/a	
• Areal extent (ha)	n/a	n/a	n/a	

(a) All predicted values based on ISC3BE model unless otherwise noted.
(b) Predictions based on CALPUFF model

A review of the potential impacts on air quality of air concentrations of SO_2, NO_2, CO, PM, VOC and TRS was completed using the ISC3BE dispersion model. The model results were then compared to Alberta Ambient Air Quality Guidelines, Canadian Federal Air Quality Objectives or other guidelines to assist in the assessment of impacts following the approach outlined in Section A2. The assessment is summarized as follows:

- The predicted cumulative impacts of hourly, daily and annual SO_2 emissions and concentrations are very similar to Project Millennium and the conclusion is the same. For hourly and daily SO_2, the environmental consequence of the impacts are low. The annual SO_2 environmental consequence is predicted to be moderate. However, because most of the maximum annual concentrations that exceed guidelines are inside the development area, the impact is not deemed to be significant.
- The predicted cumulative impacts for NO_2 are the same as developed for Project Millennium. The hourly environmental consequences are low while the environmental consequences for the maximum annual daily and annual concentrations are moderate. As in the case of SO_2, this moderate environmental consequence is tempered by the limited areal extent of the concentrations exceeding the Alberta guidelines. While more area is involved in the annual maximum average, the high values continue to be within the existing or proposed development areas. Therefore, this impact is rated as not significant.
- Particulate emissions and concentrations for the cumulative assessment are very similar to Project Millennium and the conclusions are the same. That is, the predicted environmental consequence of these impacts is low.
- Cumulative impacts for VOC emissions and concentrations are discussed in the Human Health Section (F1).
- The cumulative impacts of the TRS emissions were rated as moderate environmental consequence for Project Millennium and the same prediction holds for the cumulative case. As indicated in Section B3, TRSs may continue to be an occasional odour issue. Viewed in the context that most of the concentrations exceeding guidelines lie inside the development areas, and the conservatism built into the Suncor component of the emission estimate, the impact is not deemed to be significant.

The acidification of water, soils and vegetation was addressed using the CALPUFF dispersion model to determine the Potential Acid Input (PAI) resulting from the SO_2 and NO_x emitted by Project Millennium and the combined developments. A background PAI of 0.1 keq/ha/y has been incorporated into the PAI generated numbers. The areal extent of the 0.25 keq/ha/y PAI contour represents approximately 60% of the RSA. The PAI results were incorporated into the Cumulative Aquatics (C6) and Cumulative Terrestrial (D5) sections of this EIA.

pathway for this key question is depicted by the narrow line in Figure B3-1. Comparison of emissions and concentrations are presented in Table B3-14. A discussion of each parameter follows:

Table B3-14 Summary of Air Emissions for Project Millennium

Description	Baseline Case[a]	Project Millennium Case[a]	Comments
Suncor Process Information			
Capacity **[bbl/d]**	105,000	210,000	
Emission Rate of SO_2 [t/cd]	65.3	70.2	
Emission Rate of NO_x [t/cd]	47.7	67.7	
Emission Rate of CO [t/cd]	33.5	38.5	
Emission Rate of PM_{10} [t/cd]	1.7	2.2	
Emission Rate of VOC [t/cd]	130	240.4	
Emission Rate of TRS [t/cd]	1.5	2.73	
Predicted SO_2 Concentrations			
Hourly			
• Maximum average [μg/m^3]	648	870	Below Federal Acceptable
• Exceedance [number]	3	49	
• Areal extent [ha]	33,313	58,860	Approximately 70% in Lease Area
Daily			
• Maximum average [μg/m^3]	199	200	Below Federal Acceptable
• Exceedance [number]	6	9	
• Areal extent of exceedance [ha]	358	289	In Development Area
Annual			
• Maximum average [μg/m^3	74	82	Above Federal Acceptable
• Exceedance [number]	1	1	
• Areal extent of exceedance [ha]	356	409	In Development Area
Predicted NO_2 Concentrations			
Hourly			
• Maximum average [μg/m^3]	316	320	Below Alberta Guideline
• Exceedance [number]	0	0	
• Areal extent of exceedance [ha]	0	0	
Daily			
• Maximum average [μg/m^3]	259	260	Above Federal Acceptable
• Exceedance [number]	n/a	101	
• Areal extent of exceedance [ha]	825	2,185	In Development Area
Annual			
• Maximum average [(μg/m^3]	162	162	Above Federal Acceptable
• Exceedance [number]	1	1	
• Areal extent of exceedance [ha]	5,818	8,343	
Predicted CO Concentrations			
Hourly			
• Maximum average [μg/m^3]	5561	5560	Below Alberta Guideline
• Exceedance [number]	0	0	
• Areal extent of exceedance [ha]	0	0	
8-Hour			
• Maximum average [μg/m^3]	2226	2226	Below Alberta Guideline
• Exceedance [number]	n/a	n/a	
• Areal extent of exceedance [ha]	n/a	n/a	

Description	Baseline Case(a)	Project Millennium Case(a)	Comments
• Areal extent of exceedance [ha]	n/a	n/a	
Predicted PM Concentrations			
Daily			
• Maximum average [$\mu g/m^3$]	113	113	
• Exceedance [number]	33	33	
• Areal extent of exceedance [ha]	n/a	n/a	
Annual			
• Maximum average [$\mu g/m^3$]	45.8	45.9	
• Exceedance [number]	0	0	
• Areal extent of exceedance [ha]	n/a	n/a	
Predicted VOC Concentrations			
Annual			
• Maximum average [$\mu g/m^3$]	50	76	**Fort McMurray**
• Maximum average [$\mu g/m^3$]	107	163	**Fort McKay**
• Exceedance [number]	n/a	n/a	
• Areal extent of exceedance [ha]	n/a	n/a	
Predicted TRS Concentrations			
Hourly			
• Maximum average H_2S [$\mu g/m^3$]	9.2	14.1	**Fort McMurray**
• Maximum average H_2S [$\mu g/m^3$]	11.7	17.8	**Fort McKay**
• Exceedance [number]	n/a	n/a	
• Areal extent of exceedance [ha]	n/a	n/a	
Daily			
• Maximum average H_2S [$\mu g/m^3$]	**0.9**	1.3	**Fort McMurray**
• Maximum average H_2S [$\mu g/m^3$]	**1.7**	2.4	**Fort McKay**
• Exceedance [number]	n/a	n/a	
• Areal extent of exceedance [ha]	n/a	n/a	

(a) All calculated values based on ISC3BE model unless otherwise noted.
(b) Calculations based on CALPUFF model

Sulphur Dioxide (SO_2)

The ISC3BE model was used to predict SO_2 concentrations resulting from the Project Millennium case. The model provides predicted maximum concentrations, areal extent of land above the Alberta guideline, number of exceedances and the location of the high readings. In comparing the results to historical levels, there has been a substantial decrease in concentrations as shown in Figures B2-11 to B2-15 and emissions (Table B2-2). Using the approach discussed in Section A2 and the analyses summarized in Table B3-15, the following impact predictions and environmental consequences have been derived for SO_2:

- The predicted impacts of hourly SO_2 emissions and concentrations on the air quality are classified as moderate in magnitude, short-term in duration, moderate in frequency, regional in geographic extent and reversible. The environmental consequence of these impacts is low.
- The predicted impacts of daily SO_2 emissions and concentrations on the air quality are classified as moderate in magnitude, short-term in

D6 TERRESTRIAL CUMULATIVE EFFECTS ASSESSMENT

D6.1 INTRODUCTION

D6.1.1 Introduction

This section of the Project Millennium (the Project) EIA provides a cumulative effects assessment (CEA) of terrestrial resources. This review considers the potential effects from the Project plus existing, approved and planned developments.

D6.1.2 Methods

The methodologies used to assess potential effects related to the CEA are described in Section A2 and the preceding Sections of D of this EIA. If additional methodologies were employed for a specific terrestrial component, they are defined in this section. Each section compares the effects of Project Millennium and combined projects to the baseline conditions in table format. A description of the contents in the tables is presented below.

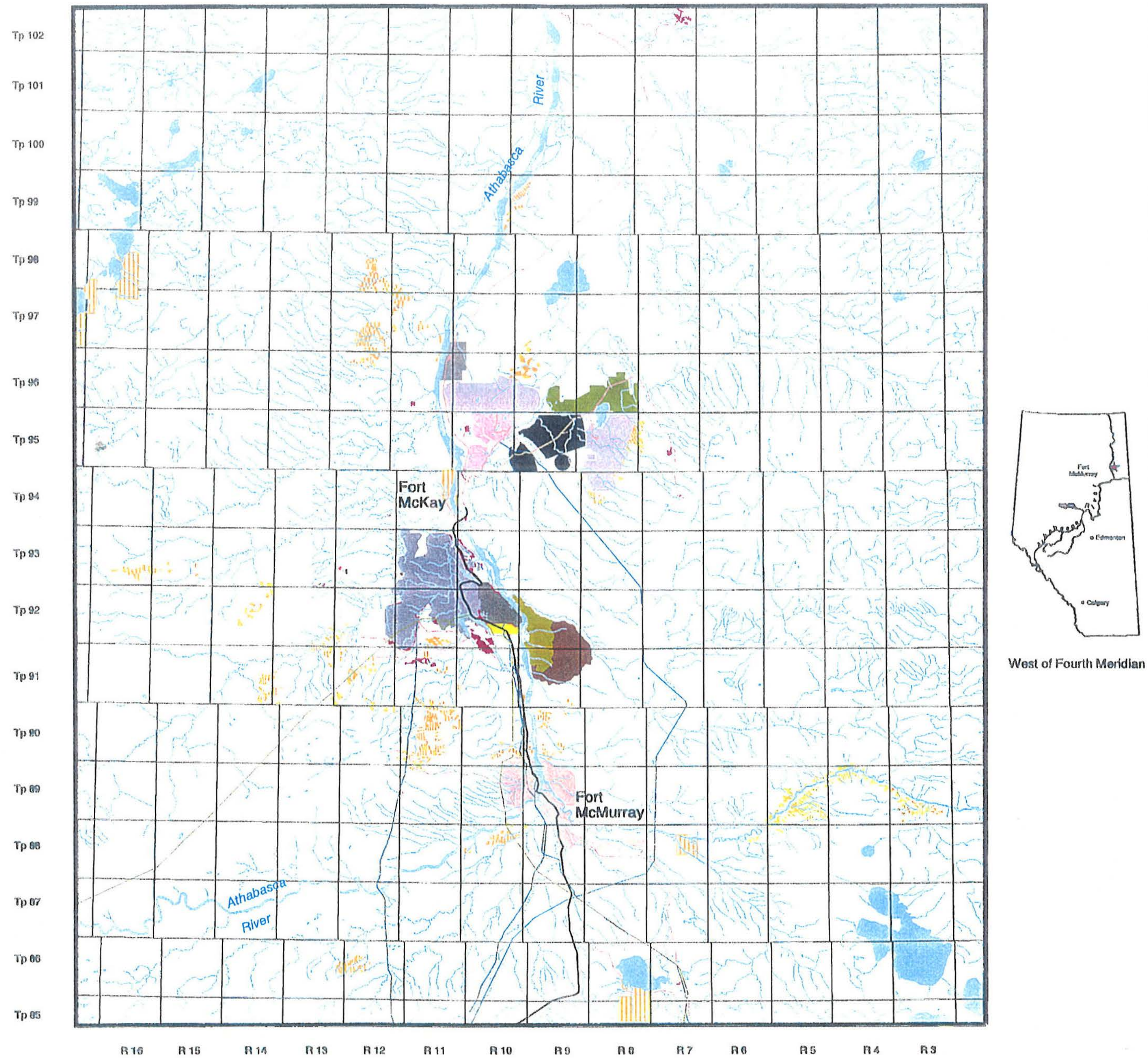
	Impacts	Far Future
Project Millennium		
Area (ha)	The total area of each (soil, terrain, vegetation, ELC) unit within the Project Millennium footprint prior to reclamation and site closure.	The total area of each terrestrial unit within the Project Millennium footprint after reclamation and site closure.
percent (%)	The incremental increase in cumulative effects due to Project Millennium prior to reclamation and closure. Expressed as a percentage of each RSA unit. (Project Millennium Impacts divided by RSA Baseline)	The incremental increase in cumulative effects due to Project Millennium after reclamation and closure. Expressed as a percentage of each RSA unit. (Project Millennium Far Future divided by RSA Baseline)
CEA		
Area (ha)	The total area of terrestrial units in the combined development footprints within the RSA (including Project Millennium) prior to reclamation.	The total area of terrestrial units in the combined development footprints in the RSA, including Project Millennium, after reclamation **and closure.**
percent (%)	The impact of combined developments (including Project Millennium) prior to reclamation and closure. Expressed as a percent of each terrestrial unit area within the RSA. (CEA Impacts divided by RSA Baseline)	The impact of combined developments, including Project Millennium **after** reclamation and closure. Expressed as a percent of each terrestrial unit area within the RSA. (CEA Far Future divided by RSA Baseline)

D6.1.3 Planned Developments

In addition to the existing and approved developments, it is recognized that other oil sands developments have been publicly disclosed or are planned for the region. Although all of these developments have not been the subject of formal approval applications, if they were to proceed they may result in additional environmental impacts in the RSA. The planned developments included in the CEA, as well as existing and approved developments, are shown in Figure A2-8 and detailed in Table A2-11. Table A2-14 reviews the Athabasca Oil Sands production for the CEA.

This CEA predicts the effects of The Project plus existing, approved and planned developments (Table D6-1) on the terrestrial resources including soils, terrain, vegetation, wetlands and wildlife, in the Regional Study Area (RSA). The following developments, as shown in Figure D6-1 are included in the CEA:

- Suncor Lease 86/17
- Suncor Steepbank Mine
- Suncor Steepbank Mine and Fixed Plant Expansion
- Suncor Project Millennium
- Shell Muskeg River Mine Project
- Shell Lease 13 East
- Petro-Canada MacKay River
- JACOS Hangingstone
- Suncor Fee Lot 2 Development, including Novagas Natural Gas Liquids Plant
- Pipelines, utility corridors and roadways
- Syncrude Aurora Mine
- Syncrude Mildred Lake
- Syncrude Mildred Lake Upgrader Expansion
- Syncrude Mildred Lake Debottlenecking Phase 1/2
- SOLV-EX
- Mobil Kearl Mine and Upgrader
- Gulf Surmont
- Northstar Energy
- Municipalities and Municipal Growth
- Forestry



SOURCES: Suncor, Syncrude, Petro-Canada, Mobil, Al-Pac, Golder

Scale 1:1,000,000

10 0 10 20 30 40

Kilometres

LEGEND

- Regional Study Area
- Highway
- Secondary Roads
- Pipelines
- Power Lines

- Open Water
- Municipalities
- Suncor Lease 86/17
- Suncor Steepbank Mine
- Suncor Project Millennium
- Suncor Fee Lot 2
- Syncrude Mildred Lake
- Aurora Mines
- SOLV-EX

- Northstar Energy
- Muskeg River Mine Project
- Mobil Kearl Oil Sands Mine
- Petro-Canada MacKay River
- Shell Lease 13 East
- Cutblocks (recent)
- Cutblocks (reforested)
- Other Disturbances
- Indian Reserves

N

SUNCOR ENERGY

Project Millennium

REGIONAL STUDY AREA
REGIONAL DEVELOPMENTS FOR CUMULATIVE EFFECTS ASSESSMENT

16 Apr. 1998

Figure D6-1

PRODUCED BY: K.K.Q.
REVIEWED BY:

Table D6-1 Regional Developments Included in the Cumulative Effects Assessment

Developments	Area (ha)
Baseline (existing and approved)	
Suncor Lease 86/17	2,877
Syncrude Mildred Lake	18,782
Suncor Steepbank	3,776
Suncor Fee Lot 2	522
Northstar Energy	22
SOLV-EX	2,088
municipalities	4,002
pipelines/roadways/others	2,904
Syncrude Aurora Mine	15,171
Sub-total	**50,144**
Project Millennium	**5,644**
Planned Projects	
Muskeg River Mine Project	4,343
Shell Lease 13 East	7,215
Syncrude Upgrader (at Mildred Lake)	0
Mobil Kearl Oil Sands Mine	5,350
Petro-Canada MacKay River	33
JACOS Hangingstone	0[a]
Gulf Surmont	0[a]
Fort McMurray Expansion	5,902
Sub Total	**22,843**
Total Developed Area	**78,631**
Regional Study Area	**2,428,645**

[a] These developments fall outside the Regional Study Area. However, they are considered in the cumulative effects assessment for air emissions.

Details on the basis of assumptions for each development in the CEA are provided in Section A2. The CEA discussion for terrestrial resources is presented as follows:

- soil and terrain
- terrestrial vegetation and wetlands
- ecological land units
- wildlife

D6.2 SOIL AND TERRAIN

The soil and terrain CEA included consideration of the following points of clarification, which must be made to place the analyses in context.

- Forestry development was assumed to have a negligible impact on soils and terrain. Unlike open pit mining, the disturbances resulting from forestry are largely superficial and transitory in nature. Therefore, this variable was not considered in the analysis.
- The Syncrude Upgrader is to be located within the Mildred Lake development footprint and does not require additional area. It is incorporated here because it will increase the level of potentially acidifying emissions within the RSA. The same reasoning holds for the Mobil Upgrader at the Kearl Mine.
- Although JACOS Hangingstone and Gulf Surmont fall outside the spatial boundaries of the RSA, they are considered here because their emission plumes may impact soil within the RSA.

Data from Syncrude's Aurora Mine and Suncor's Steepbank Mine Applications were used to determine the vegetation communities, land capabilities for forest ecosystems, soils and terrain units which would be found in the respective mines. Suncor's Steepbank Mine Application provided similar information for Suncor's Lease 86/17. Data for Syncrude's Mildred Lake facility were extrapolated from the Aurora Mine Application.

The following section addresses the soil and terrain portion of key question CTER-1: What impacts will result from changes to ecological land units (soils, terrain, vegetation and wetlands) associated with Project Millennium and the combined developments?

D6.2.1 Soil and Terrain Units, Quantity and Distribution

D6.2.1.1 Analysis and Results

Analysis of soil and terrain units at the RSA level was conducted in the following manner:

- preliminary digital files of soil maps for the region (Turchenek and Lindsay 1982) were acquired and additional information required to encompass the eastern portion of the RSA incorporated; and
- following completion of soil mapping, terrain units were derived by combining all soil types having similar genetic characteristics into common groups (e.g., all soil series with eolian parent materials became eolian terrain units).

Table D6-2 outlines the distribution of RSA soil units, which are illustrated in Figure D6-2 for baseline conditions. Table D6-3 shows the extent of the terrain units in the RSA, while Figure D6-3 illustrates the distribution for the CEA scenario. Both tables provide details of the baseline conditions, the Project and the full CEA impacts.

Naturally occurring soil and terrain features will be removed during development and construction. However, phased reclamation over the life spans of the various developments will produce a closure landscape wherein these have been replaced with reclamation substitutes. Examination of the data indicate that 78,631 ha (3.2% of the RSA) will be affected by the developments considered in the CEA scenario. The majority of this area, approximately 16,000 ha, are bog or fen terrain units (primarily Kenzie soils) which will be converted to either reclaimed terrestrial or wetland areas in the closure landscape. At closure, approximately 80% of the disturbed areas will be reclaimed for regrowth of terrestrial vegetation while the remaining 20% will be either reclaimed wetlands or open water areas.

D6.2.1.2 Residual Impact Classification

The areas disturbed by development will be reclaimed as similar but not identical landscapes. Evaluated in a strictly objective sense, this would be seen as a loss of soil and terrain when in fact it is more accurately a change in the types and distribution of the units.

The Environmental Consequence of residual impacts has been assessed according to the classification system described in Section A2 and is presented in Table D6-4. The low magnitude (<10% change) and the positive influence of reclaimed soils are primarily responsible for a low Environmental Consequence.

At closure, the residual impacts would be close to off-setting in a quantitative sense. This is a function of the relatively small percentage of the total RSA area that will be disturbed at maximum CEA impact. It may be possible to question the assertion that the positive aspects of reclamation will off-set the losses due to development and thus have a low Environmental Consequence. Reclamation objectives set out in the Terms of Reference for the Project state precisely what the end land use objectives are and, since these are fulfilled by the C & R Plan (Section E of Volume 1 of the Application), the objective measurement criteria are met.

Table D6-2 Soil Units of the Project Millennium RSA, CEA Scenario

			Project Millennium				CEA[c]		Far Future	
	Baseline RSA[a]		Impact[b]		Far Future		Impact[b]			
Soils Series/Map Unit	Total (ha)	%	Total (ha)	%	Total (ha)	%	Total (ha)	%	Total (ha)	%
Algar	47,879	2.0	0	0	0	0	157	0.3	47,722	99.7
Bitumount	11,087	0.5	47	0.4	1	<0.1	177	1.6	10,910	98.4
Buckton	32,571	1.3	0	0	0	0	0	0	32,571	100.0
Dover	83,169	3.4	0	0	0	0	1,619	2.0	81,550	98.0
Eaglesham (Mc)[d]	148,031	6.1	1,885	1.3	14	<0.1	2,803	1.9	145,228	98.1
Firebag	128,206	5.3	0	0	0	0	2,409	1.9	125,797	98.1
Horse River	26,076	1.1	0	0	0	0	0	0	26,076	100.0
Heart	87,154	3.6	0	0	0	0	769	0.9	86,385	99.1
Joslyn	86,797	3.6	0	0	0	0	18	0	86,779	100.0
Kearl	1,167	<0.1	0	0	0	0	0	0	1,167	100.0
Kinosis	73,757	3.0	803	1.0	44	<0.1	803	1.1	72,954	98.9
Kenzie (Mus)[e]	803,804	33.1	1,797	0.2	23	<0.1	12,943	1.6	790,861	98.4
Legend	105,507	4.3	0	0	0	0	0	0	105,507	100.0
Livock	47,198	2.0	0	0	0	0	1,874	4.0	45,324	96.0
Mildred	205,128	8.4	35	<0.1	0	0	1,004	0	204,124	99.5
Mikkwa	112,834	4.6	0	0	0	0	0	0	112,834	100.0
McMurray	71,247	2.9	6	<0.1	1	<0.1	140	0.2	71,107	99.8
Namur	55,302	2.3	0	0	0	0	0	0	55,302	100.0
Rock	19,329	0.8	0	0	0	0	0	0	19,329	100.0
Rough Broken	66,792	2.8	247	0.4	24	<0.1	1,186	1.8	65,606	98.2
Ruth Lake	22,709	0.9	0	0	0	0	1,309	5.8	21,400	94.2
Surmont	18,808	0.8	0	0	0	0	0	0	18,808	100.0
Steepbank	40,717	1.7	818	2.0	30	<0.1	1,601	3.9	39,116	96.1
Reclaimed Soils Terrestrial	3,600	0.1	0	0	4,873	135	0	0	57,900	0
Reclaimed Wetlands and Open-water	0	0	0	0	634	-	0	0	14,556	0
Total, Soil Units	**2,298,869**	**94.8**	**5,638**	**0.2**	**5,644**	**0.2**	**28,812**	**1.3**	**2,338,913**	**101.7**
AIM[f]	49,814	2.1	1	0	0	0	49,814	100	9,904	19.9
NWL[f]	72,763	3.0	5	<0.1	0	0	5	<0.1	72,629	99.8
IR[g]	7199	<0.1	0	0	**0**	**0**		**0**	**7,199**	**100.0**
Total, Non-soil	**129,776**	**5.2**	**7**	**<0.1**	**0**	**0**	**0**	**0**	**89,732**	**69.1**
Total	**2,428,645**	**100**	**5,644**	**0.2**	**5,644**	**0.2**	**78,631**	**3.2**	**2,428,645**	**100**

(a) Current situation in RSA, with consideration of existing and approved developments.
(b) Incremental increase because of Project.
(c) Total impacts from Project, Approved Projects and planned developments does not include forestry as operations do not impact soils.
(d) McLelland in the LSA.
(e) **Muskeg in the LSA.**
(f) AIM = Undeveloped, developed and reclaimed areas; NWL = Open water, rivers streams and lakes.
(g) IR - Indian Reserves, no classification for these areas.

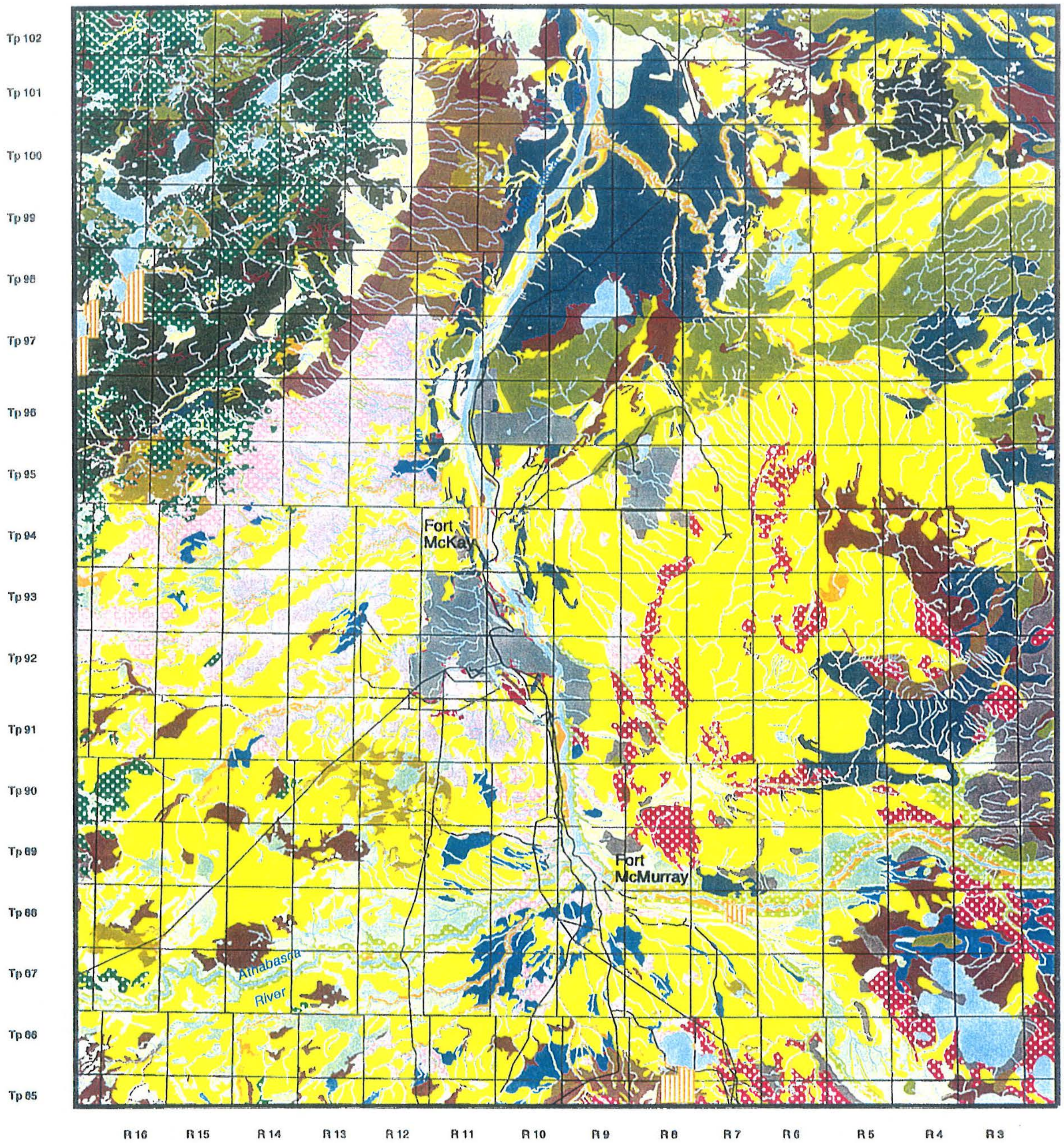
Table D6-3 Terrain Units of the Project Millennium RSA, CEA Scenario

Terrain	Baseline RSA[a]		Project Millennium				CEA[c]			
			Impact[b]		Far Future		Impact[b]		Far Future	
	Total (ha)	%	Total (ha)	%	Total (ha)	%	Total (ha)	%	Total (ha)	%
Bog	458,289	19.0	223	<0.1	12	<0.1	4,442	0.9	453,847	99.0
Shallow Bog	457,069	18.9	1,573	0.3	124	<0.1	8,256	1.8	448,813	98.2
Eolian	87,154	3.6	0	0	0	0	769	0.9	86,385	99.1
Fluvial	126,549	5.2	6	<0.1	6	<0.1	135	0.1	126,414	99.9
Glaciofluvial	367,130	15.1	900	<0.1	224	<0.1	5,324	1.5	361,806	98.5
Glaciofluvial and Glaciolacustrine, medium, over Morainal Till	47,198	1.9	0	0	0	0	1,874	4.0	45,324	96.0
Glaciolacustrine over Morainal/Till	258,562	10.6	0	0	0	0	2,577	1.0	255,985	99.0
Glaciolacustrine	1,167	<1	0	0	0	0	0	0	1,167	100.0
Morainal/Till, fine	184,242	7.6	803	0.4	266	0.1	537	0.3	183,705	99.7
Morainal/Till, coarse	73,757	3.0	0	0	0	0	1,047	1.4	72,710	98.6
Fen	148,031	6.0	1,885	1.3	105	<0.1	2,698	1.8	145,333	98.2
Rough Broken	66,792	2.8	248	0.4	34	<0.1	1,153	1.7	65,639	98.3
Rock	19,329	0.8	0	0	0	0	0	0	19,329	100.0
Reclaimed Terrestrial	3,600	<1	0	0	4,357	121	0	0	57,905	
Reclaimed Wetland and open water	0	0	0	0	516	-	0	0	14,556	
Total, Terrain Units	2,298,869	94.8	5,638	0.2	5,644	0.2	28,812	15.0	**2,338,918**	
AIM [d]	49,814	2.1	1	<0.1	0	0	49,814	100.0	9,904	19.9
NWL [d]	72,763	3.0	5	<0.1	0	0	5	0	72,629	99.8
IR [e]	7199	<0.1	0	0	0	0	0	0	**7,199**	**100.0**
Total, Non-terrain	129,776	5.2	6	<0.1	0	0	0	**100**	**89,732**	**69.1**
TOTAL	**2,428,645**	**100**	**5,644**	**0.2**	**5,644**	**0.2**	**78,631**	**115**	**2,428,650**	**100**

(a) Current situation in RSA, with consideration of existing and approved developments.
(b) Incremental increase because of Projects.
(c) Total impacts from Project, Approved Projects and planned developments does not include forestry as operations do not impact soils.
(d) **AIM = Undeveloped, developed and reclaimed areas; NWL = Open water, rivers streams and lakes.**
(e) **IR - Indian Reserves, no classification for these areas.**)

Table D6-4 Residual Impacts for Soils and Terrain of the RSA, CEA Scenario

	Direction	Magnitude	Geographic Extent	Duration	Reversibility	Frequency	Environmental Consequence
Natural Units	Negative	Low	Regional	Long-term	Irreversible	Low	Low
Reclaimed Units	Positive	Low	Regional	Long-term	Irreversible	Low	Low



West of Fourth Meridian

SOURCES: Suncor, Syncrude, Petro-Canada, Golder, Alberta Research Council AOSERP (Report 122)

Scale 1:1,000,000

10 0 10 20 30 40

Kilometres

Map Projection: UTM 12
Datum: NAD 83

LEGEND

- Regional Study Area
- Linear Disturbances
- Open Water
- Existing Open Pit Mines
- Other Disturbances
- Municipalities
- Indian Reserves

SOIL CLASSIFICATION

- Algar
- Buckton
- Bitumont
- Dover
- Eaglesham
- Firebag
- Horse River
- Heart
- Joslyn
- Kearl
- Kinosis
- Kenzie
- Legend
- Livock (Fort)
- Mildred
- Mikkwa
- McMurray
- Namur
- Rock
- Rough Broken
- Ruth Lake
- Surmont
- Steepbank

N

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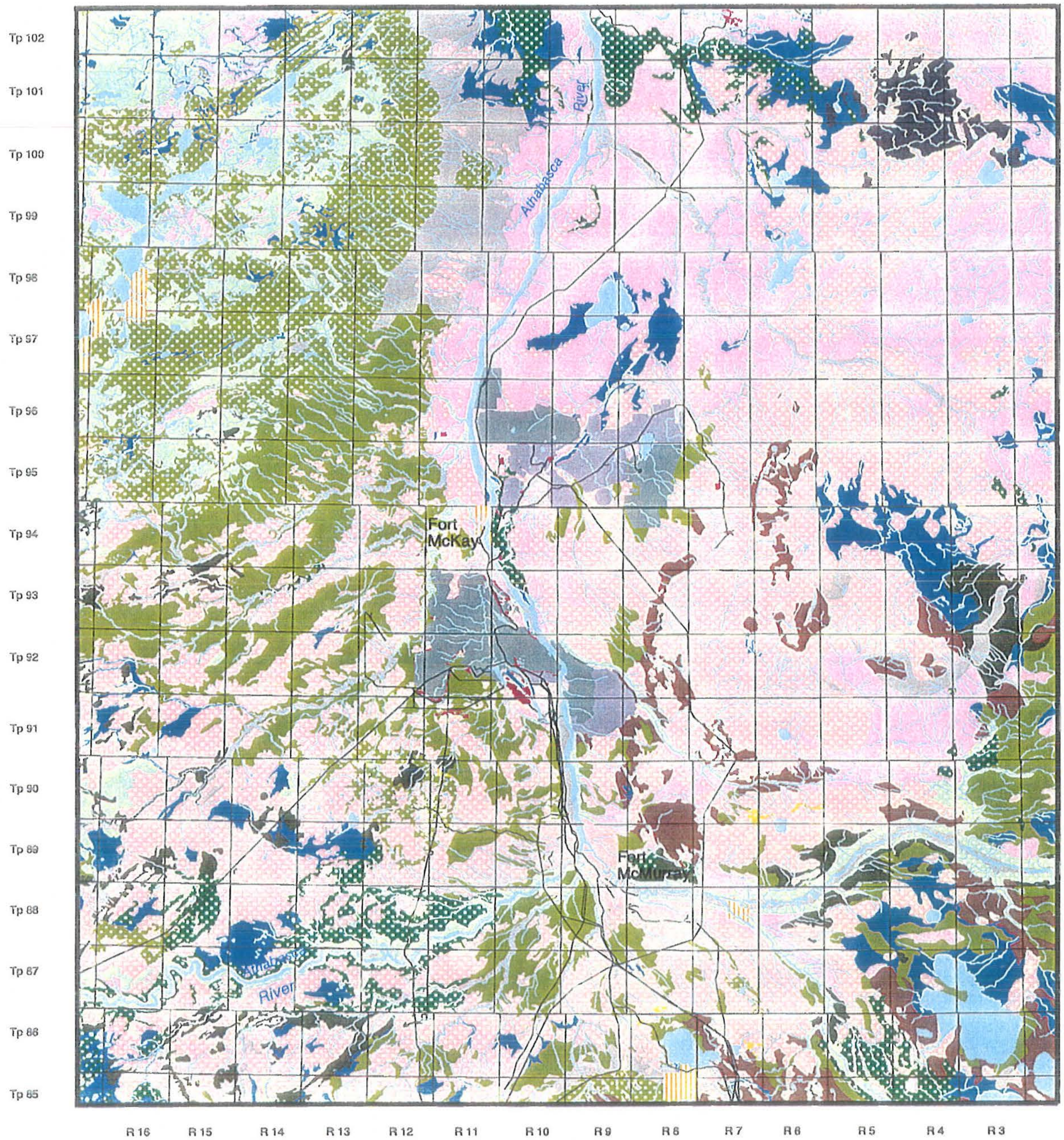
REGIONAL STUDY AREA
SOIL CLASSIFICATION
IMPACT ASSESSMENT BASELINE

16 Apr. 1998	Figure D6-2	PRODUCED BY: K.K.O. REVIEWED BY:



West of Fourth Meridian

SOURCES: Suncor, Syncrude, Petro-Canada, Mobil, Al-Pac, Golder, Alberta Research Council AOSERP (Report 122)

Scale 1:1,000,000

10 0 10 20 30 40

Kilometres

Map Projection: UTM 12
Datum: NAD 83

LEGEND

- Regional Study Area
- Linear Disturbances
- Open Water
- Existing Open Pit Mines
- Other Disturbances
- Municipalities
- Proposed Open Pit Mines
- In-Situ
- Indian Reserves

TERRAIN CLASSIFICATION

- Bog
- Shallow Bog
- Eolian
- Fluvial
- Glaciofluvial
- Glaciolacustrine/Morainal
- Glaciolacustrine
- Glaciolacustrine, Glaciofluvial
- Moraine / Till, fine
- Morainal / Till, coarse
- Fen
- Rock
- Rough Broken

SUNCOR ENERGY

Project Millennium

N

REGIONAL STUDY AREA
TERRAIN CLASSIFICATION
CUMULATIVE EFFECTS ASSESSMENT

16 Apr. 1998	Figure D6-3	PRODUCED BY: K.K.Q. REVIEWED BY:

/data14/suncor/regional/8700/8740/arcview/terrain2.apr

D6.2.2 Land Capability for Forest Ecosystems

This facet of the CEA addresses land capability which is defined herein as the potential to support forest ecosystems. Soil capability for the RSA was evaluated in the same manner as for the LSA. A detailed description of this method may be found in Section D2.2.7. Note that because of the differences in the resolution of the available data, a small area of the LSA was rated as Class 1 - this does not appear in the RSA inventory. To account for this anomaly, 465 ha was subtracted from Class 2 and placed in Class 1.

D6.2.2.1 Analysis and Results

The distribution of land capabilities for forest ecosystems is shown in Table D6-5 and Figures D6-4 and D6-5 for baseline and CEA conditions, respectively. As shown in Table D6-6 there is a significant change in the proportions of the various capability classes between the baseline and CEA closure landscapes. The major difference is the conversion of approximately 50,000 ha (2% of the RSA) from either existing disturbed or non-productive class 5 lands to a low forest capability class 3 rating. This enhancement in overall forest capability potential is the result of the reclamation soil mixture applied over the reconfigured terrain units in the closure landscape.

Table D6-5 Land Capability Classification for Forest Ecosystems in the RSA

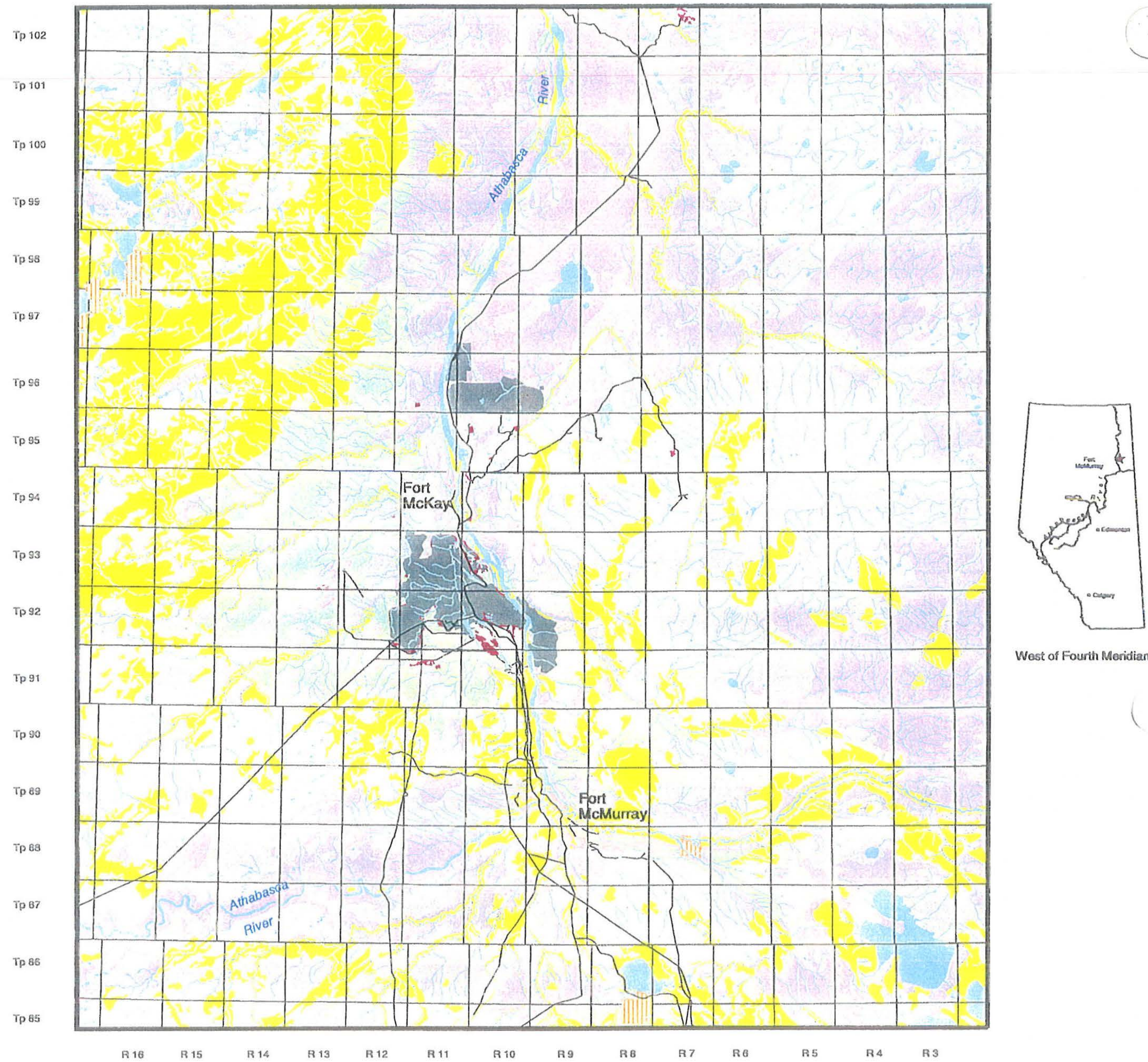
Capability Class	Area, ha	Area, % of RSA
Class 1[a]	465	<0.1
Class 2	439,060	18.1
Class 3	332,722	13.7
Class 4	438,304	18.0
Class 5[b]	1,210,895	49.9
Unclassified [c]	7,199	<0.1
Total	2,428,645	100.0

[a] Class 1 - no Class 1 capabilities were assigned in the broad scheme used for the RSA; however, the finer resolution within the LSA resulted in 465 ha fitting the criteria. For consistency this value was subtracted from the Class 2 values and used in this analysis.

[b] Previously disturbed lands and water were assumed to be non-productive for forestry.

| [c] **Includes** Indian Reserves, **which** were not classified.

As shown in Table D6-5 there are 7,199 ha of existing disturbed lands which cannot be placed in a capability class; however, they must be considered herein. The impact of the Project will be on 3646 ha of class 5 (4.5% of CEA impact) lands currently rated as non-productive which will be reclaimed to low productivity class 3 land.



SOURCES: Suncor, Syncrude, Petro-Canada, CAN-AG, Golder, Alberta Research Council AOSERP (Report 122)

Scale 1:1,000,000

10 0 10 20 30 40

Kilometres

Map Projection: UTM 12
Datum: NAD 83

LEGEND
- Regional Study Area
- Linear Disturbances
- Open Water
- Existing Open Pit Mines
- Other Disturbances
- Municipalities
- Indian Reserves

LAND CAPABILITY
- High (1)
- Moderate (2)
- Low (3)
- Conditionally Productive (4)
- Non-Productive (5)

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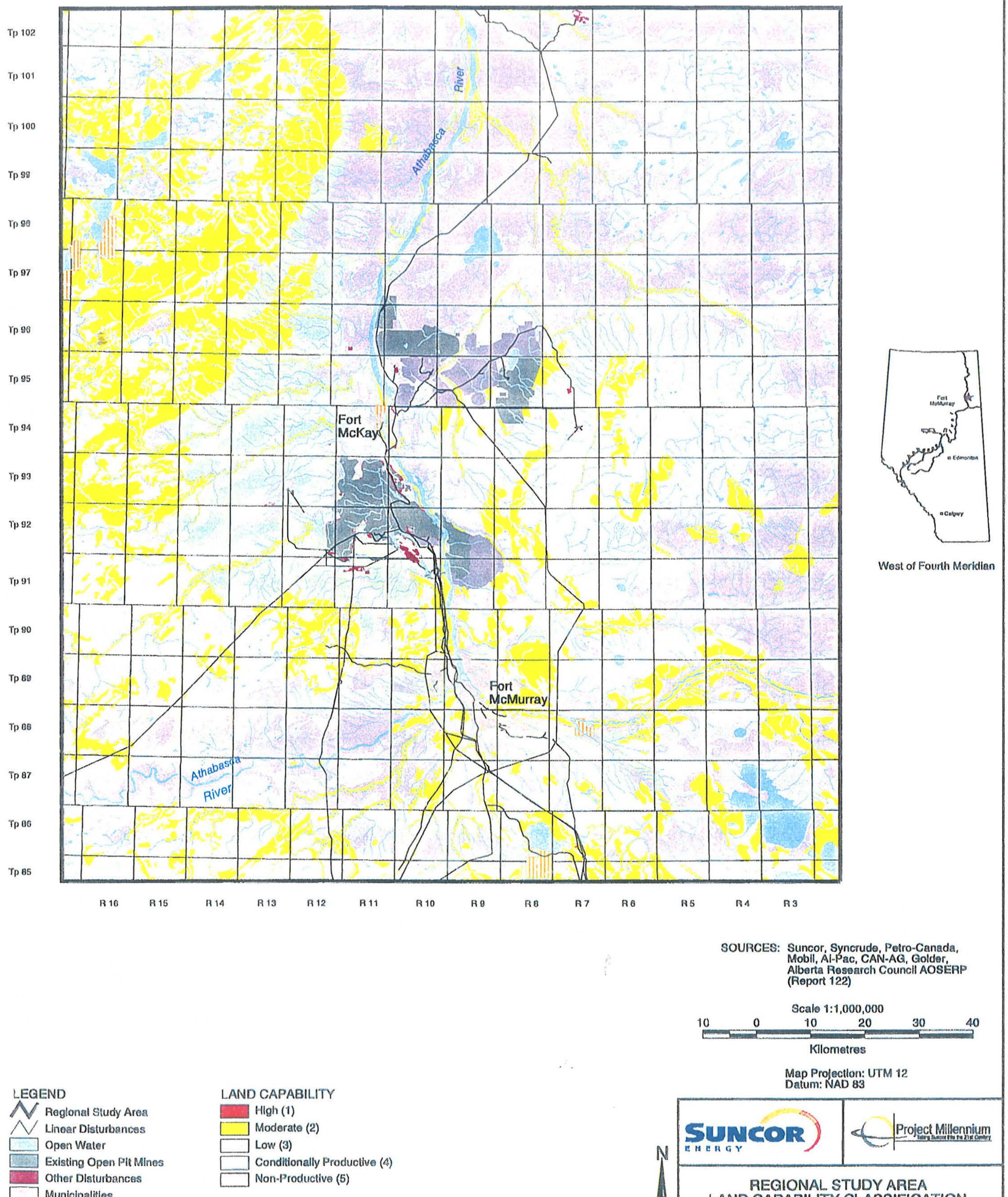
Project Millennium

REGIONAL STUDY AREA
LAND CAPABILITY CLASSIFICATION
FOR FOREST ECOSYSTEMS
IMPACT ASSESSMENT BASELINE

16 Apr. 1998	Figure D6-4	PRODUCED BY: K.K.O. REVIEWED BY:

/data14/suncor/regional/8700/8740/arcview/land_cap2.apr



REGIONAL STUDY AREA
LAND CAPABILITY CLASSIFICATION
FOR FOREST ECOSYSTEMS
CUMULATIVE EFFECTS ASSESSMENT

16 Apr. 1998 | Figure D6-5 | PRODUCED BY: K.K.O. REVIEWED BY:

D6.2.2.2 Residual Impacts Classification

Land capability for forest ecosystems is a function of the combined interactions of terrain and soil, hence alterations in these components will alter the capabilities. Evaluation of the data in Table D6-6 allows the assignment of the residual impacts provided in Table D6-7. Existing disturbed soils and those in currently non-productive class 5 will be reclaimed to low productivity class 3. This should be interpreted as a positive, qualitative alteration to land capability for forest ecosystems in the RSA.

Table D6-6 Land Capability for Forest Ecosystems in the RSA, CEA Scenario

			Project Millennium				CEA[c]			
	Baseline RSA[a]		Change[b]		Far Future		Impact		Final Landscape	
CLASS	Total (ha)	% RSA	Total (ha)	% RSA	Total (ha)	% RSA	Total (ha)	% RSA	Total (ha)	% RSA
1	465	<0.1	106	22.8	8	1.7	106	22.8	359	77.2
2	439,060	18.1	672	0.1	39	<0.1	4,680	1.1	434,380	98.9
3	332,722	13.7	476	0.1	4,074	1.2	2,772	0.8	392,855	118.1
4	438,304	18.0	584	0.1	626	0.1	5,771	1.3	432,533	98.7
5 [d]	1,210,895	49.9	3,646	0.3	264	<0.1	65,302	5.4	1,161,320	95.9
IR [e]	7,199	<0.1	0	0	0	0	0	0	7199	100
TOTAL	**2,428,645**	**100.0**	**5,484[f]**	**0.2**	**5,644**	**0.2**	**78,631**	**3.2**	**2,428,645**	**100**

(a) Undeveloped plus revegetated land (not classified).
(b) Incremental change.
(c) Effects of projects approved and planned developments on baseline conditions, excludes forestry.
(d) All disturbed lands and water were assumed to be non-productive for forestry.
(e) IR - Indian Reserves were not classified.
(f) 5484 - development of the Project calls for some small areas to be "unmined development" areas, these account for 160 ha of terrain units.

Table D6-7 Residual Impacts and Environmental Consequence on Land Capabilities for Forest Ecosystems Due to Regional Development

Capability Class	Direction	Magnitude	Geographic Extent	Duration	Reversibility	Frequency	Environmental Consequence
1	negative	high	local	long-term	irreversible	low	high
2	negative	negligible	regional	long-term	irreversible	low	negligible
3	positive	low	regional	long-term	irreversible	low	low
4	negative	negligible	regional	long-term	irreversible	low	low
5	positive	low	regional	long-term	irreversible	low	low
Disturbed	positive	low	regional	long-term	irreversible	low	low

A number of points in Table D6-7 require further elaboration. The high Environmental Consequence assigned to the losses in class 1 may be artificial since identification of class 1 soils was only possible at the LSA level of analysis. As discussed previously this is more a function of a lack of data than a true estimate of potential class 1 soil in the RSA. The second item is to reiterate that much of the class 5 land disturbed by CEA development, both existing and planned, will be reclaimed to class 3. The land capability potential will be upgraded for a significant portion of the disturbed areas.

D6.2.3 Soil Sensitivity to Acidifying Emissions

Soil sensitivity is evaluated in the context of the capacity of the soils in the RSA to resist the acidifying effects of anthropogenic inputs (i.e., emissions from industrial sources). The potentially acidifying emissions in studies of this nature are oxides of sulfur (SO_x) and oxides of nitrogen (NO_x). The present approach is to combine these and other atmospheric variables to produce Potential Acid Input (PAI) values.

An extensive background discussion on the limitations and uncertainties involved in assessing acidifying emissions and their potential impacts on soils may be found in Section D2.2 of this EIA. A conceptual approach to assigning relative sensitivities to both mineral and organic soils is outlined and appropriate values assigned to each soil series in the RSA. This allows a degree of quantification with respect to acidifying impact potentials.

The World Health Organization has proposed critical PAI loading factors for highly sensitive ecosystems of 0.25 keq/ha/a and 0.50 keq/ha/a for moderately sensitive ecosystems (WHO 1994). These values have been adopted for an interim 5 year period in Alberta on the recommendation of the CASA Target Loading Subgroup so they are the benchmarks used in the evaluations for all three specified emission scenarios. As described in Section B3 - Air Quality, PAI values in the immediate vicinity of the existing and approved developments either do at present or will, once the facilities are in operation, exceed the critical loading benchmarks. It follows, therefore, that potential soil acidification would have the greatest likelihood of occurring in these same areas. However, it must be emphasized that the PAI values are for operational maxima, whereas in reality they will be phased in as the various developments come on-stream, then cease at the end of development.

Table D6-8 provides data on the areas of the three soil sensitivity classes estimated to be affected by PAI for baseline, Project Millennium and full CEA emissions scenarios. These numbers are further analyzed in Table D6-9 to show the incremental impacts associated with Project Millennium on the soils in the RSA. A brief discussion of the incremental increases in area attributable to Project Millennium for sensitive ecosystems, defined as those receiving a critical load of 0.25 keq/ha/a, is warranted. As shown in Table D6-9, Project Millennium is predicted to have the following effects:

a) For highly sensitive soils, the additional area potentially impacted by Project emissions is estimated to be 33,024 ha or 19% of the total CEA affected area.

b) For moderately sensitive soils, the additional area potentially affected by Project Millennium is estimated to be 28,755 ha or 18% of the total CEA impact.

c) For <u>low sensitivity soils</u>, the additional area potentially affected by Project emissions is predicted to be 115,713 ha or 34% of the total CEA impact area.

Comparable data for the 0.50 keq/ha/a area are also shown in Tables D6-8 and D6-9 from which it may be seen that the Project is estimated to contribute relatively little in the way of additional PAI affected area. Figures D6-6 and D6-7 illustrate the PAI isopleths for baseline and CEA emission levels, respectively, superimposed on the soil sensitivity maps.

Table D6-8 Areas Within Specified Critical Load Isopleths for Baseline, Impact and CEA Scenarios in the RSA

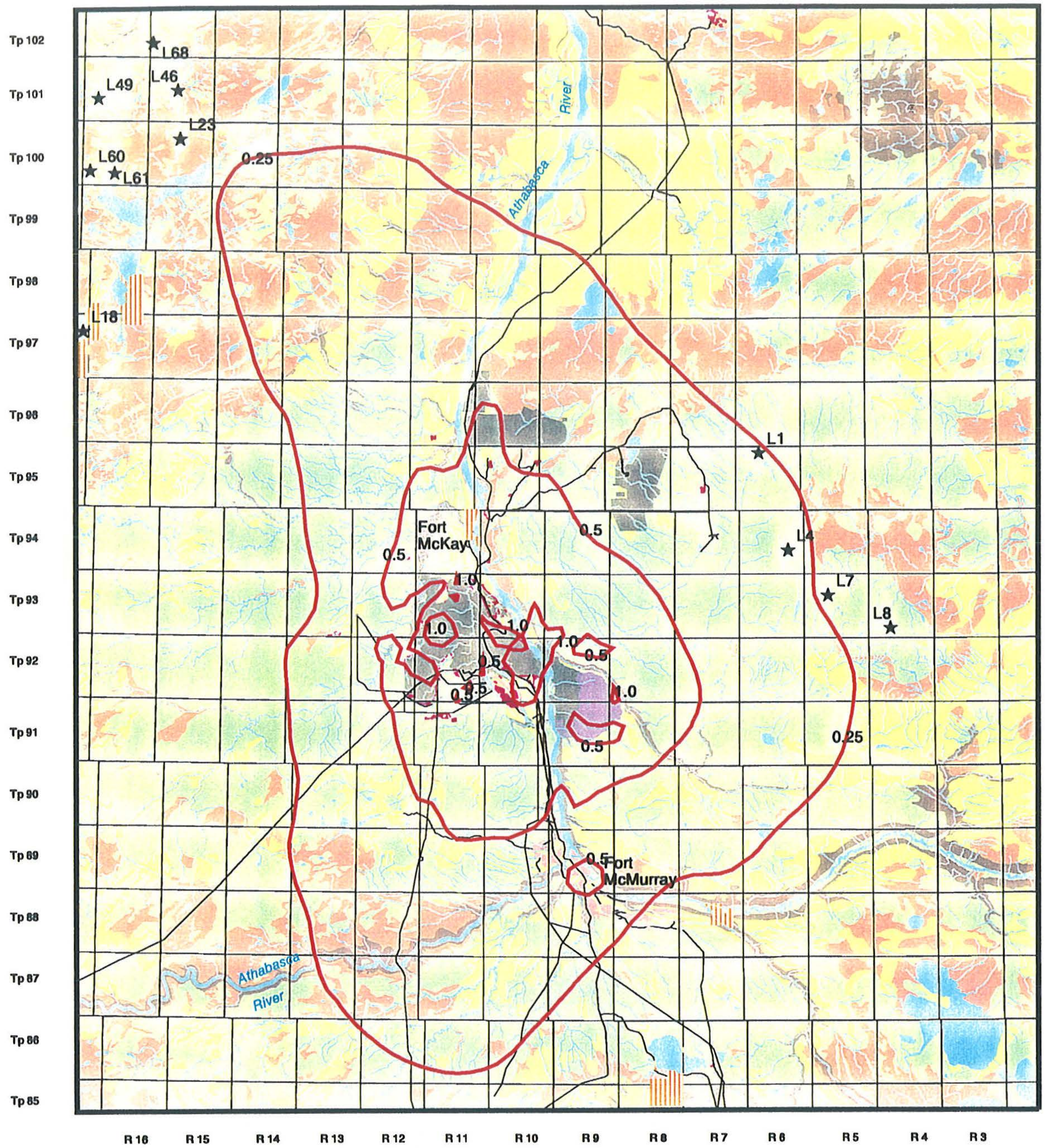
PAI Critical Load Value	Soil Sensitivity Rating	Baseline		Project Millennium Impact		CEA Scenario	
		ha	% RSA	ha	% RSA	ha	% RSA
>0.25 keq/ha/a	Low	391,660	16	507,373	21	734,983	30
	Moderate	102,706	4	131,461	5	266,279	11
	High	88,778	4	121,802	5	266,883	11
	Variable[(a)]	26,104	1	28,846	1	39,852	2
	Not Applicable[(b)]	61,261	3	71,677	3	107,885	4
>0.50 keq/ha/a	Low	62,763	3	126,324	5	229,889	9
	Moderate	12,105	<1	18,494	<1	57,923	2
	High	4,443	<1	5,007	<1	40,163	2
	Variable[(a)]	5,230	<1	8,454	<1	12,781	<1
	Not Applicable[(b)]	31,157	1	37,359	2	79,332	3

(a) Variable = Rough Broken and Rock are variable in sensitivity across the RSA and, therefore, not included in this analysis
(b) Not Applicable = this included all disturbed lands and water which could not be confidently assigned sensitivity ratings

Table D6-9 Contribution of Project Millennium to Areas Affected by Acidifying Emissions in the RSA

PAI Critical Load Value	Soil Sensitivity Rating	CEA Baseline		Project Millennium - Baseline		Incremental Impact of Project Millennium,
		ha	% RSA	ha	% RSA	% of CEA Impact
>0.25 keq/ha/a	Low	343,323	14	115,713	5	34
	Moderate	163,573	7	28,755	1	18
	High	178,573	7	33,024	1	19
	Variable[(a)]	13,748	<1	2,742	1	20
	Not Applicable[(b)]	46,624	2	10,416	<1	22
>0.50 keq/ha/a	Low	167,126	7	63,561	3	38
	Moderate	45,818	2	6,389	<1	14
	High	35,720	1	564	<1	2
	Variable[(a)]	7,551	<1	3,224	<1	43
	Not Applicable[(b)]	48,175	2	6,202	<1	13

(a) Variable = Rough Broken and Rock are variable in sensitivity across the RSA and, therefore, not included in this analysis
(b) Not Applicable = this included all disturbed lands and water which could not be confidently assigned sensitivity ratings



West of Fourth Meridian

SOURCES: Suncor, Syncrude, Petro-Canada, Mobil, Al-Pac, Golder, Alberta Research Council AOSERP (Report 122)

Scale 1:1,000,000

10 0 10 20 30 40

Kilometres

Map Projection: UTM 12
Datum: NAD 83

LEGEND

- ★ Lakes Rated for Sensitivity to Acidifying Deposition
- PAI Isopleths (keq/ha/a)
- Regional Study Area
- Linear Disturbances
- Open Water
- Existing Open Pit Mines
- Other Disturbances
- Municipalities
- Proposed Open Pit Mines
- In-Situ
- Indian Reserves

SOIL SENSITIVITY

- Low
- Moderate
- High
- Variable

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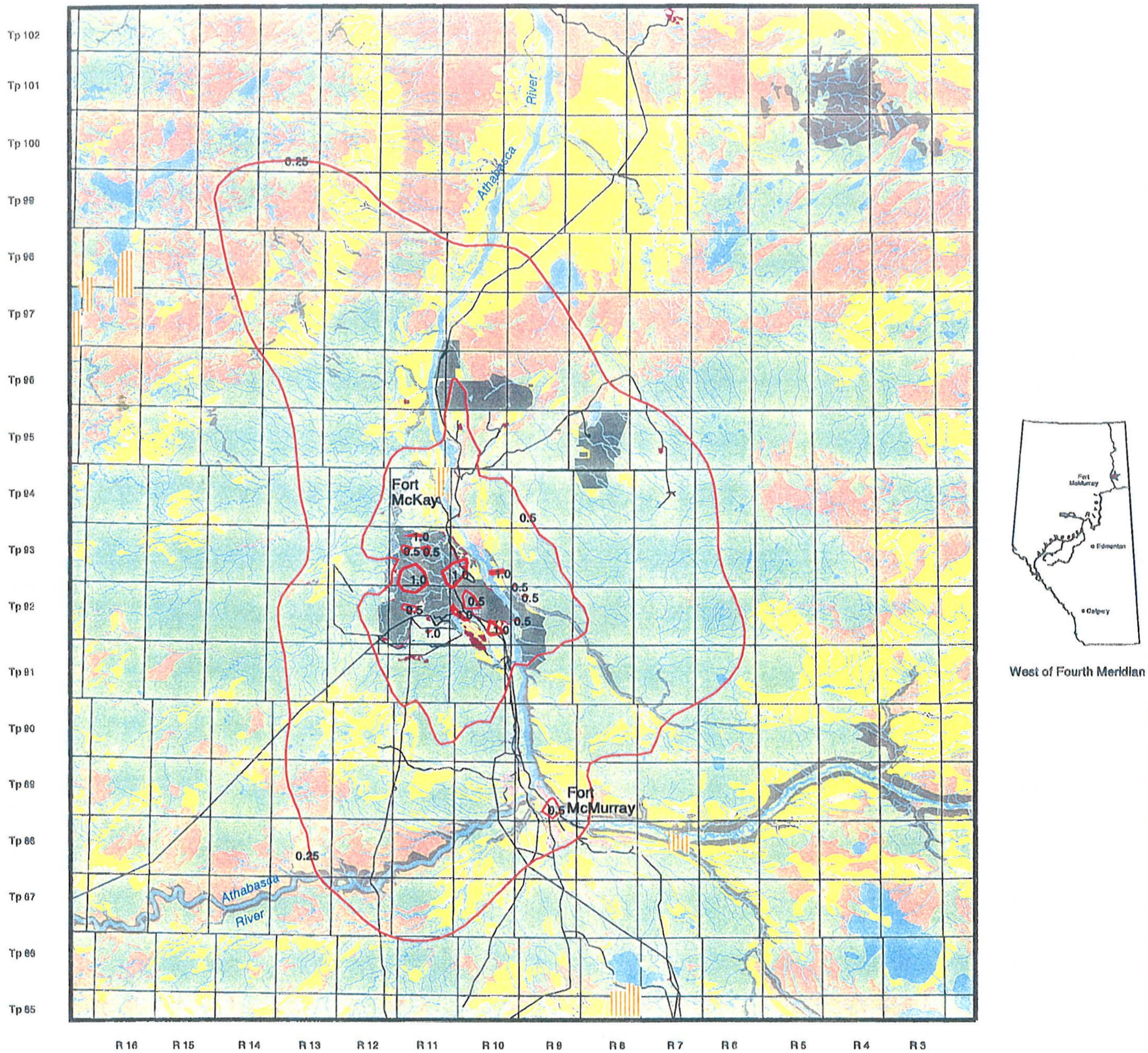
N

REGIONAL STUDY AREA RELATIVE SOIL SENSITIVITIES TO ACIDIFYING EMISSIONS PAI IMPACT ASSESSMENT

24 Sept. 1998	Figure	PRODUCED BY: K.Q., J.H. REVIEWED BY:



SOURCES: Suncor, Syncrude, Petro-Canada, Golder, Alberta Research Council AOSERP (Report 122)

Scale 1:1,000,000

10 0 10 20 30 40

Kilometres

Map Projection: UTM 12
Datum: NAD 83

LEGEND

- PAI Isopleths (keq/ha/a)
- Regional Study Area
- Linear Disturbances
- Open Water
- Existing Open Pit Mines
- Other Disturbances
- Municipalities
- Indian Reserves

SOIL SENSITIVITY

- Low
- Moderate
- High
- Variable

N

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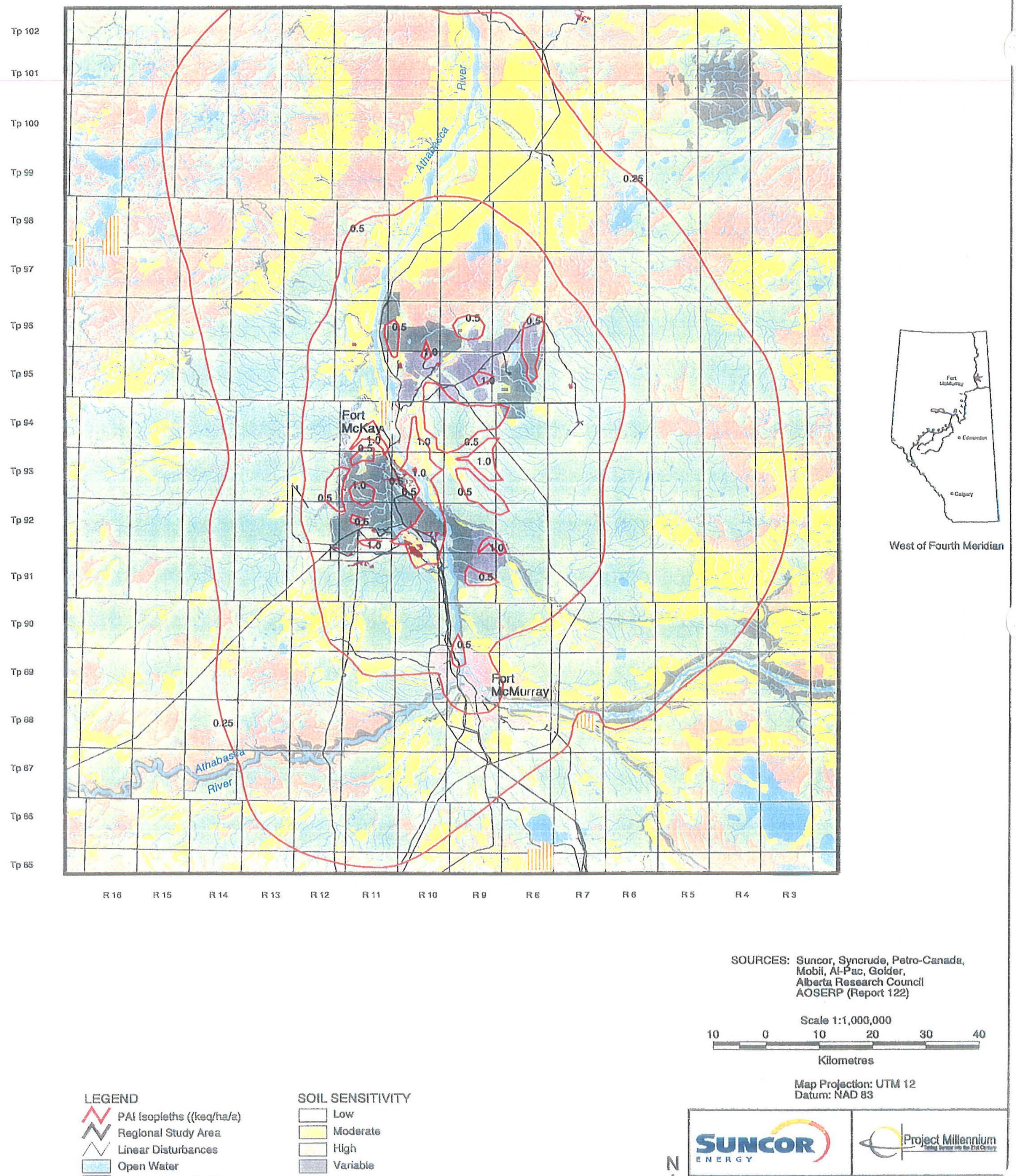
REGIONAL STUDY AREA
RELATIVE SOIL SENSITIVITIES
TO ACIDIFYING EMISSIONS
PAI BASELINE

16 Apr. 1998	Figure D6-6	PRODUCED BY: K.K.O. REVIEWED BY:



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Project Millennium

REGIONAL STUDY AREA
RELATIVE SOIL SENSITIVITIES
TO ACIDIFYING EMISSIONS
PAI CUMULATIVE EFFECTS ASSESSMENT

16 Apr. 1998	Figure D6-7	PRODUCED BY: K.K.O. REVIEWED BY:

/data14/suncor/regional/9700/9740/arcview/air.apr

D6.2.3.1 Residual Impacts Classification

There is a high level of scientific uncertainty in the assessment of environmental consequence of soil acidification due to the ill-defined nature of the emissions-soil acidification relationship and the relationship of deposition to effect (as discussed at length in Section D2.2 of this EIA). The most definitive statement that may be made with any degree of confidence is that soils classified as highly sensitive and falling within the area defined by the 0.25 keq/ha/a isopleth are the most logical candidates to experience adverse impacts associated with the Project. Monitoring recommendations to address the scientific uncertainty are discussed in Section D2.2.11.

It is estimated that the environmental consequence associated with potential soil acidification resulting from the CEA be rated as low but emphasis must be placed on the high level of scientific uncertainty in the analysis.

D6.2.4 Conclusion/Summary

Table D6-10 summarizes the residual impacts for Soils and Terrain under the CEA. This summary addresses Key Question CTER-1 regarding the potential impacts of combined developments on soil and the terrain resources.

Table D6-10 Summary of Residual Impacts

Key Question	CEA Results
Quantity and Distribution of Soil and Terrain Units	During the construction and operation phases, the combined developments will cause a loss of 3.2% of the natural soil and terrain units in the RSA, the impacts associated with this are estimated to be: negative in direction, low in magnitude, regional in extent, of long-term duration, irreversible and low in frequency. This will generate a low Environmental Consequence. This is a worst case perspective as it is unlikely that all sites will be developed to their maximum extent concurrently. The phased nature of development and reclamation will mediate the Environmental Consequence. Reclamation of the developed areas and existing disturbed areas with reconfigured terrain units covered by a reclamation soil mixture will produce very Positive impacts by increasing the diversity of terrain units.
Land Capability for Forest Ecosystems and Soil Sensitivity to Acidifying Emissions	As a result of alterations in the quantity and distribution of soil and terrain units between the baseline and closure landscapes, changes in land capability will be produced. These are estimated to be: positive in direction, low in magnitude, regional in extent, of long-term in duration, irreversible, low in frequency and generate a low Environmental Consequence. The positive direction of change is the result of significant areas of non-productive class 5 land being reclaimed to low capability class 3. Operational activities of the developments will increase the levels of potentially acidifying emissions released into the RSA air shed. The potential impacts are estimated to be: negative in direction, variable in magnitude, regional in extent, lasting for an undetermined period, potentially reversible, continuous in frequency (for the duration of production) with a moderate to low Environmental Consequence. Associated with this is a high level of scientific uncertainty as the PAI-soil acidification linkage is ill-defined and the precise nature of the impacts are highly site specific.

D6.3 TERRESTRIAL VEGETATION AND WETLANDS

D6.3.1 Approach and Methods

The approach used to assess terrestrial vegetation and wetlands for the CEA is consistent with Section D3. This vegetation assessment includes all developments described in Section D6.1.3 (Planned Developments) as well as Forestry developments, which were not included in Sections D6.2 (Soil and Terrain). There are three main CEA vegetation issues in the RSA: direct losses of vegetation from Project developments, subsequent changes in vegetation diversity, and indirect losses to vegetation as a result of air emissions. For the purpose of cumulative effects assessment, the terrestrial vegetation effects are divided into three sections as follows:

- vegetation community quantity and distribution;
- vegetation diversity; and
- vegetation sensitivity to acidifying emissions.

D6.3.1.1 Classification Scheme

Vegetation communities were classified according to dominant overstorey species and site conditions using Landsat Imagery. Due to the coarser mapping scale, vegetation could not be classified to one specific ecosite site phase or wetland class (AWI) but rather each vegetation class reflects a complex of ecosite phases. Table D6-11 provides a summary of the vegetation classification developed for the RSA. There are 17 vegetation classes and three disturbance classes, which include forestry cutblocks and natural non-vegetated (i.e., sand dunes) and anthropogenic disturbances (i.e., gravel pits) in the RSA. The corresponding ecosite phases for each of the three Ecological Areas represented in the RSA are also presented in Table D6-11. A detailed description of each vegetation class is provided in the Baseline Terrestrial Vegetation Report (1998l).

D6.3.1.2 Mapping

Landsat Thematic Mapper Satellite imagery was collected for two areas ("scenes") in July 1994 and July 1996 respectively to classify and map vegetation classes in the RSA. The majority of the RSA was covered with the more recent 1996 imagery; however, due to cloud cover constraints, small portions were covered by the 1994 imagery. A supervised classification of the imagery was undertaken, including the selection of a number of "training" or test areas determined from information collected from aerial photographs, Alberta Phase 3 Forest Inventory Maps, Alberta Vegetation Inventory Maps (AVI), Vegetation Maps produced for oil sands projects, Soil Inventory Maps of the Alberta Oil Sands Environmental

Table D6-11 Regional Vegetation Classification

Land Cover Classes	Boreal Mixedwood Ecosite Phases	Boreal Highlands Ecosite Phases	Subarctic Ecosite Phases	AWI
Open Pine Lichen	Lichen (Pj) a1	Bearberry/lichen a1	Bearberry (Pl) a1	
Mixed Deciduous (Trembling Aspen Dominant)	Blueberry Aw (Bw) b2 Low-bush cranberry (Aw) d1 Dogwood (Pb-Aw) e1 <10% Horsetail (Pb-Aw) f1 <10%	Blueberry Aw (Bw) b2 Low-bush cranberry (Aw) d1	Bearberry (Aw) a3 Canada buffalo-berry (Aw) b2 Horsetail (Pb-Bw) d1 <10%	
Mixedwood (White Spruce- Trembling Aspen Dominant)	Blueberry (Aw-Sw) b3 Low-bush cranberry (Aw-Sw) d2 Dogwood (Pb-Sw) e2 <10% Horsetail (Pb-Sw) f2 <10%	Low-bush cranberry (Aw-Sw-Sb) d2	Canada buffalo-berry (Aw-Sw-Sb) b3 Horsetail (Aw-Sw) d2	
Mixed Coniferous (White Spruce Dominant)	Low-bush cranberry (Sw) d3 Dogwood (Sw) e3<10% Horsetail (Sw) f3<10%	Low-bush cranberry (Sw) d3	Canada buffalo-berry (Sw) b4 Horsetail (Sw) d3	
Mixed Coniferous (White Spruce-Pine Dominant)	Blueberry (Sw-Pj) b4	Blueberry (Sw-Pj) b3	Labrador tea - hygric (Pl-Sb) e1	
Mixed Coniferous (Pine Dominant)	Blueberry (Sw-Pj) b4 Labrador tea -mesic (Pj-Sb) c1 Labrador tea-subhygric (Sb-Pj) g1	Blueberry (Sw-Pj) b3 Labrador tea -mesic (Pj-Sb) c1 Labrador tea-subhygric (Sb-Pj) g1	Labrador tea - mesic (Pl-Sb) c1 Labrador tea - hygric (Pl-Sb) e1	
Mixed Coniferous (Black Spruce-Tamarack)	Non-wetland Sb-Lt	Non-wetland Sb-Lt	Non-wetland Sb-Lt	
Pine Recolonization (Pine <2m)	shrubland dominated by Pine	shrubland dominated by Pine	shrubland dominated by Pine	
Shrubland (low shrub recolonization no pine)			shrubland (upland dry-mesic moisture regime)	
Wet Closed Coniferous (Black Spruce)	Treed poor fen j1 Treed rich fen k1 Treed bog i1	Treed poor fen i1 Treed rich fen j1 Treed bog h1	Treed bog f1 Treed poor fen g1 Treed rich fen h1	
Wet Open Coniferous (Black Spruce)	Treed poor fen j1 Treed rich fen k1 Treed bog i1	Treed poor fen i1 Treed rich fen j1 Treed bog h1	Treed bog f1 Treed poor fen g1 Treed rich fen h1	FTNN/F FNN
Bog (sphagnum around edges of graminoid fens)	Shrubby bog i2	Shrubby bog h2	Shrubby bog f2	BTNN, BTNI
Low Shrub wetland (bog)			Shrubby bog f2	BONS
Shrubby Fen	Shrubby poor fen j2 Shrubby rich fen k2	Shrubby poor fen i1 Shrubby rich fen j2	Shrubby poor fen g2 Shrubby rich fen h2	FONS
Graminoid Fen	Graminoid rich fen k3	Graminoid rich fen j3	Graminoid rich fen h3	FONG/ MONG
Marsh emergent	marsh l1	marsh	marsh	MONG
Water				WONN, NWL, NWF, NWR

Research Program (AOSERP) and a 1997 field investigation. An accuracy assessment of the classified imagery based on field data collected in July 1997 indicated a final overall accuracy of 80% (Golder 1997o: Terrestrial Vegetation Baseline Report).

Vegetation Classes from the Landsat imagery were transferred to a geographical information system (GIS) to allow the relative abundance of vegetation classes to be compared within the RSA. By superimposing baseline, Project Millennium and planned developments over the existing vegetation "polygons", the distribution and amounts of each class affected can be quantified and an assessment of significance made using the criteria previously described. Similarly, by superimposing the successive reclamation activities onto the combined development area, the progression of revegetation can be quantified and monitored.

This classification is at a coarser scale than completed for the local study area. This is reflected in slight differences in area calculations for baseline and impact values for the Project.

D6.3.1.3 Biodiversity Measurements

Biodiversity was assessed for vegetation communities in the RSA by quantifying community richness and patch size. Richness was determined by counting the number of different classified units within the RSA for pre and post-development scenarios. Patch size assessment is described in detail in Section D6.3.3.1.

D6.3.1.4 Potential Linkages: Construction and Operation

The first vegetation resources linkage pertains to the potential impacts of Project construction and operation on the terrestrial vegetation and wetlands communities in the RSA. Project activities that may affect the vegetation resource include, but are not limited to: site clearing, soil and overburden stripping and storage, changes in soil properties, development of Project facilities and infrastructure, changes to hydrology and emissions and releases to the air, ground and water. The impacts from these activities are expected to include direct losses or alteration of terrestrial vegetation and wetlands as a result of site clearing and the physical removal of terrestrial vegetation and wetlands, while the indirect losses may result from air emissions and/or water releases.

Effects on terrestrial vegetation and wetlands may include changes in vegetation community diversity. Linkage may also be drawn to other related resources, as a result of potential impacts to terrestrial vegetation and wetlands, including changes in resource use, wildlife habitat and human health.

D6.3.1.5 Potential Linkages: Closure

A second linkage identifies the potential impacts on the vegetation and wetlands resource at (and beyond) closure of developments. Development activities that affect vegetation communities and species at closure include, but are not limited to: reclamation activities, such as grading and replacement of overburden and topsoil materials, development of end pit lakes and alterations to surface drainage patterns. These activities will result in a variety of reclamation surfaces which will be revegetated to meet end land use objectives. Revegetation efforts will eventually replace plant communities displaced during development constructions and operation.

Reclaimed vegetation, however, will initially result in changes in vegetation successional stage within and among the reclaimed communities. This change has the potential to affect resource use and wildlife habitat while succession proceeds.

D6.3.2 Vegetation Community Quantity and Distribution

D6.3.2.1 Analysis and Results

Direct Losses/Alterations

The combined developments will result in direct losses and alteration to terrestrial vegetation (Table D6-12). A discussion detailing activities associated with these developments is presented in Section A2. Baseline regional vegetation is shown in Figure D3a-d.

Table D6-12 Direct Losses/Alteration of Existing Terrestrial Vegetation, Wetlands, Lakes, Rivers and Other Areas in the RSA

General Community Types	Baseline		Project Millennium		CEA[a]		
	(ha)	(% of RSA)	(ha)	(% of RSA)	(ha)	(% of RSA)	(% of Total RSA)
Uplands	970,774	40	1,116	0.1	93,219	9.6	3.8
Wetlands	1,235,595	51	4,448	0.4	89,581	7.2	3.7
Water	64,429	3	1	<0.1	896	<1	<1
Forestry Activity	13,867	<1	0	0	157,230	n/a	n/a
Developed, Nonvegetated, or Unclassified	144,085	6	79	<0.1	119,157	n/a	n/a
TOTAL	**2,428,750**	**100**	**5,644**	**0.2**	**n/a**	**n/a**	**8**

[a] includes forestry activities at 50% of total FMA area

There are approximately 75,665 ha which could not be classified through Landsat Imagery in the RSA. Existing forestry disturbances occupy 13,872 ha or less than 1% of the RSA. The total baseline disturbance to vegetation due to developments is 69,629 ha or 3% of the RSA.

Construction of the Project will result in the clearing of 5,644 ha (less than 1% of the RSA). Other approved and existing developments (including forestry) will contribute an additional 250,674 ha, therefore, the combined cumulative impact is approximately 256,318 ha or 10% of the RSA.

Disturbance Summary for the RSA

Baseline terrestrial vegetation accounts for 970,774 ha or 40% in the RSA. The Project will clear 1,116 ha or <1 of upland vegetation within the RSA. While combined developments will clear 93,219 ha or 11% of the RSA. The Project, therefore, contributes only a small proportion (1.2%) of this loss. Commercial logging contributes the most to this disturbance in the RSA.

Within upland (terrestrial) plant communities (Table D6-13), the greatest impacts occur within the mixed coniferous (11% Sw dominant), mixed deciduous (11% Aw dominant) and mixedwood (13% Sw-Aw dominant). The lowest impacts will occur within the open pine-lichen, where 6,080 ha or less than 5% of the community will be cleared.

Overall, terrestrial vegetation will increase by 39,251 ha due to reclamation from 970,774 ha at baseline to 1,010,025 ha in the RSA.

Wetlands

Effect on wetlands from the Project is estimated to be 4,448 ha or 2% of all wetlands in the RSA. Combined developments, including Forestry, will result in either permanent or temporary losses to **88,423** ha or 7%. It is expected that in the Far Future wetlands disturbed by forestry will return to baseline conditions. Oil sands developments, however, will reclaim fens and bogs to other upland vegetation communities, marsh wetlands, or lakes.

Impacts from the Project will result in a loss of 2,953 ha or 1% of wet closed coniferous (Sb dominant) and 159 ha or <1% of wet open coniferous (Sb dominant). Shrubby and graminoid fens will be reduced by 1% as a result of the Project. Combined developments will affect 48,664 ha or 10% of wet closed coniferous (Sb dominant); 10,749 ha or 8% wet open coniferous (Sb dominant). In addition, combined developments will affect a total of 12% of fens in the RSA.

Table D6-13 Baseline, CEA and Closure Vegetation and Other Land Cover Types in the RSA

Vegetation Types	Baseline RSA		Project Millennium		CEA[a]		Far Future	
	(ha)	(%)	(ha)	(%)	(ha)	(%)	(ha)	%
Open Pine-Lichen	130,819	5	1	<0.1	6,080	4.6	130,819	100
Mixed Deciduous (Aspen dominant)	177,541	7	357	0.2	20,189	11.4	180,758	102
Mixedwood (White Spruce - Aspen dominant)	318,772	13	437	0.1	40,154	12.6	344,546	108
Mixed Coniferous (White Spruce dominant)	112,186	5	321	0.3	12,654	11.3	122,446	109
Mixed Coniferous (White Spruce - Pine dominant)	18,778	1	0	0	1,130	6.0	18,778	100
Mixed Coniferous (Pine dominant)	15,075	1	0	0	3,085	20.5	15,075	100
Mixed Coniferous (Black Spruce - Tamarack)	93,444	4	951	1.0	7,361	7.9	93,444	100
Pine Recolonization (Pine <2m)	87,474	4	0	0	2,566	2.9	87,474	100
Shrubland (low shrub recolonization, no pine)	16,685	1	0	0	0	0	16,685	100
Terrestrial Communities Total	**970,774**	**41**	**2,067**	**0.2**	**93,219**	**9.6**	**1,010,025**	**104**
Wet Closed Coniferous (Black Spruce)	511,785	21	2,953	0.6	48,664	9.5	499,546	98
Wet Open Coniferous (Black Spruce)	135,784	6	159	0.1	10,749	7.9	133,415	98
Bog (Sphagnum around edges of graminoid fens)	3,333	<1	0	0	1	<0.1	3,333	100
Low Shrub Wetland (bog)	64,798	3	0	0	1,229	1.9	64,798	100
Shrubby Fen	289,689	12	232	<0.1	17,678	6.1	289,445	100
Graminoid Fen	224,531	9	153	<0.1	9,682	4.3	224,531	100
Marsh Emergent	5,675	0	0	0	420	7.4	9,267	163
Wetland Communities Total	**1,235,595**	**51**	**3,497**	**0.3**	**88,423**	**7.1**	**1,224,335**	**99**
Water	64,429	3	1	0	1,158	1.8	73,772	115
Barren Ground/Exposed Bedrock	12,660	1	4	0	896	7.1	12,660	100
Unclassified	75,665	3	76	0.1	6,107	8.1	75,665	100
Disturbances								
Forestry Activity	13,867	1	0	n/a	157,230	n/a	13,867	100
Municipalities	4,002	0	0	n/a	5,902	n/a	9,904	247
Open Pit Mines	43,238	2	5,644	n/a	22,552	n/a	n/a	n/a
Other Disturbances	5,618	<1	0	n/a	1,602	n/a	5,618	100
In-Situ	0	0	0	n/a	33	n/a	0	0
Additional Linear Disturbances	2,904	<1	0	n/a	3,838	n/a	2,904	100
Sub-Total Disturbances in RSA	***69,629***	***3***	***5,644***	***<1***	***191,157***	***8***	***75,531***	***n/a***
TOTAL	**2,428,750**	**100**	**5,644**	**<1**			**2,428,750**	**100**

[a] includes Forestry

In the Far Future scenario, wetlands will decrease from 1,235,595 ha to 1,224,335 ha. A total of 11,260 ha of fens will be converted to upland vegetation types or lakes (i.e., end pit lakes).

Old-Growth Forests

The RSA supports very few forest communities classified as "old-growth". This conclusion is based on field inventory results and a search of forest age records maintained by Alberta Environmental Protection (AEP). Tree age criteria for old-growth forests has been defined for this area as outlined in Section D3.

The **three** forest communities most likely to support old-growth forests included open pine lichen, mixed coniferous (Sw dominant) and mixed deciduous (Aw dominant) forests. These are described in Section D3. A description of commercial forestry under the CEA is provided in Section F3.6 - Resource Use.

Rare or Endangered Terrestrial Plant Species or Communities

Rare plants often require unique habitat types, a number of which were observed in the RSA including the Project. Rare plants are found to a limited extent in upland locations depending upon the species requirements.

Traditional Plants (Food, Medicinal and Spiritual)

A description of traditional plants is provided in Section F3. Due to the generalized vegetation classification of the RSA and the widespread habitat requirements, traditional plants identified may be found in multiple ecosite phases within the RSA. Accordingly, many of the plants can potentially be found over large areas within the RSA.

As most of the traditional plants are widespread in the RSA, particularly in wetlands, losses associated with the Project Millennium and combined developments are equally distributed across all species. Many wetlands, such as wooded fens, are lost because of oil sands developments. Combined development will decrease wetlands by 5,062 ha or 15% within the RSA.

Indirect Losses/Alterations

The combined developments will result in indirect losses/alterations to vegetation resources within the RSA. Such impacts are difficult to quantify and are largely due to the effects of acidifying emissions and changes in surface water hydrology. These issues are addressed within the LSA in Sections C2.2 and C3.2 (respectively). Changes in surface water hydrology affecting soil mixture conditions and vegetation resources have been quantified for those areas affected by groundwater drawdown; however other indirect impacts such as those areas adjacent to roads and drainages are not quantified within the RSA.

Other indirect impacts to vegetation within the RSA include, for example, the accidental introduction of exotic species on temporarily disturbed surfaces and changes in stand structure as a result of soil disturbance. These changes will be monitored within the LSA and extrapolated within the regional context.

D6.3.2.2 Residual Impact Classification and Environmental Consequence

A total of 16,129 ha or 2% of terrestrial vegetation in the RSA will be removed from combined developments. This represents a low magnitude, high in frequency and a low Environmental Consequence.

Open and closed coniferous (black spruce) in the RSA represent approximately 26% of the wetlands. The loss of wetlands from combined developments is 33,661 ha or 3% of wetlands within the RSA. The impacts to wetlands therefore are negative in direction, low in magnitude and of a low Environmental Consequence. Table D6-14 summarizes the impacts to vegetation communities in the RSA.

Table D6-14 Residual Impact Classification on Terrestrial Vegetation and Wetlands in the RSA and Environmental Consequence

Vegetation Community Type	Impact Assessment Criteria						
Ecosite Phases	Direction	Magnitude	Geographic Extent	Duration	Reversibility	Frequency	Environmental Consequence
Open Pine-Lichen	Positive	Low	Regional	Long-term	Irreversible	Low	Low
Mixed Coniferous (Sw dominant)	Positive	Low	Regional	Long-term	Irreversible	Low	Low
Mixed Deciduous (Aw dominant)	Positive	Low	Regional	Long-term	Irreversible	Low	Low
Mixedwood (Sw-Aw dominant)	Positive	Low	Regional	Long-term	Irreversible	Low	Low
Wet Closed Coniferous (Sb)	Negative	Low	Regional	Long-term	Irreversible	Low	Low
Wet Open Coniferous (Sb)	Negative	Low	Regional	Long-term	Irreversible	Low	Low
Graminoid Fen	Negative	Low	Regional	Long-term	Irreversible	Low	Low
Low Shrub Wetland (bog)	Negative	Low	Regional	Long-term	Irreversible	Low	Low
Bog (Sphagnum around edges of graminoid fens)	Positive	Low	Regional	Long-term	Irreversible	Low	Low
Marsh Emergent	Positive	Low	Regional	Long-term	Irreversible	Low	Low

The primary residual impacts include:

- a change in dominant vegetation type from wetlands to upland communities;
- a decrease in areas of wetlands;
- an increase in deciduous shrub communities; and
- an increase in areas of ponds/wetlands and lakes.

In general, the direct and indirect impacts to the vegetation resources do not represent a significant reduction. Some vegetation types such as fens and bogs will represent a permanent loss of that resource, however several upland ecosite phases will be replaced during reclamation. In addition, loss/alteration to vegetation will be phased over the construction and operation phases of development. Substantial increases in community types, for example, open pine-lichen and mixed coniferous (Sw dominant) are foreseen following mine closures based on reclamation plans.

The CEA is presented as the worst case scenario. Developments may not occur simultaneously and reclamation will be phased over time.

D6.3.3 Vegetation Diversity

D6.3.3.1 Richness (Patch Types)

Richness of patch types is determined by counting the number of different classified units within a given landscape or community unit. These values can be determined for baseline, impact and reclaimed areas.

Patch dynamics examines vegetation communities as mosaics of different areas in which disturbances and biological interactions proceed. A patch habitat is an environment within which there are significant variations in size and quality of habitat available for particular species. The variability (range) in patch size will prove some indication of diversity at the landscape and community level. The number and size of vegetation patches (polygon) with the RSA are quantified in hectares. Polygons are assessed by comparing the number of polygons (patches) within the RSA before and after impacts by the combined developments. The assessment of polygons was determined by vegetation types, for example, mixed coniferous (Sw dominant).

D6.3.3.2 Diversity

Species diversity has been a central theme of much research in community ecology in the last score of years. General discussions of species diversity are presented in Whittaker (1972), Pielou (1975), Ricklys (1979), Pianka (1983), and Krebs (1989).

Species diversity is composed of two components: 1) the number of species that coexist in an area; and 2) the relative number of individuals belonging to each species.

Three levels of diversity analysis are provided in this EIA - landscape level is provided in the ELC sections, vegetation community level assessment can be found in the Vegetation Impact Analysis section and species diversity level of analysis is presented in the Terrestrial Vegetation Wetlands Environmental Setting.

The CEA assessment showed that no vegetation communities will be completely removed in the RSA due to combined developments. Therefore vegetation community diversity in the RSA will not be significantly altered from developments considered in the CEA scenario.

D6.3.3.3 Residual Classification and Environmental Consequence

The residual impact classification of changes in diversity of terrestrial vegetation communities for the combined developments is positive in direction, low in magnitude, regional in extent and of long-term duration. The Environmental Consequence is moderate.

Table D6-15 outlines patch size impacts to each ecosite phase. The largest impact will occur to the low shrub wetland (bog) ecosite phase with an increase in average patch size from 14 to 16 ha. Average patch size will decrease by 1 ha in the mixed coniferous ecosite phase (Pj/Pl dominant) and will increase by 1 ha in open pine lichen, pine recolonization and graminoid fen ecosite phases. The remainder do not change significantly due to the combined developments. The impact to diversity is Low magnitude, with a Low environmental consequence.

Table D6-15 Patch Size for Baseline and CEA Vegetation Communities

Ecosite Phase	Baseline Patch Size (ha)			CEA Patch Size (ha)			Change in Patch Size (ha)			
	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg[a]	% of Baseline
Open pine lichen	0.25	19,245	16	0.25	30,255	17	0	-11,010	0.34	2.0
Mixed coniferous (Sw dominant)	0.25	4,130	5	0.25	4,130	5	0	0	-0.03	-0.3
Mixed deciduous (Aw dominant)	0.25	12,422	11	0.25	12,422	11	0	0	-0.23	-2.1
Mixedwood (Sw/Aw dominant)	0.25	20,987	9	0.25	10,359	9	0	10,629	-0.44	-4.9
Mixed coniferous (Pj/Pl dominant)	0.25	24,523	6	0.25	821	5	0	2	-1.77	-27.8
Mixed coniferous (Sb--Lt dominant)	0.25	4,722	4	0.25	4,722	4	0	0	-0.02	-0.4
Mixed coniferous (Sw-Pj/Pl dominant)	0.25	853	5	0.25	589	5	0	265	0.12	2.5
Pine recolonization	0.25	32,628	11	0.25	32,628	12	0	0	5.80	5.1
Shrubland (low shrub recolonization)	0.75	15,167	232	0.75	15,167	232	0	0	0	0
Marsh emergent	0.25	209	2	0.25	209	2	0	0	-0.004	-0.2
Wet closed coniferous (Sb dominant)	0.25	98,640	20	0.25	98,645	20	0	-4	0.57	-2.8
Wet open coniferous (Sb dominant)	0.25	5,594	4	0.25	5,594	4	0	0	0.21	5.5
Shrubby fen	0.25	22,299	7	0.25	20,053	7	0	2,246	0.30	4.5
Graminoid fen	0.25	17,351	7	0.25	22,870	8	0	-5,518	0.40	5.6
Bog (shagnum dominant)	0.25	301	4	0.25	301	4	0	0	0.01	0.3
Low shrub wetland (bog)	0.25	41,414	14	0.25	41,414	16	0	0	1.66	11.8

[a] A negative sign indicates a reduction in patch size.

D6.3.4 Vegetation Sensitivity to Acidifying Emissions

Potential Acid Input (PAI) from combined developments, including fully disclosed, is predicted to centered around oil sands development areas. The World Health Organization (1994) has proposed a PAI critical loading factor of 0.25 keq/ha/a for sensitive ecosystems and 0.5 keq/ha/a for moderately sensitive ecosystems. The only dominant vegetation community not occurring within isopleths of 0.25 keq/ha/a is shrubland. Within the 0.25 keg/ha/a isopleth, the combined developments will have the highest impacts on open pine-lichen and mixed coniferous (Sw-Pj/Pl dominant) vegetation types. The lowest impacts will occur within the mixed coniferous (Pj/Pl dominant) vegetation type. PAI impacts are described in detail in Section D3.2.

D6.3.4.1 Residual Classification and Environmental Consequence

The residual impact classification of acid emissions and vegetation health for the combined developments is Negative in direction, Undetermined in magnitude, Regional in extent and of Long-Term duration. These impacts are of High frequency and are Reversible. The Environmental Consequence is Undetermined.

D6.3.5 Conclusion and Summary

Table D6-16 summarizes the residual impacts to terrestrial vegetation under the CEA.

Table D6-16 Summary of Residual Impacts to Terrestrial Vegetation

Issue	CEA Results
Vegetation Community Quantity and Distribution	**For the CEA, loss of vegetation communities (16,129 ha or >1%) is predicted in the RSA. The Project contributes 5,644 ha or >1% of this impact.** **The CEA impact on loss or alteration of vegetation communities is Positive in direction, Low in magnitude, Regional in geographic extent, Long-term in duration and reversible. The Environmental Consequence is Low.** **The CEA reclamation will increase terrestrial vegetation in the RSA by 4% (39,251 ha). This impact is Positive in direction, Low in magnitude, Regional in geographic extent, Long-term in duration, and the Environmental Consequence is Moderate.** **The total loss to wetlands from the combined developments is 11,260 ha or 1% of wetlands in the RSA. The Project's contribution to this loss is >1% under the CEA. This impact is Negative in direction, Low in magnitude, Regional in geographic extent, Long-term in duration, and the Environmental Consequence is Moderate.** **Reclamation activities and reforestation will result in changes to the distribution of wetland types in the RSA. Overall, wet open coniferous and wet closed coniferous will be reduced by 2% each but marsh emergent communities will increase by 163% in the RSA.**
Vegetation Diversity	The CEA impact on diversity to vegetation communities is Low in magnitude, Regional in geographic extent, Long-term in duration, and the Environmental Consequence is Low. The CEA impact on diversity to wetlands is Positive in direction, Low in magnitude, Regional in geographic extent, Long-Term in duration, and the Environmental Consequence is Moderate.
Vegetation Sensitivity to Acidifying Emissions	The CEA impact on air emission to vegetation health is Negative in direction, Undetermined in magnitude, Regional in geographic extent, Long-term in duration, and the Environmental Consequence is Undetermined.

D6.4 ECOLOGICAL LAND CLASSIFICATION

D6.4.1 Approach and Methods

An ecological land classification (ELC) was utilized within the RSA to identify relatively homogeneous, spatially distinct areas, referred to as ELC units. These units fundamentally classify the landscape in a three dimensional sense, composed of a "terrain layer" (geology and surface geology), overlain by a "soil layer", in turn overlain by a "vegetation layer". The inter-relationships between these "layers", combined with physical and biological modifying processes, allows the landscapes to be classified and analyzed at a variety of scales and levels of complexity. The first level of classification was to identify landforms or macroterrain units, which represent permanent features in the landscape. Boundaries of macroterrain units were based on terrain units described in the Soils and Terrain Section of this EIA. Macroterrain will be assessed to determine the cumulative effects of developments in the RSA. Macroterrain or landforms are permanent features of the landscape. Oil Sands development will occur in only a few macroterrain units. As such, utilizing macroterrain as a broad geographical unit assists in focusing the assessment on a few key landform features.

The approach used to assess potential cumulative effects on the ecological land classification component was consistent with the approach described for the ELC Impact Assessment in Section D4.2.

D6.4.2 Potential Linkages and Key Questions

Figure D4.2-1 shows the linkage diagram for Project activities and potential changes in the ELC component. The same linkage diagrams apply to the CEA.

The overall impacts to ELC units falls under two distinct categories which are discussed in this section - macroterrain quantity and distribution and macroterrain diversity.

D6.4.3 Macroterrain Quantity and Distribution

D6.4.3.1 Analysis and Results

The analysis of potential linkages indicates that the valid linkage necessary for determining cumulative losses or alteration of ELC units at the macroterrain level involves site clearing during development. For oil sands developments, site clearing involves the direct removal of landforms, and associated soils and vegetation communities. Forestry disturbances will not affect macroterrain units.

There are fifteen macroterrain units in the RSA. A detailed description of each macroterrain type is found in the Baseline Ecological Land Classification Document (Golder 1998c). Figure D6-8 shows baseline regional macroterrain units and Figure D6-9 shows macroterrain units within the combined developments.

Project Millennium will impact two macroterrain units; namely the Athabasca-Clearwater River Valley (492 ha or <1% loss) and the Steepbank Organic Plain (5,152 ha or 1% loss). Within the RSA, open pit mine will increase by 5,644 ha or 13% due to Project Millennium. As such, the relative contribution of Project Millennium to these macroterrain units is low.

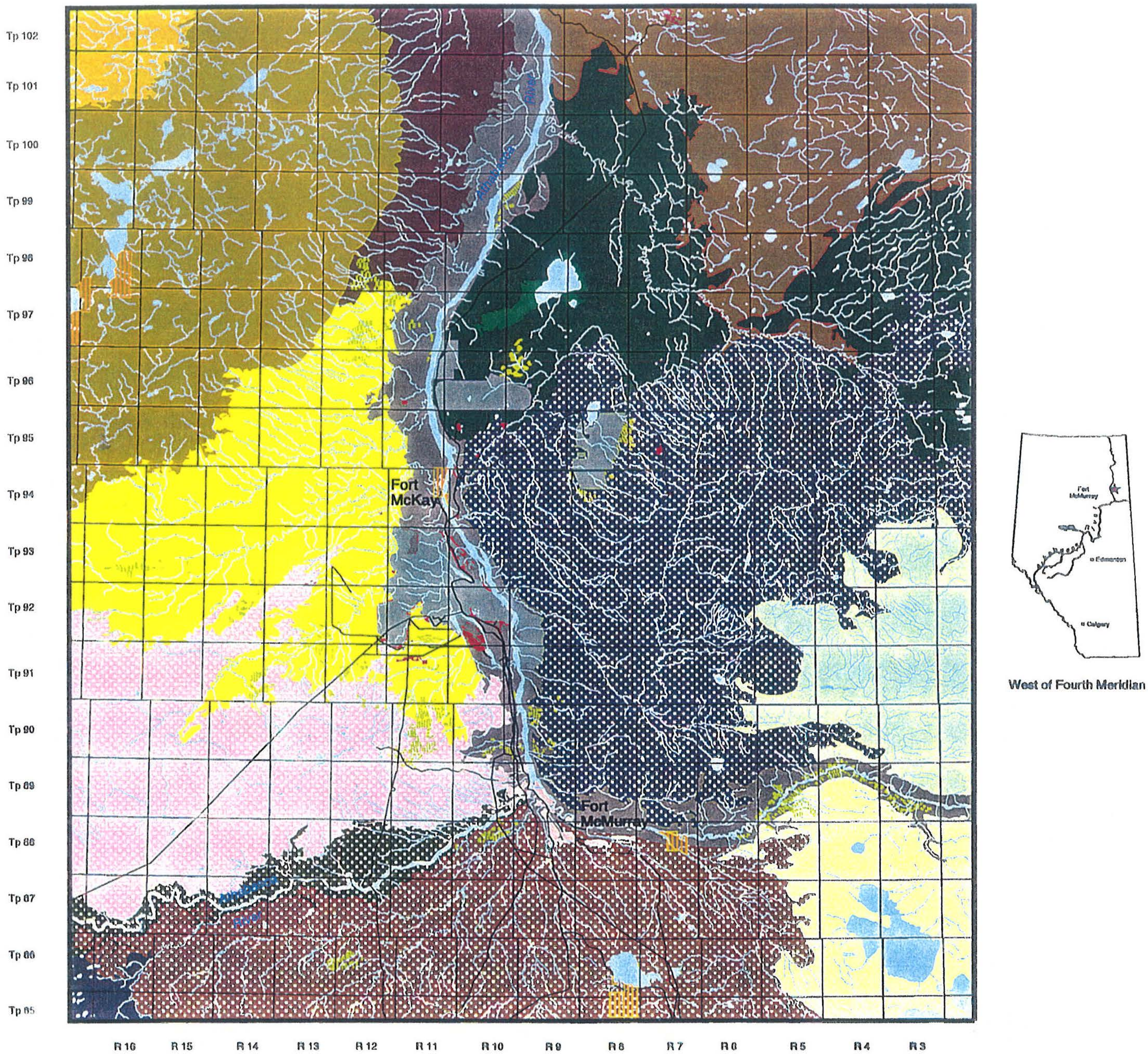
Combined developments, which include such developments as Syncrude Aurora Mine and Shell's Muskeg River Mine will impact a total of seven macroterrain units within the RSA; namely Athabasca-Clearwater River Valley, Thickwood Plain, Dover Lacustrine Plain, McKay Organic-Morainal Complex, East Athabasca River, Steepbank Organic Plain and McLelland Lake Glaciofluvial Plain (Table D6-17). Combined developments will affect 4,418 ha (3%) of the Athabasca-Clearwater River Valley macroterrain unit within the RSA (singly). The Steepbank Organic Plain is the macroterrain unit most affected by cumulative developments in the RSA. The total loss is 25,789 ha or 5% of the RSA; Project Millennium will reduce the unit's area by 5,152 ha, while the approved developments will impact 20,637 ha. The Project Millennium will remove a total area of 5,644 ha of macroterrain units and the approved developments will remove 58,015 ha in total. The total area disturbed including baseline, Project and Combined developments is 63,659 ha or 2% of RSA. This area will be reclaimed to new macroterrain units.

As a result of increased development in the RSA, municipalities are expected to increase by 5,902 ha or 60%; open pit mines will increase by 35%; and other disturbances are expected to increase by approximately 6%.

This CEA scenario represents the worst case scenario, as all developments do not occur simultaneously. Additionally, phased reclamation will also occur for each development scenario. Thereby reducing the total area under development at any one time.

D6.4.4 ELC Diversity

A discussion of biodiversity and how it was assessed for the Project EIA was provided in Section D3.2. The CEA assessment showed that no macroterrain units will be completely removed by the combined developments. Therefore, the overall biodiversity at the macroterrain level will not be significantly be altered by developments in the RSA. Moreover, within macroterrain units, the vegetation diversity, does not change substantially as a result of the combined developments or reclamation activities.



SOURCES: Suncor, Syncrude, Petro-Canada, Golder, Alberta Research Council AOSERP (Report 122)

Scale 1:1,000,000

10 0 10 20 30 40

Kilometres

Map Projection: UTM 12
Datum: NAD 83

LEGEND

- Regional Study Area
- Linear Disturbances
- Open Water
- Forestry
- Existing Open Pit Mines
- Other Disturbances
- Municipalities
- Indian Reserves

MACROTERRAIN

- High Hill Glaciofluvial Plain
- Athabasca - Clearwater River
- Clearwater Upland
- Thickwood Plain
- Schultz's Bog Diversity Area
- Birch Mountains Organic Plain
- Birch Mountains Upland
- Dover Lacustrine Plain
- MacKay Organic - Morainal Complex
- East Athabasca River
- Steepbank Organic Plain
- McClelland Lake Glaciofluvial Plain
- Athabasca Shield
- Birch Mountain Fluvial Terrace

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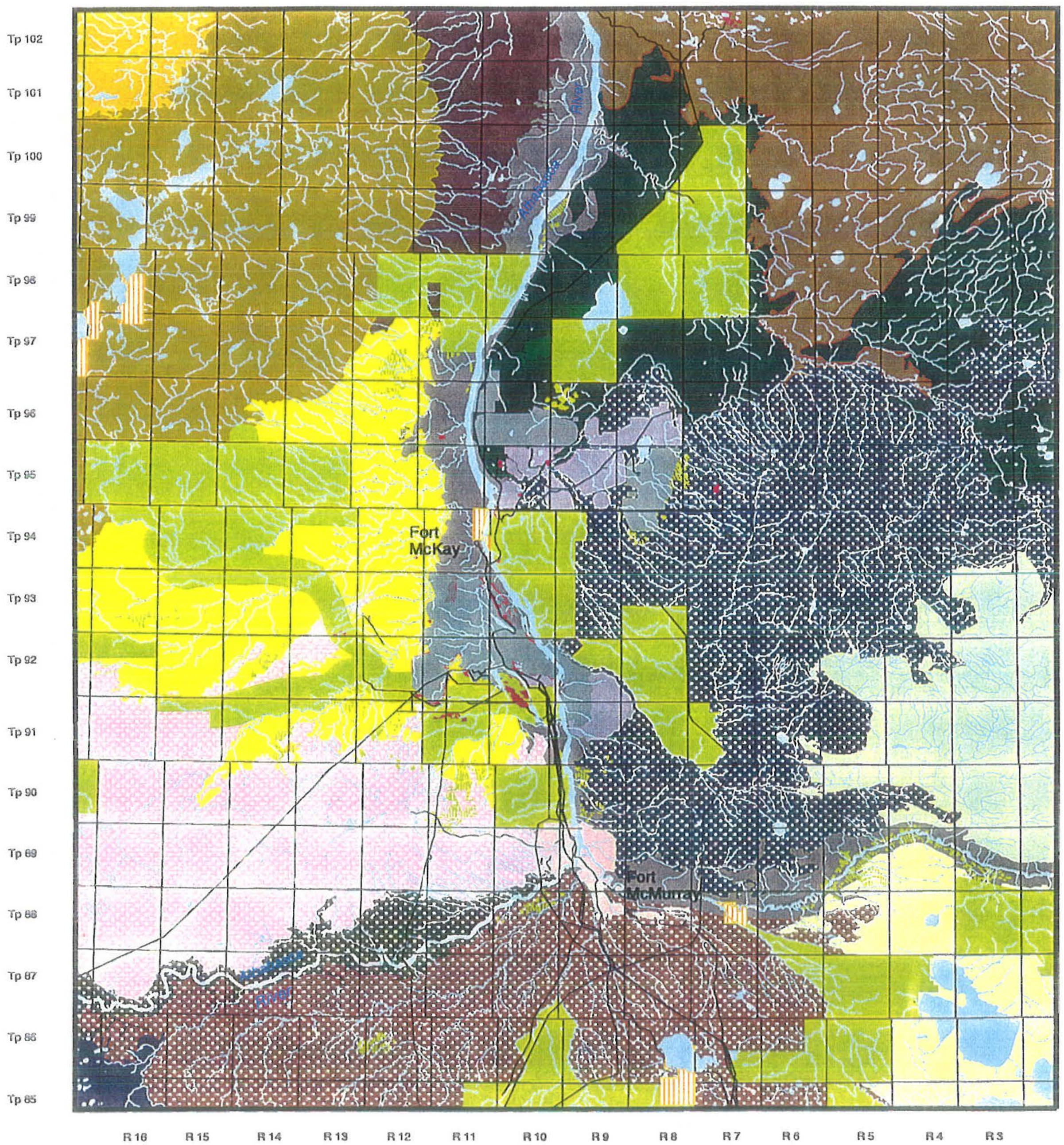
SUNCOR ENERGY

Project Millennium

REGIONAL STUDY AREA MACROTERRAIN IMPACT ASSESSMENT BASELINE

16 Apr. 1998	Figure D6-6	PRODUCED BY: K.K.O. REVIEWED BY:



West of Fourth Meridian

SOURCES: Suncor, Syncrude, Petro-Canada, Mobil, Al-Pac, Golder, Alberta Research Council AOSERP (Report 122)

Scale 1:1,000,000

10 0 10 20 30 40

Kilometres

Map Projection: UTM 12
Datum: NAD 83

LEGEND

- Regional Study Area
- Linear Disturbances
- Open Water
- Forestry
- Existing Open Pit Mines
- Other Disturbances
- Municipalities
- Proposed Open Pit Mines
- In-Situ
- Indian Reserves

MACROTERRAIN

- High Hill Glaciofluvail Plain
- Athabasca - Clearwater River
- Clearwater Upland
- Thickwood Plain
- Schultz's Bog Diversity Area
- Birch Mountains Organic Plain
- Birch Mountains Upland
- Dover Lacustrine Plain
- MacKay Organic - Morainal Complex
- East Athabasca River
- Steepbank Organic Plain
- McClelland Lake Glaciofluvial Plain
- Athabasca Shield
- Birch Mountain Fluvial Terrace

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SUNCOR ENERGY

Project Millennium

REGIONAL STUDY AREA
MACROTERRAIN
CUMULATIVE EFFECTS ASSESSMENT

16 Apr. 1998	Figure D6-9	PRODUCED BY: K.K.Q. REVIEWED BY:

/data14/suncor/regional/9700/9740/arcview/macro2.apr

Table D6-17 Direct Losses/Alteration of Existing Macroterrain in the RSA

Macroterrain	Baseline RSA[a]		Project Millennium Change[b]		Project Millennium Far Future		Approved Developments Change[c]		Approved Developments Far Future	
	Total (ha)	% RSA	Total (ha)	% Resource	Total (ha)	% Resource	Total (ha)	% Resource	Total (ha)	% Resource
High Hill Glaciofluvial	101,534	4	0	0	0	0	0	0	101,534	100
Athabasca-Clearwater River Valley	142,637	6	492	0.3	0	0	4,418	3	137,727	97
Clearwater	106,555	4	0	0	0	0	0	0	106,555	100
Thickwood Plain	269,274	11	0	0	0	0	2	0	269,272	100
Schutzes Bog Diversity Area	11,159	0	0	0	0	0	**0**	0	11,159	100
Birch Mountains Organic Plain	26,845	1	0	0	0	0	**0**	0	26,845	100
Birch Mountains	304,894	13	0	0	0	0	**0**	0	304,894	100
Dover Lacustrine Plain	231,191	10	0	0	0	0	**33**	0	231,158	100
McKay Organic-Morainal Complex	225,340	9	0	0	0	0	**314**	**0**	225,026	100
East Athabasca River	45,576	2	0	0	0	0	**487**	**1**	45,089	99
Steepbank Organic Plain	408,876	17	5,152	1.3	0	0	**20,637**	**5**	383,087	94
McLelland Lake Glaciofluvial Plain	217,420	9	0	0	0	0	**2,926**	**1**	214,494	99
Athabasca Shield	209,497	9	0	0	0	0	0	0	209,497	100
McLelland Lake Glaciofluvial Plain	7,338	0	0	0	0	0	0	0	7,338	100
Birch Mountain Fluvial Terrace	70,695	3	0	0	0	0	**0**	**0**	70,695	100
Municipalities	4,002	0	0	0	0	0	**5,902**	0	-1,900	n/a
Open Pit Mines	42,717	2	-5,644	13.0	0	0	**23,073**	n/a	25,288	n/a
Other Disturbances	3,095	0	0	0	0	0	**191**	n/a	2,904	n/a
In-Situ	0	0	0	n/a	0	0	**33**	**n/a**	-33	n/a
Total	**2,428,645**	**100**	**0**	**0**	**0**	**0**	**58,015**	**2**	**2,370,630**	**98**
Existing Developments					5,644	100				
Reclamation Units [d]									58,015	2
Total	**2,428,645**	**100**	**5,644**	**0.2**	**5,644**	**0.2**	**58,015**	**2**	**2,428,645**	**100**

[a] Undeveloped macroterrain units plus existing developed area.
[b] Incremental changes to undeveloped terrain units.
[c] Cumulative effect of Project and Approved Developments on Baseline conditions.
[d] Newly created macroterrain units (revegetated tailings sand, overburden storage areas).

D6.4.4.1 Residual Impact Classification and Environmental Consequence

Table D6-18 details the residual impact classification and Environmental Consequence for macroterrain units. In summary, the direction is negative, the magnitude is negligible to low, regional in geographic extent and the Environmental Consequence is low.

Table D6-18 Residual Cumulative Impact Summary for Macroterrain Units

Macroterrain Types	Direction	Magnitude	Geographic Extent	Duration	Reversibility	Frequency	Environmental Consequence
High Hill Glaciofluvial	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Athabasca-Clearwater River Valley	Negative	Low	Regional	Long-term	No	Low	Low
Clearwater	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Thickwood Plain	Negative	Negligible	Regional	Long-term	No	Low	Low
Schutzes Bog Diversity Area	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Birch Mountains Organic Plain	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Birch Mountains	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Dover Lacustrine Plain	Negative	Negligible	Regional	Long-term	No	Low	Low
McKay Organic-Morainal Complex	Negative	Negligible	Regional	Long-term	No	Low	Low
East Athabasca River	Negative	Negligible	Regional	Long-term	No	Low	Low
Steepbank Organic Plain	Negative	Low	Regional	Long-term	No	Low	Low
McLelland Lake Glaciofluvial Plain	Negative	Negligible	Regional	Long-term	No	Low	Low
Athabasca Shield	n/a	n/a	n/a	n/a	n/a	n/a	n/a
McLelland Lake Glaciofluvial Plain	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Birch Mountain Fluvial Terrace	n/a	n/a	n/a	n/a	n/a	n/a	n/a

D6.4.5 Summary of Impacts

Table D6-19 summarizes the impacts of the CEA results on Ecological Land Classification.

Table D6-19 Summary of Impacts on Ecological Land Classification

Key Question	CEA Results
ELC Quantity and Distribution	In this CEA, the total losses are 63,659 ha or 3% of the RSA. The Project will contribute 5,644 ha or <1 % of the loss in the RSA
ELC Diversity	The CEA impact on diversity to vegetation communities is negative in direction, negligible to low in magnitude, regional in geographic extent, long-term in duration and the Environmental Consequence is low.

D6.5 WILDLIFE

Discussion on the wildlife baseline for the Project was provided in Section D5.1, while the potential impacts of the Project on wildlife were detailed in Section D5.2 and summarized in Section D5.3 of this EIA.

D6.5.1 Approach and Methods

The approach used to assess wildlife resources for the CEA is consistent with Section D5. This approach consisted of a quantitative analysis of changes to wildlife habitat abundance and diversity. Habitat Suitability Index (HSI) models were used as a tool to quantitatively assess changes in habitat.

D6.5.2 Potential Linkages and Key Questions

Figure D5.2-1 (Section D5.2) shows the linkage diagram for project activities and potential changes in wildlife associated with the Project. Generally the same linkages and key questions apply to the CEA.

The key question for the wildlife CEA was:

CTER-2: What impacts will result from changes to wildlife habitat, abundance, or diversity associated with Project Millennium and the combined developments?

This key question is addressed in four sections below.

- Wildlife Habitat
- Wildlife Abundance
- Wildlife Diversity
- Wildlife Health

A summary of the cumulative effects as they relate to wildlife is presented in Section D6.5.6.

D6.5.3 Wildlife Habitat

Wildlife can be directly or indirectly affected by project developments. Direct habitat change occurs through the removal or alteration of vegetation communities during construction of project facilities (e.g., site clearing). Indirect habitat change can occur through changes in hydrology, creation of barriers to movement, and sensory disturbance. Potential changes to wildlife habitat were discussed in detail in Section D5.2.

D6.5.3.1 Analysis and Results

Direct incremental changes to wildlife habitat due to the Project and combined developments are shown in Table D6-20.

Table D6-20 Cumulative Effects of Habitat Loss for KIRs in the RSA

KIR	Baseline HUs [a]	Habitat Units (HUs) Lost				
		Project Millennium	% Change from Baseline	Total Developments	% Change from Baseline	% Change Attributed to Project Millennium [b]
Moose	1,535,910	-3,433	-0.2	-20,205	-1.3	17
Fisher	1,508,485	-4,045	-0.3	-21,591	-1.4	19
Black Bear	1,247,278	-2,300	-0.2	-13,150	-1.1	18
Beaver	192,045	-117	-0.1	-1,896	-1.0	6
Red-backed Vole	1,679,543	-3,623	-0.2	-20,566	-1.2	18
Snowshoe Hare	1,638,593	-5,115	-0.3	-25,705	-1.6	20
Dabbling Ducks	243,130	-99	-0.0	-1,564	-0.6	6
Ruffed Grouse	765,545	-1,938	-0.3	-7,133	-0.9	27
Cape May Warbler	903,110	-1,545	-0.2	-11,682	-1.3	13
Western Tanager	662,250	-554	-0.1	-8,430	-1.3	7
Pileated Woodpecker	782,295	-1,758	-0.2	-6,469	-0.8	27
Great Gray Owl	1,510,550	-2,037	-0.1	-31,076	-2.1	7

[a] Number of HUs for Existing and Approved Developments within the RSA.
[b] The percent change resulting from Project Millennium divided by the percent change of all of the developments.

Over baseline conditions, the Project will result in a loss of 0.0 to 0.3% of the baseline HUs within the RSA. In total, disturbances for the CEA will range from 0.6 to 2.1% of baseline conditions. Changes attributed to the Project represent from 6 to 27% of the total disturbances. The project will have the greatest effect on ruffed grouse habitat, **fisher** habitat and snowshoe hare habitat. The Project will have the least effect on dabbling duck habitat, beaver habitat, western tanager habitat, and great gray owl habitat.

D6.5.3.2 Residual Impact Classification

Cumulative, residual losses of wildlife habitat were considered to be **moderate** in magnitude, because no KIR will experience losses of more than 21% of baseline HUs within the RSA. The impacts are negative in direction (Table D6-21). However, eventual reclamation of the sites is expected to return wildlife habitats to equivalent capability. The geographic extent of the impacts is regional, the duration is long-term, and the frequency is generally low.

The Environmental Consequence for all KIRs was considered to be low for the total impact scenario due to the low magnitude of the impacts (Table D6-21).

Table D6-21 Residual Impact Classification on Wildlife Habitat

Direction	Magnitude	Geographic Extent	Duration	Reversibility	Frequency	Environmental Consequence
Negative	**Moderate**	Regional	Long-term	Reversible	Low	Low

D6.5.4 Wildlife Abundance

Wildlife abundance can be affected either directly or indirectly. The removal or alteration of vegetation communities, creation of barriers to movement, sensory disturbance, and the release of air or water emissions (see Section D6.5.5) can result in indirect impacts on wildlife abundance. Site clearing may also result in direct loss of a variety of wildlife species. Direct mortality impacts also can include the effects of increased hunting and trapping due to increased access, removal of problem or nuisance wildlife (e.g., beavers and black bears), increased traffic-caused mortality of wildlife, and interactions of wildlife with project infrastructure (e.g., tailings ponds, transmission lines, towers). Potential changes in wildlife abundance were discussed in detail in Section D5.2.

Within a CEA context, it is very difficult to assess changes in wildlife abundance as it is extremely difficult to estimate the numbers of animals that may be affected by various developments. Such estimates are often subjective and may be misleading. Rather, in this CEA, professional judgement is used to classify the impacts on wildlife abundance.

D6.5.4.1 Analysis and Results

Site clearing will have the greatest effect on wildlife abundance. While larger, more mobile species may be able to move away from disturbances, site clearing for the various projects may result in direct mortality for animals that have small home ranges, limited mobility or who are susceptible in their early life stages. It is anticipated that the indirect effects of barriers to movement, changes in hydrology, and sensory disturbance will be minor compared to the effects from site clearing. However, when examined within a regional context, the amount of area lost to site clearing is quite small (10%). Thus, the potential loss in wildlife abundance is low.

As a result of Project Millennium, increased hunting and trapping will result in a cumulative effect on wildlife abundance. Increased hunting and trapping is not an issue for Project Millennium as access is controlled during the life of the Project. Changes in wildlife abundance due to removal of problem or nuisance wildlife, increased traffic-caused mortality, and interactions of wildlife with project infrastructure are expected to be low to negligible.

D6.5.4.2 Residual Impact Classification

Changes in wildlife abundance due to the combination of Project Millennium and the various other existing, approved and planned developments are negative in direction, low in magnitude, regional in geographic extent, long-term in duration, reversible and of varying frequencies. Although there is considerable scientific uncertainty due to all the unknown variables associated with wildlife abundance, the overall environmental consequence is considered to be low (Table D6-22).

Table D6-22 Residual Impact Classification on Wildlife Abundance

Direction	Magnitude	Geographic Extent	Duration	Reversibility	Frequency	Environmental Consequence
Negative	Low	Regional	Long-term	Reversible	Low to High	Low

D6.5.5 Wildlife Diversity

Similar to wildlife abundance, wildlife diversity can be affected either directly or indirectly. Within a CEA context, it is difficult to assess changes in wildlife diversity as there are numerous factors which can affect wildlife species, (e.g., seasonality of disturbance, individual sensitivity, proximity to human activity, intensity of human activity, and various natural factors, such as forest fires). For this CEA, we estimated the change in wildlife diversity potential using HSI modelling as a tool (Section D5.2). We estimated potential diversity by predicting all of the species that might be found within a particular vegetation type. This number was then multiplied by the area of that particular vegetation type (ha) within the RSA, resulting in the number of habitat units (HUs) available. The number of diversity HUs for each taxa (e.g., mammals, birds, and amphibians/reptiles), or baseline conditions, are presented in Table D6-23. While such an estimate is subjective and may be misleading, it does provide a means of comparing the potential of each project to affect diversity. Thus, the number of HUs lost for each taxa are presented in Table D6-23. Professional judgement was used to further classify the magnitude of impacts on wildlife diversity.

Table D6-23 Cumulative Effects of Loss of Potential Diversity in the RSA

		Habitat Units (HUs) Lost				
Taxa	Baseline [a]	Project Millennium	% Change	Total Developments	% Change	Change Attributed to Project Millennium [b]
Mammals	1,851,217	-4,735	-0.3	-25,275	-1.4	19
Birds	1,686,496	-4,783	-0.3	-22,888	-1.4	21
Amphibians and Reptiles	1,826,347	-4,864	-0.3	-23,040	-1.3	21

[a] Number of HUs for the Existing and Approved Developments.
[b] The percent change resulting from east bank mining area divided by the percent change of all of the developments.

The Project will result in a loss of diversity of 0.3% of the baseline HUs within the RSA for each taxa. In total, disturbances for the CEA will range from 1.3 to 1.4% of baseline conditions. Changes attributed to the Project represent 19 to 21% of the total disturbances.

D6.5.5.1 Residual Impact Classification

Changes in wildlife diversity due to the combination of Project Millennium and the various other existing, approved, and planned developments are negative in direction, low in magnitude, regional in geographic extent, long-term in duration, reversible, and of varying frequencies. The overall environmental consequence is low (Table D6-24).

Table D6-24 Residual Impact Classification on Wildlife Diversity

Direction	Magnitude	Geographic Extent	Duration	Reversibility	Frequency	Environmental Consequence
Negative	Low	Regional	Long-term	Reversible	Low to High	Low

D6.5.6 Wildlife Health

The CEA for wildlife health evaluated the potential for adverse effects to wildlife health due to the release of chemicals in air and water emissions from Project Millennium and the combined developments. Quantitative risk assessment methods, as presented in Section D5.1.7, were used where data were available (i.e., water quality). However, due to uncertainty surrounding future developments, assessment of other cumulative effects were more qualitative in nature. This section addresses the potential wildlife health impacts associated with cumulative releases of water and air to the extent that the current database allows. The CEA considered four exposure scenarios as described in Table D6-25.

Table D6-25 Exposure Scenarios Evaluated in CEA for Wildlife Health

Exposure Scenario	Operation	Closure	Far Future
Water Ingestion	✓	✓	✓
Fish/Invertebrate Ingestion	✓		
Air Inhalation and Vegetation Ingestion	✓		
Chemical Exposures From Reclaimed Landscape			✓

D6.5.6.1 Analysis and Results

Effects of Water Quality on Wildlife Health

To evaluate the potential linkage between cumulative changes to water quality and wildlife health, a quantitative wildlife health risk assessment was conducted using methods described in Section D5.1.7. The following wildlife species were evaluated because they are representative of both aquatic and terrestrial wildlife species:

- water shrew
- river otter
- killdeer

- great blue heron
- moose
- snowshoe hare
- beaver

These animals may be exposed through ingestion of water from the Athabasca River as a drinking water source.

Cumulative chemical concentrations were predicted for the Athabasca River according to the method described in Section C5. Predicted future chemical concentrations in the Athabasca River as a result of the cumulative scenario were compared to predicted concentrations for Project Millennium plus existing and approved developments (i.e., the Project scenario). Where the concentrations for the cumulative scenario were equal to or less than those for the Project scenario, and no unacceptable wildlife health risks were predicted for these chemicals in the baseline and Project impact risk assessments (Sections D5.1.8, D5.2.7 and D5.2.8), these chemicals were excluded from further evaluation in the CEA. In general, concentrations of most chemicals predicted for the cumulative scenario during the operational phase and in the far future were equivalent to those predicted for the Project scenario. Chemical concentrations which exceeded predicted concentrations for the Project scenario were conservatively screened against one-tenth of the Risk-Based Concentrations (RBC). Refer to Appendix VI.1.2 for screening tables. Chemical concentrations in the Athabasca River did not exceed the RBCs, and therefore no chemicals were identified for further evaluation in the risk assessment.

The predicted concentrations of naphthenic acids in the Athabasca River for the cumulative scenario were unchanged from those predicted for the Project scenario during the operational phase, at closure and in the far future. Therefore, the combined release of these substances from Project Millennium and other developments is not predicted to result in a cumulative impact. Thus, naphthenic acids are not evaluated further in the CEA.

Since no chemicals of concern were identified in the chemical screening process, no impacts to wildlife health are predicted due to exposure to Athabasca River water affected by the Project, existing, approved and planned developments.

Effects of Fish and Aquatic Invertebrate Quality on Wildlife Health

In the risk assessment conducted for the Project (Section D5.2.7), the impact analysis showed that predicted conservative exposures likely to be incurred by wildlife who consume local fish and aquatic invertebrates were well within acceptable limits. Minor changes to the water quality of the

Athabasca River, resulting from the combined regional developments, should not significantly increase the tissue concentrations of metals in fish or invertebrates. Since the exposure concentration (i.e., tissue concentration) is unlikely to change, the consequent health risks from consumption of fish and aquatic invertebrates is expected to remain within acceptable limits. However, no data were available to further evaluate this exposure route.

Effects of Air Emissions and Vegetation Quality on Wildlife Health

As discussed in Section D5.2.7, direct inhalation of air is a minor exposure pathway for wildlife, compared to exposures through the food chain, and there is considerable uncertainty associated with estimating wildlife health risks based on air inhalation. Thus, direct air inhalation was not evaluated in either the EIA or CEA. However, the indirect effects of cumulative air emissions on wildlife health were assessed through ingestion of vegetation.

Chemical concentrations in vegetation consumed by wildlife may increase as a result of the deposition of airborne chemicals onto plants and soils. Therefore, ingestion of vegetation is considered to be an important exposure pathway. Results of a vegetation sampling program indicated that oil sands operations do not appear to contribute to increases in chemical concentrations in plants. The impact analysis showed that predicted conservative exposures likely to be incurred by wildlife who consume local plants were well within acceptable limits (Section D5.1.8).

Under future conditions when Project Millennium and other planned developments are operational, air deposition onto plants may change. In response to concerns articulated by stakeholders respecting air deposition of airborne chemicals onto vegetation, Suncor undertook a stack survey to collect information respecting particulate matter, select organic chemicals and metals. However, the results of the survey were not received in time to be incorporated into this section at the time of submission. The results for wildlife are anticipated to be available in the near future.

Effects of Chemical Releases from the Reclaimed Landscape on Wildlife Health

In the Project impact analysis for Key Question W-3 (Section D5.2.8), it was conservatively assumed that wildlife foraging ranges were confined to the Project boundaries, despite the fact that the foraging ranges of many species will extend beyond the Project boundaries into undisturbed areas. Nevertheless, this conservative exposure scenario did not result in significant adverse effects to wildlife populations.

The results of the impact analysis for wildlife living for extended periods of time on the reclaimed Project site would be applicable to reclaimed landscapes for other regional developments. This assumes that chemical releases from the reclaimed landscapes of other regional developments are not significantly greater than those predicted for the Project. Similar exposure scenarios evaluated for the reclaimed landscapes of the Steepbank Mine and the Muskeg River Mine Project indicated a similarly low probability of potential impacts to wildlife health (Golder 1996r, Shell 1998).

Thus, chemical releases from multiple reclaimed landscapes within the region are unlikely to result in increased exposures on reclaimed areas. Rather, due to the larger area of reclaimed landscapes in the Athabasca oil sands region, there is a greater likelihood for wildlife to forage in a reclaimed area. Therefore, this exposure pathway becomes more likely, but the health risks are not significantly enhanced.

D6.5.6.2 Residual Impact Classification

For exposures to water during the operation phases of combined developments, no wildlife health impacts were identified. However, due to the uncertainty regarding the potential chronic effects of naphthenic acids, the magnitude of impact is rated as Low, rather than negligible. This finding is the same as that predicted for the Project.

For exposures on reclaimed landscapes, while the magnitude of the impact is considered to remain unchanged and low, it is recognized that there is an increased likelihood on a regional basis for this exposure pathway to be realized. Therefore, the scope of the residual impact (i.e., affected population) is likely to be enhanced in the CEA, relative to the impact predicted for the Project (Section D5.2.8). The predicted enhancement is based on a greater likelihood of animals being exposed to chemicals on reclaimed landscapes. However, the magnitude of exposure and associated health risks for a given individual animal should not be increased in the CEA, relative to the Project. Further data are necessary to substantiate this prediction. The impact is shown in Table D6-26.

Table D6-26 Residual Impact Classification for Wildlife Health

Direction	Magnitude	Geographic Extent	Duration	Reversibility	Frequency	Environmental Consequence
Negative	Low	Regional	Long-term	Reversible	Moderate-High	Low

Certainty

The assessment of potential impacts to local wildlife health from exposure to Athabasca River water was based on a number of highly conservative assumptions as outlined in Sections D5.2.7 and D5.2.8. Hence, the actual risks to wildlife health will likely be even lower than those suggested by ER estimates because of the multiple protective assumptions. However, there is some uncertainty associated with fish and aquatic invertebrate quality, plant quality and exposures on reclaimed landscapes, as a result of cumulative chemical releases. Ongoing monitoring is required to address these uncertainties.

D6.5.7 Summary of Impacts

Table D6-27 summarizes the predicted impacts and corresponding concern levels identified in the CEA assessment for wildlife. This summary addresses the Key Question CTER-2 regarding the impacts which will result from changes to wildlife habitat abundance or diversity associated with Project Millennium and combined developments.

Table D6-27 Summary of CEA for Wildlife for the Existing, Approved, Planned and Project Millennium Developments

Key Question	CEA Results
CTER-2: What impacts will result from changes to wildlife habitat, abundance or diversity associated with Project Millennium and the combined developments?	During the construction phase of the oil sands developments, the combined developments will cause relatively small losses of wildlife habitat due to site clearing. These impacts are predicted to be negative in direction, low in magnitude, regional in geographic extent, long-term in duration, and of varying frequency. The Environmental Consequence for the cumulative effects is low. As well, minor changes in wildlife abundance and diversity are expected to occur as a result of site clearing, sensory disturbance, removal of nuisance wildlife, wildlife-traffic mortalities, and wildlife interactions with infrastructure. These impacts represent a worst case scenario, as it is unlikely that all sites will be cleared to their maximum extent at the same time. The phased nature of site clearing and progressive reclamation will mitigate the cumulative effects of habitat loss. Eventual reclamation of all sites should result in equivalent habitat capability for wildlife within the region. **During operation of combined developments, no significant health impacts were identified for wildlife from exposures to water from the Athabasca River; however there is some uncertainty regarding the chronic toxicity of naphthenic acids.** **In the far future when equilibrium conditions have been established for all combined developments, a potential impact has been identified in CEA. The scope of the residual impact (i.e., affected population) is likely to be enhanced in the CEA, relative to the impact predicted for the Project, since there is a greater likelihood on a regional basis for this exposure pathway to be realized. However, the magnitude of exposure and associated health risks for a given individual animal should not be increased in the CEA. The cumulative effects on wildlife health are predicted to be Negative in direction, Low in magnitude, Regional in geographic extent, Long -Term in duration, Reversible and of Moderate-High frequency. The Environmental Consequence is Low, reflecting the regional extent and degree of uncertainty associated with impact predictions.**

D6.6 TERRESTRIAL CEA SUMMARY AND CONCLUSIONS

This CEA evaluated the potential effects of Project Millennium plus existing, approved and planned developments on the terrestrial resources including soils, terrain, vegetation, wetlands and wildlife, in the Regional Study Area (RSA). It is difficult to quantify cumulative effects with certainty due to the multitude of variables associated with various developments, including the phased nature of various developments such as oil sands mining. As well, reclamation practices may reduce various impacts by returning resources to equivalent capabilities, often resulting in enhancement of the land. For these reasons, a conservative approach was taken for the CEA, under the assumption that all developments occurred concurrently over the entire project area.

D6.6.1 Soils and Terrain

The construction and operation phases of the combined developments will cause a loss of 3.2% of the natural soil and terrain units in the RSA. Reclamation of the developed areas and existing disturbed areas with reconfigured terrain units covered by a reclamation soil mixture will achieve positive impacts by increasing the diversity of terrain units. The impacts associated with this are estimated to be: negative in direction, low in magnitude, regional in extent, of long-term duration, irreversible and low in frequency. The environmental consequence is rated as low.

As a result of alterations in the quantity and distribution of soil and terrain units between the pre-development and closure landscapes, changes in land capability will be produced. These are estimated to be: positive in direction, low in magnitude, regional in extent and of long-term duration. The positive direction of change is the result of significant areas of non-productive Class 5 land being reclaimed to low capability Class 3. The environmental consequence is rated as low.

Operational activities of the developments will increase acidifying emissions released into the RSA air shed. The environmental consequence is rated as being undetermined because of the high level of uncertainty associated with soil acidification.

D6.6.2 Terrestrial Vegetation and Wetlands

For the CEA, loss of terrestrial vegetation communities (16,129 ha or <1%) is predicted in the RSA. The Project contributes 5,644 ha to this loss. Reclamation will increase terrestrial vegetation **in the RSA by 4% or 39,251 ha.**

The residual impact on loss or alteration of terrestrial vegetation communities as low in magnitude, regional in geographic extent, long-term in duration and reversible. The environmental consequence is rated as low.

The total loss to wetlands from the combined developments is 11,260 ha or 1% of the RSA. The Project's contribution to this loss is 4,448 ha. Reclamation activities and reforestation will result in changes to the distribution of wetlands types in the RSA. Overall, wet open coniferous and wet closed coniferous will be reduced by 2% each, but marsh emergent communities will increase by 163% in the RSA.

The residual impact to wetlands is low in magnitude, regional in geographic extent, and long-term in duration. Some impacts, such as those to bogs and fens, are not reversible, therefore the environmental consequence has been rated as low.

The impact of air emissions on vegetation health is undetermined. Additional data is required to assign an environmental consequence.

D6.6.3 Ecological Land Classification Units

The CEA showed that 63,659 ha or 3% of ELC units in the RSA will be impacted by the combined developments. The Project contributes 5,644 or <1% of the loss in the RSA.

The impact on diversity to ELC units is negligible to low in magnitude, regional in geographic extent and long-term in duration. The environmental consequence in the RSA is rated as low.

D6.6.4 Wildlife

During the construction phase of the oil sands developments, the combined developments will cause relatively small losses of wildlife habitat due to site clearing. These impacts are predicted to be negative in direction, low in magnitude, regional in geographic extent, long-term in duration and of varying frequency. The environmental consequence for the cumulative effects is low.

As well, minor changes in wildlife abundance and diversity are expected to occur as a result of site clearing, sensory disturbance, removal of nuisance wildlife, wildlife-traffic mortalities and wildlife interactions with infrastructure. These impacts represent a worst case scenario, as it is unlikely that all sites will be cleared to their maximum extent at the same time. The phased nature of site clearing and progressive reclamation will mitigate the cumulative effects of habitat loss. Eventual reclamation of all sites should result in equivalent habitat capability for wildlife within the region.

With the expectation of equivalent habitat capability, the residual impact to wildlife abundance and diversity is rated as being of low environmental consequence.

In the far future when equilibrium conditions have been established for all combined developments, a potential impact has been identified. The residual impact (i.e., affected population) is likely to be enhanced in the CEA, relative to the impact predicted for the Project, since there is a greater likelihood on a regional basis for this exposure pathway to be realized. However, the magnitude of exposure and associated health risks for a given individual animal should not be increased. The cumulative effects on wildlife health are predicted to be low in magnitude, regional in geographic extent, long-term in duration, reversible and of moderate to high.