Suncor Reclamation Landscape Performance Assessment

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1.0 FRAMEWORK

Suncor Inc., Oil Sands Group (Suncor) currently operates oil sands mining facilities located on the Athabasca River near Fort McMurray in northeastern Alberta (Figure 1.0-1). Suncor plans to expand their operations in the near future. In anticipation of these expansions, Suncor has acquired Leases 97, 25 and 19 (Steepbank Mine) on the east side of the Athabasca River in the vicinity of the Steepbank River, McLean Creek and Leggett Creek and Lease 23 on the west side of the Athabasca River near Poplar Creek (Figure 1.0-2). Suncor plans to reclaim the large volumes of tailings generated in the mining process using a dry landscape option where the tailings are chemical treated and dewatered to form a trafficable surface.

While there are precedents which provide guidance from other industrial facilities, reclamation and abandonment of an oil sands mining lease is unique. Prediction of reclamation performance and potential impacts is required for decades or even centuries into the future. This prediction process involves modelling the mechanisms which will occur in the future based on current experience. The oil sands industry has developed the Oil Sands Reclamation Performance Assessment Framework (OSRPAF) to assist in this process.

The OSRPAF incorporates a suite of methodologies for predicting long term environmental sustainability of reclaimed landforms and potential end use habitats. Figure 1.0-3 shows the relationship between the key components, which can be summarized as follows:

- Reclamation Plan Alternatives: In Suncor's situation, the basic topography is essentially fixed but there are various measures that can be employed (e.g., surface contouring, remediation initiatives) to improve surface drainage, decrease erosion potential and enhance revegetation performance.

- Performance Analysis: This involves the prediction of the future performance of the reclaimed lease to allow identification of potential adverse effects with respect to both:

    1. Geotechnical stability of reclamation landforms in terms of static, dynamic and erosional stability.

2. Future local and regional ecosystem sustainability, based on landform configuration, substrate and topsoil materials, revegetation species and diversity, and distribution and fate of chemicals in either on-site or off-site ecosystems. This process requires the development and validation of predictive models that, although calibrated from current conditions, predict ecosystem sustainability on the reclamation timescale.

- Risk/Effects Analysis: This process, environmental risk assessment, quantifies predictions of magnitudes and probabilities of potential impacts on the health of people, wildlife and/or aquatic biota that might arise from exposure to chemicals originating from the site.

- Decision Analysis: This phase examines the predicted level of risk and cost of remediation and, using an iterative process, identifies the optimum reclamation plan considering the requirements of both Suncor and its stakeholders.

If, based on comparison with the general reclamation criteria adopted by Suncor and its stakeholders, it is decided that further remediation and/or mitigative alternatives should be considered, the overall process is repeated. The general reclamation criteria used in this decision making process are as follows:

1. Structures must be geotechnically secure. Catastrophic discharge of earth materials (e.g., coarse and fine tailings, overburden), particularly to the Athabasca River, must have an extremely low probability of occurrence.

2. Discharge of earth materials through surface erosion processes must be controlled to rates that are consistent with acceptable environmental impacts.

3. Discharge of surface and seepage waters must be controlled such that there is minimal impact on the Athabasca River.

4. The ecosystems reconstructed on disturbed lands must be fully self-sustaining and participate in natural biological evolutionary processes while not presenting significant risk to people or wildlife that use the site.

Details of the first three points are described in other reports and summarized in this report. The focus of this report is the issue of ecological sustainability of the reclamation landscape and of the health of people and wildlife who might use the site and be exposed to chemicals associated with the reclamation materials.

In particular, the following sections of the report provide:

- a summary of the reclamation plan (Section 2.0);
- a summary of the geotechnical analysis of the reclamation landscape (Section 3.0);
- a detailed characterization of chemicals associated with environmental media expected in the reclaimed landscape (Section 4.1);
- a detailed assessment of the ecological sustainability of the reclaimed landscape (Section 4.2);
- a detailed assessment of the health risks to people and wildlife that might use the reclaimed landscape (Section 5.1); and
- a summary of the health risks to people and wildlife that might use the Athabasca River and be exposed to chemicals originating from the reclaimed landscape (Section 5.2).

The findings presented in this report provide additional information to facilitate informed decisions respecting the suitability of the proposed reclamation plan.

2.0 RECLAMATION CONCEPT PLAN

2.1 Consolidated Tailings Technology

One of the major issues in the reclamation of an oil sands mining lease is dealing with the very large volumes of tailings which accumulate over the life of the mine. Since operations commenced in 1967, Suncor has used the caustic-based, Clark Hot Water Extraction process to remove bitumen from the oil sands. The waste from the extraction process is transported hydraulically to tailings ponds. During deposition, the tailings stream segregates into a coarse fraction consisting of sand size particles and a fine clay fraction that contains hydrocarbons. The fine fraction settles out over a period of years to form mature fine tails (MFT), which is a semi-solid with only about 30% by weight solids. This fine tailings material consolidates extremely slowly (i.e., over hundreds or perhaps thousands of years) with the result that these fluid tailings would require storage over an equally long period. The coarse sand fraction is used to construct dykes to retain the fluid tailings.

Suncor is proposing to eliminate permanent storage of fluid fine tailings through the use of a Consolidated Tailings (CT) technology. The CT process allows the fine and coarse fractions to be recombined into a stable deposit as a result of adding gypsum to the mixture. The resulting combined tailings will consolidate and gain strength in a much faster time frame (i.e., decades rather than centuries). The geotechnical risks associated with long-term disposal (i.e., storage) of tailings in the form of CT are thus much reduced compared with the previous strategy involving fluid tailings. Further, the final surface of the CT materials will be sufficiently strong to be trafficable within a short-time frame; thus the tailings disposal areas can be reclaimed as dry landscapes.

Implementation of the CT process began in November 1995 on a six month commercial trial basis; Full implementation is to commence in August 1996. Current projections indicate that CT implementation through 2015 would consume the current fine tailings inventory and eliminate future fine tailings accumulation.

One of the critical issues in the adoption of CT technology is the effect of gypsum, which is added to create CT, on the recycle water chemistry. The results of chemical modelling and evaluation of mass water balance indicates that (Golder 1996a):

- Elevated levels of bicarbonate in CT release water is an advantage in recycling and the sources of bicarbonate are significant relative to its sinks;
- The sinks for calcium are large enough to tie up the calcium loading on the recycle water so that there is no impact on extraction; and
- Sulphate build-up will not exceed levels that would create an adverse effect on extraction.

Since oil sands extraction requires water input, CT water can be recycled for extraction; thus reducing or eliminating the need to release large volumes of CT water to the environment.

2.2 Reclamation Plan - Landforms and Drainage

Details of the operating and reclamation plan are given in (Suncor 1996) and summarized below for five time periods - 1995, 2001, 2010, 2020 and long-term conditions. These time "snapshots" were selected for detailed analysis since each one represents a distinct change in mining and/or reclamation practices on both Lease 86/17 and the Steepbank Mine that will lead to changes in the reclamation landscape and water drainage patterns. Activities on both sites are described since there is transfer of materials between the areas. However, more emphasis is placed on Lease 86/17, which is the focus of this report.

2.2.1 1995: Baseline Conditions

Lease 86/17:

Reclamation work to date has focused on dyke surfaces and waste dumps. Drainage from all active areas is routed through the closed circuit mine process system. Some seepage from Tar Island Dyke (TID) and other reclaimed overburden storage areas enters natural receiving streams. Most seepage and surface runoff from TID is collected in a drainage system at the toe of the dyke and routed to the mine/plant process system. All coke filter drainage water is recycled.

Mining and materials movement/placement activities have resulted in the formation of several major landforms including:

- Pond 1: Filled with MFT
  Most seepage and surface runoff collected in dyke drainage system and recycled
  Some seepage from TID into Athabasca River
- Pond 1A: Active recycle water pond
  No off-site seepage or surface runoff
- Pond 2/3: Active tailings disposal pond
  Coke filter drainage water recycled
  MFT being used for production of CT
- Pond 4: Tailings storage pond
  Seepage and surface runoff recycled
- Pond 5: Being filled with CT
  Seepage and surface runoff recycled
- Mine drainage water discharged to the Athabasca River via North Mine, Mid-Plant and South Mine Drainage Systems (i.e., drainage from areas not within active mine areas and overburden structures (e.g., Waste Area #8)
- Plant site: Active
  Some surface runoff discharged to Athabasca River via Mid-Plant Drainage

Steepbank Mine:

No work has begun at this mine site, other than preliminary site investigations.

2.2.2 2001: Start-up Conditions for Steepbank Mine

Lease 86/17:

Active mining of these leases will have been completed and filling and reclamation of several mined-out pits will have begun. In 2001, oil sands will be imported from Steepbank Mine and processed at the existing plant. All tailings will be stored on Lease 86/17.

CT release waters recycled to extraction. Drainage from all active areas continues to be routed through the closed circuit mine process system.

The status of the individual ponds and other areas will be as follows:

- Pond 1: Infilling with lean CT (sand:CT mixture) commencing, no surface reclamation
  Most seepage and surface runoff collected in dyke drainage system and recycled
  Some deep seepage from TID discharges into the Athabasca River
- Pond 1A: Active recycle water pond
  No off-site seepage or surface runoff
- Pond 2/3: Active MFT recycle pond (i.e., MFT transferred from other ponds to Pond 2/3 and MFT from Pond 2/3 to the CT process)
  Coke filter drainage water recycled
- Pond 4: Active gypsum disposal pond
  Seepage and surface runoff recycled
- Pond 5: Filling with CT complete, dewatering occurring with release water recycled
  Seepage and surface runoff recycled
- Pond 6: Being filled with CT
  Seepage and surface runoff recycled
- NESSA: Sand storage underway
- Plant site: Active
  Some surface runoff discharged to Athabasca River via Mid-Plant Drainage

Steepbank Mine:

No major reclamation except for 10 hectares of the north dump at this stage. Key activities include development of site drainage, major retention basins and initial pre-mining drainage. Mining of Pit 1 has commenced. Mine depressurization water will be recycled.

2.2.3 2010: Infilling of Steepbank Mine Pits Begins

Lease 86/17:

CT and sand disposal on these leases will be nearly complete, and most CT and sand will be transferred to Steepbank Mine except for some sand and CT required to infill Lease 86/17 pond areas to make up for settlement. Fine tailings will continue to be stored on site for production of CT and waste water will continue to be stored and recycled on site.

- Pond 1: Surface reclamation commencing, drainage recycled. Some deep seepage from TID discharges into the Athabasca River
- Pond 1A: Active recycle water pond
  No off-site seepage or surface runoff
- Pond 2/3: Active MFT recycle pond
  Coke filter drainage water recycled
- Pond 4: Active gypsum disposal pond
  Seepage and surface runoff recycled
- Pond 5/6: CT settlement is taking place
  Seepage and surface runoff is recycled
- NESSA: Infilled with sand
  Surface runoff drains off-site
- Plant site: Active
  Some surface runoff discharged to the Athabasca River via Mid-Plant Drainage

Steepbank Mine:

- Pond 7 Infilling of Pond 7 with CT
  Seepage and surface runoff recycled
- Pond 8 Active mining of Pit 2
  Mine drainage water recycled
- North overburden dump reclaimed
- Starting construction on dyke 10
- Surface water diverted to Athabasca River

2.2.4 2020: Partial Reclamation of Lease 86/17 and Steepbank Mine

Lease 86/17:

Surface reclamation of Pond 1 completed, while Ponds 5 and 6 have been capped with a lean CT (8:1, sand:fines ratio). Surface reclamation activities initiated. Fine tailings will continue to be stored at Pond 2/3 for production of CT and wastewaters will continue to be stored and recycled on site.

- Pond 1: Surface reclamation complete; surface drainage is released to off-site wetlands
  Some deep seepage from TID discharges into the Athabasca River
- Pond 1A: Active recycle water pond
  No off-site seepage or surface runoff
- Pond 2/3: Active MFT disposal pond
  Coke filter drainage water from Dyke 2 East is recycled; drainage at Dyke 2 West is released to off-site wetlands
- Pond 4: Active gypsum disposal pond
  Seepage and surface runoff is recycled
- Pond 5/6: Surface capped with lean CT or clean sand in ~2015-2017 to account for CT settlement
  Reclamation started in 2018
  Surface drainage to Athabasca River through off-site wetlands
- NESSA: Final surface reclamation is complete

Surface runoff drains off-site

- Plant site: Active

  Surface runoff discharged to Athabasca River via waste water and Mid-Plant Drainage

Steepbank Mine:

- Pond 7 Infilling of Pond 7 with CT complete

  Seepage and surface runoff recycled
- Pond 8 Infilling of Pond 8A with CT

  Active mining of Pit 2B

  Mine drainage water recycled

Surface water diverted to Athabasca River.

2.2.5 Long-Term Scenario: Following Reclamation of All Leases

Lease 86/17:

- Pond 1: Filled and reclaimed
- Pond 1A: Filled with CT and reclaimed
- Pond 2/3: Filled with CT and reclaimed
- Pond 4: Filled with gypsum, capped with lean CT and reclaimed
- Pond 5/6: Filled with CT and reclaimed
- NESSA: Filled with tailings sand and reclaimed
- Plant site: Removed and reclaimed
- Drainage: All directed through wetlands to the Athabasca River

Steepbank Mine:

- Pond 7: Filled with CT and reclaimed
- Pond 8: Partially filled with CT and capped with water

2.2.6 End-Use

As outlined above, Suncor's leases will be reclaimed over a number of years. It is expected that Pond 1 will be reclaimed by 2020, at which time a variety of wildlife habitats will have developed. While wildlife will make use of this habitat, the site will remain within Suncor's lease and will not be made available for recreational use by humans. People will, however, likely continue to use Poplar Creek and other off-site areas for recreational activities such as fishing.

Over the longer term, when the vegetation cover has been established and is sustainable, it is expected that people could use much of the reclaimed areas for traditional land use activities like trapping, collecting berries and medicinal plants and harvesting wildlife for food.

More details on end-use scenarios are given in Section 5.0.

3.0 GEOTECHNICAL PERFORMANCE ANALYSIS

The goal of the reclamation program is to achieve maintenance-free, self sustaining ecosystems with equivalent capability on disturbed lands relative to the predisturbance situation. Maintenance-free means that human maintenance activities are not required, except where future human activities lead to continued disturbance. However, this does not imply a changeless state. The landforms will experience the normal geomorphic processes typical of the region leading to gradual reshaping of the landscape. A series of studies have been initiated to examine geotechnical components of the proposed reclaimed landscape: (AGRA 1996a, 1996b, 1996c, 1996d). Findings of these studies are summarized below.

The relative stability of constructed landforms is essential to the establishment of self-sustaining ecosystems. Suncor's dykes are all designed as fluid retaining structures. All the existing dykes meet the accepted Canadian standards for these structures. CT technology allows the development of a reclamation plan which does not require the long term storage of fluids behind constructed containment structures. Following initial consolidation of CT deposits, the resulting landforms will be technically reclassified as "dumps", which are not required to meet the same high stability criteria because the consequences of failure are more limited. As drainage occurs within these landforms, the internal water pressures will decrease, thereby improving the security of the landforms. To ensure continued landform security over the post-reclamation maintenance-free time frame, consideration must be given to design elements which either now require maintenance, or can be expected to require maintenance in the future. A full analysis of existing structures in this context has been completed (AGRA 1996a). A brief summary is provided below for structure stability, surface erosion and riverbank erosion protection and Athabasca River stability.

Stability - Water pressures within existing structures are controlled by a system of internal drains. These systems can be expected to require maintenance in the future. Therefore, Suncor will design and install provisions for reclamation drainage as part of the reclamation process. This may include the construction of toe buttresses consisting of inverted filter drains coupled with surface riprap. In addition, the colonization of appropriate plant species which favour such wet areas will be encouraged to provide long term stabilization. There may be specific areas which require some degree of slope flattening or toe berm construction. For instance, Dyke 5 may require specific consideration when Pond 2/3 is no longer required as a thickening pond for CT production and is ready for reclamation (2020 or later).

Surface Erosion - A significant study of the erosion resistance of reclamation slopes has been conducted (AGRA 1996b). Erosion rates on slopes populated with mature vegetation were projected to within the spectrum of natural processes. Significant environmental consequences are not anticipated. This conclusion assumes that soil reconstruction provides the basis for development of healthy cover which produces an organic detrital layer. Erosion rates were measured to be low even where the vegetation was burned away simulating a forest fire, and followed by 1 in a 1000 year rainfall event. Therefore, flattening of slopes to reduce erosion rates is not considered justifiable.

River Bank Erosion Protection - Before abandonment of the TID Area, bank protection must be provided which will protect against unacceptable rates of river erosion. However, to design long term, maintenance-free bank protection, the future stability of the river channel must be determined. In particular, the likelihood of channel shifts leading to changes in erosion patterns must be understood. The only other structure that is within the river flood plain, and may therefore require bank protection before abandonment, is Waste Area 8. However, this structure is constructed of erosion resistant overburden materials and has been extensively re-vegetated. In addition, there is natural vegetation between the toe of the waste area and the river bank. It is concluded that additional protection is unjustified. If future monitoring indicates erosion of the bank adjacent to Waste Area 8, the need for bank protection will be reviewed. Currently, there are no requirements for abandonment level river bank protection for the Steepbank Mine. This requirement will be reviewed as part of the final design of the Steepbank Mine facilities.

Athabasca River stability - A geomorphological assessment of the stability of the Athabasca River was undertaken to understand the processes that have lead to the current river regime and predict future flow patterns (AGRA 1996c). This assessment was then used to develop a bank protection design that will provide the Tar Island Reclamation Area (TIRA) long term, maintenance-free erosion resistance from the Athabasca River. The results of the geomorphic assessment showed that:

- In the Suncor area, the Athabasca River is confined by extensive Devonian limestone outcrops.
- Although the river is presently considered to be in a down cutting modal regime, the rate and extent of down cutting is limited by the low channel gradient and the elevation of Lake Athabasca (18 m over 265 km).
- The Athabasca River near TIRA is classed as a single, sinuous, stable channel system with a shifting and migrating bed.
- The river is not susceptible to abrupt channel shifts and is becoming more stable with time.

The results of this assessment showed that abandonment level bank protection can be designed based on current river morphology.

4.0 ENVIRONMENTAL PERFORMANCE ANALYSIS

4.1 Site-Wide Chemical Profile

Large volumes of fine tails are created during the extraction of bitumen from the oil sands. Currently, these fine tailings are stored on site in tailings ponds. Reclamation of the site will involve stabilizing these fine tails through gypsum and sand treatments to create CT. In turn, the CT will be placed in mined-out pits and capped with a layer of sand. The CT will consolidate within a reasonable time into a trafficable surface, which can be shaped and reclaimed to form the base for a healthy ecosystem.

The primary source of chemicals in the reclaimed landscape will be the CT deposits and the major pathways for off-site transport of chemicals include water, air and biota (Figure 4.1-1). In turn, the ultimate source of most of the chemicals associated with the CT deposits are the oil sands themselves. Typical oil sands consist of approximately 10 wt% bitumen, and the remainder is made up of 85% coarse sand (>22 μm) and 15% fines (<22 μm) (FTFC 1995). Bitumen, the solid component of petroleum, is the primary source of organic compounds in the oil sands, while connate waters and clay minerals are the primary sources of inorganic compounds in the oil sands. Naturally-occurring chemicals that are present in the oil sands deposits include naphthenic acids, polycyclic aromatic hydrocarbons (PAHs), alkyl, sulphur (PASH) and nitrogen (PANH) substituted PAHs, trace elements and metals (FTFC 1995). Based on these and other factors, a detailed list of parameters has been developed for analysis of oil sands related chemicals (Appendix I).

During the CT consolidation process, large volumes of entrained water will be released to the surface where it may form wetlands. These wetlands will afford some level of chemical (e.g., precipitation of certain metals) and biological (e.g., biodegradation of naphthenates) treatment before the water moves off-site as surface runoff. In erosional areas, surface runoff may also transport particulates off-site. In addition, chemicals associated with the CT deposits (and entrained porewater within the sand dykes) may be transported off-site via groundwater, either to springs and wetlands along the toe of the dykes or through deeper flow paths directly to the Athabasca River.

Air provides another environmental medium for off-site transport of chemicals from the reclamation units. Volatile chemicals may be released from CT deposits by volatilization into the atmosphere. In addition, exposed areas of the reclamation landscape will be subject to erosion and off-site transport by wind (i.e., fugitive dust).

Biota that will live in the reclaimed landscapes have the potential to accumulate oil sands related chemicals within their tissue. For example, there is potential for uptake of soluble chemicals through the plant roots and uptake of volatile chemicals through the foliage of plants growing on CT deposits. Animals may accumulate chemicals as a result of incidental ingestion of CT soils (e.g., in erosional areas where CT might be directly exposed to the surface), drinking affected surface water, or by eating affected prey (i.e., food chain effects).

The types and concentrations of chemicals expected in these environmental media are discussed in detail below.

4.1.1 Soils

CT will be the primary source of most of the chemicals in the reclaimed landscape. Secondary sources will include tailings sands (used for dyke construction or from Plant 4 waste), gypsum and coke storage units. Chemical concentrations in these different materials are summarized in Table 4.1-1.

In general, PAH concentrations in CT are low relative to those measured in natural oil sands, with concentrations decreasing in tailings sand, overburden and muskeg. One exception is tailings sand from Plant 4 (deposited in Pond 1 along the north end of TID), a material containing a wider range of PAHs, which are generally at higher concentrations than those present in CT. PAH concentrations in naturally occurring oil sands are higher than in any other solid phase material tested, with concentrations often two orders of magnitude greater than in CT. Concentrations of PANHs and phenols in CT, overburden and muskeg are all less than analytical detection limits. Trace metal concentrations in gypsum, as detailed in Suncor's Application for a Gypsum Disposal Pond (Suncor 1995), are elevated relative to metal concentrations in other process-affected soils and variable when compared to natural soils from the region. Because the Flue Gas Desulphurization (FGD) Plant is not yet completed, the gypsum analyzed for that study serves as a rough measure of the gypsum expected once the FGD Plant is operable (Autumn 1996). No data are available on the concentrations of naphthenic acids in background or process-affected soils. Also, no data are available on the chemistry of the coke.

4.1.2 Water

The Oil Sands Water Release Technical Working Group (OSWRTWG) classed water releases into two groups: operational and reclamation waters (OSWRTWG 1995). Operational waters are defined as those waters that are:

- discharged from a channel or outfall (i.e., point source),
- discharged over the life of the project, or a shorter time-frame,
- controllable,
- treatable in a managed treatment system,
- amenable to comparing to ambient water quality criteria, and
- potentially of concern with respect to regional off-site impacts.

Sources of operational waters include:

- consolidated tails,
- drainage water collected from dykes and structures,
- mine drainage,
- upgrading process,
- cooling water, and
- sewage treatment facility.

Reclamation waters are defined as those waters that are:

- non-point source, diffuse waters that may be directed through wetlands, streams or lakes prior to discharge into the Athabasca or Steepbank Rivers,

- released at slow rates over large areas for extended periods of time,
- non-controllable,
- non-treatable (but may be altered through natural systems or constructed wetlands),
- not amenable to conventional end-of-pipe approval requirements, and
- primarily an on-site water management concern and a component of a maintenance-free reclamation landscape.

Sources of reclamation waters include surface runoff and groundwater seepage from:

- sand dumps and dykes,
- CT deposits,
- coke piles, gypsum storage units and other waste dumps,
- overburden dumps and dykes, and
- wetlands treatment systems.

Three processes are present that could potentially contact and mobilize chemicals in an aqueous form within the reclaimed landscape: consolidation and dewatering of CT deposits, groundwater flux and surface runoff.

The quality of operational and reclamation waters, as detailed in Table 4.1-2, is discussed below. In general, concentrations of naphthenic acids are higher in CT and dyke drainage (DD) waters, lower in other operational and reclamation waters and below analytical detection limits in Athabasca River water. In addition, concentrations of PAHs and other trace organics are highest in CT exfiltration waters, intermediate in Plant 4 tailings waters, decreasing further in DD and refinery wastewaters and low in other operational and reclamation waters. With the exception of PANH concentrations in refinery wastewaters, concentrations of PANHs, phenols and volatile chemicals are below analytical detection limits in nearly all operational and reclamation waters. Background concentrations of organic chemicals, measured in Athabasca River water, are below analytical detection limits for nearly all chemicals analyzed. Levels of nutrients and oxygen demand are low in all waters while salts levels are high in CT and DD waters. Concentrations of trace elements and metals are highly variable in all operational and reclamation waters.

Groundwater moving through the reclaimed landscape could potentially contact five types of reclamation deposits: CT, tailings sand, overburden, gypsum and coke. Groundwater that originates from CT deposits is expected to be generally comparable to CT release water collected in various lab and field trials (Table 4.1-2). However, it is likely that the CT groundwater will contain lower concentrations of most chemicals than was measured in the laboratory and field experiments because of physical (e.g., mixing with precipitation, dispersion), chemical (sorption of organics to solids) and biological (microbial decay) processes within the groundwater that will reduce concentrations of certain chemicals. Hence, the use of CT data from the current laboratory and field experiments is expected to serve as a conservative surrogate for CT seepage water. Like CT, there are no direct measures of the quality of seepage water expected from gypsum storage units, since the gypsum will only be produced after the Flue Gas Desulphurization Plant is operating (Autumn 1996). An indication of the quality of gypsum water is provided in Table 4.1-2; however, these results were based on water leached from gypsum created as part of Suncor's Application for a Gypsum Disposal Pond (Suncor 1995), and serve only as a rough measure of the water quality expected once the FGD Plant is operable.

In contrast to CT and gypsum, direct measures of seepage water originating from tailings sands are available from analysis of water collected from TID's seepage collection system and from groundwater wells installed downgradient of the Plant 4 tailings sand beach (north end of Pond 1, TID). In addition, direct measures of the quality of overburden groundwater is available from analysis of water collected from wells installed in overburden units.

No data are available on the chemical composition of coke water.

Surface runoff water is derived from precipitation and may potentially transport chemicals from reclaimed CT ponds by (1) mixing with CT exfiltration waters, (2) mobilizing soluble chemicals within the upper layers of the soils as a result of interflow (i.e., percolation through shallow soils) and (3) erosion and transport of particulates. During operational phases of the site, all surface runoff in contact with process-affected soils is collected and contained on site so the potential for off-site transport by surface water is restricted to reclamation conditions. However, the CT ponds will be capped with a layer of sand, which in turn will be capped with a layer of muskeg and reclaimed with vegetation. Hence, no direct contact between CT soils and surface runoff water is expected. Further, dewatering of the CT deposits will occur rapidly, so mixing of surface runoff water with CT release water will only occur for a few years following filling the ponds with CT. Given this reclamation scenario, it is unlikely that surface runoff from the site will be affected by the processes described above, and runoff water from the existing north and south mine drainages (which drain natural areas and overburden and muskeg storage areas) can serve as surrogates for the quality of water that is expected to run off the reclaimed landscape. This water has been well characterized and the chemical analyses data are presented in Table 4.1-2.

4.1.3 Biota

A number of laboratory and field studies have been completed in which data on bioaccumulation of oil sands related chemicals has been investigated. Data from these studies are summarized in Tables 4.1-3 to 4.1-6 and discussed below.

Plants

In general, the chemical composition of plant tissues will reflect the chemical composition of the growth media. Many variables, however, such as soil pH, soil type, tolerance mechanisms, uptake mechanisms (e.g., active vs. passive uptake) and the presence of other chemicals, can influence this relationship. In addition, translocation of trace elements within plants varies with both species of plant and element(s) present, thus making generalizations about the uptake of chemicals to plants difficult. There are, however, data available on chemical concentrations in plants, such as willow, balsam poplar, reed canary grass, cattail and bulrush, grown in various reclamation materials. Although there are also data on the concentrations of chemicals in plants growing on clean agricultural soils, these are not reflective of the naturally elevated chemical concentrations present in the oil sands region.

Sandbar willow and balsam poplar are found in both upland and wetlands conditions and both will be present in the reclaimed landscape. Data on the uptake of inorganic chemicals into these two species grown in acid/lime treated tailings are presented in Table 4.1-3 (no data on organic chemical concentrations are available). These data serve as a conservative surrogate to plants grown in CT as it is expected that for most trace metals mobilization is higher in acid/lime treated tails than in gypsum-treated tails because of the lower pH associated with the acid/lime treatment. In general, trace metal concentrations in willow stems and leaves were greater than concentrations in poplar stems and leaves. The concentrations of trace metals in the leaves of these two plants were slightly greater than concentrations in the stems.

The uptake of organic and inorganic chemicals into wetlands plant species has been investigated by analyzing cattail, bulrush and reed canary grass tissues grown in a variety of soils (Table 4.1-4). Alberta Environment (Xu 1995, 1996) examined the uptake of inorganic chemicals from acid/lime CT into cattail and reed canary grass leaves and stems. Nix et al. (1994) studied the uptake inorganic chemicals into cattail and bulrush exposed to DD and CT water. In addition, Syncrude investigated the uptake of inorganic and organic chemicals into cattails grown in MFT (Syncrude Research, person. commun.). In general, concentrations of trace metals in cattail shoots tended to be highest, followed by reed canary grass and bulrush shoots. Concentrations in reed canary grass stems were lower than in leaves. While PAHs were detected in the Syncrude cattail composite samples, the concentrations of these chemicals in cattails are low relative to the concentrations reported in fine tails (Golder 1994a).

No data are available on the uptake of chemicals from gypsum-treated CT or capping materials into plants. In addition, no data are available on the uptake of chemicals from plants growing in natural oil sands.

__Invertebrates__

Data on the uptake of inorganic chemicals into chironomids and other benthic and emergent macroinvertebrates are available from studies investigating the effects of DD waters on the performance of constructed wetlands (Nix et al. 1994, 1995; Table 4.1-5). Tissue concentrations of inorganic chemicals in benthic macroinvertebrates collected from DD wetlands were generally comparable to those measured in benthos collected from control wetlands and reference sites along the Athabasca River, upstream of TID (Nix et al. 1994, 1995). Furthermore, inorganic chemical concentrations of arsenic, cadmium and mercury, which are known to bioaccumulate in animal tissue, are not elevated in organisms exposed to DD water relative to concentrations measured in organisms exposed to control waters. Data on the uptake of organic chemicals into benthos were only available for insects collected from the Athabasca River upstream of TID, and concentrations were below detection for most PAHs. No data are available on chemical concentrations in terrestrial invertebrates exposed to reclamation soils.

Fish

Uptake of oil sands related chemicals into fish tissue has been investigated with both field and laboratory experiments. HydroQual Laboratories (1996) measured the concentrations of organic and inorganic chemicals in rainbow trout and walleye as part of a fish health study examining effects associated with exposure of fish to DD waters. In addition, Syncrude measured the concentrations of organic chemicals in fish exposed for ten weeks to water from Syncrude's Pond 5 (Syncrude Research, person. commun.). Background fish tissue concentration data are given in Golder (1996b) and HydroQual Laboratories (1996). In general, organic chemical concentrations in fish exposed to DD and pond waters are below analytical detection limits for most PAHs, and comparable to the concentrations measured in fish exposed to background conditions. Inorganic chemical concentrations in fish exposed to dyke and pond waters are also low relative to background concentrations. Furthermore, inorganic chemical concentrations of arsenic, cadmium and mercury, which are known to bioaccumulate in animal tissue, are not elevated in organisms exposed to dyke and pond waters relative to concentrations measured in organisms exposed to reference waters.

Birds and Mammals

Information on the uptake of organic and inorganic chemicals by mammals is available from tissues analyzed from bison and muskrat (Table 4.1-6). The bison was being held on Syncrude's toe berm pasture, which consisted of tailings sand covered with a 50-cm cap. The animal was seriously injured in 1993 during handling and had to be destroyed. The liver tissues were analyzed for PAHs, and adipose, muscle and liver tissues were analyzed for inorganic chemical residues. The muskrat was collected from one of Suncor's wetlands trenches during spring 1995. Tissue samples were taken from brain, liver and muscle tissues and analyzed for PAHs and inorganic chemical residues. No PAHs were detected in buffalo or muskrat tissues, with the exception of naphthalene, which was present at 0.008 mg/kg in the bison liver. Concentrations of metals and trace elements were generally low relative to background concentrations, although concentrations were slightly higher in the bison than in the muskrat, and tended to be higher in liver tissues than in muscle. Background inorganic chemical concentrations in deer mice and red-backed voles collected from the Fort McMurray region were somewhat elevated relative to concentrations in animals collected from the Suncor Lease.

Inorganic chemical concentrations were also measured in duckling livers as part of a study investigating the effects of water-borne chemicals present in artificial wetlands on ducklings (*Anas platyrynchos*; Wolfe and Norman, as cited in Bishay and Nix 1996). Ducklings were exposed for four weeks to water in a CT pond, CT wetlands, DD pond and DD wetlands. Metal concentrations in the livers of ducklings exposed to treatment wetlands were within the range of background concentrations measured in the livers of ducklings exposed to an experimental control wetlands. Furthermore, inorganic chemical concentrations of arsenic, cadmium and mercury are not elevated in ducklings exposed to CT and DD waters (Wolfe and Norman in Bishay and Nix 1996).

4.1.4 Air

No data are available with respect to soil vapour or above ground air concentrations for CT reclaimed landscapes.

4.2 Ecosystem Sustainability

4.2.1 Revegetation Plan

Detailed information on the proposed revegetation plan are given in Suncor's Steepbank Mine Application (Suncor 1996). The following summary is included as a basis for establishing the sustainability of vegetation in the long term and understanding the potential exposure pathways for chemical-fate and exposure modeling.

The primary objective of the Suncor revegetation program is to develop a self-sustaining ecosystem consistent with those in the region. Specific objectives are to:

- provide erosion-controlling plant cover on the tailings dyke slopes and overburden dump slopes;
- establish a diverse range of plant species, to re-create the level of biodiversity common to the pre-disturbed site;
- reclaim tailings ponds in Upland Ecosection to wetlands habitat; and
- establish a permanent, viable plant community, capable of developing into a self-sustaining cover of forest and shrub species suitable for traditional land uses and for wildlife use and with possibilities for recreation and other end land uses.

The revegetation program will include a program of planting of woody stem species similar to others found in the region that are used by a variety of wildlife species. Tree species will also be planted to provide ecosystem diversity. The vegetation developing from this program together with the profusion of native plants developing from the soil amendment will provide a diverse vegetative community on the reclamation sites.

4.2.1.1 Soil Salvage and Soil Reconstruction:

The restoration of soil capabilities to a state equal to, or better than, the pre-disturbed conditions requires that the reconstructed soil provides:

- adequate moisture supply,
- adequate nutrient supply,
- acceptable erosion control, and
- acceptable soil chemistry.

The current soil reconstruction technique, which has been used since 1984, involves the excavation and hauling of undisturbed muskeg soils to the reclamation area. This is designated as "Type 1 muskeg soil" and is typically used as the principal soil amendment for tailings sand and overburden. Another soil amendment, which is designated as "Type 2 muskeg soil", is formed from muskeg mixed with coarse textured materials (e.g., sand and gravel). Type 2 muskeg soil is primarily used to amend overburden spoil when the Type 1 supply is exhausted or when mine logistics dictate the use of an alternative to Type 1.

The muskeg soils used in reclamation initially were obtained from stockpiles. However, since 1983/84 the source of muskeg for reclamation changed to deposits in unmined areas where disturbance is minimal. A further refinement is to excavate and haul soil building materials during winter months so that dormant in-situ native seed and root fragments are included. Spreading of the muskeg soil is completed in early spring with the usual result being the emergence of a variety of native woody stemmed plants, forbs, wildflowers and grasses. This prolific vegetative growth provides an erosion controlling cover which is diverse and consistent with regional ecosystems.

4.2.1.2 Revegetation Program

The revegetation program will involve:

- seeding of reclamation areas with ground covers designed to control erosion;
- area fertilization;
- establishment of appropriate woody plant species;
- use of native seed mixtures, native trees and shrub seedlings; and
- maintenance.

The revegetation plan takes into account the variability of the materials which make up the three main reclamation platforms and distributes vegetation types which are related to the type of surface materials, soils and drainage regime. The revegetation program includes planting of woody-stemmed species, which enhances the return of the area to ecosystems similar to others found in the region and which assists in the creation of four primary reclamation starter vegetation types, including:

- *Closed Mixed-Wood Forest (Pine Forest)*: This vegetation type will be established on the edges of tailings sand plateaus and tailings sand slopes.

- *Closed Mixed-Wood Forest - Deciduous Dominant (Poplar-White Spruce/Shrub)*: This vegetation type will be established on the moist areas of the tailings sand plateaus and consolidated tailings deposits. It will also be established on overburden dykes used to reestablish Steepbank Mine escarpment areas within the Athabasca River Valley.
- *Closed Mixed-Wood Forest - Coniferous Dominant (White Spruce-Poplar/Shrub)*: This vegetation type will be established on the overburden dumps, the more mesic sites on tailings dyke slopes (lower portions of the slopes, areas with northerly aspects) and on reclaimed tailings ponds (where CT is used to create areas with lower water tables than poplar-dominated sites).
- *Wetlands Closed Shrub Complex*: This vegetation type will be established on poorly drained areas of the tailings sand plateaus and consolidated tailings deposits.

Fertilizer is applied during the initial years of reclamation (typically for three years) as an aid for the development of an erosion controlling vegetative cover. Annual fertilization will then be discontinued so the developing herbaceous cover will not compete vigorously with planted woody seedlings.

Herbaceous ground cover will be established by seeding barley which provides nearly immediate erosion control in the first growing season. It also produces a litter and root biomass that further controls erosion in succeeding growing seasons. Native plants may easily invade the areas or regenerate from muskeg soil applied during seedbed preparation, while outplanted woody stock performance is also greatly enhanced.

There is also significant experience on the Lease 86/17 area in terms of establishing woody plants on reclamation areas. This well established approach, which has evolved from experience, will be continued. Thus, seedlings will be propagated from seeds and cuttings collected from the Fort McMurray area. Outplanting periods are early spring and late summer depending on logistics and availability of reclaimed areas. Planting of trees and shrub seedlings will be undertaken as early as possible after soil reconstruction at a density of 2500 stems per hectare to permit establishment of volunteer plants and provide adequate stocking of each species after initial mortality.

Maintenance activities will involve fertilization of revegetation areas, erosion repair as well as control and reseeding of areas with poor performance. Fertilizer rates are determined from soil tests and cover performance. Maintenance periods are expected to be 2-3 years for overburden and 3-4 years for tailings sand.

To date, reclamation has focused on the completed areas of the lease, which consist of the dyke surfaces and waste dumps. Reclamation activities planned between 1996 and 2020 will focus on reclaiming the oversize dump, completed tailings plateaus and some smaller overburden dump sites. Reclamation maintenance activities will continue for all previously reclaimed sites including, where applicable, fertilizer application and infill tree planting. Muskeg salvaged as part of the stripping operation will be applied as a soil amendment to available sites with surplus being stockpiled for later use. Revegetation of surface areas and tailings sand slopes will continue throughout 1996-2000. Revegetation of the various sites will immediately follow reclamation of the areas.

4.2.2 Ecological Land Classification (ELC) Analysis for Undisturbed Areas

4.2.2.1 Regional ELC Analysis

A regional ecological land classification (ELC) map was produced using Landsat Thematic Mapper (TM) satellite data together with field data from both the Suncor and Syncrude 1995 terrestrial field surveys and ancillary air photos. Data included 101 field transects supplied by Suncor and 135 transects provided by Syncrude. Details of the approach used in this development are given in Golder (1996c). From these data, 16 classes representing vegetation, landcover and landuse were derived using a maximum likelihood classifier approach and verified using ground-truthing. The regional ELC map produced in this manner is shown on Figure 4.2-1.

4.2.2.2 Local Study Area ELC Analysis

An ELC classification for the local study area (i.e., the Suncor EIA baseline study area) was developed in a similar manner to the regional study approach, with the exception of the addition of a digital elevation model (DEM) into the classification. The DEM provided the basis for a more sophisticated terrain analysis and the inclusion of variables, such as elevation, slope, aspect and slope curvature to be included in the overall imagery classification. The local study area ELC classification map is shown on Figure 4.2-2.

The first level in the ELC hierarchy is represented by a terrain classification which was undertaken using the DEM and ancillary air-photo interpretation. The following broad ELC landform classes (or ecosections) were mapped primarily on the basis of elevation, physiography and surficial materials:

- Riparian Floodplain
- Riparian Terraces
- Riparian Escarpment
- Midland Organic/Lacustrine Plain
- Midland Drainages
- Upland Organic/Lacustrine Plain
- Highland Moraine

The second level of mapping ecosites involved the integration of digitized vegetation and soil classification data within the broader landform data. These soils data have been mapped at 1:50,000 and also at 1:10,000 (CAN-AG Enterprises Ltd. 1996). Forestry data was mapped at a detailed scale of 1:10,000 (EnviResource 1996).

The ecosite map was generated using these data sources, as well as field data collected in the summer of 1995 (101 field transects). Fourteen ecosite classes were identified primarily on vegetation types recognized from satellite image analysis; however, landform, soil and drainage conditions were incorporated into the classification scheme to provide a more fully integrated database.

1. Wetlands Open Water - Emergent Vegetation Zone
2. Wetlands Shrub Complex
3. Peatland: Closed Black Spruce Bog

4. Peatland: Open Black Spruce Bog
5. Peatland: Black Spruce - Tamarack Fen
6. Closed Mixed Coniferous, Black Spruce Dominant
7. Closed Deciduous Forest
8. Closed Mixedwood
9. Closed Mixedwood, White Spruce Dominant
10. Closed White Spruce
11. Closed Jack Pine
12. Closed Lodgepole Pine
13. Disturbed/Herb-Grass Dominant
14. Industrial/Sparsely-Vegetated (Primarily Lease 86/17)

The field data sites were used to guide the selection of larger homogeneous spatial elements that were representative of a particular class. The resulting ELC vegetation classification was subjected to an accuracy assessment.

4.2.2.3 ELC Analysis of the Proposed Revegetation Plan

Reclamation information was provided by Suncor in the form of detailed revegetation maps based on a number of general reclamation prescriptions that Suncor has developed depending on the site characteristics, soil treatments and intended long-term land use for a particular area. For the purposes of maintaining a consistent mapping terminology and to allow reclamation to be factored into the calculation of the net vegetation balance for the overall impact assessment, Suncor's reclamation vegetation classes were combined into the ELC vegetation classification. A time-table was also developed to model the succession pathway of a reclamation vegetation type from initial establishment through to a climax state according to the assumptions outlined in Table 4.2-1.

The elements representing reclaimed vegetation types were evolved through the successional time-table according to the reclamation and revegetation plan at an interval defined by the scenario years of 1995, 2001, 2010, 2020 and long-term. The progression of mine development and reclamation sequences is shown graphically in Figures 4.2-2 to 4.2-6.

4.2.3 Sustainability of Revegetated Areas

4.2.3.1 Vegetation Development and Sustainability

Sustainability of the ecosystems developed on reclaimed oil sands landscapes is a primary consideration in assessing the suitability of the reclamation plan. Since 1976, Suncor has conducted programs to monitor the ecological development on its reclaimed sites. These monitoring programs include, an annual Reclamation Monitoring Program run specifically to assess herbaceous vegetation growth, as well as soil physical and chemical properties. Annual assessments of tree and shrub survival and growth have been conducted in areas where known numbers of seedlings were outplanted. Results of these annual programs are documented and reported to Alberta Environmental Protection (AEP) in an annual C&R report.

Suncor recently summarized the results of its reclamation monitoring program within its February 1995 Application for an Environmental Operating Approval. Specific studies were initiated in 1995 to assess the vegetation and soil characteristics of reclaimed sand structures, as well as natural forested areas on the Suncor and Syncrude mining leases. The objective of these studies was to determine the effectiveness of methods used to establish suitable vegetation species that control erosion and develop into self-sustaining communities compatible with the surrounding ecosystems.

Summarized below are the results of the 1995 study, which was detailed within the report "Vegetation Development and Sustainability on Reclaimed Tailings Sand Structures" (AGRA 1996e).

- Most of the areas surveyed had originally been seeded to agronomic mixtures of grasses and legumes. These species dominated the herb/ground cover, even in areas that were 20 or more years old. Native herbaceous species were only common in areas that had not been seeded to grasses and legumes. Pine and poplar were the dominant trees at Suncor, although substantial areas with spruce trees were found. Willows, red-osier dogwood and caragana were the dominant shrubs.

- Vegetation development was projected over a 100 year period. Projections were estimated by using the basic assumptions of growth characteristics of individual species and their competitive interactions. During the first 50 years, tree communities will increase, especially deciduous (poplar or aspen) dominated stands. Shrub communities are projected to increase during the first 50 years, but then decline during the next 50 years due to shading of the developing tree communities. Herb/ground communities are projected to develop into native forb-dominated stands during the first 50 years, while nonvascular species (e.g., mosses) will increase throughout the 100 year projection period.
- Characteristics of the reclaimed sites were compared with those of nearby natural forest stands. For most of the reclaimed sites, thickness' of the surface organic layer ranged from 16 to 33 cm. However, in natural mixedwood forest stands, surface layers ranging in depths between 14 and 22 cm were found. Whereas, in natural jack pine and aspen stands, the average surface organic layer ranged between 2 to 4 cm. The litter layer of the natural stands ranged from 2 to 8 cm, much higher than the maximum 1 cm found on reclaimed sites. Rooting depth of herbaceous species at both the natural and reclaimed sites averaged close to 50 cm. With respect to species composition, there was little similarity between the reclaimed sites and natural stands. The lack of similarity was most apparent for the herbaceous species. The lack of similarity is attributed to the seeding of competitive grasses and legumes on the older reclamation areas, a practice which has restricted the invasion of native species. Sites that were not seeded were generally more similar to natural forests even though they were younger than the seeded sites.
- The number of tree stems per hectare was highest on sites reclaimed without seeding to grasses and legumes. Numbers averaged 1500 to 3000 stems per hectare among non-seeded sites, whereas, seeded sites averaged less than 1000 stems/ha. By comparison, natural forest stands had from 1200 stems/ha (jack pine forest) to almost 5000 stems per hectare (spruce-dominated mixedwood forests). The most obvious difference between the reclaimed and natural forest stands was the relative areal cover of the various vegetation groups. Trees accounted for 55 to 90% of the cover in the natural stands compared with an average of 20 to 30% in the best treed reclaimed areas (older non-seeded sites).
- A comparison of vegetation cover among varying slope aspects at older seeded sites revealed relatively few significant differences. Where differences did occur, the results generally indicated better growth on the north to northeast aspect compared with southern aspects. A

comparison of vegetation cover on Suncor's TID revealed that the lower slopes had better growth of trees, shrubs and native vascular species compared to the upper slopes, where grasses and legumes tended to perform best. This is probably due to the lower slopes having more favorable moisture conditions and deeper surface soil.

- Site index tables developed for the forestry industry were used to predict future forest productivity on the reclaimed slopes of tailings sand structures. Site indices and heights were calculated for both natural (pre-mining) and reclaimed sites. Where possible, site indices were also determined for sites seeded with cover crops versus those left unseeded, to compare the influence of site preparation techniques on tree growth. Lastly, the indices for natural and reclaimed sites were used to predict tree height at 20 year intervals for each of the dominant tree species.

  - Site indices for reclaimed sites at Suncor fell in the poor/fair/low class for all species except white spruce, which was in the good classification. These indices were slightly lower than those for natural sites, except for white spruce which was slightly higher. Poplar had a good site index on unseeded sites in comparison with the poor/fair/low index on seeded sections. This difference, however, may have been the result of site conditions other than seeding versus non-seeding.

  - Predicted forest growth calculated from site indices reflects the slower rate of growth estimated for reclaimed sites. Trees in these areas would be expected to be slightly smaller than similarly aged trees in the surrounding, native forest.

- Vegetated species in reclaimed areas were evaluated on the basis of their long-term sustainability. Most of the species were considered to have either a moderate or high sustainability rating.
- Wildlife habitat suitability was assessed by evaluating the usefulness of vegetation communities for use as food or cover. Individual trees, shrub and ground cover species were evaluated for suitability for seven wildlife species groups, including deer, moose, small mammals, furbearers, songbirds, game birds and raptors. Two key species were balsam poplar and aspen, which were used for food, cover, or both by all seven species groups. Fruiting shrubs (Saskatoon and chokecherry) were also important for forage, as well as

nesting habitat and escape cover. Although, many of the grasses are highly palatable, they are used by relatively few species groups, mainly deer, moose and small mammals.

- Predicted vegetation communities for the year 2095 were used to make qualitative assessments of habitat value, for three selected species groups: ungulates, birds and large furbearers. Predicted habitat value at Suncor was high for all species groups across a majority of the treed communities. Mixed deciduous and coniferous forests scored high for all of the species groups examined, mainly because of the variety of food and cover niches available in this community. Similarly, the mixedwood community had high value for most of the wildlife species. Introduced species communities (e.g., Manitoba maple) and sparsely treed units had lower ratings due to the unknown or lack of suitability of the introduced (dominant) species and the lack of strata, respectively. As sparsely treed areas, conifer/deciduous and deciduous communities are predicted to predominate on reclaimed areas in the year 2095, future habitat value is expected to be good.

Another study conducted in 1995 at Suncor, involved an assessment of the potential impact of forest fires on reclaimed areas. This study included components to examine potential impacts of fires on erosion rates, as well as on the alteration of the vegetated community. The latter component was designed to examine the available information concerning the reclaimed site and vegetation conditions, and identify the impacts that wildfires of varying severity might have on plant communities and site attributes, now and in the future. Fire weather data from nine weather stations in the Fort McMurray area was analyzed to determine when, during the fire season, high fire hazard conditions occurred. This was cross-referenced to historical records of fire "start dates" within the Athabasca forest. The results of the vegetation assessment is detailed with the report "The Effects of Fire on Reclaimed Sites of the Oil Sands Region of Alberta" (Silvacom 1996). The results of this study are summarized below.

- High severity fires will have devastating effects on reclaimed sites, regardless of age. In all cases, fire severity is determined by fuel condition. Dry fuel will burn until all fuel is consumed. In the absence of soil organic layers there will be no plant growth for a long period of time. However, there is only a low probability that any of the reclaimed sites (as they now exist) will experience a high severity fire; fuel loading and fuel particle size are not capable of producing fires that would not be easily controlled. Additionally, the density of the live plant tissue and the fact that most of the live surface fuels are "green" throughout the period of greatest danger would contribute to "ease of control". As these sites mature, soil organic layers will thicken, tree canopies will close and downed and roundwood fuels will dominate in the surface litter layer. As a result of these changes, control will become more difficult and the probability of containing these fires burning under high hazard conditions will be much lower. Due to the steepness of some of the slopes associated with some reclaimed sites, soil erosion is likely in the absence of vegetation.

- Moderately severe fires will likely have little effect on the stands and sites for which data is available. Most plants are fairly resistant to burning or have protected tissue and will be able to survive the effects of burning (or regenerate after it). Most reclaimed sites are small in size or have adequate firebreaks. These two features will tend to reduce the ability of fires to build up momentum, thus reducing the level of fire severity to be expected at these sites. Soil erosion is not expected to be common after moderately severe fires. The frequency of moderately severe fires will increase with time, largely due to the shift in larger fuel size classes over time.
- Low severity fires will be the norm for reclaimed sites, should fires start on them within the next 30 to 40 years. However, currently grasses and herbs dominate (most common ground cover) on all reclaimed areas and the shrub cover in most sites is too low to have much of an effect on fire behavior or severity. As these sites mature, the probability that fires will be more severe increases.

4.2.4 Wetlands Sustainability

Reclamation areas on Lease 86/17 will include surface water drainage systems to collect and channel water from the reclaimed area with eventual discharge to the environment. Eventually there will be six drainage basins (Figure 4.2-7). The quality of water from these various sources will vary from relatively high in surface runoff to DD water which is known to contain chemicals of site origin. Within this drainage system, a treatment pond-wetlands system (e.g., constructed wetlands) will be placed to ensure a high level of water quality before these drainage waters are discharged to the receiving environment.

Constructed wetlands offer an attractive alternative to conventional wastewater treatment approaches by providing:

- a self-sustaining treatment system utilizing natural microbial populations capable of degrading complex chemicals with a large surge capacity;
- a flexible response to variable chemical loadings;
- a natural surge capacity for episodic rainfall events;
- aesthetically attractive vegetated areas which incorporate important ecological features, such as small bird and mammal habitat; and
- a treatment system with relatively low capital and operating costs.

The wetlands area associated with Basin 1 will be developed first as a field scale demonstration of the proposed reclamation drainage treatment system. The Basin 1 will receive water from the following drainage areas:

- drainage and runoff from Pond 2/3 south dyke (e.g., DD water);
- runoff from Fee Lot 2, as collected in the area to the south of Pond 2/3;
- drainage from wetlands and other areas on the level tailings sand area to the south of Pond 2/3;
- runoff from Waste Area 5; and
- drainage running from the Lot 2 area south of Lease 86 and east of the Suncor access road.

Based on research on Lease 86/17 over the past four years, there is significant information related to the ecological characteristics and sustainability of constructed wetlands and their efficiency in processing process-affected oil sands wastewater. These treatment wetlands have been used to treat process-affected oil sands wastewaters, such as DD water or CT release water. Ecological data from this field research has indicated that these wetlands will function as viable and productive ecosystems, although some aspects of their ecological characteristics will differ from nearby natural wetlands (Nix et al. 1995).

The input of specific organic and inorganic chemicals to these wetlands will result in some differences in the community structure of microorganisms and planktonic organisms compared with nearby natural wetlands. This difference would be expected since these constructed wetlands are "treatment" systems and would logically show a biological response to inputs of wastewaters. No response in biological structure would be evidence that the wetlands were not transforming wastewaters into non-toxic effluent. For example, an acclimated bacterial community could develop the capability to biodegrade many of the chemicals associated with oil sands wastewater, such as ammonia, hydrocarbons and naphthenic acids (Nix et al. 1993). Rates of bacterial respiration will be elevated when compared with nearby natural wetlands, indicating an increase in overall bacterial numbers, and also indicating a positive response to the input of chemicals (e.g., the initiation of biodegradation processes).

Next in the level of complexity in the aquatic food web, are the planktonic communities, such as phytoplankton (algae), which may show small reductions in diversity (e.g., taxa), but increases in abundance, while zooplankton may show small decreases in both diversity and abundance (Nix et al. 1994). However, there was no strong relationship between plankton richness and chemical levels and any identified differences may have been due to indirect effects (e.g., decreased oxygen levels) or general effects (e.g., increased total organic loading). In general, even if differences in chemical concentrations were large, differences in planktonic community structure between treatment (e.g., DD) wetlands and reference wetlands were small.

There were no substantial differences in the benthic invertebrate community (e.g., sediment dwellers) between treatment and control wetlands; however, this result may have reflected the small size of these experimental wetlands which did not allow exact comparisons with nearby natural wetlands. Preliminary analysis of hydrocarbons within larval insects (chironomids) did suggest that bioaccumulation of organic chemicals within these insect larvae may occur (Nix et al. 1993). In terms of inorganic compounds, aluminum, iron and zinc tended to be higher in emergent insects in the DD wetlands when compared with controls, however, these trends were not statistically significant (Nix et al. 1994).

After construction of the wetlands, a macrophyte community (i.e., aquatic plants) was established in both control and treatment wetlands. During treatment, a weak trend was shown for hydrocarbon accumulation within cattail (*Typha* spp.) roots in the treatment wetlands. Metal uptake into plant tissue was also demonstrated; however, metals were bioaccumulated to a greater extent into plants sampled from nearby "natural" wetlands (Nix et al. 1994). Aluminum was elevated in macrophyte shoots of some treatment wetlands (e.g., those receiving DD) compared with controls, although the difference was not statistically significant. In general, there was no trend of increasing accumulation of chemicals with increasing loads to the system. Overall, a thriving plant community was established in the treatment wetlands, although both the growth and species diversity of aquatic plants was reduced slightly compared with control wetlands and nearby reference wetlands.

In 1995, investigations at a higher level of the aquatic food web were initiated. In a scoping experiment (Wolfe and Norman, as cited in Bishay and Nix 1996), mallard ducklings (*Anas platyrhynchos*) were exposed to various CT and DD constructed wetlands. The principal route of exposure during the study was by ingestion of water. After a period of four weeks, there were no differences among treatment groups or between treatment and control groups in growth rates, and there were no sign of gross organ pathology upon necropsy. All ducklings had moderate to heavy body fat. After exposure to both DD and CT waters, there was no uptake of metals sufficient to present a health risk to young mallards. Additionally, no uptake of PAHs was observed through analysis of bile PAH metabolites.

In summary, there is no existing evidence of any substantial adverse impact on the ecology within constructed wetlands used to treat oil sands wastewater (most research has utilized DD water) and no evidence of any harmful impact on waterfowl.

4.2.5 Wildlife Habitat Scenario

This section of the report describes the foraging habitat use by wildlife and provides the basis of the receptor exposure scenario used in the assessment of wildlife health risks. Values used to represent the time spent foraging in each ELC by different wildlife species are general estimates based on each species foraging preferences with consideration given to seasonal variation of food availability and preference, residency (e.g., permanent, permanent but wandering over a large area or migratory) and size of home range. General estimates of foraging time were based on habitat preferences and diet outlined in the species accounts given for each wildlife species used in the risk assessment (Appendix V). A summary of the estimated proportion of time spent foraging by individual wildlife species in each of the ELC vegetation classes is given in Table 4.2-2.

Ruffed Grouse are primarily herbivorous, consuming 80% buds, leaves, flowers, seeds and fruit and the remaining 20% of their diet consists of insects, spiders, snails and young vertebrates (Ehrlich et al. 1988). Principal species of trees, shrubs and forbs consumed (e.g., buds, catkins, fruits and leaves) include aspen, poplar, apple, grape, sumac, beech and alder (Johnsgard 1983). Based on this information, the closed deciduous, aspen dominant vegetation class was considered to be of the highest importance to Ruffed Grouse and the closed mixedwood vegetation classes were considered to be of moderate importance based on the understory cover (e.g., shrubs producing potential food items, such as berries or buds). Other classes were considered to be less important, although this could be variable.

Mallards were evaluated primarily on the availability of water in any ecosite type, as summer residents in the area who would likely rely primarily on wetlands food, such as invertebrates and aquatic plants.

Moose wander widely (home ranges are thousands of hectares) and their diet varies depending on nutritional requirements and food availability. For example, moose may spend time foraging in wetlands or on wetlands margins feeding on aquatic macrophytes to meet sodium requirements (Stelfox 1993) during warm months, and feed in upland areas, browsing on shrubs, such as red osier dogwood and willow, during winter when browse is the only type of forage available to them. Common forages for moose include a variety of tree and shrub species, fallen leaves, bark, forbs, sedges and horsetail (Stelfox 1993). ELCs that do not support appropriate forage species of plants were considered to be less important than ELCs where forage plants were considered to be abundant. Given a moose's capability to cover wide areas of land, it was assumed that a given population might forage for significant amounts of time in a variety of ELCs.

During summer, snowshoe hares feed on succulent vegetation and during winter, twigs, buds and bark (Burt 1976). Summer foods include grasses, wildflowers (especially pea-family plants and clover) and new leaves of aspen, willow and birch (Gadd 1995). In winter, they eat the leaves of plants that stay green, such as kinnikinnick and wintergreen, the twig-ends and buds of shrubs and sometimes lichens (Gadd 1995). Based on this information the closed deciduous, aspen dominant and closed mixedwood vegetation classes were considered to be most important as potential forage areas for snowshoe hares, as these community types support appropriate food items. Based on understory vegetation communities, other classes were considered to be of much less importance to foraging hares.

Preferred foods for beaver include, the cambium layer of aspen, poplar, birch, maple, willow and alder. Additionally, beaver feed on leaves, bark and small twigs and they will store branches and small sections of logs underwater near their lodge (Burt 1976, Gadd 1995). They will also eat the seeds of some water plants (Gadd 1995). Beaver are most likely to feed in habitat types which are adjacent or near water. This factor was considered when estimating the proportion of time beaver might spend feeding in each area. Vegetation classes considered to be of highest importance for beaver include closed mixedwood and closed deciduous, aspen dominant classes. Some classes were eliminated based on the absence of appropriate plant species for foraging and/or the distance from open water.

American kestrel perch on high points to watch for potential prey items, such as small mammals or large insects on or close to the ground. To be successful, these birds require relatively open habitats to hunt in. Consequently, vegetation classes that would support prey items and were also relatively open were considered to be of importance to foraging kestrels. Ranking highest was the disturbed herb, grass dominant vegetation class, as it is both open and capable of supporting small mammals, such as deer mice. Jack pine and the closed mixedwood vegetation classes were also considered important as they have relatively open understories where birds may forage.

American robin primarily consume invertebrates and fruits (Ehrlich et al. 1988). They are considered to be habitat generalists, using open and broken woodlands, forest edges along rivers, lakes and natural openings and second growth in burnt or cut-over areas (Semenchuk 1992), as well as moist forests, swamps, orchards, parks and lawns (U.S. EPA 1993a). Four vegetation classes were considered to be of most importance for foraging American robins and these included: closed deciduous, aspen dominant; closed jack pine; and the two closed mixedwood classes. Less important classes included those which did not support vegetation that produced berries, an important summer food for breeding robins.

Ermine primarily prey upon small mammals, such as voles and mice, but will also take ground squirrels their own size and even young snowshoe hares (Burt 1976, Gadd 1995). They have been known to climb trees and kill birds, and will readily swim and sometimes catch fish and may also eat carrion (Gadd 1995). Ermine kill their prey, then usually carry it home to their burrow or to a storage burrow nearby for consumption at a later date (Burt 1976, Gadd 1995). Ermine prefer coniferous and mixed forests (Smith 1993). This species is more common in the north and less common throughout the parklands and groveland areas (Smith 1993). Ermine could potentially forage anywhere there are abundant prey (e.g., small mammals), however, they may choose areas where burrow construction is most feasible. Wet areas and disturbed areas were considered less important because burrow building may be more difficult in these habitat types and because ermine appear to have a preference for more forested areas.

Deer mice are habitat generalists (Smith 1993) and given their relatively small home range size (under 1 hectare) could hypothetically exist in any given ELC, including the open water ecosite, which includes habitat types along edges of wetlands capable of supporting mouse populations.

5.0 RISK ASSESSMENT

As discussed in Section 4.1, there are numerous organic and inorganic chemicals associated with the reclaimed landscape. These chemicals can exist in a variety of environmental media within the landscape, including solids, water, air and biota. Thus, people and wildlife that use these lands following reclamation may be exposed to oil sands related chemicals from a variety of pathways. In addition, chemicals may be transported off-site to the Athabasca River by surface runoff, groundwater and wind. Thus, aquatic biota within the Athabasca River may be exposed to chemicals derived from the reclaimed landscape as might people and wildlife that use the Athabasca River, downstream of the reclaimed landscape.

A preliminary human health and ecological risk assessment has been conducted to evaluate risks from exposure of people and wildlife to chemicals associated with the reclaimed landscape. This risk assessment was based on data collected up to January 1996; however the database of information is rapidly expanding. Therefore, the results of this risk assessment are preliminary in nature, but provide the necessary information to identify the most important exposure pathways and chemicals of concern.

Risk assessment is a component of the integrated risk management process and its application provides information about estimated health risks associated with exposure to chemicals present at a site. The risk assessment framework used in this report is consistent with approaches developed by Environment Canada (1994), Health Canada (1995) and U.S. EPA (1994) and consists of three phases: Problem Formulation, Exposure and Effects Assessment and Risk Characterization as shown in Figure 5.0-1. The objective of the first phase, Problem Formulation, is to use risk assessment techniques to assist in developing and documenting a site-specific conceptual model to be used in the Exposure and Effects Assessment phase. The results of the Exposure and Effects Assessments are integrated to provide an estimate of risk in the Risk Characterization phase.

Problem Formulation is the first phase in the risk assessment framework. In this phase the geographical location, scope of the project and future plans for the site are outlined. Next, the receptors, chemicals and exposure pathways of concern are identified and screened to focus the remainder of the assessment. It is this phase in which the goals, breadth and focus of the assessment are established and communicated so that the results of the analyses will be useful to those charged with making decisions about the suitability of the reclamation plan.

Considerable effort is expended during the Problem Formulation phase to thoroughly screen chemicals, exposure pathways and receptors to identify the chemicals, pathways and receptors that require further consideration in subsequent phases of the risk assessment. A conservative approach is followed during these screening steps to ensure that the specific constituents and exposure pathways that might contribute significantly to risk are included, while at the same time removing from further consideration those exposure pathways and chemicals that are likely to be insignificant or irrelevant to this specific assessment.

During the Problem Formulation phase, a focused understanding of the site is developed and working hypotheses are defined and illustrated in the Conceptual Model. The Conceptual Model forms the basis for subsequent phases of the risk assessment. The ultimate goal of the Problem Formulation phase is to develop a site-specific Conceptual Model that illustrates how chemicals of potential concern may reach specific receptors, thus potentially creating risk to the receptor, and how risk is to be evaluated.

Risk Analysis involves two discrete components: Exposure Assessment and Effects Assessment. Exposure Assessment is the process of characterizing concentrations or doses, duration, frequency and routes of exposure for the chemicals of potential concern and for all pertinent exposure pathways. Effects Assessment is the process of assembling information on chemical exposure conditions that cause particular effects and developing exposure limits based on preventing effects or minimizing them to levels deemed to be acceptably low by regulatory agencies. For humans, Effects Assessment is often based upon daily exposure limits developed primarily by regulatory agencies such as Health Canada or the U.S. EPA for each of the chemicals of concern. For wildlife, Effects Assessment is based on a literature review to help develop exposure limits from animal studies.

Risk characterization is the integration of information from the Exposure and Effects Assessments. It involves a quantitative comparison of estimates of exposure to the exposure limit of the chemicals of potential concern. This information along with findings from other field and laboratory investigations are integrated, using a weight-of-evidence approach, to assess whether the site poses a significant health risk to people or wildlife. Risk Characterization also identifies and discusses sources of uncertainty, possible impacts of these uncertainties on the results, and how uncertainties are handled (i.e., conservatism).

5.1 Local On-Site Effects

5.1.1 Problem Formulation

The objective of the Problem Formulation phase of a risk assessment is to develop a focused understanding of how chemical releases from the site might contribute to health risks for people or wildlife that might use the reclaimed landscape. This is achieved by characterizing the setting, both physically and from a regulatory perspective, by identifying the wildlife and human activity that is expected to occur on-site, by focusing on the chemicals that are present at concentrations that may be hazardous and identifying the important chemical exposure pathways. The outcome of the Problem Formulation phase is a list of chemicals of potential concern and a qualitative Conceptual Model of the exposure pathways to be considered in the quantitative risk analysis portion of the risk assessment. In the case of ecological health, the Conceptual Model also includes statements about the ecosystem under consideration and the relationship between assessment and measurement endpoints (U.S. EPA 1994).

As discussed above, the Problem Formulation is the critical initial phase of the risk assessment and is conducted by completing three major steps as illustrated in Figure 5.1-1:

1) Preliminary Considerations
2) Screening Process
3) Development of the Conceptual Model

The geographical location, the scope of the problem, regulatory context and remediation plans are outlined in the Preliminary Consideration step. Next, the chemicals, exposure pathways and wildlife sub-populations of concern are identified and screened to focus the remainder of the assessment. This is a critical step since the existence of risk at any site is based on three components, as illustrated in Figure 5.1-2: i) chemicals must be present at hazardous concentrations; ii) people or wildlife must be present; and, iii) pathways must exist for the chemicals to migrate from the source to the receptor. In the absence of any one of the three components outlined in Figure 5.1-2, health risks cannot occur.

As discussed above, the product of Problem Formulation is the development of a site-specific Conceptual Model, which is qualitative in nature, and provides both the basis for and guidance to conduct the quantitative risk analysis phase.

5.1.1.1 Preliminary Considerations

Suncor's development is located on the Athabasca River near Fort McMurray in northeastern Alberta (Figure 1.0-1 and 1.0-2). Oil sands, which are a mixture of sand, clay, water and hydrocarbons in the form of bitumen, occur naturally in the area in seams of varying thickness. The oil-rich sand is excavated to produce high-quality, synthetic crude oil. However, the extraction process generates large volume of tailings, consisting of water, sand and fine clay particles, along with small quantities of unextracted bitumen. The tailings are hydraulically transported and deposited in tailings ponds, where the sand particles settle out and form a beach. The fine particles (<22 μm), on the other hand, remain in suspension in the water and accumulate in the ponds, eventually forming "mature" fine tails (MFT) with an average solids content of 30% by weight.

As of December 1995, MFT has been stored in ponds on Lease 86/17. Reclamation of these ponds involves dewatering MFT using a mixture of sand and gypsum and incorporating the resulting CT into various mined-out pits. This chemical treatment results in rapid dewatering such that a trafficable surface can be established within several years of treatment, as opposed to the hundreds of years (or more) required for natural consolidation of MFT.

The ultimate reclamation of the Suncor mine site is governed by AEP and Alberta Energy and Utility Board (AEUB). These regulatory authorities require that the reclaimed mine site achieves a level of biological capability approximating the original undisturbed condition

(AEP 1995). In addition, the reclaimed site must, over a reasonable period of time, develop into a normal, healthy ecosystem that can maintain itself without further human intervention. The health of organisms supported by the ecosystem must not be impaired by tailings chemicals, and movement and/or cycling of water and nutrients must eliminate the need for further additions or interventions. In addition, any potential for both short-term and long-term off-site impacts must be mitigated in the reclamation design.

Details of the operating and reclamation plan are given in Section 2.0.

5.1.1.2 Chemical Screening

The objective of screening chemicals is to focus the list of chemicals measured in various media (e.g., water, soil) to those chemicals that may be a concern because of their concentrations on-site and their potential to adversely affect people or wildlife. This list of chemicals of potential concern is used to assist in wildlife receptor and pathway screening, and the chemicals identified here are carried forward into the Risk Analysis phase.

The screening process used for both the human health and ecological risk assessments followed a methodical, step-wise process as shown schematically in Figure 5.1-3 and outlined in detail below. Detailed screening tables are presented in Tables 5.1-1 to 5.1-27.

Step 1: Compile Validated Data of Chemical Concentrations from Site Investigations:

Site-specific data were collected, evaluated and appropriate concentrations were selected for the screening process. For this assessment, the maximum concentrations measured were selected as a conservative estimate of the chemical concentrations. This step is identical for both human and wildlife health assessments.

Water - Three primary types of process-affected reclamation waters were screened: dyke drainage (DD) water, CT release water and Plant 4 Tailings Sand Water (Table 4.1-2).

DD water consists of process-affected water that is entrained in the coarse sand tailings that are used to form some or all of the dykes surrounding tailings ponds 1/1A, 2/3, and 4. DD water quality data are available from composite samples collected from the TID collection system (ID: RW 127). These samples are assumed to be representative of water that will seep from sand dykes structures associated with the reclaimed landscape. In addition, one area of particular concern with respect to tailings sand is the quality of seepage water associated with Plant 4 tailing sand. This tailings sand is beached in Pond 1 resulting in a large area of exposed tailings sand. Raw tailings from Plant 4, Beach #2 contain a wider range of PAHs, and generally higher concentrations than those present in most other TID water and, thus, represents worst case concentrations for dyke seepage water. Quality of Plant 4 tailings seepage waters are based on groundwater samples (ID: RG 088 and RG 089) and Plant 4 tailings water (ID: E504203-02, Beach #2).

Samples of CT release waters were obtained from laboratory and field experiments conducted by Suncor and Syncrude in 1995:

- Suncor's 1995 CT field trial experiments - Pit 1 without nutrients, static pit (RW 163);
- Suncor's 1995 CT field trial experiments - Pit 2 without nutrients (RW 164);
- Suncor's 1995 CT field trial experiments - Pit 3 with nutrients (RW 162);
- Suncor's 1996 pilot CT study (1219 and PD 5); and
- Syncrude's 1995 CT laboratory flume test experiment (CT 900; CT 1400).

Background water quality data used in this assessment included water samples that were collected in the Athabasca River upstream of Lease 19 and water samples collected in the tributaries of the Athabasca River within or adjacent to Lease 86, 17, 97 and 19 (i.e., Steepbank River, Leggett Creek, McLean Creek and Wood Creek).

Soil - Two types of process-affected solid-phase material were screened: CT and tailings sand. Only limited solid-phase CT data are available: (1) a low gypsum CT sample from Suncor's 1995 CT field trial experiments and (2) a sample from Syncrude's 1995 CT laboratory flume test experiment (Table 4.1-1). Background soil data were represented by two samples: (1) an overburden clay shale from Syncrude's site and (2) muskeg soil from Suncor's Lease 86 (Table 4.1-1).

Wetlands Plants - The uptake of organic and inorganic chemicals into wetlands plant species has been investigated by analyzing cattail, bulrush and reed canary grass tissues grown in a variety of soils (Table 4.1-3).

Alberta Environment examined the uptake of inorganic chemicals from acid/lime CT into cattail and reed canary grass leaves and stems (Xu 1995, 1996) and these data were used for screening against wildlife species. Two plant species (reed canary grass and cattails) were grown in two kinds of engineered tailings (freeze-thaw and acid-lime treated tailings) under greenhouse conditions at the Alberta Environmental Centre, Vegreville. The residue data from plants grown on CT were used as a basis for chemical screening of plant tissue that might be consumed by wildlife species. The maximum of the mean residue concentration data reported were used for screening.

As part of the constructed wetlands performance assessment, Nix et al. (1994) studied the uptake of oil sands related inorganic chemicals into cattail and bulrush shoots. They reported mean metal residue concentrations for shoots of bulrushes and cattails grown in three types of constructed wetlands including: (1) experimental control (i.e., surface runoff from a nearby lake); (2) DD water (i.e., seepage water from tailings ponds dykes); and, (3) Pond 1A recycle water (i.e., water from surface of a tailings pond). Data were also collected from plants within a reference wetlands (Shipyard Lake) located on Fee Lot#3 and Lease 25. Residue data from plants grown in DD water and Pond 1A recycle water were used as a basis for chemical screening of plant tissue that might be consumed by wildlife species. The residue data from the experimental control and the reference wetlands were used to represent background data. The maximum of the mean residue concentration data reported for each type of wetlands were used for screening.

In addition, Syncrude (unpublished data) investigated the uptake of inorganic and organic chemicals into cattails from growing in fine tails. The maximum residue concentration data reported were used for screening.

Terrestrial Plants - No data were available for terrestrial plants that might be ingested by humans. Sandbar willow and balsam poplar are found in both upland and wetlands conditions and both will be present in the reclaimed landscape. Data on the uptake of inorganic chemicals into these two species grown in acid/lime treated tailings are presented in Table 4.1-4 (Xu 1995, 1996). These data serve as a conservative surrogate to plants grown in CT (no data are available) as it is expected that for most trace metals, mobilization is higher in acid/lime treated tails than in gypsum-treated tails because of the lower pH associated with the acid/lime treatment. Two plant species (willow and poplar) were grown in acid-lime treated tailings under both field and greenhouse conditions at the Alberta Environmental Centre, Vegreville. The residue data from these plants grown on CT were used as a basis for chemical screening of plant tissue that might be consumed by wildlife species. For comparison, residue data from plants on Erskine topsoil and a clean agricultural soil, were used to represent background data. The maximum of the mean residue concentration data reported were used for screening.

Animals - Wolfe and Norman (as cited in Bishay and Nix 1996) conducted a scoping and feasibility study on the uptake of water-borne chemicals by ducklings exposed via the constructed wetlands. The objective of the study was to determine the toxicity of CT and DD water to mallard ducklings exposed via effluent in artificial wetlands reclamation ponds compared to experimental controls exposed to untreated water and to natural wetlands. In addition, tissue metal analysis was conducted for duckling livers. The duckling liver chemical data obtained from this study were used in chemical screening as a surrogate for wild game tissue that might be consumed by humans. It is recognized that liver is not the most appropriate tissue for screening metals since metals tend to accumulate in other tissues. However, these were the only data available and comparison between liver and other tissues from bison indicated that the liver contained the highest metal concentrations.

Pauls et al. (1995) reported residue concentrations for adipose, skeletal muscle and liver tissue from a female bison, which had been held on the toe berm pasture (an area consisting of tailing sand with a 50 cm cap), and which died of injuries from handling. The liver sample was analyzed for various PAHs and adipose, muscle and liver tissues were analyzed for trace metals. In general, concentrations of metals in liver tissue were higher than those in other tissues and therefore were used in chemical screening as a surrogate for wild game tissue that might be consumed by humans.

Fish - Fish tissue data were obtained from walleye, goldeye and longnose sucker collected from the Athabasca River during spring and summer of 1995 and were analyzed for PAH/PANH, alkylated PAH/PANH and trace metals (Golder 1996b). These data were considered to be representative of baseline conditions. In addition, tissue analysis were performed on walleye and rainbow trout held in 10% TID water in the laboratory and these data were considered to represent a worst-case exposure scenario (HydroQual Laboratories 1996). Maximum concentrations were used for screening purposes.

Background fish tissue data were obtained from laboratory experiments in which walleye and rainbow trout were exposed to Athabasca River water collected upstream of the site (HydroQual Laboratories 1996). The fish tissue samples were analyzed for PAH/PANH, alkylated PAH/PANH and trace ICP metals.

Aquatic Invertebrates - Nix et al. (1995) investigated the use of constructed wetlands as a method of treatment of oil sands wastewater. In that study, metal residue concentrations were reported for benthic invertebrates and emergent insects from two types of constructed wetlands including: (1) experimental control (i.e., surface runoff from a nearby lake), (2) DD water (i.e., seepage water from tailings ponds dykes). Reference data were also collected from a reference drainage ditch. Residue data from invertebrates found in the DD water were used as a basis for chemical screening of prey tissue that might be consumed by wildlife species (e.g., mallard). Residue data from the experimental control, natural wetlands and a reference drainage ditch were used as background data. The maximum residue concentrations were used for screening.

Air - Ambient air quality data in the local and regional study areas are summarized by Bovar (1996a) and predicted changes associated with air emissions for Suncor, Syncrude and Solv-Ex are given in Bovar (1996b).

PEOPLE

Step 2: Compile Relevant Environmental Criteria and Select Screening Level Criteria:

Human health criteria were compiled from various published sources and used to identify Screening Level Criteria (SLC). Each chemical identified in Step 1 and measured at concentrations above the analytical detection limit was compared to the SLC as outlined below. Chemicals for which SLCs were lacking were grouped according to their structure, physiochemical and toxicological properties. Groupings and rationale are presented in Appendix II.

Water - Drinking water criteria included:

- Health and Welfare Canada (HWC) Guidelines for Canadian Drinking Water Quality, Maximum Acceptable Concentration (HWC 1993);
- U.S. EPA's (U.S. Environmental Protection Agency) Maximum Contaminant Level for Drinking Water for Humans (U.S. EPA 1993b); and
- BC Environment (BCE) Water Quality Criteria. Ambient Criteria. Drinking Water (BCE 1994).

The lowest value of the three above criteria was used as the SLC for chemicals in drinking water (Table 5.1-1).

Soil - Soil quality criteria for residential soils included:

- Canadian Council of Ministers of the Environment (CCME) Interim Canadian Environmental Quality Criteria for Contaminated Sites. Remediation Criteria for Soil. Residential/Parkland (CCME 1991);
- Alberta Environment Alberta Tier I Criteria for Contaminated Soil Assessment and Remediation (Alberta Environment 1990); and
- BC Environment (BCE) Criteria for Managing Contaminated Sites in British Columbia. Soil Numerical Criteria. Residential (BCE 1995).

The lowest value of the three above criteria was used as the SLC for chemicals in soils (Table 5.1-2).

Meat - No pertinent criteria were located for screening chemicals in meat.

Step 3: Comparison of Observed Background Concentrations to SLCs:

The Suncor site is located in a unique environment, having near-surface pools of naturally occurring petroleum hydrocarbons. Therefore, background concentrations of some petroleum-derived chemicals would be naturally high in this region in comparison to other areas of Alberta. Site-specific background concentrations of chemicals are important in defining those chemicals in which exposure-point concentrations may increase as a result of site reclamation.

Observed background concentrations were compared to SLC (as defined in Step 2) to determine the relevance of regulatory criteria for this unique site. If the observed background concentrations fell below the SLC, then the criteria were considered to be appropriate for the site. If an observed background concentration was greater than the SLC, then the applicability of the criterion was further discussed as part of the risk characterization (for those chemicals retained for Risk Analysis). Chemical detection limits were also reviewed at this stage. If a chemical detection limit exceeded the SLC, then the chemical was identified and the implications were further discussed as part of the risk characterization (for those chemicals retained for the Risk Analysis).

Water - Concentrations of aluminum, iron, manganese and phosphorus in Athabasca River and reference tributaries exceeded the SLC for drinking water (Table 5.1-3). Several chemicals, including benzo(a)pyrene, phosphorus and uranium, had chemical detection limits above the SLC for water.

Soil - Concentrations of one inorganic (arsenic) and several organics (dibenzothiophene group, naphthalene group and phenanthrene group) in overburden exceeded SLC for soils; however, chemical concentrations in muskeg did not exceed SLC (Table 5.1-4). Arsenic was the only chemical that had a chemical detection limit above the SLC for soil.

Step 4: Comparison of Maximum Observed Concentration to SLCs:

If the concentration of a chemical exceeded its SLC, or if there was no SLC for a particular chemical, then the chemical was retained for further analysis and carried forward to Step 5. If the concentration of a chemical did not exceed the SLC, then the chemical was eliminated from further consideration.

Water - The following chemicals exceeded SLCs for drinking water and were carried forward to the next screening step (Table 5.1-5):

benzo(a)anthracene group	benzo(a)pyrene group	aluminum
cadmium	chloride	iron
manganese	molybdenum	phosphorus
sodium	sulphate	vanadium

The following chemicals did not have any relevant criteria to determine a SLC for drinking water and were carried forward to the next screening step:

acenaphthylene	acenaphthene group	benzo(ghi)perylene
biphenyl	dibenzothiophene group	fluorene group
fluoranthene group	naphthalene group	phenanthrene group
pyrene	quinoline group	naphthenic acids
2,4-dimethylphenol	ammonia	calcium
cobalt	lithium	potassium
silicon	strontium	tin
zirconium		

Several chemicals, including benzo(a)pyrene, ethylbenzene and uranium had chemical detection limits above the SLC for water.

Soils - The following chemicals exceeded SLCs for residential soils and were carried forward to the next screening step (Table 5.1-6):

benzo(a)anthracene group	benzo(a)pyrene group	benzo(b&k)fluoranthene
dibenzothiophene group	fluorene group	fluoranthene group
naphthalene group	phenanthrene group	pyrene

The following chemicals did not have any relevant criteria to determine a SLC for residential soils water and were carried forward to the next screening step:

biphenyl group	aluminum	calcium
iron	magnesium	manganese

Arsenic was the only chemical that had a chemical detection limit above the SLC for soils.

Step 5: Comparison of Observed Chemical Concentrations to Background Values:

The maximum chemical concentrations observed in environmental medium (i.e., water, soil, meat) were compared to background levels. If the maximum chemical concentrations measured at the site were less than or equal to maximum concentrations measured in background samples, then these chemical concentrations were assumed to be natural in origin and typical of the area and were removed from any further chemical screening.

Water - The maximum concentrations of the following chemicals exceeded background concentrations and were carried forward to the next screening step (Table 5.1-7):

acenaphthylene	acenaphthene group	benzo(a)anthracene group
benzo(a)pyrene group	benzo(ghi))perylene	biphenyl
dibenzothiophene group	fluorene group	fluoranthene group
naphthalene group	phenanthrene group	pyrene
quinoline group	naphthenic acids	2,4-dimethylphenol

ammonia	cadmium	calcium
chloride	cobalt	iron
lithium	manganese	molybdenum
phosphorus	potassium	silicon
sodium	strontium	vanadium

The following chemicals did not have any relevant background data for surface water and were, thus, carried forward to the next screening step:

tin	zirconium

Soils - The maximum concentrations of the following chemicals exceeded background concentrations and were carried forward to the next screening step (Table 5.1-8):

benzo(a)anthracene group	benzo(a)pyrene group	benzo(b&k)fluoranthene
biphenyl group	dibenzothiophene group	fluorene group
fluoranthene group	naphthalene group	phenanthrene group
pyrene		

Meat - The maximum concentrations of the following chemicals exceeded background concentrations in meat and were carried forward to the next screening step (Table 5.1-9):

barium	chromium	copper
lead	nickel	

Step 6: Comparison of Maximum Observed Concentration to Risk-Based Concentration:

Risk-Based Concentrations (RBCs) for the ingestion of tap water, residential soils and fish are available from U.S. EPA's Region III Risk-Based Concentration Table (Smith 1995). In this step, the maximum chemical concentrations measured in release waters, reclamation materials and meat were compared to the RBCs. If the maximum concentration of a chemical exceeded the RBC or if a RBC was not available, then the chemical was retained for further analysis. If the RBC was not exceeded, then the chemical was eliminated from further consideration. The RBCs used here are based on the assumption that people will drink the source water, ingest soils and meat on a daily basis, 350 days per year for 30 years.

Water - Concentrations of the following chemicals exceeded RBCs for drinking water and were carried forward to the next screening step (Table 5.1-10):

benzo(a)anthracene group	benzo(a)pyrene group	ammonia
chloride	manganese	molybdenum

The following chemicals were retained because RBCs were not available:

naphthenic acids	calcium	iron
phosphorus	potassium	silicon
sodium	sulphate	zirconium

Soil - Concentrations of the following chemicals exceeded RBCs for residential soils and were carried forward to the next screening step (Table 5.1-11):

benzo(a)anthracene group	benzo(a)pyrene group

Meat - Concentrations of the following chemicals in duck and bison liver exceeded RBCs for consumption of meat and were carried forward to the next screening step (Table 5.1.12):

copper	manganese

The following chemicals were retained because RBCs were not available:

calcium	iron	magnesium
phosphorus	potassium	silicon
sodium	sulphur	titanium

Step 7: Substance is Essentially Non-Toxic Under Environmental Exposure Scenarios:

Certain constituents may be eliminated from further consideration based on their importance as a dietary component, status as an essential nutrient, or general lack of toxic effects at the measured concentrations. Calcium, magnesium, potassium, iron and sodium can generally be eliminated from an evaluation at the screening stage based on dietary and nutritional status (U.S. EPA 1989a).

Although considered an odour nuisance at low concentrations in water, ammonia is not considered a human health concern via the ingestion pathway (HEAST 1995).

Chloride is an essential nutrient for humans functioning to ensure the proper fluid-electrolyte balance. Further, ingestion of chloride in drinking water is a relatively minor contributor of chloride compared to intake from other sources such as food (CCREM 1987). Therefore, health implications with respect to chloride are not considered to be significant. The main consideration regarding chloride is prevention of undesirable taste in water and water-based beverages. Given that chloride is essential for human health, chloride was eliminated from further consideration.

Phosphorus is a natural element that may be removed from igneous and other types of rock by leaching or weathering (CCREM 1987). Environmental concentrations in western Canada range from 0.003 to 3 mg/L for total phosphorus (NAQUADAT 1985). Concentrations in waters at the site ranged from 0.006 to 0.43 mg/L (Table 4.1-2). Given that phosphorus occurs naturally and that concentrations at the site fall within concentrations reported for western Canada, phosphorus was eliminated from further consideration.

Silicon is insufficiently bioavailable to be absorbed following intake and is also considered biologically inert (HSDB 1995), therefore, it is considered non-hazardous for the purpose of this assessment and eliminated from further evaluation.

Soluble sulphate salts of sodium, magnesium, potassium, lithium, etc. are rather slowly absorbed from the alimentary tract. The amount of sulphate anion usually absorbed has no toxicological significance (Gosselin et al. 1984); therefore, it is considered non-hazardous for the purpose of this assessment.

Most zirconium compounds in common use are insoluble and considered inert (Sax 1975). The limited toxicity data available suggest that zirconium is considered toxic via inhalation, however; it does not appear to be a human health concern via the ingestion pathway (Gough et al. 1978). Therefore, zirconium was eliminated from further consideration.

Step 8: List of Chemicals of Potential Concern following Chemical Screening:

The chemical screening process incorporated several conservative assumptions to ensure that chemicals of potential concern would not fall through the screening process:

- The maximum recorded concentration of each chemical was used.
- No chemical-fate processes were incorporated into this screening. These processes would substantially reduce chemical concentrations prior to exposure (e.g., dilution by Athabasca River).
- SLCs were based on published criteria that are designed to prevent any adverse health effects.
- If no SLC were available for a chemical, it was retained and carried forward to the next chemical screening step.
- RBCs were based on extremely conservative exposure scenarios (e.g., assuming that people drink untreated operational and reclamation waters 350 days of every year for 30 years).

Considering all of the above protective assumptions, chemicals that are retained for further analysis after this screening are ones that require further investigation and do not necessarily pose a risk to people's health.

Water - Based on this screening, the following chemicals were identified as ones that required more detailed investigation with respect to people who might drink waters derived from the reclamation landscape (Table 5.1-13):

benzo(a)anthracene group	benzo(a)pyrene group	manganese
molybdenum	naphthenic acids	

It is important to emphasize that this screening process was restricted to chemicals related to Suncor's operations. Other chemicals, such as chlorinated organics derived from pulp mills, were not investigated here because Suncor is not a source for these chemicals. In addition, there are natural hazards such as bacteria and viruses, associated with the river water that pose a health hazard to people who drink untreated river water.

Soil - Based on this screening, the following chemicals were identified as ones that required more detailed investigation with respect to people who might ingest soils derived from the reclamation landscape (Table 5.1-13):

benzo(a)anthracene group	benzo(a)pyrene group

Meat - Based on this screening, the following chemicals were identified as ones that required more detailed investigation with respect to people who might ingest soils derived from the reclamation landscape (Table 5.1-13):

copper	manganese

WILDLIFE HEALTH

A similar, methodical step-wise screening process was applied to identify chemicals of potential concern that might affect the health of wildlife drinking water from the Athabasca River downstream of Suncor's operations.

Step 1: Compile Validated Data of Chemical Concentrations from Site Investigations:

This is identical to that described above for screening chemicals against human health criteria.

Step 2: Compile Relevant Environmental Criteria and Select SLC:

Water - Pertinent drinking water criteria included:

- Canadian Council of Resource and Environment Ministers (CCREM) Water Quality Guidelines. Guidelines for Livestock Drinking Water Quality (CCREM 1987); and,
- BC Environment (BCE) Water Quality Criteria. Ambient Criteria. Wildlife and/or Livestock (BCE 1994).

The lowest available value of the two criteria was chosen as the SLC for wildlife species for ingestion of water (Table 5.1-14).

Soils - Pertinent soil quality criteria included:

- Canadian Council of Ministers of the Environment (CCME) Interim Canadian Environmental Quality Criteria for Contaminated Sites. Remediation Criteria for Soil. Agricultural (CCME 1991);
- Alberta Environment Alberta Tier I Criteria for Contaminated Soil Assessment and Remediation (Alberta Environment 1990);
- BC Environment (BCE) Criteria for Managing Contaminated Sites in British Columbia. Soil Numerical Criteria. Agricultural (BCE 1995);
- Ontario Ministry of Environment and Energy (OMEE) Rationale for the Development of Generic Soil, Groundwater and Sediment Criteria for Clean-up of Contaminated Sites. Surface Soil and Groundwater Clean-up Criteria. Agricultural Land Use (OMEE 1994).

The lowest value of the four above criteria was used as the SLC for wildlife for ingestion of solid-phase materials (Table 5.1-15).

Step 3: Comparison of Observed Background Concentrations to SLC:

Water - The chemical concentration of aluminum in the Athabasca River exceeded the SLC; chemical concentrations in the reference tributaries did not exceed the SLC (Table 5.1-16).

Soil - The chemical concentration of several organics (dibenzothiophene group, naphthalene group, phenanthrene group and pyrene) in overburden exceeded the SLC; chemical concentrations in the muskeg did not exceed the SLC (Table 5.1-17).

Step 4: Comparison of Maximum Observed Concentration to SLCs:

Water - The following chemicals exceeded the SLC for drinking water supplies and were carried forward to the next screening step (Table 5.1-18):

molybdenum	potassium	sulphate
vanadium		

The following chemicals did not have SLCs and were carried forward to the next screening step:

acenaphthene group	acenaphthylene	benzo(a)anthracene group
benzo(a)pyrene group	benzo(ghi)perylene	biphenyl
dibenzothiophene group	fluorene group	fluoranthene group
naphthalene group	phenanthrene group	pyrene
quinoline group	naphthenic acids	ethylbenzene
xylenes	2,4-dimethylphenol	ammonia
antimony	barium	chloride
cyanide	iron	magnesium
manganese	phosphorus	silicon
sodium	strontium	tin
titanium	zirconium	

Soil - The following chemicals exceeded the SLC for agricultural soils and were carried forward to the next screening step (Table 5.1-19):

benzo(a)anthracene group	benzo(a)pyrene group	benzo(b&k)fluoranthene
dibenzothiophene group	fluorene group	fluoranthene group
naphthalene group	phenanthrene group	pyrene

The following chemicals did not have SLCs and were carried forward to the next screening step:

aluminum	calcium	iron
magnesium	manganese	

Step 5: Comparison of Observed Chemical Concentrations to Background Values:

Water - The maximum concentrations of the following chemicals exceeded background concentrations and were carried forward to the next screening step (Table 5.1-20):

acenaphthylene	acenaphthene group	benzo(a)anthracene group
benzo(a)pyrene group	benzo(ghi)perylene	biphenyl
dibenzothiophene group	dibenzothiophene group	fluorene group
fluoranthene group	naphthalene group	phenanthrene group
pyrene	quinoline group	naphthenic acids
ethylbenzene	xylenes	2,4-dimethylphenol
ammonia	antimony	cadmium
barium	chloride	cyanide
iron	magnesium	manganese
molybdenum	phosphorus	potassium
silicon	sodium	strontium
sulphate	titanium	vanadium

The following chemical did not have any background water data available and were carried forward to the next screening step:

tin	zirconium

Soils - The maximum concentrations of the following chemicals exceeded background soil concentrations and were carried forward to the next screening step (Table 5.1-21):

benzo(a)anthracene group	benzo(a)pyrene group	benzo(b&k)fluoranthene
dibenzothiophene group	fluorene group	fluoranthene group
naphthalene group	phenanthrene group	pyrene

Terrestrial Plants - There were a lack of appropriate background data for terrestrial plants, therefore, chemical screening was not completed for terrestrial plants. Inorganic residue data from plants grown in clean agricultural soils were available; however, these soils are not representative of soils that naturally occur with the site area.

Emergent Wetlands Plants - The maximum concentrations of the following chemicals exceeded background concentrations in bulrush and cattail shoots and were carried forward to the next screening step (Table 5.1-22):

aluminum	barium	boron
lithium	mercury	nickel
phosphorus	sodium	strontium

Benthic Invertebrates - The maximum concentrations of the following chemicals exceeded background concentrations in benthic invertebrates and were carried forward to the next screening step (Table 5.1-23):

copper	zinc

Emergent Insects - The maximum concentrations of the following chemicals exceeded background concentrations in emergent insects and were carried forward to the next screening step (Table 5.1-23):

barium	titanium

Chironomid Larvae - The maximum concentrations of the following chemicals exceeded background concentrations in chironomid larvae and were carried forward to the next screening step (Table 5.1-23):

cadmium	iron	lead

Step 6: Comparison of Maximum Observed Concentration to Risk-Based Concentration:

RBCs were calculated for water, soils, plants and prey, and were based on the method by Opresko et al. (1994) and chronic No-Observed-Adverse-Effect Levels (NOAEL) derived from the toxicological literature (Appendix III). In general, adverse effects are observed at levels ten times greater than the NOAEL; therefore, an RBC based on a chronic NOAEL is considered to be conservative (Opresko et al. 1994).

Water - The following chemicals were retained for further analysis because no RBC was available (Table 5.1-24):

naphthenic acids	ammonia	chloride
magnesium	phosphorus	potassium
silicon	sodium	sulphate
tin		

Soils - Concentrations of the following chemicals exceeded RBCs for soils and were carried forward to the next screening step (Table 5.1-25):

benzo(a)pyrene group

Terrestrial Plants - For a chemical to be of concern at the site, there must be a source for that chemical. Given that no inorganic chemicals exceeded background or criteria for soils and only a few inorganics exceeded background or criteria for water, it is not expected that the reclaimed soils would be a source for metals. Therefore, chemical screening was not done for terrestrial plants.

Emergent Wetlands Plants - Concentrations of the following chemicals exceeded RBCs for plants and were carried forward to the next screening step (Table 5.1-26):

aluminum	arsenic	cadmium
molybdenum	nickel	strontium
thallium	uranium	vanadium
zirconium		

The following chemicals were retained for further analysis because RBCs were not available (Table 5.1-26):

calcium	chloride	iron
sodium	tin	thorium
titanium		

Benthic Invertebrates - Concentrations of the following chemical exceeded the RBC for prey and the chemical was carried forward to the next screening step (Table B.1-27):

zinc

Emergent Insects - Concentrations of the following chemical exceeded the RBC for prey and the chemical was carried forward to the next screening step (Table B.1-27):

barium

The following chemicals were retained for further analysis because RBCs were not available (Table B.1-27):

iron titanium

Step 7: Substance is Essentially Non-Toxic Under Environmental Exposure Scenarios:

Certain constituents may be eliminated from further consideration based on their importance as a dietary component, status as an essential nutrient, or general lack of toxic effects. Calcium, magnesium, potassium, iron and sodium can generally be eliminated from an evaluation at the screening stage based on dietary and nutritional status (NAS 1980). Therefore, these chemicals were eliminated from further consideration.

Although considered an odour nuisance at low concentrations in water, ammonia was not considered a wildlife health concern via the ingestion pathway (HSDB 1995).

Chloride is also an essential nutrient for the growth of plants (CCREM 1987) and is an essential nutrient for animals, functioning to ensure the proper fluid-electrolyte balance (NAS 1980). Typically, when animals suffer from sodium and chloride deficiency, they will be drawn to salt licks (NAS 1980). Given that chloride is essential for plant and animal health and that there is no anthropogenic source for this chemical, chlorine was eliminated from further consideration.

Phosphorus is a natural element that may be removed from igneous and other types of rock by leaching or weathering (CCREM 1987). Environmental concentrations in western Canada range from 0.003 to 3 mg/L for total phosphorus (NAQUADAT 1985). Concentrations in waters at the site ranged from 0.006 to 0.43 mg/L (Table 4.1-2). Given that phosphorus occurs naturally and that concentrations at the site fall within concentrations reported for western Canada, phosphorus was eliminated from further consideration.

Silicon is important in the formation of bone in young animals and birds and toxicity does not appear to be a serious problem in animals (NAS 1980). In addition, silicon is insufficiently bioavailable to be absorbed following intake (HSDB 1995). Therefore, it is considered non-hazardous for the purpose of this assessment and was eliminated from further consideration.

High sulphate concentrations in water can be tolerated in livestock but a loss in agricultural production (i.e., decreased water and food consumption and weight loss) can be expected at concentrations above 1000 mg/L. Concentrations of sulphate in TID and CT water ranged from 29.1 to 1290 mg/L falling well within the reported range of environmental concentrations of sulphate for western Canadian surface waters (i.e., 1 to 3,149 mg/L) (NAQUADAT 1985). Given that sulphate is a major ion, and that measured concentrations fall within the reported range for environmental concentrations, sulphate was not considered to be an ecological health concern via the ingestion pathway and was eliminated from further consideration.

A number of trace inorganic parameters (i.e., tin, thorium, titanium) did not have RBCs for the ingestion of plants for wildlife (see Step 6). Kabata-Pendias and Pendias (1992) reported approximate concentrations of trace elements in mature leaf tissue of terrestrial plants and the concentrations of these elements measured by Xu (1995 and 1996) in willow fall within the reported range. In addition, the potential for tin toxicity is negligible because this element is poorly absorbed, while titanium is considered to be inert and innocuous and there has been no evidence of oral toxicity of titanium in animals (NAS 1980). Therefore, given that there is no anthropogenic source for these elements, that the concentrations measured in plants grown in CT fall within the reported range and that these compounds appear to be innocuous, these chemicals were eliminated from further consideration.

Step 8: List of Chemicals of Potential Concern following Chemical Screening:

The following is a list of chemicals of potential concern for one or more wildlife receptors:

benzo(a)pyrene group	aluminum	arsenic
barium	cadmium	molybdenum
nickel	strontium	thallium
uranium	vanadium	zinc
naphthenic acids		

5.1.1.3 Receptor Screening

PEOPLE

Suncor is located in northeastern Alberta approximately 46 kilometres from Fort McMurray and 20 kilometres from Fort MacKay. As such, it is reasonable to assume that following reclamation the site might be used by members of the Fort McKay First Nations for traditional activities, including hunting, trapping and gathering.

It was assumed that exposures by people would occur only following reclamation of Lease 86/17 or the Steepbank Mine, since access to the sites will be controlled during the operational phase of the project. Although all ages of people might utilize these lands, the most extensive uses would be from adults who might live on the land for extended periods of time while hunting and trapping. Hence, the end-users evaluated in this assessment were assumed to be adult hunters and trappers, who might reside on-site throughout the year. This is likely to be a conservative assumption given the seasonal nature of these activities.

Potential food items for end-users of the reclaimed landscape include numerous herbs, berries, shrubs, water tolerant plants, trees, big game animals, fur-bearers, migratory and predatory birds, upland game birds and fish (Fort McKay Environmental Services Ltd. 1996). It was assumed that 25% of the diet of these individuals would be from plants and animals harvested from Lease 86/17 and that these foods are intensively exposed to chemicals derived from the site. This is a very conservative assumption given the relatively small area of the site, the large foraging areas of big-game animals and the climate that restricts the growing season for plants.

Potential sources of drinking water associated with the reclaimed landscape include groundwater, surface water associated with wetlands, snow and nearby rivers and streams such as the Athabasca River. Groundwater derived from the tailings sands deposits was excluded as a source of drinking water since the associated hydrocarbon odours would deter potential users. In addition, CT deposits are of low permeability so it is unlikely that they would produce sufficient quantities of water. Wetlands are expected on sections of the top of CT deposits and also along sections of the base of the reclamation structures. However, these wetlands are expected to be intermittently dry and stagnant and would not offer good quality water considering the potential for anoxia, warm temperatures and naturally-occurring pathogens. Snow is a potential source of good quality water but only during winter. Thus, it was assumed that the primary source of drinking water would be from the Athabasca River, since it offers a constant and accessible source of water near the reclaimed landscape, and that people would obtain all of their drinking water from the Athabasca River.

WILDLIFE

Suncor's reclaimed site must, according to government regulations (AEP 1995), develop into a normal, healthy ecosystem. In addition, exposure to chemicals associated with the site must not lead to unacceptable impacts in organisms supported by the ecosystem. It is, therefore, necessary to assess potential impacts for all major trophic levels. It is of course, impossible, and not necessary, to examine potential effects on every organism that might be exposed to chemicals associated with the site. Instead, representative species (or receptors) were selected as the basis for evaluating potential impacts.

Specific receptors representative of soil microbe, soil macroinvertebrate and plant communities were not utilized in this study. Instead, effects on these communities were evaluated using a combination of laboratory and field toxicity tests plus analysis of plant community structure as discussed in Section 4.2.2.

The objective of screening wildlife receptors during the Problem Formulation phase is to: i) identify wildlife that might use the reclaimed landscape and ii) to focus the assessment on a manageable number of key receptors. Receptors were selected based on a wildlife inventory of the area, discussions with wildlife biologists conducting baseline studies, and guidance from the literature (Suter 1993; Algeo et al. 1994). The overall emphasis of the ecological receptor screening was the selection of representative receptors that would be at greatest risk, that play a key role in the food web and that have sufficient characterization data to facilitate calculations of exposure and health risks. Receptors were also selected to include animals that have societal relevance and that are a food source for people.

Wildlife species determined to be Valued Ecosystem Components (VECs) for the Suncor EIA (Westworth, Brusnyk & Associates 1996) were also given extra weight in the evaluation. An attempt was also made to represent various trophic levels (i.e., large and small mammalian herbivores, mammalian predators, mammalian omnivores, avian insectivores, avian predators, avian omnivores). Herbivores were thought to be important as metals can potentially accumulate in some plant tissues, and insectivores were considered important as PAHs may accumulate in some invertebrate prey. Predators were included to assess potential for food chain effects. Candidate wildlife species are is summarized in Table 5.1-28.

The following wildlife receptors were selected:

Mammalian Trophic Level	*Receptors*
semi-aquatic herbivore	beaver
large herbivore	moose
small terrestrial herbivore	snowshoe hare
terrestrial omnivore	deer mouse
small terrestrial predator	ermine
Avian Trophic Level	
semi-aquatic omnivore	mallard
terrestrial herbivore	ruffed grouse
terrestrial insectivore/omnivore	American robin
terrestrial vertebrate predator	American kestrel

5.1.1.4 Exposure Pathway Screening

The objective of screening exposure pathways during the Problem Formulation phase is to: i) identify potential routes through which people and wildlife could be exposed to chemicals; and, ii) determine the relative significance or importance of operable exposure pathways. As noted above, a chemical represents a health risk only if it can reach receptors through an exposure pathway at a concentration that could potentially lead to adverse effects. If there is no pathway for a chemical to reach a receptor, there can be no risk, regardless of the source concentration.

The goal of this task is to identify all possible exposure pathways and then to evaluate which pathways are likely to be realistic and applicable to the site under investigation. The characterization and quantification of exposure is conducted in the Exposure Assessment phase of the study.

Suncor's reclamation plan involves extensive use of CT to form trafficable surfaces and habitat for native fauna and flora, as well as recreational land for people. The primary sources for all potential chemical exposure related to the site will be the CT and tailings sand, in particular:

- sediment-bound chemicals associated with CT deposits;
- sediment-bound chemicals associated with tailings sand deposits;
- soluble chemicals associated with water entrained in CT deposits; and
- soluble chemicals associated with water entrained in tailings sand deposits.

Natural processes such as erosion, leaching and volatilization can release the chemicals in the CT and tailings sand, creating numerous chemical exposure pathways for people and wildlife. Potential environmental residency and exposure media could include:

- surface water
- soil
- sediment
- biota
- air

Exposure pathways have been identified for the two major classes of chemicals: water soluble (hydrophilic) compounds, such as naphthenic acids, volatile organic compounds (VOCs) and some trace metals (depending on pH of solution); and non-water soluble (hydrophobic) compounds, such as most PAHs and most metals at higher pH values. Potential transport and exposure pathways associated with the reclamation of Suncor's leases are outlined below for people and wildlife and shown diagramatically in Figure 5.1-4. Critical pathways to be modelled for assessing health impacts on people and wildlife are shown in Figures 5.1-5 and 5.1-6, respectively.

EXPOSURE PATHWAYS FOR PEOPLE

Inhalation:

Volatile Chemicals - Volatilization of VOCs from surface water and soils into the air can result in direct exposure to people, particularly to those that might live on the reclaimed site following reclamation, through inhalation of vapours. However, this pathway was not evaluated due to the lack of air quality data from CT deposits

Fugitive dust generation from surface soils - Fugitive dust generated from surface soils can result in exposure to people through inhalation of chemicals bound to soil particles. However, this is not expected to be a significant exposure pathway because CT deposits will be capped with sand and muskeg so erodible chemical concentrations of soils will be comparable to natural background levels and landscapes will also be covered with vegetation; thereby further reducing potential for dust generation. Therefore, this exposure pathway has been excluded from further evaluation.

Dermal Exposure:

Direct contact with air - Volatilization of chemicals from surface water and soils into the air can result in direct exposure to people through dermal uptake of chemicals present in air vapours. this pathway was not evaluated due to the lack of air quality data from CT deposits. To date only low levels of volatile compounds have been detected in tailings pond water. Elimination of these large open water areas and entrainment of remaining waters in soils will reduce the extent of the release of volatile compounds to the air. Hence, dermal uptake of volatile chemicals is not expected to contribute significantly to exposure of people, and has been excluded from further analysis.

Direct contact with soils - Digging and fugitive dust generation can result in exposure to people through dermal contact with soils. However, this is not expected to be a significant exposure pathway because the proposed capping and reclamation scheme will prevent direct contact with CT deposits.

Direct contact with surface water - Water soluble chemicals can leach from the tailings materials into groundwater and ultimately seep into surface water bodies (e.g., springs, wetlands, streams). People could be exposed by directly contacting surface water. Since large volumes of water are associated with CT reclamation units, the presence of hydrophilic chemicals in surface water is potentially a major environmental transport and residency media for exposure of people. However, the contribution of dermal exposure to chemicals in surface water is expected to be small relative to ingestion exposure (discussed below), and this pathway is evaluated in detail as part of the assessment of off-site human health impacts (Golder 1996a). Hence, this pathway has been excluded from further evaluation.

Ingestion:

Ingestion of fugitive dust - Fugitive dust generated from surface soils can result in exposure to people through ingestion of chemicals bound to soil particles. However, this is not expected to be a significant exposure pathway because the proposed capping and reclamation scheme will prevent dust arising from wind-based erosion of CT deposits. Therefore this pathway has been removed from further consideration.

Ingestion of surface water - Water soluble chemicals can leach from the tailings materials into groundwater and ultimately seep into surface water bodies (e.g., springs, wetlands, streams). People could be exposed by ingesting surface water intentionally or through incidental ingestion while swimming. Since large volumes of water are associated with CT reclamation units, drinking surface water is a potential exposure pathway for people.

Ingestion of soils/sediment - Digging and fugitive dust generation can result in exposure to people through incidental ingestion of soils. However, this is not expected to be a significant exposure pathway because the proposed capping and reclamation scheme will prevent ingestion of CT deposits. Therefore this pathway has been removed from further consideration.

Ingestion of plants - Plants that are growing on reclaimed surfaces may accumulate metals and organic compounds in their tissue. People could be exposed by consuming these plants. Hence, this is a potential exposure pathway for people.

Ingestion of animals - Animals living and feeding in the reclaimed landscape may accumulate metals and organic compounds in their tissue. People could be exposed by consuming these animals. Hence, this is a potential exposure pathway for people.

EXPOSURE PATHWAYS FOR WILDLIFE

Inhalation:

Volatile Chemicals - Volatilization of VOCs from surface water and soils into the air can result in direct exposure to wildlife, especially soil dwelling and burrowing insects and mammals, through inhalation of vapours. However, this pathway was not evaluated due to the lack of air quality data from CT deposits.

Fugitive dust generation from surface soils - Fugitive dust generated from surface soils can result in exposure to wildlife through inhalation of chemicals bound to soil particles. However, this is not expected to be a significant exposure pathway because CT deposits will be capped with sand and muskeg so erodible chemical concentrations of soils will be comparable to natural background levels and landscapes will also be covered with vegetation; thereby further reducing potential for dust generation. Therefore, this exposure pathway has been excluded from further evaluation.

Dermal:

Direct contact with air - Volatilization of chemicals from surface water and soils into the air can result in direct exposure to wildlife through dermal uptake of chemicals present in air vapours. this pathway was not evaluated due to the lack of air quality data from CT deposits. To date only low levels of volatile compounds have been detected in tailings pond water. Elimination of these large open water areas and entrainment of remaining waters in soils will reduce the extent of the release of volatile compounds to the air. Hence, dermal uptake of volatile chemicals is not expected to contribute significantly to exposure of wildlife, and has been excluded from further analysis.

Direct contact with soils - Digging and fugitive dust generation can result in exposure to wildlife through dermal contact with soils. However, this is not expected to be a significant exposure pathway because of the proposed capping and reclamation scheme will prevent direct contact with CT deposits. In addition, dermal exposure of birds and furbearing mammals is generally considered an insignificant exposure pathway, except directly after pesticide spraying (Environment Canada 1994). Therefore, this exposure pathway has been excluded from further consideration.

Direct contact with surface water - Water soluble chemicals can leach from the tailings materials into groundwater and ultimately seep into surface water bodies (e.g., springs, wetlands, streams). Although wildlife could be exposed by directly contacting surface water, birds and fur-bearing mammals likely receive insignificant doses through this route relative to other routes, such as direct ingestion of water (Environment Canada 1994). Therefore, this pathway has been excluded from further consideration.

Direct contact with surface water - Water soluble chemicals can leach from the tailings materials into groundwater and ultimately seep into surface water bodies (e.g., springs, wetlands, streams). Wildlife could be exposed by directly contacting surface water. Since large volumes of water are associated with CT reclamation units, the presence of hydrophilic chemicals in surface water is potentially a major environmental transport and residency media for exposure of wildlife. Although wildlife could be exposed by directly contacting surface water, birds and fur-bearing mammals likely receive insignificant doses through this route relative to other routes, such as direct ingestion of water (Environment Canada 1994). Therefore, this pathway has been excluded from further consideration.

Ingestion:

Ingestion of fugitive dust - Fugitive dust generated from surface soils can result in exposure to wildlife through ingestion of chemicals bound to soil particles. However, this is not expected to be a significant exposure pathway because the proposed capping and reclamation scheme will prevent dust arising from wind-based erosion of CT deposits. Therefore this pathway has been removed from further consideration.

Ingestion of surface water - Water soluble chemicals can leach from the tailings materials into groundwater and ultimately seep into surface water bodies (e.g., springs, wetlands, streams). Wildlife could be exposed by drinking surface water. Since large volumes of water are associated with CT reclamation units, drinking surface water is a potential exposure pathway for people.

Ingestion of soils/sediment - Digging and fugitive dust generation can result in exposure to wildlife through incidental ingestion of soils. However, this is not expected to be a significant exposure pathway because the proposed capping and reclamation scheme will prevent ingestion of CT deposits. Therefore this pathway has been removed from further consideration.

Ingestion of plants - Plants that are growing on reclaimed surfaces may accumulate metals and organic compounds in their tissue. Herbivorous wildlife could be exposed by consuming the plants. Since large areas of reclaimed landscape are to be constructed, ingestion of plants is a potential exposure pathway for wildlife.

Ingestion of animals - Carnivorous and omnivorous animals have the potential to accumulate some metals and organic compounds in tissue from their prey. Since large areas of reclaimed landscape are to be constructed, the consumption of prey is a potential exposure pathway for wildlife.

5.1.1.5 Assessment and Measurement Endpoints

Explicit definitions of assessment and measurement endpoints are not necessary for assessing risks to human health since protection of sensitive individuals from adverse effects is the accepted endpoint for human health risk assessments. However, there is no general agreement on endpoints for ecological risk assessments, so explicit definition of the endpoints are required.

Information compiled in the first stage of problem formulation is used to help select ecologically-based endpoints that are relevant to decisions about protecting the environment (U.S. EPA 1992a). Endpoints are characteristics of ecological components that may be affected by exposure to a stressor (e.g., chemical). Assessment endpoints are explicit expressions of the actual ecological value that is to be protected and are the ultimate focus in risk characterization. For this investigation, the assessment endpoints include protection of the viability of populations of wildlife species previously selected as VECs (Section 5.1.1.3). Since these species encompass different taxa and trophic levels, it is assumed that they also serve as surrogates to other levels of organization and/or species not directly included in this evaluation.

Assessment endpoints tend to be qualitative or semi-qualitative, and are rarely directly measurable. As a result, measurement endpoints are usually defined as surrogates for assessment endpoints. Measurement endpoints are the quantitative response of the ecosystem component or receptor to the stressor, which is related to the characteristics of the assessment endpoint. In other words, it is the response to which exposure to the chemicals of potential concern is related, so that one can identify whether a specific exposure scenario might adversely affect wildlife. For this study, measurement endpoints are based on laboratory, field and modelling studies of adverse effects (e.g., mortality, reproduction, growth) on surrogate species that may ultimately result in adverse effects on populations, communities or hierarchical structures or wildlife (Table 5.1-29).

5.1.1.6 Development of a Conceptual Model

The Conceptual Model is the end-point of the Problem Formulation phase of the risk assessment and outlines how the chemical stressors might affect humans and wildlife. This involves detailing the sources of chemicals, chemical release mechanisms, transport pathways and media and important exposure routes that are to be pursued in the quantitative risk analysis portion of the risk assessment.

A graphical representation of pertinent exposure pathways that will be pursued in the subsequent phases of the risk assessment is given in Figures 5.1-5 and 5.1-6, and the critical pathways for each receptor are listed in Table 5.1-30.

5.1.2 Risk Analysis

Risk Analysis involves two discrete components: Exposure Assessment and Effects Assessment. Exposure Assessment is the process of characterizing concentrations or doses, duration, frequency and routes of exposure for the chemicals of potential concern and for all pertinent exposure pathways. Effects Assessment is the process of assembling information on chemical exposure conditions that cause particular effects and developing exposure limits based on preventing effects or minimizing them to levels deemed to be acceptably low by regulatory agencies. For humans, Effects Assessment is often based upon daily exposure limits developed primarily by regulatory agencies such as Health Canada or the U.S. EPA for each of the chemicals of concern. For wildlife, Effects Assessment is based on a literature review to help develop exposure limits from animal studies.

5.1.2.1 Exposure Assessment

Exposure Assessment is the process of describing and quantifying exposure concentrations and doses for the chemicals of concern and for all pertinent exposure pathways identified during the Problem Formulation phase. This includes analysis of the magnitude, duration, frequency and route of exposure to chemicals using data on (1) chemical sources, (2) chemical distributions in water, soil and biota and (3) for wildlife, considerations of their ecology. A combination of data collection, modelling, literature review and professional judgment are utilized.

People:

This section presents the methods and results for estimating the intake rate (dose) of chemicals associated with on-site, post-reclamation exposures. Exposures by people are assumed to occur only in the "long-term", post-reclamation time frame because access to the site will be restricted until that time. It was assumed that a trapper would be the end user receiving the highest exposure to the reclaimed site. Given that the receptors are assumed to be hunters and trappers, younger receptors (infants and children) were not evaluated. Adults are assumed to reside on-site throughout the year. This is likely to be a conservative assumption given the probable seasonal nature of their activities.

It was assumed that the hypothetical trapper would reside on the reclaimed site throughout the year (i.e., 365 days/year), live on the site from ages 20 to 70 years (Health Canada 1994a), obtain 25% of all food (both meat and plants) directly from the site and obtain all drinking water from the Athabasca River. Other exposure pathways (incidental ingestion of CT, fugitive dust inhalation, dermal exposures to CT) are assumed not to occur since the proposed capping scheme will prevent direct access to CT.

Intake rates for meat and plant ingestion are estimated from (Health Canada 1994a):

$$\text{Intake} = \frac{IR \times BA \times C_{meat/plant} \times EF \times ED \times SC}{BW \times AT} \qquad (5.1)$$

where:

Intake = chemical intake by meat consumption (mg chemical/kg body weight/day)

IR = ingestion rate (meat: adults = 0.183 kg/day; plant: adults = 0.436 kg/day) (Health Canada 1994a)

BA = oral bioavailability of compound (chemical-specific, unitless)

$C_{meat/plant}$	=	chemical concentration in meat or plant (mg /g; upper 95th percentile used for deterministic modelling)
EF	=	frequency of exposure (365 days/year)
ED	=	duration of exposure (adult = 50 years)
SC	=	site contribution (0.25, unitless)
BW	=	receptor body weight (adult = 70 kg)
AT	=	averaging time (years; *ED* for noncarcinogens; 70 years for carcinogens)

The fraction of ingested meat and plants that is assumed to be affected by or grown in the reclaimed landscape was set at 25%. That value is based on two considerations: it is unlikely that many of the game animals will live and obtain food from within the reclaimed area; and it is also unlikely that on-site residents will obtain a large portion of their food from the relatively small area of the reclaimed site.

Chemical concentrations assumed for meat were based on mean concentrations measured in the muscle of a buffalo that grazed in a pasture in a reclaimed tailing sands area (Table 5.1-31). It is reasonable to use muscle data for this assessment because muscle tissue represents the largest source of edible meat from a buffalo. Benzo(a)anthracene and benzo(a)pyrene concentrations were not detected and were thus set at zero.

Inorganic chemical concentrations in plants were set at upper 95th percentile concentrations measured in terrestrial plants (willow and poplar) growing in: acid/lime CT; muskeg and CT; and sand, muskeg and CT (Xu 1995, 1996; Table 5.1-31). Organic chemical concentrations in plants were modeled using the method presented in Travis and Arms (1988). This model provides reasonable estimates of tissue concentrations for plants grown in MFT deposits (Golder 1994a) and is thus expected to provide reasonable estimates for plants grown on reclaimed landscapes.

Exposure to chemicals through ingestion of water is calculated using the following equation:

$$\text{Intake} = \frac{IR \times BA \times C_{water} \times EF \times ED}{BW \times AT} \qquad \textbf{(5.2)}$$

where:

Intake	=	chemical intake from water consumption (mg chemical/kg body weight/day)
IR	=	ingestion rate (adults = 1.5 L/day) (Health Canada 1994a)
BA	=	oral bioavailability of compound (chemical-specific, unitless)
C_{water}	=	chemical concentration in water (mg /L)
EF	=	frequency of exposure (365 days/year)
ED	=	duration of exposure (adult = 50 years)
BW	=	receptor body weight (adult = 70 kg)
AT	=	averaging time (years; ED for noncarcinogens; 70 years for carcinogens)

Chemical concentrations in Athabasca River water were modeled as described in Golder (1996a; Table 5.1-31); upper 95 percentile concentrations were used in this assessment.

Oral bioavailability is used to estimate the amount of a chemical which will enter the bloodstream following ingestion of the chemical. This is an important issue because many chemicals exert their toxic effects only following absorption, which is a chemical-specific process. For the human health risk assessment, the oral bioavailability of each chemical via ingestion is assumed to be 100%. This is a conservative assumption since it implies that all of an ingested chemical is absorbed into the blood. A more refined assessment of bioavailability may indicate that absorption is significantly less than 100%.

Using the equations and parameter values presented above, the calculated intake values are given in Table 5.1-32. These intake rate calculations are preliminary. The available input data, upon which the intake rate calculations are based, are changing rapidly and being updated as the study continues. Also, human health intake does not take into account background chemical exposures, and therefore, exposure ratios represent incremental exposure to chemicals via exposure to the mine-affected site.

<u>Wildlife:</u>

As discussed in section 5.1.1.5, the assessment endpoint for the assessment of wildlife health impacts is the protection of populations of wildlife species present. An exposure model was therefore developed to assess the potential for population level effects for terrestrial wildlife exposed to chemicals associated with CT reclaimed landscapes. The model incorporates information on the spatial distribution of chemicals within the landscape as well as foraging and movement of the wildlife species. For this model, a wildlife species population was defined as the hypothetical population bounded by the regional study area which includes both mine-site affected areas and natural areas.

Exposure pathways include ingestion of seven (7) different food and water types that may be present within fifteen (15) different ELCs associated with the reclaimed landscape. Each ELC may contain up to eight (8) different soil types (7×15×8=840 possible exposure sources). Depending upon the receptor, exposure may occur due to ingestion of water, invertebrates (aquatic or terrestrial), vertebrates (aquatic or terrestrial) and/or plants (aquatic or terrestrial) growing on the reclaimed landscape. The amount consumed by a given receptor is determined by ingestion rates and foraging ranges of each species, which were assigned a probabilistic distribution following a literature review (Table 5.1-33). It was assumed that each species would move randomly among the preferred habitat types.

The wildlife exposure model predicted chemical concentrations in food (vegetation, vertebrates, invertebrates and water) expected for the reclaimed landscape. The model then computed a dose by randomly selecting foraging areas for each wildlife species according to foraging preferences and areas for each species. By repeating this exposure calculation many times, an estimate of the dose distribution that might be expected for the regional population was determined.

Daily intake rates were estimated for water, plant and prey (mg chemical per kg-body weight per day) according to (EDI_{water}, EDI_{plant}, and EDI_{prey} respectively):

$$EDI_{water} = \frac{R_{water} C_{water} f}{BW} \qquad (5.3)$$

$$EDI_{plant} = \frac{R_{plant} C_{plant} f}{BW} \qquad (5.4)$$

$$EDI_{prey} = \frac{R_{prey} C_{prey} f}{BW} \qquad (5.5)$$

where:

R	=	ingestion rates of soil, water, plants and prey (kg dry weight per day, except water, L per day)
f	=	fraction of food, water and soil derived from the site (receptor specific; unitless)
C	=	chemical concentration in water, plants and prey (mg/kg in plants and prey, mg/L in water)
BW	=	receptor body weight (receptor specific; kg)

Because of the uncertainties associated with wildlife parameter estimates, a probabilistic assessment was used to quantify intake rates. The probabilistic method offers advantages over deterministic (single point) methods. First, all valid data collected from the site and obtained from the scientific literature can be incorporated into the analysis, rather than limiting the analysis to a single data point or study. Second, the approach provides an accurate estimate of the upperbound or maximum plausible risk, since statistically-derived input distributions are used in the models rather than single upperbound values. Third, the results of the probabilistic assessment provide a quantitative estimate of the conservatism of the deterministic point estimate of risk, i.e., the probability of occurrence of the deterministic risk estimate can be identified. Fourth, the probabilistic analysis can be used to identify the variables that are most strongly affecting predicted exposure estimates (i.e., through the use of uncertainty analysis). These features provide valuable additional information for making informed decisions about reclamation options.

Intake rate distributions are estimated by modelling the exposure of a typical individual using probabilistic input parameters, then repeating the simulation for 500 iterations using Monte Carlo simulation. Monte Carlo simulation is the process of estimating the intake rate using random deviates for each input in the mathematical equations, then repeating the calculations with new random deviates on each cycle of the simulation, to determine the distribution of possible outcomes. Each iteration consists of a unique set of input values, which are specified by sampling the input parameters from assumed probability distributions. The iterations are repeated many times, such that the full range of the input distributions are adequately sampled in combination with the ranges from other input distributions. The Monte Carlo simulation was conducted using Excel© with Crystal Ball.©

Foraging and movement patterns of wildlife were accounted for by assuming that each species would prefer specific habitat types for foraging, and that ELCs could be used to represent preferred habitats. The landscape of the reclaimed terrain has been classified using 15 ELC units as discussed in Section 4.2.2. Each wildlife species' preference towards specific ELCs was taken into account by specifying the likelihood that a particular species will visit a specific ELC unit on the reclaimed mine site and the surrounding region, based on each species' habitat preferences (see Section 4.2.5 and Table 5.1-34). The number of ELC areas selected by a specific species is dependent on the size of a species home range and the size of the ELC area. The foraging areas that would be used by each species were selected randomly in the model based on information in Table 5.1-34.

The spatial distribution of chemicals in the reclaimed landscape was accounted for in differences of food tissue concentrations, where tissue concentrations were assumed to vary as a function of reclamation material. Specifically, the reclaimed mine site is divided into eight soil types: natural, CT covered with sand, gypsum, overburden, coke pile, other (primarily the old Suncor processing site), sand dykes plus open water areas. Chemical concentrations in soil, and the approaches used to estimate plant and animal tissue concentrations, are described in Section 4.1.1

A chemical fate model was used to predict chemical concentrations in environmental media and biota when measured concentrations were not available. Predicted concentrations were then used as input concentrations for the wildlife exposure model. In particular, exposure point concentrations are required for water (Athabasca River and on-site surface water for wildlife), plant and animal tissues.

The concentrations of the chemicals of potential concern in waters will be highly variable within the reclaimed landscape, given the diversity of sources (CT release water, groundwater seepage and surface runoff from many different reclamation units). Estimates of on-site concentrations were made using a mixing model, where the various on-site waters combine at several nodes prior to discharge to the Athabasca River (see Golder 1996a for a detailed description of this model). These on-site surface waters are assumed to be available to wildlife as a source of drinking water and are composed of water from south mine drainage discharge point, TID seepage, wastewater discharge point, mid-plant drainage discharge point, Pond 4 seepage, north mine drainage point, Pond 5 seepage and Pond 6 seepage. These on-site concentrations represent worst-case conditions since biodegradation processes (e.g., wetlands processing) were not accounted for in the water quality model.

Soil concentration data were required since chemical concentrations in plant and terrestrial invertebrate tissues were based on bioconcentration models. The mine landscape will have four soil types for the purposes of the risk analysis modelling: natural soil (the chemistry of which was derived from available data on the overburden and clay-shale soils), gypsum, CT and beach sands. For the final reclamation landscape, sand will be used as a capping layer to the process-affected material such as CT. However, for this assessment it was assumed that plants and soil invertebrates would be exposed directly to the reclamation deposits (e.g., CT). Measured soil concentrations were available for each of the four soil types (Table 5.1-35).

Chemical tissue data for terrestrial plants and aquatic plants were available from laboratory experiments of plants grown in acid-lime soil (Xu 1995, 1996). Site specific bioconcentration factors were derived from these data. Tissue concentrations for plants growing on the four soil types were determined using:

$$C_{plant} = BCF_{plant}\, C_{soil} \qquad \textbf{(5.6)}$$

where C_{soil} (mg/kg) is the chemical concentration in the soil, BCF_{plant} is the chemical-specific bioconcentration factor and C_{plant} (mg/kg) is the estimated plant concentration, see Table 5.1-36.

Soil invertebrate tissue concentrations were required to compute doses for wildlife that feed on this food source. Soil invertebrates were divided into terrestrial and aquatic groups. The terrestrial invertebrate food group tissue concentrations were predicted based on soil concentrations, C_{soil}, (mg/kg) and terrestrial invertebrate prey bioconcentration factors, BCF_{TIP}. Tissue concentrations in terrestrial invertebrate prey were determined according to:

$$C_{TIP} = BCF_{soil} C_{soil}. \quad \mathbf{(5.7)}$$

where C_{TIP} [mg/kg dry wt] is the chemical concentration in the terrestrial invertebrate prey. Aquatic invertebrate prey tissue concentrations, C_{AIP}, (mg/kg) were estimated based on observed concentrations in organisms collected from experimental wetlands (Table 4.1-5).

Benzo(a)pyrene is the only chemical of potential concern with respect to vertebrate prey, which is a food source for American kestrel. In general, PAHs show little tendency to biomagnify in food chains since they are rapidly metabolized (Eisler 1987). The biological half-life of PAHs is extremely rapid, for example, benzo(a)pyrene in rat blood and liver had a half-life of 5-10 minutes. In addition, PAHs also show little tendency for bioaccumulation (e.g., most food contains 1-10 μg total PAH/g fresh weight). There was no evidence of bioconcentration in vertebrates collected in the regional study area; concentrations of benzo(a)pyrene measured in duck, muskrat and bison were all less than detection limit (<0.002 mg/kg). Therefore, vertebrate prey tissue concentrations used in the simulation were taken from available measured concentrations of benzo(a)pyrene (<0.002 mg/kg; Table 4.1-6).

In summary, a wildlife exposure model was developed to compute chemical intake for wildlife populations, taking into account spatial differences in chemical concentrations and use of the reclaimed landscape. Intake rates for individuals within the regional study area were estimated as follows:

1. Predict chemical concentration distribution for water, soil, plants and animals within the reclaimed landscape.
2. Assume each species forages randomly within the regional study area based on preferences for habitat, as defined by ELC type.

3. Simulate the movement of an individual within the regional study according to its foraging habitat.
4. Compute chemical intake rates according to Eq. (5.3) to (5.5).
5. Repeat steps (3) and (4). The number of ELC areas the individual moves to depends on the foraging requirements of the species and the area of the ELC type. If the species foraging area requirement is greater than the area of the selected ELC, additional ELC areas are added to the forage range for the individual until its foraging requirements are met.
6. Repeat steps (2) to (5) for many individuals. On each loop, a new set of input parameters are selected based on random sampling of the input data distributions.

Thus, output from this process represents the intake rate distribution expected for all individuals of a given species within the regional study area (Table 5.1-37). The table shows relative proportions of doses received from different exposure pathways. For nearly all receptors and chemicals, ingestion of plants is the single most important exposure pathway.

The intake rate estimates presented here are preliminary, since the chemical database on which the calculations are based is rapidly expanding. Also, the wildlife rate estimates presented here assume background exposures are nil, therefore, the intake rates represent incremental doses resulting from exposure to the reclaimed landscape.

5.1.2.2 Effects Assessment

Effects Assessment is the identification and quantification of the chemical concentration or dose above which exposure to a receptor might cause an adverse effect (U.S. EPA 1988a). In this section of the report, available toxicological data were compiled for each chemical of potential concern for people and wildlife.

<u>People:</u>

The effects assessment section presents toxicity information used to provide qualitative and quantitative estimates of health effects associated with exposure to site chemicals. The human health effects assessment considers both the cancer or noncancer (threshold) effects that a chemical may cause. Quantitative toxicity reference values (i.e., exposure limits) used to evaluate carcinogens are called Risk Specific Doses (RsDs); toxicity values used to evaluate noncarcinogens are called Reference Doses (RfDs).

Reference values are daily exposure rates that could occur over a lifetime of a sensitive person without causing any measurable, adverse effect. These values are based on information on concentrations or doses of chemicals that cause particular effects. This information is usually available through toxicological databases such as IRIS (*Integrated Risk Information System)*; RTECS (*Registry of Toxic Effects of Chemical Substances*); TOXLINE (*Toxicology information on-line*); MEDLINE (*Medlars on-line*); HSDB (*Hazardous Substances Databank*) and OHMTADS (*Oil and Hazardous Materials/Technical Assistance Data System.*

Carcinogens are assumed not to exhibit a dose-response threshold since mutations in the DNA are passed on from one cell generation to the next generation (assuming no repair); therefore, effects are assumed even at doses approaching zero. For such chemicals, an exposure limit is derived from mathematical models that estimate a unit risk carcinogenic slope factor (depending on potency) from which an RsD is developed. The RsD is calculated from the carcinogenic slope factor by dividing the lifetime risk of cancer development by the slope factor value (i.e., RsD = 1 $x10^{-5}$/slope factor).

Benzo(a)pyrene has been classified as a B2 carcinogen indicating that benzo(a)pyrene is a probable human carcinogen based on sufficient evidence from animal experiments but inadequate or limited evidence from human exposure data. An oral slope factor of 7.3 mg/kg-day was developed based on stomach tumours (U.S. EPA 1996); hence the RsD is 1.4×10^{-6} mg/kg-day.

Although benzo(a)anthracene has been classified as a B2 carcinogen indicating that benzo(a)anthracene is a probable human carcinogen, a slope factor has not been developed for benzo(a)anthracene (U.S. EPA 1996). However, the carcinogenic potency of certain PAHs, such as benzo(a)anthracene, can be estimated by using toxicity equivalency factors (TEFs). TEFs are unitless factors used to estimate the carcinogenicity of carcinogenic PAHs. The approach simplifies the evaluation of PAHs by relating their carcinogenic potential to that of benzo(a)pyrene. The TEF for benzo(a)anthracene used in this report (0.1) was provided by the U.S. EPA (1992b) memo "Risk Assessment for Polyaromatic Hydrocarbons". An oral slope factor for a particular PAH is calculated by multiplying the oral slope factor of benzo(a)pyrene by the associated TEF for that PAH. For example, the slope factor for benzo(a)anthracene is 7.3 mg/kg-day x 0.1 = 0.73 mg/kg-bw/day, hence the RsD is 1.4×10^{-5} mg/kg-day.

Copper, manganese, molybdenum and naphthenic acids are not evaluated for their carcinogenic potential. Manganese falls within the Group D Class (not classifiable as to human carcinogenicity). Copper and molybdenum have not been assigned to a group. There are insufficient data with which to classify naphthenic acids with respect to carcinogenic potential.

For noncarcinogens, the exposure limit used in this assessment is a chemical's RfD. An RfD is defined as an estimate of a daily exposure level for the human population, including sensitive populations, that is likely to be without an appreciable risk of deleterious effects during a lifetime. Chronic RfDs are specifically developed to be protective for long-term exposure to a compound.

To date, there are insufficient mammalian toxicological data to calculate a defensible RfD for naphthenic acids (Appendix IV). RfDs are normally calculated based on chronic or subchronic studies in laboratory animals. Currently, there are only acute toxicity mammalian data available for naphthenic acids. Methylcyclohexane has been used as a surrogate for determining the RfD for naphthenates (Syncrude 1993). If methylcyclohexane had been used to derive an RfD for naphthenates, then we would have concluded that naphthenates pose no risk to human health under the exposure scenarios discussed above. However, upon further review, we have concluded that methylcyclohexane was not an adequate surrogate because of the differences in ring chemistry (e.g., planarity, number of rings), substituted side chains (methyl versus carboxylic acid, alkyl, allyl, aryl and functional-substituted chains), polarity (nonpolar versus polar/bipolar), surfactant properties (hydrophobic versus bipolar with high degree of surfactant action), molecular weight (low versus medium to high) and salt formation capacity (none versus high probability). In addition, the toxicity information available for methylcyclohexane is limited to short-term toxicity determinations with high concentrations. The toxicity of naphthenic acids is, therefore, identified as a data gap. Intakes of naphthenic acids are presented (as shown in Section 5.1.2), but these intakes are not interpreted with respect to impacts on human health.

RfD values have not been developed for benzo(a)pyrene and benzo(a)anthracene. However, if RfDs for these chemicals were to be identified, it is likely that their carcinogenic potential would be of greater concern.

The RfD for copper (0.04 mg/kg-day) is based on a "safe and adequate" intake for adults that protects against the adverse health effects associated with copper deficiency; that is, the level 0.04 mg/kg-day represents the upper end of the recommended daily allowance for copper. A World Health Organization expert committee on food additives concluded that a copper intake (from dietary sources) as high as 0.5 mg/kg-day would not result in adverse health effects (U.S. EPA 1991). An RfD range of 0.04 to 0.07 mg/kg-day for an RfD has been suggested by U.S. EPA (1991).

The RfD for manganese in water (0.005 mg/kg-day) is provided by U.S. EPA (1996). Manganese is an essential element found in varying amounts in all diets. For comparison, the average daily intake of manganese in water is estimated to be 0.008 mg/kg-day (ATSDR 1991). The LOAEL for manganese in water (0.06 mg/kg-day, U.S. EPA 1996) is approximately ten times the RfD.

The RfD for manganese in food is based on a NOAEL of 10 mg/day which is considered to be safe for an occasional intake by the National Research Council. The RfD for manganese (0.14 mg/kg-day) is equal to the NOAEL divided by the body weight of an adult (70 kg). The Food and Nutrition Board for the NRC (NRC 1989) has also determined an "adequate and safe" intake of manganese to be 2-5 mg/day; this level represents a recommended daily allowance. For comparison, an average daily intake of manganese in food is estimated to be 3.8 mg/day (ATSDR 1991).

Molybdenum is an essential dietary nutrient which has established Estimated Safe and Adequate Daily Intake values of 0.002-0.004 mg/kg-day for infants, 0.002-0.005 mg/kg-day for children, and 0.002-0.004 mg/kg-day for adults (NRC 1989). The RfD (0.005 mg/kg-day) is formed from a LOAEL (0.14 mg/kg-day) that is based on an epidemiological study correlating the dietary intake of molybdenum with serum uric acid levels in a human six year-to-lifetime dietary exposure study (U.S. EPA 1996).

Reference values are summarized in Table 5.1-38.

Wildlife:

Exposure limits for terrestrial wildlife are based on the daily exposure rates that may occur over a lifetime, without causing any measurable, adverse effect on typical individuals from the population. Chronic oral NOAELs were derived for all chemicals of concern since ingestion is the most significant pathway of exposure for terrestrial wildlife.

The general method used to derive chronic NOAELs for wildlife species is based on U.S. EPA methodology for deriving human toxicity values from animal data (U.S. EPA 1986a; 1986b; 1988b, 1989b). For this assessment, experimentally derived NOAELs and LOAELs were used to estimate receptor-specific NOAELs for wildlife by adjusting the dose according to differences in body size as outlined in the Opresko et al. (1994):

$$NOAEL_{wildlife} = NOAEL_{test} (BW_{test} / BW_{wildlife})^{1/3}$$

where:

$NOAEL_{wildlife}$	=	receptor-specific adjusted NOAEL
$NOAEL_{test}$	=	test species NOAEL (derived experimentally)
BW_{test}	=	body weight of the test species
$BW_{wildlife}$	=	body weight of the wildlife receptor species

NOAELs and LOAELs for terrestrial wildlife were obtained from several sources including the Opresko et al. (1994); U.S. Fish and Wildlife *Contaminant Hazard Reviews*, on-line searches of toxicological databases (*TOXLINE/MEDLINE*), and a general review of the available toxicological literature. If there was a lack of wildlife data, the EPA's on-line database, Integrated Risk Information System (*IRIS*), was searched and the NOAEL or LOAEL from the best available laboratory animal study was chosen. These data were reviewed and the most appropriate available NOAEL or LOAEL was chosen from the most appropriate study and was used to calculate the chronic receptor-specific NOAEL. In general, the lowest NOAEL or LOAEL for the most sensitive species is used to derive the chronic NOAEL. Consequently, a high degree of conservatism is built into the chronic NOAEL, and it is likely that the chronic NOAEL is an overestimate of the dose that would cause potential effects to wildlife populations. The rationale for deriving the chronic NOAELs for each of the chemicals of potential concern are outlined in Appendix IV.

If a NOAEL was not available for either wildlife or laboratory species but a LOAEL has been determined experimentally, the NOAEL can be estimated by applying an uncertainty factor to the LOAEL to account for the difference between an observed effect and the threshold for no effects. In the U.S. EPA methodology, the LOAEL can be reduced by a factor of <10 to derive the NOAEL (i.e., NOAEL = LOAEL/<10). Although a factor of 10 is usually used in the calculation, the true NOAEL may be only slightly lower than the experimental LOAEL, particularly if the observed effect is of low severity. For this assessment, an uncertainty factor of 10 was used to extrapolate from the LOAEL to the NOAEL.

If the only data available consists of a NOAEL or LOAEL for subchronic exposure, then the equivalent NOAEL or LOAEL for a chronic exposure can be estimated by applying an uncertainty factor of ≤10 (i.e., chronic NOAEL = subchronic NOAEL/10). The minimum requirement for subchronic exposure is 90-days for mammalian species and 28-days for avian species (U.S. EPA 1993c). Exposure is considered to be chronic if it exceeds greater than 50% of a species lifespan. For this assessment, an uncertainty factor of 10 was applied to extrapolate from subchronic exposure to chronic exposure for wildlife.

In addition to duration of exposure, the time when chemical exposure occurs is critical. Reproduction is a very sensitive lifestage due to the stressed condition of the adults and the rapid growth and differentiation occurring within the embryo. For many species, chemical exposure of a few days to as little as a few hours during gestation and embryo development may produce severe adverse effects. Since the chronic NOAELs are intended to evaluate the potential for adverse effects on wildlife populations and impaired reproduction is likely to affect populations, chemical exposures that are less than one year (mammals) or ten weeks (birds) but occur during reproduction were considered to represent chronic exposures.

Cancer risks were not considered for wildlife. Threshold-response effects such as reproductive and developmental toxicity were considered to be more appropriate than cancer effects for wildlife, given that impaired reproduction rather than cancer is more likely to affect populations of wildlife (Opresko et al. 1994). In addition, cancer effects often take many years to develop whereas threshold effects tend to produce more immediate toxic effects on wildlife populations.

Table 5.1-38 summarizes the RfDs derived for wildlife.

5.1.3 Risk Characterization

Risk Characterization is the integration of information from Exposure and Effects Assessments. It involves a quantitative comparison of estimated chemical dose to the chemical exposure limits. Moreover, the results of the risk assessment are discussed with respect to the types and extent of effects to assess the relevance of these findings.

In particular, Exposure Ratios (ER) are calculated as the ratio of the predicted dose to the reference value. For non-carcinogenic chemicals, an ER value of less than one represents exposure scenarios that do not pose a significant health risk to exposed individuals and wildlife (Environment Canada 1994, Health Canada 1995).

ER = (chronic daily intake) / (RfD)

For carcinogenic chemicals, an ER value that is less than one indicates that the rate of intake for a chemical or group of chemicals is less than that attributed to an incremental lifetime risk of cancer of one per 100,000 individuals ($1x10^{-5}$), which does not pose a significant health risk to exposed individuals (Health Canada 1995). It is important to note that ER values greater than one do not necessarily indicate that adverse health effects will occur. However, when the ER is greater than one, the scenarios pose a potential concern and require further investigation.

ER = (chronic daily intake) / (RsD)

5.1.3.1 People

An ER is calculated for each chemical of concern and for each exposure scenario. Using the intake values presented in Section 5.1.2.2.1 and the exposure limits presented in Section 5.1.2.3, Table 5.1-39 lists the ERs for the meat, water and plant ingestion pathways.

An ER value greater than 1 means that the predicted exposure for a chemical exceeds its associated exposure limit, suggesting that an adverse human health effect may occur. Conversely, an ER value less than 1 suggests that adverse health effects are not expected to occur.

The Exposure Ratio value for copper is below one, therefore, this chemical does not pose a significant health risk to exposed individuals (Health Canada 1995). This result suggests that residential exposure to this chemical at the reclaimed Suncor site would not cause adverse effects for the scenario investigated here.

Exposure Ratio values were slightly greater than one for the other chemicals. These relatively high values are attributable primarily to ingestion of plants (Table 5.1-39). However, it is probable that this exposure pathway will be effectively eliminated by the proposed capping sequence using sand and muskeg. In addition, because this assessment was based on multiple conservative assumptions, the actual health risks are likely to be considerably lower than those suggested by the ER values and may be as low as zero. Notwithstanding these mitigating factors, ER values above one indicate that intake of plant food from the reclaimed landscape is an issue that requires further scrutiny.

In reporting the results of the risk assessment, it is necessary to consider the uncertainty associated with ER estimates. An examination of each of the input parameter values indicates that they are biased in a way that tends to overestimate the estimate (also known as a conservative or protective bias). For example, exposure point concentrations represent a 95% confidence limit on the mean annual concentration. Exposure parameter values represent reasonable maximum exposure values; that is, they are reasonable upper bounds and not average values. Bioavailability is set to a maximum value (100%). Exposure limits for noncarcinogens are designed to be protective of sensitive populations under chronic exposure conditions.

As indicated in Section 5.1.2.3, benzo(a)pyrene and benzo(a)anthracene are classified as B2 (probable human) carcinogens (U.S. EPA 1996). Human data specifically linking these chemicals to a carcinogenic effect are lacking. There are, however, animal studies in several different species demonstrating benzo(a)pyrene to be carcinogenic following administration by numerous routes. Benzo(a)anthracene is a component of mixtures (e.g., coal tar, soots, cigarette smoke) that have been associated with human cancer. It is not possible, however, to conclude from this information that benzo(a)anthracene is the responsible agent. In spite of this lack of direct evidence of human carcinogenicity, cancer risks are calculated as if the slope factor represent carcinogenic potential to people.

With respect to the confidence in the effects assessment for manganese, it is important to consider a number of factors. In spite of the low uncertainty and modifying factors, confidence in the RfD is classified as medium. While several studies have determined average levels of manganese in various diets, no quantitative information is available to indicate toxic levels of manganese in people's diet (U.S. EPA 1996). Because of the homeostatic control people maintain over manganese, it is generally not considered to be very toxic when ingested with the diet. It is important to recognize that while the RfD process involves the determination of a point estimate on an oral intake, it is also stated that this estimate is associated with uncertainty spanning perhaps an order of magnitude. All of this information suggests that manganese may not be as toxic as suggested by the current RfD.

It is important to note that molybdenum is an essential dietary nutrient, and that the oral RfD is equal to the upper limit of recommended daily allowances (0.005 mg/kg-day). An exposure ratio of 3 means that intake is three times this recommended daily allowance (or 0.015 mg/kg-day). There is no evidence that such an exposure level results in adverse health effects. This level of exposure is still ten times lower than the lowest observed adverse effects level of 0.14 mg/kg-day.

In addition to these conservative biases of the individual input parameters, the use of multiple conservative assumptions itself mathematically compounds the conservative bias in the ER values. Consequently, cancer risk estimates are likely to be lower than those reported here, and ER values greater than 1 do not necessarily represent a human health concern.

5.1.3.2 Wildlife

Ecological risks are a function of the severity of ecological effects, the area over which effects occur, and the duration of effects (Suter et al. 1995). However, there is no standard scale for defining bounds that represent *de minimis* or *de manifestis* risk. *De minimis* risks include mild, transient or localized effects on ecological entities. *De manifestis* risks include risks that are severe, long-lasting or widespread. The severity, extent and duration of estimated effects on these entities are attributes that help define whether risks are *de minimis* or *de manifestis* (Suter et al. 1995).

Suter et al. (1994) outlined a convincing argument suggesting that a 20% reduction in ecological parameters (e.g., growth, fecundity) would be indistinguishable from normal variability and should be considered as an "effect threshold" in characterizing ecological risks. This argument is based on a practical assessment of the limitations in measuring changes in wild populations, statistical changes in laboratory studies and on the basic principles of population ecology. Citing examples from currently accepted practices in aquatic and terrestrial assessments, a change of 20% or greater is required to distinguish the change from normal background variability, implying that a 20% or less reduction in ecological parameters could be considered *de minimis* with respect to potential severity of the estimated effect.

Similarly, the extent of the potential impact also is important in characterizing risk. For example, a potential effect on only a few individuals is insignificant with respect to populations of small mammals such as deer mice but may be significant with respect to threatened and endangered species. For this assessment, *de minimis* risks were defined as those in which 20%

or fewer of the individuals in a non-threatened or endangered population are potentially affected by exposure to the site.

Similarly, the duration of exposure and the effect is of importance in characterizing risks. For example, potential effects that are short-lived (e.g., less than one generation) will have no long-term impact on a population. In contrast, the same effect sustained over several generations may pose significant ecological risks to the population.

This information is brought together in the Risk Characterization phase of the assessment, using a weight of evidence approach to assess whether the site poses a significant health risk to wildlife populations.

For wildlife, Exposure Ratios (*ER)* were computed as discussed above, where:

ER = Intake / [Exposure Limit (RfD)]

An ER value greater than 1 means that the predicted exposure for a chemical exceeds its associated exposure limit, suggesting that an adverse health effect may occur. Conversely, an ER value less than 1 suggests that adverse health effects are not expected to occur.

For this assessment, distributions of exposure concentrations and doses were derived using Monte Carlo simulations. An ER was calculated for each chemical of concern identified for specific wildlife species as described in Section 5.1.1.2. The results of the ER calculations are given in Appendix VI and summarized in Table 5.1-40. This table also gives the proportion of the individuals within the simulated population for which ERs are greater than 1. In other words, this represents the proportion of the population that might be adversely affected by exposure to the site.

ER values for benzo(a)pyrene, barium, nickel, strontium, thallium, uranium and zinc were below one for all simulations and wildlife species modelled (Figure 5.1-7). Therefore, risks to wildlife associated with exposure to these chemicals were considered to be *de minimis*.

ER values exceeded one for less than 20% of the simulations for seven cases: intake of aluminum by deer mice, arsenic by beaver, cadmium by moose, molybdenum by beaver, molybdenum by deer mice, vanadium by deer mice and vanadium by snowshoe hare (Figure 5.1-7; Table 5.1-40). Thus, there is no risk to the viability of wildlife populations living at the reclaimed site from exposure to these chemicals.

ER values exceeded one for more than 20% of the simulations for four cases: cadmium by beaver, cadmium by deer mice, cadmium by snowshoe hare and vanadium by beaver (Table 5.1-40; Figure 5.1-7). Therefore, the health risks associated with these chemicals were considered to be *de manifestis.* In all cases, the pathway driving the risk is ingestion of plants (Table 5.1-37). However, there are several mitigating factors that need to be considered:

- Data used for the quantitative risk assessment modelling were derived from experimental studies in plants grown directly in CT (Xu 1995, 1996).
- The CT used in the experiments was acid-lime and might be different from gypsum-treated CT that is to be used for the reclamation area.
- The proposed capping scheme includes a layer of sand and muskeg over the CT. This layer will provide a direct barrier between the plants and the CT, thus, reducing or eliminating intake via plant ingestion.

In addition, a number of conservative assumptions were incorporated into the Exposure and Effects Assessments, including:

- water concentrations represent worst-case conditions since biodegradation processes (e.g., wetlands processing) were not accounted for in the water quality model;
- plants and soil invertebrates (i.e., food sources) were assumed to be exposed directly to the reclamation deposits (e.g., CT);
- all wildlife species, with the exception of migratory species, were assumed to frequent the area year-round; and
- the lowest NOAEL or LOAEL for the most sensitive species was used to derive the chronic NOAEL for the effects assessment.

Because this assessment was based on multiple conservative assumptions, the actual health risks are likely to be considerably lower than those suggested by the ER values and may be as low as zero. Nonetheless, the findings of the study indicate that intake of plant food from the reclaimed landscape is an issue that requires further scrutiny.

5.2 Regional Off-Site Effects

A detailed investigation of regional off-site effects were reported in Golder (1996a) and are summarized below.

5.2.1 Aquatic Biota

Three separate approaches were used to investigate potential impacts on aquatic biota: chemical-specific wasteload allocation, toxicity testing and a risk-based assessment.

The chemical-specific wasteload allocation approach indicates that it is unlikely that Suncor's release waters either are currently affecting or will in the future affect aquatic biota in the Athabasca River.

There is no evidence from the battery of laboratory toxicity tests used that the cumulative impact from operational and reclamation waters will adversely affect ecosystem health in either the Athabasca or Steepbank Rivers.

Similarly, the risk-based assessment of fish health suggest that it is extremely unlikely that fish populations either are currently being affected or will, in the future be affected by the cumulative releases of operational and reclamation waters associated with oil sands operations. These predictions are supported by observations of current fish populations, which have been exposed to water releases from Suncor operations for the past three decades. These populations continue to successfully utilize habitat in the Suncor study area, and exhibit normal growth and reproduction. Since future concentrations of water releases to the Athabasca River are predicted to be lower than current conditions, future populations of fish should continue to be healthy.

5.2.2 People

A quantitative, human health risk assessment was conducted to examine potential health effects associated with the release of operational and reclamation waters from oil sands operations. The potential for exposure to these chemicals was investigated by estimating the chemical dose that people might receive who occasionally drink water or swim in the Athabasca River, downstream of Suncor's operations. The results of the risk assessment indicated that the use of the Athabasca River, downstream of Suncor's operations, does not currently or will not in the future pose a risk to people's health.

5.2.3 Wildlife

No chemicals of concern were identified with respect to off-site exposure to wildlife. Hence, no adverse effects on terrestrial wildlife from current or proposed water releases are expected.

6.0 CONCLUSIONS

A preliminary assessment was conducted to examine risks to people and wildlife associated with the use of Suncor's reclaimed landscape. The assessment was based on limited data; additional data are being collected and, in future, should be incorporated to more accurately predict risks to people and wildlife using the site. Nonetheless, this preliminary assessment provides useful information and identifies the primary issues of concern for people and wildlife using the reclaimed landscape.

6.1 People

A quantitative risk assessment was conducted to examine the potential health risks for a hypothetical adult trapper who might live year-round on the reclaimed landscape. That individual was assumed to obtain all of his/her drinking water from the Athabasca River and obtain 25% of his/her food directly from the site. The findings of the study indicate that with the possible exception of a few chemicals, health risks associated with the use of the reclaimed site are negligible. One issue that requires additional investigation is chemical uptake of plants grown on the reclaimed landscape and use of these plants as a source of food. However, it is likely that this exposure pathway will be effectively eliminated by the proposed capping sequence using sand and muskeg.

6.2 Wildlife

A quantitative risk assessment was conducted to examine the potential health risks for representative wildlife species, American kestrel, mallard, deer mice, beaver, snowshoe hare, ruffed grouse and moose, that might use the reclaimed landscape. The findings of the study indicate that with the possible exception of a few chemicals, wildlife health risks associated with the use of the reclaimed site are negligible. One issue that requires additional investigation is chemical uptake of plants grown on the reclaimed landscape and use of these plants as a source of food. However, it is likely that this exposure pathway will be effectively eliminated by the proposed capping sequence using sand and muskeg.

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8.0 GLOSSARY OF TERMS

Acute	Having a sudden onset lasting a short time. Of a stimulus, severe enough to induce a response rapidly. Can be used to define either the exposure or the response of an exposure (effect). The duration of an acute aquatic toxicity test is generally 4 days or less and mortality is the response usually measured.
Acute Tests	A toxicity test of short duration, typically 4 days or less, and usually of a short duration relative to the lifespan of the test organism.
Acute Toxicity	Toxicity expressed over a short period of time relative to the lifespan of the organism, usually minutes to days.
Advection	Physical transport of materials (e.g., dust) by the bulk movement of an environmental medium (e.g., air).
Adverse Effect	An undesirable or harmful effect to an organism (human, animal or plant) indicated by some result such as mortality, altered food consumption, altered body and organ weights, altered enzyme concentrations or visible pathological changes.
AEP	Alberta Environmental Protection
AEUB	Alberta Energy and Utility Board
Ambient	The conditions surrounding an organism or area.
Assessment Endpoint	An explicit expression of the environmental value that is to be protected.
Background Concentration	The concentration of a chemical in a defined control area during a fixed

	period of time before, during, or after a data-gathering operation.
BCF	Bioconcentration Factor.
Benthic Community (Benthos)	The community of organisms dwelling at the bottom of a river, lake or ocean.
Benthic Invertebrates	Invertebrate organisms living at, in or associated with the bottom (benthic) substrate of lakes, ponds and streams. Examples of benthic invertebrates include several aquatic insect species (such as caddisfly larvae) which spend at least part of their lifestages dwelling on bottom sediments in the river. These organisms are involved in mineralization and recycling of organic matter produced in the open water above or brought in from external sources, and they are important second and third links in the trophic sequence of aquatic communities. Many benthic invertebrates are major food sources for small fish.
Bioaccumulation	A general term, meaning that an organism stores within its body, a higher concentration of a substance than is found in the environment. This is not necessarily harmful. For example, freshwater fish must bioaccumulate salt in order to survive in intertidal waters. Many chemicals, such as arsenic, are not included among the dangerous bioaccumulative substances because they can be handled and excreted by aquatic organisms.
Bioavailability	The amount of chemical that enters the general circulation of the body following administration or exposure.
Bioconcentration	A process by which there is a net accumulation of a chemical directly from an exposure medium into an organism.

Biodegradation	Decomposition into more elementary compounds by the action of microorganisms such as bacteria.
Biomagnification	Result of the process of bioaccumulation by which tissue concentrations of chemicals increase as the chemical passes up through two or more trophic levels. The term implies an efficient transfer of the chemical from food to consumer.
Cancer	A disease characterized by the rapid and uncontrolled growth of aberrant cells into malignant tumours.
Carcinogen	An agent that is reactive or toxic enough to act directly to cause cancer.
Chronic	Involving stimulus that is lingering or continues for a long time; often signifies periods from several weeks to years, depending on the reproductive life cycle of the species. Can be used to define either the exposure or the response to an exposure (effect). Chronic exposures typically induce a biological response of relatively slow progress and long duration.
Chronic Exposure	A relatively long duration of time (Health Canada considers periods of human exposure greater than three months to be chronic while the U.S. EPA only considers human exposure that are greater than seven years to be chronic).
Chronic Tests	A toxicity test used to study the effects of continuous, long-term exposure of a chemical or the potentially toxic material on an organism.
Chronic Toxicity	The development of adverse effects after an extended exposure of time relative to the life span of the organism, usually from several weeks to years depending on the reproductive cycle of the organism.

Community	An assemblage of populations of different species within a specified location and time.
Computer Model	Equations that represent a mathematical interpretation of a natural phenomenon.
Concentration	Quantifiable amount of a chemical in environmental media.
Conceptual Model	A model developed at an early stage of the risk assessment process that describes a series of working hypotheses of how the chemicals of concern may affect potentially exposed populations. The model identifies and describes the populations potentially at risk and exposure pathways and scenarios.
Consolidated Tailings (CT)	Consolidated tailings (CT) is a non-segregating mixture of plant tailings which consolidates relatively quickly in tailings deposits. At Suncor, consolidated tailings will be prepared by combining mature fine tails with thickened (cycloned) fresh sand tailings. This mixture is chemically stabilized to prevent segregation of the fine and coarse mineral solids using gypsum ($CaSO_4$).
Conservative Approach	Approach taken to incorporate protective assumptions to ensure that risks will not be underestimated.
Control	A treatment in a toxicity test that duplicates all the conditions of the exposure treatments but contains no test material. The control is used to determine basic test conditions in the absence of toxicity (e.g. health of test organisms, quality of dilution water).
Critical Exposure Pathway	The exposure pathway which either maximizes the dose or is the primary pathway of exposure to an identified receptor of concern.

CT Release Water	Water derived from consolidated tailings deposits.
Degradation	Conversion of an organic compound to one containing a smaller number of carbon atoms.
Detection Limit (DL)	The lowest concentration at which individual measurement results for a specific analyte are statistically different from a blank (that may be zero) with a specified confidence level for a given method and representative matrix.
Deterministic	Risk approach using a single number from each parameter set in the risk calculation and producing a single value of risk.
Dispersion	Physical processes of mixing.
Dose	A measure of integral exposure. Examples include (1) the amount of a chemical ingested, (2) the amount of a chemical taken up, (3) the product of ambient exposure concentration and the duration of exposure.
Dose Rate	Dose per unit time, for example in mg/day, sometimes also called dosage. Dose rates are often expressed on a per-unit body-weight basis, yielding units such as mg/kg body weight/day expressed as averages over some time period, for example a lifetime.
Dose-Response	The quantitative relationship between exposure of an organism to a chemical and the extent of the adverse effect resulting from that exposure.
Ecological Risk Assessment	The process that evaluates the likelihood that adverse ecological effects may occur or are occurring as a result of exposure to one or more stressors.

Ecosystem	An integrated and stable association of living and nonliving resources functioning with a defined physical location.
Ecotoxicology	A subfield of toxicology, dealing with the effects of chemicals and other stressors on natural systems, as opposed to human health effects.
Effects Assessment	Review of literature regarding the toxicity of any given material to an appropriate receptor. Also known as Toxicity Assessment.
Effluent	Stream of water discharging from a source.
EIA	Environmental Impact Assessment
ELC	Ecological Land Classification
Environmental Media	One of the major categories of material found in the physical environment that surrounds or contacts organisms (e.g., surface water, groundwater, soil, food or air) and through which chemicals can move and reach the organism.
Exposure	The contact reaction between a chemical and a biological system, or organism.
Exposure Assessment	The determination or estimation (qualitative or quantitative) of the magnitude, frequency, duration, and route of exposure.
Exposure Concentration	The concentration of a chemical in its transport or carrier medium at the point of contact.
Exposure Limit	The maximum acceptable dose (per unit-body-weight and unit of time) of a chemical to which a specified receptor can be exposed to, assuming a specified risk (e.g., one in a hundred thousand). May be

	expressed as a Reference Dose (RfD) for threshold-response chemicals (i.e., noncarcinogens) or as a Risk Specific Dose (RsD) for non-threshold response chemicals (i.e., carcinogens).
Exposure Pathway	The path a chemical or physical agent takes from a source to exposed organism. Each exposure pathway includes a source or release from a source exposure point, and an exposure route. Examples of exposure pathways include the ingestion of water, food and soil, the inhalation of air and dust, and dermal absorption.
Exposure Pathway Model	A model in which potential pathways of exposure are identified for the selected receptor species.
Exposure Ratio (ER)	A comparison between total exposure from all predicted routes of exposure and exposure limits for chemicals of concern. This comparison is calculated by dividing the predicted exposure by the exposure limit.
Exposure Route	The way a chemical or physical agent comes in contact with an organism (e.g., by ingestion, inhalation, or dermal contact).
Exposure Scenario	A set of facts, assumptions and inferences about how exposure takes place that aid the risk assessor in evaluating, estimating and quantifying exposures
Fate	In the context of the study of contaminants, fate refers to the chemical form of a contaminant when it enters the environment and the compartment of the ecosystem in which that chemical is primarily concentrated (e.g., water or sediments). Fate also includes transport of the chemical within the ecosystem (via water, air or mobile biota) and the potential for food chain accumulation.

Fecundity	The most common measure of reproductive potential in fish. It is the number of eggs in the ovary of a female fish. Fecundity increases with the size of the female.
FGD	Flue Gas Desulphurization
Food Chain Transfer	A process by which materials accumulate in the tissues of lower trophic level organisms and are passed on to higher trophic level organisms by dietary intake.
Forage (Feeding) Area	The area utilized by an organism for hunting or gathering food.
Golder	Golder Associates Ltd.
Habitat	The place where a plant or animal naturally or normally lives and grows, for example, a stream habitat or a forest habitat.
Hazard	Likelihood that a chemical will cause an injury or adverse effect under specified conditions.
Histology/Histological	The microscopic study of tissues.
Home Range	The area to which an animal confines its activities.
Hydrophilic	A characteristic of charged molecules in which they tend to interact with water molecules.
Hydrophobic	With regard to a molecule or side group, tending to dissolve readily in organic solvents, but not in water, resisting wetting, not containing polar groups.
ICP (Metals)	Inductively Couple Plasma (Atomic Emission Spectroscopy). This

	analytical method is a U.S. EPA designated method (Method 6010). The method determines elements within samples of groundwater, aqueous samples, leachates, industrial wastes, soil sludges, sediments and other solid wastes. Sample require chemicals digestion prior to analysis.
Ingestion Rate	The rate at which an organism consumes food, water, or other material (e.g., soil, sediment). Ingestion rate is usually expressed in terms of unit of mass or volume per unit of time (e.g., kg/day, L/day).
Lowest-Observable-adverse Adverse-Effect-Level (LOAEL)	The lowest dose to an organism that has a statistically significant Effect on the exposed population of test organisms as compared with controls.
Measurement Endpoint	A measurable ecological characteristic that is related to the valued characteristic chosen as the assessment endpoint. Measurement endpoints are often expressed as the statistical or arithmetic summaries of the observations that make up the measurement.
Media	The physical form of environmental sample under study (e.g. soil, water, air).
Metabolism	Metabolism is the total of all enzymatic reactions occurring in the cell; a highly coordinated activity of interrelated enzyme systems exchanging matter and energy between the cell and the environment. Metabolism involves both the synthesis and breakdown (catabolism) of individual compounds.
Metabolites	Organisms alter or change compounds in many various ways like removing parts of the original or parent compound or in other cases adding new parts. Then, the parent compound has been metabolized

	and the newly converted compound is called a metabolite.
MFT	Mature Fine Tails, fine tailings that have dewatered to a level of about 30% solids.
Mortality	Death
NESSA	Northeast Sand Storage Area
Noncarcinogen	A chemical that does not cause cancer and has a threshold concentration.
No Observed Adverse Effect Level (NOAEL)	The highest level of a stressor evaluated in a test that causes no statistically significant difference in effect as compared with the controls. Same as NOEL (no observed effect level).
Nutrients	Environmental substances (elements or compounds), such as nitrogen or phosphorus, which are necessary for the growth and development of plants and animals.
Operational Waters	Waters that are discharged from a channel or outfall, discharged over the life of the project, or a shorter time frame, controllable, treatable in a managed treatment system, amenable to comparing to ambient water quality criteria and potentially of concern with respect to regional off-site impacts. Sources of operational waters include CT, drainage waters collected from dykes and structures, mine drainage, upgrading process, cooling water and sewage treatment facility.
OSRPAF	Oil Sands Reclamation Performance Assessment Framework
OSWRTWG	Oil Sands Water Release Technical Working Group

PAH(s)	Polycyclic aromatic hydrocarbon(s). A chemical by-product of petroleum-related industry. Aromatics are considered to be highly toxic components of petroleum products. PAHs are composed of at least two fused benzene rings, many of which are potential carcinogens. Toxicity increases along with molecular size and degree of alkylation of the aromatic nucleus.
PANH	Polycyclic aromatic nitrogen heterocycles.
PASH	Polycyclic aromatic sulphur heterocycles.
Pathology	The science which deals with the cause and nature of disease or diseased tissues.
Physiological	Related to function in the cells, organs or entire organisms, in accordance with the nature processes of life.
Population	An aggregate of individuals of a species within a specified location in space and time.
Problem Formulation	The first phase in a risk assessment where the geographical location, scope fo the project and future plans are outlined. In addition, receptors, chemical and exposure pathways of concern are identified and screened to focus the remainder of the assessment. A focused understanding of the site is developed and brought together in a Conceptual Model that illustrates how chemicals may reach specific receptors, thus potentially creating risk to the receptor, and how risk is to be evaluated.
RBC	Risk-Based Concentration. Concentration in environmental media below which health risks are not expected to occur.

Receptor	The person or plant or animal subjected to exposure to chemical or physical agents.
Reclaimed Landscape	Dry landscape created following the reclamation of tailings generated in the mining process where the tailings are chemically treated and dewatered to form a trafficable surface.
Reclamation Waters	Waters derived from a non-point source, released at slow rates over large areas for extended periods of time, non-controllable, nontreatable, not amenable to conventional end-of-pipe approval requirements and primarily an on-site water management concern and a component of a maintenance-free reclamation landscape. Sources of reclamation waters include surface runoff and groundwater seepage from sand dumps and dykes, CT deposits, coke piles, gypsum storage units and other waste dumps, overburden dumps and dykes and wetlands treatment system.
Reference Site	A relatively unpolluted site used for comparison to polluted sites in environmental monitoring studies, often incorrectly referred to as a control.
RfD (Reference Dose)	The maximum recommended daily exposure for a chemical exhibiting a threshold (highly nonlinear) dose-response (i.e., noncarcinogen) based upon the NOAEL determined for the chemical from human and/or animals studies and the use of an appropriate uncertainty factor.
Risk	The likelihood or probability, that the toxic effects associated with a chemical will be produced in populations of individuals under their actual conditions of exposure. Risk is usually expressed as the probability of occurrence of an adverse effect, i.e., the expected ratio between the number of individuals that would experience an adverse effect at a given time and the total number of individuals exposed to

	the factor. Risk is expressed as a fraction without units and takes values from 0 (absolute certainty that there is no risk, which can never be shown) to 1.0, where there is absolute certainty that a risk will occur.
Risk Assessment	The process that evaluates the probability of adverse effects that may occur, or are occurring on target organism(s) as a result of exposure to one or more stressors.
Risk Characterization	A phase of ecological risk assessment that integrates the results of the exposure and ecological effects analyses to evaluate the likelihood of adverse ecological effects associated with exposure to the stressor. The ecological significance of the adverse effects is discussed, including consideration of the types and magnitudes of the effects, their spatial and temporal patterns, and the likelihood of recovery.
RsD (Risk Specific Dose)	The exposure limit determined for chemicals assumed to act as genotoxic, non-threshold carcinogens. An RsD is a function of carcinogenic potency (q_1^*)and defined acceptable risk (i.e., RsD = target level of risk ÷ q_1^*).
Sample	Representative fraction of a material tested or analysed; a selection or collection from a larger collection.
Screening	The process of filtering and removal of implausible or unlikely exposure pathways, chemical or substances, or populations from the risk assessment process to focus the analysis on the chemicals, pathways and populations of greatest concern.
Seepage	The act of trickling from a substrate.
Site	The area determined to be significantly impacted after the iterative

	evaluaitons of the risk asessment. Also can be applied to political or legal boundaries.
SLC	Screening Level Criteria. The lowest of available published criteria used for screening for chemicals of concern.
Species	A group of organisms that actually or potentially interbreed and are reproductively isolated from all other such groups; a taxonomic grouping of genetically and morphologically similar individuals; the category below genus.
Species Composition	A term that refers to the species found in the sampling area.
Statistic	A computed or estimated statistical quantity such as the mean, the standard deviation, or the correlation coefficient.
Stressor	Any physical, chemical, or biological entity that can induce an adverse effect on an organism.
Subchronic Toxicity	The adverse effects occurring as a result of the repeated daily exposure to a chemical for a short time.
Suncor	Suncor Inc., Oil Sands Group
Syncrude	Syncrude Canada Ltd.
TEF	Toxicity Equivalent Factor.
Threshold Concentration	A concentration above which some effect (or response) will be produced and below which it will not.
TID	Tar Island Dyke

TIRA	Tar Island Reclamation Area
Toxic	A substance, dose or concentration that is harmful to a living organism.
Toxic Threshold	Almost all compounds become toxic at some level with no evident harm or adverse effect below that level. Scientists refer to the level or concentrations where they first see evidence for an adverse effect on an organism as the toxic threshold.
Toxicity	The inherent potential or capacity of a material to cause adverse effects in a living organism.
Toxicity Assessment	Review of literature regarding the toxicity of any given material to an appropriate receptor.
Toxicity Test	The means by which the toxicity of a chemical or other test material is determined. A toxicity test is used to measure the degree of response produced by exposure to a specific level of stimulus (or concentration of chemical).
Trafficable	A solid material capable of supporting weight.
Trophic Level	A functional classification of taxa within a community that is based on feeding relationships (e.g., aquatic and terrestrial plants make up the first trophic level and herbivores make up the second).
Uncertainty	Imperfect knowledge concerning the present or future state of the system under consideration; a component of risk resulting from imperfect knowledge of the degree of hazard or of its spatial and temporal distribution.
Uncertainty Factor	A unitless numerical value that is applied to a reference toxicological

	value (i.e., NOAEL) to account for uncertainties in the experimental data used to derive the toxicological value (e.g., short testing period, lack of species diversity, small test group, etc.) And to increase confidence in the safety of the exposure dose as it applies to species other than the test species (e.g., sensitive individuals in the human population). RfD equals the NOAEL divided by the uncertainty factor.
Uptake	The process by which a chemical crosses an absorption barrier and is absorbed in the body.
U.S. EPA	U.S. Environmental Protection Agency
Valued Ecosystem Component (VEC)	Components of an ecosystem (either plant, animal, or abiotic feature) considered valuable by various sectors of the public.
VOC(s).	Volatile Organic Compound(s).
Volatilization	The conversion of a chemical substance from a liquid or solid state to a gaseous vapour state.
Worst-Case	A semi-quantitative term referring to the maximum possible exposure, dose or risk, that can conceivably occur, whether or not this exposure, dose or risk actually occurs is observed in a specific population. It should refer to a hypothetical situation in which everything that can plausibly happen to maximize exposure, dose, or risk does happen. The worst-case may occur in a given population, but since it is usually a very unlikely set of circumstances in most cases, a worst-case estimate will be somewhat higher than what occurs for a specific population.

TABLES

TABLE 4.1-1

SUMMARY TABLE OF CHEMICAL CONCENTRATIONS IN SUNCOR'S OPERATIONAL AND RECLAMATION MATERIALS

CHEMICAL	NATURAL			PROCESS-AFFECTED			OTHERS
	Oil Sands[1]	Muskeg[2]	Overburden[3]	Consolidated Tailings[4]	Tailings Sand[5]	Plant 4 Beach[6]	Gypsum[7]
ORGANICS							
Total Petroleum Hydrocarbons (µg/g)							
Total Petroleum Hydrocarbons	-	221	-	2480	-	-	-
Polynuclear Aromatic Hydrocarbons (µg/g)							
1-Methyl-7-isopropylphenanthrene (Retene)	<0.01	<0.02	<0.01	<0.08	<0.01	<0.06	-
Acenaphthene	1.1	<0.01	<0.01	<0.04 - 0.05	<0.01	0.35	-
Acenaphthylene	<0.01	<0.01	<0.01	<0.01 - <0.04	<0.01	<0.03	-
Anthracene	<0.01	<0.01	<0.01	<0.01 - <0.04	<0.01	0.04	-
Benzo(a)anthracene/Chrysene	7	0.01	<0.01	0.02 - 0.32	0.15	0.44	-
Benzo(a)pyrene	0.92	<0.01	<0.01	0.02 - 0.05	<0.01	0.05	-
Benzo(b&k) fluoranthene	<0.01	<0.01	<0.01	0.02 - 0.12	0.03	0.04	-
Benzo(ghi)perylene	<0.01	<0.01	<0.01	<0.01 - <0.04	<0.01	<0.03	-
Biphenyl	<0.01	<0.02	<0.01	<0.02 - <0.08	0.01	<0.06	-
C2 sub'd benzo(a)anthracene/chrysene	13	0.02	<0.01	0.12 - 0.46	0.29	0.53	-
C2 sub'd benzo(b&k)fluoranthene/benzo(a) pyrene	2.2	<0.02	<0.01	<0.02 - 0.12	0.07	0.07	-
C2 sub'd biphenyl	<0.01	<0.02	<0.01	<0.08 - 0.19	<0.01	2.2	-
C2 sub'd dibenzothiophene	36	<0.02	0.01	0.27 - 0.51	0.07	11	-
C2 sub'd fluorene	1.2	<0.02	<0.01	<0.08 - 0.25	<0.01	3.7	-
C2 sub'd naphthalene	0.12	<0.02	0.39	<0.08 - 0.02	<0.01	0.49	-
C2 sub'd phenanthrene/anthracene	40	<0.02	0.02	0.29 - 1	0.12	10	-
C3 sub'd dibenzothiophene	55	<0.02	0.05	0.53 - 1.7	0.19	15	-
C3 sub'd naphthalene	1.5	<0.02	0.06	<0.08 - 0.22	<0.01	3	-
C3 sub'd phenanthrene/anthracene	40	0.03	0.03	1.4 - 1.6	0.11	6.9	-
C4 sub'd dibenzothiophene	10	<0.02	0.11	0.83 - 4.5	0.52	10	-
C4 sub'd naphthalene	7.9	<0.02	<0.01	<0.08 - 0.4	<0.01	5.7	-
C4 sub'd phenanthrene/anthracene	25	<0.02	<0.01	1.1 - 4.3	0.23	3.1	-
Dibenzo(a,h)anthracene	<0.01	<0.01	<0.01	<0.01 - <0.04	<0.01	<0.03	-
Dibenzothiophene	<0.01	<0.01	0.05	<0.04 - 0.02	<0.01	<0.03	-
Fluoranthene	0.69	<0.01	<0.01	<0.04 - 0.04	<0.01	0.13	-
Fluorene	0.14	<0.01	0.05	<0.04 - 0.06	<0.01	<0.03	-
Indeno(c,d-123)pyrene	<0.01	<0.01	<0.01	<0.01 - <0.04	<0.01	<0.03	-
Methyl acenaphthene	<0.01	<0.02	<0.01	<0.01 - <0.08	<0.01	0.92	-
Methyl benzo(a)anthracene/chrysene	18	<0.02	<0.01	0.12 - 0.42	0.21	0.39	-
Methyl benzo(b&k)fluoranthene/methyl benzo(a) pyrene	0.03	<0.02	<0.01	<0.02 - 0.29	0.13	0.11	-
Methyl biphenyl	<0.01	<0.02	<0.01	<0.02 - <0.08	<0.01	0.43	-
Methyl dibenzothiophene	9	<0.02	0.02	<0.08 - 0.28	0.02	2.3	-

TABLE 4.1-1

SUMMARY TABLE OF CHEMICAL CONCENTRATIONS IN SUNCOR'S OPERATIONAL AND RECLAMATION MATERIALS

	NATURAL			PROCESS-AFFECTED			OTHERS
CHEMICAL	Oil Sands[1]	Muskeg[2]	Overburden[3]	Consolidated Tailings[4]	Tailings Sand[5]	Plant 4 Beach[6]	Gypsum[7]
Methyl fluoranthene/pyrene	1	<0.02	<0.01	0.41 - 0.53	0.01	1.1	-
Methyl fluorene	1.8	<0.02	<0.01	<0.08 - 0.28	<0.01	0.73	-
Methyl naphthalene	<0.01	0.04	0.04	<0.01 - <0.04	<0.01	0.12	-
Methyl phenanthrene/anthracene	35	<0.02	0.04	0.15 - 0.75	0.08	1.3	-
Naphthalene	<0.01	0.01	<0.01	<0.01 - <0.04	<0.01	0.05	-
Phenanthrene	4.7	<0.01	0.06	<0.04 - 0.46	0.02	0.92	-
Pyrene	2	<0.01	<0.01	<0.01 - 0.16	0.04	0.08	-
Polycyclic, Aromatic Nitrogen containing Heterocycles (µg/g)							
7-Methyl quinoline	-	<0.01	<0.01	<0.01 - <0.04	-	-	-
Acridine	-	<0.01	<0.01	<0.01 - <0.04	-	-	-
C2 Alkyl subst'd carbazoles	-	<0.01	<0.01	<0.01 - <0.04	-	-	-
C2 Alkyl subst'd quinolines	-	<0.01	<0.01	<0.01 - <0.04	-	-	-
C3 Alkyl subst'd quinolines	-	<0.01	<0.01	<0.01 - <0.04	-	-	-
Carbazole	-	<0.01	<0.01	<0.01 - <0.04	-	-	-
Methyl acridine	-	<0.01	<0.01	<0.01 - <0.04	-	-	-
Methyl carbazoles	-	<0.01	<0.01	<0.01 - <0.04	-	-	-
Phenanthridine	-	<0.01	<0.01	<0.01 - <0.04	-	-	-
Quinoline	-	<0.01	<0.01	<0.01 - <0.04	-	-	-
Phenols (µg/g)							
2,4-Dimethylphenol	-	<0.02	<0.01	<0.02	-	-	-
2,4-Dinitrophenol	-	<1	<0.01	<1	-	-	-
2-Nitrophenol	-	<0.04	<0.01	<0.04	-	-	-
4,6-Dinitro-2-methylphenol	-	<1	<0.01	<1	-	-	-
4-Nitrophenol	-	<1	<0.01	<1	-	-	-
m-Cresol	-	<0.02	<0.01	<0.02	-	-	-
o-Cresol	-	<0.02	<0.01	<0.02	-	-	-
p-Cresol	-	<0.02	<0.01	<0.02	-	-	-
Phenol	-	<0.02	<0.01	<0.02	-	-	-
INORGANICS							
Metals and Trace Elements (µg/g)							
Aluminum	748	-	10500	-	172	-	-
Antimony	<0.05	-	0.06	-	<0.05	-	-
Arsenic	1.55	<20	15.8	<20	0.63	-	-
Barium	18.7	121	219	19.1	4.9	-	20.1
Beryllium	0.4	0.3	1	0.3	<0.1	-	<1
Boron	2.9	-	7.2	-	<0.1	-	-

TABLE 4.1-1

SUMMARY TABLE OF CHEMICAL CONCENTRATIONS IN SUNCOR'S OPERATIONAL AND RECLAMATION MATERIALS

CHEMICAL	NATURAL			PROCESS-AFFECTED			OTHERS
	Oil Sands[1]	Muskeg[2]	Overburden[3]	Consolidated Tailings[4]	Tailings Sand[5]	Plant 4 Beach[6]	Gypsum[7]
Cadmium	<0.3	<0.3	<0.3	<0.3	<0.3	-	<0.5
Calcium	2570	-	8540	-	559	-	-
Chromium	2	6.2	5.1	15.4	<0.5	-	26.9
Cobalt	4	2.8	12	2	2	-	6
Copper	2	8.4	25.1	2.7	<0.5	-	13
Iron	7450	-	23400	-	3350	-	-
Lead	<2	2.5	10	4.4	<2	-	8
Magnesium	1230	-	8060	-	133	-	-
Manganese	217	-	117	-	56.5	-	-
Mercury	0.02	0.037	0.07	<0.02	0.03	-	-
Molybdenum	<2	1.4	<2	1.1	<2	-	81
Nickel	15	8.4	30	14.4	2	-	312
Phosphorus	54	-	450	-	22	-	-
Potassium	267	-	2330	-	110	-	-
Selenium	<0.02	<0.2	0.74	<4	<0.02	-	-
Silver	-	-	-	-	-	-	<1
Sodium	207	-	5550	-	<50	-	-
Strontium	-	-	-	-	-	-	127
Thallium	-	<0.1	-	0.1	-	-	<1
Tin	-	-	-	-	-	-	<5
Vanadium	26.2	12.3	15.1	23.7	2.8	-	916
Zinc	10.7	25.5	72.7	13.6	5.8	-	22.2

[1] ETL (1993). Sample ID: CP10, n=1.
[2] Suncor unpublished data, n=1.
[3] ETL (1993). Sample ID: CP3, n=1.
[4] Suncor and Syncrude, 1995 unpublished data from Consolidated Tailings Field Study, n=2 organics, n=1 inorganics.
[5] ETL (1993). Sample ID: CP5, n=1.
[6] Suncor, 1995 unpublished data, n=1.
[7] Suncor, 1995 unpublished data from FGD Plant Study (sample is mixture of 50% FGD Gypsum and 50% Flyash Solids), n=1.

TABLE 4.1-2

SUMMARY OF CHEMICAL CONCENTRATIONS IN SUNCOR'S OPERATIONAL WATERS

Chemical	NATURAL WATERS Athabasca River[1]	Reference Tributaries[2]	OPERATIONAL/RECLAMATION WATERS Consolidated Tailings Release Water[3]	Tar Island Dyke Seepage Water[4]	Plant 4 Seepage[5]	Mine Drainage[6]	Refinery Wastewater[7]	Cooling Pond E[8]	Gypsum Leachate[9]
ORGANICS									
Total Petroleum Hydrocarbons (mg/L)									
Total Petroleum Hydrocarbons	-	-	-	-	-	-	99-113	-	-
Hydrocarbons, Recoverable	<1-1	<1-9	<1-22	<1-19	-	<1	<1	<1	-
Total Extractable Hydrocarbons (mg/L)									
Total Extractable Hydrocarbons	-	-	38.9-59.8	-	-	-	<1	<1	-
Naphthenic Acids (mg/L)									
Naphthenic acids	<1	<1	62-94	47-55	-	<2-5	<1-4	<1-5	-
Polycyclic Aromatic Hydrocarbons (µg/L)									
1-Methyl-7-isopropylphenanthrene (Retene)	<0.04	<0.04	<0.04	<0.04	<0.04-<0.1	<0.04	<0.04	<0.04	-
Acenaphthene	<0.02	<0.02	<0.02-<0.08	<0.02	<0.02-0.12	<0.02	<0.02	<0.02	-
Acenaphthylene	<0.02	<0.02	<0.02-0.16	<0.02	<0.02-<0.05	<0.02	<0.02	<0.02	-
Anthracene	<0.02	<0.02	<0.02-<0.04	<0.02	<0.02-<0.05	<0.02	<0.02	<0.02	-
Benzo(a)anthracene/chrysene	<0.02	<0.02	<0.02-0.27	<0.02	<0.02-0.1	<0.02	<0.02-1	<0.02	-
Benzo(a)pyrene	<0.02	<0.02	<0.02-<0.04	<0.02	<0.02-0.02	<0.02	<0.02	<0.02	-
Benzo(b&k)fluoranthene	<0.02	<0.02	<0.02-<0.04	<0.02	<0.02-<0.05	<0.02	<0.02	<0.02	-
Benzo(ghi)perylene	<0.02	<0.02	<0.02-<0.04	<0.02	<0.02-0.03	<0.02	0.02-0.03	<0.02	-
Biphenyl	<0.04	<0.04	<0.04-0.08	<0.04	<0.04-<0.1	<0.04	<0.04	<0.04	-
C2 sub'd benzo(a)anthracene/chrysene	<0.04	<0.04	<0.04-0.83	<0.04	<0.04-0.05	<0.04	<0.04-0.12	<0.04	-
C2 sub'd benzo(b&k)fluoranthene/ benzo(a)pyrene	<0.04	<0.04	<0.04-0.18	<0.04	<0.04-0.04	<0.04	<0.04-0.07	<0.04	-
C2 sub'd biphenyl	<0.04	<0.04	<0.04-0.25	<0.04	<0.04-<0.1	<0.04	<0.04	<0.04	-
C2 sub'd dibenzothiophene	<0.04	<0.04	<0.04-2.2	<0.04	<0.1-0.52	<0.04	<0.04-0.19	<0.04	-
C2 sub'd fluorene	<0.04	<0.04	<0.04-1.1	<0.04-0.28	<0.04-0.35	<0.04	<0.04-0.16	<0.04	-
C2 sub'd naphthalene	<0.04	<0.04	<0.04-0.25	<0.04-0.07	0.25-0.3	<0.04	<0.04-0.04	<0.04	-
C2 sub'd phenanthrene/anthracene	<0.04	<0.04	<0.04-4.5	<0.04-0.06	<0.1-0.39	<0.04	<0.04-0.22	<0.04	-
C3 sub'd dibenzothiophene	<0.04	<0.04	<0.04-4.1	<0.04	<0.1-0.08	<0.04	<0.04-0.12	<0.04	-
C3 sub'd naphthalene	<0.04	<0.04	<0.04-0.3	<0.04-0.27	<0.1-0.78	<0.04	<0.04-0.34	<0.04	-
C3 sub'd phenanthrene/anthracene	<0.04	<0.04	<0.04-3.6	<0.06-0.12	<0.1-0.21	<0.04	<0.04-0.25	<0.04	-
C4 sub'd dibenzothiophene	<0.04	<0.04	<0.04-4.4	<0.04	<0.1-0.06	<0.04	<0.04	<0.04	-
C4 sub'd naphthalene	<0.04	<0.04	<0.04-2	0.04-0.56	<0.1-0.6	<0.04	<0.04-0.09	<0.04	-
C4 sub'd phenanthrene/anthracene	<0.04	<0.04	<0.04-1.7	<0.04-0.06	<0.04-<0.1	<0.04	<0.04-0.33	<0.04	-
Dibenzo(a,h)anthracene	<0.02	<0.02	<0.02-<0.04	<0.02	<0.02-<0.05	<0.02	<0.02	<0.02	-
Dibenzothiophene	<0.02	<0.02	<0.02-0.07	<0.02	<0.02-0.03	<0.02	<0.02-0.09	<0.02	-
Fluoranthene	<0.02	<0.02	<0.02-<0.04	<0.02	<0.02-0.03	<0.02	<0.02	<0.02	-
Fluorene	<0.02	<0.02	<0.02-0.03	<0.02	<0.02-0.14	<0.02	<0.02	<0.02	-
Indeno(c,d-123)pyrene	<0.02	<0.02	<0.02	<0.02	<0.02-<0.05	<0.02	<0.02	<0.02	-
Methyl acenaphthene	<0.04	<0.04	<0.04-0.19	<0.04-0.28	<0.04-<0.1	<0.04	<0.04	<0.04	-
Methyl benzo(a)anthracene/chrysene	<0.04	<0.04	<0.04-0.5	<0.04	<0.04-0.11	<0.04	<0.04-0.12	<0.04	-

TABLE 4.1-2

SUMMARY OF CHEMICAL CONCENTRATIONS IN SUNCOR'S OPERATIONAL WATERS

	NATURAL WATERS		OPERATIONAL/RECLAMATION WATERS						
Chemical	Athabasca River[1]	Reference Tributaries[2]	Consolidated Tailings Release Water[3]	Tar Island Dyke Seepage Water[4]	Plant 4 Seepage[5]	Mine Drainage[6]	Refinery Wastewater[7]	Cooling Pond E[8]	Gypsum Leachate[9]
Methyl benzo(b&k)fluoranthene/ methyl benzo(a)pyrene	<0.04	<0.04	<0.04-0.3	<0.04	<0.04-0.05	<0.04	<0.04-0.07	<0.04	-
Methyl biphenyl	<0.04	<0.04	<0.04-<0.08	<0.04	<0.04-<0.1	<0.04	<0.04	<0.04	-
Methyl dibenzothiophene	<0.04	<0.04	<0.04-0.65	<0.04-0.05	<0.1-0.21	<0.04	<0.04-0.21	<0.04	-
Methyl fluoranthene/pyrene	<0.04	<0.04	<0.04-0.65	<0.04-0.08	<0.1-0.12	<0.04	<0.04-0.31	<0.04	-
Methyl fluorene	<0.04	<0.04	<0.04-0.3	<0.04-0.26	<0.04-0.25	<0.04	<0.04	<0.04	-
Methyl naphthalene	<0.02-<0.1	<0.02	<0.02-<0.08	<0.02-0.05	<0.02-0.34	<0.02	<0.02-0.1	<0.02	-
Methyl phenanthrene/anthracene	<0.04	<0.04	<0.04-0.79	<0.04-0.07	<0.1-0.46	<0.04	<0.04-0.19	<0.04	-
Naphthalene	<0.02	<0.02-0.02	<0.02-0.05	<0.02-0.09	0.23-0.56	<0.02	<0.02	<0.02	-
Phenanthrene	<0.02	<0.02	<0.02-0.09	<0.02	<0.02-0.12	<0.02	<0.02	<0.02	-
Pyrene	<0.02	<0.02	<0.02-0.04	<0.02	<0.02-0.09	<0.02	<0.02-0.16	<0.02	-
Polycyclic Aromatic Nitrogen Heterocycles (µg/L)									
7-Methyl quinoline	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.12-0.46	<0.02	-
Acridine	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02-0.13	<0.02	-
C2 Alkyl subst'd carbazoles	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	-
C2 Alkyl subst'd quinolines	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.09-0.4	<0.02	-
C3 Alkyl subst'd quinolines	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	-
Carbazole	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	-
Methyl acridine	<0.02	<0.02	<0.02-<0.04	<0.02	<0.02	<0.02	<0.02-0.6	<0.02	-
Methyl carbazoles	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	-
Phenanthridine	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02-0.21	<0.02	-
Quinoline	<0.02	<0.02	<0.02	<0.02-0.09	<0.02	<0.02	<0.02-0.71	<0.02	-
Phenols (µg/L)									
2,4-Dimethylphenol	<0.1	<0.1	<0.2-1	<0.02	<0.1	<0.1	<0.1-1	<0.1	-
2,4-Dinitrophenol	<2	<2	<4-<20	<1-<20	<20	<2	<2	<2	-
2-Nitrophenol	<0.2	<0.2	<0.4-<2	<0.4-<2	<2	<0.2	<0.2	<0.2	-
4,6-Dinitro-2-methylphenol	<2	<2	<20	<4-<20	<20	<2	<2	<2	-
4-Nitrophenol	<2	<2	<4-<20	<4-<20	<20	<2	<2	<2	-
m-Cresol	<0.1	<0.1	<0.1-<1	<0.1-<1	<0.1	<0.1	<0.1	<0.1	-
o-Cresol	<0.1	<0.1	<0.1-<1	<0.1-<1	<0.1	<0.1	<0.1	<0.1	-
p-Cresol	<0.1	<0.1	<0.1-<1	<0.1-<1	<0.1	<0.1	<0.1	<0.1	-
Phenol	<0.1	<0.1	<0.1-<1	<0.1-<1	<0.1	<0.1	<0.1	<0.1	-
Phenols	-	-	<0.002	<0.002	-	<0.002	<0.002	<0.002	-
Volatiles (µg/L)									
1,1,1-Trichloroethane	<1	<1	<1-<15	<1	<1	<1	<1-4	<1	-
1,1,2,2-Tetrachloroethane	<5	<5	<5-<75	<5	<5	<5	<5	<5	-
1,1,2-Trichloroethane	<1	<1	<1-<15	<1	<1	<1	<1	<1	-
1,1-Dichloroethane	<1	<1	<1-<15	<1	<1	<1	<1	<1	-
1,1-Dichloroethene	<1	<1	<1-<15	<1	<1	<1	<1	<1	-
1,2,3-Trichloropropane	<2	<2	<2-<30	<2	<2	<2	<2	<2	-
1,2-Dichlorobenzene	<1	<1	<1-<15	<1	<1	<1	<1	<1	-

TABLE 4.1-2

SUMMARY OF CHEMICAL CONCENTRATIONS IN SUNCOR'S OPERATIONAL WATERS

	NATURAL WATERS		OPERATIONAL/RECLAMATION WATERS						
Chemical	Athabasca River[1]	Reference Tributaries[2]	Consolidated Tailings Release Water[3]	Tar Island Dyke Seepage Water[4]	Plant 4 Seepage[5]	Mine Drainage[6]	Refinery Wastewater[7]	Cooling Pond E[8]	Gypsum Leachate[9]
1,2-Dichloroethane	<1	<1	<1-<15	<1	<1	<1	<1	<1	-
1,2-Dichloropropane	<1	<1	<1-<15	<1	<1	<1	<1	<1	-
1,3-Dichlorobenzene	<1	<1	<1-<15	<1	<1	<1	<1	<1	-
1,4-Dichlorobenzene	<1	<1	<1-<15	<1	<1	<1	<1	<1	-
2-Butanone (MEK)	<100	<100	<100-<1500	<100	<100	<100	<100	<100	-
2-Chloroethylvinylether	<5	<5	<5-<75	<5	<5	<5	<5	<5	-
2-Hexanone	<200	<200	<200-<3000	<200	<200	<200	<200	<200	-
4-Methyl-2-pentanone (MIBK)	<200	<200	<200-<3000	<200	<200	<200	<200	<200	-
Acetone	<100	<100	<100-<1500	<100	<100	<100	<100	<100	-
Acrolein	<100	<100	<100-<1500	<100	<100	<100	<100	<100	-
Acrylonitrile	<100	<100	<100-<1500	<100	<100	<100	<100	<100	-
Benzene	<1	<1	<1-<15	<1	<1	<1	<1	<1	-
Bromodichloromethane	<1	<1	<1-<15	<1	<1	<1	<1	<1	-
Bromoform	<1	<1	<1-<15	<1	<1	<1	<1	<1	-
Bromomethane	<10	<10	<10-<150	<10	<10	<10	<10	<10	-
Carbon disulfide	<1	<1	<1-<15	<1	<1	<1	<1	<1	-
Carbon tetrachloride	<1	<1	<1-<15	<1	<1	<1	<1-3	<1	-
Chlorobenzene	<1	<1	<1-<15	<1	<1	<1	<1	<1	-
Chloroethane	<10	<10	<10-<150	<10	<10	<10	<10	<10	-
Chloroform	<1	<1	<1-<15	<1	<1	<1	<1-3	<1	-
Chloromethane	<10	<10	<10-<150	<10	<10	<10	<10	<10	-
cis-1,3-Dichloropropene	<1	<1	<1-<15	<1	<1	<1	<1	<1	-
cis-1,4-Dichloro-2-butene	<2	<2	<2-<30	<2	<2	<2	<2	<2	-
Dibromochloromethane	<1	<1	<1-<15	<1	<1	<1	<1	<1	-
Dibromomethane	<1	<1	<1-<15	<1	<1	<1	<1	<1	-
Dichlorodifluoromethane	<1	<1	<1-<15	<1	<1	<1	<1	<1	-
Ethanol	<100	<100	<100-<1500	<100	<100	<100	<100	<100	-
Ethyl methacrylate	<200	<200	<200-<3000	<200	<200	<200	<200	<200	-
Ethylbenzene	<1	<1	<1-<15	<1-1.5	<1	<1-1.2	<1-1.2	<1-1.5	-
Ethylene dibromide	<1	<1	<1-<15	<1	<1	<1	<1	<1	-
Iodomethane	<1	<1	<1-<15	<1	<1	<1	<1	<1	-
m+p-Xylenes	<1	<1	<1-15	<1-5	<1	<1 - 4.1	<1-4.5	<1-5.7	-
Methylene chloride	<1	<1	<1-<30	<1	<1	<1	<1-5.7	<1	-
o-Xylene	<1	<1	<1-15	<1-2.7	<1	<1-1.7	<1-2.2	<1-2.8	-
Styrene	<1	<1	<1-<15	<1	<1	<1	<1	<1	-
Tetrachloroethylene	<1	<1	<1-<15	<1	<1	<1	<1	<1	-
Toluene	<1	<1	<1-<15	<1	<1	<1	<1-1	<1	-
trans-1,2-Dichloroethene	<1	<1	<1-<15	<1	<1	<1	<1	<1	-
trans-1,3-Dichloropropene	<1	<1	<1-<15	<1	<1	<1	<1	<1	-
trans-1,4-Dichloro-2-butene	<5	<5-5	<5-<75	<5	<5	<5	<5	<5	-
Trichloroethene	<1	<1	<1-<15	<1	<1	<1	<1	<1	-

TABLE 4.1-2

SUMMARY OF CHEMICAL CONCENTRATIONS IN SUNCOR'S OPERATIONAL WATERS

	NATURAL WATERS		OPERATIONAL/RECLAMATION WATERS						
Chemical	Athabasca River[1]	Reference Tributaries[2]	Consolidated Tailings Release Water[3]	Tar Island Dyke Seepage Water[4]	Plant 4 Seepage[5]	Mine Drainage[6]	Refinery Wastewater[7]	Cooling Pond E[8]	Gypsum Leachate[9]
Trichlorofluoromethane	<1	<1	<1-<15	<1	<1	<1	<1	<1	-
Vinyl acetate	<100	<100	<100-<1500	<100	<100	<100	<100	<100	-
Vinyl chloride	<20	<20	<20-<300	<20	<20	<20	<20	<20	-
INORGANICS									
General (mg/L)									
pH (pH units)	7.63-7.82	7.4-8.18	7.91-8.54	7.99-8.2	8.01-8.07	7.66-8.31	6.8-8.9	7.3-8.4	6.6
Specific Conductance (µS/cm)	200-268	159-572	1891-4900	1325-1514	1740-1790	588-747	381-1650	209-465	-
Calcium	27-33	19-60	33.3-118	23.5-57.1	29.9-43.2	54-99	32-69	26-55	-
Chloride	3.1-14.8	<0.5-57	45.4-510	15.3-17.3	<0.5-33.4	29-41	30-354	1.0-18	-
Magnesium	7.9-21	6.4-18.4	7.2-28	8.7-11.3	2.73-18.1	19-30	8-18.7	6.0-16	-
Potassium	0.9-2.65	0.41-2.2	<11.5-29	8.4-10.8	0.5-18.9	1.9-3.1	1.2-9.3	0.7-8	-
Sodium	8.6-25	7.5-61	347-1170	273-335	7.7-16600	26-53	28-246	5.0-23	-
Bicarbonate	108-267	97-29	330.84-800	847-884	34-1210	222-309	116-220	116-207	-
Carbonate	<0.5-10	<0.5	<0.05-20	<0.5	<0.5	<0.5-4	<0.5-10	<0.5-5	-
Biological Oxygen Demand	0.1-3.3	-	1.6-6.9	5-9.6	-	<0.1-0.9	<0.1-11.2	<0.1-2.5	-
Chemical Oxygen Demand	<5-28	-	200-430	120-360	-	19-47	11-305	<5-49	-
Dissolved Organic Carbon	1-17.2	12-27.5	52-65.3	36.1-42.5	-	9.8-15	5.0-42	4.0-17	-
Nitrate & Nitrite	<0.001-0.19	<0.003-0.1	<0.003-0.05	0.11-0.26	0.011	<0.003-0.01	<0.003-0.01	<0.003-0.12	0.2
Phenols	<0.001-0.01	<0.001-0.005	<0.002-0.02	<0.001-0.004	0.01	<0.001-0.08	<0.001	<0.001-0.001	-
Sulphate	13.1-58	1.6-53	555-1290	29.1-143	6.7-118	60-142	30-116	15-49	-
Sulphide	<0.001-0.002	-	-	-	-	-	-	-	-
Total Ammonia	<0.01-0.08	<0.01-0.11	0.098-3.98	4.37-6.01	17.2-19.9	<0.001-0.04	<0.006-25	<0.01-0.22	-
Total Dissolved Solids	117-319	87-339	1400-1805	878-1007	1090-1100	365-518	440-510	145-175	-
Total Kjeldahl Nitrogen	0.26-0.46	-	0.95-6.8	7.4-8.75	-	0.3-0.44	0.5-36.3	0.19-0.7	-
Total Organic Carbon	3.2-19	-	56.1-68	38.4-45	-	10.1-12.2	8.2-16	6.5-15.3	-
Total Phosphorus	0.003-0.39	0.014-0.20	0.006-0.1	0.14-0.43	<0.1-0.2	0.01-0.04	<0.003-0.29	0.02-0.17	-
Total Sulphur	6.6	2.1-17.3	186-266	12.7-48.4	5.6-12.2	20.5-44	15-19	5.9-7.9	-
Total Suspended Solids	4-624	0.4-211	<0.4-17	17-64		<0.4-20	6.0-27	2-126	-
Metals and Trace Elements (mg/L)									
Aluminum	<0.01-8.64	<0.01-1.89	<0.01-1.92	0.08-1.15	<0.01-0.88	<0.01-0.07	0.23-5.93	0.05-1.15	-
Antimony	<0.0002 - 0.0002	<0.0002-0.0003	-	-	0.0006	-	0.002	-	<0.2
Arsenic	0.0004-0.007	<0.0002-0.002	0.0007-0.0058	0.0026-0.003	0.0036	<0.0002-0.002	<0.0001-0.17	0.0002-0.004	<0.2
Barium	0.04-0.2	0.02-0.07	0.05-0.18	0.08-0.1	0.15-0.77	0.07-0.12	0.05-0.1	0.05-0.1	0.13
Beryllium	<0.001-0.004	<0.001-0.004	<0.001-0.004	<0.001-0.002	<0.001	<0.001-0.003	<0.001-0.005	<0.001-0.002	<0.01
Boron	0.01-0.09	0.05-0.14	2.26-4.26	1.65-1.88	0.21-2.31	0.12-0.22	0.05-0.15	0.01-0.07	1.21
Cadmium	<0.0002-0.003	<0.003-0.005	<0.003-0.007	<0.003-0.004	<0.0002-<0.001	<0.003-0.003	<0.001-0.01	<0.001-0.003	<0.01
Chromium	<0.002-0.032	<0.002-0.014	<0.002-0.003	<0.002-0.002	<0.002-0.03	<0.002-0.002	<0.0002-0.03	<0.002-0.01	<0.005
Cobalt	<0.001-0.01	<0.003-0.005	<0.003-0.007	<0.003-0.005	0.003-0.02	<0.003-0.01	<0.001-0.01	<0.001-0.004	<0.02
Copper	<0.001-0.01	<0.001-0.002	<0.001-0.004	0.002-0.01	<0.001	<0.001-0.01	<0.001-0.064	0.006-0.03	0.01
Cyanide	<0.001-0.005	<0.001-0.03	<0.001-0.06	0.001-0.002	-	<0.001-0.002	<0.002-0.003	<0.001-0.001	0.07
Fluoride	0.08-0.18	0.14-0.24	-	-	2.1-2.8	-	0.07-0.38	-	0.9

TABLE 4.1-2

SUMMARY OF CHEMICAL CONCENTRATIONS IN SUNCOR'S OPERATIONAL WATERS

	NATURAL WATERS		OPERATIONAL/RECLAMATION WATERS						
Chemical	Athabasca River[1]	Reference Tributaries[2]	Consolidated Tailings Release Water[3]	Tar Island Dyke Seepage Water[4]	Plant 4 Seepage[5]	Mine Drainage[6]	Refinery Wastewater[7]	Cooling Pond E[8]	Gypsum Leachate[9]
Iron	0.101-17.9	0.38-4.81	<0.01-1.01	1.24-2.21	0.01-22.5	0.007-0.3	0.005-2.56	0.22-2.28	0.35
Lead	<0.001-0.01	<0.02	<0.0003-0.02	<0.02	<0.0003-<0.01	<0.02	<0.002-0.05	<0.02-<0.05	<0.05
Lithium	<0.005-0.02	0.006-0.02	0.16-0.27	0.12-0.14	0.19-0.23	<0.013-0.02	0.009-0.022	0.004-0.01	-
Manganese	<0.004-0.51	0.014-0.21	<0.001-0.06	0.12-0.21	0.06 - 1.76	0.02-0.11	<0.001-0.12	0.012-0.15	1.41
Mercury(µg/L)	<0.05-0.2	<0.05	<0.05-0.05	<0.05-0.26	0.4	<0.05-0.52	<0.05-0.62	<0.05-0.52	<0.1
Molybdenum	<0.001-0.01	<0.003-0.004	0.15-1.42	<0.003-0.02	<0.003-0.07	<0.003-0.003	<0.004-0.6	<0.002-0.002	2.23
Nickel	<0.005-0.01	<0.005-0.012	<0.005-0.03	<0.005-0.01	0.005-0.06	<0.005-0.01	<0.002-0.15	<0.001-0.02	0.5
Selenium	<0.0001-0.0004	<0.0002-0.0003	<0.0002-0.004	<0.0002-0.0002	<0.00004	<0.0002	<0.0001-0.006	<0.0001-0.0005	<0.2
Silicon	2.12	1.13-3.6	2.32-5.58	5.63-10.1	1.1-6.12	2.82-3.89	2.45-3.53	2.17-5.05	-
Silver	<0.001-0.001	<0.002-0.003	<0.0002-0.002	<0.002	<0.0002-<0.001	<0.002-0.002	<0.002-0.005	<0.002	<0.01
Strontium	0.18-0.36	0.073-0.21	0.75-2.12	0.27-0.34	0.42-0.77	0.15-0.28	0.24-0.29	0.18-0.22	-
Thallium	-	-	-	-	<0.0003-<0.01	-	<0.01-<1	<0.1	<0.05
Tin	-	-	-	-	<0.0003-0.44	-	-	-	-
Titanium	0.004-0.09	<0.003-0.05	<0.003-0.02	<0.003-0.02	0.004-0.01	<0.003-0.003	<0.003-0.047	<0.003-0.01	-
Uranium	<0.5	<0.5	<0.5-0.007	<0.5	<0.0002-<0.1	<0.5	<0.5	<0.5	<0.2
Vanadium	<0.002-0.02	<0.002-0.008	<0.002-0.17	0.003-0.01	<0.002-0.05	<0.002-0.005	0.005-1.61	<0.002-0.013	0.13
Zinc	<0.001-0.09	0.012-0.16	0.003-0.06	0.01-0.06	0.01-0.07	0.003-0.04	0.001-0.273	<0.005-0.05	0.12
Zirconium	-	-	-	-	0.0012-0.0013	-	-	-	-

[1] Golder, 1995 unpublished data (site: upstream of L19, n= 1 to 4); NAQUADAT (code: 00AL07CC0600, 1985-1995, n= 1 to 26).
[2] Data from the tributaries were grouped and included data from Legget Creek, McLean Creek, Steepbank River and Wood Creek sampled by Golder during 1995 (Golder 1996b; n= 1 to 20).
[3] Suncor and Syncrude, 1995 unpublished data from CT field studies, (n= 6 to 18).
[4] Suncor, 1995 unpublished data from Lease 86 Study, ID: RW 127, (n= 1 to 4).
[5] Suncor, 1995 unpublished data, samples from Plant 4 Beach #2 aqueous extract and RG088/089, (n=1 to 4).
[6] Suncor, 1995 unpublished data from Lease 86 Study (Suncor ID: RW250 & 252, n= 2 to 8).
[7] Suncor, 1995 unpublished data from Lease 86 Study (Suncor ID: RW254, n= 2 to 4); NAQUADAT (codes: 20AL07DA1000/1001, 1980-1995, (n=1 to 80); Suncor's Monthly Water Monitoring Reports.
[8] Suncor, 1995 unpublished data from Lease 86 Study (Suncor ID: RW256, n= 1 to 4); NAQUADAT (code: 20AL07DA1013, 1980-1995, n= 1 to 18); Suncor's Monthly Water Monitoring Reports.
[9] Suncor, 1995 unpublished FGD Pilot Study (Sample is 50% gypsum : 50% flyash, n=1).

SUMMARY TABLE OF CHEMICAL CONCENTRATIONS IN TERRESTRIAL PLANTS

CHEMICAL	BACKGROUND					TREATMENT				
	Willow Stems[1]	Willow Leaves[2]	Poplar Stems[3]	Poplar Leaves[4]	Willow Composites[5]	Willow Stems[6]	Willow Leaves[7]	Poplar stems[8]	Poplar Leaves[9]	Willow Composites[10]
	Clean Agric. Soils	Clean Agric. Soils	Clean Agric. Soils	Clean Agric. Soils	Reference Erskine Soil	Acid/Lime CT	Acid/Lime CT	Acid/Lime CT	Acid/Lime CT	Acid/Lime CT
	(µg/g)	(µg/g)	(µg/g)	(µg/g)	(µg/g)	(µg/g)	(µg/g)	(µg/g)	(µg/g)	(µg/g)
	Range	Range	Range	Range	Range	Range	Range	Range	Range	Range
INORGANICS										
General										
Calcium	8243	17554	9289	19103	11197	5146-7933	8329-12844	5032-5704	9119-11178	7424-19088
Magnesium	1275	4796	1057	4909	1935	926-1476	3317-4338	1060-1278	2951-3894	1946-4218
Potassium	4419	18177	4096	21337	-	4391-9077	17084-18352	5125-6209	16138-22031	-
Sodium	20.7	20.1	68.4	165	-	37.5-133	34.8-92.2	23.7-386	50.8-422	-
Metals and Trace Organics										
Aluminum	11.0	28.5	20.9	26.6	30	54.4-88.9	95.2-150	26.7-31.6	36.7-52.2	47.1-418
Antimony	0.006	0.004	0.004	0.005	0.006	0.004-0.008	0.01	0.004-0.006	0.01-0.02	0.02-0.03
Arsenic	0.04	0.11	0.07	0.08	0.06	0.05-0.07	0.03-0.10	0.03-0.08	<0.03-0.08	0.40-0.61
Barium	10.6	17.1	15.6	23.5	16.7	12.0-16.3	10.6-15.7	13.9-15.5	10.1-12.8	34.6-86.5
Boron	15.5	78.1	17.3	65.5	22.2	21.9-27.2	90.3-569	15.9-21.5	70.8-295	156-232
Cadmium	0.9	1.73	0.62	1.09	1.26	0.72-1.37	0.75-1.15	0.35-0.62	0.35-0.55	2.75-8.69
Chlorine	733	5683	1503	4523	1459	554-1062	3911-7886	377-1341	2510-4896	4628-4869
Chromium	0.2	0.47	0.38	0.55	0.27	0.42-0.67	0.42-0.67	0.28-0.33	0.36-0.48	1.17-1.19
Cobalt	0.08	0.51	0.11	1.01	1.12	0.38-0.74	1.66-5.42	0.56-2.11	3.57-21.7	4.15-7.00
Copper	4.09	7.91	2.34	3.34	5.19	2.46-5.90	2.70-5.27	1.57-2.96	0.90-2.41	6.40-8.91
Iron	28.9	111	85.4	122	54.8	115-134	167-202	61.1-67.3	103-140	272-442
Lead	0.02	0.11	0.07	0.14	0.12	0.09-0.25	0.11-0.15	0.05-0.07	0.09-0.11	0.93-1.02
Lithium	0.08	0.52	0.08	2.77	0.37	0.39-2.54	0.95-10.9	0.18-0.65	2.06-20.7	8.02-8.09
Manganese	52.7	224	35.5	93.4	71.1	30.7-54.8	94.5-171	23.4-76.3	90.5-194	112-307
Molybdenum	0.03	0.43	0.04	0.29	0.42	0.13-0.17	1.14-2.58	0.05-0.11	0.76-1.52	3.02-17.4
Nickel	0.43	0.77	0.51	0.37	2.57	0.89-1.31	2.26-4.93	0.74-1.63	1.03-3.82	4.49-8.60
Selenium	0.09	0.12	<0.09	0.21	0.05	<0.05-0.10	0.08-0.37	<0.02-<0.07	0.13-0.16	0.07-0.19
Strontium	35.1	83.9	43.0	85.2	63	25.5-36.6	31.9-58.6	21.2-46.3	30.1-49.6	60.4-129
Thallium	0.002	0.005	0.006	0.003	0.008	0.003-0.006	0.003-0.004	0.003-0.004	0.001-0.003	0.01-0.03
Thorium	0.07	0.008	0.02	0.01	0.005	0.02-0.07	0.02-0.05	0.01-0.07	0.02-0.06	0.02-0.09
Tin	0.08	0.16	0.02	0.1	0.01	0.002-0.02	0.002-0.01	0.003-0.06	0.006-0.05	0.057-0.064
Titanium	3.66	9.72	4.82	8.1	4.84	3.35-5.41	6.90-9.72	2.80-3.51	4.03-6.32	10.3-22.3
Uranium	0.0003	0.003	0.003	0.004	0.009	0.005-0.008	0.01-0.02	0.002-0.004	0.004-0.01	0.01-0.05
Vanadium	0.03	0.1	0.08	0.08	0.07	0.27-0.43	0.56-0.74	0.12-0.19	0.28-0.42	1.25-14.7
Zinc	92.9	268	82.5	181	41.9	51.2-74.6	67.1-86.2	44.0-51.1	25.6-62.2	74.9-193

[1]Willow stem background uptake data from Xu (1996). Plants grown in clean agricultural soils (n=1).
[2]Willow leaf background uptake data from Xu (1996). Plants grown in clean agricultural soils (n=1).
[3]Poplar stem background uptake data from Xu (1996). Plants grown in clean agricultural soils (n=1).
[4]Poplar leaf background uptake data from Xu (1996). Plants grown in clean agricultural soils (n=1).
[5]Willow composite background uptake data from Xu (1995). Plants grown in reference erskine topsoil (n=1).
[6]Willow stem data from Xu (1996). Plants grown acid/lime-treated consolidated tails (CT), CT with muskeg, and CT, sand and muskeg (n=3).
[7]Willow leaf data from Xu (1996). Plants grown acid/lime-treated consolidated tails (CT), CT with muskeg, and CT, sand and muskeg (n=3).
[8]Poplar stem data from Xu (1996). Plants grown acid/lime-treated consolidated tails (CT), CT with muskeg, and CT, sand and muskeg (n=3).
[9]Poplar leaf data from Xu (1996). Plants grown acid/lime-treated consolidated tails (CT), CT with muskeg, and CT, sand and muskeg (n=3).
[10]Willow composite samples from Xu (1995). Plants grown in acid/lime-treated consolidated tails (n=2).

TABLE 4.1-4

SUMMARY TABLE OF CHEMICAL CONCENTRATIONS IN WETLANDS PLANTS

CHEMICAL	BACKGROUND							TREATMENT						
	Reed Canary Grass Stems[1]	Reed Canary Grass Leaves[2]	Cattail Leaves[3]	Cattail Shoots[4]	Bulrush Shoots[5]	Reed Canary Grass Composites[6]	Cattail Composites[7]	Reed Canary Grass Stems[8]	Reed Canary Grass Leaves[9]	Cattail Leaves[10]	Cattail Shoots[11]	Bulrush Shoots[12]	Reed Canary Grass Composites[13]	Cattail Foliage[14]
	Clean Agric. Soils	Clean Agric. Soils	Clean Agric. Soils	Clean Agric. Soils	Cntrl. & Ref. Wetlands	Reference Erskine Soil	Syncrude Reference Wetland	Acid/Lime CT	Acid/Lime CT	Acid/Lime CT	Suncor Dyke and Pond 1A Drainage Wetlands	Suncor Dyke and Pond 1A Drainage Wetlands	Acid/Lime CT	Fine Tails
	(μg/g)	(μg/g)	(μg/g)	(μg/g)	(μg/g)	(μg/g)	(μg/g)	(μg/g)	(μg/g)	(μg/g)	(μg/g)	(μg/g)	(μg/g)	(μg/g)
	Range	Range	Range	Range	Range	Range	Range	Range	Range	Range	Range	Range	Range	Range
ORGANICS														
Polycyclic Aromatic Hydrocarbons														
1-Methyl-7-isopropyl phenanthrene	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.002
Acenaphthene	-	-	-	-	-	-	-	-	-	-	-	-	-	0.006
Acenaphthylene	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.001
Anthracene	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.001
Benzo(a)anthracene/chrysene	-	-	-	-	-	-	-	-	-	-	-	-	-	0.05
Benzo(a)pyrene	-	-	-	-	-	-	-	-	-	-	-	-	-	0.02
Benzo(b&k)fluoranthene	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.001
Benzo(ghi)perylene	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.001
Biphenyl	-	-	-	-	-	-	-	-	-	-	-	-	-	0.002
C2 sub'd benzo(a)anthracene/chrysene	-	-	-	-	-	-	-	-	-	-	-	-	-	0.03
C2 sub'd benzo(b&k)fluranthene/ benzo(a)pyrene	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.002
C2 sub'd biphenyl	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.002
C2 sub'd dibenzothiophene	-	-	-	-	-	-	-	-	-	-	-	-	-	0.29
C2 sub'd fluorene	-	-	-	-	-	-	-	-	-	-	-	-	-	0.1
C2 sub'd naphthalene	-	-	-	-	-	-	-	-	-	-	-	-	-	0.007
C2 sub'd phenanthrene/anthracene	-	-	-	-	-	-	-	-	-	-	-	-	-	0.35
C3 sub'd dibenzothiophene	-	-	-	-	-	-	-	-	-	-	-	-	-	0.36
C3 sub'd naphthalene	-	-	-	-	-	-	-	-	-	-	-	-	-	0.06
C3 sub'd phenanthrene/anthracene	-	-	-	-	-	-	-	-	-	-	-	-	-	0.43
C4 sub'd dibenzothiophene	-	-	-	-	-	-	-	-	-	-	-	-	-	0.04
C4 sub'd naphthalene	-	-	-	-	-	-	-	-	-	-	-	-	-	0.22
C4 sub'd phenanthrene/anthracene	-	-	-	-	-	-	-	-	-	-	-	-	-	0.53
Dibenzo(a,h)anthracene	-	-	-	-	-	-	-	-	-	-	-	-	-	0.001
Dibenzothiophene	-	-	-	-	-	-	-	-	-	-	-	-	-	0.001
Fluoranthene	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.001
Fluorene	-	-	-	-	-	-	-	-	-	-	-	-	-	0.003
Indeno(c,d-123)pyrene	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.001
Methyl acenaphthene	-	-	-	-	-	-	-	-	-	-	-	-	-	0.007
Methyl benzo(a)anthracene/chrysene	-	-	-	-	-	-	-	-	-	-	-	-	-	0.04
Methyl benzo(b&k)fluoranthene/ benzo(a)pyrene	-	-	-	-	-	-	-	-	-	-	-	-	-	0.002
Methyl biphenyl	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.002
Methyl dibenzothiophene	-	-	-	-	-	-	-	-	-	-	-	-	-	0.08
Methyl fluoranthene/pyrene	-	-	-	-	-	-	-	-	-	-	-	-	-	0.04
Methyl fluorene	-	-	-	-	-	-	-	-	-	-	-	-	-	0.04
Methyl naphthalene	-	-	-	-	-	-	-	-	-	-	-	-	-	0.006
Methyl phenanthrene/anthracene	-	-	-	-	-	-	-	-	-	-	-	-	-	0.14
Naphthalene	-	-	-	-	-	-	-	-	-	-	-	-	-	0.006
Phenanthrene	-	-	-	-	-	-	-	-	-	-	-	-	-	0.02
Pyrene	-	-	-	-	-	-	-	-	-	-	-	-	-	0.001
INORGANICS														
General														
Calcium	1204	7233	11235	-	-	4596	8490	1295-1668	5732-7252	14145-16634	-	-	3289-3306	6110-6150
Magnesium	677	2883	2053	-	-	1904	2600	898-1344	2198-3266	1413-1960	-	-	1943-2378	2120-2130
Phosphorus	-	-	-	-	-	-	1060	-	-	-	-	-	-	1310-1350
Potassium	15358	28180	25649	-	-	-	12200	15235-25762	17841-24633	5588-21720	-	-	-	6690-6770
Sodium	59.5	72.6	979	-	-	-	3750	117-548	183-924	2838-3701	-	-	-	-
Metals and Trace Elements														
Aluminum	59.1	47.0	77.8	166-227	83.1-359	136	1440	13.2-43.2	110-132	160-614	95.6-683	115-702	84.5-109	1420-1610
Antimony	0.004	0.01	0.003	-	-	0.01	<0.1	0.004-0.01	0.02-0.03	-	-	-	0.008-0.02	<0.1
Arsenic	0.13	0.2	0.09	-	-	0.06	2.5	0.05-0.14	0.07-0.31	0.03-0.56	-	-	0.32-0.55	1.4-1.6
Barium	7.96	25.9	12.8	-	-	21.1	21.5	5.10-8.55	12.7-26.9	20.3-24.3	-	-	27.0-30.5	28.4-28.7
Beryllium	-	-	-	-	-	-	0.15	-	-	-	-	-	-	0.13-0.14
Bismuth	-	-	-	-	-	-	<0.1	-	-	-	-	-	-	<0.1
Boron	2.09	23.9	20.7	-	-	12.2	15	3.26-6.59	15.9-41.4	25.0-69.0	-	-	114-344	29-44
Cadmium	0.23	0.16	0.11	0.05-0.06	0.05-0.1	0.26	0.34	0.23-1.01	0.13-4.47	0.34-0.49	0.05-0.06	0.05-0.07	0.17-0.22	0.28-0.29
Chlorine	1990	9908	16063	-	-	3380	-	7916-10468	28174-39205	18516-41818	-	-	6714-33526	-
Chromium	0.23	0.55	0.54	-	-	0.41	5.8	0.34-0.43	0.89-3.69	0.92-2.05	-	-	0.49-0.82	3.1

TABLE 4.1-4

SUMMARY TABLE OF CHEMICAL CONCENTRATIONS IN WETLANDS PLANTS

Page 2 of 2

CHEMICAL	BACKGROUND							TREATMENT							
	Reed Canary Grass Stems[1]	Reed Canary Grass Leaves[2]	Cattail Leaves[3]	Cattail Shoots[4]	Bullrush Shoots[5]	Reed Canary Grass Composites[6]	Cattail Composites[7]	Reed Canary Grass Stems[8]	Reed Canary Grass Leaves[9]	Cattail Leaves[10]	Cattail Shoots[11]	Bulrush Shoots[12]	Reed Canary Grass Composites[13]	Cattail Foliage[14]
	Clean Agric. Soils	Clean Agric. Soils	Clean Agric. Soils	Clean Agric. Soils	Cntrl. & Ref. Wetlands	Reference Erskine Soil	Syncrude Reference Wetland	Acid/Lime CT	Acid/Lime CT	Acid/Lime CT	Suncor Dyke and Pond 1A Drainage Wetlands	Suncor Dyke and Pond 1A Drainage Wetlands	Acid/Lime CT	Fine Tails
	(µg/g)	(µg/g)	(µg/g)	(µg/g)	(µg/g)	(µg/g)	(µg/g)	(µg/g)	(µg/g)	(µg/g)	(µg/g)	(µg/g)	(µg/g)	(µg/g)
	Range	Range	Range	Range	Range	Range	Range	Range	Range	Range	Range	Range	Range	Range
Cobalt	0.1	0.08	0.29	-	-	0.11	1.5	0.47-2.03	0.40-2.06	0.26-7.55	-	-	0.72-3.64	2.2
Copper	3.41	5.28	3.53	1.63-1.71	2.18-3.66	5.04	9.74	3.38-5.14	3.18-4.89	2.65-4.26	1.21-2.36	2.06-2.82	3.22-3.77	6.0-6.2
Iron	66.4	124	115	257-338	170-937	135	4400	42.5-118	185-256	238-1196	189-508	224-643	105-118	2300
Lead	0.11	0.31	0.15	-	-	0.37	1.2	0.04-0.14	0.20-0.29	0.26-1.12	-	-	0.26-0.31	0.5-0.6
Lithium	0.38	0.51	0.57	-	-	1.29	<4	0.56-2.16	1.71-5.67	1.09-5.34	-	-	4.46-15.7	<4.0-5.0
Manganese	60.9	141	571	536-689	404-469	49.3	828	39.2-114	59.1-117	79.4-200	153-303	106-193	209-249	211-217
Mercury	-	-	-	0.01-0.02	0.01-0.02	-	-	-	-	-	0.01-0.11	0.01-0.07	-	<0.02
Molybdenum	0.28	1.31	4.08	-	-	1.63	2.3	0.28-0.63	1.89-4.41	1.34-5.87	-	-	2.84-12.5	1.7
Nickel	0.7	0.95	0.35	2.0-2.66	2.0-2.2	1.81	2.7	2.44-6.60	2.49-7.22	1.57-12.9	2.0-2.27	2.0-2.01	2.12-11.5	3.3-3.5
Selenium	0.01	0.17	0.23	-	-	0.15	<0.1	0.11-0.14	0.37-0.38	0.50-0.64	-	-	0.22-0.58	<0.1
Silicon	-	-	-	-	-	-	302	-	-	-	-	-	-	274-283
Strontium	7.68	33.5	51.4	-	-	27.9	34.1	5.88-15	17.4-46.4	48.3-99.2	-	-	29.3-38.7	59.7-60.3
T. Sulphur	-	-	-	-	-	-	3060	-	-	-	-	-	-	2880-2940
Thallium	0.006	0.007	0.001	-	-	0.006	-	0.002-0.01	0.002-0.004	<0.0002-0.01	-	-	0.008-0.01	-
Thorium	0.02	0.02	0.002	-	-	0.03	<0.4	0.02-0.09	0.02-0.07	0.02-0.19	-	-	0.01-0.03	<0.4
Tin	0.01	0.06	0.02	-	-	0.03	<2	0.01-0.09	0.01-0.07	0.001-0.02	-	-	0.03-0.04	<2
Titanium	5.54	9.57	12.1	-	-	6.89	16.3	4.60-5.71	9.81-11.5	8.02-17.3	-	-	5.65-6.49	8.73-9.48
Uranium	0.007	0.01	0.01	-	-	0.01	<4	0.001-0.01	0.01-0.03	0.02-0.22	-	-	0.008-0.04	<4.0
Vanadium	0.13	0.15	0.19	-	-	0.33	5.1	0.10-0.20	0.74-1.86	0.84-11.9	-	-	0.31-1.63	4.4-4.7
Zinc	101	50.9	21.5	18.8-27.4	22.3-41.4	38.3	34.1	39.5-56.3	16.0-27.4	11.6-16.4	11.2-33.8	13.7-25.2	47.5-64.9	21.9-22.1
Zirconium	-	-	-	-	-	-	1.5	-	-	-	-	-	-	1.7-2.0

[1]Reed canary grass stems background plant uptake data from Xu (1996). Plants grown in clean agricultural soils (n=1).
[2]Reed canary grass leaves background plant uptake data from Xu (1996). Plants grown in clean agricultural soils (n=1).
[3]Cattail leaves background plant uptake data from Xu (1996). Plants grown in clean agricultural soils (n=1).
[4]Cattail shoots background plant uptake data from Nix et al. (1994). Plants grown in control and reference wetlands (n=5).
[5]Bullrush shoots background plant uptake data from Nix et al. (1994). Plants grown in control and reference wetlands (n=5).
[6]Reed canary grass composites background plant uptake data from Xu (1995). Plants grown in reference erskine topsoil (n=1).
[7]Cattail foliage background plant uptake data from Syncrude reference wetland (1994; unpublished data; n=1).
[8]Reed canary grass stem data from Xu (1996). Plants grown in acid/lime-treated consolidated tails (CT), CT and muskeg, and CT, sand, and muskeg (n=3).
[9]Reed canary grass leaf data from Xu (1996). Plants grown in acid/lime-treated consolidated tails (CT), CT and muskeg, and CT, sand, and muskeg (n=3).
[10]Cattail leaf data from Xu (1996). Plants grown in acid/lime-treated consolidated tails (CT), CT and muskeg, and CT, sand, and muskeg (n=3).
[11]Cattail shoot data from Nix et al. (1994). Plants grown in Suncor Dyke and Pond 1A drainage wetlands (n=6).
[12]Bullrush shoot data from Nix et al. (1994). Plants grown in Suncor Dyke and Pond 1A drainage wetlands (n=6).
[13]Reed canary grass composite samples from Xu (1995). Plants grown in acid/lime-treated consolidated tails (n=2).
[14]Cattail foliage uptake data from Syncrude, Pit 7 (1994; unpublished data). Plants grown in fine tails (n=2).

TABLE 4.1-5

SUMMARY TABLE OF CHEMICAL CONCENTRATIONS IN FISH AND AQUATIC MACROINVERTEBRATES

Page 1 of 3

CHEMICAL	BACKGROUND							TREATMENT					
	Chironomid Larvae[1]	Benthic Macroinvertebrates[2]	Emergent Insects[3]	Benthic Macroinvertebrates[4]	Athabasca River Baseline[5]	Rainbow Trout[6]	Walleye[7]	Chironomid Larvae[8]	Benthic Macroinvertebrates[9]	Emergent Insects[10]	Rainbow Trout[11]	Walleye[12]	Rainbow Trout[13]
	Control Wetlands	Control Wetlands	Control Wetlands	Athabasca River	Athabasca River Water	Athabasca River Water	Athabasca River Water	Suncor Dyke Drainage Wetlands	Suncor Dyke and Split Dyke Drainage Wetlands	Dyke Drainage Wetlands	10% TID Water	10% TID Water	Syncrude Pond #5
	(µg/g)	(µg/g)	(µg/g)	(µg/g)	(µg/g)	(µg/g)	(µg/g)	(µg/g)	(µg/g)	(µg/g)	(µg/g)	(µg/g)	(µg/g)
	Range	Range	Range	Range	Range	Range	Range	Range	Range	Range	Range	Range	Range
ORGANICS													
Total Extractable Hydrocarbons	-	14-99.8	-	-	-	-	-	-	-	-	-	-	-
Polycyclic Aromatic Hydrocarbons													
1-Methyl-7-isopropyl	-	-	-	<0.04	<0.04	<0.04	<0.04	-	-	-	<0.04	<0.04	-
Acenaphthene	-	-	-	<0.02	<0.02	<0.02	<0.02	-	-	-	<0.02	<0.02	<0.001
Acenaphthylene	-	-	-	<0.02	<0.02	<0.02	<0.02	-	-	-	<0.02	<0.02	<0.0002
Anthracene	-	-	-	<0.02	<0.02	<0.02	<0.02	-	-	-	<0.02	<0.02	<0.0006
Benzo(a)anthracene	-	-	-	-	-	-	-	-	-	-	-	-	<0.00009
Benzo(a)anthracene/chrysene	-	-	-	<0.02	<0.02	<0.02	<0.02	-	-	-	<0.02	<0.02	-
Benzo(a)pyrene	-	-	-	<0.02	<0.02	<0.02	<0.02	-	-	-	<0.02	<0.02	0.001
Benzo(e)pyrene	-	-	-	-	-	-	-	-	-	-	-	-	0.001
Benzo(b&k)fluoranthene	-	-	-	<0.02	<0.02	<0.02	<0.02	-	-	-	<0.02	<0.02	<0.0008
Benzo(ghi)perylene	-	-	-	<0.02	<0.02	<0.02	<0.02	-	-	-	<0.02	<0.02	<0.001
Biphenyl	-	-	-	<0.04	<0.04	<0.04	<0.04	-	-	-	<0.04	<0.04	-
C2 sub'd benzo(a)anthracene/ chrysene	-	-	-	<0.04	<0.04	<0.04	<0.04	-	-	-	<0.04	<0.04	-
C2 sub'd benzo(b&k)fluoranthene/ benzo(a)pyrene	-	-	-	<0.04	<0.04	<0.04	<0.04	-	-	-	<0.04	<0.04	-
C2 sub'd biphenyl	-	-	-	0.06	<0.04	<0.04	<0.04	-	-	-	<0.04	<0.04	-
C2 sub'd dibenzothiophene	-	-	-	<0.04	<0.04	<0.04	<0.04	-	-	-	<0.04	<0.04	<0.01
C2 sub'd fluorene	-	-	-	<0.04	<0.04	<0.04	<0.04	-	-	-	<0.04	<0.04	-
C2 sub'd naphthalene	-	-	-	<0.04	<0.04	<0.04	<0.04	-	-	-	<0.04	<0.04	<0.01
C2 sub'd phenanthrene/antharacene	-	-	-	<0.04	<0.04	<0.04	<0.04	-	-	-	<0.04	<0.04	<0.01
C3 sub'd dibenzothiophene	-	-	-	<0.04	<0.04	<0.04	<0.04	-	-	-	<0.04	<0.04	-
C3 sub'd naphthalene	-	-	-	<0.04	<0.04	<0.04	<0.04	-	-	-	<0.04	<0.04	<0.01
C3 sub'd phenanthrene/anthracene	-	-	-	<0.04	<0.04	<0.04	<0.04	-	-	-	<0.04	<0.04	<0.01
C4 sub'd dibenzothiophene	-	-	-	<0.04	<0.04	<0.04	<0.04	-	-	-	<0.04	<0.04	-
C4 sub'd naphthalene	-	-	-	<0.04	<0.04	<0.04	<0.04	-	-	-	<0.04	<0.04	<0.01
C4 sub'd phenanthrene/anthracene	-	-	-	<0.04	<0.04	<0.04	<0.04	-	-	-	<0.04	<0.04	<0.01
Chrysene	-	-	-	-	-	-	-	-	-	-	-	-	<0.00007
Dibenzo(a,h)anthracene	-	-	-	<0.02	<0.02	<0.02	<0.02	-	-	-	<0.02	<0.02	<0.002
Dibenzothiophene	-	-	-	<0.02	<0.02	<0.02	<0.02	-	-	-	<0.02	<0.02	<0.01
Fluoranthene	-	-	-	<0.02	<0.02	<0.02	<0.02	-	-	-	<0.02	<0.02	<0.001
Fluorene	-	-	-	<0.02	<0.02	<0.02	<0.02	-	-	-	<0.02	<0.02	0.003
Indeno(c,d-123)pyrene	-	-	-	<0.02	<0.02	<0.02	<0.02	-	-	-	<0.02	<0.02	<0.001
Methyl acenaphthene	-	-	-	<0.04	<0.04	<0.04	<0.04	-	-	-	<0.04	<0.04	-
Methyl	-	-	-	<0.04	<0.04	<0.04	<0.04	-	-	-	<0.04	<0.04	-
Methyl benzo(b&k)fluoranthene/ benzo(a)pyrene	-	-	-	<0.04	<0.04	<0.04	<0.04	-	-	-	<0.04	<0.04	-
Methyl biphenyl	-	-	-	<0.04	<0.04	<0.04	<0.04	-	-	-	<0.04	<0.04	-
Methyl dibenzothiophene	-	-	-	<0.04	<0.04	<0.04	<0.04	-	-	-	<0.04	<0.04	<0.01
Methyl fluoranthene/pyrene	-	-	-	<0.04	<0.04	<0.04	<0.04	-	-	-	<0.04	<0.04	-
Methyl fluorene	-	-	-	0.06	<0.04	<0.04	<0.04	-	-	-	<0.04	<0.04	-
Methyl naphthalene	-	-	-	<0.02	<0.02-0.03	<0.02-0.03	<0.02	-	-	-	0.03	<0.02	0.006
Methyl phenanthrene/anthracene	-	-	-	<0.04	<0.04	<0.04	<0.04	-	-	-	<0.04	<0.04	<0.01

TABLE 4.1-5

SUMMARY TABLE OF CHEMICAL CONCENTRATIONS IN FISH AND AQUATIC MACROINVERTEBRATES

CHEMICAL	BACKGROUND							TREATMENT					
	Chironomid Larvae[1]	Benthic Macroinvertebrates[2]	Emergent Insects[3]	Benthic Macroinvertebrates[4]	Athabasca River Baseline[5]	Rainbow Trout[6]	Walleye[7]	Chironomid Larvae[8]	Benthic Macroinvertebrates[9]	Emergent Insects[10]	Rainbow Trout[11]	Walleye[12]	Rainbow Trout[13]
	Control Wetlands	Control Wetlands	Control Wetlands	Athabasca River	Athabasca River Water	Athabasca River Water	Athabasca River Water	Suncor Dyke Drainage Wetlands	Suncor Dyke and Split Dyke Drainage Wetlands	Dyke Drainage Wetlands	10% TID Water	10% TID Water	Syncrude Pond #5
	(µg/g)	(µg/g)	(µg/g)	(µg/g)	(µg/g)	(µg/g)	(µg/g)	(µg/g)	(µg/g)	(µg/g)	(µg/g)	(µg/g)	(µg/g)
Naphthalene	-	-	-	<0.02	<0.02-0.04	<0.02-0.02	<0.02	-	-	-	0.03	<0.02	0.005
Perylene	-	-	-	-	-	-	-	-	-	-	-	-	<0.001
Phenanthrene	-	-	-	<0.02	<0.02	<0.02	<0.02	-	-	-	<0.02	<0.02	0.001
Pyrene	-	-	-	<0.02	<0.02	<0.02	<0.02	-	-	-	<0.02	<0.02	<0.0008
Polycyclic Aromatic Nitrogen Heterocycles													
7-Methyl quinoline	-	-	-	-	<0.02	<0.02	<0.02	-	-	-	<0.02	<0.02	-
Acridine	-	-	-	-	<0.02	<0.02	<0.02	-	-	-	<0.02	<0.02	-
C2 Alkyl subst'd carbazoles	-	-	-	-	<0.02	<0.02	<0.02	-	-	-	<0.02	<0.02	-
C2 Alkyl subst'd quinolines	-	-	-	-	<0.02	<0.02	<0.02	-	-	-	<0.02	<0.02	-
C3 Alkyl subst'd quinolines	-	-	-	-	<0.02	<0.02	<0.02	-	-	-	<0.02	<0.02	-
Carbazole	-	-	-	-	<0.02	<0.02	<0.02	-	-	-	<0.02	<0.02	-
Methyl acridine	-	-	-	-	<0.02	<0.02	<0.02	-	-	-	<0.02	<0.02	-
Methyl carbazoles	-	-	-	-	<0.02	<0.02	<0.02	-	-	-	<0.02	<0.02	-
Phenanthridine	-	-	-	-	<0.02	<0.02	<0.02	-	-	-	<0.02	<0.02	-
Quinoline	-	-	-	-	<0.02	<0.02	<0.02	-	-	-	<0.02	<0.02	-
INORGANICS													
General	-	-	-				-	-	-	-	-	-	-
Calcium	-	-	-	7940	246-680	2260	7090	-	-	-	261	7660	-
Magnesium	-	-	-	2230	277-331	380	457	-	-	-	302	371	-
Phosphorus	-	-	-	3950	2140-2960	3620	6060	-	-	-	2640	5820	-
Potassium	-	-	-	4560	3950-5190	4840	5090	-	-	-	4880	4390	-
Sodium	-	-	-	4270	338-409	471	635	-	-	-	480	748	-
Metals and Trace Elements	-	-	-										
Aluminum	17.9-71.0	70-220	20-40	-	<2-11	18	14	15.8-18.4	100-1800	20-70	12	12	-
Arsenic	-	-	-	0.8	<0.5	<0.1	2.3	-	-	-	<0.1	1.1	-
Barium		7-52.6	<2-41	44	<0.5	<0.5	0.9	-	8-71.5	<20-84.4	<0.5	0.9	-
Beryllium	-	-	-	0.2	<0.5	<1	<1	-	-	-	<1	<1	-
Boron	-	-	-	10	<5	<5	<5	-	-	-	<5	<5	-
Cadmium	0.06-0.34	<1	<1	<0.3	<0.5	<0.5	<0.5	0.17-0.57	<1	<1	<0.5	<0.5	-
Chromium	-	-	-	31.8	<0.5	<0.5	<0.5	-	-	-	<0.5	<0.5	-
Cobalt	-	-	-	3.5	<0.5	<1	<1	-	-	-	<1	<1	-
Copper	-	<8-20	<60-70	13.7	<1-2	<1	<1	-	10-40	60-70	<1	<1	-
Iron	3080-4528	810-2100	420-1800	5660	7-16	23	8	1431-6590	1070-2970	220-650	4	<1	-
Lead	0.9-2.4	<1	<1	3	<2	<5	<5	3.84-5.73	<1	<1	<5	<5	-
Lithium	-	-	-	3.2	-	-	-	-	-	-	-	-	-
Manganese	-	20-46	20-80	193	<0.5-0.9	0.9	5.1	-	20-110	<30-190	0.2	6.1	-
Mercury	3.0-8.5	<1	<1	0.06	-	0.04	0.45	3.84-5.39	<1	<1	0.03	0.44	-
Molybdenum	-	-	-	2.2	<1	<1	<1	-	-	-	<1	<1	-
Nickel	-	-	-	23	<1-2	<2	<2	-	-	-	<2	<2	-
Selenium	-	-	-	<0.2	<0.5-0.3	0.3	0.4	-	-	-	<0.4	0.4	-
Silicon	-	-	-	654	4-12	<50	<50	-	-	-	<50	<50	-
Silver	-	-	-	<0.2	-	<1	<1	-	-	-	<1	<1	-
Strontium	-	-	-	21.7	<0.5-0.9	2	8	-	-	-	<1	8	-
Thallium	-	-	-	-	<1	<1	<1	-	-	-	<1	<1	-
Tin	-	-	-	-	<2	<5	<5	-	-	-	<5	<5	-
Titanium	-	3-9	<3-<30	38.9	-	-	-	-	4-30	8-10	-	-	-
Uranium	-	-	-	<50	-	-	-	-	-	-	-	-	-

TABLE 4.1-5

SUMMARY TABLE OF CHEMICAL CONCENTRATIONS IN FISH AND AQUATIC MACROINVERTEBRATES

CHEMICAL	BACKGROUND							TREATMENT					
	Chironomid Larvae[1]	Benthic Macroinvertebrates[2]	Emergent Insects[3]	Benthic Macroinvertebrates[4]	Athabasca River Baseline[5]	Rainbow Trout[6]	Walleye[7]	Chironomid Larvae[8]	Benthic Macroinvertebrates[9]	Emergent Insects[10]	Rainbow Trout[11]	Walleye[12]	Rainbow Trout[13]
	Control Wetlands	Control Wetlands	Control Wetlands	Athabasca River	Athabasca River Water	Athabasca River Water	Athabasca River Water	Suncor Dyke Drainage Wetlands	Suncor Dyke and Split Dyke Drainage Wetlands	Dyke Drainage Wetlands	10% TID Water	10% TID Water	Syncrude Pond #5
	(µg/g)	(µg/g)	(µg/g)	(µg/g)	(µg/g)	(µg/g)	(µg/g)	(µg/g)	(µg/g)	(µg/g)	(µg/g)	(µg/g)	(µg/g)
Vanadium	-	-	-	9.7	<1	<1	<1	-	-	-	<1	<1	-
Zinc	69.2-234	42-94	89-200	78.1	5-6	8.9	17.2	131-145	60-110	80-220	10.3	17.5	-

[1]Chironomid larvae background uptake data from Nix et al. (1994). Chironomid larvae collected from control sites (n=3).
[2]Benthic macroinvertebrate background uptake data from Nix et al. (1994). Macroinvertebrates collected from control sites (n=3).
[3]Emergent insect background uptake data from Nix et al. (1994). Emergent insects collected from control sites (n=9).
[4]Benthic Macroinvertebrates collected from Athabasca River upstream of TID (Golder 1994b, n=1).
[5]Athabasca River baseline uptake data from Golder Associates Ltd. (1996b). Data are ranges of composite samples based on filets from 10 fish/composite, seperated by gender and species (walleye, goldeye and longnose sucker; n=6-7).
[6]Rainbow trout background uptake data from HydroQual (1996). Fish were held for 28 days in Athabasca River water (n=1).
[7]Walleye background uptake data from HydroQual (1996). Fish were held for 28 days in Athabasca River water (n=1).
[8]Chironomid uptake data from Nix et al. (1994). Chironomids sampled from Suncor Dyke Drainage trenches (n=3).
[9]Benthic macroinvertebrate uptake data from Nix et al. (1994). Macroinvertebrates sampled from Suncor Dyke Drainages and Split Dyke Drainages (n=9).
[10]Emergent insect uptake data from Nix et al. (1994). Emergent insects collected from Suncor Dyke Drainages (n=9).
[11]Rainbow trout uptake data from HydroQual (1996). Fish were held for 28 days in 10% Tar Island Dyke Water (n=1).
[12]Walleye uptake data from HydroQual (1996). Fish were held for 28 days in 10% Tar Island Dyke Water (n=1).
[13]Rainbow trout uptake data from Syncrude (1992; unpublished data). Fish were held for 10 weeks in water from Syncrude Pond #5 (n=1).

TABLE 4.1-6

SUMMARY TABLE OF CHEMICAL CONCENTRATIONS IN BIRDS AND MAMMALS

CHEMICAL	Background			Treatment		
	Duckling[1]	Deer Mice[2]	Red-backed Voles[3]	Duckling[4]	Muskrat[5,6]	Bison[7]
	Control Wetland	Ft. McMurray Region	Ft. McMurray Region	CT and DD Ponds and Wetlands	Suncor Drainage wetland	Tailings sand with 50 cm cap
	(µg/g)	(µg/g)	(µg/g)	(µg/g)	(µg/g)	(µg/g)
	Range	Range	Range	Range	Range	Range
ORGANICS						
Polycyclic Aromatic Hydrocarbons						
Acenaphthene	-	-	-	-	<DL	<0.002
Acenaphthylene	-	-	-	-	<DL	<0.002
Benzo(a)anthracene/chrysene	-	-	-	-	<DL	<0.002
Benzo(a)pyrene	-	-	-	-	<DL	<0.002
Benzo(b&k)fluoranthene	-	-	-	-	<DL	<0.002
Benzo(ghi)perylene	-	-	-	-	<DL	<0.002
Biphenyl	-	-	-	-	<DL	<0.002
C2 sub'd naphthalene	-	-	-	-	<DL	<0.002
C3 sub'd naphthalene	-	-	-	-	<DL	<0.002
C4 sub'd naphthalene	-	-	-	-	<DL	<0.002
Dibenzo(a,h)anthracene	-	-	-	-	<DL	<0.002
Dibenzothiophene	-	-	-	-	<DL	<0.002
Fluoranthene	-	-	-	-	<DL	<0.002
Fluorene	-	-	-	-	<DL	<0.002
Indeno(c,d-123)pyrene	-	-	-	-	<DL	<0.002
Methyl naphthalene	-	-	-	-	<DL	<0.002
Methyl phenanthrene/anthracene	-	-	-	-	<DL	<0.002
Naphthalene	-	-	-	-	<DL	0.008
Phenanthrene	-	-	-	-	<DL	<0.002
Pyrene	-	-	-	-	<DL	<0.002
INORGANICS						
General						
Calcium	-	-	-	-	40-160	20-312
Magnesium	-	-	-	-	170-260	6-802

TABLE 4.1-6

SUMMARY TABLE OF CHEMICAL CONCENTRATIONS IN BIRDS AND MAMMALS

CHEMICAL	Background			Treatment		
	Duckling[1]	Deer Mice[2]	Red-backed Voles[3]	Duckling[4]	Muskrat[5, 6]	Bison[7]
	Control Wetland	Ft. McMurray Region	Ft. McMurray Region	CT and DD Ponds and Wetlands	Suncor Drainage wetland	Tailings sand with 50 cm cap
	(µg/g)	(µg/g)	(µg/g)	(µg/g)	(µg/g)	(µg/g)
	Range	Range	Range	Range	Range	Range
Phosphorus	-	-	-	-	1730-2920	85.7-7100
Potassium	-	-	-	-	2430-3840	240-12700
Sodium	-	-	-	-	700-1580	436-2770
Metals and Trace Elements						
Aluminum	3-5	43.0-172	17.5-356	<1-5	<1-13	<0.8-43
Antimony	-	-	-		-	<0.1
Arsenic	<2	-	-	<2	-	<0.1
Barium	0.14-0.92	9.8-19.3	7.3-11.5	0.08-1.09	<1-2	0.1-2.8
Beryllium	-	-	-	-	<0.1	<0.04
Cadmium	-	-	-	-	<0.3	<0.02-0.27
Chromium	0.1	6.5-13	4.0-18.0	0.09-0.5	0.3-0.5	0.2-0.4
Cobalt	-	-	-	-	<0.1	<0.08-0.2
Copper	221-278	6.5-9.9	6.5-8.6	207-281	0.8-1.9	0.4-52.4
Iron	-	-	-	-	56-1700	4.6-434
Lead	<1	-	-	<0.9-1	<2	<0.8
Lithium	-	-	-	-	<0.5	<4
Manganese	-	6.5-22.5	5.4-42.0	-	<0.1-2	<0.08-12.4
Mercury	<0.1	-	-	<0.1	<0.02	<0.05
Molybdenum	-	-	-	-	<0.3	<0.2-4.7
Nickel	<0.2	-	-	<0.2-0.2	<0.5	0.1-1.0
Selenium	-	-	-	-	-	<0.1-1.0
Silicon	-	-	-	-	5.0-15	<2-103
Strontium	-	-	-	-	<0.2-0.6	<0.4-2.3
Sulphur	-	-	-	-	-	308-7500
Thorium	-	-	-	-	-	<0.4
Tin	-	-	-	-	-	<2

TABLE 4.1-6

SUMMARY TABLE OF CHEMICAL CONCENTRATIONS IN BIRDS AND MAMMALS

CHEMICAL	Background			Treatment		
	Duckling[1]	Deer Mice[2]	Red-backed Voles[3]	Duckling[4]	Muskrat[5,6]	Bison[7]
	Control Wetland	Ft. McMurray Region	Ft. McMurray Region	CT and DD Ponds and Wetlands	Suncor Drainage wetland	Tailings sand with 50 cm cap
	(µg/g)	(µg/g)	(µg/g)	(µg/g)	(µg/g)	(µg/g)
	Range	Range	Range	Range	Range	Range
Titanium	-	0.9-5.7	0.8-20.0	-	<0.3-0.8	<0.04-1.89
Uranium	-	-	-	-	<50	<4
Vanadium	<0.2	-	-	<0.2	<0.2	<0.2
Zinc	-	77.8-109	82.0-108	-	12.4-31.7	1.95-138

[1]Background duckling uptake data from tissue uptake study on duckling livers. Duckling kept in an experimental control wetland (Wolfe and Norman, as cited in Bishay and Nix 1996; unpublished data; n=2-3).

[2]Deer mice background uptake data from Pauls and Arner (1989). Concentrations reported are from samples 17B-22; collected from areas unimpacted by mining, west of Fort McMurray (n=4).

[3]Red-backed vole background uptake data from Pauls and Arner (1989). Concentrations reported are from samples 17B-22; collected from areas unimpacted by mining, west of Fort McMurray (n=6 for most samples).

[4]Duckling data from tissue uptake study on duckling livers. Ducklings exposed via CT pond, CT wetland, dyke drainage pond and dyke drainage wetland (Wolfe and Norman, as cited in Bishay and Nix 1996; unpublished data; n=9-10)

[5]Muskrat collected from Suncor wetland trench, spring 1995 (unpublished data). Data presented are maximum concentrations detected in brain, liver and muscl tissues (n=3 tissue types).

[6]All muskrat organic tissue data was below detection level. Detection levels ranged from 0.01 - 0.2 ppm depending on the tissue and compound being analyzed.

[7]Bison uptake data from Pauls, Peden and Johnson (1995; unpublished data). Bison collected from Syncrude toe berm pasture (kept on tailings sand capped with 50 cm cap). Bison liver was analyzed for organic residues (n=1), and liver, adipose and muscle tissues were analyzed for inorganic chemical concentrations (n=3).

TABLE 4.2-1

ASSUMPTIONS FOR TIME-TABLE FOR SUCCESSION OF RECLAMATION VEGETATION TYPES

Reclamation Vegetation Type	ELC Vegetation Type - Existing and Projected: 2001, 2010, 2020, 2100				
Time Frame	**Existing**	**2001**	**2010**	**2020**	**2100**
Spruce/Poplar/Pine	Disturbed HG	Disturbed HG	Mixedwood Spruce domn.	Mixedwood Spruce domn.	Mixedwood Spruce domn.
Spruce/Pine/Poplar	Disturbed HG	Disturbed HG	Mixedwood Spruce domn.	Mixedwood Spruce domn.	Mixedwood Spruce domn.
Spruce/Poplar	Disturbed HG	Disturbed HG	Mixedwood Spruce domn.	Mixedwood Spruce domn.	Mixedwood Spruce domn.
Spruce	Disturbed HG	Disturbed HG	Closed White Spruce	Closed White Spruce	Closed White Spruce
Spruce/Grass	Disturbed HG	Disturbed HG	Disturbed HG	Closed White Spruce	Closed White Spruce
Poplar/Pine/Spruce	Disturbed HG	Disturbed HG	Mixedwood	Mixedwood	Mixedwood Spruce domn.
Poplar/Spruce	Disturbed HG	Disturbed HG	Mixedwood	Mixedwood	Mixedwood Spruce domn.
Poplar/Pine	Disturbed HG	Disturbed HG	Mixedwood	Mixedwood	Mixedwood
Poplar	Disturbed HG	Disturbed HG	Closed Shrub	Closed Deciduous	Closed Deciduous
Pine/Poplar/Spruce	Disturbed HG	Disturbed HG	Disturbed HG	Closed Pine pockets within Mixedwood	Closed Pine within Mixedwood
Pine/Poplar	Disturbed HG	Disturbed HG	Disturbed HG	Closed Pine pockets within Mixedwood	Closed Pine within Mixedwood
Pine	Disturbed HG	Disturbed HG	Disturbed HG	Closed Pine	Closed Pine
Pine/Grass	Disturbed HG	Disturbed HG	Disturbed HG	Closed Pine	Closed Pine

TABLE 4.2-2

FORAGE TIMES BY WILDLIFE SPECIES AND ELC

Proportion of Time Spent Foraging by Each Wildlife Species in Each of the 14 ELC Vegetation Classes														
	ECOLOGICAL LAND CLASSIFICATION (ELC) - VEGETATION CLASS													
	Disturbed, herb, grass dominant	Industrial, non-vegetated	Closed shrub	Closed deciduous, aspen dominant	Closed jack pine	Closed black spruce/larch	Closed mixed coniferous, black spruce dominant	Closed mixedwood	Closed mixedwood, white spruce dominant	Closed black spruce	Closed white spruce	Open larch, bog birch	Open black spruce, laborador tea	Water
Wildlife Species														
ruffed grouse	0-10	0	0-5	40-65	0-20	0-5	0-20	30-50	20-40	0-5	0-5	0-5	0-5	0-5
mallard	0-50	0	0-15	0	0	0-5	0-5	0	0	0-5	0	0-25	0-5	50-100
moose	0	0	50-100	50-100	0-10	0-25	0-25	0-25	0-25	0-25	0-35	0-35	0-25	25-75
snowshoe hare	0-20	0	0-20	25-75	0-10	0-5	0-10	10-65	0-25	0-5	0-10	0-5	0-5	0-5
beaver	0	0	0	25-50	0	0-5	0-5	50-100	25-50	0-5	0	0	0	65-100
American kestrel	25-75	0	0-20	0-15	0-50	0-5	0-5	0-50	0-50	0-5	0-5	0-5	0-15	0-5
American robin	0-35	0	0-5	50-100	20-60	0-5	0-35	20-60	20-60	0-5	0-5	0-5	0-5	20-60
ermine	0-2	0	0-5	0-25	20-80	20-80	25-75	25-75	25-75	0-50	25-75	0-25	0-5	0-5
deer mouse	0-100	0-100	0-100	0-100	0-100	0-100	0-100	0-100	0-100	0-100	0-100	0-100	0-100	0-100

TABLE 5.1-1

SCREENING LEVEL CRITERIA FOR CHEMICALS IN DRINKING WATER FOR PEOPLE

Chemicals	HWC[1] Drinking Water Criteria (mg/L)	U.S. EPA[2] Drinking Water Criteria (mg/L)	BC MOE[3] Drinking Water Criteria (mg/L)	Screening Level[4] Criteria (mg/L)
PAHS AND SUBSTITUTED PAHS				
Acenaphthylene	-[5]	-[5]	-[5]	-[5]
Acenaphthene group[6]	-[5]	-[5]	-[5]	-[5]
Benzo(a)anthracene group[6]	-[5]	0.0001	-[5]	0.0001
Benzo(a)pyrene group[6]	0.00001	0.0002	0.00001	0.00001
Benzo(ghi)perylene	-[5]	-[5]	-[5]	-[5]
Biphenyl	-[5]	-[5]	-[5]	-[5]
Dibenzothiophene group[6]	-[5]	-[5]	-[5]	-[5]
Fluorene group[6]	-[5]	-[5]	-[5]	-[5]
Fluoranthene group[6]	-[5]	-[5]	-[5]	-[5]
Naphthalene group[6]	-[5]	-[5]	-[5]	-[5]
Phenanthrene group[6]	-[5]	-[5]	-[5]	-[5]
Pyrene	-[5]	-[5]	-[5]	-[5]
SUBSTITUTED PANH COMPOUNDS				
Quinoline group[6]	-[5]	-[5]	-[5]	-[5]
VOLATILES				
Ethylbenzene	0.0024[7]	0.7	-[5]	0.0024[7]
m-+p-xylenes	0.3[7]	10	-[5]	0.3[7]
o-xylene	0.3[7]	10	-[5]	0.3[7]
PHENOLIC COMPOUNDS				
2,4-Dimethylphenol	-[5]	-[5]	-[5]	-[5]
NAPHTHENIC ACIDS				
Naphthenic acids	-[5]	-[5]	-[5]	-[5]
INORGANICS				
Aluminum	-[5]	0.2[7]	0.2	0.2[7]
Ammonia	-[5]	-[5]	-[5]	-[5]
Antimony	-[5]	-[5]	0.006	0.006

TABLE 5.1-1

SCREENING LEVEL CRITERIA FOR CHEMICALS IN DRINKING WATER FOR PEOPLE

Chemicals	HWC[1] Drinking Water Criteria (mg/L)	U.S. EPA[2] Drinking Water Criteria (mg/L)	BC MOE[3] Drinking Water Criteria (mg/L)	Screening Level[4] Criteria (mg/L)
Arsenic	0.025	0.05	0.05	0.025
Barium	1	2	1	1
Beryllium	–[5]	0.004	–[5]	0.004
Boron	5	–[5]	5	5
Cadmium	0.005	0.005	0.005	0.005
Calcium	–[5]	–[5]	–[5]	–[5]
Chloride	250[7]	–[8]	250[7]	250[7]
Chromium	0.05	0.1	0.05	0.05
Cobalt	–[5]	–[5]	–[5]	–[5]
Copper	1[15]	1.3	0.5	0.5
Cyanide	0.2	0.2	0.2	0.2
Iron	0.3[7]	–[5]	0.3[7]	0.3[7]
Lead	0.01	0.015	0.05	0.01
Lithium	–[5]	–[5]	–[5]	–[5]
Magnesium	–[5]	–[5]	100[8]	100[8]
Manganese	0.05[8]	–[5]	0.05[8]	0.05[8]
Mercury	0.001	0.002	0.001	0.001
Molybdenum	–[5]	–[5]	0.25	0.25
Nickel	–[5]	0.1	0.2	0.1
Phosphorus	–[5]	–[5]	0.01	0.01
Potassium	–[5]	–[5]	–[5]	–[5]
Selenium	0.01	0.05	0.01	0.01
Silicon	–[5]	–[5]	–[5]	–[5]
Sodium	200[7]	–[5]	200[7]	200[7]
Strontium	–[5]	–[5]	–[5]	–[5]
Sulphate	500[7]	–[5]	500[7]	500[7]
Tin	–[5]	–[5]	–[5]	–[5]

TABLE 5.1-1

SCREENING LEVEL CRITERIA FOR CHEMICALS IN DRINKING WATER FOR PEOPLE

Page 3 of 3

Chemicals	HWC[1] Drinking Water Criteria (mg/L)	U.S. EPA[2] Drinking Water Criteria (mg/L)	BC MOE[3] Drinking Water Criteria (mg/L)	Screening Level[4] Criteria (mg/L)
Titanium	-[5]	-[5]	0.1	0.1
Uranium	-[5]	0.02	0.1	0.02
Vanadium	-[5]	-[5]	0.1	0.1
Zinc	5[7]	-[5]	5[7]	5[7]
Zirconium	-[5]	-[5]	-[5]	-[5]

1 Health and Welfare Canada Maximum Acceptable Concentrations (MAC) have been derived to safeguard health assuming lifelong consumption of drinking water containing the substance at that concentration (HWC 1993).

2 U.S. Environmental Protection Agency Maximum Contaminants Level for drinking water for human health (U.S. EPA 1993, as cited in CRWQCB 1993).

3 BC criteria are generally intended to serve as benchmarks related to the protection of human health (BCE 1994).

4 Screening Level Criteria were based the lowest available criteria.

5 No criterion.

6 For information on grouping of chemicals and the use of surrogate chemicals, please refer to Appendix II.

7 Based on an aesthetic objective for drinking water.

8 Based on taste threshold for sensitive people.

TABLE 5.1-2

SCREENING LEVEL CRITERIA FOR CHEMICALS IN SOILS FOR PEOPLE

Chemicals	CCME[1] (mg/kg soil) (residential)	Alberta[2] Environment (Tier I) (mg/kg soil)	BC MOE[3] (mg/kg soil) (residential)	Screening Level[4] Criteria (mg/kg soil)
PAHS AND SUBSTITUTED PAHS				
Acenaphthene	-[5]	0.1	-[5]	0.1
Benzo(a)anthracene group[6]	1	0.1	1	0.1
Benzo(a)pyrene group[6]	1	0.1	1	0.1
Benzo(b&k)fluoranthene	1	0.1	1	0.1
Biphenyl group[6]	-[5]	-[5]	-[5]	-[5]
Diibenzothiophene group[6]	-[5]	0.1	-[5]	0.1
Fluorene group[6]	-[5]	0.1	-[5]	0.1
Fluoranthene group[6]	-[5]	0.1	-[5]	0.1
Naphthalene group[6]	5	0.1	5	0.1
Phenanthrene group[6]	5	0.1	5	0.1
Pyrene	10	0.1	10	0.1
INORGANICS				
Aluminum	-[5]	-[5]	-[5]	-[5]
Arsenic	30	10	30	10
Barium	500	400	500	400
Beryllium	4	5	4	4
Calcium	-[5]	-[5]	-[5]	-[5]
Chromium	250	100	250	100
Cobalt	50	20	50	20
Copper	100	80	100	80
Iron	-[5]	-[5]	-[5]	-[5]
Lead	500	50	500	50
Magnesium	-[5]	-[5]	-[5]	-[5]
Manganese	-[5]	-[5]	-[5]	-[5]

TABLE 5.1-2

SCREENING LEVEL CRITERIA FOR CHEMICALS IN SOILS FOR PEOPLE

Chemicals	CCME[1] (mg/kg soil) (residential)	Alberta[2] Environment (Tier I) (mg/kg soil)	BC MOE[3] (mg/kg soil) (residential)	Screening Level[4] Criteria (mg/kg soil)
Mercury	2	0.2	2	0.2
Molybdenum	10	4	10	4
Nickel	100	40	100	40
Thallium	-[5]	1	-[5]	1
Vanadium	200	50	200	50
Zinc	500	120	500	120

1 CCME remediation criteria are considered generally protective of human and environmental health for specified uses of soil at contaminated sites (CCME 1991).

2 Alberta Tier I values are generic and approximate acceptable concentrations of soil contaminants for all site conditions and land uses without defining actual risk (Alberta Environment 1990).

3 BC criteria are generally intended to serve as benchmarks related to the protection of human health and the environment with respect to current or future land uses of soil and water at contaminated sites (BCE 1995).

4 Screening Level Criteria are the lowest of the listed criteria values.

5 No criterion.

6 For information on grouping of chemicals and the use of surrogate chemicals, please refer to Appendix II.

TABLE 5.1-3

COMPARISON OF CHEMICAL CONCENTRATIONS IN REFERENCE BACKGROUND SAMPLES TO SCREENING LEVEL CRITERIA FOR WATER FOR PEOPLE

Chemical	Athabasca[1] River Water (mg/L)	Reference[2] Tributaries (mg/L)	Screening Level[3] Criteria (mg/L)	Comments
	Max	Max		
PAHS AND SUBSTITUTED PAHS				
Acenaphthylene	<0.00002	<0.00002	–[5]	No criterion
Acenaphthene group[6]	<0.00004	<0.00004	–[5]	No criterion
Benzo(a)anthracene group[6]	<0.00004	<0.00004	0.0001	Does not exceed.
Benzo(a)pyrene group[6]	<0.00004	<0.00004	0.00001	Does not exceed.
Benzo(ghi)perylene	<0.00002	<0.00002	–[5]	No criterion
Biphenyl	<0.00004	<0.00004	–[5]	No criterion
Dibenzothiophene group[6]	<0.00004	<0.00004	–[5]	No criterion
Fluorene group[6]	<0.00004	<0.00004	–[5]	No criterion
Fluoranthene group[6]	<0.00004	<0.00004	–[5]	No criterion
Naphthalene group[6]	<0.00002	0.00002	–[5]	No criterion.
Phenanthrene group[6]	<0.00004	<0.00004	–[5]	No criterion
Pyrene	<0.00002	<0.00002	–[5]	No criterion
SUBSTITUTED PANH COMPOUNDS				
Quinoline group[6]	<0.00002	<0.00002	–[5]	No criterion
NAPHTHENIC ACIDS				
Naphthenic acids	<1	<1	–[5]	No criterion
VOLATILES				
Ethylbenzene	<0.001	<0.001	0.0024[7]	Does not exceed.
m-+p-xylenes	<0.001	<0.001	0.3[7]	Does not exceed.
o-xylene	<0.001	<0.001	0.3[7]	Does not exceed.
PHENOLS				
2,4-Dimethylphenol	<0.0001	<0.0001	–[5]	No criterion
INORGANICS				
Aluminum	8.64	1.890	0.2	EXCEEDS

TABLE 5.1-3

COMPARISON OF CHEMICAL CONCENTRATIONS IN REFERENCE BACKGROUND SAMPLES TO SCREENING LEVEL CRITERIA FOR WATER FOR PEOPLE

Chemical	Athabasca[1] River Water (mg/L)	Reference[2] Tributaries (mg/L)	Screening Level[3] Criteria (mg/L)	Comments
	Max	Max		
Ammonia	0.08	0.110	-[5]	No criterion.
Antimony	0.0002	0.0003	0.006	Does not exceed.
Arsenic	0.007	0.0015	0.025	Does not exceed.
Barium	0.2	0.070	1	Does not exceed.
Beryllium	0.004	0.004	0.004	Does not exceed.
Boron	0.09	0.140	5	Does not exceed.
Cadmium	0.003	0.005	0.005	Does not exceed.
Calcium	74	60	-[5]	No criterion
Chloride	14.8	56.900	250[7]	Does not exceed.
Chromium	0.032	0.014	0.05[7]	Does not exceed.
Cobalt	0.01	0.005	-[5]	No criterion.
Copper	0.01	0.002	0.5	Does not exceed.
Cyanide	0.005	0.025	0.2	Does not exceed.
Iron	17.9	4.810	0.3[7]	EXCEEDS
Lead	<0.02	<0.02	0.01	Does not exceed.
Lithium	0.02	0.020	-[5]	No criterion.
Magnesium	21	18.4	100[8]	Does not exceed.
Manganese	0.509	0.210	0.05[7]	EXCEEDS
Mercury	0.0002	<0.00005	0.001	Does not exceed.
Molybdenum	0.01	0.004	0.25	Does not exceed.
Nickel	0.01	0.012	0.1	Does not exceed.
Phosphorus	0.4	<0.1	0.01	EXCEEDS
Potassium	2.65	2.2	-[5]	No criterion
Selenium	0.0004	0.0003	0.01	Does not exceed.
Silicon	2.12	3.7600	-[5]	No criterion

TABLE 5.1-3

COMPARISON OF CHEMICAL CONCENTRATIONS IN REFERENCE BACKGROUND SAMPLES TO SCREENING LEVEL CRITERIA FOR WATER FOR PEOPLE

Chemical	Athabasca[1] River Water (mg/L) Max	Reference[2] Tributaries (mg/L) Max	Screening Level[3] Criteria (mg/L)	Comments
Sodium	24.6	61.300	200[7]	Does not exceed.
Strontium	0.36	0.210	-[5]	No criterion.
Sulphate	58	53.200	500[7]	Does not exceed.
Tin	-[5]	-[5]	-[5]	No data
Titanium	0.085	0.046	0.1	Does not exceed.
Uranium	<0.5	<0.5	0.02	Does not exceed.
Vanadium	0.02	0.008	0.1	Does not exceed.
Zinc	0.085	0.162	5[7]	Does not exceed.
Zirconium	-[5]	-[5]	-[5]	No data

1 Athabasca River upstream of Lease 19 sampled by Golder during 1995 (Suncor EIA data, Golder 1996b) and NAQUADAT data (n=26) sampled in 1985-1995 (site: 00AL07CC0600).

2 Data from the tributaries were grouped and included data from Legget Creek, McLean Creek, Steepbank River and Wood Creek sampled by Golder during 1995 (Golder 1996b).

3 Screening Level Criteria were based on water quality criteria for human drinking water. Please see table 5.1-1 for derivation of values.

4 These compounds were not detected above detection limits.

5 No data or criterion.

6 For information on grouping of chemicals and the use of surrogate chemicals, please refer to Appendix II.

7 Based on an aesthetic objective for drinking water.

8 Based on taste threshold for sensitive people.

TABLE 5.1-4

COMPARISON OF CHEMICAL CONCENTRATIONS IN REFERENCE SOILS TO SCREENING LEVEL CRITERIA FOR PEOPLE

Chemicals	Overburden[1] (mg/kg soil)	Muskeg[2] (mg/kg soil)	Screening Level[3] Criterai (mg/kg soil)	Comments
PAHS AND SUBSTITUTED PAHS				
Acenaphthene	<0.01[4]	<0.01	0.1	Does not exceed
Benzo(a)anthracene group[6]	<0.01	0.03	0.1	Does not exceed
Benzo(a)pyrene group[6]	<0.01	<0.01	0.1	Does not exceed
Benzo(b&k)fluoranthene	<0.01	<0.01	0.1	Does not exceed
Biphenyl group[6]	<0.01	<0.02	-[5]	No criterion
Dibenzothiophene group[6]	0.24	<0.01	0.1	EXCEEDS
Fluorene group[6]	0.05	<0.01	0.1	Does not exceed
Fluoranthene group[6]	<0.01	<0.01	0.1	Does not exceed
Naphthalene group[6]	0.49	0.05	0.1	EXCEEDS
Phenanthrene group[6]	0.15	0.03	0.1	EXCEEDS
Pyrene	<0.01	<0.01	0.1	Does not exceed
INORGANICS				
Aluminum	10500	-[5]	-[5]	No criterion
Arsenic	15.8	<20[4]	10	EXCEEDS
Barium	219	121	400	Does not exceed
Beryllium	1	0.3	4	Does not exceed
Calcium	8540	-[5]	-[5]	No criterion
Chromium	5.1	6.2	100	Does not exceed
Cobalt	12	2.8	20	Does not exceed
Copper	25.1	8.4	80	Does not exceed
Iron	23400	-[5]	-[5]	No criterion
Lead	10	2.5	50	Does not exceed
Magnesium	8060	-[5]	-[5]	No criterion
Manganese	117	-[5]	-[5]	No criterion

TABLE 5.1-4

COMPARISON OF CHEMICAL CONCENTRATIONS IN REFERENCE SOILS TO SCREENING LEVEL CRITERIA FOR PEOPLE

Page 2 of 2

Chemicals	Overburden[1] (mg/kg soil)	Muskeg[2] (mg/kg soil)	Screening Level[3] Criterai (mg/kg soil)	Comments
Mercury	0.07	0.037	0.2	Does not exceed
Molybdenum	<2	1.4	4	Does not exceed
Nickel	30	8.4	40	Does not exceed
Thallium	-[5]	<0.1	1	Does not exceed
Vanadium	15.1	12.3	50	Does not exceed
Zinc	72.7	25.5	120	Does not exceed

[1] Overburden (KCa; CP3) data as reported by ETL (1993). This sample is considered to be representative of background soils (n=1).

[2] Muskeg soil analyzed by CHEMEX labs Alberta Inc. Oct. 30, 1995. This sample is considered to be representative of background soils (n=1)

[3] Screening Level Criteria were based on soil quality criteria. Please see Table 5.1-2 for derivation of values.

[4] These compounds were not detected above detection limits.

[5] Not analyzed or no data available.

[6] For information on grouping of chemicals and the use of surrogate chemicals, please refer to Appendix II.

TABLE 5.1-5

COMPARISON OF CHEMICAL CONCENTRATIONS IN WATER TO SCREENING LEVEL CRITERIA FOR PEOPLE

Page 1 of 3

Chemical	Tar Island[1] Dyke Water (mg/L)	Plant 4 Tailings[2] Sand Water (mg/L)	Consolidated[3] Tailings Water (mg/L)	Screening Level[4] Criteria (mg/L)	Comments
	Max	Max	Max		
PAHS AND SUBSTITUTED PAHS					
Acenaphthylene	<0.00002[7]	<0.00005	0.00016	-[5]	No criterion.
Acenaphthene group[6]	0.00028	0.00012	0.00019	-[5]	No criterion.
Benzo(a)anthracene group[6]	<0.00004	0.00026	0.0016	0.0001	EXCEEDS
Benzo(a)pyrene group[6]	<0.00004	0.00011	<0.00002	0.00001	EXCEEDS
Benzo(ghi)perylene	<0.00002	0.00003	<0.00004	-[5]	No criterion.
Biphenyl	<0.00004	<0.00004	0.00008	-[5]	No criterion.
Dibenzothiophene group[6]	0.00005	0.0009	0.01142	-[5]	No criterion.
Fluorene group[6]	0.00026	0.00074	0.00143	-[5]	No criterion.
Fluoranthene group[6]	0.00008	0.00015	0.00065	-[5]	No criterion.
Naphthalene group[6]	0.00104	0.00258	0.00268	-[5]	No criterion.
Phenanthrene group[6]	0.00031	0.00118	0.01068	-[5]	No criterion.
Pyrene	<0.00002	0.00009	0.00004	-[5]	No criterion.
SUBSTITUTED PANH COMPOUNDS					
Quinoline group[6]	0.00009	<0.00002	<0.00002	-[5]	No criterion.
NAPHTHENIC ACIDS					
Naphthenic acids	55	-[5]	94	-[5]	No criterion.
VOLATILES					
Ethylbenzene	0.0015	<0.001	<0.015	0.0024[8]	Does not exceed
m-+p-xylenes	0.005	<0.001	0.015	0.3[8]	Does not exceed
o-xylene	0.0027	<0.001	0.015	0.3[8]	Does not exceed
PHENOLS					
2,4-Dimethylphenol	<0.001	<0.0001	0.001	-[5]	No criterion.
INORGANICS					
Aluminum	1.15	0.88	1.92	0.2	EXCEEDS
Ammonia	6.01	19.9	3.98	-[5]	No criterion.

TABLE 5.1-5

COMPARISON OF CHEMICAL CONCENTRATIONS IN WATER TO SCREENING LEVEL CRITERIA FOR PEOPLE

Chemical	Tar Island[1] Dyke Water (mg/L)	Plant 4 Tailings[2] Sand Water (mg/L)	Consolidated[3] Tailings Water (mg/L)	Screening Level[4] Criteria (mg/L)	Comments
	Max	Max	Max		
Antimony	-[5]	0.0006	-[5]	0.006	Does not exceed
Arsenic	0.003	0.0036	0.0058	0.025	Does not exceed
Barium	0.1	0.772	0.18	1	Does not exceed
Beryllium	0.002	<0.001	0.004	0.004	Does not exceed
Boron	1.88	2.31	4.26	5	Does not exceed
Cadmium	0.004	<0.001	0.007	0.005	EXCEEDS
Calcium	57.1	43.2	118	-[5]	No criterion.
Chloride	17.3	33.4	510	250[8]	EXCEEDS
Chromium	0.002	0.028	0.003	0.05[8]	Does not exceed
Cobalt	0.005	0.018	0.007	-[5]	No criterion.
Copper	0.006	0.001	0.004	0.5[8]	Does not exceed
Cyanide	0.002	-[5]	0.055	0.2	Does not exceed
Iron	2.21	22.5	1.01	0.3[8]	EXCEEDS
Lead	<0.0003	<0.005	<0.0003	0.01	Does not exceed
Lithium	0.144	0.229	0.272	-[5]	No criterion.
Magnesium	11.3	18.1	28	100[9]	Does not exceed
Manganese	0.213	1.76	0.058	0.05[8]	EXCEEDS
Mercury	0.00026	0.0004	<0.00005	0.001	Does not exceed
Molybdenum	0.018	0.071	1.42	0.25	EXCEEDS
Nickel	0.005	0.055	0.0295	0.1	Does not exceed
Phosphorus	0.43	0.2	0.096	0.01	EXCEEDS
Potassium	10.8	18.9	29	-[5]	No criterion.
Selenium	0.0002	<0.00004	0.0036	0.01	Does not exceed
Silicon	10.1	6.12	5.58	-[5]	No criterion.
Sodium	335	16600	1170	200[8]	EXCEEDS
Strontium	0.337	0.771	2.12	-[5]	No criterion.

TABLE 5.1-5

COMPARISON OF CHEMICAL CONCENTRATIONS IN WATER TO SCREENING LEVEL CRITERIA FOR PEOPLE

Chemical	Tar Island[1] Dyke Water (mg/L)	Plant 4 Tailings[2] Sand Water (mg/L)	Consolidated[3] Tailings Water (mg/L)	Screening Level[4] Criteria (mg/L)	Comments
	Max	Max	Max		
Sulphate	143	118	1290	500[8]	EXCEEDS
Titanium	0.02	0.013	0.02	0.1	Does not exceed
Tin	-[5]	0.44	-[5]	-[5]	No criterion.
Uranium	<0.5	<0.1	0.0068	0.1	Does not exceed
Vanadium	0.01	0.05	0.17	0.1	EXCEEDS
Zinc	0.058	0.068	0.056	5[8]	Does not exceed.
Zirconium	-[5]	0.0013	-[5]	-[5]	No criterion.

[1] Tar Island Dyke Seepage Water taken from TID collection system; composite sample from tanks (RW-127).

[2] Groundwater samples (ID: RG088 and GG089) and Plant 4 Beach #2 Tailings water sample (ID: E504203-02).

[3] Consolidated Tailings Release Waters samples RW-162, RW-163 and RW164; and 1995 Suncor and Syncrude CT field study.

[4] The Screening Level Criteria were based on water quality criteria for drinking water. Please see table 5.1-1 for derivation of values.

[5] No data or criterion.

[6] For information on grouping of chemicals and the use of surrogate chemicals, please refer to Appendix II.

[7] These compounds were not detected above detection limits.

[8] Based on an aesthetic objective for drinking water.

[9] Based on taste threshold for sensitive people.

TABLE 5.1-6

COMPARISON OF CHEMICAL CONCENTRATIONS IN RECLAMATION MATERIALS TO SCREENING LEVEL CRITERIA FOR SOILS FOR PEOPLE

Chemicals	Low Gypsum[1] Consolidated Tailings (mg/kg soil)	Tailings Sand[2] Suncor Beach (mg/kg soil)	Screening Level[3] Criteria (mg/kg soil)	Comments
PAHs				
Acenaphthene	0.05	<0.01	0.1	Does not exceed
Benzo(a)anthracene group[6]	1.2	0.65	0.1	EXCEEDS
Benzo(a)pyrene group[6]	0.46	0.2	0.1	EXCEEDS
Benzo(b&k)fluoranthene	0.12	0.03	0.1	EXCEEDS
Biphenyl group[6]	0.19	<0.01	-[5]	No criterion
Dibenzothiophene group[6]	7.01	0.8	0.1	EXCEEDS
Fluorene group[6]	0.59	<0.01	0.1	EXCEEDS
Fluoranthene group[6]	0.57	0.01	0.1	EXCEEDS
Naphthalene group[6]	0.64	<0.01	0.1	EXCEEDS
Phenanthrene group[6]	8.11	0.56	0.1	EXCEEDS
Pyrene	0.16	0.04	0.1	EXCEEDS
INORGANICS				
Aluminum	-[5]	172	-[5]	No criterion
Arsenic	<20	0.63	10	Does not exceed
Barium	19.1	4.9	400	Does not exceed
Beryllium	0.3	<0.1	4	Does not exceed
Calcium	-[5]	559	-[5]	No criterion
Chromium (total)	15.4	<0.5	100	Does not exceed
Cobalt	2	2	20	Does not exceed
Copper	2.7	<0.5	80	Does not exceed
Iron	-[5]	3350	-[5]	No criterion
Lead	4.4	<2	50	Does not exceed
Magnesium	0.6	133	-[5]	No criterion
Manganese	-[5]	56.5	-[5]	No criterion
Mercury	<0.02	0.03	0.2	Does not exceed

TABLE 5.1-6

COMPARISON OF CHEMICAL CONCENTRATIONS IN RECLAMATION MATERIALS TO SCREENING LEVEL CRITERIA FOR SOILS FOR PEOPLE

Chemicals	Low Gypsum[1] Consolidated Tailings (mg/kg soil)	Tailings Sand[2] Suncor Beach (mg/kg soil)	Screening Level[3] Criteria (mg/kg soil)	Comments
Molybdenum	1.1	<2	4	Does not exceed
Nickel	14.4	2	40	Does not exceed
Thallium	0.1	-[5]	1	Does not exceed
Vanadium	23.7	2.8	50	Does not exceed
Zinc	13.6	5.8	120	Does not exceed

[1] Low Gypsum Consolidated Tailings analyzed by CHEMEX Labs Alberta Inc., October 1995 and Envirotest Laboratories, May and November, 1995.

[2] Tailings Sand (Suncor Beach; CP5) data as reported by ETL (1993; n=1).

[4] The Screening Level Criteria were based on soil quality criteria. Please see table 5.1-2 for derivation of values.

[4] These compounds were not detected above detection limits.

[5] Not anaylzed or no data available.

[6] For information on grouping of chemicals and the use of surrogate chemicals, please refer to Appendix II.

TABLE 5.1-7

COMPARISON OF CHEMICAL CONCENTRATIONS IN WATER TO BACKGROUND CONCENTRATIONS AT REFERENCE SITES

Chemical	RECLAMATION WATERS			REFERENCE WATERS		Comments
	Tar Island[1] Dyke Water (mg/L)	Plant 4 Tailings[2] Sand Water (mg/L)	Consolidated[3] Tailings Water (mg/L)	Athabasca[4] River Water (mg/L)	Reference[5] Tributaries Water (mg/L)	
PAHS AND SUBSTITUTED PAHS						
Acenaphthylene	<0.00002	<0.00005	0.00016	<0.00002	<0.00002	EXCEEDS
Acenaphthene group[6]	0.00028	0.00012	0.00019	<0.00004	<0.00004	EXCEEDS
Benzo(a)anthracene group[6]	<0.00004	0.00026	0.0016	<0.00004	<0.00004	EXCEEDS
Benzo(a)pyrene group[6]	<0.00004	0.00011	0.00048	<0.00004	<0.00004	EXCEEDS
Benzo(ghi)perylene	<0.00002	0.00003	<0.00002	<0.00002	<0.00002	EXCEEDS
Biphenyl	<0.00004	<0.00004	0.00008	<0.00004	<0.00004	EXCEEDS
Dibenzothiophene group[6]	0.00005	0.0009	0.01142	<0.00004	<0.00004	EXCEEDS
Fluorene group[6]	0.00054	0.00074	0.00143	<0.00004	<0.00004	EXCEEDS
Fluoranthene group[6]	0.00008	0.00015	0.00065	<0.00004	<0.00004	EXCEEDS
Naphthalene group[6]	0.00104	0.00258	0.00268	<0.00002	0.00002	EXCEEDS
Phenanthrene group[6]	0.00031	0.00118	0.01068	<0.00004	<0.00004	EXCEEDS
Pyrene	<0.00002	0.00009	0.00004	<0.00002	<0.00002	EXCEEDS
SUBSTITUTED PANH COMPOUNDS						
Quinoline group[6]	0.00009	<0.00002	<0.00002	<0.00002	<0.00002	EXCEEDS
NAPHTHENIC ACIDS						
Naphthenic acids	55	-[8]	94	<1	<1	EXCEEDS
PHENOLS						
2,4-Dimethylphenol	<0.001	<0.0001	0.001	<0.0001	<0.0001	EXCEEDS
INORGANICS						
Aluminum	1.15	0.88	1.92	8.64	1.89	Does not exceed
Ammonia	6.01	19.9	3.98	0.08	0.11	EXCEEDS
Cadmium	0.004	<0.001	0.007	0.003	0.005	EXCEEDS
Calcium	57.1	43.2	118	74	60	EXCEEDS
Chloride	17.3	33.4	510	14.8	56.9	EXCEEDS
Cobalt	0.005	0.018	0.007	0.01	0.005	EXCEEDS

TABLE 5.1-7

COMPARISON OF CHEMICAL CONCENTRATIONS IN WATER TO BACKGROUND CONCENTRATIONS AT REFERENCE SITES

Chemical	RECLAMATION WATERS			REFERENCE WATERS		Comments
	Tar Island[1] Dyke Water (mg/L)	Plant 4 Tailings[2] Sand Water (mg/L)	Consolidated[3] Tailings Water (mg/L)	Athabasca[4] River Water (mg/L)	Reference[5] Tributaries Water (mg/L)	
Iron	2.21	22.5	1.01	17.9	4.81	EXCEEDS
Lithium	0.144	0.229	0.272	0.02	0.02	EXCEEDS
Manganese	0.213	1.76	0.058	0.509	0.21	EXCEEDS
Molybdenum	0.018	0.071	1.42	0.01	0.004	EXCEEDS
Phosphorus	0.43	0.2	0.096	0.4	<0.1	EXCEEDS
Potassium	10.8	18.9	29	2.65	2.2	EXCEEDS
Silicon	10.1	6.12	5.58	2.12	3.76	EXCEEDS
Sodium	335	16600	1170	24.6	61.3	EXCEEDS
Strontium	0.337	0.771	2.12	0.36	0.21	EXCEEDS
Sulphate	143	118	1290	58	53.2	EXCEEDS
Tin	-[8]	0.44	-[8]	-[8]	-[8]	No background data
Vanadium	0.01	0.05	0.17	0.02	0.008	EXCEEDS
Zirconium	-[8]	0.0013	-[8]	-[8]	-[8]	No background data

1 Tar Island Dyke Seepage Water taken from TID collection system; composite sample from tanks (RW-127).
2 Groundwater samples (ID: RG088 and RG089) and Plant 4 Beach #2 Tailings water sample (ID: E504203-02).
3 Consolidated Tailings Release Waters samples RW-162, RW-163 and RW164; and 1995 Suncor and Syncrude field CT study.
4 Athabasca River upstream of Lease 19 sampled by Golder during 1995 (Suncor EIA data, Golder 1996b) and NAQUADAT data (n=26) sampled in 1985-1995 (site: 00AL07CC0600).
5 Data from the tributaries were grouped and included data from Legget Creek, McLean Creek, Steepbank River and Wood Creek sampled by Golder during 1995 (Golder 1996b).
6 For information on grouping of chemicals and the use of surrogate chemicals, please refer to Appendix II.
7 These compounds were not detected above detection limits.
8 No data or criteria available.

TABLE 5.1-8

COMPARISON OF CHEMICAL CONCENTRATIONS IN RECLAMATION MATERIALS TO BACKGROUND SOILS

Chemicals	RECLAMATION MATERIALS		BACKGROUND SOILS		Comments
	Low Gypsum[1] Consolidated Tailings (mg/kg soil)	Tailings Sand[2] Suncor Beach (mg/kg soil)	Overburden[3] (mg/kg soil)	Muskeg[4] (mg/kg soil)	
PAHs					
Benzo(a)anthracene group[6]	1.2	0.65	<0.01	0.04	EXCEEDS
Benzo(a)pyrene group[6]	0.46	0.2	<0.01	0.025	EXCEEDS
Benzo(b&k)fluoranthene	0.12	0.03	<0.01[5]	<0.01	EXCEEDS
Biphenyl group[6]	0.19	,0.01	<0.01	<0.01	EXCEEDS
Dibenzothiophene group[6]	7.01	0.8	0.24	0.04	EXCEEDS
Fluorene group[6]	0.59	<0.01	0.05	<0.01	EXCEEDS
Fluoranthene group[6]	0.57	0.01	<0.01	<0.01	EXCEEDS
Naphthalene group[6]	0.64	<0.01	0.49	0.05	EXCEEDS
Phenanthrene group[6]	8.11	0.56	0.155	0.065	EXCEEDS
Pyrene	0.16	0.04	<0.01	<0.01	EXCEEDS
INORGANICS					
Aluminum	-[7]	172	10500	-[7]	Does not exceed
Calcium	-[7]	559	8540	-[7]	Does not exceed
Iron	-[7]	3350	23400	-[7]	Does not exceed
Magnesium	0.6	133	8060	-[7]	Does not exceed
Manganese	-[7]	56.5	117	-[7]	Does not exceed

[1] Low Gypsum Consolidated Tailings analyzed by CHEMEX Labs Alberta Inc., October 1995 and EnviroTest Laboratories, May and November, 1995.

[2] Tailings Sand (Suncor Beach; CP5) data as reported by ETL (1993; n=1).

[3] Overburden (KCa; CP3) data as reported by ETL (1993). This sample is considered to be representative of background soils (n=1).

[4] Muskeg soil analyzed by CHEMEX labs Alberta Inc. Oct. 30, 1995. This sample is considered to be representative of background soils (n=1).

[5] These compounds were not detected above detection limits.

[6] For information on grouping of chemicals and the use of surrogate chemicals, please refer to Appendix II.

[7] Not analyzed or no data available.

TABLE 5.1-9

COMPARISON OF METAL RESIDUES IN MEAT FROM VARIOUS WETLANDS

Chemicals	BACKGROUND[1]	TREATMENTS[2]				Comments
	Control (ug/g)	CT Pond (Trench 5) (ug/g)	CT Wetland (Trench 8) (ug/g)	DD Pond (Trench 2) (ug/g)	DD Wetland (Trench 6) (ug/g)	
INORGANICS						
Aluminum	5	4	2	3	5	Does not exceed
Barium	0.92	1.09	0.35	0.2	0.23	EXCEEDS
Chromium	0.1	0.5	0.09	0.2	0.1	EXCEEDS
Copper	278	281	255	247	251	EXCEEDS
Lead	<1[3]	<1	<1	<1	1	EXCEEDS
Nickel	<0.2	0.2	<0.2	<0.2	<0.2	EXCEEDS

[1] Duckling liver tissue residue data (max. detected) from Wolfe and Norman as cited in Bishay and Nix (1996). These samples were considered to be background reference values.

[2] Duckling liver tissue residue data (max. detected) from Wolfe and Norman as cited in Bishay and Nix (1996). These were samples treated with consolidated tailings or dyke drainage water.

[3] These compounds were not detected above detection limits.

TABLE 5.1-10

COMPARISON OF CHEMICAL CONCENTRATIONS IN WATER TO RISK-BASED CONCENTRATIONS (RBCs) FOR DRINKING WATER

Chemical	Tar Island[1] Dyke Water (mg/L)	Plant 4 Tailings[2] Sand Water (mg/L)	Consolidated[3] Tailings Water (mg/L)	RBC for[4] Water Ingestion (mg/L)	Comments
PAHS					
Acenaphthylene	<0.00002[5]	<0.00005	0.00016	2.2[5]	Does not exceed
Acenaphthene group[6]	0.00028	0.00012	0.00019	2.2	Does not exceed
Benzo(a)anthracene group[6]	<0.00004	0.00026	0.0016	0.000092	EXCEEDS
Benzo(a)pyrene group[6]	<0.00004	0.00011	0.00048	0.0000092	EXCEEDS
Benzo(ghi)perylene	<0.00002	0.00003	<0.00002	1.1[5]	Does not exceed
Biphenyl	<0.00004	<0.00004	0.00008	1.8	Does not exceed
Dibenzothiophene group[6]	0.00005	0.0009	0.01142	1.1[5]	Does not exceed
Fluorene group[6]	0.00054	0.00074	0.00143	1.5[5]	Does not exceed
Fluoranthene group[6]	0.00008	0.00015	0.00065	1.1[5]	Does not exceed
Naphthalene group[6]	0.00104	0.00258	0.00268	1.5[5]	Does not exceed
Phenanthrene group[6]	0.00031	0.00118	0.01068	1.1[5]	Does not exceed
Pyrene	<0.00002	0.00009	0.00004	1.1[5]	Does not exceed
SUBSTITUTED PANH COMPOUNDS					
Quinoline group[6]	0.00009	<0.00002	<0.00002	0.037[5]	Does not exceed
NAPHTHENIC ACIDS					
Naphthenic acids	55	-[7]	94	-[7]	No RBC
PHENOLS					
2,4-Dimethylphenol	<0.001	<0.0001	0.001	0.73	Does not exceed
INORGANICS					
Ammonia	6.01	19.9	3.98	1	EXCEEDS
Barium	0.1	0.772	0.18	2.6	Does not exceed
Cadmium	0.004	<0.001	0.007	0.018	Does not exceed
Calcium	57.1	43.2	118	-[7]	No RBC
Chloride	17.3	33.4	510	3.7	EXCEEDS
Cobalt	0.005	0.018	0.007	2.2	Does not exceed

TABLE 5.1-10

COMPARISON OF CHEMICAL CONCENTRATIONS IN WATER TO RISK-BASED CONCENTRATIONS (RBCs) FOR DRINKING WATER

Chemical	Tar Island[1] Dyke Water (mg/L)	Plant 4 Tailings[2] Sand Water (mg/L)	Consolidated[3] Tailings Water (mg/L)	RBC for[4] Water Ingestion (mg/L)	Comments
Iron	2.21	22.5	1.01	-[7]	No RBC
Lithium	0.144	0.229	0.272	0.73	Does not exceed
Manganese	0.213	1.76	0.058	0.18	EXCEEDS
Molybdenum	0.018	0.071	1.42	0.18	EXCEEDS
Phosphorus	0.43	0.2	0.096	-[7]	No RBC
Potassium	10.8	18.9	29	-[7]	No RBC
Silicon	10.1	6.12	5.58	-[7]	No RBC
Sodium	335	16600	1170	-[7]	No RBC
Strontium	0.337	0.771	2.12	22	Does not exceed
Sulphate	143	118	1290	-[7]	No RBC
Tin	-[7]	0.44	-[7]	22	Does not exceed
Vanadium	0.01	0.05	0.17	0.26	Does not exceed
Zirconium	-[7]	0.0013	-[7]	-[7]	No RBC

[1] Tar Island Dyke Seepage Water taken from TID collection system; composite sample from tanks (RW-127).

[2] Groundwater samples (ID: RG088 and RG089) and Plant 4 Beach #2 Tailings sand water sample (ID: E504203-02).

[3] Consolidated Tailings Release Waters samples RW-162, RW-163 and RW164; 1995 Suncor and Syncrude CT field study.

[4] RBCs were based on EPA Region III Risk-Based Concentrations (Smith 1995).

[5] These compounds were not detected above detection limits.

[6] Refer to Appendix II for grouping of chemicals for screening and the use of surrogate data.

[7] No data.

TABLE 5.1-11

COMPARISON OF CHEMICAL CONCENTRATIONS IN RECLAMATION MATERIALS TO RISK-BASED CONCENTRATIONS

Chemicals	Low Gypsum[1] Consolidated Tailings (mg/kg soil)	Tailings Sand[2] Suncor Beach (mg/kg soil)	RBC for[3] Soil Ingestion (mg/kg soil)	Comments
PAHS AND SUBSTITUTED PAHS				
Benzo(a)anthracene group[4]	1.2	0.65	0.88	EXCEEDS
Benzo(a)pyrene group[4]	0.46	0.2	0.088	EXCEEDS
Benzo(b&k)fluoranthene	0.12	0.03	0.88	Does not exceed
Biphenyl group[4]	0.19	<0.01	3900	Does not exceed
Dibenzothiophene group[4]	7.01	0.8	2300	Does not exceed
Fluorene group[4]	0.59	<0.01	3100	Does not exceed
Fluoranthene group[4]	0.57	0.01	3100	Does not exceed
Naphthalene group[4]	0.64	<0.01	3100	Does not exceed
Phenanthrene group[4]	8.11	0.56	2300	Does not exceed
Pyrene	0.16	0.04	2300	Does not exceed

1 Low Gypsum Consolidated Tailings analyzed by CHEMEX Labs Alberta Inc., October 1995 and EnviroTest Laboratories, May and November, 1995.

2 Tailings Sand (Suncor Beach; CP5) data as reported by ETL (1993; n=1).

3 Risk-Based Concentrations were based on EPA Region III Risk-Based Concentrations (Smith 1995).

4 For information on grouping of chemicals and the use of surrogate chemicals, please refer to Appendix II.

TABLE 5.1-12

COMPARISON OF CHEMICAL CONCENTRATIONS IN DUCKLING AND BISON LIVER TISSUE TO REFERENCE CONCENTRATIONS FOR PEOPLE

Chemicals	Duckling Tissue[1]				Bison Tissue[2]	Risk-Based[3] Concentration for meat (ug/g)	Comments
	CT Pond (Trench 5) (ug/g)	CT Wetland (Trench 8) (ug/g)	DD Pond (Trench 2) (ug/g)	DD Wetland (Trench 6) (ug/g)			
ORGANICS							
Naphthalene	-[4]	-[4]	-[4]	-[4]	0.008	54	Does not exceed
INORGANICS							
Aluminum	-[4]	-[4]	-[4]	-[4]	43	1400	Does not exceed
Barium	1.09	0.35	0.2	0.23	2.8	95	Does not exceed
Cadmium	-[4]	-[4]	-[4]	-[4]	0.27	0.68	Does not exceed
Calcium	-[4]	-[4]	-[4]	-[4]	312	-[4]	No RBC
Chromium	0.5	0.09	0.2	0.1	0.4	6.8	Does not exceed
Cobalt	-[4]	-[4]	-[4]	-[4]	0.2	81	Does not exceed
Copper	281	255	247	251	52.4	50	EXCEEDS
Iron	-[4]	-[4]	-[4]	-[4]	434	-[4]	No RBC
Lead	<1[5]	<1	<1	1	<0.8	4.8[6]	Does not exceed
Magnesium	-[4]	-[4]	-[4]	-[4]	736	-[4]	No RBC
Manganese	-[4]	-[4]	-[4]	-[4]	12.4	6.8	EXCEEDS
Molybdenum	-[4]	-[4]	-[4]	-[4]	4.7	6.8	Does not exceed
Nickel	0.2	<0.2	<0.2	<0.2	1	27	Does not exceed
Phosphorus	-[4]	-[4]	-[4]	-[4]	7100	-[4]	No RBC
Potassium	-[4]	-[4]	-[4]	-[4]	10900	-[4]	No RBC
Selenium	-[4]	-[4]	-[4]	-[4]	1	6.8	Does not exceed
Silicon	-[4]	-[4]	-[4]	-[4]	103	-[4]	No RBC
Sodium	-[4]	-[4]	-[4]	-[4]	2770	-[4]	No RBC
Sulfur	-[4]	-[4]	-[4]	-[4]	7550	-[4]	No RBC
Titanium	-[4]	-[4]	-[4]	-[4]	1.89	-[4]	No RBC
Zinc	-[4]	-[4]	-[4]	-[4]	121	410	Does not exceed

1 Duckling liver tissue residue data from Wolfe and Norman as cited in Bishay and Nix (1996).
2 Bison liver tissue residue data from Pauls et al. (1995).
3 The Risk-Based Concentration was based on EPA Region III Risk-Based Concentration Table (Smith 1995).
4 Not analyzed or no data.
5 These compounds were not detected above detection limits.
6 RBC based on EPA Region III methodology and oral RfD of 3.57 mg/kg-bw/day as reported by Health Canada (1994b).

TABLE 5.1-13

LIST OF CHEMICALS OF CONCERN IN WATER RETAINED FOLLOWING CHEMICAL SCREENING FOR PEOPLE

Chemical	Tar Island[1] Dyke Water (mg/L)	Plant 4 Tailings[2] Sand Water (mg/L)	Consolidated[3] Tailings Water (mg/L)	Comments
DRINKING WATER				
Benzo(a)anthracene group[5]	<0.00004[4]	0.00026	0.0016	EXCEEDS RBC
Benzo(a)pyrene group[5]	<0.00004	0.00011	0.00048	EXCEEDS RBC
Naphthenic acids	55	-[6]	94	No RBC
Manganese	0.213	1.76	0.058	EXCEEDS RBC
Molybdenum	0.018	0.071	1.42	EXCEEDS RBC
Chemical	**Low Gypsum[7] Consolidated Tailings (mg/kg soil)**	**Tailings Sand[8] Suncor Beach (mg/kg soil)**		**Comments**
SOILS				
Benzo(a)anthracene group[5]	1.2	0.65		EXCEEDS RBC
Benzo(a)pyrene group[5]	0.53	0.205		EXCEEDS RBC
Chemical	**Duck[9] Tissue (ug/g tissue)**	**Bison[10] Tissue (ug/g tissue)**		**Comments**
MEAT				
Copper	281	52.4		EXCEEDS RBC
Manganese	-[6]	12.4		EXCEEDS RBC

1 Tar Island Dyke Seepage Water taken from TID collection system; composite sample from tanks (RW-127).
2 Groundwater samples (ID: RG088 and RG089) and Plant 4 Beach #2 Tailings water sample (ID: E504203-02).
3 Consolidated Tailings Release Waters samples RW-162, RW-163 and RW164 and Syncrude CT water.
4 These compounds were not detected above detection limits.
5 Refer to Appendix II for grouping of chemicals for screening and the use of surrogate data.
6 No data.
7 Low Gypsum Consolidated Tailings analyzed by CHEMEX Labs Alberta Inc., October 1995 and Envirotest Laboratories, May and November, 1995.
8 Tailings Sand (Suncor Beach; CP5) data as reported by ETL (1993; n=1).
9 Residue data from Wolfe and Norman as cited in Nix and Bishay (1994).
10 Residue data from Pauls et al. (1995).

TABLE 5.1-14

SCREENING LEVEL CRITERIA FOR CHEMICALS IN WATER FOR WILDLIFE

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Chemicals	CCREM[1] (mg/L) (livestock)	BC MOE[2] (mg/L) (livestock/ wildlife)	Screening[3] Level Criteria (mg/L)
PAHS			
Acenaphthylene	-[4]	-[4]	-[4]
Acenapthene group[5]	-[4]	-[4]	-[4]
Benzo(a)anthracene group[5]	-[4]	-[4]	-[4]
Benzo(a)pyrene group[5]	-[4]	-[4]	-[4]
Benzo(ghi)perylene	-[4]	-[4]	-[4]
Benzo(b&k)fluoranthene	-[4]	-[4]	-[4]
Biphenyl group[5]	-[4]	-[4]	-[4]
Diibenzothiophene group[5]	-[4]	-[4]	-[4]
Fluorene group[5]	-[4]	-[4]	-[4]
Fluoranthene group[5]	-[4]	-[4]	-[4]
Naphthalene group[5]	-[4]	-[4]	-[4]
Phenanthrene group[5]	-[4]	-[4]	-[4]
Pyrene	-[4]	-[4]	-[4]
SUBSTITUTED PANH COMPOUNDS			
Quinoline group[12]	-[4]	-[4]	-[4]
NAPHTHENIC ACIDS			
Naphthenic acids	-[4]	-[4]	-[4]
VOLATILES			
Ethylbenzene	-[4]	-[4]	-[4]
m-+p-xylenes	-[4]	-[4]	-[4]
o-xylene	-[4]	-[4]	-[4]
PHENOLS			
Phenol	-[4]	-[4]	-[4]
2,4-Dimethylphenol	-[4]	-[4]	-[4]
m-Cresol	-[4]	-[4]	-[4]

TABLE 5.1-14

SCREENING LEVEL CRITERIA FOR CHEMICALS IN WATER FOR WILDLIFE

Chemicals	CCREM[1] (mg/L) (livestock)	BC MOE[2] (mg/L) (livestock/ wildlife)	Screening[3] Level Criteria (mg/L)
o-Cresol	-[4]	-[4]	-[4]
INORGANICS			
Aluminum	5	5	5
Ammonia	-[4]	-[4]	-[4]
Antimony	-[4]	-[4]	-[4]
Arsenic	0.5	0.5	0.5
Barium	-[4]	-[4]	-[4]
Beryllium	0.1	0.1	0.1
Boron	5	5	5
Cadmium	0.02	0.02	0.02
Calcium	1000	1000	1000
Chloride	-[4]	-[4]	-[4]
Chromium	1	1	1
Cobalt	1	1	1
Copper	0.5	0.3	0.3
Cyanide	-[4]	-[4]	-[4]
Iron	-[4]	-[4]	-[4]
Lead	0.1	0.1	0.1
Lithium	-[4]	5	5
Magnesium	-[4]	-[4]	-[4]
Manganese	-[4]	-[4]	-[4]
Mercury	0.003	0.003	0.003
Molybdenum	0.5	0.05	0.05
Nickel	1	1	1
Phosphorus	-[4]	-[4]	-[4]
Potassium	-[4]	20	20

TABLE 5.1-14

SCREENING LEVEL CRITERIA FOR CHEMICALS IN WATER FOR WILDLIFE

Chemicals	CCREM[1] (mg/L) (livestock)	BC MOE[2] (mg/L) (livestock/ wildlife)	Screening[3] Level Criteria (mg/L)
Selenium	0.05	0.05	0.05
Silicon	-[4]	-[4]	-[4]
Sodium	-[4]	-[4]	-[4]
Strontium	-[4]	-[4]	-[4]
Sulphide	-[4]	-[4]	-[4]
Sulphate	1000	1000	1000
Tin	-[4]	-[4]	-[4]
Titanium	-[4]	-[4]	-[4]
Vanadium	0.1	0.1	0.1
Zinc	50	50	50
Zirconium	-[4]	-[4]	-[4]

1 Canadian Council of Resource and Environment Ministers Water Quality Guidelines for Livestock Drinking Water Quality (CCREM 1987).

2 BC Water Quality Criteria are safe levels of contaminants for the protection of livestock and/or wildlife (BCE 1994).

3 Screening Level Criteria are the lowest of the listed criteria values.

4 No criterion.

5 For information on grouping of chemicals and the use of surrogate chemicals, please refer to Appendix II.

TABLE 5.1-15

SCREENING LEVEL CRITERIA FOR CHEMICALS IN SOILS FOR WILDLIFE

Chemicals	Alberta[1] Environment (Tier I) (mg/kg soil)	CCME[2] (mg/kg soil) (agricultural)	BC MOE[3] (mg/kg soil) (agricultural)	Ontario MOE[4] (mg/kg soil) (agricultural)	Screening Level[5] Criteria (mg/kg soil)
PAHS AND SUBSTITUTED PAHS					
Acenaphthene	0.1	-[6]	0.1	15	0.1
Benzo(a)anthracene group[7]	0.1	0.1	0.1	6.6	0.1
Benzo(a)pyrene group[7]	0.1	0.1	0.1	1.2	0.1
Benzo(b&k)fluoranthene	0.1	0.1	0.1	12	0.1
Biphenyl group[7]	-[6]	-[6]	-[6]	0.89	0.89
Diibenzothiophene group[7]	0.1	0.1	0.1	0.1	0.1
Fluorene group[7]	0.1	-[6]	-[6]	340	0.1
Fluoranthene group[7]	0.1	0.1	0.1	0.1	0.1
Naphthalene group[7]	0.1	0.1	0.1	4.6	0.1
Phenanthrene group[7]	0.1	0.1	0.1	40	0.1
Pyrene	0.1	0.1	0.1	1.3	0.1
INORGANICS					
Aluminum	-[6]	-[6]	-[6]	-[6]	-[6]
Arsenic	10	20	20.0	20	10
Barium	400	750	750.0	750	400
Beryllium	5	4	4.0	2.5	2.5
Calcium	-[6]	-[6]	-[6]	-[6]	-[6]
Chromium	100	750	750.0	750	100
Cobalt	20	40	40.0	40	20
Copper	80	150	150.0	150	80
Iron	-[6]	-[6]	-[6]	-[6]	-[6]
Lead	50	375	375.0	60	50
Magnesium	-[6]	-[6]	-[6]	-[6]	-[6]
Manganese	-[6]	-[6]	-[6]	-[6]	-[6]
Mercury	0.2	0.8	0.8	10	0.2

TABLE 5.1-15

SCREENING LEVEL CRITERIA FOR CHEMICALS IN SOILS FOR WILDLIFE

Chemicals	Alberta[1] Environment (Tier I) (mg/kg soil)	CCME[2] (mg/kg soil) (agricultural)	BC MOE[3] (mg/kg soil) (agricultural)	Ontario MOE[4] (mg/kg soil) (agricultural)	Screening Level[5] Criteria (mg/kg soil)
Molybdenum	4	5	5.0	5	4
Nickel	40	150	150.0	150	40
Thallium	1	1	1.0	4.1	1
Vanadium	50	200	200.0	200	50
Zinc	120	600	600.0	600	120

1 Alberta Tier I values are generic and approximate acceptable concentrations of soil contaminants for all site conditions and land uses without defining actual risk (Alberta Environment 1990).

2 CCME remediation criteria are considered generally protective of human and environmental health for specified uses of soil at contaminated sites (CCME 1991).

3 BC criteria are generally intended to serve as benchmarks related to the protection of human health and the environment with respect to current or future land uses of soil and water at contaminated sites (BCE 1995).

4 Ontario MOE criteria are ecologically based designed to protect grazing animals and bioaccumulating plant species (OMEE 1994).

5 Screening Level Criteria are the lowest of the listed criteria values.

6 No criterion.

7 For information on grouping of chemicals and the use of surrogate chemicals, please refer to Appendix II.

TABLE 5.1-16

COMPARISON OF REFERENCE BACKGROUND WATER SAMPLES TO SCREENING LEVEL CRITERIA FOR WILDLIFE

Chemical	Athabasca[1] River Water (mg/L)	Reference[2] Tributaries (mg/L)	Screening Level[3] Criteria (mg/L)	Comments
PAHS AND SUBSTITUTED PAHS				
Acenaphthylene	<0.00002[4]	<0.00002	_[5]	No criterion
Acenaphthene group[6]	<0.00004	<0.00004	_[5]	No criterion
Benzo(a)anthracene group[6]	<0.00004	<0.00004	_[5]	No criterion
Benzo(a)pyrene group[6]	<0.00004	<0.00004	_[5]	No criterion
Benzo(b&k)fluoranthene	<0.00004	<0.00004	_[5]	No criterion
Benzo(ghi)perylene	<0.00002	<0.00002	_[5]	No criterion
Biphenyl group[6]	<0.00004	<0.00004	_[5]	No criterion
Diibenzothiophene group[6]	<0.00004	<0.00004	_[5]	No criterion
Fluorene group[6]	<0.00004	<0.00004	_[5]	No criterion
Fluoranthene group[6]	<0.00004	<0.00004	_[5]	No criterion
Naphthalene group[6]	<0.00002	0.00002	_[5]	No criterion
Phenanthrene group[6]	<0.00004	<0.00004	_[5]	No criterion
Pyrene	<0.00002	<0.00002	_[5]	No criterion
SUBSTITUTED PANH COMPOUNDS				
Quinoline group[6]	<0.00002	<0.00002	_[5]	No criterion
NAPHTHENIC ACIDS				
Naphthenic acids	<1	<1	_[5]	No criterion
VOLATILES				
Ethylbenzene	<0.001	<0.001	_[5]	No criterion
m-+p-xylenes	<0.001	<0.001	_[5]	No criterion
o-xylene	<0.001	<0.001	_[5]	No criterion
PHENOLS				
2,4-Dimethylphenol	<0.0001	<0.0001	_[5]	No criterion
INORGANICS				
Aluminum	8.64	1.89	5	Athabasca River EXCEEDS

TABLE 5.1-16

COMPARISON OF REFERENCE BACKGROUND WATER SAMPLES TO SCREENING LEVEL CRITERIA FOR WILDLIFE

Chemical	Athabasca[1] River Water (mg/L)	Reference[2] Tributaries (mg/L)	Screening Level[3] Criteria (mg/L)	Comments
Ammonia	0.08	0.11	-[5]	No criterion
Antimony	0.0002	0.0003	-[5]	No criterion
Arsenic	0.007	0.0015	0.5	Does not exceed
Barium	0.2	0.07	-[5]	No criterion
Beryllium	0.004	0.004	0.1	Does not exceed
Boron	0.09	0.14	5	Does not exceed
Cadmium	0.003	0.005	0.02	Does not exceed
Calcium	74	60	1000	Does not exceed
Chloride	14.8	56.9	-[5]	No criterion
Chromium	0.032	0.014	1	Does not exceed
Cobalt	0.01	0.005	1	Does not exceed
Copper	0.01	0.002	0.3	Does not exceed
Cyanide	0.005	0.025	-[5]	No criterion
Iron	17.9	4.81	-[5]	No criterion
Lead	<0.02	<0.02	0.1	Does not exceed
Lithium	0.02	0.02	5	Does not exceed
Magnesium	21	18.4	-[5]	No criterion
Manganese	0.509	0.21	-[5]	No criterion
Mercury	0.0002	<0.00005	0.003	Does not exceed
Molybdenum	0.01	0.004	0.05	Does not exceed
Nickel	0.01	0.012	1	Does not exceed
Phosphorus	0.4	<0.1	-[5]	No criterion
Potassium	2.65	2.2	20	Does not exceed
Selenium	0.0004	0.0003	0.05	Does not exceed
Silicon	2.12	3.76	-[5]	No criterion
Sodium	24.6	61.3	-[5]	No criterion

TABLE 5.1-16

COMPARISON OF REFERENCE BACKGROUND WATER SAMPLES TO SCREENING LEVEL CRITERIA FOR WILDLIFE

Chemical	Athabasca[1] River Water (mg/L)	Reference[2] Tributaries (mg/L)	Screening Level[3] Criteria (mg/L)	Comments
Strontium	0.36	0.21	-[5]	No criterion
Sulphate	58	53.2	1000	Does not exceed
Tin	-[5]	-[5]	-[5]	No criterion
Titanium	0.085	0.046	-[5]	No criterion
Vanadium	0.02	0.008	0.1	Does not exceed
Zinc	0.085	0.162	50	Does not exceed
Zirconium	-[5]	-[5]	-[5]	No criterion

[1] Athabasca River upstream of Lease 19 sampled by Golder during 1995 (Suncor EIA data, Golder 1996b) and NAQUADAT data (n=26) sampled in 1985-1995 (site: 00AL07CC0600).

[2] Data from the tributaries were grouped and included data from Legget Creek, McLean Creek, Steepbank River and Wood Creek sampled by Golder during 1995 (Golder 1996b).

[3] Screening Level Criteria were based on water quality criteria for wildlife or livestock. Please see table 5.1-14 for derivation of values.

[4] These compounds were not detected above detection limits.

[5] No data or criterion.

[6] For information on grouping of chemicals and the use of surrogate chemicals, please refer to Appendix II.

TABLE 5.1-17

COMPARISON OF REFERENCE SOIL SAMPLES TO SCREENING LEVEL CRITERIA FOR SOILS

Chemicals	Overburden[1] (mg/kg soil)	Muskeg[2] (mg/kg soil)	Screening Level[3] Criteria (mg/kg soil)	Comments
PAHS AND SUBSTITUTED PAHS				
Acenaphthene	<0.01[4]	<0.01	0.1	Does not exceed
Benzo(a)anthracene group[6]	<0.01	0.03	0.1	Does not exceed
Benzo(a)pyrene group[6]	<0.01	<0.01	0.1	Does not exceed
Benzo(b&k)fluoranthene	<0.01	<0.01	0.1	Does not exceed
Biphenyl group[6]	<0.01	<0.02	0.89	Does not exceed
Dibenzothiophene group[6]	0.24	<0.01	0.1	Overburden EXCEEDS
Fluorene group[6]	0.05	<0.01	0.1	Does not exceed
Fluoranthene group[6]	<0.01	<0.01	0.1	Does not exceed
Naphthalene group[6]	0.49	0.05	0.1	Overburden EXCEEDS
Phenanthrene group[6]	0.15	0.03	0.1	Overburden EXCEEDS
Pyrene	<0.01	<0.01	0.1	Overburden EXCEEDS
INORGANICS				
Aluminum	10500	-[5]	-[5]	No criterion
Arsenic	15.8	<20	20	Does not exceed
Barium	219	121	750	Does not exceed
Beryllium	1	0.3	2.5	Does not exceed
Calcium	8540	-[5]	-[5]	No criterion
Chromium	5.1	6.2	750	Does not exceed
Cobalt	12	2.8	40	Does not exceed
Copper	25.1	8.4	80	Does not exceed
Iron	23400	-[5]	-[5]	No criterion
Lead	10	2.5	50	Does not exceed
Magnesium	8060	-[5]	-[5]	No criterion
Manganese	117	-[5]	-[5]	No criterion

TABLE 5.1-17

COMPARISON OF REFERENCE SOIL SAMPLES TO SCREENING LEVEL CRITERIA FOR SOILS

Chemicals	Overburden[1] (mg/kg soil)	Muskeg[2] (mg/kg soil)	Screening Level[3] Criteria (mg/kg soil)	Comments
Mercury	0.07	0.037	0.2	Does not exceed
Molybdenum	<2	1.4	4	Does not exceed
Nickel	30	8.4	40	Does not exceed
Thallium	-[5]	<0.1	1	Does not exceed
Vanadium	15.1	12.3	50	Does not exceed
Zinc	72.7	25.5	120	Does not exceed

[1] Overburden (KCa; CP3) data as reported by ETL (1993). This sample is considered to be representative of background soils (n=1).
[2] Muskeg soil analyzed by CHEMEX labs Alberta Inc. Oct. 30, 1995. This sample is considered to be representative of background soils (n=1).
[3] Screening Level Criteria were based on soil quality criteria. Please see table 5.1-15 for derivation of values.
[4] These compounds were not detected above detection limits.
[5] Not analyzed or no data available.
[6] For information on grouping of chemicals and the use of surrogate chemicals, please refer to Appendix II.

TABLE 5.1-18

COMPARISON OF CHEMICAL CONCENTRATIONS IN WATER TO SCREENING LEVEL CRITERIA FOR WILDLIFE

Chemical	Tar Island[1] Dyke Water (mg/L)	Plant 4 Tailings[2] Sand Water (mg/L)	Consolidated[3] Tailings Water (mg/L)	Screening Level[4] Criteria (mg/L)	Comments
PAHS AND SUBSTITUTED PAHS					
Acenaphthylene	<0.00002[7]	<0.00005	0.00016	–[5]	No criterion
Acenaphthene group[6]	0.00028	0.00012	0.00019	–[5]	No criterion
Benzo(a)anthracene group[6]	<0.00004	0.00026	0.0016	–[5]	No criterion
Benzo(a)pyrene group[6]	<0.00004	0.00011	0.00048	–[5]	No criterion
Benzo(ghi)perylene	<0.00002	0.00003	<0.00002	–[5]	No criterion
Biphenyl	<0.00004	<0.00004	0.00008	–[5]	No criterion
Dibenzothiophene group[6]	0.00005	0.0009	0.01142	–[5]	No criterion
Fluorene group[6]	0.00054	0.00074	0.00143	–[5]	No criterion
Fluoranthene group[6]	0.00008	0.00015	0.00065	–[5]	No criterion
Naphthalene group[6]	0.00104	0.00258	0.00268	–[5]	No criterion
Phenanthrene group[6]	0.00031	0.00118	0.01068	–[5]	No criterion
Pyrene	<0.00002	0.00009	0.00004	–[5]	No criterion
SUBSTITUTED PANH COMPOUNDS					
Quinoline group[6]	0.00009	<0.00002	<0.00002	–[5]	No criterion
NAPHTHENIC ACIDS					
Naphthenic acids	55	–[5]	94	–[5]	No criterion
VOLATILES					
Ethylbenzene	0.0015	<0.001	<0.001	–[5]	No criterion
m-+p-xylenes	0.005	<0.001	0.015	–[5]	No criterion
o-xylene	0.0027	<0.001	0.015	–[5]	No criterion
PHENOLS					
2,4-Dimethylphenol	<0.0001	<0.0001	0.001	–[5]	No criterion
INORGANICS					
Aluminum	1.15	0.88	1.92	5	Does not exceed
Ammonia	6.01	19.9	3.98	–[5]	No criterion

TABLE 5.1-18

COMPARISON OF CHEMICAL CONCENTRATIONS IN WATER TO SCREENING LEVEL CRITERIA FOR WILDLIFE

Chemical	Tar Island[1] Dyke Water (mg/L)	Plant 4 Tailings[2] Sand Water (mg/L)	Consolidated[3] Tailings Water (mg/L)	Screening Level[4] Criteria (mg/L)	Comments
Antimony	-[5]	0.0006		-[5]	No criterion
Arsenic	0.003	0.0036	0.0058	0.5	Does not exceed
Barium	0.1	0.772	0.18	-[5]	No criterion
Beryllium	0.002	<0.001	0.004	0.1	Does not exceed
Boron	1.88	2.31	4.26	5	Does not exceed
Cadmium	0.004	<0.001	0.007	0.02	Does not exceed
Calcium	57.1	43.2	118	1000	Does not exceed
Chloride	17.3	33.4	510	-[5]	No criterion
Chromium	0.002	0.028	0.003	1	Does not exceed
Cobalt	0.005	0.018	0.007	1	Does not exceed
Copper	0.006	0.001	0.004	0.3	Does not exceed
Cyanide	0.002	-[5]	0.055	-[5]	No criterion
Iron	2.21	22.5	1.01	-[5]	No criterion
Lead	<0.0003	<0.005	<0.0003	0.1	Does not exceed
Lithium	0.144	0.229	0.272	5	Does not exceed
Magnesium	11.3	18.1	28	-[5]	No criterion
Manganese	0.213	1.76	0.058	-[5]	No criterion
Mercury	0.00026	0.0004	<0.00005	0.003	Does not exceed
Molybdenum	0.018	0.071	1.42	0.05	EXCEEDS
Nickel	0.005	0.055	0.0295	1	Does not exceed
Phosphorus	0.43	0.2	0.073	-[5]	No criterion
Potassium	10.8	18.9	29	20	EXCEEDS
Selenium	0.0002	<0.00004	0.0036	0.05	Does not exceed
Silicon	10.1	6.12	5.58	-[5]	No criterion
Sodium	335	16600	1170	-[5]	No criterion
Strontium	0.337	0.771	2.12	-[5]	No criterion

TABLE 5.1-18

COMPARISON OF CHEMICAL CONCENTRATIONS IN WATER TO SCREENING LEVEL CRITERIA FOR WILDLIFE

Chemical	Tar Island[1] Dyke Water (mg/L)	Plant 4 Tailings[2] Sand Water (mg/L)	Consolidated[3] Tailings Water (mg/L)	Screening Level[4] Criteria (mg/L)	Comments
Sulphate	143	118	1290	1000	EXCEEDS
Tin	-[5]	0.44	-[5]	-[5]	No criterion
Titanium	0.02	0.013	0.02	-[5]	No criterion
Uranium	<0.5	<0.1	0.0068	0.2	Does not exceed
Vanadium	0.01	0.05	0.17	0.1	EXCEEDS
Zinc	0.058	0.068	0.056	50	Does not exceed
Zirconium	-[5]	0.0013	-[5]	-[5]	No criterion

[1] Tar Island Dyke Seepage Water taken from TID collection system; composite sample from tanks (RW-127).

[2] Groundwater samples (ID: RG088 and GG089) and Plant 4 Beach #2 Tailings sand water sample (ID: E504203-02).

[3] Consolidated Tailings Release Waters samples RW-162, RW-163 and RW164; 1995 Suncor and Syncrude CT field study.

[4] Screening Level Criteria were based on water quality criteria for wildlife or livestock. Please see table 5.1-14 for derivation of values.

[5] No data or criterion.

[6] For information on grouping of chemicals and the use of surrogate chemicals, please refer to Appendix II.

[7] These compounds were not detected above detection limits.

TABLE 5.1-19

COMPARISON OF CHEMICAL CONCENTRATIONS IN RECLAMATION MATERIALS TO SCREENING LEVEL CRITERIA FOR WILDLIFE

Chemicals	Low Gypsum[1] Consolidated Tailings (mg/kg soil)	Tailings Sand[2] Suncor Beach (mg/kg soil)	Screening Level[3] Criteria (mg/kg soil)	Comments
PAHS AND SUBSTITUTED PAHS				
Acenaphthene	0.05	<0.01[4]	0.1	Does not exceed
Benzo(a)anthracene group[6]	1.2	0.65	0.1	EXCEEDS
Benzo(a)pyrene group[6]	0.46	0.2	0.1	EXCEEDS
Benzo(b&k)fluoranthene	0.12	0.03	0.1	EXCEEDS
Biphenyl group[6]	0.19	0.01	0.89	Does not exceed
Dibenzothiophene group[6]	7.01	0.8	0.1	EXCEEDS
Fluorene group[6]	0.59	<0.01	0.1	EXCEEDS
Fluoranthene group[6]	0.57	0.01	0.1	EXCEEDS
Naphthalene group[6]	0.64	<0.01	0.1	EXCEEDS
Phenanthrene group[6]	8.11	0.56	0.1	EXCEEDS
Pyrene	0.16	0.04	0.1	EXCEEDS
INORGANICS				
Aluminum	-[5]	172	-[5]	No criterion
Arsenic	<20	0.63	20	Does not exceed
Barium	19.1	4.9	750	Does not exceed
Beryllium	0.3	<0.2	2.5	Does not exceed
Calcium	-[5]	559	-[5]	No criterion
Chromium	15.4	<0.5	750	Does not exceed
Cobalt	2	2	40	Does not exceed
Copper	2.7	<0.5	80	Does not exceed
Iron	-[5]	3350	-[5]	No criterion
Lead	4.4	<2	50	Does not exceed
Magnesium	-[5]	133	-[5]	No criterion
Manganese	-[5]	56.5	-[5]	No criterion
Mercury	<0.02	0.03	0.2	Does not exceed

TABLE 5.1-19

COMPARISON OF CHEMICAL CONCENTRATIONS IN RECLAMATION MATERIALS TO SCREENING LEVEL CRITERIA FOR WILDLIFE

Chemicals	Low Gypsum[1] Consolidated Tailings (mg/kg soil)	Tailings Sand[2] Suncor Beach (mg/kg soil)	Screening Level[3] Criteria (mg/kg soil)	Comments
Molybdenum	1.1	<2	4	Does not exceed
Nickel	14.4	2	40	Does not exceed
Thallium	0.1	-[5]	1	Does not exceed
Vanadium	23.7	2.8	50	Does not exceed
Zinc	13.6	5.8	120	Does not exceed

[1] Low Gypsum Consolidated Tailings analyzed by CHEMEX Labs Alberta Inc. in October 1995 and by EnviroTest Laboratories on May and November 1995.

[2] Tailings Sand (Suncor Beach; CP5) data as reported by ETL (1993; n=1).

[3] Screening Level Criteria are based on soil quality criteria. Please see Table 5.1-15 for derivation of values.

[4] These compounds were not detected above detection limits.

[5] Not analyzed or no data available.

[6] For information on grouping of chemicals and the use of surrogate chemicals, please refer to Appendix II.

TABLE 5.1-20

COMPARISON OF CHEMICAL CONCENTRATIONS IN WATER TO BACKGROUND CONCENTRATIONS AT REFERENCE SITES

Chemical	RECLAMATION WATERS			REFERENCE WATERS		Comments
	Tar Island[1] Dyke Water	Plant 4 Tailings[2] Sand Water (mg/L)	Consolidated[3] Tailings Water (mg/L)	Athabasca[4] River Water (mg/L)	Reference[5] Tributaries Water (mg/L)	
PAHS AND SUBSTITUTED PAHS						
Acenaphthylene	<0.00002[7]	<0.00005	0.00016	<0.00002	<0.00002	EXCEEDS
Acenaphthene group[6]	0.00028	0.00012	0.00019	<0.00004	<0.00004	EXCEEDS
Benzo(a)anthracene group[6]	<0.00004	0.00026	0.0016	<0.00004	<0.00004	EXCEEDS
Benzo(a)pyrene group[6]	<0.00004	0.00011	0.00048	<0.00004	<0.00004	EXCEEDS
Benzo(ghi)perylene	<0.00002	0.00003	<0.00002	<0.00002	<0.00002	EXCEEDS
Biphenyl	<0.00004	<0.00004	0.00008	<0.00004	<0.00004	EXCEEDS
Dibenzothiophene group[6]	0.00005	0.0009	0.01142	<0.00004	<0.00004	EXCEEDS
Fluorene group[6]	0.00054	0.00074	0.00143	<0.00004	<0.00004	EXCEEDS
Fluoranthene group[6]	0.00008	0.00015	0.00065	<0.00004	<0.00004	EXCEEDS
Naphthalene group[6]	0.00104	0.00258	0.00268	<0.00002	0.00002	EXCEEDS
Phenanthrene group[6]	0.00031	0.00118	0.01068	<0.00004	<0.00004	EXCEEDS
Pyrene	<0.00002	0.00009	0.00004	<0.00002	<0.00002	EXCEEDS
SUBSTITUTED PANH COMPOUNDS						
Quinoline group[6]	0.00009	<0.00002	<0.00002	<0.00002	<0.00002	EXCEEDS
NAPHTHENIC ACIDS						
Naphthenic acids	55	–[8]	94	<1	<1	EXCEEDS
VOLATILES						
Ethylbenzene	0.0015	<0.001	<0.001	<0.001	<0.001	EXCEEDS
m-+p-xylenes	0.005	<0.001	0.015	<0.001	<0.001	EXCEEDS
o-xylene	0.0027	<0.001	0.015	<0.001	<0.001	EXCEEDS
PHENOLS						
2,4-Dimethylphenol	<0.001	<0.0001	0.001	<0.0001	<0.0001	EXCEEDS
INORGANICS						
Ammonia	6.01	19.9	3.98	0.08	0.11	EXCEEDS
Antimony	–[8]	0.0006	–[8]	0.0002	0.0003	EXCEEDS
Cadmium	0.004	<0.001	0.007	0.003	0.005	EXCEEDS

TABLE 5.1-20

COMPARISON OF CHEMICAL CONCENTRATIONS IN WATER TO BACKGROUND CONCENTRATIONS AT REFERENCE SITES

Chemical	RECLAMATION WATERS			REFERENCE WATERS		Comments
	Tar Island[1] Dyke Water	Plant 4 Tailings[2] Sand Water (mg/L)	Consolidated[3] Tailings Water (mg/L)	Athabasca[4] River Water (mg/L)	Reference[5] Tributaries Water (mg/L)	
Barium	0.1	0.772	0.18	0.2	0.07	EXCEEDS
Chloride	17.3	33.4	510	14.8	56.9	EXCEEDS
Cyanide	0.002	-[8]	0.055	0.005	0.025	EXCEEDS
Iron	2.21	22.5	1.01	17.9	4.81	EXCEEDS
Magnesium	11.3	18.1	28	21	18.4	EXCEEDS
Manganese	0.213	1.76	0.058	0.509	0.21	EXCEEDS
Molybdenum	0.018	0.071	1.42	0.01	0.004	EXCEEDS
Phosphorus	0.43	0.2	0.096	0.4	<0.1	EXCEEDS
Potassium	10.8	18.9	29	2.65	2.2	EXCEEDS
Silicon	10.1	6.12	5.58	2.12	3.76	EXCEEDS
Sodium	335	16600	1170	24.6	61.3	EXCEEDS
Strontium	0.337	0.771	2.12	0.36	0.21	EXCEEDS
Sulphate	143	118	1290	58	53.2	EXCEEDS
Titanium	0.02	0.013	0.02	0.085	0.046	Does not exceed
Tin	-[8]	0.44	-[8]	-[8]	-[8]	No bkgd data.
Vanadium	0.01	0.05	0.17	0.02	0.008	EXCEEDS
Zirconium	-[8]	0.0013	-[8]	-[8]	-[8]	No bkgd data.

[1] Tar Island Dyke Seepage Water taken from TID collection system; composite sample from tanks (RW-127).
[2] Groundwater samples (ID: RG088 and RG089) and Plant 4 Beach #2 Tailings water sample (ID: E504203-02).
[3] Consolidated Tailings Release Waters samples RW-162, RW-163 and RW164; and 1995, Suncor and Syncrude CT field study.
[4] Athabasca River upstream of Lease 19 sampled by Golder during 1995 (Suncor EIA data, Golder 1996b) and NAQUADAT data (n=26) sampled in 1985-1995 (site: 00AL07CC0600).
[5] Data from the tributaries were grouped and included data from Legget Creek, McLean Creek, Steepbank River and Wood Creek sampled by Golder during 1995 (Golder 1996b).
[6] For information on grouping of chemicals and the use of surrogate chemicals, please refer to Appendix II.
[7] These compounds were not detected above detection limits.
[8] No data or criteria available.

TABLE 5.1-21

COMPARISON OF CHEMICAL CONCENTRATIONS IN RECLAMATION MATERIALS TO BACKGROUND SOILS

Chemicals	RECLAMATION MATERIALS		BACKGROUND SOILS		Comments
	Low Gypsum[1] Consolidated Tailings (mg/kg soil)	Tailings Sand[2] Suncor Beach (mg/kg soil)	Overburden[3] (mg/kg soil)	Muskeg[4] (mg/kg soil)	
PAHs					
Benzo(a)anthracene group[6]	1.2	0.65	<0.01	0.03	EXCEEDS
Benzo(a)pyrene group[6]	0.46	0.2	<0.01	<0.01	EXCEEDS
Benzo(b&k)fluoranthene	0.12	0.03	<0.01[5]	<0.01	EXCEEDS
Diibenzothiophene group[6]	7.01	0.8	0.24	<0.01	EXCEEDS
Fluorene group[6]	0.59	<0.01	0.05	<0.01	EXCEEDS
Fluoranthene group[6]	0.57	0.01	<0.01	<0.01	EXCEEDS
Naphthalene group[6]	0.64	<0.01	0.49	0.05	EXCEEDS
Phenanthrene group[6]	8.11	0.56	0.15	0.003	EXCEEDS
Pyrene	0.16	0.04	<0.01	<0.01	EXCEEDS
INORGANICS					
Aluminum	-[7]	172	10500	-[7]	Does not exceed
Calcium	-[7]	559	8540	-[7]	Does not exceed
Iron	-[7]	3350	23400	-[7]	Does not exceed
Magnesium	0.6	133	8060	-[7]	Does not exceed
Manganese	-[7]	56.5	117	-[7]	Does not exceed

[1] Low Gypsum Consolidated Tailings analyzed by CHEMEX Labs Alberta Inc., October 1995 and ETL, May and November, 1995.

[2] Tailings Sand (Suncor Beach; CP5) data as reported by ETL (1993; n=1).

[3] Overburden (KCa; CP3) data as reported by ETL (1993). This sample is considered to be representative of background soils (n=1).

[4] Muskeg soil analyzed by CHEMEX labs Alberta Inc. Oct. 30, 1995. This sample is considered to be representative of background soils (n=1).

[5] These compounds were not detected above detection limits.

[6] For information on grouping of chemicals and the use of surrogate chemicals, please refer to Appendix II.

[7] Not analyzed or no data available.

TABLE 5.1-22

COMPARISON OF CHEMICAL CONCENTRATIONS IN EMERGENT MACROPHYTES GROWN IN TREATED WETLANDS TO BACKGROUND WETLANDS

Chemicals	TREATMENT			BACKGROUND		Comments
	Dyke Drainage[1] Wetlands (ug/g)	Pond 1A [2] Wetlands (ug/g)	Syncrude[3] Pit 7 (ug/g)	Syncrude[4] Reference Wetlands (ug/g)	Control[5] Wetlands (ug/g)	
ORGANICS						
Acenaphthene group[6]	-[7]	-[7]	0.013	<0.001[8]	-[7]	EXCEEDS
Benzo(a)anthracene group[6]	-[7]	-[7]	0.118	<0.001	-[7]	EXCEEDS
Benzo(a)pyrene group[6]	-[7]	-[7]	0.019	<0.001	-[7]	EXCEEDS
Biphenyl	-[7]	-[7]	0.002	0.001	-[7]	EXCEEDS
Dibenzo(a,h)anthracene	-[7]	-[7]	0.001	<0.001	-[7]	EXCEEDS
Dibenzothiophene group[6]	-[7]	-[7]	0.774	0.001	-[7]	EXCEEDS
Fluoranthene group[6]	-[7]	-[7]	0.035	<0.001	-[7]	EXCEEDS
Fluorene group[6]	-[7]	-[7]	0.141	0.018	-[7]	EXCEEDS
Naphthalene group[6]	-[7]	-[7]	0.299	0.013	-[7]	EXCEEDS
Phenanthrene group[6]	-[7]	-[7]	1.762	<0.001	-[7]	EXCEEDS
Pyrene	-[7]	-[7]	0.001	<0.001	-[7]	EXCEEDS
INORGANICS						
Aluminum	367	701.86	1610	1440	358.67	EXCEEDS
Arsenic	-[7]	-[7]	1.6	2.5	-[7]	Does not EXCEED
Barium	-[7]	-[7]	28.7	21.5	-[7]	EXCEEDS
Beryllium	-[7]	-[7]	0.14	0.15	-[7]	Does not EXCEED
Boron	-[7]	-[7]	44	15	-[7]	EXCEEDS
Cadmium	0.06	0.07	0.29	0.34	0.07	Does not EXCEED
Calcium	-[7]	-[7]	6150	8490	-[7]	Does not EXCEED
Copper	2.29	2.82	6.2	9.74	3.66	Does not EXCEED
Lead	-[7]	-[7]	0.6	1.2	-[7]	Does not EXCEED
Lithium	-[7]	-[7]	5	<4	-[7]	EXCEEDS
Iron	642.67	363.43	2300	4400	936.78	Does not EXCEED

TABLE 5.1-22

COMPARISON OF CHEMICAL CONCENTRATIONS IN EMERGENT MACROPHYTES GROWN IN TREATED WETLANDS TO BACKGROUND WETLANDS

Chemicals	TREATMENT			BACKGROUND		Comments
	Dyke Drainage[1] Wetlands (ug/g)	Pond 1A [2] Wetlands (ug/g)	Syncrude[3] Pit 7 (ug/g)	Syncrude[4] Reference Wetlands (ug/g)	Control[5] Wetlands (ug/g)	
Magnesium	-[7]	-[7]	2130	2600	-[7]	Does not EXCEED
Manganese	266.88	303	217	828	741.5	Does not EXCEED
Mercury	0.07	0.11	-[7]	-[7]	0.02	EXCEEDS
Nickel	2.22	2.27	3.5	2.7	2.66	EXCEEDS
Phosphorus	-[7]	-[7]	1350	1060	-[7]	EXCEEDS
Potassium	-[7]	-[7]	6730	12200	-[7]	Does not EXCEED
Silicon	-[7]	-[7]	283	302	-[7]	Does not EXCEED
Sodium	-[7]	-[7]	11100	3750	-[7]	EXCEEDS
Strontium	-[7]	-[7]	60.3	34.1	-[7]	EXCEEDS
Titanium	-[7]	-[7]	9.48	16.3	-[7]	Does not EXCEED
Vanadium	-[7]	-[7]	4.7	5.1	-[7]	Does not EXCEED
Zinc	33.75	20.78	22.1	34.1	41.35	Does not EXCEED
Zirconium	-[7]	-[7]	2	1.5	41.35	Does not EXCEED

[1] Data from dyke drainage water constructed wetland (Nix et al. 1995).

[2] Data from Pond 1A constructed wetland (Nix et al. 1995).

[3] Data from Syncrude, Pit 7 (unpublished data). Plants grown in fine tails.

[4] Data from Syncrude reference wetlands (unpublished data). This sample was considered to be representative of background values.

[5] Data from control constructed wetlands (Nix et al. 1995). This sample was considered to be representative of background values.

[6] For information on grouping of chemicals and the use of surrogate chemicals, please refer to Appendix II.

[7] Not analyzed or no data available.

[8] These compounds were not detected above detection limits.

TABLE 5.1-23

COMPARISON OF CHEMICAL CONCENTRATIONS IN AQUATIC INVERTEBRATE TISSUE TO BACKGROUND CONCENTRATIONS

Chemical	Dyke Drainage[1] (ug/g)	Split Dyke[1] Drainage (ug/g)	Control[2] (ug/g)	Comments
Benthic Invertebrates				
Aluminum	450	1800	220	Does not exceed
Barium	71.5	29	52.6	Does not exceed
Cadmium	<[3]	<[3]	<[3]	Does not exceed
Copper	40	20	20	EXCEEDS background
Iron	2650	2970	2100	Does not exceed
Lead	<[3]	<[3]	<[3]	Does not exceed
Manganese	77	110	46	Does not exceed
Mercury	<[3]	<[3]	<[3]	Does not exceed
Titanium	20	30	9	Does not exceed
Total Extractable Hydrocarbons	74.1	66.8	99.8	Does not exceed
Zinc	110	94	94	EXCEEDS background
Emergent Insects				
Aluminum	70	-[4]	40	Does not exceed
Barium	84.4	-[4]	41	EXCEEDS background
Cadmium	<[3]	-[4]	<[3]	Does not exceed
Copper	70	-[4]	70	Does not exceed
Iron	650	-[4]	1800	Does not exceed
Lead	<[3]	-[4]	<[3]	Does not exceed
Manganese	190	-[4]	80	Does not exceed
Mercury	<[3]	-[4]	<[3]	Does not exceed
Titanium	10	-[4]	<30	EXCEEDS background
Zinc	220	-[4]	200	Does not exceed
Chironomid Larvae				
Aluminum	18.38	-[4]	71	Do not exceed
Cadmium	0.57	-[4]	0.34	EXCEEDS background

TABLE 5.1-23

COMPARISON OF CHEMICAL CONCENTRATIONS IN AQUATIC INVERTEBRATE TISSUE TO BACKGROUND CONCENTRATIONS

Chemical	Dyke Drainage[1] (ug/g)	Split Dyke[1] Drainage (ug/g)	Control[2] (ug/g)	Comments
Iron	6590.6	-[4]	3394	EXCEEDS background
Lead	5.73	-[4]	2.4	EXCEEDS background
Mercury	5.39	-[4]	8.5	Do not exceed
Zinc	145.11	-[4]	234.07	Do not exceed

[1] Data from dyke drainage water constructed wetland (Nix et al. 1995).

[2] Data from control constructed wetlands (Nix et al. 1995) considered to be representative of background values.

[3] Not detected. Detection limit not specified.

[4] Not analyzed.

TABLE 5.1-24

COMPARISON OF CHEMICAL CONCENTRATIONS IN WATER TO RISK-BASED CONCENTRATIONS (RBCs) FOR WILDLIFE

Chemical	Tar Island[1] Dyke Water (mg/L)	Plant 4[2] Tailings Sand Water (mg/L)	Consolidated[3] Tailings Water (mg/L)	RBC for[4] Beaver (mg/L)	RBC for[4] Moose (mg/L)	RBC for[4] Mouse (mg/L)	RBC for[4] Ermine (mg/L)	RBC for[4] Hare (mg/L)	RBC for[4] Kestrel (mg/L)	RBC for[4] Grouse (mg/L)	RBC for[4] Robin (mg/L)	RBC for[4] Mallard (mg/L)	Comments
PAHS													
Acenaphthylene	<0.00002	<0.00005	0.00016	28	14	139	103	50	216	193	224	182	Does not exceed
Acenaphthene group[7]	0.00028	0.00012	0.00019	28	14	139	103	50	216	193	224	182	Does not exceed
Benzo(a)anthracene group[7]	<0.00004	0.00026	0.0016	36	18	180	133	65	0.77	0.69	0.81	0.65	Does not exceed
Benzo(a)pyrene group[7]	<0.00004	0.00011	<0.00002	1.6	0.78	7.9	5.9	2.9	0.079	0.071	0.082	0.067	Does not exceed
Benzo(ghi)perylene	<0.00002	0.00003	<0.00004	12	5.9	59	44	21	216	193	224	182	Does not exceed
Biphenyl	<0.00004	<0.00004	0.00008	181	89	899	664	324	-[5]	-[5]	-[5]	-[5]	Does not exceed
Dibenzothiophene group[7]	0.00005	0.0009	0.01142	12	5.9	59	44	21	216	193	224	182	Does not exceed
Fluorene group[7]	0.00054	0.00074	0.00143	20	10	99	73	36	216	193	224	182	Does not exceed
Fluoranthene group[7]	0.00008	0.00015	0.00065	12	5.9	59	44	21	216	193	224	182	Does not exceed
Naphthalene group[7]	0.00104	0.00258	0.00268	21	10	105	78	38	-[5]	-[5]	-[5]	-[5]	Does not exceed
Phenanthrene group[7]	0.00031	0.00118	0.01068	6.4	3.1	32	23	11	216	193	224	182	Does not exceed
Pyrene	<0.00002	0.00009	0.00004	12	5.9	59	44	21	216	193	224	182	Does not exceed
SUBSTITUTED PANH COMPOUNDS													
Quinoline group[7]	0.00009	<0.00002	<0.00002	3.6	1.8	18	13	6.4	-[5]	-[5]	-[5]	-[5]	Does not exceed
NAPHTHENIC ACIDS													
Naphthenic acids	55	-[5]	94	-[5]	-[5]	-[5]	-[5]	-[5]	-[5]	-[5]	-[5]	-[5]	No RBC
VOLATILES													
Ethylbenzene	0.0015	<0.001	<0.001	35	17	175	129	63	-[5]	-[5]	-[5]	-[5]	Does not exceed
m-+p-xylenes	0.005	<0.001	0.015	3.3	1.6	16	12	5.9	-[5]	-[5]	-[5]	-[5]	Does not exceed
o-xylene	0.0027	<0.001	0.015	3.3	1.6	16	12	5.9	-[5]	-[5]	-[5]	-[5]	Does not exceed
PHENOLS													
2,4-Dimethylphenol	<0.0001	<0.0001	0.001	8.0	3.9	40	29	14	-[5]	-[5]	-[5]	-[5]	Does not exceed
INORGANICS													
Ammonia	6.01	19.9	3.98	-[5]	-[5]	-[5]	-[5]	-[5]	-[5]	-[5]	-[5]	-[5]	No RBC
Antimony	-[5]	0.0006	-[5]	0.2	0.1	1	0.73	0.36	-[5]	-[5]	-[5]	-[5]	Does not exceed
Cadmium	0.004	<0.001	0.007	0.3	0.15	1.5	1.1	0.55	15	13	15	12	Does not exceed
Chloride	17.3	33.4	510	-[5]	-[5]	-[5]	-[5]	-[5]	-[5]	-[5]	-[5]	-[5]	No RBC
Cyanide	0.002	-[5]	0.055	114	84	41	23	11	-[5]	-[5]	-[5]	-[5]	Does not exceed
Magnesium	11.3	18.1	28	-[5]	-[5]	-[5]	-[5]	-[5]	-[5]	-[5]	-[5]	-[5]	No RBC
Manganese	0.213	1.76	0.058	318	156	1583	1169	570	1543	1381	1605	1301	Does not exceed

TABLE 5.1-24

COMPARISON OF CHEMICAL CONCENTRATIONS IN WATER TO RISK-BASED CONCENTRATIONS (RBCs) FOR WILDLIFE

Chemical	Tar Island[1] Dyke Water (mg/L)	Plant 4[2] Tailings Sand Water (mg/L)	Consolidated[3] Tailings Water (mg/L)	RBC for[4] Beaver (mg/L)	RBC for[4] Moose (mg/L)	RBC for[4] Mouse (mg/L)	RBC for[4] Ermine (mg/L)	RBC for[4] Hare (mg/L)	RBC for[4] Kestrel (mg/L)	RBC for[4] Grouse (mg/L)	RBC for[4] Robin (mg/L)	RBC for[4] Mallard (mg/L)	Comments
Molybdenum	0.018	0.071	1.42	8.5	4.2	42	31	15	77	69	80	65	Does not exceed
Phosphorus	0.43	0.2	0.096	-[5]	-[5]	-[5]	-[5]	-[5]	-[5]	-[5]	-[5]	-[5]	No RBC
Potassium	10.8	18.9	20.2	-[5]	-[5]	-[5]	-[5]	-[5]	-[5]	-[5]	-[5]	-[5]	No RBC
Silicon	10.1	6.12	5.58	-[5]	-[5]	-[5]	-[5]	-[5]	-[5]	-[5]	-[5]	-[5]	No RBC
Sodium	335	16600	500	-[5]	-[5]	-[5]	-[5]	-[5]	-[5]	-[5]	-[5]	-[5]	No RBC
Strontium	0.337	0.771	1.09	950	468	4731	3494	1702	-[5]	-[5]	-[5]	-[5]	Does not exceed
Sulphate	143	118	1290	-[5]	-[5]	-[5]	-[5]	-[5]	-[5]	-[5]	-[5]	-[5]	No RBC
Tin	-[5]	0.44	-[5]	-[5]	-[5]	-[5]	-[5]	-[5]	-[5]	-[5]	-[5]	-[5]	No RBC
Vanadium	0.01	0.05	0.17	0.69	0.34	3.4	2.5	1.2	115	103	119	97	Does not exceed
Zirconium	-[5]	0.0013	-[5]	6.3	1.4	14	10	6	-[5]	-[5]	-[5]	-[5]	Does not exceed

[1] Tar Island Dyke Seepage Water taken from TID collection system; composite sample from tanks (RW-127).

[2] Groundwater samples (ID: RG088 and GG089) and Plant 4 Beach #2 Tailings water sample (ID: E504203-02).

[3] Consolidated Tailings Release Waters samples RW-162, RW-163 and RW164; and 1995, Suncor and Syncrude CT field study.

[4] Risk-Based Concentration (RBCs) as derived in Appendix III.

[5] No data or criterion.

[6] For information on grouping of chemicals and the use of surrogate chemicals, please refer to Appendix II.

[7] These compounds were not detected above detection limits.

TABLE 5.1-25

COMPARISON OF CHEMICAL CONCENTRATIONS IN RECLAMATION MATERIALS TO RISK-BASED CONCENTRATIONS (RBCs) IN SOILS FOR WILDLIFE

Chemicals	Low Gypsum[1] Consolidated Tailings (mg/kg soil)	Tailings Sand[2] Suncor Beach (mg/kg soil)	RBC for[3] Mouse (mg/kg soil)	RBC for[3] Ermine (mg/kg soil	RBC for[3] Hare (mg/kg soil	RBC for[3] Beaver (mg/kg soil)	RBC for[3] Moose (mg/kg soil)	RBC for[3] Robin (mg/kg soil)	RBC for[3] Kestrel (mg/kg soil)	RBC for[3] Grouse (mg/kg soil)	RBC for[3] Mallard (mg/kg soil)	Comments
PAHS AND SUBSTITUTED PAHS												
Benzo(a)anthracene group[5]	1.2	0.65	3378	380	550	497	1237	8.5	3.9	46	42	Does not exceed
Benzo(a)pyrene group[5]	0.53	0.2	338	38	55	50	124	0.87	0.40	4.7	4.3	EXCEEDS for kestrel
Benzo(b&k)fluoranthene	0.12	0.03	3378	380	550	497	1237	8.5	3.9	46	42	Does not exceed
Dibenzothiophene group[5]	7.01	0.8	2534	285	412	373	928	2377	1094	12793	11771	Does not exceed
Fluorene group[5]	0.59	<0.01[4]	4223	474	687	621	1546	2377	1094	12793	11771	Does not exceed
Fluoranthene group[5]	0.57	0.01	2534	285	412	373	928	2377	1094	12793	11771	Does not exceed
Naphthalene group[5]	0.64	<0.01	4493	505	731	661	1645	-[6]	-[6]	-[6]	-[6]	Does not exceed
Phenanthrene group[5]	8.11	0.56	1351	152	220	199	495	2377	1094	12793	11771	Does not exceed
Pyrene	0.16	0.04	2534	285	412	373	928	2377	1094	12793	11771	Does not exceed

[1] Low Gypsum Consolidated Tailings analyzed by CHEMEX Labs Alberta Inc. in October 1995 and by ETL on May and November 1995.

[2] Tailings Sand (Suncor Beach; CP5) data as reported in ETL (1993; n=1).

[3] Risk-Based Concentration (RBCs) as derived in Appendix III.

[4] These compounds were not detected above detection limits.

[5] For information on grouping of chemicals and the use of surrogate chemicals, please refer to Appendix II.

[6] No data available.

TABLE 5.1-26

COMPARISON OF CHEMICAL CONCENTRATIONS IN AQUATIC PLANTS TO RISK-BASED CONCENTRATIONS (RBCs) FOR WILDLIFE

Chemicals	Consolidated[1] Tailings (mg/kg plant)	Consolidated[2] Tailings (mg/kg plant)	Syncrude[3] (mg/kg plant)	Tailings[4] Sand Water (mg/kg plant)	RBC for[5] Mallard (mg/kg plant)	RBC for[5] Beaver (mg/kg plant)	RBC for[5] for Moose (mg/kg plant)	RBC for[5] Mouse (mg/kg plant)	RBC for[5] Hare (mg/kg plant)	RBC for[5] Grouse (mg/kg plant)	Comments
Cattails and bulrushes											
Acenaphthene group[7]	-[6]	-[6]	0.013	-[6]	1533	52	43	204	61	384	Does not exceed
Benzo(a)anthracene grou	-[6]	-[6]	0.118	-[6]	5.5	30	25	116	35	1.4	Does not exceed
Benzo(a)pyrene	-[6]	-[6]	0.019	-[6]	0.56	3	2.5	12	3.5	0.14	Does not exceed
Biphenyl	-[6]	-[6]	0.002	-[6]	-[6]	5633	281	1320	393	-[6]	Does not exceed
Dibenzo(a,h)anthracene	-[6]	-[6]	0.001	-[6]	0.112	0.6	0.5	2.3	0.69	0.028	Does not exceed
Dibenzothiophene group[7]	-[6]	-[6]	0.774	-[6]	1533	373	19	87	26	384	Does not exceed
Fluoranthene group[7]	-[6]	-[6]	0.035	-[6]	1533	621	31	146	687	384	Does not exceed
Fluorene group[7]	-[6]	-[6]	0.141	-[6]	1533	621	31	146	687	384	Does not exceed
Naphthalene group[7]	-[6]	-[6]	0.299	-[6]	-[6]	661	33	155	731	-[6]	Does not exceed
Phenanthrene group[7]	-[6]	-[6]	1.47	-[6]	1533	199	10	47	220	384	Does not exceed
Aluminum	-[6]	614.4	1610	701.86	-[6]	0.37	0.31	1.5	0.43	-[6]	EXCEEDS
Antimony	-[6]	0.04	-[6]	-[6]	-[6]	0.37	0.31	1.5	0.43	-[6]	Does not exceed
Arsenic	-[6]	0.56	-[6]	-[6]	349	0.38	0.31	1.5	0.44	15	EXCEEDS
Barium	-[6]	24.25	28.70	-[6]	700	37	31	144	43	175	Does not exceed
Boron	-[6]	69.0	36.5	-[6]	819	238	198	929	276	205	Does not exceed
Cadmium	-[6]	0.49	-[6]	-[6]	103	0.57	0.47	2.2	0.66	26	EXCEEDS
Calcium	-[6]	16634.44	-[6]	-[6]	-[6]	-[6]	-[6]	-[6]	-[6]	-[6]	No RBC
Chloride	-[6]	41818.44	-[6]	-[6]	-[6]	-[6]	-[6]	-[6]	-[6]	-[6]	No RBC
Chromium	-[6]	2.05	-[6]	-[6]	73	22	18	2513	26	18	Does not exceed
Cobalt	-[6]	7.55	2.2	-[6]	56	16	13	61	18	14	Does not exceed
Copper	-[6]	4.26	-[6]	-[6]	1832	112	93	439	131	459	Does not exceed
Iron	-[6]	1196.21	-[6]	-[6]	-[6]	-[6]	-[6]	-[6]	-[6]	-[6]	No RBC
Lead	-[6]	1.12	-[6]	-[6]	133	54	45	211	63	33	Does not exceed
Lithium	-[6]	5.34	5	-[6]	-[6]	90	75	352	105	-[6]	Does not exceed
Mercury	-[6]	-[6]	-[6]	0.07	0.44	0.14	0.12	-[6]	-[6]	-[6]	Does not exceed

TABLE 5.1-26

COMPARISON OF CHEMICAL CONCENTRATIONS IN AQUATIC PLANTS TO RISK-BASED CONCENTRATIONS (RBCs) FOR WILDLIFE

Chemicals	Consolidated[1] Tailings (mg/kg plant)	Consolidated[2] Tailings (mg/kg plant)	Syncrude[3] (mg/kg plant)	Tailings[4] Sand Water (mg/kg plant)	RBC for[5] Mallard (mg/kg plant)	RBC for[5] Beaver (mg/kg plant)	RBC for[5] for Moose (mg/kg plant)	RBC for[5] Mouse (mg/kg plant)	RBC for[5] Hare (mg/kg plant)	RBC for[5] Grouse (mg/kg plant)	Comments
Molybdenum	-[6]	5.87	-[6]	-[6]	547	16	13	0.16	18	137	EXCEEDS
Nickel	-[6]	12.94	3.5	-[6]	4848	270	225	2.7	314	1214	EXCEEDS
Selenium	-[6]	0.64	-[6]	-[6]	27	1.6	1.3	184	1.9	7	Does not exceed
Sodium	-[6]	3701.33	11100	-[6]	-[6]	-[6]	-[6]	-[6]	-[6]	-[6]	No RBC
Strontium	-[6]	99.22	60.3	-[6]	-[6]	1777	1479	18	2066	-[6]	EXCEEDS
Thallium	-[6]	0.01	-[6]	-[6]	-[6]	0.051	0.042	0.00051	0.059	-[6]	EXCEEDS
Thorium	-[6]	0.19	-[6]	-[6]	-[6]	-[6]	-[6]	-[6]	-[6]	-[6]	No RBC
Tin	-[6]	0.023	-[6]	-[6]	-[6]	-[6]	-[6]	-[6]	-[6]	-[6]	No RBC
Titanium	-[6]	17.32	-[6]	-[6]	-[6]	-[6]	-[6]	-[6]	-[6]	-[6]	No RBC
Uranium	-[6]	0.22	-[6]	-[6]	1172	8.9	7.4	0.091	10	293	EXCEEDS
Vanadium	-[6]	11.87	-[6]	-[6]	815	1.3	1.1	0.013	1.5	204	EXCEEDS
Zinc	-[6]	-[6]	-[6]	33.75	204	1081	900	-[6]	-[6]	-[6]	Does not exceed
Zirconium	-[6]	-[6]	2	-[6]	-[6]	12	4.3	0.052	7.3	-[6]	EXCEEDS

[1] Metal concentrations in plants grown on consolidated tailings (Xu 1995; greenhouse experiments).

[2] Metal concentrations in plants grown on consolidated tailings (Xu 1996; field experiments).

[3] Unpublished data from Syncrude experiments as analyzed by Envirotest Laboratories.

[4] Data from constructed wetlands (Nix et al. 1995).

[5] The Risk-based Concentration as derived in Appendix III.

[6] Not analyzed or no data available.

[7] For information on grouping of chemicals and the use of surrogate chemicals, please refer to Appendix II.

TABLE 5.1-27

COMPARISON OF CHEMICAL CONCENTRATIONS IN AQUATIC INVERTEBRATE TISSUE TO RISK-BASED CONCENTRATIONS FOR WILDLIFE

Chemical	Dyke Drainage[1] (mg/kg)	Dyke Drainage[1] (split trench) (mg/kg)	RBC for[2] Mallard (mg/kg prey)	Comments
Benthic Invertebrates				
Copper	40	20	621	Does not exceed
Zinc	110	94	69	EXCEEDS for mallard
Emergent Insects				
Barium	84.4	-[3]	238	EXCEEDS for mallard
Titanium	10	-[3]	-[3]	No RBC
Chironomid Larvae				
Cadmium	0.57	-[3]	35	Does not exceed
Iron	6590.6	-[3]	-[3]	No RBC
Lead	5.73	-[3]	45	Does not exceed

[1] Data from dyke drainage water constructed wetland (Nix et al. 1995).

[2] Risk-Based Concentration (RBCs) as derived in Appendix III.

[3] Not analyzed, or no data available.

Table 5.1-28

CANDIDATE WILDLIFE RECEPTORS FOR THE SUNCOR RISK ASSESSMENT
Page 1 of 8

Common Name	*Scientific Name*	Diet	Habitat
Mammals of northeastern Alberta (data from Smith 1993 and Burt 1976).			
Masked shrew	*Sorex cinereus*	insectivore	• damp meadows to uplands, deadfall, all types of forest • shrews usu nest under deadfall or in grass nests in litter • common to very common
Dusky shrew	*Sorex monticolus*	insectivore	• ubiquitous • common
Water shrew	*Sorex palustris*	insectivore	• near water • uncommon
Arctic shrew	*Sorex arcticus*	insectivore	• damp meadows, aspen groves, black spruce-larch bogs, deadfall, lodgepole pine-aspen forest • relatively common
Pygmy shrew	*Sorex hoyi*	insectivore	• dry upland coniferous and deciduous • uncommon
Snowshoe hare	*Lepus americanus*	herbivore	• forests, shrubby areas, no nest, lives under shrubs • common
Least chipmunk	*Tamias minimus*	omnivore (but more of a herbivore)	• uses a variety of forest types • nests beneath stumps, logs, rocks, makes own burrow, hibernates • common
Woodchuck	*Marmota monax*	herbivore	• dens extensive, burrow may be 4-5 ft (120-150 cm) deep and 25-30 ft. (8-9.5 m) long • hibernates • home range 40-160 acres (16.2-65 ha) • beneficial as its burrow is home to many other mammals such as game or furbearers • locally may be common, generally uncommon
Red squirrel	*Tamiasciurus hudonicus*	herbivore	• coniferous and mixed wood forests, tree squirrel, nests in trees
Northern flying squirrel	*Glaucomys sabrinus*	herbivore	• coniferous and mixed woods, nests in holes in trees • common

Table 5.1-28

CANDIDATE WILDLIFE RECEPTORS FOR THE SUNCOR RISK ASSESSMENT

Common Name	*Scientific Name*	Diet	Habitat
Beaver	*Castor canadensis*	herbivore	• requires water, builds lodges, may burrow in banks (high potential for consuming dirt) • common
Deer mouse	*Peromyscus maniculatus*	omnivore (seeds, insects)	• all habitats • burrow in ground or under rocks, stumps (could use groundhog holes) • common
Southern red-backed vole	*Clethrionomys gapperi*	herbivore (eats a few insects)	• nest under roots, logs • common and abundant
Heather vole	*Phenacomys intermedius*	herbivore	• shrubby areas, nests aboveground in winter, below in summer (gen. under rocks and debris) • uncommon in forested areas
Meadow vole	*Microtus pennsylvanicus*	herbivore	• nests either above or below ground, burrows along surface runways
Muskrat	*Ondatra zibethicus*	omnivore (aquatic vegetation, clams, frogs and fish)	• builds houses in shallow water, also burrows in banks, entrance underwater • common
Northern bog lemming	*Synaptomys borealis*	herbivore	• muskeg, heath, sedges • winter nest aboveground, summer below surface • uncommon
Meadow jumping mouse	*Zapus hudsonius*	omnivore (seeds, insects)	• moist meadows, esp. along streams and bogs • winter nest 2-3 ft. (61-91 cm) below surface in well-drained site; hibernates; summer nest on surface or beneath brush, logs, stumps • common
Porcupine	*Erethizon dorsatum*	herbivore	• mixed woods, wooded riparian • dens in hollow trees or natural caves in rocks • common
Coyote	*Canis latrans*	omnivore (predom. rabbits, small rodents)	• variable • dens in ground, also other shelters • common

Table 5.1-28

CANDIDATE WILDLIFE RECEPTORS FOR THE SUNCOR RISK ASSESSMENT

Common Name	*Scientific Name*	Diet	Habitat
Gray wolf	*Canis lupus*	carnivore (primarily birds, mammals)	• variable • dens in ground, also other shelters • common
Red fox	*Vulpes vulpes*	omnivore (insects, mice, rabbits, fruits)	• variable habitats • builds dens (and spare dens) on slopes in porous soil • common to uncommon
Black bear	*Ursus americanus*	omnivore (does a lot of digging for food, tubers, grubs, roots)	• coniferous and mixed woods • digs dens, winters in hollow trees • common
Marten	*Martes americana*	carnivore (red squirrels and small mammals, also fruits and nuts)	• mature coniferous forest • dens in logs and hollow trees, will use previously dug burrows • common
Fisher	*Martes pennanti*	carnivore	• dense coniferous forest • dens in hollow tree or in ground (likely uses previously dug burrows) • uncommon to rare
Ermine	*Mustela erminea*	carnivore (expert mouser)	• coniferous and mixed woods • dens in ground, burrows, under stumps, rock piles • common
Least weasel	*Mustela nivalis*	carnivore (almost entirely feeds on mice)	• coniferous and mixed woods • dens in ground (may take over mouse nests) • common
Mink	*Mustela vison*	carnivore (primarily small mammals, birds, eggs, frogs, crayfish and fish)	• margins of lakes, sloughs, creeks, rivers and marshes • dens along streams or in lake banks • common
Wolverine	*Gulo gulo*	carnivore	• dense forests • dens in any sheltered place • rare

Table 5.1-28

CANDIDATE WILDLIFE RECEPTORS FOR THE SUNCOR RISK ASSESSMENT

Common Name	*Scientific Name*	Diet	Habitat
Striped skunk	*Mephistes mephistes*	omnivorous	• variable habitats, prefer uplands where their burrows cannot be flooded • dens in ground burrows, under rock piles or wood piles • common
River otter	*Lutra canadensis*	carnivore (fish, frogs, crayfish, aquatic inverts)	• rivers, creeks, lakes, ponds • dens in banks, entrance below water • uncommon
Canada lynx	*Lynx canadensis*	carnivore (hares and rodents)	• coniferous and mixed woods • dens in hollow logs, beneath roots or other sheltered places • common
Mule deer	*Odocoileus hemionus*	herbivore	• river valleys, mixed woods • uncommon in northern part of range
White-tailed deer	*Odocoileus virginianus*	herbivore	• deciduous forests with clearings, riparian forests • common to uncommon
Moose	*Alces alces*	herbivore	• mixed woods • common
Caribou	*Rangifer tarandus caribou*	herbivore	• mature coniferous and mixed woods • rare

Table 5.1-28

CANDIDATE WILDLIFE RECEPTORS FOR THE SUNCOR RISK ASSESSMENT

Common Name	*Scientific Name*	Diet	Habits
Ground-dwelling or ground-feeding bird species of northeastern Alberta, specifically those delineated as a potential VEC for the Suncor EIA (Golder 1996c).			
Spruce Grouse	*Dendragapus canadensis*	herbivore (mostly spruce, fir and jackpine buds and needles; include. insects esp grasshoppers)	• mature, old growth conif forest, oft with dense understory • resident year-round
Ruffed Grouse	*Bonasa umbellus*	omivorous, ~80% buds, leaves and flowers, seeds and fruit; 20% bugs	• deci and mixed forest with dense understory, strongly associated with aspen • resident year round
Sharp-tailed Grouse	*Tympanuchus phasianellus*	herbivore (yg are insectivorous)	• grassland, savanna, partially cleared boreal forest, shrubland, sagebrush • resident year-round
Sandhill Crane	*Grus canadensis*	omnivore	• shallow wetlands, freshwater margins • breeds in NE AB
Killdeer	*Charadrius vociferous*	insectivore	• fields, meadows, pastures, mudflats, freshwater margins • breeds in NE AB
Spotted Sandpiper	*Actitis macularia*	insectivore	• variety of habitats, us feeds near water • breeds in NE AB
Northern Flicker	*Colaptes auratus*	insectivore (esp ants, also occ seeds, nuts, grain)	• ubiquitous below tree line where nest sites and open feeding areas are available • breeds in NE AB
Swainson's Thrush	*Catharus ustulatus*	insectivore (also eats fruit)	• woodland, conif. forest edge (esp where damp), riparian thickets • breeds in NE AB
Hermit Thrush	*Catharus guttatus*	insectivore (also eats fruit) include spiders, earthworms, small salamanders	• conif, mixed or decid forest and forest edge • breeds in NE AB

Table 5.1-28

CANDIDATE WILDLIFE RECEPTORS FOR THE SUNCOR RISK ASSESSMENT

Common Name	*Scientific Name*	Diet	Habits
American Robin	*Turdus migratorius*	insectivore (also eats fruit) include earthworms, snails	• habitat generalist, forest woodlands, gardens parks • breeds in NE AB
Ovenbird	*Seiurus aurocapillus*	insectivore (include worms, spiders, snails and seeds)	• decid, rarely pine forests • breeds in NE AB
Northern Waterthrush	*Seiurus noveboracensis*	insectivore (aquatic and terrestrial insects, molluscs, crustaceans, occ small fish)	• wooded swamps, forests (oft conif) with standing or slow-moving water • breeds in NE AB
Chipping Sparrow	*Spizella passerina*	insectivore (include spiders, seeds of grass and forbs)	• open conif forest, forest edge, thickets • breeds in NE AB
Clay-coloured Sparrow	*Spizella pallida*	insectivore	• thickets, esp near water, forest openings, fields with scattered shrubs • breeds in NE AB
Vesper Sparrow	*Pooecetes gramineus*	omnivore (50% insects; 50% seeds)	• grassland, prairie, savanna, old fields, arid scrub, woodland clearings • breeds in NE AB
Savannah Sparrow	*Passerculus sandwichensis*	insectivore (include spiders, snails and seeds)	• grassland, meadow, tundra, marsh, bog, cultivated grassy areas • breeds in NE AB
LeConte's Sparrow	*Ammodramus leconteii*	insectivore (include spiders, grass and forb seeds; yg almost all insects)	• moist meadows, marsh and bog edges • breeds in NE AB
Fox Sparrow	*Passerella iliaca*	insectivore (include spiders, millipedes, buds, seeds, berries)	• conif or decid forest undergrowth, edge, woodland thickets, scrub, riparian woodland • breeds in NE AB

Table 5.1-28

CANDIDATE WILDLIFE RECEPTORS FOR THE SUNCOR RISK ASSESSMENT

Common Name	*Scientific Name*	Diet	Habits
Song Sparrow	*Melospiza melodia*	insectivore (include grass and forb seeds, some berries)	• dense veg along watercourses, marshes, forest edge, clearings, bogs • breeds in NE AB
Lincoln's Sparrow	*Melospiza lincolnii*	insectivore	• bogs, wet meadows, riparian thickets • breeds in NE AB
Swamp Sparrow	*Melospiza georgiana*	insectivore (include seeds)	• emergent veg around water, marsh, bog, wet meadow • breeds in NE AB
White-throated Sparrow	*Zonotrichia albicollis*	insectivore (include few spiders, millipedes, snails, seeds)	• conif and mixed conif-decid forest, edge and clearings, thickets, open woodland • breeds in NE AB
Dark-eyed Junco	*Junco hyemalis*	seeds, and insects	• conif and decid forest and edge, open woodland and bogs • breeds in NE AB
Rusty Blackbird	*Euphagus carolinus*	insectivore (include few spiders, crustaceans, snails, salamanders, fish, little fruit)	• moist conif woodland, bogs, riparian habitats • breeds in NE AB
Brewer's Blackbird	*Euphagus cyanocephalus*	insectivore (include spiders, crustaceans, snails, seeds)	• shrubby, brushy areas (esp near water), riparian woodland, aspen parkland • breeds in NE AB
Common Grackle	*Quiscalus quiscula*	omnivore (insects, crustaceans, other terrestrial and aquatic inverts, fish, small verts, bird eggs, nestlings, fruit, grain and seeds, acorns and nuts)	• partly open areas with scattered trees, open woodlands, around human habitation • breeds in NE AB
Brown-headed Cowbird	*Molothrus ater*	insectivore (spiders, snails, seeds)	• woodland, forest (esp decid), forest edge, grassland • breeds in NE AB

Table 5.1-28

CANDIDATE WILDLIFE RECEPTORS FOR THE SUNCOR RISK ASSESSMENT
Page 8 of 8

Common Name	*Scientific Name*	Diet	Habits
American Kestrel	*Falco sparverius*	omnivore (mostly mice but also large insects)	• deciduous, mixedwood forest, forest edge, open grasslands • breeds in NE AB
Mallard	*Anas platyrhyncos*	omnivore (invertebrates, seeds shoots of aquatic macrophytes)	• marshes, meadows, small islands • breeds in NE AB
Canada Goose	*Branta canadensis*	herbivore (shoots, roots, seeds, grain, bulbs)	• marshes, meadows, small islands • breeds in NE AB

TABLE 5.1-29

TOOLS FOR ASSESSING ECOLOGICAL RISKS
(adapted from Pastorok and Linder (1993))

Habitat:	Aquatic[a]		Riparian/Upland[b]	
Media:	Water	Sediment	Sediment/Soil	Water/Sediment/Soil
Receptors:	Fish	Macroinvertebrates	Macroinvertebrates	Birds
	Macroinvertebrates		Plants	Mammals
Field/Laboratory Data:				
Chemical Analysis (media)	●	●	●	●
Soil/Sediment/Water	●	●	●	●
Tissue (receptors)	●	●	●	○
Toxicity Tests	●	●	●	○
Community Analysis	●	●	●	
Models:				
Exposure Models[c]	●			●
Ecological Models[d]	●			●

● Primary Tool
○ Secondary Tool

a Subject of separate studies - Golder (1996a,b).
b This report
c Includes transport and fate models to estimate exposure concentrations and doses
d Includes models to extrapolate measurement endpoints (e.g., organism - level effects) to assessment endpoints (e.g., population - level effects).

TABLE 5.1-30

PERTINENT EXPOSURE PATHWAYS FOR SELECTED RECEPTORS

Receptors	Ingestion								Inhalation		Dermal		
	Soil	Water	Food						Vapours	Dust	Air	Soil	Water
			Animals				Plants						
			Invertebrates		Vertebrates		Aquatic	Terrestrial					
			Aquatic	Terrestrial	Aquatic	Terrestrial							
People	✓	✓	✗	✗	✓	✓	✓	✓	✗	✗	✗	✓	✓
Wildlife:													
Moose	✓	✓	✗	✗	✗	✗	✓	✓	✗	✗	✗	✗	✗
Snowshoe hare	✓	✓	✗	✗	✗	✗	✗	✓	✗	✗	✗	✗	✗
Beaver	✓	✓	✗	✗	✗	✗	✓	✓	✗	✗	✗	✗	✗
Ruffed grouse	✓	✓	✗	✓	✗	✗	✗	✓	✗	✗	✗	✗	✗
Deer mouse	✓	✓	✗	✓	✗	✗	✗	✓	✗	✗	✗	✗	✗
Mallard duck	✓	✓	✓	✓	✗	✗	✓	✓	✗	✗	✗	✗	✗
American robin	✓	✓	✓	✓	✗	✗	✗	✓	✗	✗	✗	✗	✗
Ermine	✓	✓	✗	✓	✗	✓	✗	✗	✗	✗	✗	✗	✗
American kestrel	✓	✓	✗	✓	✗	✓	✗	✗	✗	✗	✗	✗	✗

✓ = Critical pathway
✗ = Insignificant pathway, not modelled

TABLE 5.1-31

EXPOSURE PARAMETERS FOR PEOPLE FOR THE RECLAMATION LANDSCAPE SCENARIO

Parameter	Value	Source
Exposure Parameters		
Body Weight (kg)	70	Health Canada (1994a)
Water Ingestion Rate (L/d)	1.5	Health Canada (1994a)
Site Contribution (unitless)	1.0	For drinking water
Meat Ingestion Rate (kg/d)	0.183	Health Canada (1994a)
Plant Ingestion Rate (kg/d)	0.436	Health Canada (1994a)
Site Contribution (unitless)	0.25	For meat and plants
Exposure Frequency (events/year)	365	Assumed for this report
Exposure Duration (years)	50	Assumed for this report
Averaging Time- Non-carcin. (years)	50	Assumed for this report
Averaging Time- Carcinogens (years)	70	Health Canada (1994a)
Drinking Water Concentrations (mg/L)		
Benzo(a)anthracene/Chrysene	0.00000062	Predicted Athabasca River Concentrations (Golder 1996a)
Benzo(a)pyrene	0.00000093	Predicted Athabasca River Concentrations (Golder 1996a)
Naphthenic Acids	0.36	Predicted Athabasca River Concentrations (Golder 1996a)
Copper	0.0090	Predicted Athabasca River Concentrations (Golder 1996a)
Manganese	0.24	Predicted Athabasca River Concentrations (Golder 1996a)
Molybdenum	0.013	Predicted Athabasca River Concentrations (Golder 1996a)
Concentrations in Meat (mg/kg)		
Benzo(a)anthracene/Chrysene	0	Bison liver tissue (Pauls et al. 1995)
Benzo(a)pyrene	0	Bison liver tissue (Pauls et al. 1995)
Naphthenic Acids	--	No data available
Copper	52.4	Bison liver tissue (Pauls et al. 1995)
Manganese	12.4	Bison liver tissue (Pauls et al. 1995)
Molybdenum	4.7	Bison liver tissue (Pauls et al. 1995)
Concentrations in Plants (mg/kg)		
Benzo(a)anthracene/Chrysene	0.025	Predicted concentrations
Benzo(a)pyrene	0.0046	Predicted concentrations
Naphthenic Acids	--	No data available
Copper	7.28	Willow and poplar tissue (Xu 1995 and 1996)
Manganese	234	Willow and poplar tissue (Xu 1995 and 1996)
Molybdenum	8.05	Willow and poplar tissue (Xu 1995 and 1996)

TABLE 5.1-32

ON-SITE EXPOSURE SCENARIO - MEAT, WATER, AND PLANT CALCULATED INTAKES (mg/kg-day)

Chemical	Meat Ingestion	Water Ingestion	Plant Ingestion	Total Dose
benzo(a)anthracene	0	0.0000000095	0.000028	0.000028
benzo(a)pyrene	0	0.000000014	0.0000051	0.0000051
naphthenic acids	-	0.0055	-	0.0055
copper	0.025	0.00014	0.0081	0.033
manganese	0.0081	0.0052	0.3644	0.38
molybdenum	0.0031	0.00029	0.0125	0.016

TABLE 5.1-33

PHYSIOLOGICAL PARAMETER DISTRIBUTIONS[1] FOR WILDLIFE

Species	BW [kg][2]	Food Intake [kg dry weight/day][2,3]				Home Range[2]	Fraction[2]
		Plants	Vertebrates	Invertebrates	WI [L/day]	[ha]	of Year on site
Ruffed Grouse	norm(0.543,0.0303)	80% x 0.0582 $BW^{0.651}$	-	20% x 0.0582 $BW^{0.651}$	0.123 $BW^{0.73}$	uni(4.1,22.9)	1
Mallard	norm(1.107,0.129)	25% x 0.0582 $BW^{0.651}$	-	75% x 0.0582 $BW^{0.651}$	0.123 $BW^{0.73}$	uni(307,719)	0.54
Moose	uni(272,436)	0.0875 $BW^{0.727}$	-	-	0.099 $BW^{0.9}$	uni(7000,33000)	1
Snowshoe Hare	uni(1.05,2.05)	0.0875 $BW^{0.727}$	-	-	0.099 $BW^{0.9}$	uni(4,7)	1
Beaver	norm(17.9,2.62)	0.0875 $BW^{0.727}$	-	-	0.099 $BW^{0.9}$	4.5	1
American Kestrel	norm(0.137,0.0057)	-	75% x 0.0604 $BW^{0.749}$	25% x 0.0604 $BW^{0.749}$	0.123 $BW^{0.73}$	tri(13,13,130)	0.46
Deer Mouse	norm(0.0187,0.0043)	41.7% x 0.0306 $BW^{0.564}$	-	58.3% x 0.0306 $BW^{0.564}$	0.099 $BW^{0.9}$	tri(0.01,0.22,1.1)	1

[1] Distribution types: uni (uniform), norm (normal) and tri (triangular).
[2] Please refer to Appendix IV for derivation of values.
[3] Food intake of plants, vertebrates and invertebrates may be aquatic or terrestrial depending on ELC and species.

TABLE 5.1-34

WILDLIFE HABITAT PREFERENCE SPECIFIED AS PERCENT LIKELIHOOD OF FINDING THE SPECIES IN THE ELC

Species	1		2		3		4		5		6		7		8		9		10		11		12		13		14		15	
	lo	hi	lo	hi	lo	hi	lo	hi	lo	hi	lo	hi	lo	hi	lo	hi	lo	hi	lo	hi	lo	hi	lo	hi	lo	hi	lo	hi	lo	hi
Ruffed Grouse	0	20	0	5	40	65	30	50	0	20	0	5	0	5	20	40	0	5	0	5			0	10			0	5		
Mallard									0	5	0	5	0	5			0	5	0	25	0	15	0	50			50	100		
Moose	0	10	0	35	50	100	0	25	0	25	0	25	0	25	0	25	0	25	0	35	50	100					25	75		
Snowshoe Hare	0	10	0	10	25	75	10	65	0	10	0	5	0	5	0	25	0	5	0	5	0	20	0	20			0	5		
Beaver					25	50	50	100	0	5	0	5	0	5	25	50											65	100		
American Kestrel	0	50	0	5	0	15	0	50	0	5	0	5	0	5	0	50	0	15	0	5	0	20	25	75			0	5		
Deer Mouse	100	100			100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100			100	100	100	100				

TABLE 5.1-35

SOIL CONCENTRATION DISTRIBUTIONS[1] USED FOR WILDLIFE EXPOSURE MODEL

Parameter	Natural[2] [mg/kg]	Sand[3] [mg/kg]	CT[4] [mg/kg]	Gypsum[5] [mg/kg]
Benzo(a)pyrene	uni(0,0.05)	uni(0,0.2)	uni(0,0.46)	--
Aluminum	10500	172	--	--
Arsenic	15.8	0.63	uni(0,20)	--
Barium	219	4.9	19.1	20.1
Cadmium	uni(0,0.3)	uni(0,0.3)	uni(0,0.3)	uni(0,0.5)
Molybdenum	1.4	uni(0,2)	1.1	81
Nickel	30	2	14.4	312
Strontium	--	--	--	127
Thallium	uni(0,0.1)	--	0.1	uni(0,1)
Uranium	--	--	--	--
Vanadium	15.1	2.8	23.7	916
Zinc	72.7	5.8	13.6	22.2

[1] Distribution types: uni (uniform), norm (normal), tri (triangular), -- (no data available).

[2] Natural soil concentrations were estimated from the maximum of muskeg (Suncor, unpublished data; n=1) and overburden (ETL 1993 (CP 3); n=1) soil chemistry.

[3] Tailings sand chemistry data from ETL (1993; CP 5; n=1).

[4] CT chemistry data from Suncor and Syncrude (1995 unpublished data; n=2 for org., n=1 for inorg.).

[5] Gypsum chemistry data from FGD Pilot Study (Suncor 1995 unpublished data; n=1).

TABLE 5.1-36

SOIL TO PLANT BCF DISTRIBUTIONS[1] USED FOR WILDLIFE EXPOSURE MODEL

Parameter	Plant BCF[2]	
	Terrestrial	Aquatic
Benzo(a)pyrene	0.010[3]	0.010[3]
Aluminum	_[4]	_[4]
Arsenic	uni(0.042,0.058)	uni(0.163,0.295)
Barium	uni(0.067,0.103)	uni(0.083,0.139)
Cadmium	uni(9.722,28.611)	uni(9.444,124.167)
Molybdenum	uni(1.6,2.716)	uni(4.642,6.179)
Nickel	uni(0.268,0.345)	uni(0.506,0.906)
Strontium	uni(1.815,2.142)	uni(1.699,3.629)
Thallium	uni(0.007,0.021)	uni(0.014,0.029)
Uranium	uni(0.012,0.023)	uni(0.015,0.333)
Vanadium	uni(0.01,0.021)	uni(0.053,0.34)
Zinc	uni(1.873,4.874)	uni(1.164,1.191)

[1] Distribution types: uni (uniform), norm (normal) and tri (triangular).
[2] Inorganic chemical BCFs calculated using soil and plant concentrations from the AEP plant uptake studies (Xu 1995 and 1996).
[3] BCF for Benzo(a)pyrene calculated from octanol-water partitioning coeficient using the equation provided by Travis and Arms (1988).
[4] Insufficient data to calculate soil:plant BCF for aluminum.

TABLE 5.1-37

CONTRIBUTION OF INGESTION PATHWAYS FOR WILDLIFE

Parameter	Receptor	Total Dose (mg/kg-day)	% Plant	% Invertebrate	% Vertebrate	% Water Ingestion
Benzo(a)pyrene	American Kestrel	0.000076	0.00	0.00	83.64	34.73
Aluminum	Beaver	0.12	0.00	0.00	0.00	100.00
Aluminum	Deer Mouse	69	0.00	99.98	0.00	0.35
Aluminum	Moose	0.0049	0.00	0.00	0.00	100.00
Aluminum	Snowshoe Hare	0.15	0.00	0.00	0.00	100.00
Arsenic	Beaver	0.053	99.37	0.00	0.00	1.53
Arsenic	Moose	0.0012	97.46	0.00	0.00	2.94
Arsenic	Snowshoe Hare	0.029	98.44	0.00	0.00	2.25
Barium	Mallard	0.377	0.92	98.76	0.00	1.11
Cadmium	Beaver	0.67	99.97	0.00	0.00	0.06
Cadmium	Deer Mouse	1.14	44.74	56.98	0.00	0.07
Cadmium	Moose	0.012	99.60	0.00	0.00	0.18
Cadmium	Snowshoe hare	0.56	99.95	0.00	0.00	0.09
Molybdenum	Beaver	9.2	99.67	0.00	0.00	1.27
Molybdenum	Deer Mouse	12	99.81	0.00	0.00	2.00
Molybdenum	Moose	0.023	83.04	0.00	0.00	24.17
Nickel	Deer Mouse	5.71	40.85	28.59	0.00	0.14
Strontium	Deer Mouse	15.03	99.12	0.00	0.00	1.87
Thallium	Deer Mouse	0.00027	100.00	0.00	0.00	0.00
Uranium	Deer Mouse	0.06	0.00	0.00	0.00	100.00
Vanadium	Beaver	1.62	99.42	0.00	0.00	0.68
Vanadium	Deer Mouse	0.88	99.89	0.00	0.00	2.50
Vanadium	Moose	0.0055	94.67	0.00	0.00	9.25
Vanadium	Ruffed Grouse	0.75	98.94	0.00	0.00	2.86
Vanadium	Snowshoe hare	0.93	99.29	0.00	0.00	1.53
Zinc	Mallard	1.43	5.36	98.17	0.00	0.09

Note: Percentages don't necessarilly add to 100% because they are derived from the 95% of the individual distributions.

TABLE 5.1-38

REFERENCE VALUES FOR CHEMICALS OF CONCERN FOR PEOPLE AND WILDLIFE

Chemicals	People	Avian Receptors[2]		Mammalian Receptors[2]			
		American Kestrel	Mallard	Deer Mouse	Beaver	Snowshoe Hare	Moose
	(mg/kg-day)	(mg/kg-day)	(mg/kg-day)	(mg/kg-day)	(mg/kg-day)	(mg/kg-day)	(mg/kg-day)
ORGANICS							
Benzo(a)anthracene	0.000014[1]	--	--	--	--	--	--
Benzo(a)pyrene	0.0000014[1]	0.016	--	--	--	--	--
INORGANICS							
Aluminum	--	--	--	2.3	0.23	0.52	0.083
Arsenic	--	--	--	--	0.015	0.034	0.0054
Barium	--	--	10	--	--	--	--
Cadmium	--	--	--	--	--	--	0.0082
Copper	0.04	--	--	--	--	--	--
Manganese (food)	0.14	--	--	--	--	--	--
Manganese (water)	0.005	--	--	--	--	--	--
Molybdenum	0.005	--	--	6.2	--	--	--
Nickel	--	--	--	106	--	--	--
Strontium	--	--	--	698	--	--	--
Thallium	--	--	--	0.020	--	--	--
Uranium	--	--	--	3.50	--	--	--
Vanadium	--	--	--	0.50	0.051	0.12	0.018
Zinc	--	--	2.9	--	--	--	--

[1] Risk-specific doses for carcinogens.

[2] Please see Appendix IV for derivation of RfD values.

TABLE 5.1-39

EXPOSURE RATIOS AND PATHWAY CONTRIBUTIONS FOR PEOPLE

Chemical	Water Ingestion ERs	Meat Ingestion ERs	Plant Ingestion ERs	Total ERs
benzo(a)anthracene	0.00069	0	2.0	2.0
benzo(a)pyrene	0.010	0	3.7	3.7
copper	0.0034	0.61	0.20	0.8
manganese	0.036	0.056	2.5	2.6
molybdenum	0.058	0.61	2.5	3.2

TABLE 5.1-40

EXPOSURE RATIOS FOR WILDLIFE

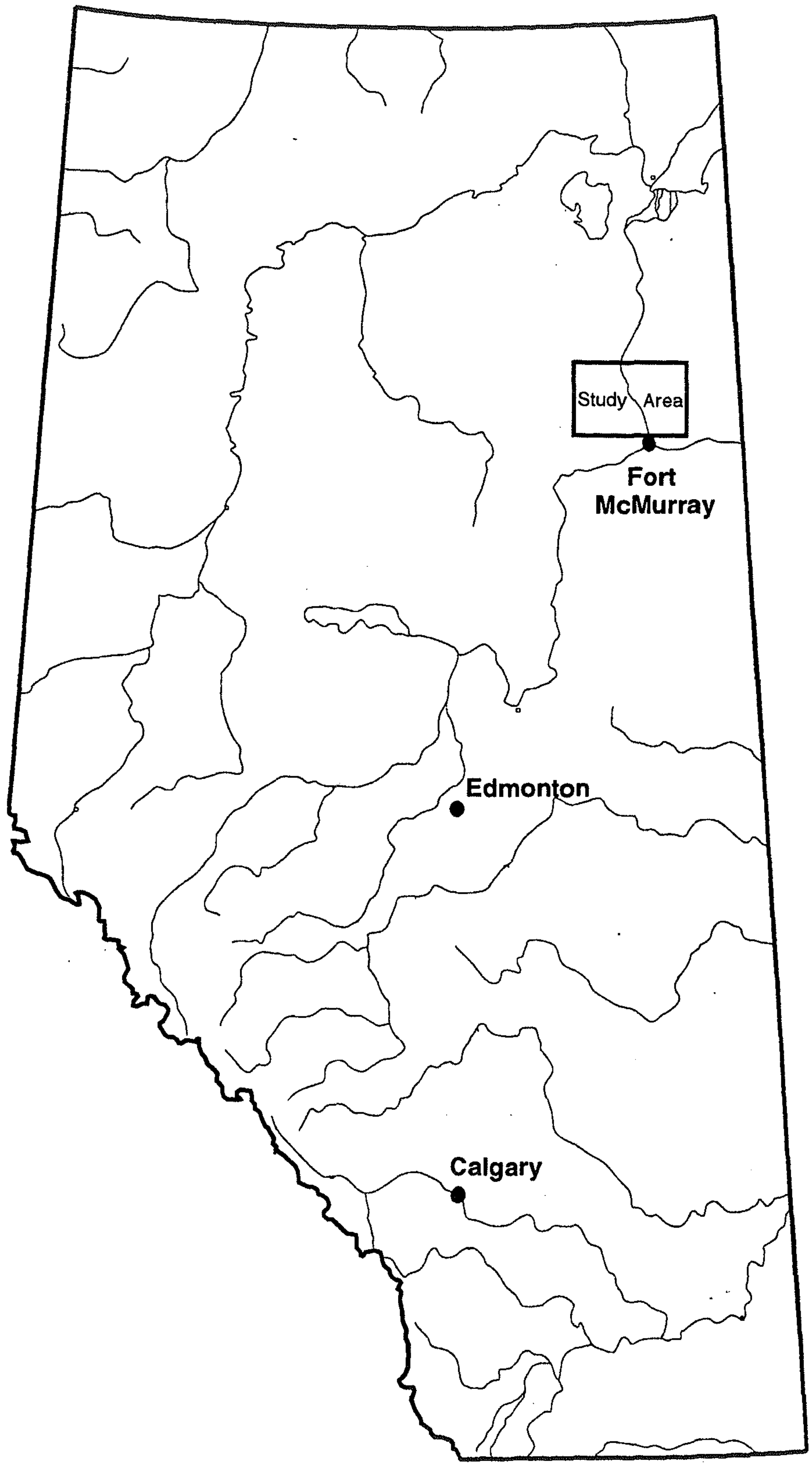
Parameter	Receptor	95%'ile Exposure Ratio	% of Population With ER>1.0
Benzo(a)pyrene	American Kestrel	0.005	<0.2 [a]
Aluminum	Beaver	0.5	<0.2 [a]
Aluminum	Deer Mouse	30.7	12.0
Aluminum	Moose	0.06	<0.2 [a]
Aluminum	Snowshoe Hare	0.3	<0.2 [a]
Arsenic	Beaver	3.6	9.6
Arsenic	Moose	0.2	<0.2 [a]
Arsenic	Snowshoe Hare	0.9	<0.2 [a]
Barium	Mallard	0.038	<0.2 [a]
Cadmium	Beaver	28.9	65.4
Cadmium	Deer Mouse	5.1	37.2
Cadmium	Moose	1.5	11.0
Cadmium	Snowshoe Hare	10.8	44.0
Molybdenum	Beaver	14.6	16.2
Molybdenum	Deer Mouse	1.9	6.4
Molybdenum	Moose	0.1	<0.2 [a]
Nickel	Deer Mouse	0.05	<0.2 [a]
Strontium	Deer Mouse	0.022	<0.2 [a]
Thallium	Deer Mouse	0.01	<0.2 [a]
Uranium	Deer Mouse	0.02	<0.2 [a]
Vanadium	Beaver	31.8	21.2
Vanadium	Deer Mouse	1.8	7.4
Vanadium	Moose	0.3	<0.2 [a]
Vanadium	Ruffed Grouse	0.05	<0.2 [a]
Vanadium	Snowshoe Hare	7.9	8.40
Zinc	Mallard	0.49	0.4

[a] 500 Iterations were used in the simulation; none of the populations exceeded an ER=1.

FIGURES

Location of the Study Area Within Alberta

Figure 1.0-1



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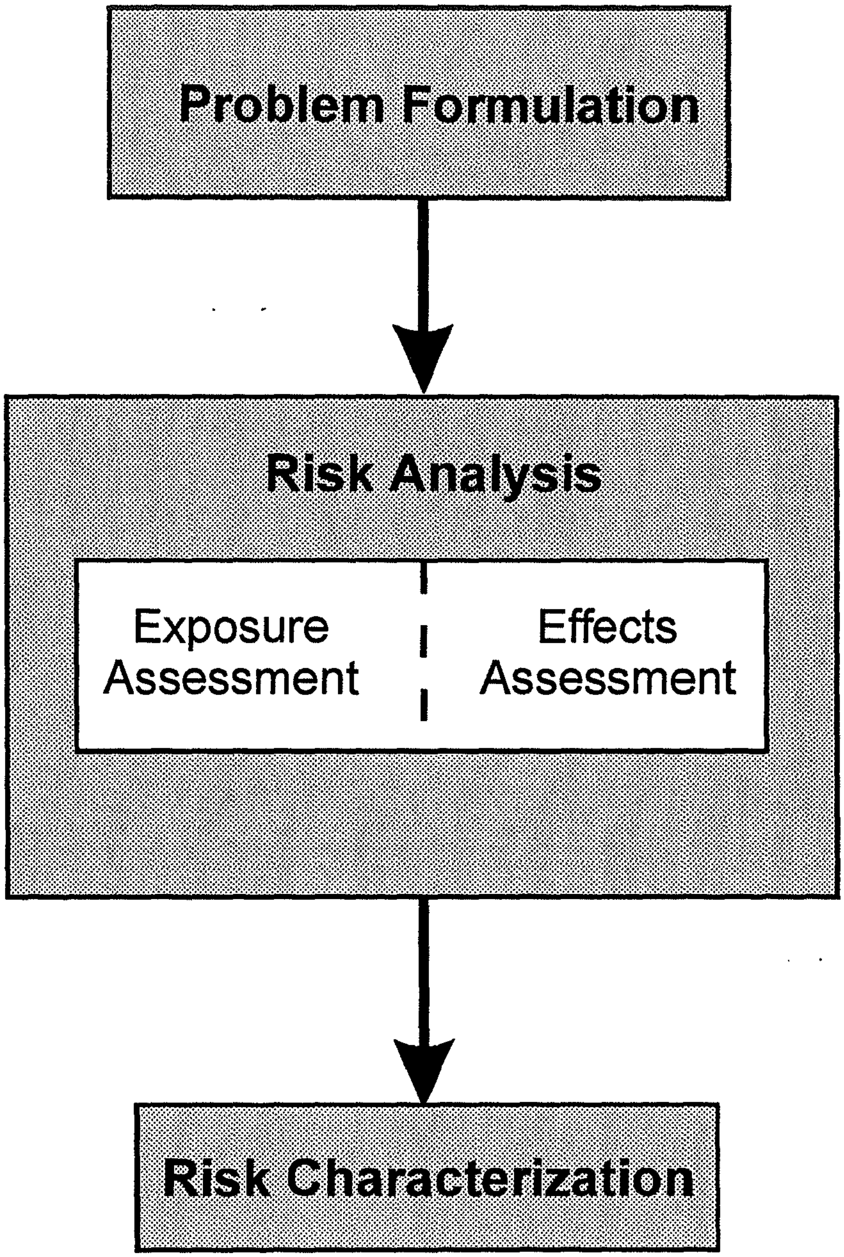

Figure 5.0-1. Environmental Risk Assessment (Human and Ecological)

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Figure 5.1-1

Problem Formulation

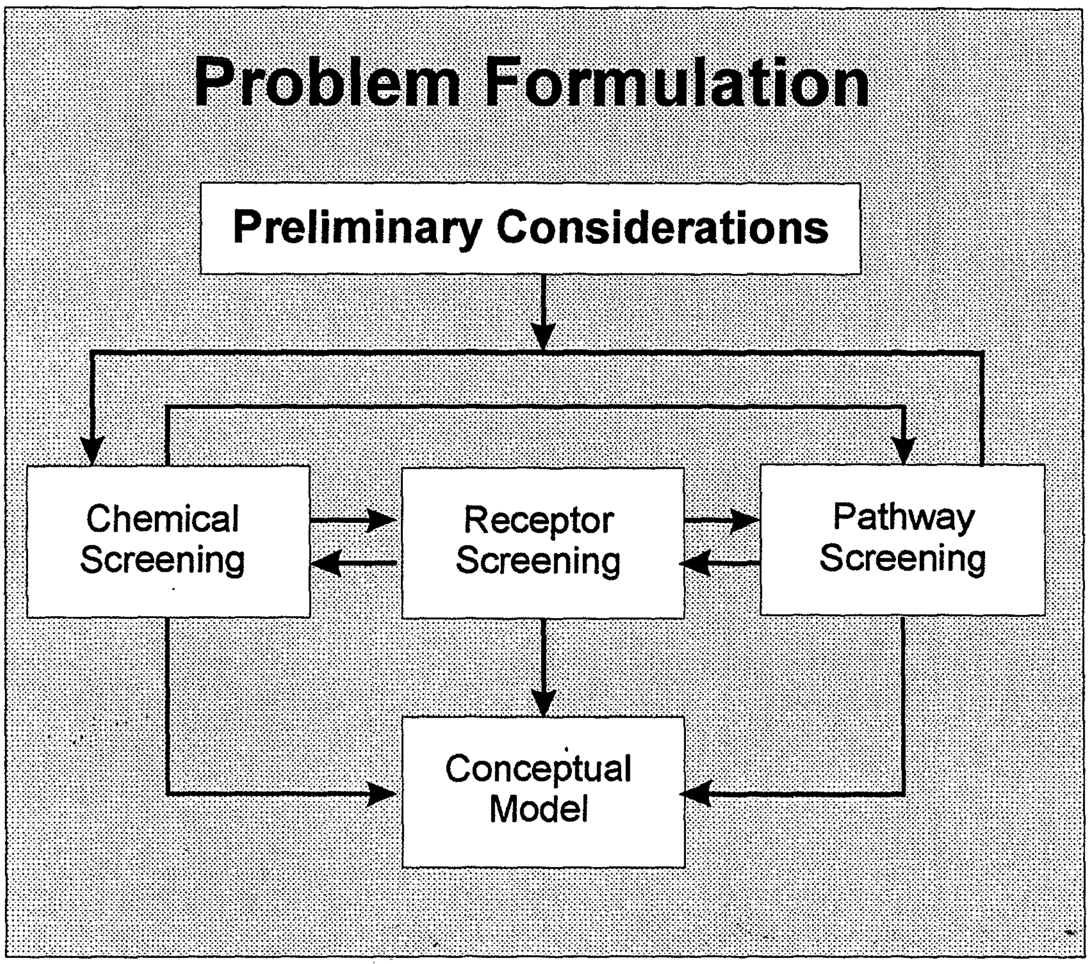

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Figure 5.1-2

Risk Components

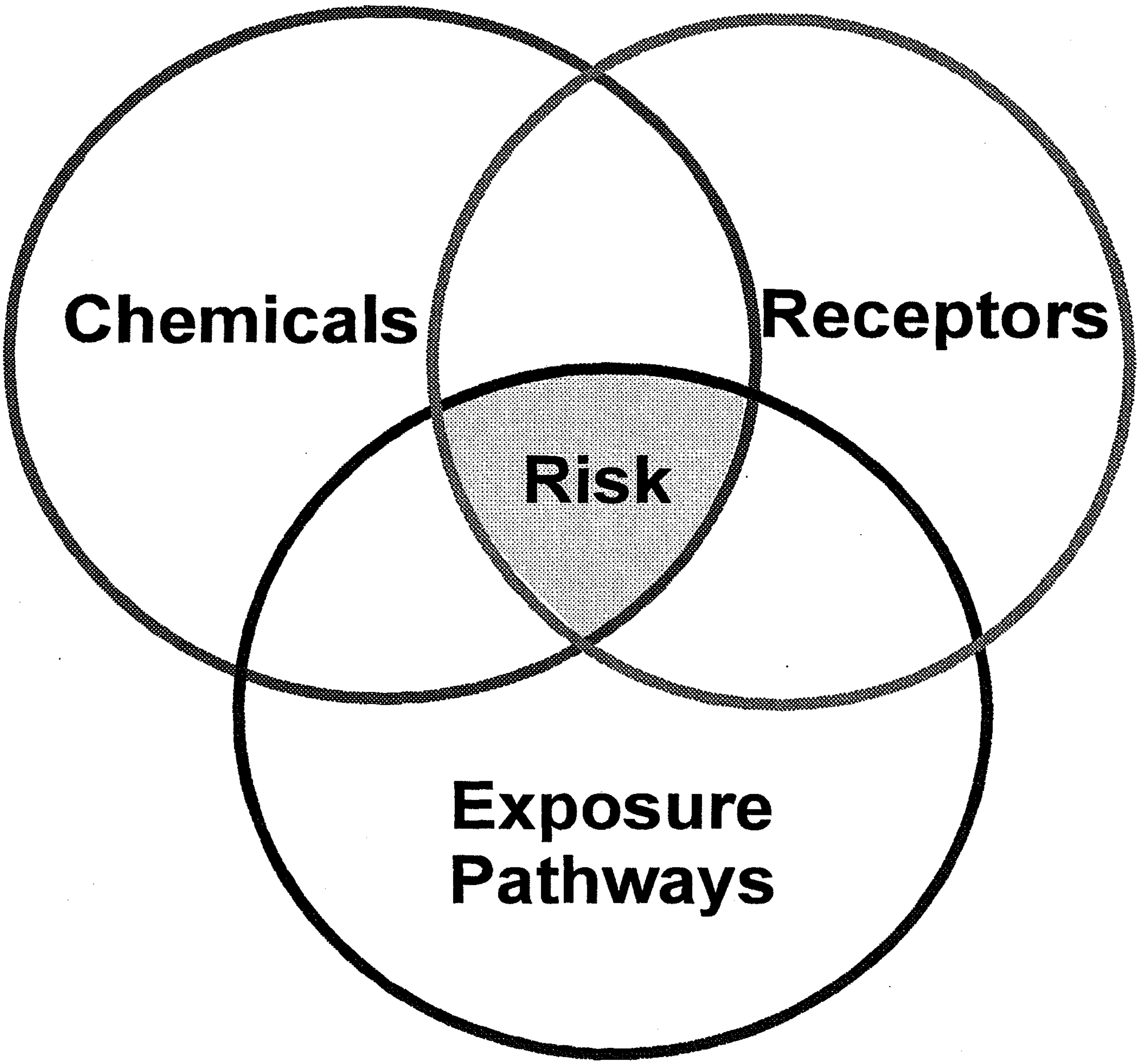

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Figure 5.1-3
Process for Chemical Screening

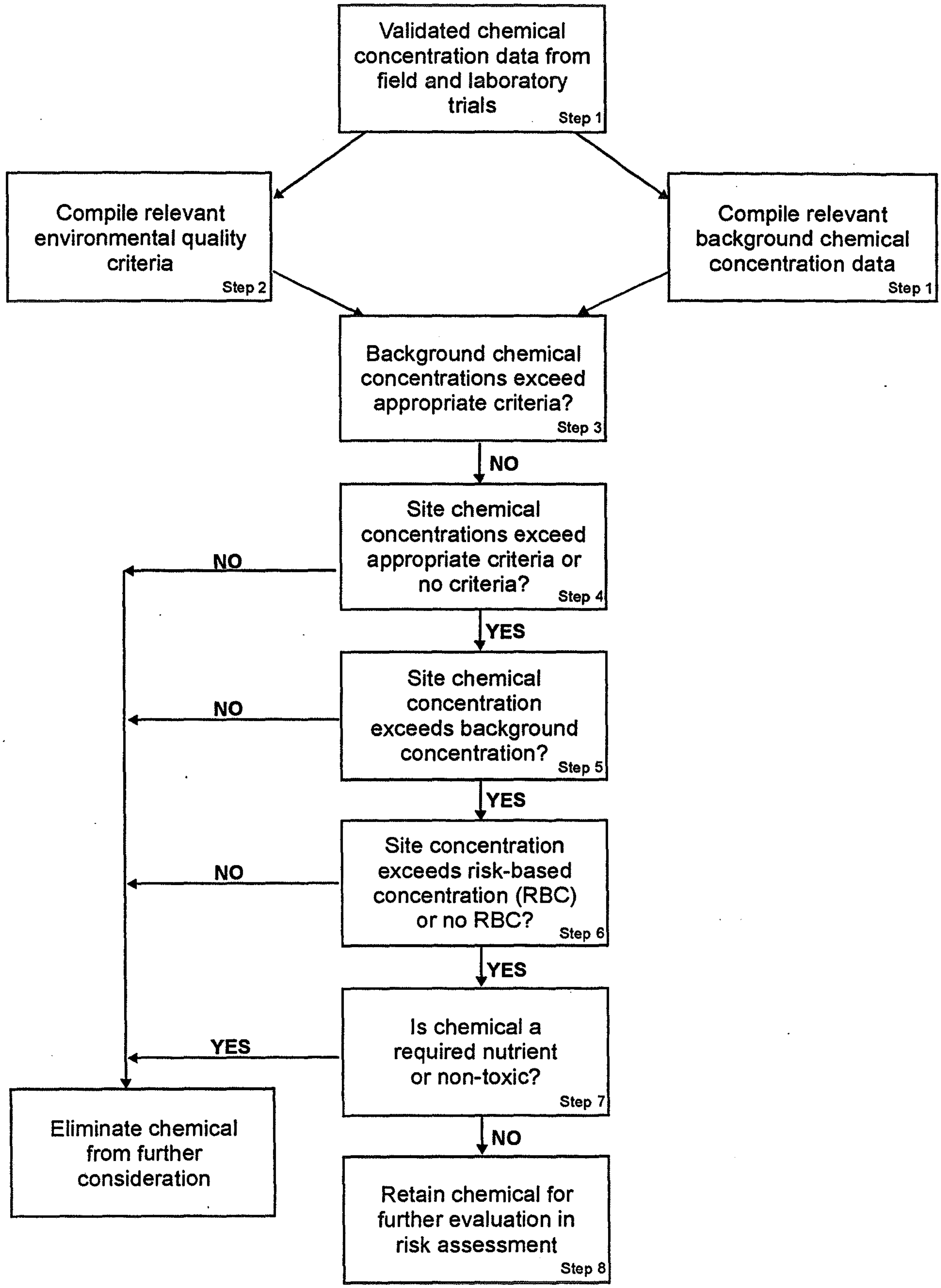

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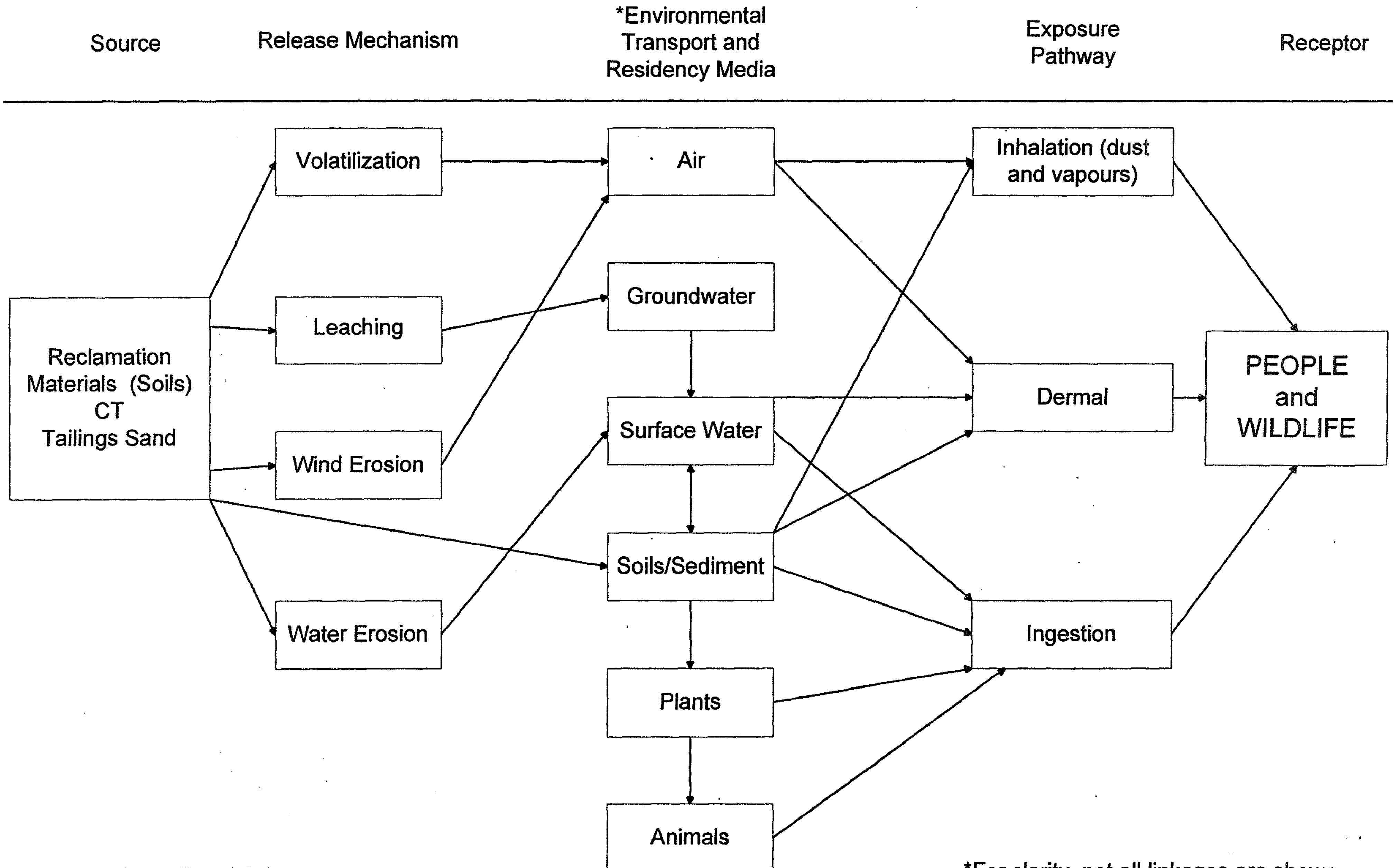
Figure 5.1-4
Potential Pathways For Exposure of People and Wildlife



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*For clarity, not all linkages are shown.

Figure 5.1-5
Conceptual Model For Human Health

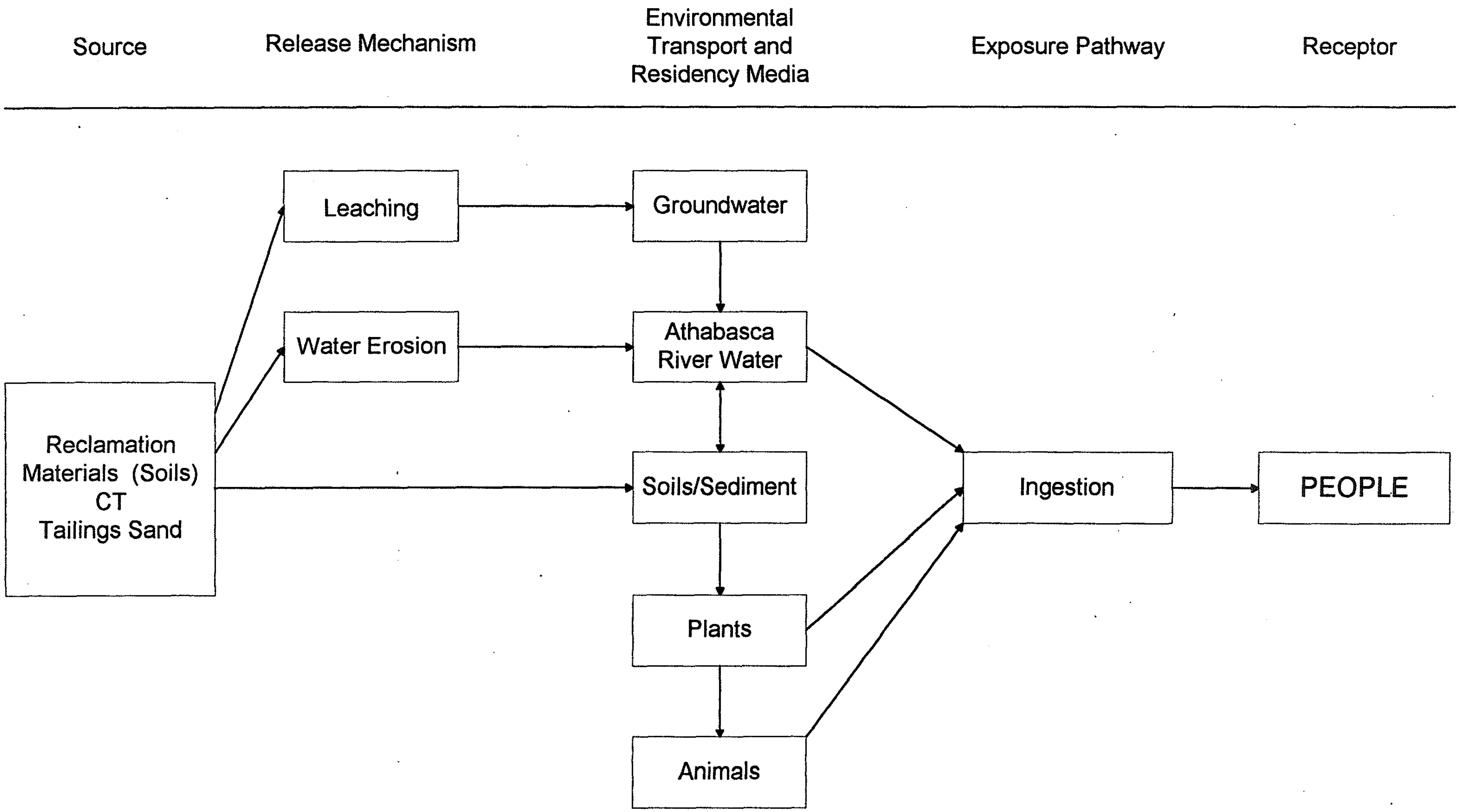

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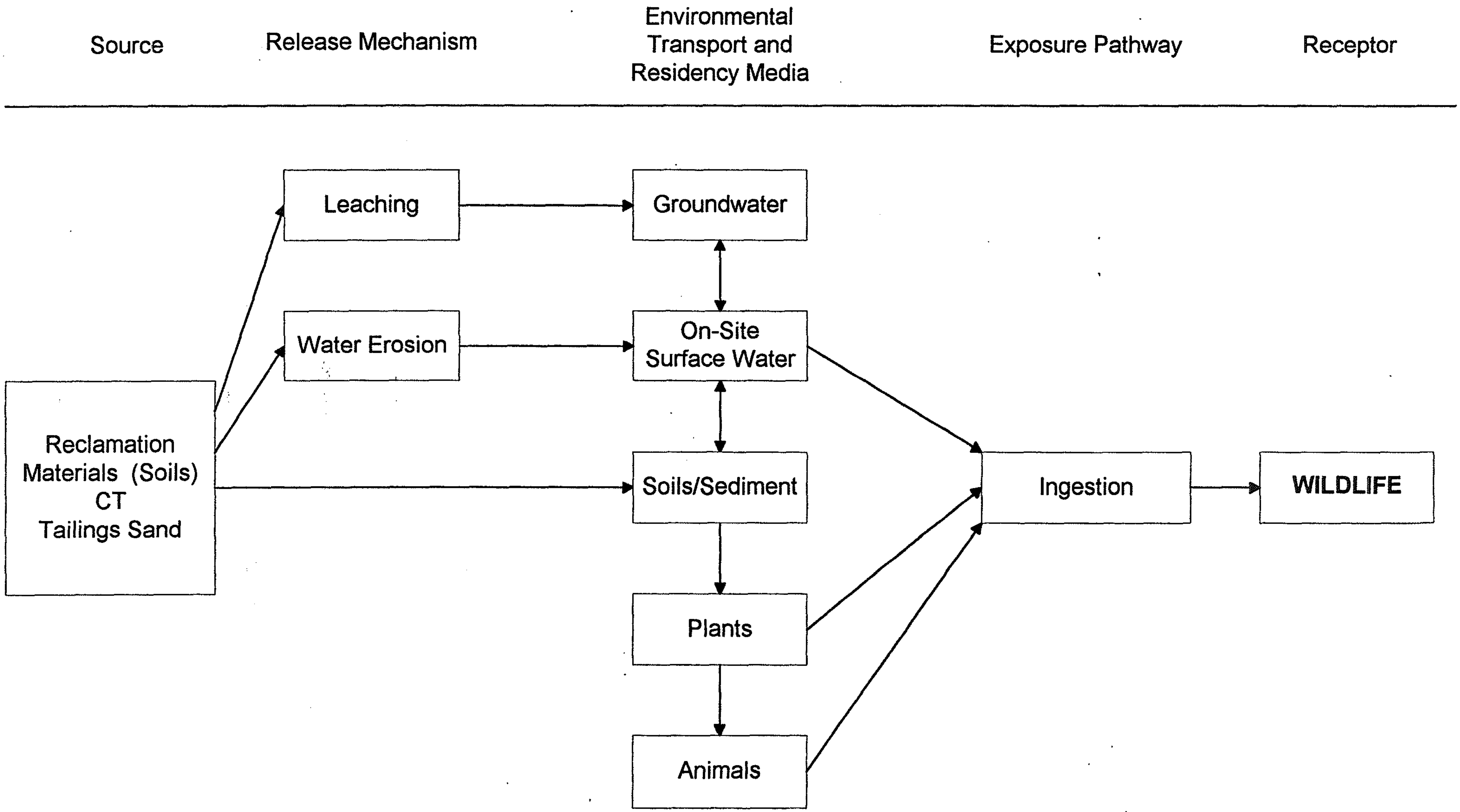
Figure 5.1-6
Conceptual Model For Wildlife Health



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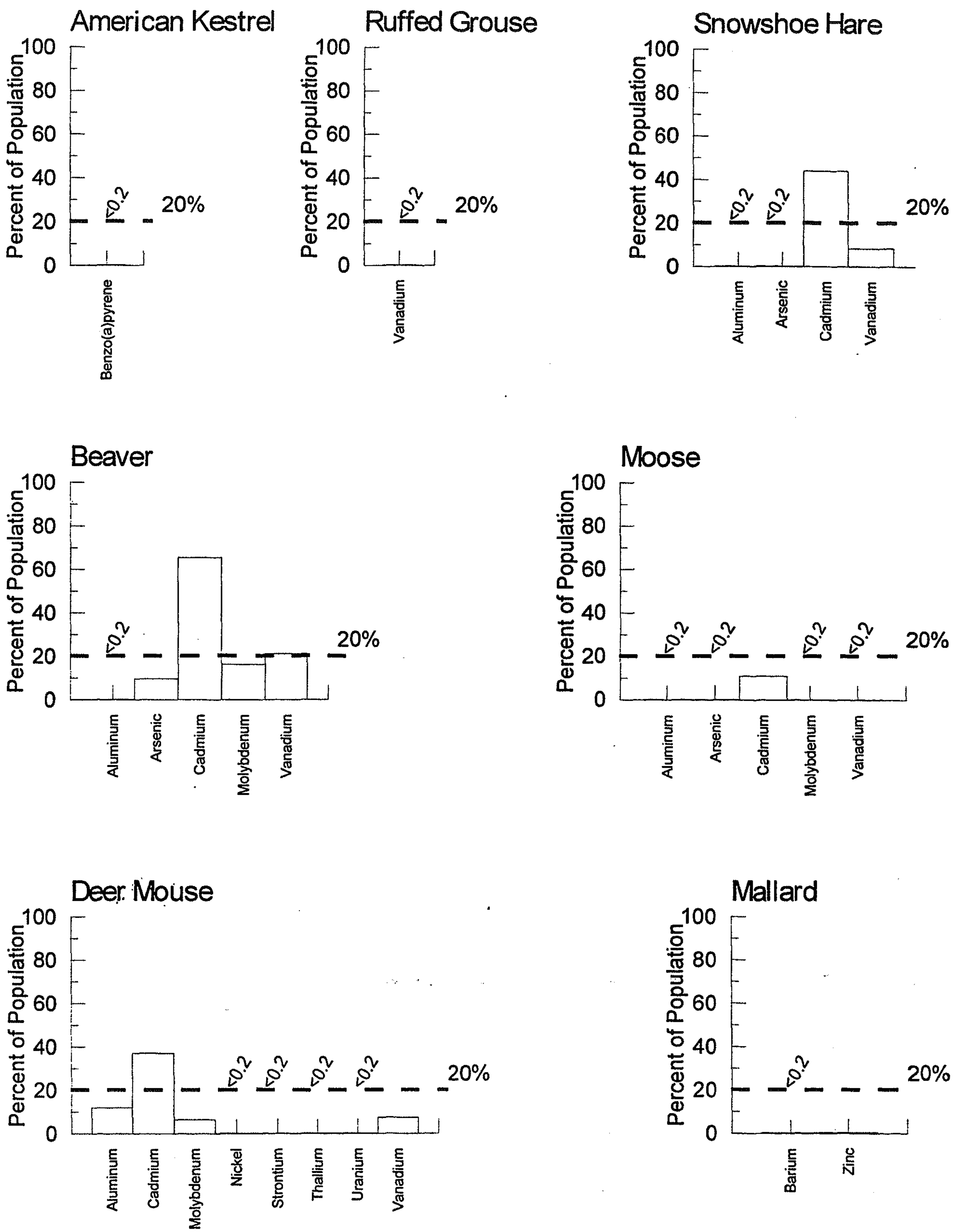

Figure 5.1-7: Percent of population with exposure ratios greater than unity.

Local Study Area for the Steepbank Mine

Figure 1.0-2

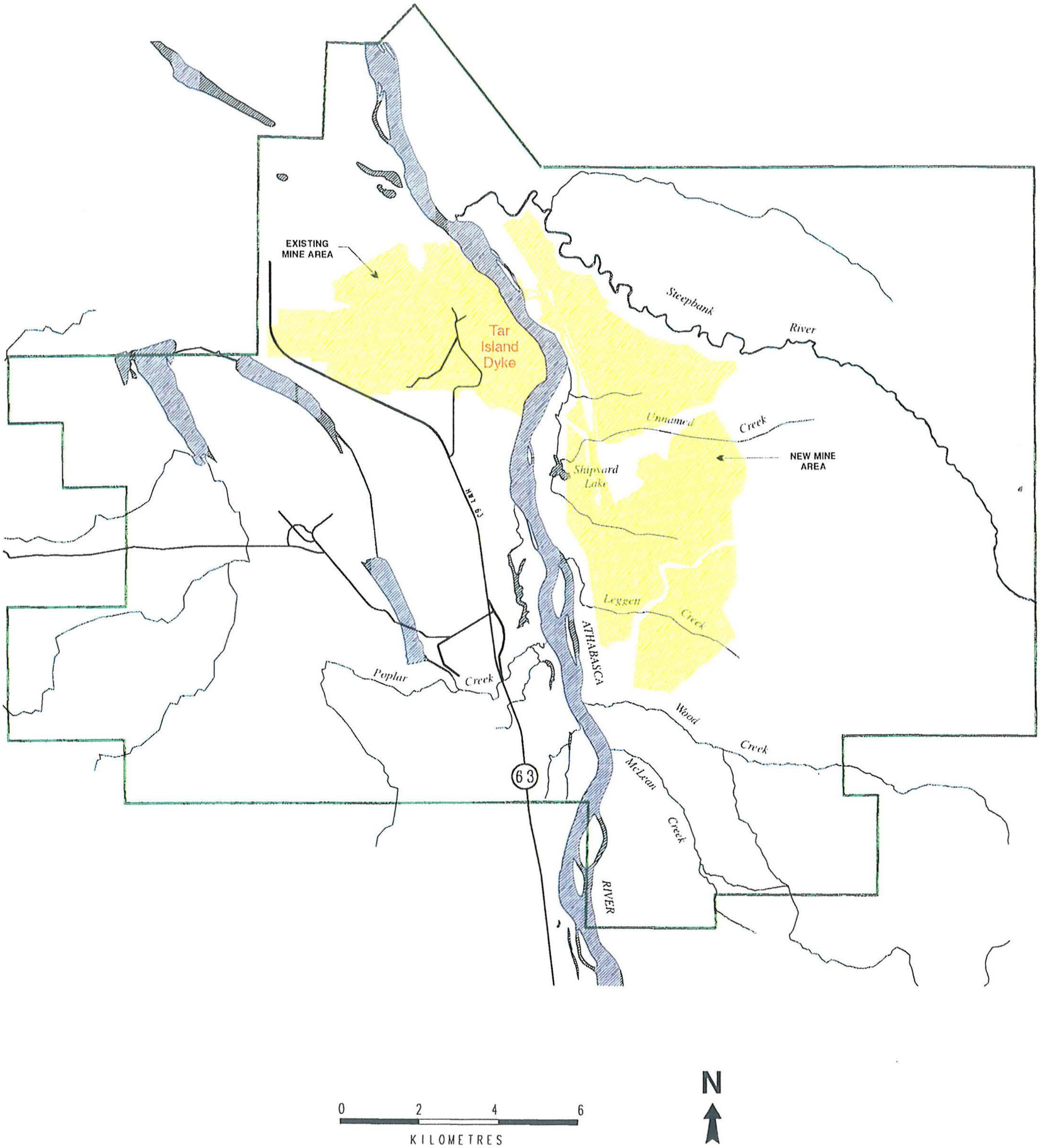

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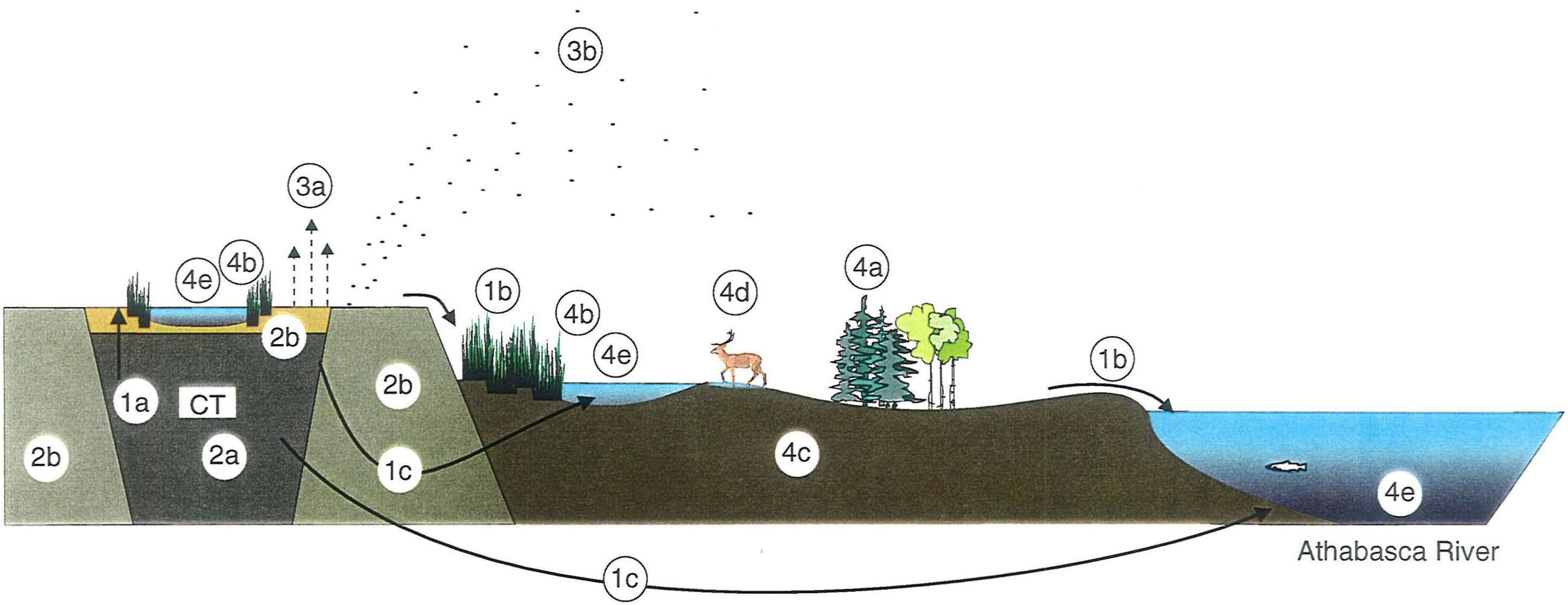
Figure 4.1-1 Conceptual Overview of Chemical Transport and Fate Pathways



1. WATER

1a. Exfiltration water
1b. Surface runoff
1c. Groundwater

2. SOILS

2a. Consolidated tails
2b. Tailings sand/overburden

3. AIR

3a. Volatilization
3b. Fugitive dust generation

4. BIOTA

4a. Terrestrial plants
4b. Wetland plants
4c. Terrestrial soil invertebrates
4d. Terrestrial vertebrates
4e. Aquatic organisms

Golder Associates

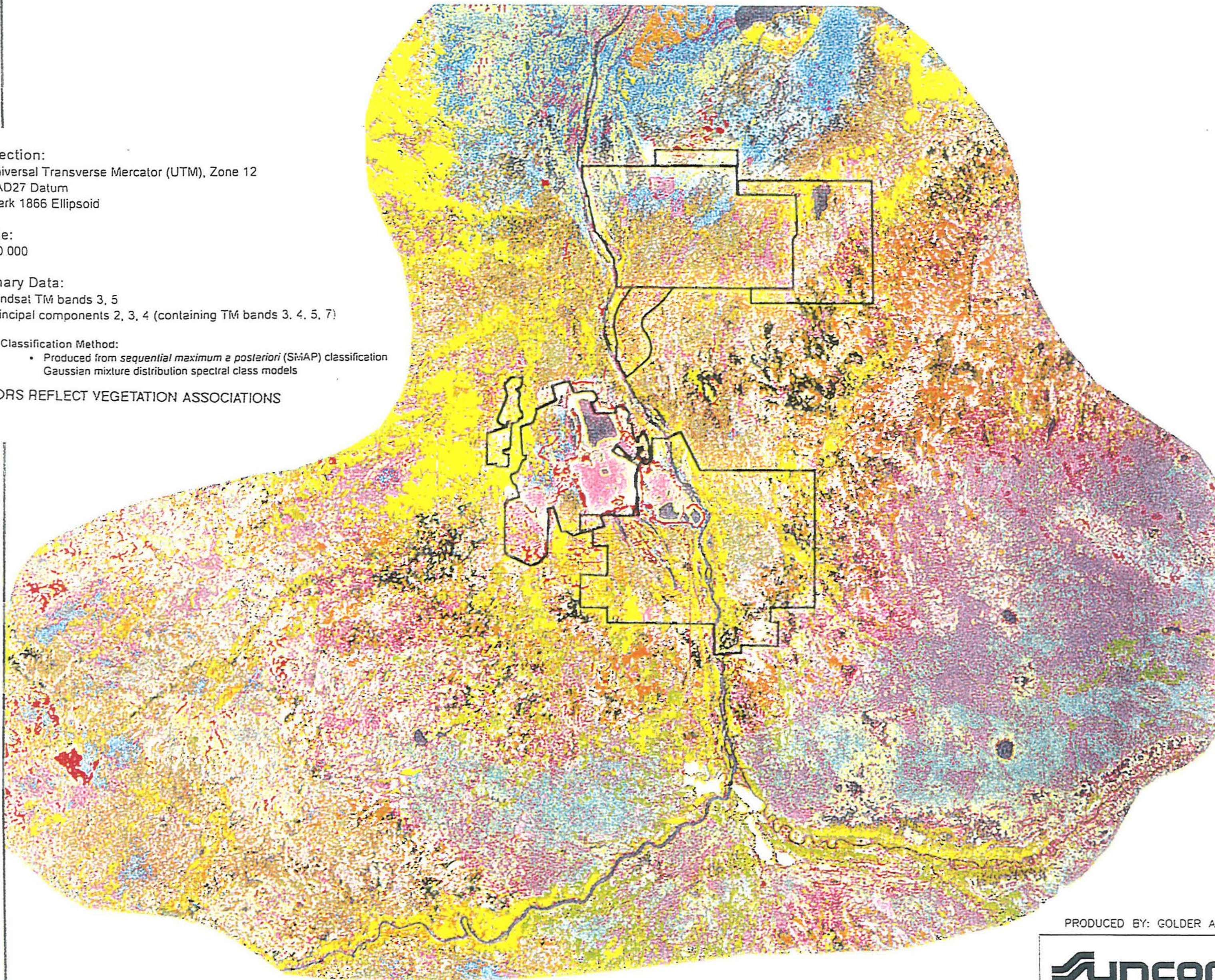
Projection:
- Universal Transverse Mercator (UTM), Zone 12
- NAD27 Datum
- Clark 1866 Ellipsoid

Scale:
1:160 000

Primary Data:
- Landsat TM bands 3, 5
- Principal components 2, 3, 4 (containing TM bands 3, 4, 5, 7)

Classification Method:
- Produced from *sequential maximum a posteriori* (SMAP) classification Gaussian mixture distribution spectral class models

COLORS REFLECT VEGETATION ASSOCIATIONS



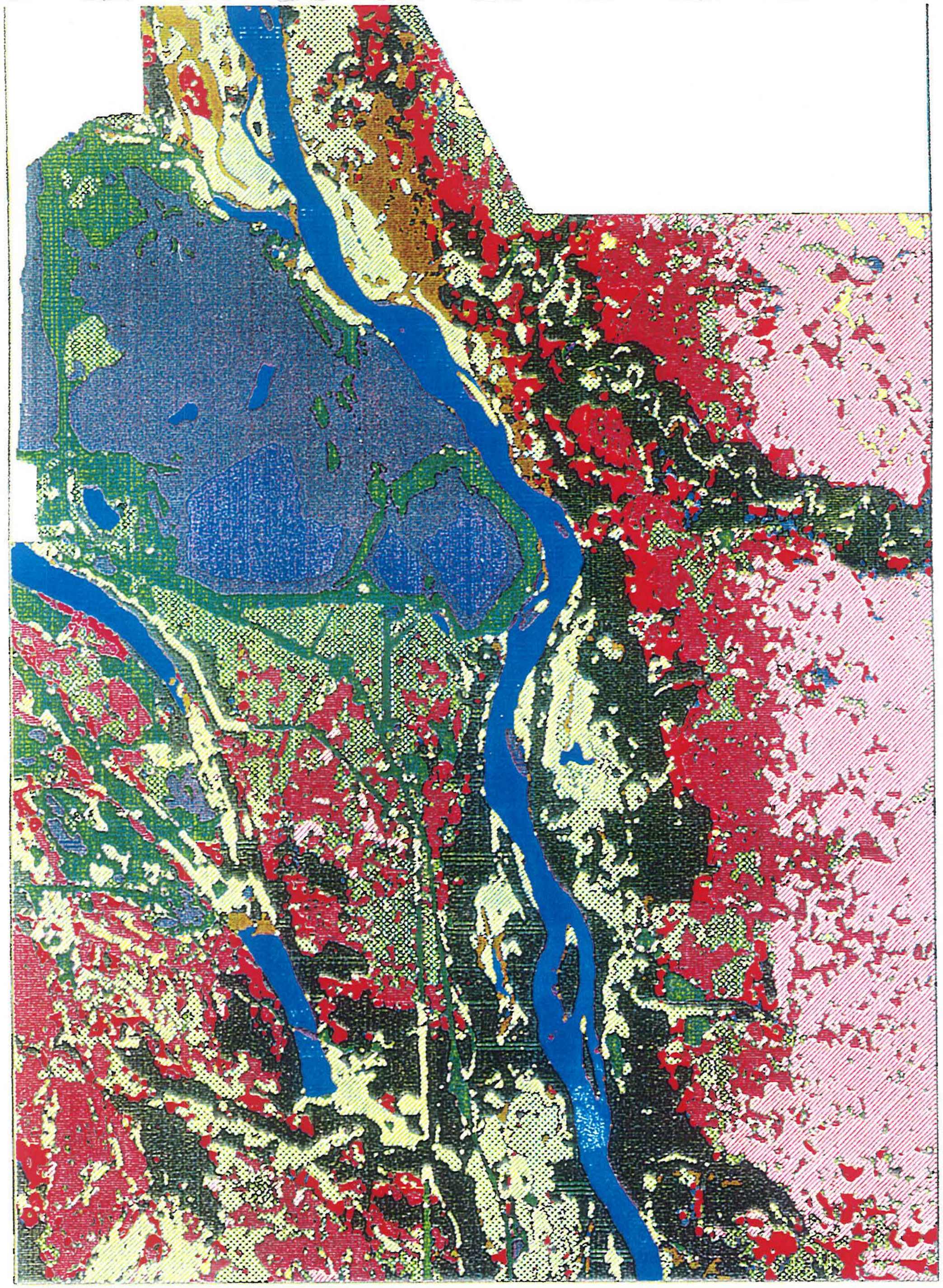
PROJECTION: UTM
PRODUCED BY: GOLDER ASSOCIATES LTD. FOR SUNCOR INC.

Suncor Inc. Oil Sands Group

JOINT SUNCOR/SYNCRUDE REGIONAL ECOLOGICAL LAND (ELC) CLASSIFICATION

SCALE: AS SHOWN	Steepbank Mine Application	REVIEWED BY:
DATE: 22 APR 96		REVISION No.: 2
DRAWN BY:		FIGURE No.: 4.2-1

SUNCOR ELC CLASSIFICATION
LOCAL STUDY AREA, YEAR 1995



LEGEND

- Closed Jack Pine
- Closed White Spruce
- Deciduous forest
- Closed Mixedwood
- Closed Mixed Coniferous, Black Spruce Dominant
- Peatland: Closed Black Spruce Bog
- Peatland: Black Spruce-Tamarack Fen
- Closed Mixedwood, White Spruce Dominant
- Peatland: Open Black Spruce Bog
- Peatland: Open Tamarack Fen
- Wetland Closed Shrub Complex
- Disturbed/Herb, Grasses
- Industrial/Sparsely Vegetated
- Industrial Open Water
- Wetland Open Water-Emergent Vegetation Zone

Scale = 1:100,000

0 2 4 6

KILOMETRES

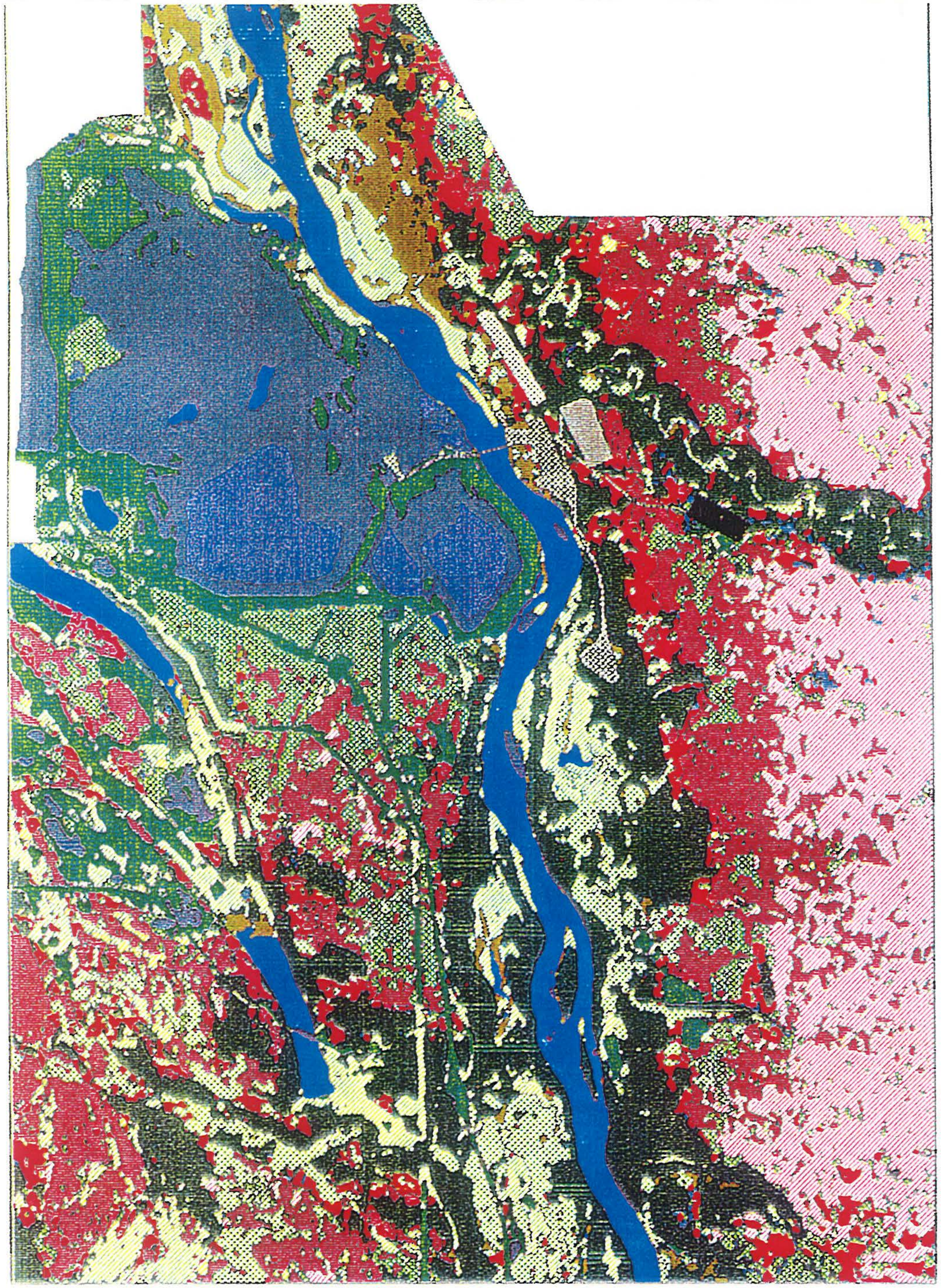
N

Suncor Inc. | Golder Associates

SUNCOR STEEPBANK MINE ADVANCE, ELC ECOSITE CLASSIFICATION

4-19-96 BP/KS	Steepbank Mine Application	Figure No.
952-2307.5665		4.2-2

SUNCOR ELC CLASSIFICATION
LOCAL STUDY AREA, YEAR 2001



LEGEND

- Closed Jack Pine
- Closed White Spruce
- Deciduous forest
- Closed Mixedwood
- Closed Mixed Coniferous, Black Spruce Dominant
- Peatland: Closed Black Spruce Bog
- Peatland: Black Spruce-Tamarack Fen
- Closed Mixedwood, White Spruce Dominant
- Peatland: Open Black Spruce Bog
- Peatland: Open Tamarack Fen
- Wetland Closed Shrub Complex
- Disturbed/Herb, Grasses
- Industrial/Sparsely Vegetated
- Industrial Open Water
- Steepbank Mine Infrastructure
- North Overburden Storage
- Active Mine Pit (Pit 7)
- East Steepbank Gravel Pit
- Wetland Open Water-Emergent Vegetation Zone

Scale = 1:100,000

0 2 4 6

KILOMETRES

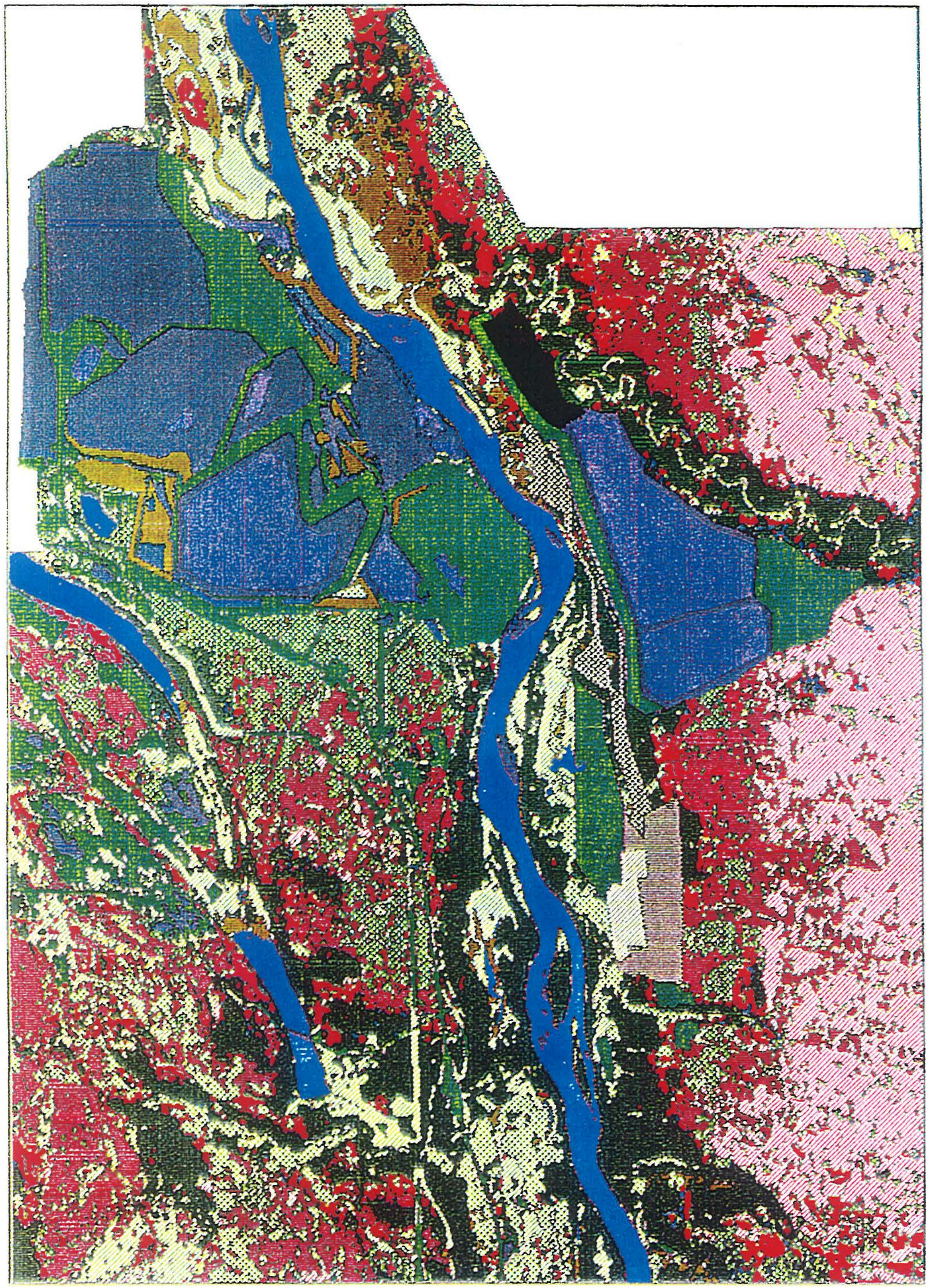
N

Suncor Inc. | Golder Associates

SUNCOR STEEPBANK MINE ADVANCE,
ELC ECOSITE CLASSIFICATION

4-19-96 BP/KS 952-2307.5865	Steepbank Mine Application	Figure No. 4.2-3

SUNCOR ELC CLASSIFICATION
LOCAL STUDY AREA, YEAR 2010



LEGEND

- Closed Jack Pine
- Closed White Spruce
- Deciduous forest
- Closed Mixedwood
- Closed Mixed Coniferous, Black Spruce Dominant
- Peatland: Closed Black Spruce Bog
- Peatland: Black Spruce-Tamarack Fen
- Closed Mixedwood, White Spruce Dominant
- Peatland: Open Black Spruce Bog
- Peatland: Open Tamarack Fen
- Wetland Closed Shrub Complex
- Disturbed/Herb, Grasses
- Industrial/Sparsely Vegetated
- Industrial Open Water
- Lease 97 Mine Infrastructure
- Lease 97 Active Mine Area
- Lease 97 Dyke 11
- Lease 97 North Overburden Storage
- Wetland Open Water-Emergent Vegetation Zone

Scale = 1:100,000

0 2 4 6

KILOMETRES

N

Suncor Inc. | Golder Associates

SUNCOR STEEPBANK MINE ADVANCE, ELC ECOSITE CLASSIFICATION

4-19-96 RP/KS	Steepbank Mine Application	Figure No.
952-2307.5665		4.2-4

SUNCOR ELC CLASSIFICATION
LOCAL STUDY AREA, YEAR 2020

LEGEND

- Closed Jack Pine
- Closed White Spruce
- Deciduous forest
- Closed Mixedwood
- Closed Mixed Coniferous, Black Spruce Dominant
- Peatland: Closed Black Spruce Bog
- Peatland: Black Spruce-Tamarack Fen
- Closed Mixedwood, White Spruce Dominant
- Peatland: Open Black Spruce Bog
- Peatland: Open Tamarack Fen
- Wetland Closed Shrub Complex
- Disturbed/Herb. Grasses
- Industrial/Sparsely Vegetated
- Industrial Open Water
- Upland Lodgepole Pine (Reclaimed)
- Lease 97 Mine Infrastructure
- Lease 97 West Overburden Pile
- Lease 97 Active Mine Pit
- Wetland Open Water-Emergent Vegetation Zone

Scale = 1:100,000

0 2 4 6

KILOMETRES

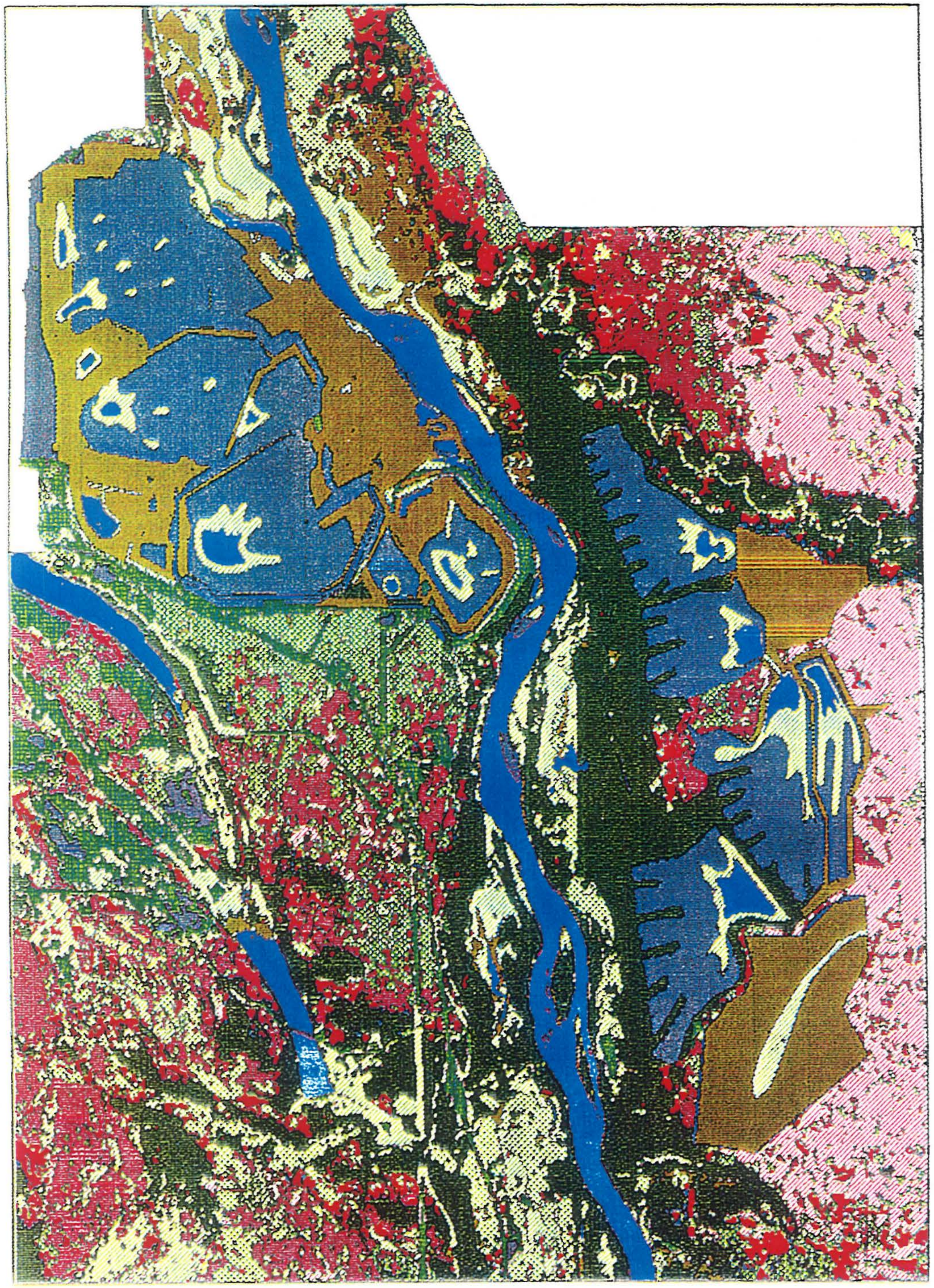
N

Suncor inc. | Golder Associates

SUNCOR STEEPBANK MINE ADVANCE,
ELC ECOSITE CLASSIFICATION

4-19-96 RP/KS	Steepbank Mine Application	Figure No.
952-2307.5685		4.2-5

SUNCOR ELC CLASSIFICATION
LOCAL STUDY AREA, LONGTERM PLANNED



LEGEND

- Closed Jack Pine
- Closed White Spruce
- Deciduous forest
- Closed Mixedwood
- Closed Mixed Coniferous, Black Spruce Dominant
- Peatland: Closed Black Spruce Bog
- Peatland: Black Spruce-Tamarack Fen
- Closed Mixedwood, White Spruce Dominant
- Peatland: Open Black Spruce Bog
- Peatland: Open Tamarack Fen
- Wetland Closed Shrub Complex
- Disturbed/Herb, Grasses
- Industrial/Sparsely Vegetated
- Wetland Open Water-Emergent Vegetation Zone

Scale = 1:100,000

0 2 4 6

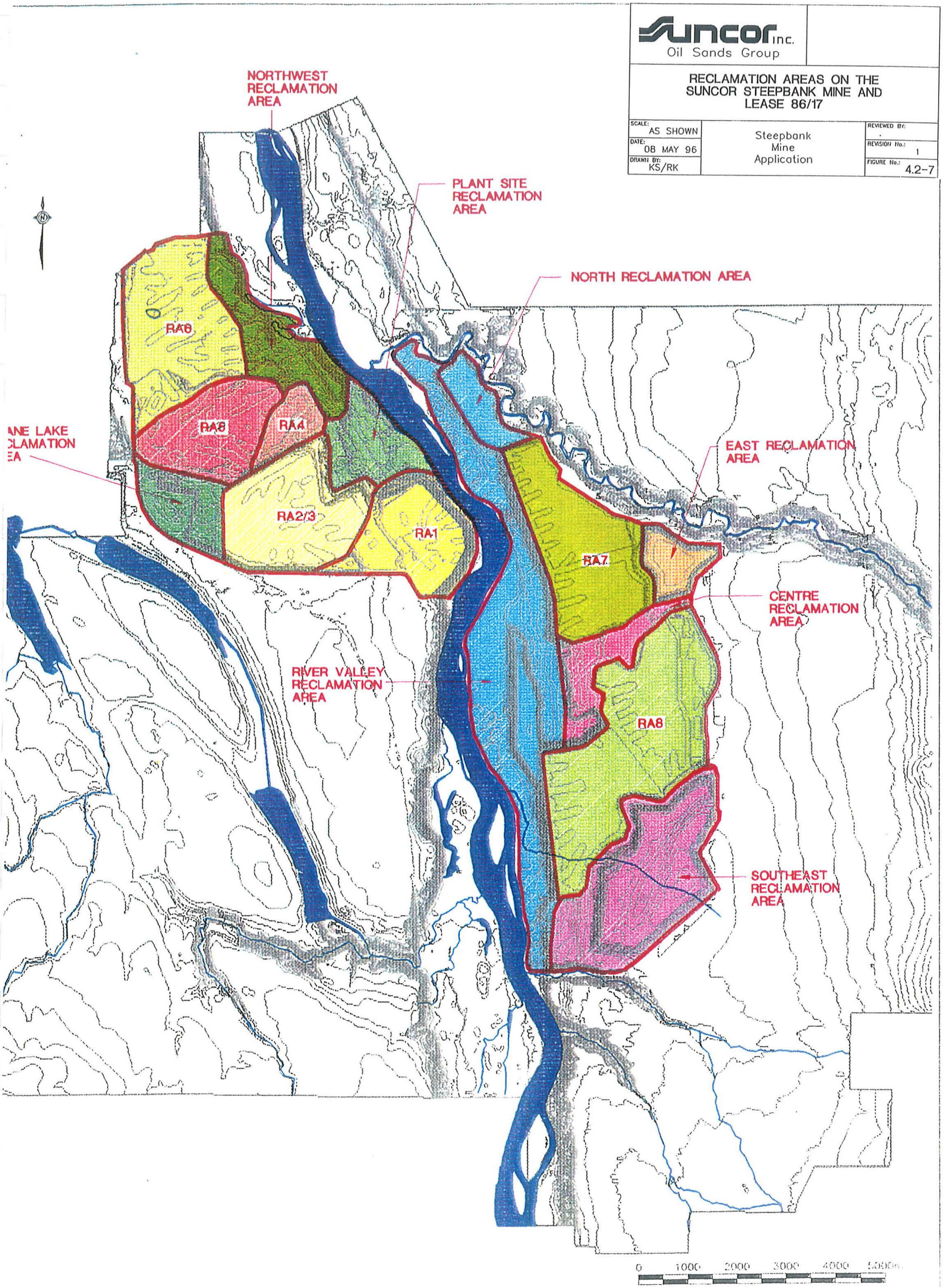
KILOMETRES

N

Suncor Inc. | Golder Associates

SUNCOR STEEPBANK MINE ADVANCE,
ELC ECOSITE CLASSIFICATION

4-19-96 RP/KS	Steepbank Mine Application	Figure No.
952-2307.5685		4.2-6


Suncor inc.
Oil Sands Group
RECLAMATION AREAS ON THE SUNCOR STEEPBANK MINE AND LEASE 86/17
SCALE: AS SHOWN
DATE: 08 MAY 96
DRAWN BY: KS/RK
Steepbank Mine Application
REVIEWED BY:
REVISION No.: 1
FIGURE No.: 4.2-7
NORTHWEST RECLAMATION AREA
PLANT SITE RECLAMATION AREA
NORTH RECLAMATION AREA
ANE LAKE
CLAMATION
EA
EAST RECLAMATION AREA
CENTRE RECLAMATION AREA
RIVER VALLEY RECLAMATION AREA
SOUTHEAST RECLAMATION AREA
RA6
RA5
RA4
RA2/3
RA1
RA7
RA8
0
1000
2000
3000
4000
5000

APPENDICES

APPENDIX I

RATIONALE FOR CHEMICAL ANALYSIS

APPENDIX I

RATIONALE FOR CHEMICAL ANALYSES

Naphthenic Acids - Oil sands wastewater and fine tailings originate from extracting bitumen from oil sands, so it is not surprising that the predominant issues identified to date are related to organic compounds. The most important issue with respect to acute toxicity to aquatic organisms is elevated concentrations of naphthenic acids in oil sands tailings recycle and pore waters. Naphthenic acids, which are a complex group of naturally-occurring organic acids/surfactants leached from the oil sands during the hot water extraction process, account for nearly all of the acute toxicity to aquatic organisms of tailings pond water and porewater from Suncor's and Syncrude's wastewater ponds. These compounds naturally detoxify in aerobic environments due to biodegradation, however, it is not known whether significant detoxification occurs within anaerobic groundwater. In addition, these compounds are highly soluble and it is unlikely that they readily partition to solid-phase material. Hence, they are likely persistent and mobile in groundwater, so seepage of naphthenic acids to surface waters is of potential concern.

Benthic invertebrates (small, bottom-dwelling animals) and fish are the primary organisms at risk with respect to exposure to these compounds. The mode of toxicity may be related to adherence of the compounds to organism membranes, thus disrupting oxygen transfer and resulting in suffocation.

Limited naphthenic acids data exists because of the difficulty in measuring naphthenic acid concentrations. However, Syncrude Canada Ltd. has developed a promising method for quantifying total naphthenic acid concentrations using Fourier Transform Infra-Red Spectroscopy (FTIR) and absorbance at two wave numbers present in the 1700-1800 cm^{-1} range. Typical naphthenic aids concentrations based on the FTIR method range from 1-2 mg/L in the Athabasca River to over 100 mg/L in fresh tailings water.

Substituted PAHs and PASHs - While concentrations of unsubstituted polycyclic aromatic hydrocarbons (PAHs) are generally low or below detection limits even in tailings pond recycle water, the presence of alkyl-substituted PAHs is an emerging issue. In many oil sands waste samples, concentrations of alkyl-substituted PAHs are considerably higher than the parent compounds. The lower molecular weight PAHs (2-3 rings such as naphthalene and phenanthrene) are generally more acutely toxic to aquatic organisms than the higher molecular weight PAHs. However, the higher weight PAHs have a greater affinity to lipids and therefore bioconcentrate more in animal tissue. Hence, they are a potential issue with respect to food chain biomagnification. Further, alkyl-substituted PAHs are a particular concern because alkyl substituents may enhance both the carcinogenic potency and the persistence of these compounds.

Another issue is the potential for tainting of fish flesh, primarily associated with polycyclic aromatic sulphur heterocycles (PASHs) such as dibenzothiophene and alkyl-substituted dibenzothiophenes. These compounds have been detected in oil sands wastewater and in the Athabasca River downstream of Suncor's lease. PASHs are generally more persistent and more toxic than other PAHs. In addition, they readily bioaccumulate in animal tissues .

PANHs - Polycyclic aromatic nitrogen heterocycles (PANHs) such as quinoline and alkyl-substituted quinolines have been identified in both natural and synthetic crude oils. These compounds have been detected in oil sands wastewater and in the Athabasca River downstream of Suncor's lease. PANHs can be toxic, teratogenic, mutagenic, and/or carcinogenic.

Non-Chlorinated Phenols - Concentrations of phenols and cresols ranging from 25-152 µg/L have been measured in samples from Syncrude's settling pond. A number of simple alkylphenols were also identified in the pond samples. Samples from dyke drainage, groundwaters and surface waters contained <1 µg/L of the simple phenols analyzed and did not contain any of the simple alkylphenols identified in the MLSB samples. A sample of surface water that drained over exposed oil sands contained low concentrations of phenol (4 µg/L) but no detectable concentrations of cresols or simple alkylphenols. Low concentrations of simple phenols are of concern because of the potential for tainting fish flesh.

Volatile Organics - Low molecular weight, non-polar, volatile organic compounds represent another potential issue as they account for up to 20 % of the acute toxicity of Suncor's Pond 1A surface water. The exact compound(s) causing the toxicity have not been identified, however, naphtha, which is used as a dilutant in the bitumen froth treatment, is likely the source of these light-end hydrocarbons.

Oil and Grease/Total Extractable Hydrocarbons - TEH is a parameter that indicates of the quantity of hydrocarbons in a sample. Typically, the bulk of hydrocarbons in process-affected waters are in the C_{15} to C_{28} range, which is consistent with the presence of naphthenic acids. In addition, work on Suncor's constructed wetlands indicates that the GC chromatographs can serve as a useful marker to monitor oil sands wastewater and to assist in identifying the source of hydrocarbons in water. However, since (1) most of the TEH in process-affected waters and in natural waters exposed to bitumen is naphthenic acids and (2) naphthenic acids are being measured on all water samples collected from the site, it would be redundant to measure TEH in water samples. We are, therefore, proposing to measure oil and grease, gravimetrically, following silica gel clean-up. Silica gel removes polar compounds (such as naphthenic acids), thus, the residual represents the non-polar component of the hydrocarbons.

Cyanide and Phenolics - These groups of compounds are associated with oil sands water and are potentially toxic to aquatic life.

Organic Carbon and Particle Size - Organic carbon content and particle size of soils are key parameters to assist in understanding partitioning between water and sediments and are required for modelling contaminant-fate processes.

Nutrients - The nutrients nitrogen and phosphorus are essential elements for growth of plants in aquatic environments. However, high levels of these nutrients can lead to excessive plant growth in lakes and streams. In addition, ammonia-nitrogen is toxic to aquatic life at high concentrations.

Metals and Trace Elements - Metal concentrations in Suncor's process-affected waters are typically within the range observed in background groundwater and surface waters; the only notable exception appears to be arsenic. Arsenic is, however, toxic to aquatic life and wildlife and is classed as a human carcinogen. Lead has also been observed at relatively high concentrations in emergent insects from Suncor's constructed wetlands.

APPENDIX II

GROUPING OF CHEMICALS FOR SCREENING AND THE USE OF TOXICITY SURROGATES

APPENDIX II
GROUPING OF CHEMICALS FOR SCREENING AND THE USE OF TOXICITY SURROGATES

Chemical Groupings

All chemicals detected were classified and grouped for screening purposes according to their structure and physiochemical and toxicological properties.

Closely-related chemicals were combined together to form chemical groups when insufficient human and/or ecological toxicity data were available to evaluate them individually. Maximum detected concentrations for each member of a chemical group were summed to provide a total concentration for each group in each sampling media. Within each chemical group, chemicals that were not detected in a particular media did not contribute to the overall group concentration.

For example, a chemical group designated the Naphthalene Group includes naphthalene, methyl naphthalene as well as the C_2, C_3, and C_4 substituted naphthalenes. Details of chemical grouping are summarized in Table 1.

Selection of Surrogate Toxicity Values for Screening Purposes

For the purpose of risk-based screening, all the chemicals of a group are assumed to have the same toxicological properties. Therefore, the quantitative toxicity value of a single compound (*i.e.,* the toxicity surrogate) was used to characterize the toxicity of the group. In selecting a toxicity surrogate for a group, the first choice was the parent compound found within that group. For example, naphthalene was chosen as the toxicity surrogate for the Naphthalene Group. For the Benzo(a)anthracene Group, sufficient data existed for two parent compounds (benzo(a)anthracene and chrysene). In this case, the chemical with the more protective toxicity value (benzo(a)anthracene) was selected as the toxicity surrogate.

When adequate toxicity data were not available or a more protective toxicity value was desired, a toxicity surrogate not present within the chemical group was chosen. For example, pyrene was chosen as a toxicity surrogate for the Phenanthrene and Dibenzothiophene Groups. Pyrene was selected as a surrogate for these groups for the following reasons:

- pyrene and the constituents of these three groups are classified as noncarcinogens;
- of the PAHs with sufficient toxicity data, pyrene has the second lowest reference dose (RfD) (naphthalene has the lowest RfD). However, there is greater uncertainty associated with the naphthalene RfD compared to the pyrene RfD.

Therefore, the use of pyrene as a toxicity surrogate for noncarcinogenic PAHs for which insufficient toxicity was available data is assumed to be sufficiently protective.

In some cases, toxicity surrogates were used for individual compounds (not groups of compounds) that have insufficient toxicity data. For example, acenaphthene was chosen as a surrogate for acenaphthylene based on their similar chemical structures and similar physio-chemical properties.

The toxicity surrogates used in the risk analysis for each of these chemical groups and other chemicals are listed in Table II-1.

TABLE II-1

CHEMICAL GROUPINGS AND TOXICITY SURROGATES

Chemical / Chemical Groups	Contains Following Compounds	Toxicity Surrogate
Acenaphthene Group	• acenapthene • methyl acenaphthene	acenaphthene
Acenaphthylene	• acenaphthylene	acenaphthene
Benzo(a)anthracene Group	• benzo(a)anthracene/chrysene • methyl benzo(a)anthracene/chrysene • C_2 substituted benzo(a)anthracene/chrysene	benzo(a)anthracene[1]
Benzo(ghi)perylene	• benzo(ghi)perylene	pyrene
Benzo(a)pyrene Group	• benzo(a)pyrene • methyl benzo(b or k)fluoranthene/methyl benzo(a)pyrene • C_3 substituted benzo(b or k)fluoranthene/benzo(a)pyrene	benzo(a)pyrene
Biphenyl Group	• biphenyl • methyl biphenyl • C2 substituted biphenyl	biphenyl
Dibenzothiophene Group	• dibenzothiophene • methyl dibenzothiophene • C_2, C_3, and C_4 substituted dibenzothiophenes	pyrene
Fluoranthene Group	• fluoranthene • methyl fluoranthene/pyrene	fluoranthene
Fluorene Group	• fluorene • methyl fluorene • C_2 substituted fluorene	fluorene
Naphthalene Group	• naphthalene • C_2, C_3, and C_4 substituted naphthalenes • methyl naphthalene	naphthalene
Phenanthrene Group	• phenanthrene/anthracene • methyl phenanthrene/anthracene • C_2, C_3, and C_4 substituted phenanthrene/anthracene	pyrene
Acridine Group	• acridine • methyl acridine	anthracene
Quinoline Group	• quinoline • 7-methyl quinoline • C_2 alkyl substituted quinolines	pyridine

[1] Based on B(a)P and toxicity equivalent factors for ecological receptors due to lack of data for benzo(a)anthracene.
[2] Based on B(a)P and toxicity equivalent factors for ecological receptors due to lack of data for benzo(ghi)perylene.
[3] Based on phenanthrene as there was sufficient laboratory data for ecological receptors.

APPENDIX III

RATIONALE FOR NOAELS AND RISK-BASED CONCENTRATIONS FOR CHEMICAL SCREENING

TABLE III-1

SUMMARY OF CHRONIC WILDLIFE NOAELS FOR WILDLIFE

Chemicals	Test Species	Test[1] Species NOAEL (mg/kg-BW/day)	Toxicological Endpoint	Test Species Body Weight (kg)	Endpoint[2] Species Body Weight (kg)	Estimated[3] Chronic Wildlife NOAEL (mg/kg-BW/day)	References
Deer Mouse							
Acenaphthene	laboratory mice	17.5	hepatotoxicity	0.03	0.0187	20	U.S. EPA 1989a.
Acenaphthylene	laboratory mice	17.5	hepatotoxicity	0.03	0.0187	20	Based on acenaphthene.
Anthracene	laboratory mice	100	mortality, clinical signs, body weight	0.03	0.0187	117	U.S. EPA 1989b.
Benzo(a)anthracene	laboratory mice	10	reproduction	0.03	0.0187	12	Based on benzo(a)pyrene and TEFS.
Benzo(a)pyrene	laboratory mice	1	reproduction	0.03	0.0187	1.2	Mackenzie and Angevine 1981.
Benzo(b,k)fluoranthene	laboratory mice	10	reproduction	0.03	0.0187	12	Based on benzo(a)pyrene and TEFS.
Biphenyl	laboratory rats	50	reproduction	0.35	0.0187	133	Ambrose et al. 1960.
Ethylbenzene	laboratory rats	9.71	liver and kidney toxicity	0.35	0.0187	26	Wolf et al. 1956.
Xylene	laboratory mice	2.06	reproduction	0.03	0.0187	2.4	Marks et al. 1982.
Phenol	laboratory rats	60	reproduction	0.35	0.0187	159	NTP 1983.
2,4-Dimethylphenol	laboratory mice	5	clinical signs and blood changes	0.03	0.0187	5.9	U.S. EPA 1989c.
m-cresol	mink	216.2	reproduction	1	0.0187	815	Based on o-cresol.
o-cresol	mink	216.2	reproduction	1	0.0187	815	Hornshaw et al. 1986.
Dibenzo(a,h)anthracene	laboratory mice	0.2	reproduction	0.03	0.0187	0.23	Based on benzo(a)pyrene and TEFS.
Dibenzothiophene	laboratory mice	7.5	kidney effects	0.03	0.0187	8.8	Based on pyrene.
Fluoranthene	laboratory mice	12.5	nephropathy, liver changes,	0.03	0.0187	15	U.S. EPA 1988.
Fluorene	laboratory mice	12.5	hematological effects	0.03	0.0187	15	U.S. EPA 1989d.
Naphthalene	laboratory mice	13.3	mortality, body & organ weights	0.03	0.0187	16	Shopp et al. 1984.
Phenanthrene	laboratory mice	4	mortality, clinical signs	0.03	0.0187	4.7	Buening et al. 1979.
Pyrene	laboratory mice	7.5	kidney effects	0.03	0.0187	8.8	U.S. EPA 1989e.
Quinoline	laboratory rat	1	increased liver weight	0.35	0.0187	2.7	U.S. EPA 1986. Based on pyridine.
Aluminum	laboratory mice	1.93	reproduction	0.03	0.0187	2.3	Ondreicka et al. 1966.
Antimony	laboratory mice	0.125	lifespan, longevity	0.03	0.0187	0.15	Schroeder et al. 1968.
Arsenic	laboratory mice	0.126	reproduction	0.03	0.0187	0.15	Schroeder and Mitchener 1971.
Barium	laboratory rat	5.06	growth, hypertension	0.435	0.0187	14	Perry et al. 1983.
Boron	cattle	3.63	maximum tolerable level	318	0.0187	93	NAS 1980.
Cadmium	laboratory mice	0.1913	reproduction	0.03	0.0187	0.22	Schroeder and Mitchener 1971.
Chromium (hexavalent)	laboratory rat	3.28	body weight; food consumption	0.35	0.0187	8.7	Mackenzie et al. 1958.
Chromium (trivalent)	laboratory rat	2737	reproduction, longevity	0.35	0.0187	7267	Ivankovic and Preussmann 1975.
Cobalt	cattle	0.24	maximum tolerable level	318	0.0187	6.2	NAS 1980.
Copper	mink	11.71	reproduction	1	0.0187	44	Aulerich et al. 1982.
Cyanide	laboratory rat	6.87	reproduction	0.273	0.0187	17	Tewe and Maner 1981.
Lead	laboratory rat	8	reproduction	0.35	0.0187	21	Azar et al. 1973.
Lithium	laboratory rat	9.39	reproduction	1	0.0187	35	Marathe and Thomas 1986.
Manganese	laboratory rat	88	reproduction	0.35	0.0187	234	Laskey et al. 1982.

TABLE III-1

SUMMARY OF CHRONIC WILDLIFE NOAELS FOR WILDLIFE

Chemicals	Test Species	Test[1] Species NOAEL (mg/kg-BW/day)	Toxicological Endpoint	Test Species Body Weight (kg)	Endpoint[2] Species Body Weight (kg)	Estimated[3] Chronic Wildlife NOAEL (mg/kg-BW/day)	References
Mercury	mink	0.015	clinical intoxication	1	0.0187	0.057	Wobeser et al. 1976.
Molybdenum	cattle	0.242	maximum tolerable level	318	0.0187	6.2	NAS 1980.
Nickel	laboratory rat	40	reproduction	0.35	0.0187	106	Ambrose et. al 1976.
Selenium	laboratory rat	0.24	anemia, spleen, liver, pancreas effec	0.35	0.0187	0.64	Halverson et al. 1966.
Strontium	laboratory rat	263	body weight and bone changes	0.35	0.0187	698	Skornya 1981.
Thallium	laboratory rat	0.0074	reproduction	0.365	0.0187	0.020	Formigli et al. 1986.
Uranium	laboratory mice	3.07	reproduction	0.028	0.0187	3.5	Paternain et al. 1989.
Vanadium	laboratory rat	0.21	reproduction	0.26	0.0187	0.50	Domingo et al. 1986.
Zinc	laboratory rat	160	reproduction	0.35	0.0187	425	Schlicker and Cox 1968.
Zirconium	laboratory mice	1.738	lifespan; longevity	0.03	0.0187	2.0	Schroeder et al. 1968.
Ermine							
Acenaphthene	laboratory mice	17.5	hepatotoxicity	0.03	0.0692	13	U.S. EPA 1989a.
Acenaphthylene	laboratory mice	17.5	hepatotoxicity	0.03	0.0692	13	Based on acenaphthene.
Benzo(a)anthracene	laboratory mice	10	reproduction	0.03	0.0692	7.6	Based on benzo(a)pyrene and TEFS.
Benzo(a)pyrene	laboratory mice	1	reproduction	0.03	0.0692	0.76	Mackenzie and Angevine 1981.
Benzo(b,k)fluoranthene	laboratory mice	10	reproduction	0.03	0.0692	7.6	Based on benzo(a)pyrene and TEFS.
Biphenyl	laboratory rats	50	reproduction	0.35	0.0692	86	Ambrose et al. 1960.
Dibenzothiophene	laboratory mice	7.5	kidney effects	0.03	0.0692	5.7	Based on pyrene.
Fluorene	laboratory mice	12.5	hematological effects	0.03	0.0692	9.5	U.S. EPA 1989d.
Naphthalene	laboratory mice	13.3	mortality, body & organ weights	0.03	0.0692	10	Shopp et al. 1984.
Phenanthrene	laboratory mice	4	mortality, clinical signs	0.03	0.0692	3.0	Buening et al. 1979.
Pyrene	laboratory mice	7.5	kidney effects	0.03	0.0692	5.7	U.S. EPA 1989e.
Quinoline	laboratory rat	1	increased liver weight	0.35	0.0692	1.7	U.S. EPA 1986. Based on pyridine.
Ethylbenzene	laboratory rats	9.71	liver and kidney toxicity	0.35	0.0692	17	Wolf et al. 1956.
Xylene	laboratory mice	2.06	reproduction	0.03	0.0692	1.6	Marks et al. 1982.
Phenol	laboratory rats	60	reproduction	0.35	0.0692	103	NTP 1983.
2,4-Dimethylphenol	laboratory mice	5	clinical signs and blood changes	0.03	0.0692	3.8	U.S. EPA 1989c.
m-cresol	mink	216.2	reproduction	1	0.0692	527	Based on o-cresol.
o-cresol	mink	216.2	reproduction	1	0.0692	527	Hornshaw et al. 1986.
Aluminum	laboratory mice	1.93	reproduction	0.03	0.0692	1.5	Ondreicka et. al 1966.
Antimony	laboratory mice	0.125	lifespan, longevity	0.03	0.0692	0.095	Schroeder et al. 1968.
Arsenic	laboratory mice	0.126	reproduction	0.03	0.0692	0.10	Schroeder and Mitchener 1971.
Barium	laboratory rat	5.06	growth, hypertension	0.435	0.0692	9.3	Perry et al. 1983.
Boron	cattle	3.63	maximum tolerable level	318	0.0692	60	NAS 1980.
Cadmium	laboratory mice	0.1913	reproduction	0.03	0.0692	0.14	Schroeder and Mitchener 1971.
Chromium (hexavalent)	laboratory rat	3.28	body weight; food consumption	0.35	0.0692	5.6	Mackenzie et al. 1958.

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Chromium (trivalent)	laboratory rat	2737	reproduction, longevity	0.35	0.0692	4698	Ivankovic and Preussmann 1975.
Cobalt	cattle	0.24	maximum tolerable level	318	0.0692	4.0	NAS 1980.
Copper	mink	11.71	reproduction	1	0.0692	29	Aulerich et al. 1982.
Cyanide	laboratory rat	6.87	reproduction	0.273	0.0692	11	Tewe and Maner 1981.
Lead	laboratory rat	8	reproduction	0.35	0.0692	14	Azar et al. 1973.
Lithium	laboratory rat	9.39	reproduction	1	0.0692	23	Marathe and Thomas 1986.
Manganese	laboratory rat	88	reproduction	0.35	0.0692	151	Laskey et al. 1982.
Mercury	mink	0.015	clinical intoxication	1	0.0692	0.037	Wobeser et al. 1976.
Molybdenum	cattle	0.242	maximum tolerable level	318	0.0692	4.0	NAS 1980.
Nickel	laboratory rat	40	reproduction	0.35	0.0692	69	Ambrose et. al 1976.
Selenium	laboratory rat	0.24	anemia, spleen, liver, pancreas effec	0.35	0.0692	0.41	Halverson et al. 1966.
Strontium	laboratory rat	263	body weight and bone changes	0.35	0.0692	451	Skornya 1981.
Thallium	laboratory rat	0.0074	reproduction	0.365	0.0692	0.013	Formigli et al. 1986.
Uranium	laboratory mice	3.07	reproduction	0.028	0.0692	2.3	Paternain et al. 1989.
Vanadium	laboratory rat	0.21	reproduction	0.26	0.0692	0.33	Domingo et al. 1986.
Zinc	laboratory rat	160	reproduction	0.35	0.0692	275	Schlicker and Cox 1968.
Zirconium	laboratory mice	1.738	lifespan; longevity	0.03	0.0692	1.3	Schroeder et al. 1968.
Snowshoe hare							
Acenaphthene	laboratory mice	17.5	hepatotoxicity	0.03	1.505	4.7	U.S. EPA 1989a.
Acenaphthylene	laboratory mice	17.5	hepatotoxicity	0.03	1.505	4.7	Based on acenaphthene.
Benzo(a)anthracene	laboratory mice	10	reproduction	0.03	1.505	2.7	Based on benzo(a)pyrene and TEFS.
Benzo(a)pyrene	laboratory mice	1	reproduction	0.03	1.505	0.27	Mackenzie and Angevine 1981.
Benzo(b,k)fluoranthene	laboratory mice	10	reproduction	0.03	1.505	2.7	Based on benzo(a)pyrene and TEFS.
Biphenyl	laboratory rats	50	reproduction	0.35	1.505	31	Ambrose et al. 1960.
Dibenzo(a,h)anthracene	laboratory mice	0.2	reproduction	0.03	1.505	0.054	Based on benzo(a)pyrene and TEFS.
Dibenzothiophene	laboratory mice	7.5	kidney effects	0.03	1.505	2.0	Based on pyrene.
Fluoranthene	laboratory mice	12.5	nephropathy, liver changes,	0.03	1.505	3.4	U.S. EPA 1988.
Fluorene	laboratory mice	12.5	hematological effects	0.03	1.505	3.4	U.S. EPA 1989d.
Naphthalene	laboratory mice	13.3	mortality, body & organ weights	0.03	1.505	3.6	Shopp et al. 1984.
Phenanthrene	laboratory mice	4	mortality, clinical signs	0.03	1.505	1.1	Buening et al. 1979.
Pyrene	laboratory mice	7.5	kidney effects	0.03	1.505	2.0	U.S. EPA 1989e.
Quinoline	laboratory rat	1	increased liver weight	0.35	1.505	0.61	U.S. EPA 1986. Based on pyridine.
Ethylbenzene	laboratory rats	9.71	liver and kidney toxicity	0.35	1.505	6.0	Wolf et al. 1956.
Xylene	laboratory mice	2.06	reproduction	0.03	1.505	0.56	Marks et al. 1982.
Phenol	laboratory rats	60	reproduction	0.35	1.505	37	NTP 1983.
2,4-Dimethylphenol	laboratory mice	5	clinical signs and blood changes	0.03	1.505	1.4	U.S. EPA 1989c.

TABLE III-1

SUMMARY OF CHRONIC WILDLIFE NOAELS FOR WILDLIFE

Chemicals	Test Species	Test[1] Species NOAEL (mg/kg-BW/day)	Toxicological Endpoint	Test Species Body Weight (kg)	Endpoint[2] Species Body Weight (kg)	Estimated[3] Chronic Wildlife NOAEL (mg/kg-BW/day)	References
m-cresol	mink	216.2	reproduction	1	1.505	189	Based on o-cresol.
o-cresol	mink	216.2	reproduction	1	1.505	189	Hornshaw et al. 1986.
Aluminum	laboratory mice	1.93	reproduction	0.03	1.505	0.52	Ondreicka et. al 1966.
Antimony	laboratory mice	0.125	lifespan, longevity	0.03	1.505	0.034	Schroeder et al. 1968.
Arsenic	laboratory mice	0.126	reproduction	0.03	1.505	0.034	Schroeder and Mitchener 1971.
Barium	laboratory rat	5.06	growth, hypertension	0.435	1.505	3.3	Perry et al. 1983.
Boron	cattle	3.63	maximum tolerable level	318	1.505	22	NAS 1980.
Cadmium	laboratory mice	0.1913	reproduction	0.03	1.505	0.052	Schroeder and Mitchener 1971.
Chromium (hexavalent)	laboratory rat	3.28	body weight; food consumption	0.35	1.505	2.0	Mackenzie et al. 1958.
Chromium (trivalent)	laboratory rat	2737	reproduction, longevity	0.35	1.505	1683	Ivankovic and Preussmann 1975.
Cobalt	cattle	0.24	maximum tolerable level	318	1.505	1.4	NAS 1980.
Copper	mink	11.71	reproduction	1	1.505	10	Aulerich et al. 1982.
Cyanide	laboratory rat	6.87	reproduction	0.273	1.505	3.9	Tewe and Maner 1981.
Lead	laboratory rat	8	reproduction	0.35	1.505	4.9	Azar et al. 1973.
Lithium	laboratory rat	9.39	reproduction	1	1.505	8.2	Marathe and Thomas 1986.
Manganese	laboratory rat	88	reproduction	0.35	1.505	54	Laskey et al. 1982.
Mercury	mink	0.015	clinical intoxication	1	1.505	0.013	Wobeser et al. 1976.
Molybdenum	cattle	0.242	maximum tolerable level	318	1.505	1.4	NAS 1980.
Nickel	laboratory rat	40	reproduction	0.35	1.505	25	Ambrose et al. 1976.
Selenium	laboratory rat	0.24	anemia, spleen, liver, pancreas effec	0.35	1.505	0.15	Halverson et al. 1966.
Strontium	laboratory rat	263	body weight and bone changes	0.35	1.505	162	Skornya 1981.
Thallium	laboratory rat	0.0074	reproduction	0.365	1.505	0.0046	Formigli et al. 1986.
Uranium	laboratory mice	3.07	reproduction	0.028	1.505	0.81	Paternain et al. 1989.
Vanadium	laboratory rat	0.21	reproduction	0.26	1.505	0.12	Domingo et al. 1986.
Zinc	laboratory rat	160	reproduction	0.35	1.505	98	Schlicker and Cox 1968.
Zirconium	laboratory mice	1.738	lifespan; longevity	0.03	1.505	0.47	Schroeder et al. 1968.
Beaver							
Acenaphthene	laboratory mice	17.5	hepatotoxicity	0.03	18.275	2.1	U.S. EPA 1989a.
Acenaphthylene	laboratory mice	17.5	hepatotoxicity	0.03	18.275	2.1	Based on acenaphthene.
Benzo(a)anthracene	laboratory mice	10	reproduction	0.03	18.275	1.2	Based on benzo(a)pyrene and TEFS.
Benzo(a)pyrene	laboratory mice	1	reproduction	0.03	18.275	0.12	Mackenzie and Angevine 1981.
Benzo(b,k)fluoranthene	laboratory mice	10	reproduction	0.03	18.275	1.2	Based on benzo(a)pyrene and TEFS.
Biphenyl	laboratory rats	50	reproduction	0.35	18.275	13	Ambrose et al. 1960.
Dibenzo(a,h)anthracene	laboratory mice	0.2	reproduction	0.03	18.275	0.024	Based on benzo(a)pyrene and TEFS.
Dibenzothiophene	laboratory mice	7.5	kidney effects	0.03	18.275	0.88	Based on pyrene.
Fluoranthene	laboratory mice	12.5	nephropathy, liver changes,	0.03	18.275	1.5	U.S. EPA 1988.

TABLE III-1

SUMMARY OF CHRONIC WILDLIFE NOAELS FOR WILDLIFE

Chemicals	Test Species	Test[1] Species NOAEL (mg/kg-BW/day)	Toxicological Endpoint	Test Species Body Weight (kg)	Endpoint[2] Species Body Weight (kg)	Estimated[3] Chronic Wildlife NOAEL (mg/kg-BW/day)	References
Fluorene	laboratory mice	12.5	hematological effects	0.03	18.275	1.5	U.S. EPA 1989d.
Naphthalene	laboratory mice	13.3	mortality, body & organ weights	0.03	18.275	1.6	Shopp et al. 1984.
Phenanthrene	laboratory mice	4	mortality, clinical signs	0.03	18.275	0.47	Buening et al. 1979.
Pyrene	laboratory mice	7.5	kidney effects	0.03	18.275	0.88	U.S. EPA 1989e.
Quinoline	laboratory rat	1	increased liver weight	0.35	18.275	0.27	U.S. EPA 1986. Based on pyridine.
Ethylbenzene	laboratory rats	9.71	liver and kidney toxicity	0.35	18.275	2.6	Wolf et al. 1956.
Xylene	laboratory mice	2.06	reproduction	0.03	18.275	0.24	Marks et al. 1982.
Phenol	laboratory rats	60	reproduction	0.35	18.275	16	NTP 1983.
2,4-Dimethylphenol	laboratory mice	5	clinical signs and blood changes	0.03	18.275	0.59	U.S. EPA 1989c.
m-cresol	mink	216.2	reproduction	1	18.275	82	Based on o-cresol.
o-cresol	mink	216.2	reproduction	1	18.275	82	Hornshaw et al. 1986.
Aluminum	laboratory mice	1.93	reproduction	0.03	18.275	0.23	Ondreicka et. al 1966.
Antimony	laboratory mice	0.125	lifespan, longevity	0.03	18.275	0.015	Schroeder et al. 1968.
Arsenic	laboratory mice	0.126	reproduction	0.03	18.275	0.015	Schroeder and Mitchener 1971.
Barium	laboratory rat	5.06	growth, hypertension	0.435	18.275	1.5	Perry et al. 1983.
Boron	cattle	3.63	maximum tolerable level	318	18.275	9.4	NAS 1980.
Cadmium	laboratory mice	0.1913	reproduction	0.03	18.275	0.023	Schroeder and Mitchener 1971.
Chromium (hexavalent)	laboratory rat	3.28	body weight; food consumption	0.35	18.275	0.88	Mackenzie et al. 1958.
Chromium (trivalent)	laboratory rat	2737	reproduction, longevity	0.35	18.275	732	Ivankovic and Preussmann 1975.
Cobalt	cattle	0.24	maximum tolerable level	318	18.275	0.62	NAS 1980.
Copper	mink	11.71	reproduction	1	18.275	4.4	Aulerich et al. 1982.
Cyanide	laboratory rat	6.87	reproduction	0.273	18.275	1.7	Tewe and Maner 1981.
Lead	laboratory rat	8	reproduction	0.35	18.275	2.1	Azar et al. 1973.
Lithium	laboratory rat	9.39	reproduction	1	18.275	3.6	Marathe and Thomas 1986.
Manganese	laboratory rat	88	reproduction	0.35	18.275	24	Laskey et al. 1982.
Mercury	mink	0.015	clinical intoxication	1	18.275	0.0057	Wobeser et al. 1976.
Molybdenum	cattle	0.242	maximum tolerable level	318	18.275	0.63	NAS 1980.
Nickel	laboratory rat	40	reproduction	0.35	18.275	11	Ambrose et. al 1976.
Selenium	laboratory rat	0.24	anemia, spleen, liver, pancreas effec	0.35	18.275	0.064	Halverson et al. 1966.
Strontium	laboratory rat	263	body weight and bone changes	0.35	18.275	70	Skornya 1981.
Thallium	laboratory rat	0.0074	reproduction	0.365	18.275	0.0020	Formigli et al. 1986.
Uranium	laboratory mice	3.07	reproduction	0.028	18.275	0.35	Paternain et al. 1989.
Vanadium	laboratory rat	0.21	reproduction	0.26	18.275	0.051	Domingo et al. 1986.
Zinc	laboratory rat	160	reproduction	0.35	18.275	43	Schlicker and Cox 1968.
Zirconium	laboratory mice	1.738	lifespan; longevity	0.03	1.505	0.47	Schroeder et al. 1968.
Moose							

TABLE III-1

SUMMARY OF CHRONIC WILDLIFE NOAELS FOR WILDLIFE

Chemicals	Test Species	Test[1] Species NOAEL (mg/kg-BW/day)	Toxicological Endpoint	Test Species Body Weight (kg)	Endpoint[2] Species Body Weight (kg)	Estimated[3] Chronic Wildlife NOAEL (mg/kg-BW/day)	References
Acenaphthene	laboratory mice	17.5	hepatotoxicity	0.03	381	0.75	U.S. EPA 1989a.
Acenaphthylene	laboratory mice	17.5	hepatotoxicity	0.03	381	0.75	Based on acenaphthene.
Benzo(a)anthracene	laboratory mice	10	reproduction	0.03	381	0.43	Based on benzo(a)pyrene and TEFS.
Benzo(a)pyrene	laboratory mice	1	reproduction	0.03	381	0.043	Mackenzie and Angevine 1981.
Benzo(b,k)fluoranthene	laboratory mice	10	reproduction	0.03	381	0.43	Based on benzo(a)pyrene and TEFS.
Biphenyl	laboratory rats	50	reproduction	0.35	381	4.9	Ambrose et al. 1960.
Dibenzo(a,h)anthracene	laboratory mice	0.2	reproduction	0.03	381	0.0086	Based on benzo(a)pyrene and TEFS.
Dibenzothiophene	laboratory mice	7.5	kidney effects	0.03	381	0.32	Based on pyrene.
Fluoranthene	laboratory mice	12.5	nephropathy, liver changes,	0.03	381	0.54	U.S. EPA 1988.
Fluorene	laboratory mice	12.5	hematological effects	0.03	381	0.54	U.S. EPA 1989d.
Naphthalene	laboratory mice	13.3	mortality, body & organ weights	0.03	381	0.57	Shopp et al. 1984.
Phenanthrene	laboratory mice	4	mortality, clinical signs	0.03	381	0.17	Buening et al. 1979.
Pyrene	laboratory mice	7.5	kidney effects	0.03	381	0.32	U.S. EPA 1989e.
Quinoline	laboratory rat	1	increased liver weight	0.35	381	0.10	U.S. EPA 1986. Based on pyridine.
Ethylbenzene	laboratory rats	9.71	liver and kidney toxicity	0.35	381	0.94	Wolf et al. 1956.
Xylene	laboratory mice	2.06	reproduction	0.03	381	0.088	Marks et al. 1982.
Phenol	laboratory rats	60	reproduction	0.35	381	5.8	NTP 1983.
2,4-Dimethylphenol	laboratory mice	5	clinical signs and blood changes	0.03	381	0.21	U.S. EPA 1989c.
m-cresol	mink	216.2	reproduction	1	381	30	Based on o-cresol.
o-cresol	mink	216.2	reproduction	1	381	30	Hornshaw et al. 1986.
Aluminum	laboratory mice	1.93	reproduction	0.03	381	0.083	Ondreicka et. al 1966.
Antimony	laboratory mice	0.125	lifespan, longevity	0.03	381	0.0054	Schroeder et al. 1968.
Arsenic	laboratory mice	0.126	reproduction	0.03	381	0.0054	Schroeder and Mitchener 1971.
Barium	laboratory rat	5.06	growth, hypertension	0.435	381	0.53	Perry et al. 1983.
Boron	cattle	3.63	maximum tolerable level	318	381	3.4	NAS 1980.
Cadmium	laboratory mice	0.1913	reproduction	0.03	381	0.0082	Schroeder and Mitchener 1971.
Chromium (hexavalent)	laboratory rat	3.28	body weight; food consumption	0.35	381	0.32	Mackenzie et al. 1958.
Chromium (trivalent)	laboratory rat	2737	reproduction, longevity	0.35	381	266	Ivankovic and Preussmann 1975.
Cobalt	cattle	0.24	maximum tolerable level	318	381	0.23	NAS 1980.
Copper	mink	11.71	reproduction	1	381	1.6	Aulerich et al. 1982.
Cyanide	laboratory rat	6.87	reproduction	0.273	381	0.61	Tewe and Maner 1981.
Lead	laboratory rat	8	reproduction	0.35	381	0.78	Azar et al. 1973.
Lithium	laboratory rat	9.39	reproduction	1	381	1.3	Marathe and Thomas 1986.
Manganese	laboratory rat	88	reproduction	0.35	381	8.6	Laskey et al. 1982.
Mercury	mink	0.015	clinical intoxication	1	381	0.0021	Wobeser et al. 1976.
Molybdenum	cattle	0.242	maximum tolerable level	318	381	0.23	NAS 1980.

TABLE III-1

SUMMARY OF CHRONIC WILDLIFE NOAELS FOR WILDLIFE

Chemicals	Test Species	Test[1] Species NOAEL (mg/kg-BW/day)	Toxicological Endpoint	Test Species Body Weight (kg)	Endpoint[2] Species Body Weight (kg)	Estimated[3] Chronic Wildlife NOAEL (mg/kg-BW/day)	References
Nickel	laboratory rat	40	reproduction	0.35	381	3.9	Ambrose et. al 1976.
Selenium	laboratory rat	0.24	anemia, spleen, liver, pancreas effec	0.35	381	0.023	Halverson et al. 1966.
Strontium	laboratory rat	263	body weight and bone changes	0.35	381	26	Skornya 1981.
Thallium	laboratory rat	0.0074	reproduction	0.365	381	0.00073	Formigli et al. 1986.
Uranium	laboratory mice	3.07	reproduction	0.028	381	0.13	Paternain et al. 1989.
Vanadium	laboratory rat	0.21	reproduction	0.26	381	0.018	Domingo et al. 1986.
Zinc	laboratory rat	160	reproduction	0.35	381	16	Schlicker and Cox 1968.
Zirconium	laboratory mice	1.738	lifespan; longevity	0.03	381	0.074	Schroeder et al. 1968.
American robin							
Acenaphthene	mallard	22.55	liver weights, blood flow	1	0.0836	52	Patton and Dieter 1980.
Acenaphthylene	mallard	22.55	liver weights, blood flow	1	0.0836	52	Based on acenaphthene.
Benzo(a)anthracene	herring gull	0.11	weight gain; osmoregulation	0.4	0.0836	0.19	Based on benzo(a)pyrene and TEFS.
Benzo(a)pyrene	herring gull	0.0112	weight gain; osmoregulation	0.4	0.0836	0.019	Peakall et al. 1982.
Benzo(b,k)fluoranthene	herring gull	0.11	weight gain; osmoregulation	0.4	0.0836	0.19	Based on benzo(a)pyrene and TEFS.
Dibenzothiophene	mallard	22.55	liver weights, blood flow	1	0.0836	52	Based on pyrene
Fluorene	mallard	22.55	liver weights, blood flow	1	0.0836	52	Patton and Dieter 1980.
Phenanthrene	mallard	22.55	liver weights, blood flow	1	0.0836	52	Patton and Dieter 1980.
Pyrene	mallard	22.55	liver weights, blood flow	1	0.0836	52	Patton and Dieter 1980.
Aluminum	ringed dove	111.4	reproduction	0.155	0.0836	137	Carriere et al. 1986.
Arsenic	cowbird	2.46	mortality	0.049	0.0836	2.1	USFWS 1969.
Arsenic	mallard	5.135	mortality	1	0.0836	12	USFWS 1964.
Barium	day-old chicks	20.826	mortality	0.121	0.0836	24	Johnson et al. 1960.
Boron	chicken	10.3	maximum tolerable level	1.6	0.0836	28	NAS 1980.
Cadmium	mallard	1.45	reproduction	1.153	0.0836	3.5	White and Finley 1978.
Chromium	black duck	1	reproduction	1.25	0.0836	2.5	Haseltine et al., unpub. data.
Cobalt	chicken	0.7	maximum tolerable level	1.6	0.0836	1.9	NAS 1980.
Copper	day-old chicks	33.21	growth	0.534	0.0836	62	Mehring et al. 1960.
Lead	american kestrel	3.85	reproduction	0.13	0.0836	4.5	Pattee 1984.
Manganese	chicken	138	maximum tolerable level	1.6	0.0836	369	NAS 1980.
Mercury	mallard	0.0064	reproduction	1	0.0836	0.015	Heinz 1979.
Molybdenum	chicken	6.875	maximum tolerable level	1.6	0.0836	18	NAS 1980.
Nickel	mallard duckling	77.4	mortality, growth, behavior	0.782	0.0836	163	Cain and Pafford 1981.
Selenium	mallard	0.5	reproduction	1	0.0836	1.1	Heinz et al. 1987.
Selenium	mallard	0.4	reproduction	1	0.0836	0.91	Heinz et al. 1989.
Uranium	black duck	16	mortality, body weight	1.25	0.0836	39	Haseltine and Sileo 1983.
Vanadium	mallard	11.38	mortality, body weight	1.17	0.0836	27	White and Dieter 1978.

TABLE III-1

SUMMARY OF CHRONIC WILDLIFE NOAELS FOR WILDLIFE

Chemicals	Test Species	Test[1] Species NOAEL (mg/kg-BW/day)	Toxicological Endpoint	Test Species Body Weight (kg)	Endpoint[2] Species Body Weight (kg)	Estimated[3] Chronic Wildlife NOAEL (mg/kg-BW/day)	References
Zinc	mallard	3	mortality, body weight	1	0.0836	6.9	Gasaway and Buss 1972.
American kestrel							
Acenaphthene	mallard	22.55	liver weights, blood flow	1	0.137	44	Patton and Dieter 1980.
Acenaphthylene	mallard	22.55	liver weights, blood flow	1	0.137	44	Based on acenaphthene.
Anthracene	mallard	22.55	liver weights, blood flow	1	0.137	44	Patton and Dieter 1980.
Benzo(a)anthracene	herring gull	0.11	weight gain; osmoregulation	0.4	0.137	0.16	Based on benzo(a)pyrene and TEFS.
Benzo(a)pyrene	herring gull	0.0112	weight gain; osmoregulation	0.4	0.137	0.016	Peakall et al. 1982.
Benzo(b,k)fluoranthene	herring gull	0.11	weight gain; osmoregulation	0.4	0.137	0.16	Based on benzo(a)pyrene and TEFS.
Dibenzothiophene	mallard	22.55	liver weights, blood flow	1	0.137	44	Based on pyrene
Fluorene	mallard	22.55	liver weights, blood flow	1	0.137	44	Patton and Dieter 1980.
Phenanthrene	mallard	22.55	liver weights, blood flow	1	0.137	44	Patton and Dieter 1980.
Pyrene	mallard	22.55	liver weights, blood flow	1	0.137	44	Patton and Dieter 1980.
Aluminum	ringed dove	111.4	reproduction	0.155	0.137	116	Carriere et al. 1986.
Arsenic	cowbird	2.46	mortality	0.049	0.137	1.7	USFWS 1969.
Arsenic	mallard	5.135	mortality	1	0.137	10	USFWS 1964.
Barium	day-old chicks	20.826	mortality	0.121	0.137	20	Johnson et al. 1960.
Boron	chicken	10.3	maximum tolerable level	1.6	0.137	23	NAS 1980.
Cadmium	mallard	1.45	reproduction	1.153	0.137	2.9	White and Finley 1978.
Chromium	black duck	1	reproduction	1.25	0.137	2.1	Haseltine et al., unpub. data.
Cobalt	chicken	0.7	maximum tolerable level	1.6	0.137	1.6	NAS 1980.
Copper	day-old chicks	33.21	growth	0.534	0.137	52	Mehring et al. 1960.
Lead	american kestrel	3.85	reproduction	0.13	0.137	3.8	Pattee 1984.
Manganese	chicken	138	maximum tolerable level	1.6	0.137	313	NAS 1980.
Mercury	mallard	0.0064	reproduction	1	0.137	0.012	Heinz 1979.
Molybdenum	chicken	6.875	maximum tolerable level	1.6	0.137	16	NAS 1980.
Nickel	mallard duckling	77.4	mortality, growth, behavior	0.782	0.137	138	Cain and Pafford 1981.
Selenium	mallard	0.5	reproduction	1	0.137	1.0	Heinz et al. 1987.
Selenium	mallard	0.4	reproduction	1	0.137	0.78	Heinz et al. 1989.
Uranium	black duck	16	mortality, body weight	1.25	0.137	33	Haseltine and Sileo 1983.
Vanadium	mallard	11.38	mortality, body weight	1.17	0.137	23	White and Dieter 1978.
Zinc	mallard	3	mortality, body weight	1	0.137	5.8	Gasaway and Buss 1972.
Ruffed grouse							
Acenaphthene	mallard	22.55	liver weights, blood flow	1	0.54285	28	Patton and Dieter 1980.
Acenaphthylene	mallard	22.55	liver weights, blood flow	1	0.54285	28	Based on acenaphthene.
Benzo(a)anthracene	herring gull	0.11	weight gain; osmoregulation	0.4	0.54285	0.10	Based on benzo(a)pyrene and TEFS.
Benzo(a)pyrene	herring gull	0.0112	weight gain; osmoregulation	0.4	0.54285	0.010	Peakall et al. 1982.

TABLE III-1

SUMMARY OF CHRONIC WILDLIFE NOAELS FOR WILDLIFE

Chemicals	Test Species	Test[1] Species NOAEL (mg/kg-BW/day)	Toxicological Endpoint	Test Species Body Weight (kg)	Endpoint[2] Species Body Weight (kg)	Estimated[3] Chronic Wildlife NOAEL (mg/kg-BW/day)	References
Benzo(b,k)fluoranthene	herring gull	0.11	weight gain; osmoregulation	0.4	0.54285	0.10	Based on benzo(a)pyrene and TEFS.
Dibenzothiophene	mallard	22.55	liver weights, blood flow	1	0.54285	28	Based on pyrene
Fluorene	mallard	22.55	liver weights, blood flow	1	0.54285	28	Patton and Dieter 1980.
Phenanthrene	mallard	22.55	liver weights, blood flow	1	0.54285	28	Patton and Dieter 1980.
Pyrene	mallard	22.55	liver weights, blood flow	1	0.54285	28	Patton and Dieter 1980.
Aluminum	ringed dove	111.4	reproduction	0.155	0.54285	73	Carriere et al. 1986.
Arsenic	cowbird	2.46	mortality	0.049	0.54285	1.1	USFWS 1969.
Arsenic	mallard	5.135	mortality	1	0.54285	6.3	USFWS 1964.
Barium	day-old chicks	20.826	mortality	0.121	0.54285	13	Johnson et al. 1960.
Boron	chicken	10.3	maximum tolerable level	1.6	0.54285	15	NAS 1980.
Cadmium	mallard	1.45	reproduction	1.153	0.54285	1.9	White and Finley 1978.
Chromium	black duck	1	reproduction	1.25	0.54285	1.3	Haseltine et al., unpub. data.
Cobalt	chicken	0.7	maximum tolerable level	1.6	0.54285	1.0	NAS 1980.
Copper	day-old chicks	33.21	growth	0.534	0.54285	33	Mehring et al. 1960.
Lead	american kestrel	3.85	reproduction	0.13	0.54285	2.4	Pattee 1984.
Manganese	chicken	138	maximum tolerable level	1.6	0.54285	198	NAS 1980.
Mercury	mallard	0.0064	reproduction	1	0.54285	0.0078	Heinz 1979.
Molybdenum	chicken	6.875	maximum tolerable level	1.6	0.54285	10	NAS 1980.
Nickel	mallard duckling	77.4	mortality, growth, behavior	0.782	0.54285	87	Cain and Pafford 1981.
Selenium	mallard	0.5	reproduction	1	0.54285	0.61	Heinz et al. 1987.
Selenium	mallard	0.4	reproduction	1	0.54285	0.49	Heinz et al. 1989.
Uranium	black duck	16	mortality, body weight	1.25	0.54285	21	Haseltine and Sileo 1983.
Vanadium	mallard	11.38	mortality, body weight	1.17	0.54285	15	White and Dieter 1978.
Zinc	mallard	3	mortality, body weight	1.0	0.54285	3.7	Gasaway and Buss 1972.
Mallard							
Acenaphthene	mallard	22.55	liver weights, blood flow	1	1.107	22	Patton and Dieter 1980.
Acenaphthylene	mallard	22.55	liver weights, blood flow	1	1.107	22	Based on acenaphthene.
Benzo(a)anthracene	herring gull	0.11	weight gain; osmoregulation	0.4	1.107	0.078	Based on benzo(a)pyrene and TEFS.
Benzo(a)pyrene	herring gull	0.0112	weight gain; osmoregulation	0.4	1.107	0.0080	Peakall et al. 1982.
Benzo(b,k)fluoranthene	herring gull	0.11	weight gain; osmoregulation	0.4	1.107	0.078	Based on benzo(a)pyrene and TEFS.
Dibenzothiophene	mallard	22.55	liver weights, blood flow	1	1.107	22	Based on pyrene
Fluorene	mallard	22.55	liver weights, blood flow	1	1.107	22	Patton and Dieter 1980.
Phenanthrene	mallard	22.55	liver weights, blood flow	1	1.107	22	Patton and Dieter 1980.
Pyrene	mallard	22.55	liver weights, blood flow	1	1.107	22	Patton and Dieter 1980.
Aluminum	ringed dove	111.4	reproduction	0.155	1.107	58	Carriere et al. 1986.
Arsenic	cowbird	2.46	mortality	0.049	1.107	0.87	USFWS 1969.

TABLE III-1

SUMMARY OF CHRONIC WILDLIFE NOAELS FOR WILDLIFE

Chemicals	Test Species	Test[1] Species NOAEL (mg/kg-BW/day)	Toxicological Endpoint	Test Species Body Weight (kg)	Endpoint[2] Species Body Weight (kg)	Estimated[3] Chronic Wildlife NOAEL (mg/kg-BW/day)	References
Arsenic	mallard	5.135	mortality	1	1.107	5.0	USFWS 1964.
Barium	day-old chicks	20.826	mortality	0.121	1.107	10	Johnson et al. 1960.
Boron	chicken	10.3	maximum tolerable level	1.6	1.107	12	NAS 1980.
Cadmium	mallard	1.45	reproduction	1.153	1.107	1.5	White and Finley 1978.
Chromium	black duck	1	reproduction	1.25	1.107	1.0	Haseltine et al., unpub. data.
Cobalt	chicken	0.7	maximum tolerable level	1.6	1.107	0.79	NAS 1980.
Copper	day-old chicks	33.21	growth	0.534	1.107	26	Mehring et al. 1960.
Lead	american kestrel	3.85	reproduction	0.13	1.107	1.9	Pattee 1984.
Manganese	chicken	138	maximum tolerable level	1.6	1.107	156	NAS 1980.
Mercury	mallard	0.0064	reproduction	1	1.107	0.0062	Heinz 1979.
Molybdenum	chicken	6.875	maximum tolerable level	1.6	1.107	7.8	NAS 1980.
Nickel	mallard duckling	77.4	mortality, growth, behavior	0.782	1.107	69	Cain and Pafford 1981.
Selenium	mallard	0.5	reproduction	1	1.107	0.48	Heinz et al. 1987.
Selenium	mallard	0.4	reproduction	1	1.107	0.39	Heinz et al. 1989.
Uranium	black duck	16	mortality, body weight	1.25	1.107	17	Haseltine and Sileo 1983.
Vanadium	mallard	11.38	mortality, body weight	1.17	1.107	12	White and Dieter 1978.
Zinc	mallard	3	mortality, body weight	1	1.107	2.9	Gasaway and Buss 1972.

TABLE III-2

SUMMARY OF RISK-BASED CONCENTRATIONS (RBCs) FOR THE INGESTION OF SOIL, FOOD AND WATER FOR WILDLIFE

Chemicals	Estimated[1] Chronic Wildlife NOAEL (mg/kg-BW/day)	Endpoint[2] Species Body Weight (kg)	Soil[2] Ingestion Rate (kg/day)	Plant[2] Ingestion Rate (kg/day)	Prey[2] Ingestion Rate (kg/day)	Water[2] Ingestion Rate (L/day)	Risk-Based[3] Concentration (mg/kg soil)	Risk-Based[3] Concentration (mg/kg plant)	Risk-Based[3] Concentration (mg/kg prey)	Risk-Based[3] Concentration (mg/L water)
Deer Mouse										
Acenaphthene	20.5	0.0187	0.0000648	0.00188	0.00136	0.00276	5912	204	282	139
Acenaphthylene	20.5	0.0187	0.0000648	0.00188	0.00136	0.00276	5912	204	282	139
Benzo(a)anthracene	11.7	0.0187	0.0000648	0.00188	0.00136	0.00276	3378	116	161	79
Benzo(a)pyrene	1.17	0.0187	0.0000648	0.00188	0.00136	0.00276	338	12	16	7.9
Benzo(b,k)fluoranthene	11.7	0.0187	0.0000648	0.00188	0.00136	0.00276	3378	116	161	79
Biphenyl	133	0.0187	0.0000648	0.00188	0.00136	0.00276	38310	1320	1825	899
Dibenzo(a,h)anthracene	0.23	0.0187	0.0000648	0.00188	0.00136	0.00276	66	2.3	3.2	1.6
Dibenzothiophene	8.78	0.0187	0.0000648	0.00188	0.00136	0.00276	2534	87	121	59
Fluoranthene	14.6	0.0187	0.0000648	0.00188	0.00136	0.00276	4223	146	201	99
Fluorene	14.6	0.0187	0.0000648	0.00188	0.00136	0.00276	4223	146	201	99
Naphthalene	15.6	0.0187	0.0000648	0.00188	0.00136	0.00276	4493	155	214	105
Phenanthrene	4.68	0.0187	0.0000648	0.00188	0.00136	0.00276	1351	47	64	32
Pyrene	8.78	0.0187	0.0000648	0.00188	0.00136	0.00276	2534	87	121	59
Quinoline	2.7	0.0187	0.0000648	0.00188	0.00136	0.00276	768	26	37	18
Ethylbenzene	26	0.0187	0.0000648	0.00188	0.00136	0.00276	7440	256	354	175
Xylene	2.4	0.0187	0.0000648	0.00188	0.00136	0.00276	696	24	33	16
Phenol	159	0.0187	0.0000648	0.00188	0.00136	0.00276	45972	1585	2190	1079
2,4-Dimethylphenol	5.9	0.0187	0.0000648	0.00188	0.00136	0.00276	1689	58	80	40
m-cresol	815	0.0187	0.0000648	0.00188	0.00136	0.00276	235058	8102	11200	5519
o-cresol	815	0.0187	0.0000648	0.00188	0.00136	0.00276	235058	8102	11200	5519
Aluminum	2.26	0.0187	0.0000648	0.00188	0.00136	0.00276	652	22	31	15
Antimony	0.146	0.0187	0.0000648	0.00188	0.00136	0.00276	42	1.5	2.0	1.0
Arsenic	0.148	0.0187	0.0000648	0.00188	0.00136	0.00276	43	1.5	2.0	1.0
Barium	14.4	0.0187	0.0000648	0.00188	0.00136	0.00276	4168	144	199	98
Boron	93	0.0187	0.0000648	0.00188	0.00136	0.00276	26938	929	1284	632
Cadmium	0.224	0.0187	0.0000648	0.00188	0.00136	0.00276	65	2.2	3.1	1.5

TABLE III-2

SUMMARY OF RISK-BASED CONCENTRATIONS (RBCs) FOR THE INGESTION OF SOIL, FOOD AND WATER FOR WILDLIFE

Chemicals	Estimated[1] Chronic Wildlife NOAEL (mg/kg-BW/day)	Endpoint[2] Species Body Weight	Soil[2] Ingestion Rate (kg/day)	Plant[2] Ingestion Rate (kg/day)	Prey[2] Ingestion Rate (kg/day)	Water[2] Ingestion Rate (L/day)	Risk-Based[3] Concentration (mg/kg soil)	Risk-Based[3] Concentration (mg/kg plant)	Risk-Based[3] Concentration (mg/kg prey)	Risk-Based[3] Concentration (mg/L water)
Chromium (hexavalent)	8.71	0.0187	0.0000648	0.00188	0.00136	0.00276	2513	87	120	59
Chromium (trivalent)	7267	0.0187	0.0000648	0.00188	0.00136	0.00276	2097089	72283	99920	49236
Cobalt	6.2	0.0187	0.0000648	0.00188	0.00136	0.00276	1781	61	85	42
Copper	44.1	0.0187	0.0000648	0.00188	0.00136	0.00276	12731	439	607	299
Cyanide	16.8	0.0187	0.0000648	0.00188	0.00136	0.00276	4845	167	231	114
Lead	21.2	0.0187	0.0000648	0.00188	0.00136	0.00276	6130	211	292	144
Lithium	35.4	0.0187	0.0000648	0.00188	0.00136	0.00276	10209	352	486	240
Manganese	234	0.0187	0.0000648	0.00188	0.00136	0.00276	67426	2324	3213	1583
Mercury	0.0565	0.0187	0.0000648	0.7236	0.00136	0.00276	16	0.0015	0.78	0.38
Molybdenum	6.2	0.0187	0.0000648	0.7236	0.00136	0.00276	1796	0.16	86	42
Nickel	106	0.0187	0.0000648	0.7236	0.00136	0.00276	30648	2.7	1460	720
Selenium	0.64	0.0187	0.0000648	0.7236	0.00136	0.00276	184	0.016	8.8	4.3
Strontium	698	0.0187	0.0000648	0.7236	0.00136	0.00276	201511	18	9601	4731
Thallium	0.0199	0.0187	0.0000648	0.7236	0.00136	0.00276	5.7	0.00051	0.27	0.13
Uranium	3.51	0.0187	0.0000648	0.7236	0.00136	0.00276	1014	0.091	48	24
Vanadium	0.505	0.0187	0.0000648	0.7236	0.00136	0.00276	146	0.013	6.9	3.4
Zinc	425	0.0187	0.0000648	0.7236	0.00136	0.00276	122592	11	5841	2878
Zirconium	2.0	0.0187	0.0000648	0.7236	0.00136	0.00276	577	0.052	28	14
Ermine										
Acenaphthene	13.2	0.0692	0.00138	-	0.01239	0.00894	664	-	74	103
Acenaphthylene	13.2	0.0692	0.00138	-	0.01239	0.00894	664	-	74	103
Benzo(a)anthracene	7.6	0.0692	0.00138	-	0.01239	0.00894	380	-	42	59
Benzo(a)pyrene	0.76	0.0692	0.00138	-	0.01239	0.00894	38	-	4.2	5.9
Benzo(b,k)fluoranthene	7.6	0.0692	0.00138	-	0.01239	0.00894	380	-	42.3	59
Biphenyl	86	0.0692	0.00138	-	0.01239	0.00894	4304	-	479	664
Dibenzothiophene	5.68	0.0692	0.00138	-	0.01239	0.00894	285	-	32	44
Fluorene	9.5	0.0692	0.00138	-	0.01239	0.00894	474	-	53	73
Naphthalene	10.1	0.0692	0.00138	-	0.01239	0.00894	505	-	56	78

TABLE III-2

SUMMARY OF RISK-BASED CONCENTRATIONS (RBCs) FOR THE INGESTION OF SOIL, FOOD AND WATER FOR WILDLIFE

Chemicals	Estimated[1] Chronic Wildlife NOAEL (mg/kg-BW/day)	Endpoint[2] Species Body Weight	Soil[2] Ingestion Rate (kg/day)	Plant[2] Ingestion Rate (kg/day)	Prey[2] Ingestion Rate (kg/day)	Water[2] Ingestion Rate (L/day)	Risk-Based[3] Concentration (mg/kg soil)	Risk-Based[3] Concentration (mg/kg plant)	Risk-Based[3] Concentration (mg/kg prey)	Risk-Based[3] Concentration (mg/L water)
Phenanthrene	3.03	0.0692	0.00138	-	0.01239	0.00894	152	-	17	23
Pyrene	5.68	0.0692	0.00138	-	0.01239	0.00894	285	-	32	44
Quinoline	1.72	0.0692	0.00138	-	0.01239	0.00894	86	-	10	13
Ethylbenzene	17	0.0692	0.00138	-	0.01239	0.00894	836	-	93	129
Xylene	1.6	0.0692	0.00138	-	0.01239	0.00894	78	-	9	12
Phenol	103	0.0692	0.00138	-	0.01239	0.00894	5165	-	575	797
2,4-Dimethylphenol	3.8	0.0692	0.00138	-	0.01239	0.00894	190	-	21	29
m-cresol	527	0.0692	0.00138	-	0.01239	0.00894	26407	-	2941	4076
o-cresol	527	0.0692	0.00138	-	0.01239	0.00894	26407	-	2941	4076
Aluminum	1.46	0.0692	0.00138	-	0.01239	0.00894	73	-	8.2	11
Antimony	0.095	0.0692	0.00138	-	0.01239	0.00894	4.7	-	0.53	0.73
Arsenic	0.095	0.0692	0.00138	-	0.01239	0.00894	4.8	-	0.53	0.74
Barium	9.3	0.0692	0.00138	-	0.01239	0.00894	468	-	52	72
Boron	60	0.0692	0.00138	-	0.01239	0.00894	3026	-	337	467
Cadmium	0.145	0.0692	0.00138	-	0.01239	0.00894	7.3	-	0.81	1.1
Chromium (hexavalent)	5.63	0.0692	0.00138	-	0.01239	0.00894	282	-	31	44
Chromium (trivalent)	4698	0.0692	0.00138	-	0.01239	0.00894	235589	-	26240	36366
Cobalt	4.0	0.0692	0.00138	-	0.01239	0.00894	200	-	22	31
Copper	28.5	0.0692	0.00138	-	0.01239	0.00894	1430	-	159	221
Cyanide	10.9	0.0692	0.00138	-	0.01239	0.00894	544	-	61	84
Lead	13.7	0.0692	0.00138	-	0.01239	0.00894	689	-	77	106
Lithium	22.9	0.0692	0.00138	-	0.01239	0.00894	1147	-	128	177
Manganese	151	0.0692	0.00138	-	0.01239	0.00894	7575	-	844	1169
Mercury	0.037	0.0692	0.00138	-	0.01239	0.00894	1.8	-	0.20	0.28
Molybdenum	4.0	0.0692	0.00138	-	0.01239	0.00894	202	-	22	31
Nickel	69	0.0692	0.00138	-	0.01239	0.00894	3443	-	383	531
Selenium	0.41	0.0692	0.00138	-	0.01239	0.00894	21	-	2.3	3.2
Strontium	451	0.0692	0.00138	-	0.01239	0.00894	22638	-	2521	3494

TABLE III-2

SUMMARY OF RISK-BASED CONCENTRATIONS (RBCs) FOR THE INGESTION OF SOIL, FOOD AND WATER FOR WILDLIFE

Chemicals	Estimated[1] Chronic Wildlife NOAEL (mg/kg-BW/day)	Endpoint[2] Species Body Weight	Soil[2] Ingestion Rate (kg/day)	Plant[2] Ingestion Rate (kg/day)	Prey[2] Ingestion Rate (kg/day)	Water[2] Ingestion Rate (L/day)	Risk-Based[3] Concentration (mg/kg soil)	Risk-Based[3] Concentration (mg/kg plant)	Risk-Based[3] Concentration (mg/kg prey)	Risk-Based[3] Concentration (mg/L water)
Thallium	0.0129	0.0692	0.00138	-	0.01239	0.00894	0.65	-	0.072	0.10
Uranium	2.27	0.0692	0.00138	-	0.01239	0.00894	114	-	13	18
Vanadium	0.326	0.0692	0.00138	-	0.01239	0.00894	16	-	1.8	2.5
Zinc	275	0.0692	0.00138	-	0.01239	0.00894	13772	-	1534	2126
Zirconium	1.3	0.0692	0.00138	-	0.01239	0.00894	65	-	7.3	10
Snowshoe hare										
Acenaphthene	4.7	1.505	0.00742	0.1178	-	0.143	962	61	-	50
Acenaphthylene	4.7	1.505	0.00742	0.1178	-	0.143	962	61	-	50
Benzo(a)anthracene	2.7	1.505	0.00742	0.1178	-	0.143	550	35	-	29
Benzo(a)pyrene	0.27	1.505	0.00742	0.1178	-	0.143	55	3.5	-	2.9
Benzo(b,k)fluoranthene	2.7	1.505	0.00742	0.1178	-	0.143	550	35	-	29
Biphenyl	31	1.505	0.00742	0.1178	-	0.143	6237	393	-	324
Dibenzo(a,h)anthracene	0.054	1.505	0.00742	0.1178	-	0.143	11	0.69	-	0.57
Dibenzothiophene	2.03	1.505	0.00742	0.1178	-	0.143	412	26	-	21
Fluoranthene	3.4	1.505	0.00742	0.1178	-	0.143	687	43	-	36
Fluorene	3.4	1.505	0.00742	0.1178	-	0.143	687	43	-	36
Naphthalene	3.6	1.505	0.00742	0.1178	-	0.143	731	46	-	38
Phenanthrene	1.08	1.505	0.00742	0.1178	-	0.143	220	14	-	11
Pyrene	2.03	1.505	0.00742	0.1178	-	0.143	412	26	-	21
Quinoline	0.61	1.505	0.00742	0.1178	-	0.143	124	7.8	-	6.4
Ethylbenzene	5.97	1.505	0.00742	0.1178	-	0.143	1211	76	-	63
Xylene	0.56	1.505	0.00742	0.1178	-	0.143	113	7.1	-	5.9
Phenol	37	1.505	0.00742	0.1178	-	0.143	7484	471	-	388
2,4-Dimethylphenol	1.4	1.505	0.00742	0.1178	-	0.143	275	17	-	14
m-cresol	189	1.505	0.00742	0.1178	-	0.143	38266	2410	-	1986
o-cresol	189	1.505	0.00742	0.1178	-	0.143	38266	2410	-	1986
Aluminum	0.52	1.505	0.00742	0.1178	-	0.143	106	6.7	-	5.5
Antimony	0.034	1.505	0.00742	0.1178	-	0.143	6.9	0.43	-	0.36

TABLE III-2

SUMMARY OF RISK-BASED CONCENTRATIONS (RBCs) FOR THE INGESTION OF SOIL, FOOD AND WATER FOR WILDLIFE

Chemicals	Estimated[1] Chronic Wildlife NOAEL (mg/kg-BW/day)	Endpoint[2] Species Body Weight	Soil[2] Ingestion Rate (kg/day)	Plant[2] Ingestion Rate (kg/day)	Prey[2] Ingestion Rate (kg/day)	Water[2] Ingestion Rate (L/day)	Risk-Based[3] Concentration (mg/kg soil)	Risk-Based[3] Concentration (mg/kg plant)	Risk-Based[3] Concentration (mg/kg prey)	Risk-Based[3] Concentration (mg/L water)
Arsenic	0.034	1.505	0.00742	0.1178	-	0.143	6.9	0.44	-	0.36
Barium	3.3	1.505	0.00742	0.1178	-	0.143	679	43	-	35
Boron	22	1.505	0.00742	0.1178	-	0.143	4385	276	-	228
Cadmium	0.052	1.505	0.00742	0.1178	-	0.143	11	0.66	-	0.55
Chromium (hexavalent)	2.02	1.505	0.00742	0.1178	-	0.143	409	26	-	21
Chromium (trivalent)	1683	1.505	0.00742	0.1178	-	0.143	341390	21504	-	17714
Cobalt	1.4	1.505	0.00742	0.1178	-	0.143	290	18	-	15
Copper	10.2	1.505	0.00742	0.1178	-	0.143	2073	131	-	108
Cyanide	3.9	1.505	0.00742	0.1178	-	0.143	789	50	-	41
Lead	4.9	1.505	0.00742	0.1178	-	0.143	998	63	-	52
Lithium	8.2	1.505	0.00742	0.1178	-	0.143	1662	105	-	86
Manganese	54	1.505	0.00742	0.1178	-	0.143	10976	691	-	570
Mercury	0.013	1.505	0.00742	0.1178	-	0.143	2.7	0.17	-	0.14
Molybdenum	1.4	1.505	0.00742	0.1178	-	0.143	292	18	-	15
Nickel	25	1.505	0.00742	0.1178	-	0.143	4989	314	-	259
Selenium	0.15	1.505	0.00742	0.1178	-	0.143	30	1.9	-	1.6
Strontium	162	1.505	0.00742	0.1178	-	0.143	32804	2066	-	1702
Thallium	0.0046	1.505	0.00742	0.1178	-	0.143	0.94	0.059	-	0.049
Uranium	0.81	1.505	0.00742	0.1178	-	0.143	165	10	-	8.6
Vanadium	0.117	1.505	0.00742	0.1178	-	0.143	24	1.5	-	1.2
Zinc	98	1.505	0.00742	0.1178	-	0.143	19957	1257	-	1036
Zirconium	0.57	1.505	0.00742	0.1178	-	0.143	116	7.3	-	6.0
Beaver										
Acenaphthene	2.06	18.275	0.0434	0.7237	-	1.353	869	52	-	28
Acenaphthylene	2.06	18.275	0.0434	0.7237	-	1.353	869	52	-	28
Benzo(a)anthracene	1.2	18.275	0.0434	0.7237	-	1.353	497	30	-	16
Benzo(a)pyrene	0.12	18.275	0.0434	0.7237	-	1.353	50	3.0	-	1.6
Benzo(b,k)fluoranthene	1.2	18.275	0.0434	0.7237	-	1.353	497	30	-	16

TABLE III-2

SUMMARY OF RISK-BASED CONCENTRATIONS (RBCs) FOR THE INGESTION OF SOIL, FOOD AND WATER FOR WILDLIFE

Chemicals	Estimated[1] Chronic Wildlife NOAEL (mg/kg-BW/day)	Endpoint[2] Species Body Weight	Soil[2] Ingestion Rate (kg/day)	Plant[2] Ingestion Rate (kg/day)	Prey[2] Ingestion Rate (kg/day)	Water[2] Ingestion Rate (L/day)	Risk-Based[3] Concentration (mg/kg soil)	Risk-Based[3] Concentration (mg/kg plant)	Risk-Based[3] Concentration (mg/kg prey)	Risk-Based[3] Concentration (mg/L water)
Biphenyl	13.4	18.275	0.0434	0.7237	-	1.353	5633	338	-	181
Dibenzo(a,h)anthracene	0.024	18.275	0.0434	0.7237	-	1.353	10	0.61	-	0.32
Dibenzothiophene	0.88	18.275	0.0434	0.7237	-	1.353	373	22	-	12
Fluoranthene	1.47	18.275	0.0434	0.7237	-	1.353	621	37	-	20
Fluorene	1.47	18.275	0.0434	0.7237	-	1.353	621	37	-	20
Naphthalene	1.57	18.275	0.0434	0.7237	-	1.353	661	40	-	21
Phenanthrene	0.47	18.275	0.0434	0.7237	-	1.353	199	12	-	6.4
Pyrene	0.88	18.275	0.0434	0.7237	-	1.353	373	22	-	12
Quinoline	0.27	18.275	0.0434	0.7237	-	1.353	114	6.8	-	3.6
Ethylbenzene	2.60	18.275	0.0434	0.7237	-	1.353	1094	66	-	35
Xylene	0.24	18.275	0.0434	0.7237	-	1.353	102	6.1	-	3.3
Phenol	16	18.275	0.0434	0.7237	-	1.353	6760	405	-	217
2,4-Dimethylphenol	0.6	18.275	0.0434	0.7237	-	1.353	248	15	-	8.0
m-cresol	82.1	18.275	0.0434	0.7237	-	1.353	34562	2073	-	1109
o-cresol	82.1	18.275	0.0434	0.7237	-	1.353	34562	2073	-	1109
Aluminum	0.228	18.275	0.0434	0.7237	-	1.353	96	5.7	-	3.1
Antimony	0.0147	18.275	0.0434	0.7237	-	1.353	6.2	0.37	-	0.20
Arsenic	0.0149	18.275	0.0434	0.7237	-	1.353	6.3	0.38	-	0.20
Barium	1.46	18.275	0.0434	0.7237	-	1.353	613	37	-	20
Boron	9.4	18.275	0.0434	0.7237	-	1.353	3961	238	-	127
Cadmium	0.0226	18.275	0.0434	0.7237	-	1.353	10	0.57	-	0.30
Chromium (hexavalent)	0.88	18.275	0.0434	0.7237	-	1.353	370	22	-	12
Chromium (trivalent)	732	18.275	0.0434	0.7237	-	1.353	308351	18492	-	9891
Cobalt	0.62	18.275	0.0434	0.7237	-	1.353	262	16	-	8.4
Copper	4.4	18.275	0.0434	0.7237	-	1.353	1872	112	-	60
Cyanide	1.69	18.275	0.0434	0.7237	-	1.353	712	43	-	23
Lead	2.14	18.275	0.0434	0.7237	-	1.353	901	54	-	29
Lithium	3.6	18.275	0.0434	0.7237	-	1.353	1501	90	-	48

TABLE III-2

SUMMARY OF RISK-BASED CONCENTRATIONS (RBCs) FOR THE INGESTION OF SOIL, FOOD AND WATER FOR WILDLIFE

Chemicals	Estimated[1] Chronic Wildlife NOAEL (mg/kg-BW/day)	Endpoint[2] Species Body Weight	Soil[2] Ingestion Rate (kg/day)	Plant[2] Ingestion Rate (kg/day)	Prey[2] Ingestion Rate (kg/day)	Water[2] Ingestion Rate (L/day)	Risk-Based[3] Concentration (mg/kg soil)	Risk-Based[3] Concentration (mg/kg plant)	Risk-Based[3] Concentration (mg/kg prey)	Risk-Based[3] Concentration (mg/L water)
Manganese	23.5	18.275	0.0434	0.7237	-	1.353	9914	595	-	318
Mercury	0.0057	18.275	0.0434	0.7237	-	1.353	2.4	0.14	-	0.077
Molybdenum	0.63	18.275	0.0434	0.7237	-	1.353	264	16	-	8.5
Nickel	10.7	18.275	0.0434	0.7237	-	1.353	4506	270	-	145
Selenium	0.064	18.275	0.0434	0.7237	-	1.353	27	1.6	-	0.87
Strontium	70	18.275	0.0434	0.7237	-	1.353	29630	1777	-	950
Thallium	0.00201	18.275	0.0434	0.7237	-	1.353	0.85	0.051	-	0.027
Uranium	0.35	18.275	0.0434	0.7237	-	1.353	149	8.9	-	4.8
Vanadium	0.051	18.275	0.0434	0.7237	-	1.353	21	1.3	-	0.69
Zinc	43	18.275	0.0434	0.7237	-	1.353	18026	1081	-	578
Zirconium	0.47	18.275	0.0434	0.7237	-	1.353	198	12	-	6.3
Moose										
Acenaphthene	0.75	381	0.132	6.586	-	20.83	2165	43	-	14
Acenaphthylene	0.75	381	0.132	6.586	-	20.83	2165	43	-	14
Benzo(a)anthracene	0.43	381	0.132	6.586	-	20.83	1237	25	-	7.8
Benzo(a)pyrene	0.043	381	0.132	6.586	-	20.83	124	2.5	-	0.78
Benzo(b,k)fluoranthene	0.43	381	0.132	6.586	-	20.83	1237	25	-	7.8
Biphenyl	4.9	381	0.132	6.586	-	20.83	14029	281	-	89
Dibenzo(a,h)anthracene	0.0086	381	0.132	6.586	-	20.83	25	0.50	-	0.16
Dibenzothiophene	0.32	381	0.132	6.586	-	20.83	928	19	-	5.9
Fluoranthene	0.54	381	0.132	6.586	-	20.83	1546	31	-	10
Fluorene	0.54	381	0.132	6.586	-	20.83	1546	31	-	10
Naphthalene	0.57	381	0.132	6.586	-	20.83	1645	33	-	10
Phenanthrene	0.17	381	0.132	6.586	-	20.83	495	10	-	3.1
Pyrene	0.32	381	0.132	6.586	-	20.83	928	19	-	5.9
Quinoline	0.10	381	0.132	6.586	-	20.83	289	5.8	-	1.8
Ethylbenzene	0.94	381	0.132	6.586	-	20.83	2724	55	-	17
Xylene	0.09	381	0.132	6.586	-	20.83	255	5.1	-	1.6

TABLE III-2

SUMMARY OF RISK-BASED CONCENTRATIONS (RBCs) FOR THE INGESTION OF SOIL, FOOD AND WATER FOR WILDLIFE

Chemicals	Estimated[1] Chronic Wildlife NOAEL (mg/kg-BW/day)	Endpoint[2] Species Body Weight	Soil[2] Ingestion Rate (kg/day)	Plant[2] Ingestion Rate (kg/day)	Prey[2] Ingestion Rate (kg/day)	Water[2] Ingestion Rate (L/day)	Risk-Based[3] Concentration (mg/kg soil)	Risk-Based[3] Concentration (mg/kg plant)	Risk-Based[3] Concentration (mg/kg prey)	Risk-Based[3] Concentration (mg/L water)
Phenol	6	381	0.132	6.586	-	20.83	16835	337	-	107
2,4-Dimethylphenol	0.2	381	0.132	6.586	-	20.83	619	12	-	3.9
m-cresol	29.8	381	0.132	6.586	-	20.83	86079	1725	-	545
o-cresol	29.8	381	0.132	6.586	-	20.83	86079	1725	-	545
Aluminum	0.083	381	0.132	6.586	-	20.83	239	4.8	-	1.5
Antimony	0.0054	381	0.132	6.586	-	20.83	15	0.31	-	0.10
Arsenic	0.0054	381	0.132	6.586	-	20.83	16	0.31	-	0.10
Barium	0.53	381	0.132	6.586	-	20.83	1526	31	-	10
Boron	3.4	381	0.132	6.586	-	20.83	9865	198	-	63
Cadmium	0.0082	381	0.132	6.586	-	20.83	24	0.47	-	0.15
Chromium (hexavalent)	0.32	381	0.132	6.586	-	20.83	920	18	-	5.8
Chromium (trivalent)	266	381	0.132	6.586	-	20.83	767963	15392	-	4867
Cobalt	0.23	381	0.132	6.586	-	20.83	652	13	-	4.1
Copper	1.6	381	0.132	6.586	-	20.83	4662	93	-	30
Cyanide	0.61	381	0.132	6.586	-	20.83	1774	36	-	11
Lead	0.78	381	0.132	6.586	-	20.83	2245	45	-	14
Lithium	1.3	381	0.132	6.586	-	20.83	3739	75	-	24
Manganese	8.6	381	0.132	6.586	-	20.83	24692	495	-	156
Mercury	0.0021	381	0.132	6.586	-	20.83	6.0	0.12	-	0.038
Molybdenum	0.23	381	0.132	6.586	-	20.83	658	13	-	4.2
Nickel	3.9	381	0.132	6.586	-	20.83	11223	225	-	71
Selenium	0.023	381	0.132	6.586	-	20.83	67	1.3	-	0.43
Strontium	26	381	0.132	6.586	-	20.83	73794	1479	-	468
Thallium	0.00073	381	0.132	6.586	-	20.83	2.1	0.042	-	0.013
Uranium	0.13	381	0.132	6.586	-	20.83	371	7.4	-	2.4
Vanadium	0.018	381	0.132	6.586	-	20.83	53	1.1	-	0.34
Zinc	16	381	0.132	6.586	-	20.83	44894	900	-	284
Zirconium	0.07	381	0.132	6.586	-	20.83	214	4.3	-	1.4

TABLE III-2

SUMMARY OF RISK-BASED CONCENTRATIONS (RBCs) FOR THE INGESTION OF SOIL, FOOD AND WATER FOR WILDLIFE

Chemicals	Estimated[1] Chronic Wildlife NOAEL (mg/kg-BW/day)	Endpoint[2] Species Body Weight	Soil[2] Ingestion Rate (kg/day)	Plant[2] Ingestion Rate (kg/day)	Prey[2] Ingestion Rate (kg/day)	Water[2] Ingestion Rate (L/day)	Risk-Based[3] Concentration (mg/kg soil)	Risk-Based[3] Concentration (mg/kg plant)	Risk-Based[3] Concentration (mg/kg prey)	Risk-Based[3] Concentration (mg/L water)
American robin										
Acenaphthene	52	0.0836	0.001814	0.004884	0.01256	0.019227	2377	883	343	224
Acenaphthylene	52	0.0836	0.001814	0.004884	0.01256	0.019227	2377	883	343	224
Benzo(a)anthracene	0.19	0.0836	0.001814	0.004884	0.01256	0.019227	8.5	3.2	1.2	0.81
Benzo(a)pyrene	0.019	0.0836	0.001814	0.004884	0.01256	0.019227	0.87	0.32	0.13	0.082
Benzo(b,k)fluoranthene	0.19	0.0836	0.001814	0.004884	0.01256	0.019227	8.5	3.2	1.2	0.81
Dibenzothiophene	52	0.0836	0.001814	0.004884	0.01256	0.019227	2377	883	343	224
Fluorene	52	0.0836	0.001814	0.004884	0.01256	0.019227	2377	883	343	224
Phenanthrene	52	0.0836	0.001814	0.004884	0.01256	0.019227	2377	883	343	224
Pyrene	52	0.0836	0.001814	0.004884	0.01256	0.019227	2377	883	343	224
Aluminum	137	0.0836	0.001814	0.004884	0.01256	0.019227	6307	2343	911	595
Arsenic	2.1	0.0836	0.001814	0.004884	0.01256	0.019227	95	35	14	9.0
Arsenic	12	0.0836	0.001814	0.004884	0.01256	0.019227	541	201	78	51
Barium	24	0.0836	0.001814	0.004884	0.01256	0.019227	1086	403	157	102
Boron	28	0.0836	0.001814	0.004884	0.01256	0.019227	1270	472	183	120
Cadmium	3.5	0.0836	0.001814	0.004884	0.01256	0.019227	160	60	23	15
Chromium	2.5	0.0836	0.001814	0.004884	0.01256	0.019227	114	42	16	11
Cobalt	1.9	0.0836	0.001814	0.004884	0.01256	0.019227	86	32	12	8.1
Copper	62	0.0836	0.001814	0.004884	0.01256	0.019227	2840	1055	410	268
Lead	4.5	0.0836	0.001814	0.004884	0.01256	0.019227	206	76	30	19
Manganese	369	0.0836	0.001814	0.004884	0.01256	0.019227	17012	6319	2457	1605
Mercury	0.015	0.0836	0.001814	0.004884	0.01256	0.019227	0.67	0.25	0.10	0.064
Molybdenum	18	0.0836	0.001814	0.004884	0.01256	0.019227	848	315	122	80
Nickel	163	0.0836	0.001814	0.004884	0.01256	0.019227	7516	2792	1085	709
Selenium	1.1	0.0836	0.001814	0.004884	0.01256	0.019227	53	20	7.6	5.0
Selenium	0.91	0.0836	0.001814	0.004884	0.01256	0.019227	42	16	6.1	4.0
Uranium	39	0.0836	0.001814	0.004884	0.01256	0.019227	1817	675	262	171
Vanadium	27	0.0836	0.001814	0.004884	0.01256	0.019227	1264	469	183	119

TABLE III-2

SUMMARY OF RISK-BASED CONCENTRATIONS (RBCs) FOR THE INGESTION OF SOIL, FOOD AND WATER FOR WILDLIFE

Chemicals	Estimated[1] Chronic Wildlife NOAEL (mg/kg-BW/day)	Endpoint[2] Species Body Weight	Soil[2] Ingestion Rate (kg/day)	Plant[2] Ingestion Rate (kg/day)	Prey[2] Ingestion Rate (kg/day)	Water[2] Ingestion Rate (L/day)	Risk-Based[3] Concentration (mg/kg soil)	Risk-Based[3] Concentration (mg/kg plant)	Risk-Based[3] Concentration (mg/kg prey)	Risk-Based[3] Concentration (mg/L water)
Zinc	6.9	0.0836	0.001814	0.004884	0.01256	0.019227	316	117	46	30
American kestrel										
Acenaphthene	44	0.137	0.00548	-	0.01211	0.0278	1094	-	495	216
Acenaphthylene	44	0.137	0.00548	-	0.01211	0.0278	1094	-	495	216
Benzo(a)anthracene	0.16	0.137	0.00548	-	0.01211	0.0278	3.9	-	1.8	0.77
Benzo(a)pyrene	0.016	0.137	0.00548	-	0.01211	0.0278	0.40	-	0.18	0.079
Benzo(b,k)fluoranthene	0.16	0.137	0.00548	-	0.01211	0.0278	3.9	-	1.8	0.77
Dibenzothiophene	44	0.137	0.00548	-	0.01211	0.0278	1094	-	495	216
Fluorene	44	0.137	0.00548	-	0.01211	0.0278	1094	-	495	216
Phenanthrene	44	0.137	0.00548	-	0.01211	0.0278	1094	-	495	216
Pyrene	44	0.137	0.00548	-	0.01211	0.0278	1094	-	495	216
Aluminum	116	0.137	0.00548	-	0.01211	0.0278	2902	-	1313	572
Arsenic	1.75	0.137	0.00548	-	0.01211	0.0278	44	-	20	8.6
Arsenic	10.0	0.137	0.00548	-	0.01211	0.0278	249	-	113	49
Barium	20	0.137	0.00548	-	0.01211	0.0278	500	-	226	98
Boron	23	0.137	0.00548	-	0.01211	0.0278	584	-	264	115
Cadmium	2.9	0.137	0.00548	-	0.01211	0.0278	74	-	33	15
Chromium	2.1	0.137	0.00548	-	0.01211	0.0278	52	-	24	10
Cobalt	1.59	0.137	0.00548	-	0.01211	0.0278	40	-	18	7.8
Copper	52	0.137	0.00548	-	0.01211	0.0278	1307	-	591	258
Lead	3.8	0.137	0.00548	-	0.01211	0.0278	95	-	43	19
Manganese	313	0.137	0.00548	-	0.01211	0.0278	7827	-	3542	1543
Mercury	0.012	0.137	0.00548	-	0.01211	0.0278	0.31	-	0.14	0.061
Molybdenum	16	0.137	0.00548	-	0.01211	0.0278	390	-	176	77
Nickel	138	0.137	0.00548	-	0.01211	0.0278	3458	-	1565	682
Selenium	0.97	0.137	0.00548	-	0.01211	0.0278	24	-	11	4.8
Selenium	0.78	0.137	0.00548	-	0.01211	0.0278	19	-	8.8	3.8
Uranium	33	0.137	0.00548	-	0.01211	0.0278	836	-	378	165

TABLE III-2

SUMMARY OF RISK-BASED CONCENTRATIONS (RBCs) FOR THE INGESTION OF SOIL, FOOD AND WATER FOR WILDLIFE

Chemicals	Estimated[1] Chronic Wildlife NOAEL (mg/kg-BW/day)	Endpoint[2] Species Body Weight	Soil[2] Ingestion Rate (kg/day)	Plant[2] Ingestion Rate (kg/day)	Prey[2] Ingestion Rate (kg/day)	Water[2] Ingestion Rate (L/day)	Risk-Based[3] Concentration (mg/kg soil)	Risk-Based[3] Concentration (mg/kg plant)	Risk-Based[3] Concentration (mg/kg prey)	Risk-Based[3] Concentration (mg/L water)
Vanadium	23	0.137	0.00548	-	0.01211	0.0278	582	-	263	115
Zinc	5.8	0.137	0.00548	-	0.01211	0.0278	145	-	66	29
Ruffed Grouse										
Acenaphthene	28	0.54285	0.001173	0.0391	-	0.07776	12793	384	-	193
Acenaphthylene	28	0.54285	0.001173	0.0391	-	0.07776	12793	384	-	193
Benzo(a)anthracene	0.099	0.54285	0.001173	0.0391	-	0.07776	46	1.4	-	0.69
Benzo(a)pyrene	0.010	0.54285	0.001173	0.0391	-	0.07776	4.7	0.14	-	0.071
Benzo(b,k)fluoranthene	0.099	0.54285	0.001173	0.0391	-	0.07776	46	1.4	-	0.69
Dibenzothiophene	28	0.54285	0.001173	0.0391	-	0.07776	12793	384	-	193
Fluorene	28	0.54285	0.001173	0.0391	-	0.07776	12793	384	-	193
Phenanthrene	28	0.54285	0.001173	0.0391	-	0.07776	12793	384	-	193
Pyrene	28	0.54285	0.001173	0.0391	-	0.07776	12793	384	-	193
Aluminum	73	0.54285	0.001173	0.0391	-	0.07776	33948	1018	-	512
Arsenic	1.1	0.54285	0.001173	0.0391	-	0.07776	511	15	-	7.7
Arsenic	6.3	0.54285	0.001173	0.0391	-	0.07776	2913	87	-	44
Barium	13	0.54285	0.001173	0.0391	-	0.07776	5844	175	-	88
Boron	15	0.54285	0.001173	0.0391	-	0.07776	6834	205	-	103
Cadmium	1.9	0.54285	0.001173	0.0391	-	0.07776	863	26	-	13
Chromium	1.3	0.54285	0.001173	0.0391	-	0.07776	611	18	-	9.2
Cobalt	1.0	0.54285	0.001173	0.0391	-	0.07776	464	14	-	7.0
Copper	33	0.54285	0.001173	0.0391	-	0.07776	15285	459	-	231
Lead	2.4	0.54285	0.001173	0.0391	-	0.07776	1106	33	-	17
Manganese	198	0.54285	0.001173	0.0391	-	0.07776	91567	2747	-	1381
Mercury	0.0078	0.54285	0.001173	0.0391	-	0.07776	3.6	0.11	-	0.055
Molybdenum	9.9	0.54285	0.001173	0.0391	-	0.07776	4562	137	-	69
Nickel	87	0.54285	0.001173	0.0391	-	0.07776	40454	1214	-	610
Selenium	0.61	0.54285	0.001173	0.0391	-	0.07776	284	8.5	-	4.3
Selenium	0.49	0.54285	0.001173	0.0391	-	0.07776	227	6.8	-	3.4

TABLE III-2

SUMMARY OF RISK-BASED CONCENTRATIONS (RBCs) FOR THE INGESTION OF SOIL, FOOD AND WATER FOR WILDLIFE

Chemicals	Estimated[1] Chronic Wildlife NOAEL (mg/kg-BW/day)	Endpoint[2] Species Body Weight	Soil[2] Ingestion Rate (kg/day)	Plant[2] Ingestion Rate (kg/day)	Prey[2] Ingestion Rate (kg/day)	Water[2] Ingestion Rate (L/day)	Risk-Based[3] Concentration (mg/kg soil)	Risk-Based[3] Concentration (mg/kg plant)	Risk-Based[3] Concentration (mg/kg prey)	Risk-Based[3] Concentration (mg/L water)
Uranium	21	0.54285	0.001173	0.0391	-	0.07776	9778	293	-	147
Vanadium	15	0.54285	0.001173	0.0391	-	0.07776	6803	204	-	103
Zinc	3.7	0.54285	0.001173	0.0391	-	0.07776	1702	51	-	26
Mallard										
Acenaphthene	22	1.107	0.00205	0.01574	0.0464	0.13277	11771	1533	520	182
Acenaphthylene	22	1.107	0.00205	0.01574	0.0464	0.13277	11771	1533	520	182
Benzo(a)anthracene	0.078	1.107	0.00205	0.01574	0.0464	0.13277	42	5.5	1.9	0.65
Benzo(a)pyrene	0.0080	1.107	0.00205	0.01574	0.0464	0.13277	4.3	0.56	0.19	0.067
Benzo(b,k)fluoranthene	0.078	1.107	0.00205	0.01574	0.0464	0.13277	42	5.5	1.9	0.65
Dibenzothiophene	22	1.107	0.00205	0.01574	0.0464	0.13277	11771	1533	520	182
Fluorene	22	1.107	0.00205	0.01574	0.0464	0.13277	11771	1533	520	182
Phenanthrene	22	1.107	0.00205	0.01574	0.0464	0.13277	11771	1533	520	182
Pyrene	22	1.107	0.00205	0.01574	0.0464	0.13277	11771	1533	520	182
Aluminum	58	1.107	0.00205	0.01574	0.0464	0.13277	31237	4068	1380	482
Arsenic	0.87	1.107	0.00205	0.01574	0.0464	0.13277	470	61	21	7.3
Arsenic	5.0	1.107	0.00205	0.01574	0.0464	0.13277	2681	349	118	41
Barium	10	1.107	0.00205	0.01574	0.0464	0.13277	5377	700	238	83
Boron	12	1.107	0.00205	0.01574	0.0464	0.13277	6289	819	278	97
Cadmium	1.5	1.107	0.00205	0.01574	0.0464	0.13277	794	103	35	12
Chromium	1.0	1.107	0.00205	0.01574	0.0464	0.13277	562	73	25	8.7
Cobalt	0.79	1.107	0.00205	0.01574	0.0464	0.13277	427	56	19	6.6
Copper	26	1.107	0.00205	0.01574	0.0464	0.13277	14065	1832	621	217
Lead	1.9	1.107	0.00205	0.01574	0.0464	0.13277	1018	133	45	16
Manganese	156	1.107	0.00205	0.01574	0.0464	0.13277	84255	10974	3722	1301
Mercury	0.0062	1.107	0.00205	0.01574	0.0464	0.13277	3.3	0.44	0.15	0.052
Molybdenum	7.8	1.107	0.00205	0.01574	0.0464	0.13277	4197	547	185	65
Nickel	69	1.107	0.00205	0.01574	0.0464	0.13277	37224	4848	1645	575
Selenium	0.48	1.107	0.00205	0.01574	0.0464	0.13277	261	34	12	4.0

TABLE III-2

SUMMARY OF RISK-BASED CONCENTRATIONS (RBCs) FOR THE INGESTION OF SOIL, FOOD AND WATER FOR WILDLIFE

Chemicals	Estimated[1] Chronic Wildlife NOAEL (mg/kg-BW/day)	Endpoint[2] Species Body Weight	Soil[2] Ingestion Rate (kg/day)	Plant[2] Ingestion Rate (kg/day)	Prey[2] Ingestion Rate (kg/day)	Water[2] Ingestion Rate (L/day)	Risk-Based[3] Concentration (mg/kg soil)	Risk-Based[3] Concentration (mg/kg plant)	Risk-Based[3] Concentration (mg/kg prey)	Risk-Based[3] Concentration (mg/L water)
Selenium	0.39	1.107	0.00205	0.01574	0.0464	0.13277	209	27	9.2	3.2
Uranium	17	1.107	0.00205	0.01574	0.0464	0.13277	8997	1172	397	139
Vanadium	12	1.107	0.00205	0.01574	0.0464	0.13277	6260	815	277	97
Zinc	2.9	1.107	0.00205	0.01574	0.0464	0.13277	1566	204	69	24

[1] No-Observed Adverse Effect Level (NOAEL) based on the toxicological literature and the method by Opresko *et. al.* 1994. See Table III-1.

[2] Based on literature derived values. See Appendix V for derivation and summary.

[3] Risk-Based Concentration (RBC) = (NOAEL x body weight) / (ingestion rate x exposure frequency ratio x bioavailability factor)
Note that for the screening assessment, both exposure frequency and bioavailability factors were set equal to one.

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APPENDIX IV

DERIVATION OF EXPOSURE LIMITS FOR CHEMICALS OF CONCERN

APPENDIX IV

DERIVATION OF EXPOSURE LIMITS FOR CHEMICALS OF CONCERN

1.0 HUMAN RECEPTORS

1.1 Naphthenic Acids

An extensive literature search was performed to identify toxicity information on naphthenic acids that would be applicable to human and ecological health risk assessment. The following is a summary of the toxicity data available

Acute and Subchronic Toxicity Studies

An oral (gavage) dose of 3,500 mg/kg and an intraperitoneal dose of 860 mg/kg of naphthenic acid each resulted in 50% mortality (LD_{50}) in young male white mice. These lethal doses also demonstrated symptoms of toxicity including central nervous depression without analgesia, corneal eye opacity, dryness of mouth, convulsions and diarrhea. Death was due to respiratory arrest. A daily oral (gavage) dose of 1,000 mg/kg/day repeated for 30 days produced central nervous system depression without loss of analgesia, hematological changes, weight loss and death due to respiratory arrest. Gross morphological changes in the liver and stomach were noted as well as histopathological changes in a few selected organs (Pennisi and dePaul Lynch 1977).

The acute oral toxicities of two naphthenic acid fractions and seven commercial metal naphthenates were determined in rats using oral gavage. A fraction of naphthenate derived from crude kerosene acids produced 50% mortality at a dose of 3,000 mg/kg and a fraction derived from mixed crude acids proved lethal at 5,200 mg/kg. The metal naphthenates, with their respective metal contents (calcium, 4%; cobalt, 6%; copper, 8%; lead, 24%; mercury, 10 %; manganese, 6% and zinc, 8%) produced 50% mortality at various concentrations. Four of the metal salts (Mn, Cu, Zn and Ca) possessed an LD_{50} greater than 6,000 mg/kg, while lead was slightly below at 5,100 mg/kg and cobalt was at 3,900 mg/kg. Only the phenyl mercury naphthenate proved to be more toxic than the naphthenic acids at 390 mg/kg. Symptomatically, the deaths appeared to result from gastrointestinal disturbances including anorexia, diarrhea, and severe weakness (Rockhold 1955). This study also included an investigation of the subchronic toxicity of lead naphthenate administered orally. Rats received 20 daily doses of 1% (as Pb) solution of lead naphthenate over a four week period. No abnormal characteristics in either action or appearance were observed. No deaths occurred and no changes were noted during gross and histopathological examinations conducted on animals sacrificed on termination of the 30 day experimentation period.

A developmental and teratogenic toxicity study evaluated zinc naphthenate administered to pregnant rats during the major period of fetal organogenesis. Maternal toxicity was confined to the highest dose group (938 mg/kg/day) and indicated symptoms of lethargy and less body weight gain. That dosage also produced a higher incidence of resorptions and lower average fetal body weight. Dams receiving 94.0 or 188 mg/kg/day were not affected, nor were their developing fetuses. It was concluded that zinc naphthenate only affected the developing fetus at a dosage level which produced signs of maternal toxicity (Angerhofer et al. 1991).

Chronic Toxicity Studies

No chronic studies assessing the effects of naphthenic acids were available in the literature.

Human Toxicity Studies

Insufficient data regarding the effects of naphthenic acids on human health were available in the literature. There was also insufficient evidence to suggest that naphthenic acids are carcinogenic to humans.

Human Health Criteria

Studies were identified that assessed the acute toxicity of naphthenic acids as well as the acute and subchronic toxicity of various naphthenic compounds. These investigations did not, however, provide a range of data adequate to derive human health criteria. Therefore, an RfD was not derived for naphthenic acids

The table below compares the doses that cause 50% mortality in various species:

Chemical	LD_{50} rat	LD_{50} mice	TDLo rabbit	Reference
naphthenic acids	3,000 mg/kg	3550 mg/kg	NA	Rockhold 1955, Pennisi & dePaul Lynch 1977
calcium naphthenate	>6,000 mg/kg	NA	NA	Rockhold 1955
cobalt naphthenate	3,900 mg/kg	NA	NA	Rockhold 1955
copper naphthenate	>6,000 mg/kg	NA	NA	Rockhold 1955
lead naphthenate	5,100 mg/kg	NA	NA	Rockhold 1955
phenyl mercury naphthenate	390 mg/kg	NA	NA	Rockhold 1955
manganese naphthenate	>6000 mg/kg	NA	NA	Rockhold 1955
zinc naphthenate	>6000 mg/kg	NA	NA	Rockhold 1955

References

Angerhofer, R.A., M.W. Michie, M.P. Barlow and P.A. Beall. 1991. Assessment of the developmental toxicity of zinc naphthenate in rats. Govt. Reports Announcements & Index. Issue 18, 32p.

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2.0 ECOLOGICAL RECEPTORS

2.1 BENZO(A)PYRENE

No specific data were found on the oral toxicity of benzo(a)pyrene to avian wildlife. Most toxicological studies have been conducted on polyaromatic mixtures such as crude oils. A study was reviewed in which Prudhoe Bay crude oil was administered in single oral doses ranging from 200 to 2000 mg/kg body weight to nestling herring gulls (Peakall et al. 1982). Herring gulls were observed to have a reduced weight gain and a transient impairment of their osmoregulatory capacity. The high molecular weight fraction of Prudhoe Bay Crude Oil was reported as being responsible for these effects. In the absence of receptor specific and chemical-specific data, oral RfDs were derived based on the acute LD_{50} of 200 mg/kg body weight derived for this study. It has been reported that benzo(a)pyrene constitutes 0.75-2.8% of crude oil. Assuming that the crude oil contains 2.8% of benzo(a)pyrene, an acute LD_{50} of 5.6 mg/kg body weight was derived. For avian wildlife, the following uncertainty factors were applied: 5 to extrapolate from the acute LD_{50} to a acute NOEL; 10 to extrapolate from an acute dose to a subchronic dose; 10 to extrapolate from subchronic dose to a chronic dose. These uncertainty factors were applied to the acute LD_{50} of 5.6 mg/kg body weight/day to derive an oral RfD of 0.011 mg/kg body weight/day (RfD = 5.6 mg/kg body weight/day/500).

For this assessment, the chronic RfD was used to estimate receptor-specific RfD for avian wildlife by adjusting the dose according to differences in body size as outlined in the Opresko et al. (1994) and summarized in Section 5.1.2.3.2 and Table 5.1-34. For the American kestrel, a receptor-specific RfD of 0.016 mg/kg-BW/day was derived.

For the current assessment, the ingestion bioavailability for benzo(a)pyrene was assumed to be 100%.

References

Opresko, D.M., B.E. Sample and G.W. Suter II. 1994. Toxicological benchmarks for wildlife: 1994 revision. Oak Ridge National Laboratory. Oak Ridge, Tennessee.

Peakall, D.B., D.J. Hallet, J.R. Bend, G.L. Foureman and D.S. Miller. 1982. Toxicity of Prudhoe Bay crude oil and its aromatic fractions to nestling herring gulls. Environ. Res. 27:206-215.

2.2 ALUMINUM

No specific data were located on the oral toxicity of aluminum to mammalian wildlife. A LOAEL of 19.3 mg/kg-BW/day was reported for reproductive effects (i.e., decreased growth in generations two and three) in laboratory mice that were exposed to aluminum in drinking water for three generations (Ondreicka et al. 1966). An uncertainty factor of 10 was applied to the LOAEL to extrapolate from the LOAEL to a NOAEL resulting in an RfD of 1.93 mg/kg-BW/day. Exposure was considered to be chronic because it was greater than one year and occurred during a critical lifestage.

For this assessment, the chronic RfD was used to estimate a receptor-specific RfD for mammalian wildlife by adjusting the dose according to differences in body size as outlined in the Opresko et al. (1994) and summarized in Section 5.1.2.3.2 and Table 5.1-34. For deer mice, beaver, snowshoe hare and moose, receptor-specific RfDs of 2.3, 0.23, 0.52 and 0.083 mg/kg-BW/day, respectively, were derived.

For the current assessment, the ingestion bioavailability for aluminum was assumed to be 100%.

References

Ondreicka, R., E. Ginter and J. Kortus. 1966. Chronic toxicity of aluminum in rats and mice and its effects on phosphorus metabolism. Brit. J. Indust. Med. 23:305-313.

Opresko, D.M., B.E. Sample and G.W. Suter II. 1994. Toxicological benchmarks for wildlife: 1994 revision. Oak Ridge National Laboratory. Oak Ridge, Tennessee.

2.3 ARSENIC

No specific data were located on the oral toxicity of arsenic to mammalian wildlife. A LOAEL of 1.261 mg/kg-BW/day was reported for reproductive effects (i.e., declining litter sizes) in laboratory mice that were exposed to arsenic in drinking water for three generations (Schroeder and Mitchener 1971). An uncertainty factor of 10 was applied to the LOAEL to extrapolate from the LOAEL to a NOAEL resulting in an RfD of 0.1261 mg/kg-BW/day. Exposure was considered to be chronic because it was greater than one year and occurred during a critical lifestage.

For this assessment, the chronic RfD was used to estimate receptor-specific RfD for mammalian wildlife by adjusting the dose according to differences in body size as outlined in the Opresko et al. (1994) and summarized in Section 5.1.2.3.2 and Table 5.1-34. For beaver, snowshoe hare and moose, receptor-specific RfDs of 0.015, 0.034 and 0.0054 mg/kg-BW/day, respectively, were derived.

For the current assessment, the ingestion bioavailability for arsenic was assumed to be 100%.

References

Opresko, D.M., B.E. Sample and G.W. Suter II. 1994. Toxicological benchmarks for wildlife: 1994 revision. Oak Ridge National Laboratory. Oak Ridge, Tennessee.

Schroeder, H.A. and M. Mitchener. 1971. Toxic effects of trace elements on the reproduction of mice and rats. Arch. Environ. Health. 23:102-106.

2.4 BARIUM

No specific data were located on the oral toxicity of barium to avian wildlife. A NOAEL of 208.26 mg/kg-BW/day was reported for mortality for day-old chicks that were exposed to barium hydroxide in the diet for four weeks (Johnson et al. 1960). An uncertainty factor of 10 was applied to the NOAEL to extrapolate from subchronic to chronic exposure resulting in a chronic RfD of 20.826 mg/kg-BW/day.

For this assessment, the chronic RfD was used to estimate receptor-specific RfD for avian wildlife by adjusting the dose according to differences in body size as outlined in the Opresko et al. (1994) and summarized in Section 5.1.2.3.2 and Table 5.1-34. For mallard, a receptor-specific RfD of 10 mg/kg-BW/day was derived.

For the current assessment, the ingestion bioavailability for barium was assumed to be 100%.

References

Johnson, D., Jr., A.L. Mehring, Jr. and H.W. Titus. 1960. Tolerance of chickens for barium. Proc. Soc. Exp. Biol. Med. 104: 436-438.

Opresko, D.M., B.E. Sample and G.W. Suter II. 1994. Toxicological benchmarks for wildlife: 1994 revision. Oak Ridge National Laboratory. Oak Ridge, Tennessee.

2.5 CADMIUM

No specific data were located on the oral toxicity of cadmium to mammalian wildlife. A LOAEL of 1.913 mg/kg-BW/day was reported for reproductive effects (i.e., reduced survival and congenital deformities) in laboratory mice that were exposed to cadmium for two generations (Schroeder and Mitchener 1971). An uncertainty factor of 10 was applied to the LOAEL to extrapolate from the LOAEL to a NOAEL resulting in an RfD of 0.1913 mg/kg-BW/day. Exposure was considered to be chronic because it was greater than one year and occurred during a critical lifestage.

For this assessment, the chronic RfD was used to estimate receptor-specific RfD for mammalian wildlife by adjusting the dose according to differences in body size as outlined in the Opresko et al. (1994) and summarized in Section 5.1.2.3.2 and Table 5.1-34. For moose, a receptor-specific RfD of and 0.0082 mg/kg-BW/day was derived.

For the current assessment, the ingestion bioavailability for cadmium was assumed to be 100%.

References

Opresko, D.M., B.E. Sample and G.W. Suter II. 1994. Toxicological benchmarks for wildlife: 1994 revision. Oak Ridge National Laboratory. Oak Ridge, Tennessee.

Schroeder, H.A. and M. Mitchener. 1971. Toxic effects of trace elements on the reproduction of mice and rats. Arch. Environ. Health. 23: 102-106. Cited in: Opresko et al. (1994).

2.6 MOLYBDENUM

No suitable toxicological studies were located in the literature from which an exposure limit could be derived for molybdenum. However, the National Research Council reported maximum tolerable levels for molybdenum of 10 mg/kg diet for cattle that would not be expected to result in adverse effects (NAS 1980). This maximum tolerable level converts to a concentration of 0.24 mg/kg body weight/day for cattle (assuming a grazing steer eats 7.7 kg food/day and weighs 318 kg). Therefore in the absence of molybdenum toxicity data for mammals, the maximum tolerable level for cattle of 0.24 mg/kg body weight/day was assumed to represent a conservative estimate of a chronic NOAEL for mammalian wildlife.

For this assessment, the chronic RfD was used to estimate receptor-specific RfD for mammalian wildlife by adjusting the dose according to differences in body size as outlined in the Opresko et al. (1994) and summarized in Section 5.1.2.3.2 and Table 5.1-34. For deer mice, a receptor-specific RfD of 6.2 mg/kg-BW/day was derived.

References

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Opresko, D.M., B.E. Sample and G.W. Suter II. 1994. Toxicological benchmarks for wildlife: 1994 revision. Oak Ridge National Laboratory. Oak Ridge, Tennessee.

2.7 NICKEL

No specific data were located on the oral toxicity of nickel to mammalian wildlife. A NOAEL of 40 mg/kg-BW/day was reported for reproductive effects in laboratory rats that were exposed to nickel sulfate hexahydrate in the diet for three generations (Ambrose et al. 1976). Exposure was considered to be chronic because it was greater than one year and occurred during a critical lifestage.

For this assessment, the chronic RfD was used to estimate receptor-specific RfD for mammalian wildlife by adjusting the dose according to differences in body size as outlined in the Opresko et al. (1994) and summarized in Section 5.1.2.3.2 and Table 5.1-34. For deer mice, a receptor-specific RfD of 106 mg/kg-BW/day was derived.

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Ambrose, A.M., P.S. Larson, J.F. Borzelleca and G.R. Hennigar, Jr. 1976. Long-term toxicologic assessment of nickel in rats and dogs. J. Food Sci. Tech. 13: 181-187.

Opresko, D.M., B.E. Sample and G.W. Suter II. 1994. Toxicological benchmarks for wildlife: 1994 revision. Oak Ridge National Laboratory. Oak Ridge, Tennessee.

2.8 STRONTIUM

No specific data were located on the oral toxicity of strontium to mammalian wildlife. A NOAEL of 263 mg/kg-BW/day was reported for body weight and bone changes in laboratory rats that were exposed to strontium chloride (55% strontium) in drinking water for three years (Skoryna 1981). Exposure was considered to be chronic because it was greater than one year.

For this assessment, the chronic RfD was used to estimate receptor-specific RfD for mammalian wildlife by adjusting the dose according to differences in body size as outlined in the Opresko et al. (1994) and summarized in Section 5.1.2.3.2 and Table 5.1-34. For deer mice, a receptor-specific RfD of 698 mg/kg-BW/day was derived.

References

Skoryna, S.C. 1981. Effects of oral supplementation with stable strontium. Can. Med. Assoc. J. 125: 703-712.

Opresko, D.M., B.E. Sample and G.W. Suter II. 1994. Toxicological benchmarks for wildlife: 1994 revision. Oak Ridge National Laboratory. Oak Ridge, Tennessee.

2.9 THALLIUM

No specific data were located on the oral toxicity of thallium to mammalian wildlife. A LOAEL of 0.74 mg/kg-BW/day was reported for reproductive effects (i.e., male testicular function) in laboratory rats that were exposed to thallium sulfate in drinking water for 60 days (Formigli et al. 1986). Uncertainty factors of 10 were applied to the NOAEL to extrapolate from subchronic to chronic exposure, and additional uncertainty factors of 10 were applied to extrapolate from LOAEL to NOAEL, resulting in a chronic RfD of 0.0074 mg/kg-BW/day.

For this assessment, the chronic RfD was used to estimate receptor-specific RfD for mammalian wildlife by adjusting the dose according to differences in body size as outlined in the Opresko et al. (1994) and summarized in Section 5.1.2.3.2 and Table 5.1-34. For deer mice, a receptor-specific RfD of 0.02 mg/kg-BW/day was derived.

References

Formigli, L., R. Scelsi, P. Poggi, C. Gregotti, A. DiNucci, E. Sabbioni, L. Gottardi and L. Manxo. 1986. Thallium-induced testicular toxicity in the rat. Environ. Res. 40: 531-539.

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2.10 URANIUM

No specific data were located on the oral toxicity of uranium to mammalian wildlife. A NOAEL of 3.07 mg/kg-BW/day was reported for reproductive effects (i.e., decreased survival, reduced number of young per litter, reduced size and weight of offspring) in laboratory mice that were exposed to uranyl acetate by oral gavage for 60 days prior to gestation, during gestation, delivery and lactation (Paternain et al. 1989). Exposure was considered to be chronic because it occurred during a critical lifestage.

For this assessment, the chronic RfD was used to estimate receptor-specific RfD for mammalian wildlife by adjusting the dose according to differences in body size as outlined in the Opresko et al. (1994) and summarized in Section 5.1.2.3.2 and Table 5.1-34. For deer mice, a receptor-specific RfD of 3.5 mg/kg-BW/day was derived.

References

Opresko, D.M., B.E. Sample and G.W. Suter II. 1994. Toxicological benchmarks for wildlife: 1994 revision. Oak Ridge National Laboratory. Oak Ridge, Tennessee.

Paternain, J.L., J.L. Domingo, A. Ortega and J.M. Llobet. 1989. The effects of uranium on reproduction, gestation, and postnatal survival in mice. Ecotoxicol. Environ. Saf. 17: 291-296.

2.11 VANADIUM

No specific data were located on the oral toxicity of vanadium to mammalian wildlife. A LOAEL of 2.1 mg/kg-BW/day was reported for reproductive effects (i.e., decreased survival, reduced number of young per litter, reduced size and weight of offspring) in laboratory rats that were exposed to sodium metavanadate by oral gavage for 60 days prior to gestation, during gestation, delivery and lactation (Domingo et al. 1986). An uncertainty factor of 10 was applied to the LOAEL to extrapolate from the LOAEL to a NOAEL, resulting in an RfD of 0.21 mg/kg-BW/day. Exposure was considered to be chronic because it occurred during a critical lifestage.

For this assessment, the chronic RfD was used to estimate receptor-specific RfD for mammalian wildlife by adjusting the dose according to differences in body size as outlined in the Opresko et al. (1994) and summarized in Section 5.1.2.3.2 and Table 5.1-34. For deer mice, beaver, snowshoe hare and moose, receptor-specific RfDs of 0.5, 0.051, 0.12 and 0.018 mg/kg-BW/day, respectively, were derived.

No specific data were located on the oral toxicity of vanadium to avian wildlife. A NOAEL of 11.38 mg/kg-BW/day was reported for mortality, body weight changes and blood chemistry changes in mallards that were exposed to vanadyl sulfate in the diet for 12 weeks (White and Dieter 1978). Exposure was considered to be chronic because it was greater than 10 weeks duration.

For this assessment, the chronic RfD was used to estimate receptor-specific RfD for avian wildlife by adjusting the dose according to differences in body size as outlined in the Opresko et al. (1994) and summarized in Section 5.1.2.3.2 and Table 5.1-34. For ruffed grouse, a receptor-specific RfD of 15 mg/kg-BW/day was derived.

References

Domingo, J.L., J.L. Paternain, J.M. Llobet and J. Corbella. 1986. Effects of vanadium on reproduction, gestation, parturition and lactation in rats upon oral administration. Life Sci. 39: 819-824.

Opresko, D.M., B.E. Sample and G.W. Suter II. 1994. Toxicological benchmarks for wildlife: 1994 revision. Oak Ridge National Laboratory. Oak Ridge, Tennessee.

White, D.H. and M.P. Dieter. 1978. Effects of dietary vanadium in mallard ducks. J. Toxicol. Environ. Health. 4: 43-50.

2.12 ZINC

No specific data were located on the oral toxicity of zinc to avian wildlife. A LOAEL of 300 mg/kg-BW/day was reported for mortality, body weight changes and blood chemistry changes in mallards that were exposed to zinc carbonate in the diet for 60 days (Gasaway and Buss 1972). Uncertainty factors of 10 were applied to the LOAEL to extrapolate from subchronic to chronic exposure, and 10 to extrapolate from LOAEL to NOAEL, resulting in a chronic RfD of 3 mg/kg-BW/day.

For this assessment, the chronic RfD was used to estimate receptor-specific RfD for avian wildlife by adjusting the dose according to differences in body size as outlined in the Opresko et al. (1994) and summarized in Section 5.1.2.3.2 and Table 5.1-34. For mallards, a receptor-specific RfD of 2.9 mg/kg-BW/day was derived.

References

Gasaway, W.C. and I.O. Buss. 1972. Zinc toxicity in the mallard. J. Wildl. Manage. 36: 1107-1117.

Opresko, D.M., B.E. Sample and G.W. Suter II. 1994. Toxicological benchmarks for wildlife: 1994 revision. Oak Ridge National Laboratory. Oak Ridge, Tennessee.

APPENDIX V

WILDLIFE EXPOSURE FACTORS

APPENDIX V

WILDLIFE EXPOSURE FACTORS

1.0 ECOLOGICAL AND PHYSIOLOGICAL ASSUMPTIONS FOR RUFFED GROUSE (*Bonasa umbellus*)

Body Weight:

Mean body mass adult female grouse (kg)[1]	0.543
standard deviation (SD)	0.0303
coefficient of variation (CV)	0.0558
sample size	12

Distribution: Normal

Deterministic value for body mass (minimum mean body mass; mean - 2SD)	0.482

[1] Mean body mass for female ruffed grouse given in Bump et al. (1947) for New York, USA.

Food Ingestion Rate: Primarily herbivorous, ruffed grouse consume 80% buds, leaves, flowers, seeds and fruit and the remaining 20% of their diet consists of insects, spiders, snails and young vertebrates (Ehrlich et al. 1988). Principal species of trees, shrubs and forbs consumed (i.e., buds, catkins, fruits and leaves) include aspen, poplar, apple, grape, sumac, beech and alder (Johnsgard 1983). Other plants include, clover, greenbrier, hazelnut blueberry, birches, chokecherry, maple, rosehips, dogwood fruits, willow buds, wild strawberry leaves and fruit, wintergreen leaves, saskatoon berries (see Johnsgard 1983). Ruffed grouse chicks consume primarily insects during the first week to 10 days of life (Bump et al. 1947). Approximately 70% of the food taken in the first 2 weeks consists of insects, as compared with 30% during the third and fourth weeks and dropping to 5% by the end of July (Bump et al. 1947). Ants are a frequent food item and other invertebrate species consumed include sawflies, ichneumons, beetles, spiders, grasshoppers and a variety of caterpillar species (Bump et al. 1947). Plant foods taken include sedge achenes and the fruits of strawberries, raspberries, blackberries and cherries (Bump et al. 1947).

For modelling purposes, we will assume an adult female grouse eating a completely herbivorous diet.

Food ingestion rate[2] (FI rate) (kg/day):
(dry weight - herbivorous diet)

for birds with mean mass (0.532 kg)	0.0391
for birds with minimum mass (0.482 kg)	0.0362
Standard deviation[3]	0.0022

Distribution: Normal[4]

Deterministic value for food ingestion rate (maximum FI rate; mean + 2SD):

for birds with mean mass (0.532 kg)	0.0435 kg/day
for birds with minimum mass (0.482 kg)	0.0406 kg/day

[2] Food ingestion rates estimate based on an allometric equation for all birds (Nagy 1987): FI (kg dry weight /day) = $0.0582(\text{Body weight kg})^{0.651}$.
[3] Standard deviation for food ingestion based on the coefficient of variation for body mass as FI is correlated to body mass (standard deviation = CV x FI rate for mean mass bird).
[4] Assumed to be the same as for body mass.

Foraging Home Range Size:

Mean home range size[5] (ha)	11.3
standard deviation (SD)[6]	4.6
coefficient of variation (CV)	0.41
sample size[5]	3

Distribution: not normal[7]

[5] Mean foraging home range size calculated from three study groups (Godfrey 1975, Maxon 1978).
[6] Standard deviation calculated from the three studies.
[7] Distribution considered not normal due to variation given in Godfrey (1975).

Fraction of Food Derived From Site: Ruffed grouse could obtain 100% of their annual food requirements on-site as they are present and active in the area year-round (Semenchuk 1992).

Water Ingestion Rate:

Water ingestion rate[8] (WI rate) (L/day):

for birds with mean mass (0.532 kg)	0.0780
for birds with minimum mass (0.482 kg)	0.0712
standard deviation (SD)[9]	0.0043

Distribution: Given mean and standard deviation, MEI is a normal distribution.[10]

Deterministic value for food ingestion rate (mean WI rate; mean + 2SD):	
for birds with mean mass (0.532 kg)	0.0864
for birds with minimum mass (0.482 kg)	0.080

[8] Water ingestion rate estimated using four allometric equations: (1) Calder and Braun (1983), WI (L/day) = 0.059(Body weight kg)$^{0.67}$; Ohmart et al. (1970), WI (L/day) = 0.111(Body weight kg)$^{0.69}$; Thomas and Phillips (1975) WI (L/day) = 0.203(Body Weight kg)$^{0.81}$; Walter and Hughes (1978), WI (L/day) = 0.119(Body Weight kg)$^{0.75}$.

[9] Standard deviation for water ingestion based on the coefficient of variation for body mass as WI is correlated to body mass (standard deviation = CV x WI rate for mean mass grouse).

[10] Assumed to be the same as for body mass.

Fraction of Water Derived From Site: Ruffed grouse could obtain 100% of their annual water requirements on-site as they are present and active in the area year-round (Semenchuk 1992).

Soil Ingestion Rate: Beyer et al. (1994) estimate that soil in the diet of a ruffed grouse amounts to approximately 2-4% of daily food intake (food in dry mass). For modelling purposes, we assume 4% soil in the diet.

Soil ingestion rate[11] (SI rate) (kg/day):	
for birds with mean mass (0.532 kg)	0.0016
for birds with minimum mass (0.482 kg)	0.0015
standard deviation (SD)[12]	0.0022

Distribution: Normal[13]

Deterministic value for soil ingestion rate, kg/day (maximum SI rate; mean + 2SD):	
for birds with mean mass (0.532 kg)	0.0059
for birds with minimum mass (0.482 kg)	0.0058

[11] Soil ingestion rate estimated.

[12] Standard deviation for soil ingestion based on the coefficient of variation for body mass as SI is correlated to body mass (standard deviation = CV x SI rate for mean mass ruffed grouse).

[13] Assumed to be the same as for body mass.

Fraction of Soil Derived From Site: Ruffed grouse could obtain 100% of the soil they ingest from the study area as they are present and active in the area year-round (Semenchuk (1992).

Time Spent On Site

Ruffed grouse are present and active year-round in the study area (Semenchuk 1992).

Habitat Preferences

In Alberta, ruffed grouse are most abundant in aspen-dominated and mixed wood forests (Semenchuk 1992). Small openings in the deciduous forest function as brood cover and represent an important part of their overall preferred habitat type (Johnsgard 1973). A heavy understory is needed for drumming sites (Johnsgard 1973).

General Information

Alberta populations of ruffed grouse are quite healthy and populations generally vary on a 10 year cycle (Semenchuk 1992). High winter mortality is often experienced due to predators (i.e., raptors) and severe weather conditions (Semenchuk 1992).

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2.0 ECOLOGICAL AND PHYSIOLOGICAL ASSUMPTIONS FOR MALLARDS (*Anas platyrhyncos*)

Body Weight:

Mean body mass adult female (kg)[14]	1.107
standard deviation (SD)	0.129
coefficient of variation (CV)	0.117
sample size (# studies)	3

Distribution: **Normal**

Deterministic value for body mass (minimum mean body mass; mean - 2SD)	0.849 kg

[14] Mean body mass calculated from data given in Owen and Cook (1977), Nelson and Martin (1953) and Krapu and Doty (1979).

Food Ingestion Rate: Mallards are considered 'dabbling' ducks which means that they feed in shallow water tipping up and down while foraging on bulrush seeds, snails and invertebrates from the bottom (Gadd 1995). Infrequently, they may also ingest tadpoles or scavenge dead fish (Gadd 1995). Other items included in the diet are crustacea, annelids, various seeds, tubers and stems (Dillon 1959, Swanson et al. 1985).

Food ingestion rate[15] **(FI rate) (kg/day): (dry weight - 75% invertebrates; 25% plant material)**[16]	**animal**	**plant**
for birds with mean mass (1.107 kg)	0.0464	0.0157
for birds with minimum mass (0.849 kg)	0.039	0.0132
standard deviation (SD)[17]	0.0072	

Distribution: **Normal (based on the fact that FI is dependant on body mass which is normally distributed.**[18]

Deterministic value for food ingestion rate (maximum FI rate; mean + 2SD):	**animal**	**plant**
for birds with mean mass (1.107 kg)	0.0573	0.0194
for birds with minimum mass (0.849 kg)	0.0499	0.0169

[15] Food ingestion rates estimate based on an allometric equation for all birds (Nagy 1987): FI (g dry weight /day) = 0.648 (Body weight g)$^{0.651}$.

[16] Diet composition from Swanson et al. (1985).

[17] Standard deviation for food ingestion based on the coefficient of variation for body mass as FI is correlated to body mass (standard deviation = CV x FI rate for mean mass bird).

[18] Assumed to be the same as for body mass.

Foraging Home Range Size:

Mean home range size[19] (ha)	468
standard deviation (SD)	159
coefficient of variation (CV)	0.34
sample size (n)	6

Distribution: not normal

[19] Mean foraging home range size calculated from data given in Dwyer et al. (1979) in north Dakota.

Fraction of Food Derived From Site: Mallards are likely in this area for a maximum of 197 days per year (Semenchuk 1992). Assuming that birds spend 100% of their time on site while in Canada, the maximum fraction of food from the contaminated sites would be 197/365 = 0.54 of their annual food requirements.

Water Ingestion Rate:

Water ingestion rate[20] (WI rate) (L/day):	
for birds with mean mass (1.107 kg)	0.133
for birds with minimum mass (0.849 kg)	0.109
standard deviation (SD)[21]	0.016

Distribution: Given mean and standard deviation, MEI is a normal distribution.[22]

Deterministic value for water ingestion rate (mean WI rate; mean + 2SD):	
for birds with mean mass (1.107 kg)	0.164 L/day
for birds with minimum mass (0.849 kg)	0.140 L/day

[20] Water ingestion rate estimated using four allometric equations: (1) Calder and Braun (1983), WI (L/day) = 0.059(Body weight kg)$^{0.67}$; Ohmart et al. (1970), WI (L/day) = 0.111(Body weight kg)$^{0.69}$; Thomas and Phillips (1975) WI (L/day) = 0.203(Body Weight kg)$^{0.81}$; Walter and Hughes (1978), WI (L/day) = 0.119(Body Weight kg)$^{0.75}$.

[21] Standard deviation for water ingestion based on the coefficient of variation for body mass as WI is correlated to body mass (standard deviation = CV x WI rate for mean mass duck).

[22] Assumed to be the same as for body mass.

Fraction of Water Derived From Site: Mallards are likely in this area for a maximum of 197 days per year (Semenchuk 1992). Assuming that birds spend 100% of their time on site while in Canada, the maximum fraction of water from the contaminated sites would be 197/365 = 0.54 of their annual water requirements.

Soil Ingestion Rate: Beyer et al. (1994) estimate that soil in the diet of a mallard amounts to approximately 3.3% of daily food intake (food in dry mass) based on 88 samples from Minnesota mallards.

Soil ingestion rate[23] (SI rate) (kg/day):	
for birds with mean mass (1.107 kg)	0.0021
for birds with minimum mass (0.849 kg)	0.0017
standard deviation (SD)[24]	0.00024

Distribution: Normal[25]

Deterministic value for soil ingestion rate, kg/day (maximum SI rate; mean + 2SD):	
for birds with mean mass (1.107 kg)	0.0025
for birds with minimum mass (0.849 kg)	0.0022

[23] Soil ingestion rate estimated based on ingestion rates for mallard ducks (Beyer et al. 1994).

[24] Standard deviation for soil ingestion based on the coefficient of variation for body mass as SI is correlated to body mass (standard deviation = CV x SI rate for mean mass duck).

[25] Assumed to be the same as for body mass.

Fraction of Soil Derived From Site: Mallards are likely in this area for a maximum of 197 days per year (Semenchuk 1992). Assuming that birds spend 100% of their time on site while in Canada, the maximum fraction of soil from the contaminated sites would be 197/365 = 0.54 of their annual soil ingestion.

Time Spent On Site

Mallards are migratory birds which breed in the study area during the summer months. Mallards arrive in Alberta in late March, early April and leave by late November (estimated number of days present is approximately 197) (Semenchuk 1992). Some birds may overwinter in Fort McMurray (Semenchuk 1992).

Habitat Preferences

Habitat preferences for mallards are variable. They are adaptable birds that may use marshes, ponds, the margins of small and large lakes, islands, quiet waters of rivers, ditches, or flooded land in both treeless and wooded country (Semenchuk 1992).

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3.0 ECOLOGICAL AND PHYSIOLOGICAL ASSUMPTIONS FOR MOOSE (*Alces alces*)

Body Weight:

Mean body mass (kg)[26]	381.17
standard deviation (SD)	35.14
coefficient of variation (CV)	0.0922
sample size (# studies)	3

Distribution: Normal

Deterministic value for body mass (minimum body mass; mean - 2SD)	310.88

[26] Mean body mass for female moose calculated for data given in Doutt (1970), Smith (1993) and Stelfox (1993).

Food Ingestion Rate: Common forages for moose include a variety of tree and shrub species, fallen leaves, bark, forbs, sedges and horsetail (Stelfox 1993, see table below for list of species).

Food ingestion rate[27] **(FI rate) (kg/day):**

for moose with mean mass (381.17 kg)	6.59
for moose with minimum mass (310.88 kg)	5.68
standard deviation (SD)[28]	0.607

Distribution: Normal (based on the fact that FI is dependant on body mass which is normally distributed.[29]

Deterministic value for food ingestion rate (maximum FI rate; mean + 2SD)

for moose with mean mass (381.17 kg)	7.801 kg/day
for moose with minimum mass (48.9 kg)	6.894 kg/day

[27] food ingestion rate calculated as a function of body mass using one allometric equation FI (g dry weight /day) = 0.577(Body weight g)$^{0.727}$ (Nagy 1987).

[28] Standard deviation for food ingestion based on the coefficient of variation for body mass as FI is correlated to body mass (standard deviation = CV x FI rate for mean mass moose).

[29] Assumed to be the same as for body mass.

Home Range:

Mean home range[30] (ha)
we have three very different values for home range 1352 ha; 25800 ha (sd=6820) and 8180 ha (sd=1120)

standard deviation (SD)
coefficient of variation (CV)
sample size (n)

Distribution: **not normal**

[30] Home range calculated from data given in Ballard et al. (1991) and from Harestad and Bunnell's (1979) allometric equation: Home range (ha) = 6.06(Body weight kg)$^{0.91}$.

Fraction of Food Derived From Site:

Water Ingestion Rate:

Water ingestion rate[31] (WI rate) (L /day):	
for moose with mean mass (381.17 kg)	20.83
for moose with minimum mass (310.88 kg)	17.34
standard deviation (SD)[32]	1.92

Distribution: Normal[33]

Deterministic value for water ingestion rate, L/day (maximum WI rate; mean + 2SD):	
for moose with mean mass (381.17 kg)	24.67
for moose with minimum mass (310.88 kg)	21.18

[31] Water ingestion rate estimated based on one allometric equation, Calder and Braun (1983).
[32] Standard deviation for water ingestion based on the coefficient of variation for body mass as WI is correlated to body mass (standard deviation = CV x WI rate for mean mass moose).
[33] Assumed to be the same as for body mass.

Fraction of Water Derived From Site:

Soil Ingestion Rate: Beyer et al. (1994) estimate that soil in the diet of moose amounts to approximately 2.0% of daily food intake (food in dry mass).

Soil ingestion rate[34] (SI rate) (kg/day):	
for moose with mean mass (381.17 kg)	0.1317
for moose with minimum mass (310.88 kg)	0.1136
standard deviation (SD)[35]	0.0122

Distribution: Normal[36]

Deterministic value for soil ingestion rate, kg/day (maximum SI rate; mean + 2SD):	
for moose with mean mass (381.17 kg)	0.1560
for moose with minimum mass (310.88 kg)	0.1379

[34] Soil ingestion rate estimated based data from Beyer et al. (1994).
[35] Standard deviation for soil ingestion based on the coefficient of variation for body mass as SI is correlated to body mass (standard deviation = CV x SI rate for mean mass moose).
[36] Assumed to be the same as for body mass.

Time Spent On Site

Moose are present in the area year-round (Burt 1976, Smith 1993, Gadd 1995).

Habitat Preferences

Preferred habitat of moose in Alberta is mixedwoods (Smith 1993). Moose are often found near the edges of lakes, bogs and streams (Smith 1993).

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LIST OF COMMON FORAGES FOR MOOSE (Stelfox 1993):

Common Name	***Scientific Name***
Trees and Shrubs	
alder	*Alnus* spp.
alpine fir	*Abies lasiocarpa*
aspen	*Populus tremuloides*
balsam poplar	*Populus balsamifera*
beaked hazelnut	*Corylus cornuta*
buckbrush	*Symphoricarpos occidentalis*
buffaloberry	*Sheperdia canadensis*
choke cherry	*Prunus virginiana*
clematis	*Clematis* spp.
Douglas fir	*Pseudotsuga menziesii*
dwarf birch	*Betula glandulosa*
high-bush cranberry	*Vibirnum opulus*
honeysuckle	*Lonicera* spp.
juniper	*Juniperus* spp.
Labrador tea	*Ledum groenlandicum*
low-bush cranberry	*Vibirnum edule*
paper birch	*Betula papyrifera*
pin cherry	*Prunus pensylvanica*
pine	*Pinus* spp.
raspberry	*Rubus idaeus*
red-osier dogwood	*Cornus stolonifera*
rose	*Rosa* spp.
saskatoon	*Amelanchier alnifolia*
spruce	*Picea* spp.
water birch	*Betula occidentalis*
wild gooseberry	*Ribes oxyacanthoides*
willow	*Salix* spp.
Fallen Leaves and Bark	
aspen	*Populus tremuloides*
balsam poplar	*Populus balsamifera*
willow	*Salix* spp.
Forbs	
Canada thistle	*Cirsium arvense*
clover	*Trifolium* spp.
common yarrow	*Achillea millefolium*
fleabane	*Erigeron* spp.
Indian paint-brush	*Castilleja* spp.

Common Name	***Scientific Name***
low-bush cranberry	*Vibirnum edule*
nettle	*Urtica dioica*
pea vine	*Lathyrus* spp.
Sago pondweed	*Potamogeton pectinatus*
wild raspberry	*Rubus idaeus*
yellow pond lily	*Nuphar variegatum*
Graminoids	
common cattail	*Typha latifolia*
sedge	*Carex* spp.
Horsetail	*Equisetum* spp.

4.0 ECOLOGICAL AND PHYSIOLOGICAL ASSUMPTIONS FOR SNOWSHOE HARE (*Lepus americanus*)

Body Weight:

Mean body mass (kg)[37]	1.505
standard deviation (SD)	0.065
coefficient of variation (CV)	0.043
sample size(# studies)	4

Distribution: Normal

Deterministic value for body mass (kg) (minimum body mass; mean - 2SD)	1.376

[37] Mean body mass for snowshoe hare based on data from four studies (Roman and Keith 1959, Soper 1973, Windberg and Keith 1976 and Smith 1993).

Food Ingestion Rate: During summer, snowshoe hares feed on succulent vegetation and during winter, twigs, buds and bark (Burt 1976). Summer foods include grasses, wildflowers (especially pea-family plants and clover) and new leaves of aspen, willow and birch (Gadd 1995). In winter they eat the leaves of plants that stay green, such as kinnikinnick and wintergreen, the twig-ends and buds of shrubs and sometimes lichens (Gadd 1995).

Food ingestion rate[38] **(FI rate) (kg/day):**	
for hare with mean mass (1.505 kg)	0.118
for hare with minimum mass (1.376 kg)	0.110
standard deviation (SD)[39]	0.005

Distribution: Normal (based on the fact that FI is dependant on body mass which is normally distributed.[40]

Deterministic value for food ingestion rate (maximum FI rate; mean + 2SD)

for hare with mean mass (1.505 kg)	0.128 kg/day
for hare with minimum mass (1.376 kg)	0.121 kg/day

[38] Food ingestion rate calculated as a function of body mass using the allometric equation FI (g dry weight /day) = $0.577(\text{Body weight g})^{0.727}$ (Nagy 1987).

[39] Standard deviation for food ingestion based on the coefficient of variation for body mass as FI is correlated to body mass (standard deviation = CV x FI rate for mean mass hare).

[40] Assumed to be the same as for body mass.

Home Range:

Mean home range[41] (ha)	4-7
standard deviation (SD)	
coefficient of variation (CV)	
sample size (n)	

Distribution: not normal

[41] Home range size estimate given in the U.S. EPA Exposure Factors Handbook (1993) and Gadd (1995); see also Burt (1976).

Fraction of Food Derived From Site:

Water Ingestion Rate:

Water ingestion rate[42] (WI rate) (L /day):	
for snowshoe hare with mean mass (1.505 kg)	0.143
for snowshoe hare with min. mass (1.376 kg)	0.132
standard deviation (SD)[43]	0.006

Distribution: Normal[44]

Deterministic value for water ingestion rate (L/day) (maximum WI rate; mean + 2SD):	
for snowshoe hare with mean mass (1.505 kg)	0.155
for snowshoe hare with min. mass (1.376 kg)	0.144

[42] Water ingestion rate estimated an allometric equation, WI (L/day) = $0.099Wt^{0.90}$ where Wt is body weight in (kg) (Calder and Braun 1983).
[43] Standard deviation for water ingestion based on the coefficient of variation for body mass as WI is correlated to body mass (standard deviation = CV x WI rate for mean mass hare).
[44] Assumed to be the same as for body mass.

Fraction of Water Derived From Site:

Soil Ingestion Rate: Arthur and Gates (1988) estimate that soil in the diet of a similar species, the black-tailed jackrabbit, amounts to approximately 6.3% of daily food intake (food in dry mass).

Soil ingestion rate[45] (SI rate) (kg/day):	
for hare with mean mass (1.505 kg)	0.0074
for hare with minimum mass (1.376 kg)	0.0070
standard deviation (SD)[46]	0.00032

Distribution: Normal[47]

Deterministic value for soil ingestion rate, kg/day (maximum SI rate; mean + 2SD):	
for hare with mean mass (1.505 kg)	0.0081
for hare with minimum mass (1.376 kg)	0.0076

[45] Soil ingestion rate estimated based data for black-tailed jackrabbits from Arthur and Gates (1988).
[46] Standard deviation for soil ingestion based on the coefficient of variation for body mass as SI is correlated to body mass (standard deviation = CV x SI rate for mean mass hare).
[47] Assumed to be the same as for body mass.

Time Spent On Site

Snowshoe hares are resident year round on the study area (Burt 1976, Smith 1993, Gadd 1995).

Habitat Preference

Snowshoe hares prefer forests and shrubby areas and will use open areas only rarely and only if a quick route to brushy cover is available (Smith 1993). Daytime resting spots are called 'forms' which consist of a beaten-down spot under the drooping, thickly needled lower branches of spruce trees, sometime in dense brush and long grass, or under a log in a tangle of fallen trees (Gadd 1995).

General Information

Generally, snowshoe hares are common throughout their range although populations may fluctuate dramatically (Smith 1993).

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5.0 ECOLOGICAL AND PHYSIOLOGICAL ASSUMPTIONS FOR BEAVER (*Castor canadensis*)

Body Weight:

Mean body mass (kg)[48]	18.275
standard deviation (SD)	3.02
coefficient of variation (CV)	0.165
sample size (# studies)	4

Distribution: Normal

Deterministic value for body mass (kg) (minimum body mass; mean - 2SD)	12.232

[48] Mean body mass for beaver calculated from four estimates in three studies (Soper 1973, Lancia et al. 1978 and Smith 1993).

Food Ingestion Rate: Preferred food includes, the cambium layer of aspen, poplar, birch, maple, willow and alder. Beaver also feed on leaves, bark and small twigs and they will store branches and small sections of logs underwater near their lodge (Burt 1976, Gadd 1995). They will also eat the seeds of some water plants (Gadd 1995).

Food ingestion rate[49a] **(FI rate) (kg/day):**

for beaver with mean mass (18.275 kg)	0.724
for beaver with minimum mass (12.232 kg)	0.541
standard deviation (SD)[50]	0.120

Distribution: Normal (based on the fact that FI is dependant on body mass which is normally distributed.[51]

Deterministic value for food ingestion rate (maximum FI rate; mean + 2SD)

for beaver with mean mass (18.275 kg)	0.963
for beaver with minimum mass (12.232 kg)	0.780

[49] Food ingestion rate calculated as a function of body mass using the allometric equation FI (g dry weight /day) = 0.577(Body weight g)$^{0.727}$ (Nagy 1987).

[50] Standard deviation for food ingestion based on the coefficient of variation for body mass as FI is correlated to body mass (standard deviation = CV x FI rate for mean mass beaver).

[51] Assumed to be the same as for body mass.

Home Range:

Mean home range[52] (ha)	4.5
standard deviation (SD)	
coefficient of variation (CV)	
sample size (n)	

Distribution: **not normal**

[52] Home range size estimated based on a family unit of 7 kits and two adult beavers and a requirement of 0.5 ha per beaver to support it for one year (Gadd 1995).

Fraction of Food Derived From Site:

Water Ingestion Rate:

Water ingestion rate[53] (WI rate) (L /day):	
for beaver with mean mass (18.275 kg)	1.353
for beaver with minimum mass (12.232 kg)	0.943
standard deviation (SD)[54]	0.224

Distribution: Normal[55]

Deterministic value for water ingestion rate (L/day) (maximum WI rate; mean + 2SD):	
for beaver with mean mass (18.275 kg)	1.8
for beaver with minimum mass (12.232 kg)	1.39

[53] Water ingestion rate estimated an allometric equation, WI (L/day) = $0.099Wt^{0.90}$ where Wt is body weight in (kg) (Calder and Braun 1983).

[54] Standard deviation for water ingestion based on the coefficient of variation for body mass as WI is correlated to body mass (standard deviation = CV x WI rate for mean mass beaver).

[55] Assumed to be the same as for body weight.

Fraction of Water Derived From Site:

Soil Ingestion Rate: Soil ingestion rate likely varies depending on activity and type of food ingested. High soil ingestion would be expected when beavers are digging bank burrows, canals, building lodges or dams and when foraging on tubers and roots (e.g., cattail roots). Proportion of soil ingested in the diet likely ranges between 2-6%. To be conservative, an estimate of 6% soil ingestion is used.

Soil ingestion rate[56] (SI rate) (kg/day):	
for beaver with mean mass (18.275 kg)	0.043
for beaver with minimum mass (12.232 kg)	0.032
standard deviation (SD)[57]	0.0072

Distribution: Normal[58]

Deterministic value for soil ingestion rate, kg/day (maximum SI rate; mean + 2SD):	
for beaver with mean mass (18.275 kg)	0.058
for beaver with minimum mass (12.232 kg)	0.047

[56] Soil ingestion rate estimated.
[57] Standard deviation for soil ingestion based on the coefficient of variation for body mass as SI is correlated to body mass (standard deviation = CV x SI rate for mean mass beaver).
[58] Assumed to be the same as for body mass.

Time Spent On Site

Beaver are on site year round and do not hibernate (Smith 1993, Gadd 1995).

Habitat Preference

Beavers require water. Areas attracting beavers include sloughs, rivers, creeks and lakes with trees (for foraging) within easy access (Smith 1993). Aspen is a favoured forage species (Gadd 1995).

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6.0 ECOLOGICAL AND PHYSIOLOGICAL ASSUMPTIONS FOR AMERICAN KESTREL (*Falco sparverius*)

Body Weight:

Mean body mass[59]	0.137 kg
standard deviation (SD)	0.0057
coefficient of variation (CV)	0.042
sample size	73

Distribution: **Normal**

Deterministic value for body mass (minimum mean body mass; mean - 2SD)	0.1256 kg

[59] Mean body mass calculated from data given in Bortolotti et al. (1991) for a population in north-central Saskatchewan.

Food Ingestion Rate: The diet of American kestrels is estimated to include 75% vertebrate and 25% invertebrate prey during the summer breeding period (Gard and Bird 1990).

Food ingestion rate[60] **(FI rate) (kg/day):**	**dry weight mice**	**dry weight insects**
for birds with mean mass (0.137 kg)	0.0091	0.0030
for birds with minimum mass (0.1256 kg)	0.0085	0.0028
standard deviation (SD)[61]	0.0005	

Distribution: **Normal (based on the fact that FI is dependant on body mass which is normally distributed.**[62]

Deterministic value for food ingestion rate (maximum FI rate; mean + 2SD):	**dry weight mice**	**dry weight insects**
for birds with mean mass (0.137 kg)	0.0098	0.0033
for birds with minimum mass (0.1256 kg)	0.0093	0.0031

[60] Food ingestion rates estimate based on an allometric equation for non-passerines where FI (g/day) = $0.301 Wt^{0.751}$ where weight is in (g) (Nagy 1987).

[61] Standard deviation for food ingestion based on the coefficient of variation for body mass as FI is correlated to body mass (standard deviation = CV x FI rate for mean mass bird).

[62] Assumed to be the same as for body mass.

Foraging Home Range Size:

Mean home range size[63] (ha)	13.1
standard deviation (SD)	3.99
coefficient of variation (CV)	0.31
sample size	15

Distribution: Normal

[63] Mean foraging home range size calculated from data given in Gard and Bird (1990) in Quebec.

Fraction of Food Derived From Site: American kestrels are likely in this area for a maximum of approximately 168 days per year (Semenchuk 1992). Assuming that birds spend 100% of their time on site while in Canada, the maximum fraction of food from the contaminated sites would be 168/365 = 0.46 of their annual food requirements.

Water Ingestion Rate:

Water ingestion rate[64] (WI rate) (L/day):	
for birds with mean mass (0.137 kg)	0.028
for birds with minimum mass (0.1256 kg)	0.026
standard deviation (SD)[65]	0.0012
Distribution: Given mean and standard deviation, MEI is a normal distribution.[66]	
Deterministic value for food ingestion rate (mean WI rate; mean + 2SD):	
for birds with mean mass (g)	0.0301
for birds with minimum mass (g)	0.0284

[64] Water ingestion rate estimated using four allometric equations: (1) Calder and Braun (1983), WI (L/day) = 0.059(Body weight kg)$^{0.67}$; Ohmart et al. (1970), WI (L/day) = 0.111(Body weight kg)$^{0.69}$; Thomas and Phillips (1975) WI (L/day) = 0.203(Body Weight kg)$^{0.81}$; Walter and Hughes (1978), WI (L/day) = 0.119(Body Weight kg)$^{0.75}$.

[65] Standard deviation for water ingestion based on the coefficient of variation for body mass as WI is correlated to body mass (standard deviation = CV x WI rate for mean mass bird).

[66] Assumed to be the same as for body mass.

Fraction of Water Derived From Site: American kestrels are likely in this area for a maximum of approximately 168 days per year (Semenchuk 1992). Assuming that birds spend 100% of their time on site while in Canada, the maximum fraction of water from the contaminated sites would be 168/365 = 0.46 of their annual water requirements.

Soil Ingestion Rate:

We make a conservative estimate of soil in the diet of American kestrels to be represented by 4% of the bird's body mass. Soil ingestion for this species may be relatively high as a result of feeding on terrestrial invertebrates and vertebrates taken from the ground surface.

Soil ingestion rate[67] (SI rate) (kg/day):	
for birds with mean mass (2.204 kg)	0.0055
for birds with minimum mass (1.53 kg)	0.0050
standard deviation (SD)[68]	0.00023

Distribution: Normal[69]

Deterministic value for soil ingestion rate, kg/day (maximum SI rate; mean + 2SD):	
for birds with mean mass (2.204 kg)	0.0059
for birds with minimum mass (1.53 kg)	0.0055

[67] Soil ingestion rate estimated.

[68] Standard deviation for soil ingestion based on the coefficient of variation for body mass as SI is correlated to body mass (standard deviation = CV x SI rate for mean mass kestrel).

[69] Assumed to be the same as for body mass.

Fraction of Soil Derived From Site:

American kestrels are likely in this area for a maximum of approximately 168 days per year (Semenchuk 1992). Assuming that birds spend 100% of their time on site while in Canada, the maximum fraction of soil ingested from the contaminated sites would be 168/365 = 0.46 of their annual soil ingestion.

Time Spent in Area

American kestrels start arriving in northern Alberta in mid-April and leave by the end of September for an estimated total of 168 days per year (Semenchuk 1992).

Habitat Preference

Preferred habitat types include semi-open to open country, breeding where trees, man-made structures or cliffs provide cavities for nesting (Semenchuk 1992). Typical habitat types include grasslands, farms, woodlots, river bottom lands, woodland edges, burns, meadows, wooded lakeshores and highway or railway rights-of-way (Semenchuk 1992).

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7.0 ECOLOGICAL AND PHYSIOLOGICAL ASSUMPTIONS FOR AMERICAN ROBIN (*Turdus migratorius*)

Body Weight:

Mean body mass (kg) [70]	0.0836 kg
standard deviation (SD)	0.0064
coefficient of variation (CV)	0.077
sample size	18

Distribution: **Normal**

Deterministic value for body mass (minimum mean body mass; mean - 2SD)	0.0708 kg

[70] Mean body mass calculated from data given in Wheelwright (1988).

Food Ingestion Rate: Robins primarily consume invertebrates and fruits (Ehrlich et al. 1988). Specifically, their diet includes earthworms, snails, beetles, caterpillars, moths, grasshoppers, spiders and millipedes (Martin et al. 1951, Wheelwright 1988, Paszkowski 1982) and various fruits including plums, dogwood, sumac, hackberries, blackberries, cherries, greenbriers, raspberries and juniper (Martin et al. 1951, Wheelwright 1988). Based on data in Howell (1942) and Wheelwright (1988), the diet of the American robin consists of 72% invertebrate material and 28% vegetative material on average over the breeding season (i.e., the period during which they are on-site).

Food ingestion rate[71] **(FI rate) (kg/day):**	**Invertebrate**	**Vegetation**
for birds with mean mass (0.0836 kg)	0.0126	0.0049
for birds with minimum mass (0.0708 kg)	0.0111	0.0043
Standard deviation[72]		

Distribution: **Normal (based on the fact that FI is dependant on body mass which is normally distributed.**[73]

Deterministic value for food ingestion rate (maximum FI rate; mean + 2SD):	**Invertebrate**	**Vegetation**
for birds with mean mass (0.0836 kg)	0.0145	0.0056
for birds with minimum mass (0.0708 kg)	0.0130	0.0051

[71] Food ingestion rates estimate based on an allometric equation for the free-living metabolic rate for passerines (Nagy 1987): FMR (kcal/day) = $2.123(Wt)^{0.749}$ where Wt is in (g); and assuming an omnivorous diet with a metabolizable energy value of 3.35 kcal/g (Nagy 1987).
[72] Standard deviation for food ingestion based on the coefficient of variation for body mass as FI is correlated to body mass (standard deviation = CV x FI rate for mean mass bird).
[73] Assumed to be the same as for body mass.

Foraging Home Range Size:

Mean home range size[74] (ha)	0.25
standard deviation (SD)	0.16
coefficient of variation (CV)	0.64
sample size (n)	3

Distribution: not normal

Mean foraging home range size[75] (ha)	0.48
standard deviation (SD)	0.47
coefficient of variation (CV)	0.97
sample size (n)	2

Distribution: not normal

[74] Mean territory size calculated from data given in Pitts (1984) and Howell (1942).
[75] Mean foraging home range size calculated from data given in Weatherhead and McRae (1990).

Fraction of Food Derived From Site:

Water Ingestion Rate:

Water ingestion rate[76] (WI rate) (L/day):	
for birds with mean mass (0.0836 kg)	0.019
for birds with minimum mass (0.0708 kg)	0.017
standard deviation (SD)[77]	0.0015

Distribution: Given mean and standard deviation, MEI is a normal distribution.[78]

Deterministic value for food ingestion rate (mean WI rate; mean + 2SD):	
for birds with mean mass (0.0836 kg)	0.022
for birds with minimum mass (0.0708 kg)	0.020

[76] Water ingestion rate estimated using four allometric equations: (1) Calder and Braun (1983), WI (L/day) = $0.059(\text{Body weight kg})^{0.67}$;

Ohmart et al. (1970), WI (L/day) = 0.111(Body weight kg)$^{0.69}$; Thomas and Phillips (1975) WI (L/day) = 0.203(Body Weight kg)$^{0.81}$; Walter and Hughes (1978), WI (L/day) = 0.119(Body Weight kg)$^{0.75}$.

[77] Standard deviation for water ingestion based on the coefficient of variation for body mass as WI is correlated to body mass (standard deviation = CV x WI rate for mean mass bird).

[78] Assumed to be the same as for body mass.

Fraction of Water Derived From Site:

Soil Ingestion Rate:

Based on the assumption that the diet of American woodcock represents the diet of American robins (both species probe the soil and ingest earthworms) soil in the diet of an American robin amounts to approximately 10.4% of daily food intake (food in dry mass; estimates for soil ingestion are from Beyer et al. 1994).

Soil ingestion rate[79] (SI rate) (kg/day):	
for birds with mean mass (0.0836 kg)	0.0018
for birds with minimum mass (0.0708 kg)	0.0016
standard deviation (SD)[80]	0.00014

Distribution: Normal[81]

Deterministic value for soil ingestion rate, kg/day (maximum SI rate; mean + 2SD):	
for birds with mean mass (0.0836 kg)	0.0021
for birds with minimum mass (0.0708 kg)	0.0019

[79] Soil ingestion rate estimated based on an ecologically similar species, the American Woodcock (data from Beyer et al. 1994)..

[80] Standard deviation for soil ingestion based on the coefficient of variation for body mass as SI is correlated to body mass (standard deviation = CV x SI rate for mean mass robin).

[81] Assumed to be the same as for body mass.

Fraction of Soil Derived From Site:

Time Spent On Site

American robins are reported to arrive in Alberta in early March and move south by October (Semenchuk 1992). The estimated number of days on site is 214.

Habitat Preferences

American robins require open, grassy ground for feeding and sturdy trees and shrubbery for nesting (Semenchuk 1992). In forested areas, this species inhabits open and broken woodlands, forest edges along rivers, lakes and natural openings and second growth in burnt or cut-over areas (Semenchuk 1992). Breeding areas also include moist forests, swamps, open woodlands, orchards, parks and lawns (U.S. EPA Exposure Factors Handbook 1993).

Robins forage on the ground in open areas, along habitat edges, or the edges of streams; they also forage above the ground in shrubs and within the lower branches of trees (Paszkowski 1982, Malmborg and Wilson 1988).

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8.0 ECOLOGICAL AND PHYSIOLOGICAL ASSUMPTIONS FOR ERMINE (*Mustela erminea*)

Body Weight:

Mean body mass[82] (kg)	0.0692
standard deviation (SD)[83]	0.00692
coefficient of variation (CV)	0.23
sample size (# studies)	3

Distribution: Normal

Deterministic value for body mass (kg) (minimum body mass; mean - 2SD)	0.0554

[82] Mean body mass for ermine calculated from Burt (1976), Soper (1973), Smith (1993) and Seidel (1959).

[83] The standard deviation in this case was estimated to be 10% of the mean. This value reflects a distribution which is closer to the range of 28-85 g given by Burt (1976) and 54.8-90.2 g given by Smith (1993).

Food Ingestion Rate: Ermine primarily prey upon small mammals such as voles and mice but will also take ground squirrels their own size and even young snowshoe hares (Burt 1976, Gadd 1995). They have also been known to climb trees and kill birds, will readily swim and sometimes catch fish (Gadd 1995). Ermine kill their prey by biting through the neck vertebrae, after which they usually carry their prey home to their burrow or to a nearby storage burrow nearby for consumption at a later date (Burt 1976, Gadd 1995). They may also eat carrion (Gadd 1995).

Food ingestion rate[84] (FI rate) (kg/day):

for an ermine with mean mass (0.0692 kg):	0.0077
for an ermine with minimum mass (0.0554 kg)	0.0064
standard deviation (SD)[85]	0.0017

Distribution: Normal (based on the fact that FI is dependant on body mass which is normally distributed.[86]

Deterministic value for food ingestion rate (maximum FI rate; mean + 2SD)

for an ermine with mean mass (0.0692 kg):	0.011
for an ermine with minimum mass (0.0554 kg)	0.0098

[84] Food ingestion rate calculated as a function of body mass using the allometric equation FI (g dry weight /day) = 0.0687(Body weight g)$^{0.822}$ (Nagy 1987).

[85] Standard deviation for food ingestion based on the coefficient of variation for body mass as FI is correlated to body mass (standard deviation = CV x FI rate for mean mass weasel).

[86] Assumed to be the same as for body mass.

Home Range:

Mean home range[87] (ha) 0.8
standard deviation (SD)
coefficient of variation (CV)
sample size (n)

Distribution: not normal

87 Home range size given in Burt (1976).

Fraction of Food Derived From Site:

Water Ingestion Rate:

Water ingestion rate[88] (WI rate) (L /day):	
for an ermine with mean mass (0.0692 kg):	0.00895
for an ermine with minimum mass (0.0554 kg)	0.0073
standard deviation (SD)[89]	0.002

Distribution: Normal[90]

Deterministic value for water ingestion rate (L/day) (maximum WI rate; mean + 2SD):	
for an ermine with mean mass (0.0692 kg):	0.0130
for an ermine with minimum mass (0.0554 kg)	0.0114

88 Water ingestion rate estimated an allometric equation, WI (L/day) = $0.099Wt^{0.90}$ where Wt is body weight in (kg) (Calder and Braun 1983).
89 Standard deviation for water ingestion based on the coefficient of variation for body mass as WI is correlated to body mass (standard deviation = CV x WI rate for mean mass ermine).
90 Assumed to be the same as for body weight.

Fraction of Water Derived From Site:

Soil Ingestion Rate: Soil ingestion rate likely varies depending on activity and type of food ingested. Low soil ingestion for this species is expected as it primarily will be attacking small mammals. Proportion of soil ingested in the diet likely ranges between 1-2% of the animal's body mass. To be conservative a soil ingestion rate of 2% of the animal's body mass was used.

Soil ingestion rate[90] (SI rate) (kg/day):	
for an ermine with mean mass (0.0692 kg):	0.0014
for an ermine with minimum mass (0.0554 kg)	0.0011
standard deviation (SD)[91]	0.0003

Distribution: Normal[92]

Deterministic value for soil ingestion rate, kg/day (maximum SI rate; mean + 2SD):	
for an ermine with mean mass (0.0692 kg):	0.0020
for an ermine with minimum mass (0.0554 kg)	0.0017

[90] Soil ingestion rate estimated.
[91] Standard deviation for soil ingestion based on the coefficient of variation for body mass as SI is correlated to body mass (standard deviation = CV x SI rate for mean mass ermine).
[92] Assumed to be the same as for body mass.

Time Spent On Site

Ermine are active and present in the area year-round (Smith 1993, Gadd 1995).

Habitat Preferences

Ermine prefer coniferous and mixed forests (Smith 1993). Common in the north, this species is less common through the parklands and groveland areas (Smith 1993).

General Information

Ermine populations tend to cycle up and down with their prey populations (i.e., mice and voles). Thus, when there are lots of mice, there are also lots of ermine (Gadd 1995).

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9.0 ECOLOGICAL AND PHYSIOLOGICAL ASSUMPTIONS FOR DEER MOUSE (*Peromyscus maniculatus*)

Body Weight:

Mean body mass (kg)[92]	0.0187
standard deviation (SD)	0.0043
coefficient of variation (CV)	0.23
sample size (n)	73

Distribution: Normal

Deterministic value for body mass (minimum body mass; mean - 2SD) 0.0101 kg

[92] Mean body mass for pre-parous female in the Kananaskis region of Alberta (Millar et al. 1992).

Food Ingestion Rate: Generally, deer mice diets vary with the time of year. For example, during spring deer mice rely heavily on invertebrates. During summer, they largely consume seeds and some insects; and throughout winter, it believed that deer mice rely entirely on cached and gathered seeds (pers. commun. S. Sharpe, B.C.M.O.E., Smithers, B.C.). Based on this information, deer mice diet is assumed to be composed as reported below.

<u>**Diet Composition**</u>:

May through June:	**100% insects**
July through Sept.:	**25% insects, 75% seeds**
Oct. through April:	**100% seeds**

Food ingestion rate[93] **(FI rate) (kg/day):**

for mouse with mean mass (0.0187 kg)	0.00324
for mouse with minimum mass (0.0101 kg)	0.0023
standard deviation (SD)[94]	0.0007

Distribution: Normal (based on the fact that FI is dependant on body mass which is normally distributed.[95]

Deterministic value for food ingestion rate (maximum FI rate; mean + 2SD)

for mouse with mean mass (0.0187 kg)	0.00473 kg/day
for mouse with minimum mass (0.0101 kg)	0.00378 kg/day

[93] Food ingestion rate calculated as a function of body mass using Nagy's (1987) allometric equation for rodents, FI (g dry weight /day) = $0.621(\text{Body weight g})^{0.564}$.

[94] Standard deviation for food ingestion based on the coefficient of variation for body mass as FI is correlated to body mass (standard deviation = CV x FI rate for mean mass deer mouse).

[95] Assumed to be the same as for body mass.

Home Range:

Mean home range[96] (ha)	0.223
standard deviation (SD)	0.222
coefficient of variation (CV)	1
sample size (n)	10

Distribution: not normal

[96] Home range calculated from data given in Banfield (1974), Mullican (1988) and King (1968).

Fraction of Food Derived From Site:

Water Ingestion Rate:

Water ingestion rate[97] (WI rate) (L /day):	
for mouse with mean mass (0.0187 kg)	0.0028
for a mouse with minimum mass (0.0101 kg)	0.0016
standard deviation (SD)[98]	0.000634

Distribution: Normal[99]

Deterministic value for water ingestion rate (maximum WI rate; mean + 2SD):

for mouse with mean mass (0.0187 kg)	0.004 L/day
for mouse with minimum mass (0.0101 kg)	0.003 L/day

[97] Water ingestion rate estimated one allometric equation, Calder and Braun (1983).
[98] Standard deviation for water ingestion based on the coefficient of variation for body mass as WI is correlated to body mass (standard deviation = CV x WI rate for mean mass deer mouse).
[99] Assumed to be the same as for body mass.

Fraction of Water Derived From Site:

Soil Ingestion Rate: Beyer et al. (1994) estimate that soil in the diet of a white-footed mouse amounts to approximately 2.0% of daily food intake (food in dry mass). Deer mice are ecologically very similar to white-footed mice and therefore likely ingest similar amounts of soil (i.e., 2.0% of daily food intake).

Soil ingestion rate[100] (SI rate) (kg/day):	
for mouse with mean mass (0.0187 kg)	6.5×10^{-5}
for mouse with minimum mass (0.0101 kg)	4.6×10^{-5}
standard deviation (SD)[101]	

Distribution: Normal[102]

Deterministic value for soil ingestion rate, kg/day (maximum SI rate; mean + 2SD):

for mouse with mean mass (0.0187 kg)	9.6×10^{-5}
for mouse with minimum mass (0.0101 kg)	7.6×10^{-5}

[100] Soil ingestion rate estimated based on ingestion rates for white-footed mice (Beyer et al. 1994).

[101] Standard deviation for soil ingestion based on the coefficient of variation for body mass as SI is correlated to body mass (standard deviation = CV x SI rate for mean mass deer mouse).

[102] Assumed to be the same as for body mass.

Time Spent in Area

Deer mice are present on site year round and are active year round (Burt 1976, Gadd 1995). *Peromyscus maniculatus* is active throughout the year in Alberta (Robinson and Bolen 1989).

Habitat Preference

Deer mice are found in almost all habitats in the province from human habitation to open sand dunes, dense northern forests, alpine meadows and open grasslands (Smith 1993). A common species, the deer mouse is likely the most abundant mammal in the province (Smith 1993).

Body fat composition of Peromyscus is required to calculate contaminant tissue concentrations. Millar (1975) calculated the body fat of non-breeding, pregnant and lactating females as follows:

reproductive condition	sample size (n)	mass (g)	body fat (g)	standard deviation (SD)
non-breeding	10	21.6	0.912	0.00018
pregnant	5	22.3	0.832	0.0161
lactating	4	20.1	0.486	0.081

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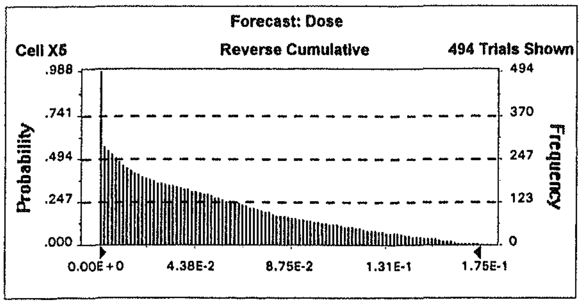
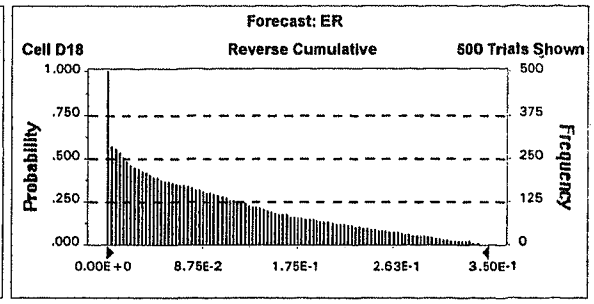
APPENDIX VI

WILDLIFE RISK ASSESSMENT RESULTS

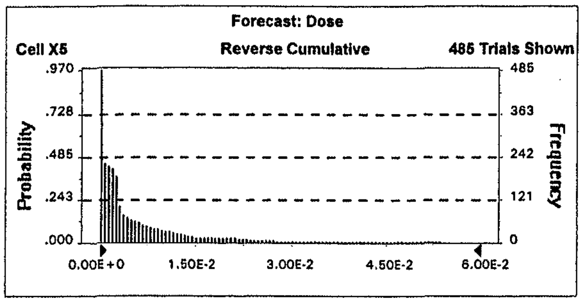
SNOWSHOE HARE

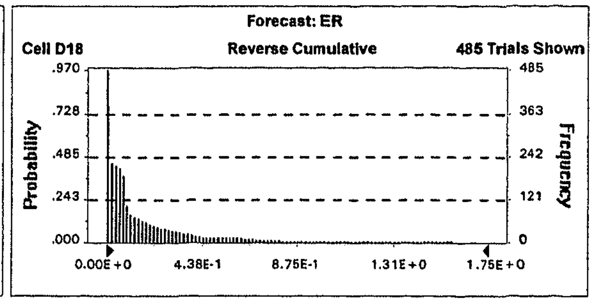
Snowshoe Hare — Aluminum



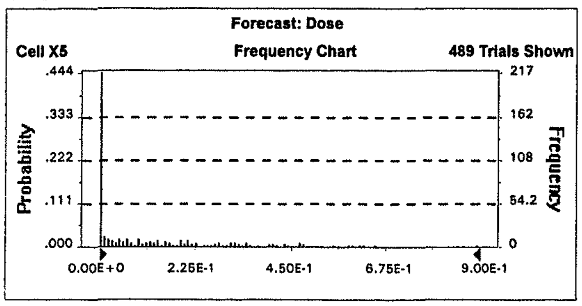


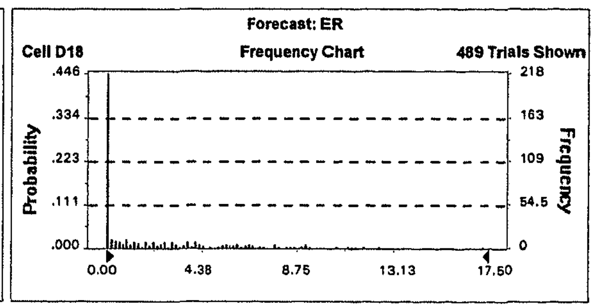
Snowshoe Hare — Arsenic



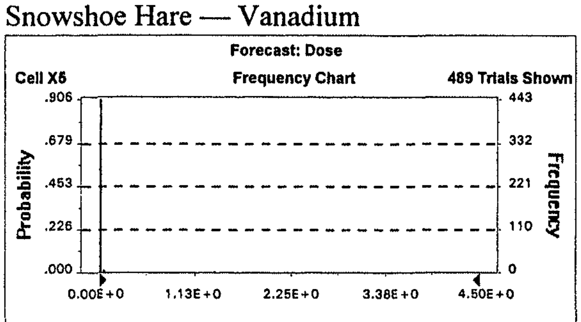


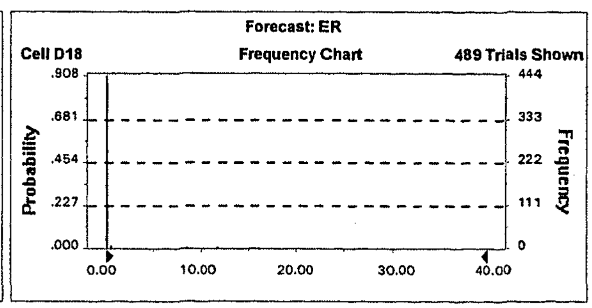
Snowshoe Hare — Cadmium





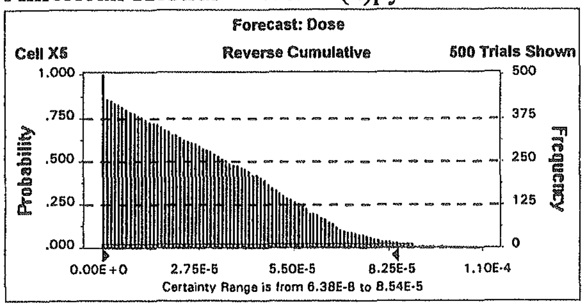
Snowshoe Hare — Vanadium

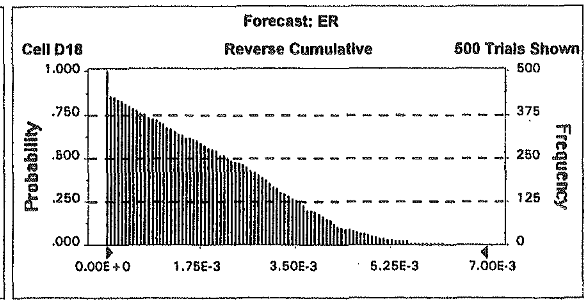




AMERICAN KESTREL

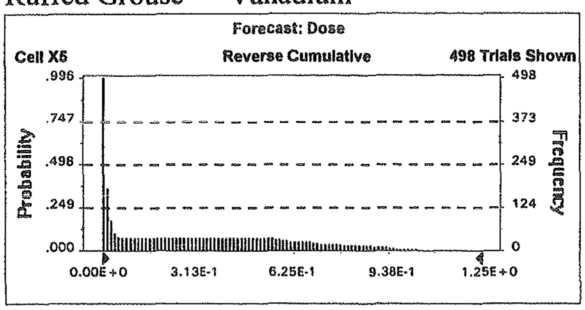
American Kestral — Benzo(a)pyrene

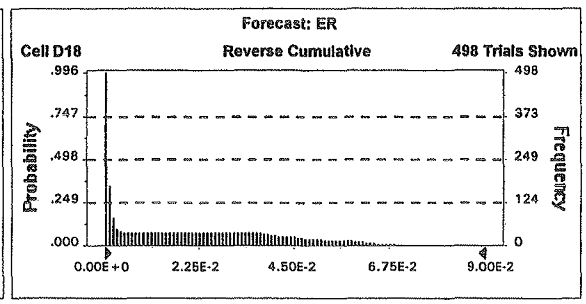




RUFFED GROUSE

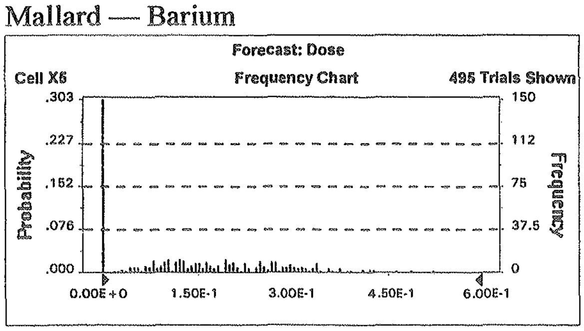
Ruffed Grouse — Vanadium

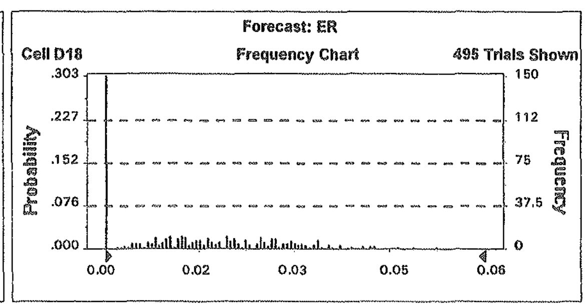




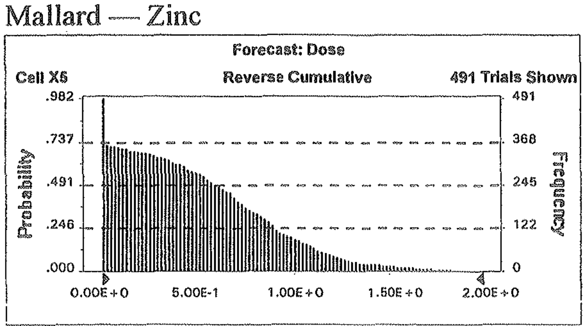
MALLARD

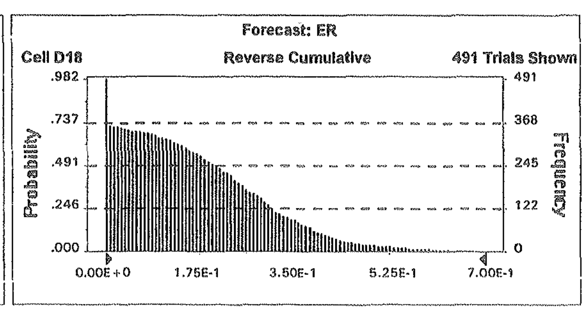
Mallard — Barium





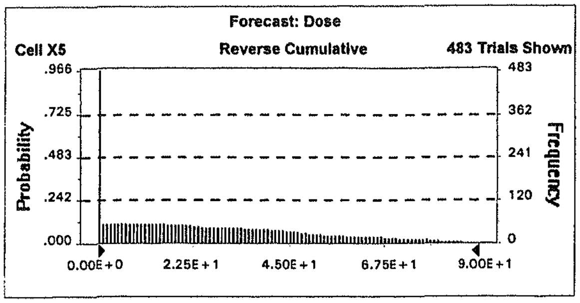
Mallard — Zinc

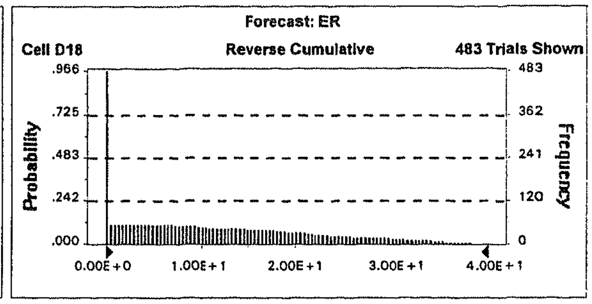




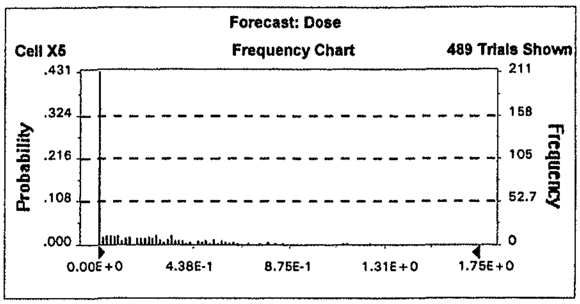
DEER MOUSE

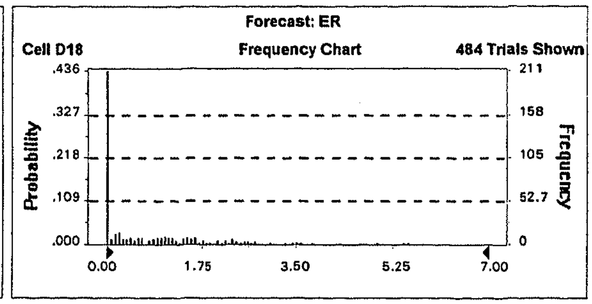
Deer Mouse — Aluminum



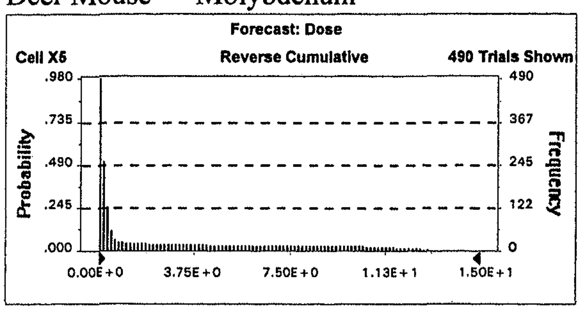


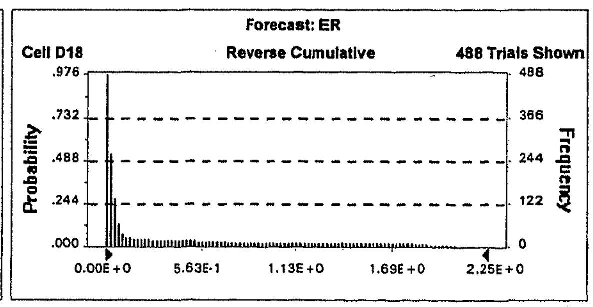
Deer Mouse — Cadmium



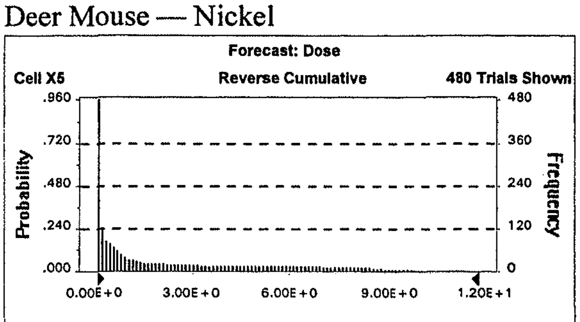


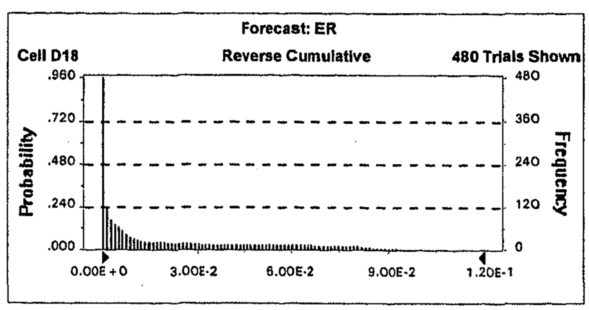
Deer Mouse — Molybdenum





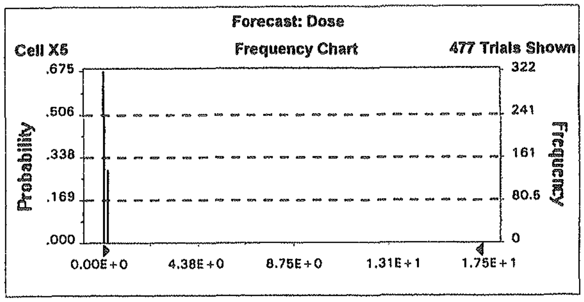
Deer Mouse — Nickel

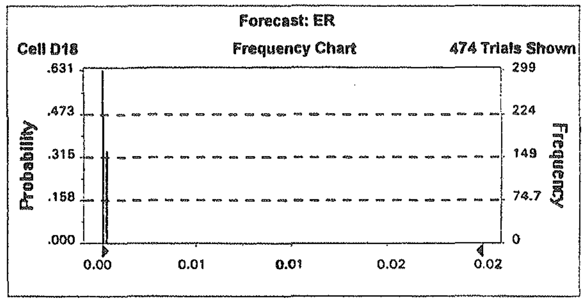




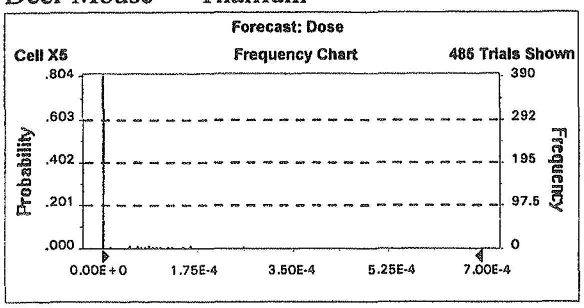
DEER MOUSE (CONTINUED)

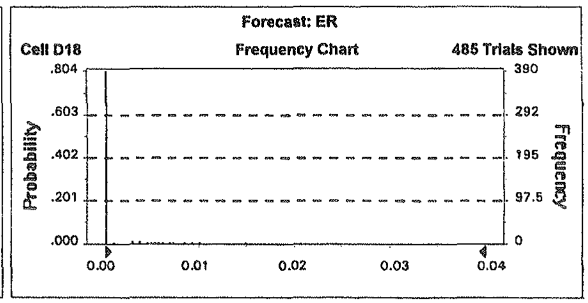
Deer Mouse — Strontium



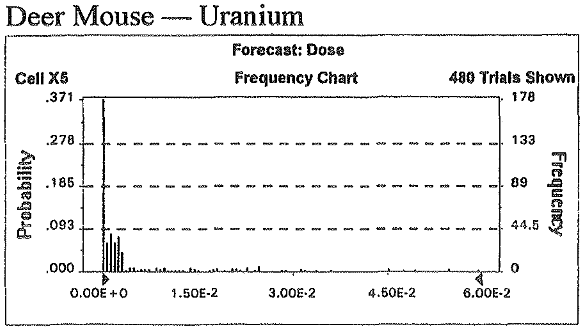


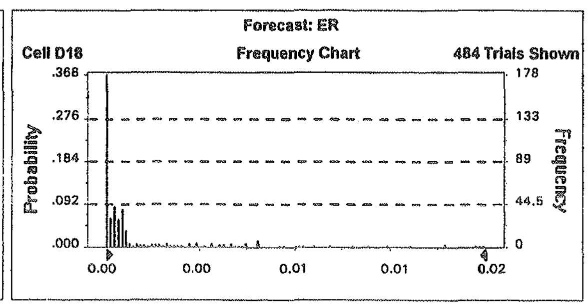
Deer Mouse — Thallium



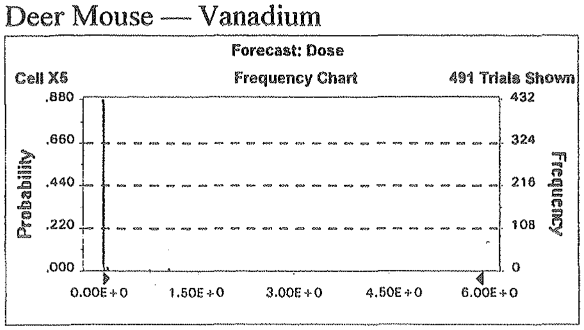


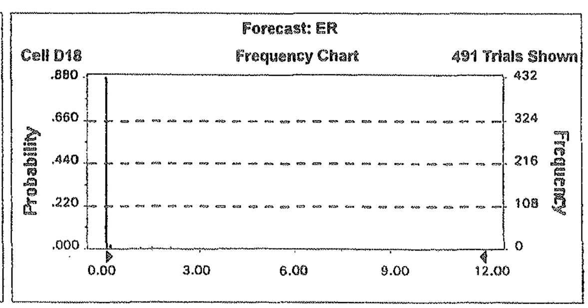
Deer Mouse — Uranium





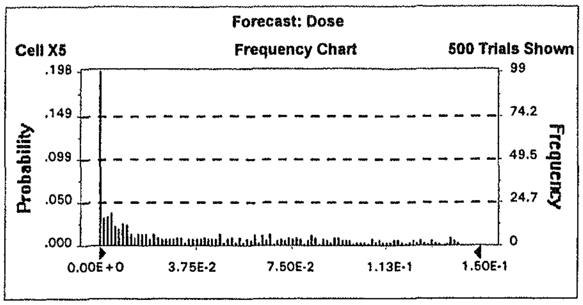
Deer Mouse — Vanadium

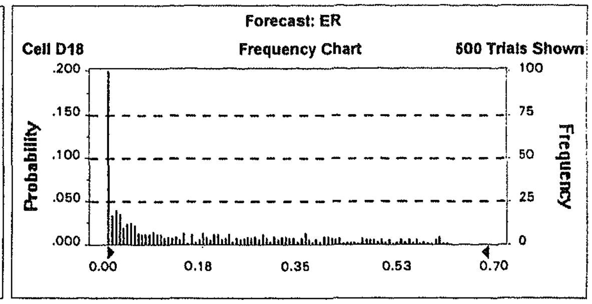




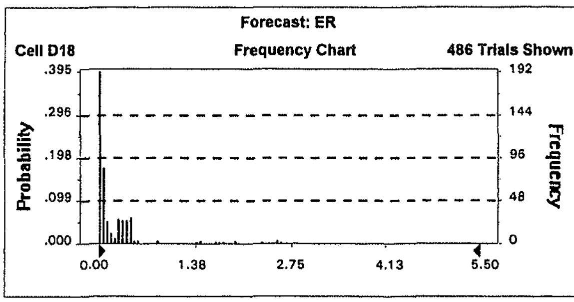
BEAVER

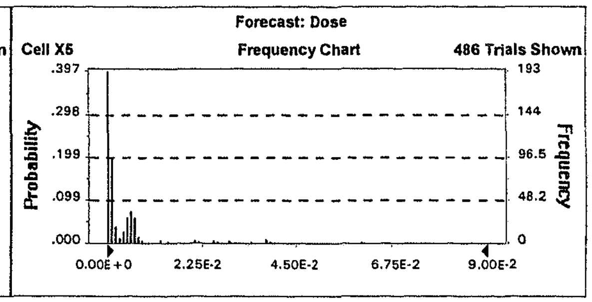
Beaver — Aluminum



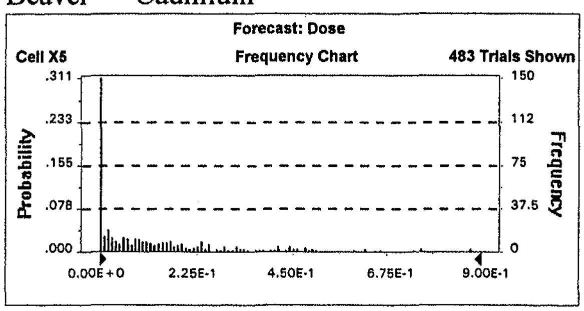


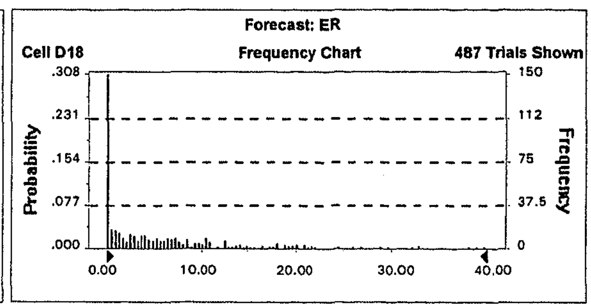
Beaver — Arsenic



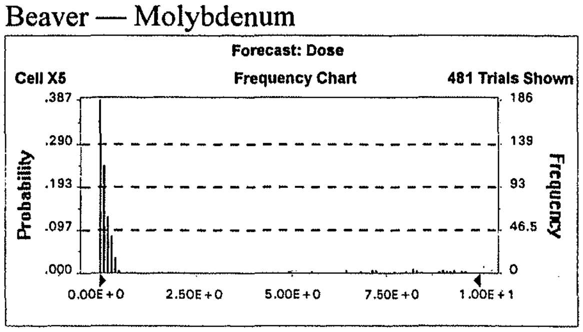


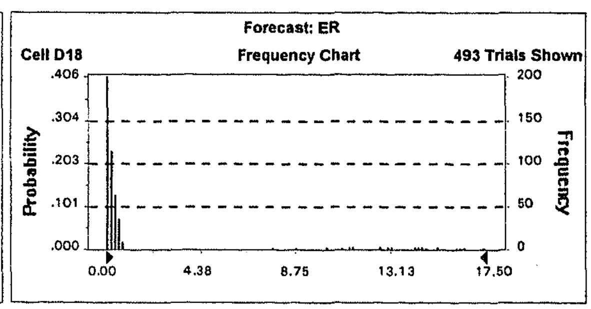
Beaver — Cadmium





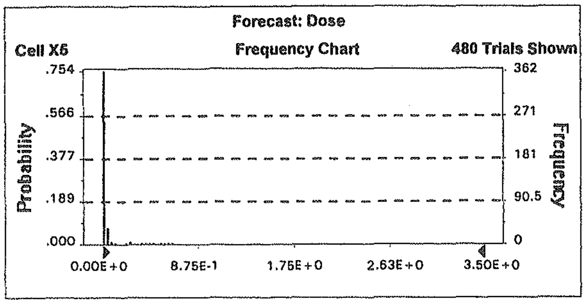
Beaver — Molybdenum

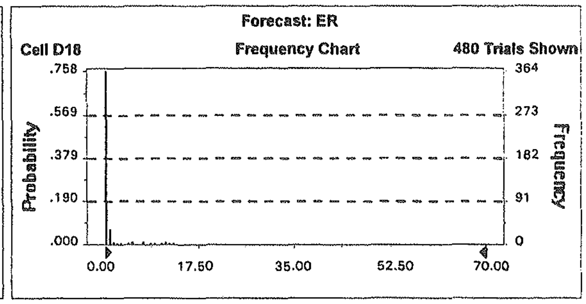




BEAVER (CONTINUED)

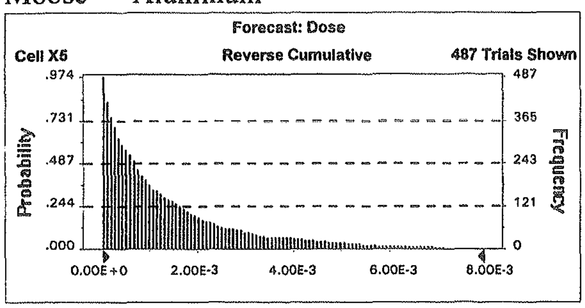
Beaver — Vanadium

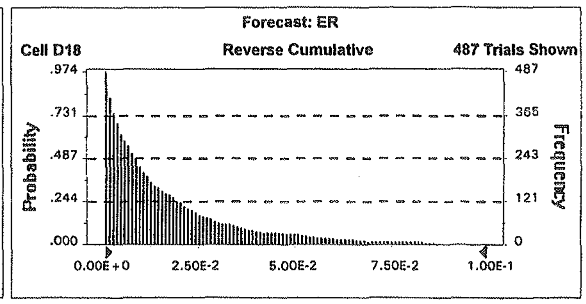




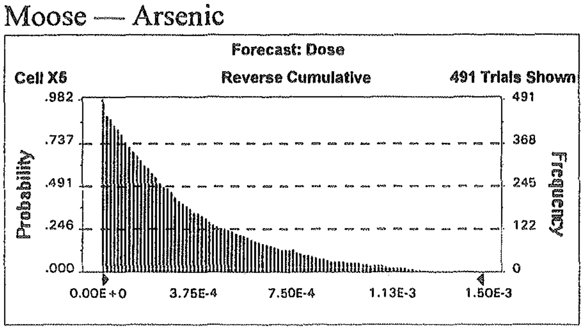
MOOSE

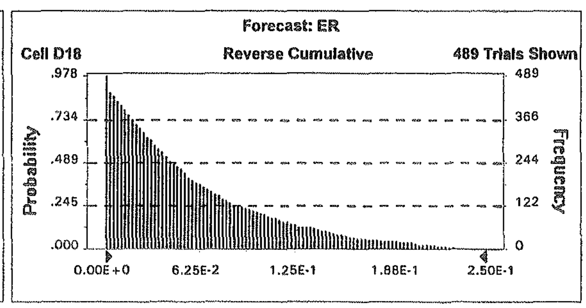
Moose — Aluminum



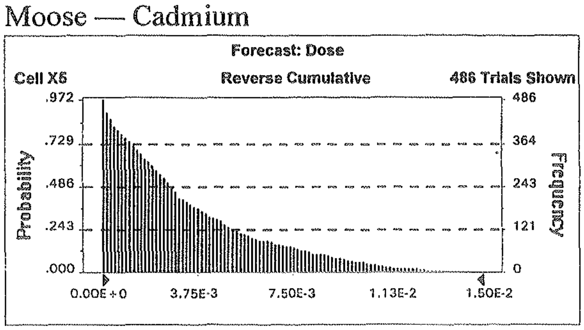


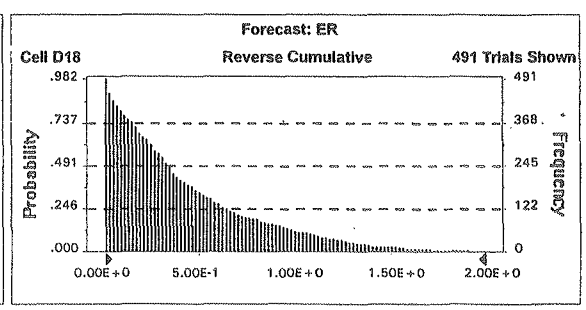
Moose — Arsenic





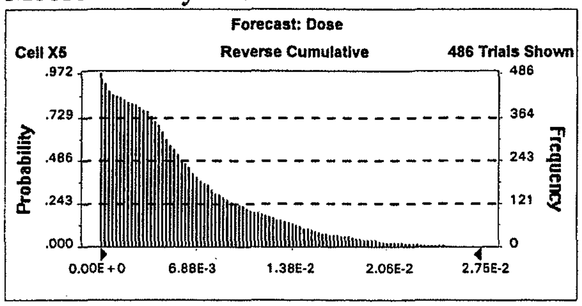
Moose — Cadmium

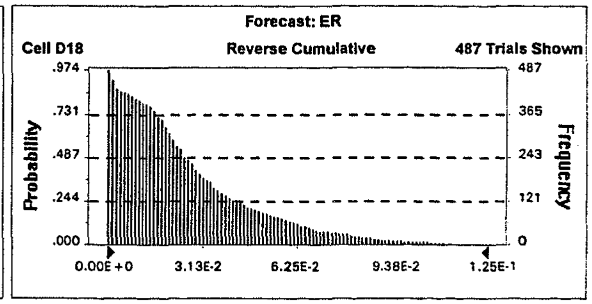




MOOSE (CONTINUED)

Moose — Molybdenum





Moose — Vanadium