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REPORT ON

PROJECT MILLENNIUM CONCEPTUAL PLAN FOR "NO NET LOSS" OF FISH HABITAT

Submitted to:

Suncor Energy Inc., Oil Sands
Fort McMurray, AB

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1. INTRODUCTION

The Suncor Energy Inc., Oil Sands (Suncor) proposed Project Millennium is an integrated expansion of Suncor's mining, extraction and upgrading operations. The project includes expansion of the recently approved Steepbank Mine area on the east side of the Athabasca River. It also involves establishment of primary extraction facilities and support utility infrastructure on the east side of the river. The third major component of Project Millennium is an expansion of the upgrading capability at the Lease 86/17 facility.

The expansion of the mine area will provide ore for over 25 years at a rate of 210,000 barrels per day of production. The construction of a primary extraction plant on the east side of the river will result in the phase out of the existing Lease 86/17 primary extraction facility. Secondary extraction will remain at the existing facility. The upgrading expansion will involve additional process units similar to the existing plant, updated to current technology. A second train is planned to consist of diluent recovery, delayed coking and hydrotreaters, supported by hydrogen production, amine plant and sulphur recovery (with tail gas recovery).

Regulatory agencies are focusing attention on cumulative impacts on aquatic resources in the Steepbank and Athabasca river watersheds because of the number of existing and proposed oil sands developments in the region. In response to these concerns, Suncor has initiated a conceptual plan for achieving no net loss of the productive capacity of fish habitat on Leases 97, 25 and 19 and the adjacent reaches of the Steepbank and Athabasca rivers through the life of the project. Suncor is committed to maintaining or creating, for the mine development area, fisheries habitat that is equivalent to, or greater in productive capacity than what is currently available.

Mine plans are in the feasibility stage at this time. Hence, this plan is conceptual and is subject to change as mine plans evolve and input is received from regulatory agencies and other stakeholders.

Scientific names of fish and plant species discussed in this document are provided in Appendix I.

1.1 OBJECTIVES

The objectives of the conceptual no net loss plan are:

- to demonstrate the feasibility of fish habitat protection and replacement through all phases of mine development;

- to demonstrate a plan to mitigate short-term impacts to fish habitat during construction; and

- to provide a basis for discussion and resolution of fisheries issues with regulators and stakeholders.

1.2 OVERVIEW OF NO NET LOSS PLAN

1.2.1 No Net Loss Principle

The no net loss principle is based on the concept that projects should not result in the loss of productive capacity of fish habitat (DFO 1986). Productive capacity reflects both the quantity and quality of fish habitat.

Application of the no net loss principle is based on a hierarchy of preferences (DFO 1986):

- protect habitats in question by avoiding any loss or alteration to habitat where possible, while maintaining without disruptions, the natural productive capacity;

- mitigate/prevent habitat alteration by reliable techniques; and

- where it is impractical to use the first two approaches, assess compensation options:
  - replace natural habitat at or near the site;
  - replace habitat off-site; or
  - increase the productivity of the affected stock.

1.2.2 Suncor's Conceptual No Net Loss Plan

Suncor's conceptual no net loss plan is based on feasibility plans for Project Millennium (Figure 1). In accordance with the above-noted hierarchy, Suncor's plan includes:

- avoidance of disruption to fish habitats where feasible;
- implementation of a code of good construction and operational practices to prevent or minimize short-term impacts during construction and operation of the mine; and
- replacement of disturbed habitat with equivalent or better habitat.

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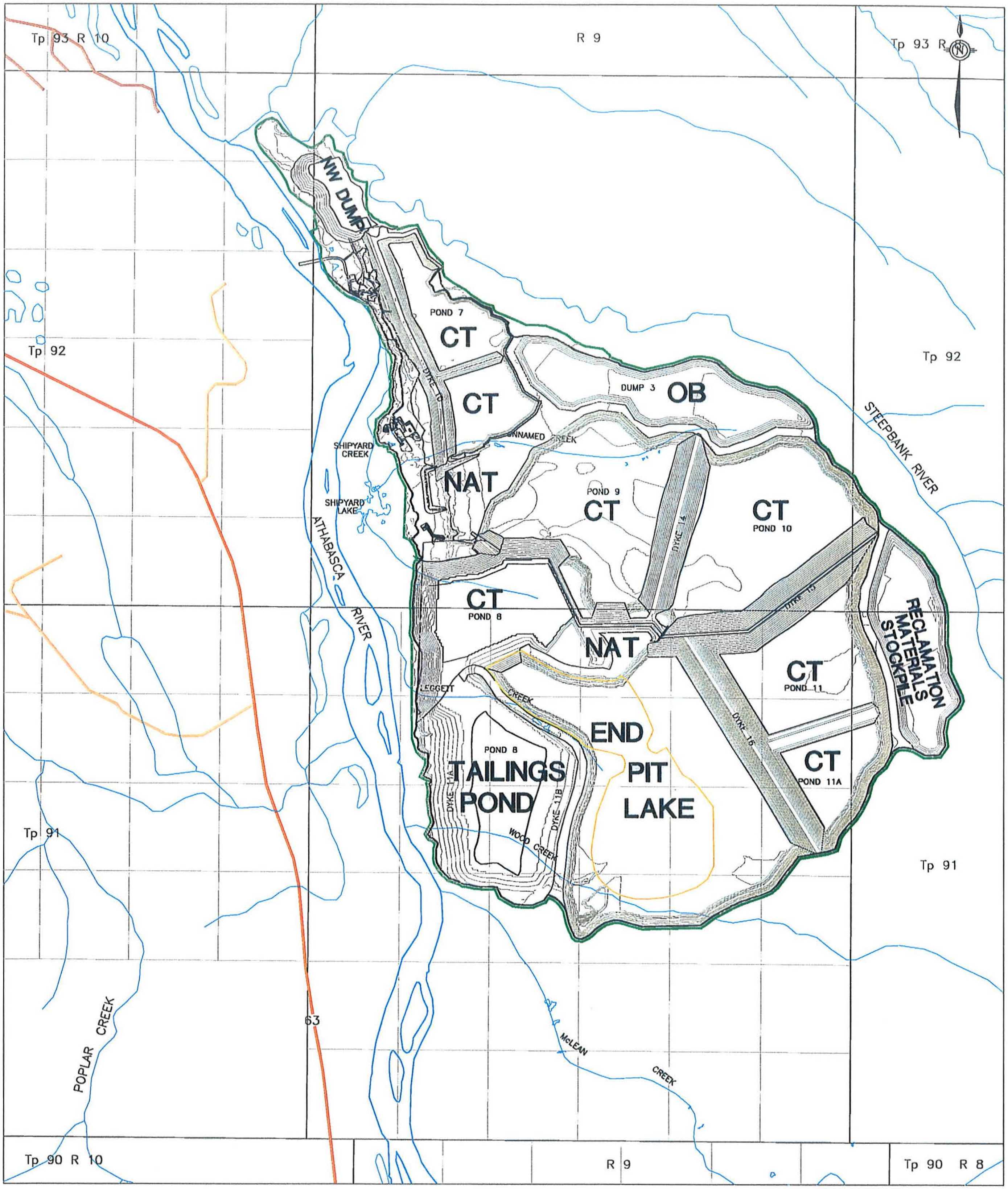

LEGEND

NAT	NATURAL GROUND
OB	OVERBURDEN DUMP
CT	CONSOLIDATED TAILINGS DEPOSIT

REFERENCE

DIGITAL DATA SETS 74D AND 74E RESOURCE DATA DIVISION, ALBERTA ENVIRONMENTAL PROTECTION, 1997.
MINE PLAN SUPPLIED BY SUNCOR ENERGY, MAR 1998.
DATUM IS IN NAD83 UTM

0 1 2 3km
SCALE 1:100,000

SUNCOR ENERGY

Project Millennium
Taking Suncor into the 21st Century

PROJECT MILLENNIUM
FEASIBILITY MINE PLAN

20 Mar. 1998	Figure 1	DRAWN BY: RFM/CG

1.2.3 Project Area

Suncor's proposed Millennium Project is located on the east side of the Athabasca River, in the vicinity of the recently approved Steepbank Mine, within Leases 97, 19 and 25 and Fee Lots 1, 3 and 4. A large portion of the Steepbank River and several other Athabasca River tributaries (Shipyard, McLean, Wood and Leggett creeks) are located on these leases (Figure 1).

A graminoid and shrubby marsh complex (wetlands) area is located adjacent to the Athabasca River on the floodplain area. This wetlands complex is known as Shipyard Lake. Several small creeks feed Shipyard Lake from upland areas. The main surficial discharges to Shipyard Lake are Unnamed Creek, which enters from the northeast, and Creek Two, which enters from the southeast (Golder 1996c).

The Local Study Area (LSA) for the no net loss plan includes the area within the boundaries of Leases 97, 19 and 25. As well, the study area includes the portion of the Steepbank and Athabasca rivers adjacent to Leases 97, 19 and 25.

2. FISH HABITAT AND USE IN THE PROJECT AREA

2.1 ATHABASCA RIVER

Fish habitat in the Athabasca River near Suncor project areas (Lease 86/17, Steepbank Mine and project Millennium was mapped in 1996 and 1997 (Golder 1996a, 1998a). The most recent habitat maps of this reach of the river are presented in the Regional Aquatics Monitoring Program (RAMP) report (Golder 1998a).

The Athabasca River has turbid cool-water habitat and dynamic shifting-sand channels (Golder 1996a). In the LSA, single channels are the major channel type, but near islands and sand bars, multiple channels are present (Golder 1998a). Major habitat features include backwaters and snyes associated with islands and sandbars. The substrate is almost entirely sand. Instream cover is minimal except for that provided by depth and turbidity. River banks are mainly armoured or erosional with some depositional areas and cliffs.

Fish habitat within the Athabasca River mainstem is relatively homogeneous with a shifting-sand bottom. Fish are usually associated with distinct habitat features such as backwaters, snyes and tributary mouths (Golder 1996a, 1998a). The Athabasca River is an important migratory corridor for fish that move from overwintering and feeding areas to spawning areas in tributaries or rapids (e.g., lake whitefish, longnose sucker) (Golder 1996a).

Twenty-seven species have been reported from the Athabasca River in the area near Suncor (Bond 1980). In 1995, 18 species of fish were captured in the study area. Longnose sucker, goldeye, lake whitefish and walleye were the most abundant large fish species in the area downstream of Suncor (Golder 1996a).

Most of the large fish species that have been reported from the Athabasca River during the open-water season are thought to overwinter in Lake Athabasca and migrate into the Athabasca River for at least part of the year (Bond 1980). Northern pike are thought to overwinter in the Athabasca River (Tripp and McCart 1979). Longnose sucker migrate upstream in the spring and move into the tributaries to spawn (Bond 1980, Golder 1996a). Shortly after spawning they move back into the Athabasca River, and remain there to feed for the rest of the open-water season. Immature goldeye are known to migrate to the area near Suncor in the spring to feed. In contrast to previous studies, mature goldeye in spawning condition were found near Suncor in spring 1995 (Golder 1996a). Walleye also move upstream in the spring to spawn. The Athabasca River near Suncor provides rearing and summer feeding habitat for walleye (Golder 1996a). Walleye spawning locations have not been located with certainty but there is evidence that they spawn at the rapids upstream of Fort McMurray (Bond 1980). Lake whitefish spawn in the rapids upstream of Fort McMurray in the fall and the Athabasca River near Suncor is an important feeding and resting area for lake whitefish moving upstream to spawn (McCart et al. 1977, Bond 1980, Golder 1996a). Other less common large fish species captured in the Athabasca River in 1995 include: northern pike, burbot, mountain whitefish, white sucker and yellow perch.

The most common small fish species in the Athabasca River in 1995 were trout-perch, flathead chub, lake chub, emerald shiner, spottail shiner and slimy sculpin (Golder 1996a). Most of these species overwinter in the Athabasca River, except emerald shiner, which are thought to overwinter in the Athabasca Delta (Bond 1980). Flathead chub is one of the most common small fish species, which are generally confined to the mainstem and rarely enter tributaries (McCart et al. 1977). Species composition and relative abundance of small forage fish in 1995 was similar to the findings of studies in the late 1970s (McCart et al. 1977, Bond 1980, Tripp and McCart 1979).

2.2 STEEPBANK RIVER

The Steepbank River is located in the Athabasca River watershed, and supports an abundant and diverse fish fauna. Twenty-five species of fish have been recorded from the Steepbank River, of which ten (Arctic grayling, northern pike, longnose sucker, white sucker, lake chub, pearl dace, longnose dace, trout-perch, brook stickleback and slimy sculpin) are common and widespread (Sekerak and Walder 1980). In the LSA, the lower reach of the Steepbank River consists of swift, armoured riffles separated by run sections with the occasional pool occurring on meander bends. Riffles are less common in this portion of the river than farther upstream. Moderate to low quality runs are the most common habitat type in this section of the river. Pools are moderate quality and fairly deep with good instream and overhead cover from boulders and fallen trees.

Fish species that use the Steepbank River fall into three main categories: migratory populations that rely on the Steepbank River for an important part of their life cycle, resident fish species and species that use the lower reaches for feeding and resting.

In the spring, longnose sucker, white sucker and Arctic grayling move into the Steepbank River to spawn. As well, spring feeding migrations of mountain whitefish are common. In the spring of 1995, mountain whitefish was the most common species, followed by Arctic grayling and longnose sucker (Golder 1996a). Relative abundance (as measured by catch-per-unit-effort) for all three of these species was highest in the upper section of the study area where riffle habitat is common and boulders provide excellent instream cover. White sucker relative abundance also followed this pattern, although white sucker were far less abundant. Longnose sucker and Arctic grayling spawning sites were also documented in 1995 throughout the study area on the Steepbank River but they were more common in the top half of the study reach. White sucker spawning was not documented.

The abundance of Arctic grayling, longnose sucker, white sucker and mountain whitefish changes throughout the year. In 1995, most adult longnose sucker and white sucker left the Steepbank River shortly after spawning while some juveniles remained throughout the open-water season, possibly overwintering in the Steepbank River. Mountain whitefish abundance decreased progressively through summer and fall, indicating that the fish were moving out of the river or to areas farther upstream. Data from 1995 as well as historical fish fence and fish inventory data indicate that most adult Arctic grayling appear to leave the Steepbank River in the fall, prior to freeze-up (Machniak and Bond 1979, Golder 1996a). Young-of-the-year Arctic grayling are thought to overwinter in the Steepbank River (Machniak and Bond 1979).

Fisheries sampling in winter 1996 indicated that some of the pools in the Steepbank were of sufficient depth and had oxygen concentrations high enough to provide overwintering habitat for adults of larger fish species (e.g., Arctic grayling, longnose sucker) (Golder 1997). However, no fish were captured at these sites and historical reports indicate that large numbers of fish vacate the Steepbank River in the fall (Machniak and Bond 1979).

Several small fish species (lake chub, pearl dace, longnose dace, slimy sculpin, spoonhead sculpin, trout-perch and brook stickleback) are thought to be year-round residents of the Steepbank River (Machniak and Bond 1979). In 1995, lake chub, longnose dace, and spoonhead sculpin were the most common small fish species captured during the open-water season (Golder 1996a). Spoonhead sculpin was more common in 1995 than reported in previous studies (Golder 1996a, Sekerak and Walder 1980).

Several additional species occasionally use the lowermost portion of the Steepbank River. In 1995, goldeye, lake whitefish, longnose dace, northern pike and walleye were captured near the mouth of the river (Golder 1996a). Post-spawning feeding migrations of northern pike have also been reported in the lower reaches of the Steepbank River (Machniak and Bond 1979). Lake whitefish use the mouth of the river as a staging and resting area on their upstream spawning migration (Bond 1980, Golder 1996a).

2.3 SHIPYARD LAKE AND SMALL ATHABASCA RIVER TRIBUTARIES

2.3.1 Shipyard Creek

Shipyard Creek drains from the northern end of Shipyard Lake and flows into the Athabasca River (Figure 1). The mouth of Shipyard Creek was examined in 1995 and 1996 for potential use by fish (Golder 1996a, 1996b). In 1995 no water was present in the lower portion of the creek (Golder 1996a). Therefore, during the spring spawning season of 1995, fish passage into this creek and into Shipyard Lake was not possible. In May 1996 a spot flow of 0.50 m^3/s was present in the lower portion of Shipyard Creek. The average monthly flow from July to October was 0.34 m^3/s (Klohn-Crippen 1997). The creek was passable to large fish species from the Athabasca River for approximately 2 km, to a point where a large beaver dam extended across the channel. Later that season, water levels in Shipyard Creek were elevated above the beaver dam (Ken Manly, Klohn-Crippen, pers. comm.). Hence, it is likely that fish use of Shipyard Creek varies with flow conditions. In 1996, the average monthly flow from July to October was 0.34 m^3/s (Klohn-Crippen 1996).

Habitat in Shipyard Creek is entirely composed of low quality run habitat with sand/silt substrate (Golder 1996b). Some instream cover was available from wood debris and breached beaver dams.

Most fish captured in Shipyard Creek in May 1996 were forage fish species, including spottail shiner, lake chub, trout-perch, brook stickleback and emerald shiner (Golder 1996b). The only sport fish captured were four yellow perch collected near a partially washed out beaver dam about 350 m from the confluence with the Athabasca River.

2.3.2 Shipyard Lake

Although termed a lake, Shipyard Lake is actually a shallow, graminoid and shrubby marsh wetlands located on the Athabasca River floodplain. Floating aquatic vegetation borders the open-water area in Shipyard Lake and emergent vegetation, primarily cattail, occurs along the perimeter of the wetland. Water depths in the summer of 1996 ranged from 1.5 to 2.3 m (Golder 1996c).

The types of habitat present in Shipyard Lake would provide spawning and rearing areas for sport fish species such as northern pike and yellow perch which utilize areas with aquatic vegetation for spawning (Scott and Crossman 1973). Overwintering habitat, which was assessed in Shipyard

Lake in February 1997, was relatively poor due to low dissolved oxygen levels (mean = 2.5 mg/L) and shallow water depths (mean = 0.6 m) under the ice (Golder 1997). However, fish species which are relatively tolerant to low dissolved oxygen (e.g., fathead minnow, yellow perch and northern pike) could possibly overwinter in Shipyard Lake (Barton and Taylor 1996).

Hydrological investigations in 1996 indicated that there are several small drainages that provide flow into Shipyard Lake. Unnamed Creek is a tributary to the northeast portion of Shipyard Lake. There are also five small tributaries that enter Shipyard Lake from the southeast. These creeks have no gazetted names and were called Creeks One to Five (from north to south) for the purposes of the hydrology study. All of these creeks are small (channel width < 2 m) (Golder 1996c). Unnamed Creek and Creek Two provide 40 to 50% of the inflow to Shipyard Lake (Golder 1996c). The remaining hydrological input is typically from overland flow or intermittent creeks. Hydrology studies also indicate that the Athabasca River inundates Shipyard Lake for several days a year on a frequent basis (the data indicate a 1 in 2 year to a 1 in 5 year with 95% confidence) (Golder 1996c).

Shipyard Lake was found to be utilized in the spring of 1996 by spawning northern pike (Golder 1996b). No fish were captured in winter 1997 fisheries inventories (Golder 1997). It is not clear if northern pike captured in spring 1996 are a resident population, or if these fish originated from the Athabasca River prior to 1996. In either case, it is likely that northern pike from the Athabasca River utilize this lake for spawning when flow and passage conditions in Shipyard Creek permit. Spawning habitat for this species is limited in the mainstem Athabasca River (R.L.&L. 1994) and northern pike would be expected to use any suitable waterbodies, tributaries or side channels in the Athabasca River floodplain when accessible. The presence of yellow perch in Shipyard Creek downstream of the lake suggests that this species may also use this drainage for spawning when conditions permit.

2.3.3 Unnamed Creek

Unnamed Creek (Figure 2) is a small stream that enters the northeast side of Shipyard Lake. The catchment of this creek is on the order of 10 km long. However, only the lower 1.5 to 2 km of the creek where it runs down the escarpment has a well defined channel. The remainder of the catchment consists of fens and ponded areas.

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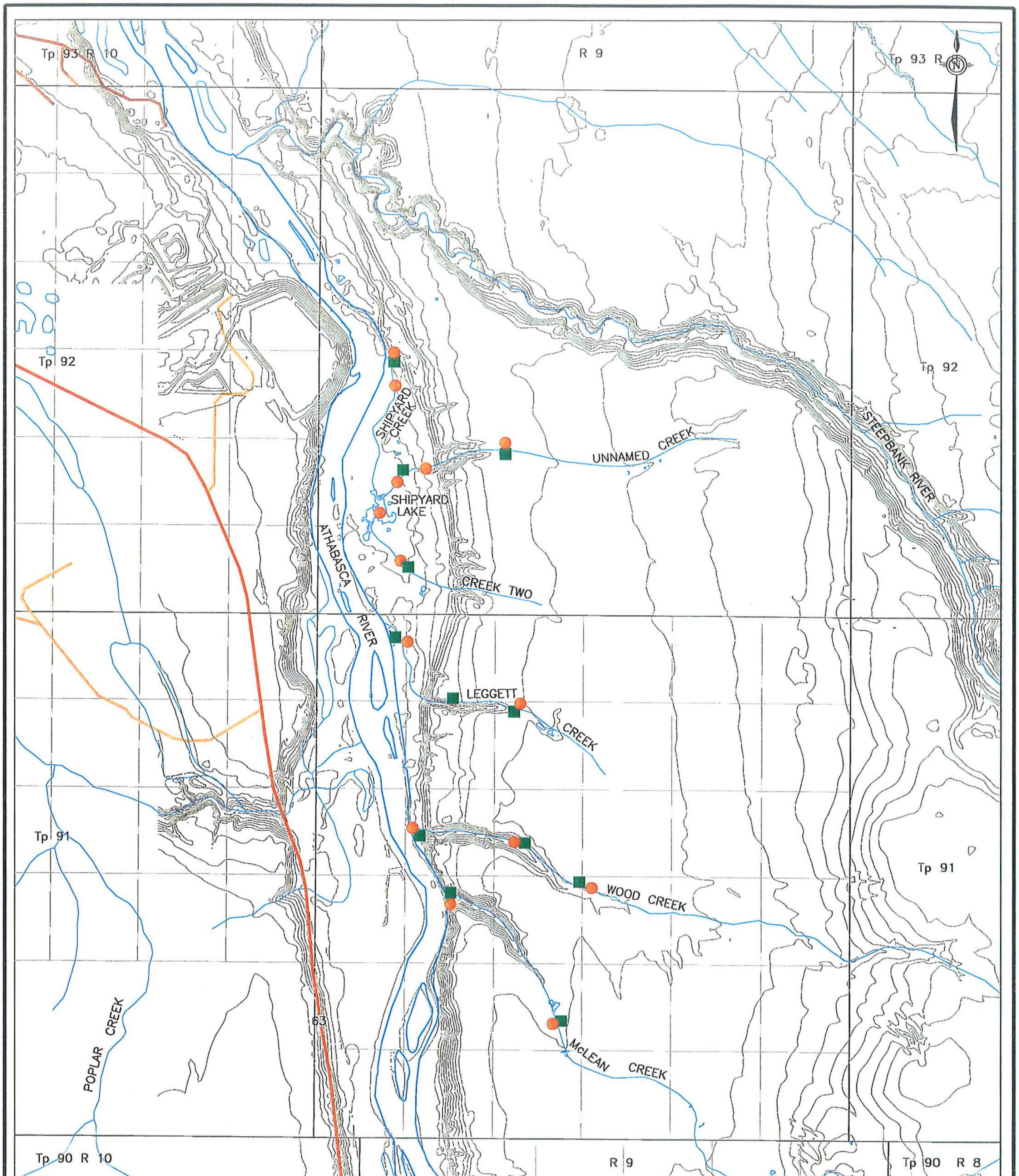

REFERENCE

- FISH SAMPLING SITE
- HABITAT ASSESSMENT SITE

REFERENCE

DIGITAL DATA SETS 74D AND 74E RESOURCE DATA DIVISION, ALBERTA ENVIRONMENTAL PROTECTION, 1997.
MINE PLAN SUPPLIED BY SUNCOR ENERGY, JAN 1998.
DATUM IS IN NAD83 UTM

0 1 2 3km
SCALE 1:100,000

SUNCOR ENERGY

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WATERCOURSES AND SAMPLING SITES

17 Mar 1998	Figure 2	DRAWN BY: RFM/CG

In May 1996, the mean channel width was 1.7 m, the mean wetted width was 1.2 m, and a point flow measurement was 0.10 m^3/s in the lower portion of the stream near the confluence with Shipyard Lake (Golder 1996b). The average monthly flow from July to October was 0.04 m^3/s (Klohn-Crippen 1997). The lower area is comprised mainly of run habitats (about 70%) with some riffle areas (about 20%) and pools (about 10%) also present. The substrate in the lower portion of the stream was primarily silt.

Several beaver dams were present throughout the creek causing ponding and potentially affecting fish passage. In the reaches through the escarpment slope, where a defined channel existed, riffles were the dominant habitat type reflecting the higher stream gradient compared to the lower reaches. The average stream gradient in the escarpment area is about 8 to 10%. Cobble and gravel substrate was present in riffle areas whereas the lower velocity run and pool areas had substrates composed of fines.

No fish were captured in Unnamed Creek during fisheries inventories in May 1996. Unnamed Creek is too small and has too low a flow to provide significant habitat for sports fish species. Numerous obstructions such as instream debris and beaver dams would limit or eliminate fish movements within the drainage.

2.3.4 Creek Two

Creek Two is also a small stream that enters Shipyard Lake from the southeast. The average monthly flow from July to October was 0.09 m^3/s (Klohn-Crippen 1997). Near where it enters Shipyard Lake it has a defined channel which was about 2.0 m wide and 0.7 m deep in October 1997. In this area it has a low stream gradient, stable stream banks and consists almost entirely of low quality runs (Golder 1998b). Pools comprise the remaining available habitat in this section. The substrate consists of fines. Woody debris and inundated riparian vegetation provide instream and overhead cover and beaver dams are present throughout the creek.

The portion of the stream that runs through the escarpment has a steep gradient of 8 to 10%, faster flowing runs, with a gravel substrate and less instream cover. Above the escarpment there is no defined creek channel.

In the fall of 1997, brook stickleback was the only fish species captured in Creek Two. They were found in still water within the first 400 m from creek mouth (Golder 1998b).

2.3.5 Leggett Creek

Leggett Creek is a small tributary to the Athabasca River located south of Shipyard Lake. Leggett Creek was examined in 1995 and 1996 for potential use by fish from the Athabasca River. Similar to other small tributaries in the area, Leggett Creek showed very little flow in the spring of 1995: water present at the mouth was backed up from the Athabasca River (Golder 1996a). Flow was present in 1996 in the creek, with a point flow measurement of 0.28 m^3/s (Golder 1996b). The average flow from April to November has been estimated at 0.15 m^3/s (Klohn-Crippen 1996). Average channel width was 8.5 m and the average wetted width was 5.6 m. Medium quality run habitat was the most common habitat type but pools and riffles were also present. The substrate was dominated by fines.

In the middle and upper habitat assessment sites (Figure 2) of Leggett Creek the stream discharge in May 1996 was similar to the lower reaches but the channel width was smaller (about 2.5 to 3.0 m). The gradient in the middle and upper habitat assessment sites of Leggett Creek was somewhat higher than at the mouth. In the middle habitat assessment site, riffle areas were the dominant habitat type (about 85%) with low quality run habitat also present.

Habitat was more diverse in the upper segment which consisted of 60% riffle habitat, 30% run habitat and 10% pool habitat (Golder 1996b). Instream debris and overhead cover were abundant. Substrate was composed of fines in the lower velocity areas and larger particles (gravel and cobble) in faster moving areas. Log jams and beaver dams were common and likely reduces the potential for fish passage

Habitat conditions in Leggett Creek are suitable for forage fish but have limited utility for sport fish species. Only forage fish species have been captured from the drainage. Sampling in 1995 and 1996 captured lake chub, emerald shiner, spottail shiner and pearl dace (Golder 1996a, 1996b). Fish were captured only in the lower portion of Leggett Creek in both 1995 and 1996. The middle and upper habitat assessment sites (Figure 2) of Leggett Creek consist of a small channel with beaver activity, instream debris and low discharge levels which limit fish passage.

2.3.6 Wood Creek

Wood Creek is another small tributary of the Athabasca River located south of Leggett Creek. Habitat in representative reaches of Wood Creek was mapped in spring 1996 (Golder 1996b). At that time the average channel width was 5.5 m, the average wetted width 4.6 m, and the discharge 0.54 m^3/s. The average flow from April to November has been estimated at

0.17 m^3/s (Klohn-Crippen 1996). The portions of the creek below the escarpment have a moderately high gradient consisting primarily of riffles with some low quality run habitat. A portion of the riffle areas consists of boulder garden habitat that provides a high degree of instream cover and velocity breaks. The substrate is dominated by cobbles and gravels with some bedrock intrusions. The substrate in low velocity areas is dominated by fines. Cover is abundant from undercut banks, instream debris and overhanging vegetation.

The portion of Wood Creek above the escarpment has numerous beaver dams resulting in a series of ponds and wetlands areas including fens, bogs and swamps. In areas where a defined channel is present, low quality run habitats are predominant with occasional riffles. Substrate is mainly fines with cobble present only in the centre of the channel in riffle areas.

As with Leggett Creek, fish in Wood Creek were found to be present only in the lower reaches. Three immature mountain whitefish were captured in 1996 indicating that the lower portion of the creek is being utilized to a limited extent as a rearing area for this species. Other fish captured in Wood Creek were forage species, including spoonhead sculpin, longnose sucker and brook stickleback.

2.3.7 McLean Creek

McLean Creek is a small stream (3.0 m wide and 0.6 m deep) located south of Wood Creek (Figure 2). In 1995, a dry year, the mouth of McLean Creek had very little flow making fish passage into the creek unlikely. Surveys in 1997, indicate the lower reach of McLean Creek has a moderate to high stream gradient with riffle-run-pool sequences and occasional backwaters. Substrate is dominated by small boulders, cobble and gravel, and fines in backwaters. The stream is also characterized by unstable and undercut banks. There is abundant instream debris and overhanging vegetation to provide cover for fish. Woody debris piles and chutes present in McLean Creek pose potential barriers to upstream migration of fish.

Farther upstream at the upper habitat assessment site (Figure 2) McLean Creek has a lower stream gradient. In this area there area there is no defined channel. Fish habitat and substrate is similar to the lower site, except there are flooded beaver ponds present. The stream banks are generally stable, vegetated and not undercut. Woody debris and aquatic plants provide overhead and instream cover. Beaver dams, chutes and debris piles would possibly prevent fish movement.

In October 1997, three young-of-the-year Arctic grayling were captured in the lower section of McLean Creek, near the confluence of the Athabasca

River (Golder 1997). The presence of young-of-the-year Arctic grayling indicates lower McLean Creek may provide spawning for this species in the spring. No fish were captured in the upper section, indicating that this area is likely impassable for fish.

3. APPROACH TO ACHIEVING NO NET LOSS OF FISH HABITAT

Since plans for Project Millennium are in the feasibility stage and are likely to change as the project evolves, this "no net loss" plan is conceptual. However, any changes to the mine plan would not alter Suncor's basic approach to achieve no net loss. For each habitat type (i.e., streams and wetlands) potentially affected by the mine the following aspects are discussed:

- potential impacts based on current mine plan;
- options and mitigations to prevent habitat degradation; and
- where prevention of habitat degradation is not feasible, options for habitat creation to replace disturbed habitat.

A comparison of water quality of Shipyard Lake to Athabasca River and muskeg dewatering water is presented in Appendix II. Appendix III shows stream enhancement features that could be used for mitigation or habitat creation.

3.1 STEEPBANK RIVER

Current project plans avoid direct impacts on the Steepbank River. Mitigation measures as outlined in the Steepbank Mine EIA will be followed to minimize effects on the Steepbank River (Golder 1996d). Design and mitigation measures include mining set back 100 m from the escarpment, erosion and sedimentation protection, minimal effects on the watershed of the river and no instream construction.

3.2 SHIPYARD LAKE

Shipyard Lake would not be directly affected by mining. However, since it is adjacent to mining activity and its watershed would be significantly altered, it may be necessary to compensate for the alteration of current surface and groundwater flows to Shipyard Lake. The approach to no net loss for Shipyard Lake would depend on the stage of mine development. Strategies for maintaining Shipyard Lake water quality and levels include:

- early stages of mining (1998 to 2015): divert natural runoff and muskeg dewatering water[1] from upland areas through Unnamed Creek;

- later stages of mining (2015 to 2030): make up water from the Athabasca River or Wood or McLean creek catchments; and

- closure (after 2030): route surface runoff from the reclaimed landscape.

The strategies are further discussed below.

Early Stages of Mining (1998 to 2015)

During initial stages of mining (from 1998 to 2015), natural runoff from uplands areas (e.g. Leggett Creek) would be diverted to Shipyard Lake through Unnamed Creek. This diversion system is the same as was approved for the Steepbank Mine.

The present sources of water for Shipyard Lake include runoff from the fens to the east and periodic flooding (approximately a 1:3 year return period) directly from Athabasca River. Monitoring to date during the open water season indicates that this flooding happened twice in 1996 (two events in June) and twice again in 1997 (late June and early July). Runoff from Unnamed Creek and Creek Two account for about half to two-thirds of the flow during other periods.

During mine operations from about 1999 to about 2015, natural runoff and water produced from muskeg dewatering in advance of mine operations will be diverted to Shipyard Lake primarily via Unnamed Creek to maintain the upland runoff water contribution. Muskeg dewatering water will be routed through sedimentation ponds and wetlands to remove suspended solids prior to entering Unnamed Creek. Since all these waters originate in the fens, no substantial changes to inflowing water quality (e.g, dissolved oxygen or temperature) to Shipyard Lake are anticipated. See Appendix II for a comparison of water quality for Shipyard Lake and muskeg dewatering water.

The diversion of water into Shipyard Lake would be monitored for both quantity and quality. Suncor has initiated a program to monitor the Shipyard Lake ecosystem.

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[1] The term muskeg dewatering water refers to water that is the result of dewatering of wetlands (e.g., fens).

This monitoring includes assessments of:

- water levels in the wetlands;
- inflows and outflows;
- water and sediment quality;
- aquatic vegetation; and
- fish resources.

Further investigations into other aspects of Shipyard Lake ecology (e.g., changes in carbon loadings from upland sources) would be conducted if necessary.

Suncor is proposing to install a permanent pathway to Shipyard Lake as well as a small dock into the wetlands. This path and dock will facilitate access to the wetlands to allow effective completion of the routine monitoring program.

Suncor has established flow monitoring stations at Unnamed Creek, Creek Two and Shipyard Creek which have been in operation during the open water season since 1996. Therefore, data are being collected on baseline variation in flows.

Baseline water quality data are available for Shipyard Lake from 1992 and 1996 (Hamilton 1992, Golder 1996c). Monitoring data could be incorporated into a predictive model to assess changes in both water quantity and quality.

Appropriate mitigation measures would be implemented should monitoring indicate parameters are outside of historical ranges and potentially negatively affecting the water quantity or quality. For example, erosion control, sedimentation ponds and wetlands would be sized to prevent sediment impacts, as well as regulate peak flows.

Later Stages of Mining (2015 to 2030)

During the later stages of mining the entire natural catchment area to the east of Shipyard Lake will be disturbed by mining activities. Runoff from the reclaimed portions of overburden Dumps 3 and 4 as well as the narrow portion of the Unnamed Creek catchment will be directed to Unnamed Creek. Preliminary flow analysis indicates that flow from these areas will be sufficient to maintain the water level in Shipyard Lake. However, if monitoring indicates that a make-up source is necessary three makeup sources are available: 1) Wood Creek catchment southeast of the mine, 2) McLean Creek catchment south of the mine, and 3) Athabasca River water. Utilizing any of these options would require pumping and pipelines from the source to Shipyard Lake.

Using the Wood and McLean catchments has the advantage of consistent quality with respect to originating in a fen environment. However, pumping distances on the order of 10 to 12 km would be required with a change of elevation of about 200 m. In addition suitable withdrawal points are limited.

Athabasca River water is similar in quality to Shipyard Lake except for parameters related to suspended solids (Appendix II). The Athabasca River periodically floods into Shipyard Lake. Hence, it already influences the water quality of Shipyard Lake.

Athabasca River water could be withdrawn from either the existing water intake on Lease 17 or from a new location on the east side of the river. Using the existing intake would require construction of a pipeline approximately 6 km long. If a location on the east side of the river was chosen, then a conventional surface water intake, an infiltration gallery or water wells could be used.

Water withdrawn through a conventional intake would be piped to a sedimentation pond for removal of suspended solids prior to discharge to Shipyard Lake. Both infiltration galleries and water wells produce sediment free water.

Note that during high flow periods Athabasca River water would not need to be pumped into Shipyard Lake since it naturally floods the lake through overland flows.

Overall benefits to the fisheries habitat of Shipyard Creek may be realized if Athabasca River water is used to maintain water levels in Shipyard Lake. At Shipyard Creek six fish species have been captured during normal flow years, but in dry years no water is likely to be present, temporarily eliminating Shipyard Creek as fish habitat. Routing water from the Athabasca River may allow the water levels in Shipyard Lake to be kept high enough so that water is maintained in Shipyard Creek, resulting in more permanent fish habitat.

Closure and Far Future

At closure and into the far future, baseline flows to Shipyard Lake will be maintained by routing runoff from reclaimed surfaces through a sedimentation pond and then into Unnamed Creek. Water quality from the reclaimed surfaces will be monitored in the later stages of mining. It will not be routed into Unnamed Creek until water quality is acceptable.

3.3 SMALL ATHABASCA RIVER TRIBUTARIES

3.3.1 Leggett Creek

Leggett Creek would be dewatered early in the mine development. The upper reaches of Leggett Creek would be lost to mining activities. Surveys indicated the mouth of Leggett Creek was the only section of the creek which contained fish, providing habitat for forage fish species. The lower reach of Leggett Creek would not be directly impacted by mining activities, however the channel would remain intact but dry.

3.3.2 Wood Creek

Feasibility mine plans include a tailings pond that will be located during the mine operation phase in an area west of East Bank Mining Area 2 within the catchment of Wood Creek. The end pit lake will also be located within the catchment of Wood Creek on mine closure. The current locations of these mine features would require rerouting the flow of water from the upper portion of the Wood Creek catchment to McLean Creek which would eliminate flow in Wood Creek.

Waters from the upper catchment of Wood Creek would be diverted into McLean Creek during mining operations. This would approximately triple the existing flows into McLean Creek during operations. During mine closure and into the far future, the runoff from the Wood Creek catchment would be diverted into the end pit lake to supplement water levels in the lake (refer to Section 3.3.4 for end pit lake).

The system for diverting water from upper Wood Creek to McLean Creek could also be designed to provide fish habitat, on a temporary basis until the Wood Creek headwater is re-diverted to the end pit lake. However, since fish passage to areas above the escarpment is unlikely, this option is not considered practical.

3.3.3 McLean Creek

The Project Millennium tailings pond would not impinge on McLean Creek. Therefore, direct physical alterations as a result of mining activities would not occur. Some indirect effects would occur as a result of diverting Wood Creek upper catchment to McLean Creek during operations. This diversion will occur during operations until end pit lake filling begins. The water will be re-routed to the end pit lake and flows in McLean will be back to baseline while the lake fills. Once reclamation activities are complete, the end pit lake will discharge into McLean Creek and flows will be similar to those occurring from the Wood Creek catchment diversion.

Similar to the scenario of diverting water to Shipyard Lake, diverting the upper portion of the Wood Creek catchment basin to McLean Creek is not expected to have substantial impacts to McLean Creek water quality (e.g., temperature or dissolved oxygen). As both Wood and McLean creeks originate from overland flow through fens the water quality of these creeks in similar. Monitoring of McLean Creek after the Wood Creek catchment diversion is completed will be implemented and the resulting data used to establish appropriate mitigation measures if required. Similarly, end pit lake water will not be discharged into McLean Creek until it is of suitable quality.

Flow regulation by use of sedimentation ponds and wetlands above the escarpment and appropriate in channel works will be implemented to control potential channel degradation in McLean Creek. Other effects to McLean Creek as a result of increased flow (e.g., unstable banks or loss of instream cover) could be mitigated by standard stream rehabilitation methods (e.g., bank stabilization or root wads). A natural channel system approach will be used to design the mitigation in McLean Creek (Ontario Ministry of Natural Resources 1994). An example of a successful mitigation and enhancement of a creek that has received increased flows as a result of development is described in Appendix IV.

Young-of-the year Arctic grayling were captured near the mouth of McLean Creek in 1997. A survey will be conducted in spring 1998 to determine if there is Arctic grayling spawning in McLean Creek. If spawning is confirmed in McLean Creek, mitigation and enhancement measures will be implemented to ensure that suitable spring spawning habitat is maintained.

3.3.4 Habitat Mitigation for Small Athabasca River Tributaries

Fish habitat at the mouths of Leggett and Wood creeks will be lost. No sport fish have been captured from Leggett Creek (Golder 1996b). However, juvenile mountain whitefish have been captured from Wood Creek (Golder 1996b). Hence, habitat compensation for Wood Creek would likely include creation of rearing habitat for this species. As well, Wood Creek will also be examined for Arctic grayling spawning in the spring when McLean Creek is surveyed since its habitat is similar. If Arctic grayling spawning is found in Wood Creek, habitat compensation for Wood Creek will also include replacement of Arctic grayling spawning habitat.

Flows in McLean Creek will be increased as a result of Project Millennium but negative impacts will be prevented by mitigation measures described in Section 3.3.3.

On-site Options

There are four *on-site* options to compensate for habitat lost in Leggett and Wood Creeks:

- create side channel habitat in the Athabasca River;
- create more habitat in the lower portion of McLean Creek;
- improve habitat in Shipyard Creek; and
- create habitat in the end pit lake outlet channel.

Depending on the final mine plans and regulatory approval, all or some of these options may be pursued.

Side channel habitat could be created in the Athabasca River to compensate for fish habitat lost at the mouths of Leggett and Wood creeks. A channel could be cut from the Athabasca River and tied into lower Leggett and/or Wood Creeks forming a side channel. With appropriate enhancement structures (e.g., overhanging cover or log sills) this side channel could provide suitable habitat for forage fish and young-of-the-year sport fish (refer to Appendix III for design drawings and descriptions of typical stream enhancement structures). This option is feasible, although the channels would have a tendency to silt in and would likely require occasional maintenance.

An alternative to creating side channel habitat in the Athabasca River is to create habitat in the lower portion of McLean Creek. As there is no defined channel above the escarpment and no fish were captured above the escarpment (which is likely impassable to fish), enhancement efforts should be directed at the lower portion (i.e, below the escarpment) of McLean Creek. Additional channels could be designed to provide suitable rearing and spawning habitat for fish from the Athabasca River. Habitat would be created during the early stages of mining (i.e., when impacts to Leggett and Wood creeks occur). It would be designed to be self-sustaining and to provide compensation for habitat into the far future.

Habitat loss in Leggett and Wood creeks could also be offset by improving habitat quality and accessibility in Shipyard Creek. Flows in Shipyard Creek could be augmented during operation by pumping water from the Athabasca River to maintain flow even during dry periods. This could feasibly be done during the later stages of operations (from 2015 to 2030) if water from the Athabasca River were already being pumped into Shipyard

Lake. Water could be pumped into Shipyard Creek to increase flow. Elevated flows in Shipyard Creek would likely enhance fish access throughout its 3 km length. Stream enhancement features could also be employed to improve the quality of the habitat.

At closure, the end pit lake outflow will be routed through an area between the tailings pond and an overburden dump to route end pit lake water to McLean Creek. Although such a channel would not be put into use until after mine closure, the outlet channel of the end pit lake could be built to provide forage fish habitat. End pit lake water would be non-toxic prior to release to McLean Creek.

Off-site Options

Creating or enhancing habitat on-site is preferable to off-site options. However, if on-site options do not result in sufficient quality or quantity of habitat compensation, off-site options will be considered.

One off-site habitat creation option is to create a wetlands by dredging out a low lying area adjacent to the Athabasca River. Fish habitat could be created in the wetlands. As well, tributary confluence habitat (similar to that found at Wood or Leggett creeks) could be created in the outlet channel.

A second option for off-site habitat compensation is to improve habitat in the lower portion of Poplar Creek (below the bridge at Highway 63). Any habitat enhancement work on this creek would be done in consultation with Syncrude Canada Ltd., who currently use the Poplar Creek spillway.

3.4 END PIT LAKE

One feature of the Closure Plan is an end pit lake. This area of the landscape represents the final mining location on the Project Millennium development area. The end pit lake would be bounded by overburden dyke/infill areas or undisturbed lands. Because this is the last mining area, there would not be sufficient mining by-product (e.g., overburden, CT or fine tailings) to completely fill the area to original ground level.

The end pit area would be used as a final receptacle for any fine tailings remaining in the tailings pond area at the cessation of mining activities at Project Millennium. Other fluids that will be directed to the end pit area include:

- surface runoff from the reclaimed southern sections of the Project Millennium area;

- seepage from the CT deposits in mine cells located around the end pit lake area;

- water from the headwater area of Wood Creek; and

- water from the Athabasca River, as required, to complete filling of the end pit lake concurrent with completion of reclamation activities on the Project Millennium area.

The end pit lake would be designed to evolve into a functional, self-sustaining aquatic ecosystem. To achieve this goal, the following parameters would be included in the design of the area:

- use of upslope runoff (Wood Creek drainage) to maintain water levels after closure;

- inclusion of approximately 20% of the surface area as a littoral zone composed of shallow wetlands and shoreline areas;

- design as wetlands/fish habitat areas, those locations where streams would discharge into the lake (e.g., Wood Creek, drainage stream from the reclaimed tailings pond area, drainage streams from reclaimed CT deposit areas), as well as where a discharge stream from end pit lake would connect with the mouth area of McLean Creek; and

- contouring of shoreline area to enhance future potential use of the lake as a recreational area (e.g., wildlife observation).

The inclusion of shallow littoral areas into the design of end pit lake should allow for the establishment of aquatic vegetation, which would be important for populations of vegetation-dependent fish species. Once the water of the end pit lake is determined to be non-toxic to fish, stocking of fish species into the lake could be initiated. In order that both the shallow and deep water habitat is utilized, a possible species assemblage for stocking into the end pit lake includes brook stickleback, lake chub, spottail shiner, white sucker, yellow perch, northern pike and Arctic grayling.

One method to increase the fish habitat/wetlands area of the end pit lake is to construct small dendritic islands in the vicinity of inlet and outlet creeks to the lake. Again, the shallow areas associated with these islands could be important as spawning and rearing areas for fish, and the islands themselves could be important as nesting areas for waterfowl and waterbirds. Some larger trees removed during mining operations could be salvaged and installed as submerged habitat structures along the littoral zone of the lake and islands, improving habitat for the fish fauna.

3.5 MONITORING

Created and enhanced stream habitat would be monitored to evaluate fish utilization throughout the phases of mine operation and closure. Habitat improvements would be implemented if it is not found to be providing the required habitat components for the target fish species `lifecycle requirements. Streams would also be monitored and compared to baseline information to ensure that there are no negative effects to existing fish habitat or populations. Aquatic monitoring would be done in conjunction with hydrological monitoring. This would include water quality, thermal regime, benthic invertebrate and fish population monitoring.

Monitoring results would be used in a feedback loop to adjust, if necessary, existing habitats and mitigation measures, and make improvements where indicated for subsequent design. Monitoring will be the key to ensure the "no net loss" objective is being achieved.

Habitat monitoring for this project may be incorporated into the oil sands Regional Aquatics Monitoring Program (RAMP), once project approval is received. Suncor initiated the RAMP in spring 1997 along with Syncrude Canada Ltd. and Shell Canada Limited. Monitoring on the Suncor leases in 1997 consists of water quality, benthic invertebrates and fisheries in the Steepbank River and aquatic vegetation in Shipyard Lake.

The RAMP would provide a vehicle to satisfy regulatory monitoring requirements and allow assessment of regional trends and cumulative effects. The RAMP would also provide a framework for oil sands operators in the region to work cooperatively with stakeholders to achieve no net loss of fish habitat on a regional basis.

4. CLOSURE

We trust this initial draft of the Suncor "No Net Loss Plan" meets your present requirements. If you have any questions or require additional details please contact the undersigned.

Respectfully submitted,

GOLDER ASSOCIATES LTD.

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APPENDIX I

FISH AND PLANT SPECIES COMMON AND SCIENTIFIC NAMES

Table 1 Fish and Plant Species Common and Scientific Names

Arctic Grayling	*Thymallus arcticus*
Brook Stickleback	*Culaea inconstans*
Burbot	*Lota lota*
Emerald Shiner	*Notropis atherinoides*
Flathead Chub	*Platygobio gracilis*
Goldeye	*Hiodon alosoides*
Lake chub	*Couesius plumbeus*
Lake Whitefish	*Coregonus clupeaformis*
Longnose Dace	*Rhinichthys cataractae*
Longnose Sucker	*Catostomus catostomus*
Mountain Whitefish	*Prosopium williamsoni*
Northern Pike	*Esox lucius*
Pearl Dace	*Semotilus margarita*
Slimy Sculpin	*Cottus cognatus*
Spoonhead Sculpin	*Cottus ricei*
Spottail Shiner	*Notropis hudsonius*
Trout-Perch	*Percopsis omiscomaycus*
Walleye	*Stizostedion vitreum*
White Sucker	*Catostomus commersoni*
Yellow Perch	*Perca flavescens*
Cattail	*Typha latifolia*

APPENDIX II

WATER QUALITY COMPARISON BETWEEN SHIPYARD LAKE, ATHABASCA RIVER AND MUSKEG DRAINAGE WATER

WATER QUALITY COMPARISON BETWEEN SHIPYARD LAKE, ATHABASCA RIVER AND MUSKEG DRAINAGE WATER

Since development of Project Millennium would affect surface drainage into Shipyard Lake, the potential to use Athabasca River water to supplement Shipyard Lake feedwaters was investigated. Athabasca River water quality was examined and compared to Shipyard Lake water quality. Muskeg drainage water was also compared to Shipyard Lake water because the proportion of natural muskeg drainage sources into the lake may be affected during mining. Data availability, comparison methodology and results are presented.

DATA AVAILABILITY

Shipyard Lake water quality data were available for winter, spring and summer seasons (Golder 1996, Golder 1997). The comparisons described are therefore limited to these three seasons.

Spring and summer water quality data for the Athabasca River originated from a sampling station near Donald Creek, which was the closest data collection point upstream of Shipyard Lake. No winter water quality information was available for this location. Winter data from a NAQUADAT station upstream of Fort McMurray (00AL07CC0500/550/600) was used.

Muskeg drainage water data are from Syncrude (1997, unpublished data) and Schwartz (1980).

TEST METHODOLOGY

Comparisons are generally presented for average water quality conditions observed in each season. However, this was not always possible, because, at times, only one water sample was available to describe water quality in either the Athabasca River or Shipyard Lake. Therefore, some comparisons were done using only one sample from one of the waterbodies compared.

RESULTS

During the winter, sulphate was more concentrated in the Athabasca River than in Shipyard Lake or standing muskeg water (Table 1). On the other hand, Shipyard Lake contained higher amounts of colour, carbon (both total and dissolved), nitrogen, phosphorus and iron than the Athabasca River. This is consistent with muskeg drainage waters providing the majority of the lake's feedwater. Anoxic conditions in the lake may also be indirectly contributing to high phosphorus levels, via release from sediments.

In spring, sulphate levels were again higher in the Athabasca River (Table 2). Suspended sediment and total metal concentrations in the Athabasca River were variable; suspended sediment and total metal levels in Shipyard Lake were generally near the lower end of the ranges observed in the Athabasca River.

Suspended solids, total phosphorus and certain total metal levels were considerably higher in the Athabasca River in summer, compared to Shipyard Lake (Table 3). The Athabasca River also contained higher concentrations of sulphate, nitrogen and ammonia. Values reported for total metals, such as iron, take into account both iron present in the liquid phase of the water sample, as well as iron bound to suspended sediments in that sample. The same is true for total phosphorus readings. As a result, it is reasonable to assume that total metal and total phosphorus levels in Athabasca River water would drop to levels comparable to those in Shipyard Lake if suspended sediments in the Athabasca River were given time to settle. Hence, if Athabasca River water were used to supplement Shipyard Lake, a settling pond would be required.

CONCLUSIONS

Overall, Athabasca River water quality does not appear to be substantially different from that of Shipyard Lake. This finding is not unexpected, considering that the Athabasca River tends to flood Shipyard Lake once every three years (K. Manly, pers. com.). Most of the differences observed in this study involve suspended sediments and the substances associated with these particles (e.g., iron and phosphorus). Muskeg drainage waters were also a factor in winter. However, since biological activity is at a minimum in winter, replacing muskeg drainage water with Athabasca River water should not result in significant impacts. Therefore, it should be possible to supplement Shipyard Lake feedwaters with Athabasca River water which has passed through a suitable sedimentation pond. Sulphate and nutrient levels in Athabasca River waters may require additional monitoring and possible mitigation.

REFERENCE

Shwartz, F.W. 1980. Hydrological investigations of Muskeg River Basin, Alberta. Report for the Alberta Oil Sands Research program. University of Alberta, Department of Geology. AOSERP report. 97 p.

Table 1 Winter Water Quality in the Athabasca River, Shipyard Lake and Muskeg Drainage Water

Parameter	Units	Shipyard Lake*			Athabasca River			Syncrude Muskeg Drainage Water		Schwartz 1980 Standing Muskeg Water	
		mean	min	max	mean	min	max	min	max	min	max
Conventional Parameters and Major Ions											
Bicarbonate (HCO3)	mg/L	275	272	279				296	421	19.5	566
Calcium	mg/L	61.1	60.6	61.4	50.0	39	74	78.5	106	0.7	33.6
Chloride	mg/L	7.1	4.5	11.7	5.7	2.7	14	< 0.05	< 0.5	1.3	9.1
Conductance	uS/cm	442	428	456	399	267	530	458	614		
Hardness	mg/L	209	207	211	187	142	271	245	319		
Magnesium	mg/L	13.8	13.6	14	13.9	10.6	21	11.5	13	0.5	9.9
pH		7.0	6.9	7.1	7.9	7.4	8.53	6.95	7.19	5.51	8.27
Potassium	mg/L	1.9	1.7	2.2	1.7	0.1	2.65	0.41	1.31	0.1	2.4
Sodium	mg/L	12	10	15	16.5	11.5	24.6	3.8	5.75	1.3	212
Sulphate	mg/L	4.6	4.5	4.7	42.0	27	58	< 0.1	3.1	3.2	15.6
Total Alkalinity	mg/L	226	223	229	167	127	231	243	345		
Total Dissolved Solids	mg/L	290	280	300	249	183	355	247	334		
Total Organic Carbon	mg/L	37.7	37.0	38.0	9.2	5.7	21	9.1	12.2		
Total Suspended Solids	mg/L	2.5	2.0	3.0	8.0	0.4	92.3	9	162		
Nutrients											
Nitrate + Nitrite	mg/L	< 0.15	< 0.05	< 0.2	0.16	0.13	0.19	0.016	< 0.03		
Nitrogen - Ammonia	mg/L	0.78	0.6	0.91	0.04	0.01	< 0.08	0.13	0.91		
Nitrogen - Kjeldahl	mg/L	2.3	1.8	2.8	0.6	0.2	1.46	0.13	1.4		
Phosphorus, Total	mg/L	0.17	0.07	0.25	0.03	0.003	0.18	< 0.1	< 0.1		
Phosphorus,Total Dissolved	mg/L	0.07	0.04	0.09	0.01	0.003	0.035				
General Organics and Toxicity											
Biochemical Oxygen Demand	mg/L	13	12	14	0.7	0.1	3	< 0.05	8		
Metals (Total)											
Aluminum (Al)	mg/L	0.09	0.03	0.14	0.09	0.01	0.35	0.06	0.53		
Arsenic (As)	mg/L	0.0009	0.0008	0.001	0.0004	0.0002	0.0007				
Barium (Ba)	mg/L	0.06	0.05	0.07	0.09	0.08	0.12	0.08	0.2		
Beryllium (Be)	mg/L	< 0.001			< 0.001			< 0.001	0.001		
Boron (B)	mg/L	0.03	0.03	0.03	0.03	0.01	0.05	0.02	0.04		
Cadmium (Cd)	mg/L	0.0004	< 0.0002	0.0005	0.001	0.001	< 0.003	< 0.0002	< 0.0002		
Chromium (Cr)	mg/L	0.003	< 0.0004	0.0077	0.003	0.001	0.006	0.009	0.023		
Cobalt (Co)	mg/L	0.001	0.0007	0.0008	0.001	0.001	< 0.004	< 0.0003	0.0311		
Copper (Cu)	mg/L	0.002	0.0006	0.0028	0.002	0.001	0.007	< 0.001	0.01		
Iron (Fe)	mg/L	9.0	7.7	9.8	0.2	0.1	0.25	2.58	6.12	0.06	0.6
Lithium (Li)	mg/L	0.012	0.010	0.013	0.013	0.005	0.02	0.003	0.008		
Mercury (Hg)	mg/L	< 0.0002			0.0001	0.00004	< 0.0005				
Silver (Ag)	mg/L	< 0.001			< 0.001			< 0.0001	< 0.0001		
Strontium (Sr)	mg/L	0.18	0.17	0.19	0.34	0.32	0.36	0.103	0.168		
Zinc (Zn)	mg/L	0.02	0.009	0.03	0.01	0.001	0.034	0.007	0.204		
Metals (Dissolved)											
Aluminum (Al)	mg/L	0.008	0.006	0.009	0.01	0.01	0.020				
Arsenic (As)	mg/L	0.0005			0.0006	0.0002	0.0015				
Boron (B)	mg/L	0.02	0.02	0.03	0.05	0.01	0.14				
Cadmium (Cd)	mg/L	0.0001			< 0.001						
Chromium (Cr)	mg/L	< 0.0004			0.003	0.003	0.01				
Cobalt (Co)	mg/L	0.0002			0.002						
Copper (Cu)	mg/L	0.0009	0.0007	0.001	< 0.001						
Iron (Fe)	mg/L	3.64	2.39	4.89	0.13	0.1	0.170				
Selenium (Se)	mg/L	< 0.0004			< 0.000325	< 0.0002	0.0005				
Zinc (Zn)	mg/L	0.005	0.004	0.006	0.002						

* blank cells indicate that values could not be calculated either due to insufficient data or non-detectable results

Table 2 Spring Water Quality in the Athabasca River, Shipyard Lake and Muskeg Drainage Water

Parameter	Units	Shipyard Lake*			Athabasca River			Syncrude Muskeg Drainage Water		Schwartz 1980 Standing Muskeg Water	
		mean	min	max	mean	min	max	min	max	min	max
Conventional Parameters and Major Ions											
Bicarbonate (HCO3)	mg/L	132	129	134	119			296	421	19.5	566
Calcium	mg/L	32.6	31.0	33.6	30.7			78.5	106	0.7	33.6
Chloride	mg/L	5.9	5.8	6.2	9.6			< 0.05	< 0.5	1.3	9.1
Conductance	uS/cm	239	227	248	253			458	614		
Hardness	mg/L	111	106	114	111			245	319		
Magnesium	mg/L	7.2	7.0	7.3	8.4			11.5	13	0.5	9.9
pH		6.8	6.8	6.9	7.8			6.95	7.19	5.51	8.27
Sulphate	mg/L	4.2	4.0	4.3	18.3			< 0.1	3.1	3.2	15.6
Total Alkalinity	mg/L	108	106	110	97.4			243	345		
Total Suspended Solids	mg/L	157	150	165	100	19	181	9	162		
Nutrients											
Nitrate + Nitrite	mg/L	0.012			0.015			0.016	< 0.03		
Nitrogen - Ammonia	mg/L	0.01			< 0.01			0.13	0.91		
Nitrogen - Kjeldahl	mg/L	0.7	0.7	0.8	1.2			0.13	1.4		
Phosphorus, Total	mg/L	0.03	0.02	0.03	0.14	0.14	0.14	< 0.1	< 0.1		
Phosphorus, Total Dissolved	mg/L	0.019	0.017	0.021	0.02						
Metals (Total)											
Aluminum (Al)	mg/L	0.02	< 0.01	0.02	2.68	0.17	5.18	0.06	0.53		
Arsenic (As)	mg/L	0.0002			0.0013	0.0006	0.002				
Barium (Ba)	mg/L	0.02	0.02	0.03	0.07	0.05	0.10	0.08	0.2		
Beryllium (Be)	mg/L	< 0.001			< 0.001			< 0.001	0.001		
Boron (B)	mg/L	0.04	0.03	0.05	0.05	0.04	0.05	0.02	0.04		
Cadmium (Cd)	mg/L	< 0.0002				< 0.0002	< 0.003	< 0.0002	< 0.0002		
Calcium (Ca)	mg/L	34.4	31.3	36.8	27.1						
Chromium (Cr)	mg/L	0.006	< 0.002	0.008	0.004	< 0.002	0.005	0.009	0.023		
Cobalt (Co)	mg/L	0.0006	0.0005	0.0006		0.0021	< 0.003	< 0.0003	0.0311		
Copper (Cu)	mg/L	0.001			0.004	< 0.001	0.007	< 0.001	0.01		
Iron (Fe)	mg/L	1.39	1.15	1.87	2.84	0.43	5.24	2.58	6.12	0.06	0.6
Lead (Pb)	mg/L	0.0010	0.0008	0.0011		0.0038	< 0.02	< 0.0003	0.0019		
Lithium (Li)	mg/L	0.005	0.005	0.006	0.009	0.006	0.011	0.003	0.008		
Magnesium (Mg)	mg/L	7.61	7.04	8.05	8.88						
Manganese (Mn)	mg/L	0.05	0.044	0.05	0.07	0.04	0.11	0.241	0.801		
Mercury (Hg)	mg/L	< 0.05				< 0.0002	< 0.05				
Molybdenum (Mo)	mg/L	< 0.003				0.003	< 0.003	< 0.003	0.003		
Nickel (Ni)	mg/L	0.010	0.009	0.012	0.005	0.005	0.005	0.004	< 0.005		
Potassium (K)	mg/L	1.78	1.77	1.8	3.59						
Selenium (Se)	mg/L	< 0.0002				< 0.0002	< 0.0004				
Silicon (Si)	mg/L	2.95	2.80	3.09	7.36	2.12	12.6				
Silver (Ag)	mg/L	0.001	0.0005	0.002		< 0.001	< 0.002	< 0.0001	< 0.0001		
Sodium (Na)	mg/L	8.51	8.15	8.99	8.80						
Strontium (Sr)	mg/L	0.08	0.08	0.09	0.17	0.15	0.19	0.103	0.168		
Titanium (Ti)	mg/L	< 0.003			0.029	0.004	0.054	< 0.003	0.019		
Uranium (U)	mg/L	0.0006	< 0.0004	0.0009	< 0.5			< 0.0004	< 0.0004		
Vanadium (V)	mg/L	< 0.002			0.007	< 0.002	0.013	< 0.002	0.005		
Zinc (Zn)	mg/L	0.02	0.01	0.02	0.42	0.02	0.81	0.007	0.204		

* blank cells indicate that values could not be calculated either due to insufficient data or non-detectable results

Table 3 Summer Water Quality in the Athabasca River, Shipyard Lake and Muskeg Drainage Water

Parameter	Units	Shipyard Lake*			Athabasca River			Syncrude Muskeg Drainage Water		Schwartz 1980 Standing Muskeg Water	
		mean	min	max	mean	min	max	min	max	min	max
Conventional Parameters and Major Ions											
Bicarbonate (HCO3)	mg/L	165	165	166	108			296	421	19.5	566
Calcium	mg/L	40.3	39.3	41.1	32.5			78.5	106	0.7	33.6
Chloride	mg/L	4.5	3.7	4.9	3.1			< 0.05	< 0.5	1.3	9.1
Conductance	uS/cm	273	269	275	200			458	614		
Hardness	mg/L	134	130	138	114			245	319		
Magnesium	mg/L	8.2	7.8	8.5	8			11.5	13	0.5	9.9
pH		7.4	7.3	7.5	7.6			6.95	7.19	5.51	8.27
Potassium	mg/L	0.8	0.7	0.9	0.9			0.41	1.31	0.1	2.4
Sodium	mg/L	9.2	8.8	9.5	8.6			3.8	5.75	1.3	212
Sulphate	mg/L	1.8	1.7	1.9	13.1			< 0.1	3.1	3.2	15.6
Total Alkalinity	mg/L	135	135	136	88.2			243	345		
Total Dissolved Solids	mg/L	147.4131	146.1844	149	120			247	334		
Total Suspended Solids	mg/L	182	175	190	624			9	162		
Nutrients											
Nitrate + Nitrite	mg/L	0.0203333	0.016	0.026	0.11			0.016	< 0.03		
Nitrogen - Ammonia	mg/L	0.091	< 0.07	0.11	< 0.04			0.13	0.91		
Phosphorus, Total	mg/L	0.03	0.03	0.04	1.17			< 0.1	< 0.1		
General Organics and Toxicity											
Total Recoverable Hydrocarbons	mg/L	1			< 1						
Metals (Total)											
Aluminum (Al)	mg/L	0.05	< 0.05	0.06	8.64			0.06	0.53		
Antimony (Sb)	mg/L	0.0002			0.0002						
Arsenic (As)	mg/L	0.001			0.007						
Barium (Ba)	mg/L	0.03			0.20			0.08	0.2		
Beryllium (Be)	mg/L	< 0.001			< 0.004			< 0.001	0.001		
Boron (B)	mg/L	0.0366667	0.02	0.06	0.05			0.02	0.04		
Cadmium (Cd)	mg/L	< 0.003			< 0.003			< 0.0002	< 0.0002		
Chromium (Cr)	mg/L	0.010	< 0.004	0.017	0.003			0.009	0.023		
Cobalt (Co)	mg/L	0.0030			< 0.003			< 0.0003	0.0311		
Iron (Fe)	mg/L	2.5366667	2.22	2.74	17.90			2.58	6.12	0.06	0.6
Lead (Pb)	mg/L	0.0200			< 0.02			< 0.0003	0.0019		
Lithium (Li)	mg/L	0.007	0.007	0.008	0.014			0.003	0.008		
Manganese (Mn)	mg/L	0.19	0.179	0.215	0.51			0.241	0.801		
Mercury (Hg)	mg/L	< 0.05			< 0.05						
Molybdenum (Mo)	mg/L	< 0.003			< 0.003			< 0.003	0.003		
Nickel (Ni)	mg/L	0.011	0.008	0.014	0.005			0.004	< 0.005		
Selenium (Se)	mg/L	< 0.001			< 0.0002						
Silver (Ag)	mg/L	0.002			< 0.002			< 0.0001	< 0.0001		
Strontium (Sr)	mg/L	0.12	0.12	0.12	0.23			0.103	0.168		
Titanium (Ti)	mg/L	< 0.019	< 0.017	< 0.02	0.085			< 0.003	0.019		
Vanadium (V)	mg/L	< 0.002			0.009			< 0.002	0.005		
Zinc (Zn)	mg/L	0.01	0.01	0.02	0.09			0.007	0.204		

* blank cells indicate that values could not be calculated either due to insufficient data or non-detectable results

APPENDIX III

DESIGN DRAWINGS OF TYPICAL STREAM ENHANCEMENT STRUCTURES

Stream Enhancement Structure Descriptions (refer to Figures III-1 and III-2)

V-Shaped Log Sill - Provides a stable, high quality, self maintaining run/pool habitat, with feeding, resting and shelter opportunities. Boulders added to the pool provides visual isolation for fish. Gravel may accumulate upstream of the sill providing additional spawning habitat.

Cobble Fill Spawning Riffles - Cobble and boulder fill are added to a graded stream bottom to provide spawning habitat for species such as Arctic grayling. Spawning riffles are built as a sloping platform to promote a good supply of oxygen-rich water to developing eggs.

Log Sill Structures - Similar to V-shaped log sills. Appropriate for straight, channelized sections of creek with little gravel and cobble present. Gravel and cobble accumulate behind the sill providing spawning habitat for fish and areas for insect colonization. A small plunge pool will form providing some cover for fish.

Overhanging Cover - Provides resting, shelter and feeding areas for fish in stream sections where overhead cover is lacking.

Lunker Structures - Lunker structures are secured to the stream bottom, providing cover for larger fish.

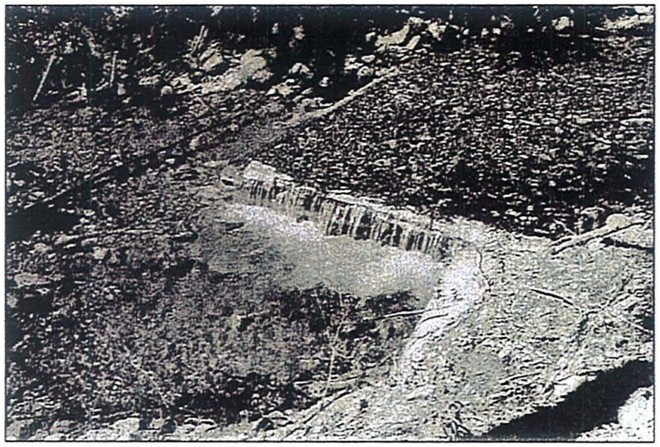
Deflector and Cover Log - The deflector is constructed to narrow, deepen, direct and increase the velocity of the stream flow, with the objective of creating a lateral scour pool. The cover log provides additional overhead cover.

Cross Log Revetment - Similar to a deflector and cover log structure, this structure can be used at stream bends to create lateral scour pools, provide overhead cover, and afford some bank stability.

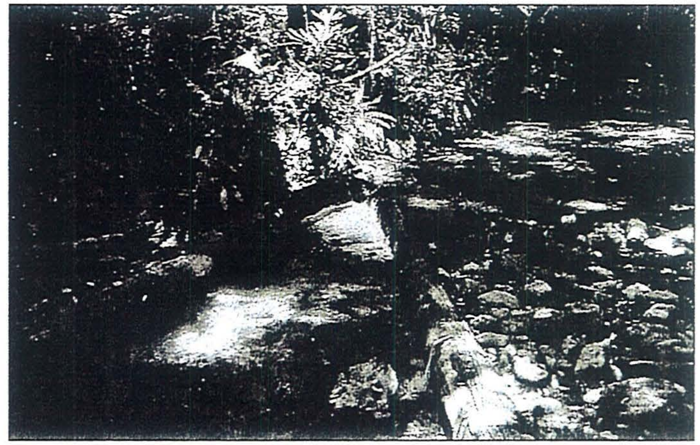
Brush Bundles - Built to narrow sections of stream which are too wide. These bundles can be effective for trapping silt and debris, leading to the establishment of aquatic vegetation. The brush bundles and aquatic vegetation will provide good cover for small fish.

Channel Constrictor - Modified deflectors which are designed to scour and deepen the streambed and provide overhead cover for fish similar to that provided by undercut banks.

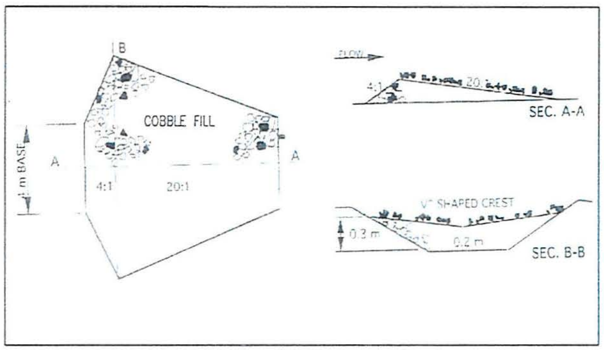
J:\1997\2205\6080\



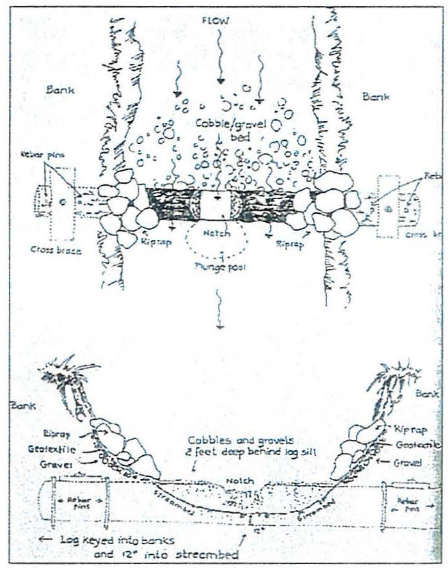
A V-Shaped Log Sill



C Cross Log Revetment



B Cobble Fill Spawning Riffles



D Log Sill Structures

REFERENCE

FIGURES from HUNTER (1991)
and from NEWBURY and GABOURY (1994)

Scale 1:250 (Approx.)
Schematic Only

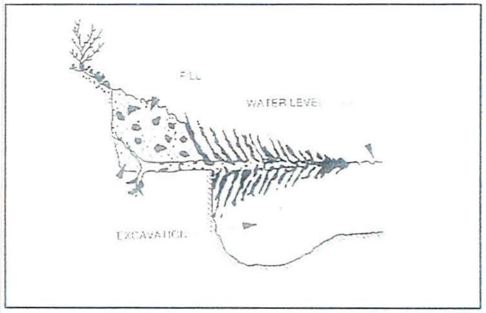
SUNCOR ENERGY

Project Millennium
Taking Suncor Into the 21st Century

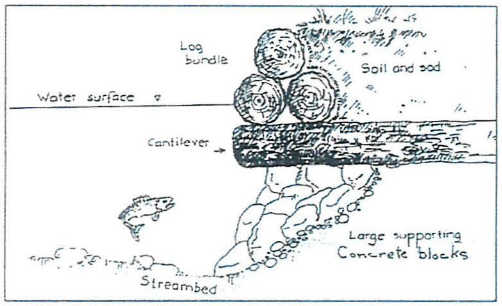
HABITAT ENCHANCEMENT OPTIONS: SILLS/WEIRS

11 Feb 1998	Figure III-1	DRAWN BY: CG

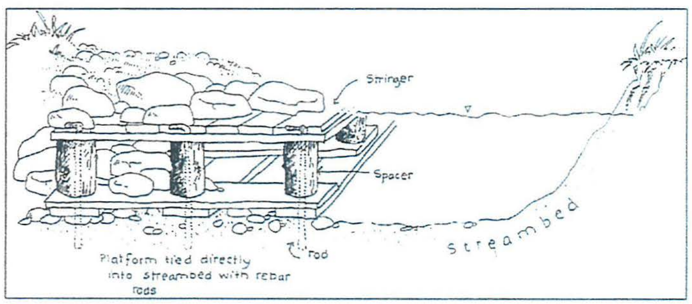
J:\1997\2205\6080\DEFLECT.dwg



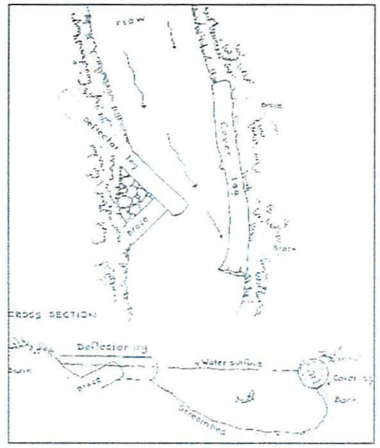
A Overhanging Cover



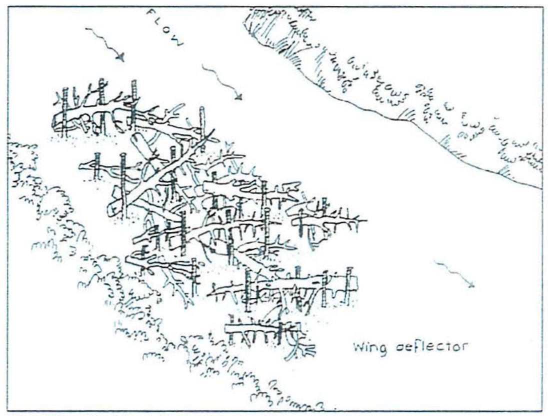
B Overhanging Bank Cover



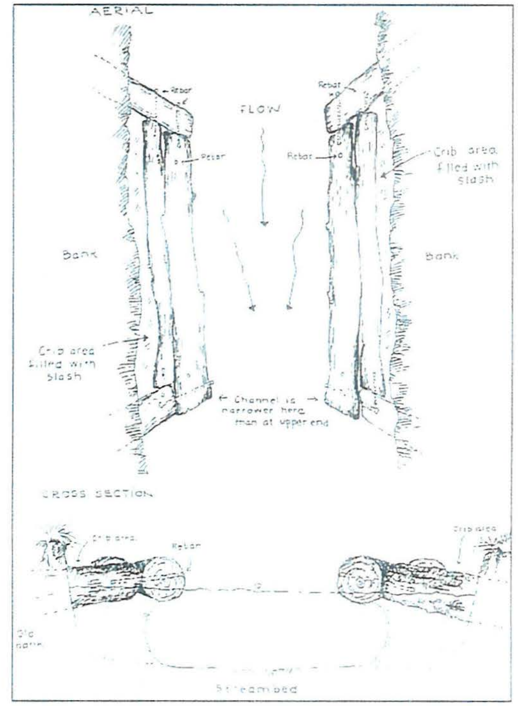
C Lunkers Structure



D Deflector and Cover Log



E Brush Bundles



F Channel Constrictor

REFERENCE
FIGURES FROM HUNTER (1991)

Scale 1:250 (Approx.)
Schematic Only

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HABITAT ENCHANCEMENT OPTIONS: DEFLECTORS/COVER

11 Feb 1998	Figure III–2	DRAWN BY: CG

APPENDIX IV

AN EXAMPLE OF SUCCESSFUL STREAM MITIGATION

An Example of Successful Stream Mitigation

Poplar Creek (a small tributary on the west bank of the Athabasca River) is a local example of how fish habitat enhancement can mitigate the effects of increased flow on fish habitat. Poplar Creek's drainage was affected as part of Syncrude's Mildred Lake oil sands development. Water from Beaver River is directed through Poplar Creek Reservoir and enters Poplar Creek through a spillway about 3 km from the creek mouth. Habitat above the location where the spillway enters is characterized by silt bed and banks which is representative of pre-development conditions (Photo IV-1).

The stream reach between where the spillway enters Poplar Creek and the Highway 63 Bridge was improved to provide for an increased conveyance capacity and erosion protection to allow for the large increase in flows (about 3 times natural flow) caused by the Beaver River diversion (Les Sawatsky, Golder Associates, pers. comm.). The improvement consisted of rock berms across the floodplain to prevent channel avulsion and a series of gravel/cobble chutes (riffles) for erosion protection. The result is a series of riffles and pools and a river which exhibits characteristics of natural channels (Photo IV-2). The gravel/cobble bed and vegetated banks provide for some improvement to the fish habitat. This area has been documented as an Arctic grayling and sucker spawning area (Golder 1996a). The difference between the improved channel upstream of the bridge and pre-development conditions is shown in Photo IV-1 and IV-3.

In contrast, no improvement measures were implemented downstream of the Poplar Creek Bridge except for a single chute located just downstream of the bridge. Consequently, the downstream reach of the Poplar Creek channel has been subject to a major transformation as a result of the increased flow. It has been subject to significant bank erosion and a dramatic change in regime from a side channel system to a braided channel with ill-defined banks.

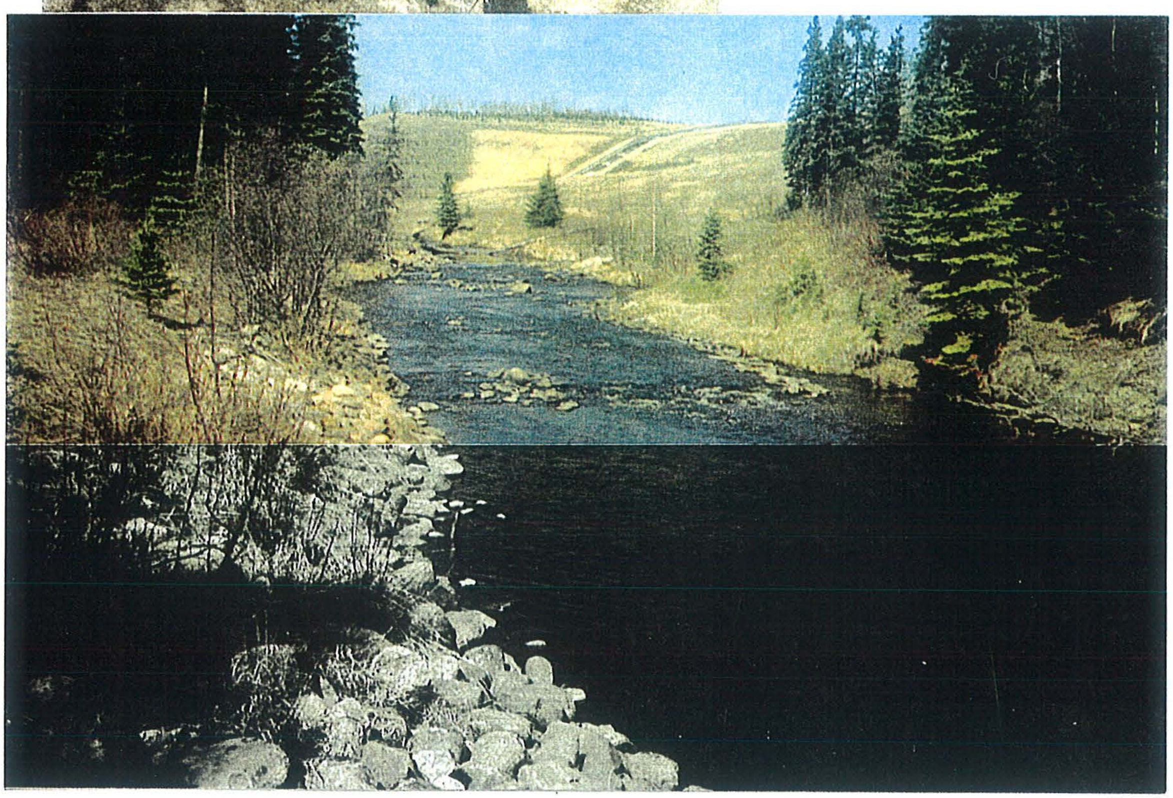
Photographs

Photograph IV-1 Poplar Creek upstream of the spillway (pre-development conditions)

Photographs

Photograph IV-2

Aerial view of improved portion of Poplar Creek downstream of the spillway



Photograph IV-3 Improved habitat in Poplar Creek downstream of the spillway