Shore Gold Inc.

TECHNICAL MEMO

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SUBJECT: Updated Water Management Strategy- Star-Orion South Diamond Project

Introduction

As a result of Federal review comments about the discharge water quality as described in the Revised Environmental Impact Statement for the proposed Star-Orion South Diamond Project, Shore has re-evaluated overall site water management to increase flexibility based on the following:

1. feedback from Environment Canada (EC) and the Canadian Environmental Assessment Agency (CEAA);
2. potential increases in plant water requirements due to the processing change to allow for increased throughput;
3. the recently initiated process to develop diamond mining regulations under the Metal Mining Effluent Regulations (MMER) of the *Fisheries Act*;
4. need for increased flexibility in the water management system to ensure that varying environmental conditions or other contingences can be adequately addressed; and
5. WorleyParsons' recent review of total dissolved solids (TDS) and chloride treatment technology (Worley Parsens, 2009; "Identification of Best Available Control Technologies Applicable to Canadian Diamond Mining Effluent", prepared for Environment Canada).

This report describes the updated water management strategy, provides justification for the changes, and presents updated water quality modeling results. Note that this update only changes management of water for Star kimberlite mining. Once Orion South ore is processed, water management does not change from the Revised EIS. In addition, further details have been developed and are provided on monitoring locations and contingency. As well, this document addresses relevant Provincial comments received on the revised EIS.

Updated Water Management

Background

During the feasibility design process several concerns and questions were raised which in part necessitated this review. In previous applications, water management did not include contingencies or flexibility to manage varying environmental conditions or changes in plant requirements. For example, during the feasibility study concerns were raised that the surficial wells that were planned

to provide fresh water for recovery within the plant might be impacted by the expected drawdowns created by pit dewatering. As this was the only consistent source of fresh water for the plant this was a concern from the design engineers to ensure constant supply. During, and subsequently to, the feasibility study, some changes in the processing plant operation are being considered that would require potential increases in throughput of the plant, that would in turn, require additional fresh water. The proposed changes to the throughput would not result in any increase in overall plant requirements, as only the recovery circuit of the mill requires fresh water. All other water can be internally recycled into the autogenous grinding mills at the front end of the plant.

The previous water management strategy relied on a fixed recycling rate from the PKCF to the plant to supply water. This fixed rate did not allow for flexibility to manage water quality as described in WorleyParsons (2009), nor did it allow Shore to manage for environmental variability.

Key Changes

The updated water management strategy can be summarized by changes in the following key areas:

1. Intake in the Saskatchewan River to supply water to the plant;
2. Removal of the shallow groundwater wells for process water;
3. Management of site water in the PKCF;
4. Co-management of PKCF decant and Mannville water prior to discharge; and
5. Replacement of the diffuser with a simple outfall structure.

These areas and the overall water management strategy are discussed below in terms of:

- Sources of Processing Plant Water;
- Processed kimberlite Containment Facility (PKCF);
- Site Water Management;
- Discharge to the Saskatchewan River;
- Water Balance Model and Water Quality; and
- Monitoring and Contingence Planning.

Sources of Processing Plant Water Management

Previously, the water for the processing plant was sourced from: recycled water in the PKCF, Mannville groundwater and also the proposed shallow water supply wells (located to the northeast of the plant). Under the revised water management strategy the processing plant would get its water from:

- Saskatchewan River water;
- East Ravine runoff collection (minus water used for supplementing low flows in other area Ravines); and
- Recycled water from the PKCF (there would now be different flows going into this facility).

The fresh water Saskatchewan River water that would supply the plant would be piped directly from the river, with an intake structure specifically designed for this purpose. This intake structure would be designed according to Department of Fisheries and Oceans specifications. The intake would be designed for up to 68,900 m3/d of water, which is the maximum required rate of fresh water. However the actual extraction rate would vary depending on seasonal variation in East Ravine runoff collection and recycling from the PKCF, environmental conditions and the physical properties of the kimberlite. Saskatchewan River water could supply between 0 and 100% of plant water requirements for the processing plant.

The surficial groundwater wells originally planned to supply fresh water to the plant would be eliminated. However the shallow well providing potable water (up to 50 m3/d) would remain, as it

was felt that this area should be able to sustain one well and, if there was insufficient water supply, a second potable water supply well could be complete in this area.

The remaining water supply for the processing plant would come from East Ravine runoff or the Processed Kimberlite Containment Facility (PKCF). The PCKF would supply between 0 to100% of the required water demand. As described in the Revised EIS (Section 2.6.9.1) the processing plant would discharged approximately 64,704 m3/d to the PKCF .with the remaining approximately 4,200 m3/day would be discharged as residual water adhering to the coarse processed kimberlite (CPK).

Process Kimberlite Containment Facility (PKCF) Water Management

The PKCF would be used to manage most site water during mining of the Star kimberlite. After year 17, when mining of the Orion South kimberlite begins, most site water will be placed in the Star Pit. A variation of this concept was considered in the Draft EIS using the water management reservoir. The PKCF would receive:

- Process water;
- Shallow passive inflow from the Star pit (minus water directed to the lower reach of the East Ravine);
- deep passive inflow from the Star pit;
- Site runoff from the plant site;
- Seepage and runoff from the CPK;
- Seepage and runoff from the PKCF; and
- precipitation.

Discharges from the PKCF would consist of seepage (estimated at 1,000 m3/d), decant (or overflow), and depending on water recycled into the plant. Losses due to evaporation are also included in the model.

Seepage and runoff from the PKCF will be collected in drainage ditches keyed into the underlying clay where practical, and if not keyed into the clay, subsurface drainage and/or pumping will be installed. It is estimated that 90% of the seepage will be captured. Exact locations of keyed in ditches, subsurface drainage and pumping will be determined during detailed design.

Seepage water will be returned to the PKCF or directed to local natural wetlands depending on water quality. Water quality will be measured prior to discharge to wetlands (i.e., in the seepage collection system), after the wetland in the Ravine and at the mouth of the Ravine. Seepage will be collected in small retention ponds in-line with the ditch system to manage sediment, and to control discharge or pumping back to the PKCF. Seepage water quality will be compared to the wetland efficiencies described in Arcadis (2013; provided as #3 wetland treatment.pdf (provincial) and NRC #11 Wetland Treatment.pdf (federal)), and if it is determined that water quality achievable at the end of the wetland complies with the relevant discharge limits, then it will be directed to the wetlands. In the event that water quality pre-wetland is not such that applicable guidelines will be met, then it will be pumped back to the PKCF. As described below, water quality will be monitored in three locations, following the path of the water to the Saskatchewan River: in the seepage collection system prior to wetland discharge, after the wetland, and at the mouth of Duke Ravine.

Additional details about the potential effects of changes to flow in the Duke Ravine are discussed in DFO SIR #1 Response to Duke Ravine Flow.pdf.

After year 17, any ponded water on the PKCF will be drained into the Star Pit, and reclamation will begin on the PKCF. Reclamation will include at least 100 cm of sand or other overburden material (which includes till and clay) on sites expected to be dry or moist, with 100 cm of till or clay placed in the low lying areas expected to be reclaimed to wet-moderate sites in order to limit infiltration.

Infiltration through the fine processed kimberlite is expected to be minimal, as hydraulic conductivities through this material is low (5 x 10-10 m/s; Klohn 2011). At closure, drainage will be contoured to feed into the existing drainage ditches, to natural wetlands leading to the Ravines for eventual discharge into the Saskatchewan River. Note that closure water quality estimates have not changed for the updated scenario.

Site Water Management

Site runoff from the processing plant site will be collected in on site settling ponds and pumped to the PKCF with the process water.

Coarse Processed Kimberlite (CPK) Pile Water Management

Seepage through the Coarse Processed Kimberlite will be collected in drainage ditches and/or subsurface drainage similar to those at the PKCF. Runoff is considered low during operations due to the coarse nature of the material. All seepage collected from the CPK will be placed in the PKCF. Inputs into the CPK include residual water adhering to the processed kimberlite (estimated at about 4,200 m3/day) and precipitation. Outputs include seepage and evaporation, which are considered in the water balance model.

Mannville Water Management

Mannville water would be blended with the PKCF decant water in-line with the discharge pipe, in a mixing box type structure. Recycle to the plant will occur after this mixing box, and remaining water would be discharged to the Saskatchewan River. Water quality at end of pipe is being modeled by AMEC Environment and Infrastructure described below in Section XXX, and is anticipated to meet requirements of the Fisheries Act and of the Province.

Pumping for years 1-14 is estimated to be fairly constant at 98,100 m3/day, with a peak of 130,800 m3/day predicted during mining of Orion South. Up to 68,900 m3/day of blended effluent would be recycled to the plant with any excess being discharged to the Saskatchewan River.

Star Pit Water Management

Water sources within the Star pit include residual passive inflows (RPI) from the shallow and deep groundwater system, and runoff due to precipitation. Estimates of RPI are contained in SRK groundwater modeling report (SRK, 2011). Shallow RPI and runoff from upper benched in the glacial sediments will be collected with a network of on bench using a network of drainage ditches and sumps. The majority of this RPI water will be pumped to the PKCF for management. A small amount of this RPI water that will be collected from the uppermost benches on the south side of the pit and is of sufficient quality, will be released to the lower reaches of the East Ravine.

Deep aquifer RPI and runoff from the kimberlite benches will be collected in in-pit sumps and pumped to the PKCF for management.

Note that once operations cease at Star and processing of OS kimberlite begins, all process water and Mannville water will be managed in the Star Pit.

East Ravine Water Management

Water from the upper reaches of East Ravine will be collected in a runoff pond to intercept drainage before it reaches the Star Pit. This water will be used to supplement low flows in 101 Ravine, Duke Ravine and English Creek if levels drop to within 115% of base flow and any amount not used for flow supplementation will be used in the process plant and reduce withdrawal from the

Saskatchewan River. East Ravine water is modeled to make up from 5 to 25% of plant water requirements depending on the season.

Overburden and Rock Storage Pile Water Management

Precipitation causing runoff will be managed primarily for suspended solids at the Overburden and Rock Storage Pile. Retention and drainages structures will be constructed as needed for settling, however progressive reclamation of lower side slopes of the structure will be the primary mitigation for sediments. Any runoff from this facility will drain naturally into existing watersheds according to the watershed boundary. Note that the Colorado group shale is not considered suitable reclamation material and will be encapsulated with at least 2 m of low permeability till of clay as described in the response to Provincial Industrial Branch Comment #23.

Potable Water Management

Potable water management is a separate system from the updated mine water management strategy. Potable water will be sourced from the shallow aquifer using a dedicated well(s) to supply up to 50 m3/d and then treated to relevant drinking water standards using as previously described in the Revised EIS. The waste water will be treated in a two-stage lagoon constructed as per regulatory standards (see relevant supplement information requests) with treated discharge released to the Duke Ravine.

Discharge to the Saskatchewan River

Previously the EIS indicated that all of the Mannville water would be discharged to the Saskatchewan River through a diffuser. The new water system envisions discharge of the co-managed water from the PKCF and the Mannville Formations. As previously indicated the PKCF will now be used to manage a greater volume of water from more variable sources of water. The discharge water quality to the Saskatchewan River is expected to improve (see Table 1). Due to the improvement in the discharge water quality the need for the diffuser will be re-evaluated and the possibility of direct discharge to the Saskatchewan River through an outfall structure will be explored.

Table 1. Discharge Water Quality at End-of-Pipe

Parameter	Unit	Minimum	Mean	Median	95th Percentile	Maximum	Standard Deviation	Cv
Chloride	mg/L	1090.69	1119.67	1115.32	1099.46	1175.52	19.69	0.02
Ammonia	mg/L	1.286	1.321	1.316	1.297	1.382	0.022	0.017
Phosphorus	mg/L	0.0548	0.0556	0.0555	0.0550	0.0563	0.0003	0.0057
Selenium	mg/L	0.00026	0.00027	0.00027	0.00026	0.00027	0.000003	0.0103
Cadmium	mg/L	0.0000345	0.0000367	0.0000369	0.0000349	0.000038	0.0000008	0.0230
Chromium	mg/L	0.000698	0.000747	0.000750	0.000706	0.000764	0.000016	0.0217
Nickel	mg/L	0.00115	0.00123	0.00123	0.00116	0.00128	0.00003	0.0238
Copper	mg/L	0.00243	0.00245	0.00245	0.00244	0.00247	0.00001	0.0032
Boron	mg/L	1.228	1.259	1.255	1.237	1.321	0.022	0.017
Zinc	mg/L	0.01272	0.01323	0.01326	0.01291	0.01346	0.00015	0.0114

Monitoring and Contingency Planning

Monitoring is discussed below in terms of:

- surface water and groundwater quality monitoring;
- Flow monitoring; and
- Supplementation and Fisheries and Aquatic Resource Monitoring.

Surface Water and Groundwater Quality Monitoring

The water quality model (AMEC 2013) predicts water quality in site facilities (CPK Pile, PKCF) and in local watersheds based on mass balance calculations. As such, water quality monitoring site have been selected as listed below. New sites added as a result of review comments are identified as well as sites previously listed in Table 7.4-1 of the revised EIS. Sites are presented on Figure 7.4-3 of the EIS that has been updated and included in this report.

Table 7.4-1: Rationale for Surface Water Quality Site Section

Site	Rationale	Commitment	Link to WQ model
English Creek above the PKCF	Control site upstream of the Project	Revised EIS	No effect predicted; not modeled
English Creek at mouth	Control site down gradient of the Project facilities	Revised EIS	
Wapiti Ravine at mouth	Monitor effects of PKCF on water quality	Revised EIS	
Duke Ravine at mouth	Monitor effects of Project facilities on water quality before entering the Saskatchewan River	Revised EIS	
East Ravine upstream of access road	Control site upstream of the Project	Revised EIS	No effect predicted; not modeled
East Ravine at mouth	Monitor Project effects on water quality before East Ravine enters the Saskatchewan River	Revised EIS	
West Ravine at mouth	Monitor Project effects on water quality before West Ravine enters the Saskatchewan River	Revised EIS	
101 Ravine downslope of overburden & rock storage	Near field site to monitor effects of the storage facility on water quality	Revised EIS	
101 Ravine at mouth	Monitor effects of the OB & rock storage facility on water quality before it enters the Saskatchewan River	Revised EIS	
Caution Creek upslope of the overburden & rock storage	Control site above the facility	Revised EIS	No effect predicted; not modeled

Site	Rationale	Commitment	Link to WQ model
facility			
Caution Creek at mouth	Monitor effects of the OB & rock storage facility on water quality before it enters the Saskatchewan River	Revised EIS	
Saskatchewan River upstream of the Project	Control site for Saskatchewan River water quality	Revised EIS	No effect predicted; not modeled
Saskatchewan River downstream 200 m below English Creek	Monitor Saskatchewan River water quality downstream of the Project below the mixing zone with English Creek.	Revised EIS	
PKCF	Monitor water quality of the PKCF	Revised EIS	
Discharge to Saskatchewan River	Monitor discharge water quality	Revised EIS	
PKCF drainage ditch	Monitor water quality prior to release to wetlands	New site	
Duke Ravine upstream of facilities	Server as control site, and measure changes in water quality after natural wetlands	New site	
Stream F at mouth	Control Site	New site	No effect predicted; not modeled
Stream F upstream	Control Site	New site	No effect predicted; not modeled
Pehonan Creek at Mouth	Control Site	New site	No effect predicted; not modeled
Pehonan Creek 1,500 m upstream	Control Site	New site	No effect predicted; not modeled

Flow monitoring and Supplementation

Previously monitored sites (English Creek, Caution Creek, 101 Ravine and East Ravine) will be monitored at the same sites that were used during baseline data collection. These sites have established stage-discharge curves, and will be continuously monitored using water level gauges. Similar monitoring will be established on the lower reach of Duke Ravine, Peonan Creek and Stream F. Flow monitoring will also occur on upper reaches of Duke, 101, and East Ravine, and at the crossing of Division Road and English Creek. These upper locations are expected to detect any changes in flow earlier than the locations at the mouth. Once established, sites will be monitored continuously throughout operations.

Flow supplementation will be sourced either from the East Ravine runoff pond or from the same location that provides the plant. As precipitation and surfical groundwater supply the East Ravine pond, water quality should be very similar to the water quality in the supplemented streams. Field

measurements of ph, EC, temperature, dissolved oxygen and TSS will be taken from the source water, and the supplemented water, daily during the first week of pumping, then weekly thereafter for the duration of the program. East Ravine water and supplemented water is also sampled monthly for water quality as described in Table 7.4-1, so the compatibility of these waters should be well understood. Supplementation will be triggered once levels in any monitoring station on these waterways reach 115% of base flow, and will be managed to maintain or exceed 115% of base flow.

Sites are presented on Figure 7.4-3 of the EIS that has been updated and included in this report.

Fisheries and Aquatic Resource Monitoring

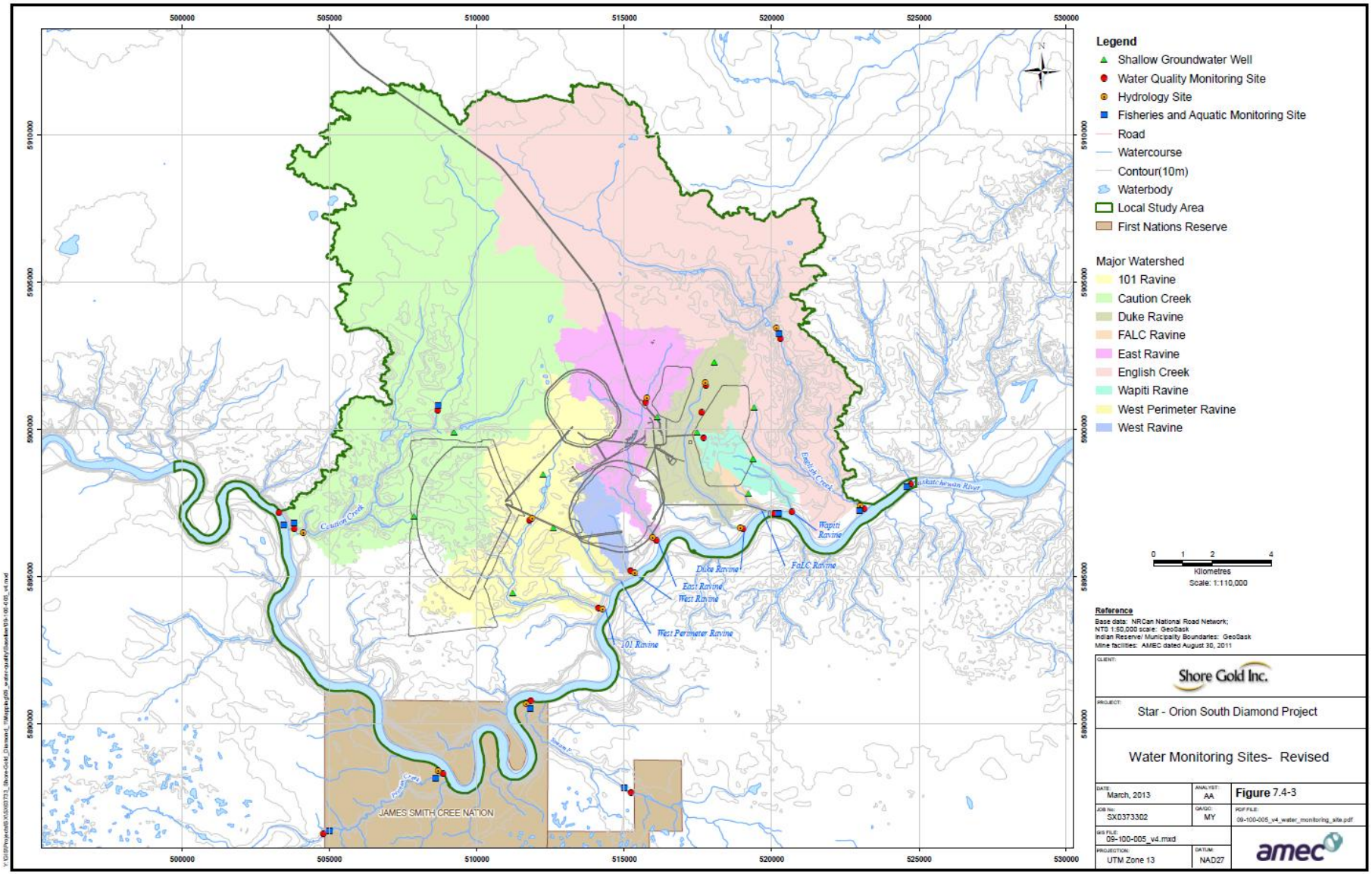
Stream F and Peonan Creek will be incorporated into the Aquatic Monitoring Plan according to the principles currently described in the MMER (see 7.4.2.6, 7.4.2.7 and 7.4.2.8 of the revised EIS) and adjusted based on future requirements. Fisheries and aquatic resources will be monitored as described in 7.4.2.8 at the mouth of Stream F and Pehonan Creek, and an upstream location to establish baseline conditions, with monitoring up the upstream location continuing throughout operations. Should changes in flow be detected, then operational monitoring of the mouth locations will resume.

Sites are presented on Figure 7.4-3 of the EIS that has been updated and included in this report.

Water Management Contingency Planning

The updated plan allows for contingency planning for upset conditions and natural variability by

- including the option to return all seepage water to the PKCF
- including limited storage in the PKCF
- including various sources of water to supply the plant to account for natural variability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Shallow Groundwater Well
Water Quality Monitoring Site
Hydrology Site
Fisheries and Aquatic Monitoring Site
Road
Watercourse
Contour(10m)
Waterbody
Local Study Area
First Nations Reserve
Major Watershed
101 Ravine
Caution Creek
Duke Ravine
FALC Ravine
East Ravine
English Creek
Wapiti Ravine
West Perimeter Ravine
West Ravine
Caution Creek
English Creek
Wapiti Ravine
FALC Ravine
Duke Ravine
East Ravine
West Ravine
West Perimeter Ravine
101 Ravine
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Reference
Base data: NRCan National Road Network;
NTS 1:50,000 scale: GeoSask
Indian Reserve/ Municipality Boundaries: GeoSask
Mine facilities: AMEC dated August 30, 2011
CLIENT:
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Figure 7.4-3
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