SECTION 3.0

EVALUATION OF PROJECT OPTIONS

TABLE OF CONTENTS

Page

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

3.0 EVALUATION OF PROJECT OPTIONS AND ALTERNATIVES

During the planning stages of the Project leading up to the EIS, a number of options were considered for various aspects of the Project dealing with the following topics:

- the Project itself;
- processing method;
- mining methods;
- overburden and rock storage;
- Coarse PK and Fine PK management and storage;
- water management;
- road access;
- power line right of way;
- gas line corridor; and
- construction camp.

The following sub-sections detail the alternatives considered within these topics and identification of preferred options.

3.1 ALTERNATIVES FOR THE STAR-ORION SOUTH DIAMOND PROJECT

The high level alternatives for the Star-Orion South Diamond Project were as follows:

- open pit mining;
- underground mining; and
- no project.

The preliminary feasibility study (PFS; P&E 2010) and subsequent feasibility study (FS; Read et al., 2011) demonstrated that mining of the Project could be done economically. The potential financial benefits of the Project to Shore's shareholders, to communities, First Nations and Métis in the region, to the Province of Saskatchewan and Canada, justified Shore's initiation of the environmental assessment process in November 2008.

The option of 'no project' would not create these benefits. Development of the Project is consistent with the Saskatchewan Ministry of Energy and Resources Plan for 2010/11, in which the strategy for sustainable development of petroleum and mineral resources calls for the promotion of responsible development and conservation of mineral resources to achieve the goal of benefits of economic growth to the people of Saskatchewan. Consequently, the 'no project' option was not considered further.

Open pit mining was selected as the preferred mining method. Project economics dictated that underground mining was not feasible at either the Star or Orion South kimberlites. The extraction of high tonnage from these relatively low grade deposits would require very large daily mining rates which are not economically viable using current underground mining methods. The only feasible way to extract the required tonnages is to employ large economies of scale achievable using open pit mining methods.

Further analysis using pit optimisation software concluded that the preferred approach was to mine the Star Kimberlite followed by the Orion South Kimberlite (P&E 2010; Read et al., 2011). The locations of the pits are shown in Figure 2.1-1 (Section 2.0 Project Description).

3.2 PROCESSING

Two methods were considered for diamond liberation:

- conventional crushing; and
- autogenous grinding (AG) milling.

AG milling was shown to be beneficial for diamond liberation and would cause less diamond damage than conventional crushing equipment based on detailed processing test work and simulations. AG milling can also be adjusted to accommodate various kimberlite characteristics. By altering the kimberlite feed rate and changing the speed of rotation, it is possible to adjust the amount of energy transmitted to the kimberlite, thus accommodating variations in rock hardness. Since Shore is proposing to process kimberlite from many different eruptive units, each with particular kimberlite and diamond characteristics, this flexibility was considered very important. As a result, AG milling was selected as the best liberation method.

3.2.1 Fine PK Management

Three major methods of managing Fine PK were considered:

- thickening to remove water from Fine PK prior to placement in the processed kimberlite containment facility (PKCF);
- placement of all fines in slurry form directly to the PKCF; and
- placement of fines from Star into the PKCF and fines from Orion South in to the Star pit.

Thickening involves the removal and possible recycling of process water from the processing circuit, while the second option involves direct discharge of all fines without further thickening. Thickening is normally utilized in areas where water supply is a major concern and water needs to be recycled through the mining and processing systems. Thickening typically creates thickened tails made up of fine particles (i.e., clay and silt) with a paste-like consistency. This thickened tails commonly has settlement and consolidation issues which can create challenges at closure. Inclusion of a thickening circuit would increase costs and create potential environmental issues at closure due to the uncertain settling characteristics of the thickened tails.

The Project has a surplus of water from pit dewatering; therefore, the addition of a thickening circuit to recycle water is unnecessary. In addition, the Fine PK would not be segregated into thickened tailings, and could be sent directly to the PKCF. Compared to the thickening circuit, direct placement of all fines would be less costly, and cause fewer potential environmental effects; and therefore thickening was not considered furhter.

Designing a PKCF to contain all fines produced would require additional height, area and cost as compared to using the Star pit to contain fine OK from Orion South. Due to the environmental and economic benefits, use of the Star pit was considered the best option.

3.3 MINING METHOD

Two major options were examined for the mining method:

- in-pit crush and convey (IPCC); and
- standard truck and shovel.

Both options were considered during pit optimisation; detailed cost analysis led to the IPCC system being selected as the mining method. Other options such as drag lines and dredging were examined in less detail but were discounted early in the analysis as they were clearly not viable for the Project.

3.4 COARSE AND FINE PK STORAGE, AND OVERBURDEN AND ROCK STORAGE FACILITIES

The following subsections detail the Project options and final locations for Fine and Coarse PK piles along with the overburden and rock storage pile.

A constraints mapping approach was conducted in response to technical review comments on the draft EIS to avoid direct impacts to aquatic habitat. As a result, a 100 m buffer was applied to any valley breaks and wetlands at the headwaters of ravines in the LSA in order to constrain the footprint (Figure 3.4-1). Other factors, specifically wildlife habitat and traditional and non-traditional activities in the 101 Ravine were also considered, however the primary driver of the constraint map was aquatic habitat.

3.4.1 Regulatory and Legal Context- Site Selection

During the review of the draft EIS, federal reviewers indicated that there currently was no regulatory mechanism to permit the construction of facilities within aquatic habitat. Federal reviewers also noted that the existing Metal Mining Effluent Regulations (MMER) under the *Fisheries Act* did not apply to the Project, since the mining proposed is for diamonds, and diamonds are not specifically mentioned in the MMER. Specifically, the listing of a Tailings Impoundment Area under Schedule 2 of the MMER (subject to an alternatives assessment) is not available for diamond mines. As such, federal permitting of the original placement of the PKCF and other facilities was uncertain. Federal reviewers identified a regulatory gap that prevents diamond mining from being permitted to do the same types of activities that would otherwise be permitted if proposed by gold or other metal mines. Since submission of the draft EIS, the Federal Government has recognized this regulatory gap and has committed to develop regulations under the *Fisheries Act* for diamonds as part of Bill C-38. Shore supports the development of diamond regulations, however, since the timeline for the enactment of new regulations in uncertain, an alternate solution was explored.

As a result of this regulatory gap, and other review comments regarding minimization of direct impacts to aquatic habitat, a constraints mapping approach was taken as described below.

3.4.2 Coarse PK Storage

In addition to the constraints mapping, the design criteria for the Coarse PK storage at the Project site incorporate the following concepts:

- create a separate Coarse PK facility;
- minimize distance to plant site facilities;
- avoid known potentially economic kimberlite deposits;
- maintain a minimum offset distance of 1 km from the ultimate open pit rims;
- maintain a minimum offset distance of 1 km from the Saskatchewan River;
- maintain a minimum offset distance of 100 m from English Creek;
- limit the number of watersheds impacted by the facilities and ensure runoff would not interfere with the open pits;
- fit within the footprint of existing mineral dispositions;
- fulfill storage volumes and containment requirements while minimizing footprint;
- minimize capital and operating costs;
- balance cut/fill requirements;
- create a facility that can be successfully and safely constructed, operated and closed/reclaimed; and
- minimize risks and environmental issues.

The site for the Coarse PK pile was selected to the north-east side of the plant between East Ravine and Duke Ravine, outside of the immediate pit watersheds to ensure that drainage could easily be directed away from the open pit. This location is the closest to the plant site that fulfills all the above criteria. Within the draft EIS, the Coarse PK pile was located directly east of the plant location. In the revised EIS, the location was chosen to avoid direct impact to waterways and riparian habitat. The revised EIS Coarse PK pile is also smaller in footprint size due to engineering refinement as part of the feasibility study.

There are limited options in design of the Coarse PK pile. Only two alternatives were considered:

1. placement of a mixed pile of +1 to -45 mm material in a single pile; and
2. placement of two separate piles, +1 to -8 mm and +8 to -45 mm, using duplicate conveyers and stackers.

In order to facilitate potential future re-processing of the coarser size fraction, Option 2 was selected.

3.4.3 Processed Kimberlite Containment Facility (PKCF)

In addition to the constraints mapping, the design criteria for the Processed Kimberlite Containment Facility (PKCF) incorporate the following concepts:

- accept all Fine PK produced at the processing plant;
- incorporate cycloned PK underflow in the dyke construction;
- minimize distance to plant site facilities;
- minimize capital and operating costs;
- avoid known potentially economic kimberlite deposits;
- fit within the footprint of the existing mineral dispositions;
- fulfill storage volumes and containment requirements while minimizing footprint;
- incorporate surface water management;
- limit the number of watersheds impacted by the facilities and make sure runoff could easily flow away from the open pits;
- maintain a minimum offset distance of 1 km from the ultimate open pit rims;
- maintain a minimum offset distance of 1 km from the Saskatchewan River;
- maintain a minimum offset distance of 100 m from English Creek;
- balance cut/fill requirements;

- create a facility that can be successfully and safely constructed, operated and closed/reclaimed; and
- minimize risks and environmental issues.

With little topographic relief and no significant dry valleys close to the proposed plant site, or within the pit watershed, a self contained management facility for Star fine PK is the preferred PKCF layout (i.e., using a ring dyke). The location for the PKCF, determined using the above criteria and the constraints mapping, is east of the plant between the Duke Ravine and English Creek, outside of the immediate pit watersheds. This location fulfills all the above requirements and is the most economic and environmentally acceptable location. The revised EIS location diverges from the draft EIS in order to avoid direct impact to waterways and riparian habitat in response to regulatory requests. The footprint area has increased as a result of topography constraints within the revised location.

The PKCF dyke is designed as an engineered free-draining structure constructed with Fine PK cycloned underflow (granular material). An alternative to this method would be to construct the berms entirely out of overburden material. Cycloning would reduce the overall footprint and is more cost effective.

The starter dykes will be constructed of suitable sand obtained while stripping the open pit. The berms will be progressively built up using fines greater than 0.25 mm and smaller than 1 mm, which have been cycloned to remove water. Fine PK less than 0.25 mm in diameter and all the process water would be placed directly in the PKCF.

3.4.4 Overburden and Rock Storage Pile

In addition to the constraints mapping, the design criteria for the overburden and rock storage pile at the Project site incorporate the following concepts:

- create a separate overburden and rock storage pile;
- minimize distance to the open pits;
- minimize capital and operating costs;
- avoid known potentially economic kimberlite deposits;
- fit within the footprint of the existing mineral dispositions;
- maintain a minimum offset distance of 1 km from the Saskatchewan River;
- balance cut / fill requirements;
- create a facility that can be successfully and safely constructed, operated and closed/reclaimed; and
- minimize risks and environmental issues.

With the Coarse PK pile and PKCF located using the constraints map on the east side of the pits and the plant, the only viable location for the overburden and rock storage pile was to the west of the pit locations. No other locations were evaluated at the design stage. Relative to the draft EIS, and in response to regulatory request, the revised EIS has an overburden and rock storage pile with an irregular outline in order to avoid direct impact on waterways and riparian habitats of the 101 Ravine.

The overburden and rock storage pile was designed with a maximum height of 60 m and an area of 2,008 ha to accommodate overburden from both Star and Orion South. It is unlikely that the full height of the overburden pile will be reached, as the potential for backfilling overburden from Orion South into the Star pit will be evaluated at the detailed design stage.

3.4.5 Conclusion

Balancing the configuration of the overburden and rock storage pile, the locations of the processed kimberlite piles and the plant site considered economic and environmental factors. The location, final shape and design of the facilities thus incorporate a combination of both financial and environmental considerations.

3.5 WATER MANAGEMENT

The objective of the Project water management strategy is to manage the flow of groundwater, surface water and runoff within environmental and operational constraints. The water management strategy must also ensure that there are sufficient volumes of water available for the processing plant. The use of water from the water management system as process water is designed to reduce the potential effects on the environment.

The water management system design criteria are based on the following:

- using dewatering wells for deep groundwater systems;
- using in-pit dewatering for shallow groundwater systems and runoff;
- controlling surface water and runoff and preventing it from entering the pit;
- capturing precipitation and draining it away from roads and active mining areas;
- discharging water from the PKCF;
- removing surface water within the pit to prevent flooding of the working areas; and
- providing water to the processing plant.

The selected water management system, as discussed below, includes both in-pit and well dewatering activities, and a water recycling program through the PKCF. The recycling allows separate management of Mannville formation water, process water, surficial groundwater, and site seepage/runoff according to the specific characteristics of the water.

To dewater the pits, two separate groundwater collection systems are required due to the differing natures of the shallow and deep groundwater flow systems. An in-pit system will collect precipitation and groundwater that seeps into the pit from the shallow groundwater flow system. In addition, dewatering wells will depressurize the deep groundwater aquifers to reduce the amount of the water that flows into the pits. In addition, various other water management structures will be required to manage the runoff from waste management facilities, the processing plant site area and to minimize erosion.

3.5.1 Regulatory and Legal Context- Water Management

3.5.1.1 Regulatory Gap

Similar to the regulatory gap described in Section 3.4.1, Federal reviewers have indicated that the existing discharge limits described in the Metal Mining Effluent Regulations do not apply to diamond mines. As such, Federal reviewers maintain that, despite extensive scientific review and consultation conducted during the development of the MMER, that activities and discharges permitted with the MMER cannot be considered reasonable for diamond mining. In the absence of regulation, consideration and permitting of diamond project discharges fall to the wording contained in the body of the *Fisheries Act.* This regulatory gap, which allows other mines to discharge effluent of a particular water quality but does not allow diamond mining to discharge identical water, has been identified by the Federal government in Bill C-38, which outline commitments to develop diamond specific regulations. Shore supports the development of diamond regulations, but the timeline and the specifics of these regulations are not known at this time.

3.5.1.2 The Fisheries Act

Central to the *Fisheries Act* concerning water discharge and pollution control are Sections 36(3) and 36(4), which prohibits deposition of “deleterious substances” unless authorized by regulation and Section 34(1), which defines a “deleterious substance”. As a result of the regulatory gap identified above, for this Project authorization to discharge to an aquatic environment depends on if the discharge can be considered deleterious. These sections are reproduced below for reference. From the *Fisheries* Act:

> Section 36
>
> Deposit of deleterious substance prohibited
>
> (3) Subject to subsection (4), no person shall deposit or permit the deposit of a deleterious substance of any type in water frequented by fish or in any place under any conditions where the deleterious substance or any other deleterious substance that results from the deposit of the deleterious substance may enter any such water.

Deposits authorized by regulation

(4) No person contravenes subsection (3) by depositing or permitting the deposit in any water or place of

- (*a*) waste or pollutant of a type, in a quantity and under conditions authorized by regulations applicable to that water or place made by the Governor in Council under any Act other than this Act; or
- (*b*) a deleterious substance of a class, in a quantity or concentration and under conditions authorized by or pursuant to regulations applicable to that water or place or to any work or undertaking or class thereof, made by the Governor in Council under subsection (5).

and

34. (1) For the purposes of sections 35 to 43,

"deleterious substance"
« substance nocive »

"deleterious substance" means

- (*a*) any substance that, if added to any water, would degrade or alter or form part of a process of degradation or alteration of the quality of that water so that it is rendered or is likely to be rendered deleterious to fish or fish habitat or to the use by man of fish that frequent that water, or
- (*b*) any water that contains a substance in such quantity or concentration, or that has been so treated, processed or changed, by heat or other means, from a natural state that it would, if added to any other water, degrade or alter or form part of a process of degradation or alteration of the quality of that water so that it is rendered or is likely to be rendered deleterious to fish or fish habitat or to the use by man of fish that frequent that water,

and without limiting the generality of the foregoing includes

- (*c*) any substance or class of substances prescribed pursuant to paragraph (2)(*a*),
- (*d*) any water that contains any substance or class of substances in a quantity or concentration that is equal to or in excess of a quantity or concentration prescribed in respect of that substance or class of substances pursuant to paragraph (2)(*b*), and
- (*e*) any water that has been subjected to a treatment, process or change prescribed pursuant to paragraph (2)(*c*);

3.5.1.3 Legal Interpretation of 34(1) defining a deleterious substance

It has been noted that the definitions of “a deleterious substance” uses the word ‘deleterious’ in its definition. This circular definition has caused regulators and industry to seek clarification as to what is ‘deleterious’ with the Courts. Numerous cases have dealt with 34(1)(a), which has been interpreted to be a strict prohibition regardless of “quantity or concentration” (i.e., that the quantity of a deleterious substance deposited is not relevant,), and that conditions in the ultimate receiving environment are also not relevant, because, by definition, adding a substance to any water would increase the concentration of the substance in the water. To use a hypothetical scenario, depositing one milliliter or 1,000 liters of hydrocarbons into fish bearing water can both be considered violations of the *Fisheries Act*. Cases often cited pertaining to 34(1)(a), among others, include:

- Regina v. MacMillan, Bloedel (Alberni) Ltd. (1978), 42 C.C.C. (2d) 70 (B.C.Co.Ct.) [affirmed], [1979] 47 C.C.C. (2d) 118 (B.C.C.A.), (leave to appeal to S.C.C. refused June 19, 1979); and
- *R. v. Kingston (City)* (2004), 185 C.C.C. (3d) 446 (O.C.A).

Environment Canada has confirmed on December 13, 2011, that Section 34(1)(b) is the appropriate section of the *Fisheries Act* to apply to a determination if the proposed Mannville discharge is deleterious. Shore is not aware of any legal precedent concerning interpretation of Section 34(1)(b).

In contrast to Section 34(1)(a), the wording of 34(1)(b) specifically mentions the two parameters mentioned above, the quantity and concentration of a substance, which have been determined to be not relevant under legal interpretation of 34(1)(a). This contradiction between the legal interpretation of 34(1)(a) and the specific wording of 34(1)(b) suggests a material difference between 34(1)(a) and 34(1)(b), and suggests that a different legal interpretation would be expected. The three key differences between 34(1)(a) and 34(1)(b) are:

1. The addition of the words “in such quantity” in 34(1)(b);
2. The addition of the words “in such concentration” in 34(1)(b); and
3. The addition of the term “any other water” specifying that the receiving water is different than the water containing a substance.

The first difference is consideration if the “water contains a substance in such quantity” that it “would degrade or alter or form part of a process of degradation or alteration of the quality of that water so that it is rendered or is likely to be rendered deleterious to fish or fish habitat…”. Quantity is usually measured on a mass basis (i.e., expressed in grams or kilograms). When dealing with quantity of a substance contained in water, the only way to determine the absolute quantity is to multiply the volume of the water by the concentration of the substance, and when dealing with water flows, is to multiply the water flow (i.e., m^3/s) by the concentration of the substance (i.e., g/l) to get quantity over time. A simple mass or rate of a substance, on its own, does not inform or allow a determination if it would “degrade or alter…rendered deleterious to fish or fish habitat”. Only within the context of the receiving environment (i.e., volume of the receiving water, flow rate of the receiving environment, or behavior in the receiving environment) does quantity provide any insight within the context of 34(1)(b).

The second difference is consideration if the “water contains a substance in such concentration”. It is not possible to directly conclude that a specific concentration of a substance will “degrade or alter or form part of a process of degradation or alteration of the quality of that water” without consideration of the discharge environment. It is possible that the discharge environment will have higher, lower or the same concentrations of the substance contained in the discharge water. The Act specifically mentions concentration in order to allow regulators tools to deal with each of these scenarios, as aquatic habitat, and water quality can be extremely variable across Canada. These considerations also imply a means test, where actual changes in water quality need to be demonstrated

Within Saskatchewan, fish have been found in lakes with up to 10,000 mg/l total dissolved solids (TDS; Rawson and Moore 1944). If concentrations are not relevant under 34(1)(b), then it would be a violation of the Fisheries Act to place water with a TDS of 6,000 mg/l into a fish bearing lake with a TDS of 10,000 mg/l, even though this addition would, on a mathematical basis, improve the water quality by lowering the TDS.

These considerations also imply a means test, where actual changes in water quality need to be demonstrated. However, Section 34(1)(b) contains different wording that suggests that a different interpretation and test for deleteriousness is required. Continuing the hypothetical hydrocarbon example, discharging water that naturally contains hydrocarbons would not be prohibited under the Fisheries Act applying Section 34(1)(b), even if the hydrocarbons themselves could be considered deleterious under Section 34(1)(a), unless the “quantity or concentration” leads to a change in water quality in the receiving environment such that it is rendered, or is likely to be rendered, deleterious to fish or fish habitat. If no change in water quality results, or if the change is small enough that it is not likely to be rendered deleterious to fish or fish habitat, then the discharge water would not be deleterious.

The third change is the specification that “any water that contains a substance” is added to “any other water”. It is not possible to differentiate between the “water that contains a substance” and the “any other water” without consideration of the quality of the “any other water.” Without this clause, and consideration of the receiving water quality, it could be a violation of the Fisheries Act to remove water from a water body and return it to the same or identical water body, without any alteration.

In summary, 34(1)(b) is different from 34(1)(a) in that it instructs the Crown:

1. to determine if the receiving water is in fact different than the discharge water ("any water" vs. "Any other water");
2. to determine if the amount of a substance contained in the water is such that, if added to any other water, the water quality is altered so that it is rendered deleterious; and
3. to determine if the concentration of a substance contained in the water is such that, if added to any other water, the water quality is altered so that it is rendered deleterious.

These three clauses cannot be evaluated without consideration of the receiving environment, in direct contrast to section 34(1)(a). As such, it is reasonable to consider the receiving environment in the determination of deleteriousness under 34(1)(b). As noted above, changes are proposed to the *Fisheries Act* by the Federal Government through introduction of Bill C-38. These changes may change the focus of the Act, and may further reduce the applicability of use of non-fish species in sub-lethal testing as it pertains to the definition of deleteriousness.

3.5.1.4 Permitted Diamond Mines in Canada

Despite the regulatory gap described in Section 3.4.1 and 3.5.1, several diamond mines have been permitted in Canada, specifically Diavik, Ekati and Snap Lake in the North West Territories, Victor in Ontario, and Jericho in Nunavut (currently non operational). Discharge criteria for the operational mines are summarized in Table 3.5-1 below. Note that each mine effluent stream only requires acute toxicity testing, with a pass defined as 50% survival at a concentration of 100% effluent. The applicability of acute testing to the proposed Star-Orion South Project was confirmed in Federal Review comment #156 where "It is recommended that the proponent undertake routine acute lethality testing of any effluent prior to entering fishery waters to affirm its non deleterious character". No diamond mines are regulated based on chronic or sub-lethal toxicity tests. In addition, existing metal and other mines in Canada are permitted on a basis that effluent passes acute toxicity (Worsley Parsons 2009).

Table 3.5-1: Summary of Discharge Criteria for Existing Permitted Diamond Mines in Canada

Parameter (mg/L)	MMER (monthly average)	Current Diamond Operations (range of monthly or 6 day average limits)	Notes
Ammonia	-	2.0 - 10.0	one as <0.02 mg/L as unionized

Parameter (mg/L)	MMER (monthly average)	Current Diamond Operations (range of monthly or 6 day average limits)	Notes
Nitrite	-	0.5 – 1.0	
Nitrate	-	4.0 – 22.0	
Aluminum	-	0.1 – 1.5	
Cadmium	-	0.0015 – 0.003	
Chromium	-	0.01 - 0.02	
Copper	**0.3**	**0.003 - 0.1**	
Lead	**0.2**	**0.005 – 0.01**	
Nickel	**0.5**	**0.05 – 0.15**	
Zinc	-	0.01 – 0.03	
Arsenic	**0.5**	**0.007 – 0.05**	
Hydrocarbon	-	3	TPH, F1/F3 Fraction, Oil and Grease
Chloride	-	160 – 1500	
Fluoride	-	0.15	
Sulphate	-	75	
Phosphorus	-	256 – 1000 kg/yr	one as 0.2 mg/L
Total Suspended Solids	**15.0**	**7.0 – 30.0**	**surface runoff 50.0 mg/L**
Turbidity	-	10	
pH lower	**6.0**	**6.0**	**surface runoff 5.0**
pH upper	**9.5**	**8.4 – 9.5**	
Acute toxicity	**50% Mortality – 100% effluent**	**50% Mortality – 100% effluent**	

Note: Current diamond operations includes Victor, Ekati, Snap Lake and Diavik, which are located in a different ecozone that the proposed Star-Orion South Project.

3.5.1.5 Toxicity Testing

Acute toxicity is the standard testing used on effluent generated by mining operations (Worsley Parsons 2009) and is the standard by which 'deleteriousness' is determined under the *Fisheries Act*. In Environment Canada (2011):

"All effluents that are generated must be non-lethal to rainbow trout[1] if and when samples of that effluent are sampled for analysis by Fisheries Officers.

Chronic or sub-lethal toxicity testing involves measuring a biological response in lab conditions in organisms exposed to a particular quality of water subject to two variables. These variables are concentration (as various dilutions are tested) and time, as the test measures biological response over 7-8 days. Since these two variables are central to the test method, it is not scientifically defensible to apply sublethal testing without consideration of exposure time of the proposed test organisms in a real world environment (i.e. the fact that in an end of pipe discharge scenario the exposure time for these organisms is assumed to be instantaneous as they would only pass the discharge point) and consideration of concentration. In addition, some of the test organisms involved in the sub-lethal testing such as *Ceriodaphnia dubia* are known to be very sensitive and respond to a number of factors and as a result may not produce a result that is indicative of the effect of the effluent in the natural environment. As a result, it is Shore's opinion that these sublethal tests are not appropriate for this scenario.

3.5.1.6 History of Recent Discussion about the Use of sub-lethal testing

The appropriate use of chronic toxicity testing has been long debated by the scientific and regulatory community. The following is a brief account of some of the discussions and decisions that have occurred over time and that relate to this issue.

1. **The Assessment of the Aquatic Effects of Mining in Canada (AQUAMIN) Final Report of 1999**

This was a multi-stakeholder initiative from 1993-1996, to recommend amendments to the then-existing Metal Mining Liquid Effluent Regulations (MMLER 1977) and to design a national Environmental Effects Monitoring (EEM) program for metal mining. The report contains no reference to chronic toxicity testing and stated at the time, that there was not enough data to justify requiring regulation of non-acutely-lethal effluent.

[1] Biological Test Method: Reference Methods for Determining Acute Lethality of Effluents to Rainbow Trout (Reference Method EPS 1/RM/13)."

2. Ontario Municipal Industrial Strategy for Abatement (MISA)--1994

The Ontario MISA Regulation (560/94) developed regulations for effluent testing. This document contains limits for acute lethality testing for *Daphnia magna* and Rainbow Trout (no more that 50% of the test species shall die in undiluted effluent samples), but does not have any limits for the semi-annual sub-lethal testing for *Ceriodaphnia dubia* or fathead minnow. Requirements for sub-lethal testing are for monitoring and reporting only.

3. Aquatic Effects Technology Evaluation (AETE)

This was an Industry-government science-based program from 1994-1998 designed to help the mining industry meet the developing EEM requirements and to evaluate new and existing monitoring techniques for the assessment of environmental impacts. With regard to the use of sublethal toxicity tests, the program conducted a number of literature studies, as well as three field studies (in 1997), evaluating different monitoring components. One of the questions tested during the field program was whether there was a link between effluent sublethal toxicity test results and instream biological (fish or benthos) responses. The tests involved *Ceriodaphnia*, fathead minnow, algae (*Selanastrum*) and duckweed (*Lemna minor*).

The AETE Synthesis Report of 1999 states that these three field studies “suggest that effluent sublethal toxicity tests may prove to be a useful tool for predicting biological effects in the receiving environment”. The four above tests were therefore recommended tools for “routine monitoring”, with some limitations—most notably that the test could be invalid if the receiving waters are toxic to the test organisms, and that some acclimation may be necessary.

It is interesting to note on page 68 of the AETE Synthesis Report, the possibility that some natural surface waters may be toxic to test organisms due to watershed geology. The report states:

> Surficial mineralization and weathering of bedrock can lead to high background metal concentrations in the water and sediments. This matter was examined by collecting a sample of Highly Mineralized Water (HMW) from an upstream location at one mining site and testing the water with the suite of sublethal toxicity tests….HMW was considered to include water coming into contact with naturally mineralized zones and containing elevated levels of metals and major ions….A second objective of the HMW test was to determine, if the sample was toxic, whether *Ceriodaphnia* and fathead minnows could be acclimated to the HMW water.
>
> The Labrador natural HMW…sample displayed considerable toxicity to all test organisms with most animals dying during the test. Similarly, slow acclimation to HMW using fathead minnows and Ceriodaphnia was unsuccessful. It is

suggested that a larger survey be undertaken throughout Canada to identify the scale of the issue and degree of variability in background conditions.

4. **Using Sublethal Toxicity Tests to Predict Receiving-Environment Effects, Stantec Consulting Ltd., 2007**

This report was commissioned by the Subgroup on Sublethal Toxicity Testing of the Metal Mining EEM Review Team in 2006. The report examines the three AETE field studies that were completed and notes that the resulting data set is small.

At one site, "**the results [of the AETE study] did not demonstrate a correlation between toxicological and biological responses because the observations were not synoptic. The data provided an example of the co-occurrence of sublethal toxicity and receiving-environment effects, but receiving environment effects were as easily explained by historical inputs as by effluent quality….**"

Benthic community effects at another site could also have been caused by historical contamination of the sediments, and not effluent quality.

Effects on the benthic community at the third site were observed "**at metal concentrations in water that produced sublethal toxicity in *Ceriodaphnia*, duckweed and algae. Fathead minnows did not show any deleterious effects of mine effluent, and thus did not co-occur with the observed benthic community impairment. This study provides an example of the co-occurrence of sublethal and receiving-environment biological responses, but does not demonstrate a correlation between responses.**"

5. **Recommendations from the *Metal Mining Environmental Effects Monitoring Review Team Report, August 2007***

The full report is attached as Appendix 3-B, which contains the report from the Sublethal Toxicity Subgroup as well as Stantec (2007) referred to above.

Chapter 5.3 of the report (Appendix 3-B) discussed Sublethal Toxicity. In it, the conclusions of the Stantec Report are reported as follows:

> There is presently inadequate data to demonstrate that sublethal toxicity tests are predictive of receiving-environment effects. Sublethal toxicity at the end-of-pipe often co-occurs with receiving-environment biological effects, but mainly when effluents dominate the receiving environment. Where effects co-occur, there tend to be inconsistencies in the endpoints that correlate. Most (one exception) studies that evaluated the relationship between sublethal toxicity and receiving-environment effects were observational studies conducted on receiving

> environments that had historical impacts that confounded the interpretation of correlation.

Neither the Sublethal Toxicity Subgroup nor the Review Team itself could reach consensus regarding the utility and application of sublethal testing in the EEM program. Four options for action were developed (see page 20, Appendix 3-B), the fourth being:

> 4) Recognizing the debate has been ongoing for many years, routine, regulated sublethal toxicity testing requirement is removed from the MMER as there is no confidence that a multi-stakeholder group would be able to advance the issue until new science is available.

The report goes on to say:

> Each of the options received some level of support from members, therefore no consensus was reached. A wide range of opinions was expressed on the utility of sublethal toxicity testing within the EEM program, the type and the number of tests required, and the frequency of testing. However, it was clear that maintaining the status quo is not an acceptable way forward and that there is a need for change on sublethal toxicity testing requirements within EEM.

Therefore, the following recommendations are included in the Review Team Report:
Recommendation 22: Environment Canada should facilitate a broad discussion on the utility and application of sublethal toxicity tests within EEM and then Environment Canada should clearly articulate the goals for sublethal toxicity tests and how the results will be used.

Recommendation 23: As the status quo is considered unacceptable, Environment Canada should consider changes to sublethal toxicity testing within the EEM program.

Recommendation 24: Environment Canada should consider an amendment to modify the wording of Schedule 5, s. 17(g) of the MMER to remove the requirement to determine if there is a correlation between sublethal toxicity data and fish population, fish tissues, and benthic invertebrate community survey results.

6. Regulations Amending the Metal Mining Effluent Regulations

Registered in March, 2012, these included an amendment to address Recommendation 24 above. The Regulatory Impact Analysis Statement (RIAS) accompanying the Regulations states:

> **The Amendments remove the requirement in Schedule 5, paragraph 17(g) and referred to in paragraphs 21(1)(a) and 25(a) to compare the results of**

sublethal toxicity testing with results of biological monitoring studies to determine if there is a correlation. These comparisons did not lead to meaningful results on a consistent basis.

3.5.1.7 Chronic Toxicity Testing and the Receiving Environment

As described above, there is little evidence that the results of chronic toxicity testing can be directly linked to a biological effect, and on its own, does not add to the scientific understanding of environmental effects. The importance of the receiving environment in understanding the results of sublethal (chronic) toxicity tests is well documented within the Metal Mining EEM Technical Guidance Document (Environment Canada 2011) where Chapter 6 states:

i. the main uses of sublethal testing within the EEM is to compare processes and measure changes in effluent quality; and to contribute to the understanding of the relative contributions of the mine in multiple-discharge situations;
ii. sublethal testing can provide an estimate of the potential effects on biological components (phytoplankton, zooplankton, benthic invertebrates, fish, macrophytes) in the exposure area, whether or not these components are being directly measured in the field;
iii. "The [sublethal toxicity] test chosen should primarily be based on the relevance of the species to the local receiving environment, and secondarily on the seasonal availability of test organisms. (Environment Canada 2011)"; and
iv. "Pre-acclimation of culture organisms is recommended prior to exposure to site water. As the purpose of using site water for test control and dilutions is to more accurately predict receiving-water impact, the most accurate prediction should be achieved using organisms adapted to the physicochemical conditions of the receiving environment. (Environment Canada 2011)."

3.5.1.8 Conclusions

Based on the review of the *Fisheries Act* within the context of the regulatory gap indentified by the Federal Government, a review of relevant regulatory guidance, and a review of the scientific literature documenting the appropriate use of chronic toxicity testing, Project design and analysis of alternatives proceeded based on the following conclusions:

1. Section 34(1)(b) is the appropriate section of the *Fisheries Act* to determine if direct discharge of groundwater is considered deleterious;

2. Section 34(1)(b) directs the Crown to consider the “quantity and concentration” of a substance contained in water, and consideration of these two components necessitate consideration of the receiving environment, including concentrations and flow in the discharge environment;
3. There is no scientific rational or legal precedent to consider chronic toxicity results in a determination of deleterious. Further discussion of toxicity test results are found in Section 6.2.8.

Shore is aware that Federal authorities are currently working toward the development of Diamond Mining Effluent Regulations or similar measures that address the current regulatory gap. This may provide additional guidance to Shore’s proposed water management system. In the interim, it is possible that, under proposed changes to the Fisheries Act, the Minister may develop site specific regulations as an interim or permanent measure for the Project.

3.5.2 Process Plant Water Supply

The proposed process plant requires approximately 68,900 m^3 of water per day. The following water sources were considered:

1. the Saskatchewan River;
2. surficial ground water;
3. deep groundwater from pit dewatering; and
4. a combination of deep groundwater from pit dewatering and surficial groundwater.

Use of water from the Saskatchewan River would require an intake structure, and increase the volume of water managed by the Project. Since pit dewatering would supply enough water for processing, this option was not evaluated further.

The use of groundwater from surficial aquifers was considered, however it was determined that these aquifers would not produce enough water for the entire processing plant.

Deep groundwater from pit dewatering is expected to supply more than enough water for the process plant and its quality is suitable for most of the water requirements in the plant. However, the recovery section of the process plant requires low iron content water in order to properly separate diamonds from non-diamond material. The Mannville water has an iron content that is not suitable for use in recovery. The shallow groundwater has lower iron content, and is suitable for use in the recovery section of the plant. As a result, a combination of deep groundwater and shallow ground water can be used in the process plant.

Selection

A combination of deep groundwater and shallow groundwater was selected as the best option as it minimized the use of water from surficial water sources, while still providing water of sufficient quality for use in recovery.

3.5.3 Pit Dewatering

Three options were considered for pit dewatering:

1. collection of in-pit residual passive inflow;
2. dewatering wells for deep and surface water systems; and
3. dewatering wells for deep water systems and residual passive inflow collection in-pit.

Potential other means of restricting groundwater flow into the pit such as the use of slurry walls, perimeter grout curtains and perimeter freeze walls were initially reviewed but were considered technically and financially unattainable (P&E 2010) as the pit perimeter circumferences are too large (e.g. Star pit circumference: 9.9 km) for such processes.

The in-pit dewatering system is required to manage precipitation, water contained within the rock that is mined, groundwater seepage from pit walls, and potentially any drains that may be required for geotechnical stability. The vast majority of the groundwater from the shallow groundwater system will flow into the pit along the sides of the pit. The location where this water discharges into the pit will change as the flow from small aquifers decreases with time and other aquifers are exposed. There will also be major changes in the volume handled by this system in response to precipitation events and during the spring freshet. In addition, when the pit has been excavated below the top of the Mannville aquifer, there may be additional seepage from the deep groundwater flow system that is not removed by the dewatering wells. Therefore, the in-pit dewatering system must be flexible and able to be modified with time to handle the wide range in the expected flows.

Dewatering wells will depressurize the deep groundwater flow system to restrict the amount of the water that seeps and flows into the pit. This deep aquifer needs to be depressurized to improve both the geotechnical stability of the pit slopes, and to control or preferably eliminate the flow of groundwater through the kimberlite into the pit.

Option 1, allowing all the surface and deep water systems to flow passively into the pits, was discounted as an option due to geotechnical and safety considerations.

Option 2 is feasible, however, spatial variability within the shallow aquifers, especially in the till made location and design of these shallow wells difficult. As a result, a more conservative approach was deemed more appropriate.

Option 3 was chosen as it was determined that the inflow from the surface water systems could be collected from the residual inflow to the pit. The deeper groundwater systems would, however, need to be dewatered as detailed above.

3.5.4 Water Management Strategy

The following goals must be met by the planning of the water management strategy:

- to store and / or discharge groundwater from the dewatering wells;
- to store and / or discharge the water from the in-pit collection system;
- to store and / or discharge the surface runoff from the site and surrounding areas;
- to provide a backup supply of water for the processing plant; and
- to act as a discharge point for water from the PKCF.

Several options were assessed for the appropriate strategy:

1. construction of a water reservoir north of the processing plant at the confluence of the East Ravine channels, utilizing the East Ravine area as the reservoir and diverting overflow to the river via the Duke Ravine for co-management of processing and dewatering water;
2. construction of a water reservoir within the Duke Ravine with 2 cells (upper and lower) for co-management of processing and dewatering water; and
3. Utilizing the PKCF as a water reservoir (i.e., recycling water from the PKCF to the plant) and separate management of processing and dewatering water. .

Option 1 - North of the Processing Plant at the Confluence of the East Ravine Channels

For this location, based on the site evaluation, two dams would be required. The primary or main dam would be constructed upstream of the Star pit facilities and would be required to prevent any surface flow in the East Ravine from entering the Star pit. The secondary dam would be required to prevent the water impounded behind the main dam from flooding upstream into the future pit at Orion South.

A diversion channel would be constructed to divert excess and overflow water from the water management reservoir to the Duke Ravine, located approximately 2 km east of the reservoir. The diversion channel would be designed to handle the entire water flow from the water management reservoir eastward to the Duke Ravine. The proposed location of the diversion channel was selected based on the review of several locations, as it requires the least amount of cut and fill and it also minimizes the footprint by keeping the diversion channel close to the plant site. This diversion channel would need to be crossed by the access corridor which includes a paved road. The diversion channel would be designed to handle all of the water from both groundwater dewatering systems and the surface water from the East Ravine watershed. The amount of soil that would be removed to create this diversion channel would be substantial. This option would not fit within the constraint mapping developed as a result of technical review comments.

Option 2 - Utilizing the Duke Ravine as the Reservoir, With Two Cells

Utilizing the Duke Ravine as the reservoir was Option 2. All water would be collected at various points in the pits and site and pumped or gravity fed to the reservoir. Berms would be constructed to create an upper polishing pond near the discharge location of the PKCF, and a lower pond. No large earthworks would be required to divert water, as process water would be pumped to the PKCF, and gravity would move water to the polishing pond, the lower pond, and ultimately to the Saskatchewan River. This option would not fit within the constraint mapping developed as a result of technical review comments.

Option 3 – Use of a water recycling program and separate management of processing and dewatering water

In order to avoid direct impacts on water and riparian areas of the Duke Ravine, and in response to regulatory request, an option with no water management reservoir was proposed. Within this option, recycling of water through the PKCF to the process plant, and utilizing natural wetland treatment for seepage was proposed thereby avoiding direct impacts to the Duke Ravine.

Selection

Option 3 is the preferred choice for the water management strategy. This option has more flexibility, is less expensive to construct, avoids direct impacts to water courses, meets the criteria used for the constraint mapping, provides greater control on the release of excess water and obviates the construction of a large diversion channel and additional water containment system.

3.5.5 Water Disposal

Water disposal options considered the quantity and quality of water managed by the Project. The deep groundwater (Mannville Group) is expected to have total dissolved solids (TDS) of about 4,400 ppm and is considered slightly brackish. As such, consideration of the TDS, and the specific components that make up the TDS, are required (Section 5.2.8, Water Quality baseline) for management of the Mannville water. Surficial groundwater and process water also require management, however recycling of process water and treatment of seepage through natural wetlands eliminates the need for process water to be directly discharged. Surficial groundwater will be used in the plant or to supplement low flows as needed as part of the mitigation plan. A detailed assessment of water disposal is found in

Appendix 3-A. The following water disposal options are considered, and detailed for the Mannville water, in Appendix 3-A:

- Option A: Spray Evaporation;
- Option B: Diffuser System;
- Option C: Mixing Saskatchewan River and Mannville water at treatment plant before discharge back into the Saskatchewan River;
- Option D: Mixing Saskatchewan River and Mannville water immediately before discharge back into the Saskatchewan River;
- Option E: Orion North/South Mannville water injected into infiltration gallery;
- Option F: Orion South, route Mannville water into exfiltration/evaporation pond;
- Option G: Irrigate FalC Forest with Mannville water; and
- Option H: Deep well injection of Mannville water.

Selection

Option B is the most appropriate water disposal option as discussed in detail in Appendix 3-A.

3.5.5.1 Water Discharge

Based on the disposal option selected above, only Mannville water will be discharged through a diffuser into the Saskatchewan River (see Appendix 3-A for detailed review). Orion South process water will be placed in the Star pit. In order to reduce the natural recharge time of the pit lakes, estimated at greater than 300 years, the option of pumping water from the Saskatchewan River into the pits was analysed and brought forward into the the impact assessment. Utilizing this option would reduce the duration of potential effects on the pit slopes, land use and reclamation,.

The disposal options are as follows:

1. allow the water flow down the Duke Ravine; and
2. piping the water to a diffuser in the Saskatchewan River.

Option 1 would require re-engineering the Duke Ravine to handle increased flows by armouring and re-grading the ravine channel. Option 2 does not require additional work in the ravine, is easy to remove at closure, and limits long term maintenance and potential environmental effects. Accordingly Option 2 was selected.

3.5.6 Other Components

Options for surface water runoff management, water supply, and sewage handling and removal are described in this Section.

Surface Water Runoff Management

In addition to the in-pit and groundwater dewatering systems, additional controls will be required for the diversion of surface waters and for the collection of runoff from around the pit, piles and roadways. These controls would be in the form of a constructed diversion ditch system throughout the site as mining and construction activities progress. Additional sumps and drainage ditches will need to be constructed in association with the Coarse PK pile and the PKCF areas.

Water Supply

Water supplies will be required to support personnel, facilities and facility processes. Shore has estimated potable water demand for the facility to be 50 m^3/day. Two options were considered: treating the shallow groundwater or treating the deep groundwater. The option to treat the shallow groundwater was selected as the water in this system is easier to treat.

Sewage Handling and Disposal

Personnel on site will require access to sanitary facilities during operations. To meet this demand, portable sanitary units would be deployed at the pit and other remote areas where personnel are located. There will also be a sewerage system at the main site. The main site sewage would be piped to a sewage lagoon and remote sanitary units would be serviced with a septic truck that would dispose of the sewage in the sewage lagoon. Options that were considered were:

- sewage hauled off site by truck;
- separate grey and black water management within the plant site, with black water to an on-site lagoon and grey water disposed with the process water; and
- use of a larger on site lagoon for combined sewage.

Hauling the waste off site would increase traffic and be costly due to the volume of sewage expected (approximately 50 m^3 per day) and was not selected as the preferred option. The grey water management option was compared in detail to the larger on site lagoon option during the engineering studies. The cost / benefit analysis favoured conventional disposal in a lagoon over the grey water system, as the volume of water requiring separation did not justify the additional costs and energy requirements, nor did it significantly reduce the footprint of the lagoon. Thus, construction of a conventional sewage lagoon was selected as the preferred option.

3.6 ROAD ACCESS

The selection of a permanent access route to the Project site was based on the consideration of a number of objectives and issues as follows:

- connect to, and maximize the use of, the existing paved highway system available in the area;
- minimize construction costs for the access road;
- minimize the quantity of new road construction, eliminate expensive stream or river crossings, and use existing forestry or grid roads to the full extent possible;
- minimize disruptions of access to the site during road construction;
- provide a good road connection from Prince Albert and local communities;
- avoid a routing that involves a bridge over the Saskatchewan River due to cost and permitting considerations;
- consider safety (i.e., minimizing curves and reducing non-passing zones due to poor visibility from curves or hills); and
- construct the road to provincial secondary highway grade standards similar to Highway 55.

Based on these selection criteria, the following options were identified for the access road routing:

1. road due north connecting to Highway 55 near Smeaton;
2. upgrade existing roads leading northwest to connect to Highway 55 near Shipman; and
3. road due west connecting to Garden River Road and Highway 55.

The pros and cons of the three options are listed in Table 3.6-1. Routes due east and south did not meet the design criteria so were not pursued. The east route would have required construction of a large bridge over the English Creek, and bridge costs were prohibitive to considering this option further. There is no crossing of the Saskatchewan River to the south of the site, and due to the high costs of bridge construction, this option was also not considered further.

Table 3.6-1: Access Route Selection Trade-off Summary

Selection Factor	Pros	Cons
1. New Road Due North Connecting To Highway 55 near Smeaton		
Connect to existing highways	Ties into Highway 55 near Smeaton.	Nil
Minimize new road construction	Routing ties to grid road south from Highway 55 near Smeaton. Upgrading of 10 km of grid roads will be required.	18 km of road through the Fort à la Corne (FalC) forest will be new road construction. A preliminary site investigation of this route revealed that it would pass through a large area of wet, low lying ground. Construction of the road through this area likely would result in high road construction costs.
Reduce the requirement for stream crossings	Nil	Will require a crossing over White Fox River.
Minimize disruptions to traffic during road construction	As this is a new route there will be no disruption to ongoing traffic to site.	Nil
Provide good road connection to Prince Albert	This is provided through the connection to Highway 55 near Smeaton.	Alternative 3 would be 31 km shorter distance to Prince Albert.
Provide good road connection to local communities	Ties into Highway 55 at Smeaton and thus provides good access for communities from Meath Park to Nipawin.	Nil
Safety	This road will be straight similar to the grid roads.	Nil
Construct to highway standards	New construction will be planned to meet provincial secondary highway specifications.	Nil
2. Upgrade Existing Roads to Northwest Connecting to Highway 55 near Shipman		
Connect to existing highways	Ties into Highway 55 near Shipman.	Nil

Selection Factor	Pros	Cons
Minimize new road construction	Routing following existing forestry roads in the FalC forest results in 20 km of forestry road upgrades and 5 km of new road.	Detailed review showed that due to the meandering nature of the existing forestry access road a substantial road straightening program would be required. As a result, it is not expected that there will be any significant cost savings in upgrading the current forestry road route over building new roads.
Reduce the requirement for stream crossings	Crosses White Fox River for which Shore has recently built a bridge.	This bridge is not designed to highway standards and likely would have to be replaced.
Minimize disruptions to traffic during road construction	Nil.	As the routing being considered is the main current access route there will be considerable disruptions to traffic to the site during road construction.
Provide good road connection to Prince Albert	This is provided through the connection to Highway 55 near Shipman.	Alternative 3 would be 23 km shorter distance to Prince Albert.
Provide good road connection to local communities	Ties into Highway 55 near Shipman and thus provides good access for communities from Meath Park to Nipawin.	Nil.
Safety	Will meet required standards if route is straightened.	Currently this route is winding with lots of curves.
Construct to highway standards	Nil.	The current road base is essentially in-situ sand so almost no construction advantage would be gained through its use.
3. New Road Due West Connecting to Garden River road and Highway 55 near the Pulp Mill		
Connect to existing highways	Ties into Highway 55 just west of the Pulp Mill.	Nil.
Minimize new road construction	Routing ties in to Garden River road, an existing grid road.	The first 36 km of road through the FalC forest will be new road construction.
Reduce the requirement for stream crossings	No major stream crossings.	Nil.
Minimize disruptions to traffic during road construction	As this is a new route in the FalC forest there will be little disruption to traffic to site on the Forestry roads.	Upgrading of Garden River road will disrupt a secondary route to the site.

Selection Factor	Pros	Cons
Provide good road connection to Prince Albert	This is the shortest route of all options to Prince Albert.	Nil.
Provide good road connection to local communities	Nil.	This route will not be convenient for the communities along Highway 55 from Shipman to Nipawin and will add 80 km further distance to commute to Nipawin.
Safety	This road will be straight similar to the grid roads.	Nil.
Construct to highway standards	New construction will be planned to meet provincial secondary highway specifications.	Nil.

Considering the pros and cons of the three options, Option 2, upgrade existing roads to the northwest connecting to Highway 55 near Shipman, was selected as the preferred option. Option 1, construct a new road due north to connect to Highway 55 at Smeaton, has a shorter length of road construction than Option 2, and was initially chosen as the preferred option. However, when the subsequent route investigation indicated the potential for high construction costs through low lying wet areas and associated environmental effects, the selection was changed to Option 2. Option 3, a new road due west connecting to Garden River Road and Highway 55, would provide the shortest route to Prince Albert but would have the longest road construction with the highest cost and would not give good access to the towns along Highway 55 north and east of the Project. Option 2 has better routing conditions than Option 1 and would provide good access to the communities located along Highway 55 while adding only 8 km to the drive to Prince Albert over Option 1, so was the option selected.

In addition to the main access road, this road route would form an access corridor accommodating communication lines and / or a natural gas pipeline. The length of the new access corridor would be approximately 31 km.

3.7 POWER LINE RIGHT OF WAY

Electrical service from SaskPower at 138 kV and 230 kV was considered. A 138 kV service for the Project was determined to be too weak to be practical for the Project, as it is expected the cyclical nature of the open pit shovel electrical load will cause unacceptable voltage fluctuations on a 138 kV service at this location.

It was determined that SaskPower will supply power to the site at 230 kV.

SaskPower evaluated the following three route options to provide electrical service to the Project:

1. A new 230 kV power line running to the southeast of the site and tying to an existing 230 kV power line connecting the Codette and Beatty substations. This existing line is located in the FalC provincial forest on the south side of the Saskatchewan River. The new 230 kV feeder would be approximately 16 km long and will involve a river crossing of the Saskatchewan River;
2. A new 230 kV power line running to the east of the site connecting to the Nipawin or Codette substations near Nipawin. The new 230 kV feeder would be approximately 65 km long and would run through the FalC provincial forest on the north side of the Saskatchewan River; and
3. A new 230 kV power line running due south of the site connecting to the Beatty substation. The new 230 kV feeder would be approximately 45 km long and would involve a river crossing of the Saskatchewan River. This route crosses the James Smith Cree Nation Reserve, and would be pursued only if fully supported by the James Smith Cree Nation.

Each route option had numerous advantages and disadvantages, including non-technical aspects such as cost, scheduling and permitting. As the transmission line will be owned and operated by SaskPower, the final route selection was determined by SaskPower. SaskPower determined that Option 1 (shortest line) will be used to provide power to the site. Specific alignment will be detailed and assessed in a separate application by SaskPower, and four configurations are being considered (see Section 2.0, Figure 2.5.3). The power line is considered an ancillary development in the EIS.

3.8 GAS LINE CORRIDOR

The Project site will contain a number of buildings with diverse energy requirements for heating and cooling. While the administration and warehouse spaces have relatively low heating requirements, spaces such as shops, repair areas, wash bays and dry facilities would require high ventilation rates and thus have high heating loads. The buildings require approximately 82,945,000 kBTU (87,495 GJ) of heat energy annually. The only conventional energy sources considered viable for heating are natural gas, propane, and electricity. Based on equal heating quantities, natural gas is the conventional fuel of choice.

3.8.1 Options

Several options were identified on the site for heating and cooling of buildings:

1. use of natural gas for all the Project's heating and cooling requirements;
2. use of a geothermal system for all heating and cooling requirements; and

3. use of a geothermal system for most of the heating and cooling requirements but supplemented with some natural gas for supplemental heating of smaller buildings and point heating.

Option 1 - Use of Natural Gas for All the Project's HVAC Requirements

TransGas provided a conceptual proposal for three routing options:

1. Through the James Smith Cree Nation Reserve – the line would be a 15 cm (6 inch) diameter, 40.5 km long pipeline originating at a location south of Kinistino to the southwest of the Project. A crossing over the Saskatchewan River would be required. This line would be constructed in a direct line from the tie-in point to the TransGas system and the site;
2. Around the James Smith Cree Nation Reserve – the line would be a 15 cm (6 inch), 40 km long pipeline originating at a location south of Kinistino to the southwest of the Project. A crossing over the Saskatchewan River would be required. This line would be routed from the tie-in point to the TransGas system, then almost due north maintaining the pipeline west of the James Smith Cree Nation, across the Saskatchewan River and then directly to the site; and
3. From an existing small capacity trunk line that parallels Highway 55 near Smeaton. A 10 cm (4 inch) branch line could be constructed from the trunk line near Smeaton and be routed due south to the Project along the access corridor that will be established along the planned new access road to the site.

Option 2 - Use of Geothermal System for All HVAC Requirements

The proposed open pit mining method for the Project requires deep dewatering wells to de-pressurize the Mannville Group aquifer. The flow of this water from the deep wells is expected to be up to 154,000 m^3/d. A significant amount of this water would be used for ore processing, however an equally significant amount would be excess and would be available as an energy source for heating and cooling buildings where possible.

Preliminary investigations into the use of a geothermal heat pump system for building heating and cooling were done. The geothermal heat pump system would take advantage of the fact that large amounts of ground water will be pumped from the ground for dewatering of the open pit. The outlet manifold from the pit dewatering could be tapped to supply water from that depth to the heat pumps. This type of geothermal heating is the most efficient and least costly method of the various alternatives available.

The commercialization of heat pumps has been achieved in the last few years and "off the shelf" equipment is available for implementation of geothermal heating. The system would take advantage of the slightly elevated temperature of the water being pumped from the ground to provide a "free" and green heat source. The cost to take advantage of this heat source is for the power needed to pump the water to and through the heat pumps and heating fluid through the heating units. Since water will be pumped from the dewatering wells as part of mining, the additional water pumping costs would be less than for underground buried coil systems.

The use of geothermal energy would reduce the carbon release from the Project. Initial calculations demonstrated that the use of geothermal energy could provide heating and cooling efficiently for moderate temperatures, but would have difficulty meeting peak heating loads during winter, and could not provide for point heating (e.g., rapid heating needed immediately after maintenance bay doors were opened during winter).

Option 3 - Hybrid System Using Geothermal for Most of the HVAC Requirements

In order to address limitations identified in Option 2, a hybrid system consisting of a combination of geothermal and natural gas systems, with geothermal being the primary heat source and natural gas the secondary heating system, was considered.

This system would utilize reverse cycle heat pumps to meet the requirements of the spaces. Individual heat pumps would be located in a zoned configuration and piped to a common piping loop. The water piping loop would originate as close as possible to the process water storage tank at the process plant. Due to elevated levels of dissolved solids in the Mannville water, this water cannot be pumped directly to the individual heat pumps. Instead, an intermediate, water to water heat exchanger would be used to transfer heat to, or from, a closed loop glycol/water mixture. Heat pumps in heating mode would extract heat from the common piping loop; heat pumps in cooling mode would reject heat to the common piping loop. If at any time, the common piping loop could not satisfy the heating requirement, natural gas boilers would inject additional heat into the loop. In cooling mode, heat rejected to the common piping loop would be discharged in the water pumped to the water management reservoir.

3.8.2 Recommendations

The simple payback period, before cost savings are realized, for a ground source geothermal system, would be approximately 25 years. Although installation of such a system may be feasible, and would have environmental benefits, it is costly to install and difficult to maintain. In addition, the calculated payback period is in excess of the projected mine life. As a result, the preferred option is to utilize a natural gas line brought in from the north along the new access road and that a ground source heat pump system not be considered at this time for the following reasons:

- If the ground source water were to contain suspended solids, the cost of a filtering system for the indicated flow rate would be significant;

- The required flow of 8,200 gpm (1,860 m^3/h) is a significant percentage of the estimated total pit dewatering flow rate;
- The energy savings would be offset by the added power cost for pumps needed for the intermediate circuit;
- The reliability of the proposed ground source system equipment is unknown and high maintenance costs may further erode savings;
- Other opportunities for energy use reduction (such as capturing waste heat in the process plant) should be investigated prior to committing investment capital in ground source heating systems;
- Natural gas heating equipment is proven and reliable and would minimize operating costs;
- Published heat pump efficiency takes into account both heating and cooling cycles. This project has a considerable number of areas that do not have a cooling requirement. In addition to this there are buildings with very large overhead doors creating high heating loads with quick recovery requirements. Heat pumps are not effective for these types of loads. These spaces should be heated by natural gas hot water boilers supplying heat to various terminal heating devices such as unit heaters, fan coils, air handling units etc.; and
- The consistency of the Mannville water temperature data is somewhat in question. If this temperature were to fluctuate widely, a system designed for, and dependent on, a fixed and stable temperature would prove to be unstable and unpredictable in terms of performance.

Option 1 was selected based on the low average heating requirements, coupled with high peak heating requirements in the winter. Calculations of heating load during the engineering studies indicate that Option 1-(3) utilising the small capacity trunk line that parallels Highway 55 near Smeaton, can provide sufficient gas to meet project needs.

3.9 CONSTRUCTION CAMP

The purpose of the construction camp is to provide accommodation for the construction and management personnel involved in the building and commissioning of the Project.

The camp will have to feed and house construction personnel for the duration of their work period at the Project. The camp will offer all of the amenities required for an extended stay as listed below:

- single room sleeping accommodation (with personal lockers);
- access to satellite TV connection;
- phone and internet access;

- washrooms (shower/toilet);
- laundry facility;
- dining facility;
- recreation facility;
- administration office; and
- boot room.

The camp will have the following installed utilities:

- electrical (generator / grid);
- propane (heating and cooking);
- water (potable); and
- septic.

The camp will be non smoking and dry (no alcohol).

3.9.1 Options

The following three options were considered for the construction camp.

1. camp located adjacent to the existing Shore camp in the FalC forest;
2. camp located outside of the FalC forest beside existing utilities within 45 km of construction site; and
3. no camp.

Option 1 - FalC Camp

Three operating options were looked at for a FalC forest camp:

1. purchase option on all buildings and equipment;
2. rental option on buildings; and
3. combination of rental and purchase.

Prices were developed from past operating costs and from consultant and vendor quotes and estimates. Shore would utilize existing and planned sewage lagoons for waste water removal and treated well water for potable water requirements. Power would be provided by generators for year 1 and grid power will be utilized in years 2 to 4. Propane will be utilized for kitchen equipment and most heat sources.

Purchase Option

This option involves purchasing all equipment and buildings, utilizing existing Shore-owned equipment and buildings and could include the addition of a capital recovery in year 5. Capital recovery allows for 10% depreciation per annum on all buildings, and a provision for repairs and decommissioning on all buildings.

Rental Option

This option involves renting all equipment and buildings not already owned by Shore. Costs include full decommissioning of the camp and removal of all rental and Shore-owned equipment.

Rental and Purchase Option

This option includes a combination of rental and purchase on selected equipment and buildings. Short term building requirements are rented and long term building requirements are purchased.

Option 2 - Remote Camp

This option involves utilizing the same type of layout as Option 1 but locating the camp outside of the forest in an area where local utilities and infrastructure could be utilized.

Three operating options were looked at using the same criteria as the FalC camp.

Option 3 - No Camp

This option would have all construction personnel commuting to site daily, with all construction personnel responsible for finding their own accommodations.

Cost Analysis

The lowest cost option is for a FalC forest camp, the addition of travel time from a remote camp offsets any cost benefits associated to being closer to cheaper services and workforces. The most economic option of the Shore FalC camp is the rental/purchase option. If capital recovery is included then the purchase option becomes the most economic.

3.9.2 Assessment of Options

An assessment of the three options is presented below.

Option 1 - FalC Camp

Advantages:

- most economic camp option;

- location is close to the mine and construction site; and
- offers potential opportunities for local businesses and communities.

Disadvantages:

- camp issues are a distraction to construction; and
- attracting camp personnel for short time frames may be difficult.

Option 2 - Remote Camp

Advantages:

- services (power, gas, water & septic) would be readily available and are more cost effective than self generated services;
- health centre is close by;
- camp labour pool is close by;
- economic benefit to surrounding communities;
- once construction is over the facility could be utilized for accommodation;
- this option could be operated by local towns and / or businesses; and
- no additional footprint in the FalC forest.

Disadvantages:

- location in relation to construction site; it is a 30-45 minute drive to the work area.
- increased traffic and commuting costs;
- higher contractor costs;
- increased temporary pressure on local services; and
- long term impacts or benefits to the immediate communities are unknown.

Option 3 - No Camp

Advantages:

- economic benefit to surrounding communities;
- construction work force dispersed in the region;
- services close by;
- no additional corporate management required; and
- no additional footprint in the FalC forest.

Disadvantages:

- increased traffic;

- increased commuting costs;
- contractor commuting time would be added to the workday, thus reducing efficiency;
- higher contractor costs; and
- increased temporary pressure on local services.

3.9.3 Recommendations

The recommendation is for a camp in the area of the existing Shore camp in the FalC forest. This option is the most economic and carries the least Project risk, and minimizes temporary pressures on the surrounding communities.

3.10 REFERENCES

P&E. 2010. Star - Orion South Diamond Project: Updated Prefeasibility Study and NI 43-101 Technical Report. Report prepared by P&E Mining Consultants for Shore Gold Inc. March 24, 2010.

Read, G., Brown, F. H., Ewert, W., Harvey, S., Hayden, A., Orava, D., Puritch, E., Richardson, E., Rudolf, H., and Trehin, H. (2011) Technical Report on the Feasibility Study and Updated Mineral Reserve for the Star-Orion South Diamond Project Fort à la Corne, Saskatchewan, Canada; NI 43-101 report, August 25, 2011.