Government of Nunavut

Wetlands Assessment, Sewage Treatment Wetlands, Hamlet of Repulse Bay, NU

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Executive Summary

The Government of Nunavut (GN), Department of Community and Government Services (CGS) retained **exp** Services Inc. (**exp**) to prepare a Screening Level Environmental Assessment (SLEA) under the *Canadian Environmental Assessment Act* (CEAA) in order to complete the detailed planning design for the sewage system upgrade for the Hamlet of Repulse Bay, Kivalliq Region, Nunavut, hereinafter referred to as the 'Site'.

In addition, the project included an assessment of the suitability of the existing wetland sewage treatment area to achieve further reduction of contaminants and pathogens before reaching Hudson Bay.

The purpose of the Wetlands Assessment is to determine if the Hamlet's existing wetland sewage treatment area is in compliance with the requirements of the Nunavut Water Board, water license number NWB3REP0409 – Hamlet of Repulse Bay.

The Wetlands Assessment revealed variable declines of contaminants between the truck discharge point and the wetland outlet, confirming that phytoremediation is occurring, as expected. Observations during the September 8, 2012 sampling event indicate overloading of organic material, which has resulted in varying parameter levels throughout the system. However, there is a level of uncertainty related to the typical contaminant values present in the Hamlet's raw sewage; and, such values are expected to be much higher than those observed during the September 8, 2012 sampling event.

Typical removal rates of contaminants by sewage treatment systems are variable. Free water systems (FWS) reduced biological oxygen demand (BOD) by 34 %, total suspended solids (TSS) by 93 % and fecal coliforms by 52 % (Cameron et al., 2003); whereas, a combination of treatment ponds and FWS had average reductions of BOD by 61 %, TSS by 67 % and fecal coliforms by 99.8 % (Kadlec, 2003; Kadlec et al., 2012).

Kadlec and Knight (1996) present typical wastewater component concentrations entering and leaving a residential septic bed. Assuming that the average TSS and BOD concentrations at the Hamlet's wetland inlet are much higher than observed during the September 8, 2012 sampling event, the reduction of TSS and BOD in the Hamlet's sewage wetland treatment system may each be up to 90 %.

Therefore, the Hamlet's existing sewage wetland treatment system appears to be effectively removing the contaminants of concern. However, additional sewage treatment, by way of the installation of a lagoon at the sewage inlet point, is recommended to further reduce the levels of contaminants and pathogens releasing into the wetlands area, and subsequently into Hudson Bay.

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Chapter 1 – Introduction

1 Introduction

The Government of Nunavut (GN), Department of Community and Government Services (CGS) retained **exp** Services Inc. (**exp**) to prepare a Screening Level Environmental Assessment (SLEA) under the *Canadian Environmental Assessment Act* (CEAA) in order to complete the detailed planning design for the sewage system upgrade for the Hamlet of Repulse Bay, Kivalliq Region, Nunavut, hereinafter referred to as the 'Site'.

In addition, the project included an assessment of the suitability of the existing wetland sewage treatment area to achieve further reduction of contaminants and pathogens before reaching Hudson Bay.

The purpose of the Wetlands Assessment is to determine if the Hamlet's existing wetland sewage treatment area is in compliance with the requirements of the Nunavut Water Board, water license number NWB3REP0409 – Hamlet of Repulse Bay.

1.1 Background

The Hamlet of Repulse Bay (Hamlet) is the proponent and Responsible Authority (RA) of the project, and as such, triggers the requirement for a screening level environmental assessment for the project under section 5(1)a of the *Canadian Environmental Assessment Act*. Due to the size and location of the proposed project(s) (i.e. leaving a footprint >25 m^2), it cannot be excluded under *CEAA*, and an environmental assessment as per *CEAA* must be completed prior to any physical work completed by the proponent. The Stakeholders for this project are the Hamlet of Repulse Bay, the Government of Nunavut and the Nunavut Water Board.

The Hamlet utilizes a sewage disposal facility located approximately 400 m to the northeast of the edge of the community. The sewage disposal facility is located at the solid waste disposal facility, and consists of a simple truck offload discharge area, which is directed to a natural wetlands area. The effluent at this wetlands area proceeds downstream along a 1,400 m flow path through a series of wetlands and surface water bodies, situated within a valley, until finally discharging to the marine environment entering Hudson Bay. The total area of the natural wetlands area is approximately 64,000 m^2. Refer to Figure 1 in Appendix A for the Site Location Plan.

Repulse Bay is a hamlet located at the shore of Hudson Bay, Kivalliq Region. The total area is approximately 425 km^2 (GN, 2009), with an estimated population of 999 in 2011 (95% Inuit, 5% non-Inuit) (RB, 2011). Repulse Bay lies directly on top of the Arctic Circle in central Nunavut (RB, 2011). The Inuktitut name for Repulse Bay is Naujaat, which translates to "nesting place for seagulls". The name comes from the actual nesting grounds located on cliffs approximately 5 km north of the Hamlet; and, every June, thousands of seagulls occupy the area, as well as snow birds, loons, eider ducks, longtail ducks and jaegers (RB, 2011).

Repulse Bay is situated in the Northern Arctic Terrestrial Ecozone, and is characterized by continuous permafrost 90 to 100 % of the year. The Hamlet receives an average of 150 mm of rainfall, 130 cm of snowfall and 285 mm of precipitation, per year. Average daily temperatures range from a low of approximately -30°C in January and February to a high of approximately 9.3°C in July.

The subsurface stratigraphy at the Site is within the continuous permafrost zone, and is expected to comprise glacial till with lacustrine deposits of unconsolidated sand and gravel.

Due to the current population and trend for expansion, it is necessary to assess the suitability of the Hamlet's existing wetland sewage treatment area. This suitability is determined through the analysis of the current and required assimilative capacity. The determination of assimilative capacity requires an analysis of the total volume of wetland available to treat effluent, along with the consideration of total expected effluent volumes. If the existing wetlands are demonstrated to substantially reduce the loads of

different contaminants that drain to Hudson Bay, then the assimilative capacity of the wetland will be confirmed. If the wetlands are unable to reduce the load of different contaminants that drain to Hudson Bay, then mitigation measures will need to be identified and implemented.

The subject property has a Sewage Disposal Facility license (NWB3REP0409), which provides effluent quality limits for five (5) chemical parameters; including TSS, BOD, pH, fecal coliforms, and total oil and grease. The effluent quality limits at the downgradient location prior to discharging to Hudson Bay must meet the compliance guidelines for TSS of 100 mg/L; BOD of 80 mg/L; pH between 6.0 and 9.0; fecal coliforms of 10,000 CFU per 100 mL; and, no visible sheen related to total oil and grease.

1.2 Objectives

The objective of the Wetlands Assessment is to evaluate the efficiency of the current wetland area, as part of the existing wetland sewage treatment area of the Hamlet, and its ability to effectively reduce contaminants and pathogens of effluent waters before discharging into Hudson Bay.

Chapter 2 –
Repulse Bay Wetlands Area

2 Repulse Bay Wetlands Area

A Site visit was undertaken by **exp** staff from September 6th through 8th, 2012 to carry out a vegetation survey of the wetlands area, to survey the Site and collect surface water samples. All areas of the Site were accessible during these Site visits.

2.1 Vegetation Community

Repulse Bay is situated in the Northern Arctic Terrestrial Ecozone, directly on the Arctic Circle line, and is characterized by continuous permafrost 90 to 100 % of the year. The Hamlet receives an average of 150 mm of rainfall, 130 cm of snowfall and 285 mm of precipitation, per year. Average daily temperatures range from a low of approximately -30°C in January and February to a high of approximately 9.3°C in July.

The Northern Arctic Terrestrial Ecozone is characterized by long cold winters and short cool summers. The harsh temperatures result in a shorter growing season, when compared with regions south of the Arctic Circle. This region also contains numerous surface water bodies and wetlands that serve as important wildlife habitat. Permafrost is continuous throughout the area, but there are active surface soil layers that partially thaw in the summer.

The wetlands area, located between the truck discharge point and Hudson Bay, is vegetated with Arctic tundra and wetland species, ranging in height from ground cover species to grasses up to approximately 60 cm tall. This vegetation occurs in depressions (poorly drained low-lying areas) between rock outcrops on both sides of the wetlands, which provide some protection from wind.

A vegetation survey was carried out during the Site visit in September 2012, and is presented in Table 2-1. It should be noted that a complete plant list is not available, given that the current survey only reflects the late summer season flora only; the spring species are absent or not fully represented.

Table 2-1: Plant Species Observed at the Wetlands Complex

Family	Common Name	Scientific Name
Aster (Asteraceae)	Arctic daisy	*Chrysanthemum articum*
Birch family (Betulaceae)	Dwarf birch	*Betula nana*
Heath family (Ericaceae)	Northern Labrador tea	*Rhododendron tomentosum*
	White arctic heather	*Cassiope tetragona*
Lichen	Worm lichen	*Thamnolia subuliformis*
Lichen (Cladoniaceae)	Reindeer lichen	*Cladonia rangiferina*
Lichen (Parmeliaceae)	Yellow lichen	*Cetraria tilesii*
Lichen (Teloschistaceae)	Jewel lichen	*Xanthoria elegans*
Lichen (Umbilicariaceae)	Rock tripe	*Umbilicari spp.*
Moss (Bryophytae)	Moss	*Sphagnum sp.*
	Alpine club moss	*Lycopodium alpinum*
Rose family (Rosaceae)	Mountain avens	*Dryas integrifolia*
Sedge family (Cyperaceae)	Arctic cotton	*Eriophorum callitri*

Family	Common Name	Scientific Name
Willow family (Salicaceae)	Willows	*Salix sp.*
	Feltleaf or Alaska willow	*Salix alaxensis*
	Arctic willow	*Salix arctica*

Various grasses were also observed at the wetlands area, most of which were heavily grazed by migrant birds. A list of potential species of grasses, sedges and rushes expected to be at the wetlands complex is presented in Table 2-2.

Table 2-2: Potential Grasses, Rushes and Sedges Expected at the Wetlands Complex

Family	Common Name	Scientific Name
Arrow-grass (Juncaginaceae)	Seaside arrow-grass	*Triglochin maritimum*
	Marsh arrow-grass	*Triglochin palustris*
Grass (Poaceae)	Fisher's tundra-grass	*Dupontia fisheri*
	Lyme-grass	*Elymus arenarius*
	Narrow alkali-grass	*Puccinellia contracta*
	Creeping alkali-grass	*Puccinellia phryganodes*
	Sheathed alkali-grass	*Puccinellia vaginata*
	Alpine foxtail	*Alopecurus alpinus*
Rush (Juncaceae)	Wire rush	*Junicus balticus*
	Wood rush	*Luzula sp.*
Sedge family (Cyperaceae)	Bog sedge	*Kobresia sp.*
	Sedges	*Carex sp.*
	Cotton-grass	*Eriophorum sp.*

The core of the wetlands complex was predominantly of swamp-like composition, consisting of moss and heavily-grazed grasses, sedges and rushes. Occasional willow, birch, rose, and heath species were also found at the wetlands, often nestled in between or beneath any rocks to receive shelter from the wind. An abundance of lichens of various sizes and colour were also present across the Site, predominantly growing on the rock outcrops both at the wetlands area and on both flanking sides.

It is noted that considerable evidence of wildlife grazing/foraging and nesting was observed throughout the wetlands complex.

Species richness was relatively consistent throughout the wetlands area, which is to be expected given the overall large surface area, in addition to the combination of various habitats including terrestrial, semi-aquatic and aquatic environments. Major portions of the wetlands area were also protected from the wind by adjacent rock outcrops flanking both sides; and, the amount of species present at a given area were reduced where there was little to no protection from the wind. In general, the majority of the Site was covered by moss, heavily-grazed grasses, sedges and rushes, and other low-lying vegetation typical of a swamp/wetland region of the Arctic.

It should be noted that a feltleaf willow (*Salix alaxensis*), specifically a single large specimen, was observed at the central portion of the wetlands area, approximately 100 m downgradient of the sewage inlet. A sample was returned to the laboratory and the identification was confirmed. However, this species is not to be mistaken for the felt-leaf willow (*Salix silicicola*), which is designated as a special concern species by COSEWIC (2012). It is unlikely that the special concern felt-leaf willow species is present at the Site, given that it is endemic and restricted almost exclusively to the Athabasca Sand Dunes of Saskatchewan (COSEWIC, 2012).

Due to the time of the survey in the late summer, it was not feasible to prepare a complete plant list for the Site. As such, other plants species known to the Arctic Nunavut region are listed in Table 2-3. This list cannot be considered as exhaustive but rather representative of the expected flora of the area.

Table 2-3: Other Plant Species Known to the Area

Family	Common Name	Scientific Name
Aster (Asteraceae)	Mastodon flower	*Senecio congestus*
Buckwheat (Polygonaceae)	Mountain sorrel	*Oxyria digyna*
Buttercup (Ranunculaceae	Pygmy buttercup	*Ranunculus pygmaeus*
Evening primrose (Onagraceae)	River beauty	*Epilobium latifolium*
Ferns (Polypodiaceae)	Fragrant shield fern	*Dryopteris fragrans*
Figwort (Scrophulariaceae)	Arctic lousewort	*Pedicularis langsdorffii ssp. arctica*
Heath (Ericaceae)	Crowberry	*Empetrum nigrum*
	Mountain cranberry	*Vaccinium vitis-idaea*
Legume (Fabaceae)	Yellow oxytrope	*Oxytropis campestris*
Pink (Caryophyllaceae)	Moss Campion	*Silene acaulis*
	Arctic bladder campion	*Silene latifolia*
	Chickweed	*Stellaria media*
Poppy (Papaveraceae)	Arctic poppy	*Papaver gorodkovii*
Saxifrage (Saxifragaceae)	Alpine saxifrage	*Saxifraga nivalis*
	Purple saxifrage	*Saxifraga oppositifolia*
Willow (Salicaceae)	Least willow	*Salix herbacea*
	Net-veined willow	*Salix reticulata*
Willowherb (Onagraceae)	Fireweed	*Epilobium angustifolium*

All of the vegetation observed at the Site or expected to be present at the Site are highly adapted to the extreme conditions of the Arctic region. Various species are also adapted to disturbed Sites, including fireweed. As such, the composition of the vegetation community observed to be present at the Site is considered suitable for the proposed upgrade and expansion of the existing long term sewage treatment system for the Hamlet of Repulse Bay.

2.2 Water Quality

A Site visit was undertaken by exp staff on September 8, 2012 to collect surface water samples from various locations of the sewage treatment system, which include:

- One (1) at the sewage truck discharge point (SW1);
- One (1) at the outlet of the first natural treatment pond (SW2);
- One (1) at the outlet of a natural treatment pond near the middle of the Site (SW3); and,
- One (1) at the outlet of a natural treatment pond near the discharge point (SW4).

The surface water sampling locations are presented in Figure 3, in Appendix A.

The findings and conclusions of the water quality investigation are presented in **exp's** report: *Water Sampling Letter Report, Sewage Treatment Wetlands, Hamlet of Repulse Bay, NU*, dated September 24, 2013, attached as Appendix B.

The levels of TSS, BOD, nutrients and pathogens in the surface water samples taken throughout the sewage treatment system on September 8th, 2012 are presented in Table 2-4.

Table 2-4: Surface Water Results (September 8, 2012)

	Compliance Guidelines(1)	Truck Discharge Point (SW1)	Outlet of First Pond (SW2)	Outlet of Middle Pond (SW3)	Outlet of Downstream Pond (SW4)	Percent Removal(2)
Total suspended solids (mg/L)	100	45	92	190	49	-8.9 %(3)
Biological oxygen demand (mg/L)	80	51	68	42	45	12 %
Fecal coliforms (CFU/100 mL)	10,000	>200,000	>200,000	710	<10	99 %
pH	6.0 to 9.0	7.36	7.64	7.80	8.19	NA
Total oil and grease (mg/L)	No visible sheen	4.6	1.7	<0.50	**1.2**	74 %

(1) Compliance guidelines for effluent, as per the Sewage Disposal Facility license (NWB3REP0409)

(2) Concentration reduction between the wetland inlet and the wetland outlet

(3) There was no percent reduction; concentration increased at the wetland outlet compared to the inlet

Bold = Effluent concentration (at wetland outlet) in excess of compliance guideline; NA = not applicable

The surface water samples collected at the Site on September 8, 2012 revealed TSS, BOD, fecal coliforms, and pH levels were in compliance of effluent guidelines at the wetland outlet point, as per the Sewage Disposal Facility license (NWB3REP0409). However, measureable concentrations of total oil and grease were detected at the wetland outlet; but, no visible sheen was noted at the surface water sampling location during sample collection. Nevertheless, during a walk-through of the Site, which was also conducted on September 8, 2012, the presence of sheen was identified at various surface water bodies throughout the entire Site, including downstream locations.

The percent reduction of contaminants from the truck discharge point (SW1) to the wetland outlet point (SW4) varied between tested parameters. Total suspended solids increased by 8.9 % at the wetland outlet; BOD slightly decreased by 12 %; fecal coliforms were non-detect at the wetland outlet, and achieved almost 100 % reduction; and, total oil and grease reduced by 74 % at the wetland outlet.

Chapter 3 –
Phytoremediation and Contaminants Removal

3 Phytoremediation and Contaminants Removal

3.1 Phytoremediation

Phytoremediation is the use of plants to remediate or decontaminate soil, water or air. Plants are able to contain, degrade or eliminate metals, pesticides, solvents, explosives, crude oil and its derivatives, and various other contaminants from environmental media. Constructed treatment wetlands with cattails and reeds, for example, are often used to treat landfill leachate, acid mine drainage, sewage, industrial effluents and agricultural run-off (Kadlec and Knight, 1996).

Vegetated wetlands with lower growing vegetation such as grasses and mosses have been reported as equally successful biofilters for a number of contaminants and excess nutrients, including nitrogen compounds, phosphates, salts, metals, organic contaminants and pathogenic bacteria and viruses (also see Kadlec and Knight, 1996).

The plant community present at the wetlands area of Repulse Bay can be described as typical of habitats in northern Arctic latitudes. That is, the dominant vegetation includes mosses, grasses, sedges, rushes, willow species and other low-lying species. These plants have been reported as suitable for the phytoremediation processes that will treat sewage and include the removal of TSS, BOD, nutrients and pathogens.

3.2 Contaminants Removal

In order for the Hamlet to meet the objectives of the Sewage Disposal Facility license, the effluent quality standards at the downgradient location prior to discharging to Hudson Bay must meet the compliance guidelines, as presented in Table 3-1.

Table 3-1: Effluent Quality Limits for Repulse Bay (Sewage Disposal Facility license NWB3REP0409)

Contaminant	Compliance Guidelines
Total suspended solids	100 mg/L
Biological oxygen demand	80 mg/L
Fecal coliforms	10,000 CFU/100 mL
pH	6.0 to 9.0
Total oil and grease	No visible sheen

3.2.1 Total Suspended Solids (TSS)

The majority of suspended solids are traditionally removed through sedimentation over time, such as in a sewage lagoon. The TSS remaining in the wastewater will subsequently enter the wetlands area where the solids will be trapped and settle along the route to Hudson Bay. Sewage biosolids are a source of organic matter which will be utilized by bacteria and plants to grow and reproduce (MOE, 1996).

As noted, recent observations during the September 8, 2012 water sampling event indicated that TSS increased by 8.9 % at the wetland outlet when compared with the truck discharge point concentration; and, the level of TSS at the mid-Site location (SW3) was above the sewage disposal effluent criteria of 100 mg/L. These observations indicate that the current wetland system may not be functioning properly,

as a result of increased BOD values, high algae growth, nutrient deficiency for bacteria, higher flow rates and decreased settling time. As the current system continues to be overloaded with waste, the ability for filtration will also decrease, which may pose concern for Hudson Bay. However, it should be further noted that typical TSS values for raw sewage are expected to be much higher than that observed during the September 8, 2012 sampling event. Kadlec and Knight (1996) present typical wastewater component concentrations entering and leaving a residential septic bed, with the central estimate of TSS of 500 mg/L (range of 230 to 600 mg/L). Therefore, assuming that the average TSS concentration at the wetland inlet is 500 mg/L, the reduction of TSS in the Hamlet's sewage wetland treatment system may be up to 90 %.

As such, the existing wetland sewage treatment area is expected to sufficiently remove TSS; however, additional sewage treatment is recommended for the Site to further reduce the amount of TSS entering the wetland.

3.2.2 Biological Oxygen Demand (BOD)

Removal of BOD will greatly depend on the oxygen supply, or aerobic conditions, provided within the wetlands area. Increased aeration throughout the treatment system will increase BOD removal efficiency; however, anaerobic conditions are expected at the Site, especially if the ice persists, which will deplete oxygen levels and maintain BOD levels. Increased levels of BOD can be attributed to a number of factors such as organic overloading, low hydraulic detention time, high algal growth, and accumulation of sludge.

As noted, recent observations during the September 8, 2012 water sampling event indicated that BOD slightly decreased by 12 % at the wetland outlet when compared with the truck discharge point concentration. It is also noted that the levels of BOD present in all effluent samples are below the sewage disposal effluent standard for BOD of 80 mg/L; and, the highest level of BOD was detected at the outlet of the first treatment pond (SW2) at 68 mg/L. However, it should be further noted that typical BOD values for raw sewage are expected to be much higher than that observed during the September 8, 2012 sampling event. Kadlec and Knight (1996) present typical wastewater component concentrations entering and leaving a residential septic bed, with the central estimate of BOD of 450 mg/L (range of 210 to 530 mg/L). Therefore, assuming that the average BOD concentration at the wetland inlet is 450 mg/L, the reduction of BOD in the Hamlet's sewage wetland treatment system may be up to 90 %.

As such, the existing wetland sewage treatment area is expected to sufficiently remove BOD; however, additional sewage treatment is recommended for the Site to further reduce the amount of BOD entering the wetland.

3.2.3 Pathogens

Pathogens present in sewage include fecal coliforms and *Escherichia coli*, which have a limited life span outside of their host organisms (i.e. warm-blooded animals). The majority of pathogen decline is expected in a typical sewage lagoon, where cell die off, sedimentation, filtration, absorption and predation greatly reduce coliform numbers (Martin and Johnson, 1995).

As noted, recent observations during the September 8, 2012 water sampling event indicated that fecal coliforms and *E. coli* were non-detect at the wetland outlet, and achieved almost 100 % reduction. However, it should be noted fecal coliforms and *E. coli* were detected at all other sampling locations, upstream of the wetland outlet, including at the mid-Site location (SW3).

These observations suggest that pathogens, as represented by fecal coliforms, are currently not a concern downgradient of the wetland sewage treatment system. However, given that pathogens were detected at all other sampling locations, pathogens may be a concern in the long-term, if the system continues to overload. As such, additional sewage treatment is recommended for the Site to further reduce the amount of pathogens present at the wetlands area.

3.2.4 Nutrients

Sewage effluent is high in nutrients such as phosphorus and nitrogen compounds. Nutrient-rich waters may lead to eutrophic conditions, which involves prolific growth of algae and other aquatic plants. Eutrophication may eventually lead to the depletion of the water's natural oxygen supply, which is detrimental to aquatic life.

It is noted, however, that the Arctic wetland region to which the Hamlet of Repulse Bay belongs is relatively nutrient poor, and nutrients are generally in short supply. Availability of additional nutrients is unlikely to cause eutrophication, as excess nutrients will be readily taken up by plants and metabolized. This will result in increased plant biomass and growth rates. As a consequence, more organic compounds will be available for bacteria in the rhizosphere. The presence of increased volumes of nutrients and organic compounds in the wetlands compared with surrounding habitats are thereby expected to increase bacterial growth and reproduction in the wetlands, and subsequently the degradation rate of contaminants. It is therefore unlikely that the nutrients at the Site will be a concern downgradient of the wetland sewage treatment system.

3.2.5 pH

The pH of the sewage treatment system remained relatively neutral, fluctuating between 7.36 and 8.19 during the September 8, 2012 sampling event. The increase in pH levels noted on-Site may be attributed to algal growth identified in the settling ponds. Overall, the fluctuation of pH levels at the Site is not considered to be a significant concern downgradient of the wetland sewage treatment system.

3.2.6 Total Oil and Grease

The surface water samples collected during the September 8, 2012 sampling event did not contain any visible sheen. However, a walk-through of the Site, which was also conducted on September 8, 2012, did identify occasions of sheen present at various surface water bodies throughout the entire Site, including downstream locations. Furthermore, it is noted that total oil and grease were detected in the surface water sample collected at the wetland outlet (SW4), but were reduced by 74 % when compared to the concentration detected at the truck discharge point (SW1).

These observations show some reduction in the levels of total oil and grease at the wetland outlet; however, concentrations still remain at the downstream location. As such, additional sewage treatment is recommended for the Site to further reduce the amount of total oil and grease entering the wetland.

3.3 Literature Review

Free water surface wetlands (FWS) pass over and through wetland plant material (Woerner and Lorimor, 2008). These systems have been shown to reduce the amount of contaminants contained in effluents. Such reductions include 34 % in BOD, 93% in TSS, and 52 % in fecal coliforms (Cameron et al., 2003).

Treatment ponds have been used in combination with FWS wetlands to effectively treat domestic and industrial effluent (Kadlec et al., 2012; Kadlec, 2003). Results from 21 systems reviewed in Kadlec (2003) identify a removal rate of 61% for BOD, 67 % for TSS, 61% for ammonia nitrogen (NH4-N,), 48% for total phosphorus, and 99.8% for fecal coliforms. In many instances, lagoons are often installed for the treatment of municipal waste, with installation of a wetland system afterwards to aid in the filtration of contaminants; often helping decrease TSS, BOD, fecal coliforms, phosphorus (P) and nitrogen (N) (Kadlec, 2003).

The installation of a lagoon upstream of a wetland will help with the pre-treatment quality and discharge of the effluent as well as storage and timing (Kadlec, 2003). This may provide a benefit in colder climates by holding discharge, rather than releasing directly into the wetland system during the winter months. Typically, these northern lagoon systems release water in the spring after snow melt and during higher

rain events associated with this season (Kadlec, 2003). They also release water in the fall, again due to increased precipitation, allowing room in the system for winter storage (Kadlec, 2003).

3.4 Interpretation

As noted, the Hamlet's existing wetland sewage treatment system is comprised of a simple truck offload discharge area, which is directed to a natural wetlands area. The wetland plants appear to be in good condition, and this plant community is composed of a range of some different species and morphologies. Water samples collected at the Site during the September 8, 2012 sampling event, indicate that there is some reduction in BOD, pathogens and total oil and grease at the wetland outlet compared to the truck discharge point; but, these reductions were low. Furthermore, there was an increase in TSS observed, and visible sheen was noted at various surface water bodies throughout the Site. However, it should be further noted that typical TSS and BOD values for raw sewage are expected to be much higher than those observed during the September 8, 2012 sampling event. Kadlec and Knight (1996) present typical wastewater component concentrations entering and leaving a residential septic bed. Assuming that the average TSS and BOD concentrations at the wetland inlet are much higher than observed during the September 8, 2012 sampling event, the reduction of TSS and BOD in the Hamlet's sewage wetland treatment system may each be up to 90 %.

Due to the variable decline of the majority of contaminants, the performance of the wetland to assimilate sewage cannot be confirmed. Although the current release rates are all within allowable limits, and the Hamlet's existing sewage wetland treatment system is in general compliance with the requirements of the Nunavut Water Board License Number NWB3REP0409 – Hamlet of Repulse Bay, additional sewage treatment measures are recommended for the Site to improve the function and effectiveness of the existing wetland system in the long-term.

Chapter 4 – Conclusions and Recommendations

4 Conclusions and Recommendations

The Wetlands Assessment revealed variable declines of contaminants between the truck discharge point and the wetland outlet, confirming that phytoremediation is occurring, as expected. Observations during the September 8, 2012 sampling event indicate overloading of organic material, which has resulted in varying parameter levels throughout the system. However, there is a level of uncertainty related to the typical contaminant values present in the Hamlet's raw sewage; and, such values are expected to be much higher than those observed during the September 8, 2012 sampling event.

Typical removal rates of contaminants by sewage treatment systems are variable. Free water systems reduced BOD by 34 %, TSS by 93 % and fecal coliforms by 52 % (Cameron et al., 2003); whereas, a combination of treatment ponds and FWS had average reductions of BOD by 61 %, TSS by 67 % and fecal coliforms by 99.8 % (Kadlec, 2003; Kadlec et al., 2012).

Kadlec and Knight (1996) present typical wastewater component concentrations entering and leaving a residential septic bed. Assuming that the average TSS and BOD concentrations at the wetland inlet are much higher than observed during the September 8, 2012 sampling event, the reduction of TSS and BOD in the Hamlet's sewage wetland treatment system may each be up to 90 %.

Therefore, the Hamlet's existing sewage wetland treatment system appears to be effectively removing the contaminants of concern. However, additional sewage treatment, by way of the installation of a lagoon at the sewage inlet point, is recommended to further reduce the levels of contaminants and pathogens releasing into the wetlands area, and subsequently into Hudson Bay.

4.1 Construction of a Sewage Lagoon

The presence of a sewage lagoon at the sewage inlet point will greatly reduce the amount of contaminants, pathogens and nutrients discharging into the downgradient wetlands, and subsequently into Hudson Bay. Traditionally, a sewage lagoon will remove the majority of suspended solids through sedimentation over time; and, is also expected to significantly reduce the number of pathogens, where cell die off, sedimentation, filtration, absorption and predation greatly reduce coliform counts. The downstream wetlands will then receive the remaining wastewater from the lagoon, and will trap any remaining solids and breakdown any remaining contaminants, along the route to Hudson Bay.

It is recommended that a sewage lagoon of sufficient size and lining be constructed at an upstream location of the sewage treatment system, where raw sewage is to be deposited. Various natural processes will then occur in the lagoon prior to the release of the remaining wastewater into the existing wetland area. The construction and subsequent use of a sewage lagoon at the Site is expected to greatly improve the performance of the sewage treatment system in the long-term.

Chapter 5 –
General Limitations and Closure

5 General Limitations and Closure

The purpose of this report is to provide the Government of Nunavut with an evaluation of the efficacy associated with the existing sewage treatment system at the Hamlet of Repulse Bay; and, if the system is in compliance with the requirements of the Nunavut Water Board, water license number NWB3REP0409 – Hamlet of Repulse Bay.

The information presented in this report is based on information provided by others and visual observations as identified herein. Achieving the objectives stated in this report has required us to arrive at conclusions based upon the best information presently known to us. No investigative method can completely eliminate the possibility of obtaining partially imprecise or incomplete information; it can only reduce the possibility to an acceptable level. Professional judgment was exercised in gathering and analyzing the information obtained and in the formulation of the conclusions. Like all professional persons rendering advice, we do not act as absolute insurers of the conclusions we reach, but we commit ourselves to care and competence in reaching those conclusions.

This report was prepared for the Government of Nunavut and may not be reproduced in whole or in part, without the prior written consent of **exp**, or used or relied upon in whole or in part by other parties for any purposes whatsoever. Any use which a third party makes of this report, or any part thereof, or any reliance on or decisions to be made based on it, are the responsibility of such third parties**. Exp** Services Inc. accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

The Wetlands Assessment was prepared based on the available site information and evaluated the potential effects posed on the environment based on the existing long term sewage treatment system for the Hamlet of Repulse Bay. Should additional Site information become available, the Wetlands Assessment should be re-evaluated to determine if the conclusions presented in the report are still valid.

Closure

We trust this report is satisfactory for your purposes. Should you have any questions, please do not hesitate to contact this office.

Yours truly,

exp Services Inc.

DRAFT

_____
Edyta Chorostkowska, M.Env.Sc., EPt
Ecological Specialist

DRAFT

_____
Dean Fitzgerald, Ph.D.
Team Leader, Ecological Services

Chapter 6 – References

6 References

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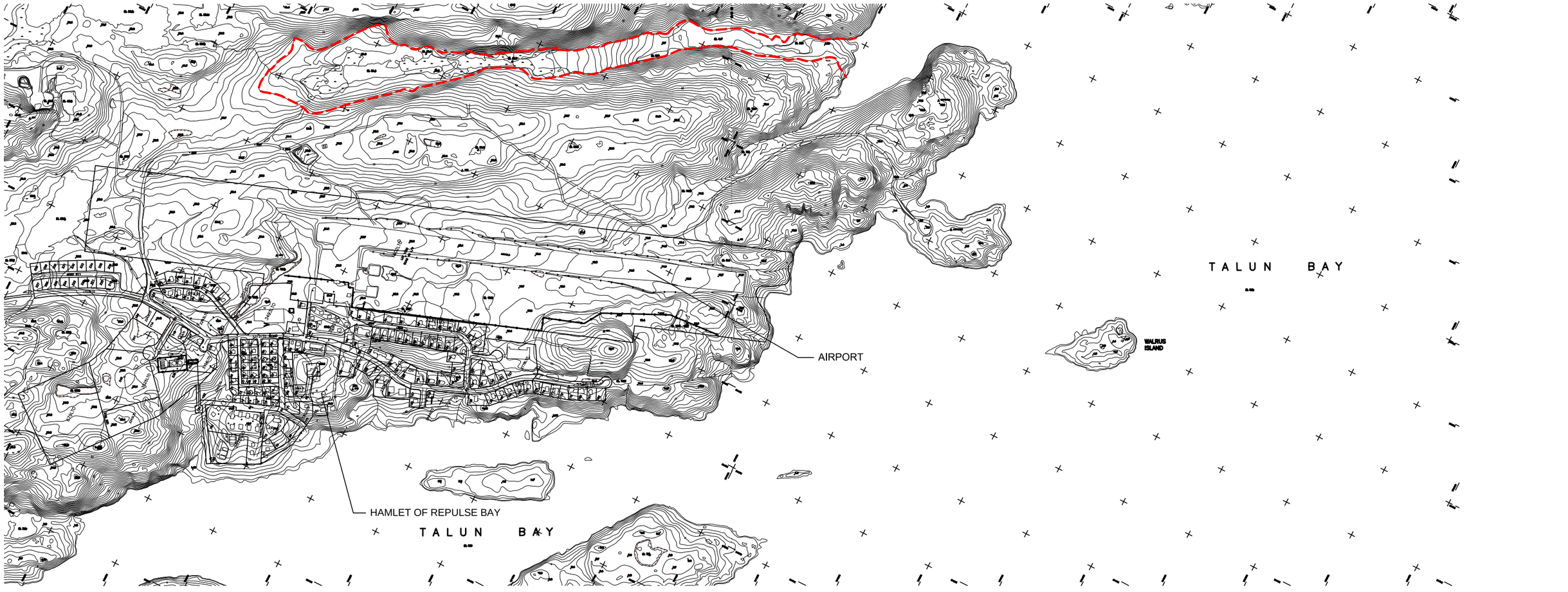
Appendix A – Figures



LEGEND:

APPROXIMATE SITE BOUNDARY

0 40 80 160 240 320 400 metres

CONTOUR INTERVAL: 0.5 METRES

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PROJECT TITLE AND LOCATION:

WETLANDS ASSESSMENT
SEWAGE TREATMENT FACILITY
HAMLET OF REPULSE BAY, NU

DRAWING TITLE:

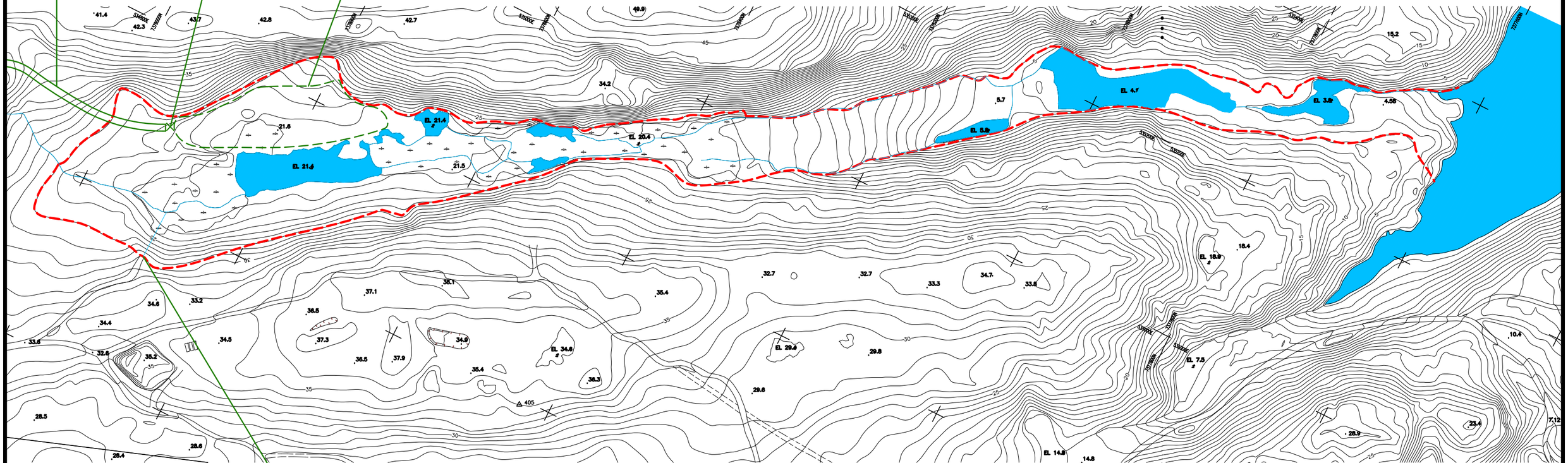
SITE LOCATION PLAN

PROJECT NO.: OTT-00207086-A0	DWN.: AZ
SCALE: AS NOTED	DWN.: EC
DATE: OCTOBER 2012	DWG. No.: 1

PROPOSED ROAD TO TRUCK DISCHARGE POINT

PROPOSED TRUCK DISCHARGE POINT

PROPOSED SEWAGE LAGOON LOCATION



CURRENT TRUCK DISCHARGE POINT

LEGEND:

- APPROXIMATE SITE BOUNDARY
- SURFACE WATER BODY
- WETLAND/SWAMP

0 20 40 80 120 160 200 metres

CONTOUR INTERVAL: 0.5 METRES

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PROJECT TITLE AND LOCATION:

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HAMLET OF REPULSE BAY, NU

DRAWING TITLE:

SITE LAYOUT PLAN

PROJECT NO.: OTT-00207086-A0	DWN.: AZ
SCALE: AS NOTED	DWN.: EC
DATE: OCTOBER 2012	DWG. No.: 2

PROPOSED ROAD TO TRUCK DISCHARGE POINT

PROPOSED TRUCK DISCHARGE POINT

PROPOSED SEWAGE LAGOON LOCATION

SW1

SW2

SW3

SW4

CURRENT TRUCK DISCHARGE POINT

LEGEND:

- APPROXIMATE SITE BOUNDARY
- SURFACE WATER BODY
- WETLAND/SWAMP
- SW1 SURFACE WATER SAMPLE LOCATION (SEPTEMBER 2012)

0 20 40 80 120 160 200 metres

CONTOUR INTERVAL: 0.5 METRES

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PROJECT TITLE AND LOCATION:

WETLANDS ASSESSMENT
SEWAGE TREATMENT FACILITY
HAMLET OF REPULSE BAY, NU

DRAWING TITLE:

LOCATIONS OF SURFACE WATER SAMPLES
(SEPTEMBER 2012)

PROJECT NO.: OTT-00207086-A0	DWN.: AZ
SCALE: AS NOTED	DWN.: EC
DATE: OCTOBER 2012	DWG. No.: 3

Appendix B –
exp's (2013) Water Sampling Letter Report

September 24, 2013

Wayne Thistle
Kivalliq Projects Manager
Department of Community and Government Services
Government of Nunavut
P.O Box 490,
Rankin Inlet, NU X0C 0G0

Re: OTT-00207086-A0 **DRAFT Water Sampling Letter Report**
Sewage Treatment Wetlands, Hamlet of Repulse Bay, NU

Dear Mr. Thistle:

The Government of Nunavut (GN), Department of Community and Government Services (CGS) retained **exp** Services Inc. (**exp**) to prepare a Screening Level Environmental Assessment (SLEA) under the *Canadian Environmental Assessment Act* in order to complete the detailed planning design for the sewage facility upgrade for the Hamlet of Repulse Bay, Kivalliq Region, Nunavut, hereinafter referred to as the 'Site'. In addition, the project included a water sampling program of the wetlands area to determine if the surface water meets the sewage disposal facility effluent quality limits.

The purpose of the water sampling program was to determine the general water quality of the water entering the wetlands area and finally discharging into the marine environment in Hudson Bay, to determine if the surface water meets the sewage disposal facility effluent quality limits, in compliance with the requirements of the Nunavut Water Board, water license number NWB3REP0409 – Hamlet of Repulse Bay.

1 Introduction

As per the Terms of Reference for the sewage treatment facility upgrade for the community of Repulse Bay in Nunavut, a Site visit was undertaken by Mr. Stephen Douglas and Ms. Edyta Chorostkowska of **exp** between September 7th to 8th, 2012. As part of this Site visit, a water sampling program of the wetlands area was completed. The following letter report summarizes the water sampling program completed at the Site.

1.1 Background

The Hamlet utilizes a sewage disposal facility located approximately 400 m to the northeast of the edge of the community. The sewage disposal facility is located at the solid waste disposal facility, and consists of a simple truck offload discharge area, which is directed to a natural wetlands area. The effluent at this wetlands area proceeds downstream along a 1,400 m flow path through a series of wetlands and surface water bodies, situated within a valley, until finally discharging to the marine environment entering Hudson Bay. The total area of the natural wetlands area is approximately 64,000 m^2. Refer to Figure 1 in Appendix A for the Site Location Plan. Refer to Figure 2 in Appendix A for the Site Layout Plan.

2 Scope of Work

The scope of work for the water sampling program consisted of the following:

- Collect water samples from the sewage truck discharge location.
- Collect water samples from several wetland locations: at the outlet of the first natural treatment pond; at the outlet of a natural treatment pond near the middle of the Site; and, the outlet of a natural treatment pond near the discharge point.
- Submit the water samples for laboratory analysis of general inorganic parameters, metals, petroleum hydrocarbons and microbiology.
- Compare the results to the license effluent quality limits.
- Prepare a letter report of the findings.

3 Sampling Program

On September 8, 2012, **exp** visited the Site and collected surface water samples from select locations with the wetlands area, including:

- One (1) at the sewage truck discharge point (SW1);
- One (1) at the outlet of the first natural treatment pond (SW2);
- One (1) at the outlet of a natural treatment pond near the middle of the Site (SW3); and,
- One (1) at the outlet of a natural treatment pond near the discharge point (SW4).

All samples were collected into laboratory-supplied bottles and submitted for chemical analysis of biological oxygen demand (BOD), chromium VI, general inorganic parameters, mercury, metals, microbiology, nutrients, oil and grease, phenols and solids.

Chain of custody forms were used to track the samples from the point of collection to the point of analysis. The water samples were submitted to Maxxam Analytics Inc. (Maxxam). Maxxam is certified by the Canadian Association for Laboratory Accreditation Inc. (CALA).

4 Results

4.1 Field Observations

During the September 2012 water sampling event, water samples were collected from surface water bodies located throughout the wetlands area.

Water collected at the sewage inlet (SW1) was brownish in colour, had low clarity with sediment present. The surface water at this location was characteristic of a narrow, low-flowing stream of water. No visible sheen or significant odour was detected at this sampling point.

Water collected at the outlet of the first natural pond (SW2) contained a high amount of algae and detritus, and was greenish in colour. The surface water at this location was characteristic of a small pond, with low-flowing water at the pond outlet. No visible sheen or significant odour was detected at this sampling point.

Water collected at the outlet of the mid-Site natural pond (SW3) had a very high amount of sediment and detritus present, and was dark brown in colour. The surface water at this location was characteristic of a small pond, with little to no flowing water at the pond outlet. No visible sheen or significant odour was detected at this sampling point.

Water collected at the outlet of a downstream natural pond (SW4) was light brown in colour, somewhat clear with some sediment. The surface water at this location was characteristic of a small pond, with low-flowing water at the pond outlet. No visible sheen or significant odour was detected at this sampling point.

It should be noted that during a walk-through of the Site, which was also conducted on September 8, 2012, the presence of sheen was identified at various surface water bodies throughout the entire Site, including at downstream locations.

4.2 Assessment Criteria

The subject property has a sewage disposal facility license (NWB3REP0409), which provides effluent quality standards for five (5) chemical parameters, as present in Table 1-1. The effluent quality limits are applicable to the effluent discharged into Hudson Bay at Monitoring Program Station REP-4, as seen in Figure 3, in Appendix A.

Table 1-1: Sewage Disposal Facility Effluent Quality Standards (Hamlet of Repulse Bay)

Parameter	Maximum Average Concentration at Effluent Point
Fecal coliforms	$1x10^{+4}$ CFU/100 mL
BOD_5	80 mg/L
Total suspended solids (TSS)	100 mg/L
Oil and grease	No visible sheen
pH	Between 6 and 9

4.3 Water Analytical Results

A summary of the water analytical results is presented in Table 1 in Appendix B, along with the effluent quality standards. The laboratory certificates of analysis are included in Appendix C.

The results of the water sampling program indicated that the surface water collected at the sewage inlet (SW1) and at the outlet of the first natural treatment pond (SW2) contained fecal coliform concentrations (>$2x10^{+5}$ CFU/100 mL) above the sewage disposal effluent quality standard of $1x10^{+4}$ CFU/100 mL. However, it is noted that the surface water samples collected at all other locations were below effluent quality standard for fecal coliforms, with 710 CFU/100 mL at the mid-Site location (SW3); and, non-detect concentration (<10 CFU/100 mL) at the downstream location (SW4). As such, although fecal coliforms

were detected at the Site, the downstream location closest to the discharge point for Hudson Bay (SW4) was within the acceptable standard.

The results of the water sampling program indicated that the surface water collected at the mid-Site location (SW3) contained total suspended solids (TSS) of 190 mg/L, above the sewage disposal effluent quality standard of 100 mg/L. This result is to be expected given that the surface water body had little to no flow at this location; and, the water sample contained high amounts of sediment and detritus. All other surface water samples were within the effluent quality standard, with 45 mg/L at SW1, 92 mg/L at SW2 and 49 mg/L at SW4. As such, although TSS was detected at the Site above effluent criteria, the downstream location closest to the discharge point for Hudson Bay (SW4) was within the acceptable standard.

The results of the water sampling program indicated that all surface water samples collected at the Site had total biological oxygen demand (BOD) and pH levels within the sewage disposal effluent quality standards.

The results of the water sampling program indicated that all surface water samples collected at the Site did not contain visible sheen; however, measureable concentrations of total oil and grease were detected at the sewage inlet (SW1) with 4.6 mg/L; at the outlet of the first pond (SW2) with 1.7 mg/L; and, at the downstream pond location (SW4) with 1.2 mg/L. As such, although no visible sheen was noted within the surface water samples collected at the Site, there is potential for oil and grease to be present at the downstream location closest to the discharge point for Hudson Bay.

Based on the reported analytical results obtained during the September 8, 2012 water sampling program, the water quality at the water license compliance point (downstream location SW4) meets the sewage disposal effluent quality standards presented in the Nunavut Water Board License for the Hamlet of Repulse Bay, with the exception of oil and grease. It should be noted that although measureable total oil and grease were detected at the downstream location (SW4), no visible sheen was noted at the surface water sampling location during sample collection. However, during a walk-through of the Site, which was also conducted on September 8, 2012, the presence of sheen was identified at various surface water bodies throughout the entire Site, including at downstream locations.

5 Summary and Conclusions

Exp field staff conducted a Site visit to the Repulse Bay sewage disposal facility on September 8, 2012 to collect four (4) surface water samples for laboratory analysis of select parameters. The purpose of the water sampling program was to determine the general water quality of the water entering the wetlands area and finally discharging into the marine environment in Hudson Bay, to determine if the surface water meets the sewage disposal facility effluent quality standards.

The subject property has a sewage disposal facility license (NWB3REP0409), which provides effluent quality standards for five (5) chemical parameters, including fecal coliforms, BOD, TSS, oil and grease, and pH.

Based on the reported analytical results obtained during the September 8, 2012 water sampling program, the water quality at the water license compliance point (downstream location SW4) meets the sewage disposal effluent quality standards presented in the Nunavut Water Board License for the Hamlet of Repulse Bay, with the exception of oil and grease. It should be noted that although measureable total oil and grease were detected at the downstream location (SW4), no visible sheen was noted at the surface water sampling location during sample collection. However, during a walk-through of the Site, which was also conducted on September 8, 2012, the presence of sheen was identified at various surface water bodies throughout the entire Site, including at downstream locations.

6 Limitations

This report was prepared for the exclusive use of the Government of Nunavut. Any other party without the express written consent of **exp** should not rely upon the contents of this report. Conclusions regarding the environmental conditions at this Site are based solely on the extent of observations and the information referenced herein.

Exp has attempted to conduct the services reported herein in a manner consistent with that level of care and skill ordinarily exercised by members of the profession currently practicing in the same locality and under similar conditions as this project. No other representation, express or implied, is included or intended in this document.

A water sampling program of this nature is based on a limited sampling of the Site. The field observations, chemical analyses, and conclusions area based on information gathered at the specific test locations, and can only be extrapolated to a limited area around the test locations. The reported information is believed to provide a reasonable representation of the general environmental conditions at the Site at the time of the investigation. Should additional information become available concerning this Site, such information should be provided to **exp** so that our recommendations may be reviewed and modified, as necessary.

Closure

We trust this report is satisfactory for your purposes, and thank you for the opportunity of this submission. We look forward to assisting the Government of Nunavut in this project. Should you have any questions, please feel free to contact the undersigned.

Yours truly,

exp Services Inc.

DRAFT

Edyta Chorostkowska, M.Env.Sc.
Environmental Specialist

DRAFT

Steven Burden, P.Eng.
Project Manager

Attachments: Appendix A: Figures
Appendix B: Analytical Summary Table
Appendix C: Laboratory Certificate of Analysis

Appendix A:
Figures

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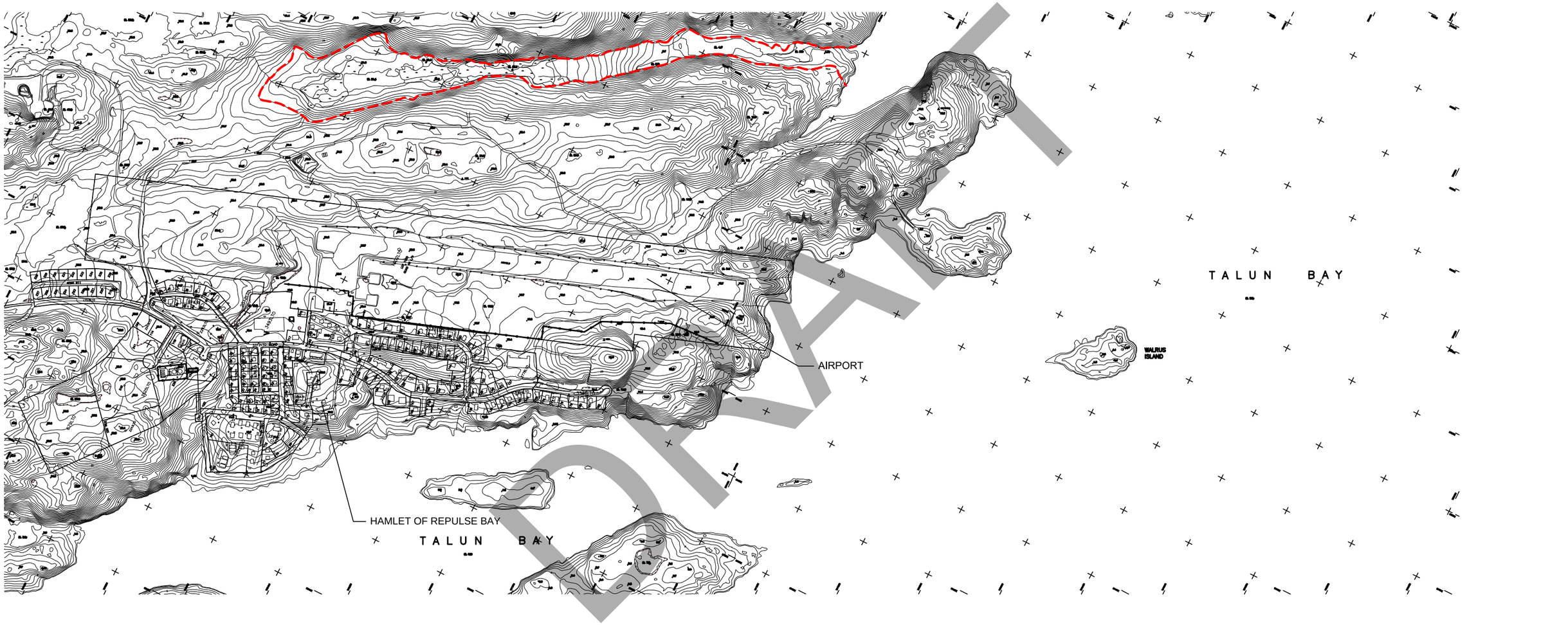

LEGEND:

APPROXIMATE SITE BOUNDARY

0 40 80 160 240 320 400 metres

CONTOUR INTERVAL: 0.5 METRES

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PROJECT TITLE AND LOCATION:

WATER SAMPLING PROGRAM
SEWAGE TREATMENT FACILITY
HAMLET OF REPULSE BAY, NU

DRAWING TITLE:

SITE LOCATION PLAN

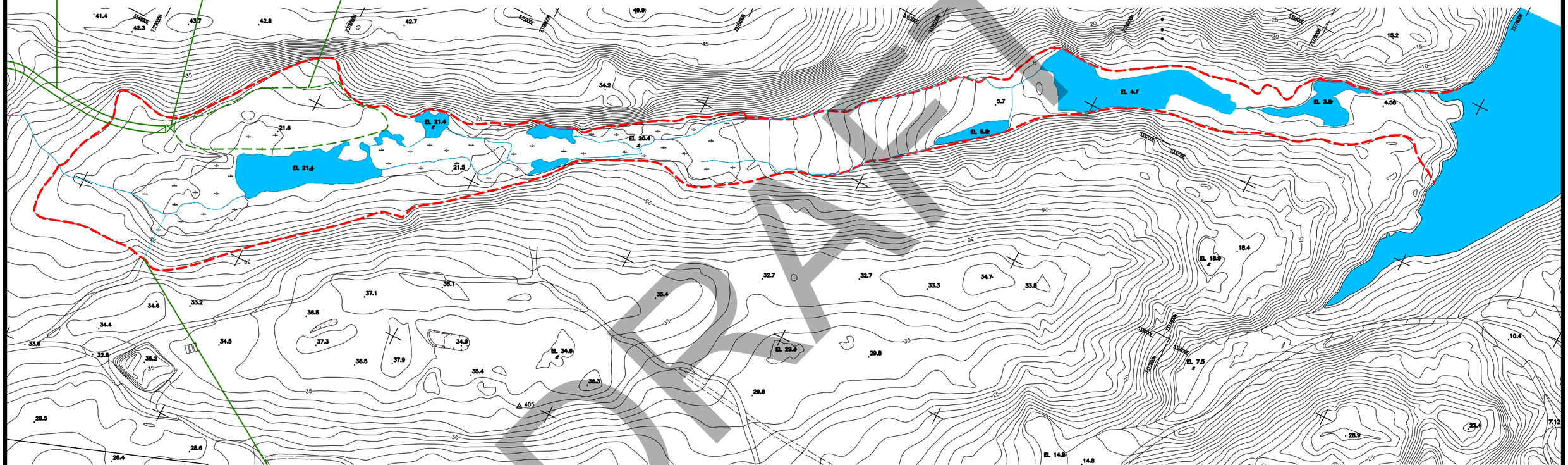
PROJECT NO.: OTT-00207086-A0	DWN.: AZ
SCALE: AS NOTED	DWN.: EC
DATE: OCTOBER 2012	DWG. No.: 1

PROPOSED ROAD TO TRUCK DISCHARGE POINT

PROPOSED TRUCK DISCHARGE POINT

PROPOSED SEWAGE LAGOON LOCATION

CURRENT TRUCK DISCHARGE POINT



LEGEND:

- APPROXIMATE SITE BOUNDARY
- SURFACE WATER BODY
- WETLAND/SWAMP

0 20 40 80 120 160 200 metres

CONTOUR INTERVAL: 0.5 METRES

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PROJECT TITLE AND LOCATION:

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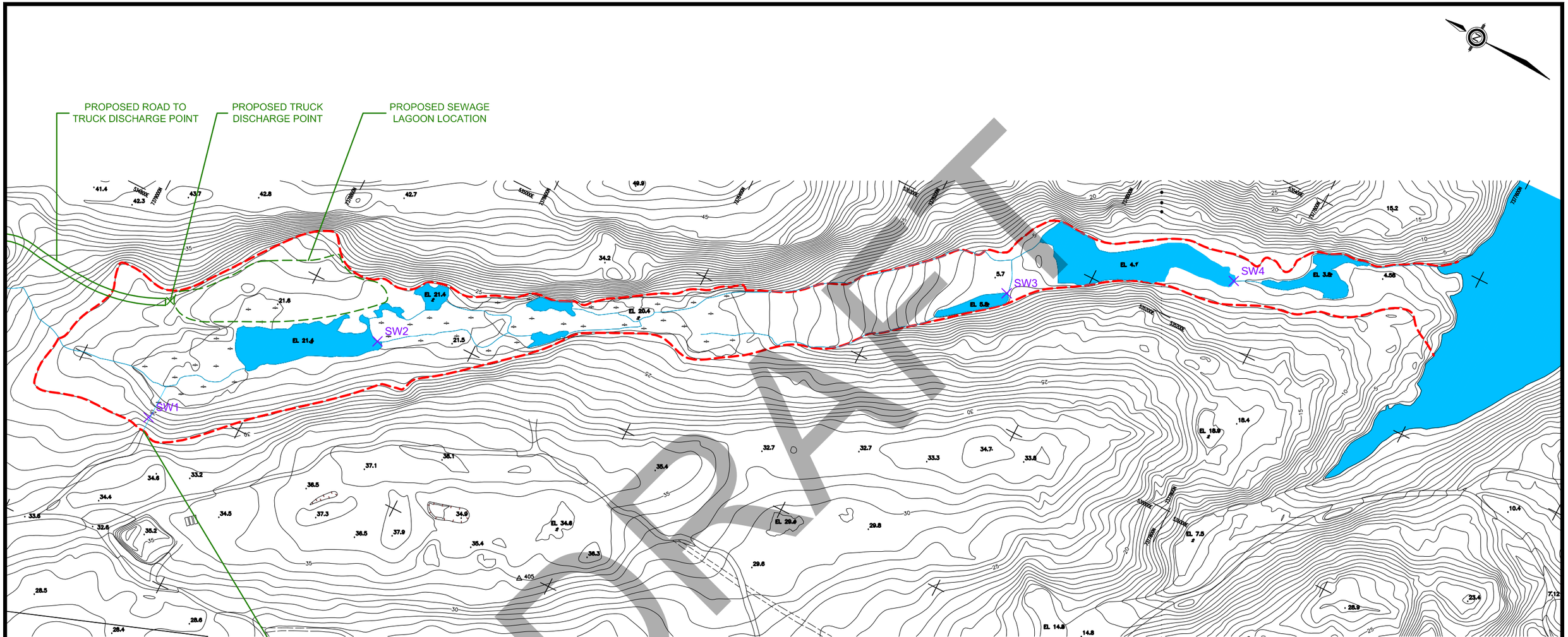
SEWAGE TREATMENT FACILITY
HAMLET OF REPULSE BAY, NU

DRAWING TITLE:

SITE LAYOUT PLAN

PROJECT NO.: OTT-00207086-A0	DWN.: AZ
SCALE: AS NOTED	DWN.: EC
DATE: OCTOBER 2012	DWG. No.: 2



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PROJECT TITLE AND LOCATION:

WATER SAMPLING PROGRAM
SEWAGE TREATMENT FACILITY
HAMLET OF REPULSE BAY, NU

DRAWING TITLE:

LOCATIONS OF SURFACE WATER SAMPLES (SEPTEMBER 2012)

PROJECT NO.: OTT-00207086-A0	DWN.: AZ
SCALE: AS NOTED	DWN.: EC
DATE: OCTOBER 2012	DWG. No.: 3

Appendix B:
Analytical Summary Table

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SURFACE WATER ANALYTICAL RESULTS
OTT-00207086-A0 - Sewage Treatment Facility, Hamlet of Repulse Bay, NU

Sample	Units	Sewage Disposal License Effluent Limits[1]	SW 1	SW 2	SW 3	SW 4
Sampling Date			8-Sep-12	8-Sep-12	8-Sep-12	8-Sep-12
Lab ID			OT7886	OT7887	OT7888	OT7889
Laboratory			Maxxam	Maxxam	Maxxam	Maxxam
Metals						
Total Aluminum (Al)	ug/L	NV	63	150	1100	43
Total Antimony (Sb)	ug/L	NV	<0.50	<0.50	1.0	0.51
Total Arsenic (As)	ug/L	NV	1.3	<1.0	1.1	<1.0
Total Barium (Ba)	ug/L	NV	13	6.3	33	9.4
Total Beryllium (Be)	ug/L	NV	<0.50	<0.50	<0.50	<0.50
Total Bismuth (Bi)	ug/L	NV	<1.0	<1.0	<1.0	<1.0
Total Boron (B)	ug/L	NV	400	160	140	120
Total Cadmium (Cd)	ug/L	NV	<0.10	0.11	0.26	<0.10
Total Calcium (Ca)	ug/L	NV	110000	55000	67000	62000
Total Chromium (Cr)	ug/L	NV	<5.0	<5.0	<5.0	<5.0
Chromium (VI)	ug/L	NV	<5.0	<5.0	<5.0	<5.0
Total Cobalt (Co)	ug/L	NV	0.55	<0.50	1.2	<0.50
Total Copper (Cu)	ug/L	NV	6.8	32	53	5.1
Total Iron (Fe)	ug/L	NV	16000	750	5600	430
Total Lead (Pb)	ug/L	NV	0.62	1.1	5.5	<0.50
Total Magnesium (Mg)	ug/L	NV	18000	12000	14000	13000
Total Manganese (Mn)	ug/L	NV	310	68	120	58
Mercury (Hg)	mg/L	NV	<0.00010	<0.00010	<0.00010	<0.00010
Total Molybdenum (Mo)	ug/L	NV	<0.50	0.54	1.3	0.69
Total Nickel (Ni)	ug/L	NV	7.6	2.4	4.8	1.9
Total Potassium (K)	ug/L	NV	25000	16000	13000	10000
Total Silicon (Si)	ug/L	NV	8500	3400	4900	2400
Total Selenium (Se)	ug/L	NV	<2.0	<2.0	<2.0	<2.0
Total Silver (Ag)	ug/L	NV	<0.10	0.23	0.51	<0.10
Total Sodium (Na)	ug/L	NV	69000	60000	52000	44000
Total Strontium (Sr)	ug/L	NV	190	110	130	120
Total Thallium (Tl)	ug/L	NV	<0.050	<0.050	0.055	<0.050
Total Tin (Sn)	ug/L	NV	1.3	<1.0	1.1	<1.0
Total Titanium (Ti)	ug/L	NV	7.2	11	67	<5.0
Total Uranium (U)	ug/L	NV	0.20	1.9	7.4	5.1
Total Vanadium (V)	ug/L	NV	<0.50	<0.50	2.9	<0.50
Total Zinc (Zn)	ug/L	NV	19	61	170	18
Calculated Parameters						
Hardness (CaCO3)	mg/L	NV	310	180	200	180
Inorganics						
Total BOD	mg/L	80	51	68	42	45
pH	pH	between 6 & 9	7.36	7.64	7.80	8.19
Alkalinity (Total as CaCO3)	mg/L	NV	600	310	280	190
Conductivity	umho/cm	NV	1400	880	770	560
Dissolved Chloride (Cl)	mg/L	NV	49	63	47	40
Total Ammonia-N	mg/L	NV	64	36	25	2.1
Total Kjeldahl Nitrogen (TKN)	mg/L	NV	62	51	39	12
Nitrite (N)	mg/L	NV	<0.010	<0.010	0.038	0.53
Nitrate (N)	mg/L	NV	<0.10	<0.10	0.42	0.98
Nitrate + Nitrite	mg/L	NV	<0.10	<0.10	0.45	1.5
Turbidity	NTU	NV	69	39	9.3	15
Total Dissolved Solids	mg/L	NV	634	502	376	436
Total Suspended Solids	mg/L	100	45	92.0	**190**	49
Phenols-4AAP	mg/L	NV	0.10	0.0039	<0.0010	<0.0010
Petroleum Hydrocarbons						
Total Oil & Grease	mg/L	No visible sheen	**4.6**	**1.7**	<0.50	**1.2**
Microbiological						
Background	CFU/100mL	NV	>200000	>200000	40000	18000
Fecal coliform	CFU/100mL	10000	**>200000**	**>200000**	710	<10
Total coliforms	CFU/100mL	NV	>200000	>200000	13000	160
Escherichia coli	CFU/100mL	NV	120000	100000	210	<10

(1) Sewage disposal license effluent limits from NWB License Number NWB3REP0409 - Hamlet of Repulse Bay
NV = No value provided
BOLD = Exceedance of Sewage Disposal License Effluent Limit.
Input By: EC

Appendix C:
Laboratory Certificate of Analysis

1595 Clark Boulevard, Brampton, ON L6T 4V1, Canada
T: +1.905.793.7800 • www.exp.com

Your Project #: OTT-00207086-A0
Site Location: Repulse Bay/Nunavat
Your C.O.C. #: 36939801, 369398-01-01

Attention: Edyta Chorostkowska
exp Services Inc
1595 Clark Blvd
Brampton, ON
L6T 4V1

Report Date: 2012/09/18

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B2D8122
Received: 2012/09/10, 08:00

Sample Matrix: Water
Samples Received: 4

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Method Reference
Alkalinity	4	N/A	2012/09/11	CAM SOP-00448	SM 2320B
Biochemical Oxygen Demand (BOD)	4	N/A	2012/09/16	CAM SOP-00427	APHA 5210B
Chloride by Automated Colourimetry	4	N/A	2012/09/11	CAM SOP-00463	EPA 325.2
Conductivity	4	N/A	2012/09/11	CAM SOP-00448	SM 2510
Chromium (VI) in Water	4	N/A	2012/09/14	CAM SOP-00436	EPA 7199
Hardness (calculated as CaCO3)	4	N/A	2012/09/13	CAM SOP 00102	SM 2340 B
Mercury in Water by CVAA	4	2012/09/13	2012/09/13	CAM SOP-00453	SW-846 7470A
Total Metals Analysis by ICPMS	4	N/A	2012/09/13	CAM SOP-00447	EPA 6020
Coliform, (CFU/100mL)	4	N/A	2012/09/10	CAM SOP-00552	MOE LSB E3371
E.coli, (CFU/100mL)	4	N/A	2012/09/10	CAM SOP-00552	MOE LSB E3371
Fecal coliform, (CFU/100mL)	4	N/A	2012/09/10	CAM SOP-00552	SM 9222D
Total Ammonia-N	1	N/A	2012/09/12	CAM SOP-00441	US GS I-2522-90
Total Ammonia-N	3	N/A	2012/09/14	CAM SOP-00441	US GS I-2522-90
Nitrate (NO3) and Nitrite (NO2) in Water (1)	4	N/A	2012/09/11	CAM SOP-00440	SM 4500 NO3I/NO2B
Total Oil and Grease	4	2012/09/11	2012/09/11	CAM SOP-00326	EPA 1664A
pH	4	N/A	2012/09/11	CAM SOP-00448	SM 4500H+ B
Phenols (4AAP)	4	N/A	2012/09/12	CAM SOP-00444	MOE ROPHEN-E3179
Total Dissolved Solids	4	N/A	2012/09/11	CAM SOP-00428	APHA 2540C
Total Kjeldahl Nitrogen in Water	1	2012/09/16	2012/09/17	CAM SOP-00454	EPA 351.2 Rev 2
Total Kjeldahl Nitrogen in Water	3	2012/09/17	2012/09/17	CAM SOP-00454	EPA 351.2 Rev 2
Total Suspended Solids	4	N/A	2012/09/11	CAM SOP-00428	SM 2540D
Turbidity	4	N/A	2012/09/11	CAM SOP-00417	APHA 2130B

Remarks:

Maxxam Analytics has performed all analytical testing herein in accordance with ISO 17025 and the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act. All methodologies comply with this document and are validated for use in the laboratory. The methods and techniques employed in this analysis conform to the performance criteria (detection limits, accuracy and precision) as outlined in the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act. Reporting results to two significant figures at the RDL is to permit statistical evaluation and is not intended to be an indication of analytical precision.

The CWS PHC methods employed by Maxxam conform to all prescribed elements of the reference method and performance based elements have been validated. All modifications have been validated and proven equivalent following the 'Alberta Environment Draft Addenda to the CWS-PHC, Appendix 6, Validation of Alternate Methods'. Documentation is available upon request. Maxxam has made the following improvements to the CWS-PHC reference benchmark method: (i) Headspace for F1; and, (ii) Mechanical extraction for F2-F4. Note: F4G cannot be added to the C6 to C50 hydrocarbons. The extraction date for samples field preserved with methanol for F1 and Volatile Organic Compounds is considered to be the date sampled.

Maxxam Analytics is accredited by SCC (Lab ID 97) for all specific parameters as required by Ontario Regulation 153/04. Maxxam Analytics is limited

Maxxam Job #: B2D8122
Report Date: 2012/09/18

exp Services Inc
Client Project #: OTT-00207086-A0
Site Location: Repulse Bay/Nunavat
Sampler Initials: E.C

in liability to the actual cost of analysis unless otherwise agreed in writing. There is no other warranty expressed or implied. Samples will be retained at Maxxam Analytics for three weeks from receipt of data or as per contract.

* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.
* Results relate only to the items tested.

(1) Values for calculated parameters may not appear to add up due to rounding of raw data and significant figures.

Encryption Key

Sara Saroop
18 Sep 2012 15:03:59 -04:00

Please direct all questions regarding this Certificate of Analysis to your Project Manager.

Sara Saroop, Project Manager
Email: SSaroop@maxxam.ca
Phone# (905) 817-5700 Ext:5821

==========

Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

Total cover pages: 2

Maxxam Job #: B2D8122
Report Date: 2012/09/18

exp Services Inc
Client Project #: OTT-00207086-A0
Site Location: Repulse Bay/Nunavat
Sampler Initials: E.C

RESULTS OF ANALYSES OF WATER

Maxxam ID		OT7886	OT7886		OT7887		
Sampling Date		2012/09/08	2012/09/08		2012/09/08		
	Units	**SW 1**	**SW 1 Lab-Dup**	**RDL**	**SW 2**	**RDL**	**QC Batch**
Calculated Parameters							
Hardness (CaCO3)	mg/L	310		1.0	180	1.0	2964618
Inorganics							
Total Ammonia-N	mg/L	64(1)		1.0	36	0.50	2968684
Total BOD	mg/L	51		2.0	68	2.0	2965784
Conductivity	umho/cm	1400		1.0	880	1.0	2965518
Total Dissolved Solids	mg/L	634		10	502	10	2965984
Total Kjeldahl Nitrogen (TKN)	mg/L	62(1)		5.0	51	2.0	2972269
pH	pH	7.36			7.64		2965680
Phenols-4AAP	mg/L	0.10	0.099	0.0050	0.0039	0.0010	2967000
Total Suspended Solids	mg/L	45		10	92	10	2966006
Turbidity	NTU	69		0.2	39	0.4	2965514
Alkalinity (Total as CaCO3)	mg/L	600		1.0	310	1.0	2965516
Dissolved Chloride (Cl)	mg/L	49		1	63(2)	10	2965513
Nitrite (N)	mg/L	<0.010		0.010	<0.010	0.010	2965998
Nitrate (N)	mg/L	<0.10		0.10	<0.10	0.10	2965998
Nitrate + Nitrite	mg/L	<0.10		0.10	<0.10	0.10	2965998
Petroleum Hydrocarbons							
Total Oil & Grease	mg/L	4.6		0.50	1.7	0.50	2966343

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
(1) - TKN < NH4: Both values fall within acceptable RPD limits for duplicates and are likely equivalent.
(2) - Due to colour interferences, sample required dilution. Detection limit was adjusted accordingly.

Maxxam Job #: B2D8122
Report Date: 2012/09/18

exp Services Inc
Client Project #: OTT-00207086-A0
Site Location: Repulse Bay/Nunavat
Sampler Initials: E.C

RESULTS OF ANALYSES OF WATER

Maxxam ID		OT7888	OT7888			OT7889	OT7889		
Sampling Date		2012/09/08	2012/09/08			2012/09/08	2012/09/08		
	Units	**SW 3**	**SW 3 Lab-Dup**	**RDL**	**QC Batch**	**SW 4**	**SW 4 Lab-Dup**	**RDL**	**QC Batch**
Calculated Parameters									
Hardness (CaCO3)	mg/L	200		1.0	2964618	180		1.0	2964618
Inorganics									
Total Ammonia-N	mg/L	25		0.50	2966604	2.1		0.050	2968684
Total BOD	mg/L	42		2.0	2965784	45		2.0	2965784
Conductivity	umho/cm	770		1.0	2965518	560		1.0	2965518
Total Dissolved Solids	mg/L	376		10	2965984	436		10	2965984
Total Kjeldahl Nitrogen (TKN)	mg/L	39		2.0	2971847	12		0.50	2972269
pH	pH	7.80			2965680	8.19			2965680
Phenols-4AAP	mg/L	<0.0010		0.0010	2967000	<0.0010		0.0010	2967000
Total Suspended Solids	mg/L	190		10	2966006	49		10	2966006
Turbidity	NTU	9.3	9.8	0.2	2965514	15		0.2	2965514
Alkalinity (Total as CaCO3)	mg/L	280		1.0	2965516	190		1.0	2965516
Dissolved Chloride (Cl)	mg/L	47	47	1	2965513	40		1	2965513
Nitrite (N)	mg/L	0.038		0.010	2965998	0.53	0.53	0.010	2965998
Nitrate (N)	mg/L	0.42		0.10	2965998	0.98	0.99	0.10	2965998
Nitrate + Nitrite	mg/L	0.45		0.10	2965998	1.5	1.5	0.10	2965998
Petroleum Hydrocarbons									
Total Oil & Grease	mg/L	<0.50		0.50	2966343	1.2		0.50	2966343

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

Maxxam Job #: B2D8122
Report Date: 2012/09/18

exp Services Inc
Client Project #: OTT-00207086-A0
Site Location: Repulse Bay/Nunavat
Sampler Initials: E.C

ELEMENTS BY ATOMIC SPECTROSCOPY (WATER)

Maxxam ID		OT7886		OT7887		OT7888		OT7889	OT7889		
Sampling Date		2012/09/08		2012/09/08		2012/09/08		2012/09/08	2012/09/08		
	Units	**SW 1**	**QC Batch**	**SW 2**	**QC Batch**	**SW 3**	**QC Batch**	**SW 4**	**SW 4 Lab-Dup**	**RDL**	**QC Batch**
Metals											
Chromium (VI)	ug/L	<5.0	2966646	<5.0	2966646	<5.0	2966646	<5.0		5.0	2966646
Mercury (Hg)	mg/L	<0.00010	2968108	<0.00010	2967642	<0.00010	2968108	<0.00010		0.00010	2967642
Total Aluminum (Al)	ug/L	63	2967746	150	2967746	1100	2967746	43	39	5.0	2967746
Total Antimony (Sb)	ug/L	<0.50	2967746	<0.50	2967746	1.0	2967746	0.51	<0.50	0.50	2967746
Total Arsenic (As)	ug/L	1.3	2967746	<1.0	2967746	1.1	2967746	<1.0	<1.0	1.0	2967746
Total Barium (Ba)	ug/L	13	2967746	6.3	2967746	33	2967746	9.4	9.2	2.0	2967746
Total Beryllium (Be)	ug/L	<0.50	2967746	<0.50	2967746	<0.50	2967746	<0.50	<0.50	0.50	2967746
Total Bismuth (Bi)	ug/L	<1.0	2967746	<1.0	2967746	<1.0	2967746	<1.0	<1.0	1.0	2967746
Total Boron (B)	ug/L	400	2967746	160	2967746	140	2967746	120	120	10	2967746
Total Cadmium (Cd)	ug/L	<0.10	2967746	0.11	2967746	0.26	2967746	<0.10	<0.10	0.10	2967746
Total Calcium (Ca)	ug/L	110000	2967746	55000	2967746	67000	2967746	62000	58000	200	2967746
Total Chromium (Cr)	ug/L	<5.0	2967746	<5.0	2967746	<5.0	2967746	<5.0	<5.0	5.0	2967746
Total Cobalt (Co)	ug/L	0.55	2967746	<0.50	2967746	1.2	2967746	<0.50	<0.50	0.50	2967746
Total Copper (Cu)	ug/L	6.8	2967746	32	2967746	53	2967746	5.1	5.1	1.0	2967746
Total Iron (Fe)	ug/L	16000	2967746	750	2967746	5600	2967746	430	400	100	2967746
Total Lead (Pb)	ug/L	0.62	2967746	1.1	2967746	5.5	2967746	<0.50	<0.50	0.50	2967746
Total Magnesium (Mg)	ug/L	18000	2967746	12000	2967746	14000	2967746	13000	12000	50	2967746
Total Manganese (Mn)	ug/L	310	2967746	68	2967746	120	2967746	58	52	2.0	2967746
Total Molybdenum (Mo)	ug/L	<0.50	2967746	0.54	2967746	1.3	2967746	0.69	0.63	0.50	2967746
Total Nickel (Ni)	ug/L	7.6	2967746	2.4	2967746	4.8	2967746	1.9	1.7	1.0	2967746
Total Potassium (K)	ug/L	25000	2967746	16000	2967746	13000	2967746	10000	9400	200	2967746
Total Silicon (Si)	ug/L	8500	2967746	3400	2967746	4900	2967746	2400	2300	50	2967746
Total Selenium (Se)	ug/L	<2.0	2967746	<2.0	2967746	<2.0	2967746	<2.0	<2.0	2.0	2967746
Total Silver (Ag)	ug/L	<0.10	2967746	0.23	2967746	0.51	2967746	<0.10	<0.10	0.10	2967746
Total Sodium (Na)	ug/L	69000	2967746	60000	2967746	52000	2967746	44000	42000	100	2967746
Total Strontium (Sr)	ug/L	190	2967746	110	2967746	130	2967746	120	110	1.0	2967746
Total Thallium (Tl)	ug/L	<0.050	2967746	<0.050	2967746	0.055	2967746	<0.050	<0.050	0.050	2967746
Total Tin (Sn)	ug/L	1.3	2967746	<1.0	2967746	1.1	2967746	<1.0	<1.0	1.0	2967746
Total Titanium (Ti)	ug/L	7.2	2967746	11	2967746	67	2967746	<5.0	<5.0	5.0	2967746
Total Uranium (U)	ug/L	0.20	2967746	1.9	2967746	7.4	2967746	5.1	4.7	0.10	2967746
Total Vanadium (V)	ug/L	<0.50	2967746	<0.50	2967746	2.9	2967746	<0.50	0.54	0.50	2967746
Total Zinc (Zn)	ug/L	19	2967746	61	2967746	170	2967746	18	19	5.0	2967746

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

Maxxam Job #: B2D8122
Report Date: 2012/09/18

exp Services Inc
Client Project #: OTT-00207086-A0
Site Location: Repulse Bay/Nunavat
Sampler Initials: E.C

MICROBIOLOGY (WATER)

Maxxam ID		OT7886	OT7886	OT7887	OT7888	OT7889		
Sampling Date		2012/09/08	2012/09/08	2012/09/08	2012/09/08	2012/09/08		
	Units	**SW 1**	**SW 1 Lab-Dup**	**SW 2**	**SW 3**	**SW 4**	**RDL**	**QC Batch**
Microbiological								
Background	CFU/100mL	>200000	>200000	>200000	40000	18000	10	2965209
Fecal coliform	CFU/100mL	>200000	>200000	>200000	710	<10	10	2965210
Total Coliforms	CFU/100mL	>200000	>200000	>200000	13000	160	10	2965209
Escherichia coli	CFU/100mL	120000		100000	210	<10	10	2965207

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

Maxxam Job #: B2D8122
Report Date: 2012/09/18

exp Services Inc
Client Project #: OTT-00207086-A0
Site Location: Repulse Bay/Nunavat
Sampler Initials: E.C

Test Summary

Maxxam ID OT7886 **Collected** 2012/09/08
Sample ID SW 1 **Shipped**
Matrix Water **Received** 2012/09/10

Test Description	Instrumentation	Batch	Extracted	Analyzed	Analyst
Alkalinity	PH	2965516	N/A	2012/09/11	Surinder Rai
Biochemical Oxygen Demand (BOD)	BOD	2965784	N/A	2012/09/16	Sonia Mira
Chloride by Automated Colourimetry	AC	2965513	N/A	2012/09/11	Alina Dobreanu
Conductivity	COND	2965518	N/A	2012/09/11	Surinder Rai
Chromium (VI) in Water	IC	2966646	N/A	2012/09/14	Sally Coughlin
Hardness (calculated as CaCO3)		2964618	N/A	2012/09/13	Automated Statchk
Mercury in Water by CVAA	CVAA	2968108	2012/09/13	2012/09/13	Lawrence Cheung
Total Metals Analysis by ICPMS	ICP/MS	2967746	N/A	2012/09/13	Arefa Dabhad
Coliform, (CFU/100mL)	PL	2965209	N/A	2012/09/10	
E.coli, (CFU/100mL)	PL	2965207	N/A	2012/09/10	Tharmini Sivalingam
Fecal coliform, (CFU/100mL)	PL	2965210	N/A	2012/09/10	
Total Ammonia-N	LACH/NH4	2968684	N/A	2012/09/14	Lemeneh Addis
Nitrate (NO3) and Nitrite (NO2) in Water	LACH	2965998	N/A	2012/09/11	Chris Li
Total Oil and Grease	BAL	2966343	2012/09/11	2012/09/11	Amjad Mir
pH	PH	2965680	N/A	2012/09/11	Surinder Rai
Phenols (4AAP)	TECH/PHEN	2967000	N/A	2012/09/12	Bramdeo Motiram
Total Dissolved Solids	SLDS	2965984	N/A	2012/09/11	Gurpreet Kaur
Total Kjeldahl Nitrogen in Water	AC	2972269	2012/09/17	2012/09/17	Anastasia Hamanov
Total Suspended Solids	SLDS	2966006	N/A	2012/09/11	Bansari Ray
Turbidity	TURB	2965514	N/A	2012/09/11	Neil Dassanayake

Maxxam ID OT7886 Dup **Collected** 2012/09/08
Sample ID SW 1 **Shipped**
Matrix Water **Received** 2012/09/10

Test Description	Instrumentation	Batch	Extracted	Analyzed	Analyst
Coliform, (CFU/100mL)	PL	2965209	N/A	2012/09/11	
Fecal coliform, (CFU/100mL)	PL	2965210	N/A	2012/09/11	
Phenols (4AAP)	TECH/PHEN	2967000	N/A	2012/09/12	Bramdeo Motiram

Maxxam Job #: B2D8122
Report Date: 2012/09/18

exp Services Inc
Client Project #: OTT-00207086-A0
Site Location: Repulse Bay/Nunavat
Sampler Initials: E.C

Test Summary

Maxxam ID OT7887 **Collected** 2012/09/08
Sample ID SW 2 **Shipped**
Matrix Water **Received** 2012/09/10

Test Description	Instrumentation	Batch	Extracted	Analyzed	Analyst
Alkalinity	PH	2965516	N/A	2012/09/11	Surinder Rai
Biochemical Oxygen Demand (BOD)	BOD	2965784	N/A	2012/09/16	Sonia Mira
Chloride by Automated Colourimetry	AC	2965513	N/A	2012/09/11	Alina Dobreanu
Conductivity	COND	2965518	N/A	2012/09/11	Surinder Rai
Chromium (VI) in Water	IC	2966646	N/A	2012/09/14	Sally Coughlin
Hardness (calculated as CaCO3)		2964618	N/A	2012/09/13	Automated Statchk
Mercury in Water by CVAA	CVAA	2967642	2012/09/13	2012/09/13	Lawrence Cheung
Total Metals Analysis by ICPMS	ICP/MS	2967746	N/A	2012/09/13	Arefa Dabhad
Coliform, (CFU/100mL)	PL	2965209	N/A	2012/09/10	
E.coli, (CFU/100mL)	PL	2965207	N/A	2012/09/10	Tharmini Sivalingam
Fecal coliform, (CFU/100mL)	PL	2965210	N/A	2012/09/10	
Total Ammonia-N	LACH/NH4	2968684	N/A	2012/09/14	Lemeneh Addis
Nitrate (NO3) and Nitrite (NO2) in Water	LACH	2965998	N/A	2012/09/11	Chris Li
Total Oil and Grease	BAL	2966343	2012/09/11	2012/09/11	Amjad Mir
pH	PH	2965680	N/A	2012/09/11	Surinder Rai
Phenols (4AAP)	TECH/PHEN	2967000	N/A	2012/09/12	Bramdeo Motiram
Total Dissolved Solids	SLDS	2965984	N/A	2012/09/11	Gurpreet Kaur
Total Kjeldahl Nitrogen in Water	AC	2972269	2012/09/17	2012/09/17	Anastasia Hamanov
Total Suspended Solids	SLDS	2966006	N/A	2012/09/11	Bansari Ray
Turbidity	TURB	2965514	N/A	2012/09/11	Neil Dassanayake

Maxxam ID OT7888 **Collected** 2012/09/08
Sample ID SW 3 **Shipped**
Matrix Water **Received** 2012/09/10

Test Description	Instrumentation	Batch	Extracted	Analyzed	Analyst
Alkalinity	PH	2965516	N/A	2012/09/11	Surinder Rai
Biochemical Oxygen Demand (BOD)	BOD	2965784	N/A	2012/09/16	Sonia Mira
Chloride by Automated Colourimetry	AC	2965513	N/A	2012/09/11	Alina Dobreanu
Conductivity	COND	2965518	N/A	2012/09/11	Surinder Rai
Chromium (VI) in Water	IC	2966646	N/A	2012/09/14	Sally Coughlin
Hardness (calculated as CaCO3)		2964618	N/A	2012/09/13	Automated Statchk
Mercury in Water by CVAA	CVAA	2968108	2012/09/13	2012/09/13	Lawrence Cheung

Maxxam Job #: B2D8122
Report Date: 2012/09/18

exp Services Inc
Client Project #: OTT-00207086-A0
Site Location: Repulse Bay/Nunavat
Sampler Initials: E.C

Test Summary

Total Metals Analysis by ICPMS	ICP/MS	2967746	N/A	2012/09/13	Arefa Dabhad
Coliform, (CFU/100mL)	PL	2965209	N/A	2012/09/10	
E.coli, (CFU/100mL)	PL	2965207	N/A	2012/09/10	Tharmini Sivalingam
Fecal coliform, (CFU/100mL)	PL	2965210	N/A	2012/09/10	
Total Ammonia-N	LACH/NH4	2966604	N/A	2012/09/12	Lemeneh Addis
Nitrate (NO3) and Nitrite (NO2) in Water	LACH	2965998	N/A	2012/09/11	Chris Li
Total Oil and Grease	BAL	2966343	2012/09/11	2012/09/11	Amjad Mir
pH	PH	2965680	N/A	2012/09/11	Surinder Rai
Phenols (4AAP)	TECH/PHEN	2967000	N/A	2012/09/12	Bramdeo Motiram
Total Dissolved Solids	SLDS	2965984	N/A	2012/09/11	Gurpreet Kaur
Total Kjeldahl Nitrogen in Water	AC	2971847	2012/09/16	2012/09/17	Anastasia Hamanov
Total Suspended Solids	SLDS	2966006	N/A	2012/09/11	Bansari Ray
Turbidity	TURB	2965514	N/A	2012/09/11	Neil Dassanayake

Maxxam ID OT7888 Dup
Sample ID SW 3
Matrix Water

Collected 2012/09/08
Shipped
Received 2012/09/10

Test Description	Instrumentation	Batch	Extracted	Analyzed	Analyst
Chloride by Automated Colourimetry	AC	2965513	N/A	2012/09/11	Alina Dobreanu
Turbidity	TURB	2965514	N/A	2012/09/11	Neil Dassanayake

Maxxam ID OT7889
Sample ID SW 4
Matrix Water

Collected 2012/09/08
Shipped
Received 2012/09/10

Test Description	Instrumentation	Batch	Extracted	Analyzed	Analyst
Alkalinity	PH	2965516	N/A	2012/09/11	Surinder Rai
Biochemical Oxygen Demand (BOD)	BOD	2965784	N/A	2012/09/16	Sonia Mira
Chloride by Automated Colourimetry	AC	2965513	N/A	2012/09/11	Alina Dobreanu
Conductivity	COND	2965518	N/A	2012/09/11	Surinder Rai
Chromium (VI) in Water	IC	2966646	N/A	2012/09/14	Sally Coughlin
Hardness (calculated as CaCO3)		2964618	N/A	2012/09/13	Automated Statchk
Mercury in Water by CVAA	CVAA	2967642	2012/09/13	2012/09/13	Lawrence Cheung
Total Metals Analysis by ICPMS	ICP/MS	2967746	N/A	2012/09/13	Arefa Dabhad
Coliform, (CFU/100mL)	PL	2965209	N/A	2012/09/10	
E.coli, (CFU/100mL)	PL	2965207	N/A	2012/09/10	Tharmini Sivalingam

Maxxam Job #: B2D8122
Report Date: 2012/09/18

exp Services Inc
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Sampler Initials: E.C

Test Summary

Fecal coliform, (CFU/100mL)	PL	2965210	N/A	2012/09/10	
Total Ammonia-N	LACH/NH4	2968684	N/A	2012/09/14	Lemeneh Addis
Nitrate (NO3) and Nitrite (NO2) in Water	LACH	2965998	N/A	2012/09/11	Chris Li
Total Oil and Grease	BAL	2966343	2012/09/11	2012/09/11	Amjad Mir
pH	PH	2965680	N/A	2012/09/11	Surinder Rai
Phenols (4AAP)	TECH/PHEN	2967000	N/A	2012/09/12	Bramdeo Motiram
Total Dissolved Solids	SLDS	2965984	N/A	2012/09/11	Gurpreet Kaur
Total Kjeldahl Nitrogen in Water	AC	2972269	2012/09/17	2012/09/17	Anastasia Hamanov
Total Suspended Solids	SLDS	2966006	N/A	2012/09/11	Bansari Ray
Turbidity	TURB	2965514	N/A	2012/09/11	Neil Dassanayake

Maxxam ID OT7889 Dup
Sample ID SW 4
Matrix Water

Collected 2012/09/08
Shipped
Received 2012/09/10

Test Description	Instrumentation	Batch	Extracted	Analyzed	Analyst
Total Metals Analysis by ICPMS	ICP/MS	2967746	N/A	2012/09/13	Arefa Dabhad
Nitrate (NO3) and Nitrite (NO2) in Water	LACH	2965998	N/A	2012/09/11	Chris Li

Maxxam Job #: B2D8122
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exp Services Inc
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Package 1	4.3°C
Package 2	1.0°C

Each temperature is the average of up to three cooler temperatures taken at receipt

GENERAL COMMENTS

Maxxam Analytics International Corporation o/a Maxxam Analytics 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.maxxam.ca

Maxxam Job #: B2D8122
Report Date: 2012/09/18

exp Services Inc
Client Project #: OTT-00207086-A0
Site Location: Repulse Bay/Nunavat
Sampler Initials: E.C

QUALITY ASSURANCE REPORT

			Matrix Spike		Spiked Blank		Method Blank		RPD		QC Standard	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	Units	Value (%)	QC Limits	% Recovery	QC Limits
2965210	Fecal coliform	2012/09/11							NC	N/A		
2965513	Dissolved Chloride (Cl)	2012/09/11	NC	80 - 120	102	80 - 120	<1	mg/L	0.4	20		
2965514	Turbidity	2012/09/11					<0.2	NTU	5.2	20	93	85 - 115
2965516	Alkalinity (Total as CaCO3)	2012/09/11					<1.0	mg/L	0.06	25	96	85 - 115
2965518	Conductivity	2012/09/11					<1.0	umho/cm	0	25	99	85 - 115
2965784	Total BOD	2012/09/16					<2.0	mg/L	NC	25	98	85 - 115
2965984	Total Dissolved Solids	2012/09/11					<10	mg/L	NC	25	99	90 - 110
2965998	Nitrite (N)	2012/09/11	NC	80 - 120	101	85 - 115	<0.010	mg/L	0.8	25		
2965998	Nitrate (N)	2012/09/11	NC	80 - 120	93	85 - 115	<0.10	mg/L	1.3	25		
2966006	Total Suspended Solids	2012/09/11					<10	mg/L	NC	25	99	85 - 115
2966343	Total Oil & Grease	2012/09/11			98	85 - 115	<0.50	mg/L	1.2	25		
2966604	Total Ammonia-N	2012/09/12	NC	80 - 120	104	85 - 115	<0.050	mg/L	0.6	20		
2966646	Chromium (VI)	2012/09/14	93	80 - 120	96	80 - 120	<5.0	ug/L	NC	20		
2967000	Phenols-4AAP	2012/09/12	NC	80 - 120	100	85 - 115	<0.0010	mg/L	5.5	25		
2967642	Mercury (Hg)	2012/09/13	107	80 - 120	103	80 - 120	<0.00010	mg/L	NC	20		
2967746	Total Aluminum (Al)	2012/09/13	102	80 - 120	105	80 - 120	6.1, RDL=5.0	ug/L	11.6	20		
2967746	Total Antimony (Sb)	2012/09/13	110	80 - 120	110	80 - 120	<0.50	ug/L	NC	20		
2967746	Total Arsenic (As)	2012/09/13	107	80 - 120	105	80 - 120	<1.0	ug/L	NC	20		
2967746	Total Barium (Ba)	2012/09/13	104	80 - 120	101	80 - 120	<2.0	ug/L	NC	20		
2967746	Total Beryllium (Be)	2012/09/13	108	80 - 120	107	80 - 120	<0.50	ug/L	NC	20		
2967746	Total Bismuth (Bi)	2012/09/13	111	80 - 120	109	80 - 120	<1.0	ug/L	NC	20		
2967746	Total Boron (B)	2012/09/13	101	80 - 120	99	80 - 120	<10	ug/L	0.6	20		
2967746	Total Cadmium (Cd)	2012/09/13	107	80 - 120	106	80 - 120	<0.10	ug/L	NC	20		
2967746	Total Calcium (Ca)	2012/09/13	NC	80 - 120	106	80 - 120	<200	ug/L	6.8	20		
2967746	Total Chromium (Cr)	2012/09/13	104	80 - 120	105	80 - 120	<5.0	ug/L	NC	20		
2967746	Total Cobalt (Co)	2012/09/13	106	80 - 120	106	80 - 120	<0.50	ug/L	NC	20		
2967746	Total Copper (Cu)	2012/09/13	102	80 - 120	105	80 - 120	1.2, RDL=1.0	ug/L	0.01	20		
2967746	Total Iron (Fe)	2012/09/13	107	80 - 120	107	80 - 120	<100	ug/L	NC	20		
2967746	Total Lead (Pb)	2012/09/13	107	80 - 120	107	80 - 120	<0.50	ug/L	NC	20		
2967746	Total Magnesium (Mg)	2012/09/13	106	80 - 120	108	80 - 120	<50	ug/L	6.6	20		
2967746	Total Manganese (Mn)	2012/09/13	101	80 - 120	107	80 - 120	<2.0	ug/L	11.9	20		
2967746	Total Molybdenum (Mo)	2012/09/13	107	80 - 120	105	80 - 120	<0.50	ug/L	NC	20		
2967746	Total Nickel (Ni)	2012/09/13	101	80 - 120	102	80 - 120	<1.0	ug/L	NC	20		
2967746	Total Potassium (K)	2012/09/13	107	80 - 120	107	80 - 120	<200	ug/L	7.2	20		
2967746	Total Silicon (Si)	2012/09/13	103	80 - 120	106	80 - 120	<50	ug/L	6.5	20		
2967746	Total Selenium (Se)	2012/09/13	105	80 - 120	102	80 - 120	<2.0	ug/L	NC	20		
2967746	Total Silver (Ag)	2012/09/13	105	80 - 120	103	80 - 120	<0.10	ug/L	NC	20		
2967746	Total Sodium (Na)	2012/09/13	NC	80 - 120	111	80 - 120	<100	ug/L	5.8	20		
2967746	Total Strontium (Sr)	2012/09/13	105	80 - 120	103	80 - 120	<1.0	ug/L	7.8	20		
2967746	Total Thallium (Tl)	2012/09/13	105	80 - 120	104	80 - 120	<0.050	ug/L	NC	20		

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QUALITY ASSURANCE REPORT

			Matrix Spike		Spiked Blank		Method Blank		RPD		QC Standard	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	Units	Value (%)	QC Limits	% Recovery	QC Limits
2967746	Total Tin (Sn)	2012/09/13	107	80 - 120	107	80 - 120	<1.0	ug/L	NC	20		
2967746	Total Titanium (Ti)	2012/09/13	106	80 - 120	111	80 - 120	<5.0	ug/L	NC	20		
2967746	Total Uranium (U)	2012/09/13	113	80 - 120	112	80 - 120	<0.10	ug/L	7.6	20		
2967746	Total Vanadium (V)	2012/09/13	106	80 - 120	109	80 - 120	<0.50	ug/L	NC	20		
2967746	Total Zinc (Zn)	2012/09/13	107	80 - 120	108	80 - 120	7.4, RDL=5.0	ug/L	NC	20		
2968108	Mercury (Hg)	2012/09/13	111	80 - 120	103	80 - 120	<0.00010	mg/L	NC	20		
2968684	Total Ammonia-N	2012/09/14	106	80 - 120	100	85 - 115	<0.050	mg/L	NC	20		
2971847	Total Kjeldahl Nitrogen (TKN)	2012/09/17	NC	80 - 120	95	85 - 115	<0.10	mg/L	0.3	20	105	85 - 115
2972269	Total Kjeldahl Nitrogen (TKN)	2012/09/14	NC(1)	80 - 120	95	85 - 115	0.12, RDL=0.10	mg/L	11.9	20	98	85 - 115

N/A = Not Applicable
RDL = Reportable Detection Limit
RPD = Relative Percent Difference
Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.
Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.
QC Standard: A blank matrix to which a known amount of the analyte has been added. Used to evaluate analyte recovery.
Spiked Blank: A blank matrix to which a known amount of the analyte has been added. Used to evaluate analyte recovery.
Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.
NC (Matrix Spike): The recovery in the matrix spike was not calculated. The relative difference between the concentration in the parent sample and the spiked amount was not sufficiently significant to permit a reliable recovery calculation.

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NC (RPD): The RPD was not calculated. The level of analyte detected in the parent sample and its duplicate was not sufficiently significant to permit a reliable calculation.
(1) - The recovery in the matrix spike was not calculated (NC). Spiked concentration was less than 2x that native to the sample.

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