Rook I Project

Environmental Impact Statement

TSD XIX: Conceptual Diffuser Design Report

28 March 2022 Reference No. 20144150

NexGen Energy Ltd.

USE OF CONCEPTUAL DIFFUSER DESIGN REPORT REVISION 0 AS TECHNICAL SUPPORT DOCUMENT FOR THE ROOK I PROJECT DRAFT ENVIRONMENTAL IMPACT STATEMENT

1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has provided ongoing support to NexGen Energy Ltd. (NexGen) related to the preparation of an Environmental Impact Statement (EIS) for the Rook I Project (Project). The EIS submission is expected to include technical support documents (TSD) that are intended to provide context for the effects assessments presented within the Draft EIS. The purpose of this cover letter is to provide context for use of the Conceptual Diffuser Design Report Revision 0, completed in fall 2019 as a TSD for the EIS, and confirm that the Conceptual Diffuser Design Report Revision 0 remains suitable considering additional knowledge accumulated since fall 2019.

2.0 BACKGROUND

In fall 2019, NexGen engaged Golder to prepare a conceptual design for a treated mine effluent diffuser at the Project. The conceptual design was completed in two phases using best information available at that time and culminated in a Conceptual Diffuser Design Report (TSD XIX), which was completed, finalized, and signed/sealed in December 2019. The Conceptual Diffuser Design Report documented the design basis and criteria, modelling of diffuser dilution performance, hydraulic analysis, and conceptual design information for the proposed diffuser.

In 2021, as part of the surface water quality component of the Environmental Assessment, Golder completed updated modelling to confirm the performance of the conceptual treated effluent diffuser configuration. The re-modelling of diffuser performance included updated design parameters for thermal stratification and lake current based on additional lake temperature and current data collected since 2018, as well as updated effluent information generated from the site-wide water balance and water quality model tool developed in support of the Project (TSD XVIII, Site-Wide Water Balance and Water Quality Modelling Report).

3.0 SUMMARY OF COMPARISON

The conceptual diffuser was designed to improve mixing of discharged treated effluent with water in the receiving environment. The evaluation of mixing performance was based on dilution factors at specific distances from the diffuser, particularly at the edge of the regulated mixing zone (RMZ).

Detailed mixing and dilution modelling was conducted in support of the Conceptual Diffuser Design using the CORMIX model system, which is commonly used to analyze and model jets and plumes for effluent discharges to waterbodies. The conceptual treated effluent diffuser was designed to target a minimum required dilution factor of 10:1 at the edge of the proposed RMZ to achieve acceptable concentrations for constituents of potential concern (i.e., meet surface water quality targets provided in EIS Section 10, Surface Water Quality and Sediment Quality) based on the input data available at that time. A total of 33 scenarios were simulated in CORMIX to represent diffuser performance under a range of conditions in the ambient environment. The predicted dilution factors ranged from 28:1 to 50:1, with an average of 40:1.

Effects of the Project on near field water quality are summarized in EIS Section 10. The Near Field Water Quality Model, developed as part of the EIS, evaluated the performance of the effluent treatment plant (ETP) diffuser and is summarized in EIS Appendix 10A, Surface Water Quality Modelling Report. Detailed mixing and dilution modelling conducted for the Near Field Water Quality Model also used the CORMIX model system, and where possible, was consistent with the modelling completed for the Conceptual Diffuser Design Report. In addition to considering the new data collected, the modelling completed for the effects assessment also accounted for accumulation of mass in Patterson Lake North Arm – West Basin over time as a result of the Project. The modelling considered two snapshots to present the lower and upper bound range of constituents of potential concern to be expected in the near field: one at the beginning of Operations representing the lowest annual average concentration during Operations and one near the end of Operations (2048) representing the highest annual average concentration during Operations. A total of 35 scenarios were used to evaluate ETP diffuser performance representing a range of current speeds, stratification depths, lake water temperature, and effluent temperatures. For the ETP diffuser, the dilution factor at the edge of the RMZ ranged form 23:1 to 35:1, with an average of 30:1. A sensitivity analysis was also completed to assess the robustness of the diffuser designs in terms of the dilution provided. The sensitivity analysis included variations in treated effluent flow rates for the ETP and total dissolved solids concentration in the ETP effluent.

The analysis completed as part of EIS Section 10 confirms that the predicted diffuser performance (based on current information) exceeds the design objectives and performance requirements established in the Conceptual Diffuser Design Report Revision 0. The predicted concentrations of constituents of potential concern were consistently less than water quality targets for aquatic and terrestrial life at the edge of the proposed RMZ, including for the reasonable upper bound sensitivity, even though the predicted dilution factors were lower in the Near Field Water Quality Model than in the conceptual diffuser design. Dilution factors are conservative because the effects assessment is driven largely by far-field accumulation at closure, not by near-field mixing when the ETP discharge will be active.

4.0 CONCLUSION

The Near Field Water Quality Model completed for surface water quality effects assessment confirms that, based on current assumptions, the conceptual diffuser design is expected to achieve acceptable mixing performance that is consistent with the design objectives. It is Golder’s opinion that the conceptual diffuser design is appropriate for the current stage of Project development with a level of detail that is appropriate for an EIS and inclusion as a technical support document to the EIS.

Current revisions to the conceptual diffuser design are not recommended at this time considering the present stage of Project development. The following activities would advance prior to refining the diffuser design to limit the number of design iterations required prior to construction:

- regulatory buy-in of water quality targets, thresholds, and size of the RMZ;
- public review of the Environmental Assessment;
- FEED (Front End Engineering Design) level engineering for upstream infrastructure associated with the diffuser; and

- preliminary constructability review for diffuser and associated upstream infrastructure.

Further, baseline data collection is ongoing and additional data can be integrated into the later stages of design.

The diffuser design will be refined in detailed design and included in a submission to the Canadian Nuclear Safety Commission as per REGDOC-2.9.2 (CNSC 2021). The conceptual design will form the basis for detailed design, which will be completed such that dilution remains adequality protective of the environment.

5.0 CLOSURE

Golder trusts that the information presented in this letter and the attached Conceptual Diffuser Design Report for the Project. Should you have any questions or require clarification on any matter, please do not hesitate to contact the undersigned. We appreciate the opportunity to continue to support the Project.

Sincerely

Golder Associates Ltd.

Ross Phillips, M.Sc., P.Eng.
Water Resources Engineer

Gerard Van Arkel, M.Sc.
Principal, Water Resources Specialist

RWP/GVA/DH/rd

Distribution: One electronic copy to Luke Moger, NexGen Energy Ltd.

Attachments: TSD XIX: Conceptual Diffuser Design Report

6.0 REFERENCES

CNSC (Canadian Nuclear Safety Commission). 2021. REGDOC-2.9.2, Environmental Principles, Controlling Releases to the Environment, Version 1.2. March 2021. Available at http://nuclearsafety.gc.ca/eng/pdfs/REGDOCS/REGDOC-2-9-2-Environmental-Principles-Controlling-Releases-to-the-environment-eng.pdf

Attachment

TSD XIX: Conceptual Diffuser Design Report

GOLDER

REPORT

Conceptual Diffuser Design

NexGen Rook I Project

Submitted to:

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Submitted by:

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December 2, 2019

Distribution List

1 - Electronic Copy to NexGen Energy Ltd.

Record of Issue

Company	Client Contact	Version	Date Issued	Method of Delivery
NexGen Energy Ltd.	Jeremy Veszi; Susan Mathieu	Originator	September 16, 2019	SharePoint Transmission
NexGen Energy Ltd.	Jeremy Veszi; Susan Mathieu	Client Reviewed Draft	September 27, 2019	SharePoint Transmission
NexGen Energy Ltd.	Jeremy Veszi; Susan Mathieu	Final	December 2, 2019	SharePoint Transmission

This document will be reviewed and updated periodically. Revision to the document will be tracked in the Record of Issue and communicated to applicable staff.

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1.0 INTRODUCTION

NexGen Energy Ltd. (NexGen) retained Golder Associates Ltd. (Golder) to prepare a conceptual design for a treated mine effluent diffuser at the proposed Rook I Project (the Project). The proposed receiving waterbody is Patterson Lake. The scope of the conceptual diffuser design was broken up into two phases.

Phase 1 consisted of the tasks to compare options for the location of the diffuser and to select a preferred location. The basis, methods and results of the Phase 1 work are summarized in a memorandum included in Appendix A.

Phase 2 work consisted of the following tasks to prepare the conceptual design of the diffuser:

- Reviewed past ice conditions based on historic monitoring data for the site. Ice thickness and typical dates of freeze-up and break-up were estimated based on historic observations made during winter water quality sampling programs and observations related to historic drilling activities.
- Collected samples of the substrate materials near the preferred location and analysed them to characterize the material types and particle size distribution.
- Conducted a hydraulic analysis of the outfall system from the outlet of the effluent treatment plant to the diffuser to calculate the hydraulic heads required at the effluent treatment plant to operate the proposed diffuser at the selected location and for a range of operating discharges or conditions.
- Prepared conceptual design drawings to present and communicate the recommended diffuser configuration.

This report documents the design basis and criteria, modelling of diffuser dilution performance, hydraulic analysis, and conceptual design information of the proposed diffuser.

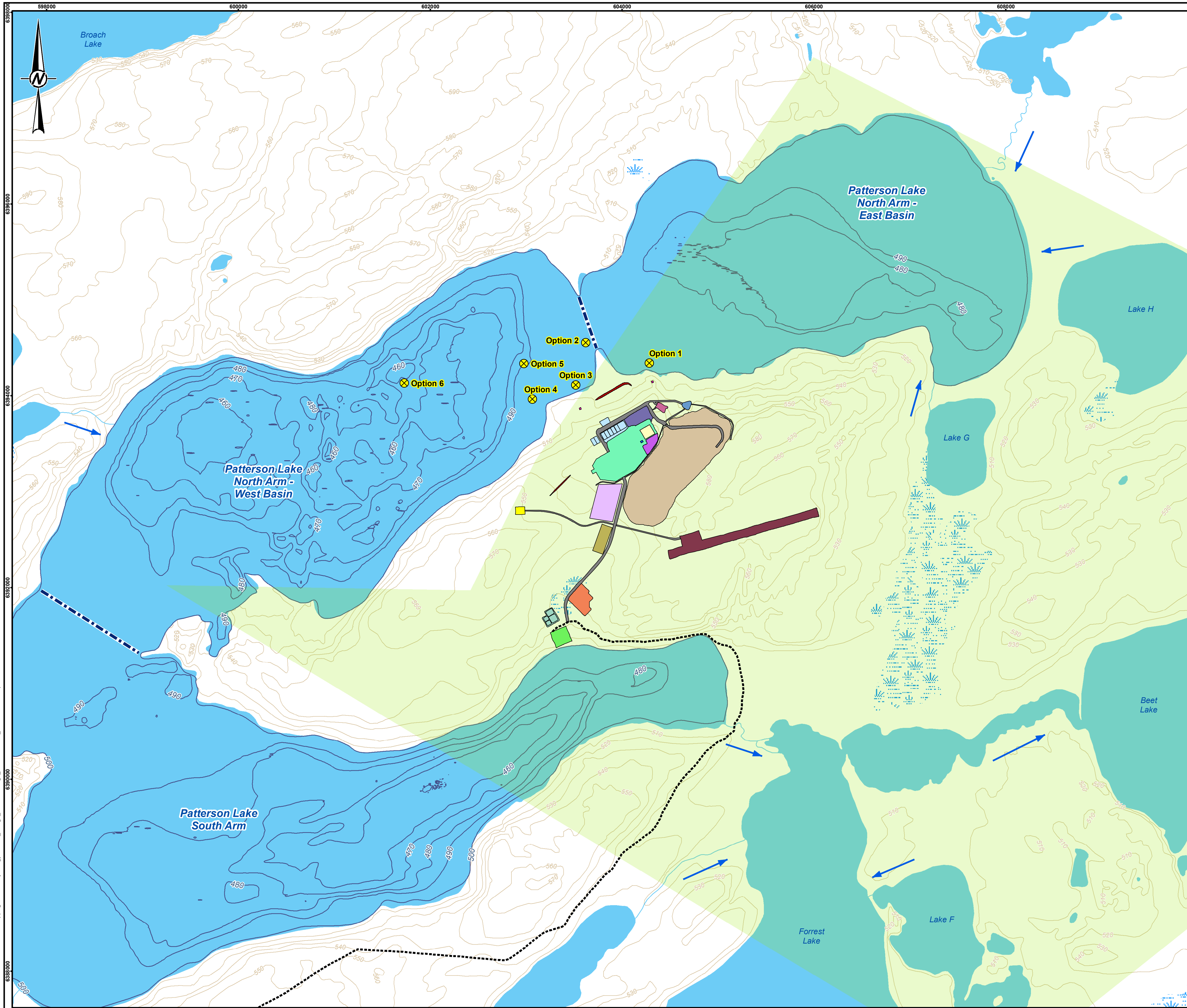
2.0 EVALUATION OF DIFFUSER LOCATION OPTIONS

Six candidate locations were identified and evaluated. All locations considered are in the North Arm of Patterson Lake near the proposed location of the effluent treatment plant and associated treated effluent monitoring ponds. The options included near shore locations in the North Arm – West Basin and North Arm – East Basin, as well as an off-shore (deep water) option, and an optimum depth option (Figure 1).

Option 5 located in the North Arm – West Basin at an optimal depth of around 10 m was ranked first among the location options evaluated. Option 5 is the selected option, which is at a location that is estimated to have favourable ambient currents in carrying discharged treated effluent away from the diffuser.

A conceptual pipeline alignment connecting the diffuser to the location of the treated effluent monitoring ponds would intersect a section of shoreline referred to as HS4 (CanNorth 2019) that consists of 95% sand and 5% organics. This shoreline section was noted by CanNorth (2019) to be not suitable spawning habitat for all large-bodied fish included in the assessment. This section was identified to have marginally suitable habitat for one fish species, yellow perch.

The results of the option evaluation are documented in the memorandum in Appendix A.



LEGEND

- BATHYMETRY CONTOUR ELEVATION (METRES)
- ELEVATION CONTOUR (10m INTERVAL)
- FLOW DIRECTION
- LAKE BASIN DIVISION
- WATERCOURSE
- WATERBODY
- WETLAND
- NEXGEN MINERAL LEASE
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- PRODUCTION SHAFT AND ASSOCIATED INFRASTRUCTURE
- ROAD
- SPECIAL WASTE ROCK PAD
- STORAGE/MONITORING POND
- STORMWATER RUNOFF POND

0 1,000 2,000
1:40,000 METRES

NOTE(S)

1. WATER SURFACE ELEVATION ESTIMATED TO BE 498.79 MASL ASSOCIATED WITH MEAN ANNUAL FLOOD.
2. LAKE VOLUME ON JUNE 6-8, 1981:
- SOUTH ARM BASIN = 236,049,630 M^3
- NORTH ARM - WEST BASIN = 234,880,210 M^3
- NORTH ARM - EAST BASIN = 65,405,551 M^3

REFERENCE(S)

1. BASE DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.
2. BATHYMETRY CONTOURS DERIVED FROM DATA COLLECTED BY NEXGEN, 2016.
PROJECTION: UTM ZONE 12 DATUM: NAD 83

CLIENT
NexGen Energy Ltd.

PROJECT
ROOK I PROJECT

TITLE
PRELIMINARY DIFFUSER LOCATION OPTIONS

CONSULTANT
GOLDER

YYYY-MM-DD	2019-11-28
DESIGNED	RP
PREPARED	LMS
REVIEWED	RWP
APPROVED	DL

PROJECT NO.	PHASE	REV.	FIGURE
18114335	6000	0	1

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3.0 BACKGROUND INFORMATION

3.1 Watershed Setting

Patterson Lake is located along the Clearwater River near its headwaters in north-western Saskatchewan. The drainage area contributing to the Clearwater River where it drains into the North Arm – East Basin of Patterson Lake is 121 square kilometres (km^2). The cumulative watershed area increases to 264 km^2 where the Clearwater River outflows at the southeast corner of Patterson Lake.

3.2 Baseline Monitoring

Various environmental baseline monitoring activities have been ongoing on Patterson Lake since 2018. The aquatic baseline conditions in Patterson Lake were characterized by CanNorth (2019). Several studies were completed by Golder to characterize the hydrological conditions of Patterson Lake, including a summary of 2018 Hydrometric Monitoring Program (Golder 2019a), a baseline geomorphological characterization (Golder 2019b), and a regional meteorological and hydrological characterization (Golder 2019c).

Throughout the winter of 2018, NexGen measured ice thickness at the location of pumps located in the North Arm of Patterson Lake, which were operated and maintained in support of the geological exploration drilling programs. Ice thickness was also measured at the water supply locations along an access road from shore to the pumping locations in weekly intervals.

3.3 Patterson Lake Physical Characteristics

Patterson Lake can be divided into the North Arm and South Arm oriented approximately southwest to northeast as shown in Figure 2. The North Arm can be further separated into the West Basin and East Basin separated by a narrow and shallow sand sill with spit formations forming on either side (Golder 2019c).

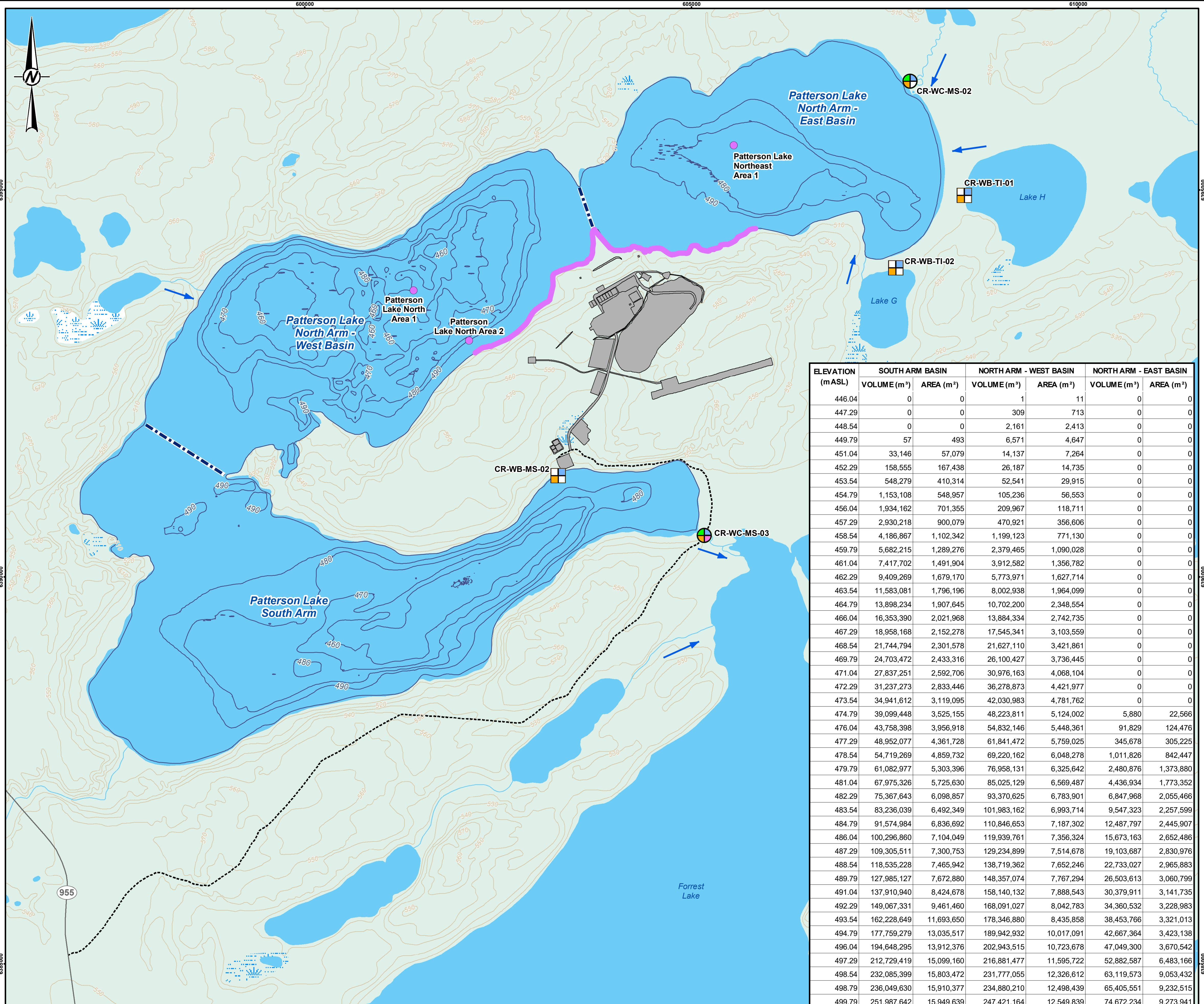
The North Arm – West Basin is the deepest of the three basins with a minimum bed elevation of 446 metres above mean sea level (masl), corresponding to a maximum depth of roughly 53 m. The deepest point in the North Arm – East Basin is 474.79 masl, corresponding to a maximum depth of roughly 24.0 m. The deepest point in the South Arm is 449.29 masl, corresponding to a maximum depth of roughly 49.5 m.

Patterson Lake has an average water surface elevation of approximately 498.8 masl, a total water volume of 536 million cubic metres (Mm^3), and a surface area of 38 km^2. The physical characteristics of Patterson Lake's three basins are summarized in Table 1.

Table 1: Summary of Patterson Lake Basin Physical Characteristics

Basin	Maximum Depth (m)	Volume (Mm^3)	Surface Area (km^2)
North Arm - East Basin	24.0	65.4	9.23
North Arm - West Basin	52.7	235	12.5
South Arm	49.5	236	15.9

km^2 = square kilometres, m = metre, Mm^3 = millions of cubic metres.



ELEVATION (m ASL)	SOUTH ARM BASIN		NORTH ARM - WEST BASIN		NORTH ARM - EAST BASIN	
	VOLUME (m^3)	AREA (m^2)	VOLUME (m^3)	AREA (m^2)	VOLUME (m^3)	AREA (m^2)
446.04	0	0	1	11	0	0
447.29	0	0	309	713	0	0
448.54	0	0	2,161	2,413	0	0
449.79	57	493	6,571	4,647	0	0
451.04	33,146	57,079	14,137	7,264	0	0
452.29	158,555	167,438	26,187	14,735	0	0
453.54	548,279	410,314	52,541	29,915	0	0
454.79	1,153,108	548,957	105,236	56,553	0	0
456.04	1,934,162	701,355	209,967	118,711	0	0
457.29	2,930,218	900,079	470,921	356,606	0	0
458.54	4,186,867	1,102,342	1,199,123	771,130	0	0
459.79	5,682,215	1,289,276	2,379,465	1,090,028	0	0
461.04	7,417,702	1,491,904	3,912,582	1,356,782	0	0
462.29	9,409,269	1,679,170	5,773,971	1,627,714	0	0
463.54	11,583,081	1,796,196	8,002,938	1,964,099	0	0
464.79	13,898,234	1,907,645	10,702,200	2,348,554	0	0
466.04	16,353,390	2,021,968	13,884,334	2,742,735	0	0
467.29	18,958,168	2,152,278	17,545,341	3,103,559	0	0
468.54	21,744,794	2,301,578	21,627,110	3,421,861	0	0
469.79	24,703,472	2,433,316	26,100,427	3,736,445	0	0
471.04	27,837,251	2,592,706	30,976,163	4,068,104	0	0
472.29	31,237,273	2,833,446	36,278,873	4,421,977	0	0
473.54	34,941,612	3,119,095	42,030,983	4,781,762	0	0
474.79	39,099,448	3,525,155	48,223,811	5,124,002	5,880	22,566
476.04	43,758,398	3,956,918	54,832,146	5,448,361	91,829	124,476
477.29	48,952,077	4,361,728	61,841,472	5,759,025	345,678	305,225
478.54	54,719,269	4,859,732	69,220,162	6,048,278	1,011,826	842,447
479.79	61,082,977	5,303,396	76,958,131	6,325,642	2,480,876	1,373,880
481.04	67,975,326	5,725,630	85,025,129	6,569,487	4,436,934	1,773,352
482.29	75,367,643	6,098,857	93,370,625	6,783,901	6,847,968	2,055,466
483.54	83,236,039	6,492,349	101,983,162	6,993,714	9,547,323	2,257,599
484.79	91,574,984	6,836,692	110,846,653	7,187,302	12,487,797	2,445,907
486.04	100,296,860	7,104,049	119,939,761	7,356,324	15,673,163	2,652,486
487.29	109,305,511	7,300,753	129,234,899	7,514,678	19,103,687	2,830,976
488.54	118,535,228	7,465,942	138,719,362	7,652,246	22,733,027	2,965,883
489.79	127,985,127	7,672,880	148,357,074	7,767,294	26,503,613	3,060,799
491.04	137,910,940	8,424,678	158,140,132	7,888,543	30,379,911	3,141,735
492.29	149,067,331	9,461,460	168,091,027	8,042,783	34,360,532	3,228,983
493.54	162,228,649	11,693,650	178,346,880	8,435,858	38,453,766	3,321,013
494.79	177,759,279	13,035,517	189,942,932	10,017,091	42,667,364	3,423,138
496.04	194,648,295	13,912,376	202,943,515	10,723,678	47,049,300	3,670,542
497.29	212,729,419	15,099,160	216,881,477	11,595,722	52,882,587	6,483,166
498.54	232,085,399	15,803,472	231,777,055	12,326,612	63,119,573	9,053,432
498.79	236,049,630	15,910,377	234,880,210	12,498,439	65,405,551	9,232,515
499.79	251,987,642	15,949,639	247,421,164	12,549,839	74,672,234	9,273,941

LEGEND

- BATHYMETRY CONTOUR ELEVATION (METRES)
- ELEVATION CONTOUR (10m INTERVAL)
- FLOW DIRECTION
- LAKE BASIN DIVISION
- SECONDARY HIGHWAY
- WATERCOURSE
- WATERBODY
- WETLAND
- WOODED AREA

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- EXISTING ACCESS ROAD
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- AQUATIC BASELINE MONITORING POINT (CANNORTH 2019)
- AQUATIC BASELINE DETAILED STUDY AREA USED BY CANNORTH (2019)

WATERBODY HYDROMETRIC STATIONS

- DISCHARGE
- SURVEYED BENCHMARK (GEODETIC DATUM)
- TOTAL SUSPENDED SOLIDS AND BEDLOAD
- WATER SURFACE ELEVATION

WATERCOURSE HYDROMETRIC STATIONS

- DISCHARGE
- SURVEYED BENCHMARK (GEODETIC DATUM)
- TOTAL SUSPENDED SOLIDS AND BEDLOAD
- WATER SURFACE ELEVATION

0 1,000 2,000
1:50,000 METRES

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2. BATHYMETRY CONTOURS DERIVED FROM DATA COLLECTED BY NEXGEN, 2016.
PROJECTION: UTM ZONE 12 DATUM: NAD 83

CLIENT
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PROJECT
ROOK I PROJECT

TITLE
PATTERSON LAKE – PHYSICAL CHARACTERISTICS AND BASELINE MONITORING ACTIVITIES

CONSULTANT
GOLDER

YYYY-MM-DD	2019-11-28
DESIGNED	RP
PREPARED	LMS
REVIEWED	RWP
APPROVED	DL

PROJECT NO.	PHASE	REV.	FIGURE
18114335	6000	0	2

4.0 DIFFUSER DESIGN CONSIDERATIONS

4.1 Mixing Zone Guidelines

A mixing zone is a transitional area within a waterbody in which a treated effluent discharge is gradually mixed with the ambient water. Saskatchewan Water Security Agency (WSA 2015) published a set of effluent mixing zone guidelines to prescribe the general characteristics that a mixing zone should have in larger surface water bodies such as Patterson Lake. These guidelines, which are the most applicable regulatory guidance, state that at the outer edge of the mixing zone, the water quality should not be appreciably different from the water quality prior to the discharge of the effluent. The size of the mixing zone will be influenced by the difference in water quality between the treated effluent and the receiving water body, and the water volume of the receiving waterbody.

The applicable general objectives for effluent discharges are summarized in Table 2 and the applicable guidelines for effluent mixing zones are noted in Table 3.

Table 2: Applicable General Objectives for Effluent Discharges (WSA 2015)

ID	Description
1	Effluent should be free from substances in concentrations or combinations which are acutely toxic or may be harmful to human, animal or aquatic life.
2	Effluent should be free from substances that will settle to form putrescent or otherwise objectionable sludge deposits, or that will adversely affect aquatic life or waterfowl.
3	Effluent should be free from debris, oil, grease, scum or other materials in amounts sufficient to be noticeable in the receiving water.
4	Effluent should be free from colour, turbidity or odour-producing materials that would adversely affect aquatic life or waterfowl, significantly alter the natural colour of the receiving water, or directly or through interaction among themselves or with chemicals used in water treatment, result in undesirable taste or odour in treated water.
5	Effluent should be free from nutrients in concentrations that create nuisance growths of aquatic weeds or algae or that results in an unacceptable degree of eutrophication of the receiving water.
6	Effluent discharged to surface waters should not utilize more than 30 percent of the assimilation capacity of the receiving waterbody when discharged via means of a diffused outfall, or more than 10 percent when discharged via a point source outfall. These design objectives should be utilized during the planning stages of projects involving effluent discharges. For purposes of determining available assimilation capacity of a receiving waterbody, a flow rate equal to or less than the average seven-day low flow which occurs once in ten years (e.g., 7Q10), at the outfall area, generally should be used.

Table 3: Applicable Guidelines for Effluent Mixing Zones (WSA 2015)

ID	Description
1	The mixing zone should be as small as practicable and should not be of such size or shape as to cause or contribute to the impairment of existing or likely water uses.
2	In lakes and other surface impoundments, surface water quality objectives applicable to that waterbody must be achieved at all points beyond a radius of 100 metres from the effluent outfall. The volume of limited use zones in lakes should not exceed 10 percent of that part of the receiving waters available for mixing.
3	The mixing zone should be designed to allow an adequate zone of passage for the movement or drift of all stages of aquatic life; specific portions of a cross-section of flow or volume may be arbitrarily allocated for this purpose.
4	The mixing zones should not interfere with fish spawning and nursery areas.
5	The mixing zones should not cause an irreversible organism response or attract fish or other organisms and thereby increase their exposure period within the zone.
6	The 96 hr LC50 toxicity criteria, for indigenous fish species and other important aquatic species should not be exceeded at any point in the mixing zones.
7	The mixing zones should not result in contamination of natural sediments so as to cause or contribute to excursions of the water quality objectives outside the mixing zone;

The following mixing zone guidelines do not apply to the proposed effluent mixing zone:

- The mixing zone will not be in close proximity or overlap with other mixing zones or effluent plumes.
- The mixing zone will not intersect domestic water supply intakes, bathing areas, or other sensitive designated use areas.

4.2 Local Meteorological Conditions

Meteorological conditions of interest to the diffuser design include ambient air temperature, wind speed, and wind direction.

A long-term record of monthly air temperature (2 m from the surface) was developed by Golder (2019c) based on global re-analysis data for the period 1979 to 2017, which is summarized in Table 4. The annual average air temperature is estimated to be -0.43 °C with the coldest month, January, having an average temperature of -19.5°C and the warmest month, July, having an average temperature of 16.9°C.

Baseline meteorology monitoring data (wind data) available from the Project Meteorological Station was summarized by Golder (2019b), from November 2015 until October 2018 with a data gap between July 15 and October 20, 2016. The analysis was conducted using the wind data for the open water season, defined as the period from May to October of each year of record. Figure 3 presents the directions and the wind classes frequency distribution measured during the period when the climate data are available.

The analysis indicated that the recorded prevailing winds are from south, and southeast, followed by winds from the west-northwest and northwest sectors (Figure 3). The calm frequency, defined as wind with less than 0.5 m/s, is 2.5% of the time and the least frequent wind direction is the east-northeast sector. The mean values for wind speed show that the strongest winds tend to be from the west-northwest (>10 m/s), followed by winds from northwest, north-northwest, and south. The prevailing wind direction is from the south, west, and northwest. An upper bound wind speed of 235 km/hr was carried forward to represent relatively common windy conditions. A lower bound wind speed of 10 km/hr was carried forward to represent routine conditions.

Table 4: Monthly and Annual Air Temperature Statistics for the Project

Air Temperature (°C)							
Month	Minimum	25th Percentile	Median	75th Percentile	Maximum	Mean	Standard Deviation
January	-40.3	-27.2	-18.8	-12.4	4.83	-19.5	9.48
February	-38.9	-22.9	-16.1	-9.60	4.49	-16.4	8.86
March	-32.5	-15.3	-8.33	-2.61	8.06	-9.36	8.42
April	-23.12	-3.11	1.21	4.62	20.7	0.36	6.56
May	-10.0	4.89	8.26	12.4	24.6	8.45	5.43
June	1.76	11.8	14.6	17.0	25.6	14.4	3.85
July	7.38	14.8	16.7	19.2	25.9	16.9	3.15
August	3.27	12.3	15.4	17.9	26.4	15.1	4.00
September	-2.98	5.94	9.20	12.3	22.3	9.14	4.44
October	-19.9	-1.37	1.59	4.89	17.5	1.56	5.10
November	-35.2	-13.7	-7.74	-3.09	6.36	-8.88	7.22
December	-42.9	-23.6	-15.8	-9.73	3.61	-17.0	9.32
Annual Average	**-19.5**	**-4.78**	**0.01**	**4.24**	**15.9**	**-0.43**	**6.32**

°C = degrees Celsius; Source: Data presented is based on European Re-analysis Interim (ERAI) data for the Project published by the European Centre for Medium-Range Weather Forecasts (ECMWF 2019) compiled by Golder (2019c).

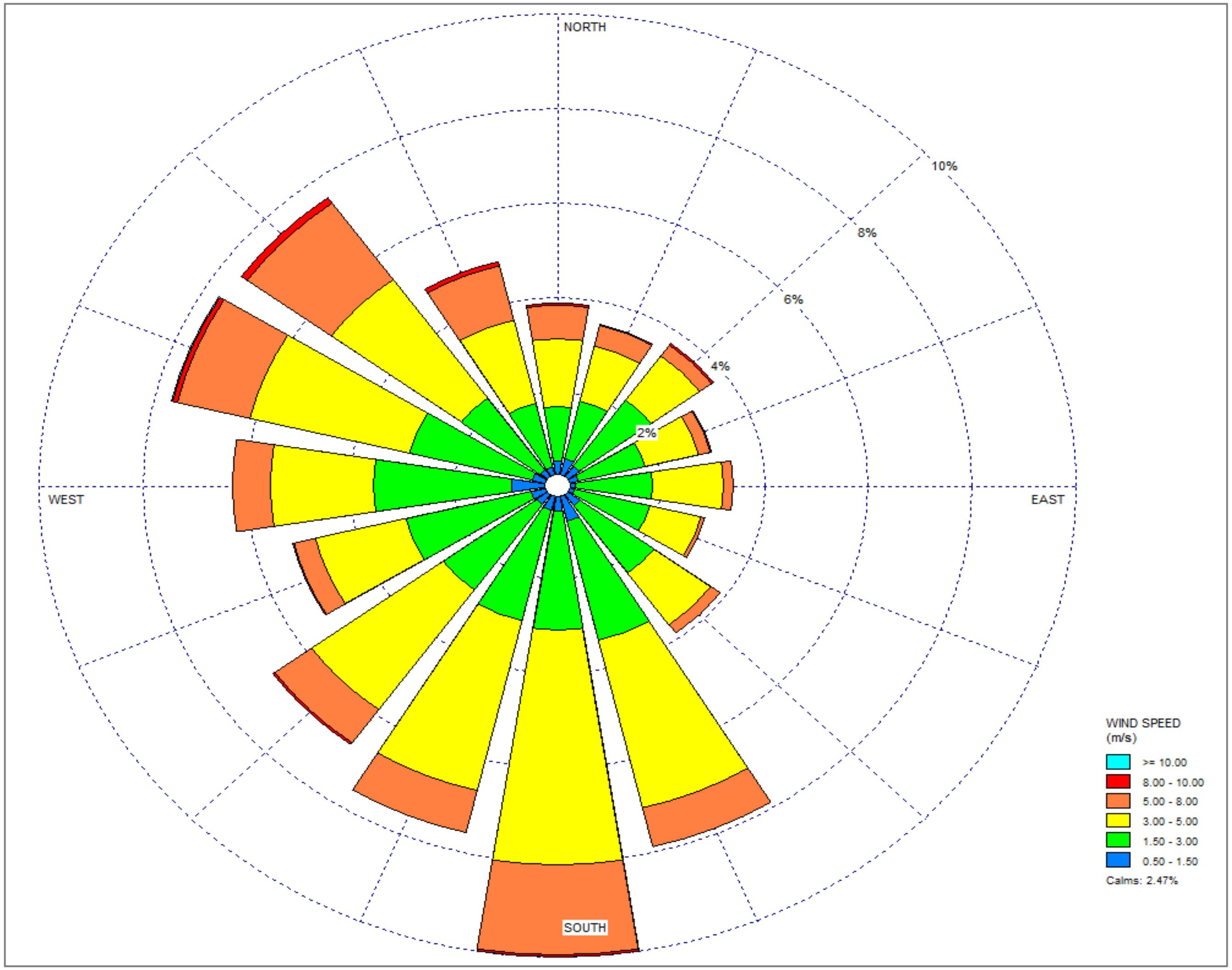


Figure 3: NexGen Rook I Weather Station, Windrose Open Water Season, 2015 to 2018

4.3 Patterson Lake Conditions

4.3.1 General

Several characteristics of the receiving waterbody (i.e. Patterson Lake) combine to affect the movement and spread of a plume and the performance of a diffuser. These characteristics include water depth, lake currents that affect mixing of the plume with ambient water, and water temperature and chemistry (total dissolved solids) that affect the ambient water density. The following sections describe the characteristics of Patterson Lake that were considered for developing the diffuser design.

4.3.2 Lake Bathymetry

The North Arm of Patterson Lake is divided into the West Basin and East Basin separated by a narrow and shallow sand sill with spit formations forming on either side. The selected site option is located in the North Arm – West Basin of Patterson Lake with the diffuser located approximately 750 m west of the narrows at a depth of 10 m.

Patterson Lake bathymetry data was collected by NexGen between June 15, 2016 and September 15, 2016 using a Trimble R10 global positioning system (GPS) with boat mounted echosounder. The local bathymetry is shown in Figure 2. To the east and south east of the selected diffuser location, the water depth is shallow and the bed slope is gradual. To the west and south west of the selected diffuser location, the bed slope is steep and drops off rapidly with depths increasing to approximately 40 m.

4.3.3 Lake Water Level

Patterson Lake water surface elevation (WSE) fluctuates throughout the year with a WSE of 498.79 masl, being representative of the normal water level. The surveyed WSE was 498.599 masl on August 8, 2018 and 498.510 masl on September 29, 2018 (see Figure 3). Both of these elevations were relative to the geodetic benchmarks established on the shore of Patterson Lake near the NexGen exploration camp.

Based on the results of preliminary hydraulic modelling completed using HEC-RAS for the Patterson Lake outlet channel (Clearwater River below Patterson Lake), the lake elevation would have an approximate range of 498.1 m (during droughts approaching zero outflow conditions) to 499.3 m (100-year flood level). The typical annual range of lake levels would be 498.5 masl to 499.0 masl.

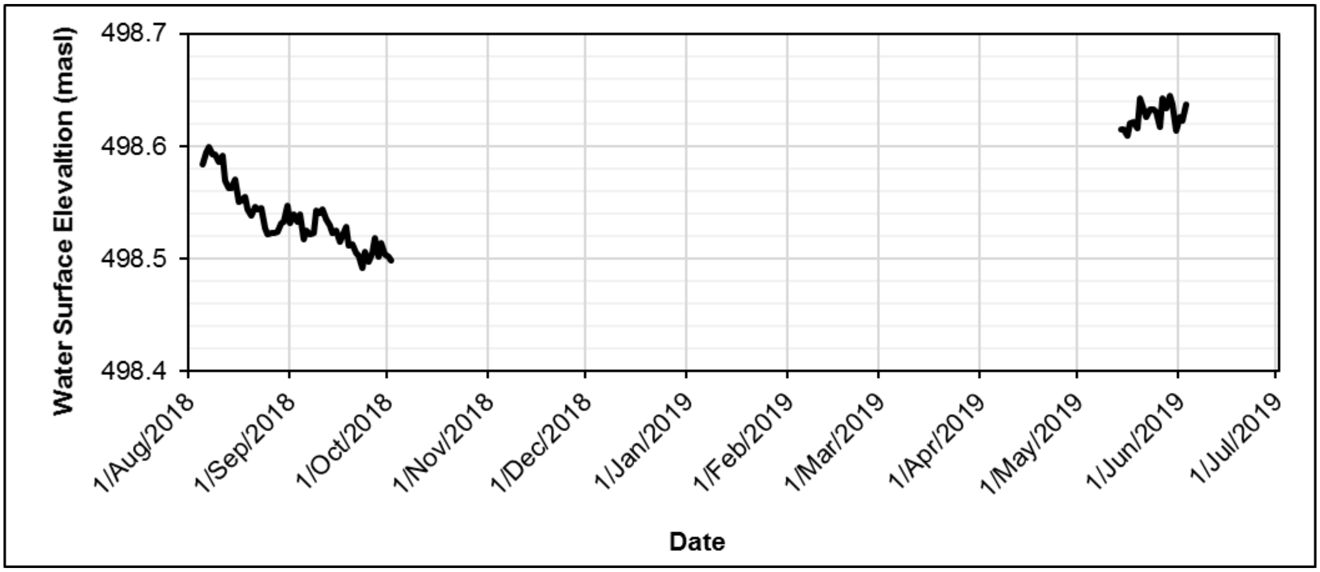


Figure 4: Observed Daily Patterson Lake Water Surface Elevation (Golder 2019)

4.3.4 Lake Water Temperature

Lake water temperature observations were made concurrently with lake water level measurements at CR-WB-MS-002 in 2018 and 2019 (Figure 1).The range of water temperature observed at CR-WB-MS-002 for the period from 2018-2019 are presented in Figure 5. The water temperature was measured using a Solinst Levellogger installed beneath 0.5 m to 1.0 m of water surface. The continuous water temperature measurements are confined to the open-water period. The peak water temperature occurred in early August 2018 at 20°C with minimum observed temperatures of 5°C measured in May 2019 shortly after the lake periphery became ice free.

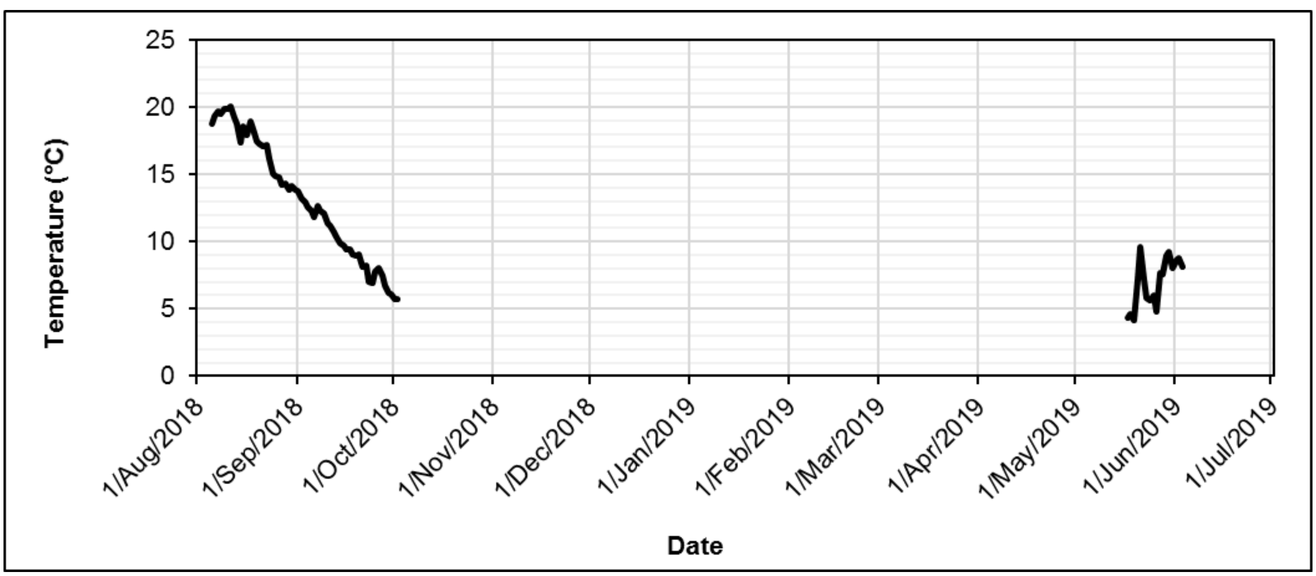


Figure 5: Observed Patterson Lake Water Temperature at a Depth of Approximately 0.5 m in 2018-2019 (Golder 2019)

The temperature profiles collected by CanNorth (2019) at Patterson Lake North Area 1 on August 2, 2018 and September 29, 2018 are shown in Figure 6. A series of additional temperature profiles (Figure 7) were observed by CanNorth on July 30, 2019 at depths of 3.9 m, 8.1 m, and 14.7 m in the vicinity of the selected diffuser location.

Figures 6 and 7 both show water temperature stratification at a depth of approximately 9 m from the water surface. The maximum stratification depth allowable in CORMIX is 60% of the total water depth, which is 6 m below the water surface when the total depth is 10 m. Three stratification depths (i.e. 4, 5 and 6 m) were simulated to test the sensitivity of diffuser performance. It was assumed that if a plume can penetrate the stratification interface at a depth of 6 m below water surface, it can also penetrate the stratification interface at depths greater than 6 m.

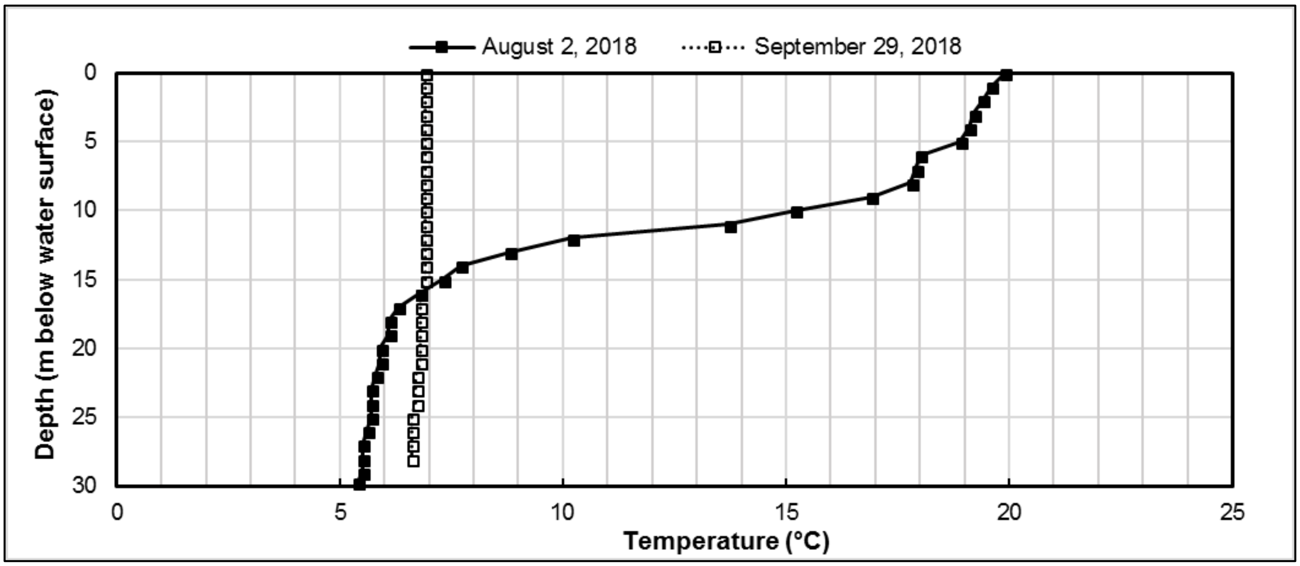


Figure 6: Temperature Profile Observed at Patterson Lake North Area 1 during 2018 by CanNorth (2019)

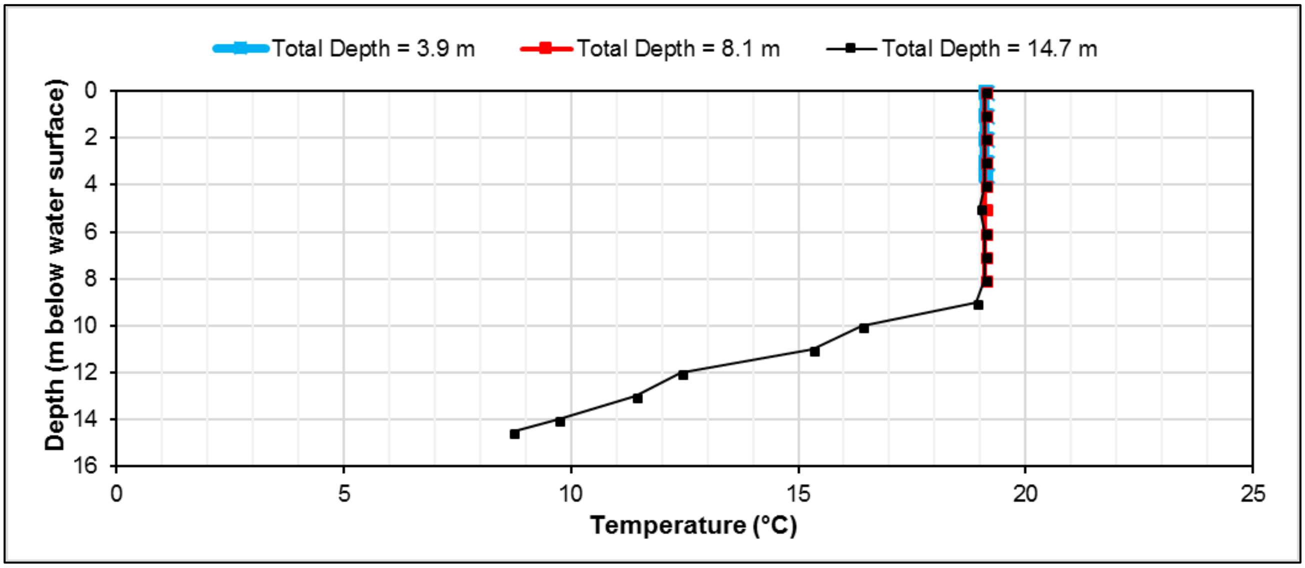


Figure 7: Temperature Profile Observed along the Proposed Pipeline Alignment at Depths of 3.9 m, 8.1 m and 14.7 m on July 30, 2019 by CanNorth (2019)

4.3.5 Bed Substrate

A bed substrate sample was collected near the selected diffuser location on May 16, 2019. The bed was found to be uniform and comprised of medium to fine grained sand. Characteristic particle sizes are summarized in Table 5. The full grain size distributions analysed for each of the samples are included in Appendix B.

The critical shear stress for disturbing the bed substrate materials was calculated using Yalin's curve (Yalin 1977) based on the median particle diameter of 0.294 millimetres (mm) and water temperature of 5°C. The critical shear velocity was calculated to be 0.015 metres per second (m/s) corresponding to a critical shear stress of 0.213 newtons per square metre (N/m²).

Table 5: Characteristic Particle Sizes of Bed Substrate Samples Collected near the Selected Diffuser Location

Waterbody	Date	Easting (m)	Northing (m)	Depth (m)	D_{15} (mm)	D_{50} (mm)	D_{85} (mm)
Patterson Lake	May 16, 2019	60280	6394011	8	0.185	0.294	0.398

m = metres; mm = millimetres

4.3.6 Lake Currents

Detailed information on lake current was not available at the time of this study. For this reason, current was estimated using 2% of the characteristic wind speeds on the lake. The average lake current is typically in the range of 1 to 3% of average wind speed (Heaps and Jones 1987) and an average value of 2% was used to estimate the lake current speed based on the wind speed.

Under ice-cover conditions, the lake current is estimated to be very small. Because the CORMIX model requires a non-zero ambient current value, calm conditions were represented by having a very small current speed of 0.001 m/s.

For the open-water season, a relatively low lake current speed equal to 0.055 m/s corresponds to persistent wind speed of 10 km/hr, and a relatively high lake current speed equal to 0.140 m/s corresponds to persistent wind speed of 25 km/hr. A calm condition during the open-water season was also assessed as a worst case.

Based on the configuration of Patterson Lake, the current direction is estimated to be predominantly from east to west at the selected diffuser location.

4.3.7 Lake Water Quality

Baseline lake ambient specific conductivity was measured by CanNorth (2019) at Patterson Lake North Area 1 on August 2, 2018 and September 29, 2018. Observations of specific conductivity in micro-Siemens per centimetre (µS/Cm) were converted to total dissolved solids (TDS) in milligrams per litre (mg/L) using a coefficient of 0.64 as recommended for natural waters by Maidment (1994).

TDS at Patterson Lake North Area 1 was observed to be approximately 24 mg/L and consistent over the range of depths observed in the profile on both dates. Golder collected a vertical water quality profile near the selected diffuser location on March 25, 2019 and the observed TDS concentration of 31 mg/L was consistent through the water column (Golder 2019d).

4.3.8 Lake Ice Thickness

Ice thickness on the lake was measured weekly during the winter of 2018-2019. The ice thickness measurements coincided with lake water pumping for mineral exploration drilling. The ice thickness was measured at ten pumping locations and at intervals along the access road to the pumping locations in the Patterson Lake North Arm near the selected diffuser location (NexGen 2019). The maximum ice thickness was approximately one metre and was observed during the first two weeks of March.

4.3.9 Duration of Lake Ice Cover

The duration of ice cover on Patterson Lake was estimated by reviewing the historic Sentinel-2 L1C and Landsat 8 satellite images available via the SentinelHub Playground Application (SentinelHub 2019). The satellite images are available from 2013 to 2019 on a near daily frequency contingent on cloud coverage.

The formation of continuous ice cover was variable from year to year with the onset of ice cover typically beginning in early November and with Patterson Lake being fully ice covered by the third week in November. Ice typically formed first on the North Arm – East Basin with full coverage of the North Arm – West Basin and South Arm following roughly one to two weeks later.

The North Arm – East Basin is typically the first area to become ice free in the last week of April or first week of May with the North Arm – West Basin and South Arm becoming fully ice free by the end of May. There is uncertainty in the exact date of break up due to the availability of satellite images. The summary in Table 6 should be considered accurate to within one week of the actual date of ice formation or break up. A conservative period of ice coverage based on historic observations between 2013 and 2019 would be from November 1 to June 1 or roughly seven months of the year. A typical sequence of Landsat 8 satellite images showing ice formation in fall 2014 and break up in 2015 is presented in Figure 8.

Table 6: Summary of Patterson Lake Ice Cover Formation and Breakup Dates based on Sentinel-2 L1C and LandSat 8 Satellite images

Year	Patterson Lake Ice Cover Formation		Patterson Lake Ice Cover Break Up	
	Start Date	End Date	Start Date	End Date
2013	05-Nov-2013	21-Nov-2013	20-May-2013	29-May-2013
2014	08-Nov-2014	24-Nov-2014	16-May-2014	01-Jun-2014
2015	20-Nov-2015	27-Nov-2015	26-Apr-2015	19-May-2015
2016	20-Nov-2016	08-Dec-2016	28-Apr-2016	28-May-2016
2017	07-Nov-2017	20-Nov-2017	08-May-2017	24-May-2017
2018	27-Oct-2018	08-Nov-2018	04-May-2018	19-May-2018
2019	No Data	No Data	07-May-2019	24-May-2019

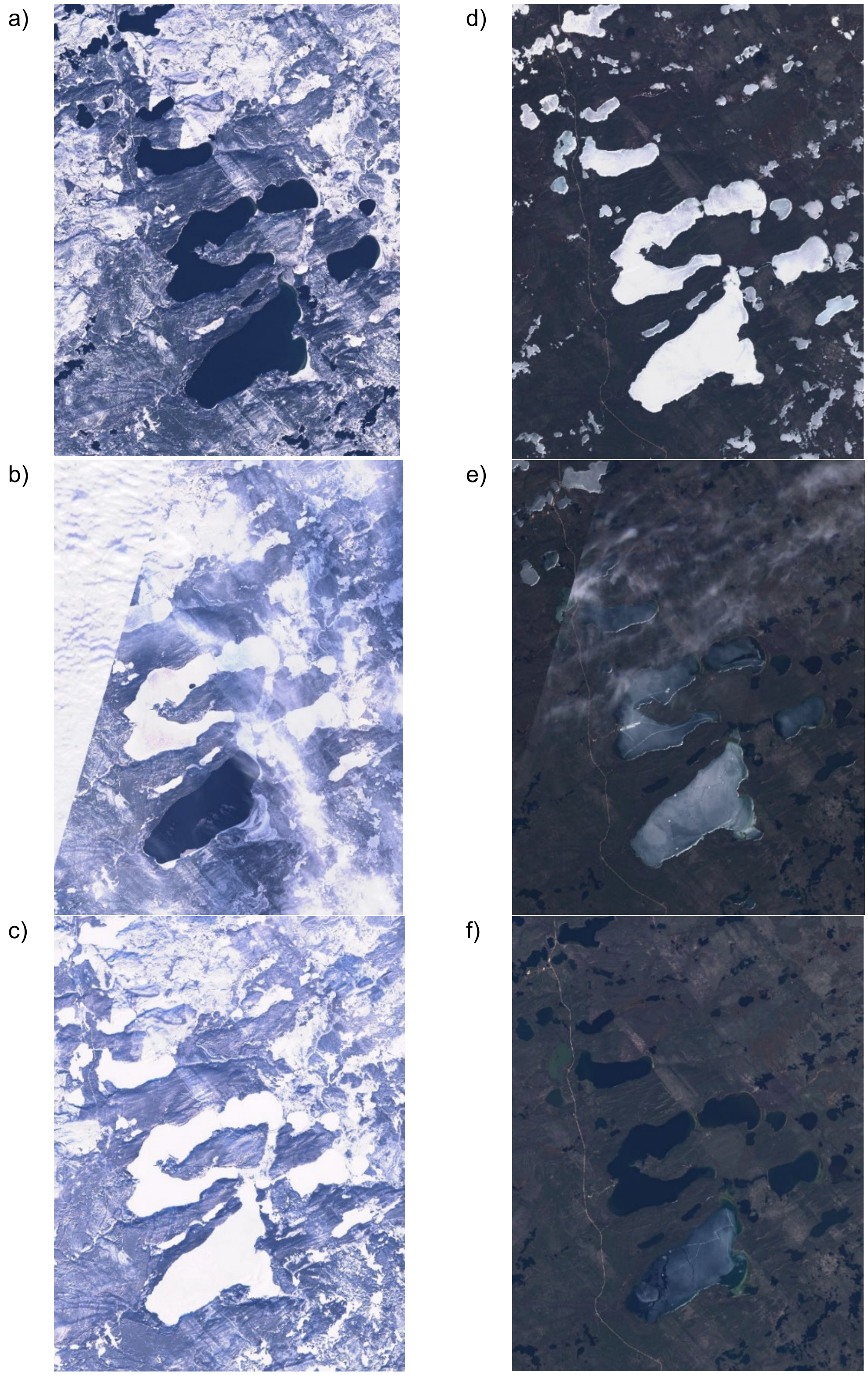


Figure 8: Typical Sequence of Landsat 8 Satellite Images showing ice formation in fall 2014 in the left column with a) November 8, 2014, b) November 17, 2014, and c) November 24, 2014 alongside Ice Break up in 2015 from top to bottom on d) April 26, 2015, e) May 12, 2015, and f) May 19, 2015

4.4 Aquatic Habitat

The proposed diffuser location is in the North Arm – West Basin of Patterson Lake. It is sited in a location that is estimated to have favourable ambient currents in carrying discharged treated effluent away from the diffuser. A conceptual pipeline alignment connecting the diffuser to the location of the treated effluent monitoring ponds would intersect a section of shoreline shown on Figure 9. This section of shoreline, referred to as HS4 (CanNorth 2019) has the following characteristics:

- The riparian zone is forested to the bank with vegetation consisting of trees and shrubs. The bank slope is gradual with slope less than 15°.
- Littoral bed substrate consists of 95% sand and 5% organics.
- All sources of cover including large woody debris, aquatic vegetation, rock, overhanging vegetation, undercut, surface turbulence were noted to be absent.
- Bottom slope was gradual with a slope less than 15° and the depth at 5 m from shore was noted to be 0.2 m.
- HS4 was noted to be not suitable spawning habitat for all large bodied fish included in the assessment except for yellow perch for which it would only be marginally suitable.

Figure 9: Patterson Lake Shoreline at the Proposed Location of the Diffuser Pipeline Entering the Lake (May 16, 2019)

4.5 Mine Site Infrastructure

The proposed layout of the effluent treatment plant and associated ponds are located in the northwest corner of the proposed mine site footprint (Figure 10). The effluent treatment plant will remove elements of concern to produce water that is suitable for release to the environment. The effluent treatment plant will treat mill effluent, underground mine water, and site runoff from potentially contaminated areas.

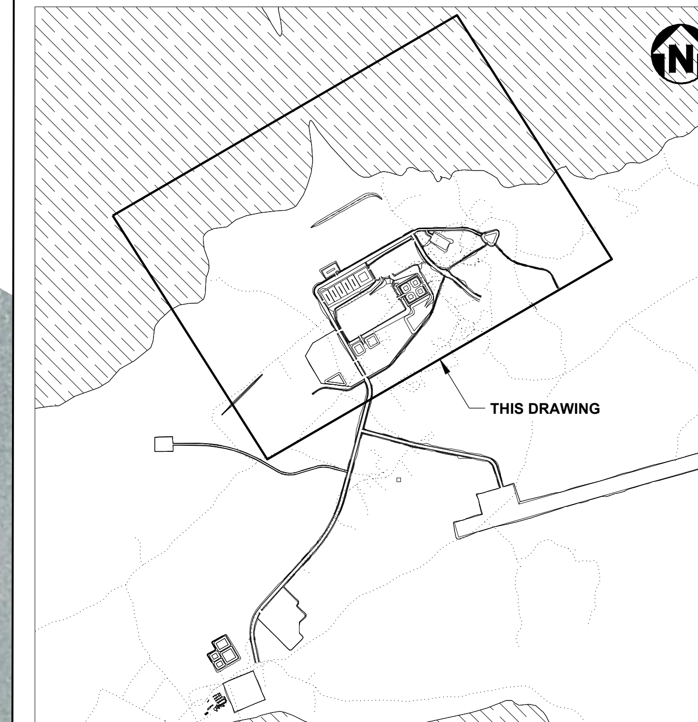
A total of six process ponds are proposed to accompany the effluent treatment plant. From west to east, there are four monitoring ponds, one contingency pond, and one feed settling pond. Treated effluent from the effluent treatment plant will be stored in the monitoring ponds until acceptable water quality has been confirmed for release to the environment.

The nominal rate of treated effluent discharge will be 262 cubic metres per hour (m^3/hr) (NexGen 2019c). However, the discharge from the monitoring ponds to Patterson Lake will be operated in batch mode. Pond emptying will have a six-hour target emptying time and the design discharge rate from the ponds to the lake is 833 m^3/hr (Boehm personal communication 2019a).

The top of the pond berm is 534.50 masl which accounts for 1.0 m above the operational high-water level of 533.50 masl. The bottom of these ponds and minimum operational water level is 528.50 masl and, as a result, the operating range is 5 m from 528.50 masl to 533.50 masl.

The proposed alignment of the pipeline on land has been constrained within the Project mineral lease boundary shown in Figure 1.

KEY MAP (NTS)



LEGEND

MONITORING / SETTLING PONDS

NOTE(S)

1. ALL UNITS ARE IN METRES UNLESS SPECIFIED OTHERWISE.

REFERENCE(S)

1. BASE MAP TAKEN FROM NEXGEN DRAWING, FILENAME '2100-DD10-SKT-00002_08Aug2019.dwg.
2. EXISTING GROUND LIDAR PROVIDED BY NEXGEN, FILENAME 2018 Rook1 Lidar_2m Grid.tif.
3. ALL COORDINATES REFERENCE NAD83 UTM ZONE 12.

NOT FOR CONSTRUCTION

0 125 250

1:7,500 METRES

CLIENT

NexGen Energy Ltd.

CONSULTANT

GOLDER

YYYY-MM-DD	2019-11-29
DESIGNED	SW
PREPARED	CV
REVIEWED	RWP
APPROVED	DL

PROJECT

ROOK I DIFFUSER DESIGN

TITLE

SITE PLAN

PROJECT NO.	CONTROL	REV.	FIGURE
18114335	6000/6010	0	10

25 mm IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

4.6 Treated Effluent Quality

Operational data is not available for the proposed treated effluent plant (NexGen 2019a). However, NexGen (2019a) recommended using analytical results of the synthetic treated effluent created from the pilot tests supported by the historical data from the effluent source terms of Rabbit Lake mill (from 2010 to 2015). The source terms for treated effluent quality were provided by NexGen (2019a) and are summarized in Table 7.

The treated effluent temperature provided by NexGen was 8.5°C (Table 7). To be conservative under winter conditions, a temperature of 4°C was used as a lower bound for the treated effluent temperature as this would be the temperature at which water density is the highest.

Table 7: Treated Effluent Source Term Data of Rook I (NexGen 2019a)

Constituents	Unit	Treated Effluent Source Terms
Metals		
Arsenic	µg/L	16.00
Cadmium	mg/L	0.0004
Chromium	mg/L	0.002
Cobalt	mg/L	0.002
Copper	mg/L	0.003
Iron	mg/L	0.070
Lead	mg/L	0.0004
Manganese	mg/L	0.140
Molybdenum	mg/L	0.400
Nickel	mg/L	0.020
Selenium	mg/L	0.007
Uranium	µg/L	73.0
Vanadium	mg/L	0.0002
Zinc	mg/L	0.004
Radionuclides		
Lead-210	Bq/L	0.080
Polonium-210	Bq/L	0.025
Radium-226	Bq/L	0.060
Thorium-230	Bq/L	0.020
General Water Chemistry and Physical Properties		
Ammonia-N (Total)	mg/L	2.50
Ammonia-N (Un-ionize)	mg/L	0.020
Nitrate as N	mg/L	5.00
pH (Lab)	pH Unit	7.0
TSS	mg/L	2
TDS	mg/L	14,300
Conductivity	µS/cm	3,200
Temperature[5]	ºC	8.5

µg/L = micrograms per litre, mg/L = milligrams per litre, Bq/L = Becquerels per litre, µS/cm = micro-Siemens per cm, ºC = degrees Celsius.

4.7 Dilution Requirement

The required minimum dilution factor at the edge of the 100 m mixing zone was calculated for the parameters which effluent concentrations have guidelines. To be conservative in the absence of modelled lake-wide concentrations at the time of this study, the 95th percentile of the measured background concentrations were used. A conservative approach was taken in this instance since the concentrations of some parameters may increase during operation. The criterion or guideline for each parameter was set as the most stringent guideline for the protection of aquatic life (freshwater) from either the Canadian Council of Ministers of the Environment (CCME) long term guidelines or the WSA objectives.

Based on the analysis, the most restrictive parameter is selenium that requires a minimum dilution factor of 7.7 (Table 8). A sensitivity analysis was conducted whereby background concentrations were increased by up to 40% to assess the sensitivity of the dilution factor to background concentrations and to better understand steady-state conditions once treated effluent has fully mixed with Patterson Lake during operation. In all instances, the minimum dilution factor did not exceed 8. To be conservative, a minimum dilution factor of 10 was selected for designing the diffuser.

Table 8: Calculated Dilution Factors at the Edge of the 100 m Mixing Zone

Parameter	Units	Effluent Concentration	Background (95th Percentile)	Criteria or Guideline[a]	Required Dilution Factor
Ammonia (Total) as N	(µg/L)	2,500	58	5,548[b]	0.4
Ammonia (Unionized) as N	(µg/L)	20	0.11	19	1.1
Chloride	(µg/L)	N/A	600	120	N/A
Nitrate as N	(µg/L)	5,000	53.5	3,000	1.7
Phosphorus	(µg/L)	N/A	50	10	N/A
Sulphate	(µg/L)	N/A	1890	N/A	N/A
Arsenic	(µg/L)	16	0.143	5	3.3
Cadmium	(µg/L)	N/A	0.01	0.017[c]	N/A
Cobalt	(µg/L)	2	0.1	N/A	N/A
Copper	(µg/L)	3	0.5	2	1.7
Lead	(µg/L)	0.4	0.1	1	0.3
Magnesium	(µg/L)	N/A	1,469	N/A	N/A
Mercury	(µg/L)	N/A	0.004	0.026	N/A
Molybdenum	(µg/L)	400	0.1	73	5.5
Nickel	(µg/L)	20	0.5	25	0.8
Selenium	**(µg/L)**	**7**	**0.1**	**1**	**7.7**
Sodium	(µg/L)	N/A	1,500	N/A	N/A
Uranium	(µg/L)	79	0.1	15	5.3
Zinc	(µg/L)	4	2.72	7	0.3
Pb-210	(Bq/L)	0.08	0.037	N/A	N/A
Po-210	(Bq/L)	0.025	0.019	N/A	N/A
Ra-226	(Bq/L)	0.06	0.01	N/A	N/A
Th-230	(Bq/L)	0.02	0.01	N/A	N/A

µg/L = micrograms per litre; Bq/L = Becquerels per litre

Notes:

a. Unless otherwise noted, criteria and guidelines from CCME freshwater long term objectives (CCME 2003)

b. Criteria based on summer conditions for unionized ammonia

c. Saskatchewan WSA Surface Water Quality Objectives (WSA 2015)

4.8 Parameter Values

The selected parameter values for analyzing the diffuser dilution performance and for supporting the diffuser design are presented in Table 9.

Table 9: Selected Parameter Values

Criterion	Units	Value	Reference/Section Number
Monitoring Pond Volume	m^3	5,000	Wood 2019
Monitoring Pond Emptying Time	hrs	6	Boehm pers. Comm. 2019b
Diffuser Discharge Rate	m^3/hr	833	Boehm pers. Comm. 2019a
Treated Effluent Temperature (Design Temperature)	ºC	8.5	NexGen 2019a, Section 4.6
Treated Effluent Temperature in Winter (Lower Bound)	ºC	4.0	Section 4.6
Treated Effluent Temperature in Summer (Upper Bound)	ºC	20.0	Section 4.6
Treated Effluent TDS Concentration	mg/L	14,300	NexGen 2019a
Lake Water Temperature Range	ºC	5 to 20	Golder (2019a); Section 4.2.
Lake Current Speed – Ice Cover	m/s	0.001	Section 4.3.5
Lake Current Speed – Open Water (Lower Bound)	m/s	0.055	Section 4.3.5
Lake Current Speed – Open Water (Upper Bound)	m/s	0.140	Section 4.3.5
Lake Current Speed – Open Water (Worst Case – Calm Condition)	m/s	0.001	Section 4.3.5
Lake Water Temperature Vertical Distribution – Ice Cover	ºC	0 ºC under the ice, 4 ºC at lake bottom, linear distribution in between	Section 4.3.2
Lake Water Temperature Vertical Distribution – Open Water	ºC	Stratified conditions: 20ºC in top layer and 6ºC in bottom layer. The depth of stratification interface was simulated as 4m, 5m, and 6m.	Section 4.3.2
Lake TDS Concentration – Ice Cover	mg/L	31 and 300	31 is from Golder 2019b; Section 4.3.6; 300 is a conservative upper bound
Lake TDS Concentration – Open Water	mg/L	24	CanNorth 2019; Section 4.3.6
Lake Ice Thickness	m	1.0	NexGen 2019b; Section 4.2.9

hrs = hours, m = metres, mg/L = milligrams per litre, m^3 = cubic metres, m^3/hr = cubic metres per hour

4.9 Diffuser Design Basis

Diffusers are typically designed to achieve maximum dilution over a relatively short distance for the design discharge and to achieve targeted dilution performance at the boundary of regulatory mixing zone. Golder designed the diffuser to achieve a minimum dilution factor of 10 at the edge of the 100 m mixing zone over a range of conditions that the diffuser will be operating under.

This design approach was adopted for satisfying the general objectives for treated effluent discharges and Guidelines for Effluent Mixing Zones as laid out by WSA (2015), which are noted in Section 4.6. In addition to satisfying the regulatory and performance requirements, the diffuser design should facilitate ease of construction, installation and maintenance.

5.0 PROPOSED DESIGN

5.1 Design Summary

The proposed design for the treated effluent outfall consists of a pipeline and a diffuser as shown in the drawings in Appendix C. The treated effluent will be conveyed by a proposed high density polyethylene (HDPE) pipeline with inside diameter of 0.33 m (i.e. 16 inch DR11, 200 psi, see specification by J-M Manufacturing Company) and an outside diameter of 0.40 m. The pipeline has a length of 770 m from the monitoring ponds to the shoreline. The elevation drop along the pipeline alignment will be approximately 29.71 m from an assumed minimum operating pond water level of 537 masl in the monitoring ponds to 498.79 masl at the shoreline. The pipeline will continue approximately 750 m from the shoreline into Patterson Lake and discharge through a diffuser at the selected location with a water depth of approximately 10 m.

The conceptual configuration of the diffuser is summarized as follows:

- The diffuser will consist of the 16 inch pipe and one vertical nozzle which has an inside diameter of 0.194 m.
- The top elevation of the 10 inch vertical nozzle will be one metre above the lakebed and 0.65 m above the 16 inch feed pipe.

5.2 Dilution Performance Analysis

5.2.1 Dilution Modelling

Detailed mixing and dilution modelling was conducted using the CORMIX model system (Doneker and Jirka 2007) to optimize the design and assess the dilution performance of the diffuser under a range of treated effluent and ambient conditions. The CORMIX model was developed at Cornell University and has been endorsed by the U.S. Environmental Protection Agency (USEPA). The CORMIX model system uses a physically-based, reliable and empirical approach by assembling all available data and resulting formulas for analysing and modelling jets and plumes.

Ambient conditions in Patterson Lake vary throughout the year. The purpose of defining the ambient conditions for simulation is to simplify representation of the variable lake ambient current and water temperature conditions in Patterson Lake and to provide the model inputs for steady-state simulation of the resulting jets or plumes from the diffuser discharge.

Three typical lake ambient conditions in Patterson Lake were defined for the modelling analysis as follows:

- Ice-cover conditions for the seven month period (November to late May) when the lake is ice-covered;

- Open-water conditions during spring with no stratification; and
- Open-water conditions during summer with stratification;

5.2.2 Ice-Cover Conditions

Table 10 presents the inputs and outputs the CORMIX modelling under ice-cover conditions. Four scenarios composed of two treated effluent temperatures (8.5°C and 4.0°C) and two ambient TDS concentrations (31 mg/L and 300 mg/L) were modelled.

The modelling results of the ice-cover scenarios show the following:

- The dilution factor at the edge of 100 m mixing zone is not sensitive to the treated effluent temperature and ambient TDS concentration.
- At approximately 30 m from the diffuser, the dilution factor would attain a value of 38 which is much greater than the required minimum dilution factor of 10.
- The maximum flow velocity near the water surface is up to 1.1 m/s. This means the ice above the diffuser will be subjected to impingement from a vertical jet with noticeable velocity.

Table 10: Inputs and Outputs of CORMIX Model Runs for the Ice-cover Scenario

Category	Description	Symbol	Units	Scenario			
				1	2	3	4
Treated Effluent	Flow rate	Q	(m³/h)	833			
			m³/s	0.231[a]			
	TDS concentration	C_{01}	(mg/L)	14,300			
	Temperature	T_0	(°C)	8.5	4.0	8.5	4.0
	Density	ρ	(kg/m³)	1011.04	1011.38	1011.04	1011.38
Ambient	Lake current speed	u_a	(m/s)	0.001			
	Lake water depth	H	(m)	10[a]			
	Ice thickness	Hi	(m)	1			
	Lake water temperature under ice	T_{as}	(°C)	0			
	Lake water temperature near bottom	T_{ab}	(°C)	4			
	Lake TDS concentration	C_{ad}	(mg/L)	31		300	
	Lake water density under ice	ρ_{a01}	(kg/m³)	999.89[a]		1000.11[a]	
	Lake water density near bottom	ρ_{a02}	(kg/m³)	1000.02[a]		1000.24[a]	
Discharge	Diffuser height above lakebed	h	(m)	1[a]			
	Number of nozzles	N	-	1[a]			
	Single nozzle discharge	q	(m³/s)	0.231[a]			
	Nozzle inside diameter	d	(inch)	7.63 [10-inch DR 7.3(318 psi)]			
			(m)	0.1938[a]			
	Nozzle cross sectional area	a	(m²)	0.0295			
	Nozzle exit flow velocity	V_0	(m/s)	7.84			

Table 10: Inputs and Outputs of CORMIX Model Runs for the Ice-cover Scenario

Category	Description	Symbol	Units	Scenario			
				1	2	3	4
Dilution Performance	Size of unstable recirculation region	x	(m)	30	29	30	29
	Bulk dilution factor at a distance of 100 m from the diffuser	S		38	38	38	38
	Maximum flow velocity at water surface	Vs	(m/s)	1.1[b]	1.1[b]	1.1[b]	1.1[b]

°C = degrees Celsius, kg/m^3 = kilograms per cubic metre, m = metre, m/s = metres per second, m^2 = square metre, mg/L = milligrams per litre
Note a: Inputs to the CORMIX model.
Note b: Based on the modelling results by assuming water depth of 50 m so that the flow velocity at the lake surface can be estimated.

5.2.3 Open-Water with No Stratification

Table 11 presents the inputs and outputs of the CORMIX model runs for the open-water scenarios with no vertical variation of the ambient conditions. A total of six scenarios composed of two different effluent temperatures (8.5°C and 20°C) and three ambient current speeds (0.001 m/s, 0.055 m/s and 0.14 m/s) were modelled.

For each of the six scenarios, four model runs were conducted for four different ambient temperatures (5°C, 10°C, 15°C and 20°C). A total of 24 model runs were conducted. The modelling results for the ice-cover conditions indicate that the diffuser dilution performance is not sensitive to the ambient TDS concentration. Therefore only one ambient TDS concentration of 24 mg/L was used as input in the 24 model runs.

The modelling results for the open-water conditions with no stratification show the following:

- At the edge of the 100 m mixing zone, the dilution factor will be at least 28 which is much higher than the required minimum dilution factor of 10.
- The maximum flow velocity at the lake water surface is up to 1.0 m/s. This may result in a small (approximately 0.05 m) local water level rise.
- The lowest dilution factor and the lowest flow velocity at the lake surface will occur for the case with an ambient current speed of 0.14 m/s. This is because the relatively high current speed has dual effects (i.e., it will accelerate mixing but will also reduce the time available for mixing before the resulting plume reaches the edge of the 100 m mixing zone).

5.2.4 Open-Water with Vertical Stratification

Table 12 presents the inputs and outputs of the CORMIX model runs for the open-water scenarios with vertical variation of the ambient conditions. A total of three scenarios composed of three ambient current speeds (0.001 m/s, 0.055 m/s and 0.14 m/s) were modelled.

For each of the three scenarios, three model runs were conducted for three different stratification interface depths from the lake water surface (4 m, 5 m, and 6 m). For a total water depth of 10 m, the maximum stratification interface depth allowable in CORMIX is 6 m which is 60% of the total lake water depth. For stratification interface depth greater than 6 m, the dilution performance is expected to be better than that for stratification depth of 6 m.

The modelling results for the open-water conditions with stratification show the following:

- At the edge of the 100 m mixing zone, the dilution factor will be at least 28 which is much higher than the required minimum dilution factor of 10.
- For the lake conditions with stratification interface depth of 6 m or greater, the dilution factor will be at least 46.

The maximum flow velocity near the lake water surface cannot be estimated using CORMIX. However, the maximum flow velocity near the lake water surface is not expected to be greater than those for the open-water conditions with no stratification.

Table 11: Inputs and outputs of CORMIX Model Runs for the Open-Water Conditions with No Vertical Stratification

Category	Description	Symbol	Units	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
Treated Effluent	Flow rate	Q	(m^3/d)	833					
			m^3/s	0.231[a]					
	TDS concentration	C_{01}	(mg/L)	14,300					
	Temperature	T_0	(°C)	8.5			20.0		
	Density	□	(kg/m^3)	1011.04[a]			1009.07[a]		
Ambient	Lake current speed	u_a	(m/s)	0.001[a]	0.055[a]	0.140[a]	0.001[a]	0.055[a]	0.140[a]
	Lake water depth	H	m	10[a]					
	Lake TDS concentration	C_{ad}	(mg/L)	24					
	Lake water temperature	T_a	(°C)	5 / 10 / 15 / 20					
	Lake water density	ρ_a	(kg/m^3)	1000.01[a] / 999.75[a] / 999.15[a] / 998.25[a]					
Diffuser	Diffuser height above lakebed	h	(m)	1[a]					
	Number of nozzles	N		1[a]					
	Single nozzle discharge	q	(m^3/s)	0.231[a]					
	Nozzle inside diameter	d	(inch)	7.63 [10-inch DR 7.3(318 psi)]					
			(m)	0.1938[a]					
	Nozzle cross sectional area	a	(m^2)	0.0295					
	Nozzle exit flow velocity	V_0	(m/s)	7.84					
Dilution Performance	Dilution factor at a distance of 100 m away from the diffuser	S		45/46/46/47	45/46/46/48	28/28/28/50	43/43/44/45	42/43/44/45	28/28/28/28
	Maximum flow velocity at water surface	V_s	(m/s)	0.99[b]/0.98/[b] 0.97[b]/0.96[b]	0.96[b]/0.95[b]/ 0.95[b]/0.94[b]	0.78[b]/0.78[b]/ 0.77[b]/0.76[b]	1.0[b]/1.0[b]/ 0.99[b]/0.99b	0.97[b]/0.97[b]/ 0.97[b]/0.96[b]	0.80[b]/0.80[b]/ 0.79[b]/0.78[b]

°C = degrees Celsius, kg/m3 = kilogram per cubic metre, m = metre, m3/d = cubic metres per day, m3/s = cubic metres per second, mg/L = milligrams per litre.

Note a: Inputs to the CORMIX model.

Note b: Based on the modelling results by assuming water depth of 50 m so that the flow velocity at the lake surface can be estimated.

Table 12: Inputs and outputs of CORMIX Model Runs for the Open-Water Conditions with Vertical Stratification

Category	Description	Symbol	Units	Scenario		
				1	2	3
Effluent	Flow rate	Q	m^3/d	833		
			m^3/s	0.231[a]		
	TDS concentration	C_{01}	mg/L	14,300		
	Temperature	T_0	°C	8.5		
	Density	ρ	kg/m^3	1011.04[a]		
Ambient	Lake current speed	u_a	m/s	0.001[a]	0.055[a]	0.140[a]
	Lake water depth	H	m	10[a]		
	Lake TDS concentration	C_{ad}	mg/L	24		
	Lake surface water temperature	T_{as}	°C	20[b]		
	Lakebed water temperature	T_{ab}	°C	6[b]		
	Lake surface water density	ρ_{as}	kg/m^3	998.25[a]		
	Lakebed water density	ρ_{ab}	kg/m^3	999.99[a]		
	Stratification interface depth from water surface	H_s	m	4 / 5 / 6[a,c]		
Diffuser	Diffuser height	h	M	1[a]		
	Number of nozzles	N		1[a]		
	Single nozzle discharge	q	m^3/s	0.231[a]		
	Nozzle inside diameter	d	Inch	7.63 [10 inch DR 7.3(318 psi)]		
			m	0.1938[a]		
	Nozzle cross sectional area	a	m^2	0.0295		
	Nozzle exit flow velocity	V_0	m/s	7.84		
Dilution Performance	Dilution factor	S		46/46/46 [d]	46/47/47 [e]	28/28/49 [f]

Note a: Inputs to CORMIX model.

Note b: Based on water temperatures measured on August 2, 2018.

Note c: For 10 m depth, the allowable maximum stratification interface depth in CORMIX is 6 m.

Note d: Dilution factor at the edge of unstable recirculation zone which is 28 m from the diffuser.

Note e: Dilution factor at a distance of 100 m from the diffuser.

5.2.5 Control of Resuspension and Entrainment of Lakebed Sediments

The diffuser should be designed to control the flow velocities near the lakebed that will be induced by the resulting jets from the diffuser. The flow velocities near the lakebed needs to be controlled to a low level so that the lakebed sediments will not be entrained into the lake water. The main feature of the diffuser design in controlling the flow velocities near the lakebed and reducing the resulting shear stresses on the lakebed is to have the elevation of the diffuser nozzle opening at one meter above the lakebed.

Critical shear stress parameter is typically used to assess if sediment particles can be resuspended by flowing water. In this study, the critical shear stress was calculated based on the water temperature of 5°C using Yalin's curve (Yalin 1977). Based on the available data, the lakebed at the diffuser is expected to have sediments comprised of medium to fine grained sands with a range of particle sizes (D_{15} = 0.185 mm, D_{50} = 0.294 mm, and D_{85} = 0.398 mm).

The critical shear stress values corresponding to D_{15}, D_{50}, and D_{85} were calculated to be 0.19 Pascals (Pa), 0.21 Pa, and 0.24 Pa, respectively. The entrainment velocity from the diffuser jet, V_e was calculated using the following equation (Rajaratnam 1976):

$$V_e = 0.0277 U_m \qquad [1]$$

where U_m is jet centreline velocity. For the design exit flow velocity of 7.84 m/s from the nozzle (U_m = 7.84 m/s), the jet entrainment velocity V_e was calculated to be 0.217 m/s.

It was estimated that the flow velocity distribution between the nozzle exit and the lakebed can be approximated by the following log-law distribution (Chow 1959):

$$\frac{u}{u_*} = 5.75 \log\left(\frac{y}{k_s}\right) + 8.5 \qquad [2]$$

where u is horizontal velocity at depth y, u_* is shear velocity, and k_s is Nikuradse roughness height. $u = V_e$ when y = nozzle height of 1.0 m. The average flow velocity V between the nozzle exit and the lakebed can be expressed as:

$$V/u_* = 5.75 \log\left(\frac{y}{k_s}\right) + 6.25 \qquad [3]$$

Based on the following Chezy's equation (Chow 1959):

$$V = C\sqrt{yi} \qquad [4]$$

where C is Chezy's coefficient and i is the energy slope, Equation 4 can be reformulated as follows:

$$V/u_* = C/\sqrt{g} \qquad [5]$$

Chezy's coefficient C was estimated based on Manning's roughness n using the following equation:

$$C = y^{1/6}/n \qquad [6]$$

Combining Equations 3, 5 and 6 resulted in the following relation among n, y and K_s:

$$K_s = 12.22y/\exp\left(\frac{0.128y^{\frac{1}{6}}}{n}\right) \qquad [7]$$

The manning's roughness n for the lakebed was estimated to be 0.02. For y = 1 m, application of Equation 7 results in K_s = 0.0205 m, and the inputs to Equation 2 result in the following:

$$\frac{0.217}{u_*} = 5.75 \log\left(\frac{1}{0.0205}\right) + 8.5 \qquad [8]'$$

Using the above equation, u_* value was calculated to be 0.012 m/s. The corresponding shear stress τ was calculated as follows:

$$\tau = 1000 * u_*^2 = 1000*0.0119^2 = 0.14 \text{ Pa} \qquad [9]$$

The shear stress value of 0.14 Pa is less than the critical shear stresses of the three particle sizes mentioned above. Therefore, it is rational to conclude that the diffuser operation will not cause disturbance and entrainment of the lakebed sediments.

5.2.6 Evaluation of Outfall System Head Loss

The total head loss of the outfall system (outfall pipeline plus the diffuser) was evaluated to provide a basis for selecting a minimum pipe diameter so that the available head can still be used to operate the outfall system by gravity. Table 13 presents the inputs and outputs of the outfall system head loss calculation. The system available head is 29.7 m, estimated based on the difference between the pond and lake water surface elevations.

The results shown in Table 13 show that a 16-inch dimeter HDPE pipe (type DR11, 200 psi, see specification from the J-M Manufacturing Company) will result in a total system head loss of 25.2 m, which is less than the available head of 29.7 m. However, the smaller 14-inch pipes would result in the system head losses greater than the available head to operate the system. This confirms that the selected pipe type and size are appropriate for the design.

Table 13: Inputs and Outputs of the Outfall System Head Loss Calculation

Variable	Symbol	Unit	Value		
Inputs for the Main Outfall Pipe					
Pipe length	L	m	1300		
Pipe type			DR 11 (200 psi)	DR 11 (200 psi)	DR 13.5 (160 psi)
Pipe diameter	D	inch	16	14	14
Pipe inside diameter	D_i	m	0.328	0.287	0.300
Discharge	Q	m^3/s	0.231		
Hazen-Williams factor	C		150		
Pipe entrance head loss coefficient	C_{en}		0.5		
Inputs for the Diffuser Nozzle					
Port diameter	D_p	inch	10		
Port inside diameter	D_{pi}	m	0.194		
Port length	l_r	m	0.6	0.65	0.65
Port Hazon-Willian coefficient	C		150		
Head Loss in the Main Outfall Pipe					
Pipe flow velocity	V_p	m/s	2.74	3.58	3.28
Pipe friction head loss	H_fp	m	19.83	38.09	30.85
Pipe entrance head loss	H_{en}	m	0.19	0.33	0.27
Pipe total head loss	H_p	m	20.03	38.41	31.12
Head Loss in the Diffuser					
Port flow velocity	V_r	m	7.84		
Port exit head loss	h_{rv}	m	3.14		
Riser entrance head loss coefficient	x_{en}	m	0.60	0.69	0.66
Port entrance head loss	h_{ren}	m	1.89	2.17	2.06
Friction head loss in port	H_{fr}	m	0.119	0.129	0.129
Diffuser total head loss	H_d	m	5.15	5.44	5.33
Total Head Loss in the Outfall System					
System head loss	H_s	m	25.18	43.85	36.45

m = metre; m/s = metres per second; m3/s = cubic metres per second.

5.3 Quantity Estimates

An estimate of the material quantities of the outfall system, including the diffuser, was made based on the selected conceptual design. The estimated quantities are summarized in Table 14.

Table 14: Conceptual Material Quantity Estimate

Material	Properties	Unit	Value
Pipeline – on Land	HDPE Solid Pipe 16 inch diameter, DR 11, 200 psi	m	770
Pipeline – in Lake	HDPE Solid Pipe 16 inch diameter, DR 11, 200 psi	m	753
Diffuser Nozzle	HDPE Solid Pipe 10 inch diameter, DR 7.3, 318 psi	m	0.65

DR = dimension ratio, HDPE = high-density polyethylene, m = metre, psi = pounds per square inch

6.0 CONCLUSIONS AND RECOMMENDATIONS

The conceptual design of the outfall system, including the diffuser, for conveying and discharging the treated effluent from the monitoring ponds to Patterson Lake, consists of a 16 inch HDPE pipeline with a total length of 1,523 m (770 m to the shoreline and 753 m from the shoreline to the diffuser) and a diffuser having one 10 inch vertical nozzle with its opening at a height of 1.0 m above the lakebed.

The conceptual design of the outfall system, including the diffuser, was developed based on the results of the diffuser dilution performance modelling and hydraulic analyses. The results show that the available hydraulic head will be sufficient to operate the system by gravity only, the diffuser operation have higher dilution than the minimum requirement established for the edge of the 100 m mixing zone (dilution factor will be greater than 10), and the induced currents around the diffuser will not cause resuspension and entrainment of the lake bed sediments.

The diffuser operation will increase the flow velocity at the lake water surface, delay ice freeze-up, reduce ice thickness if ice cover is formed, and advance ice break-up, all within a small area around the diffuser.

6.1 Recommendations

The available information in this study is sufficient to support the conceptual design of the diffuser. It is recommended that the design basis and criteria be reviewed and updated if necessary, and the design parameter values be confirmed, refined or updated during Detailed Design phase of the Project.

Signage noting the safety hazards around the diffuser (e.g., high flow velocity and thin ice) should be installed and maintained during diffuser operation.

7.0 CLOSURE

This report was prepared and reviewed by the undersigned.

Golder Associates Ltd.

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APPENDIX A

Diffuser Location Option Evaluation

TECHNICAL MEMORANDUM

DATE December 2, 2019 **Reference No.** GAL-042-18114335-TM_Rev1

TO Jeremy Veszi, NexGen Energy Ltd.

CC Sheri Stark, Susan Mathieu, Gerard Van Arkel, Golder

FROM Ross Phillips and Dejiang Long, Golder **EMAIL** ross_phillips@golder.com

CONCEPTUAL DIFFUSER DESIGN: SUMMARY OF PHASE I – DIFFUSER LOCATION SCREENING – REV1

1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been commissioned by NexGen Energy Ltd. (NexGen) to prepare a conceptual design of a diffuser for discharge of treated effluent from the proposed NexGen Rook I Project (the Project). The proposed receiving waterbody is the North Arm of Patterson Lake. The scope of the conceptual diffuser design has been broken up into two phases: Phase 1 and Phase 2. Phase 1 consists of the tasks necessary to compare options for the location of the diffuser and select a preferred location to carry forward for further analysis. Phase 2 will consist of the tasks required to prepare the conceptual design of the diffuser.

More specifically, Phase 1 consists of the following tasks:

- Review the available information including Patterson Lake bathymetry and the proposed effluent treatment plant design including its location, operational mode, and range of treated effluent discharges.
- Identify three potential outfall locations within Patterson Lake and summarize their advantages and disadvantages.
- Compare and evaluate the potential outfall locations. The evaluation is supported by a high-level mixing analysis, which focuses on generation of some preliminary dilution performance values to support the option evaluation.
- Recommend a preferred outfall location to NexGen for review and approval.

This memorandum documents the basis, method and results of the Phase 1 work. The relevant background information that provides context for location screening is included in this memorandum.

2.0 BACKGROUND INFORMATION

2.1 Watershed Setting

Patterson Lake is located along the Clearwater River near its headwaters in northwestern Saskatchewan. The drainage area contributing to the Clearwater River where it drains into the North Arm – East Basin of Patterson Lake is 121 square kilometres (km^2). The cumulative watershed area increases to 264 km^2 where the Clearwater River outflows at the southeast corner of Patterson Lake.

2.2 Baseline Monitoring

Various environmental baseline monitoring activities have been ongoing on Patterson Lake since 2018. The aquatic baseline conditions in Patterson Lake were characterized by CanNorth (2019). Several studies were completed by Golder to characterize the hydrological conditions of Patterson Lake, including a summary of 2018 Hydrometric Monitoring Program (Golder 2019a), a baseline geomorphological characterization (2019b), and a regional meteorological and hydrological characterization (Golder 2019c).

Throughout the winter of 2018, NexGen measured ice thickness at the location of pumps located in the North Arm of Patterson Lake, which were operated and maintained in support of the geological exploration drilling programs. Ice thickness was also measured in weekly intervals at the water supply locations along an access road from shore to the pumping locations.

2.3 Patterson Lake Physical Characterization

Patterson Lake can be divided into the North Arm and South Arm oriented approximately southwest to northeast as shown in Figure 1. The North Arm can be further separated into the West Basin and East Basin separated by a narrow and shallow sand sill with spit formations forming on either side (Golder 2019c).

Patterson Lake surface water elevation fluctuates throughout the year with a water surface elevation of 498.8metres above mean sea level (masl), which is representative of the normal water level. The surveyed water surface elevation was 498.6 masl on August 8, 2018 and 498.5 masl on September 29, 2018. Both of these elevations were relative to the geodetic benchmarks established on the shore of Patterson Lake near the camp. Based on the results of preliminary hydraulic modelling completed using HEC-RAS for the Patterson Lake outlet channel (Clearwater River below Patterson Lake), the lake elevation would have an approximate range of 498.1 m (during droughts approaching zero outflow conditions) to 499.3 m (100-year flood level). The typical annual range of lake levels would be 498.5 to 499.0 masl.

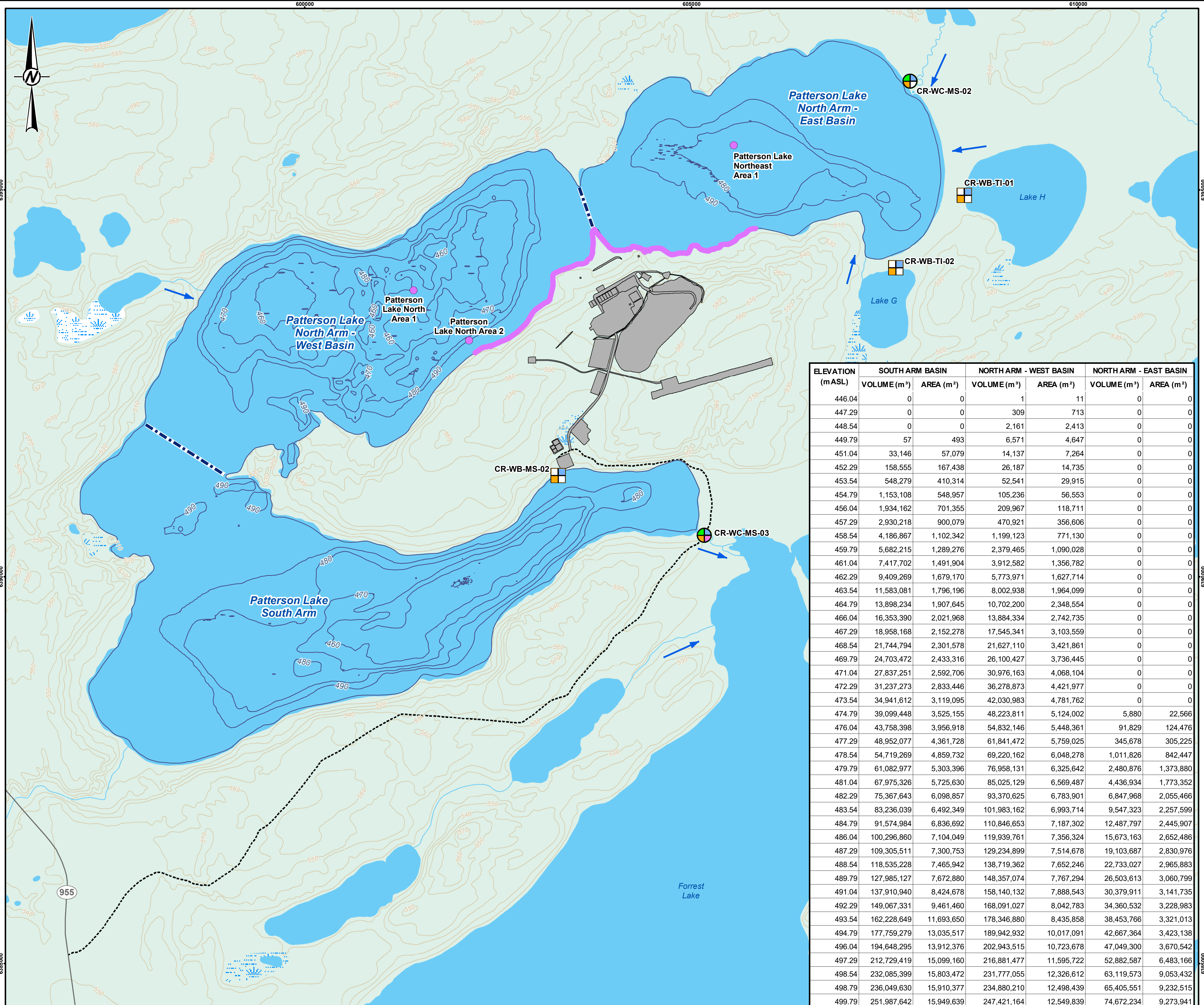
The North Arm – West Basin is the deepest of the three basins with a minimum bed elevation of 446.04 masl or a maximum depth of roughly 52.7 m. The deepest point in the North Arm – East Basin is 474.79 masl, corresponding to a maximum depth of roughly 24.0 m. The deepest point in the South Arm is 449.29, corresponding to a maximum depth of roughly 49.5 m.

Under normal conditions, Patterson Lake has a water surface elevation of 498.79 masl, a total water volume of 536 million cubic metres (Mm^3), and a surface area of 38 km^2. The physical characteristics of Patterson Lake's three basins are summarized in Table 1.

Table 1: Summary of Patterson Lake Basin Physical Characteristics

Basin	Maximum Depth (m)	Volume (Mm^3)	Surface Area (km^2)
North Arm - East Basin	24.0	65.4	9.23
North Arm - West Basin	52.7	235	12.5
South Arm	49.5	236	15.9

km^2 = square kilometres, m = metre, Mm^3 = millions of cubic metres.



ELEVATION (m ASL)	SOUTH ARM BASIN		NORTH ARM - WEST BASIN		NORTH ARM - EAST BASIN	
	VOLUME (m^3)	AREA (m^2)	VOLUME (m^3)	AREA (m^2)	VOLUME (m^3)	AREA (m^2)
446.04	0	0	1	11	0	0
447.29	0	0	309	713	0	0
448.54	0	0	2,161	2,413	0	0
449.79	57	493	6,571	4,647	0	0
451.04	33,146	57,079	14,137	7,264	0	0
452.29	158,555	167,438	26,187	14,735	0	0
453.54	548,279	410,314	52,541	29,915	0	0
454.79	1,153,108	548,957	105,236	56,553	0	0
456.04	1,934,162	701,355	209,967	118,711	0	0
457.29	2,930,218	900,079	470,921	356,606	0	0
458.54	4,186,867	1,102,342	1,199,123	771,130	0	0
459.79	5,682,215	1,289,276	2,379,465	1,090,028	0	0
461.04	7,417,702	1,491,904	3,912,582	1,356,782	0	0
462.29	9,409,269	1,679,170	5,773,971	1,627,714	0	0
463.54	11,583,081	1,796,196	8,002,938	1,964,099	0	0
464.79	13,898,234	1,907,645	10,702,200	2,348,554	0	0
466.04	16,353,390	2,021,968	13,884,334	2,742,735	0	0
467.29	18,958,168	2,152,278	17,545,341	3,103,559	0	0
468.54	21,744,794	2,301,578	21,627,110	3,421,861	0	0
469.79	24,703,472	2,433,316	26,100,427	3,736,445	0	0
471.04	27,837,251	2,592,706	30,976,163	4,068,104	0	0
472.29	31,237,273	2,833,446	36,278,873	4,421,977	0	0
473.54	34,941,612	3,119,095	42,030,983	4,781,762	0	0
474.79	39,099,448	3,525,155	48,223,811	5,124,002	5,880	22,566
476.04	43,758,398	3,956,918	54,832,146	5,448,361	91,829	124,476
477.29	48,952,077	4,361,728	61,841,472	5,759,025	345,678	305,225
478.54	54,719,269	4,859,732	69,220,162	6,048,278	1,011,826	842,447
479.79	61,082,977	5,303,396	76,958,131	6,325,642	2,480,876	1,373,880
481.04	67,975,326	5,725,630	85,025,129	6,569,487	4,436,934	1,773,352
482.29	75,367,643	6,098,857	93,370,625	6,783,901	6,847,968	2,055,466
483.54	83,236,039	6,492,349	101,983,162	6,993,714	9,547,323	2,257,599
484.79	91,574,984	6,836,692	110,846,653	7,187,302	12,487,797	2,445,907
486.04	100,296,860	7,104,049	119,939,761	7,356,324	15,673,163	2,652,486
487.29	109,305,511	7,300,753	129,234,899	7,514,678	19,103,687	2,830,976
488.54	118,535,228	7,465,942	138,719,362	7,652,246	22,733,027	2,965,883
489.79	127,985,127	7,672,880	148,357,074	7,767,294	26,503,613	3,060,799
491.04	137,910,940	8,424,678	158,140,132	7,888,543	30,379,911	3,141,735
492.29	149,067,331	9,461,460	168,091,027	8,042,783	34,360,532	3,228,983
493.54	162,228,649	11,693,650	178,346,880	8,435,858	38,453,766	3,321,013
494.79	177,759,279	13,035,517	189,942,932	10,017,091	42,667,364	3,423,138
496.04	194,648,295	13,912,376	202,943,515	10,723,678	47,049,300	3,670,542
497.29	212,729,419	15,099,160	216,881,477	11,595,722	52,882,587	6,483,166
498.54	232,085,399	15,803,472	231,777,055	12,326,612	63,119,573	9,053,432
498.79	236,049,630	15,910,377	234,880,210	12,498,439	65,405,551	9,232,515
499.79	251,987,642	15,949,639	247,421,164	12,549,839	74,672,234	9,273,941

LEGEND

- BATHYMETRY CONTOUR ELEVATION (METRES)
- ELEVATION CONTOUR (10m INTERVAL)
- FLOW DIRECTION
- LAKE BASIN DIVISION
- SECONDARY HIGHWAY
- WATERCOURSE
- WATERBODY
- WETLAND
- WOODED AREA
- AQUATIC BASELINE MONITORING POINT (CANNORTH 2019)
- AQUATIC BASELINE DETAILED STUDY AREA USED BY CANNORTH (2019)

WATERBODY HYDROMETRIC STATIONS

- DISCHARGE
- SURVEYED BENCHMARK (GEODETIC DATUM)
- TOTAL SUSPENDED SOLIDS AND BEDLOAD
- WATER SURFACE ELEVATION

PROJECT FEATURES

- EXISTING ACCESS ROAD
- PROPOSED FOOTPRINT

WATERCOURSE HYDROMETRIC STATIONS

- DISCHARGE
- SURVEYED BENCHMARK (GEODETIC DATUM)
- TOTAL SUSPENDED SOLIDS AND BEDLOAD
- WATER SURFACE ELEVATION

0 1,000 2,000

1:50,000 METRES

NOTE(S)

1. WATER SURFACE ELEVATION ESTIMATED TO BE 498.79 MASL ASSOCIATED WITH MEAN ANNUAL FLOOD.
2. LAKE VOLUME ON JUNE 6-8, 1981:
- SOUTH ARM BASIN = 236,049,630 M^3
- NORTH ARM - WEST BASIN = 234,880,210 M^3
- NORTH ARM - EAST BASIN = 65,405,551 M^3

REFERENCE(S)

1. BASE DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.
2. BATHYMETRY CONTOURS DERIVED FROM DATA COLLECTED BY NEXGEN, 2016.
PROJECTION: UTM ZONE 12 DATUM: NAD 83

CLIENT

NexGen Energy Ltd.

PROJECT

ROOK I PROJECT

TITLE

PATTERSON LAKE – PHYSICAL CHARACTERISTICS AND BASELINE MONITORING ACTIVITIES

CONSULTANT

GOLDER

YYYY-MM-DD	2019-11-28
DESIGNED	RP
PREPARED	LMS
REVIEWED	RWP
APPROVED	DL

PROJECT NO.	PHASE	REV.	FIGURE
18114335	6000	0	1

2.4 Baseline Aquatic Habitat Characterization

CanNorth (2019) documented the aquatic environment near the proposed treated effluent discharge location in Patterson Lake, including the lake morphometry, water and sediment quality, plankton and benthic invertebrate communities, aquatic macrophyte chemistry, water chemistry, and fish spawning, habitat and community.

Although fine sand and coarse sand accounted for most of the sediment on the lake bed (with 0 cm to 2 cm thickness), there was some variability (CanNorth 2019). As shown in Figure 2, an elevated silt concentration was noted in the deep Patterson Lake North Area 1. Patterson Lake North Area 2, located near shore south west of the various diffuser options, was noted to be predominantly coarse and fine sand in the first five centimetres of the bed substrate, as shown in Figure 2.

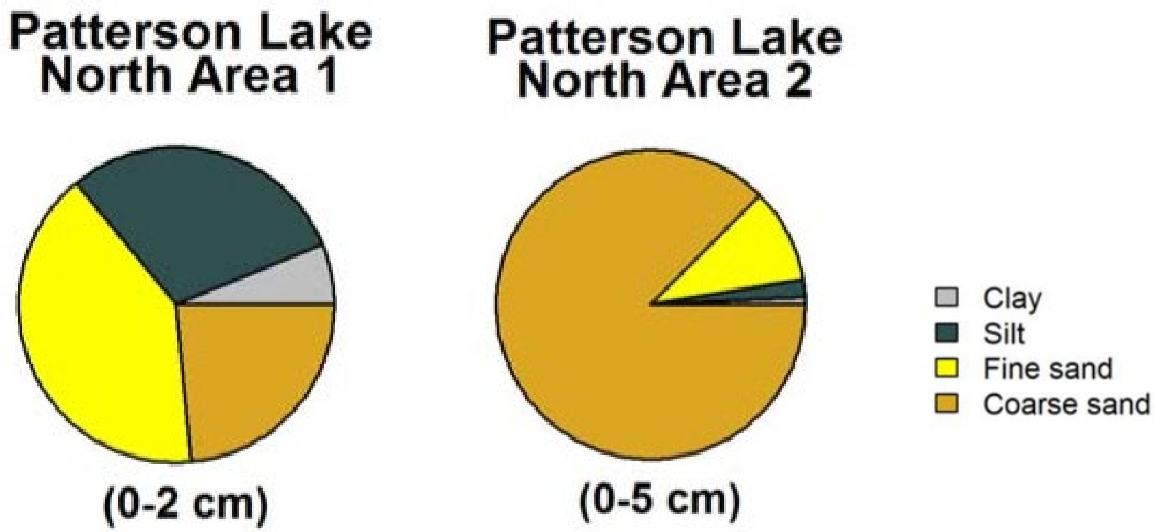


Figure 2: Particle Size Contents of the Sediment Collected by CanNorth (2019) near the Various Diffuser Options

CanNorth (2019) also completed spring and fall spawning surveys and documented specific locations used by large-bodied fish for spawning. All of Patterson Lake was included in the spawning surveys with special attention paid to the detailed study area (Figure 1). Fish habitat mapping was also completed in the Patterson Lake detailed study area to record the quantity and quality of potential spawning habitat for large-bodied fish species known to occur there. The focus of the fish habitat mapping was in the littoral zone.

2.5 Proposed Water Treatment Plant Configuration

The treated water will be stored in a series of six holding ponds. The proposed layout of the effluent treatment plant and process ponds shown on Figure 3 in the northwest corner of the proposed mine footprint. A total of six process ponds are proposed. From west to east there are four monitoring ponds, one contingency pond, and one feed settling pond (see Figure 3). There are also two additional contingency ponds located to the west of the monitoring ponds but these are not discussed in detail here. The feed settling pond will be sized to have 16,000 m^3 with 1 m of freeboard. The pond will be operated such that a capacity of 1,100 m^3 will be available to store runoff generated from the area surrounding the production shaft and in the pipe containment corridor. Each monitoring pond and the contingency pond are sized to have 5,000 cubic metres (m^3) while maintaining 1 m freeboard to accommodate the PMP event. The discharge from the monitoring ponds to the lake will be operated in batch mode. Emptying an individual monitoring pond will have a six-hour target emptying time and the design discharge rate from the ponds to the lake is 833 cubic metres per hour (m^3/h) (Boehm pers. Comm 2019a).

The existing ground surface elevation at the location of the monitoring ponds is 537 masl) though specific operating water levels are not known at this time.

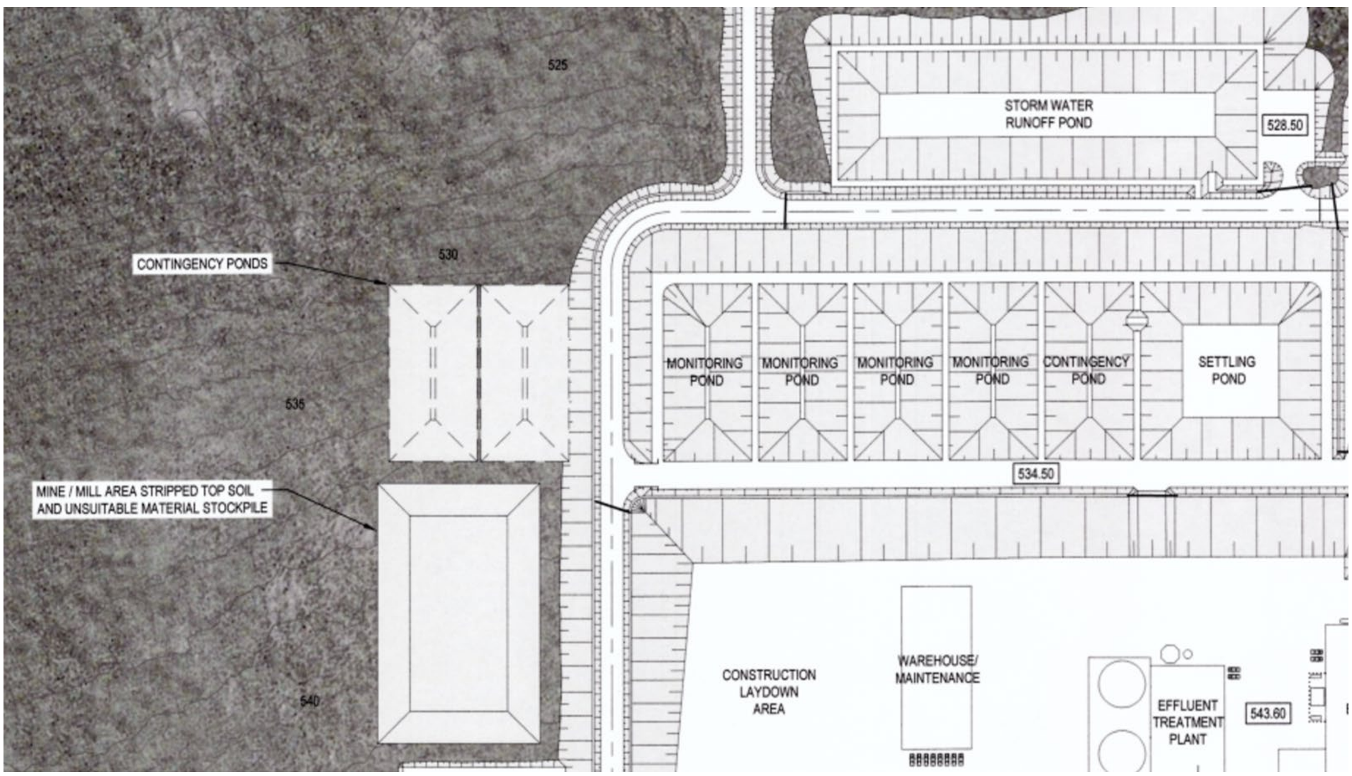


Figure 3: Process Ponds Layout (Wood 2019)

2.6 High-Level Mixing Analysis

A high-level mixing analysis was conducted to differentiate the mixing performance at various locations in Patterson Lake and to identify a preliminary depth for siting the diffuser. The high-level mixing analysis was conducted using CORMIX (Doneker and Jirka 2007) for winter operation when there is minimum ambient current and based on the following parameters:

- Ice cover of one metre thick which is consistent with the maximum annual ice development observed on Patterson Lake in late-February 2019;
- Diffuser discharge of 833 cubic metres per hour (m^3/h) (Boehm pers. Comm. 2019b); and
- Effluent with total dissolved solids (TDS) in the range of 2,500 milligrams per litre (mg/L) and 25,000 mg/L (Boehm pers. Comm. 2019a).

Based on the modelling results the optimal depth range is estimated to be between 5 m and 15 m. These high-level modelling results are preliminary and will be finalized during detailed modelling in Phase 2.

3.0 IDENTIFICATION AND EVALUATION OF LOCATION OPTIONS

3.1 Location Options

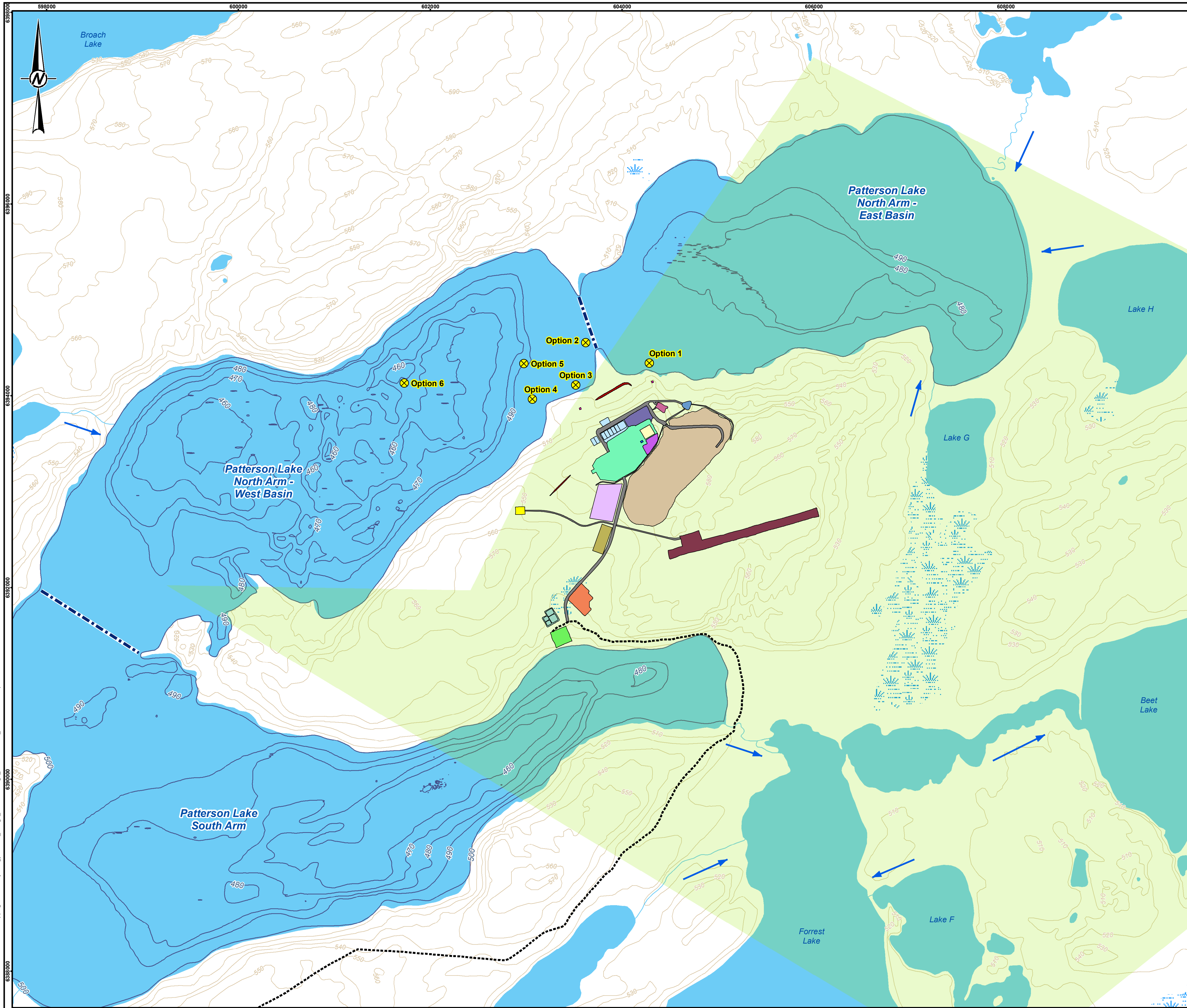
Six candidate locations were identified and evaluated. All locations considered are in the North Arm of Patterson Lake near the proposed location of the effluent treatment plant and associated process ponds. The options included near shore locations in the North Arm – West Basin and North Arm – East Basin, as well as an off shore (deep water), and optimum depth option. The locations of options in Patterson Lake and relation to the project footprint are shown in Figure 4.

Table 2 includes a description of each option and key physical characteristics of each option including the approximate coordinates, depth, and straight-line distance from an assumed upstream end of a pipeline from the process ponds that is common to all options. A pipeline to the diffuser would consist of a portion of the alignment on land and a portion of the alignment under water. For this preliminary exercise, the portion of the alignment that is on land was constrained to the extent of the mineral lease shown on Figure 4. The portion of the alignment underwater is the shortest straight line form the shore to the diffuser location.

Table 2: Summary Description of Location Options

Location	Description	Easting (m)[a]	Northing (m)[a]	Distance from Effluent Pond (m)	Water Depth[b] (m)
Option 1	North Arm, East Basin, Near Shore	604284	6394340	893	1.05
Option 2	North Arm, Narrow, Near Shore	603620	6394555	959	0.79
Option 3	North Arm, West Basin, Near Shore	603517	6394113	566	0.85
Option 4	North Arm, West Basin, Near Shore, Close to Effluent Pond	603064	6393964	790	2.39
Option 5	North Arm, West Basin, Optimal Depth	603641	6393614	1,300	10.0
Option 6	North West Basin, Maximum Depth	601635	6394182	2,220	46.4

Notes:
a) All coordinates are in UTM 12V NAD83.
b) Estimated based on water surface elevation of 498.79 metres above mean sea level (masl).



LEGEND

- BATHYMETRY CONTOUR ELEVATION (METRES)
- ELEVATION CONTOUR (10m INTERVAL)
- FLOW DIRECTION
- LAKE BASIN DIVISION
- WATERCOURSE
- WATERBODY
- WETLAND
- NEXGEN MINERAL LEASE
- DIFFUSER LOCATION OPTION

PROJECT FEATURES

- EXISTING ACCESS ROAD
- AIRSTRIP
- CLEAN WASTE ROCK
- CONSTRUCTION CAMP
- CONTINGENCY RETENTION BERM
- EXHAUST SHAFT
- EXPLOSIVE STORAGE
- DOMESTIC WASTE WATER TREATMENT FACILITY
- MILL OPERATIONS AREA
- ORE PAD
- PERMANENT CAMP
- POTENTIAL DOMESTIC/INDUSTRIAL WASTE MANAGEMENT AREA
- POTENTIAL SOLAR FACILITIES
- POTENTIAL WASTE INCINERATOR
- POTENTIAL WIND TURBINE
- PRODUCTION SHAFT AND ASSOCIATED INFRASTRUCTURE
- ROAD
- SPECIAL WASTE ROCK PAD
- STORAGE/MONITORING POND
- STORMWATER RUNOFF POND

0 1,000 2,000
1:40,000 METRES

NOTE(S)

1. WATER SURFACE ELEVATION ESTIMATED TO BE 498.79 MASL ASSOCIATED WITH MEAN ANNUAL FLOOD.
2. LAKE VOLUME ON JUNE 6-8, 1981:
- SOUTH ARM BASIN = 236,049,630 M^3
- NORTH ARM - WEST BASIN = 234,880,210 M^3
- NORTH ARM - EAST BASIN = 65,405,551 M^3

REFERENCE(S)

1. BASE DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.
2. BATHYMETRY CONTOURS DERIVED FROM DATA COLLECTED BY NEXGEN, 2016.
PROJECTION: UTM ZONE 12 DATUM: NAD 83

CLIENT
NexGen Energy Ltd.

PROJECT
ROOK I PROJECT

TITLE
PRELIMINARY DIFFUSER LOCATION OPTIONS

CONSULTANT
GOLDER

YYYY-MM-DD	2019-11-28
DESIGNED	RP
PREPARED	LMS
REVIEWED	RWP
APPROVED	DL

PROJECT NO.	PHASE	REV.	FIGURE
18114335	6000	0	4

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B 25mm

PATH: I:\CLIENTS\NexGen\18114335\Mapping\Products\Hydrology\Diffuser_Design_TechMemo\Fig4_18114335-6000_DiffuserLocationOptions.mxd PRINTED ON: 2019-11-28 AT: 9:45:57 AM

3.2 Evaluation Criteria

The criteria used in the option evaluation are summarized in Table 3. The criteria were developed in consultation with NexGen to ensure company objectives were considered as part of this process. This table includes a brief description of how each criterion was used in the evaluation. The weight assigned to each of these criteria is presented in Table 5.

Table 3: Description of Evaluation Criteria

Criteria			Application in the Evaluation
Category	Description	Weight	
Technical Factors	Adequate Water Depth	10%	The optimal depth for the diffuser is estimated to be within the range of 5 m to 15 m. The depth of each option was based on bathymetry data for Patterson Lake provided by NexGen. Bathymetry contours are shown in Figure 1 and Figure 4 and the depth at each location point is included in Table 2.
	Favourable Ambient Currents	10%	A preliminary review of lake geomorphology and wind data were used to estimate general directions of lake current relevant to near-field and far-field mixing.
	Ease of Construction	5%	Shorter pipeline length and shallower water are estimated to make construction easier.
Costs	Distance from the Effluent Pond	25%	The main differentiator in the total costs is the length of the pipeline associated with distance from effluent pond. The distance from the effluent point is noted in Table 2.
Environmental Effects	Potential Effects on Lake Water Quality	13%	Evaluated at a high level based on physical conditions and probable water quality outcomes.
	Potential Effects on Aquatic Habitat	12%	Evaluated at a high level based on a review of the baseline aquatic habitat conditions detailed by CanNorth (2019). The results of the fish habitat assessment are noted in Table 4.
Regulators and Indigenous Communities	Effects on Traditional Land Use	10%	Evaluated based on the possible changes to ice cover thickness and surface flow velocity. The less change, the better.
	Mixing Zone	15%	The smaller the estimated mixing zone, the better.

3.3 Option Rating and Ranking

The adopted rating scheme is relative with a rating of 10 for the best option and 1 for the worst option, rated based on individual criteria. The other options between the best and worst are rated on a scale between 1 and 10.

Fish habitat was noted to be quite variable in the North Arm of Patterson Lake (CanNorth 2019). Table 4 provides a summary of the findings of the habitat assessment completed by CanNorth (2019) as they pertain to the location options. The Habitat Section listed for each of the location options is the section of shoreline, according to the shoreline classification completed as part of the habitat assessment completed by CanNorth (2019), that would be intersected by a straight line connecting the location option with the process ponds.

Although the various options are situated in relative proximity, the habitat sections they would intersect with at the shoreline have variable suitability for spawning large bodied fish. Option 4 and Option 6 intersect the littoral zone in Habitat Section 7 (HS7), which has relatively high value as fish habitat and suitability for spawning. Options 1 and 3 would likely interact with littoral habitat that is moderately suitable for spawning walleye and lake whitefish and marginally suitable for spawning white sucker and long nose sucker. Conversely, Option 2 would intersect the littoral zone in habitat sections that have low suitability for spawning being only marginal spawning habitat. Option 2 would be marginal habitat for walleye and lake whitefish and not-suitable for all other large bodied fish included in the assessment. Option 5 would be marginal habitat for yellow perch and not-suitable for all other large bodied fish included in the assessment.

The results of the location option rating and weighted score are summarized in Table 5. The scores for Options 1, 2, 3, and 4 are comparable and lower than the other two options. Each of these four options has a small distance from the proposed effluent treatment plant and is sited in shallow water (<1 m). The shallow water areas would make construction relatively easy, but these options are rated low based on the other criteria. Small water depth is not favourable for mixing because of the unfavourable local and ambient conditions, and the resulting ratings in terms of environmental effects and regulatory and indigenous communities criteria would presumably be low. Options 1, 3 and 4 would interact with littoral fish habitat that is suitable for spawning by several large bodied fish that should be avoided.

Option 6 would be the furthest from the monitoring ponds and would be sited in deep (46.4 m) water. These characteristics would likely make construction difficult. The score for Option 6 is much lower than that for Option 5.

Option 5 located in the North Arm – West Basin at an optimal depth of around 10 m has the first rank. It is sited in a location that is estimated to have favourable ambient currents in carrying discharged treated effluent away from the diffuser. A conceptual pipeline alignment connecting it to the location of the monitoring ponds would intersect a section of shoreline referred to by CanNorth (2019) as HS8 which consists of 95% sand and 0% organic and was noted to be not suitable spawning habitat for all large bodied fish included in the assessment except for yellow perch for which it would only be marginally suitable.

Table 4: Summary of Habitat Assessment Results for the Location Options (CanNorth 2019)

Option	Habitat Section #	Upland Zone Upland Conditions				Riparian Zone				Littoral Zone																				Spawning Suitability Index							
										Substrate (%)								Cover						Aquatic Vegetation				Bottom Slope									
		Land Use	Forest Conditions	Canopy	Slope	Vegetation Category	Vegetation Type	Bank Slope	Bank Stability	Silt / Clay	Sand	Gravel	Cobble	Boulder	Bedrock	Organic	Rock Cleanliness	Large Woody Debris	Aquatic Vegetation	Rock	Overhanging Vegetation	Undercut	Surface Turbulence	Emergent	Floating	Submergent	Moss/Algae	Slope	Depth 5 m from shore	Northern Pike	Walleye	Lake Whitefish	Lake Trout	Yellow Perch	Arctic Grayling	White Sucker	Longnose Sucker
1	33	FOR	M	M	G	FB	S,T	M	S	0	20	40	30	10	0	0	S	A	A	S	S	A	A	A	A	S	S	D	0.4	0	2	2	0	1	NR	1	1
2	5	FOR	M	C	G	FB	S,T	G	S	0	95	0	5	0	0	0	C	A	A	A	S	A	A	A	A	A	A	G	0.2	0	1	1	0	0	NR	0	0
3	6	FOR	M	C	G	FB	S,T	G	S	0	60	20	10	10	0	0	C	A	A	S	A	A	A	A	A	A	A	G	0.4	0	2	2	0	0	NR	1	1
4	7	FOR	M	C	G	W	S,T	M	S	0	0	30	40	30	0	0	C	A	A	S	A	A	A	A	A	A	A	G	0.9	0	3	3	2	0	NR	1	1
5	4	FOR	M	M	G	FB	S,T	G	S	0	95	0	0	0	0	5	-	A	A	A	A	A	A	A	A	A	A	G	0.2	0	0	0	0	1	NR	0	0
6	7	FOR	M	C	G	W	S,T	M	S	0	0	30	40	30	0	0	C	A	A	S	A	A	A	A	A	A	A	G	0.9	0	3	3	2	0	NR	1	1

Habitat Section # is the habitat section number used by CanNorth (2019). **Land Use** is the upland zone land use with **FOR** = Forest, **WL** = Wetland; **IND** = Industrial, **N** = None; **Forest Condition** is the condition of the upland forest with **M** = Mature, **B** = Burnt, **R** = Regenerating, and **N** = None; **Canopy** is a summary classification of the predominant tree type in the forest canopy with **C** = Coniferous Trees, **D** = Deciduous Trees, **M** = Mixed, **N** = None. Upland zone **Slope** is a summary of the slope near the shoreline with **S** = Steep with slope greater than 45º, **M** = moderate with slope between 15º and 45º, **G** = gradual with slope less than 15º; The Vegetation Category is a summary classification of the category of vegetation in the riparian zone with **FB** = Forest to Bank, **GB** = Grass to Bank, **T** = Transition, **W** = Wetland; **Vegetation Type** is a summary classification of the type of vegetation in the riparian zone with **T** = Tree, **S** = Shrub, and **G** = Grass / Sedge; **Bank Slope** summarizes the slope of the bank with **S** = Steep with slope greater than 45º, **M** = moderate with slope between 15º and 45º, **G** = gradual with slope less than 15º; **Bank Stability** describes how stable the bank is with **S** = Stable, **SU** = Slightly unstable, **MU** = Moderately unstable with < 50% of banks in the unit are stable, and **HU** = Highly unstable with massive bank slumping observed; **Water Depth =** the depth in metres 5 m from the shore**; Substrate (%) = Relative abundance of each substrate category; Cover is evaluated according to the relative abundance of each cover type with A =** Absent**, S =** Sparse distribution <30%, **M =** Moderate distribution 30% to 70%**, and D =** Dense distribution > 70%**; Aquatic vegetation** is evaluated according to the relative abundance of each aquatic vegetation type with **A** = Absent, **S** = Sparse distribution <30%, **M** = Moderate distribution 30% to 70%, **and D =** Dense distribution > 70%**; Bottom Slope** is evaluated according to the slope of the bed near the shoreline with **S** = Steep with slope greater than 45º, **M** = moderate with slope between 15º and 45º, **G** = gradual with slope less than 15º; **Water Depth =** the depth in metres 5 m from the shore; **Spawning Suitability Index =** Index rating based on known spawning habitat characteristics from literature for individual species that range from a value of **0 =** Not Suitable**, 1 =** Marginal**, 2 =** Moderate**, 3 =** Most suitable.

Table 5: Multicriteria Screening for Preferred Diffuser Location

Criteria		Weight	1	2	3	4	5	6
			North Arm, East Basin, Near Shore	North Arm, Narrow, Near Shore	North Arm, West Basin, Near Shore	North Arm, West Basin, Near Shore, Close to Effluent Pond	North Arm, West Basin, Optimal Depth	North Arm, West Basin, Maximum Depth
Technical Factors	Adequate Water Depth	10%	1	1	1	1	10	5
	Favourable Ambient Conditions	10%	1	2	1	3	10	6
	Ease of Construction	5%	8	7	9	10	3	1
Costs	Distance from the Effluent Pond	25%	8	7	9	10	7	1
Environmental Effects	Effects on Lake Water Quality	13%	1	2	1	3	10	8
	Effects on Aquatic Habitat	12%	2	8	1	1	10	6
Regulators and Other Stakeholders	Effects on Traditional Land Use	10%	2	1	2	2	9	10
	Mixing Zone	15%	1	2	1	2	10	8
Weighted Score			3.3	4.0	3.5	4.4	8.8	5.4
Rank			**5**	**6**	**4**	**3**	**1**	**2**

% = percent.

4.0 CONCLUSION AND RECOMMENDATION

Option 5 was ranked first among the six locations. Option 5 has an overall evaluation score of 8.8 out of 10 whereas the second best option scores 5.4 out of 10; Therefore, Option 5 was selected as the preferred location for siting the diffuser.

Option 5 will be carried forward to Phase 2 work for preparing the conceptual design of the diffuser. The exact location of the diffuser and its design configuration will be determined in Phase 2 based on detailed CORMIX modelling. However, it should be noted that there is still opportunity for input from Indigenous communities on the final diffuser location during the Environmental Assessment process.

5.0 CLOSURE

This memorandum was prepared and reviewed by the undersigned.

Prepared by:

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MEMBER 22672
19 12 02
YR. MN. DAY
SASKATCHEWAN

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Water Resources Engineer

Reviewed by:

Dejiang Long, Ph.D., P.Eng. (Alberta)
Principal, Senior Water Resources Engineer

RP/DL/JB/al/jlb

Association of Professional Engineers & Geoscientists of Saskatchewan

CERTIFICATE OF AUTHORIZATION

Golder Associates Ltd.
Number C0230

Permission to Consult held by:

Discipline	Sk. Reg. No.	Signature
Water Resources	22672	

References

Boehm, A. 2019a. Personal Communication by Email on July 12, 2019.

Boehm, A. 2019b. Personal Communication by Email on July 25, 2019.

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APPENDIX B

Laboratory Analysis

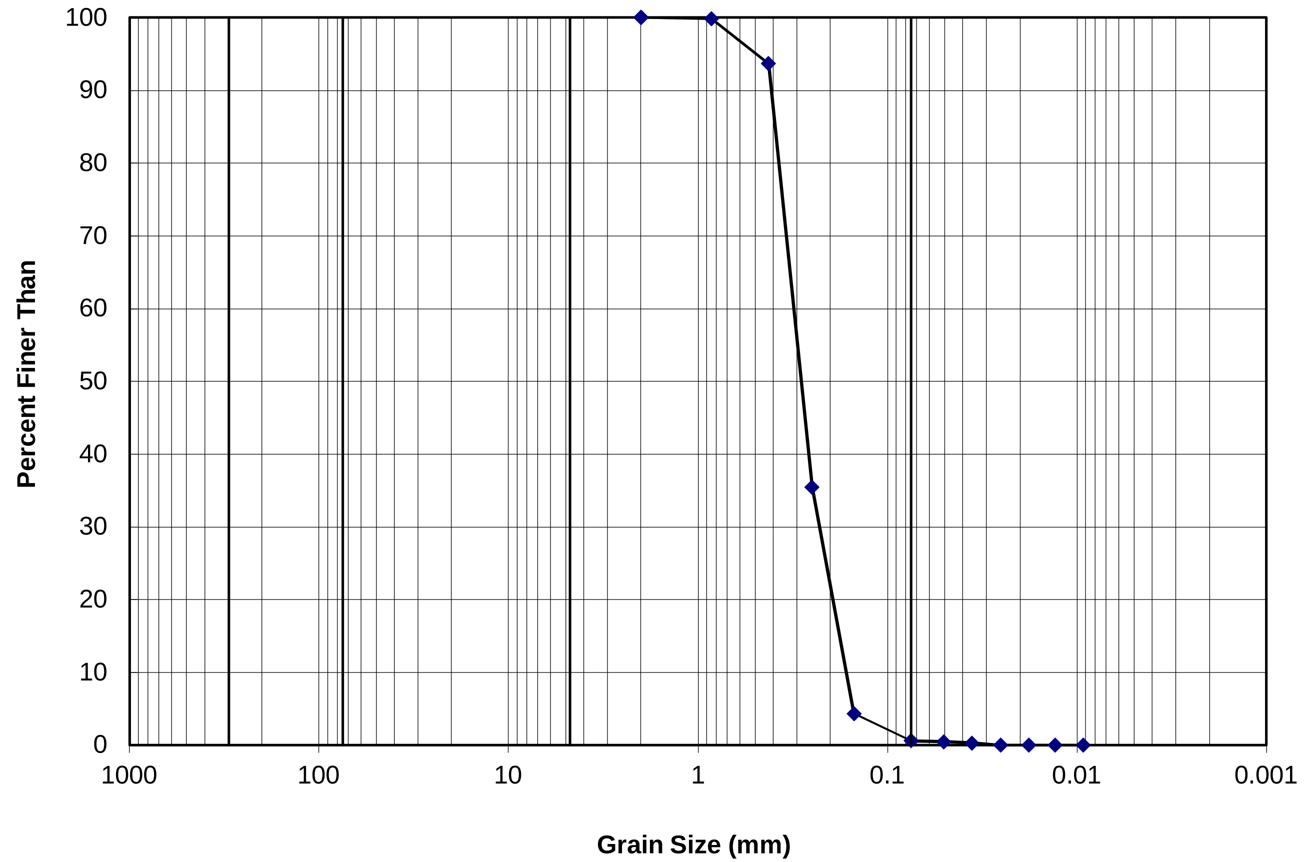
GOLDER

GRAIN SIZE ANALYSIS
(Mechanical & Hydrometer)

Project #: 19114981 | Phase: 4200 / 4202
Short Title: NexGen / RookI 2019 Baseline Programs / SK
Tested by: S.H. | Date: June 10, 2019

Sample #: Bed substrate diffuser location
Source: 8.0m deep
Date Sample Received: May 28, 2019

Graphical Analysis



BOULDERS	COBBLES	GRAVEL		SAND			SILT / CLAY
		Coarse	Fine	Coarse	Medium	Fine	

Grain Size Analysis Results:

Opening (mm)	Percent Passing (%)
51	100
38	100
25	100
19	100
9.5	100
4.75	100
2.0	100
0.850	100
0.425	94
0.250	35
0.150	4.4
0.075	0.6
0.050	0.5
0.036	0.3
0.025	0.0
0.018	0.0
0.013	0.0
0.009	0.0
0.007	0.0
0.004	0.0
0.003	0.0
0.002	0.0
0.001	0.0

Comments:

1721 8th Street E.,
Saskatoon, Saskatchewan S7N 0T4

Reviewed by:

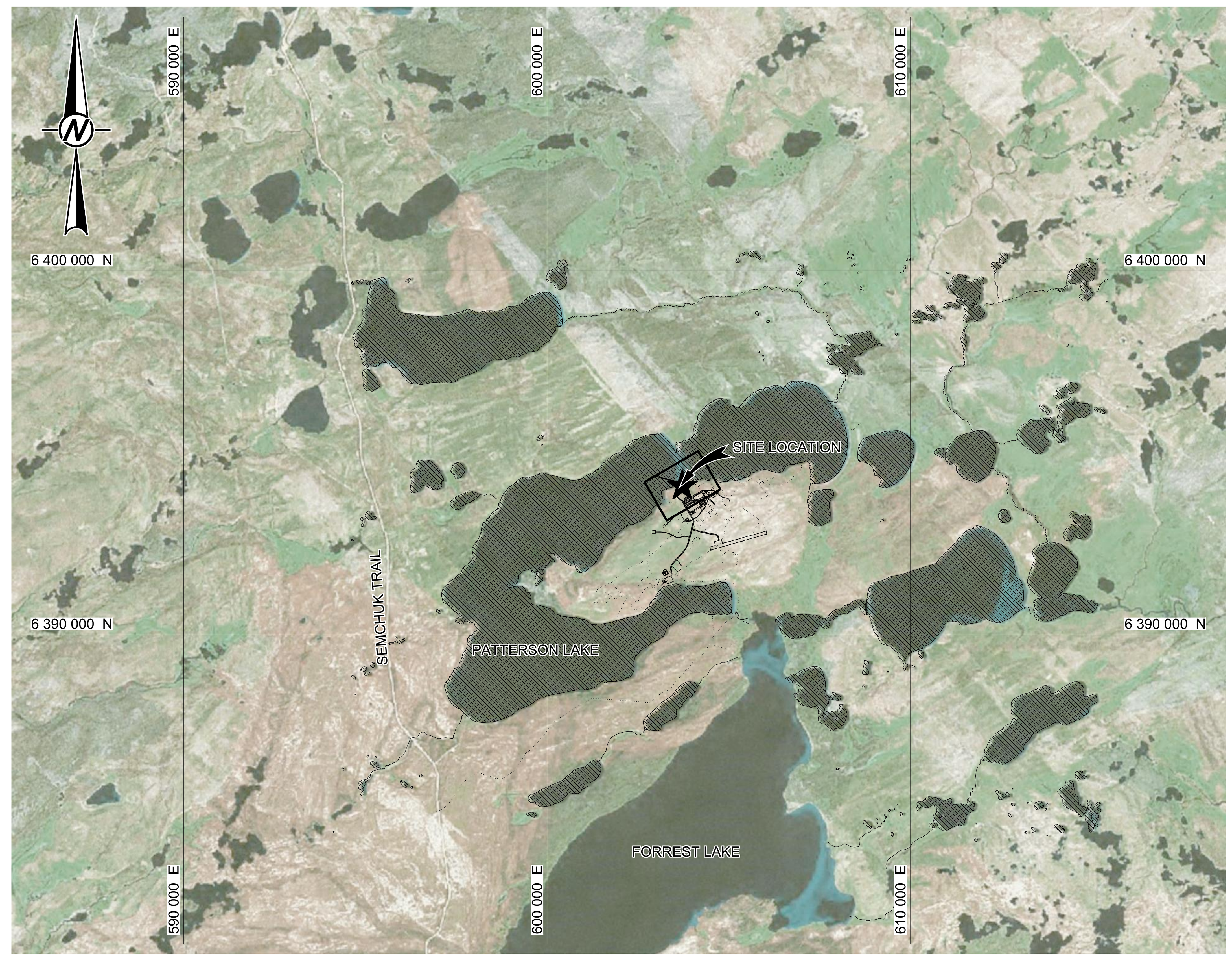
APPENDIX C

Conceptual Design Drawings

NEXGEN ENERGY LTD.
ROOK I DIFFUSER CONCEPTUAL DESIGN

SASKATCHEWAN

SITE VICINITY
SCALE: NTS



SITE LOCATION
SCALE: 1 : 100,000

DRAWING LIST		
DRAWING NUMBER	DRAWING TITLE	REV.
G-001	TITLE PAGE INCLUDING DRAWING LIST	A
G-002	LEGEND	A
C-001	SITE PLAN AND PROFILE OF THE PIPELINE ALIGNMENT	A
C-002	DETAILS AND CROSS SECTIONS	A

NOT FOR CONSTRUCTION

REV.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED
A	2019-11-29	ISSUED FOR REVIEW	SW	CV	RWP	DL

SEAL

CLIENT
NexGen Energy Ltd.

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GOLDER

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PROJECT
ROOK I DIFFUSER CONCEPTUAL DESIGN

TITLE
TITLE PAGE INCLUDING DRAWING LIST

PROJECT NO.	CONTROL	REV.		DRAWING
18114335	6000/6010	A	1 of 4	G-001

SAMPLING / MONITORING

- BOREHOLE LOCATION
- BOREHOLE LOCATION (BY OTHERS)
- BOREHOLE LOCATION (PROPOSED)
- MONITORING WELL LOCATION
- MONITORING WELL LOCATION (BY OTHERS)
- MONITORING WELL LOCATION (PROPOSED)
- PIEZOMETER LOCATION
- PIEZOMETER LOCATION (BY OTHERS)
- PIEZOMETER LOCATION (PROPOSED)
- TEST PIT LOCATION
- TEST PIT LOCATION (BY OTHERS)
- TEST PIT LOCATION (PROPOSED)
- SOIL SAMPLE
- HAND AUGER
- INCLINOMETER LOCATION (EXISTING)
- INCLINOMETER LOCATION (PROPOSED)
- CPT LOCATION (EXISTING)
- CPT LOCATION (PROPOSED)
- WATER WELL DRY
- WATER WELL - ELOG
- WATER WELL FIELD VERIFIED
- WATER WELL PRODUCING
- INJECTION WELL

SURVEY SYMBOLS

- BENCHMARK
- CONTROL POINT
- FOUND IRON PIN (FIP)
- DESIGN GRADE

GENERAL FEATURES & SYMBOLS

- CULVERT LOCATION
- LIGHT STANDARD
- MANHOLE
- CATCH BASIN
- FIRE HYDRANT
- SIGN
- POWERPOLE
- BREAKLINE
- DEPOSITION LOCATION
- FLOW DIRECTION
- GRADE INDICATOR
- SLOPE DIRECTION
- WATER SURFACE
- 1V 2H SLOPE LABEL
- PROJECT LOCATION STAR

LINETYPES - UTILITIES

ABANDONED EXISTING

- FIBER OPTIC LINE
- NATURAL GAS LINE
- NON POTABLE WATER LINE
- OVERHEAD POWERLINES
- POTABLE WATER
- POWERLINE
- SANITARY LINE
- STORM DRAIN
- TELEPHONE LINE
- T — T — TRANSMISSION LINE
- UNDERGROUND LINE
- WASTE WATER
- W — W — WATER LINE

LINETYPES - PLAN FEATURES

EXISTING NEW

- X — X — FENCE LINE
- DITCH
- SILT FENCE
- STRAW BALE
- SWALE
- GUARDRAIL
- TREELINE
- CENTERLINE (ALIGNMENT)
- DESIGN LINES
- 930 — 930 — MAJOR CONTOUR
- 931 — 931 — MINOR CONTOUR
- PERFORATED PIPING
- PIPELINE
- SOLID PIPING
- PROPERTY LINE
- RAIL LINE
- TMA BOUNDARY
- WORKING LIMITS

LINETYPES - SECTIONS / DETAILS / PROFILES

- EXISTING GROUND
- NATURAL / ORIGINAL GROUND
- FINISHED GRADE
- HATCH BOUNDARY
- HDPE LINER
- LINER OTHER
- NON-WOVEN GEOTEXTILE
- PROJECTED EMBANKMENT
- STRIPPED GROUND
- SUBGRADE / SUBCUT
- TOPSOIL
- WOVEN GEOTEXTILE
- GROUNDWATER
- SOLID PIPING
- PERFORATED PIPING

HATCH PATTERNS

- ASPHALT
- CONCRETE
- FILL
- TRAFFIC GRAVEL
- GRANULAR BASE COURSE
- GRANULAR SUBBASE COURSE
- GRANULAR FILL
- RIPRAP - CLASS A
- RIPRAP - CLASS B
- RIPRAP - CLASS I
- RIPRAP - CLASS II
- SAND FILL
- TOPSOIL
- PEAT
- CLAY
- GABION
- TAILINGS
- OVERBURDEN
- BEDROCK

GENERAL LABELS

	MATCH LINE
	DETAIL BUBBLE
2+500 2+500	ALIGNMENT STATION LABEL
1 / 203	DETAIL CALLOUT
A / 203	SECTION CALLOUT
SCALE 1:100 VERT. SCALE 1:50 A / 203 CROSS SECTION A-A	SECTION TITLE
SCALE 1:100 1 / 203 DETAIL	DETAIL TITLE
PROFILE SCALE 1:1000	VIEW TITLE
1	REV CLOUD & CALLOUT
ELEV. 501.00m	ELEVATION LABEL
LT-11-06	BOREHOLE IDENTIFIER
CPT-LT-11-30	CPT IDENTIFIER
	CPT Q_t CURVE
	CONDUCTIVITY CURVE

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LEGEND

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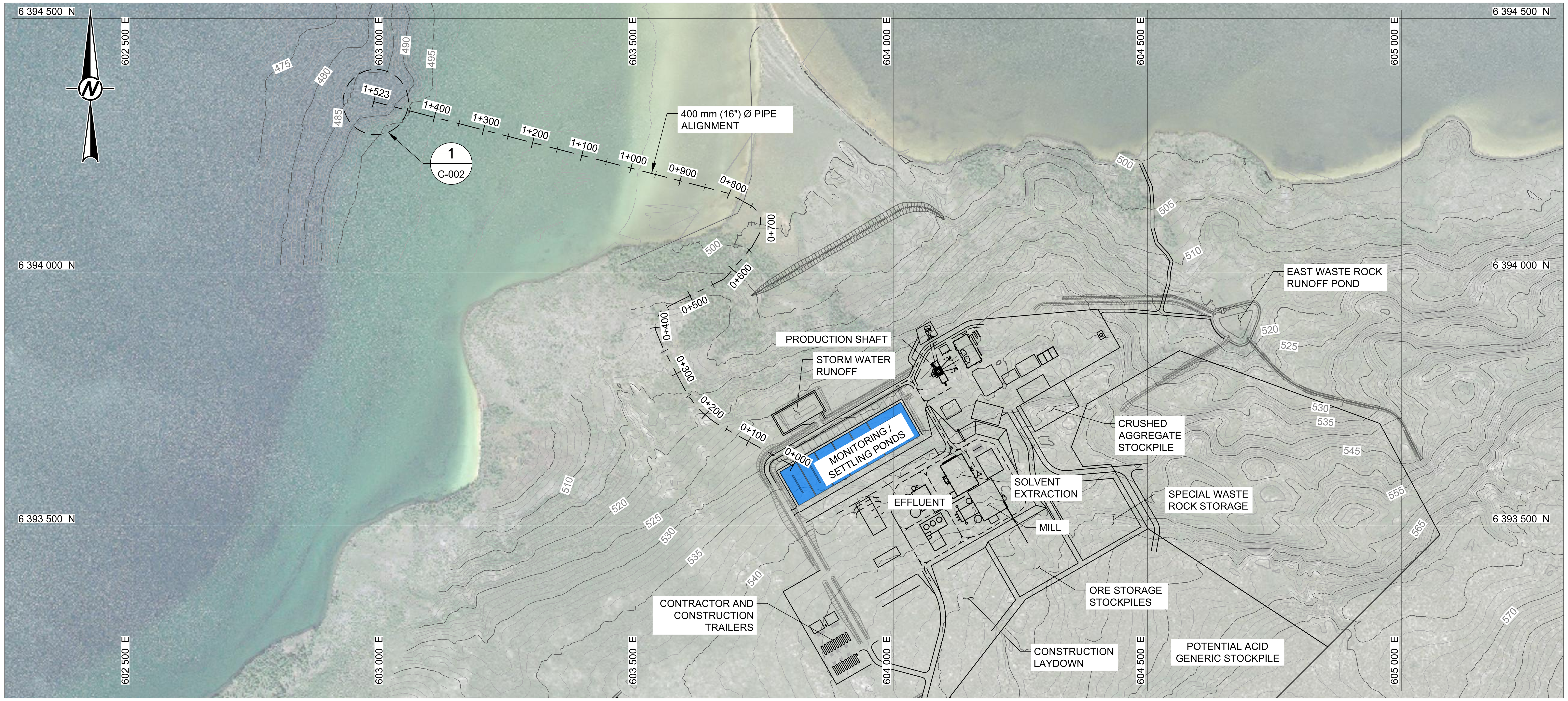
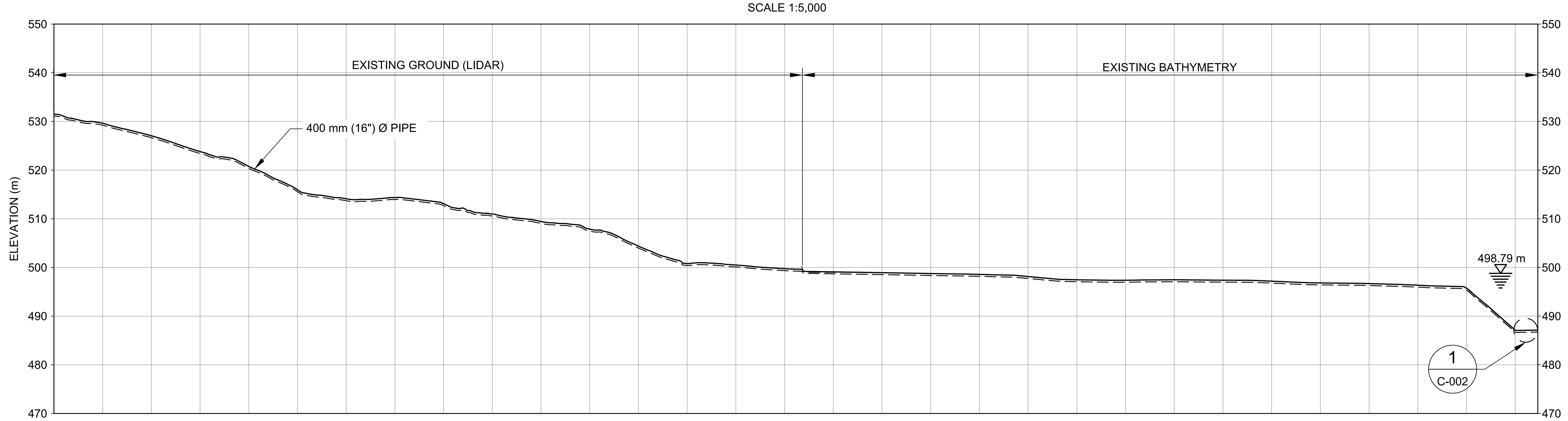


DIFFUSER PIPELINE PLAN

SCALE 1:5,000



PROFILE - PROPOSED DIFFUSER PIPELINE

SCALE 1:3,000
VERT. SCALE 1:600

LEGEND

- EXISTING GROUND CONTOURS (1m INTERVALS)
- MONITORING / SETTLING PONDS
- 400 mm (16") Ø PIPE ALIGNMENT

NOTE(S)

1. ALL UNITS ARE IN METRES UNLESS SPECIFIED OTHERWISE.

REFERENCE(S)

1. BASE MAP TAKEN FROM NEXGEN DRAWING, FILENAME '2100-DD10-SKT-00002_08Aug2019.dwg.
2. EXISTING GROUND LIDAR PROVIDED BY NEXGEN, FILENAME 2018 Rook1 Lidar_2m Grid.tif.
3. ALL COORDINATES REFERENCE NAD83 UTM ZONE 12.
4. IMAGE FROM © 2019 MICROSOFT CORPORATION © 2019 DIGITALGLOBE © CNES (2019) DISTRIBUTION AIRBUS DS.

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0 200 400
1:5,000 METRES

0 100 200
1:3,000 METRES

0 20 40
1:600 METRES

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SITE PLAN AND PROFILE OF THE PIPELINE ALIGNMENT

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25 mm
IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI D

Path: \\golder.gds\gal\calgary\EDCAD\2018\18114335\PRODUCTION\DRAWINGS\ | File Name: 18114335DWG-003.dwg | Last Edited By: cvincent Date: 2019-09-06 Time:5:37:32 PM | Printed By: CVincent Date: 2019-11-29 Time:10:07:43 AM

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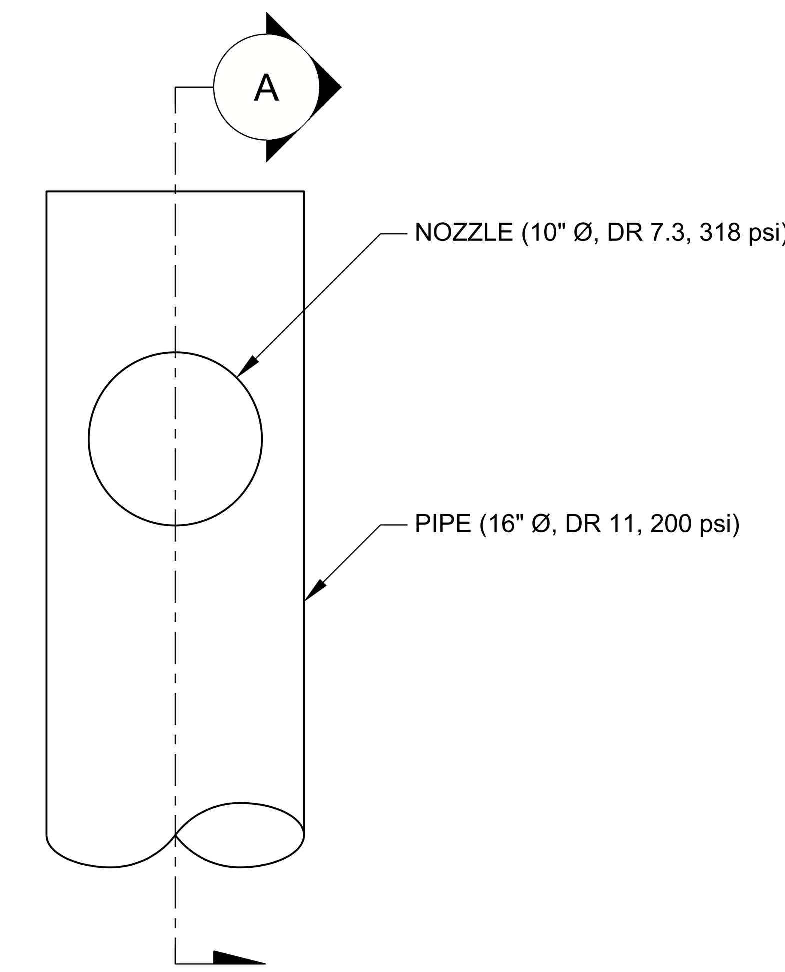
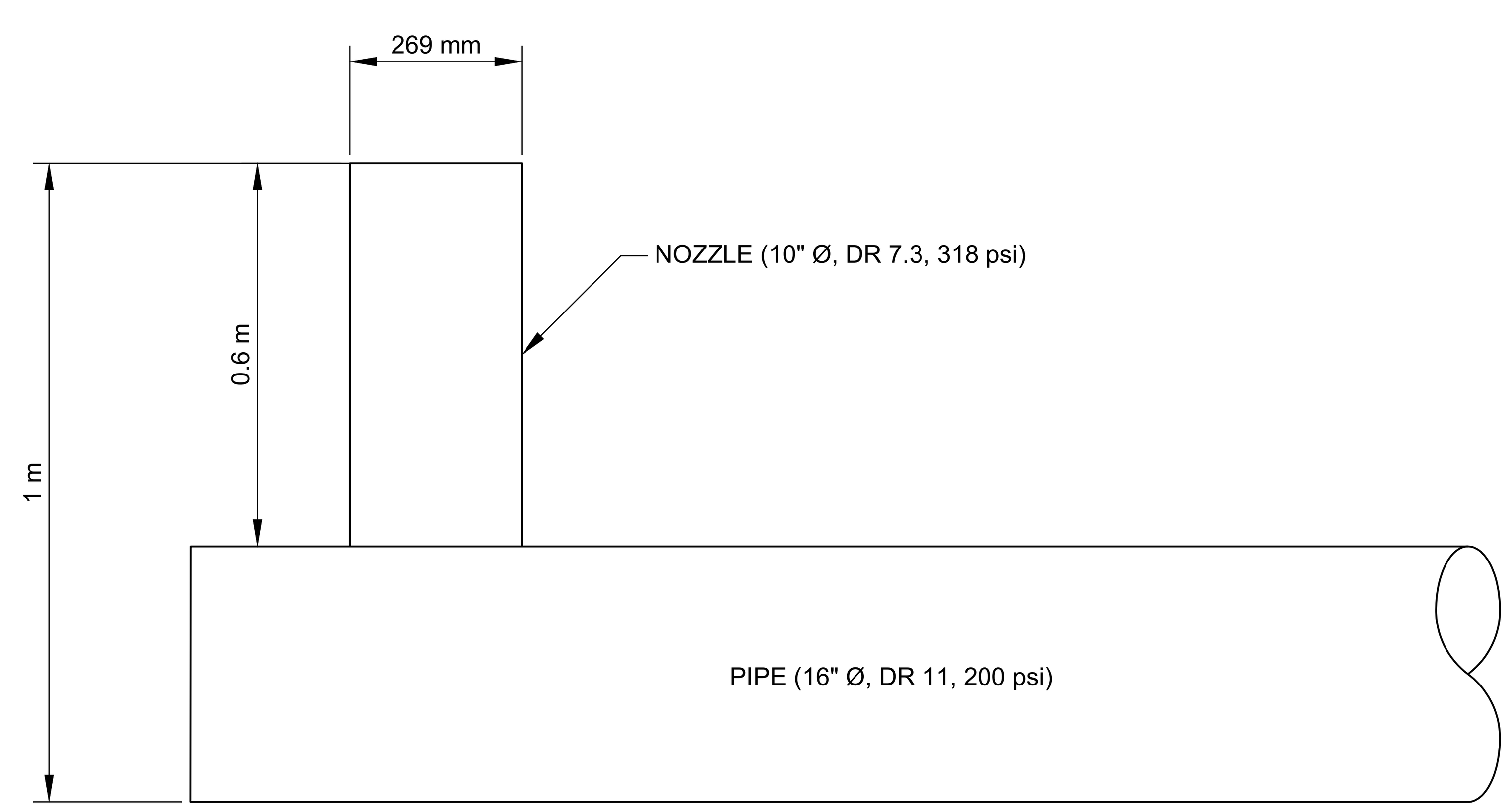
1. ALL UNITS ARE IN METRES UNLESS SPECIFIED OTHERWISE.



NTS 1 C-001 DETAIL - DIFFUSER PLAN



NTS A DIFFUSER SECTION

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