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Downstream Use and Impact Study
Thunderchild First Nation Sewage Lagoon Upgrade

THUNDERCHILD FIRST NATION

May 2021
SLR Project No.: 208.30001.00000

DOWNSTREAM USE AND IMPACT STUDY

THUNDERCHILD FIRST NATION SEWAGE LAGOON UPGRADE

SLR Project No.: 208. 30001.00000

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ACRONYMS

/100 mL	per 100 millilitres
BOD5	5-day biochemical oxygen demand
BCL	BCL Engineering Ltd.
cBOD	carbonaceous biochemical oxygen demand
CCME	Canadian Council of Ministers of the Environment
DFO	Fisheries and Oceans Canada
DO	dissolved oxygen
DUIS	Downstream Use and Impact Study
EDO	environmental discharge objective
EQO	environmental quality objective
km	kilometre
mg/L	milligrams per litre
m^3	cubic metres
m^3/s	cubic metres per second
mg/L	milligram per litre
ug/L	microgram per litre
N	nitrogen
NH_3	ammonia
P	phosphorus
SK	Saskatchewan
SLR	SLR Consulting (Canada) Ltd and SLR International Corporation
s.u.	standard unit (pH)
TSS	total suspended solids
WQG	CCME water quality guideline WSA
WQO	WSA water quality objective
WSA	Saskatchewan Water Security Agency
WSER	Wastewater System Effluent Regulations

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1.0 INTRODUCTION

1.1 Background

SLR Consulting (Canada) Ltd. and SLR International Corporation (SLR) were retained to conduct a Downstream Use and Impact Study (DUIS) by Thunderchild First Nation c/o BCL Engineering Ltd. (BCL) in support of the Thunderchild First Nation sewage lagoon upgrade project in the Province of Saskatchewan. The existing Thunderchild First Nation sewage lagoon system is located approximately 2 kilometres (km) north of the Turtle Lake River and 110 km northwest of North Battleford. It is undersized and discharges to a slough which flows towards the community.

1.2 Purpose

The preferred upgrade option is for an expanded lagoon system at the existing location with discharge directed away from the community. The purpose of this study is to evaluate the potential impacts of discharge from the expanded lagoon system on water quality in the nearby Turtle Lake River, which is the preferred discharge location. Specifically, the purpose of this study is to assess whether, and for what potential release scenarios (duration and season) discharge requirements set forth in the Wastewater Systems Effluent Regulations (WSER) are adequately protective of downstream uses of the Turtle Lake River, whether more stringent limits should apply, or if an alternative to a lagoon system is recommended. The applicable minimum WSER discharge criteria are:

- Carbonaceous biochemical oxygen demand (cBOD) not to exceed 25 milligrams per litre (mg/L)
- Total suspended solids (TSS) not to exceed 25 mg/L
- Unionized ammonia less than 1.25 mg/L

WSER requirements for free chlorine do not apply because sewage treatment does not include chlorination.

1.3 Approach

This DUIS was completed in general accordance with Saskatchewan Water Security Agency (WSA) DUIS guidance, with the exceptions that mixing zones and effluent discharge objectives (EDOs) were not defined. Potential impacts to the Turtle Lake River were assessed by estimating ambient water quality in the river after mixing with the discharge and comparing the results to Saskatchewan ambient water quality objectives (WQOs) and water quality guidelines (WQGs) from the Canadian Council of Ministers of Environment (CCME). In accordance with WSA guidance, this DUIS focuses on the regulated parameters discussed in Section 1.2 (cBOD, TSS, and unionized ammonia) as well as nitrogen, phosphorus, and bacteria.

1.4 Organization

This DUIS has been produced in general accordance with WSA guidance and includes:

- Characterization of the discharge (Section 2);
- Characterization of the receiving environment (Section 3);
- Impact assessment (Section 4);

- Summary (Section 5); and
- References (Section 6)

2.0 DISCHARGE CHARACTERIZATION

2.1 Discharge Description

The lagoon site is located approximately 2 km north of the Turtle Lake River as shown in Drawing 1. As part of the proposed upgrades to expand the lagoon system, discharge will be routed by High Density Polyethylene (HDPE) pipe to a small slough which flows south to Turtle Lake River. The initial proposed discharge route followed the path to the slough shown in blue. However, the discharge point of that path is upstream of several substantial earthen berms to the south of where that route would enter the slough, which could potentially impede flow to the river and cause the discharge to back up and towards the community. As such, it is recommended that the discharge be piped to a location on the slough downstream of the berms, as illustrated in yellow, or to the river itself.

Approximate coordinates for the location of the discharge of the slough to Turtle Lake River are shown on Table 1.

Table 1. Discharge Location

Latitude	Longitude
53°27'50.80" North	108°51'9.10" West

2.2 Discharge Volume and Flow Rate

The maximum expected release volume is 158,860 cubic metres (m^3). As part of this DUIS, release durations from 15 days to four weeks were assessed, which correspond to discharge flow rates ranging from approximately 0.07 to 0.12 m^3 per second.

2.3 Effluent Characterization

Effluent water quality data were reviewed for the period from 2009 through 2020 and are summarized on below in Table 2. Also shown for comparison are the WSER discharge criteria and WSA performance guidelines for well-operated lagoon systems. These data are shown for reference as effluent quality from the expanded lagoon system is expected to be better because the existing system is undersized. Despite being undersized, however, the existing system routinely met WSER effluent criteria and WSA performance guidelines for ammonia, cBOD, and total nitrogen (N). Total phosphorus and total coliform performance guidelines were met 90% and 80% of the time, respectively.

Table 2. Historical Lagoon Effluent Quality

	NH_3[1] (mg/L)	cBOD (mg/L)	TSS (mg/L)	Total P (mg/L)	Total N (mg/L)	E.coli (/100 mL)	Coliform[5] (/100 mL)
Effluent Quality Criteria							
WSER[2]	1.25	25	25	--	--	--	--
WSA, Fall[3,4]	--	10 - 30	10 - 40	2 - 5	5 - 20	--	200 - 20,000
WSA, Spring[3,4]	--	25 - 70	20 - 60	3.5 - 7	20 - 35	--	2,000 – 200,000
Samples	10	9	11	11	11	11	11
Minimum	ND	ND	2	0.7	1.9	2.0	471
Average	0.026	4.9	84	2.1	4.7	203	227,738
Maximum	0.385	9.4	360	5.7	8.6	1,439	>2,419,600
Exceedances	0	0	5	1	0	--	2

1 Effluent data and criteria expressed as unionized ammonia (NH_3).
2 WSER criteria taken from Wastewater System Effluent Regulations SOR/2012-139.
3 WSA performance guidelines taken from Table 4.1 of the WSA Sewage Works Design Standards – Typical effluent quality from well-operated lagoons (WSA, 2014). Historical discharges took place in Fall.
4 WSA criteria shown for cBOD are specified for 5-day biochemical oxygen demand (BOD_5) as there is no criteria for cBOD.
5 Effluent data and criteria for total coliform.

With its expanded capacity, the expanded lagoon system is designed to meet WSER effluent limits for cBOD, TSS, and unionized ammonia as well as WSA performance guidelines for guidelines for nitrogen, phosphorus, and coliforms as summarized in Table 3.

Table 3. Minimum Expected Expanded Lagoon System Effluent Quality

Criteria	Ammonia[1] (mg/L)	cBOD (mg/L)	TSS (mg/L)	Total P (mg/L)	Total N (mg/L)	Total Coliform (/100 mL)
WSER[2]	1.25	25	25	--	--	--
WSA, Fall[3]	--	10 - 30	10 - 40	2 - 5	5 - 20	200 - 20,000
WSA, Spring[3]	--	25 - 70	20 - 60	3.5 - 7	20 - 35	2,000 - 200,000

1 Ammonia criteria are expressed as unionized ammonia (NH_3), the fraction of which is pH and temperature dependent.
2 WSER criteria taken from Wastewater System Effluent Regulations SOR/2012-139.
3 WSA performance guidelines for facultative lagoons taken from Table 4.1 of the WSA Sewage Works Design Standards – Typical effluent quality (WSA, 2012). WSA criteria shown for cBOD are specified for 5-day biochemical oxygen demand (BOD_5) as there is no criteria for cBOD. WSA performance guidelines are only available for fall and spring. For the purpose of this assessment, spring guidelines were applied when assessing a potential winter discharge and fall guidelines were applied when assessing a potential summer discharge.

3.0 RECEIVING ENVIRONMENT CHARACTERIZATION

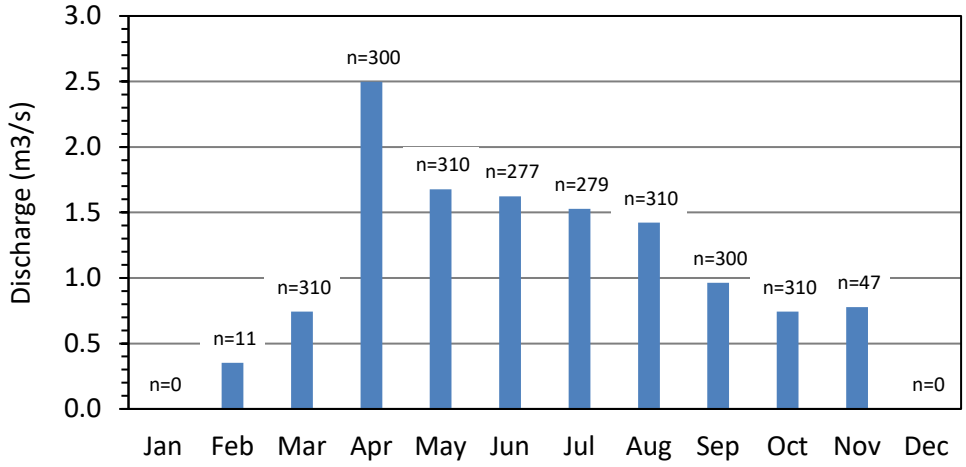
The Turtle Lake River is the ultimate receiving water body for the lagoon discharge as previously discussed in Section 2.1. The Turtle Lake River is a tributary to the North Saskatchewan River

that flows out of Turtle Lake approximately 10 km northeast of the Thunderchild First Nation lagoon site.

3.1 Ambient Flow Rate

The nearest Turtle Lake River gauging station to the lagoon site is station 05EG005 located approximately 15 km downstream near Turtleford. The most recent 10 years (2009 through 2018) of flow data were downloaded for the station from the Government of Canada Water Office webpage. No data are available for the months of December or January, likely due to ice cover and/or no flow. As shown below on Figure 1, average monthly river flows during the remainder of the year ranged from 2.7 cubic metres per second (m^3/s) in February to 19.2 m^3/s in April.

Figure 1. Turtle Lake River Average Flow by Month



Data shown for most recent 1-year period of record at station 05EG005. Number of data points (n) as shown.

3.2 Land Use

The HABISask Interactive Mapping Tool (Appendix A), was used to assess land use in the vicinity of the lagoon and along the discharge path to the Turtle Lake River. No agricultural lands are present in the vicinity of the lagoon or the discharge path to the Turtle Lake River. Agricultural crown land is present downstream along the Turtle Lake River approximately 3.5 km from the lagoon. Additional crown land is present 4 km west of the lagoons.

3.3 Downstream Water Uses and Users

As described in the draft DUIS guidance, potential beneficial uses of a water body include water supply (including industrial and agricultural), aquatic life, wildlife, and recreational uses. Turtle Lake River was assessed for these potential beneficial uses below. All maps are included in Appendix A. Based on this assessment, applicable beneficial uses of the Turtle Lake River include water supply (municipal, domestic, and irrigation), aquatic life, wildlife, and recreational uses.

3.3.1 Surface Water

3.3.1.1 Flow

The Turtle Lake River has periodic water supply problems due to drought and tends to have zero flow for a portion of most years (Saskatchewan Watershed Authority, 2008).

3.3.1.2 Water Supply

A surface water allocation map was identified in the *North Saskatchewan River Watershed Preliminary Background Report* (Saskatchewan Watershed Authority, 2007). The resolution of the map is low, but the nearest identified surface water allocations which could potentially be downstream of the lagoon discharge are in Turtleford approximately 13 km to the southwest. The map, included in Appendix A, shows municipal and domestic allocations in the vicinity of the Turtle Lake River at Turtleford. Since no other named surface water bodies were identified in the area, it is presumed these allocations are from Turtle Lake River. Similarly, there appear to be allocations for irrigation a further 10 km downstream of Turtleford.

3.3.1.3 Aquatic Life

Fisheries reports for the Turtle Lake River were produced using the HABISask mapping application. Fish species known to inhabit the Turtle Lake River include brook stickleback, fathead minnow, Iowa darter, longnose dace, longnose sucker, northern pike, northern redbelly dace, river shiner, shorthead redhorse, walleye, and white sucker (Appendix A).

3.3.1.4 Wildlife and Habitat

The Fisheries and Oceans Canada (DFO) Aquatic Species at Risk Map was used to identify potential federally protected aquatic critical habitat or species at risk in the vicinity of the lagoon site, along the discharge path, and for 10 km downstream in the Turtle Lake River, no federally listed critical aquatic habitat or at-risk species were identified in the Turtle Lake River.

The HABISask Interactive Mapping tool was used to identify rare and endangered terrestrial species, federally protected critical terrestrial habitat, terrestrial species, and protected areas in the vicinity of the lagoon site, along the discharge path, and for 10 km downstream in the Turtle Lake River (Appendix A):

- No rare and endangered species or federally protected critical habitat areas were identified in the vicinity of the lagoon site.
- No areas delineated through the Terrestrial Wildlife Habitat Inventory as being of species-level importance were identified vicinity of the lagoon site. Beaver and ruffed grouse habitat was identified along the Turtle Lake River in the vicinity of and downstream of the lagoon discharge.
- No game preserves, national wildlife areas, migratory bird sanctuaries, conservation easements, or ecological reserves were identified.

3.3.1.5 Recreational Use

Using the HABISask Interactive Mapping Tool (Appendix A), no national, provincial, or regional parks, recreation sites, protected areas, or historic sites were identified in the vicinity of the lagoon site, along the discharge path, or for at least 10 km downstream in the Turtle Lake River.

3.3.2 Groundwater

The WSA Water Wells Mapping Application was used to identify water wells in the vicinity of the lagoon site. A map of the nearby water wells and the associated well reports are included Appendix A and are summarized below. The nearest identified locations were test holes located between approximately 0.5 and 1 km from the lagoon site. The nearest identified active well was approximately 2 km away.

- WWDR-071156, Thunderchild First Nation. Municipal water test hole completed in 1978 and located approximately 0.5 km southwest of the lagoon site.
- WWDR-065227, Thunderchild First Nation. Municipal water test hole completed in 1978 and located approximately 0.5 km southwest of the lagoon site.
- WWDR-065226, Thunderchild First Nation. Domestic water test hole completed in 1978 and located approximately 1.1 km west of the lagoon site.
- WWDR-106754, Thunderchild First Nation. Domestic withdrawal well completed in 1996 and located approximately 2 km south of the lagoon site on the opposite (south) side of the Turtle Lake River from the discharge point.

3.4 Water Quality and Surface Water Quality Objectives

The SaskH2O website was searched for historical water quality data for the Turtle Lake River. The nearest available river quality data were for a location approximately 50 km downstream of the lagoon site. No upstream river quality data were found, but water quality data for Turtle Lake were identified for the period from 2000 to 2007. The Turtle Lake River flows out from Turtle Lake approximately 20 km upstream of the Thunderchild First Nation lagoon site. Since the lake monitoring site is both upstream and closer, the lake water quality data was taken as representative of the river for the purpose of this assessment and are summarized below in Table 4. Also shown on the table are the relevant WQGs from the CCME and WQOs from the Saskatchewan WSA.

Table 4. Summary of Historical Turtle Lake Water Quality

Parameter	Criteria[1]	# Samples	Minimum	Average	Maximum
pH (s.u.)	6.5 to 9.0[2,3]	33	5.7	8.7	8.9
DO (mg/L)	6.5 & 9.5[2,3,4]	27	6.8	7.9	11.0
Unionized NH_3 (mg/L as N)[4]	0.019[2,3,5]	28	<0.002	0.004	0.011
Total Phosphorus (mg/L)	<+50%[2,6]	42	<0.010	0.048	0.100
Total Nitrogen (mg/L)	none	5	1.0	1.1	1.2
Fecal coliform (/100 mL)	1,000[2,3]	20	ND	ND	10
E.coli (/100 mL)	100[2,3]	33	ND	ND	ND

ND Denotes "non-detect." Reported detection limits for fecal coliform ranged from 10 to 30 per 100 mL. Reported detection limits for *E.coli* ranged from 1 to 10 per 100 mL.
1 The pH criterion is for recreation and aesthetics, DO, unionized ammonia, and phosphorus criteria are for protection of aquatic life, and the *E.coli* criterion is for irrigation.
2 CCME WQGs.
3 WSA WQOs.
4 WQGs and WQOs dissolved oxygen (DO) are 9.5 mg/L for cold-water biota in early life stages and 6.5 mg/L for cold-water biota in other life stages.
5 Historic data for ammonia were converted from total ammonia-nitrogen to unionized ammonia nitrogen using a unionized fraction of 12.1%, which corresponds to a temperature of 15°C and the average historical ambient pH of 8.7.
6 The CCME WQG for phosphorus follows a tiered framework. Phosphorus concentrations must not exceed "trigger" ranges" for the water body or increase more than 50% above the background level. Based on the average ambient concentration of 0.048 mg/L, Turtle Lake River Lake is assumed to be in the eutrophic range 0.035 to 0.1 mg/L).

Turtle Lake routinely met WQGs and WQOs for unionized ammonia, dissolved oxygen, and *E.coli,* and met the pH WQO in all but 1 of 33 samples. Based on the historical data, Turtle Lake does not appear to be impaired with respect to these parameters. Since Turtle lake River flows out from Turtle Lake, the river is inferred to be similarly unimpaired.

In addition to reviewing historical water quality data, one ambient sample was collected by BCL Engineering during a site visit conducted on October 29, 2020. As shown on Drawing 2, the sample was collected in the Turtle Lake River, approximately 1.5 km downstream from the proposed discharge point. Results from the October 2020 sampling event are summarized below in Table 5. Concentrations met all applicable WQOs and WQGs and corroborate the conclusions made based on the historical Turtle lake water quality data, namely that there are no indications of impairment for the parameters assessed.

Table 5. Turtle Lake River Water Quality – October 2020

Parameter	Criteria[1]	Turtle Lake River
Unionized NH_3 (mg/L as N)[4]	0.019[2,3,4]	0.015
Total Phosphorus (mg/L)	<+50%[2,5]	0.07
Total Nitrogen (mg/L)	none	2.1
TSS (mg/L)	+25 short-term; +5 long-term[2]	4
Total coliform (/100 mL)	1,000[2,3]	290
E.coli (/100 mL)	100[2,3]	9

1 The unionized ammonia, total suspended solids (TSS), and phosphorus criteria are for protection of aquatic life, the total coliform and *E.coli* criteria are for irrigation.
2 CCME WQGs.
3 WSA WQOs.
4 Data for ammonia were converted from total ammonia-nitrogen to unionized ammonia nitrogen using a unionized fraction of 12.1%, which corresponds to a temperature of 15°C and the average historical ambient pH of 8.7.
5 The CCME WQG for phosphorus follows a tiered framework. Phosphorus concentrations must not exceed "trigger" ranges" for the water body or increase more than 50% above the background level. Based on the median ambient concentration of 0.06 mg/L, Fishing Lake is assumed to be in the eutrophic range 0.035 to 0.1 mg/L).

4.0 IMPACT ASSESSMENT

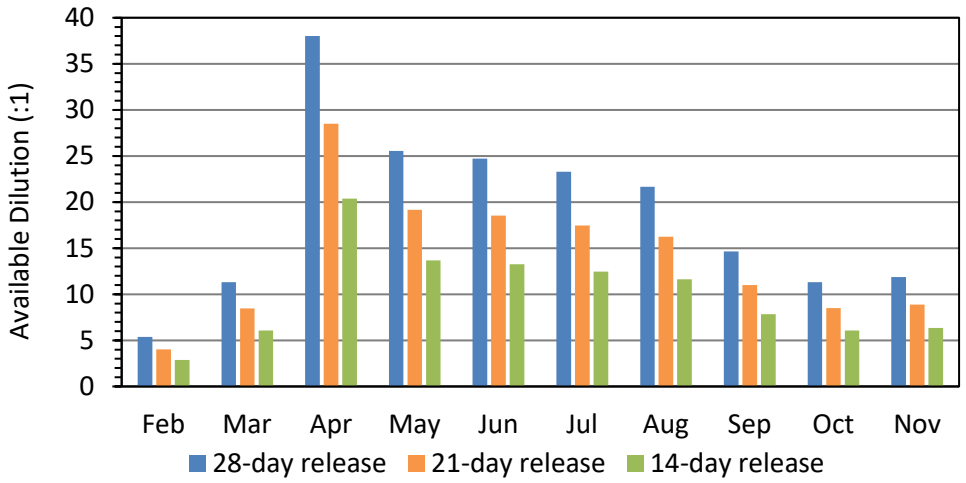
4.1 Methodology

The expanded lagoon system is expected to meet all federal WSER effluent limitations as well as provincial WSA performance guidelines for well-operated lagoon systems. Potential impacts of the lagoon discharge to Turtle Lake River were evaluated by assessing available dilution, estimating lake water quality after mixing, and comparing resulting water quality with Saskatchewan WQOs and CCME WQGs.

4.2 Available Dilution

Available dilutions for the lagoon discharge were estimated as ratios between the estimated average monthly ambient flow rates and expected discharge rates (0.07 to 0.12 m^3 per second for release durations of ranging from 15 days to four weeks). December and January were not evaluated due to lack of historical flow data available during these months. The river is likely to be iced over during these months as well, and discharge is not recommended under such conditions. As shown below in Figure 2, the greatest dilution is available in April with dilutions ranging from 20:1 for a 15-day release to 38:1 for a four-week release.

Figure 2. Estimated Available Dilution by Month



4.3 Predicted Water Quality

Water quality downstream of the lagoon discharge was estimated for February through November based on available dilutions, maximum expected effluent concentrations, and average historical ambient concentrations. The results are conservative since the estimates were developed using maximum expected effluent concentrations and the 2050 maximum expected release volume. Results are shown in Figure 3.

4.3.1 Dissolved Oxygen

The applicable WQOs for dissolved oxygen (DO) are a minimum concentration of 6.5 mg/L for early life stages and 9.5 mg/L for all other life stages. Impacts of the discharge related to DO were estimated for each month based on available dilution, average historical ambient DO, and the maximum expected effluent cBOD concentration of 25 mg/L, which corresponds to the WSER effluent limit. Resulting worst-case DO concentrations downstream in the Turtle Lake River are shown in Figure 3a.

For a 15-day release, the predicted worst-case DO concentrations are below the minimum 6.5 mg/L WQO for all but the month of April, which has the highest available dilution. For release durations of 21 or 28 days, predicted worst-case downstream DO concentrations meet WQOs for the period from April through July (August as well for a 28-day release), but exceed the minimum WQO in other months. Based on this assessment, the discharge is unlikely to result in adverse impacts related to DO provided the release takes place in spring over a duration of 21 to 28 days.

This assessment is extremely conservative, in addition to using the maximum expected effluent cBOD, it was assumed that each mg/L cBOD, results in an immediate 1 mg/L decrease in ambient DO. The assessment is also based on the more conservative WQO for early life stages, 6.5 mg/L.

4.3.2 Ammonia

The applicable WQO for ammonia is a maximum concentration of 0.019 mg/L expressed as the unionized fraction. Impacts of the discharge related to ammonia were estimated for each month based on available dilution, average ambient unionized ammonia concentrations, and the

maximum expected effluent unionized ammonia concentration of 1.25 mg/L, which corresponds to the WSER effluent limit.

Predicted worst-case downstream unionized ammonia concentrations exceeded the applicable WQO in all months for all durations of discharge when the effluent concentration was equal to the WSER effluent limit of 1.25 mg/L (Figure 3b). Based on these results, the WSER effluent limit may not be adequately protective of downstream aquatic life uses for the proposed lagoon discharge.

Rather than recommending additional or alternative treatment, a lower effluent limit of 0.4 mg/L is proposed for the lagoon system. At the proposed limit, predicted worst-case downstream unionized concentrations meet WQOs throughout the spring (April through June) for a 28-day release (Figure 3c), and in April for a 21-day release. Effluent from the existing undersized lagoon system would have consistently met the proposed limit, with a maximum historical effluent concentration of 0.385 mg/L. Although the maximum historical concentration is near the proposed 0.4 mg/L limit, the sample appeared to be a high outlier, with the second highest effluent unionized ammonia concentration being only 0.06 mg/L, which is approximately seven times lower than the proposed limit. The new lagoon system is expected to perform at least as well as the existing undersized system, therefore the proposed limit of 0.4 mg/L is considered reasonably attainable.

4.3.3 TSS

The applicable WQOs for TSS are a maximum short-term increase of 25 mg/L and a maximum long-term increase of 5 mg/L. Impacts of the discharge related to TSS were estimated for each month based on available dilution and the maximum expected effluent TSS concentration of 25 mg/L, which corresponds to the WSER effluent limit. Resulting worst-case TSS increases downstream in the Turtle Lake River are shown in Figure 3d.

Predicted worst-case increases in TSS were below the 5 mg/L long-term WQO for all but a 15-day release in February. A 5.4 mg/L increase was predicted in that scenario; however, as described above, discharge in February is not feasible. Regardless, this meets the short-term WQG of 25 mg/L, which is the applicable WQG given the short (less than 30 day) duration of the discharge.

Based on this assessment, the discharge is unlikely to result in adverse impacts related to TSS.

4.3.4 Nutrients

There are no effluent limitations for total phosphorus or total nitrogen, but effluent is expected to meet WSA performance guidelines for well-operated lagoons. As shown in Table 2, the performance standards for phosphorus are 2 to 5 mg/L for a fall release and 3.5 to 7 mg/L for a spring release. The performance standards for nitrogen are 5 to 20 mg/L for a fall release and 20 to 35 mg/L for a spring release.

CCME WQGs for phosphorus are that concentrations should not exceed the upper “trigger range” for the water body or increase concentrations more than 50% above background. There are no numeric ambient WQGs for nitrogen. Saskatchewan General Objectives for effluent discharges require that effluent 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 (WSA, 2015). For this evaluation, an assessment level corresponding to a 50% increase

over background was applied for nitrogen, which is the same as the approach used in the WQG for phosphorus.

Potential impacts of the discharge related to total phosphorus and total nitrogen were estimated for each month based on available dilution, the average ambient concentration, and the maximum expected effluent concentration as based on the upper end of the seasonal WSA performance guideline ranges. For this assessment, the fall performance guidelines were applied to both fall and summer, and the spring performance guidelines were applied to both spring and winter (there are no guidelines for summer or winter because lagoons do not typically discharge in those seasons).

The Turtle Lake River falls into the eutrophic range (35 to 100 microgram per litre (ug/L) total P) based on the estimated average phosphorus concentration of 48 µg/L; therefore, the applicable trigger level is 100 ug/L. As shown in Figure 3e, predicted worst-case phosphorus concentrations exceeded the 100 ug/L trigger level in all months and for all discharge durations. The lowest predicted concentrations of 200 and 300 ug/L occur in April and May, respectively, representing 370 and 55% increases over ambient, which is greater than the 50% increase WQG (Figure 3f).

Similarly, predicted worst-case nitrogen increases above ambient were also greater than 50% for all months and discharge durations assessed (Figure 3g). The lowest predicted increases were for a 28-day release in April, with an 80% increase, and May, with a 120% increase.

It should be noted that none of the samples used to estimate background phosphorus and nitrate concentrations were collected in April or May. In the Prairie provinces, more than 80% of surface runoff, a major nutrient source from agricultural land, comes in the snowmelt season between April and June (Cade-Menun, B.J., et al., 2013). It is therefore likely that the calculated ambient average of 48 ug/L phosphorus and 1.1 mg/L nitrogen used in the assessment underrepresents background concentrations in the spring.

The analysis above indicates that the lagoon discharge, even when in the spring (with its higher available dilution) and extended to 28 days, may result in nitrogen increases greater that 50% and phosphorus concentrations which exceed trigger levels and WQGs. However, adverse impacts related to nutrients in the discharge are probably still unlikely. The primary concern related to nutrients is the occurrence of harmful algal blooms. Such blooms tend to be associated with warmer surface water temperatures during late summer and early fall. A short (28-day or less) lagoon discharge in the spring, when water temperatures are cooler, is therefore less likely to contribute to a harmful algal bloom than a late summer or early fall discharge. Additionally, algal blooms are more prevalent in quiescent lakes than in rivers due to lower air exchange at the surface in lakes. Unlike many rivers in Saskatchewan, the Turtle Lake River does not discharge to or flow through any lakes downstream of the proposed lagoon discharge. The Turtle Lake River instead discharges to the North Saskatchewan River approximately 60 km to the southeast.

4.3.5 Total Coliform

The applicable ambient WQO for total coliform is a maximum of 1,000 per 100 mL for protection of irrigation uses. There are no effluent limitations for total coliform, but the effluent is expected to meet WSA performance guidelines for well-operated lagoons. As shown in Table 2, the performance guidelines are 200 to 20,000 per 100 mL for a fall release and 2,000 to 200,000 per 100 mL for a spring release.

Impacts of the discharge related to total coliform were estimated for each month based on available dilution, the average ambient total coliform concentration, and expected effluent total coliform concentrations as based on the upper end of the seasonal WSA performance guideline ranges. For the purpose of this assessment, the fall performance guidelines were applied to both fall and summer, and the spring performance guidelines were applied to both spring and winter (there are no guidelines for summer or winter because lagoons do not typically discharge in those seasons). Resulting worst-case total coliform concentrations downstream in the Turtle Lake River are shown in Figures 3a through 3h.

Predicted worst-case coliform concentrations after mixing are greater than the 1,000 per 100 mL WQO for all months and release durations assessed. The lowest predicted concentrations were 5,100 and 7,500 per 100 mL and corresponded to 28-day releases in April and May, respectively. Although predicted concentrations are greater than the WQO, the assessment used effluent concentrations equal to the upper end of the WSA performance guideline ranges for well operated lagoons, which is conservative. Additionally, the 1,000 per 100 mL WQO is for the protection of irrigation uses. As discussed in Section 3.3.1, the nearest identified potential irrigation withdrawal is approximately 10 km downstream of the proposed discharge. It is likely that coliform concentrations will attenuate over the intervening distance. Also, since most rainfall in the prairie regions of Saskatchewan occurs in spring and early summer (Cade-Menun, 2013), the likelihood of active withdrawals for irrigation occurring at the time of a spring lagoon release are low, and therefore the irrigation WQO likely doesn't apply.

5.0 SUMMARY AND CONCLUSIONS

The Thunderchild First Nation currently operates an undersized sewage lagoon system. The system discharges to a slough which directs effluent towards the community. As part of a planned lagoon system upgrade, a new, larger lagoon will be constructed immediately north of the existing lagoon, and a new discharge path will be constructed directing flow away from the community.

The preferred discharge location is the Turtle Lake River to the south. A review of historical data, and data collected by SLR in October 2020 did not reveal parameters of impairment or concern for the river, although, like many surface water bodies in Saskatchewan, nutrient levels were in eutrophic range.

In the preliminary design, discharge was routed by HDPE pipe to a small slough which flows south to Turtle Lake River. It was discovered through this DUIS that several substantial earthen berms span the slough between the planned end of discharge pipe and the river which could potentially impede flow to the river and cause the discharge to back up and towards the community. As such, it is recommended that the discharge be piped to a location on the slough downstream of the berms, or to the river itself.

Flow in the Turtle Lake River is low, ranging from approximately 3 m^3/s in February to 19 m^3/s in April. Since low flows limit available dilution, release durations ranging from 15 days to four weeks were assessed as part of the DUIS because. The greatest available dilution is available in April, with estimated available dilutions ranging from 20:1 for a 15-day release to 38:1 for a four-week release.

Potential impacts to the Turtle Lake River were evaluated by estimating downstream water quality and comparing resulting water quality with Saskatchewan WQOs and CCME WQGs. Downstream concentrations were estimated for each month based on available dilution, maximum expected effluent concentrations, and average historical ambient concentrations.

TSS, cBOD, and ammonia are the three federally regulated parameters in the effluent (parameters with WSER effluent criteria). Based on the results of the assessment, a fall release is not recommended due to insufficient available dilution. WQGs for TSS are likely to be met regardless of discharge duration. However, with respect to cBOD, the analysis suggests a minimum release duration of three weeks (21-day) is needed to protect against adversely affecting downstream dissolved oxygen concentrations. To prevent against ammonia toxicity, a four-week (28-day) discharge is recommended.

Additionally, it was found that the WSER effluent criteria of 1.25 mg/L for unionized ammonia may not be adequately protective of the receiving environment. It is recommended that the facility operate with an effluent limit of 0.4 mg/L unionized ammonia. The existing lagoon system, despite being undersized, consistently met this proposed limit with a maximum historic (2009 through 2020) unionized ammonia concentration of 0.385 mg/L. Although near the proposed 0.4 mg/L limit, the sample appeared to be a high outlier, with the second highest effluent unionized ammonia concentration being only 0.06 mg/L, which is approximately seven times lower than the proposed limit. The new lagoon system is expected to perform at least as well as the existing undersized system, therefore the proposed limit of 0.4 mg/L is considered reasonably attainable, and no additional or alternative treatment is recommended.

Though not required per the DUIS guidance, potential impacts related to nitrogen, phosphorus, and coliform in the lagoon effluent were also assessed as part of this DUIS. There are no effluent limits for these parameters, but there are seasonal WSA performance guidelines and effluent from the new system is expected to meet the guidelines.

Predicted worst-case phosphorus concentrations exceed WQGs, even for a 28-day discharge in spring, when available dilution is greatest. Similarly, nitrogen concentrations exceed the 50% increase assessment level used in this DUIS. Despite the potential for elevated nutrient levels, the likelihood of the discharge contributing to harmful algal blooms is small for a spring release because blooms generally are associated with warmer weather months. Additionally, algal blooms are more prevalent in quiescent lakes than in rivers due to lower air exchange at the surface in lakes. Unlike many rivers in Saskatchewan, the Turtle Lake River does not discharge to or flow through any lakes downstream of the proposed lagoon discharge. The Turtle Lake River instead discharges to the North Saskatchewan River approximately 60 km to the southeast.

With respect to total coliform, predicted worst-case coliform concentrations after mixing are greater than the 1,000 per 100 mL WQO for all months and release durations assessed. However, the WQO is for protection of irrigation uses. The nearest identified potential irrigation withdrawal is approximately 10 km downstream of the proposed discharge the need for irrigation in the wet spring months is low. As such, the irrigation WQO likely does not apply for a spring release.

In summary, it is recommended that the lagoon discharge be piped to a location on the slough downstream of the berms on the slough or to the river itself to prevent effluent from backing up towards the community. Based on the results of this impact assessment, it is unlikely the discharge will have a negative impact on water quality in the Turtle Lake River or affect downstream uses provided releases take place in the spring, specifically April or May, over a duration of four weeks. Effluent criteria should include the 25 mg/L WSER effluent standards for cBOD and TSS, and a more restrictive effluent unionized ammonia criterion of 0.4 mg/L.

6.0 REFERENCES

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7.0 STATEMENT OF LIMITATIONS

This report has been prepared and the work referred to in this report has been undertaken by SLR Consulting (Canada) Ltd. (SLR) for Thunderchild First Nation c/o BCL Engineering Ltd. (BCL). The report has been prepared in accordance with the proposed scope of work and environmental services agreement between SLR and BCL. It is intended for the sole and exclusive use of BCL and Thunderchild First Nation. Other than by Thunderchild First Nation and as set out herein, copying or distribution of this report or use of or reliance on the information contained herein, in whole or in part, is not permitted unless payment for the work has been made in full and express written permission has been obtained from SLR.

This report has been prepared for specific application to this site and site conditions existing at the time work for the report was completed. Any conclusions or recommendations made in this report reflect SLR's professional opinion.

Information contained within this report may have been provided to SLR from third party sources. This information may not have been verified by a third party and/or updated since the date of issuance of the external report and cannot be warranted by SLR. SLR is entitled to rely on the accuracy and completeness of the information provided from third party sources and no obligation to update such information.

Nothing in this report is intended to constitute or provide a legal opinion. SLR makes no representation as to the requirements of compliance with environmental laws, rules, regulations or policies established by federal, provincial or local government bodies. Revisions to the regulatory standards referred to in this report may be expected over time. As a result, modifications to the findings, conclusions and recommendations in this report may be necessary.

Thunderchild First Nation may submit this report to the Saskatchewan Water Security Agency and/or related Saskatchewan and Federal environmental regulatory authorities or persons for review and comment purposes.

DRAWINGS

Downstream Use and Impact Study
Thunderchild First Nation Sewage Lagoon Upgrade
SLR Project No.: 208.30001.00000

N

SITE LOCATION

Thunderchild

Hartwell

Turtle Lake River

NOTES:
TOPOGRAPHIC MAP SOURCE: ESRI, DIGITALGLOBE, GEOEYE, EARTHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS, AEROGRID, IGN, AND THE GIS USER COMMUNITY.

0 1 2 4 6 km

SCALE 1:100,000
WHEN PLOTTED CORRECTLY ON A 11 x 17 PAGE LAYOUT
NAD 1983 UTM Zone 12N
THIS DRAWING IS FOR CONCEPTUAL PURPOSES ONLY. ACTUAL LOCATIONS MAY VARY AND NOT ALL STRUCTURES ARE SHOWN.

SLR

THUNDERCHILD FIRST NATION
THUNDERCHILD FIRST NATION, SASKATCHEWAN

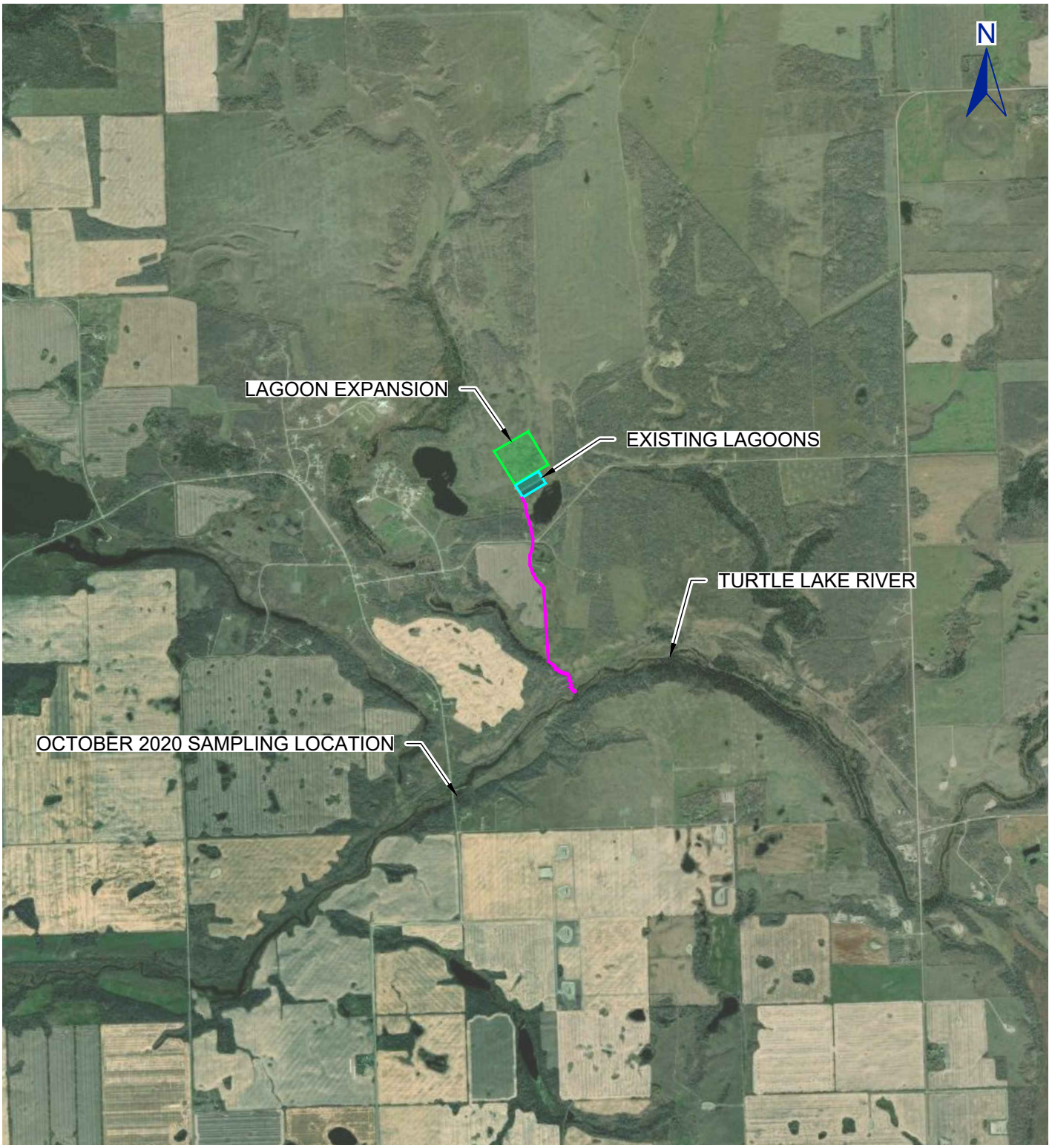
THUNDERCHILD FIRST NATION SEWAGE LAGOON EXPANSION DUIS

SITE LOCATION PLAN

Date: March 10, 2021
Project No. 208.30001.00000

Drawing No. 1

Cadfile name: S_208-30001-00000-A1.dwg



NOTES:
IMAGERY SOURCE: ESRI, DIGITALGLOBE, GEOEYE, EARTHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS, AEROGRID, IGN, AND THE GIS USER COMMUNITY.
IMAGE DATES: OCTOBER 3, 2014

LEGEND:

EXISTING LAGOONS
PROPOSED LAGOON EXPANSION
DISCHARGE PATH

0 0.5 1 2 3 km

SCALE 1:50,000
WHEN PLOTTED CORRECTLY ON A 11 x 17 PAGE LAYOUT
NAD 1983 UTM Zone 12N

THIS DRAWING IS FOR CONCEPTUAL PURPOSES ONLY. ACTUAL LOCATIONS MAY VARY AND NOT ALL STRUCTURES ARE SHOWN.

SLR

THUNDERCHILD FIRST NATION
THUNDERCHILD FIRST NATION, SASKATCHEWAN

THUNDERCHILD FIRST NATION SEWAGE LAGOON EXPANSION DUIS

SITE PLAN

Date: March 10, 2021
Project No. 208.30001.00000

Drawing No. 2

Cadfile name: S_208-30001-00000-A1.dwg

APPENDIX A
Environmental Mapping

Downstream Use and Impact Study
Thunderchild First Nation Sewage Lagoon Upgrade
SLR Project No.: 208.30001.00000

Fisheries - Lake Report

Turtlelake River

Report Generated:
11/13/2020 2:39:11 PM

Fish Species

The following fish species are known to inhabit this waterbody:

Brook Stickleback	Fathead Minnow	Iowa Darter	Longnose Dace	Longnose Sucker
Northern Pike	Northern Redbelly Dace	River Shiner	Shorthead Redhorse	Walleye
White Sucker				

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Federal Critical Habitat

Legend

- Provincial Boundary
- Black-footed Ferret
- Burrowing Owl
- Chestnut-collared Longspur
- Dusky Dune Moth
- Eastern Yellow-bellied Racer
- Gold-edged Gem
- Greater Sage-Grouse
- Greater Short-horned Lizard
- Loggerhead Shrike
- Mountain Plover
- Piping Plover
- Red Knot
- Slender Mouse-ear Cress - Tra bursifolia ssp. Virgate
- Small-flowered Sand-verbena micranthus
- Smooth Goosefoot - Chenopoc
- Sprague's Pipit
- Swift Fox
- Tiny Cryptantha - Cryptantha n
- Western Spiderwort - Tradesca var. occidentalis

Notes

7.2 0 3.58 7.2 Kilometers

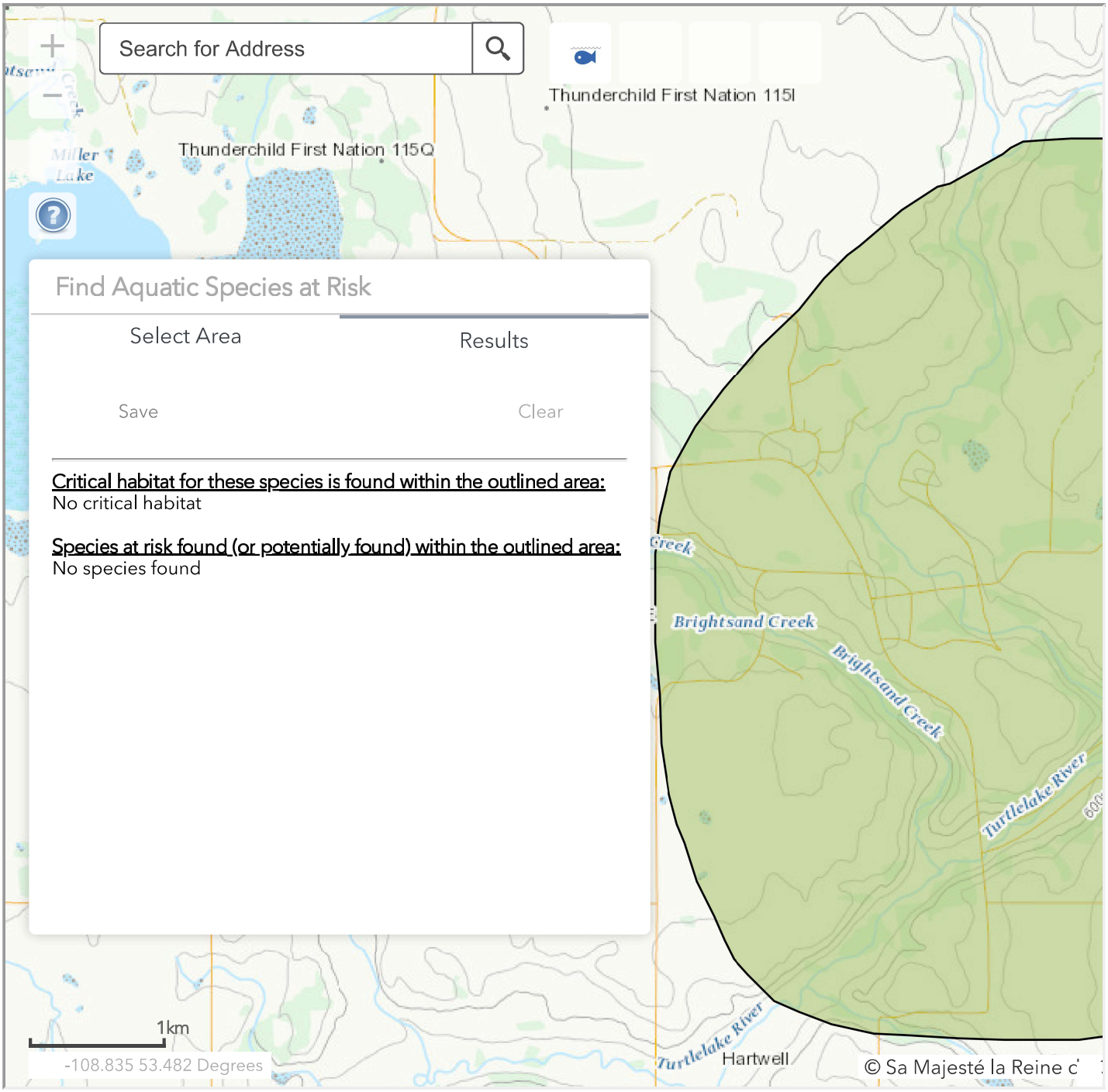
WGS_1984_Web_Mercator_Auxiliary_Sphere

Aquatic species at risk map

We've compiled critical habitat and distribution data for aquatic species listed under the Species at Risk Act (SARA). This map is intended to provide an overview of the distribution of aquatic species at risk and the presence of their critical habitat within Canadian waters. The official source of information is the Species at Risk Public Registry.

If you encounter an aquatic species at risk in an area that isn't currently mapped, please notify your regional Fisheries Protection Program office to ensure that you're compliant with SARA.

▶ **Information and legend**



Share this page

Date modified:
2019-08-23

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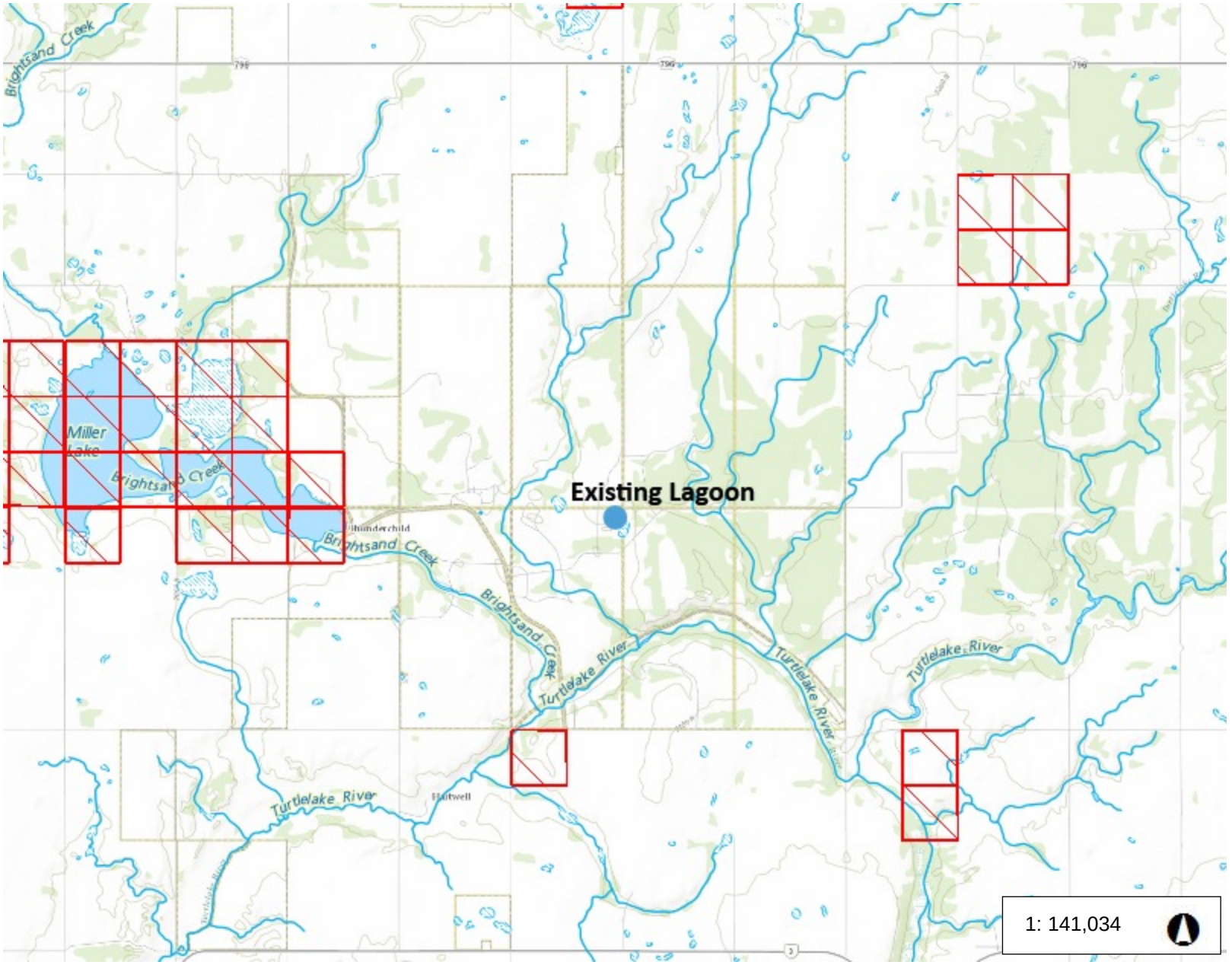
Agricultural Crown Land



Legend

- Provincial Boundary
- Agricultural Crown Land

1: 141,034

Notes

7.2 0 3.58 7.2 Kilometers

WGS_1984_Web_Mercator_Auxiliary_Sphere

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Managed Areas

Legend

- Provincial Boundary
- Water Security Agency
- Game Preserve
- National Wildlife Area
- Migratory Bird Sanctuary
- Conservation Easements
- Crown Land Subdivisions
- Ecological Reserves
- Fish and Wildlife Development
- Former Federal Pastures
- Ramsar Wetland
- Reservior Development Areas
- Representative Areas
- Provincial Pastures
- Special Management Areas
- Wildlife Habitat Protection (WH
- Wildlife Refuge
- Crown Conservation Easemen
- National Park
- Provincial Park

1: 141,034

Notes

7.2 0 3.58 7.2 Kilometers

WGS_1984_Web_Mercator_Auxiliary_Sphere

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Parks

Legend

- Provincial Boundary
- National Park
- Provincial Park
- Recreation Site
- Protected Area
- Authority
- Historic Site
- Regional Park

1: 141,034

Notes

7.2 0 3.58 7.2 Kilometers

WGS_1984_Web_Mercator_Auxiliary_Sphere

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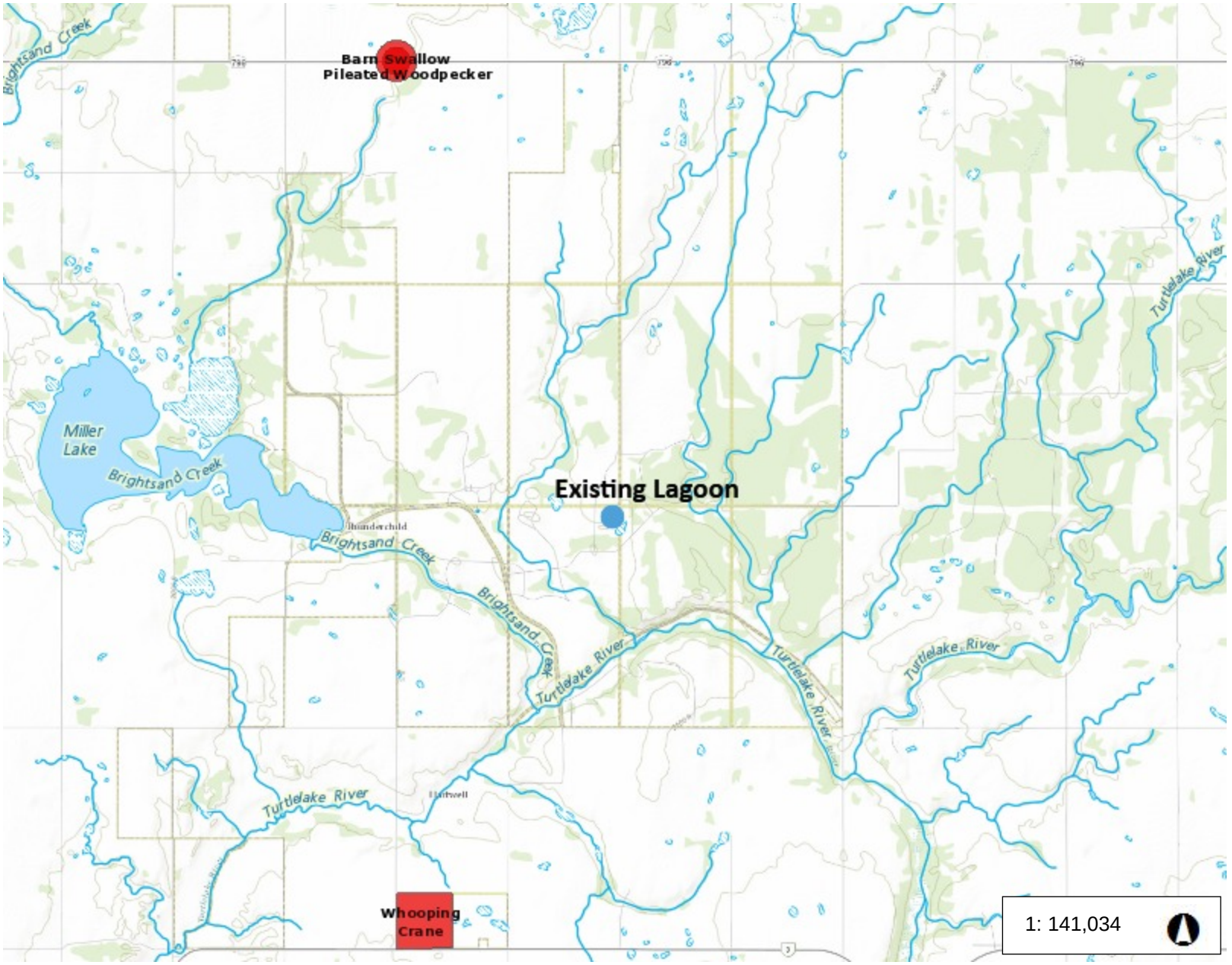
Rare and Endangered Species



Legend

- Provincial Boundary
- Rare and Endangered Species
  - Vertebrate Animal
  - Invertebrate Animal
  - Animal Assemblage
  - Vascular Plant
  - Nonvascular Plant
  - Other (Botanical)
  - Fungus
- National Park
- Provincial Park

1: 141,034

Notes

7.2 0 3.58 7.2 Kilometers

WGS_1984_Web_Mercator_Auxiliary_Sphere

This map is a user generated static output from an Internet mapping site and is for reference only. Data layers that appear on this map may or may not be accurate, current, or otherwise reliable.
THIS MAP IS NOT TO BE USED FOR NAVIGATION

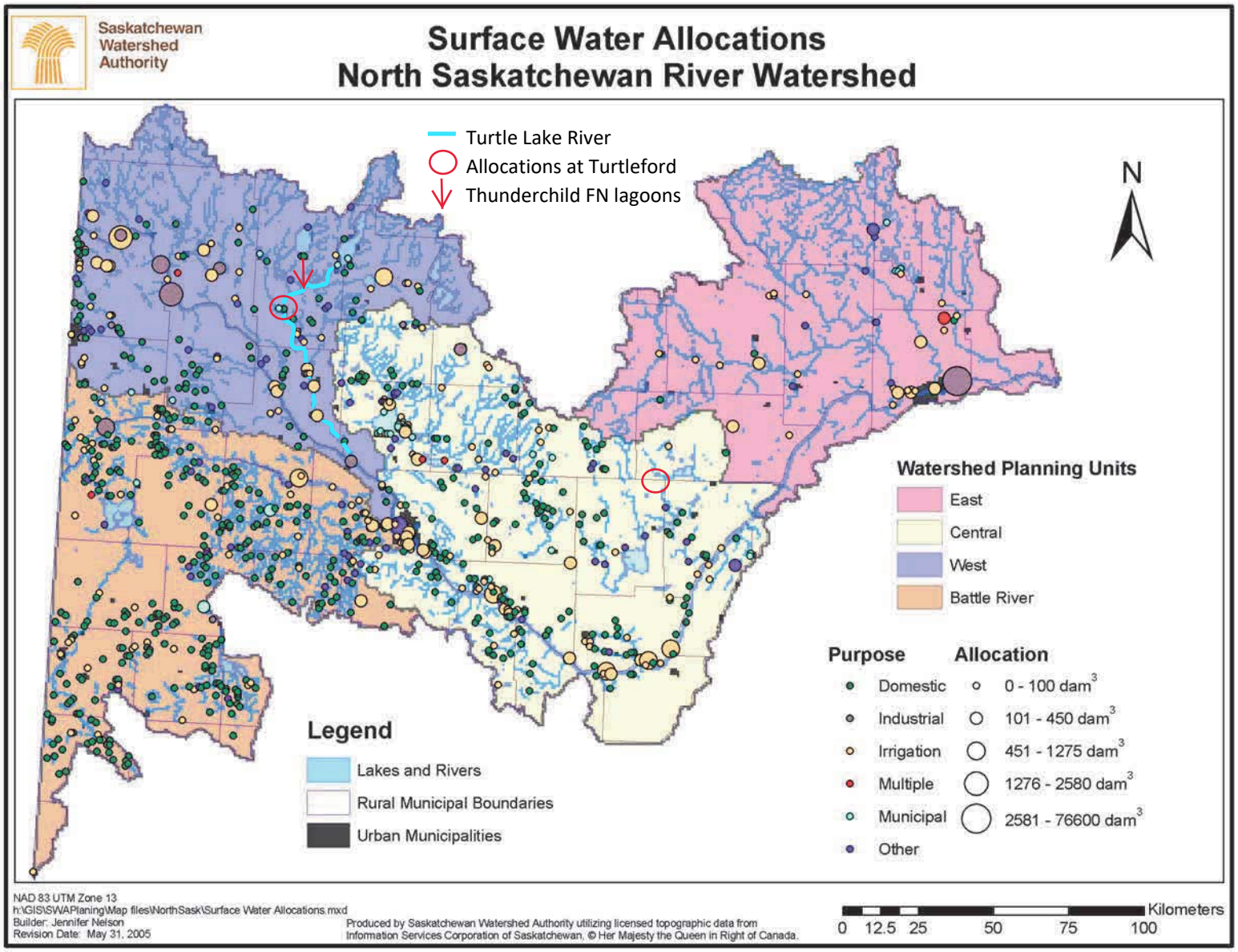


Figure 38: Surface Water Allocations

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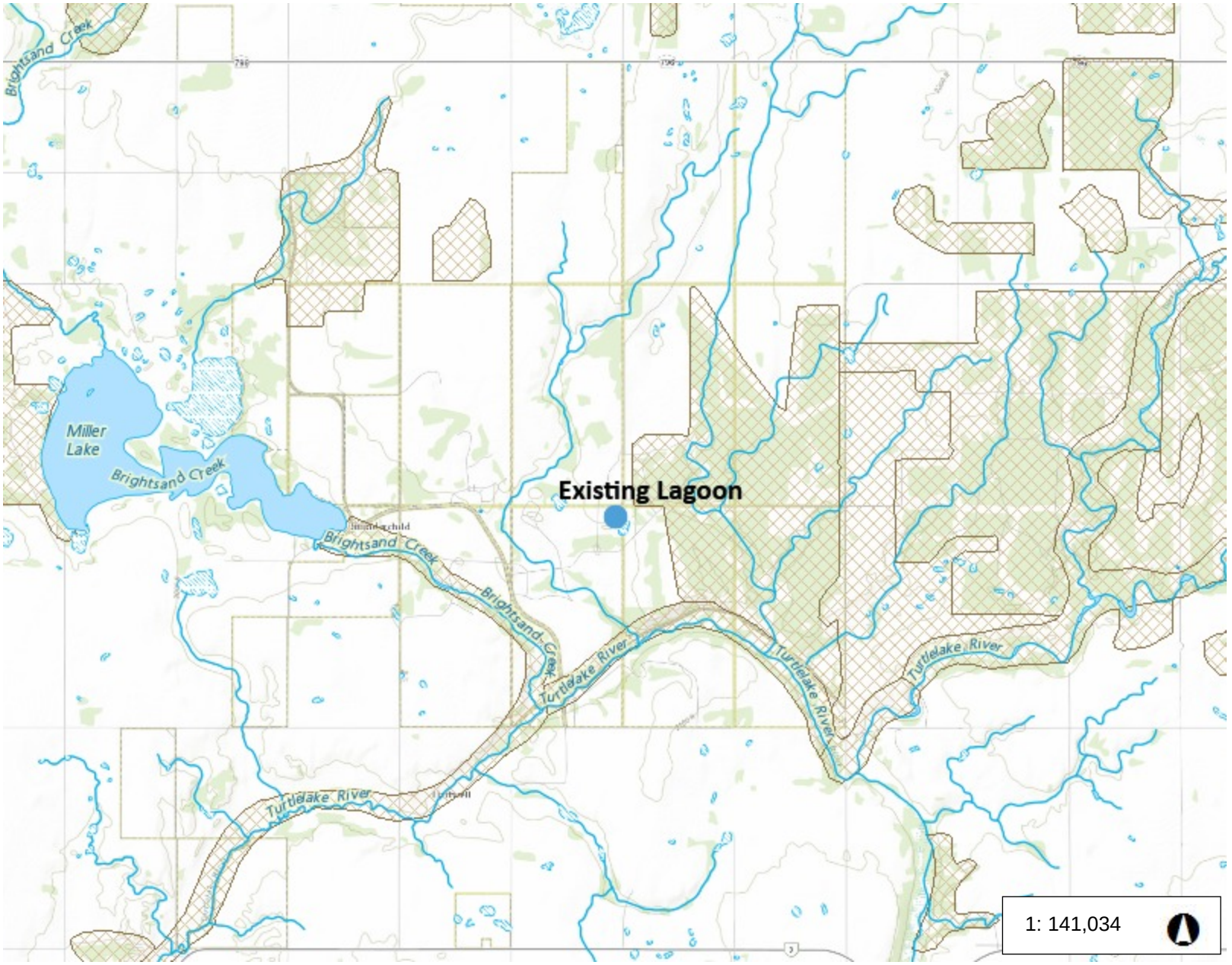
Terrestrial Habitat



Legend

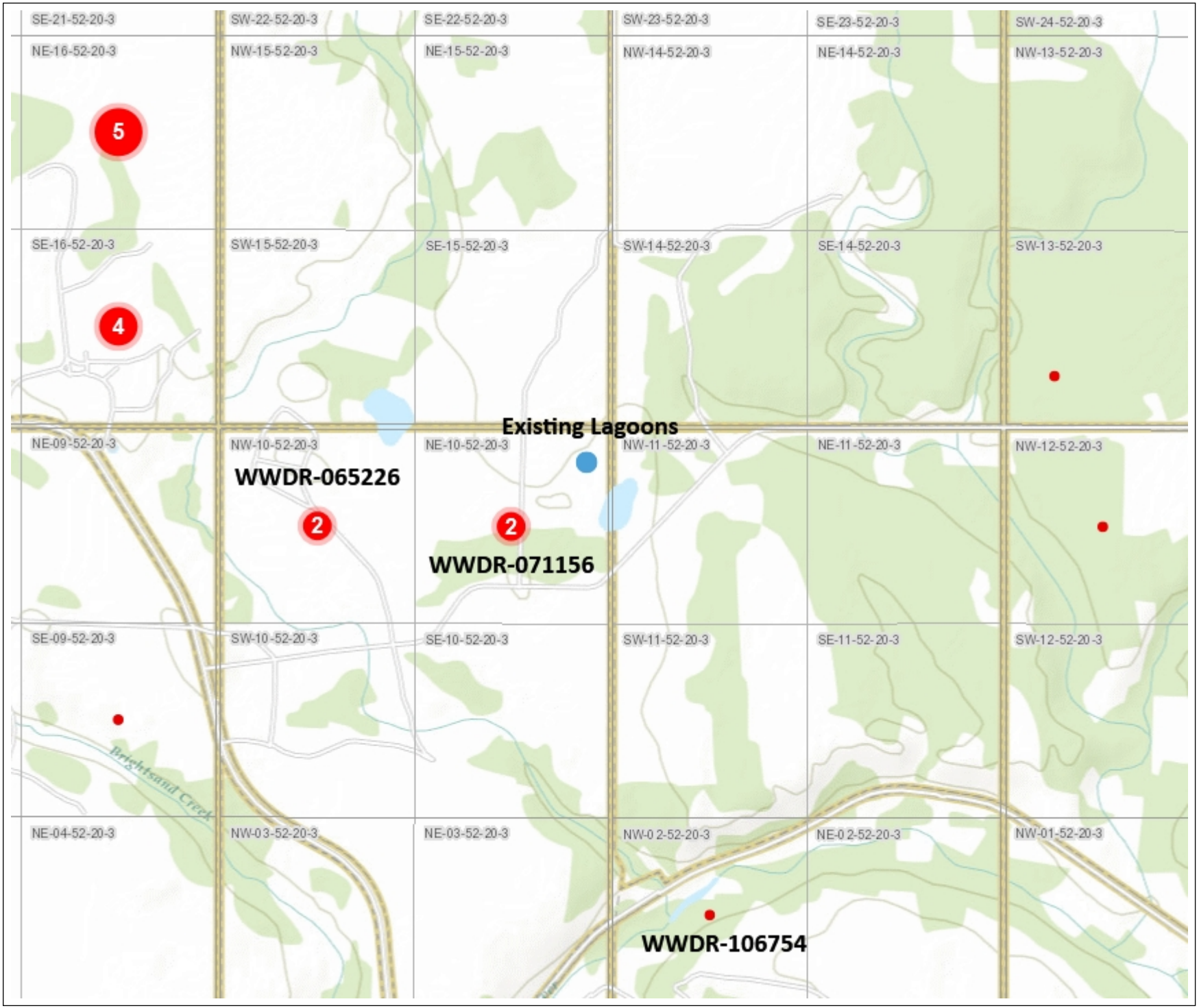
- Provincial Boundary
- National Park
- Provincial Park
- Terrestrial Wildlife Habitat Inve

1: 141,034

Notes

7.2 0 3.58 7.2 Kilometers

WGS_1984_Web_Mercator_Auxiliary_Sphere



Water Wells

Notes

Projection:

WGS_1984_Web_Mercator_Auxiliary_Sphere

Scale:

1: 36,112

Date

13-Nov-20

Disclaimer:

WSA prepares maps with varying degrees of accuracy and completeness dependant on the circumstances and available data. WSA makes no representation that this map will be sufficient for all uses. The user is advised to confirm the information contained herein in the event that precision and currency of data are required.

Water Security Agency

Water Well Driller's Report

17-Dec-2020
WSaskWWDR01

Well Name: THUNDERCHILD IR WWDR #: 065227

Well Location

Land Location	NE-10-052 -20 -W3	Location of Well (in Quarter)	
LSD	00	0	ft from N/S Boundary
Reserve		0	ft from E/W Boundary
RM:			
NTS Map:	73F00	Major Basin:	07
Elevation (ft)	2090	SubBasin:	29
Aquifer			

Well Information

Driller	ELK POINT DRILLING CORP
Completion Date	1978.06.27
Hole #	005
Install Method	Drilled
Borehole Depth (ft)	240
Bit Dia (in)	0
Water Level	0
Flowing Head	0
Water Use	Domestic
Well Use	Water Test Hole
Completion Method	
E-Log	Yes

Well Casings

Length (ft)	Btm (ft)	Dia (in)	Material
0	0	0	
0	0	0	
0	0	0	

Well Screens

Length (ft)	Bottom (ft)	Dia (in)	Slot (in)	Material
0	0	0	0	
0	0	0	0	
0	0	0	0	

Pump Test

Draw Down	0	ft
Duration	0	hrs
Pumping Rate	0	igpm
Temperature	0	deg. F
Rec. Pumping Rate	0	igpm

Lithology List

Depth (ft):	Material	Colour	Description
5	Clay	Brown	Sandy
13	Till	Brown	Sandy
20	Sand	Brown	Till Streaks
25	Sand	Unknown	Oxidized
105	Till	Grey	Unknown
200	Till	Grey	Hard
240	Shale	Unknown	Unknown

Water Well Driller's Report

13-Nov-2020
WSaskWWDR01

Well Name: THUNDERCHILD FIRST NATION WWDR #: 071156

Well Location

Land Location	NE-10-052 -20 -W3	Location of Well (in Quarter)	
LSD	00	0	ft from N/S Boundary
Reserve		0	ft from E/W Boundary
RM:			
NTS Map:	73F00	Major Basin:	07
Elevation (ft)	2090	SubBasin:	29
Aquifer			

Well Information

Driller	ELK POINT DRILLING CORP
Completion Date	1978.06.27
Hole #	TH5
Install Method	Drilled
Borehole Depth (ft)	240
Bit Dia (in)	0
Water Level	0
Flowing Head	0
Water Use	Municipal
Well Use	Water Test Hole
Completion Method	
E-Log	Yes

Well Casings

Length (ft)	Btm (ft)	Dia (in)	Material
0	0	0	
0	0	0	
0	0	0	

Well Screens

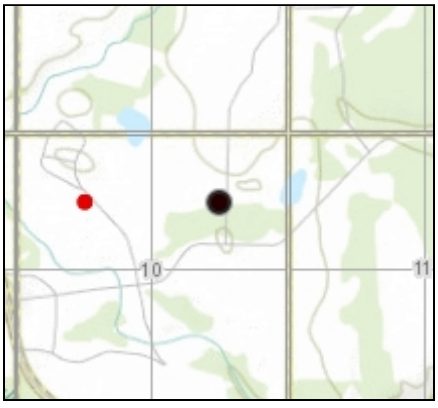
Length (ft)	Bottom (ft)	Dia (in)	Slot (in)	Material
0	0	0	0	
0	0	0	0	
0	0	0	0	

Pump Test

Draw Down	0	ft
Duration	0	hrs
Pumping Rate	0	igpm
Temperature	0	deg. F
Rec. Pumping Rate	0	igpm

Lithology List

Depth (ft):	Material	Colour	Description
5	Clay	Brown	Sandy
13	Till	Brown	Sandy
25	Sand	Unknown	Oxidized
70	Till	Grey	Unknown
105	Till	Green	Unknown
200	Till	Grey	Unknown
240	Shale	Unknown	Unknown



Water Well Driller's Report

13-Nov-2020
WSaskWWDR01

Well Name: THUNDERCHILD FIRST NATION WWDR #: 106754

Well Location

Land Location	NW-02-052 -20 -W3
LSD	00
Reserve	
RM:	499
NTS Map:	73F07
Elevation (ft)	2000
Aquifer	Glac

Location of Well (in Quarter)

0 ft from N/S Boundary

0 ft from E/W Boundary

Major Basin: 07

SubBasin: 29

Well Information

Driller	ELK POINT DRILLING CORP
Completion Date	1996.05.29
Hole #	017
Install Method	Drilled
Borehole Depth (ft)	336
Bit Dia (in)	4.8
Water Level	98
Flowing Head	0
Water Use	Domestic
Well Use	Withdrawal
Completion Method	Well Screen And Gravel Pack
E-Log	SCANNED

Well Casings

Length (ft)	Btm (ft)	Dia (in)	Material
306	304	5.5	P.V.C.
0	0	0	
0	0	0	

Well Screens

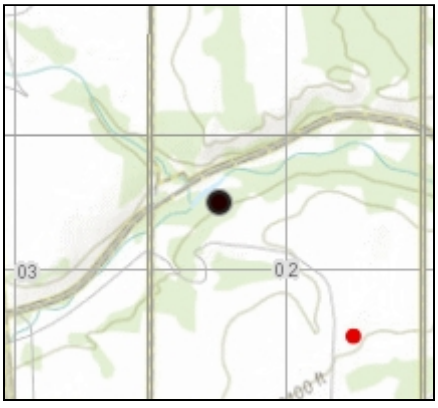
Length (ft)	Bottom (ft)	Dia (in)	Slot (in)	Material
5	309	3.8	30	Stainless Steel
0	0	0	0	
0	0	0	0	

Pump Test

Draw Down	102	ft
Duration	13	hrs
Pumping Rate	10	igpm
Temperature	0	deg. F
Rec. Pumping Rate	0	igpm

Lithology List

Depth (ft):	Material	Colour	Description
24	Till	Brown	Sandy
29	Clay	Grey	Unknown
35	Unknown	Brown	Silty
46	Sand & Gravel	Unknown	Unknown
56	Clay	Grey	Unknown
80	Till	Brown	Unknown
195	Till	Grey	Pebbly
197	Sand	Unknown	Coarse
244	Till	Grey	Sandy
246	Sand	Unknown	Coarse
286	Till	Grey	Pebbly
302	Sand	Unknown	Medium-coarse
309	Sand	Unknown	Clean
311	Till	Grey	Unknown



326	Sand	Unknown	Coarse
336	Unknown	Grey	Clayey

Water Well Driller's Report

13-Nov-2020
WSaskWWDR01

Well Name: THUNDERCHILD IR WWDR #: 065226

Well Location

Land Location	NW-10-052 -20 -W3	Location of Well (in Quarter)	
LSD	00	0	ft from N/S Boundary
Reserve		0	ft from E/W Boundary
RM:			
NTS Map:	73F00	Major Basin:	07
Elevation (ft)	2080	SubBasin:	29
Aquifer			

Well Information

Driller	ELK POINT DRILLING CORP
Completion Date	1978.06.21
Hole #	004
Install Method	Drilled
Borehole Depth (ft)	225
Bit Dia (in)	0
Water Level	0
Flowing Head	0
Water Use	Domestic
Well Use	Water Test Hole
Completion Method	
E-Log	Yes

Well Casings

Length (ft)	Btm (ft)	Dia (in)	Material
0	0	0	
0	0	0	
0	0	0	

Well Screens

Length (ft)	Bottom (ft)	Dia (in)	Slot (in)	Material
0	0	0	0	
0	0	0	0	
0	0	0	0	

Pump Test

Draw Down	0	ft
Duration	0	hrs
Pumping Rate	0	igpm
Temperature	0	deg. F
Rec. Pumping Rate	0	igpm

Lithology List

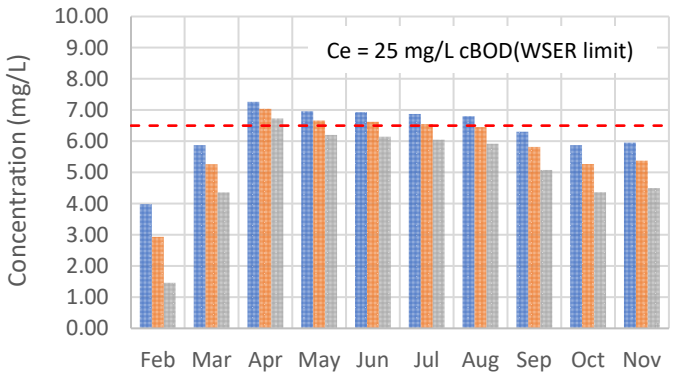
Depth (ft):	Material	Colour	Description
25	Gravel	Unknown	Unknown
27	Till	Grey	Unknown
32	Sand	Unknown	Unknown
139	Till	Grey	Soft
144	Sand	Unknown	Unknown
150	Till	Grey	Hard
169	Till	Green	Unknown
212	Till	Grey	Unknown
225	Shale	Unknown	Unknown

Appendix B
Predicted Downstream Concentrations After Mixing with Effluent

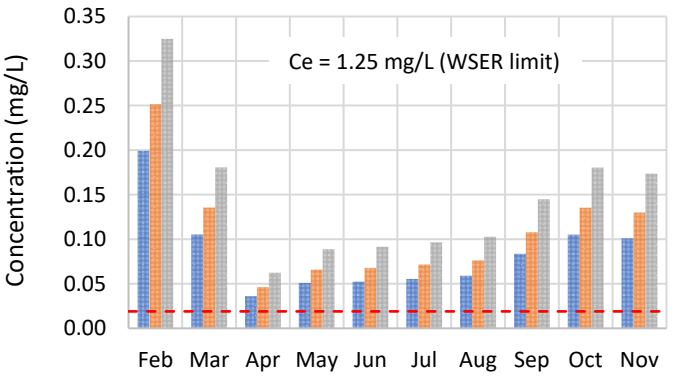
Downstream Use and Impact Study
Thunderchild First Nation Sewage Lagoon Upgrade
SLR Project No.: 208.30001.00000

Graph 3. Predicted Downstream Concentrations After Mixing with Effluent

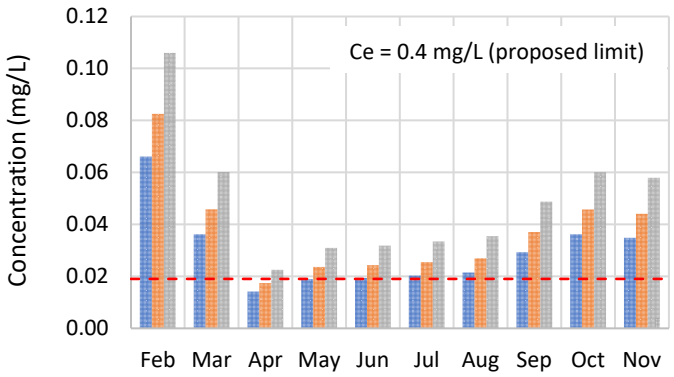
a. Dissolved Oxygen Concentration



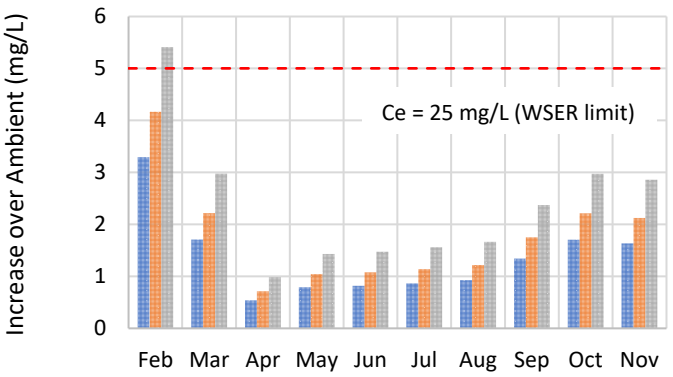
b. Unionized Ammonia Concentration



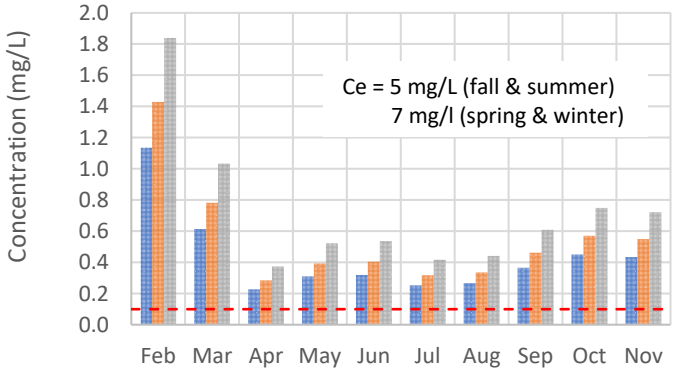
c. Unionized Ammonia Concentration



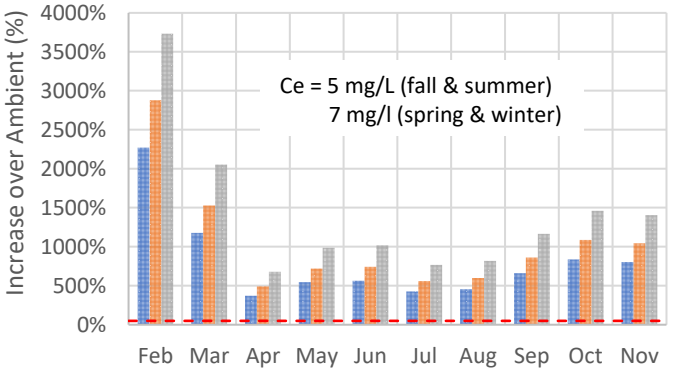
d. TSS Increase



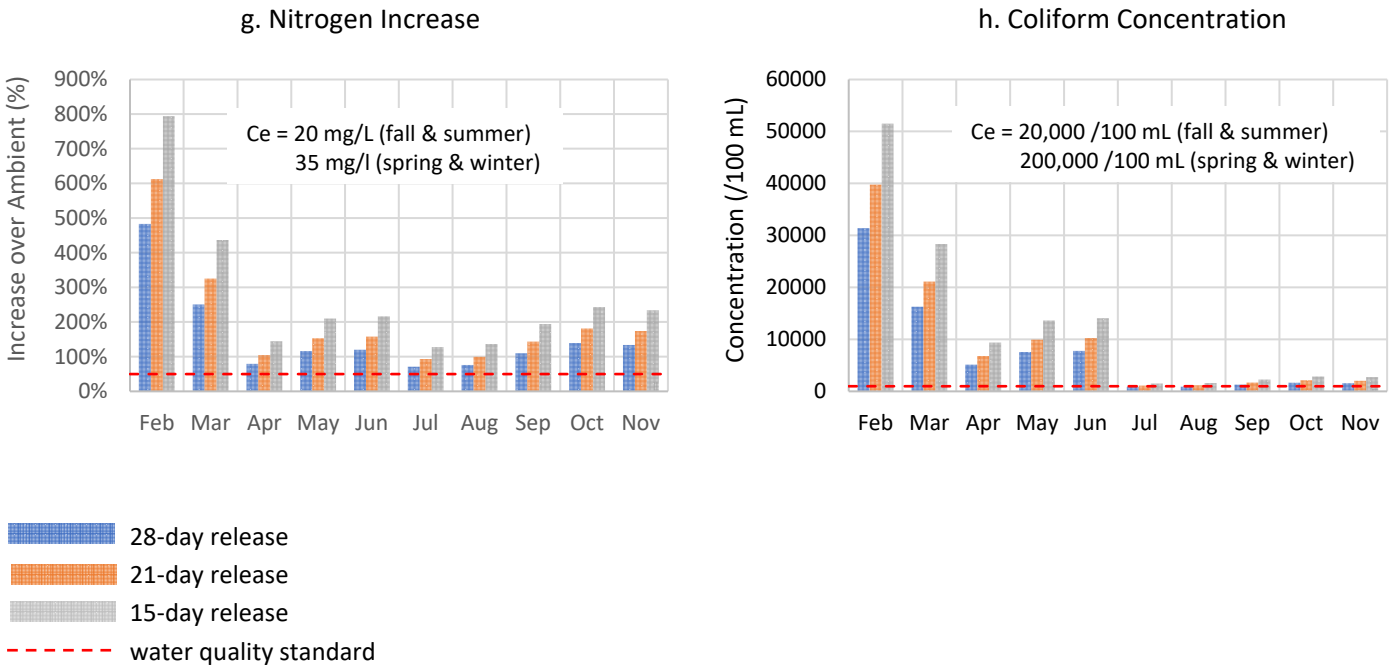
e. Phosphorus Concentration



f. Phosphorus Increase



Graph 3. Predicted Downstream Concentrations After Mixing with Effluent



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