CITY OF YELLOWKNIFE

MUNICIPAL STORMWATER MANAGEMENT PLAN
WATER LICENCE MV2009L3-0007

Version 6

January 2021

DOCUMENT CONTROL

Significant changes have been made to this document; refer to the revision table below.

Version	Date	Document Section	Page	Revision	Author
6	January 2021	Table of Contents, 1, 2, 3, 4, 9, 11, 12, Appendices B, D, F and G, All sections (Editorial Revisions)	1, 2, 3, 4, 13-15, 17, 19-24, 25	Water Licence Renewal Application	Associated Environmental on behalf of the City of Yellowknife
5	March 2020				City of Yellowknife
4	March 2017				City of Yellowknife
3	March 2014				City of Yellowknife
2-1	May 2013				City of Yellowknife
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1-2	August 2011				City of Yellowknife
1-1	April 2011				City of Yellowknife
1	December 2008				City of Yellowknife

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1. INTRODUCTION

This municipal stormwater management plan (MSWMP) describes the City of Yellowknife's (the City's) efforts to address stormwater infrastructure, maintenance, and replacement of that infrastructure. Additionally, this plan outlines strategies to minimize stormwater-related impacts on the surrounding environment.

This MSWMP is a requirement of the City's water licence that is administered by the Mackenzie Valley Land and Water Board (MVLWB). As per the water licence, the MSWMP must include best management practices (BMPs) to address stormwater issues in current and future development, a stormwater monitoring program, snow disposal practices, and a discussion on back-up power of sewage lift stations. Based on these requirements, and the City's objectives regarding built and natural drainage assets that the City manages (Section 2), this plan identifies both the current and planned strategies for dealing with stormwater.

The City will regularly update this document to record changes that may occur to its stormwater management system due to new construction, upgrades of failed or failing infrastructure, or changes in pollution control and monitoring programs.

2. OBJECTIVES

This City has established the following objectives for managing stormwater:

- Maintain or enhance the stormwater quality by establishing and implementing appropriate stormwater management practices;
- Prevent future flood damages by ensuring proper design and management methods are in place;
- Understand stormwater quality and its impact on the receiving aquatic environment by conducting a stormwater quality monitoring program, and expand or modify the program in response to system expansion, regulatory input, or monitoring program results;
- Identify system upgrade needs by reviewing and analyzing the existing storm sewer infrastructure and maintenance strategies; and
- Preserve the natural and beneficial functions of the natural drainage system.

3. CITY OF YELLOWKNIFE BACKGROUND

The City of Yellowknife is the capital of the Northwest Territories and its largest urban centre. It is located on the western shore of Yellowknife Bay, on the North Arm of Great Slave Lake, and encompasses an area of 136 square kilometres (52 square miles). It became the legislative capital of the Northwest Territories in 1967 and became incorporated as a City in 1970. Appendix A shows a map of Yellowknife and the City limits.

Yellowknife is the territorial center for mining, industry, transportation, communications, education, health, tourism, commerce, and government. Historical economic growth of Yellowknife is largely rooted in gold mining and government. However, in 1997 and 1998, the economy of Yellowknife was impacted by the NWT government downsizing of personnel due to territorial division in 1999, and weak commodity prices, particularly that of gold. The last two gold mines in Yellowknife, Con and Giant, shut down operations in November of 2003 and July 2004, respectively.

The population of Yellowknife is 20,607, as estimated in the City's draft *Community Plan*[1]. Yellowknife's population base is about half of the territory's entire population. With anticipated growth in the non-renewable resource sector, particularly diamond mining operations and oil and gas exploration and development, the population of Yellowknife is expected to reach 24,200 in 2050.

With the increase in population, land use requirements have changed, causing the landscape of the City to change. Increasing development has created an increase in the amount of stormwater being directed into the City's stormwater collection system. The largest amount of runoff occurs during the spring freshet, which creates very large quantities of water in a short period of time.

[1] City of Yellowknife. 2019. Community Plan – DRAFT. October 2019.

4. NATURAL SETTINGS

Yellowknife is located in the subarctic climate zone. The 1981 to 2010 climate normals for Yellowknife report a minimum average daily temperature of -25.6°C in January and a maximum average daily temperature of 17.0°C in July. Yellowknife receives an average of 171 mm of rainfall, mainly from May to October, and 158 cm of snow each year. There are approximately four days each year with rainfall greater than 10 mm, and approximately one day every two years with rainfall greater than 25 mm[2].

Yellowknife is located within the Great Slave Lowland High Boreal ecoregion[3], which is broadly described as a taiga shield landscape. This ecoregion is characterized by low relief, low elevation landscapes with rocky outcrops, silty till deposits, and numerous lakes. The terrestrial vegetation is predominantly coniferous or coniferous-deciduous forests. The ecoregion includes lake-adjacent wetlands, and fens and peatlands in depressions. The dominant surficial geology of Yellowknife is bedrock (i.e., granitoid in the western regions and igneous or volcanic in the eastern regions)[4], glaciofluvial and glaciolacustrine deposits, and organic deposits adjacent to the region's lakes[5].

Yellowknife has several lakes within its municipal boundaries and these lakes are the receiving bodies of stormwater captured and diverted by the City's stormwater sewer system. These lakes are Kam Lake, Range Lake, Frame Lake, Niven Lake, Rat Lake, Grace Lake, and Yellowknife Bay and Back Bay of Great Slave Lake. Recreational uses of the lakes include swimming, boating, fishing, harvesting edible plants, and walking along nature trails. Some lakes have had advisories placed against recreational use in recent years due to water quality concerns[6]. The larger lakes are generally fish-bearing (e.g., Kam Lake, Back Bay), but Frame Lake is no longer fish-bearing due to excessive nutrient enrichment and decreased water quality. The City and the Department of Health and Social Services both advise that untreated water from all lakes within Yellowknife's municipal boundaries is not fit for consumption. This advisory is relevant to recreational users but also to the houseboat community in Great Slave Lake, which does not have ready access to the treated, piped municipal water supply.

[2] Environment and Climate Change Canada. 2020. Canadian Climate Normals 1981 – 2010 Station Data for Yellowknife A*.
https://climate.weather.gc.ca/climate_normals/results_1981_2010_e.html?searchType=stnProv&lstProvince=NT&txtCentralLatMin=0&txtCentralLatSec=0&txtCentralLongMin=0&txtCentralLongSec=0&stnID=1706&dispBack=0

[3] Ecosystem Classification Group. 2008. Ecological Regions of the Northwest Territories – Taiga Shield. Department of Environment and Natural Resources, Government of the Northwest Territories, Yellowknife, NT, Canada. viii + 146 pp. + insert map.

[4] Northwest Territories Geoscience Office. 2019. Bedrock Geological Map of the Slave Craton, Northwest Territories and Nunavut. Reference Number 2019-01.

[5] Natural Resources Canada. 2015. Surficial Geology Map. https://open.canada.ca/data/en/dataset/cebc283f-bae1-4eae-a91f-a26480cd4e4a

[6] Dept. of Health and Social Services. 2019. Arsenic in Lake Water Around Yellowknife Advisory. Government of Northwest Territories. https://www.hss.gov.nt.ca/en/newsroom/arsenic-lake-water-around-yellowknife

Some of the lakes have reduced water quality due to the impacts from historical mining operations, land development, and municipal operations. For example, Kam and Rat Lakes were impacted by the adjacent Con Gold Mine tailings, and Niven Lake was used as the City's sewage treatment lagoon until the 1980s. Arsenic concentrations have been detected in several of the lakes in Yellowknife. The Northwest Territories Department of Health and Social Services has advised against swimming, fishing, and natural food harvesting around several lakes including Kam, Niven, Rat, and Frame Lakes, because the arsenic levels are above the recommended safety guidelines from Health Canada. Research has shown accumulated mercury and arsenic in fish tissues from lakes around Yellowknife and persistent additions of arsenic from submerged mining tailings in Back Bay[7]. The studies consistently identify the historical mining operations and residual tailings as the source of arsenic in the surface waters of Yellowknife.

[7] Cott, P.A., B.A. Zajdlik, M.J. Palmer, and M.D. McPherson. 2016. Arsenic and mercury in lake whitefish and burbot near the abandoned Giant Mine on Great Slave Lake. Journal of Great Lakes Research. doi: 10.1016/j.jglr.2015.11.004

5. BACKGROUND ON STORMWATER

Stormwater is received and collected as a result of precipitation events. Figure 5-1 depicts the hydrologic cycle. Once precipitation makes its way to land surface, it can be distributed in several ways. It can be received by vegetation, it can infiltrate the ground to recharge groundwater sources, and it can flow overland (i.e., surface runoff) and enter lakes, streams, stormwater system or other holding areas (Figure 5-1). Once that occurs, it can make its way back to the atmosphere through evaporation and evapotranspiration.

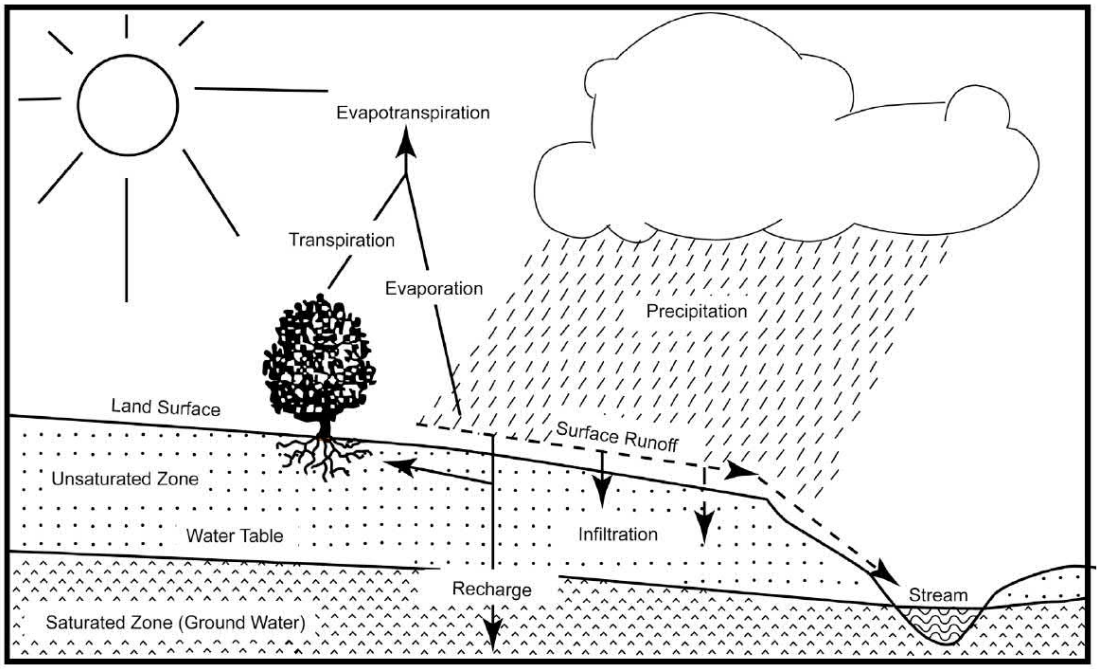


Figure 5-1: Schematic of Natural Hydrological Cycle

Land development can dramatically alter the hydrologic cycle and the surrounding environment. When land is developed, the natural topography of the land can change or be removed.

Construction activities vary depending on land development requirements and can include clearing, grubbing, blasting, backfilling, and resurfacing. Each of these activities can change the way stormwater is received and distributed throughout the catchment area. Clearing and backfilling can affect infiltration and evaporation. Infrastructure such as gutters, drainage channels, and storm sewers can transport runoff more quickly to minimize flooding, but can also introduce pollutants directly into downstream waterways. Greater flow transport systems can increase erosion and sedimentation, which can destroy natural habitat. The addition of impervious surfaces, such as asphalt, can also affect infiltration, which in turn affects stream base flow and groundwater recharge. All these activities have impacts on adjacent wetlands and other biological communities that depend on base flows.

While land development in Yellowknife is inevitable, proper design, construction, and management practices should be in place to avoid or limit impacts on stormwater.

6. STORMWATER SYSTEM COMPONENTS

The City's stormwater management system comprises several components. The type of infrastructure depends on the topography of the land, among other conditions. There are two types of stormwater infrastructure: minor and major systems.

The minor system generally comprises the underground components, such as catch basins, manholes, and piping. This system is designed to handle a 5- to 25-year storm event and move water through the system quickly.

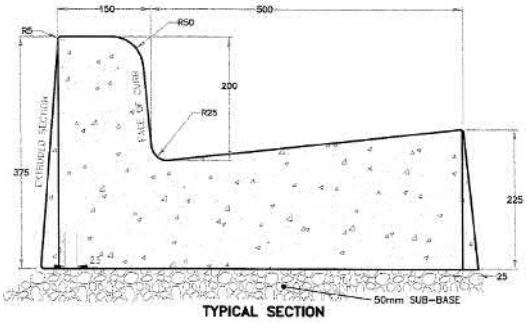
The major system comprises roadways and large overland runoff or retention areas, such as parks or green spaces. This system is seldom used and only required when the minor system is overwhelmed by a 100-year storm event.

6.1. Minor System Components

The various components of the City's minor (underground) stormwater infrastructure are as follows:

Curbs & Gutters

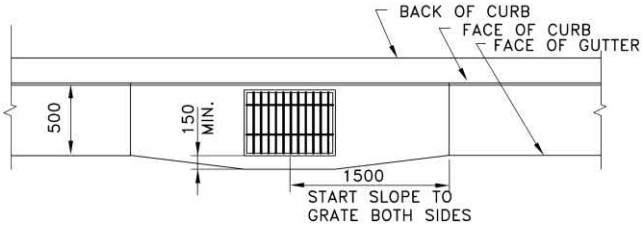
The figure to the right shows a typical standard for the City's curb and gutter detail. The roadways are designed to direct stormwater to run off into this gutter structure. From here, the stormwater is directed along the gutter to a catch basin.



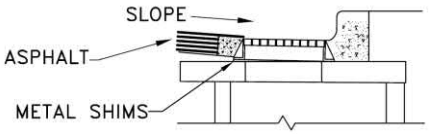
TYPICAL SECTION

Catch Basins

The aforementioned catch basins are usually located at low points in City roadways. The catch basins collect stormwater and direct it to the stormwater piping system through the part of the catch basin that is called the lead.



PLAN VIEW

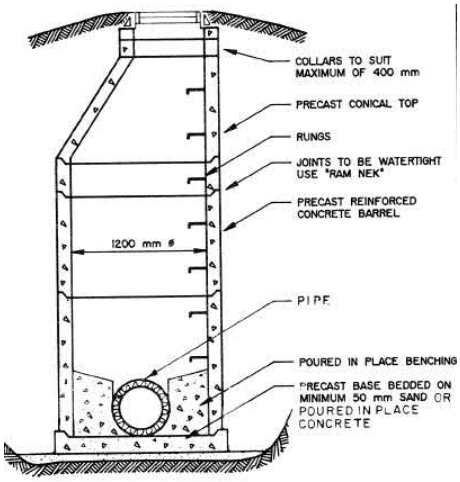


SECTION VIEW

Stormwater Manholes

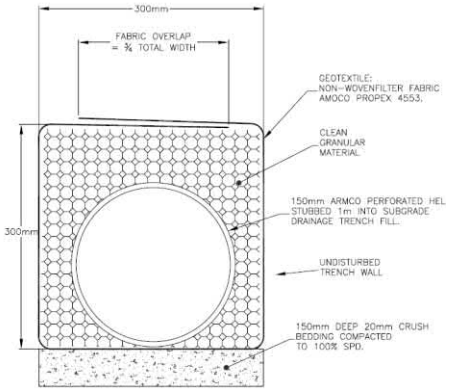
Manholes in the stormwater system are required for maintenance purposes. There are times when storm mains are plugged or frozen, and these manholes provide access points where the obstructions in the lines can be removed.

They can occasionally serve as a retention area should the pipe be completely submerged in water. However, when this occurs, the storm event is large enough that the manhole is also overwhelmed.



French Drains

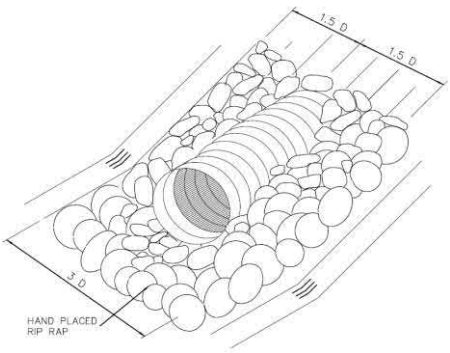
French Drains, also known as sub-drains, are structures placed under roadways where there is a large amount of ground infiltration. The perforated pipe collects the water and then transfers the water via gravity to the larger stormwater pipe system.



Outlets

Outlets are areas of discharge into the environment; these places can be ditches, lakes, wetlands, or low-lying areas that can be used to collect stormwater.

These outlets can be constructed by various methods. The figure to the right shows an outlet with hand-placed riprap to help prevent erosion around the outlet. In some areas, the pipe is exposed to the natural environment to prevent any negative impacts due to construction.



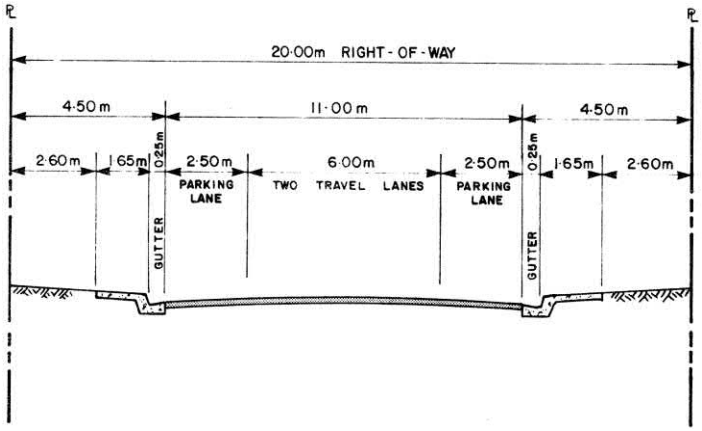
6.2. Major System Components

The various components of the City's major stormwater system are as follows:

Roadways

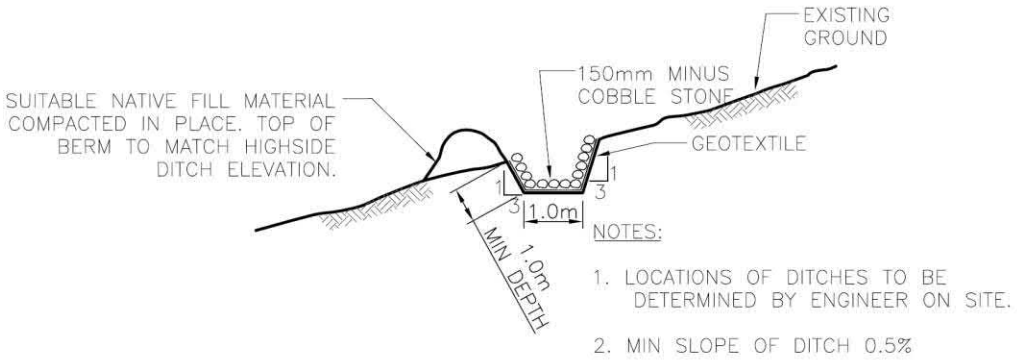
A roadway is a major collection area for a precipitation event. Roadways collect the water and then transfer it to the minor system via catch basins. However, during large rainfall events, the roadways act as a major avenue for sheet drainage when the minor system becomes overwhelmed.

Shown below is a typical roadway cross section.



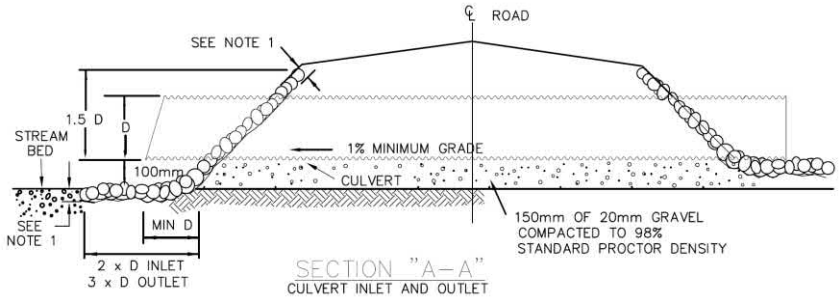
Ditches

Ditching is a common drainage path that is used when underground stormwater infrastructure is not present. The curb and gutter are not placed on the roadway as shown in the above section. Instead, the road is designed such that it moves stormwater directly to the ditch. Ditches are typically on grade and collect water at low points where the water is eventually discharged to an area that can absorb or eliminate it. Below is an example of an interceptor ditch, which differs slightly from a roadway ditch.



Culverts

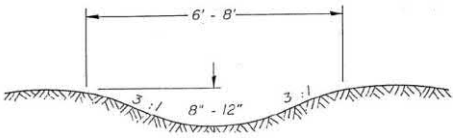
Culverts are used as a means of transporting ditch flow from one side of a roadway to another or for a driveway to cross a ditch. Culverts usually discharge into another ditch or accepting body. The following figure is a cross section of a culvert; it is shown discharging to a stream bed but is still a typical application.



Swales

A swale is a common drainage path that is used under various circumstances. Swales are shallow depressions with gently sloping sides that drain stormwater runoff. They can be created by excavating a small amount of material to create a low depression that is graded to an area of outlet. A swale is very similar to a ditch but less predominant.

A sketch of a typical swale construction is shown below:



6.3. Catchment and Discharge Areas

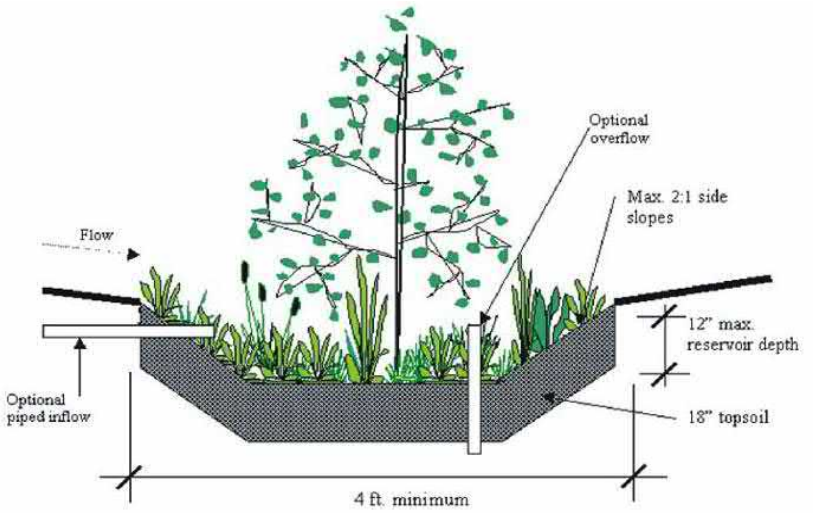
The City has been divided into eight catchment areas in which stormwater is collected by components of the stormwater management system and directed to a specific receiving water body. A map that depicts the different catchment areas is included in Appendix B.

7. LAND DEVELOPMENT PRACTICES

As stated in Section 5, land development can alter the hydrologic cycle and the surrounding environment. Responsible design when developing land can mitigate some of those effects.

Design must consider all aspects of land development such as lot grading, road networks, water and sewer infrastructure, utility infrastructure, and stormwater infrastructure. All factors must be taken into consideration during the design process, and the design process must allow for the most efficient systems possible while having the least impact on the surrounding environment.

For example, the City is currently researching different methods of stormwater retention in residential areas. The following diagram shows what is being considered for residential cul-de-sacs in some of the newly developed areas in Yellowknife.



This design allows the City to make use of stormwater runoff instead of discharging it directly to a receiving body. This method reduces the work requirements involved in the watering of the vegetation in these cul-de-sacs.

8. SNOW DISPOSAL

As most of the precipitation in Yellowknife is in the form of snow, it is necessary to have designated disposal areas for snow that has been removed from roads and parking areas. The City maintains three snow dump areas, only one of which is available for use by private contractors. The other two snow dumps are strictly for use by City crews. One is located on Deh Cho Blvd, and two are at the Solid Waste Facility (SWF). The figures in Appendix C show the locations and general drainage paths of the snow dumps.

The snow dump areas at the SWF are located such that snowmelt runoff does not enter the landfill – the area where wastes have been buried. A clay berm was developed and backfilled at the site closest to the quarry to prevent flow into the quarry. Since this addition water has not been seen flowing into the quarry. Melt water from the snow dump area closest to the quarry at the north side of the landfill is sampled as part of the Surveillance Network Program (SNP) at station 0032-13A. The second snow dump area at the landfill drains into a slough area, which eventually drains through wetlands and a small creek down to Highway 3 at SNP station 0032-16.

The snow dump on Deh Cho Blvd. drains primarily towards the stormwater drainage ditch along Deh Cho Blvd. Roughly 10% of the snow dump area drains through the wetlands towards the rear of the site. As most of the drainage from the site flows through the existing Deh Cho Blvd. stormwater sampling point, an additional sampling point specifically for the snow dump is not necessary at this time.

9. POLLUTION CONTROL

Controlling the composition of stormwater is important as the quality of the water will affect the receiving waters.

Many types of pollution can enter the stormwater system and end up entering the receiving waterbody. These include general garbage and debris, liquids and chemicals, pet waste, and in extreme circumstances, sewage. The City will continue to work with Council to review and potentially consider additional bylaws and educational activities (see also section 13) to reduce pollution at the source. For example, reviews of the water and sewer bylaw are regularly undertaken as part of City standards. The following sections describe the measures the City has undertaken to control stormwater quality.

9.1. Litter Control

The best way of controlling litter is to prevent it. To aid in reducing the amount of litter in Yellowknife, the City has increased the number of ashtray containers, garbage cans, and recycling bins in the downtown core, and has promoted anti-littering campaigns.

As littering continues to occur, the City has implemented clean-up programs and street sweeping to help reduce the amount of litter entering the stormwater system.

Clean-Up Programs

The Adopt-A-Street program relies on volunteers to maintain the cleanliness of a street, or a portion of a street, for a minimum of one year. The City provides the equipment necessary for the clean-up and posts a sign in the area recognizing the efforts of the participants. Participants also receive a signed certificate from the Mayor's office for joining the program.

As litter tends to pile up under layers of snow and ice during the winter, the City has implemented a Spring Clean-Up program. This program relies on youth-oriented, non-profit organizations or groups to participate in cleaning up an assigned area of the City. Unlike other litter clean-up programs, the Spring Clean-Up provides the groups involved with financial support.

Street Sweeping

In combination with the clean-up efforts of volunteers, the City has implemented a street sweeping program. Currently, the City has a total of three street sweepers; two waterless and one broomless sweeper. Street sweeping generally starts once temperatures remain above freezing in the spring, and continues through the fall until snow remains on the ground. In the spring, the City employs the street sweepers to clean away the street sand and debris that has accumulated over the winter. The spring street sweeping takes approximately two weeks to cover the downtown core, and one month to clean the entire city. As the warm season progresses, the requirement for sweepers lessens and work hours are reduced. Street

sweeping greatly reduces the amount of loose material that can be introduced to the stormwater system.

9.2. Stormwater Outlet Controls

Stormwater outlets are sometimes equipped with a screen to ensure that debris and garbage are unable to flow into the receiving waterbody. As City workers must be able to access the outlets periodically to clean debris from the screens, only outlets that can be accessed safely are equipped with screens. Currently, two of the City's outlets have screens. These outlets are the outlet located on School Draw Avenue and the outlet located on Bagon Drive.

The City is also implementing the use of a trash interceptor, which is a device that collects garbage in a central area much like a manhole, but at the same time allows stormwater to discharge. The current unit, which has been in use since 2005, was built specifically for the outfall near Rotary Park on School Draw Avenue. The trash interceptor is installed each spring and checked periodically for the build-up of litter. Typically, the unit only requires to be cleaned out when it is removed in the fall.

In conjunction with the installation of screens and trash interceptors, the City endeavours to inspect all stormwater outfalls following rain events that exceed the 5-year design criteria of the stormwater collection system. The purpose of these inspections is to ensure that no significant damage has occurred to the stormwater collection system and that the system is still functioning properly.

9.3. Stormwater System Clean-Out

Part of the City's annual maintenance includes cleaning out the components of the stormwater collection system, primarily catch basins and manholes. To perform this work, the City employs two vacuum-equipped trucks known as "vactor" trucks. Each catch basin and manhole is uncovered and the vactor truck's suction capabilities are used to remove the accumulated road sand and garbage. This practice greatly reduces the amount of sediment and litter that can enter the system.

Disposal of the material removed during the cleaning program is done at Fiddler's Lagoon. The stormwater cleaning vactor trucks discharge at the same location as sewage discharge (Appendix D). The material is placed along the bank of the lagoon, which allows the water to drain from the sediment into the lagoon.

9.4. Unauthorized Discharges

The release of non-stormwater discharges into the City's stormwater system is strictly prohibited as per the City's Water and Sewer By-Law[8]. Should a contaminant be introduced to the City's stormwater system, the responsible party is liable for all costs associated with the remediation of that spill.

[8] City of Yellowknife **Water and Sewer Services By-Law No. 4663, as amended**.

The City has a Spill Contingency Plan (SCP) that outlines policies and procedures that are in place for spills originating from or discovered by City Staff. The SCP is required by the City's water licence and can be found on the MVLWB registry site. Copies of the SCP can be requested by contacting the City at 867-920-5600.

9.5. Back-up Power Units

Back-up power units have been connected to most of the City's Lift stations, which handle sewage disposal throughout the City. In the event of a power disruption, these units are activated and provide power until the functionality of the City's power grid returns. These units ensure that raw sewage continues to flow to the sewage lagoon for treatment. The SCP contains more information about the City's sewage system.

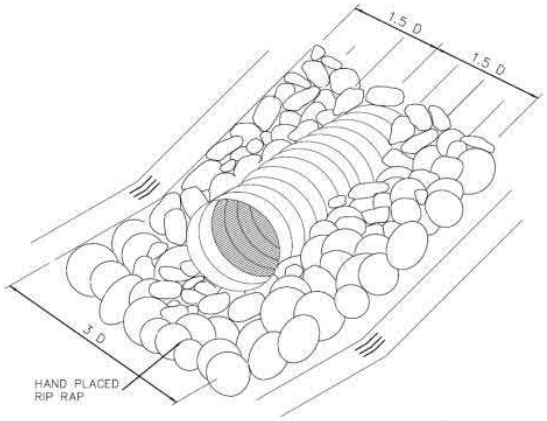
10. SEDIMENT AND EROSION CONTROL MEASURES

To ensure the amount of material entering a water body is not affected by construction projects, or the amount of water being channelled through the outlets of the stormwater collection system, the City has implemented several sediment and erosion control measures. The following are examples of typical control measures.

Silt Fencing

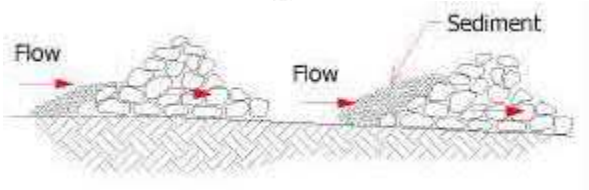
Silt fences are installed to reduce the velocity of flow and allow for the deposition of sediments before they can enter a fish-bearing body of water. They are made from filter fabric that is buried at the bottom, stretched, and supported by posts. Silt fences are not designed to withstand high heads.

Riprap Placement



Large stone (riprap) is placed on embankments or slopes to provide stability to that slope. This keeps the embankment material in place and does not allow it to erode and potentially enter the stormwater system. The figure to the right is an example of riprap placed around a culvert or outlet structure.

Rock Dams



Rock dams are used to slow down the rate of flow in a water channel, as shown in the figure to the right, to allow sediments to settle out of the water column.

Surface Roughening

Surface roughening is the practice of creating horizontal depressions on slopes. It reduces runoff velocities and increases infiltration, which helps to prevent erosion of the slope. Roughening methods include stair-step grading, grooving, and tracking. Equipment such as bulldozers with rippers or tractors with disks may be used, as shown right.

General Surfacing

Once an area has been developed, several methods of erosion control can be used to resurface an area. This can be done by seeding or sodding, or the placement of rock, concrete and asphalt.

Erosion Control Plans

The City requires the submission and approval of an Erosion Control Plan (ECP) before work begins on any project where erosion is a risk. As each project is unique, an ECP may include one or more of the erosion control measures, previously discussed.

10.1. City Standards for Sediment and Erosion Control

The City is currently updating the City Standards that regulate construction throughout the city and plans to adopt them in 2021. Included in the updated Standards will be the adoption of sediment and erosion control methods from Ontario Provincial Standards. Examples of the methods the City will be adopting are shown in Appendix E.

11. MONITORING PROGRAM

In spring 2009, the City initiated a stormwater monitoring program. This program provides an analytical record of the quality of water that is leaving the stormwater system and entering the receiving waterbodies. The monitoring program design has evolved over time in response to comments from regulatory agencies and public concerns. The program was recently revised to better address objectives that align with requirements of the water licence and to increase the confidence that samples can be obtained regularly. The objectives of the monitoring program are as follows:

1. Meet MVLWB requirements for the City's Water Licence (May 15, 2013 letter and MSWMP):
   - Analyze stormwater data to determine effects on the receiving watercourses;
   - Estimate potential impacts on the receiving watercourses, with an emphasis on effects on fish-bearing watercourses; and
   - Identify runoff profiles based on land use for industrial, commercial, and residential land uses. This serves the long-term goal to extrapolate storm impacts from the monitored catchments to the Yellowknife area and thereby enable impact assessment to all receiving waterbodies.
2. Support the City's public education and source control activities:
   - Identify pollutant hotspots for targeted public education;
   - Identify illicit discharges to the storm sewer system; and
   - Address resident concerns regarding discharge quality at specific locations.

11.1. Sampling Locations and Frequency

When stormwater monitoring began in 2009, there were seven monitoring stations. This was increased to nine in 2010. Based on a meeting with regulatory agencies that was held in February 2013, the City modified the sampling program as per Table 1. This increased sampling at places where public concern was raised, and decreased sampling in places where there was little concern.

In 2019, the City hired a consultant to review the sampling program to determine sampling locations based on the following criteria (Appendix F):

1. Identify runoff profiles based on land use for industrial, commercial, and residential;
2. Identify pollutant hotspots for targeted public education;
3. Support reporting requirements by the MVLWB;
4. Identify sites and methods to make sample collection more consistent; and
5. Address resident concerns regarding discharge quality at specific locations.

Table 1: Sampling Locations and Frequency until 2019

Outlet	Sampling Events			Total # of Samples
	Spring[1]	Summer[2]	Fall[3]	
Jan Stirling	✔	✔	✔	3
Back Bay	✔	✔	✔	3
School Draw	✔	✔	✔	3
Deh Cho Blvd	✔		✔	2
Kam Lake	✔		✔	2
Frame Lake	✔			1
Niven Lake	✔			1
Range Lake	✔			1
Grace Lake	✔			1

1. Late May/Early June
2. Late July/Early August
3. Mid-September

Based on the consultant's recommendation, the City has modified the sampling locations as per Table 2. A map of the new sampling locations can be found in Appendix G.

Table 2: Sampling Locations, Methods, and Frequency starting 2020

Site ID	Outlet	Sampling Events			Total # of Samples	Primary Catchment Land Use
		Spring[1]	Summer[2]	Fall[3]		
N1	Back Bay	✔	✔	✔	3	Residential
N2	Lundquist Road	✔	✔	✔	3	Downtown
N3	School Draw	✔	✔	✔	3	Downtown
N4	Coronation Drive	✔	✔	✔	3	Industrial
N5	Curry Drive	✔	✔	✔	3	Industrial
N6	Grace Lake South	✔	✔	✔	3	Residential
N7	Bagon Drive	✔	✔	✔	3	Residential
N8	Range Lake	✔	✔	✔	3	Mixed
N9	Frame Lake Inlet	✔	✔	✔	3	Mixed Residential and Commercial

1. Late May/Early June
2. Late July/Early August
3. Mid-September

Stormwater will be sampled at all locations three times per year, starting in 2020 (Table 2). Spring sampling will be conducted during snowmelt and summer and fall sampling during rain events.

11.2. Sampling Methods

The following sampling methods will be used to collect stormwater samples, depending on location and volumes of flow. The submerged bottle method is the preferred, standard sampling method and will be used at all sites at all events. The other two methods are less preferred methods only employed in the unlikely case that the preferred method is not possible. The Low Flow Bag Method may be used if there is visible flow, but the water is not deep enough to submerge a sampling bottle. The standpipe and bailer method may be used if the water flow at a site is very shallow or occurs below the surface. The weather forecast will be monitored closely to allow fast response to major snow melt or rain events and thus increase the chance of sufficient water flows for sampling. One duplicate and one field blank sample will be collected at each sampling event for quality assurance and quality control purposes. The stormwater sampling protocol can be found in Appendix H.

Submerged Bottle Methods

1. New latex gloves will be worn for each sample.
2. Sample bottles will be submerged upside down until the bottle is within the flowing discharge.
3. The bottle will be turned upwards and into the flow to fill the bottle.
4. The bottle will be removed from the water with the mouth upward.
5. Preservation agents provided by the laboratory will be added where applicable.
6. The cap on the bottle will be replaced and tightened.
7. The bottles will be stored on ice in a cooler and delivered to the laboratory for analysis the same day or the next morning, but within 24 hours to respect holding times for pathogen parameters.
8. Site ID, date, time, observations, amounts, etc. will be recorded.

Low Flow Bag Capture Methods

1. New, unused sturdy plastic bags (Ziploc freezer bag size large, or other) will be gathered.
2. During rain events:
   a. New latex or plastic sampling gloves will be worn for each sample.
   b. The bag will be extracted and opened while standing downstream of the sampling location.
   c. The mouth of the open bag will be flattened and lowered into the stream flow. The mouth will be oriented so that the flow runs directly into the bag. The runoff will be captured until the bag is almost overflowing (amount captured will vary depending on slope of sampling location).
   d. Captured water will be poured into the sample bottle provided by the lab before the bottle cap is replaced and tightened.
   e. Bottles will be stored as per lab instructions until delivery to the lab for analysis
   f. ID, date, time, observations, amounts, etc. will be recorded.

Standpipe and Bailer Methods

1. A permanent perforated standpipe will be installed prior to a discharge event and allowed to sit for several days to clear the silt from the standing water.
2. Depth to groundwater or ground surface within standpipe will be measured.
3. During rain events:
   a. New latex or plastic sampling gloves will be worn for each sample.
   b. A clean bailer (Waterra or similar) will be extracted for use in the standpipe while not allowing it to touch surfaces that may be contaminated.
   c. A clean bailer will be connected to a rope and marked with the sampling depth measured in Step 2.
   d. The bailer will be lowered into the standpipe to the depth marker indicated in Step 3c and collect sample.
   e. The bailer will be pulled from standpipe and emptied into sample bottle provided by lab.
   f. The cap will be replaced on the bottle and tightened.
   g. Samples will be stored as per lab instructions until delivery to the lab for analysis.
   h. ID, date, time, observations, amounts, etc. will be recorded.

11.3. Sampling Parameters

Temperature and pH will be measured in all samples in the field at the time of sample collection. Water samples will be submitted to an accredited laboratory and tested for physical parameters, fecal coliforms, major ions, nutrients, total metals, and hydrocarbons (Table 3).

Table 3: Stormwater Monitoring Parameters

Field Parameters			
pH	Temperature		
Microbiology			
Biochemical Oxygen Demand	*Escherichia coli* (*E. coli*)	Fecal Coliforms	
Physical			
Total Suspended Solids	Specific Conductivity	Alkalinity, Total (as $CaCO_3$)	Total Dissolved Solids
Major Ions			
Calcium	Chloride	Fluoride	Hardness
Magnesium	Potassium	Sodium	Sulphate
Nutrients			
Ammonia as Nitrogen	Nitrate as Nitrogen	Nitrite as Nitrogen	Total Phosphorus
Organic			
Hydrocarbons			
Trace Metals, Total			
Aluminum	Antimony	Arsenic	Barium
Beryllium	Cadmium	Cesium	Chromium
Cobalt	Copper	Iron	Lead
Lithium	Manganese	Mercury	Molybdenum
Nickel	Rubidium	Selenium	Silver
Strontium	Thallium	Titanium	Uranium
Vanadium	Zinc		

11.4. Stormwater Quality Analysis

The results of the stormwater monitoring program will be compared to the Canadian Water Quality Guidelines for Recreational Water Quality (GCRWQ)[9] and the Canadian Water Quality Guidelines for the Protection of freshwater Aquatic Life[10] (AL) (Table 4).

Table 4: CCME Surface Water Quality Guidelines for Stormwater Quality Interpretation

Analyte	Unit	Guideline		
		CCME AL	**CCME AL**	**GCRWQ**
General Parameters		Chronic	Acute	
Ammonia (total, as N)	mg/L	Calculated		NG

[9] Health Canada 2012. Guidelines for Canadian Recreational Water Quality, Third Edition, April 2012.
[10] Canadian Council for Ministers of the Environment 1999. Canadian water quality guidelines for the protection of freshwater aquatic life.

Analyte	Unit	Guideline		
		CCME AL	CCME AL	GCRWQ
Chloride	mg/L	120		NG
Fluoride	mg/L	0.12		NG
Nitrate (as N)	mg/L	3	124	NG
Nitrite (as N)	mg/L	0.060		NG
pH		6.5 - 9		5.0 - 9.0
Total suspended solids	mg/L	Narrative		NG
Microbiological				
Fecal coliforms (MPN)	MPN/100 mL	NG		200
Total Metals				
Aluminum (total)	mg/L	Calculated		NG
Arsenic (total)	mg/L	0.005		NG
Boron (total)	mg/L	1.5	28	NG
Cadmium (total)	mg/L	Calculated		NG
Chromium (total)	mg/L	0.0010*		NG
Copper (total)	mg/L	Calculated		NG
Lead (total)	mg/L	Calculated		NG
Manganese (total)	mg/L	Calculated		NG
Mercury (total)	mg/L	0.000026		NG
Molybdenum (total)	mg/L	0.073		NG
Nickel (total)	mg/L	Calculated		NG
Phosphorus (total)	mg/L	Narrative		NG
Selenium (total)	mg/L	0.0010		NG
Silver (total)	mg/L	0.00025		NG
Thallium (total)	mg/L	0.0008		NG
Uranium (total)	mg/L	0.015	0.033	NG
Zinc (total)	mg/L	Calculated		NG
Hydrocarbons				
Benzene	mg/L	0.370		NG
Ethylbenzene	mg/L	0.090		NG
Styrene	mg/L	0.072		NG
Toluene	mg/L	0.0020		NG

NG - no guideline
*Guideline is 0.0010 mg/L for chromium VI. CCME interim guideline for freshwater aquatic life is 0.0089 mg/L for chromium III. Total chromium results will be compared to the guideline of 0.0010 mg/L to identify the potential for exceeding the chromium VI and/or chromium III guidelines.

11.5. Reporting

The results of the sampling program are reported in the City's annual Water Licence report, which is submitted to the MVLWB in March each year. In addition, the City has engaged a consultant to analyze and report on three years of stormwater monitoring (2020-2022, "Stormwater Trend Analysis"). That report will discuss trends and patterns in stormwater quality across the City and evaluate potential impacts on the receiving waters, with a focus on fish-bearing waters. This will include research into background data and literature to better understand impacts on receiving waters as well as recommendations for any changes to this Stormwater Management Plan.

12. STORMWATER TREATMENT

Stormwater treatment is dependent on the quality and amount of stormwater an area generates. This information is typically determined during the design stage of the stormwater system. Major and minor components of the system are designed for the transportation, infiltration, and catchment of stormwater. In most areas, stormwater is treated through natural and man-made wetlands and retention ponds. These components reduce the flow of stormwater allowing particulate matter to be settled out by gravity. As well, the vegetation in the wetland and pond areas is able to take up minerals and nutrients contained in stormwater. These two processes combined improve the quality of water entering the receiving water body.

Typical stormwater treatment focuses on removal of particulate matter, which can be settled out of the water column. In areas where additional contaminants, such as oil, grease and large quantities of garbage or sediments are expected, treatment units can be installed. These units combine filters and settling tanks to treat stormwater.

In some cases, settling particles out of the stormwater also reduces the concentrations of certain chemical parameters, particularly heavy metals. This is particularly effective in stormwater with high Total Suspended Solids (TSS) concentrations as the heavy metals form part of the particulate matter. Yellowknife's stormwater has very little particulate matter (i.e., very low TSS concentrations), which indicates that common treatment methods that use settling tanks will not be very effective in improving the water quality. The most common method of treating stormwater for heavy metals is the construction of man-made wetlands that incorporate the use of soils for filtration and vegetation for chemical removal. The City continues to research treatment methods that are cost-effective and will improve stormwater quality.

One outcome of the 3-year Stormwater Trend Analysis will be a report that will include recommendations for stormwater treatment. The monitoring results will be used to identify substances of concern and stormwater discharge locations of concern, if any, and to provide recommendations on the need for treatment. Based on this, possibilities for source mitigation and treatment options will be discussed that are specific to the identified substances and locations of concern. Examination of the stormwater monitoring program results thus may lead to "made in Yellowknife" recommendations for enhancing stormwater quality.

13. PUBLIC EDUCATION

In 2002, the City of Yellowknife implemented the Blue Fish Program to educate the public on the storm sewer system. The program involved volunteers who painted blue fish next to each catch basin in the City, and handing out door hangers, magnets, and other publicity information. Blue fish were painted each year from 2002 to 2007.

A section of literature that was produced by the City of Yellowknife is provided in Appendix I.

In summer 2007, new storm drain markers were installed on a trial basis in the downtown area. The markers are constructed of stainless steel and identified the catch basin as storm drains. The drain markers held up well under harsh winter conditions and snow removal practices, and as a result the City is installing these markers throughout the City to eliminate the need for yearly painting of blue fish symbols. The markers are essentially indestructible symbols that will be constant reminders to the residents of what damages pollution has on stormwater.

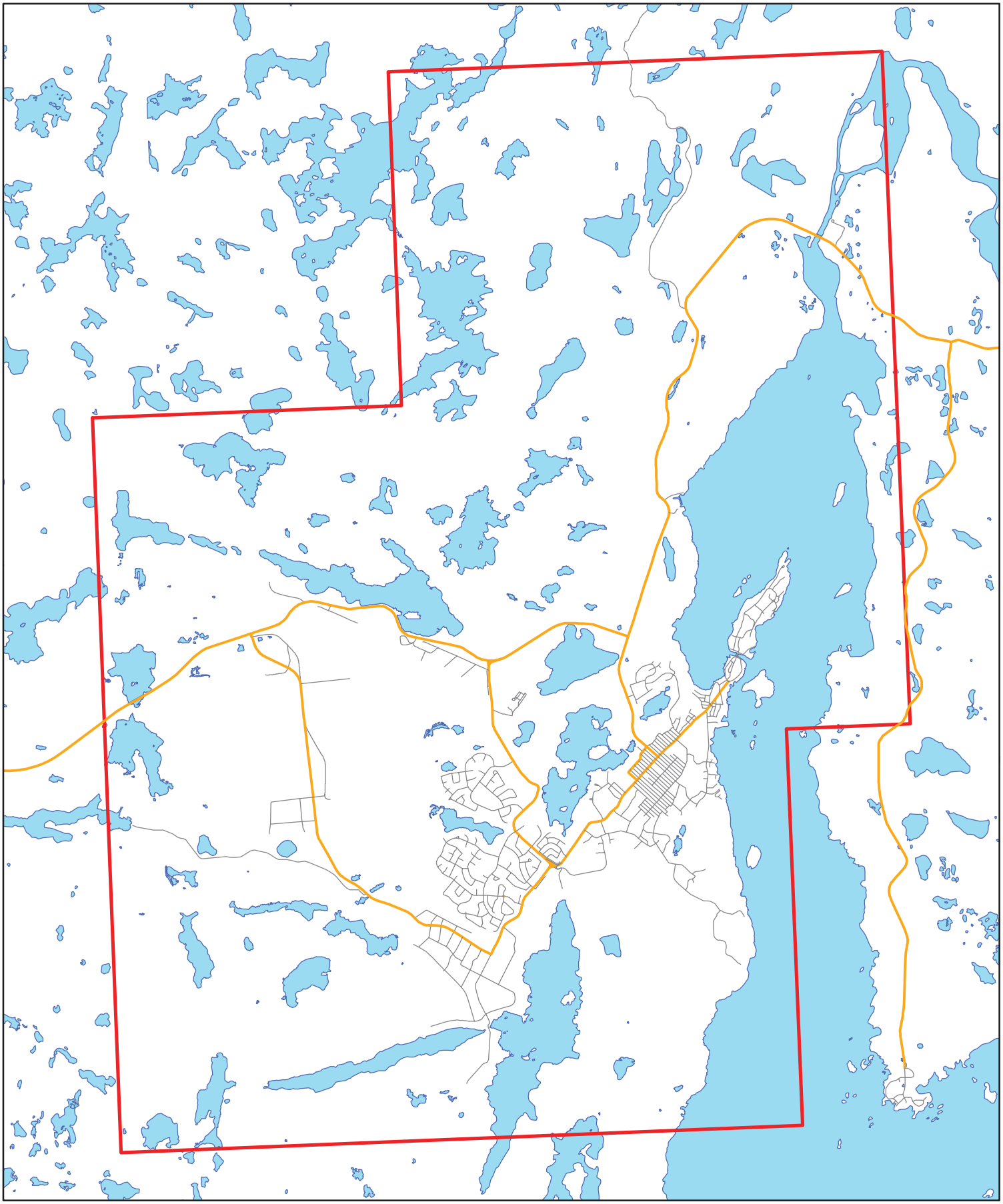
The City has also created an informative brochure about stormwater, which contains information about the City's stormwater systems and how residents can improve stormwater quality. These brochures were mailed to residents and made available at City facilities. A copy of the brochure is included in Appendix I.

As the City's website has become a popular place for residents to gather information, a page dedicated to stormwater has been created. The webpage contains general information about stormwater as well as the above-mentioned brochure. The address of the webpage is below.

https://www.yellowknife.ca/en/living-here/stormwater.asp

APPENDIX A

Map of Municipal Limits
(City of Yellowknife)



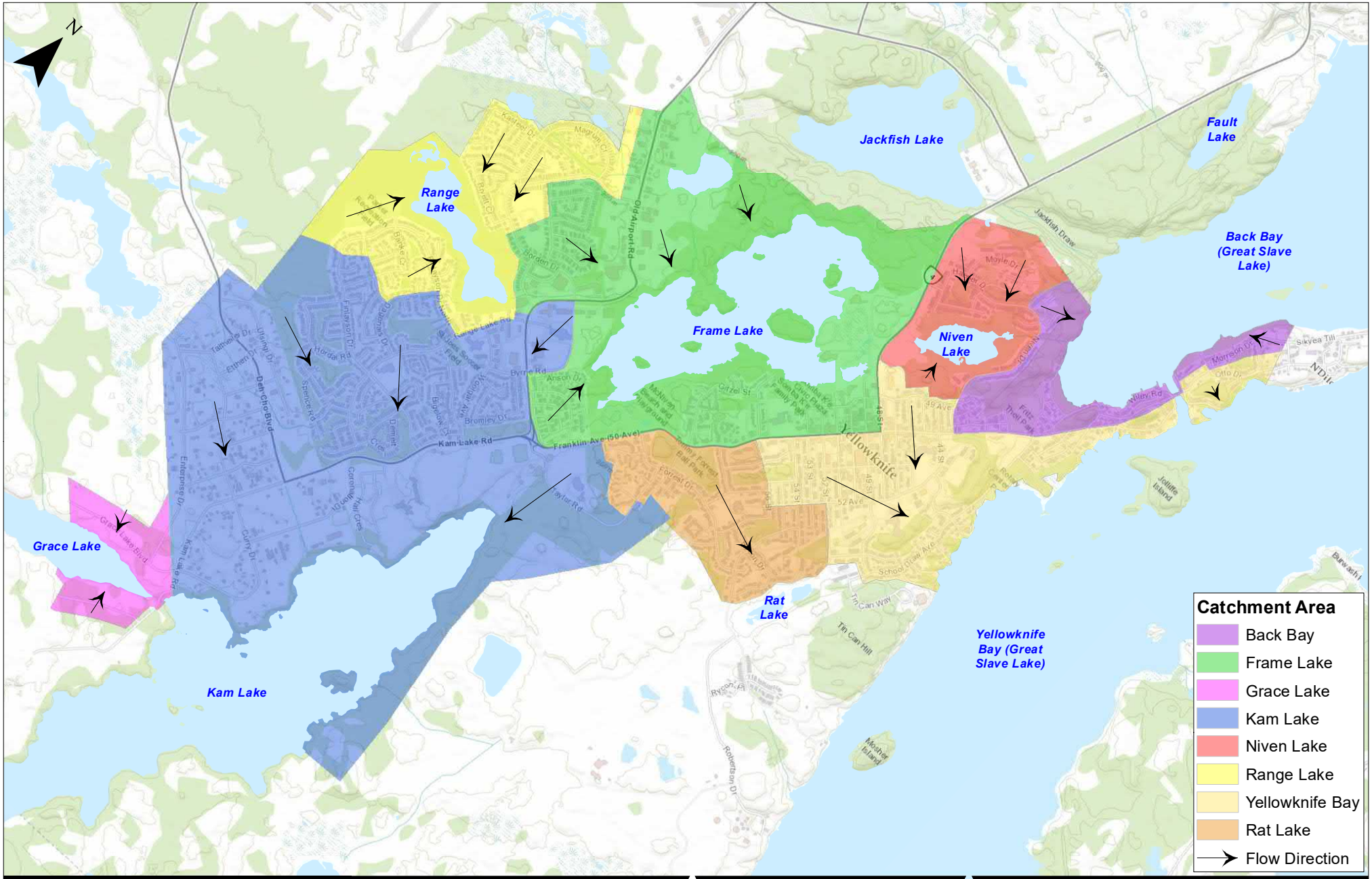
City of Yellowknife
Public Works & Engineering

PROJECT: The City of Yellowknife: Stormwater Management Plan	SCALE: 1:70,000
	CREATED BY: G. Griffiths
	FILE: 13_Stormwater_MNGT_Plan_Municipal_Limits.mxd
TITLE: Municipal Limits	DATE: March 22, 2013

APPENDIX B

Map of Catchment Areas for Main Receiving Water Bodies
(City of Yellowknife)

Outfall Catchments.mxd / 12/22/2020 / 9:10:23 AM



Associated Environmental

PROJECT NO.: 2019-8509.000.004
DATE: December 2020
DRAWN BY: DA

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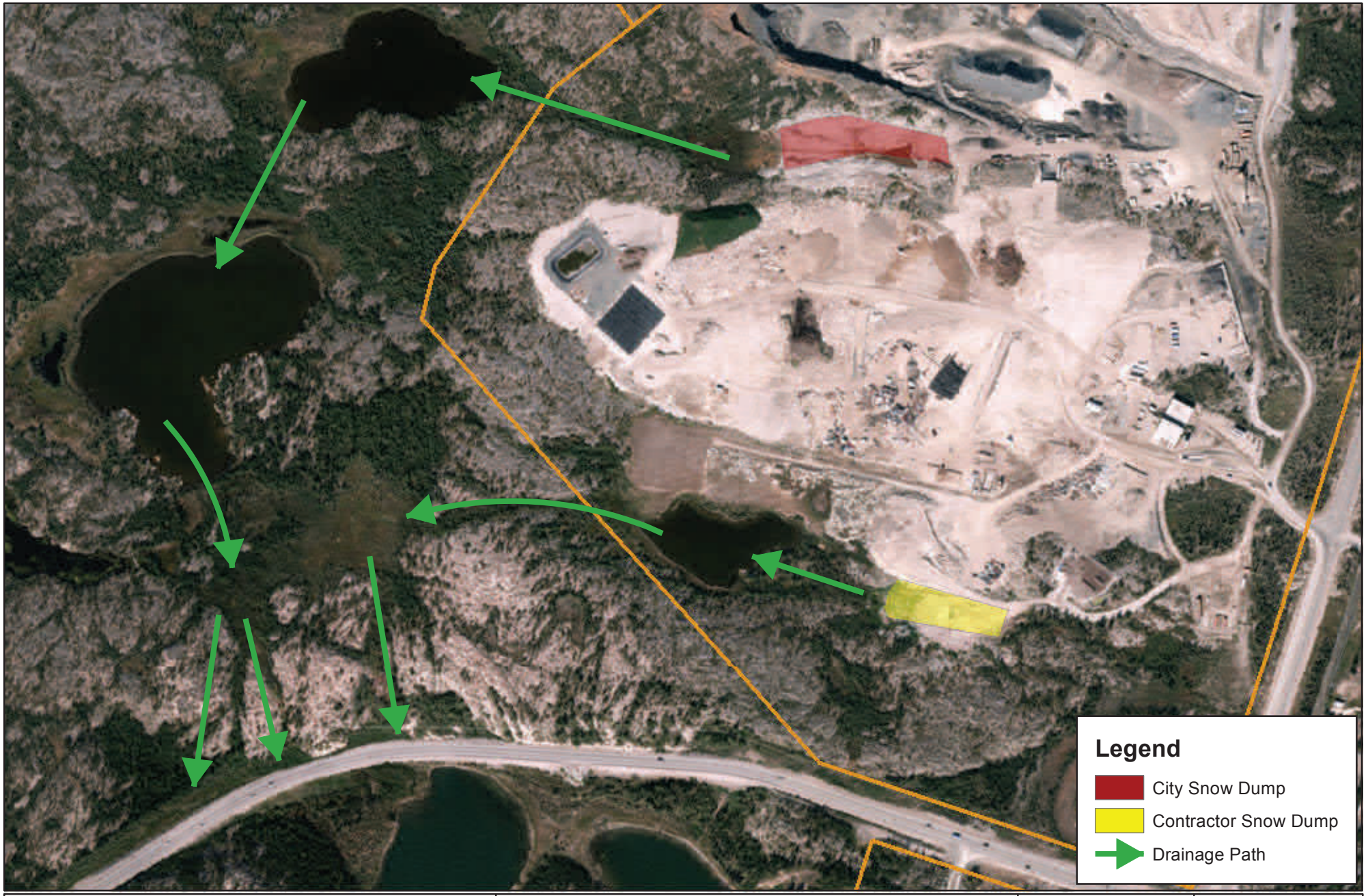
APPENDIX B: CATCHMENT AREAS FOR MAIN RECEIVING WATER BODIES

City of Yellowknife

Stormwater Management Plan

APPENDIX C

Snow Dump Locations and Drainage Paths



CITY OF YELLOWKNIFE

Public Works & Engineering

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		FILE: *17_Stormwater_MNGT_Plan_Landfill_Snow_Dump.mxd*	
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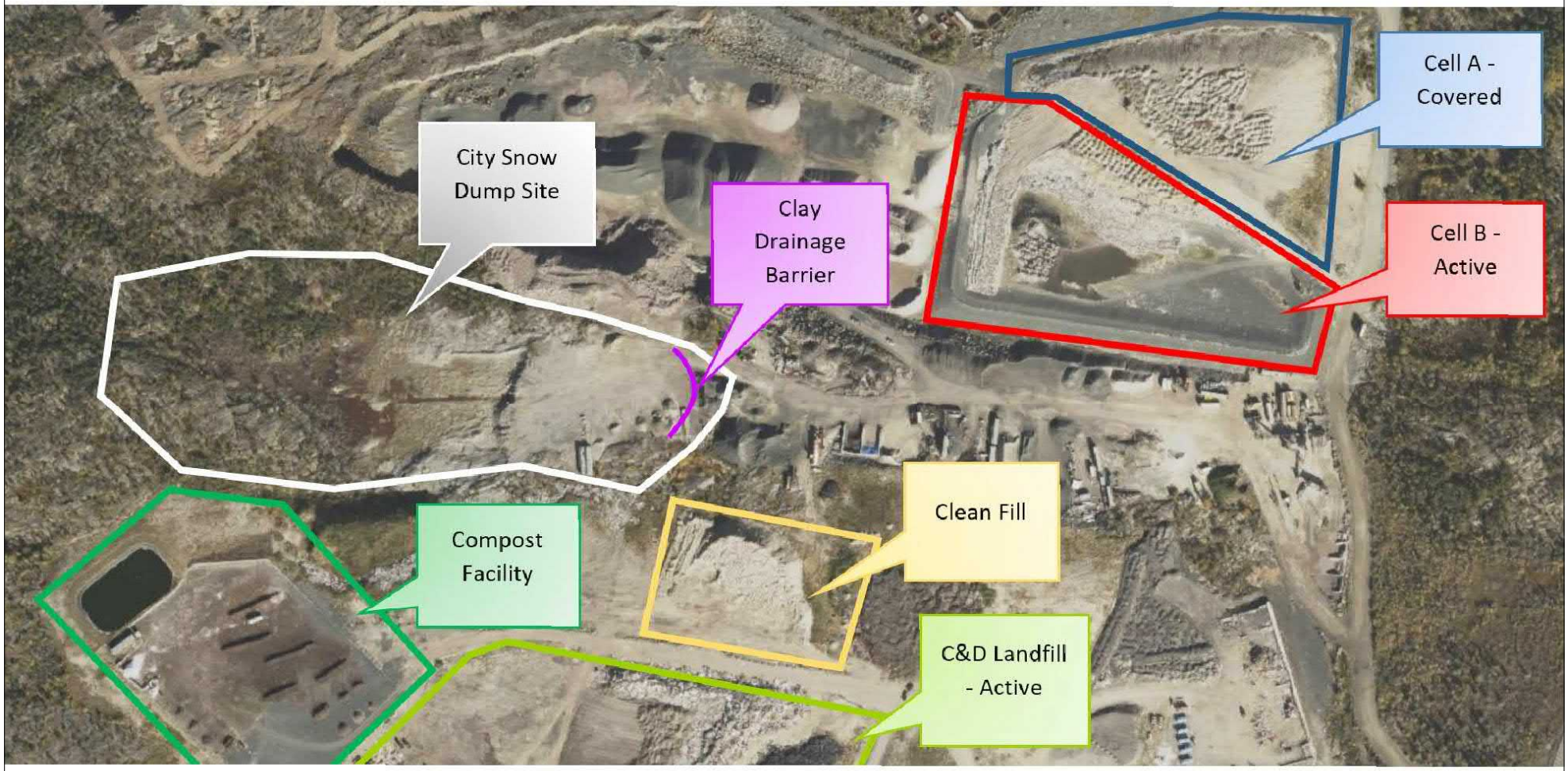

Associated Environmental

PROJECT NO.: 2019-8509.000.000
DATE: November 2020
DRAWN BY: DA

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Meters

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LANDFILL SNOW DUMP AREAS: DETAIL

City of Yellowknife

Stormwater Management Plan

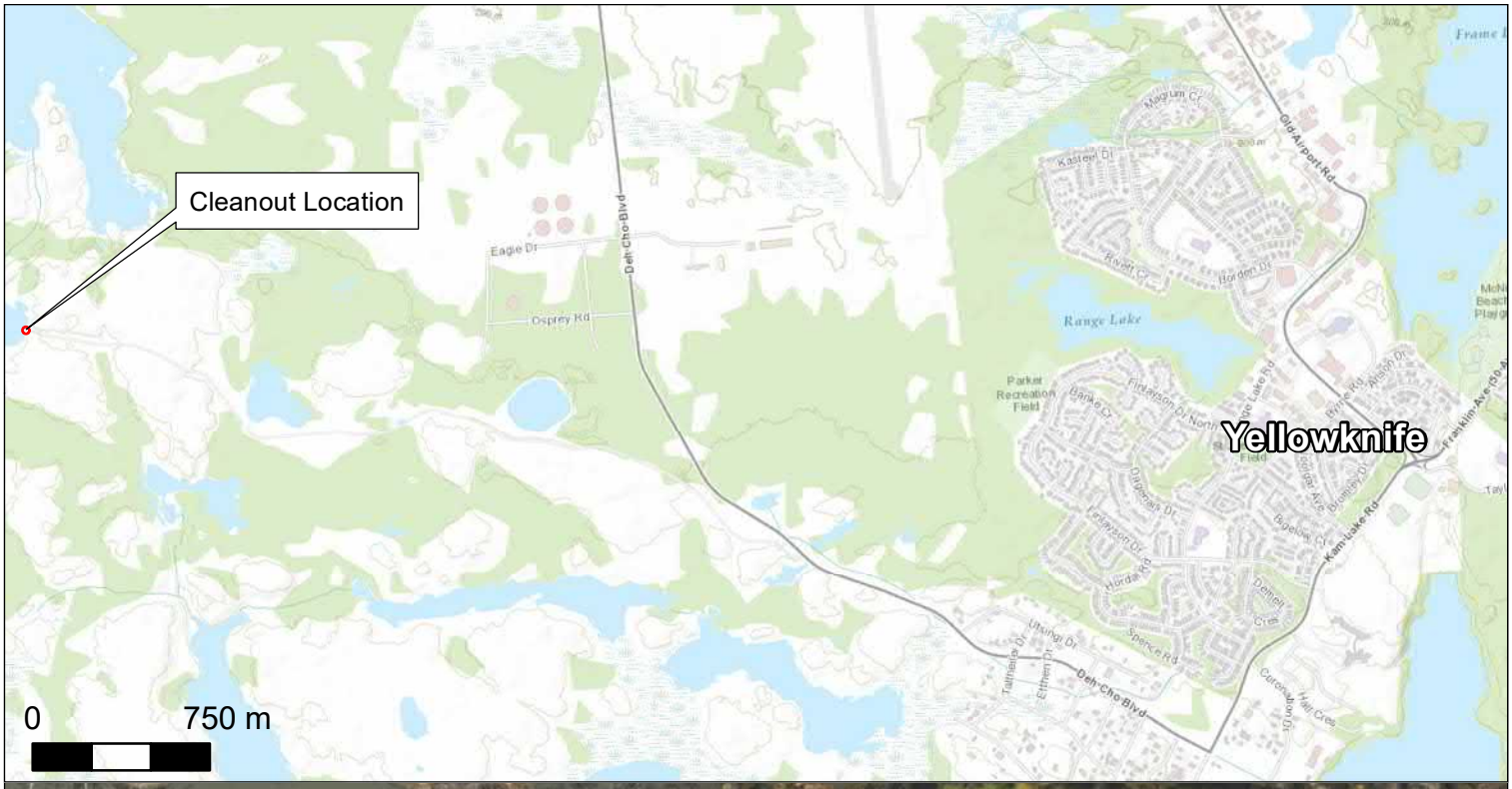
APP B.mxd / 11/20/2020 / 9:52:25 AM

CITY OF YELLOWKNIFE
Public Works & Engineering

PROJECT: Stormwater Management Plan	SCALE: 1:2,500 / CREATED BY: GT
TITLE: Deh Cho Blvd Snow Dump Area and Drainage Paths	FILE: 17_Stormwater_MNGT_Plan_DeChoBlvd_Snow_Dump.mxd
	DATE: March 22, 2013

APPENDIX D

Location of Stormwater Clean-out Material Discharge to Fiddler's Lagoon



Associated Environmental

PROJECT NO.: 2019-8509.000.000
DATE: September 2020
DRAWN BY: DA

0 10 20 30 40
Meters

STORMWATER CLEAN-OUT DISCHARGE LOCATION AT FIDDLER'S LAGOON

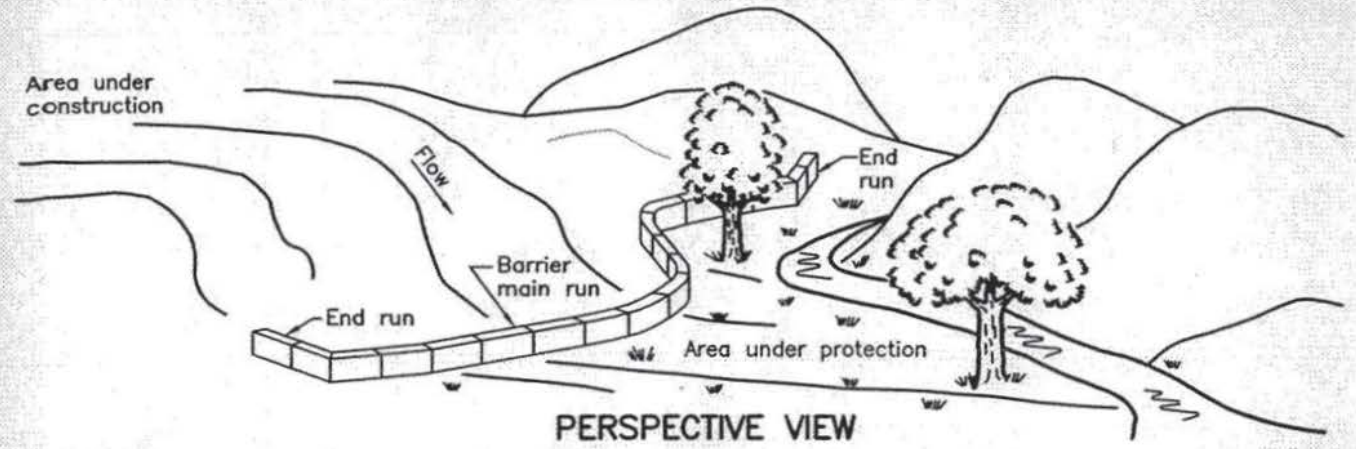
City of Yellowknife

Stormwater Management Plan

appendix storm clean out V2.mxd / 9/14/2020 / 12:52:04 PM

APPENDIX E

Sediment and Erosion Control Designs to be Adopted by the City of Yellowknife



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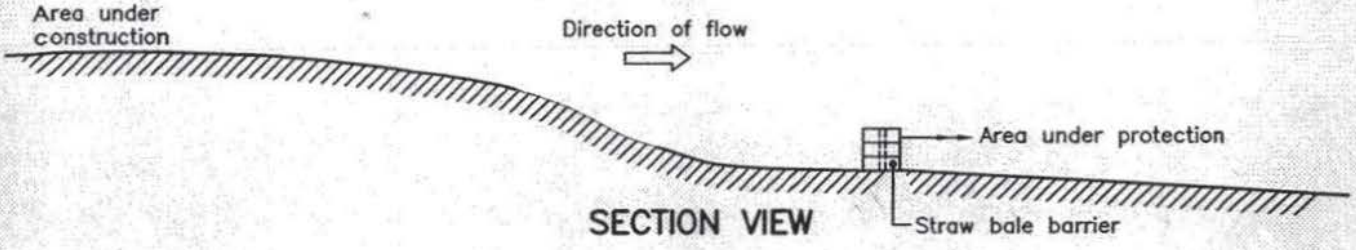

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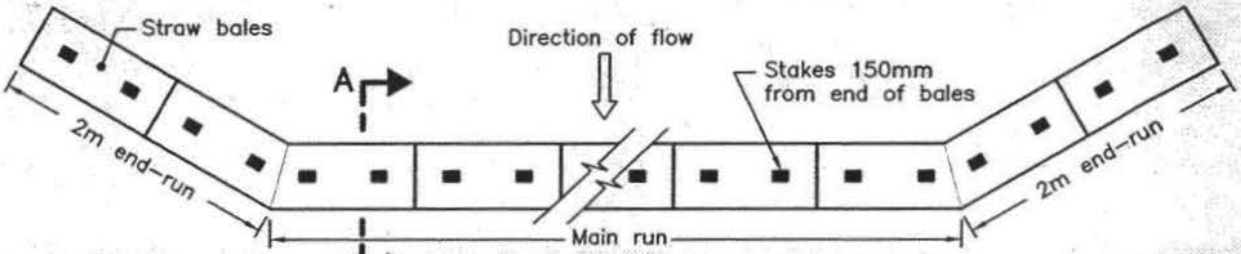
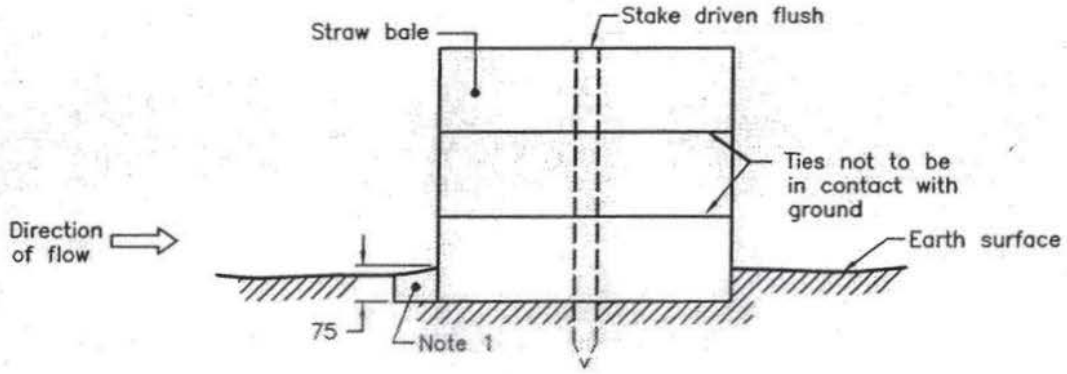


PLAN VIEW



SECTION A–A

NOTES:

1 Balance of excavated trench to be backfilled following bale placement.

A All dimensions are in millimetres or metres unless otherwise shown.

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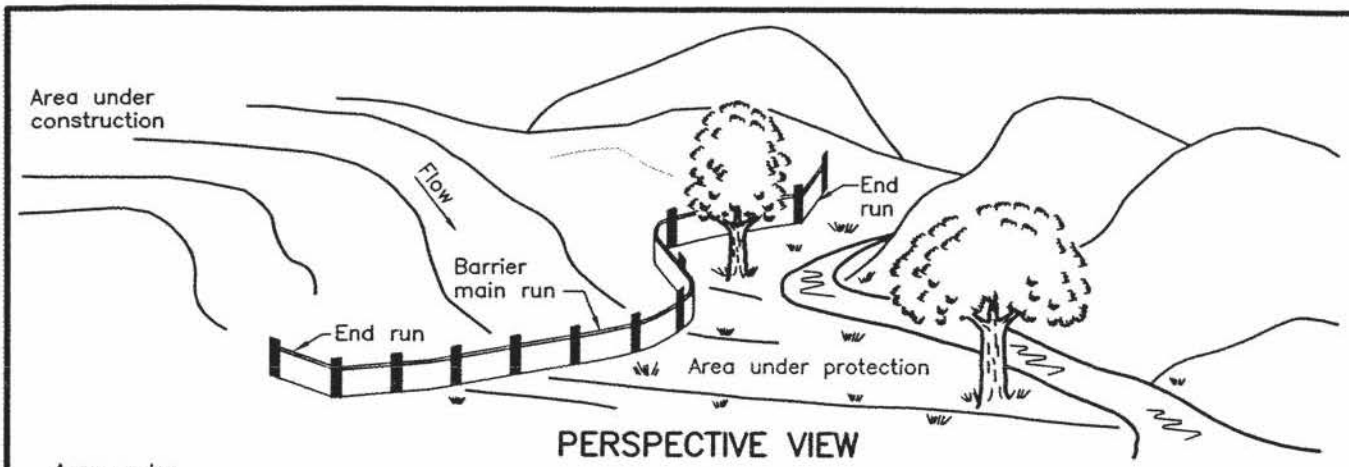
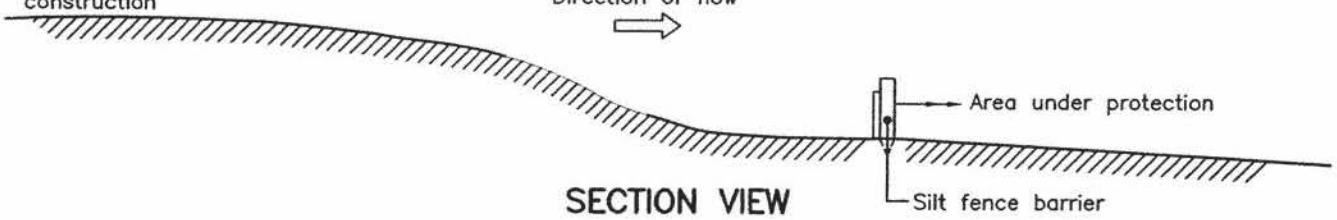
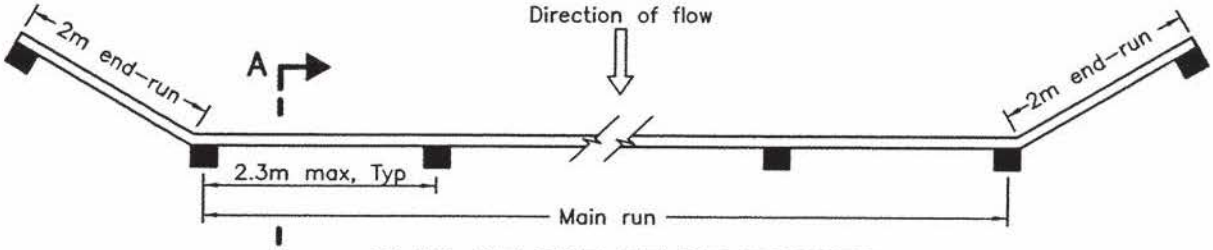
LIGHT DUTY STRAW BALE BARRIER	Date		
	OPSD – 219.100		



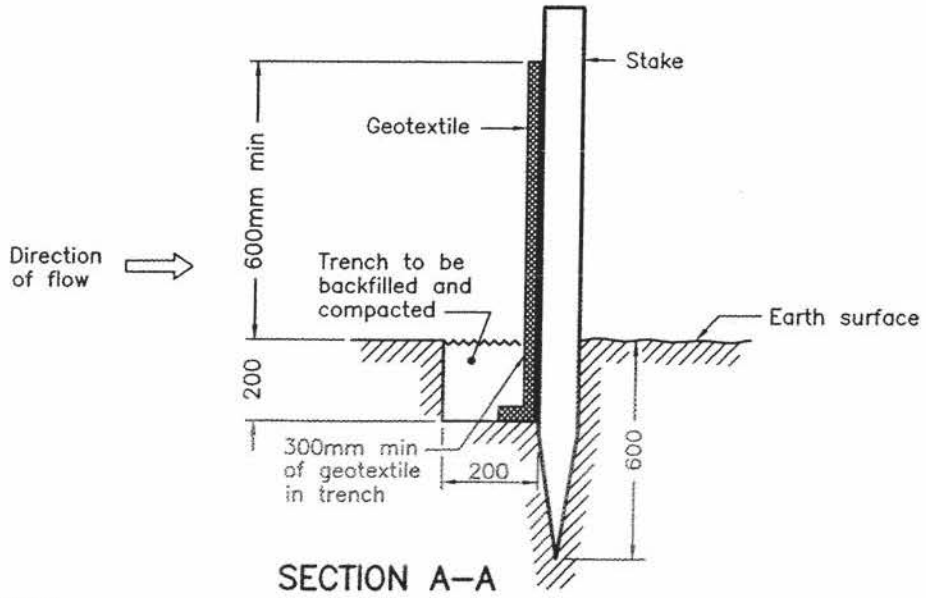
PERSPECTIVE VIEW



SECTION VIEW



A PLAN OF SILT FENCE BARRIER



SECTION A–A

NOTE:

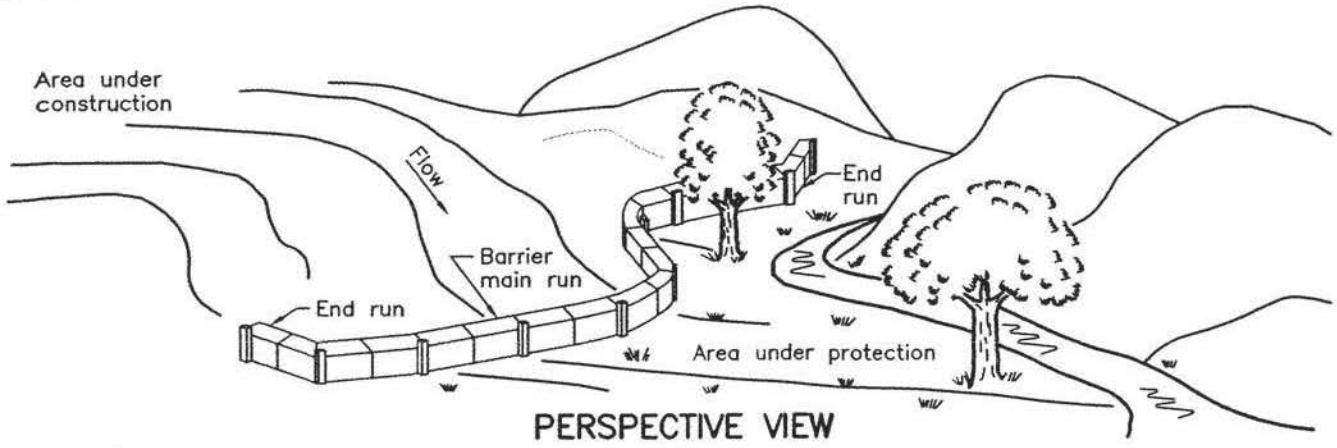
A All dimensions are in millimetres or metres unless otherwise shown.

ONTARIO PROVINCIAL STANDARD DRAWING | 1996 02 01 | Rev

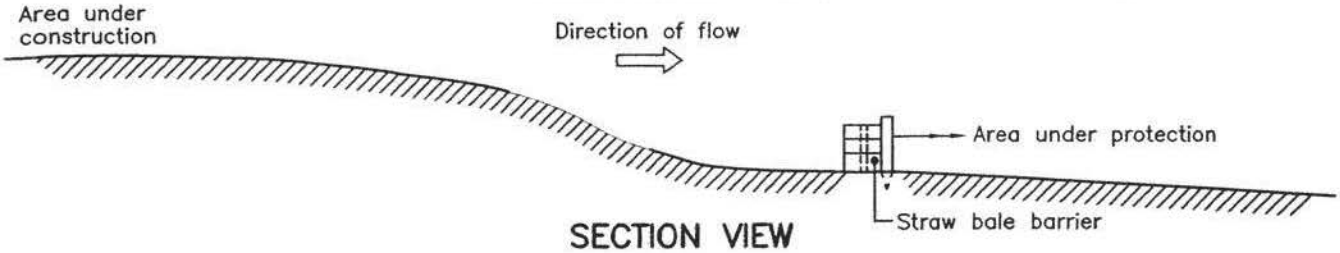
LIGHT DUTY SILT FENCE BARRIER

Date

OPSD – 219.110



PERSPECTIVE VIEW



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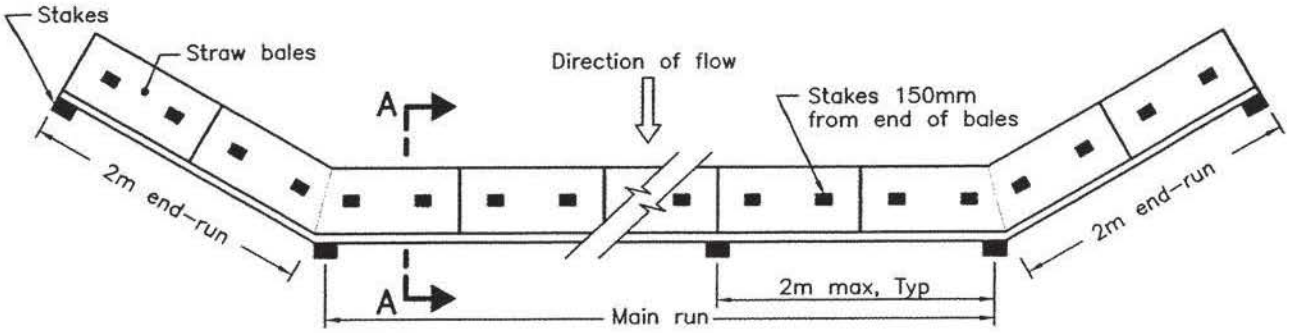

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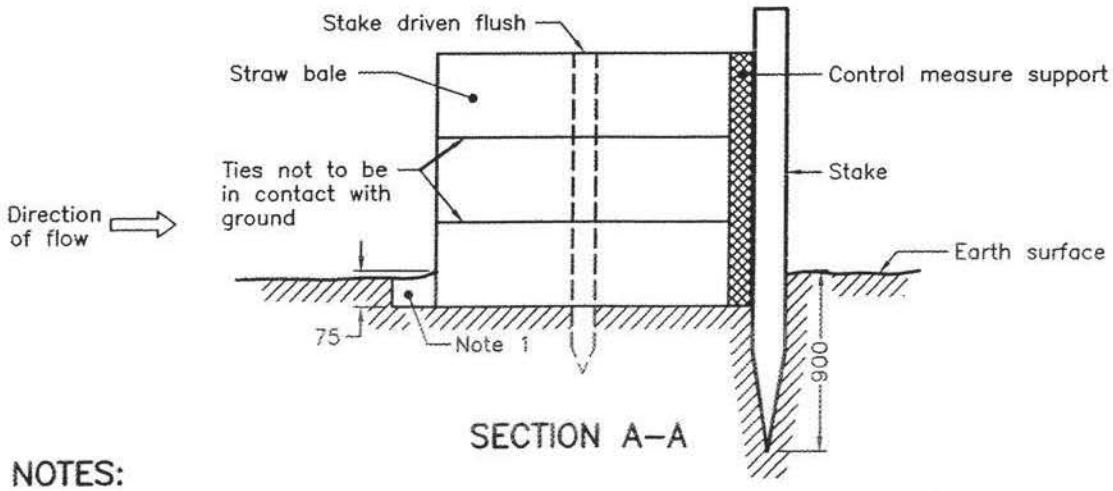


SECTION A–A

NOTES:

1 Balance of excavated trench to be backfilled following bale placement.

A All dimensions are in millimetres or metres unless otherwise shown.

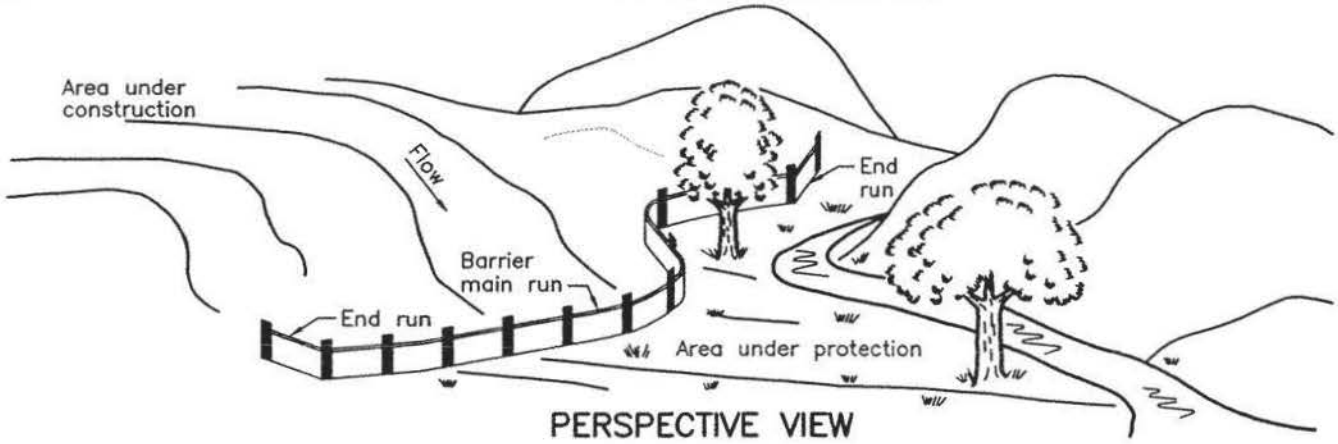
ONTARIO PROVINCIAL STANDARD DRAWING

1996 02 01 | Rev

HEAVY DUTY STRAW BALE BARRIER

Date

OPSD – 219.120



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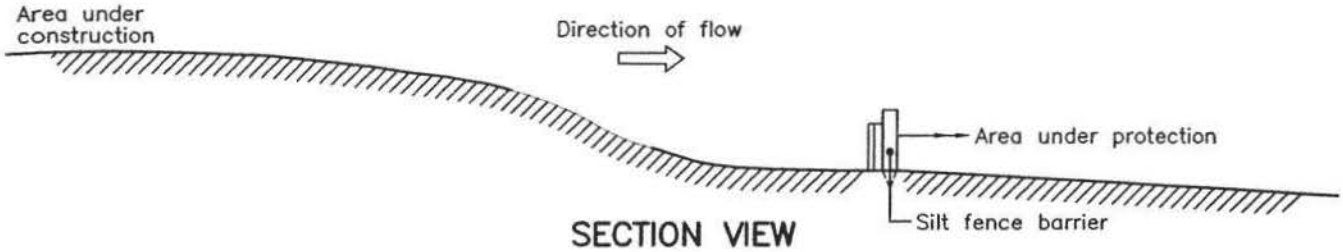

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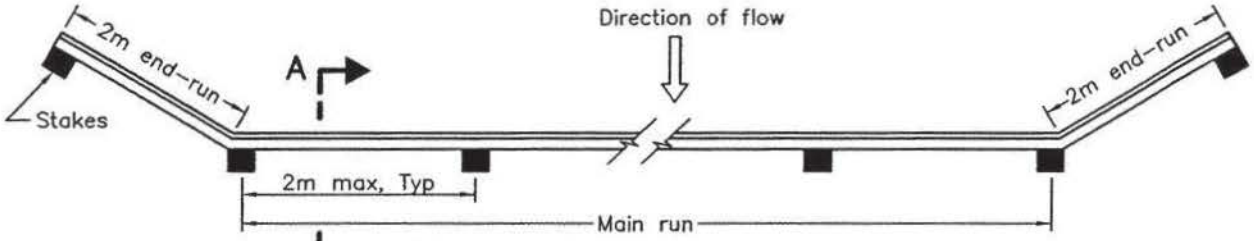
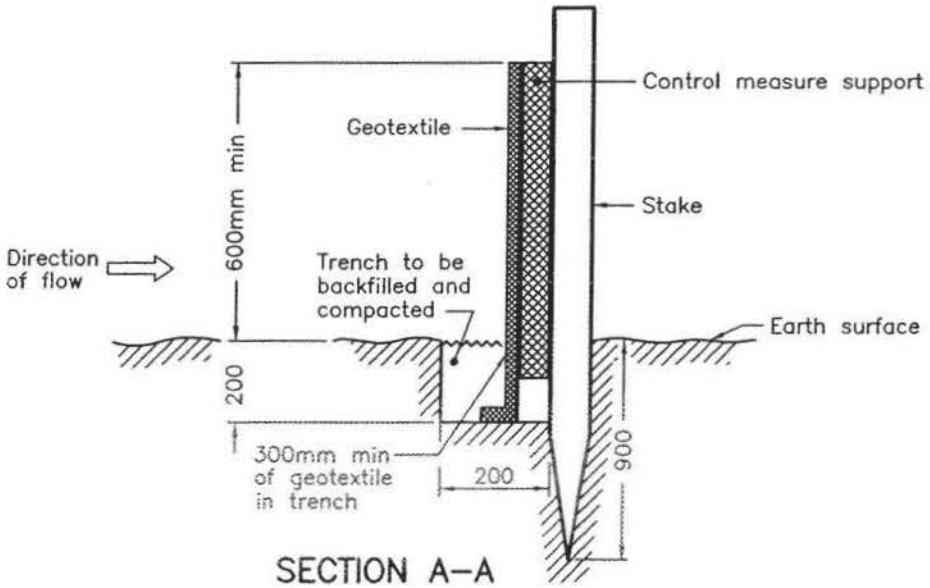


PLAN OF SILT FENCE BARRIER



SECTION A–A

NOTE:

A All dimensions are in millimetres or metres unless otherwise shown.

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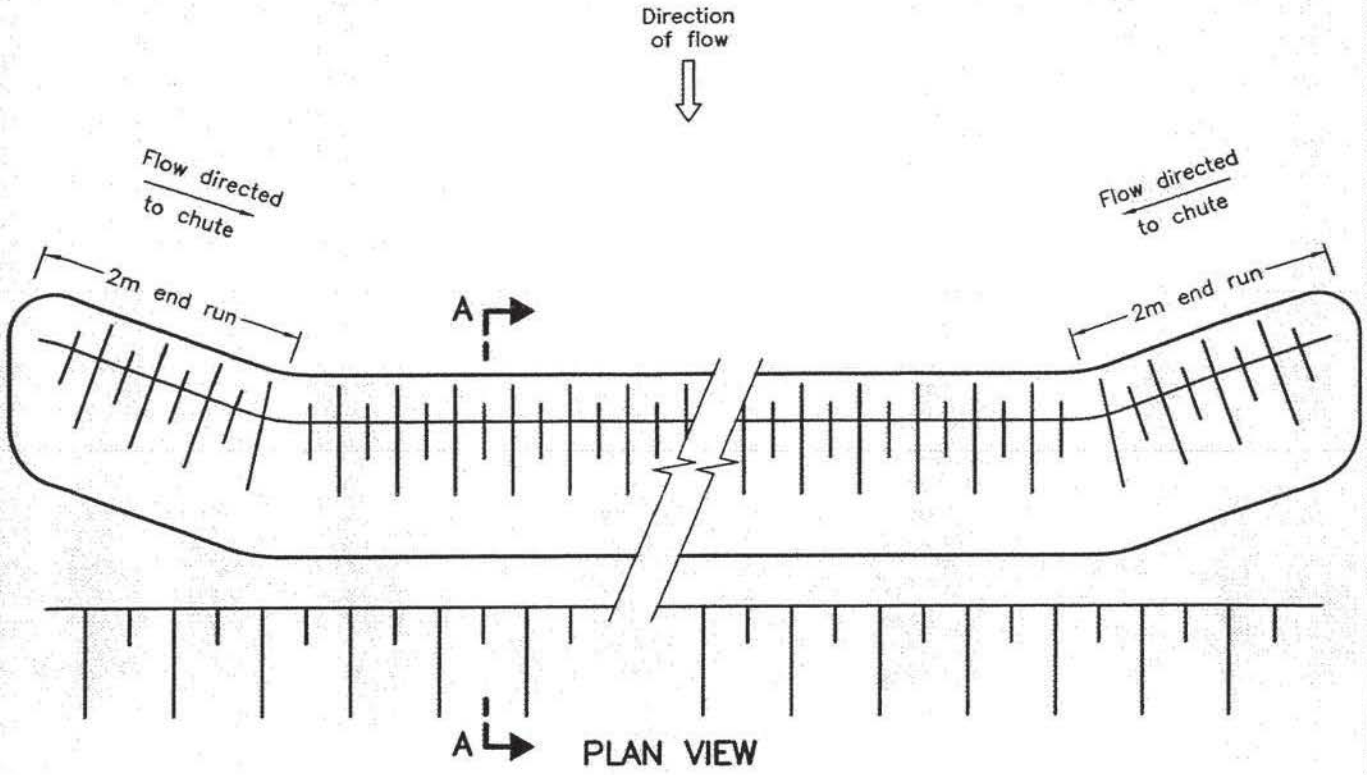
HEAVY DUTY SILT FENCE BARRIER	Date		OPSD – 219.130



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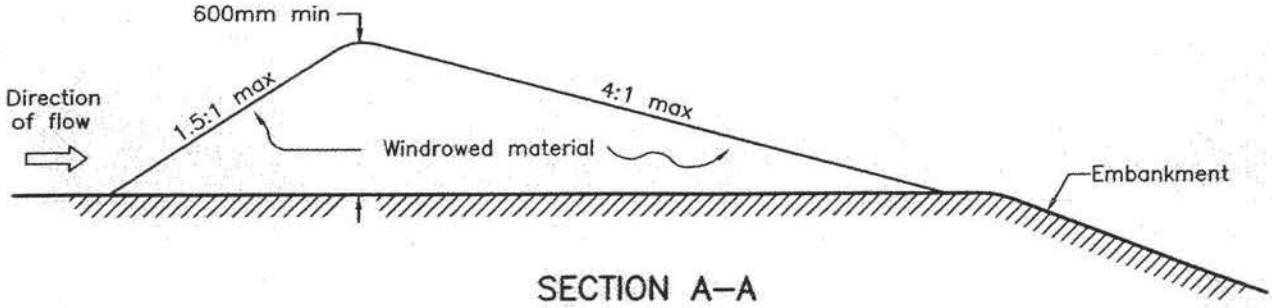

SECTION A–A

NOTES:

A All dimensions are in millimetres or metres unless otherwise shown.

B To be used with OPSD 219.230, chute.

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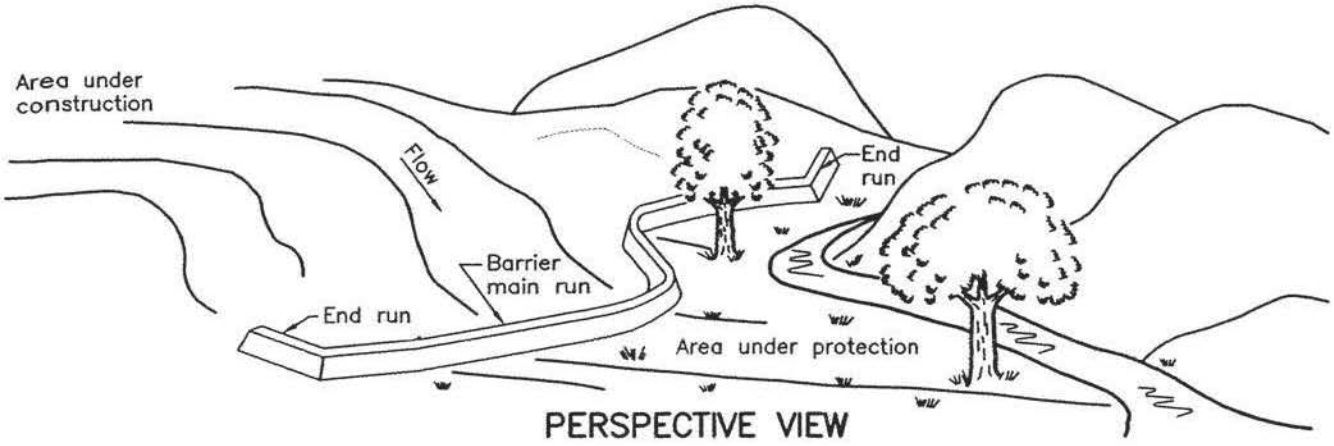
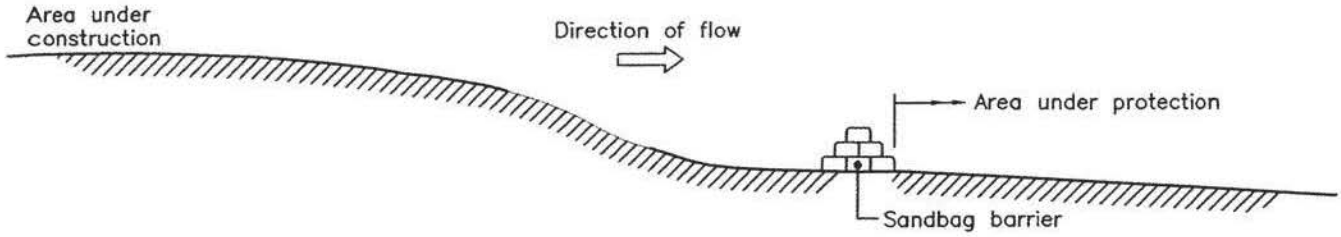
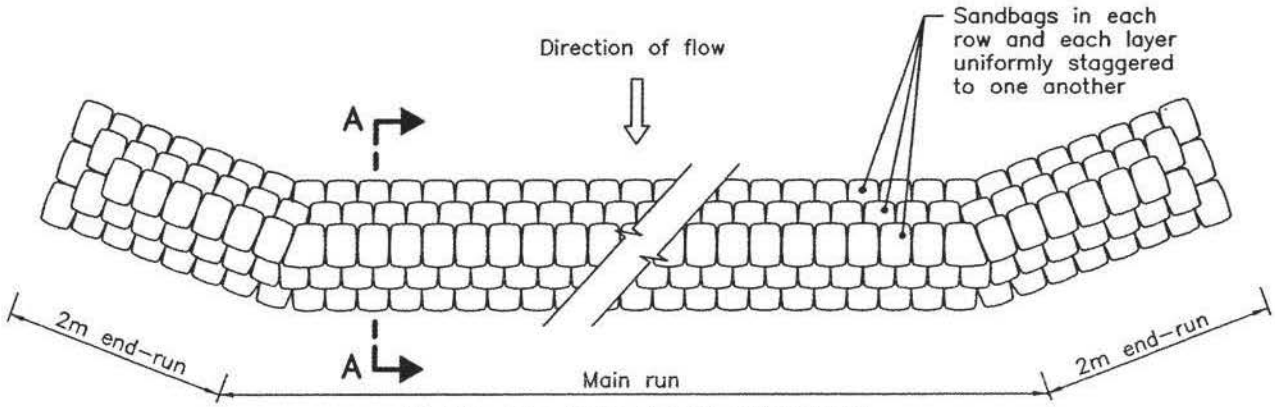
BERM BARRIER	Date _____	OPSD – 219.140



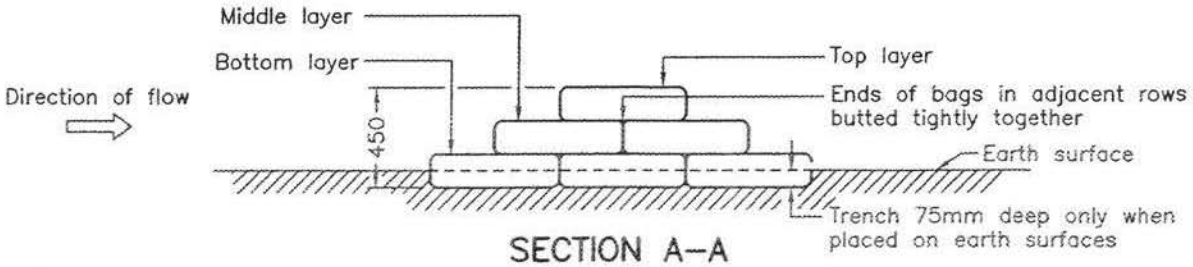
PERSPECTIVE VIEW



SECTION VIEW



PLAN OF SANDBAG BARRIER

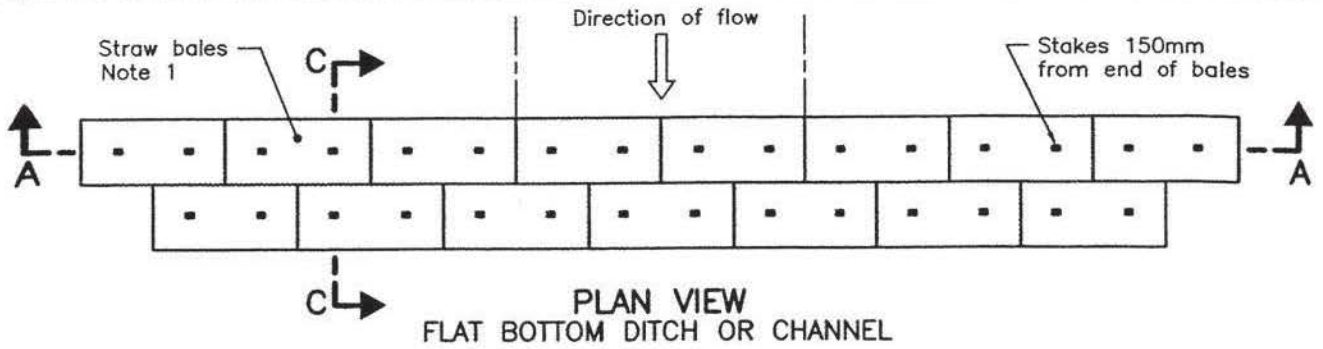


SECTION A–A

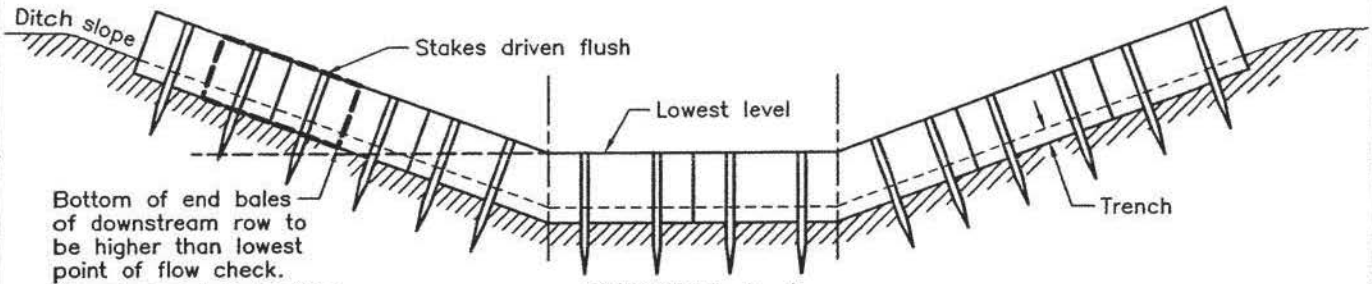
NOTE:

A All dimensions are in millimetres or metres unless otherwise shown.

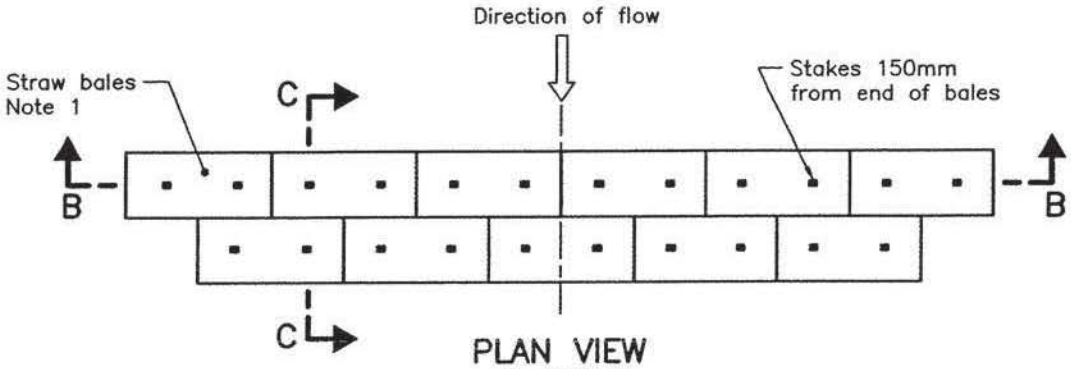
ONTARIO PROVINCIAL STANDARD DRAWING	1996 02 01	Rev	
SANDBAG BARRIER	Date		
	OPSD – 219.150		



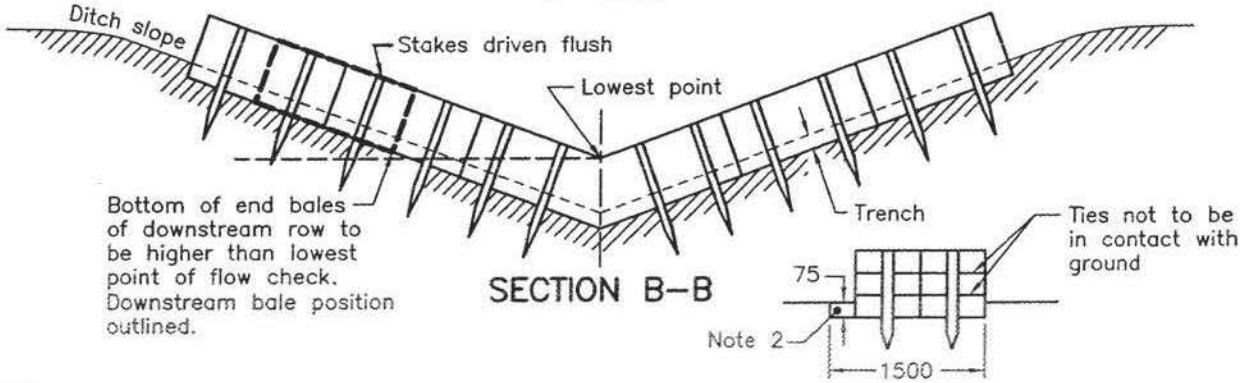
PLAN VIEW
FLAT BOTTOM DITCH OR CHANNEL



SECTION A–A



PLAN VIEW
V–DITCH



SECTION B–B

SECTION C–C

NOTES:

1 Number of bales varies to suit ditch or channel.

2 Balance of excavated trench to be backfilled following bale placement.

A All dimensions are in millimetres or metres unless otherwise shown.

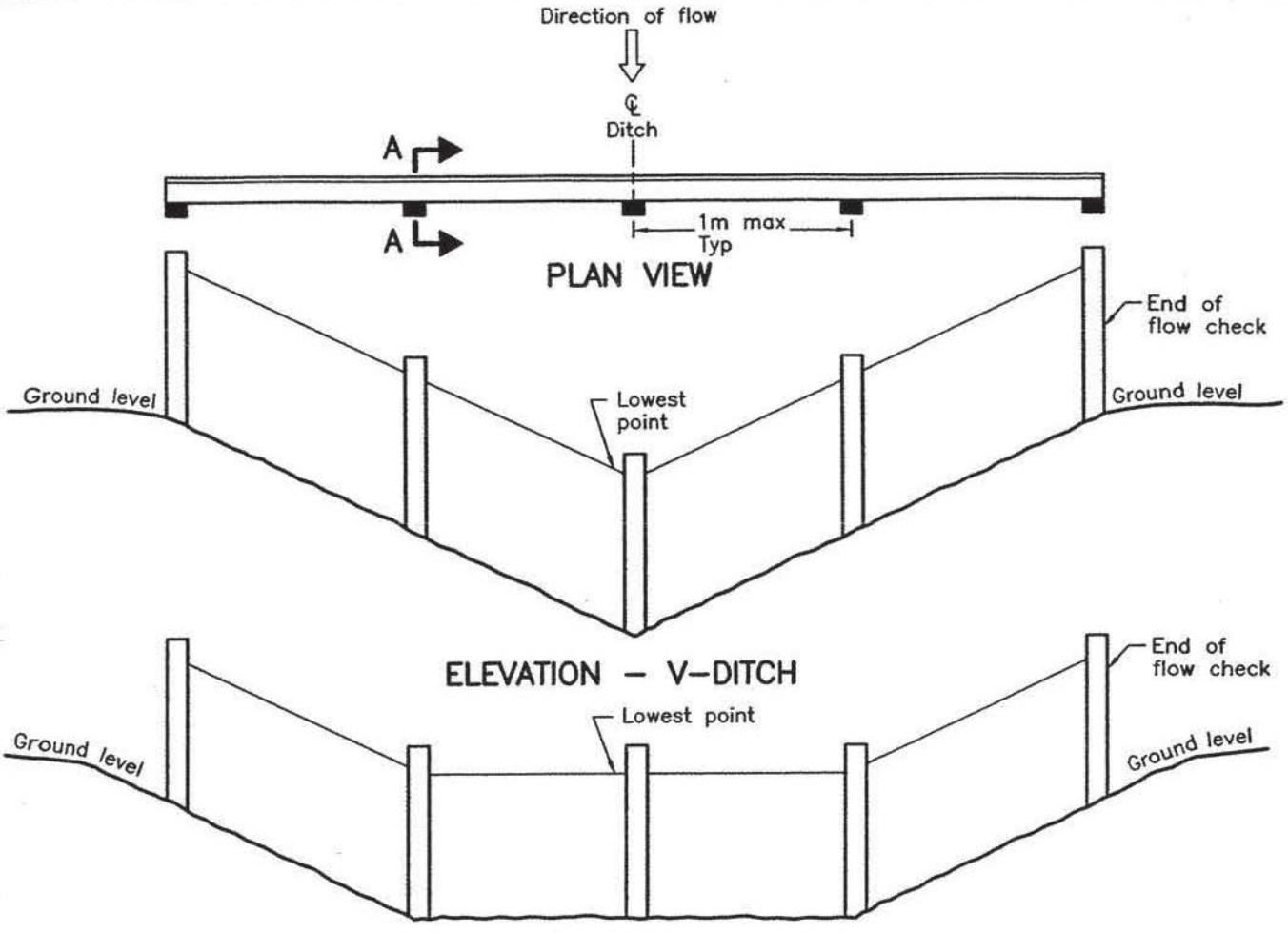
ONTARIO PROVINCIAL STANDARD DRAWING

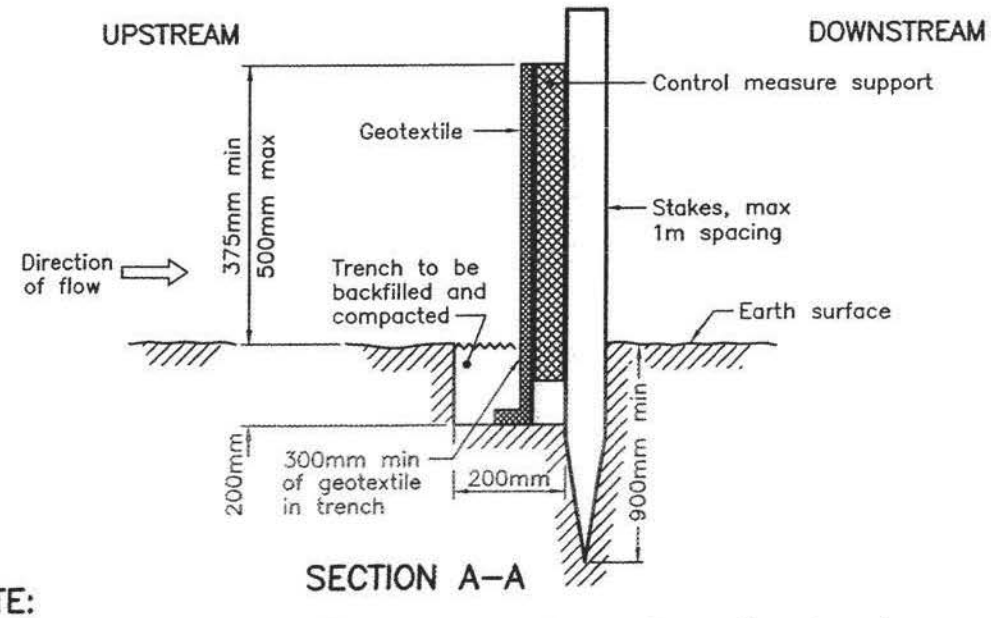
1996 02 01 | Rev

STRAW BALE FLOW CHECK

Date

OPSD – 219.180

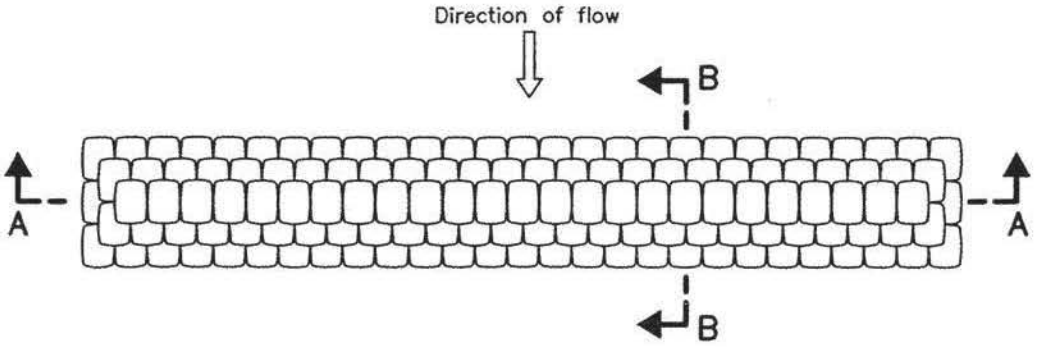




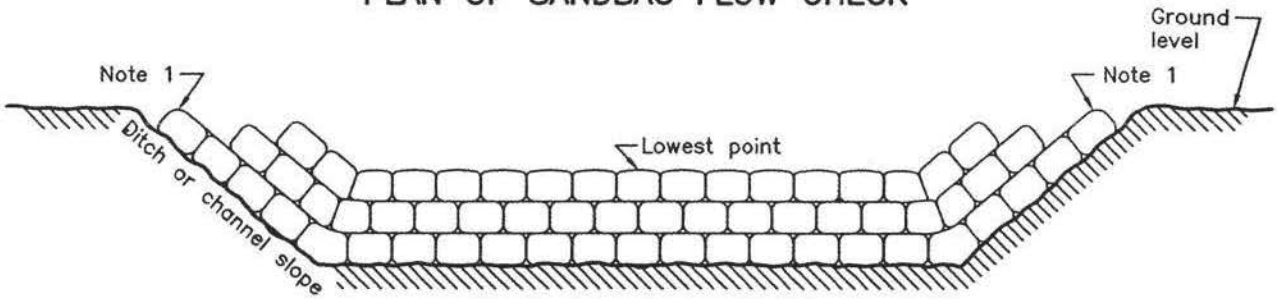
NOTE:

A All dimensions are in millimetres or metres unless otherwise shown.

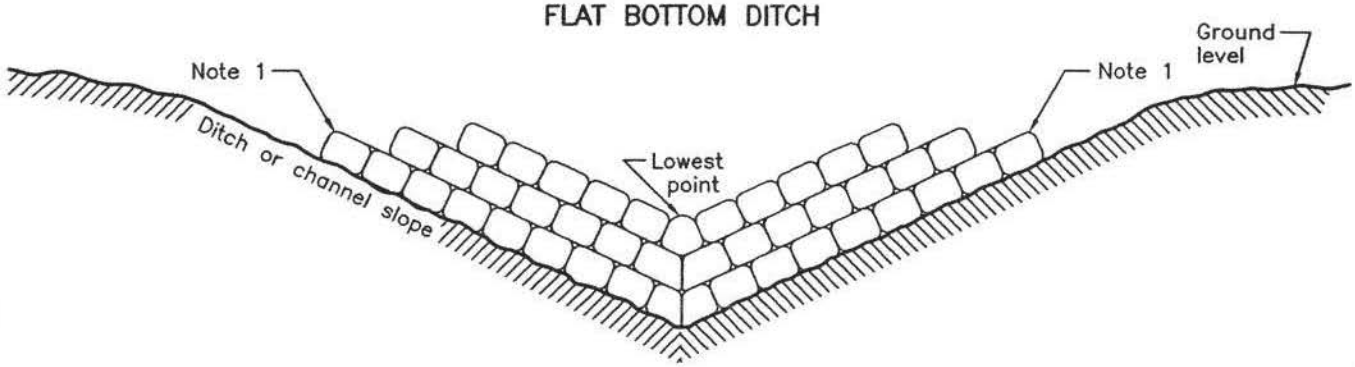
ONTARIO PROVINCIAL STANDARD DRAWING	1996 02 01	Rev	
SILT FENCE FLOW CHECK	Date _____		
	OPSD – 219.190		



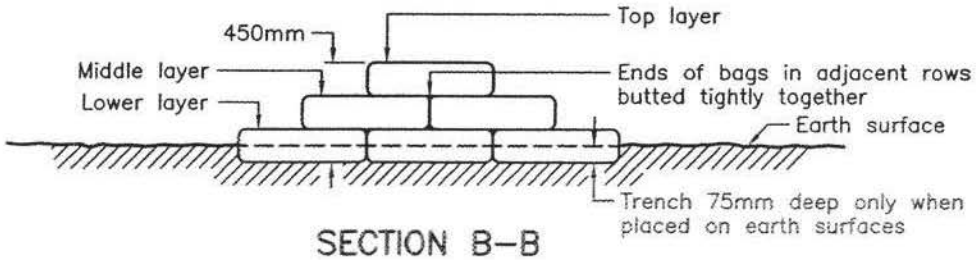
PLAN OF SANDBAG FLOW CHECK



SECTION A–A
FLAT BOTTOM DITCH



SECTION A–A
V–DITCH



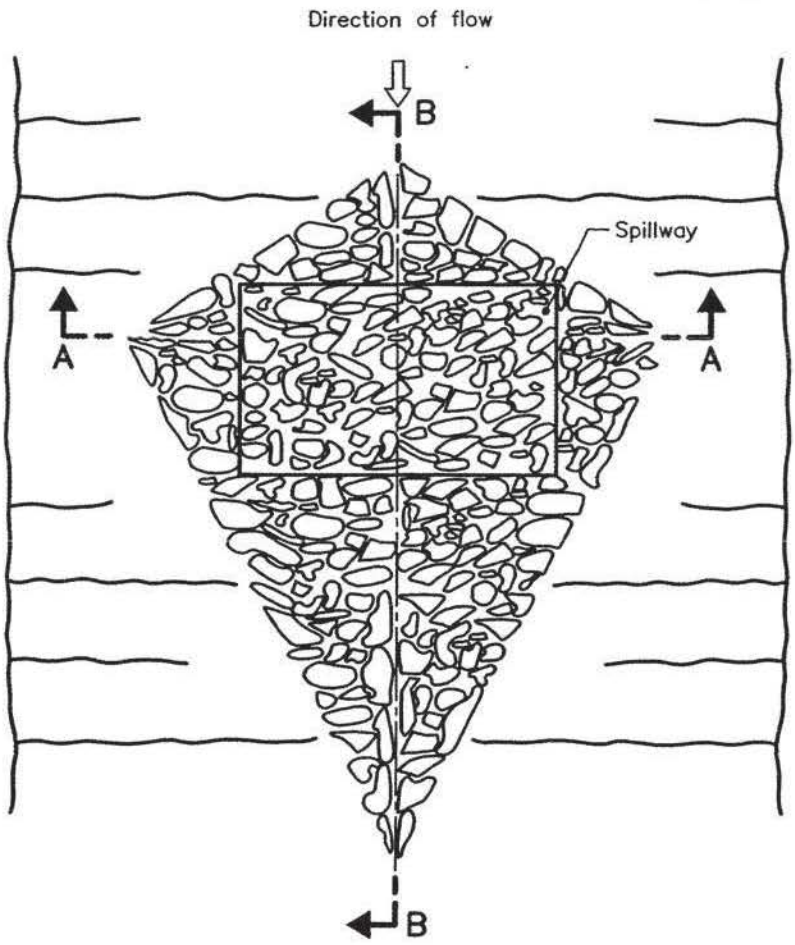
SECTION B–B

NOTES:

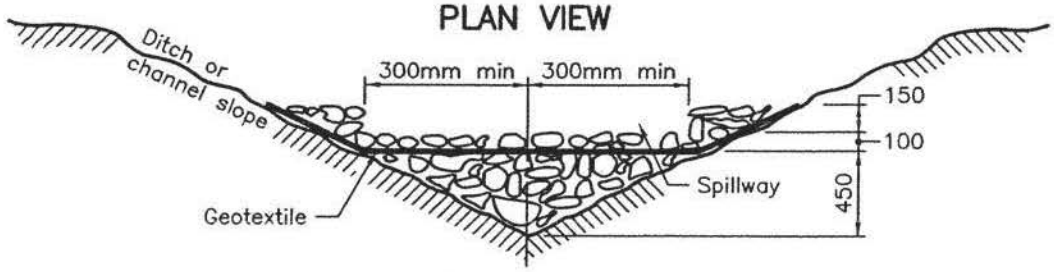
1 End of flow check at ground level to be higher than the lowest point of flow check. Sufficient sandbags are to be placed to prevent end scouring.

A All dimensions are in millimetres or metres unless otherwise shown.

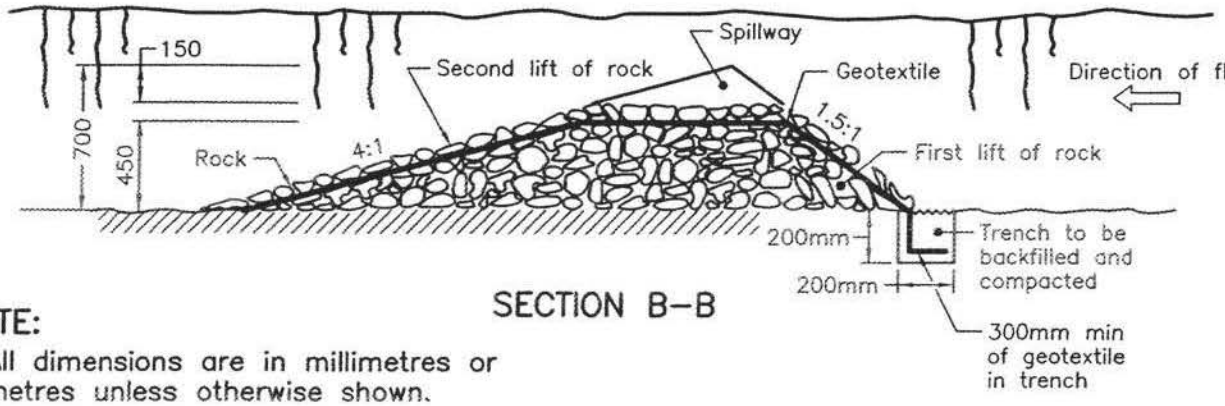
ONTARIO PROVINCIAL STANDARD DRAWING	1996 02 01	Rev
SANDBAG FLOW CHECK	Date _____	
	OPSD – 219.200	



PLAN VIEW



SECTION A–A

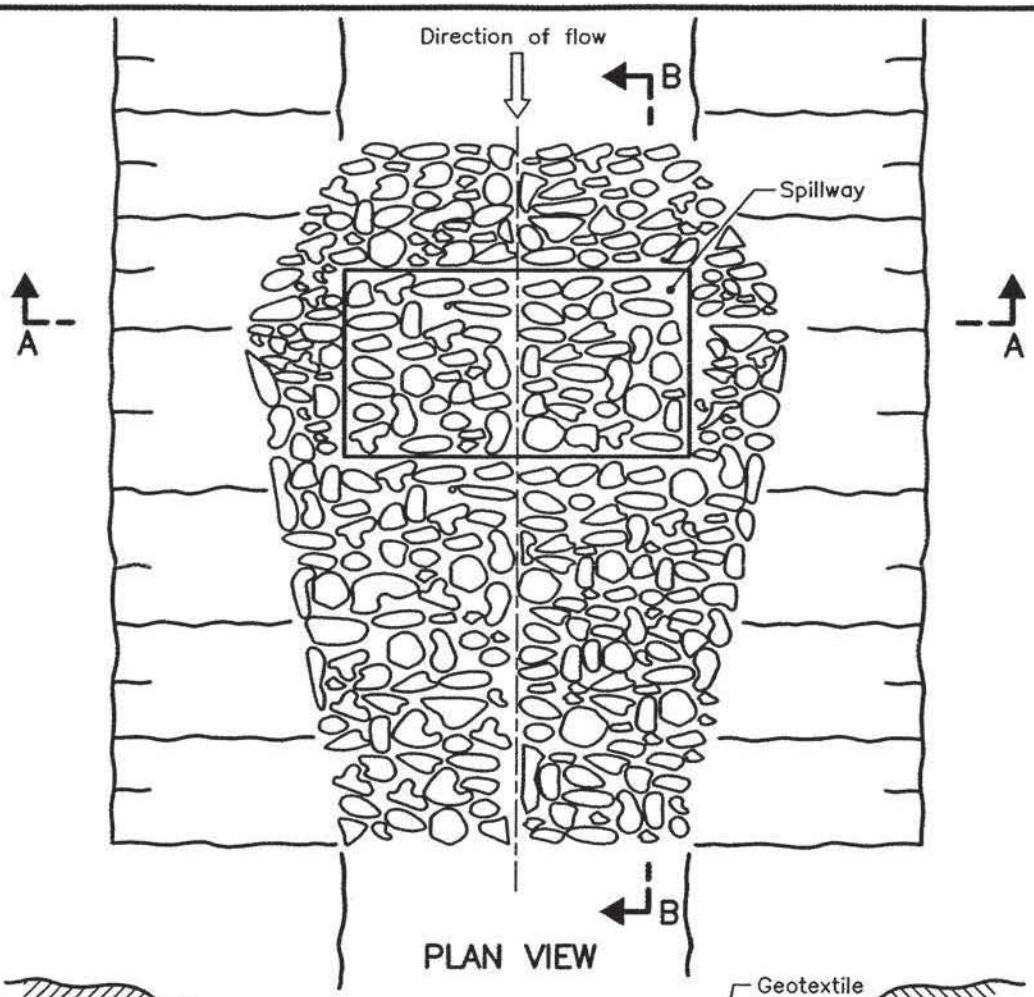


SECTION B–B

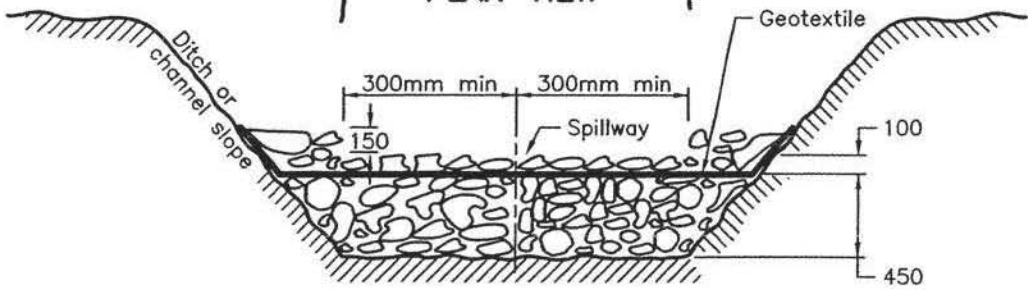
NOTE:

A All dimensions are in millimetres or metres unless otherwise shown.

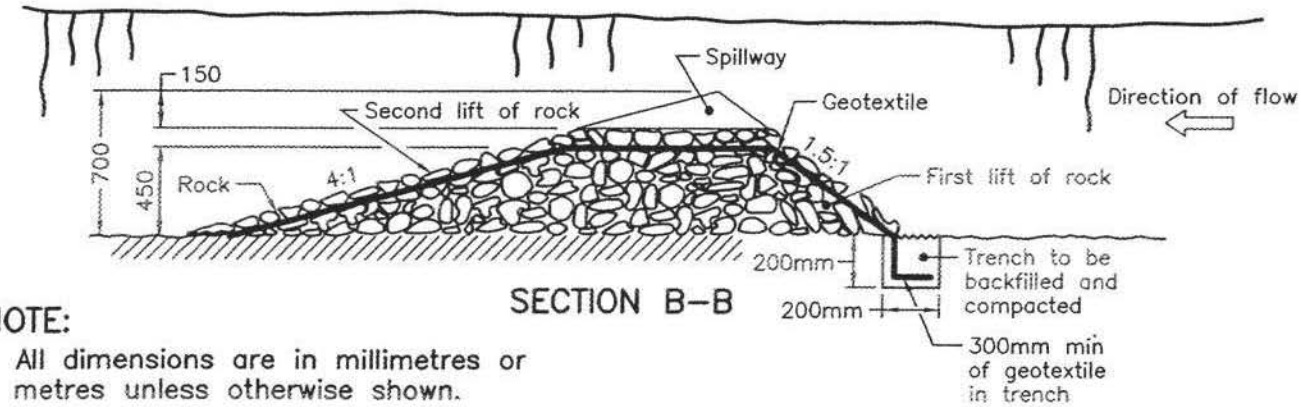
ONTARIO PROVINCIAL STANDARD DRAWING	1996 02 01	Rev	
TEMPORARY ROCK FLOW CHECK V–DITCH	Date _____		OPSD – 219.210



PLAN VIEW



SECTION A–A



SECTION B–B

NOTE:

A All dimensions are in millimetres or metres unless otherwise shown.

ONTARIO PROVINCIAL STANDARD DRAWING

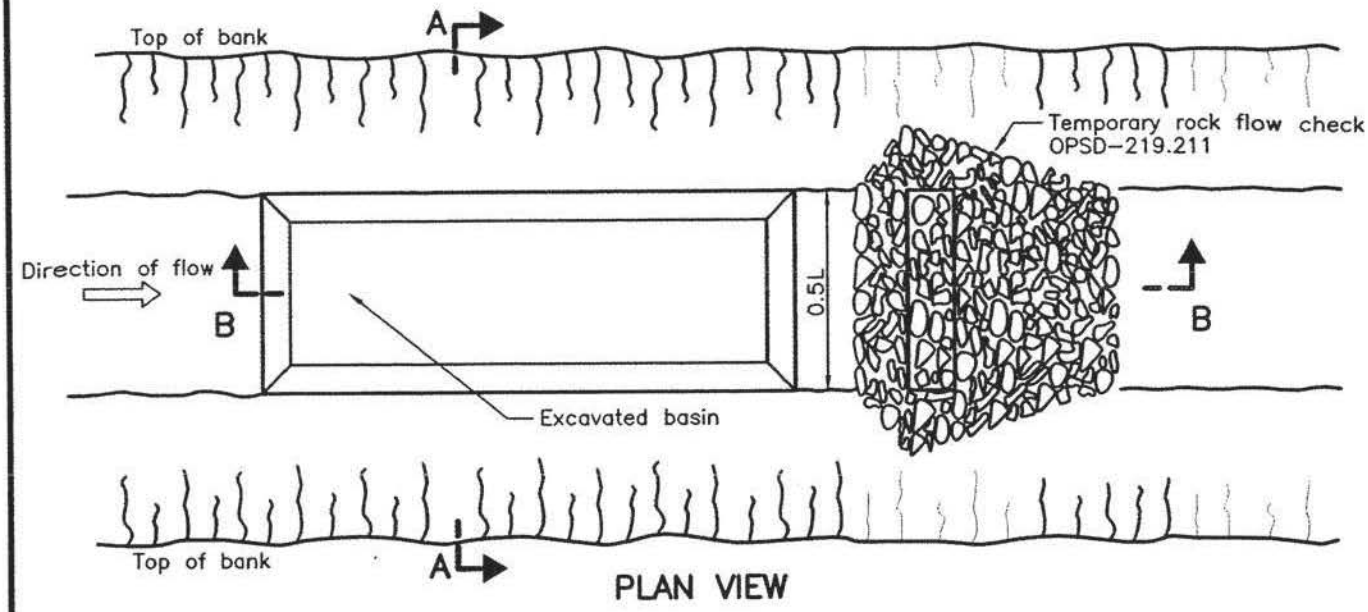
1996 02 01 | Rev

TEMPORARY ROCK FLOW CHECK

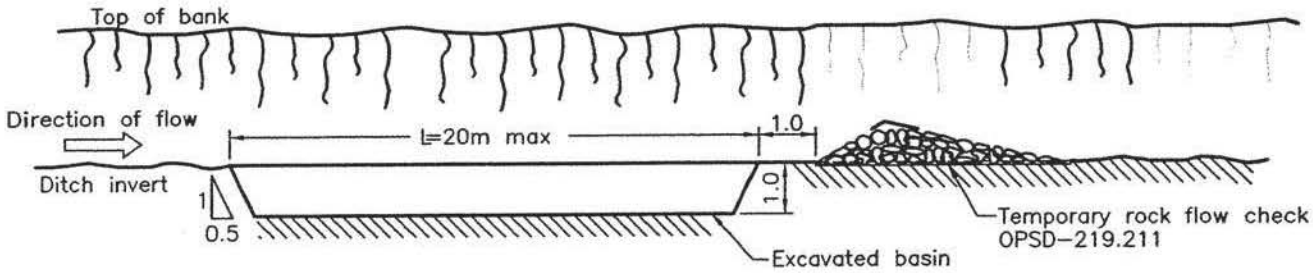
FLAT BOTTOM DITCH OR CHANNEL

Date

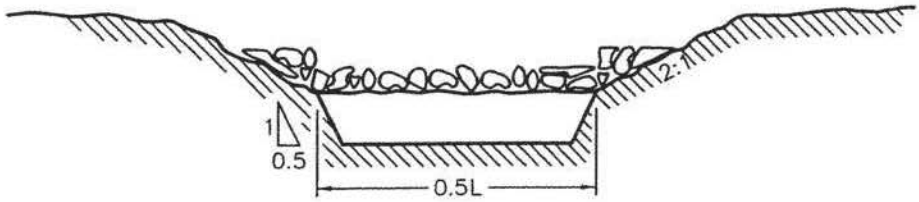
OPSD – 219.211



PLAN VIEW



SECTION B–B



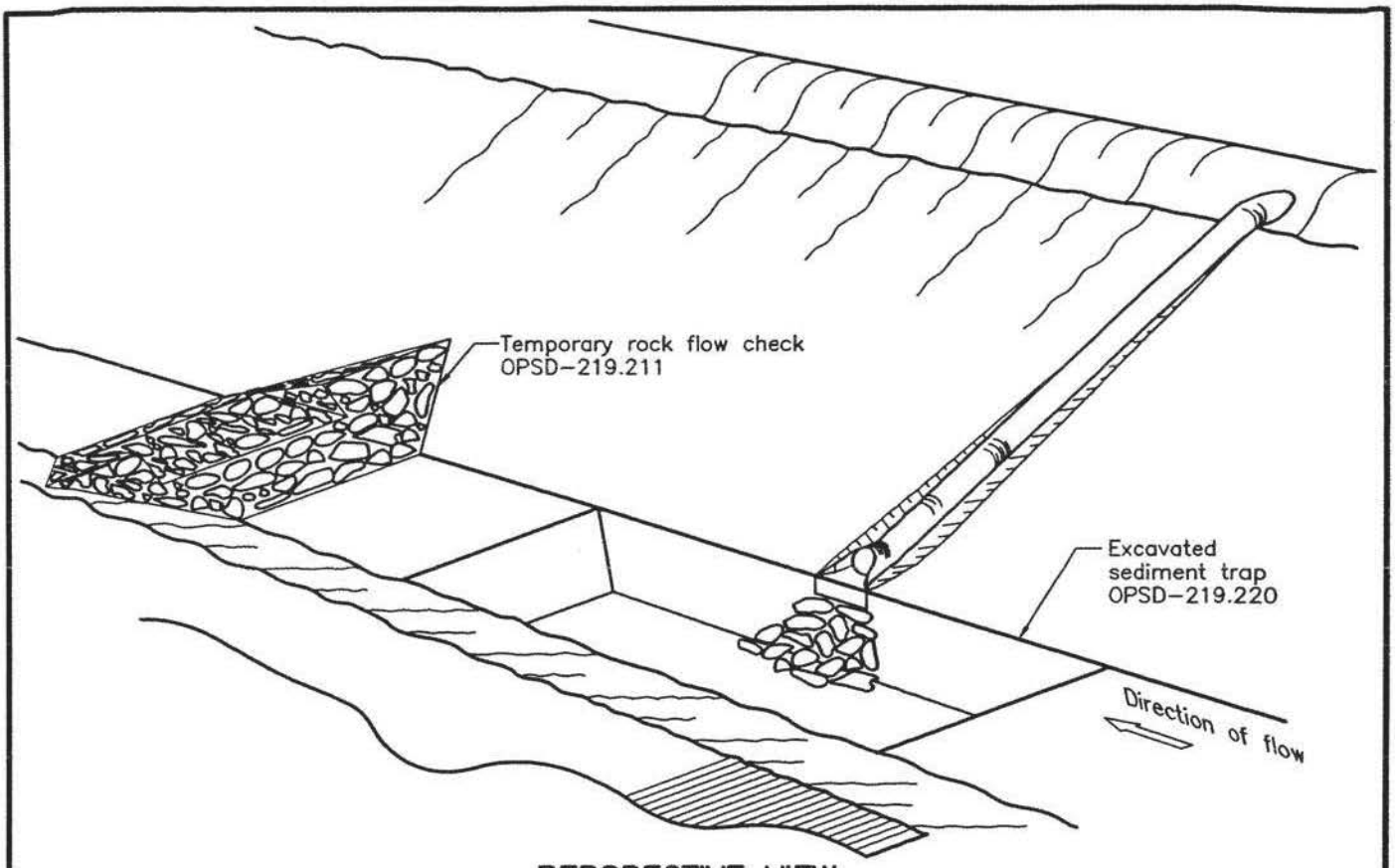
SECTION A–A

NOTES:

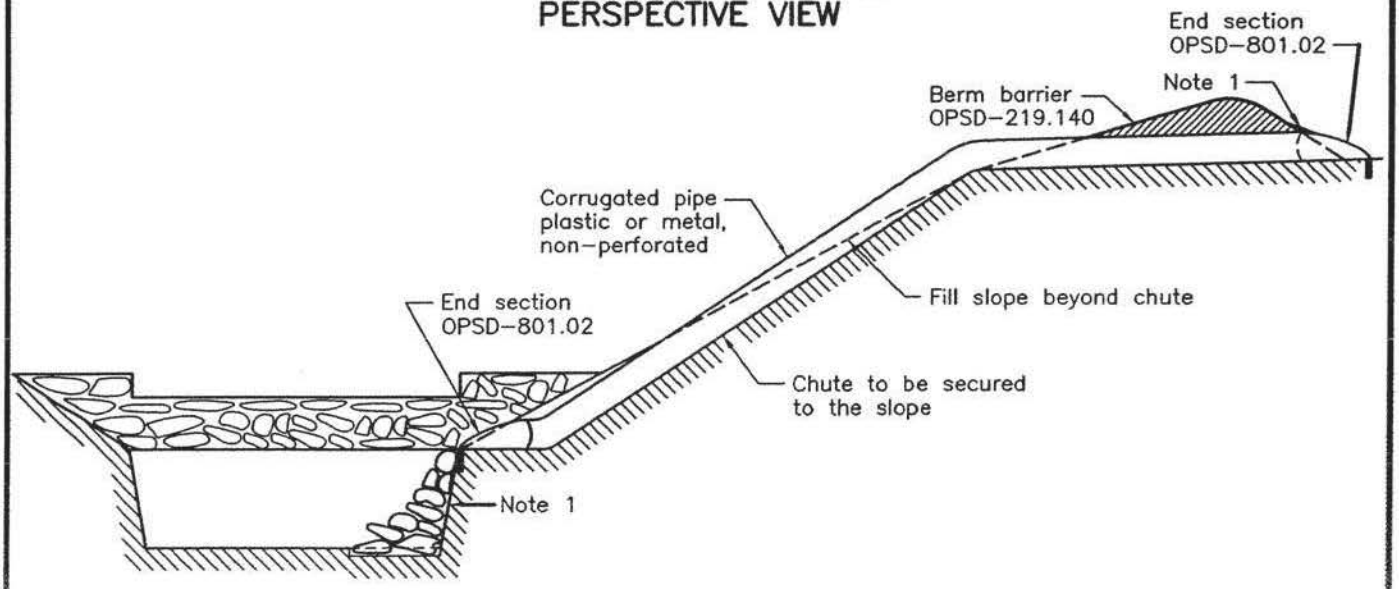
A Ditch cross section upstream or downstream of sediment trap may be flat bottom or 'V' shaped.

B All dimensions are in millimetres or metres unless otherwise shown.

ONTARIO PROVINCIAL STANDARD DRAWING	1996 02 01	Rev	
EXCAVATED SEDIMENT TRAP	Date _____		
	OPSD – 219.220		



PERSPECTIVE VIEW



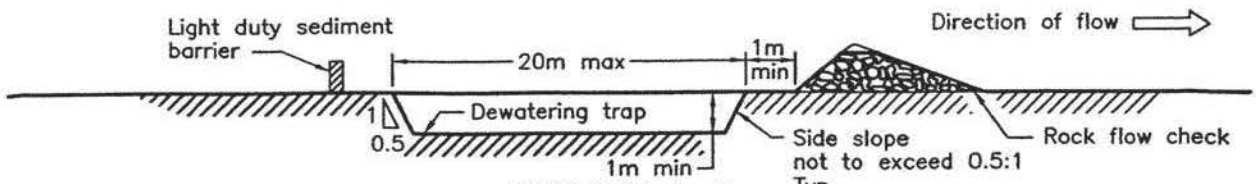
SECTION VIEW OF CHUTE

NOTES:

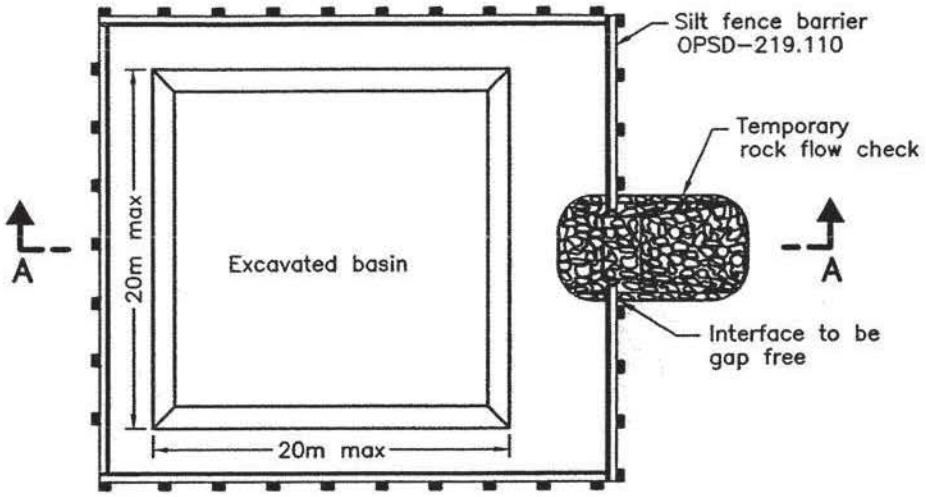
1 Scour protection required.

A All dimensions are in millimetres or metres unless otherwise shown.

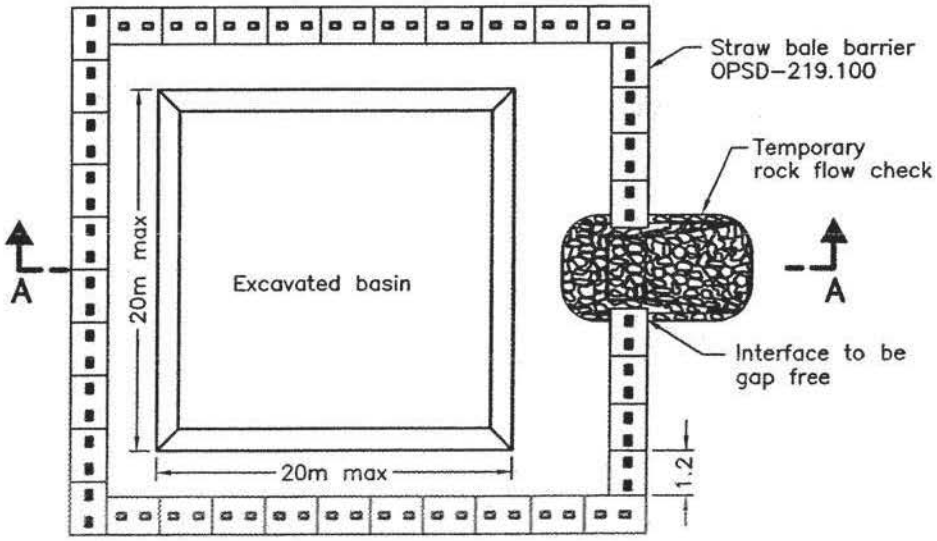
ONTARIO PROVINCIAL STANDARD DRAWING	1996 02 01	Rev
CHUTE	Date _____	
	OPSD – 219.230	



SECTION A–A



DEWATERING TRAP WITH SILT FENCE

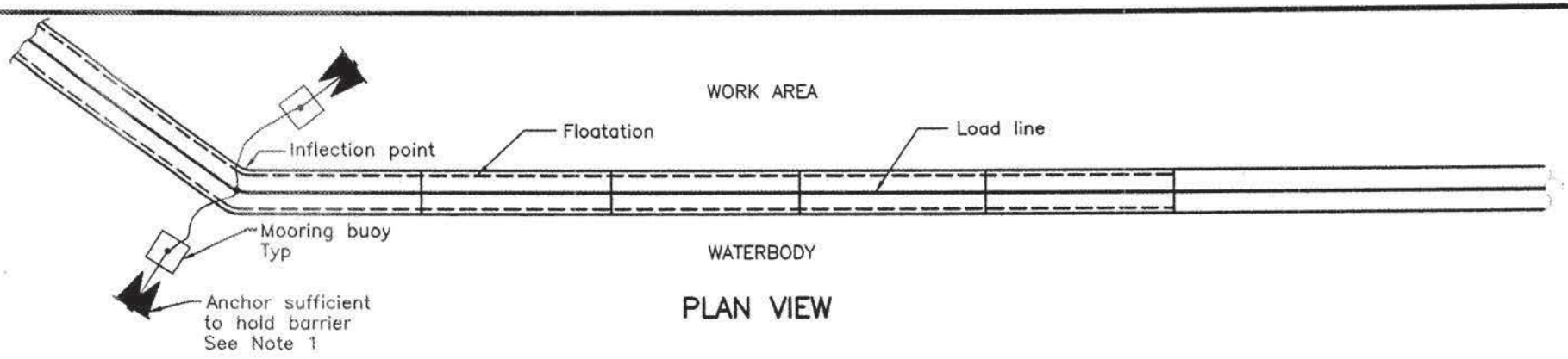


DEWATERING TRAP WITH STRAW BALES

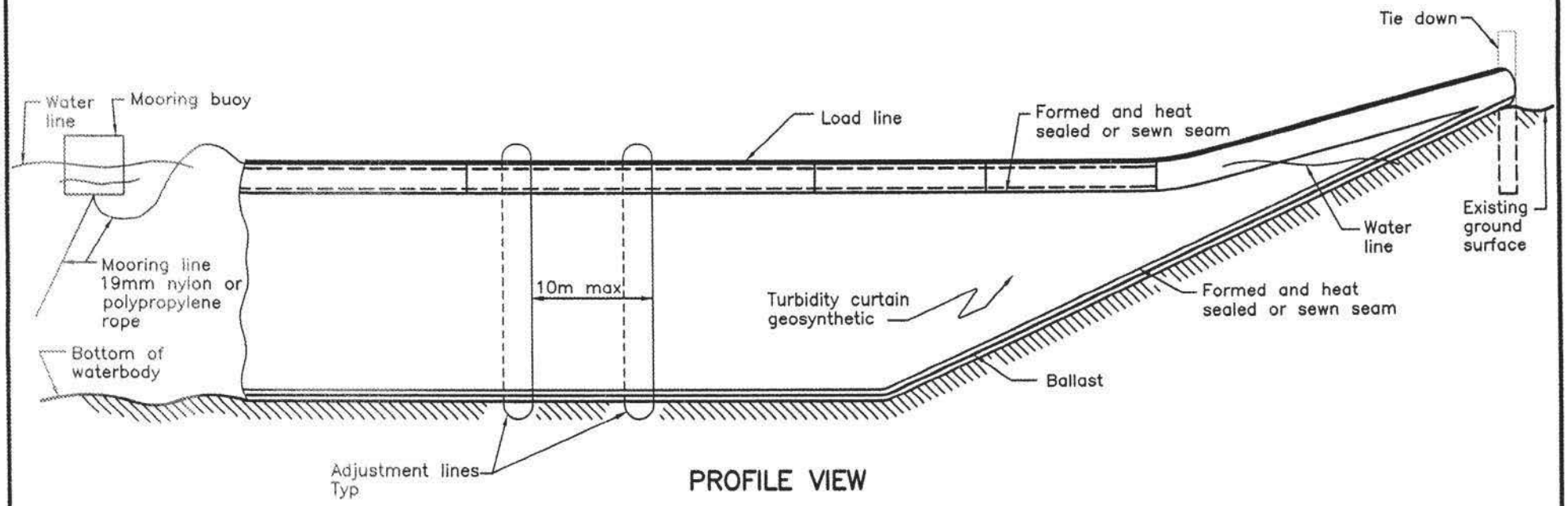
NOTE:

A All dimensions are in millimetres or metres unless otherwise shown.

ONTARIO PROVINCIAL STANDARD DRAWING	1996 02 01 Rev	
DEWATERING TRAP	Date _____	OPSD – 219.240



PLAN VIEW



PROFILE VIEW

NOTES:

1 Anchoring is to provide positive positioning for turbidity curtain.

A All dimensions are in millimetres or metres unless otherwise shown.

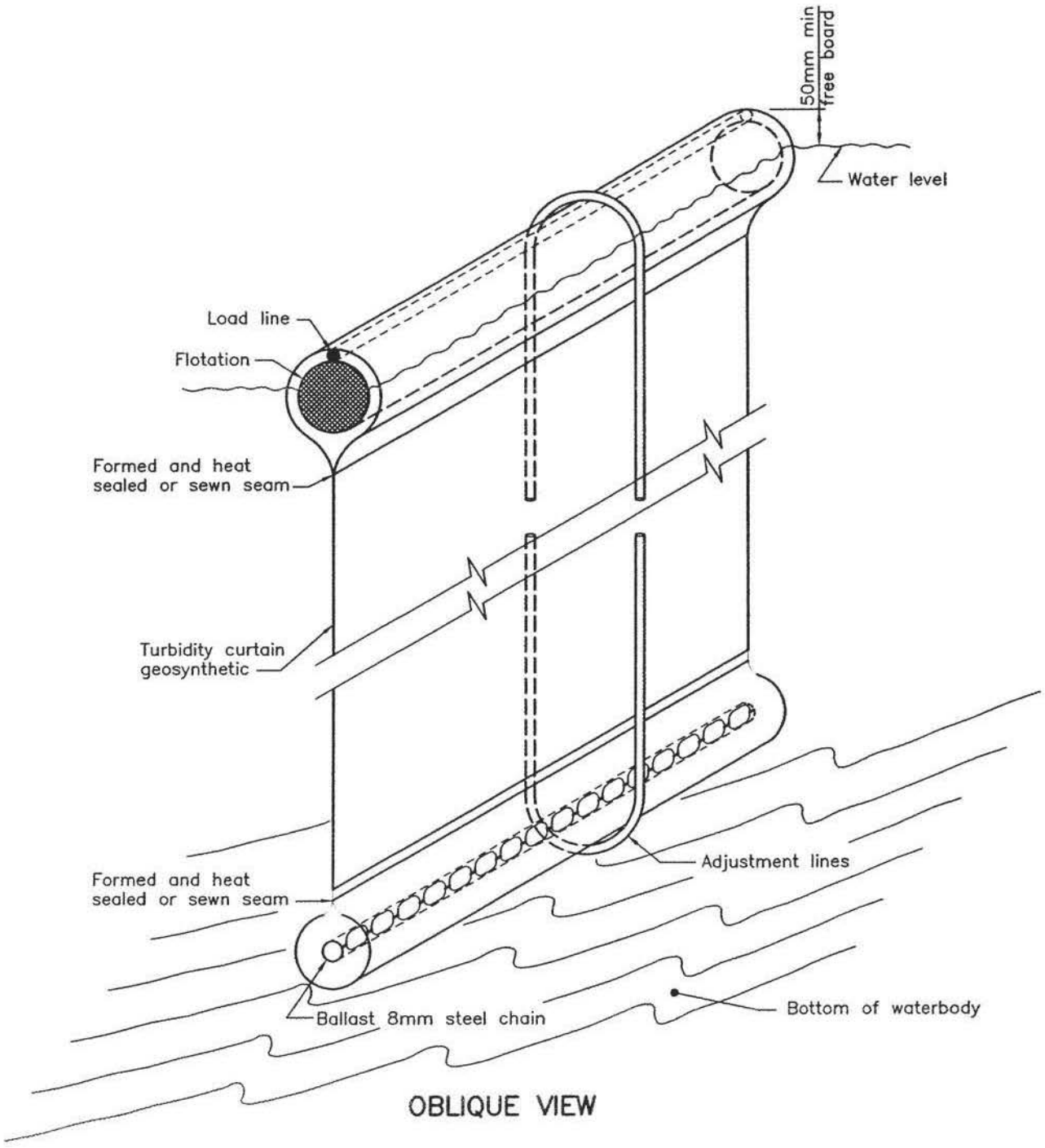
ONTARIO PROVINCIAL STANDARD DRAWING

1996 02 01 | Rev

TURBIDITY CURTAIN

Date _____

OPSD – 219.260



OBLIQUE VIEW

NOTE:

A All dimensions are in millimetres or metres unless otherwise shown.

ONTARIO PROVINCIAL STANDARD DRAWING	1996 02 01	Rev	
TURBIDITY CURTAIN SEAM DETAIL	Date _____		OPSD – 219.261

APPENDIX F

Excerpt from Stormwater Management Review Report by Arctic Weve Limited with Emmons & Olivier Resources Canada Inc.

4. SAMPLING PROGRAM EVALUATION

The City of Yellowknife (the City) is seeking to ensure their stormwater sampling program is designed to effectively evaluate the City's discharge profile and long-term trends in pollutant loading to the lakes in and around the City.

The City selected AWI-EOR to review, evaluate and provide recommendations for its stormwater sampling program. Through a series of discussions and a tour of current and potential sampling sites, the following evaluation of the program was developed (Section 4.1). Recommendations are included in Section 4.2.

The City of Yellowknife stormwater sampling program, at the time of the report, was developed informally in response to requirements set out by the MacKenzie Valley Land and Water Board (MVLWB).

In the past, storm and runoff sampling sites were selected to:

- sample stormwater from the largest catchment entering each lake in the City;
- respond to concerns from the public regarding water quality; and,
- enable easy access.

The ten current sampling sites were visited on May 15, 2019 by AWI-EOR, along with the engineering and operations personnel responsible for water quality sampling at these sites (Figure 4.1, Sites 1 to 10). Seven new sites were identified and visited at the same time (Figure 4.1, Sites A to G). Below is a summary of the characteristics, challenges, and sampling procedures at each site.

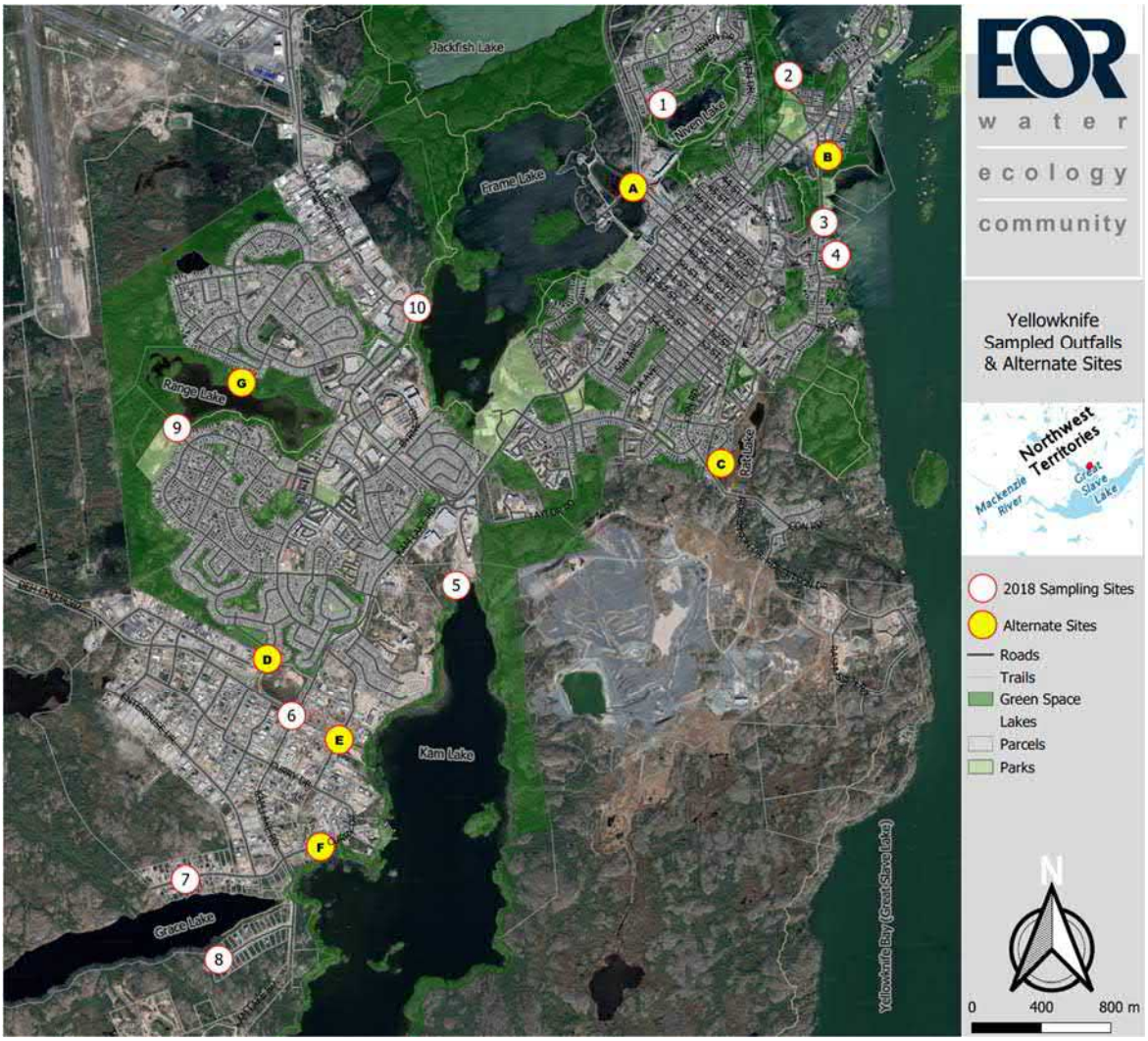


Figure 4.1 All Existing and Potential Alternate Sampling Sites Evaluated

Current Sampling Method

Runoff samples taken as part of the Yellowknife Stormwater Sampling Program are collected with bottles provided by the analytical lab.

Depending on the location, bottles may be submerged in water inundating the discharge pipe. Otherwise the sampling bottles are inserted into flowing water.

A city engineering staff member has been designated to take all water samples. Using a single person increases the likelihood of consistent sampling and observation methods. A written protocol with training could assist in providing for additional staff capability and would help ensure consistency through unexpected staffing changes.

The city has several small watersheds. In these locations, the time between a rainfall or snowmelt event and the runoff water reaching the sampling point, is short. The flashy behaviour means it is difficult for staff to be present for sampling during a flow event. Additional staffing may be a solution, but sites that are flashy may still be missed due to the short time between notification and the no

flow conditions. Automated samplers could be considered. Automated samplers costs include purchase, operations, sample collection and maintenance. The equipment can be vulnerable to vandalism, sedimentation, freezing, and other conditions. To date the City has not used automated systems in the stormwater quality monitoring program.

4.1. Characterization of Existing Sampling Sites

Site 1: Niven Lake Outfall

The drainage area of Site 1, the Niven Lake Outfall, to Niven Lake is comprised of residential land use. The drainage area is relatively small compared to the drainage area of other sampling sites.

A corrugated metal pipe outlet discharges into a marsh/pond area. The pipe is partially submerged in the marsh area during snow melt and rain events. There are two catch basins upstream of the outlet. The catch basins are located on de Weerdt Drive, next to the sewer pump station.

Samples are taken from the marshy ponding area downstream of the outfall. Samples are taken by submerging the bottle into standing or flowing water at the end of pipe.

Cons:

- Flashy storm flows that are difficult to sample due to short duration flow events.

Pros:

- Over time, a single contributing land use will allow a pollutant profile to be built for residential land uses.

Site 2: Back Bay Outfall

The Back Bay outfall captures runoff from Fritz Theil Memorial Park, several residential lots, and undeveloped areas between the south side of the Niven Lake development and Back Bay. There is a box culvert with two catch basins located at the end of Primrose Lane between the Park and the outfall. From the corrugated metal outfall to Great Slave Lake is a channel dominated by long grasses. The grasses suggest periods without flows during the growing season.

Samples are collected by submerging the sample bottle into flowing water at the downstream end of the pipe.

Cons:

- Mixed land use of undeveloped land, parks, and a few residential properties make it difficult to identify individual land use based pollutant profiles.

Pros:

- Easy site access.
- Site could be used for identifying background pollutant profiles from undeveloped and maintained park land by changing the sampling location.
- Resident concern is high and therefore it may lend itself well to public engagement and education.

Site 3: School Draw

Site 3, at the School Draw Outfall, located along School Draw Avenue discharges from a corrugated metal culvert into a vertical corrugated metal culvert. The vertical culvert acts as a sump to prevent sediment and trash from entering the receiving waters (Great Slave Lake). From the sump, water is directed into a short, screened outlet pipe for discharge into the channel and then the lake.

During the snowmelt period, a screened pipe is inserted into the vertical sump in order to prevent large trash from being released into the lake.

During the late spring and summer, following snow melt, the outlet pipe is replaced with an elbow pipe that releases water from below the water surface, trapping floatables within the vertical sump. Considerable algae was observed in the outlet channel.

Samples are collected by submerging the sample bottle into flowing water in the channel downstream of the screened outlet.

Cons:

- This site is a duplicate with Jan Stirling (Site 4) and alternate site Lundquist Drive (Site B) for land use contributions.

Pros:

- 30% of downtown contributes to this outfall as well as a significant residential area. If loading rates are calculated from other residential land use sites, an estimate of loading from the downtown area could be derived.
- Easy site access.
- No excavation or steaming is typically required at this site during the winter.

Site 4: Jan Stirling

Site 4, at the Jan Stirling Outfall, discharges through a large corrugated metal pipe into a ditch. From there the water enters the receiving water (Great Slave Lake) through twin corrugated metal culverts under a driveway.

An electric tracer wire has been installed through one of the downstream culverts to facilitate de-icing; however, winter ice removal machinery often pulls out the tracer wire.

Samples are collected from flowing water at the downstream end of the perched twin culverts.

Cons:

- Site 4 is similar to Site 3, School Draw and to alternate Site B, Lundquist, for contributing land use types.
- This site has the smallest downtown contributing area of the three sites that drain the downtown runoff.
- Excavation is typically required during the winter or spring to maintain flow to Great Slave Lake, disturbing the surrounding vegetation and soils, and possibly increasing sediment concentrations in stormwater/meltwater samples.

Pros:

- Resident concern is high and therefore it may lend itself well to public engagement and education.
- Easy site access.

Site 5: Kam Lake North

The Site 5, Kam Lake North Outfall discharges waters from several residential, commercial, and industrial areas into a ravine alongside City yards, into the north end of Kam Lake.

Stormwater in the ravine comes from three separate storm sewer networks. Two areas are entirely residential land uses (north and west) with typical suburban storm sewers. The third network is primarily commercial land use with a large parking lot directing collected flows into the ravine both overland and through storm sewers.

Samples are collected from flowing water at the natural drop (waterfall) within the ravine.

Cons:

- This site is relatively difficult to access compared to other sites.
- Overland flow occurs between the outlet pipes and this site, allowing alterations to the pollutant profile by absorption, settling, erosion, or dissolution.
- Several land use types exist in the contributing area.

Pros:

- This site captures runoff from the City storage yard.

Site 6: Deh Cho Blvd

Site 6 is located at the intersection of Deh Cho Boulevard and Kam Lake Road. The culvert across Kam Lake Road collects runoff from ditches from the south and west, and a single culvert from the north. The Kam Lake Road culvert discharges into a ditch southeast of the road that ultimately leads to the receiving waters (Kam Lake). The contributing area consists of residential and industrial land uses. More industrial lands are located downstream of Site 6 and runoff from these properties is not currently sampled.

Samples are collected by submerging the sample bottle into flowing water at the upstream end of the Kam Lake Road culvert.

Cons:

- This site consolidates runoff from a significant residential area, Range Lake outflows, and the industrial area making clear identification of industrial pollutants difficult without additional analysis.
- Site 6 is located upstream of several industrial lots with potential for significant pollutant contributions.

Pros:

- Location within the industrial zoning could allow identification of pollutant profiles from industrial land uses when combined with other land use profiles.
- Easy site access.

Site 7: Grace Lake North

Site 7, at the Grace Lake North discharge, collects runoff from three culverts (West, North and East) onto a concrete pad, from there water discharges overland into a natural ravine and into the receiving waters of Grace Lake. There are both existing and new developing residential land uses being built on blast rock that contribute to this site.

During site visits, the culverts were observed to be dry, as was the concrete pad.

Flowing water could be seen and heard within the ravine. Ongoing observations by City staff indicated that the water was running through the blast rock rather than through the storm sewer system. At Site 7, blast rock is acting as an unconfined aquifer with baseflow.

The ravine is difficult to access safely due to steep slopes and dense undergrowth. Due to a lack of overland flow, and the difficulty in reaching the runoff in the ravine, samples have not been collected at this location.

Cons:

- Runoff seems to flow through the blast rock and discharges directly to the ravine rather than through the storm sewer system.
- Accessing the storm flows within the ravine is difficult because of the steep sides, unstable blast rocks and density of vegetation in the ravine.

Pros:

- Contribution to the site is fully residential.
- Identification of background pollutant profile from runoff through the blast rock may be possible.

Site 8: Grace Lake South

Site 8, at the Grace Lake South Outfall, drains a residential area that is currently under construction, built on quick draining blast rock.

The culvert outlet was dry during the site tour. Running melt water was visible emerging from the base of the blast rock into a channel between the outfall and Grace Lake. Operations personnel noted that discharge from the culvert has not been observed during large storm events. During the summer season the channel emerging from the blast rock is also dry during storm events.

Spring snow melt samples are been collected by submerging the sample bottles into flowing water in the channel downstream of the blast rock.

Cons:

- Runoff seems to flow through the blast rock and discharges directly to the natural watercourse rather than through the storm sewer system.

Pros:

- Contribution to the site is fully residential.
- Identification of background pollutant profile from runoff through the blast rock may be possible.
- Access to this site is much easier than Grace Lake North.

Site 9: Range Lake Outfall

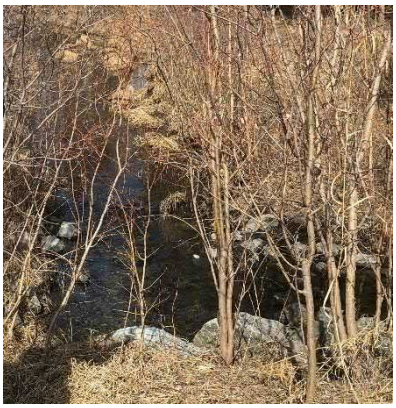
Site 9, the Range Lake Outlet, discharges through a channel into Parker Recreation Field. Range Lake receives runoff from the residential community to the north, a portion of commercial land along Old Airport Road, and a portion of the north-south runway at the Yellowknife Airport.

The channel discharges through a culvert into a wetland complex within the Parker Field dog park. Overland flow paths carry Range Lake outflows through the natural landscape before discharging into the ditch system along Kam Lake Road.

Samples are taken by submerging the sample bottle into channel flow upstream of the dog park.

Cons:

- This site receives discharge from mixed land uses which preclude separation of stormwater pollutants from their sources.



Pros:

- When combined with samples at Site 6, this site enables lake outflow contributions to be excluded from the industrial and residential pollutant profile.
- Easy site access.
- Continuous flow allows for easy timing of sample collection.

Site 10: Frame Lake Outfall

Site 10, at the Frame Lake Outfall, contains discharge runoff from both commercial and residential sources.

Site 10 discharges running water year round, possibly from suspected water breaks. The area of Frame Lake near the outfall often experiences thin ice during the winter and requires signage on the lake to ensure public safety.

Samples are collected by submerging the sample bottle into the flowing water at the downstream end of the outlet pipe.

Cons:

- Water breaks may be contributing to the year round flows observed at this site, and samples may require additional analysis to identify the stormwater pollutant profile.

Pros:

- Easy site access.
- Commercial and residential land uses contribute to the runoff. However, the pollutant profile could be used to separate commercial and residential loads if stand-alone residential samples are collected.

4.2. Characterization of Potential Sampling Sites

Site A: North Frame Lake Outlet

Site A, at the Frame Lake outlet channel, discharges to the northeast through a channel into Niven Lake. A culvert through the bermed trail connecting the Prince of Wales Northern Heritage Centre with Somba K'e Park allows all of Frame Lake to discharge into Niven Lake through this outlet. Site A was identified as a possible replacement for the Niven Lake Outfall (Site 1).

Samples could be collected by submerging the sample bottle into the flowing water in the outlet channel.

Cons:

- This site does not reflect a specific land use

Pros:

- Continuous flow allows for easy sample collection.
- The constant discharge will likely have a higher impact on the water quality of Niven Lake than the occasional summer rainfall events from the residential developments around Niven Lake.

Site B: Lundquist Road

Site B, at the Lundquist Road Outfall, is located in a green space. A storm sewer manhole is located in the road upstream of the outfall. Site B receives drainage from 34% of the downtown area and residential land uses. The discharge at this site had been directed to Site 2, the Back Bay Outlet, prior to 1994.

Samples could be collected by submerging the sample bottle into the flowing water in the outlet channel.

Cons:

- If this site does not replace an existing site additional time will be required to sample all sites in the program.

Pros:

- Much of the runoff from downtown Yellowknife discharges into Great Slave Lake at this site allowing identification of pollutant loading from a significant portion of the commercial area.
- Easy site access.
- Could possibly replace Sites 2 or 4.

Site C: Rat Lake

Site C, at the Rat Lake Outfall, is located behind the City pump house on Rycon Drive, just northeast of the intersection with Con Road. Site C receives drainage from an entirely residential land use catchment. Samples from Site C would identify the residential pollutant contributions separately from any mine runoff to Rat lake.

Samples could be collected by submerging the sample bottle into the flowing water in the outlet channel.

Cons:

- Residential pollutant profiles could be estimated from other sites with large catchments.

Pros:

- Separates residential land use profiles from mining land use pollutant profiles found in Rat Lake.
- Easy to access.

Site D: Bagon Drive

Site D is a storm sewer outfall located at the end of Bagon Drive along the walking trail heading southwest. The runoff discharging to this site is from residential land uses. The channel discharge eventually enters the culvert from the north at Deh Cho Boulevard and Kam Lake Road (Site 6).

Sampling Site D would enable separation of the residential pollutant profile from the industrial profile. Site D, combined with Site E, could replace Site 6.

Samples could be collected by submerging the sample bottle into the flowing water in the outlet channel.

Cons:

- Two sites (Sites D and E) could replace Site 6, resulting in additional time needed for sampling during rain events.

Pros:

- Separates residential land use pollutant profiles from downstream industrial land use pollutant profiles.

Site E: Coronation Drive

Site E, at the Coronation Drive Outfall, is located further down the discharge channel from Site 6. Site E discharges to Kam Lake. There are several industrial lots located between Site 6 and Site E which allows samples at Site E to capture pollutants originating from those lots.

Combined with Site D, this site will allow the City to differentiate the pollutant profiles for residential and industrial land uses. When combined with Site D, this site could replace Site 6.

Samples could be collected by submerging the sample bottle into the flowing water in the outlet channel.

Cons:

- Two sites (Sites D and E) could replace Site 6, resulting in additional time needed for sampling during rain events.

Pros:

- When combined with Site D, residential land use pollutant profiles can be separated from industrial land use pollutant profiles.
- Allow detection of illicit industrial discharges and industrial pollutant hotspots.
- Education targeting specific industrial operators can be developed with understanding of the actual runoff contributions.

Site F: Curry Drive

Site F, at the Curry Drive Outfall, is located at the culvert crossing under Curry Drive to the channel discharging stormwater to Kam Lake. Site F is downstream of several kennels; therefore, sampling at this site would identify the level of nutrient loading to Kam Lake from these land uses.

Site F would not replace an existing sampling site.

Samples could be collected by submerging the sample bottle into the flowing water in the outlet channel.

Cons:

- ENR Industrial Waste Guidelines do not include nutrients in Schedule II - Standards for Non-Point Source Discharges.

Pros:

- With additional stormwater analysis, sources of elevated nutrient concentrations discharged to Kam Lake may be identified.
- Education targeting specific industrial operators can be developed with understanding of the actual runoff contributions.

Site G: Range Lake Inflow

Site G, at the Range Lake stormwater outfall, discharges stormwater from residential land uses. Stormwater discharges from this site through a corrugated metal pipe which is inundated by Range Lake most of the year. Two manholes intersect the pipe between the outlet and the nearest roadway, both on public land.

Samples could be collected by submerging the sample bottle into the flowing water in the outlet channel.

Cons:

- The recommended sampling program contains other Sites with more suitable contributing areas that can be used to estimate residential land use loadings to Range Lake.
- Outlet (sampling point) is inundated and the potential is high for lake water to mix with stormwater during sampling.

Pros:

- The area contributing to this outfall is fully residential.
- Separates stormwater runoff pollutant profiles from the City from overland flows to the north and west.

4.3. Program Evaluation Summary

The existing City of Yellowknife Stormwater Sampling Program has been developed to gather information about urban runoff pollutants discharged into the City's lakes and bays. The topography of the City results in several small catchments, with short times of concentration, resulting in flashy discharges and difficulting capturing samples. Other sites selected contain several land uses within the catchment making isolation of different land uses to the environment difficult. Finally, the sampling methodology used is generally well suited for the sites selected however unique challenges at some sites have precluded collection. The sampling program recommendations are intended to focus the program on identifying land use pollutant profiles which can then be extrapolated, by surface area, into other catchments containing the same land uses. Recommendations on sampling methods are also included in order to facilitate collection at the challenging sites.

4.3.1. Sampling Location Recommendations

Based on the discussions at the kickoff meetings on May 10 and May 15, 2019, the sampling site visit on May 15, 2019, and information provided by the city, the following key criteria were identified. The criteria are to help direct recommendations made.

1. Identify runoff profiles based on land use for industrial, commercial, and residential
2. Identify pollutant hotspots for targeted public education
3. Support reporting requirements by the MVLWB
4. Identify illicit discharges to the storm sewer system
5. Identify sites and methods to make sample collection more consistent
6. Address resident concerns regarding discharge quality at specific locations

Table 4.1 contains a matrix that illustrates the characteristics of the 17 sites included in the sampling program evaluation.

Table 4.1: Sampling Site Characterization Matrix

		Land Use				Program Goals				
Site ID	Site Name	Industrial	Commercial	Residential	Background	Pollutant Hotspots	MVWLB Approved	Illicit Discharge	Ease of Sampling	Resident Concerns
1	Niven Lake			X			X			
2	Back Bay				X		X		X	X
3	School Draw		X	X			X		X	
4	Jan Stirling Outfall		X	X			X			X
5	Kam Lake North	X		X			X			
6	Deh Cho Boulevard	X		X			X	X	X	
7	Grace Lake North			X						
8	Grace Lake South			X			X			
9	Range Lake Outlet			X	X		X		X	
10	Frame Lake Inlet		X	X			X		X	
A	North Frame Lake Channel		X	X	X				X	
B	Lundquist Road		X	X					X	
C	Rat Lake			X					X	
D	Bagon Drive			X					X	
E	Coronation Drive	X		X	X	X		X	X	
F	Curry Drive	X		X	X	X		X	X	
G	Range Lake Inlet			X						

Municipalities typically use monitoring data to develop pollutant profiles for various land uses. The data is then used to estimate pollutant loads in the receiving waterbodies. Yellowknife also intends to develop pollutant trends for the sites being monitored, as requested by the MVLWB, in order to document progress toward reducing urban pollutant loads into sensitive lakes.

4.3.2. Recommended Sampling Sites

AWI-EOR has used the criteria developed and the characterization of the 17 sites evaluated in this project to recommend nine sites for inclusion in the program in 2020 and the future. The sites have been renumbered N1-N9 in the recommendations.

Table 4.2 summarizes the nine sites recommended for the Yellowknife Stormwater Sampling Program. Table 4.2 includes recommended sample analysis and collection methods. Figure 4.2 illustrates the distribution of the recommended sites.

Table 4.2: Recommended Sampling Site Matrix

		Land Use				Analysis				Method		
Site ID	Site Name	Industrial	Commercial	Residential	Background	Current Suite	B-Tex	Propolene Glycol	Municipal Water	Submerged Bottle	Low Flow Bag	Standpipe & Bailer
N1	Back Bay				X	X			X	X	X	
N2	Lundquist Road		X	X		X				X		
N3	School Draw		X	X		X				X		
N4	Coronation Drive	X				X	X			X		
N5	Curry Drive	X		X		X				X		
N6	Grace Lake South			X		X					X	X
N7	Bagon Drive			X		X			X	X		
N8	Range Lake Outlet			X		X		X		X		
N9	Frame Lake Inlet		X	X		X	X		X	X		

Figure 4.2 – Recommended Site Map

N1 - Back Bay –Adjusted, Short-term, Education Added

Site N1 (formerly Site 2) should be kept within the storm water sampling program for the interim in order to develop a profile for runoff from undeveloped land. Once the background water quality profile has been established following the first three-year trend analysis, the site may be considered to be discontinued.

During the three-year sampling period at this site, efforts are recommended to engage and educate the community. The education would include background information on the areas of the City actually discharging through this outfall, the land uses within the contributing area, and the technical reasons for sampling Site N1. Landowners and residents would be provided with actions they could take to reduce pollutant loads to Great Slave Lake.

Site N1 should be moved from the former Site 2 location to the ditch along the northern edge of Fritz Theil Memorial Park, or within the catch basin just south of the houses facing Back Bay. Sample bottles should be submerged into flowing stormwater with the bottle mouth oriented upstream.

Park maintenance activities should be assessed to ensure fertilizer is applied at the appropriate time (e.g. avoid application immediately before a forecasted rainfall) and in the appropriate quantities for proper turf management to limit pollutant loading to Great Slave Lake.

Samples at Site N1 should be analyzed for metals, nutrients, and fecal coliforms.

N2 - Lundquist Road – New

Site N2 (formerly Site B) should be added to the stormwater sampling program. Site N2 discharges 34% of the downtown area to Great Slave Lake.

Sample bottles should be submerged into flowing stormwater exiting the storm sewer, with the bottle mouth oriented upstream.

Samples at Site N2 should be analyzed for the full suite of constituents currently being analyzed.

N3 - School Draw – Current

Site N3 (formerly Site 3) should be kept in the stormwater sampling program. Site N3 discharges 30% of the downtown area to Great Slave Lake.

Sampling should be conducted by submerging the sample bottle into flowing water downstream of the structure grate, with the bottle mouth oriented upstream.

Samples at Site N3 should be analyzed for the full suite of constituents currently being analyzed.

N4 - Coronation Drive – New, Replacement

Site N4 (formerly Site E) should be added to the stormwater sampling program, replacing the current Site 6. Site N4 is located lakeside (southeast) of Coronation Drive, within the mixing zone of the combined discharge from the three culverts and ditches.

Sample bottles should be submerged into flowing stormwater, with the bottle mouth oriented upstream.

Samples at Site N4 should be analyzed for the full suite of constituents currently being analyzed as well as B-TEX Volatile Organic Carbons (VOCs) and specific contaminants related to industries within the catchment area.

Results from Sites N7 and N8 can be subtracted from the pollutant concentrations observed at Site N4 to isolate and build an industrial land use specific pollutant profile.

N5 - Curry Drive - New

Site N5 (formerly Site F) should be added to the stormwater sampling program in order to provide a thorough profile of any potential increases in pollutant loading resulting from the industrial catchment upstream.

The sampling site is lakeside (south) of Curry Drive, within the stormwater stream discharged from the culvert under Curry drive.

Sample bottles should be submerged into flowing stormwater, with the bottle mouth oriented upstream.

Samples at Site N5 should be analyzed for the full suite of constituents currently being sampled.

N6 - Grace Lake South – Current, Modified Method

Site N6 (formerly Site 8) should be kept in the stormwater sampling program to reflect a residential community under development. Results from this site can be extrapolated, using surface area disturbed, to the portion of the community located north of Grace Lake (formerly Site 7).

Since storm sewers at this site do not discharge during rainfall events as the runoff flows through the blast rock and discharges along the bedrock, a perforated standpipe should be installed at the location of the current sampling site, just downstream of where the blast rock meets the natural ground cover. If this site can be accessed during the storm event, a bailer should be used to draw a sample from the standpipe and emptied into the sample bottle. It may take several draws with the bailer to fill the bottle, depending on the depth of stormwater flowing through the standpipe.

Samples at Site N6 should be analyzed for the full suite of constituents currently being sampled.

N7 - Bagon Drive – New, Replacement

Site N7 (formerly Site D) should be added to the stormwater sampling program, replacing the current Niven Lake sampling site (Site 1). The contributing area at both sites is entirely residential; however, the Site N7 catchment is much larger than the Site 1 catchment and will therefore contain runoff for a longer period of time than Site 1.

Sample bottles should be submerged into flowing stormwater, with the bottle mouth oriented upstream.

Samples at Site N7 should be analyzed for the full suite of constituents currently being sampled. Consider sampling for B-TEX VOC's in order to support full isolation of the industrial land use contributions observed at Site N4.

Since Site N7 runs continuously, some discharge may be the result of water breaks. At the discretion of the City, the samples could be analyzed and compared with drinking water samples to identify any markers indicating the presence of municipal water.

N8 - Range Lake Outlet – Current, Modified Analysis

Site N8 (formerly Site 9) should be kept in the stormwater sampling program in order to provide an understanding of pollutant discharge from Range Lake. Range Lake receives runoff from a combination of residential, commercial and undeveloped land, and some airport runway runoff.

Sample bottles should be submerged into flowing water, with the bottle mouth oriented upstream.

Samples at Site N8 should be analyzed for the full suite of constituents currently being sampled. Samples should also be analyzed for propylene glycol (aircraft de-icer) due to its proximity to and lower elevation than the airport's north-south runway. If the propylene glycol analysis results in non-detects throughout the three-year trend assessment, this test can be removed from the analysis unless the airport makes adjustments to its winter operations procedures.

Site N8 results can be combined with Site N4 and Site N7 results to isolate the industrial land uses downstream at Coronation Drive. At the discretion of the City, samples may be analyzed for B-TEX VOC's in order to support full isolation of the industrial land use contributions observed at Site N4. If this analysis results in non-detects for three years, these tests can be removed from the analysis suite for Site N8.

N9 - Frame Lake Inlet - Current

Site N9 (formerly Site 10) should be kept in the stormwater sampling program to enable development of a pollutant profile for commercial land use. When combined the residential land use profiles from Sites N7 and N6, the commercial land use runoff profile can be isolated by combining results from Site N9 with Sites N2 and N3.

Sample bottles should be submerged into flowing water, with the bottle mouth oriented upstream.

Samples at Site N9 should be analyzed for the full suite of current constituents and BTEX because of the roadways and commercial land uses within the contributing area.

Since Site N9 runs continuously, some flows may be derived from water breaks between rainfall events. At the discretion of the City, the samples could be analyzed and compared with drinking water samples to identify any markers indicating the presence of municipal water.

4.3.3. Justification for Excluding Current Sites

Niven Lake

The catchment area contributing to the Niven Lake outfall (formerly Site 1) is very small. Attempts to sample in the water would likely continue to be ineffective while diverting resources away from better uses. Several other sites in this monitoring program capture residential land uses, both isolated and in combination with other land uses. Therefore, this site is no longer required to develop a residential land use discharge profile. Unless the MVLWB requires sampling of discharge into Niven Lake, this site is not recommended as part of the stormwater sampling program.

Jan Stirling Outfall

The Jan Stirling outfall (formerly Site 4) often requires excavation during the spring snowmelt to open up the storm sewer. This site does not provide an accurate assessment of the discharge from the contributing area since much of the TSS occurs immediately at the discharge point. Sampling would divert resources better used at other sites. For this reason the Jan Stirling outfall should be removed from the City's stormwater sampling program. If the City or MVLWB are interested in the site specific TSS contribution, then samples should be taken at both the sewer discharge point and the culvert discharge point to isolate the site impacts.

Kam Lake North

The Kam Lake north (formerly Site 5) captures runoff from many different land uses including commercial, light industrial, residential, park and undisturbed land. All storm sewers discharge along the top of the ravine and run overland to the collection point, allowing opportunity for mitigation of the pollutants by the natural environment and accumulation of background pollutants from the landscape, altering the pollutant profile in unpredictable ways. Sampling would divert resources better used at other sites. The Kam Lake North site can be removed from the sampling program because there are several other sites along Kam Lake that are included in the sampling program and can more easily isolate specific urban land use impacts.

Deh Cho Boulevard

The Deh Cho Boulevard site (formerly Site 6) is located mid-way through a large industrial zone, with the potential for significant pollutant contributions downstream of the site. Sampling would divert resources better used at other sites. This site should be replaced by Site N4 in order to capture as much industrial runoff as possible.

Grace Lake North

Grace Lake North is a very difficult site to sample due to the steep ravine at the culvert outlet. The blast rock on which the neighbourhood is built promotes infiltration to the underlying bedrock and stormwater is observed to move laterally and vertically within. While different

methods may be used to safely acquire samples at this site, it will remain a challenging site. Sampling would divert resources better used at other Sites. Site N6 has a similar land use, blast rock and subgrade while being much easier to sample, and would be representative of the runoff profile at Grace Lake North.

4.4. Sampling Method & Analysis Recommendations

Sampling protocols for sampling and training of staff are set out below.

4.4.1. Sampling Method Recommendations

Submerged Bottle

This method is recommended at all sites with visible surface flow deep enough to submerge a sample bottle. During rain events:

1. Wear new latex or plastic sampling gloves for each sample. Do not handle other surfaces.
2. Submerge the sample bottle upside down until the bottle is within the flowing discharge
3. Turn the bottle upwards and into the flow to fill the bottle
4. Remove the bottle from the water with the mouth upward
5. Replace the cap on the bottle and tighten
6. Store as per lab instructions until delivery to the lab for analysis
7. Record Id, date, time, temperature, observations, amounts, etc.
8. Discard gloves to approved container.

Standpipe and bailer

This method is recommended for the Grace Lake South site (Site 8). Alternately, the bailer could be installed up to 24 hours prior to an expected sampling event to capture and hold the sample until it can be removed.

1. Install permanent perforated standpipe prior to discharge event and allow it to sit several days to clear the silt from the standing water
2. Measure depth to groundwater or ground surface within standpipe
3. During rain events:
    a. Wear new latex or plastic sampling gloves for each sample. Do not handle other surfaces.
    b. Extract clean bailer (Waterra or similar) for use in the standpipe while not allowing it to touch surfaces that may be contaminated.
    c. Connect clean bailer to a rope and mark the rope or bailer with the sampling depth measured in Step 2.
    d. Lower the bailer into the standpipe to the depth marker indicated in Step 3c and collect sample. Do not allow the bailer to make contact with the ground surface so as to limit sediment disturbance or uptake during sample collection

e. Pull bailer from standpipe and empty bailer into sample bottle provided by lab
f. Repeat steps 3d and 3e until sample bottle is full
g. Replace the cap on the bottle and tighten
h. Store as per lab instructions until delivery to the lab for analysis.
i. Record Id, date, time, temperature, observations, amounts, etc.
j. Discard gloves to approved container.

4. After returning from the sampling day, clean bailer by rinsing with filtered water and brushing lightly with specially designed brush.
5. Dispose of bailers once they have significant scratches or substances that cannot be removed with rinsing and brushing.

Low Flow Bag Capture

This method is recommended at any site that does not have deep enough flow to submerge the bottle into flowing water. If flows are visible on the surface at Site N6, this method may be easier than using a standpipe and bailer.

1. Gather new unused sturdy plastic bags (Ziploc freezer bag size large, or other). Protect from contact with potentially contaminating surfaces and materials (soil, concrete, sediment, oily gloves, etc.).
2. During rain events:
   a. Wear new latex or plastic sampling gloves for each sample. Do not handle other surfaces.
   b. Extract and open new bag while not allowing it to touch surfaces that may be contaminated.
   c. Stand downstream of the collection location
   d. Flatten the mouth of the open bag and lower the mouth in the stream flow. Orient the mouth so that the flow runs directly into the bag. Be careful not to disturb sediment in the flow channel when collecting the sample.
   e. Capture runoff until the bag is almost overflowing (amount captured will vary depending on slope of sampling location)
   f. Pour captured water into the sample bottle provided by the lab
   g. Repeat steps 2c-2f until the sample bottle is full
   h. Replace the cap on the bottle and tighten
   i. Store as per lab instructions until delivery to the lab for analysis
   j. Record id, date, time, temperature, observations, amounts, etc.
   k. Discard sampling bag and gloves to approved container.

4.4.2. Land Use Based Water Quality Analysis Summary

While runoff into the lakes from the natural landscape is not currently monitored, community-based monitoring of Great Slave Lake has been recorded for several years. The MacKenzie DataStream (mackenziedatastream.ca) lists two community-based monitoring sites in proximity of the City of Yellowknife: Yellowknife at Great Slave Lake / Yellowknife Bay / Dettah and

Yellowknife at Great Slave Lake / Yellowknife Bay / N'Dilo. Samples have been collected from Great Slave Lake for several years and can be compared to discharge concentrations from Back Bay, Lundquist Drive, and School Draw in order to provide context for the urban discharge in relation to the background pollutant profile.

The recommended sampling program consists of nine new sites. Each site is selected to capture runoff from specific land uses. If several land uses are present in a catchment, other sites have been identified to enable isolation of land use contributions. These pollutant profiles can be scaled by the contributing area of the land use and then extrapolated to other sites. Rather than focusing the sampling program on each lake within the City, the program identifies the runoff pollutant profiles associated with different land uses. Combined with a GIS analysis defining the land use areas within the contributing areas of each sampling point, the resulting land use based profiles can then be applied to each catchment in the City to estimate the urban impacts on the lakes. Spot sampling of other locations of interest or concern will facilitate identification of abnormalities and pollutant hotspots when compared to the baseline trends.

Developing land use specific pollutant profiles will occur along with the trend analysis, over the three-year period. Trends can be developed for each sampling site as well as on a unit land use basis. The recommended sites were selected in order to be able to isolate land use pollutant contributions based on the areas contributing to the sampling site. The following description indicates which sites can be used to develop land use based runoff profiles.

Background

Site N1: Back Bay

Site N8: Range Lake Outfall with residential removed (check for airport pollutants)

Residential

Site N6: Grace Lake South

Site N7: Bagon Drive (check for potential water breaks)

Commercial

Site N2: Lundquist Road with residential removed

Site N3: School Draw with residential removed

Site N9: Frame Lake Outfall with residential removed (check for potential water breaks)

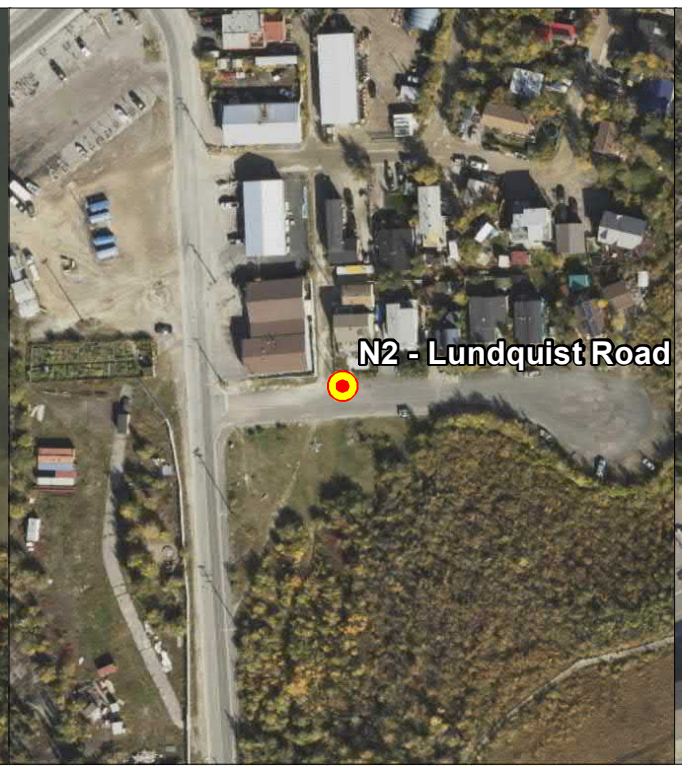
Industrial

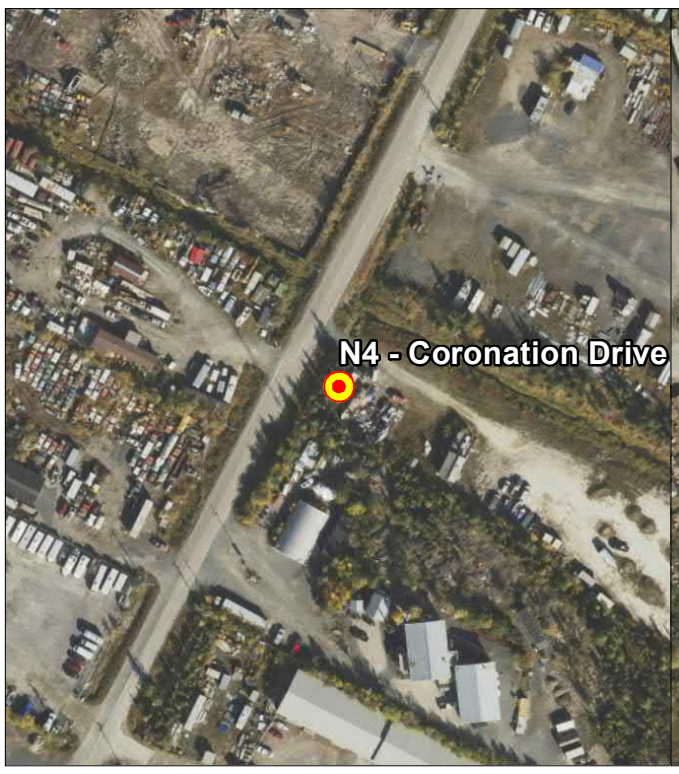
Site N4: Coronation Drive with Sites N7 and N8 removed

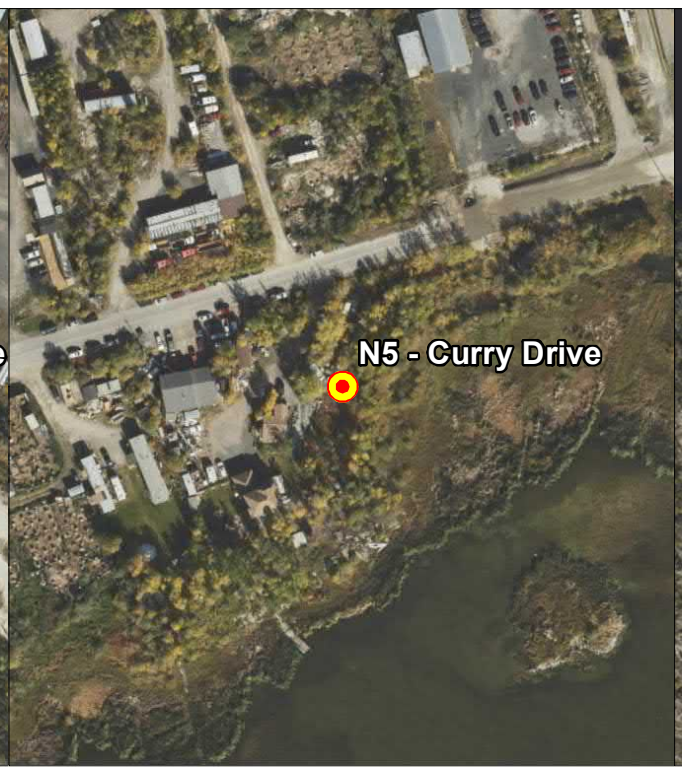
Site N5: Curry Drive

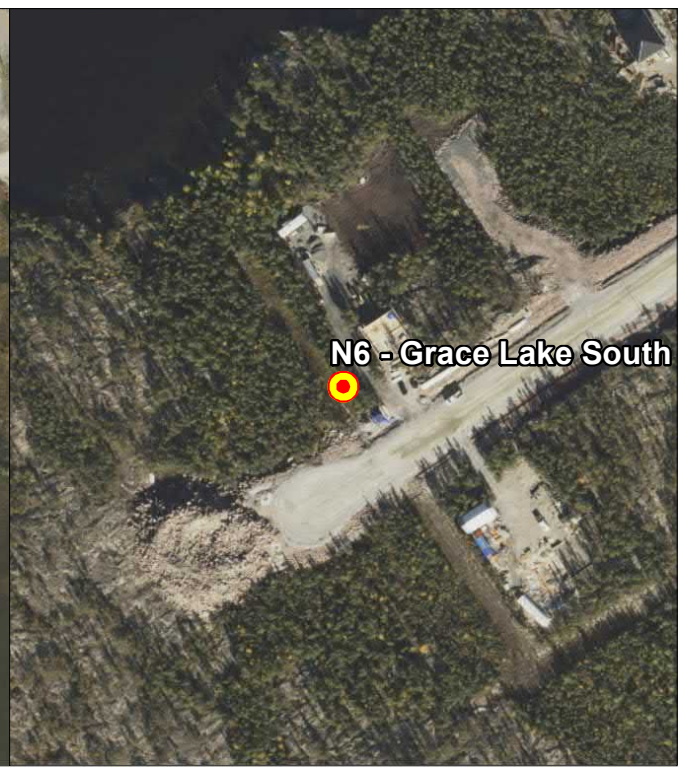
APPENDIX G

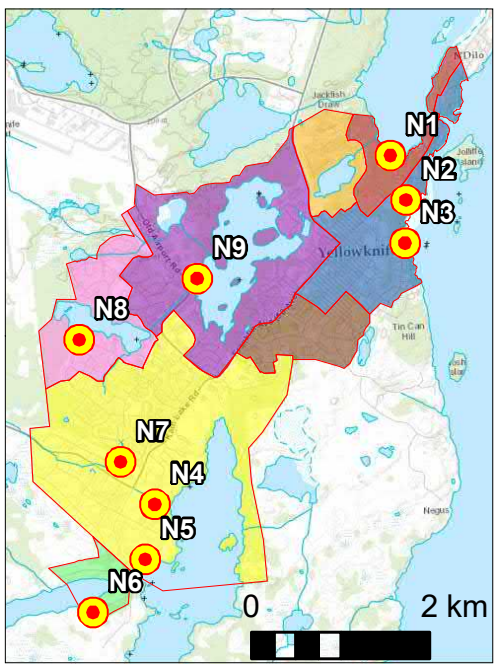
Map of Monitoring Locations











Stormwater Sample Location

Catchment Area

- Back Bay
- Frame Lake
- Grace Lake
- Kam Lake
- Niven Lake
- Range Lake
- Rat Lake
- Yellowknife Bay

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Sample ID	Location Name
N1	Back Bay
N2	Lundquist Road
N3	School Draw
N4	Coronation Drive
N5	Curry Drive
N6	Grace Lake South
N7	Bagon Drive
N8	Range Lake
N9	Frame Lake Inlet

Associated Environmental

PROJECT NO.: 2019-8509.000.000
DATE: June 2020
DRAWN BY: DA

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STORMWATER SAMPLING LOCATIONS

City of Yellowknife

Stormwater Management Plan

APPENDIX H

Stormwater Sampling Protocol

CITY OF YELLOWKNIFE

City of Yellowknife Water Licence Stormwater Sampling Protocol

Table of Contents

1. INTRODUCTION

As per the City of Yellowknife's (City) Water Licence, the City performs stormwater sampling in the spring, summer, and fall. In 2019, the City hired a consultant for the review of the existing Stormwater Management Plan. Based on the review, the following recommendations were made for the sampling program:

"A city engineering staff member has been designated to take all water samples. Using a single person increases the likelihood of consistent sampling and observation methods. A written protocol with training could assist in providing for additional staff capability and would help ensure consistency through unexpected staffing changes.

The city has several small watersheds. In these locations, the time between a rainfall or snowmelt event and the runoff water reaching the sampling point, is short. The flashy behaviour means it is difficult for staff to be present for sampling during a flow event. Additional staffing may be a solution, but sites that are flashy may still be missed due to the short time between notification and the no flow conditions. Automated samplers could be considered. Automated samplers costs include purchase, operations, sample collection and maintenance. The equipment can be vulnerable to vandalism, sedimentation, freezing, and other conditions. To date the City has not used automated systems in the stormwater quality monitoring program."

Beginning in 2020, a three-year trendline analysis of the City's stormwater data is underway. Based on the recommendations provided, the City determined that a hired consultant would be required to ensure data collection is accurate and consistent. Having a trained field technician responsible for sampling ensures that rain events will not be missed, and that sampling will remain consistent despite possible City staff changes. Additionally, the following protocol has been implemented for sampling collection.

2. SAMPLING PROTOCOL

2.1. SAMPLING SITES AND FREQUENCY

The sampling program will follow the sampling design outlined in the Stormwater Management Plan (SWMP). This consists of nine sites, sampled three times per year; in the spring, summer and fall.

The three sampling events represent three seasons and to types of runoff. The first sampling event in May/June captures spring runoff resulting from snowmelt during freshet. The largest amount of runoff occurs during freshet and creates very large quantities of water in a short period of time. The second sampling event in July/August represents a rain event and peak summer precipitation. Lastly, the third sampling event in mid-September represents an additional rain event when monthly precipitation is still high during fall in Yellowknife.

2.2. PRE-SAMPLING SITE VISIT

Prior to annual sampling beginning, the consultant sampling will conduct a site visit to all of the sampling locations. This will ensure that any problems related to site access or safety concerns can be resolved prior to a sampling event.

2.3. FIELD MOBILIZATION

Mobilizing field staff quickly is critical to stormwater sample collection, as samples must be collected at the time of a rain event. Rain events in Yellowknife are typically of short duration and the runoff is usually 'flashy', reaching the stormwater drainage system and receiving waters within a short time period. The hired consultant has a designated field technician who is responsible for all sample collection. The field staff is located in Yellowknife and is responsible for monitoring the weather forecast closely during the time periods in which sampling events are expected. Sampling outside of standard business hours may occur if required. If a significant snowmelt event or precipitation is likely to occur and a sampling event is planned, staff will prepare the equipment and sampling bottles. Sampling locations in small watersheds or in the upland portion of a drainage basin will be sampled first to maximize the chance of encountering stormwater at the sites.

2.4. SAMPLING PROCEDURES

The consultant will prepare and provide all required sampling equipment necessary to collect all samples. Stormwater samples will be collected using grab sampling and following procedures outlined in the SWMP as appropriate. Samples will be preserved according to the laboratory instructions and stored in a cooler with ice. They will be delivered to the laboratory within 24 hours of the sampling event to ensure all holding times are respected.

The pH and temperature will be recorded at each sampling location at the time of the sampling event. These parameters are important to determine site-specific guidelines that depend on pH and temperature, such as ammonia. In addition to the measured field parameters, photo will be taken at each location, and any notable observations will be recorded on field sheets.

A QA/QC sample for proper evaluation of sample result precision and accuracy will be collect, along with a duplicate and field blank sample during each field trip.

3. **CONCLUSION**

The City is working to ensure that the requirements of the Water Licence are met and that stormwater sample collection is performed properly. By hiring a consultant, the City has ensured that sampling will be performed consistently, by one field technician with the protocol outlined. Any updates to the sampling protocol will be made as required.

APPENDIX I

Public Education Information

There's **Something Fishy** Around Town!

You may have noticed a new set of blue fish painted on the roads and sidewalks around storm drains recently, and wondered what their significance was. The fish have been painted there as a part of the Storm Drain Marking Program. This volunteer-run program serves the purpose of remi ding people that unwanted household products or chemicals should not be dumped down the drains on the street. It also provides the public with the opportunity to participate in "hands-on" protection of the environment.

A lot of people don't realize that when items enter the storm drains, whether it's oil, soap, chemicals, or even litter, they travel directly into the lakes in the area. The system is designed to reduce flooding that can be caused by rain storms and run off from melted snow. Contrary to popular belief, the water does not run through s me sort of filtration system before being discharged into the environment. This means that all of those things end up polluting the water where our fish live - fish that we often eat.

Some of the products that are harmful include: pesticides, herbicides, gasoline, used motor oil, antifreeze, paint thinner, paints and other cleansers, etc. Even the water that comes off of your vehicles when you wash them can contain hazardous chemicals and oils. It's best to wash your vehicles at a car wash, or wash it over gravel or on grass.

If you see someone dumping waste products down one of the storm drains, please take the time to let them know that they're causing problems for the environment. Remember, it's up to all of us to help make a difference!

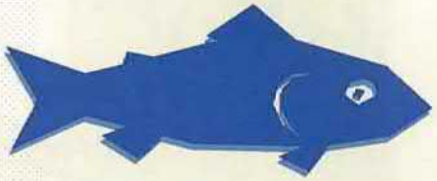
VISION

The City of Yellowknife is a community that takes full responsibility for its waste generation and the resulting consequences for today and future generations.

GOAL

To reduce waste and make the most efficient use of the resources produced by consumption.

- taken from the 2001 Community Waste Management Strategic Plan



FACTS

Just one litre of used oil can contaminate up to one million litres of fresh water.

UsedOilRecycling.com

PLEASE REPORT ALL SPILLS – CALL (867) 920-8130

The following is a list of common household products that are hazardous to fish:

Automotive Products

- motor oil
- antifreeze
- brake fluid
- transmission fluid
- gasoline and gasoline additives
- degreasers
- sealers

Paints and Solvents

- paints
- shellacs
- lacquers
- varnishes
- enamels
- paint thinners and cleaners
- paint and varnish strippers
- rustproof coatings

Pesticides

- bathroom and kitchen disinfectants
- insecticides
- fungicides (mould and mildew control)
- herbicides
- wood preservatives

Cleaning Products

- detergents
- drain and toilet cleaners
- rug and upholstery cleaners
- dry cleaning agents
- car wash detergents

Storm Drain Marking Program

The Storm Drain Marking Program has been taken on by the City over the last three summers as a part of the City's water licence. It would not be possible if it weren't for all of the people who volunteer their time and effort to go out into the community and paint some fish! The City would like to express its appreciation to all of those hardworking residents:

Sheena, Will and ShaKita Jensen
Raycine, Chris, Lauren and Katherine Spence
Cindy and Warren McLean
Kerri and Keira Nolting
Chauncey Lewis
Safiya Adam
Lanilyn Bessara
Cathy, Antonio and Michelle Lewis
Heather Potter

What Can You Do?

Properly Dispose of Wastes

Take your household wastes to the appropriate place for disposal. Household Hazardous Waste collection days are organized each year and allow residents to bring chemicals and other household products to a designated area for proper disposal.

Put garbage in proper containers. Don't litter.

Stoop & Scoop

Please clean up after your pets. Pet waste can contain bacteria, parasites and viruses which are a health risk. Nutrients in pet waste can encourage weed and algae growth which affects water quality.

Pet waste can be disposed of at the Yellowknife Solid Waste Facility at no cost.

Report Illegal Dumping & Spills

If you see something being dumped into the stormwater collection system, call the NWT Spill Line. The line is manned 24 hours a day, 7 days a week.

NWT 24 Hour Spill Report Line (867) 920-8130

For more information please contact

City of Yellowknife

Public Works Department

PO Box 580

4807-52 Street

Yellowknife, NT

X1A 2N4

867-920-5653

www.yellowknife.ca

City of Yellowknife

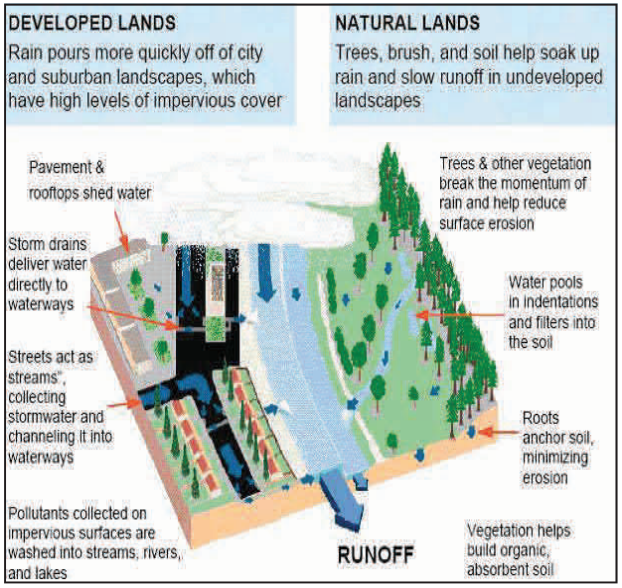
Stormwater Information

March 2011

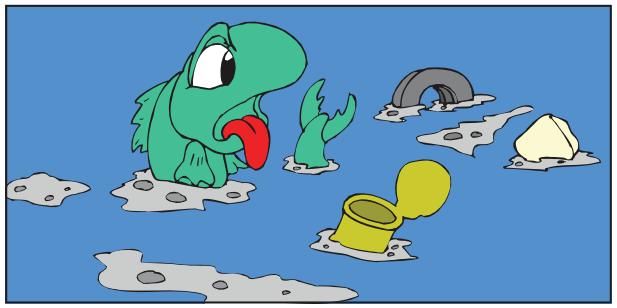
What is Stormwater?

Stormwater is rain and melted snow that runs off surfaces such as roofs, lawns, driveways, parking lots and roads. Stormwater collects debris and chemicals from these surfaces, which then travel through the storm sewer system. Any debris or chemicals that are washed from the exposed surfaces become trapped in the storm sewer system.

Stormwater is collected in **storm drains** or **catch basins** and flows through pipes and ditches until it eventually reaches a nearby lake or stream. Stormwater does not usually receive treatment before entering a water body.



Stormwater Pollutants



Common sources of stormwater pollution include:

- **Garbage & Debris**
  (cigarette butts, leaves, litter)
- **Oil & Grease**
- **Gasoline**
- **Automotive Products**
  (antifreeze, brake fluid, sealers)
- **Cleaning Products**
  (car wash detergents, cleansers)
- **Lawn & Garden Products**
  (weed killers, pest control products)
- **Other Chemicals**
  (paints, solvents, varnishes)
- **Pet Wastes**

Proper disposal of wastes will aid in protecting the bodies of water that receive stormwater.

Please visit **www.yellowknife.ca** to find out where to dispose of these and other types of wastes.

Stormdrain Marking Program

Metal markers are being installed on catch basins in Yellowknife, reminding residents that water entering the catch basin flows directly into nearby lakes.

Prior to the metal markers, blue fish were painted beside each catch basin in the City.

Originating Document / Plan	Author (Organization / Person Requesting Information)	Comment ID (from MVLWB comment table)	Section / Page	Request Information	Response	Action
COY Municipal Stormwater Management Plan Water Licence MV2009L3-0007	MVLWB	Comment within document	Foreword	Would be helpful to see a specific conformity table that lists the Board's requested revisions from their May28-20 interim approval letter for the SWMP V5.	Comment has been incorporated.	Any follow-up items arising from the May 28-20 letter were included in this conformity table.
COY Municipal Stormwater Management Plan Water Licence MV2009L3-0007	MVLWB	Comment within document	Section 1 Pg. 1	Re: 'As per the water licence,…': "Is bolded text new? I remember seeing an explanation of this in other City plans, but not seeing it in this one. If so, please include explanation."	This explanation has been included in the foreword in all previous versions and was omitted by error.	Explanation was added back into the Foreword.
COY Municipal Stormwater Management Plan Water Licence MV2009L3-0007	MVLWB	Comment within document	Section 9.4 Pg. 16	The SCP is amended… "required by"	Comment has been incorporated.	Edit made.

Originating Document / Plan	Author (Organization / Person Requesting Information)	Comment ID (from MVLWB comment table)	Section / Page	Request Information	Response	Action
COY Municipal Stormwater Management Plan Water Licence MV2009L3-0007	MVLWB	Comment within document	Section 10.1 Pg. 18	Re: updating City Standards regulating construction: “is there a timeline attached to this process?”	Comment has been incorporated.	Timeline included.
COY Municipal Stormwater Management Plan Water Licence MV2009L3-0007	MVLWB	Comment within document	Section 11.5 Pg. 24	Re: the stormwater monitoring report: “This is call the Stormwater Trend Analysis”	Comment has been incorporated.	Added
COY Municipal Stormwater Management Plan Water Licence MV2009L3-0007	MVLWB	Comment within document	Section 11.5 Pg. 24	“is it not also going to be used to evaluate whether changes to the Stormwater Management Plan should be made?”	Comment has been incorporated.	Added

Originating Document / Plan	Author (Organization / Person Requesting Information)	Comment ID (from MVLWB comment table)	Section / Page	Request Information	Response	Action
COY Municipal Stormwater Management Plan Water Licence MV2009L3-0007	MVLWB	Comment within document	Section 12 Pg. 25	Paragraph 4: ”The wording here is funny. I think it's expected that the stormwater monitoring program will continue through the life of the Licence, not be 3 years. Do you mean the three-year trend analysis here?”	Comment has been incorporated.	Reworded to “3-year Stormwater Trend Analysis.
COY Municipal Stormwater Management Plan Water Licence MV2009L3-0007	MVLWB	Comment within document	Appendix B: figure	Madison and I had talked about the potential for confusion around this legend (a member of the public interpreted the 'water' outfall as a place where stormwater discharges into the lake). This legend could benefit from clarified wording.	We have investigated this and found that several of the current outfall sampling locations are missing on this figure. We therefore realized that this figure is outdated and not useful for the SWMP.	We have removed this confusing figure from the appendices and made sure that the catchment information is evident in Appendix F (Sampling locations).

Originating Document / Plan	Author (Organization / Person Requesting Information)	Comment ID (from MVLWB comment table)	Section / Page	Request Information	Response	Action
COY Municipal Stormwater Management Plan Water Licence MV2009L3-0007	MVLWB	Comment within document	Appendix D: figure	This map would be much clearer if it was zoomed in on the discharge area.	Comment has been incorporated.	Appendix was revised to zoom in.
COY Municipal Stormwater Management Plan Water Licence MV2009L3-0007	General Public, Aleta Fowler	4	10.2	"...the incorporation of stormwater sampling requirements into the Licence SNP can be discussed at the time of the Licence renewal proceeding."	The City suggests waiting for the results of the 3-year stormwater sampling study to identify final sites to be included in the SNP.	No revision made.
COY Municipal Stormwater Management Plan Water Licence MV2009L3-0007	Aleta Fowler	6	10.3	Board staff note that stormwater data collected moving forward can be used during the renewal proceeding in order to analyze potential impacts on the receiving environment to inform Board decisions related to stormwater management options.	The City has retained a qualified consultant to complete the 3-year stormwater sampling and analysis ("Stormwater Trend Analysis"). Part of the scope of this study is to assess potential impacts to the receiving environment.	No revision made.

Originating Document / Plan	Author (Organization / Person Requesting Information)	Comment ID (from MVLWB comment table)	Section / Page	Request Information	Response	Action
COY Municipal Stormwater Management Plan Water Licence MV2009L3-0007	Aleta Fowler	8	10.3	Board staff further note that the Stormwater Management Plan Section 12 describes public education measures around the storm sewer system. The potential incorporation of additional public education requirements can be discussed at the time of the Licence renewal proceeding.	No further comments on additional public education strategies were received; therefore, this section was not changed.	No revision made.
COY Municipal Stormwater Management Plan Water Licence MV2009L3-0007	MVLWB	5	10.2	The City could be required to append their sampling protocol to the Plan for submission to Board staff for confirmation of conformity	Comment has been incorporated.	Sampling Protocol was included
COY Municipal Stormwater Management Plan Water Licence MV2009L3-0007	GNWT - ENR – EAM	16	Appendices	ENR recommends that a legend identifying all monitoring locations illustrated on the map, also be provided for clarity	Comment has been incorporated.	A new map with sampling locations and legend was added as new Appendix F

Originating Document / Plan	Author (Organization / Person Requesting Information)	Comment ID (from MVLWB comment table)	Section / Page	Request Information	Response	Action
COY Municipal Stormwater Management Plan Water Licence MV2009L3-0007	MVLWB, Erica Janes	1	10.1, App. G	The City could be reminded to add the corresponding N-series station labels to the sampling locations listed in Table 10.1.2 in the next revision of the Plan.	Comment has been incorporated.	The revised SWMP has now the N-series numbers listed in the table of sampling locations.
COY Municipal Stormwater Management Plan Water Licence MV2009L3-0007	MVLWB, Erica Janes	2	10.1	The City could be reminded to add details around timing of sampling in the next revision of the Plan.	Comment has been incorporated.	More details on sampling timing were provided.
COY Municipal Stormwater Management Plan Water Licence MV2009L3-0007	MVLWB, Erica Janes	4	10.2, 10.3	The City could be reminded to revise sections 10.2 and 10.3 to accurately reflect field sampling of temperature and pH during stormwater sampling events, in the next version of the Plan.	Comment has been incorporated.	Details on field parameter collection were added.

Originating Document / Plan	Author (Organization / Person Requesting Information)	Comment ID (from MVLWB comment table)	Section / Page	Request Information	Response	Action
COY Municipal Stormwater Management Plan Water Licence MV2009L3-0007	MVLWB, Erica Janes	4	10.4	The City could be reminded to revise the sampling parameters to report nitrate and nitrite separately in the next version of the Plan.	Comment has been incorporated.	Nitrate and nitrite are now listed as separate parameters and are being measured and reported separately in the monitoring program.
COY Municipal Stormwater Management Plan Water Licence MV2009L3-0007	MVLWB, Erica Janes	7	10.4	The City could be reminded to update the guideline information to include a table of parameters and values in the next version of the Plan.	Comment has been incorporated.	A table with all applicable CCME guidelines has been added to the SWMP.