3AM-IQA1626 Application for Amendment – Supporting Submission

August 7, 2018

Revision 2

ISSUED FOR USE

NUNAMI
STANTEC LIMITED

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1 INTRODUCTION

1.1 Purpose of this Document

The purpose of this document is to supplement the emergency Application to Amend Type A Water Licence 3AM-IQA1626 for the City of Iqaluit. This document should be read in conjunction with and constitutes part of, that application.

2 DETAILS OF AMENDMENT APPLICATION

2.1 Purpose of Amendment – Emergency Direction

On July 27, 2018, the Government of Nunavut Department of Health (DOH) Chief Medical Officer declared that the City's inability to provide adequate domestic drinking water to the community over the coming winter season 2018/19 is viewed by the DOH as a health emergency. The DOH directed the City to immediately intervene to ensure the City has sufficient water quantity for the season. This amendment to supplement the Lake Geraldine Reservoir is being sought on an emergency basis in response to this direction (the "Supplementary Pumping Program")

2.2 Background

The City of Iqaluit (the "City") relies upon the Lake Geraldine Reservoir to impound the volume of source water necessary to satisfy the drinking water demands of the City. The City has observed through monitoring that the level of source water as of early July 2018 was well below normal levels as of that date. As recharge to the reservoir occurs only during open water months, the City became concerned that sufficient water may not be present in the Lake Geraldine Reservoir by the end of the open water season to meet the City's drinking water demands for the 2018-2019 winter period.

The City immediately retained Golder Associates (Golder) to assess the current situation and to determine what level of rainfall would be required to replenish this reservoir in the remainder of the unfrozen season of 2018 under various water taking demand conditions. They also assessed what level the reservoir would attain under those same water taking conditions. The City received a report from Golder titled "Supplementary Lake Geraldine Water Balance Modelling" dated 25 July 2018 indicating that under certain climatic and demand conditions, sufficient source water would not be retained by the Reservoir to satisfy the City's winter water demands. Given the public health and safety importance of drinking water to the community, the City established a Task Force to identify and implement a number of initiatives all intended to provide sufficient water for the City to meet its winter water taking requirements.

The Task Force has identified four (4) primary means to address the potential drinking water shortfall:

1) Loss Control: identify and repair breaks and bleeds in the existing utilidor (fresh water distribution) system;
2) Conservation: develop and communicate to residents and businesses actions that can be taken to reduce drinking water consumption;
3) Supplementary Supply; includes:
    a. conserving water within the water treatment plant
    b. evaluating desalinization of seawater as a source option
    c. pumping from the Apex River watershed and available water bodies
4) Demand Management; includes:
    a. Assessing planned and approved increases to water demand as a result of Development approvals,
    b. Determine timing of these increased demands,
    c. Consider the City's ability to reduce, defer or delay these increased demands.

The above options, apart from pumping from the Apex River, are currently being implemented by the City, though none by themselves will address the shortfall. To begin supplementary pumping, the City requires approval from the Nunavut Water Board and Fisheries and Oceans Canada.

2.3 Scope of Amendment

The City is applying to:

- Withdraw up to 500,000 m^3 of water from the Apex River watershed and unnamed waterbodies
- Temporarily alter the flow of water in the Apex River watershed

2.4 Description of Works and Activities

The City proposes to withdraw and divert supplemental water from the Apex River watershed into Lake Geraldine Reservoir (reservoir) in two phases, beginning August 9 2018, and ending October 30, 2018 (Figure 2-1). The Supplementary Pumping Program may need to be conducted again in 2019 until a permanent, long-term solution is implemented.

Phase I, 2018:

Install two pumps on the south shore of the Apex River at a location approximately 1.3 km upstream of the bridge on the Road to Nowhere (the "upper Apex location"). These submersible drainage pumps (Figure 2-2) will be powered by a diesel operated power generator (Figure 2-3) with integrated fuel storage and containment system. Flexible hose (Figure 2-4) will be connected to the pumps with a manifold. Hoses will be routed overland southwards to the reservoir.

Water withdrawal from the upper Apex location is proposed at up to 95 litres per second (L/s) or 8,200 m^3/day, as flow conditions allow. Withdrawal will be ramped up or down as required to address potential impacts to fish and fish habitat, as based on monitoring. Flow and water levels will be monitored daily at the Bridge to Nowhere and observations of isolated ponds and wetted perimeter will be monitored as required by DFO.

To mitigate for fish entrainment, DFO's Freshwater Intake End-of-Pipe Fish Screen Guideline (1995) will be applied. To mitigate against excessive sediment entrainment, a free-standing or water-filled, temporary modular coffer dam may be installed to train water towards the pump location. This coffer will not impede overall flow and will not impact the bed of the watercourse.

Phase 2, 2018:

If, and once flow levels in the upper Apex River decrease below allowable levels for withdrawal (30% mean annual discharge – MAD), pumping will commence at an Unnamed Lake approximately 1.6 km northeast of the end of the Road to Nowhere. This lake is part of the Apex River watershed and seasonally discharges to an intermittent stream that joins the Apex River approximately 100 m east of the bridge on the Road to Nowhere. This lake has a surface area of over 1 million m^2 and documented to be greater than 18 m deep in places (A. Medeiros, pers. comm.), and therefore expected to be adequate as a source for the remainder of the required water withdrawal.

Pumps and hose will be set up to lift water from the Unnamed Lake over the topographic barrier that prevents year-round discharge. Water may be directed by hose, or via free flow, down the remainder of the watercourse. Water will be intercepted upstream of the bridge on the Road to Nowhere using modular coffer dam or in a natural depression and redirected to the reservoir from there using additional pumps and hose.

Additional Sources:

Small waterbodies immediately north of the reservoir may be used as supplemental water sources if depth conditions indicate that they are unlikely to support overwintering fish.

Pumping and hose configuration may be modified if the supplementary pumping is needed to be conducted during the open water period of 2019.

2.5 Timing of Activities

Flows in the Apex River, as measured by Water Survey Canada, are highest in the spring and decline throughout the summer and fall. There are no flows during winter. The supplementary pumping of water must be completed during the open water period before flows cease and before hoses would otherwise freeze. Therefore, pumping from the Upper Apex River location in 2018 is proposed to begin August 9th, and will be complete by October 30th as conditions allow.

If required in 2019, the supplementary pumping activities would be conducted between August 1st and October 30th. A 2019 Pumping Plan will be submitted for approval by the regulator(s). This plan will take into account learnings from the 2018 pumping activities.

3 ALTERNATIVES

The initial withdrawal from the Upper Apex location is required to be implemented initially because it can be implemented with existing equipment available in Iqaluit. The option to commence withdrawal from the Unnamed Lake location requires additional hoses and pumping equipment that is not currently available.

In addition to investigating an option to supplement 2018/19 winter supply with desalinized seawater, the City is investigating a long-term solution to address the deficit of water in Lake Geraldine Reservoir.

The City recognizes that a permanent solution for supplemental pumping is required, and has been making continuous progress to implement this solution. Work completed in 2017, identified that as a result of presence of overwintering fish within the Apex River, that the Apex River could not meet the City's long term needs for supplementary water, while meeting DFO water withdrawal guidelines. The City immediately shifted their assessment to the Sylvia Grinnell River and determined that sufficient flows exist in this river to meet the City's needs for supplemental pumping while complying with DFO guidelines. With this assessment, the City in 2017 has continued with field studies to be carried out in the Sylvia Grinnell River to identify potential withdrawal locations. This work identified two potential long term withdrawal points. A more detailed assessment of two preferred withdrawal locations to select a preferred point is ongoing. Once this site has been identified, the City will commence preliminary engineering of a permanent pumping station and piping systems.

The City expects that, including an allowance for permitting, the commissioning of the long term supplemental pumping solution may be 2-3 years in the future. The City has committed to determining if the commissioning of the permanent solution can be expedited.

In addition to investigating an option to supplement 2018/19 winter supply with desalinized seawater, the City is investigating a long-term solution to address the deficit of water in Lake Geraldine Reservoir.

The City recognizes that even with these efforts, it may not be possible to restore the Lake Geraldine Reservoir to full elevation by the end of the open water season. There also remains uncertainty regarding the winter precipitation that will be necessary for replenishment after the spring freshet. For this reason, the City seeks in this application approval for a second year of supplementary pumping, with the need for, and execution plan to be determined in the late spring of 2019 in consultation with the NWB and regulatory agencies.

4 ENVIRONMENTAL IMPACTS

The Apex River supports a resident population of Arctic char (Salvelinus alpinus) (Nunami Stantec 2016). All fish of this population were collected at one site immediately below what is locally known as Swimming Lake. Two other reaches further downstream were sampled but no fish were captured. One site upstream at the Road to Nowhere bridge was also sampled with no fish captured. A barrier to fish passage exists just above the mouth of the Apex River where it enters Koojesse Inlet (Nunami Stantec 2016). For further information on fish collected and habitat at sampled sites along the Apex River please refer to Nunami Stantec 2016, attached.

This resident population is unlikely to be part of a commercial, recreational or Aboriginal (CRA) fishery; due to the small size of the individual fish within the population which is common of resident populations. The Apex River has not been fished in the past. It is unknown whether individuals of this population support a CRA fishery. This would likely only occur during spring freshet if some individuals were flushed from the system into Koojesse Inlet. This supporting contribution would be negligible to other fisheries.

Serious harm to the resident population of char may occur by:

- reduction of fish habitat including overwintering habitat due to water withdrawal, and
- mortality of fish by stranding due to water withdrawal.

Water withdrawal from the upper Apex location is proposed to be up to a daily average of 95 L/s or 8,200 m^3/d as flow conditions allow. Withdrawal will be ramped up or down as required to address potential impacts to fish and fish habitat, as based on monitoring. Flow and water levels are currently monitored at the Water Survey of Canada (WSC) Apex River at Apex hydrometric station (10UH002), located downstream of the proposed Upper Apex pumping location. Flows will be scaled to the Upper Apex location using a simple drainage area ratio calculation: the Upper Apex location drains 60% of the drainage area measured at the WSC station. In addition to the streamflow, observations of isolated ponds and wetted perimeter will be monitored near the Bridge to Nowhere and as required by DFO (see details in Section 5).

Mitigation will follow DFO's measures to prevent harm to fish and fish habitat where applicable (i,e, sedimentation and erosion control, spill prevention and response) as well as applying the Freshwater Intake end-of-Pipe Fish Screen Guideline (1995); Appendix A. Where fish stranding is observed and where feasible, a fish rescue will be conducted, and fish released further downstream. A table of mitigations that may be required is provided in Appendix B.

To mitigate against excessive sediment entrainment into the pumps, a free-standing, temporary modular or water-filled coffer dam may be installed to train water towards the pump location. This coffer will not impede overall flow and will not impact the bed of the watercourse.

5 MONITORING AND RESPONSE

The Apex Supplementary Pumping Monitoring Plan for the period of water withdrawal is intended to provide information to inform adjustments of pumping rates to mitigate for effects to fish and fish habitat. The monitoring plan includes:

- Metered monitoring of water withdrawal at the pump location
- Streamflows at Water Survey Canada Apex River station (10UH002) will be monitored daily to ensure pumping rates do not exceed 30% of mean annual discharge (MAD). MAD at the withdrawal location is 0.717 m^3/s and 30% of MAD is 0.215 m^3/s (Figure 5-1).
- Streamflows at the Apex station and the MAD will be scaled to the pumping location using the drainage area ratio of 60%.
- Two cross-sections downstream of the pumping locations will be monitored to assess the potential physical effects of pumping on fish and fish habitat. These cross-sections will be surveyed and rebar installed to represent the local reference datum against which to monitor water level and wetted perimeter. Daily measurements of the distance from the top of the rebar to the water surface will be recorded.
- additional monitoring will be considered based on DFO recommendations

To minimize fish mortality due to water the emergency of isolated ponds within the watercourse will be visually monitored. Fish rescue will be conducted where necessary and feasible. Fish rescue will include:

- Two personnel will walk the river banks below the water withdrawal site daily, or as may be required during pumping from the Upper Apex River, to check for stranded pools and stranded fish, and to determine need for fish rescue. One person will be a from the local HTO while the second person will be a qualified aquatic environmental specialist (QAES).
- For fish stranded fish will be dipped netted and placed in an oxygenated tub of water from the river. For fish at risk of being stranded and cannot be easily dip netted an electrofisher will be used to capture fish and placed into the oxygenated tub of water.
- Stranded fish which may be observed by the community or others will be attempted to be rescued.
- Fish rescue will be carried downstream to a suitable release area and released once fish have recovered from their capture.
- All fish rescued will be counted and recorded.
- Fish which are stranded but cannot be rescue will be retrieved, counted and frozen for later biological sampling to obtain a better understanding of tis resident char population.

- Fish rescue will continue until water draw down due to water withdrawal has concluded.

6 REFERENCES

Nunami Stantec. 2016. Fish and Fish Habitat Assessment of the Niaqunguk (Apex) River, Lake Geraldine, and the Lake Geraldine Drainage Channel. Prepared for the City of Iqaluit.

Figure 2-1: Location of Proposed Activities

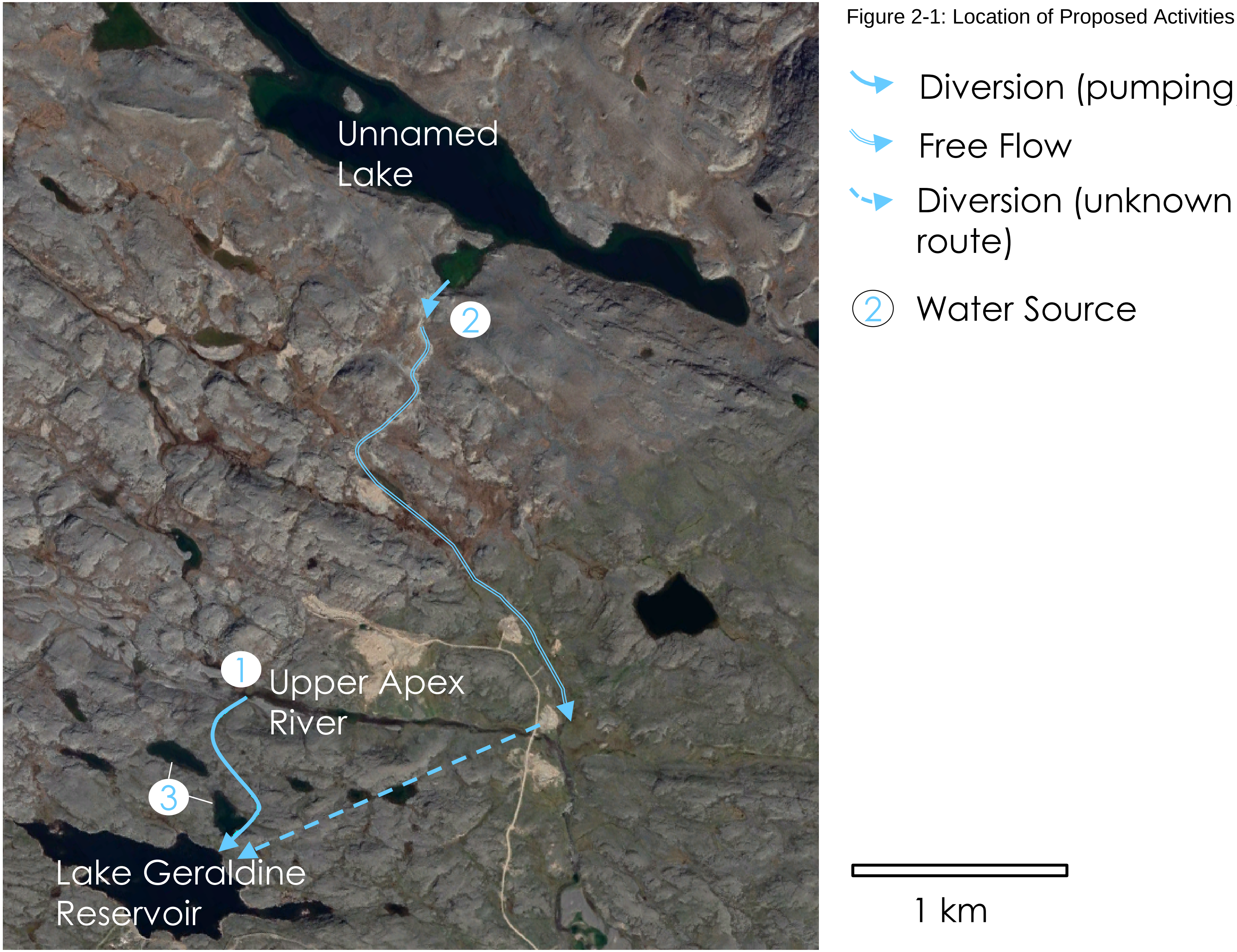


Figure 2-2: Submersible Pump

Submersible Drainage Pump J 405

SULZER

Specification

Electric submersible pump.

Maximum submergence: 20 m. Protection class IP 68.

Max temperature of pumped medium at max power input and continuous duty 40 °C.

Max medium density 1100 kg/m³. pH of the pumped medium 5-8.

Strainer hole: 8 x 34 mm. Max number of starts 30/hour.

J 405 ND Medium head, 3-phase

J 405 HD High head, 3-phase

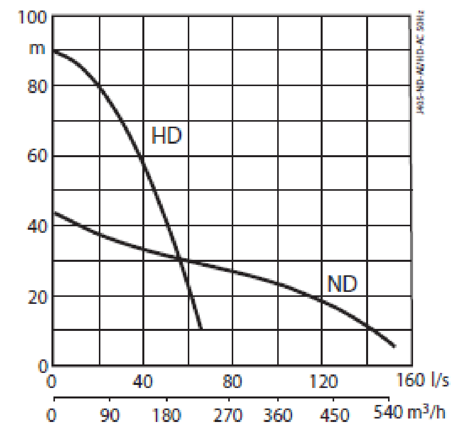
Electric Motor

3-phase squirrel-cage induction motor, 50 Hz.

Service factor 1.1. Class F insulation.

Motor rating P_2: 35.0 kW. Speed: 2930 rpm.

Voltage, V	230	400	500-550	690	1000
Nominal current, A	108	62	51	36	25



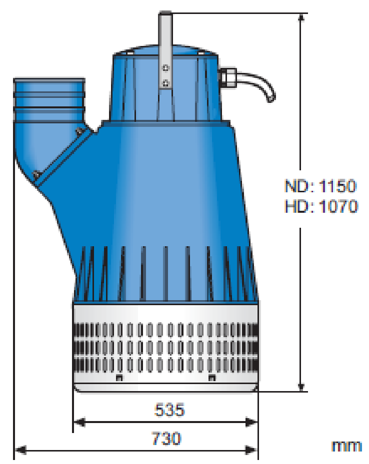


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Figure 2-3: Generator

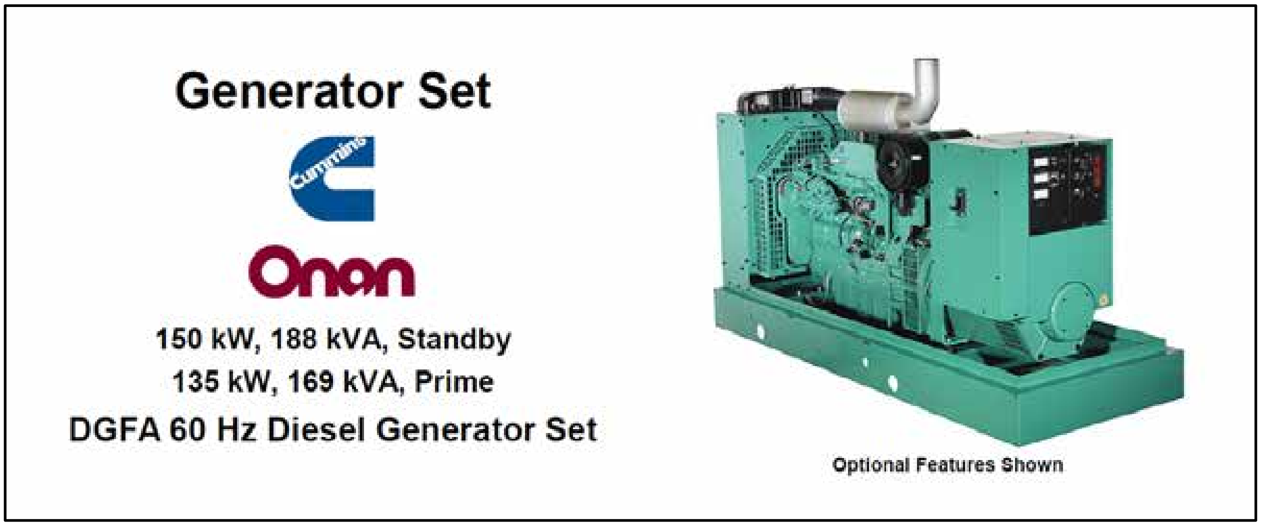
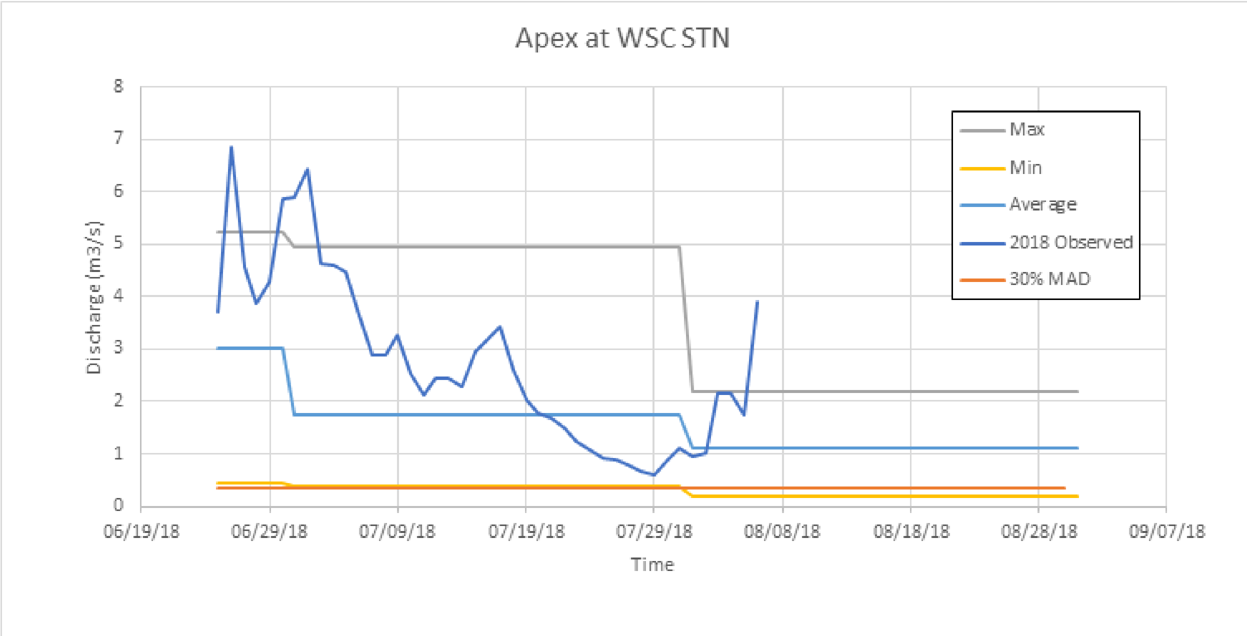


Figure 2-4: Flexible Hose

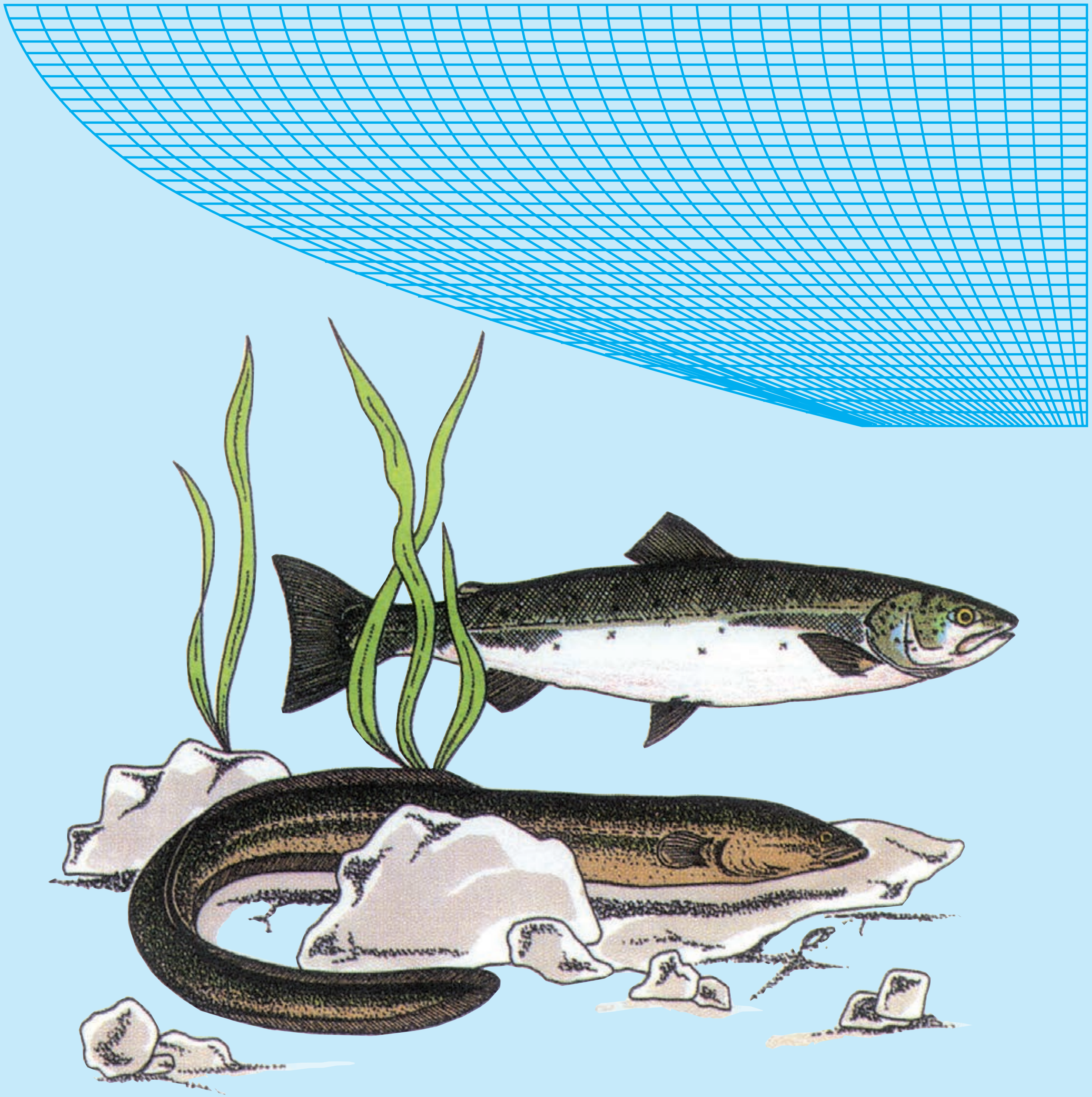
Figure 5-1: Streamflows at WSC Station 10UH002 August 6 2018 (Water Survey Canada)



Appendix A: Freshwater Intake End-of-Pipe Fish Screen Guideline

Department of Fisheries and Oceans

Freshwater Intake End-of-Pipe Fish Screen Guideline



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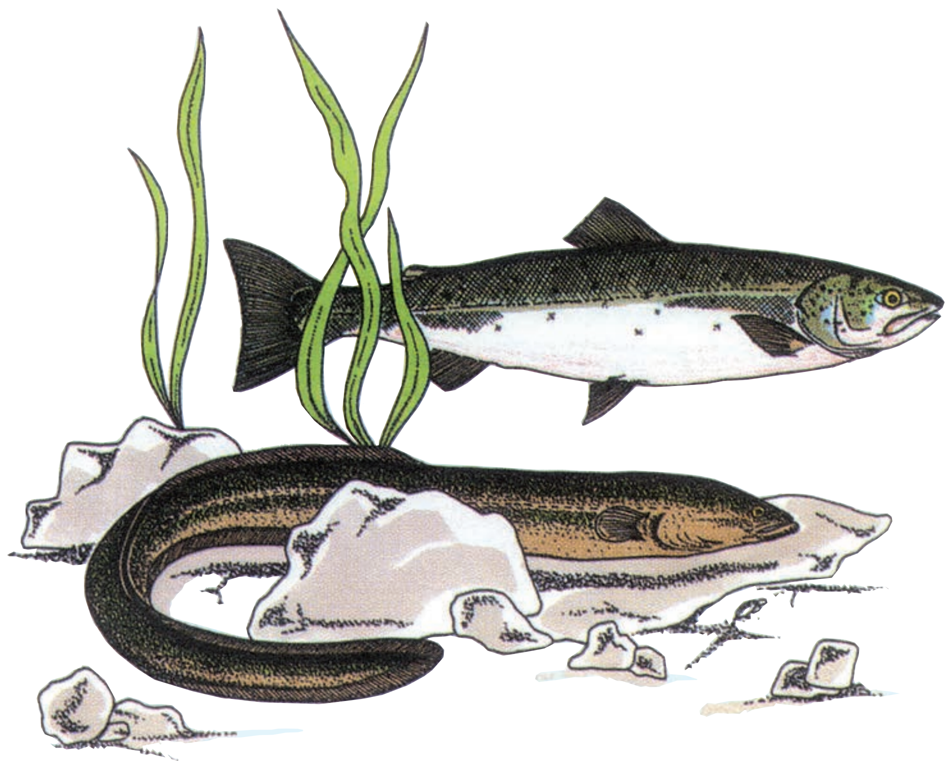
Department of Fisheries and Oceans

Freshwater Intake End-of-Pipe Fish Screen Guideline



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1.0 Introduction

The Department of Fisheries and Oceans (DFO) has prepared the **Freshwater Intake End-of-Pipe Fish Screen Guideline** to assist proponents in the design and installation of fish screens lfor the protection of anadromous and resident fish where freshwater is extracted from fish-bearing waters. This guideline will also assist regulatory agencies in the review of fish screen proposals.

A requirement for fish screening is stated under Section 30 of the *Fisheries Act*, where every water intake, ditch, channel, or canal in Canada constructed or adapted for conducting water from any Canadian fisheries waters must provide for a fish guard or a screen, covering, or netting over the entrance or intake so as to prevent the passage of fish into such water intake, ditch, channel or canal. Other sections of the *Fisheries Act*, or other Federal, Provincial, or Municipal Legislation and Policy may also apply to associated water extraction activities. Proponents are advised to contact the appropriate regulatory agencies regarding approvals or permits.

2.0 Guideline Objective

The objective of the guideline is to provide a National standard-of-practice and guidance for end-of-pipe fish screens at freshwater intakes to prevent potential losses of fish due to entrainment or impingement. Entrainment occurs when a fish is drawn into a water intake and cannot escape. Impingement occurs when an entrapped fish is held in contact with the intake screen and is unable to free itself. The severity of the impact on the fisheries resource and habitat depends on the abundance, distribution, size, swimming ability, and behaviour of the organisms in the vicinity of the intake, as well as, water velocity, flow and depth, intake design, screen mesh size, installation and construction procedures and other physical factors.

The **Freshwater Intake End-of-Pipe Fish Screen Guideline** deals exclusively with the sizing and design of fixed screens that are often placed at the end of a pipe used to extract water up to 0.125 m^3/s, or 125 litres per second (L/s) (i.e., 2000 US gallons per minute (US gpm)). The guideline is intended for use in addressing fish screens for small permanent and temporary withdrawals for irrigation, construction, small municipal and private water supplies, etc. It is *not* intended for application to hydroelectric or canal screen designs; however, such proposals can be considered by regulatory agencies on a site-specific basis. The guideline focuses on the technical aspects of intake screens and the protection of fish rather than on policy, legislation, or environmental assessment processes and their application. This guideline has been developed to provide protection of freshwater fish with a minimum fork length of 25 mm (approximately 1 inch) since most eggs and fish larvae remain in bottom substrates until they reach the fry stage (i.e., 25 mm fork length). Other designs, in addition to intake screens, may be appropiate to address fish and fish habitat protection associated with water withdrawals. Such proposed designs should be addressed with the appropriate regulatory agencies on a site-specific basis.

3.0

Information Requirements for Evaluation of Intake Screens

Information that should be provided to facilitate evaluation of an end-of-pipe intake screen design intended for fish protection during a freshwater withdrawal is highlighted below. Types of information requirements that may also be applicable to the water intake project as a whole are identified in Appendix A.

- fish presence, species, and possible fish size or fish habitat conditions at the project site
- rate or ranges of rates of withdrawal from the watercourse
- screen open and effective areas
- physical screen open parameters with respect to the intake and the watercourse
- screen material, method of installation and supporting structures
- screen maintenance, cleaning, or other special requirements

4.0

Design, Installation, & Maintenance of Freshwater Intake End-of-Pipe Fish Sereens

The appropriate design of a fish screen is largely dependent upon the species and the size of fish requiring protection. Appropriate installation and maintenance/cleaning of the screen are also important in keeping approach velocities low and ensuring satisfactory operation of the screen. For the purposes of this guideline, emphasis is placed on the protection of freshwater fish with a minimum fork length of 25 mm from entrainment and impingement due to water extraction activities. Depending upon site-specific circumstances, a case may be made whereby the minimum fork length size of fish to be protected is greater than 25 mm. In this instance, the fish screen criteria for open screen area (Table 2 and Figure 1) and screen mesh size (2.54 mm) presented here do not apply. Fish screen criteria and guidance for the protection of fish larger than 25 mm is provided by Katopodis (1992).

The following sections address the appropriate design of fixed freshwater intake end-of-pipe fish screens for the protection of fish with a minimum fork length of 25 mm. Guidance on installation, cleaning, and maintenance is provided. Common types of intake screens and associated intakes are also presented. Appendix B presents a sample calculation utilizing the guideline to determine the appropriate end-of-pipe intake screen size for the protection of freshwater fish.

4. 1 Fish Screen Criteria

To protect fish from impingement or entrainment, the approach velocity (i.e., the water velocity into, or perpendicular to, the face of an intake screen) should not exceed certain values based on the swimming mode (i.e., subcarangiform or anguilliform) of the fish present in the watercourse. The subcarangiform group includes fish that swim like a trout or salmon, and move through the water by undulating the posterior third to half of their bodies. The anguilliform group includes fish that swim like an eel, and move through the water by undulating most or all of their body. Table 1 presents the swimming modes of most common fish species in Canada. Contact DFO or provincial fisheries agencies regarding fish species that are not included in Table 1.

Envelope curves for approach velocities were developed for each swimming mode corresponding to a minimum fork length of 25 mm and a maximum endurance time of 10 minutes (the time the fish is in front of the face of the screen before it can elude it). To satisfy approach velocities of approximately 0.11 m/s and 0.038 m/s for the subcarangiform and anguilliform groups respectively, curves indicating the required open screen areas, based on fish swimming performance data, including fish species and size (Katopodis, 1990) and related to flows/extractions, were developed. Table 2 presents the required open screen area, in both metric and non-metric units, for end-of-pipe intake screens with a capacity up to 125 L/s (2000 US gpm). The open screen area is the area of all open spaces on the screen available for the free flow of water. The same information is presented graphically in Figure 1.

Table 1
Summary of Common Fish Species and Swimming Modes

SUBCARANGIFORM SWIMMING MODE

Common Name	Scientific Name
Alewife (Gaspereau)	*Alosa pseudoharengus*
Arctic Char	*Salvelinus alpinus*
Arctic Grayling	*Thymallus arcticus*
Atlantic Salmon	*Salmo salar*
Broad Whitefish	*Coregonus nasus*
Brook Trout	*Salvelinus fontinalis*
Brown Trout	*Salmo trutta*
Carp	*Cyprinus carpio*
Channel Catfish	*Ictalurus punctatus*
Chinook Salmon	*Oncorhynchus tshawytscha*
Chum Salmon	*Oncorhynchus keta*
Cisco	*Coregonus artedii*
Coho Salmon	*Oncorhynchus kisutch*
Cutthroat Trout	*Oncorhynchus clarki clarki*
Dolly Varden	*Salvelinus malma*
Goldeye	*Hiodon alosoides*
Green Sturgeon	*Acipenser medirostris*
Inconnu	*Stenodus leucichthys*
Kokanee	*Oncorhynchus nerka*
Lake Sturgeon	*Acipenser fulvescens*
Lake Trout	*Salvelinus namaycush*
Lake Whitefish	*Coregonus clupeaformis*
Largemouth Bass	*Micropterus salmoides*
Longnose Sucker	*Catostomus catostomus*
Mooneye	*Hiodon tergisus*
Mountain Whitefish	*Prosopium williamsoni*
Ouananiche	*Salmo salar ouananiche*
Pink Salmon	*Oncorhynchus gorbuscha*
Rainbow Smelt	*Osmerus mordax*
Rainbow Trout	*Oncorhynchus mykiss*
Sauger	*Stizostedion canadense*
Smallmouth Bass	*Micropterus dolomieui*
Sockeye Salmon	*Oncorhynchus nerka*
Walleye	*Stizostedio vitreum*
White Bass	*Morone chrysops*
White Perch	*Morone americana*
White Sturgeon	*Acipenser transmontanus*
White Sucker	*Catostomus commersoni*
Yellow Perch	*Perca flavescens*

ANGUILLIFORM SWIMMING MODE

Common Name	Scientific Name
American Eel	*Anguilla rostrata*
Burbot	*Lota lota*
Sea Lamprey	*Petromyzon marinus*

Note: The few data points available for Northern Pike *(Esox lucius)* are close to the anguilliform group.

4.2 Design of Fixed End-of-Pipe Fish Screens

Once the required open area has been found from Table 2 or Figure 1, the effective screen area must be calculated. It is the area occupied by the open spaces (i.e., open screen area) and the screen material available for the free flow of water. The effective screen area should be provided at the intake location and is determined as follows:

$$\text{Effective Screen Area (m}^2\text{ or ft}^2\text{)} = \frac{\text{Open Screen Area (Table 2)}}{\left(\frac{\text{\% Open Area (Table 3)}}{100}\right)}$$

It should be noted that if the percent (%) open screen area is maximized, then the effective screen area required for a given flow is minimized. The narrowest dimension of any opening on the screen is referred to as the design opening, regardless of opening shape. The maximum design opening for a fish of 25 mm fork length is estimated at 2.54 mm (0.10 inches). Guidance on screen openings and materials is presented below.

- The screen openings may be round, square, rectangular, or any combination thereof, but should not have any protrusions that could injure fish.
- Screen materials may include brass, bronze, aluminum, monel metal, galvanized or stainless steel, and plastics. The screen material should be resistant to corrosion and UV light.
- Note: clogging due to corrosion is minimized with the use of stainless steel.
- Welded wedge wire screens offer reduced debris clogging and increased open area and screen stiffness, in comparison to round wire mesh and punch plate.

Table 3 presents several common types of screening material that meet the requirements of wire diameter, clear opening width and percent open area,

The dimensions of the fish screen can be calculated after the correct shape, configuration, location, and method of installation have been determined. This will usually be determined after a site investigation and a review of these guidelines. Included in Figure 2 are common screen shapes and the associated

Table 2

Open Screen Area Required for End-of-Pipe Water Intakes

Metric Units			Non-Metric Units		
Flow (L/s)	Subcarangiform (m^2)	Anguilliform (m^2)	Flow (US gpm)	Subcarangiform (ft^2)	Anguilliform (ft^2)
1	0.01	0.03	10	0.1	0.2
5	0.05	0.13	50	0.3	0.9
6	0.06	0.16	100	0.6	1.8
8	0.07	0.21	150	0.9	2.7
10	0.09	0.26	200	1.3	3.6
12	0.11	0.31	250	1.6	4.5
14	0.13	0.37	300	1.9	5.4
15	0.14	0.39	350	2.2	6.2
16	0.15	0.42	400	2.5	7.1
18	0.17	0.47	450	2.8	8.0
20	0.18	0.52	500	3.2	8.9
22	0.20	0.58	550	3.5	9.8
24	0.22	0.63	600	3.8	10.7
25	0.23	0.65	650	4.1	11.6
26	0.24	0.68	700	4.4	12.5
28	0.26	0.73	750	4.7	13.4
30	0.28	0.79	800	5.0	14.3
32	0.30	0.84	850	5.4	15.2
34	0.31	0.89	900	5.7	16.0
35	0.32	0.92	950	6.0	16.9
36	0.33	0.94	1000	6.3	17.8
38	0.35	0.99	1050	6.6	18.7
40	0.37	1.05	1100	6.9	19.6
45	0.42	1.18	1150	7.2	20.5
50	0.46	1.31	1200	7.6	21.4
55	0.51	1.44	1250	7.9	22.3
60	0.55	1.57	1300	8.2	23.2
65	0.60	1.70	1350	8.5	24.1
70	0.65	1.83	1400	8.8	25.0
75	0.69	1.96	1450	9.1	25.8
80	0.74	2.09	1500	9.4	26.7
85	0.78	2.23	1550	9.8	27.6
90	0.83	2.36	1600	10.1	28.5
95	0.88	2.49	1650	10.4	29.4
100	0.92	2.62	1700	10.7	30.3
110	1.02	2.88	1750	11.0	31.2
120	1.11	3.14	1800	11.3	32.1
125	1.16	3.30	1850	11.6	33.0
			1900	12.0	33.9
			1950	12.3	34.8
			2000	12.6	35.7

Table 3

Examples of Sereen Material

Material	Wire Thickness	Opening Width	% Open Area
8x 8 Stainless Steel Alloy Mesh	0.711 mm (0.028”)	2.44 mm (0.096”)	60
#7 Mesh Wire Cloth	1.025mm (0.041”)	2.54 mm (0.100”)	51
#8 Mesh Wire Cloth	0.875 mm (0.035”)	2.25 mm (0.089”)	52
#8 Mesh Wire Cloth	0.700mm (0.028”)	2.54 mm (0.100”)	62
#60 Wedge Wire Screen	1.50mm (0.059”)	2.54 mm (0.100”)	63
#45Wedge Wire Screen	1.10mm (0.080”)	2.54 mm (0.100”)	69

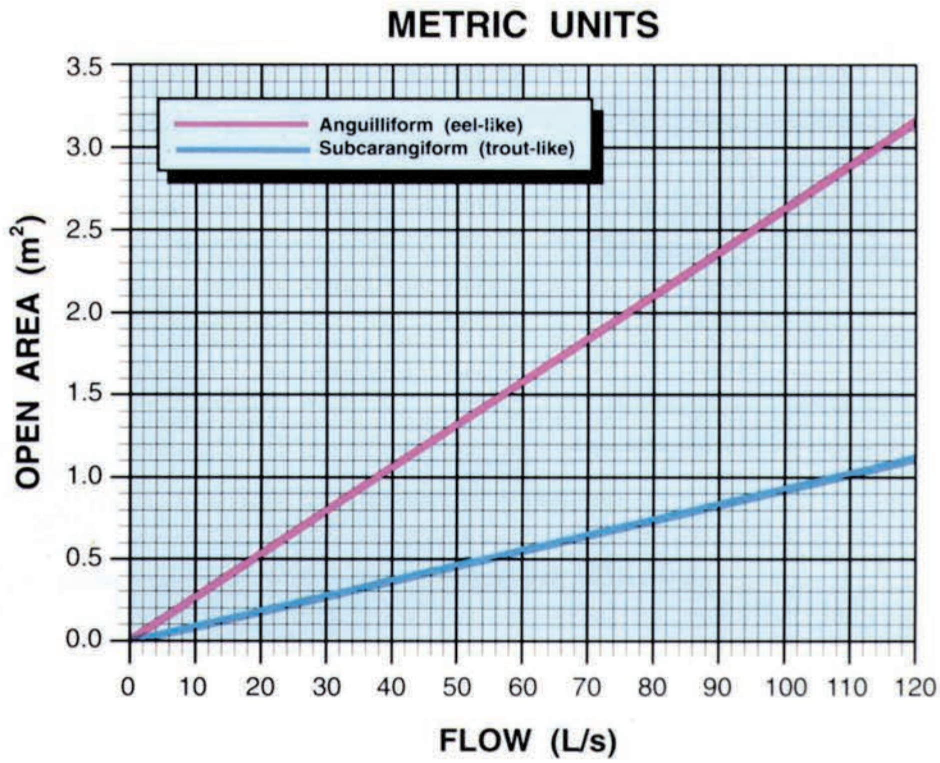
dimensions and area formulae. These are just examples of the many shapes and sizes in which fish screens can be fabricated. Screens are instream structures and, as such, should have sufficient strength and durability, and be capable of withstanding any potential large forces and impacts. Figure 3, 4, and 5 illustrate some of the various configurations, applications, and screen material types of end-of-pipe fish screens.

4.3 Installation

- Screens should be located in areas and depths of water with low concentrations of fish throughout the year.
- Screens should be located away from natural or man-made structures that may attract fish that are migrating, spawning, or in rearing habitat.
- The screen face should be oriented in the same direction as the flow.
- Ensure openings in the guides and seals are less than the opening criteria to make “fish tight”.
- Screens should be located a minimum of 300 mm (12 in.) above the bottom of the watercourse to prevent entrainment of sediment and aquatic organisms associated with the bottom area.
- Structural support should be provided to the screen panels to prevent sagging and collapse of the screen.
- Large cylindrical and box-type screens should have a manifold installed in them to ensure even water velocity distribution across the screen surface. The ends of the structure should be made out of solid materials and the end of the manifold capped.
- Heavier cages or trash racks can be fabricated out of bar or grating to protect the finer fish screen, especially where there is debris loading (woody material, leaves, algae mats, etc.). A 150 mm (6 in.) spacing between bars is typical.

Figure 1

Open Screen Area for End-of-Pipe Water Intake Flow



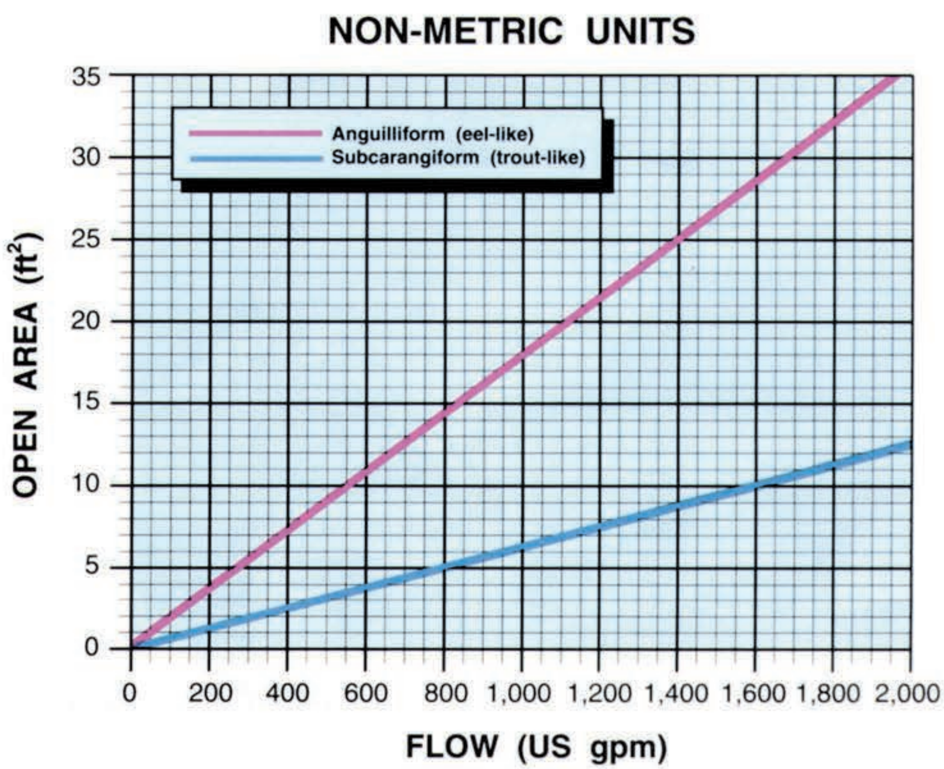


Figure 2

Common Screen Shapes and Area Formulae

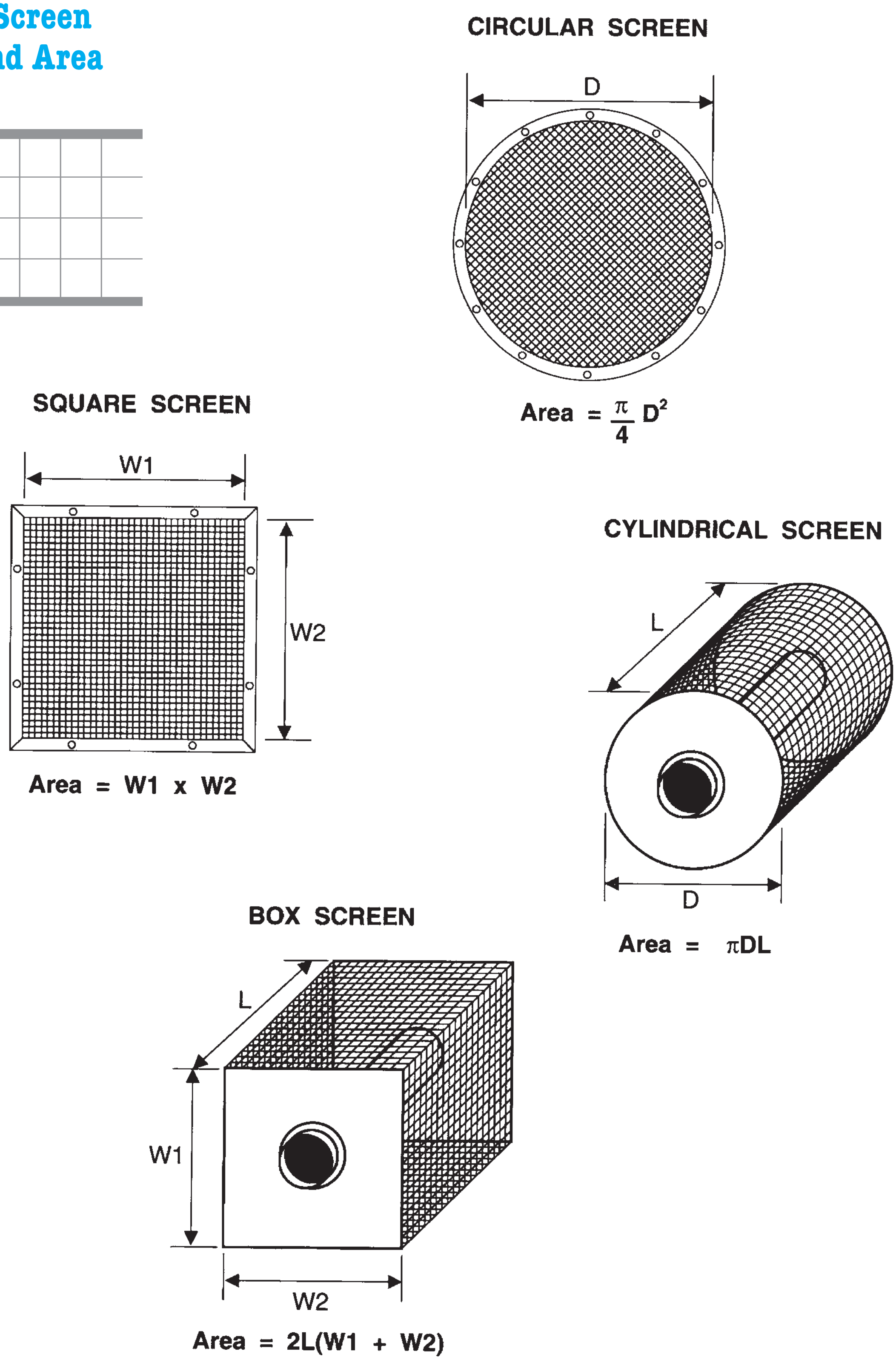


Figure 3

Typical Applications and Features of End-of-Pipe Screens

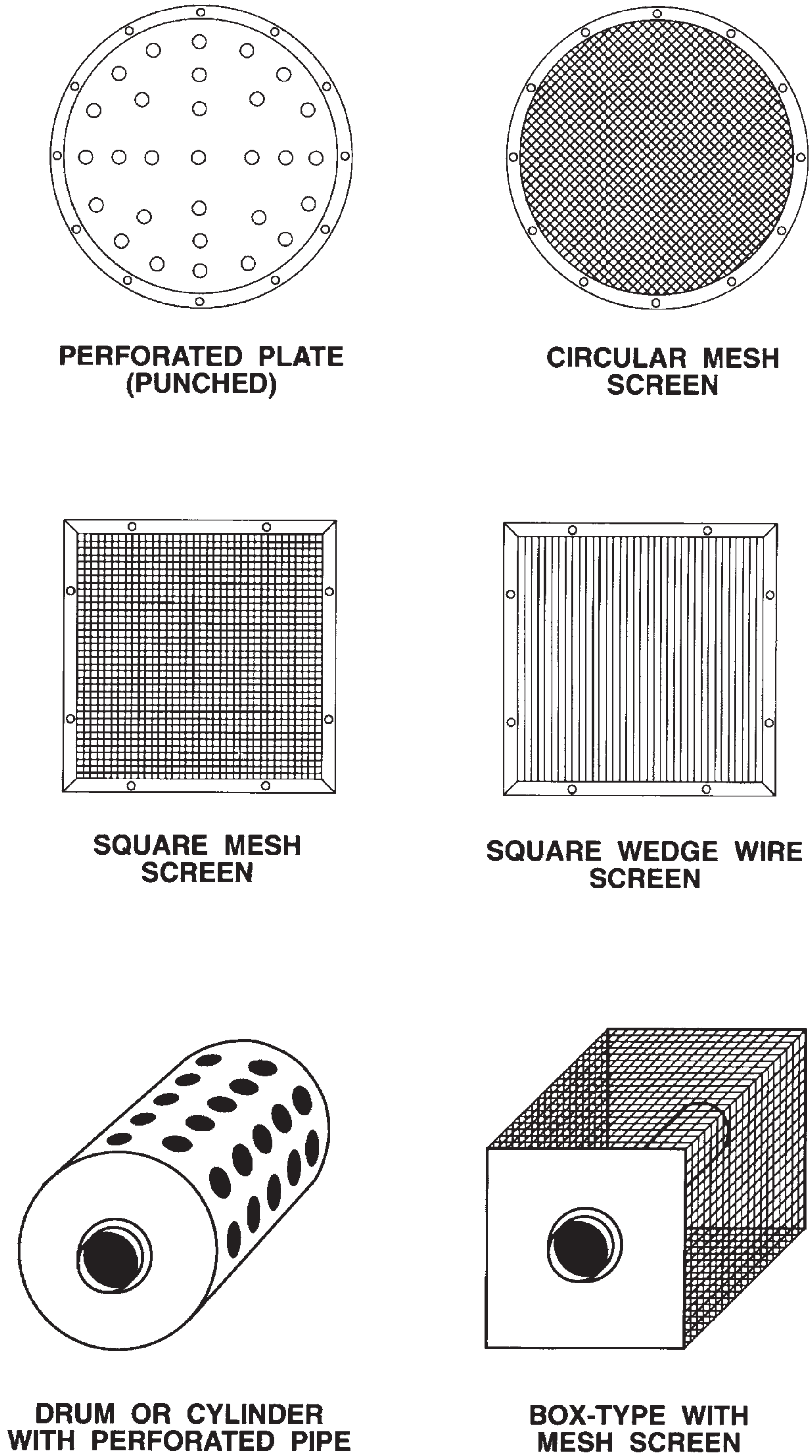
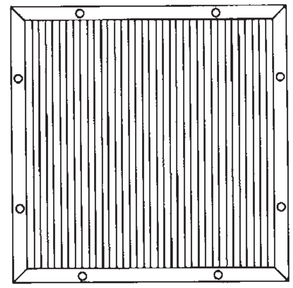
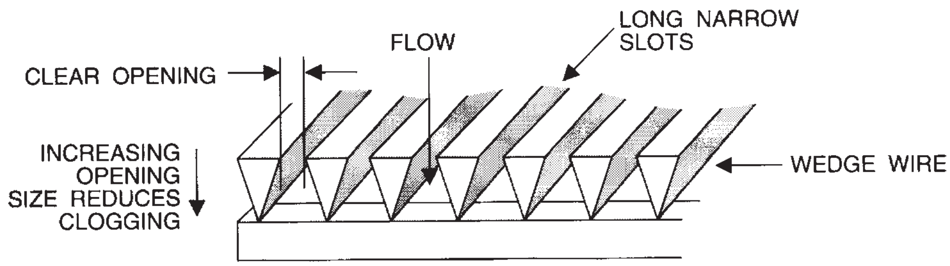


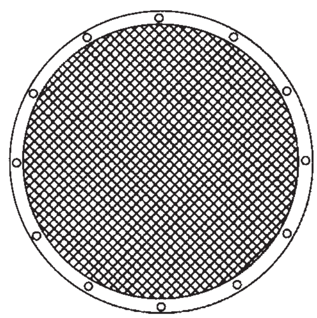
Figure 4
Examples of Typical Screen and Material Types



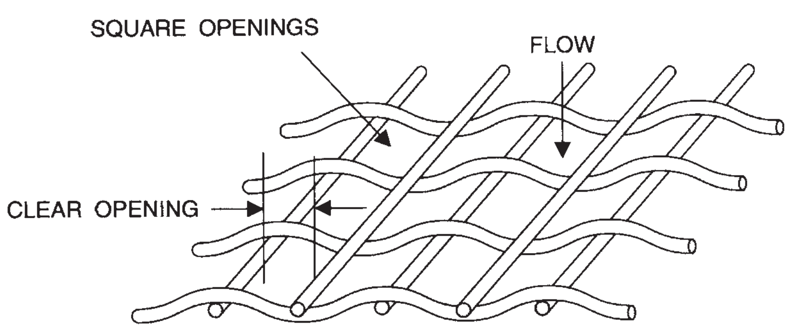
SQUARE WEDGE WIRE SCREEN



WEDGE WIRE PROFILE



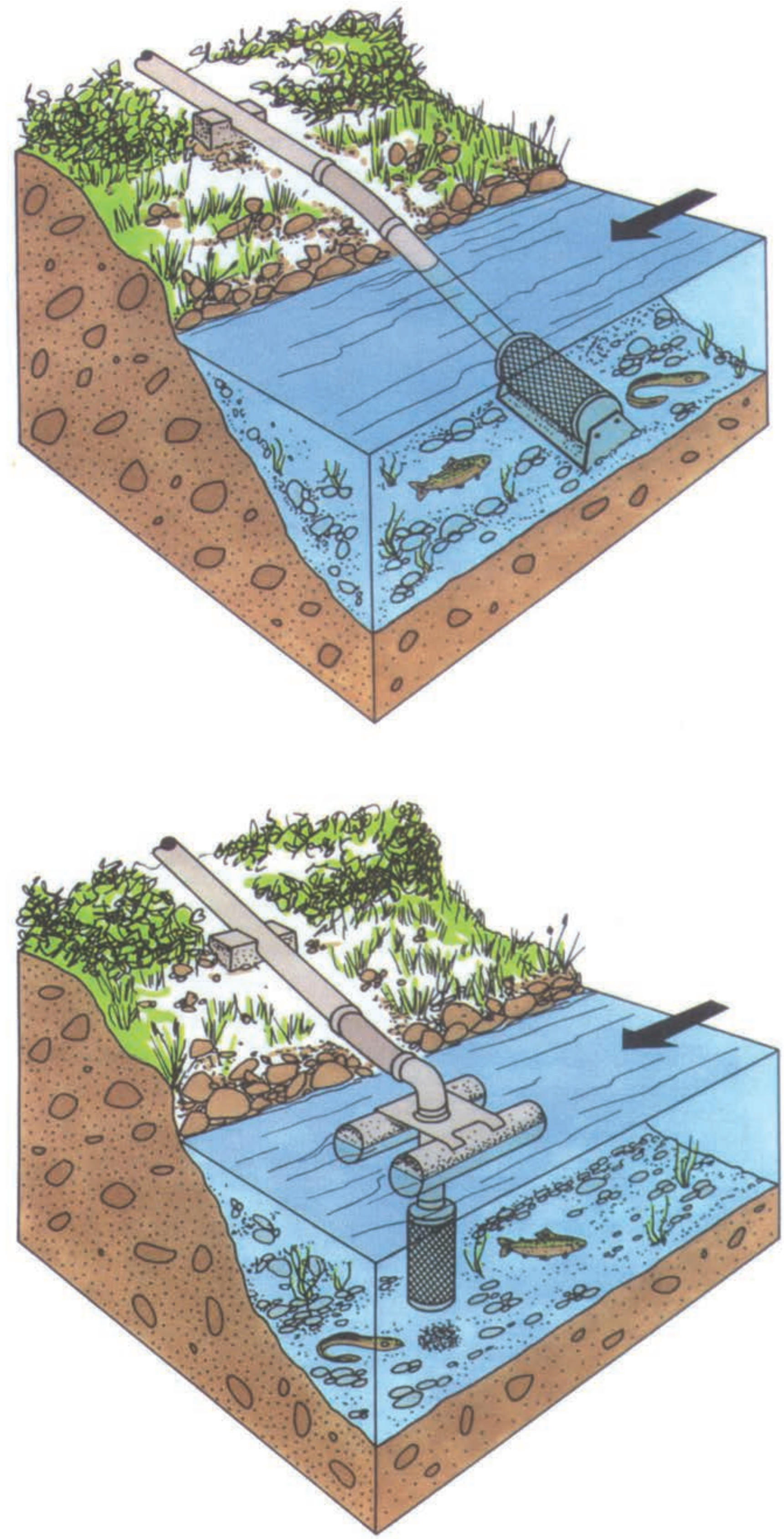
CIRCULAR MESH SCREEN

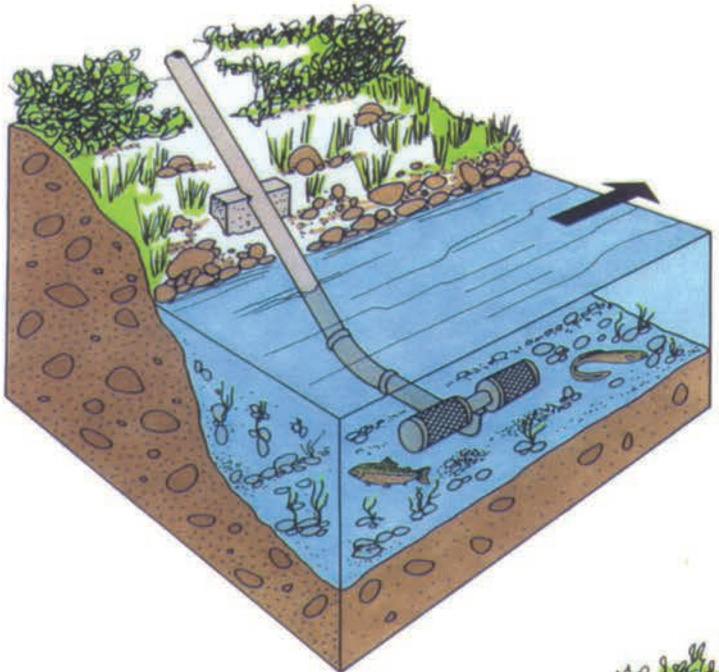


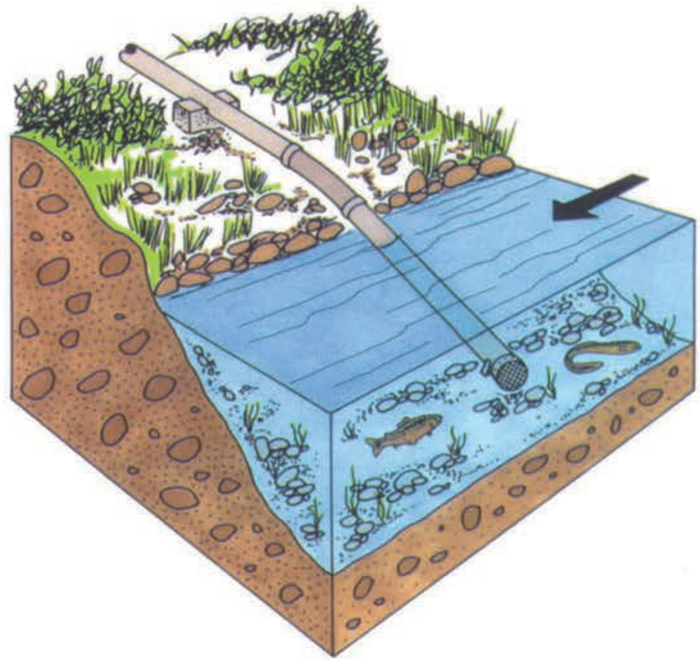
WOVEN WIRE MESH PROFILE

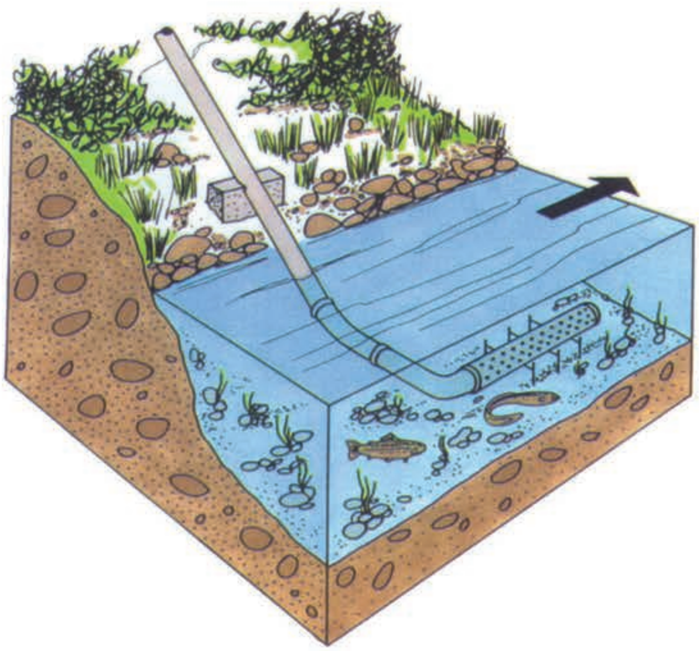
Figure 5

Examples of Typical Installations of End-of-Pipe Screen









4.4 Cleaning and Maintenance

- Provision should be made for the removal, inspection, and cleaning of screens.
- Ensure regular maintenance and repair of cleaning apparatus, seals, and screens is carried out to prevent debris-fouling and impingement of fish.
- Pumps should be shut down when fish screens are removed for inspection and cleaning.
- Screens may be cleaned by methods such as air or water, backwashing, removal and pressure washing or scrubbing.
- Under certain site-specific winter conditions, it may be appropriate to remove screens to prevent screen damage.
- Flexible suction pipe may be used instead of solid, fixed piping for ease of screen removal and cleaning.
- Pump suction pressure can be measured to assess the need for screen cleaning.

To facilitate intake screen cleaning/maintenance, design and installation features such as orientation of the screen (e.g., in a cove) or variation in mesh shape (i.e., square wire/bars versus round wire/bars), etc. may be considered for regularly cleaned screens. For screens that will not be cleaned regularly, provision of considerably more open screen area (e.g., four times more) than determined from Table 2/Figure 1 may be considered. Such design/installation features should be addressed with the appropriate regulatory agencies on a site-specific basis.

Appendix C presents a list of units of conversion.

For more information on the appropriate design of freshwater intake end-of-pipe fish screens, contact the nearest DFO office. In addition, a list of DFO Regional contacts is presented in Appendix D. Other appropriate regulatory agencies should also be contacted.

References

Fish Screening Directive. 1990. Department of Fisheries and Oceans, Ottawa, Ontario,

Katopodis, C. 1990. *Advancing the art of engineering fishways for upstream migrants.* Proceedings of International Symposium on Fishways '90, Oct. 8-10, 1990, Gifu, Japan, p. 19-28.

Katopodis, C. 1992. *Fish screening guide for water intakes*. Working Document, Freshwater Institute, Winnipeg, Manitoba.

Katopodis, C, 1994. *Analysis of ichthyomechanical data for fish passage or exclusion system design*. Proc. International Fish Physiology Symposium, July 16-21, 1994, Vancouver, B.C. American Fisheries Society and Fish Physiology Association.

Katopodis, C. and R. Gervais, 1991. *Icthyomechanics*, Working Document, Department of Fisheries and Oceans, Freshwater Institute, Winnipeg, Manitoba.

Glossary

Anadromous: Fish species that migrate from the sea to freshwater systems in order to spawn.

Anguilliform: The type of swimming mode for fish that swim like an eel, and move through the water by undulating most or all of their body.

Effective Screen Area: The area occupied by the open spaces (i.e., open screen area) and screen material available for the free flow of water.

Entrainment: Occurs when a fish is drawn into a water intake and cannot escape.

Fork Length: The straight line distance measured from the tip of the nose to the fork of the tail of a fish.

Impingement: Occurs when an entrapped fish is held in contact with the intake screen and is unable to free itself.

Open Screen Area: The area of all open spaces on the screen available for the free flow of water.

Subcarangiform: The type of swimming mode for fish that swim like trout or salmon, and move through the water by undulating the posterior third to half of their body.

Appendix A
Information Requirements

Appendix A Information Requirements

Types of information requirements that may be applicable to a freshwater intake proposal are highlighted below. While this listing is not intended to be all inclusive, it indicates information that may be necessary to enable regulatory agencies to review a water intake and fish screen proposal. The information highlighted below considers Section 30 and other sections of the *Fisheries Act* .These information requirements may also address other Federal, Provincial, and Municipal legislation and policies.

General and Site Information

- gazette or common name of the watercourse
- location of the watercourse
- type of watercourse (e.g., pond or stream)
- type of water intake
- other activities associated with the development or construction of the intake/screen structure

Biophysical Information

- fish presence, species, and possible fish size or fish habitat conditions at the protect site
- physical description of the watercourse at the intake site, including channel width and depth, direction and velocity of water currents, variations in wafer levels, sediment transport processes, lateral or channel grade movement, debris loading, etc.
- location and position of the intake within the watercourse, including dimensions, alignment, depth in the water column, wetted area, etc.
- description of the site features and characteristics, including site access

Water Use Information

- purpose of water withdrawal

- average rate, or ranges of rates, of withdrawal from the watercourse
- duration and lime of withdrawal
- estimates of ranges of flow (i.e., daily, weekly, monthly) in the watercourse during times of withdrawal with dates and times of year (with particular consideration to periods of low flow)
- expected effects of withdrawal on existing watercourse (e.g., drawdown, downstream dewatering, etc)
- description of structures or activities associated with the development of the intake
- whether the application is for a new intake, or re-development or upgrading of an existing structure

Other Information

- site plans/sketches indicating intake site and location (detailed on 1:50,000 topographic map)
- photographs/video of the site are often useful

Fish Screen Information

- screen open and effective areas
- physical screen parameters with respect to the intake and the watercourse
- screen material, method of installation and supporting structures
- screen maintenance, cleaning or other special requirements

Appendix B
Sample Calculation

A proponent wishes to withdraw water at a rate of 0.075 m^3/s from a nearby pond. The pond supports populations of brown trout, brook trout, and American eel. The intake is proposed to be cylindrical with the ends solid and #60 wedge wire screen around the cylinder.

What size must the intake screen be to satisfy the guideline requirements?

There are 4 steps to finding the answer:

1. Determine the fish swimming mode.
2. Determine the open screen area.
3. Determine the effective screen area.
4. Determine the dimensions necessary to produce the effective screen area.

1. Fish Swimming Mode

The fish swimming mode is found from Table 1. Brook trout and brown trout are listed as subcarangiform swimmers, while the American eel is an anguilliform swimmer.

2. Open Screen Area

Table 2 lists the required open screen area for both subcarangiform and anguilliform swimmers under flows up to 125 L/s (2000 US gpm). To use the table, if is necessary first to convert the flow from cubic metres per second to litres per second.

$$0.075 \frac{m^3}{s} \times \frac{1000\ L}{1\ m^3} = 75 \frac{L}{s}$$

For a flow of 75 L/s, Table 2 indicates that the open screen area must be:

- 0.69 m^2 for subcarangiform swimmers, and
- 1.96 m^2 for anguilliform swimmers.

The higher number (1.96 m^2) is the more stringent requirement, therefore, it is used in the calculation of effective screen area,

3. Effective Screen Area

The screen material in this case is # 60 Wedge Wire. A review of Table 3 indicates that the % Open Area for this material is 63%, With this value and the previously determined area from Step 2, the following formula is used to determine the Effective Screen Area.

$$\textbf{Effective Screen Area} = \frac{\textbf{Open Screen Area}}{\left(\frac{\textbf{\% Open Area}}{100}\right)}$$

$$= \frac{1.96\ m^2}{\left(\frac{63}{100}\right)}$$

$$= 3.111\ m^2$$

4. Dimensions of Intake Screen

Figure 2 lists several common screen shapes and their respective area formulae. For a cylindrical screen where the ends are solid and screening is around the cylinder, the following formula applies:

$$\text{Area} = \pi DL$$

The unknown dimensions are diameter (D) and length (L). These dimensions are determined by choosing a value for one and solving the equation for the other.

If the diameter is 0.600 m, then the length follows as:

$$\text{Area} = \pi DL$$

$$3.111\ m^2 = (0.600\ m)L$$

$$3.111\ m^2 = (1.885\ m)L$$

$$L = \frac{3.111\ m^2}{1.885\ m}$$

$$L = 1.65\ m$$

A 0.600 m diameter, 1.65 m long cylindrical screen would meet the design requirements. It should be noted that the dimensions given are representative of the screening area only; they do not include any screen that may be blocked by framing, etc. By comparison, if the pond only supported trout (subcarangiform), a 0.600 m diameter, 0.58 m long cylindrical screen would meet the design requirements.

Appendix C
Units of Conversion

To Convert	Into	Multiply By
cubic feet per second	cubic metres per second	0.0283
cubic feet per second	litres per second	28.3
cubic feet per second	US gallons per minute	448.9
cubic metres per second	cubic feet per second	35.3
cubic metres per second	US gallons per minute	15850
litres per second	cubic feet per second	0.0353
litres per second	cubic feet per minute	2.12
litres per second	cubic metres per second	0.001
litres per second	US gallons per minute	15.85
square metre	square foot	10.76
square metre	square inch	1550
square foot	square metre	0.0929
US gallons per minute	litres per second	0.0631
US gallons per minute	cubic feet per second	0.00223
US gallons per minute	Imperial gallons per minute	0.833
Imperial gallons per minute	litres per second	0.0758

Appendix D
DFO Regional Contacts

NEWFOUNDLAND REGION	Habitat Management Division P.O. Box 5667 St. John's NF A1C 5X1 Tel: 709-772-6157 Fax: 709-772-5562
GULF REGION	Habitat Management Division P.O. Box 5030 Moncton NB E1C 9B6 Tel: 506-851-6252 Fax: 506-851-6579
SCOTIA-FUNDY REGION	Habitat Management Division P.O. Box 550 Halifax NS B3J 2S7 Tel: 902-426-6027 Fax: 902-426-1489
QUEBEC REGION	Fish Habitat Management P.O. Box 15550 Quebec QC G1K 7Y7 Tel: 418-648-4092 Fax: 418-648-7777
CENTRAL & ARCTIC REGION	Habitat Management 501 University Crescent Winnipeg MB R3T 2N6 Tel: 204-983-5181 Fax: 204-984-2404
PACIFIC REGION	Habitat Management 555 W. Hastings St. Vancouver BC V6B 5G3 Tel: 604-666-6566 Fax: 604-666-7907

Local DFO offices should be contacted. Other appropriate regulatory agencies should also be contacted.

Appendix B:
Mitigations for Apex Supplementary Pumping Program

Mitigations for Apex Supplementary Pumping Program:

Mitigation applied is based on DFO pathways of effects (www.dfo-mpo.gc.ca/pnw-ppe/pathways-sequences/index-eng.html) and designed to break those pathways where feasible.

<table>
<tr><th>Activity</th><th>Mitigation</th></tr>
<tr><td rowspan="5">Operation of Machinery</td><td>Machinery is to arrive on site in a clean condition and maintained free of fluid leaks, invasive species and noxious weeds. Eco friendly (e.g., biodegradable vegetable oil) hydraulic fluid and lubrication is to be used on equipment, where feasible.</td></tr>
<tr><td>Develop and implement a Spill Contingency Plan that minimizes risk of accidental spills or releases from entering a watercourse or water body during all phases of the pumping.</td></tr>
<tr><td>Whenever possible, operate machinery on land above the high water mark (HWM), to minimize disturbance to the banks and bed of the water body.</td></tr>
<tr><td>Wash, refuel and service machinery and store fuel and other materials for the machinery in such a way as to prevent any deleterious substances from entering the water.</td></tr>
<tr><td>Remove all construction materials from site upon project completion.</td></tr>
<tr><td rowspan="4">Erosion and Sediment Control</td><td>Installation of effective erosion and sediment control measures before starting work to prevent sediment from entering the water body.
• Regular inspection and maintenance of erosion and sediment control measures and structures during the course of construction.
• Repairs to erosion and sediment control measures and structures, if damage occurs.
• Removal of non-biodegradable erosion and sediment control materials once site is stabilized.</td></tr>
<tr><td>Measures for managing water flowing onto the site, as well as water being pumped or diverted from the site, such that sediment is filtered out prior to the water entering a water body.</td></tr>
<tr><td>Measures for site isolation (e.g., silt boom or silt curtain) for containing suspended sediment, if in water work is required.</td></tr>
<tr><td>Minimize in water work areas</td></tr>
</table>

Activity	**Mitigation**
Pumping	Screen water intakes pipes to prevent entrainment or impingement of fish. Entrainment occurs when a fish is drawn into a water intake and cannot escape. Impingement occurs when an entrapped fish is held in contact with the intake screen and is unable to free itself. In freshwater, follow these measures for design and installation of intake end of pipe fish screens to protect fish where water is extracted from fish-bearing waters: • Screens are to be located in areas and depths of water with low concentrations of fish throughout the year. • Avoid placing water intakes/screens in areas of the channel that are used as migratory corridors by fish, where possible. Additional protection measures (e.g., barrier nets) may also be required. • Screens are to be located away from natural or artificial structures that may attract fish that are migrating, spawning, or in rearing habitat. • Orient the screen face in the same direction as the flow. • Openings in the guides and seals are to be less than the opening criteria to make “fish tight”. • Intakes are to be installed in a manner that prevents the uptake or entrainment of sediment and aquatic organisms associated with the bottom area. Screens should be located a minimum of 300 mm (12 in.) above the bottom of the watercourse. If the water depth is less than 300 mm (12 in.), additional measures may need to be implemented (e.g., using a screen basket with a solid bottom). • Structural support is to be provided to the screen panels to prevent sagging and collapse of the screen. For example, large cylindrical and box-type screens should have a manifold installed in them so there is even water velocity distribution across the screen surface. The ends of the structure should be made out of solid materials and the end of the manifold capped. • Heavier cages or trash racks can be fabricated out of bar or grating to protect the finer fish screen, especially where there is debris loading (woody material, leaves, algae mats, etc.). A150 mm (6 in.) spacing between bars is typical. • Make provision for the removal, inspection, and cleaning of screens. • Implement regular maintenance and repair of cleaning apparatus, seals, and screens is carried out to prevent debris-fouling and impingement of fish. • Shut down pumps when fish screens are removed for inspection and cleaning.
	Protect pump discharge area(s) to prevent erosion and the release of suspended sediments downstream, and remove this material when the works have been completed.
Coffer Dam	If feasible, use non-earthen material, such as water-inflated portable dams, pea gravel bags, concrete blocks, steel or wood wall, clean rock, sheet pile or other appropriate designs, to separate the dewatered work site from flowing water.
	If granular material is used to build dams, use clean or washed material that is adequately sized (i.e., moderately sized rock and not sand or gravel) to withstand anticipated flows during the construction. If necessary, line the outside face of dams with heavy poly-plastic to make them impermeable to water. Material to build these dams should not be taken from below the HWM of any water body.

Activity	**Mitigation**
Water Discharge into Apex River	Water should be discharged from Unnamed lake to the seasonal channel of the Apex River to minimize erosion of and the banks and surrounding areas. Where discharge is diverted to areas containing water, this water should be discharged at or near the surface water level or a diffuser used at the end-of-pipe.
Maintenance and Reclamation	Minimize the removal of natural woody debris, rocks, sand or other materials from the banks, the shoreline or the bed of the watercourse or water body below the HWM. If material is removed from the water body, set it aside and return it to the original location once water withdrawal activities are completed.
Fish Rescue	To minimize fish mortality due to water withdrawal fish rescue will be conducted where feasible. Fish rescue will include; • Two personnel will walk the river banks below the water withdrawal site daily, or as required to check for stranded or fish which will potentially stranded to rescue those fish. One person will be a local person from the HTO while the 2nd person will be a qualified aquatic environmental specialist (QAES). • For fish stranded fish will be dipped netted and placed in an oxygenated tub of water from the river. For fish at risk of being stranded and cannot be easily dip netted an electrofisher will be used to capture fish and placed into the oxygenated tub of water. • Stranded fish which may be observed by the community or others will be attempted to be rescued. • Fish rescue will be carried downstream to a suitable release area and released once fish have recovered from their capture. • All fish rescued will be counted and recorded. • Fish which are stranded but cannot be rescue will be retrieved, counted and frozen for later biological sampling to obtain a better understanding of tis resident char population. • Fish rescue will continue until water draw down due to water withdrawal has concluded.