



Fisheries and Oceans Pêches et Océans
Canada Canada

TECHNICAL REPORT

DeBeers Canada Gahcho Kué Diamond Mine Project

Submitted to:
Mackenzie Valley Environmental Impact Review Panel
October 22nd, 2012

MVEIRB Code: EIR0607-001

PLAIN LANGUAGE SUMMARY

DeBeers Canada (DeBeers) is proposing to develop a diamond mine 280 km northeast of Yellowknife, Northwest Territories. DFO is participating in the environmental impact review of the Gaucho Kué Diamond Mine project as a regulator as well as an expert advisor to the Review Board on potential physical impacts of the development on fish and fish habitat. DFO's primary focus in reviewing proposed developments in and around Canadian fisheries waters is to ensure that works, undertakings and activities are conducted in a manner that complies with the applicable provisions of the *Fisheries Act*. Specifically, DFO's technical comments and recommendations relate to the following key areas: potential impacts to aquatic resources in Kennady Lake and surrounding waterbodies during construction and operations; the mitigation measures proposed to minimize potential effects to fish and fish habitat; the assessment of mine plan alternatives that may reduce impacts to aquatic resources; monitoring plans required to detect and ensure an early response to effects to the aquatic environment that may result from the project; and, the likelihood of restoring the Kennady Lake watershed to a self-sustaining viable aquatic ecosystem following project closure.

DFO's technical review identified a number of items that need to be addressed, including: development of an acceptable conceptual fish habitat compensation plan; a sediment and erosion control plan that includes best management practices for the construction of the dykes; a revised flow mitigation plan that incorporates and details operational procedures and protocols. To ensure the development of a robust aquatic effects monitoring program capable of detecting changes to the aquatic environment, DFO recommends the Proponent adopt repeatable, standardized methods for baseline data collection, that this sampling program include additional reference lakes to those sampled to date, and that baseline collection utilizing these standard methods begin well in advance of the development of the mine. In order to promote the quickest and most efficient restoration of Kennady Lake to a self-sustaining and viable aquatic ecosystem following project closure, DFO recommends that the aquatic ecosystem within the lake meet appropriate criteria to support fish prior to the reconnection of Areas 3 and 5 to the Kennady Lake watershed and the re-introduction of fish to Kennady Lake. Finally a comprehensive revegetation program would support the re-establishment of riparian and aquatic vegetation.

With the implementation of recommendations intended to minimize aquatic impacts as outlined in DFO's technical submission, the application of appropriate mitigation measures, follow-up and monitoring programs, and with the development of a plan to provide adequate compensation for residual habitat losses, DFO is of the opinion that potential impacts to fish and fish habitat resulting from the Gahcho Kue Diamond Mine Project, could be addressed.

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1.0 INTRODUCTION

1.1 Background

DeBeers Canada (DeBeers), the Proponent, is proposing to develop a diamond mine 280 km northeast of Yellowknife, Northwest Territories. The proposed Gahcho Kué Diamond Mine Project (the Project) would involve the extraction of diamond ore through the development of 3 open pit mines located within the 8.1 km² Kennady Lake.

On December 23rd, 2010, DeBeers submitted an Environmental Impact Statement in order to satisfy the requirements of the guidelines developed for the environmental impact review of the project, initiated on June 12, 2006 through a referral by the Mackenzie Valley Impact Review Board.

The Department of Fisheries and Oceans (DFO) has completed its technical review of the proposed development, taking into consideration the information supplied by the Proponent through their correspondence with DFO, their Environmental Impact Statement (EIS), technical sessions and other pertinent documents submitted to the Mackenzie Valley Environmental Impact Review Panel (MVEIRP). DFO is submitting the following comments for the environmental assessment of the Project.

1.2 Mandate

On behalf of the Government of Canada, DFO is responsible for developing and implementing policies and programs in support of Canada's scientific, ecological, social and economic interests in relation to sea, coastal and inland fisheries, and oceans in general.

DFO is a national and international leader in marine safety and in the management of oceans and freshwater resources. Departmental activities and presence on Canadian waters help to ensure the safe movement of people and goods. As a sustainable development department, DFO will integrate environment, economic and social perspectives to ensure Canada's oceans and freshwater resources benefit this generation and those to come.

DFO's guiding legislation includes the *Oceans Act*, which charges the Minister with leading oceans management and providing coast guard and hydrographic services on behalf of the Government of Canada, and the *Fisheries Act*, which confers responsibility to the Minister for the management of fisheries, habitat and aquaculture. The Minister of Fisheries and Oceans is also one of the three responsible authorities under the *Species at Risk Act* and is responsible for the protection of aquatic species at risk.

DFO's primary focus in reviewing proposed developments in and around Canadian fisheries waters is to ensure that works, undertakings and activities are conducted in a manner that complies with the applicable provisions of the *Fisheries Act*. In particular, subsection 35(1) of the *Fisheries Act* (R.S., 1985, c. F-14, s. 35; 2012, c. 19, s. 142) prohibits the "harmful alteration or disruption, or the destruction" (HADD) of fish habitat without authorization from the Minister of Fisheries and Oceans (or other prescribed person or entity), or where the work, undertaking or activity is not in accordance

with regulations made by the Governor in Council under the *Fisheries Act*. Additionally, subsection 32(1) prohibits the killing of fish by any means other than fishing unless authorized by the Minister of Fisheries and Oceans (or other prescribed person or entity) or under regulations made by Governor in Council. There are other sections of the *Fisheries Act* that pertain to the conservation and protection of fish and fish habitat. They include section 20 (fish ways) and section 21 (fish guards), among others.

Section 36 prohibits the deposit of a deleterious substance in water frequented by fish, or in any place under any conditions where the substance may enter water frequented by fish unless authorized by a regulation under the *Fisheries Act*. Through an agreement, Environment Canada (EC) is responsible for the administration and enforcement of the pollution prevention provisions of the *Fisheries Act* on behalf of DFO (section 34 and sections 36-42). Due to the complimentary interests and mandates of DFO and EC with respect to aquatics resources, a joint information requests document was developed for the first round of information requests for the Project and submitted to the MVEIRP on January 17, 2012. The following information requests related to areas of EC's expertise and mandate, such as water and sediment quality, and will be addressed by EC:

- IR# 4, 6, 11, 20, 21, 23, 29, 30, 32, 33, 37, 42, 43, 52, 53, 54, 60, 66, 67.

DFO provides general guidance on the application of the Fish Habitat Protection provisions of the *Fisheries Act* which applies to all works, undertakings, and activities that have the potential to harm fish habitat. The long-term objective of DFO is to achieve a net gain in the productive capacity of fish habitat for Canadian fisheries resources. A fundamental strategy for achieving this objective is to prevent the further loss in productive capacity of existing habitats through habitat management. Productive Capacity is defined to mean the “maximum natural capacity of habitats to produce healthy fish, safe for human consumption, or to support or produce aquatic organisms upon which fish depend”.

In reviewing proposed works, undertakings, and activities, DFO strives, on a case-by-case basis, to maintain the productive capacity of habitats supporting fisheries resources. DFO works with project proponents to avoid impacts by the application of mitigation measures. Unavoidable habitat losses are balanced through DFO's requirement, under regulatory instrument, of fish habitat “compensation” by the Project proponent.

Should it be determined through the environmental impact and regulatory review processes that a HADD of fish habitat is unavoidable, DFO must determine whether authorization under paragraph 35(2)(b) of the *Fisheries Act* is appropriate. This regulatory decision considers the implementation of all appropriate mitigation measures to avoid impacts to fish and fish habitat, the construction of compensatory habitat (compensation) that offsets residual fish habitat losses, and an effective monitoring plan that will ensure that mitigation measures and compensation are effective.

In determining the acceptability of proposed habitat compensation measures, DFO considers the certainty or likelihood of success. This includes an evaluation of the feasibility, practicality and risks associated with compensation options, including the extent of monitoring and adaptive management that may be required in order to ensure the greatest probability of success. It is DFO's expectation that the Proponent consult with impacted Aboriginal communities during the development of any fish habitat compensation plans.

2.0 TECHNICAL COMMENTS – FISH AND AQUATIC BASELINE

2.1 Documents Reviewed

- DeBeers response to DFO Round #1 Information Requests (March 2012): IR# 3, 12, 13-19, 22, 24, 25, 40, 41

2.2 Proponent's Assessment and Conclusions

Although past baseline sampling methods have not always been consistent (e.g. fish sampling methodology, different consultants, detection limits), DeBeers is committed to developing an aquatic effects monitoring plan (AEMP) that will include appropriate baseline information as a key component. The AEMP will be developed with regulatory and stakeholder input.

2.3 DFO's Conclusions and Recommendations

Adequate baseline, collected in a consistent and defensible manner, is essential in order to properly assess potential effects from the mine during construction, operations, and closure. A robust aquatic effects monitoring plan is the key tool for detecting changes to the health of aquatic life, including fish, while also being able to differentiate those changes attributed to mine effects from those due to natural variability. The early detection of effects supports the timely implementation of mitigation measures and/or adaptive management plans which increases the likelihood that harmful impacts to aquatic life would be avoided.

In order to support an effective aquatic effects monitoring program, the following baseline information would be required:

- **Adequate reference lake data which includes regular sampling of more than one reference lake** - To be effective, the reference approach needs multiple years of pre-impact data to capture natural variability. In addition, a larger suite of reference lakes would be preferred to provide a range of natural variability. Consideration should be given to methods that employ multiple control sites such as the reference condition approach.
- **Water clarity monitored using either Secchi discs or light sensors** - Sampling should be undertaken every two weeks through the open water season for reference lakes, Kennady Lake and downstream lakes. Sampling should occur at the deepest point in the lake to maximize the vertical profile.
- **The determination of sediment quality and benthic invertebrates by way of transects** - so as to better quantify the distribution with respect to depth.
- **An assessment of the natural variability of plankton, both within and among years** – This requires regular sampling of potentially affected lakes on at least a monthly basis using standard methods. It will not be possible to effectively determine within and among-year variance if less than 2 years of data exist before the project's initiation. Furthermore, phytoplankton, zooplankton, and Chl *a* should be sampled for taxonomy and biomass in reference lakes, Kennady Lake and downstream lakes (including N9 and N11), once every two weeks for at least one entire open water season and then twice through the winter (Water

clarity and Chl *a* could serve as proxies for primary productivity, though in this case information regarding community structure would be lost). The taxon richness for phytoplankton and zooplankton communities should be calculated and the taxonomic samples should be preserved.

It is DFO's expectation that DeBeers Canada will develop and implement a comprehensive and robust AEMP in consultation with appropriate stakeholders.

Recommendation #1: The Proponent commit to adopting and using a set of standardized, repeatable methods for baseline collections, which include additional reference lakes, adequate methods for sampling reference lakes, water clarity, sediment quality, benthic invertebrates and plankton as outlined in Section 2.3, to ensure that appropriate data are collected prior to any development. Standard methods should be used for all aquatic and fisheries sampling.

3.0 TECHNICAL COMMENTS – OVERWINTERING HABITAT

3.1 Documents Reviewed

- DeBeers Response to DFO Round #1 Information Requests (March 2012): IR# 9, 46, 64

3.2 Proponent's Assessment and Conclusions

The Proponent provided additional details regarding overwintering habitat for lakes within the project area, as well as an assessment of the viability of potential measures that could be implemented to address overwintering habitat limitations. The Proponent also indicated that they were interested in perusing investigations of over-wintering potential of tundra lakes.

3.3 DFO's Conclusions and Recommendations

Overwintering habitat is often a limiting factor for fish survival in northern systems. Overall, DFO is satisfied with the information provided by the Proponent in regards to overwintering habitat. As requested, a summary table was provided which included ice-thickness measurements for the various waterbodies within the proposed Project area. However other variables of interest, such as maximum depth and dissolved oxygen were not included within this table, limiting the utility of the table for assessing overwintering potential of these waterbodies. During the May 2012 Technical Sessions, the Proponent committed to revising these tables and including other pertinent details relating to overwintering habitat.

DFO fully supports and encourages the Proponent's initiatives to investigate fish overwintering habitat in tundra lakes. This initiative should be developed in consultation with DFO with the participation of academic partners. Provided that the Proponent submits further information to DFO pertaining to overwintering habitat for further consideration during the regulatory phase, DFO is satisfied with the information presented by DeBeers Canada in the EIS and Information Requests responses

Recommendation #2: The Proponent provides a revised table to DFO that includes a summary of information pertaining to fish overwintering habitat (e.g. ice thickness, waterbody size, maximum depth, dissolved oxygen, sample dates).

4.0 TECHNICAL COMMENTS – RIVERINE HABITAT

4.1 Documents Reviewed

- DeBeers Response to DFO Round #1 Information Requests (March 2012): IR# 15

4.2 Proponent’s Assessment and Conclusions

The Proponent has expanded their assessment of riverine habitat to include that preferred for other species and life stages, in addition to pike and grayling spawning habitat.

4.3 DFO’s Conclusions and Recommendations

The information provided by the Proponent provides a good basis for understanding the preferred habitats of the various species (at different life stages) known to occur in the Project areas, but more information is needed on the existing conditions of the streams within the study area. Having an understanding of the pre-development conditions of these streams is essential for tracking and monitoring change to these systems, for example from increased siltation. This assessment should include all streams potentially impacted by the Project, not only those physically altered directly by mine infrastructure.

Recommendation #3: The Proponent commit to providing a revised tabulated summary of the pre-impacted study area streams including a detailed description of the existing substrates within these streams.

5.0 TECHNICAL COMMENTS – ALTERNATIVES ANALYSIS

5.1 Documents Reviewed

- DeBeers response to DFO Round #2 Information Requests (Sept 2012): IR # 2-3
- Detailed Alternatives Analysis Report, June 2012

5.2 Proponent’s Assessment and Conclusions

The Proponent states that the proposed mine plan with impacts to areas 2 through 7 of Kennady Lake was determined to be the alternative which encompasses the minimum watershed area required to support technical, economic, and environmental criteria. As part of this mine plan, water levels in areas 2, 3, and 5 are to be lowered by 3m to facilitate dyke construction. These areas are proposed to be subsequently used for waste water management, processed kimberlite (PK) tailings and waste rock disposal, while areas 4, 6, and 7 are to be completely drained to facilitate construction of open pits and infrastructure. From discussions with the Proponent, it is DFO’s understanding that although lake levels and habitat function of area 7 could be maintained with an in the wet construction approach, the Proponent has not proposed to construct Dyke K in the wet, due to the resulting additional construction cost and estimated one year project delay. In Section 8 of the EIS it states that, “As a result of the existing overwintering limitations in Area 8 and the elimination of alternative overwintering refugia in areas 2 through 7, lake trout (*Salvelinus namaycush*) and round whitefish

(*Prosopium cylindraceum*) may not continue to persist in area 8 throughout the operational period, as they are less tolerant of low dissolved oxygen concentrations.” The inclusion of Total Dissolved Solids and/or Total Suspended Solids treatment was considered but rejected except as a contingency measure.

5.3 DFO’s Conclusions and Recommendations

An approach that maintains the connection between areas 7 and 8, if possible, would preserve overwintering habitat allowing lake trout and round whitefish (as well as the rest of the species assemblage of Kennady Lake) to persist throughout mine operations. Maintaining self-sustaining populations in areas 7 and 8 would support an earlier return of the remainder of Kennady Lake to a self-sustaining, viable aquatic ecosystem upon closure than is predicted for DeBeers’ current proposed mine plan. Avoiding the draining of area 7 would also decrease the amount of turbid water to be managed and/or treated.

Maintaining areas 2, 3 and 5 to the extent possible during construction and operations would likely minimize closure costs and risk while increasing the success of rehabilitation initiatives at closure.

Recommendation #4: The Proponent should further evaluate alternatives which allow area 7 to be retained as it provides very important overwintering habitat for Valued Ecosystem Component (VEC) species identified in the EIS. If it is determined not to be feasible, the Proponent should consider alternatives that would refill area 7 as soon as possible after dyke construction to reduce further impacts to fish and fish habitat.

6.0 TECHNICAL COMMENTS – DYKE CONSTRUCTION

6.1 Documents Reviewed

- DeBeers Response to DFO Round #1 Information Requests (March 2012): IR# 26
- 2012 EBA Technical Memo – 2012 Gahcho Kué EIS Supplement – Summary of Dyke Conceptual Design and Construction Material for Gahcho Kué Diamond Project, NWT, Canada

6.2 Proponent’s Assessment and Conclusions

In their response to IR #26, and in the May 2012 technical session, the Proponent committed to constructing all dykes using best management practices to minimize the potential for sediment release to downstream environments.

6.3 DFO’s Conclusions and Recommendations

DFO acknowledges that the Proponent has agreed to use best management practices, such as silt curtains, for dyke construction. However, the dyke construction plans provided and referred to (2012 EBA Technical Memo – 2012 Gahcho Kué EIS Supplement – Summary of Dyke Conceptual Design and Construction Material for Gahcho Kué Diamond Project, NWT, Canada) does not include contingency plans in the event that mitigation measures are not working as intended.

Recommendation #5: The Proponent commit to developing and implementing a sediment and erosion plan for dyke construction which includes the use of best management practices (such as the use of silt curtains) to prevent potential sediment release into fish bearing waters, and impacts to fish and fish

habitat. This plan should include contingencies (including thresholds for triggering contingency actions) to be followed should the proposed mitigation not work as intended.

7.0 TECHNICAL COMMENTS – WATER WITHDRAWAL, DIFFUSER AND INTAKES

7.1 Documents Reviewed

- DeBeers Response to DFO Round #1 Information Requests (March 2012): IR# 61, 62, 63

7.2 Proponent's Assessment and Conclusions

The Proponent is proposing to recycle water throughout the mine in order limit the amount of fresh water required to be withdrawn from area 8. To further mitigate potential impacts due to water withdrawal, the Proponent has committed to follow the DFO Protocol for Winter Water Withdrawal from Ice-Covered Waterbodies in the NWT and NU (Appendix I), and install staff gauges to set minimum water levels to protect littoral habitat in the open water season. All intakes will have screens that meet the criteria outlined in DFO Freshwater Intake End-of-Pipe Fish Screen Guideline (Appendix II). If diffusers are used to minimize erosion from water discharge, the site selection and final design will consider minimizing effects to fish habitat, both in terms of water quality and habitat avoidance due to the zone of turbulence.

7.3 DFO's Conclusions and Recommendations

Impacts due to water withdrawal should be mitigated with the measures committed to by the Proponent. Further discussion will have to take place with DFO if diffusers are selected due to the potential loss of rearing and foraging habitat within the zone of turbulence.

It is DFO's expectation that the Proponent will provide, prior to or during the regulatory phase, a quantification of the zone of turbulence from diffusers, if included as part of the mine plan, in order to determine the potential impact to fish and fish habitat.

Recommendation #6: The Proponent commit to establishing minimum water level thresholds with a mitigation action plan to be initiated should these thresholds be approached in order to protect littoral habitats in water-withdrawal lakes including area 8.

8.0 TECHNICAL COMMENTS – IMPACTS FROM INITIAL DEWATERING

8.1 Documents Reviewed

- DeBeers Response to DFO Round #1 Information Requests (March 2012): IR# 65
- DeBeers Response to DFO Round #2 Information Requests (September 2012): IR# 2-3.10

8.2 Proponent's Assessment and Conclusions

The Proponent has identified that their preferred mine plan involves isolation and drawdown of various portions of Kennady Lake to facilitate dyke construction and to access diamond-bearing ore

bodies. This involves construction of perimeter and internal dams and dykes to redirect Kennady Lake inflows to other watersheds or to other parts of the Kennady Lake watershed. The Proponent also proposes to pump water with high Total Suspended Solids (TSS) concentrations from the southern basins of the lake to the isolated northern basins in order to facilitate complete draining of areas 4, 6 and 7. The Proponent has identified that a 3 metre drawdown of areas 2, 3 and 5 (northern basins) of Kennady Lake would be required and that this drawdown will eliminate 75% of the littoral habitat and increase suspended sediment concentrations due to re-suspension of lake bottom sediments. The Proponent has presented alternative mining approaches that may minimize these impacts but has concluded that the impacts can not be eliminated throughout areas 2, 3 and 5, and other approaches would increase terrestrial impacts and affect the ability to reclaim the largest portion of Kennady Lake at closure.

8.3 DFO's Conclusions and Recommendations

DFO agrees with the Proponent that an initial drawdown of the northern basins as proposed, will harmfully impact fish and fish habitat in Kennady Lake, namely by causing the physical destruction of littoral habitat and the harmful alteration and disruption of fish habitat throughout the basins. The perimeter dyking required to isolate the northern basins will also negatively impact the streams and lakes that flow into Kennady Lake and the fish habitat these waterbodies provide. Impacts to the northern basins may be minimized by limiting the total drawdown each year (see *DFO's Protocol for Winter Water Withdrawal from Ice-Covered Waterbodies in the NWT and NU* for guidance, Appendix I), by addressing inflowing streams to ensure functionality is maintained, and by implementing best management practices to address dyke construction-related impacts due to sediment re-suspension, and to manage the input of high TSS water from the southern basins of the lake.

Recommendation #7: The Proponent commit to address impacts to stream habitat from changes in drainage patterns for inflow streams.

Recommendation #8: In addition to the Proponent's plan to utilize *in situ* flocculation to reduce sediment, the Proponent is encouraged to assess and implement current best management practices to further mitigate impacts of suspended sediment to fish habitat particularly in relation to the transfer of sediment laden waters from the drawdown activities in the southern basins.

9.0 TECHNICAL COMMENTS – DOWNSTREAM IMPACTS - FLOW

9.1 Documents Reviewed

- DeBeers Response to DFO Round #1 Information Requests (March 2012): IR# 7, 8, 10, 27, 28, 31, 34, 35, 36, 44, 45, 59
- DeBeers Response to DFO Round #2 Information Requests (Sept. 2012): IR#2-1

9.2 Proponent's Assessment and Conclusions

The Proponent has committed to developing operational procedures and protocols to support the flow mitigation plan during the detailed engineering design phase. The flow mitigation plan will be adapted and based on site-specific monitoring data – including the outmigration of adult and juvenile grayling.

Future downstream monitoring will be conducted, the details of which will be developed in the Aquatics Effects Monitoring Program (AEMP).

9.3 DFO’s Conclusions and Recommendations

DFO will review the final flow mitigation plans once completed in order to ensure that there is sufficient flexibility in terms of provisions to address timing and flow issues. Given the nature of the Project, where the issue of concern is the control of water releases and not water supply, it should be possible to design a flow mitigation plan that can meet the flow rates, timing and duration needs of Arctic grayling and thereby minimize downstream effects of mining operations.

Recommendation #9: The Proponent commit to developing and implementing a revised Flow Mitigation Plan that incorporates and details operational procedures and protocols. Implementation of the plan should be adaptable to enable adjustments for site-specific changes and should include:

- A summary of available overwintering habitat in the project area once the mine is operational;
- Measures to mitigate changes in water residency times and hydrologic pathways;
- Detailed downstream flow measurements, including from lakes N11 and N1 (issue outstanding from DFO IR #7, Round 1); and,
- A detailed plan on how downstream monitoring will be conducted (as part of the AEMP).

10.0 TECHNICAL COMMENTS – EFFECTS TO FISH AND FISH HABITAT AND OFFSETTING

10.1 Documents Reviewed

- DeBeers response to DFO Round #1 Information Requests (March 2012): IR# 38, 55, 58
- DeBeers response to DFO Round #2 Information Requests (Sept 2012): IR #2-2

10.2 Proponent’s Assessment and Conclusions

DeBeers has committed to developing a fish habitat compensation plan to offset fish habitat losses due to mine construction and operations as part of a required *Fisheries Act* Authorization. A combination of physical habitat enhancement projects and research options to reduce uncertainty are being discussed both with DFO and Aboriginal organizations. Flooding of lakes as a habitat compensation option is no longer proposed.

10.3 DFO’s Conclusions and Recommendations

DFO will continue to work with the Proponent on developing a fish habitat compensation plan that will address uncertainty and offset temporal and permanent losses of habitat due to the development of the Project, if approved. The Proponent is expected to provide a revised plan that includes the input of both DFO and affected communities. The details of the final compensation plan will be dependent on habitat losses associated with an approved mine plan.

Recommendation #10: To ensure that predicted impacts to fish habitat are identified and approaches to offset these impacts are developed, the Proponent is to provide a revised draft habitat compensation

plan to offset impacts to fish and fish habitat, acceptable to DFO, which includes input received from affected communities.

11.0 TECHNICAL COMMENTS – CLOSURE

11.1 Documents Reviewed

- DeBeers Response to DFO Round #1 Information Requests (March 2012): IR# 48, 49, 50, 51, 57, Dec 2010 EIS Plain Language Summary

11.2 Proponent's Assessment and Conclusions

The overall goal of the closure and reclamation plan is to minimize the lasting environmental impacts of operations to the extent practical and to allow disturbed areas to return to productive fish and wildlife habitat as quickly as possible.

11.3 DFO's Conclusions and Recommendations

The objective of the closure and reclamation plan should be to return the area to self-sustaining viable terrestrial and aquatic ecosystems. Closure objectives should have measurable criteria associated with them to determine when and if the objectives have been met.

Depending upon the final approved mine plan, areas of Kennady Lake will be subject to refilling after being dewatered and open pit mined, whereas other areas may have experienced inputs throughout the life of the mine. In all cases, re-establishing connectivity to the watershed in terms of inflows and downstream flow will be important for achieving closure goals.

A main component of DFO's assessment of impacts is a consideration of the ability to return what remains of Kennady Lake, post-mine development, back to a self-sustaining aquatic environment with a similar fish community structure to what is currently found in the lake. In order to achieve this goal, components of the aquatic ecosystem that are required to support sustainable fish populations must be restored in the impacted areas before allowing fish to re-colonize.

Tundra systems are characterized by shallow, low-nutrient soils, and sparse, slow growing vegetation – and as such riparian and aquatic vegetation in the Project area should be seen as sensitive. Vegetation-based fish habitat is limited in the Project area and likely critical for many species, such as pike, to fulfill their life history requirements. As these critical habitats would be impacted by mine development, particular efforts should be made to re-establish riparian and aquatic vegetation in order to return the Project area into a viable self-sustaining ecosystem post-closure, with as many habitat characteristics and heterogeneity as pre-development conditions. Re-vegetation efforts should include:

- stockpiling organic overburden, sediments, and lake bed materials for use in re-vegetation efforts, and
- replacing and enhancing lost northern pike spawning and rearing habitat

Recommendation# 11: During the refilling of Kennady Lake, all fish species and life stages should be excluded until the impacted areas are restored to the extent that they can support fish.

Recommendation #12: A comprehensive aquatic and riparian re-vegetation plan should be developed in consultation with DFO, and implemented as soon as possible to ensure that vegetation efforts are establishing as intended.

12.0 TECHNICAL COMMENTS – MISCELLANEOUS

12.1 Documents Reviewed

- DeBeers Response to DFO Round #1 Information Requests (March 2012): IR# 1, 2, 68

12.2 Proponent's Assessment and Conclusions

The Proponent explained their definitions and position on valued ecosystem components (IR#1), permanent impacts (IR#2), and definitions relating to downstream effects (IR#68).

It is the opinion of the Proponent that impacts associated with a timeframe of 100 years should not be considered permanent as it is based on their prediction of how long it will take for the aquatic ecosystem to become stable and productive after closure. They do acknowledge that the impacts would be considered long term.

12.3 DFO's Conclusions and Recommendations

DFO does not support the Proponent's assertion that impacts in the order of 100 years in duration are not permanent. An impact of this duration would be considered permanent to the VEC concerned given the impacts would extend over many generations of any of the fish in the watershed. If the habitat and fish community is successfully re-established to a level commensurate with its previous state, then that community would constitute new populations.

In Round 1 Information Requests, DFO identified a number of terms (long term, desired, and persistence) used in the EIS that needed to be defined due to their importance when considering potential impacts, mitigation, and residual effects. The definitions provided for "persistence" and "desired" are still too vague to be useful when they relate to thresholds and objectives, making it difficult to determine if downstream effects have occurred.

Recommendation #13: In order to allow for an accurate assessment of impacts to fish and fish habitat from the proposed Project and to move forward on the development of a plan to offset the predicted losses to fish and fish habitat, the duration of the potential impacts to VECs should be defined in a manner which is relevant to the lifecycle of the VEC of concern. More specifically, impacts which would extend beyond the lifecycle of one generation of fish within a given waterbody should be considered "permanent".

Recommendation #14: The Proponent should provide a clear definition for "desired" (in terms of populations) and "persistence" that includes some level of quantification as to what the future abundance and distribution of fish will be measured against to determine if downstream effects have occurred.

13.0 CONCLUDING REMARKS

As outlined in this report, DFO has a number of recommendations for the MVEIRB to consider in their deliberations on the Gahcho Kué Diamond Mine Project. Again, DFO would like to reiterate that these recommendations are made relative to DFO's mandate, the relevant legislation and the policies that were described previously in this document.

The final, acceptable mine plan, based upon a complete assessment of alternatives including those approaches that will facilitate the development of a self-sustaining aquatic ecosystem and connected watershed at closure, is still to be determined. The final mine plan will dictate the extent of fish and fish habitat impacts to be considered in the regulatory phase.

With the implementation of recommendations intended to minimize aquatic impacts outlined above, the application of appropriate mitigation measures, follow-up and monitoring programs, and with the development of a plan to provide adequate compensation for residual habitat losses, impacts to fish and fish habitat can be addressed.

Any related authorizations issued by DFO will contain specific conditions to ensure that mitigation measures for the protection of fish and fish habitat are implemented; that monitoring and follow-up studies to address the efficacy of mitigation measures and verify impact predictions are undertaken; and that habitat losses identified are adequately offset.

In closing, DFO welcomes this opportunity to share our views with the Board and to provide this information for their consideration in reaching a decision with respect to Gahcho Kué Diamond Mine Project.

14.0 SUMMARY OF RECOMMENDATIONS

Recommendation #1: The Proponent commit to adopting and using a set of standardized, repeatable methods for baseline collections, which include additional reference lakes, adequate methods for sampling reference lakes, water clarity, sediment quality, benthic invertebrates and plankton as outlined in Section 2.3, to ensure that appropriate data are collected prior to any development. Standard methods should be used for all aquatic and fisheries sampling.

Recommendation #2: The Proponent provides a revised table to DFO that includes a summary of information pertaining to fish overwintering habitat (e.g. ice thickness, waterbody size, maximum depth, dissolved oxygen, sample dates).

Recommendation #3: The Proponent commit to providing a revised tabulated summary of the pre-impacted study area streams including a detailed description of the existing substrates within these streams.

Recommendation #4: The Proponent should further evaluate alternatives which allow area 7 to be retained as it provides very important overwintering habitat for VEC species identified in the EIS. If it is

determined not to be feasible, the Proponent should consider alternatives that would refill area 7 as soon as possible after dyke construction to reduce further impacts to fish and fish habitat.

Recommendation #5: The Proponent commit to developing and implementing a sediment and erosion plan for dyke construction which includes the use of best management practices (such as the use of silt curtains) to prevent potential sediment release into fish bearing waters, and impacts to fish and fish habitat. This plan should include contingencies (including thresholds for triggering contingency actions) to be followed should the proposed mitigation not work as intended.

Recommendation #6: The Proponent commit to establishing minimum water level thresholds with a mitigation action plan to be initiated should these thresholds be approached in order to protect littoral habitats in water-withdrawal lakes including area 8.

Recommendation #7: The Proponent commit to address impacts to stream habitat from changes in drainage patterns for inflow streams.

Recommendation #8: In addition to the Proponent's plan to utilize *in situ* flocculation to reduce sediment, the Proponent is encouraged to assess and implement current best management practices to further mitigate impacts of suspended sediment to fish habitat particularly in relation to the transfer of sediment laden waters from the drawdown activities in the southern basins.

Recommendation #9: The Proponent commit to developing and implementing a revised Flow Mitigation Plan that incorporates and details operational procedures and protocols. Implementation of the plan should be adaptable to enable adjustments for to site-specific changes and should include:

- A summary of available overwintering habitat in the project area once the mine is operational;
- Measures to mitigate changes in water residency times and hydrologic pathways;
- Detailed downstream flow measurements, including from lakes N11 and N1 (issue outstanding from DFO IR #7, Round 1); and,
- A detailed plan on how downstream monitoring will be conducted (as part of the AEMP).

Recommendation #10: To ensure that predicted impacts to fish habitat are identified and approaches to offset these impacts are developed, the Proponent is to provide a revised draft habitat compensation plan to offset impacts to fish and fish habitat, acceptable to DFO, which includes input received from affected communities.

Recommendation# 11: During the refilling of Kennady Lake, all fish species and life stages should be excluded until the impacted areas are restored to the extent that they can support fish.

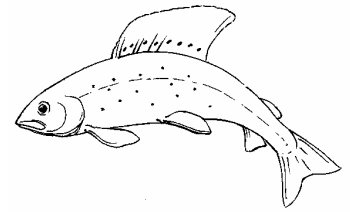
Recommendation# 12: A comprehensive aquatic and riparian re-vegetation plan should be developed in consultation with DFO, and implemented as soon as possible to ensure that vegetation efforts are establishing as intended.

Recommendation #13: In order to allow for an accurate assessment of impacts to fish and fish habitat from the proposed Project and to move forward on the development of a plan to offset the predicted losses to fish and fish habitat, the duration of the potential impacts to VECs should be defined in a manner which

is relevant to the lifecycle of the VEC of concern. More specifically, impacts which would extend beyond the lifecycle of one generation of fish within a given waterbody should be considered “permanent”.

Recommendation #14: The Proponent should provide a clear definition for "desired" (in terms of populations) and "persistence" that includes some level of quantification as to what the future abundance and distribution of fish will be measured against to determine if downstream effects have occurred.

APPENDIX I – WATER WITHDRAWAL PROTOCOL



DFO Protocol for Winter Water Withdrawal from Ice-covered Waterbodies in the Northwest Territories and Nunavut

Rationale

In the Northwest Territories and Nunavut, winter activities such as access road construction, exploratory drilling and camp operations often require large amounts of water. Excessive amounts of water withdrawn from ice-covered waterbodies can impact fish through oxygen depletion, loss of over-wintering habitat and/or reductions in littoral habitat. The potential for such negative impacts to over-wintering fish and fish habitat has made winter water withdrawal a critical issue for Fisheries and Oceans Canada (DFO) in the Northwest Territories and Nunavut. To mitigate impacts to fish from water withdrawal from ice-covered waterbodies, and to provide standardized guidance to water users, including volume limits for certain water source types, DFO has developed this protocol in conjunction with industry and other regulators.

For the purposes of this protocol, a **waterbody** is defined as any water-filled basin that is potential fish habitat. A waterbody is defined by the ordinary high water mark of the basin, and excludes connecting watercourses.

This protocol will **not** apply to the following:

- Any waterbody that is exempted by DFO (e.g. Great Bear Lake, Great Slave Lake, Gordon Lake, and others as and when determined by DFO), and;
- Any waterbody from which less than 100m³ is to be withdrawn over the course of one ice-covered period.

In order to establish a winter water withdrawal limit for a given waterbody, the following criteria must be adhered to:

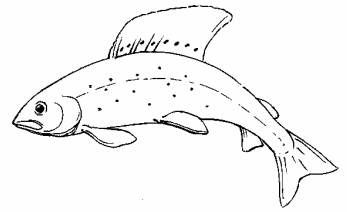
1. In one ice-covered season, total water withdrawal from a single waterbody is not to exceed 10% of the available water volume calculated using the appropriate maximum expected ice thickness provided in Table 1.
2. In cases where there are multiple users withdrawing water from a single waterbody, the total combined withdrawal volume is not to exceed 10% of the available water volume calculated using the appropriate maximum expected ice thickness provided in Table 1. Therefore, consistent and coordinated water source identification is essential.
3. Only waterbodies with maximum depths that are $\geq 1.5\text{m}$ than their corresponding maximum expected ice thickness should be considered for water withdrawal (Table 1). Waterbodies with less than 1.5m of free water beneath the maximum ice are considered to be particularly vulnerable to the effects of water withdrawal.
4. Any waterbody with a maximum expected ice thickness that is greater than, or equal to, its maximum depth (as determined from a bathymetric survey) is exempt from the 10% maximum withdrawal limit (Table 1).

To further mitigate the impacts of water withdrawal, water is to be removed from deep areas of waterbodies (>2m below the ice surface) wherever feasible, to avoid the removal of oxygenated surface waters that are critical to over-wintering fish. The littoral zone should be avoided as a water withdrawal location. Water intakes should also be properly screened with fine mesh of 2.54 mm (1/10") and have moderate intake velocities to prevent the entrainment of fish. Please refer to the *Freshwater Intake End-of-Pipe Fish Screen Guideline* (DFO, 1995) which is available upon request, or at the following internet address: www.dfo-mpo.gc.ca/Library/223669.pdf.

In order to determine the maximum water withdrawal volume from an ice-covered waterbody, and thereby conform to this protocol, the following information must be provided to DFO for review and concurrence prior to program commencement.

Water Source Identification

1. Proposed water sources, access routes, and crossing locations clearly identified on a map, with geographical coordinates (latitude/longitude and/or UTM) included.
2. Any watercourse connectivity (permanently flowing and/or seasonal) between the proposed water source and any other waterbody or watercourse.



DFO Protocol for Winter Water Withdrawal from Ice-covered Waterbodies in the Northwest Territories and Nunavut

3. Aerial photos or satellite imagery of the water sources.
4. Estimated total water withdrawal requirement for work or activity and estimated total water withdrawal per water source (in m³).

Bathymetric Survey Results

1. For all waterbodies: One longitudinal transect, connecting the two farthest shorelines, is to be conducted regardless of waterbody size. Note: a longitudinal transect may be straight or curved in order to accommodate the shape of a lake (see Figure 1).
2. For waterbodies equal to or less than 1 km in length: a minimum of one longitudinal transect and two perpendicular transects are to be conducted. Perpendicular transects should be evenly spaced on the longest longitudinal transect, dividing the lake into thirds (Figure 1).
3. For lakes greater than 1 km in length: a minimum of one longitudinal transect is to be conducted. Perpendicular transects (minimum of 2) should be evenly spaced on the longest longitudinal transect at maximum intervals of 500 m.
4. Additional transects should be run as required to include irregularities in waterbody shape such as fingers or bays (Figure 1).
5. All longitudinal and perpendicular transects are to be conducted using an accurate, continuous depth sounding methodology, such as open water echo sounding or ground penetrating radar (GPR), that provides a continuous depth recording from one shore to the farthest opposing shore (Figure 1). Any alternative technology should be reviewed by DFO prior to implementing for bathymetric surveys.

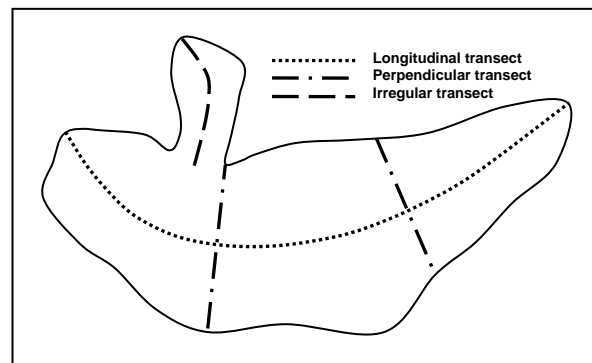
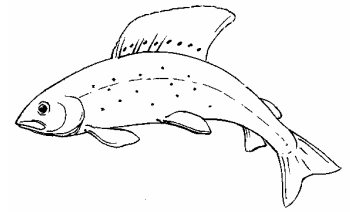


Figure 1. Minimum transect layout for a lake that is less than 1 km in length, with an irregularity.

Volume Calculations

1. Document the methods used to calculate surface area. If aerial photos or satellite imagery were used, provide the date (day/month/year) taken, as surface area may change depending on the time of year. If maps were used, provide the year that they were surveyed.
2. Detail the methods used to determine the total volume of free water, incorporating the relevant bathymetric information.
3. Calculate the available water volume under the ice using the appropriate maximum expected ice thickness, i.e. $Total\ Volume_{lake} - Ice\ Volume_{max\ thickness} = Available\ Water\ Volume$ (see Table 1 for maximum ice thickness).
4. For programs where ice-chipping is used, the total ice volume to be removed from the waterbody should be converted to total liquid volume and incorporated into the estimate of total water withdrawal requirement per water source.



DFO Protocol for Winter Water Withdrawal from Ice-covered Waterbodies in the Northwest Territories and Nunavut

Table 1. Maximum expected ice thickness, and corresponding water depth requirements, for different regions in the Northwest Territories.

Area	Maximum Expected Ice Thickness (m)	Minimum Waterbody depth Required for 10% Water Withdrawal (m)
Above the Tree Line	2.0	≥3.5
Below the Tree Line - North of Fort Simpson	1.5	≥3.0
Deh Cho –South of Fort Simpson	1.0	≥2.5

A brief project summary report documenting and confirming total water volume used per water source and corresponding dates should be submitted to DFO within 60 days of project completion. Information should be provided in the following format (this information would also be useful as part of the project description):

Lake ID	number and/or name
Coordinates	latitude and longitude and/or UTM coordinates
Surface area	in ha
Total Lake Volume	in m ³
Under Ice Volume	in m ³ (based on max ice thickness for region)
Max expected ice thickness value used	in m
Calculated 10% Withdrawal volume	in m ³
Total required water volume extracted	in m ³
Aerial photographs of waterbody	PDF format
Bathymetric Map(s) of waterbody	PDF format

Any requests deviating from the above must be submitted to DFO and will be addressed on a site-specific basis.

Beaver and Muskrat

Many species of animals are highly sensitive to water fluctuations. In areas where beaver and muskrat may occur, the appropriate agencies or organizations should be consulted to determine if harmful effects will result from your activities, and whether these effects can be successfully mitigated through modifications to your plans including best management practices.

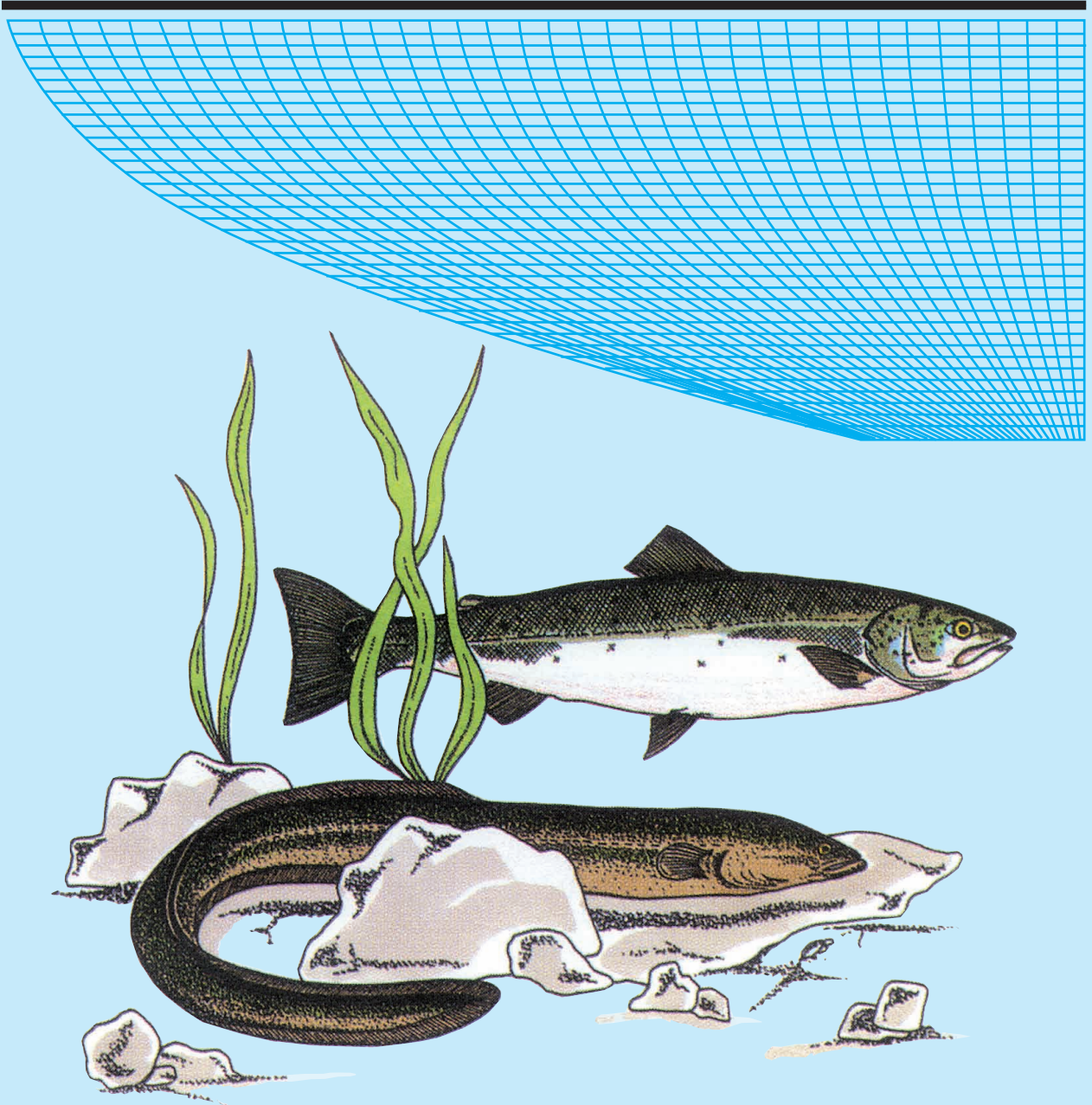
Please note that adherence to this protocol does not release the proponent of the responsibility for obtaining any permits, licenses or authorizations that may be required.

For more information contact DFO at (867) 669-4915.

APPENDIX II - DFO FRESHWATER INTAKE END-OF-PIPE FISH SCREEN GUIDELINE

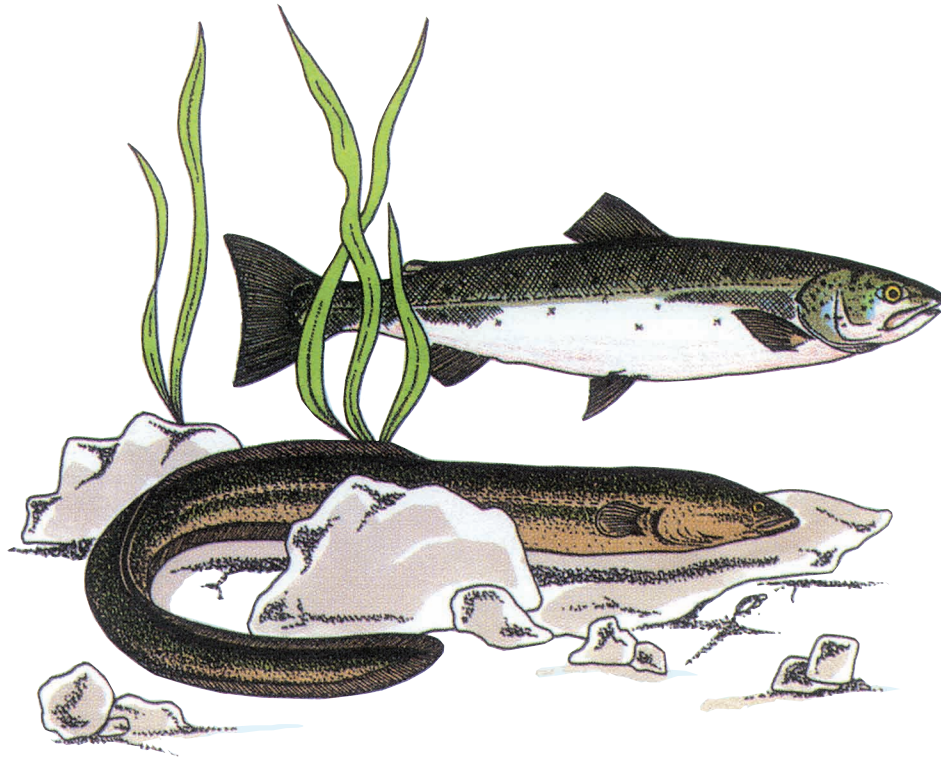
Department of Fisheries and Oceans

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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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 for 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 m³/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

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 Screens

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

Table 1
Summary of
Common Fish
Species and
Swimming Modes

SUBCARANGIFORM SWIMMING MODE

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

ANGUILLIFORM SWIMMING MODE

Common Name	Scientific Name
American Eel	<i>Anguilla rostrata</i>
Burbot	<i>Lota lota</i>
Sea Lamprey	<i>Petromyzon marinus</i>

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

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 Screen
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.

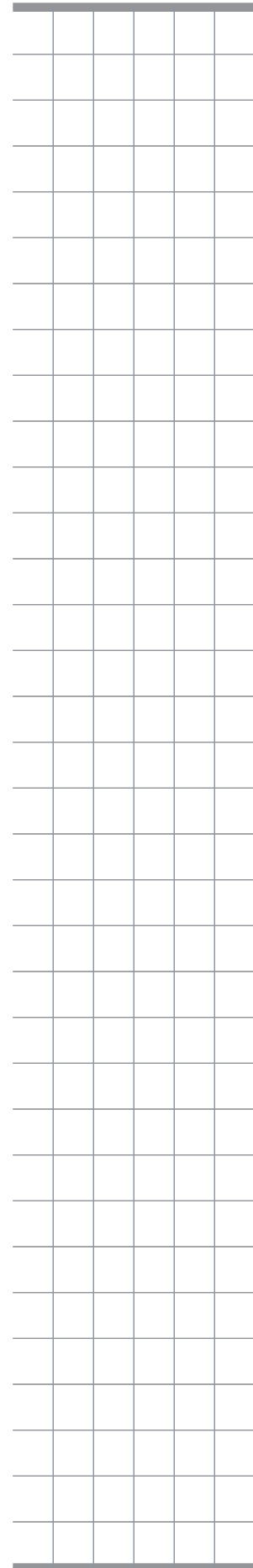


Figure 1
Open Screen Area
for End-of-Pipe
Water Intake Flow

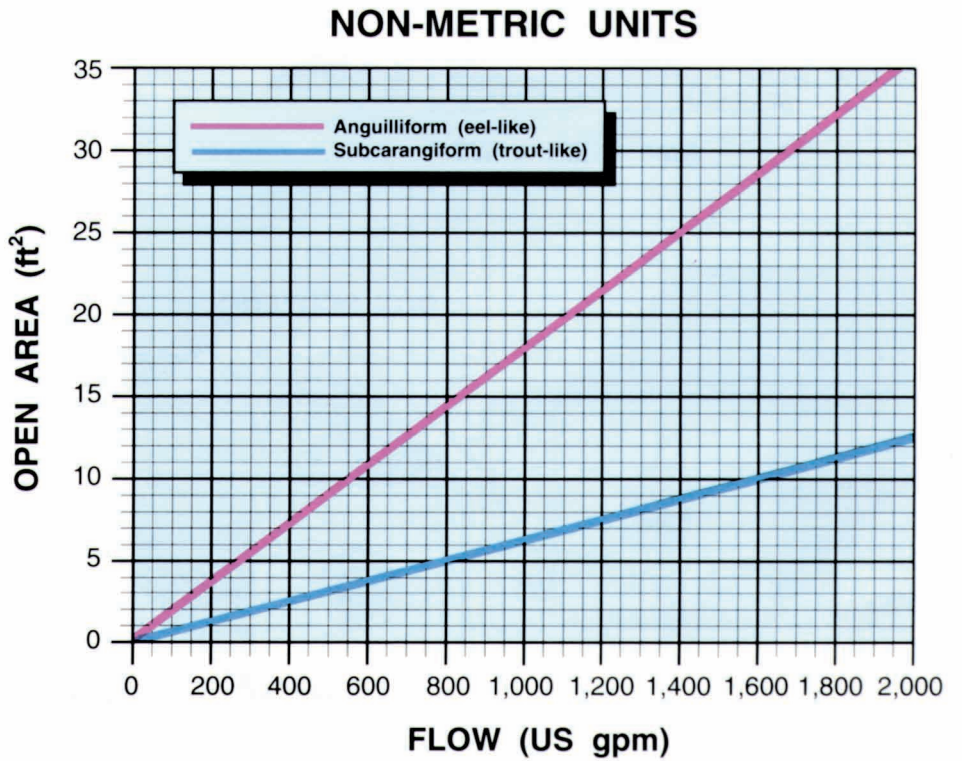
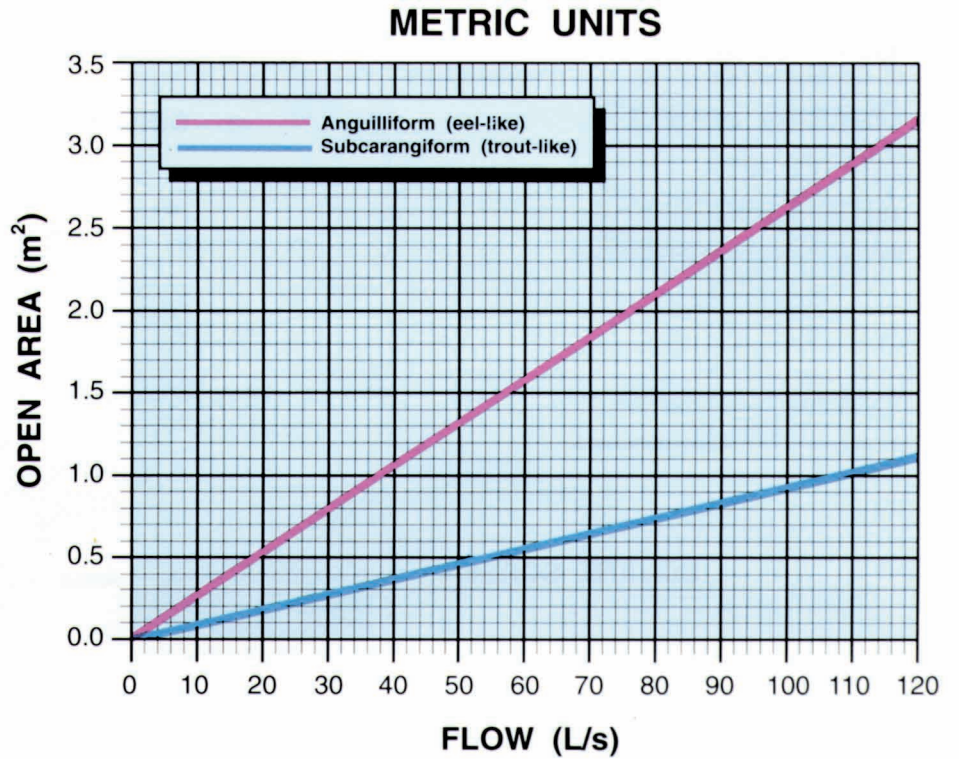
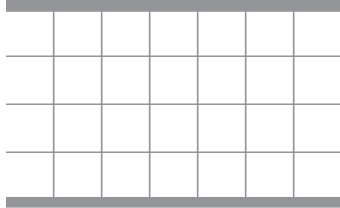
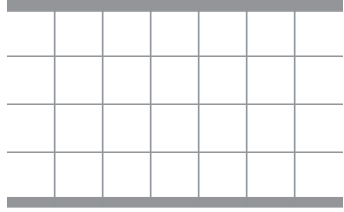
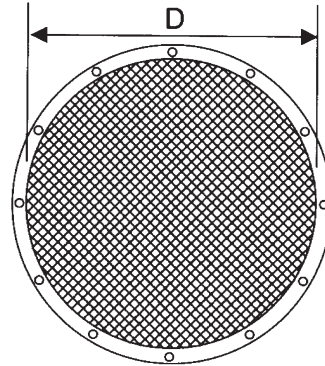


Figure 2
Common Screen
Shapes and Area
Formulae

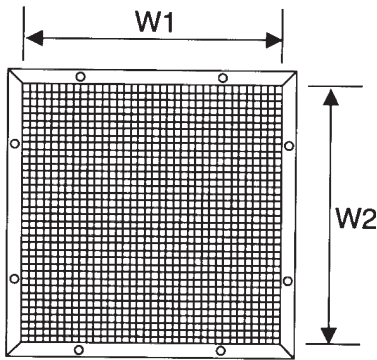


CIRCULAR SCREEN



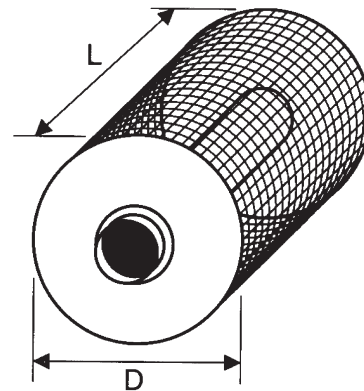
$$\text{Area} = \frac{\pi D^2}{4}$$

SQUARE SCREEN



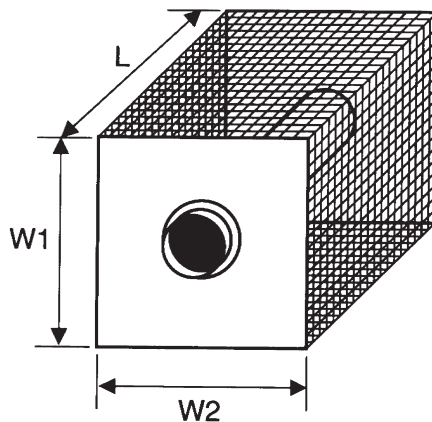
$$\text{Area} = W1 \times W2$$

CYLINDRICAL SCREEN



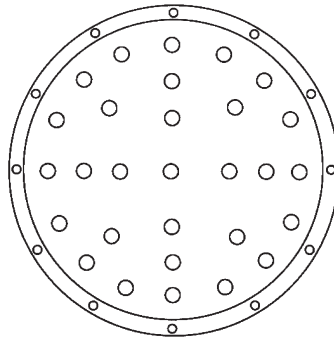
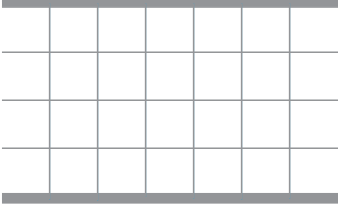
$$\text{Area} = \pi DL$$

BOX SCREEN

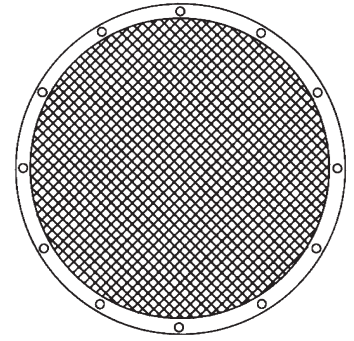


$$\text{Area} = 2L(W1 + W2)$$

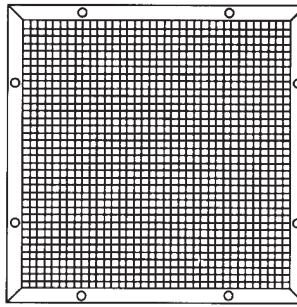
Figure 3
Typical Applications
and Features of
End-of-Pipe Screens



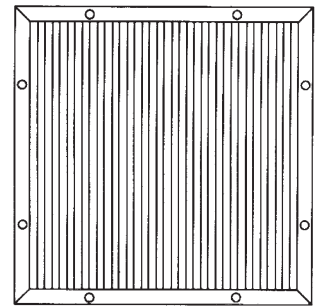
**PERFORATED PLATE
(PUNCHED)**



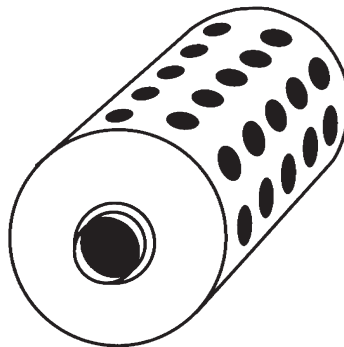
**CIRCULAR MESH
SCREEN**



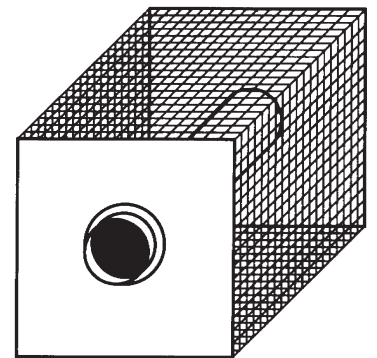
**SQUARE MESH
SCREEN**



**SQUARE WEDGE WIRE
SCREEN**

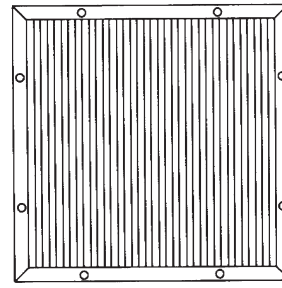
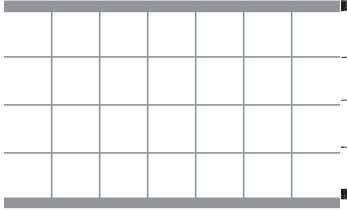


**DRUM OR CYLINDER
WITH PERFORATED PIPE**

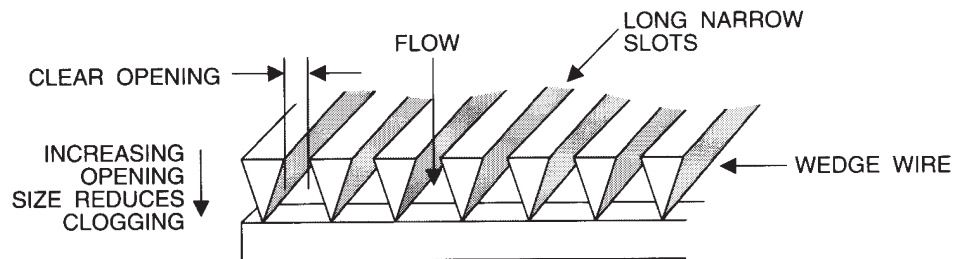


**BOX-TYPE WITH
MESH SCREEN**

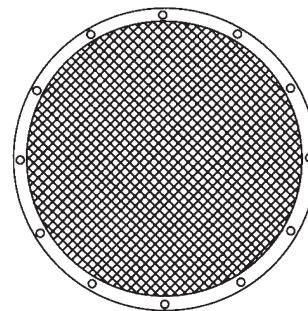
Figure 4
Examples of Typical
Screen and Material
Types



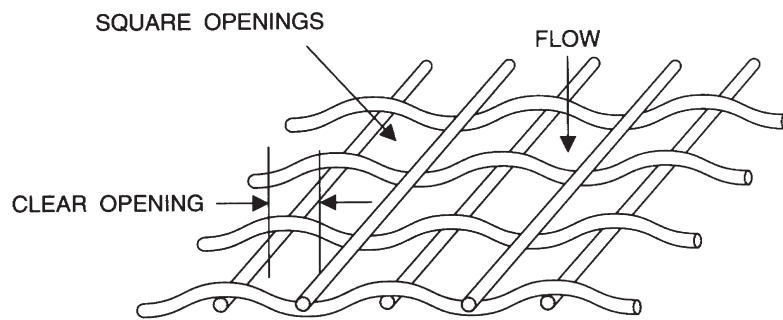
SQUARE WEDGE WIRE SCREEN



WEDGE WIRE PROFILE

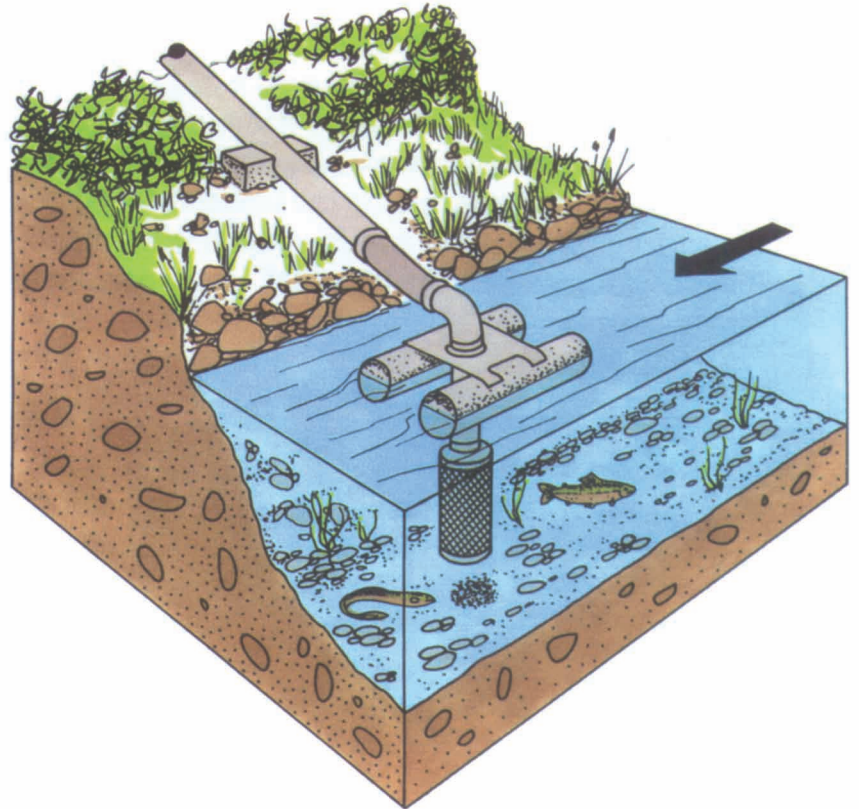
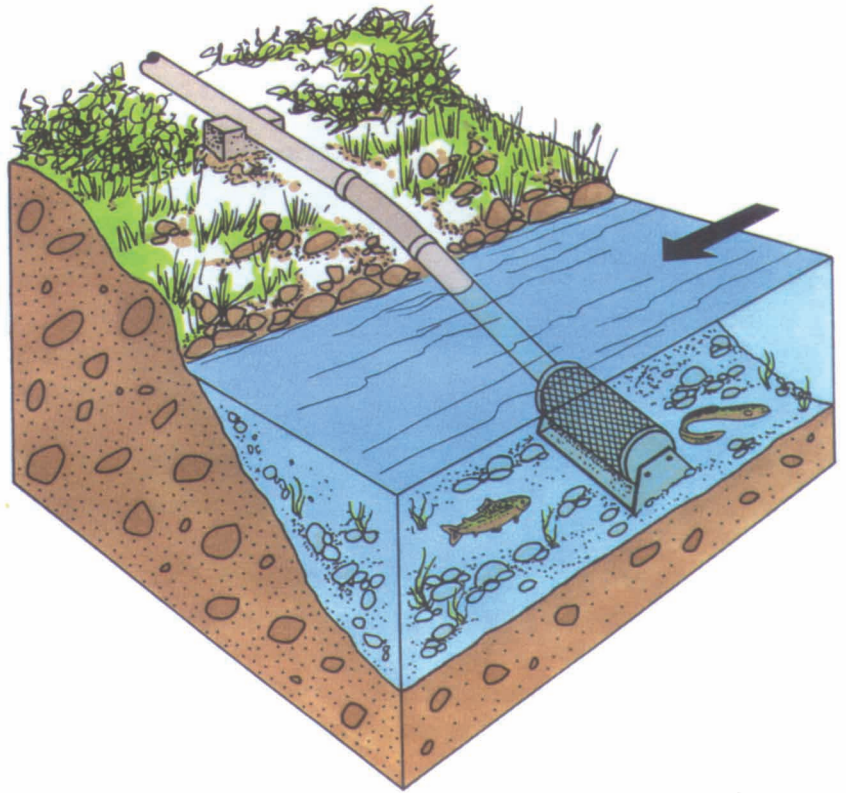


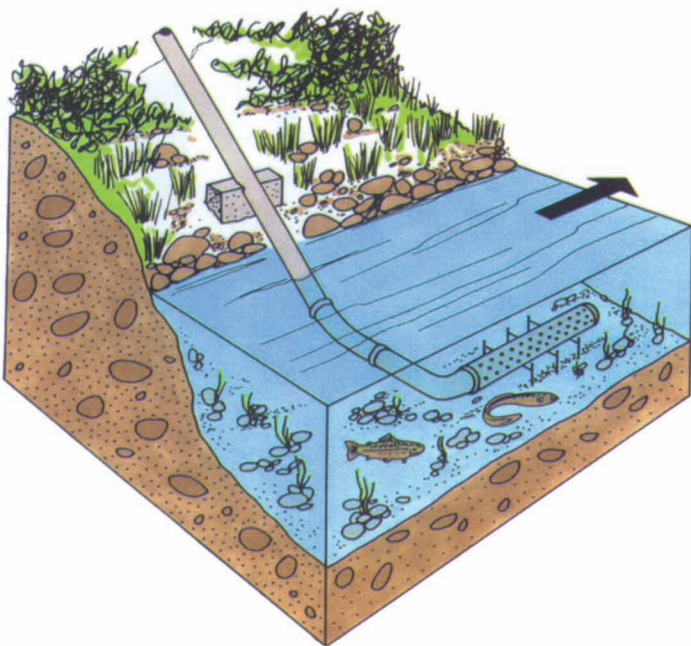
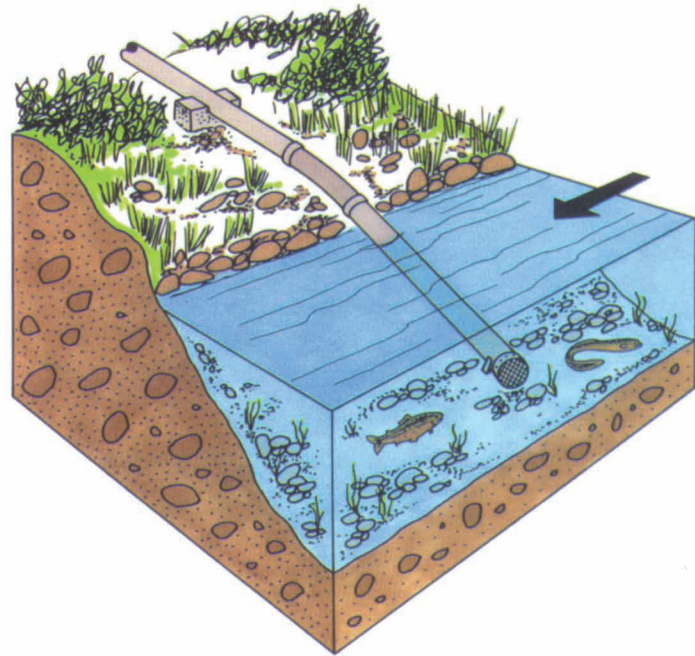
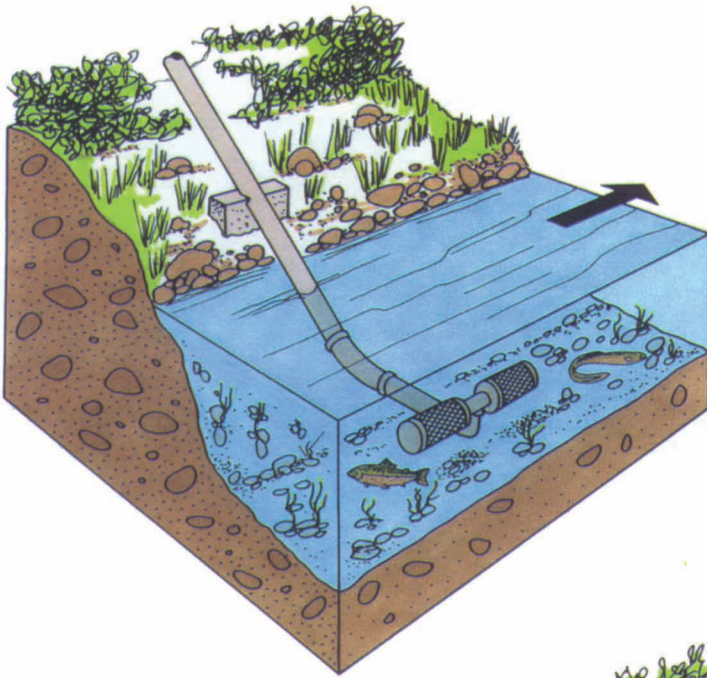
CIRCULAR MESH SCREEN



WOVEN WIRE MESH PROFILE

Figure 5
Examples of Typical
Installations of End-
of-Pipe Screen





4.4 Cleaning and Maintenance

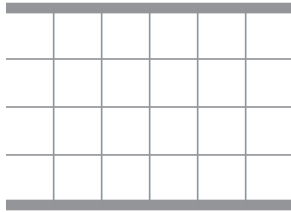
- Provision should be made for the removal, inspection, and cleaning of screens.
- Ensure regular maintenance and repair of cleaning apparatus, seals, and screens is carried out to prevent debris-fouling and impingement of fish.
- Pumps should be shut down when fish screens are removed for inspection 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,

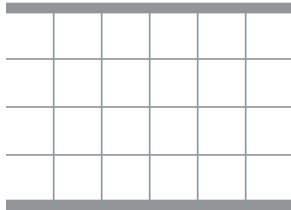
Katopodis, C. 1990. *Advancing the art of engineering fishways for upstream migrants*. Proceedings of International Symposium on Fishways '90, Oct. 8-10, 1990, Gifu, Japan, p. 19-28.

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. *Ichthyomechanics*, 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

Appendix B Sample Calculation

A proponent wishes to withdraw water at a rate of 0.075 m³/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, it is necessary first to convert the flow from cubic metres per second to litres per second.

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

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

- 0.69 m² for subcarangiform swimmers, and
- 1.96 m² for anguilliform swimmers.

The higher number (1.96 m²) 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.

$$\begin{aligned}\text{Effective Screen Area} &= \frac{\text{Open Screen Area}}{\left(\frac{\% \text{ Open Area}}{100}\right)} \\ &= \frac{1.96 \text{ m}^2}{\left(\frac{63}{100}\right)} \\ &= 3.111 \text{ m}^2\end{aligned}$$

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:

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

$$3.111 \text{ m}^2 = (0.600 \text{ m})L$$

$$3.111 \text{ m}^2 = (1.885 \text{ m})L$$

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

$$L = 1.65 \text{ m}$$

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.