Ontario Power Generation

Coniston Generating Station Life Extension Project

Supplementary Report (Final)

July 2024

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APPENDICES

Tables

Figures

1 Introduction

This Supplementary Report describes modifications to the Coniston Generating Station Life Extension Project (CSLEP) and assesses whether an Addendum may be required to the Class Environmental Assessment (EA) Environment Reports. In this Report, the revised project as proposed in 2024 is referred to as the "Revised 2024 Project" and the version of the project presented in the Ontario Waterpower Association (OWA) Class EA Report is presented as the "2023 Project". The CSLEP was subject to the OWA, 2018 Class Environmental Assessment for Waterpower Projects (Class EA). A Final Environmental Report (ER) was prepared as part of this Class EA planning process and made available for public review for the period from January 28, 2023, to April 16, 2023 (which exceeded the minimum of 30 days). No requests for a section 16 order under the *Environmental Assessment Act* that the Minister make an order requiring a higher level of study (i.e. an individual/comprehensive EA) or that conditions be imposed on the Project. were made for the Project during the public review period. A Statement of Completion of the Class EA process for the Project was filed with the Ontario Ministry of the Environment Conservation and Parks on April 17, 2023.

The issue with respect to whether revisions of a project trigger any further OWA Class EA requirements is discussed in the OWA (2018) Class EA section 8.8, which is quoted below with key statements highlighted in bold (our emphasis).

> "**The purpose of the addendum provisions is to require proponents to consider the significance of changes to projects after completing the Class EA process** or with implementation of a project more than five years after filing a Statement of Completion, and to require consultation on changes that are environmentally significant. **The changes may include**, for example, environmental conditions, **alternative project approach**, new government policies, new engineering standards or new technologies for mitigating measures.
>
> Circumstances under which proponents must apply the addendum provisions outlined in this section:
>
> - Where a project has been planned in accordance with the Class EA, **but where a proponent decides prior to or during construction that it is not feasible or desirable to implement the project in the manner described in the completed ER**.
> - Where a project has been constructed/implemented as described in a completed ER under the Class EA or Screening Report/Environmental Review Report under the Environmental Screening Process, and where the proponent wishes to make a minor modification to the project.
> - Where a project was approved under an individual EA[1], and the proponent wishes to make a minor modification to the project that is not covered by the original approval.
>
> For the purposes of this Class EA, a minor modification is a modification that is below the threshold for a significant modification under the Electricity Projects Regulation. A significant modification is any expansion of or change in the facility that would increase the name plate capacity of the facility by 25 per cent or more.

[1] This text suggests this bullet is only relevant to an Individual EA and not a Class EA.

> **Proponents shall determine, through technical review and/or consultation with interested and affected parties and by applying the potential effects identification matrix set out in Table 3[2], whether the proposed change to the project may have new negative effects to the environment."**

Therefore, this Report addresses the subject of whether the proposed changes may have new negative effects to the environment.

There is no change to the proposed capacity (megawatts) from the 2023 Project to the Revised 2024 Project.

[2] Table 3 is the Potential Effects Identification Matrix in the OWA Class EA and lists just under 50 different criteria to evaluate a project against.

2 Project Changes

The Project Changes in summary form are as follows:

- The proposed powerhouse will now be situated on the footprint of the existing powerhouse and utilizes portions of its existing substructure. The concept proposed in the 2023 Project (as presented in the Class EA ER and Figure 2-2 below) showed a new powerhouse location upstream of the current one.
- Replacement of the proposed SAXO or Kaplan Turbines with a new DIVE Turbine option.
- Eliminating the intake velocity work and major civil canal changes (reduced canal excavation, maintain existing canal walls, reduced site grading).
- Moving the upstream cofferdam to within the intake canal, thereby reducing the area of, and within, the upstream cofferdam.
- Eliminating or reducing the area and duration of the downstream cofferdam.
- The Bridge Replacement will maintain the existing abutment locations and centre pier. The work may be done in advance of the majority of the work.

The proposed changes to the project will reduce the amount of excavation required for the project and therefore reduce all the construction activities associated with that work.

The temporary construction stage laydown and materials stockpile area is also reduced in size (see Figure 2-2).

There is no change to the proposed capacity (megawatts) from the 2023 Project to the Revised 2024 Project.

2.1 Changes to the Overall Site Design and Layout

The proposed changes to the overall site design and layout are shown in the Figures below.

The 2024 Revised Project is shown below in Figure 2-1.

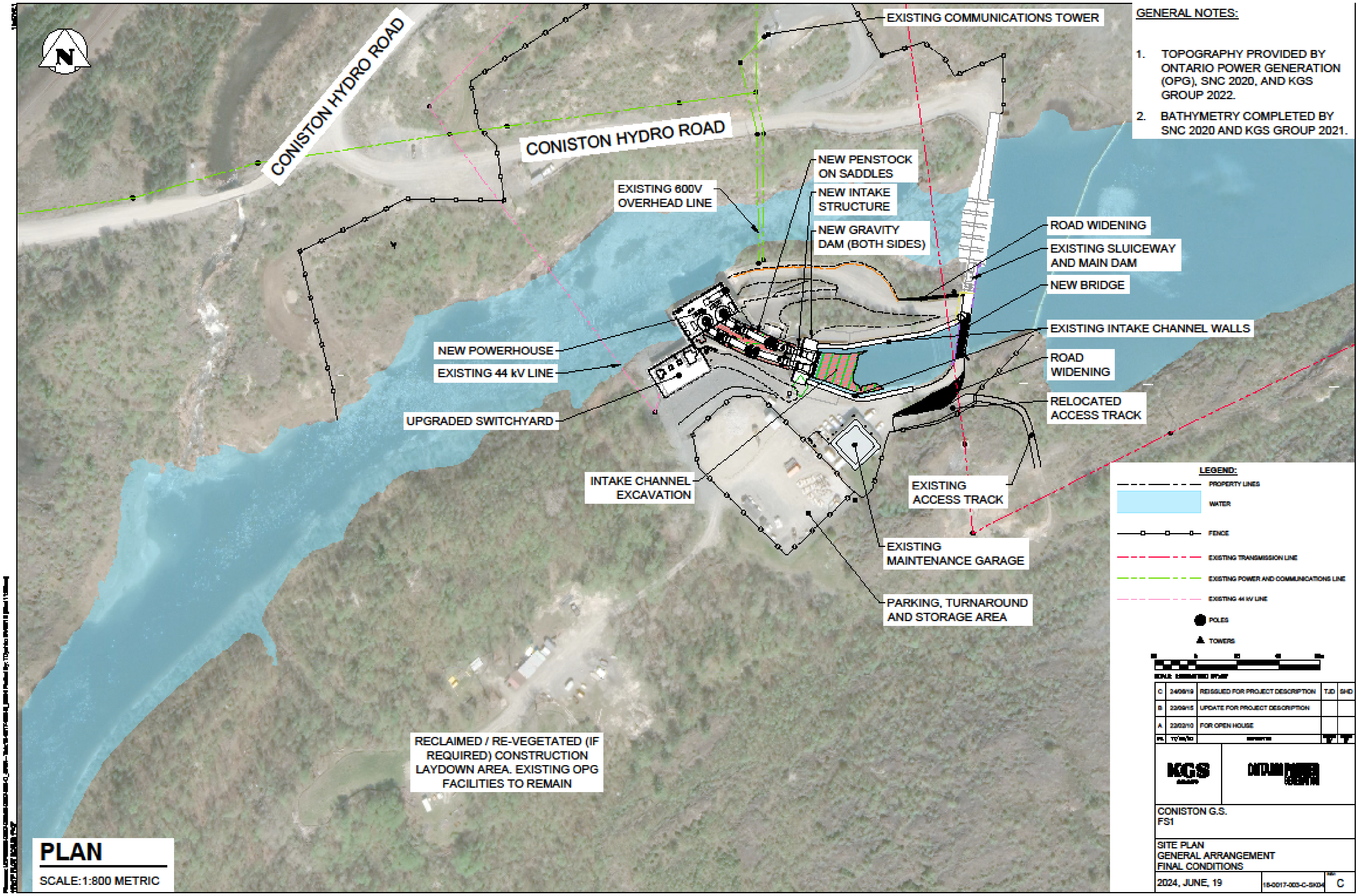


Figure 2-1 Revised 2024 Project

The 2023 Project is shown in the Figure 2-2 below.

Figure 2-2 2023 Project

Figure 2-3 below shows the Existing Conditions.

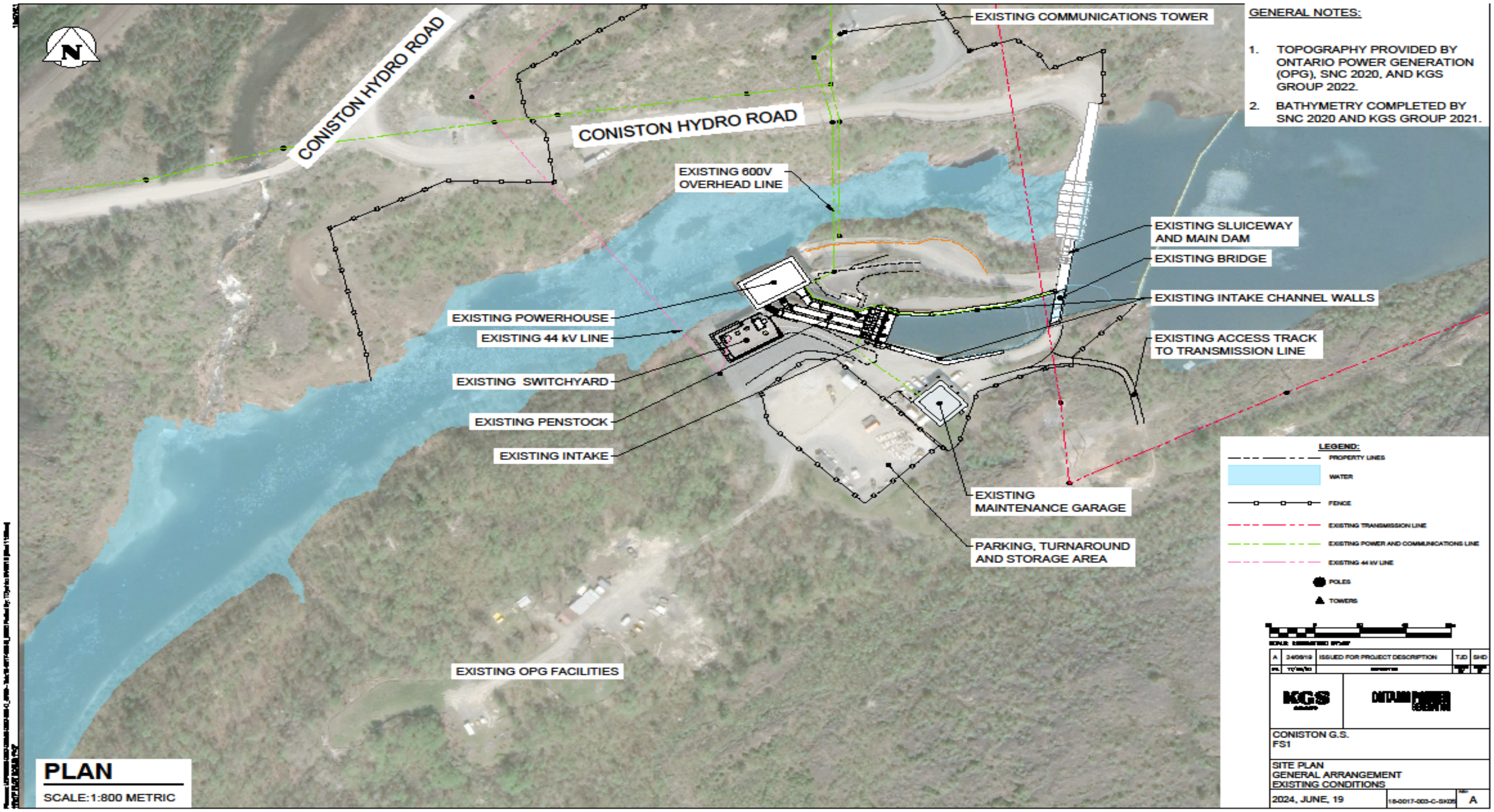


Figure 2-3 Existing Conditions

Figure 2-4 below shows the Revised 2024 Project for the construction stage.

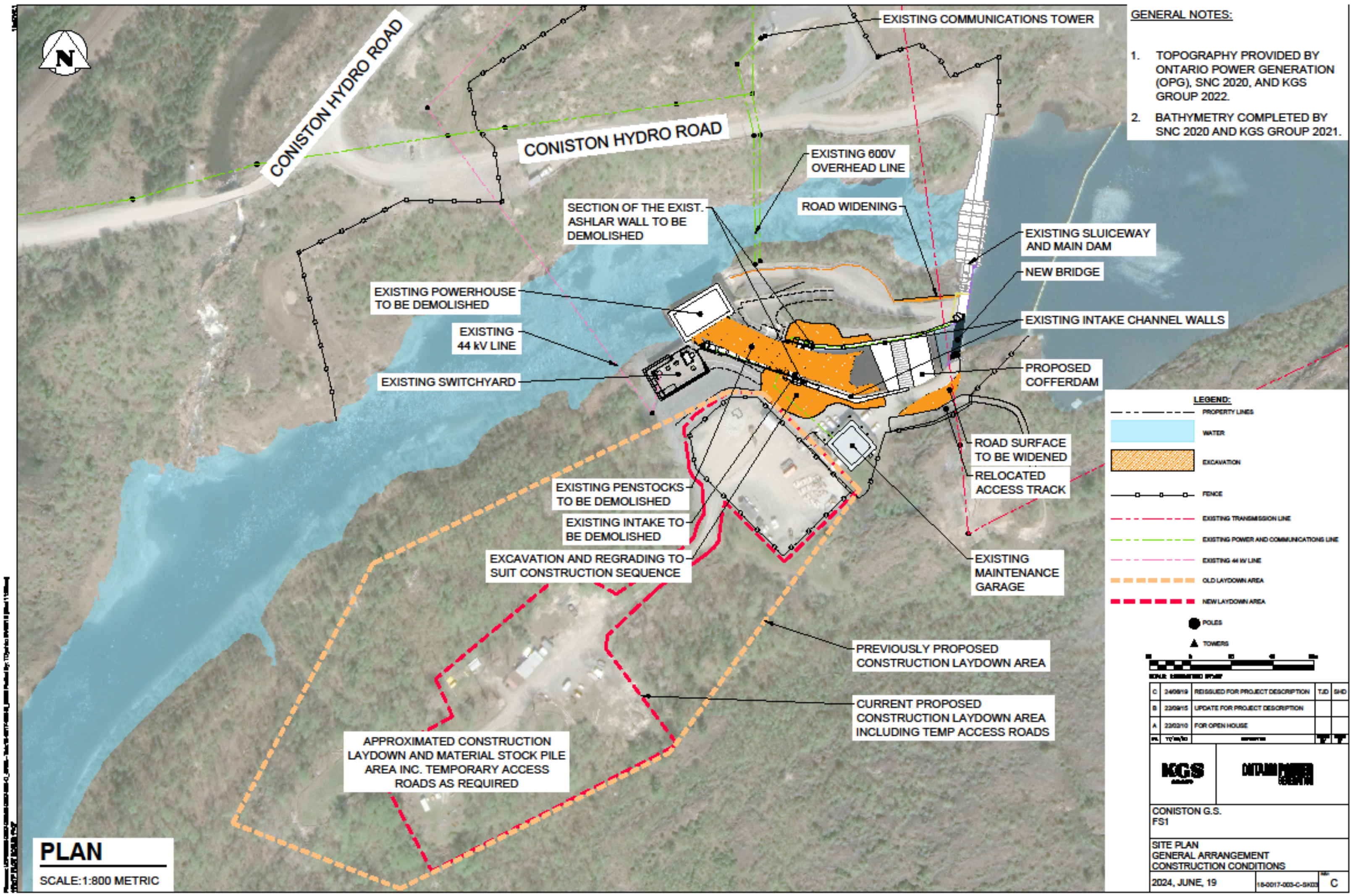


Figure 2-4 2024 Project General Arrangement Construction Stage

2.2 Turbine Changes

The Revised 2024 Project will involve using DIVE turbines instead of Kaplan or SAXO type turbines as previously proposed. Appendix A provides information on the DIVE turbine.

DIVE Turbines are Fit for Purpose, and greatly reduce civil work in comparison to Kaplan or SAXO type turbines. The general features of the DIVE turbines and their benefits for the project are as follows:

- Fit in current powerhouse footprint and can utilize the existing draft tubes.
- Civil work below the floor of the current powerhouse will be limited.
- No downstream cofferdam will be required.
- No permanent tailrace gates are required.
- Turbines are more fish friendly versus SAXO type turbines.

Figure 2-5 shows a DIVE unit and how such units would be laid out within the Coniston powerhouse.

Figure 2-5 Dive Unit Layout

2.3 Upstream Work

The Revised 2024 Project will involve the following changes:

- Reducing the scope of the bridge replacement to the deck and minor modifications to the existing abutments. The centre pier and existing abutments will remain.
- Eliminating Intake channel velocity work (included excavation within the canal and upstream of the existing bridge, widening of the bridge span and elimination of the centre pier) which will leave the velocity in the approach canal similar to existing/historical conditions.
- Eliminating Major civil canal changes (included replacement of the existing canal walls and re-grading to support).
- Construction of 2 penstocks between the new intake and the existing powerhouse.

Canal excavation will still be required upstream of the new intake within the intake canal to provide the required unit submergence. Velocity targets local to the new intake and trashrack remain similar to the 2023 design.

2.4 Cofferdams

The Revised 2024 Project significantly reduces the potential area and length of cofferdams in the river. The Revised 2024 Project involves:

- Moving the upstream coffer dam to within the intake canal, thereby reducing the area of, and within, the upstream cofferdam.
- Eliminating the need for the downstream cofferdam.

2.5 Other Changes

The changes already described in Sections 2.1 to 2.4 reduce:

- The overall length of the construction period to approximately 15 to 18 months.
- Significantly reduce the amount of material that will need to be excavated for the project.
- A revised intake geometry and added gravity dams alongside to allow placement of the intake within the existing canal and tie into existing structures. The intake will have two isolation gates with a monorail hoist.
- Rework of road grading and road slopes.
- Rework of onsite power and communications infrastructure.
- The Revised 2024 Project is expected to use a smaller temporary laydown construction area than the project proposed in 2023.

3 Environmental Impact

The environmental impact is assessed based on examining various components of the environment.

3.1 OWA Class EA Potential Effects Identification Matrix

As was previously identified the project is to be assessed according to Table 3 of the OWA Class EA which is the Potential Effects Identification Matrix. The Potential Effects are rated as one of:

- High Negative;
- Low Negative;
- Nil or Negligible;
- Unknown;
- Low Positive; or
- High Positive.

The effect that is being assessed is the comparison of the Revised 2024 Project to the 2023 Project.

In Table 3-1 below, all the mitigation and monitoring measures proposed as part of the 2023 Project would also be required for the Revised 2024 Project unless specifically noted otherwise.

Table 3-1 Potential Environmental Effects Change (Table Represents the Revised 2024 Project compared to the 2023 Project)

Criteria	Potential Level of Effect						Comments, Rationale (before and after mitigation)
	-H	-L	NIL	Unk	+L	+H	
General Natural Environment Considerations							
Air quality					X		• The Revised 2024 Project will reduce the amount of excavation and overall duration of construction and therefore the number of hours of equipment operation is reduced and therefore results in a positive air quality effect.
Facility Resilience to Climate Change			X				• The Revised 2024 Project will not change the facility's overall resilience to climate change from the 2023 Project.
Climate Change Impacts (mitigation of)					X		• The Revised 2024 Project will reduce the amount of excavation and overall duration of construction and therefore the number of hours of equipment operation is reduced and therefore will result in the emission of fewer greenhouse gases.
Water quality (surface water)					X		• The Revised 2024 Project will reduce the length of time and area cofferdams are proposed to be in place. The overall amount of excavation on the site is also reduced. Both changes lower the risk of potential effects on surface water.
Water quantity (surface water)			X				• The Revised 2024 Project will not change the water quantity of surface waters from the 2023 Project (which did not have any effect on water quantity either).
Water quality or quantity (groundwater)			X				• The 2023 Project was not anticipated to have any negative effects on groundwater quality or quantity and the Revised 2024 Project will not result in any changes to that prediction.

Table 3-1 Potential Environmental Effects Change (Cont'd)

Criteria	Potential Level of Effect						Comments, Rationale (before mitigation)
	-H	-L	NIL	Unk	+L	+H	
General Natural Environment Considerations (Cont'd)							
SAR and their habitat			X				• Neither the 2023 Project nor the Revised 2024 Project have any predicted negative effects on SAR or their habitat.
Significant earth or life science features			X				• Neither the 2023 Project nor the Revised 2024 Project have negative effects on significant earth or life science features.
Land subject to natural or human-made hazards			X				• The Revised 2024 Project does not increase the Project's susceptibility to natural or human-made disasters. Having an economically viable GS at the site ensures OPG has the economic resources to maintain and operate the facility which is beneficial for water management scenarios such as flooding.
Terrestrial wildlife (including numbers, diversity and movement of resident or migratory species)					X		• The 2023 Project had a negligible effect on terrestrial wildlife that was restricted to a temporary construction stage disturbance. By reducing the length and intensity of construction the negligible disturbance effect will be even less.
Natural vegetation and terrestrial habitat linkages			X				• The Revised 2024 Project will occur on the same footprint as the 2023 Project. No change is anticipated.
Soils and sediment quality			X				• No change is anticipated with respect to soils and sediment quality. The same mitigation measures proposed with the 2023 Project will also be in place for the Revised 2024 Project and the amount of soil excavation will be reduced. Because the excavation is reduced the overall risk to soil and sediment quality is reduced but the overall change would be considered negligible.
Significant natural heritage features and areas			X				• Neither the 2023 Project nor the 2024 Revised Project was predicted to have any negative effect on significant natural features and/or areas
Other (specify)							• No other general natural environment considerations to note.

Table 3-1 Potential Environmental Effects Change (Cont'd)

Criteria	Potential Level of Effect						Comments, Rationale (before mitigation)
	-H	-L	NIL	Unk	+L	+H	
Aquatic and Riparian Ecosystem Considerations							
Shoreline dependent species			X				• There is no anticipated change between the 2023 Project and the 2024 Revised Project with respect to any negative effects on shoreline dependent species. It is possible that less shoreline perimeter will be affected because of the proposed changes but that is uncertain.
Wetland dependent species			X				• There are no wetlands affected by the project and therefore the change from one project to the other represents no change.
Fish habitat					X		• Less fish habitat will be temporarily occupied by and enclosed within cofferdams. As such, the amount of fish habitat temporarily unavailable will be decreased. • With the 2024 project there will be no change in the area of fish habitat post-construction. The 2023 project created approximately 639 m^2 of aquatic habitat, primarily a result of excavation of a new tailrace. The old project would have converted 322 square meters of habitat with coarse substrate to bedrock, but that will not occur with the 2024 project. No new habitat will be created by the 2024 project.
Fish migration			X				• Neither the 2023 Project nor the Revised 2024 Project will have any impact on fish migration/movement. As discussed in the Aquatic TSD, the pre-development Falls would have been a barrier to upstream fish movement.
Fisheries			X				• The 2023 Project and the Revised 2024 Project would have no overall impact on fisheries.
Erosion and sedimentation					X		• Both iterations of the Project would have controls in place to prevent erosion and sedimentation. The 2024 Revised Project has probably less of a chance for erosion and sedimentation occurring as cofferdams are reduced in size and length and there is less excavation on site.
Fish injury or mortality (impingement and entrainment)			X	X			• The 2023 Project reduced intake channel velocities which would have been considered a benefit. Velocity targets local to the new intake and trashrack remain similar to the 2023 design. • The 2024 Revised Project utilizes the DIVE turbines which are identified as being fish-friendly (see Appendix A), instead of Saxo (Kaplan) turbines. • DFO will also be reviewing the project and would recommend compensation measures to address any estimated or perceived incremental fish injury or mortality. • The overall change is considered to be negligible and to some extent uncertain. More discussion on this issue appears in in Section 3.5.

Table 3-1 Potential Environmental Effects Change (Cont'd)

Criteria	Potential Level of Effect						Comments, Rationale (before mitigation)
	-H	-L	NIL	Unk	+L	+H	
Aquatic and Riparian Ecosystem Considerations (Cont'd)							
Water levels, flows and movement (surface or groundwater)			X				• Water levels, flows and movement are unchanged between the two iterations of the project. • With the 2024 Revised Project normal operation of the River (i.e., no construction) will return quicker.
Drainage, flooding and drought patterns			X				• Neither iteration of the project has any differential impact on drainage, flooding and drought patterns. Having an economically viable GS at the site ensures OPG has the economic resources to maintain and operate the facility which is beneficial for water management under either flooding or drought conditions.
Water temperature			X				• Neither iteration of the project will have any effect on water temperature.
Aboriginal Community Considerations							
First Nation reserves or other Aboriginal communities			X				• Neither iteration of the project has any impact on First Nations reserves or other Aboriginal communities.
Spiritual, ceremonial, cultural, archaeological, or burial sites			X				• Neither iteration of the project has any impact on spiritual, ceremonial, cultural, archaeological, or burial sites.
Traditional land or resources used for harvesting activities			X				• Neither iteration of the project has any impact on traditional land or resources used for harvesting activities.
Employment			X				• Both iterations of the project present the potential for employment opportunities for Indigenous communities
Lands subject to land claims			X				• The Project Site is not subject to any land claims.
Economic development			X				• Both iterations of the project present some opportunities for economic participation through contracting opportunities.
Other (Training and education)							• No other effects.

Table 3-1 Potential Environmental Effects Change (Cont'd)

Criteria	Potential Level of Effect						Comments, Rationale (before mitigation)
	-H	-L	NIL	Unk	+L	+H	
Land and Resource Use Considerations							
Access to inaccessible areas (land or water)			X				• Neither iteration of the project provides access to inaccessible areas.
Navigation			X				• Neither iteration of the project changes navigation on the river.
Riparian rights or privileges			X				• Neither iteration of the project affects riparian rights or privileges.
Recreational use – (land or water)			X				• Neither iteration of the project has a negative effect on land or water recreational use.
Angling and hunting opportunities			X				• Neither iteration of the project has a negative effect on angling and hunting opportunities.
Trapping activities			X				• Neither iteration of the project has a negative effect on trapping activities.
Baitfish harvesting activities			X				• Neither iteration of the project has a negative effect on baitfish harvesting activities.
Views or aesthetics including for transmission			X				• Neither iteration of the project alters views or aesthetics. • A shorter period of construction period could be considered an improvement.
An existing land or resource management plan			X				• Neither iteration of the project will result in a change to or negative effect on an existing land or resource management plan.
An existing water management plan			X				• Neither iteration of the project will have negative effects on the Water Management Plan (WMP). • An Amendment is required to the existing WMP because of a new powerhouse under any iteration of the project.
Protected areas			X				• Neither iteration of the project has any negative effect on a protected area.
Other (resource industries) (e.g., forest products, mineral, aggregate)			X				• Neither iteration of the project has any negative effect on resource industries.
Other							• No other effects noted.

Table 3-1 Potential Environmental Effects Change (Cont'd)

Criteria	Potential Level of Effect						Comments, Rationale (before mitigation)
	-H	-L	NIL	Unk	+L	+H	
Cultural Heritage Resources Considerations							
Archaeological sites			X				• Archaeological investigations determined that the project site does not include any archaeological sites.
Buildings or structures					X		• The Revised 2024 Project is slightly better than the 2023 Project. While both iterations remove the powerhouse superstructure, a portion of the existing substructure will remain in the 2024 Project. Keeping the powerhouse in the same location as the existing is considered to more closely resemble the historic site layout. Please see Section 3.3 for more details.
Cultural heritage landscapes			X				• Neither iteration of the project has negative effects on cultural landscapes but as indicated in the row above, preserving the original site layout is slightly preferred.
Other (specify)							• No other effects noted.
Social and Economic Considerations							
The location of people, businesses, institutions, or public facilities			X				• Neither iteration of the project has any negative effects on the location of people, businesses, institutions, or public facilities.
Community character, enjoyment of property, or local amenities			X				• Neither iteration of the project has any negative effect on community character, enjoyment of property or local amenities.
Employment			X				• Both iterations of the project will offer local employment opportunities. But the project is more likely to proceed with the 2024 iteration of the project.
Public health and/or safety			X				• There is no difference between the two iterations of the project with respect to public health and/or safety.
Local, regional, or provincial economies			X				• Both iterations of the project will offer local, regional and provincial economic benefit. But the project is more likely to proceed with the 2024 iteration of the project.
Tourism values			X				• Neither iteration of the project will have a negative effect on tourism values.
Water supply			X				• Neither iteration of the project will have a negative effect on water supply.

Table 3-1 Potential Environmental Effects Change (Cont'd)

Criteria	Potential Level of Effect						Comments, Rationale (before mitigation)
	-H	-L	NIL	Unk	+L	+H	
Social and Economic Considerations (Cont'd)							
Aesthetic image of the surrounding area			X				• Neither iteration of the project will have a negative effect on the aesthetic image of the surrounding area.
Other							• No other effect noted.
Energy/Electricity Considerations							
Reliability (e.g., voltage support)			X				• No difference between the two iterations of the project with respect to reliability.
Security (e.g., Black Start)			X				• No difference between the two iterations of the project with respect to security.
Electricity flow patterns			X				• No difference between the two iterations of the project with respect to electricity flow patterns.
Other (Pulsing)			X				• No difference between the two iterations of the project with respect to other or pulsing, etc.

As indicated in the table above, certain components of the environment are discussed in more detail below.

3.2 Archaeological Impact

The entire project occurs in an already disturbed area and as such no further archaeological investigations were proposed for the project.

The actual disturbance associated with the project will be smaller because by using the footprint of the existing powerhouse the overall amount of excavation work required will be reduced.

3.3 Built Heritage Impact

The previous Cultural Heritage Impact Assessment for the 2023 Project was based on the premise of a new powerhouse in a different Coniston site location. The Revised 2024 Project will have the powerhouse in the same location as the existing powerhouse and as such the Revised 2024 Project will visibly reflect the current/historic site layout. This is a positive, more sympathetic direct impact associated with the Revised Project.

The Coniston Powerhouse will now utilize portions of the existing substructure below the generator floor. Aspects of the Ashlar masonry walls may remain below grade in the final project configuration (pending conditions during demolition) and may be visible post project. The draft tube exist arrangement is identical to the existing configuration. The new penstocks and saddles follow the original alignment. Other site elements including the original Coniston Hydro Road and sluiceway and dam will not change. The existing switchyard will be upgraded and 44kV Line will remain in the existing location.

A memorandum (available on request) has been prepared to note that Andrew Hinshelwood, Northwest Archaeological Assessments (NAA), and Richard Unterman, Unterman McPhail Associates (UMcA), are of the opinion that the proposed redesign of the Coniston GS will not materially change the evaluation, conclusions or recommendations of the Cultural Heritage Impact Assessment prepared previously for the redevelopment project. In their memorandum they noted the following:

> "the Revised 2024 Project will visibly reflect the current and historic site layout, and this is considered a positive, more sympathetic direct impact associated with the redevelopment. We note further that the possibility for re-use of some components of the existing powerhouse, and that the arrangement of some components of the GS will be nearly identical and reflect the existing physical configurations."

In summary, the overall change from the 2023 Project to the 2024 Project is that the change is a positive and more sympathetic design the current/historic layout.

3.4 Terrestrial Impact

The Revised 2024 Project is proposed to use a smaller footprint (including temporary features such as laydown areas) than the 2023 Project. Therefore, the project will have the same or less effect on the terrestrial environment. As the amount of excavation is reduced with the project it is anticipated that the project will be constructed several months quicker than the previous version of the project and therefore reduce the overall potential for disturbance to local wildlife.

3.5 Aquatic Impact

The Revised Project needs to be assessed by its various sub-components in order to assess the potential for the project to have negative environmental effects on the aquatic environment.

3.5.1 Construction Stage Impacts

By utilizing the existing powerhouse location and making other changes to the project, as discussed above, the construction stage effects will be reduced.

The main benefit of the Revised Project from a construction aquatic impact perspective is that there is no need for a downstream cofferdam. This is a positive benefit of the revised project.

The upstream cofferdam footprint will be reduced in size and the cofferdam will be situated in the intake canal which is considered to be anthropogenic/engineered habitat. This too is a benefit.

3.5.2 Operation Stage Impacts

The Revised Project will use the existing powerhouse foundation and tailraces. As such, there would be less change to flow patterns downstream (which is a Walleye spawning area) than the 2023 Project. The effects of the 2023 Project on Walleye spawning habitat was summarized as follows:

> "With the future generating station, there is small increase in the area of habitat that is most suitable for Walleye spawning and a small decrease in the amount of habitat that is suitable for Walleye spawning at low (10th percentile) flow. At median flow there is an increase in the amount of both most suitable and suitable habitat for Walleye spawning. At maximum plant flow, which corresponds approximately to the 68th percentile of May flow, there is a decrease in both most suitable and suitable habitat for Walleye spawning. At high flows (90th percentile) there is little Walleye spawning habitat present within the modelled area because most of the areas with suitable substrate are too deep and/or too fast, regardless of whether there is flow through the powerhouse or not. It should be noted that patches of suitable substrate for Walleye spawning extend downstream from the modelled reach and these may be used, particularly during years when flow is high."

Overall, the conclusion in the ER was that there wouldn't be much change from the existing situation. The 2024 project will not involve construction of a new tailrace and therefore will have little or no effect on existing flow direction, depth, or velocity. Neither of the two alternative designs for the site results in much change to downstream habitat suitability, but the change will be less with the 2024 design.

The new turbines from the 2023 Project and those from the Revised 2024 Project will be equal in terms of overall discharge capacity and continue to be able to provide a lower minimum flow in the river than the existing station. This allows the GS to provide flow in the river at lower flows, which is considered to be ecologically preferred.

The 2023 Project included excavation and bridge pier elimination at the upstream end of the intake canal that would reduce velocities and reduce entrainment risk. With the 2024 project, no changes are made at the entrance to the intake canal and the velocities at this location are unchanged from the present. The approach velocity at the trashracks is the same for the 2023 and 2024 projects. The last consideration for the operation period is fish mortality due to passage through the turbines. Information provided to date is that, based on their design, the DIVE turbines should result in less fish mortality than SAXO type turbines. The net effect of the differences between the two projects on fish mortality remains uncertain, but the 2024 project is expected to result in less than occurs at present.

It should be noted that OPG will be required by DFO to offset for fish mortality due to operations, if it occurs. Therefore, any deemed residual impact will be mitigated/compensated for.

3.6 Indigenous Interests

The Project does not occur in an area that is used by Indigenous Peoples for traditional use but in consultations with local Indigenous communities a desire was expressed to have the least amount of impact on native vegetation as possible. Therefore, and for the same reasons as expressed above in the Terrestrial Environment the overall footprint of the project will be smaller than the 2023 project. This document is being circulated to identified Indigenous communities.

3.7 Socio-Economic

The Revised Project reduces the overall amount of excavation with the project. As such, the proposed project reduces the need to export any materials off-site. Furthermore, the overall shortened construction period will reduce the amount of traffic on local roads.

3.8 Atmospheric and Waste Management

As already explained the Revised Project will shorten the construction period and result in less excavation. As such, the emissions associated with machinery on site and workers travelling to and from the site will be reduced. This will also reduce the overall waste generated by the project.

3.9 Conclusion

Based on information on the Revised 2024 Project we are of the opinion that there is unlikely a negative effect associated with the project on the environment. With many of the components of the environment, there will be a reduced environmental impact and/or a negligible change. For the operational aquatic effects, based on information provided by the manufacturer there will be a benefit due to reduced fish mortality with the DIVE turbine. To the best of our knowledge, the difference is unquantified at this time.

Furthermore, for the purposes of the OWA (2018) Class EA, a minor modification is a modification that is below the threshold for a significant modification under the Electricity Projects Regulation (O. Reg. 116/01) of the *Environmental Assessment Act* (MOE, 2001). A significant modification is any expansion of or change in the facility that would increase the name plate capacity of the facility by 25% or more. In the final design, the capacity of the proposed project has not changed and therefore this modification is minor.

Appendix A

DIVE Turbine

Fish friendly DIVE-Turbine

Overview of studies

September 2016

Table of contents

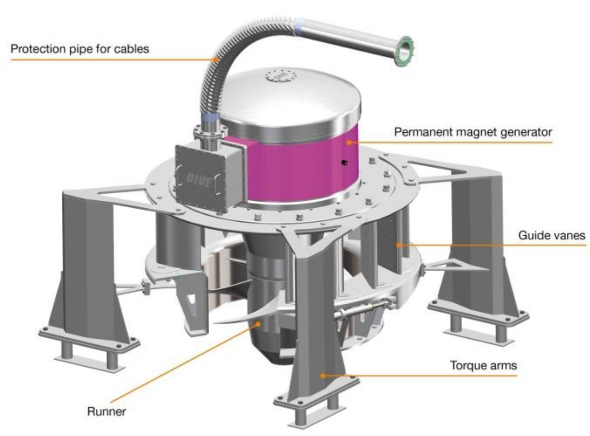
1. Overview

The DIVE-Turbine is a turbine system for high demands on efficiency and ecology in hydro power. Due to its design it proves to be state of the art regarding commonly defined characteristics of fish friendly turbines.

Even though the most striking argument for fish protection on downstream migration is an appropriate rake and bypass system, the DIVE-Turbine is of no danger to animals that enter the turbine chamber through the intake rake.

The key advantages of the DIVE-Turbine considering fish friendliness are:

- **speed variable operation** (speed is regulated depending on discharge)
  → blades remain constantly open: little collision probability and collision speed, little shear stress
- **no gaps between runner blades and runner hub** (fix runner blades)
  → no risk to get stuck
- **very small gap between runner blades and turbine vessel**
  → no risk to get stuck
- **reduced speed due to bigger scaling of the turbine**
  → no shear stress, little collision speed
- **big gap between runner blades and guide vanes**
  → no risk to get stuck
- **fixed blades design with variable number of blades**
  → number of blades can be reduced to 3 blades to reduce collision probability



Therefore the mortality rate of fish migrating downstream via the DIVE-Turbine is minimized in comparison to classical Kaplan turbines. This can be proven by numerical calculations which are based on empirical tests or by field studies. Both methods have been applied to the DIVE-Turbine.

2. Calculation of fish mortality

Calculation models based on field studies with Kaplan turbines can be applied to estimate turbine mortality of DIVE-Turbines. The following diagram derives from a calculation of salmonide smolts with intermediate size of TL=21.5cm (8.5 in).

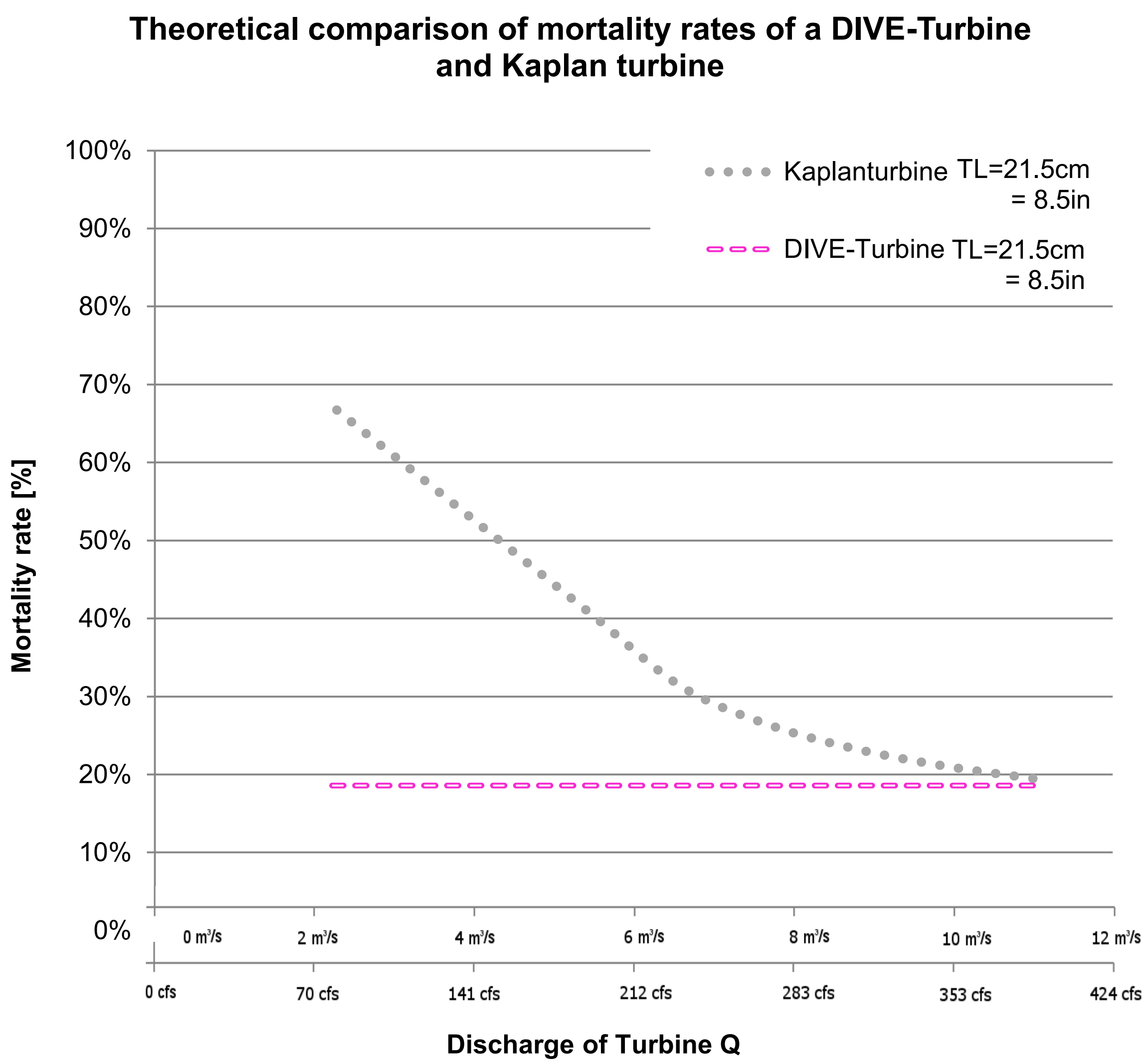


Diagram on fish mortality for a DIVE-Turbine and a Kaplan turbine, both with runner diameter of 1600mm (5ft 3in) and 3 runner blades. The intermediate size of fish is TL=21.5cm (=8.5in). This applies to a rake system with a distance of rake bars of 21.5mm (0.85in). It is important to keep in mind that the calculated mortality is the turbine mortality, only for fish that reach the turbine chamber. The overall mortality of the power plant is much lower in combination with a fish friendly rake system that ensures a safe downstream migration for example via bypass channel.

In comparison with a Kaplan turbine the mortality rate of the DIVE-Turbine remains constant on all operation points (values of discharge) because the runner speed adapts to the value of discharge. Therefore, the mortality rate of the DIVE-Turbine theoretically should decrease on reduced discharge, because the collision risk is reduced with reduced speed. But as the formulas used for the DIVE-Turbine originate from experiments with Kaplan turbines, this effect is compensated. The theoretical mortality rate of the DIVE-turbine remains constant using the Kaplan turbine mortality formulas.

For the Kaplan turbine the mortality rises with reduced discharge due to the constantly high runner speed and closing of runner blades (rising collision risk).

Even though the numerical studies have proven a significantly lower mortality for the DIVE-Turbine than for Kaplan turbines it is assumed that the mortality of the DIVE-Turbine is even lower in reality. This assumption is based on the fact that numerical models to calculate turbine mortality are based on experiments with classical Kaplan turbines which do not have the characteristics of fish friendly turbines listed above. Only geometrical and flow parameters can be varied in the numerical models. Design characteristics of Kaplan turbines like less gaps and a constant opening of the runner blades can not be eliminated from the numerical models derived from Kaplan field tests. Therefore the mortality calculations of DIVE-Turbines based on Kaplan models can only give a conservative estimation of mortality.

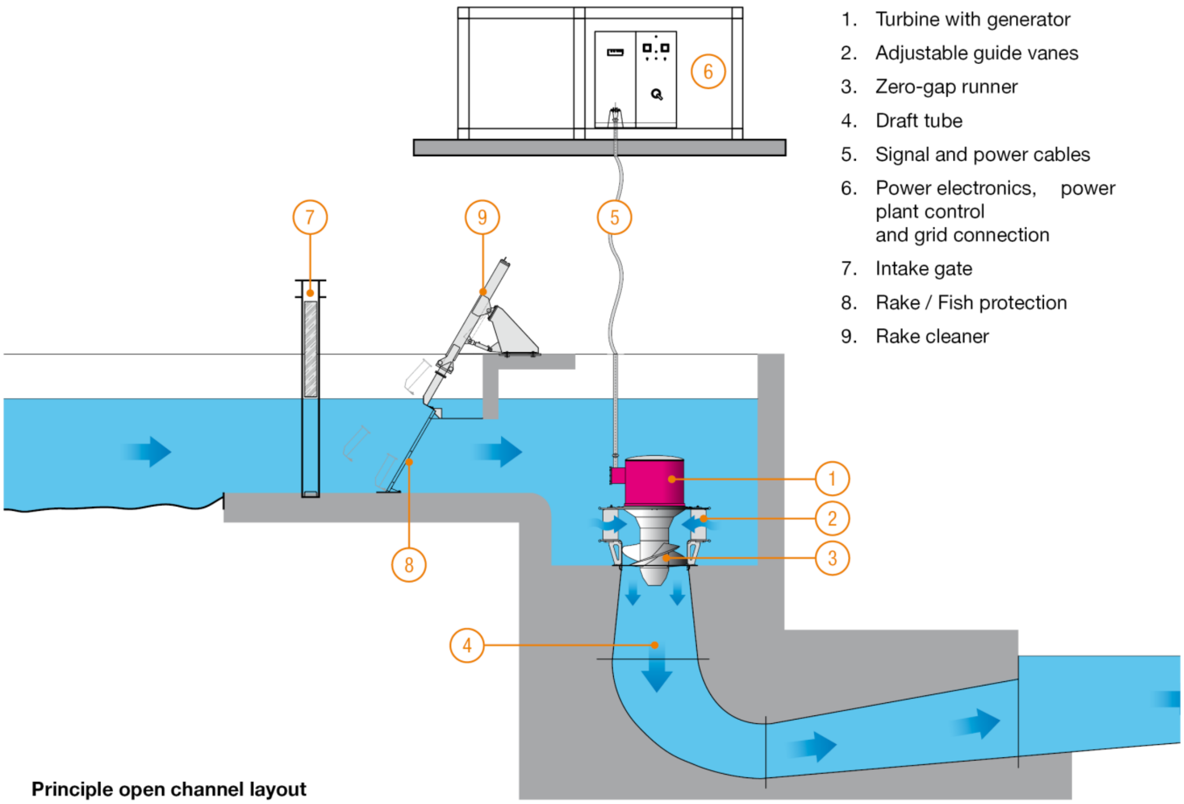
3. Field tests

First field tests on mortality of a DIVE-Turbine were conducted in June 2016.

view on the power plant where first field tests on fish mortality were conducted in 2016

A fish vet as well as local and national authorities and institutions surveilled the tests for reasons of certification and animal protection. In accordance with them rainbow trouts were used instead of salmon smolt: this is a common practice as the geometrical dimensions and swim characteristics of trout and salmon smolt are comparable, but rainbow trouts are easier to obtain and their provision is independent from natural smolt season.

3.1 Turbine Parameters of test facility



	unit	DIVE1600-540
Regulations		double
1. Regulation		guide vanes
2. Regulation		speed variable
Sense of rotation		left
Gross Head		5.50 m or 18 ft
Max. Discharge Q_{max}		11.00 m³/s or 388 cfs
Min. Discharge Q_{min}		~1.50 m³/s or 53 cfs
Nominal speed	rpm	230
Speed range	rpm	50-255

Max. Output Turbine & Generator $P_{maxGenerator}$	kW	540
Number of guide vanes		16
Numbers of runner blades		5
Runner diameter		1600mm or 5ft 3in

3.2 Test parameters

The size of the tested fish was in this experiment was between 18cm and 25cm (7in – 10in).

As the DIVE-Turbine is a speed variable turbine three different runner speeds were to be tested:

- 150rpm
- 200rpm
- 250rpm

On each runner speed 100 trouts were injected into the turbine and recaught with a recovering net at the exit of the draft tube. After the turbine passage, fish were stored for 48 hours to discover possible long term damage. Moreover a control group was directly injected into the recovering net to analise damage caused by stress and water pressure during the net storage.

Every fish passed three examinations during the test:

- visual examination by the fish vet before the test
- visual examination directly after the test by the fish vet
- visual examination 48 hours after the test OR autopsy in case of death, both by the fish vet

Test parameters				**unit**
size of trouts	18 cm – 25 cm or 7 in – 10 in			
number of trouts	100	100	100	-
runner speed	150	200	250	rpm

test facility during the test, view from downstream

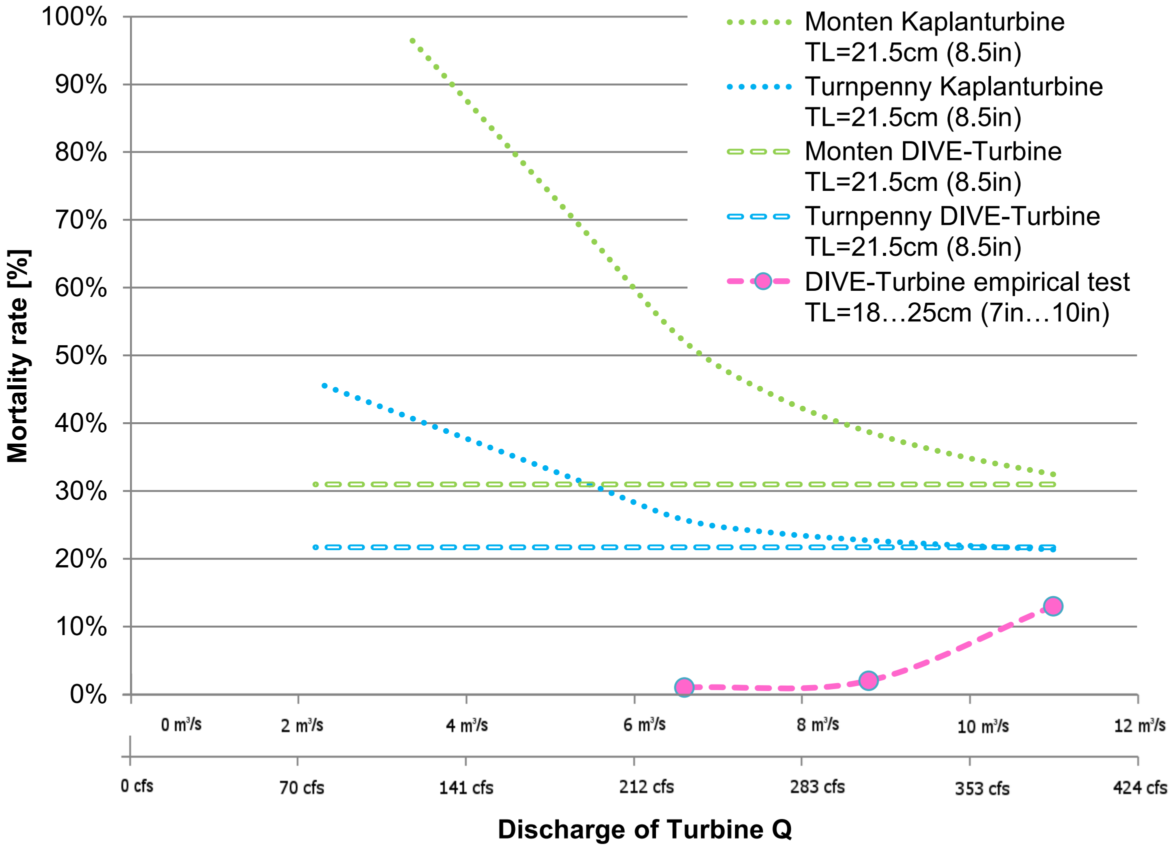
3.3 Test results

As mentioned above, all fish were examined three times. The allover mortality result 48 hours after the test was the following:

runner speed	turbine mortality
150 rpm	1%
200 rpm	2%
250 rpm	13%

The results from the empirical test can be compared to the theoretical mortality rate. The values from the empirical test show that the mortality rate is decreasing when the discharge decreases. In the diagram, theoretical values for an intermediate length of fish of TL=21.5cm (8.5in) were calculated, as the actual size of fish in the experiment was between 18cm and 25cm (7in – 10in).

The assumption that empirical mortality lies far below theoretically calculated mortality of the DIVE-Turbine is proven to be true. Moreover, it can be seen that the empirical mortality rate is decreasing with reduced discharge for the DIVE-Turbine.



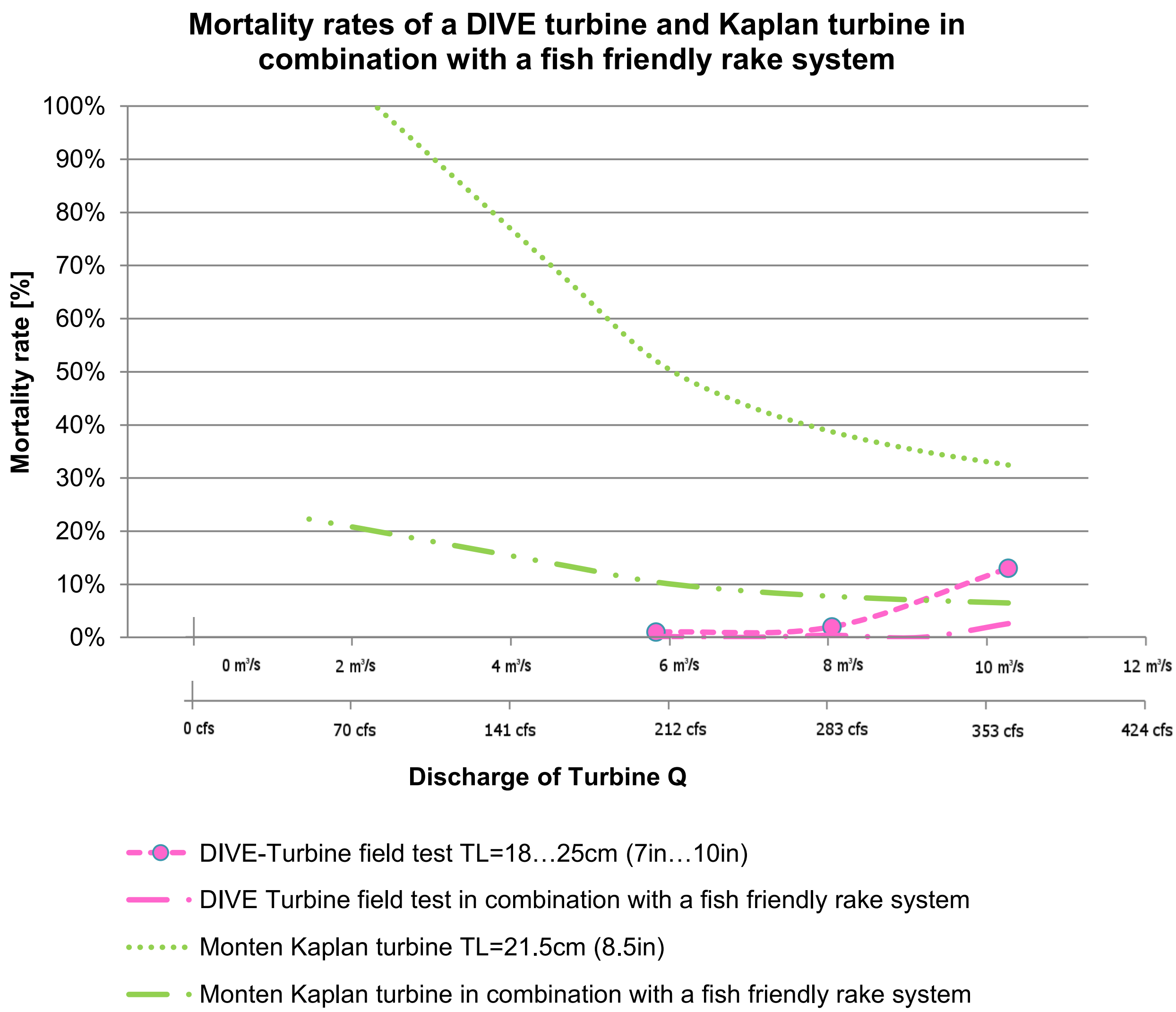
Comparison of calculated and field tested fish mortality for a DIVE-Turbine and a Kaplan turbine, both with runner diameter of 1600mm (5ft 3in) and 5 runner blades. The intermediate size of fish is TL=21.5cm (8.5in). This applies to a rake system with a distance of rake bars of 21.5mm (0.85in). It is important to keep in mind that the calculated mortality is the turbine mortality, only for fish that reach the turbine chamber. The overall mortality of the power plant is much lower in combination with a fish friendly rake system that ensures a safe downstream migration for example via bypass channel.

4. Conclusion

The first empirical tests for salmonide smolts have approved that the mortality rate of the DIVE-Turbine is much lower than mortality rates of Kaplan turbines.

- The mortality rate of the DIVE-Turbine decreases with lower discharge whilst the mortality rate of the Kaplan turbine increases with lower discharge. This result is due to the physical conditions of those types of turbines: with lowering discharge, the blades of the Kaplan turbines are closed, while the runner speed remains constant. Therefore, the collision risk of the Kaplan turbine is rising. In comparison to that, the runner speed of the DIVE-Turbine is reduced when the discharge is reduced. Therefore, the collision speed and probability is reduced. The opening angle of the runner blades remains the open, therefore the collision probability is not rising with lowering discharge, as is for the Kaplan turbine.
- In the theoretical calculation the mortality of the DIVE-Turbine was constant over the discharge, as the runner speed (collision speed) is directly proportional to the discharge. There are several facts that were not taken into account using the formula derived from experiments with Kaplan turbines to calculate for the DIVE-Turbine. One fact is that the runner blades of the DIVE-Turbine remain open. Another fact is that the shear forces of the DIVE-Turbine do not increase with lower discharge, because the runner speed is reduced proportionally with the discharge. Therefore, the empirical curve is below the calculated curves and is not straight but exponentially rising with rising discharge.
- The mortality rate of the DIVE-Turbine can roughly be calculated with calculation formulas for Kaplan turbines, but will be much lower in reality.
- Even at full load the maximum mortality of the DIVE-Turbine is about 10% - 20% lower than the max. mortality of a Kaplan turbine. This means that even for a fixed speed DIVE-Turbine the mortality rate would be much lower than for a fixed speed Kaplan turbine. This is based on the fact that the DIVE-Turbine has a runner with minimum gaps to the turbine vessel, no gaps to the runner hub, a big distance between runner and guide vanes.
- Regarding the numbers of mortality it has to be considered that the **mortality values derived from calculation models as well as from empirical studies are only valid for fish that reach the turbine despite the fine rake and bypass system.** In combination with a fish friendly power plant design, a major part of downstream migrating fish is not passing through the turbine chamber.

  Therefore the overall mortality of downstream migrating fish is much lower than the turbine mortality. For the turbine tested on the field, an intermediate mortality of 5.3% can be assumed. In combination with a fish friendly rake system the overall mortality would be reduced to an intermediate value of around 1%. Taking into consideration that the turbine mortality in part load was between 1% – 2%, the overall power plant mortality in part load can be assumed as 0%. Moreover, the empirical tests have been conducted with a DIVE-Turbine with a 5 blades runner. It can be assumed that the mortality of a 3 blade runner will be significantly lowered.



Comparison of fish mortality for a DIVE-Turbine and Kaplan turbine each with a runner diameter of 1600mm (5ft 3in) and 5 runner blades. The intermediate size of fish is TL=21.5cm (8.5in). This applies to a rake system with a distance of rake bars of 21.5mm (0.85in).
The dot-lines show the mortality rate for a power plant with a combination of turbine and a fish friendly rake system.

5. Contact

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