Fish Passage at Dams Strategic Analysis

Wisconsin Department of Natural Resources

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Nature-like Fishway at Thiensville Dam on Milwaukee River in Ozaukee County, WI

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Foreword

This document is a strategic analysis of fish passage at dams in Wisconsin, as authorized under Chapter NR 150.10 of the Wisconsin Administrative Code, consistent with Sections 1.11(2)(e) and (h) of the Wisconsin Statutes and the Wisconsin Environmental Policy Act. It addresses topics of interest identified through a public scoping process. The purpose of this and other strategic analyses is to inform decision-makers and the public about alternative courses of action and the anticipated effects of these alternatives on the quality of the human environment. Strategic analyses rely in part on the professional judgment and expertise of subject area specialists within the Wisconsin Department of Natural Resources (the department). They are not intended to be exhaustive scientific studies and do not advocate for particular alternatives.

This strategic analysis summarizes currently-available information on fish passage at dams in Wisconsin and elsewhere, including environmental impacts, economic costs and benefits, applicable regulations, and potential policy alternatives. It does not establish department policy for the review of specific fish passage projects or proposals. Rather, it is intended to serve as an informational resource to help decision-makers and the public to better understand the issue, and to aid in the crafting of future policy. This strategic analysis is limited to fish passage at intact dams and does not address the complete removal of dams, or fish passage across other natural or manmade obstructions such as perched culverts.

The department initiated this strategic analysis in September of 2015 and conducted public scoping in November and December of that year. Public comments on the draft of this document were received by the department from August 29, 2017 to October 16, 2017.

Executive Summary

Fish passage refers to the ability of fish to move through or around a dam, in one or both directions. Many fish populations depend on the ability of individuals to migrate in order to fulfill critical life-stage requirements. Dams can prohibit or delay migration and thereby lead to population declines. Across Wisconsin, there are approximately 3,900 dams. Currently, ten of these dams have fish passage facilities. Another eight have plans or proposals to develop fish passage facilities.

The importance of fish passage has long been recognized in the state. Wisconsin's earliest natural resource law required the construction of fish passage structures on navigable waterways. Under Wisconsin's Public Trust Doctrine, the Wisconsin Department of Natural Resources (department) is responsible for protecting public rights in the commercial and recreational use of navigable waters. Numerous state and federal statutes, administrative codes, guidelines and procedures may apply to fish passage projects.

In recent years, fish passage projects have become increasingly complex, involving multiple programs within the department, other state and federal agencies, tribal governments, and non-governmental organizations. From conception through implementation, projects can take several years, cost millions of dollars, and may have mixed or inconclusive results.

Many different technologies exist to pass fish around or through a dam. Fish passage can be upstream or downstream, active or passive, or any combination of these. Active passage occurs through mechanized structures such as fish elevators and locks, with electrical power sometimes used to facilitate operation. Passive passage occurs through static structures such as fish ladders and natural bypass river channels. The goal of upstream fish passage is to attract migrating fish species to a specified point in the river downstream of the structure and to induce them to move upstream through a waterway or by collecting and transporting them upstream. Effective downstream passage minimizes stress and physical injury to the fish while providing a conduit from which fish can migrate to downstream habitats.

Fish passage at dams can result in both positive and negative environmental impacts. Fish passage facilities can restore aquatic pathways for native fish, herptiles and freshwater mussels, including endangered species. This can help to meet the recovery goals of such species by expanding and re-connecting populations and improving genetic exchange. On the other hand, dams can provide a barrier to the upstream movement of aquatic invasive species (AIS). The spread of AIS can have significant ecological and economic impacts. Fish passage facilities can also affect hydroelectric generation and water levels.

Effective fish passage is dependent on the presence of specific ecological characteristics and habitats needed to support all life stages of the target fish species. The ability to assess habitat suitability is critical to estimating the carrying capacity of streams and flowages and to evaluating the importance of fish passage at a given dam. Physical, water quality, and biological characteristics are examples of parameters used by biologists to evaluate habitat suitability. Upstream and downstream assessments may be limited by the amount of data available and by biologists' knowledge of the habitat needs for all life stages of targeted fish species.

Fish passage structures are considered part of the dam infrastructure, and are therefore subject to state and federal dam safety regulations as well as historical and archaeological resource regulations. Structural changes to any dam require approved plans from a dam safety engineer.

Engineers and biologists should work together to develop a design that is both biologically and technologically feasible.

With respect to economic considerations, an overarching question is whether, and to what extent, the economic benefits of fish passage facilities outweigh their costs and how these are distributed. Experience in Wisconsin and elsewhere suggests that the economic impacts of individual fish passage projects are context-specific and highly variable. Economic impacts depend in part on dam type and size, the type of fish passage facilities implemented and the species targeted, as well as hydrologic and ecological conditions, including the presence or risk of transporting AIS and fish diseases.

In addition to providing current and pertinent information regarding fish passage at dams in Wisconsin, the strategic analysis explores some big picture policy alternatives and specific aspects of the many fish passage issues. The department may want to consider this when developing policies that affect fish passage at dams.

Many different issues can influence regulatory decisions for a given fish passage project. Developing a clear and transparent process for considering these issues could help decision-makers to make more timely and consistent decisions.

1 History of Fish Passage at Dams Policy in Wisconsin

(Editor's Note: Portions of the information reported in this section come from the article "Fish gotta swim" by Karl Scheidegger in the April 2002 *Wisconsin Natural Resources* magazine.)

In Wisconsin, there are approximately 3,900 dams, ranging from small to large, and low to high hazard. Most are owned by private parties. Dams in the state are regulated by the Wisconsin Department of Natural Resources (the department), the Federal Energy Regulatory Commission (FERC), and/or the US Army Corps of Engineers (USACE). Presently, 10 dams in the state include special facilities that enable fish to pass around or through them in one or both directions. Another 8 dams have plans or proposals for such facilities (Figure 1-1 & Table 1-1).

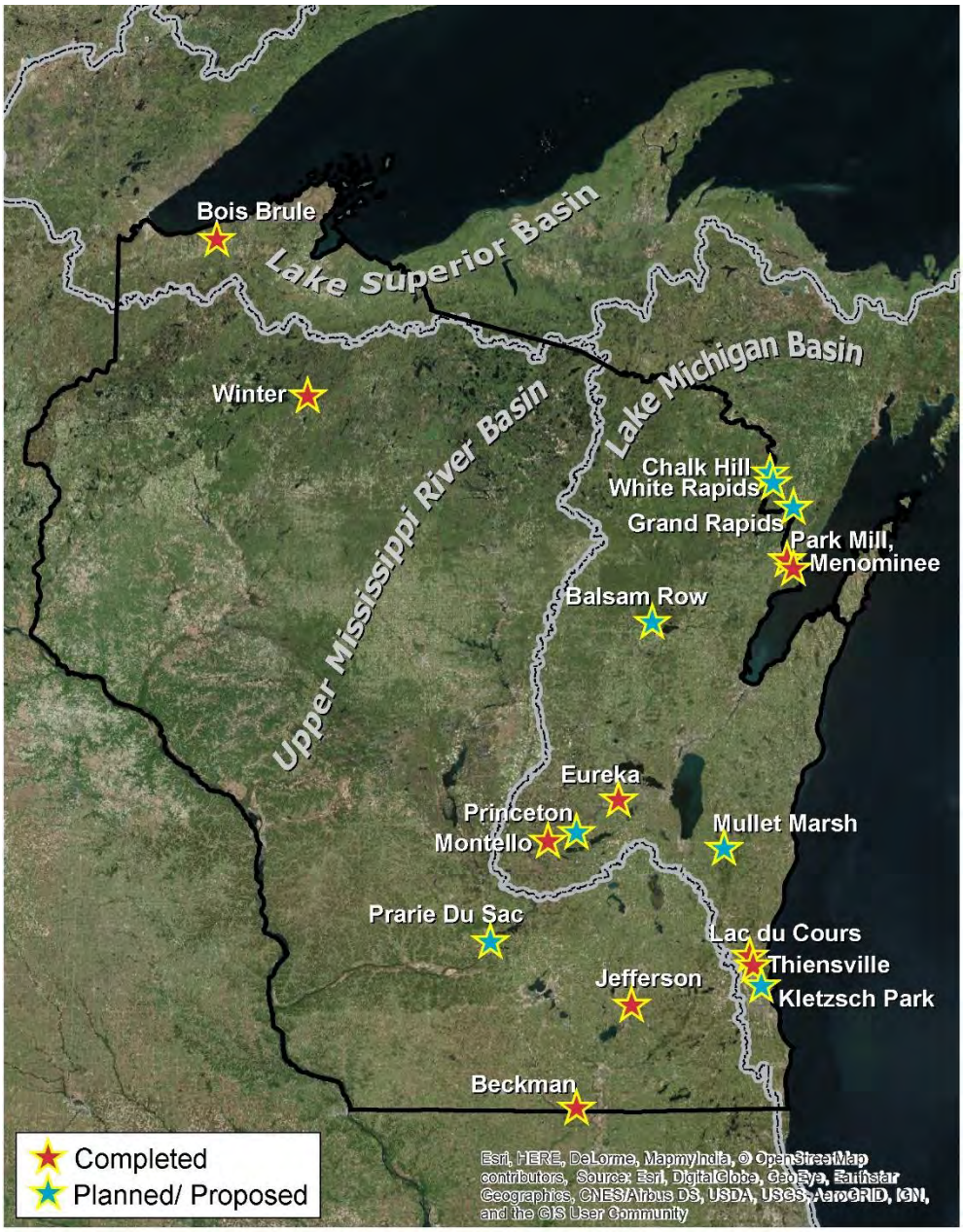

Figure 1-1, Wisconsin dams with a fish passage project as of June 2017, Source: WI DNR

Table 1-1, List of Wisconsin dams with a planned/proposed or completed fish passage project

Dam	County & River	Project Status	Targeted Species	Complete Barrier*	Facility Type
Bois Brule (State owned)	Douglas Brule River	Completed (1986)	Trout and Salmon	Yes	Ladder
Eureka Dam	Winnebago Fox River	Completed (1993)	Lake Sturgeon, Walleye	No	Ladder/ Rock Rapids
Beckman Mill	Rock Raccoon Creek	Completed (2000)	Forage Species	Yes	Bypass Pool-and-Weir
Jefferson Dam	Jefferson Rock River	Completed (2005)	Walleye, Sauger; Various species	No	Fish Ladder
Thiensville Dam	Ozaukee Milwaukee River	Completed (2010)	Northern Pike; Various species	No	Bypass Nature like
Lac du Cours Dam	Ozaukee Lac du Cours Creek	Completed (2011)	Various species	No	Modified Abutment/Streambed
Winter Dam	Sawyer East Fork Chippewa	Completed (2011)	Lake Sturgeon, Greater Redhorse	Yes	Seasonal Bypass
Montello Dam (State owned)	Marquette Fox River	Completed (2014)	Walleye, Lake Sturgeon, Flathead Catfish	No	Fish Ladder
Park Mill Dam	Marinette Menominee River	Completed (2016)	Lake Sturgeon	Yes	Bypass
Menominee Dam	Marinette Menominee River	Completed (2017)	Lake Sturgeon	Yes	Fish Elevator, electroshock & transport, trap and sort and downstream bypass
Princeton Dam (State owned)	Green Lake Fox River	Planned	Various species	No	Fish Ladder
Balsam Row Dam	Shawano Wolf River	Planned	Lake Sturgeon	Yes	Pool and weir, with trap and sort
Prairie Du Sac	Sauk Wisconsin River	Planned	Lake Sturgeon, Paddlefish, Blue Sucker	Yes	Fish Elevator with trap and sort
Mullet Marsh (State owned)	Fond Du Lac Mullet River	Proposed	Northern Pike	No	Fish ladder
Grand Rapids Dam	Marinette Menominee River	Proposed	Lake Sturgeon	Yes	Fish Elevator with trap and sort
Chalk Hill Dam	Marinette Menominee River	Proposed	Lake Sturgeon	Yes	Fish Elevator with trap and sort
White Rapids Dam	Marinette Menominee River	Proposed	Lake Sturgeon	Yes	Fish Elevator with trap and sort
Kletzsch Park Dam	Milwaukee Milwaukee River	Planned	Native Fishes	No	Ramp with Pools

* Complete Barrier - A man made or natural structure which does not allow the migration of aquatic organisms upstream up to the 100-year event.

Dams have been built on almost all of the major rivers in the state, including the Chippewa, Flambeau, Fox, Black, Wisconsin, Peshtigo, Menominee, Oconto and Iron rivers, as well as numerous smaller streams. A series of large dams and reservoirs – the Lock and Dam System – was constructed on the Mississippi River to maintain a navigation channel for barges. Although dam construction has had benefits to the state's economy and recreation, dams impede the movement of fish.

While unimpeded fish movement in rivers was recognized as important well over 150 years ago, the development of technology to effectively pass fish around or through dams has been slow,

with much being of trial-and-error. As an example, in 1939 before the Orienta Dam on the Iron River was constructed, anglers petitioned the Public Service Commission of Wisconsin to require a fishway around the proposed dam so fish could migrate upstream to spawn (Esposito 1999). Nationwide, most experiments with fish passage at dams have been conducted on the East and West coasts, where anadromous fish, such as of striped bass, blueback herring, hickory shad and pacific salmon require passage for spawning. Less research has focused on warmwater resident fish species in the Midwest.

From 1908 to 1912, fishways were evaluated on the St. Croix River at St. Croix Falls, the Kilbourn Dam on the Wisconsin River, the Eureka Dam on the Fox River, and the Weyauwega Dam on the Wolf River. These early fishways were considered unsuccessful. During this timeframe at St. Croix Falls, not a single fish used the fishway. One sucker went through the fishway at Kilbourn. There were two bass, three pike, two suckers, one carp, 13 bowfin, and one sunfish that successfully navigated the ladder at Eureka, and 49 suckers passed over the dam at Weyauwega. In 1941 a fishway ladder was constructed at the Prairie Du Sac Dam on the Wisconsin River, but was removed between the 1950s and 1960s as it was determined that fish could not use the ladder (Blank 2016).

Wisconsin's earliest natural resource law, enacted by the territorial legislature in 1839, required the construction of fish passage structures on navigable waterways. Wisconsin Fish Commission reports from the late 1800s and early 1900s documented public concern about the impeded movement of fish, particularly in tailwater areas. A report from 1878 discusses the fishes' inability to move back upstream, which led to the fish being harvested in large numbers.

In 1917, under the Water Power Law, Wisconsin Statute Chapter 31-- *Regulation of Dams and Bridges Affecting Navigable Waters*, was created. Chapter 31 states that: "The department [Department of Natural Resources] may investigate and determine all reasonable methods of construction, operation, maintenance, and equipment for any dam so as to conserve and protect all public rights in navigable waters..."

The definition of "public rights" has been broadly construed by Wisconsin courts to include fishing, and other recreation, protection of habitat, natural scenic beauty, and the protection of water quantity and quality. The federal regulatory processes ensure that state regulations and public rights are adequately addressed. FERC regulated dams must comply with state regulations and those conditions imposed by the FERC or other federal resource agencies. However, in some circumstances federal regulations may supersede state and local regulations.

Prior to changes made by the Legislature in 1999, Wisconsin Statute Chapter 31 stated: "The department may order and require any dam heretofore or hereafter constructed to be equipped and operated, in whole or part with good and sufficient fishway or fishways, or in lieu thereof the owner may be permitted to enter into an agreement with the department to pay for or supply to the state of Wisconsin annually such quantities of game fish for stocking purposes as may be agreed upon by the owner and the department.". The 1999 budget bill (Wisconsin Act 9, Section 867xs) revised the statute so that the department could only require passage after two things occurred: 1) rules created and promulgated that clarify the fish passage prescription process (what, where, when, how, *etc.*), and 2) a cost-share program is implemented and money is available to dam owners for fish passage work. As of the date of this document, rules have not been promulgated and cost-share programs have not been developed.

On January 1, 2014, the department approved a Fish Passage Guidance document (WDNR 2014). This guidance established criteria that department staff should use when reviewing

regulated activities that have the potential to increase the distribution of aquatic invasive species or fish pathogens.

In June 2014, the department created a Fisheries Ad Hoc Fish Passage Policy Task Group to develop policy and procedures for the department to use when evaluating proposed fish passage projects. In 2015, the department elected to hold off on developing the policy guidance and first conduct a Strategic Analysis (SA) of fish passage at dams.

The SA process enables the department to address the intricacies of the various department programs involved in this issue, while providing an opportunity for federal agencies, tribes, non-profit organizations, dam owners and operators, and the interested public to have a voice in the scope and content of the analysis. The SA process provides information for future policy decisions and guidance that incorporates available information with input from experts, stakeholders and decision-makers.

In November of 2015, the department invited the public to provide input on the scope of the strategic analysis. In February 2016, department staff presented the background and need for conducting a strategic analysis on fish passage at dams to the Natural Resources Board. The strategic analysis is intended to be used as an informational tool to assist the department with the drafting of potential policy and guidance for decision making processes for department staff. All interested stakeholders will have an opportunity to comment on draft policy that may be developed.

2 Regulatory Framework and Department Procedures and Guidelines

Wisconsin lakes and rivers are public resources, owned in common by all Wisconsin citizens under the state's Public Trust Doctrine. Based on the state constitution, this doctrine has been further defined by case law and statute. It declares that all navigable waters are "common highways and forever free", and held in trust by the department.

As a result, the public interest, once primarily interpreted to protect public rights to transportation on navigable waters, has been broadened to include protected public rights to water quality and quantity, recreational activities, and scenic beauty (Quick 1994).

Because of the Public Trust Doctrine, all Wisconsin citizens have the right to recreate on navigable waters, as well as enjoy the natural scenic beauty of navigable waters, and enjoy the quality and quantity of water that supports those uses (WDNR 1995). Wisconsin's Public Trust Doctrine requires the state to intervene to protect public rights in the commercial or recreational use of navigable waters. The department, as the state agent charged with this responsibility, can do so through permitting requirements for water projects, through court action to stop nuisances in navigable waters, and through statutes authorizing local zoning ordinances that limit development along navigable waterways.

While some regulations such as Wisconsin State Statute Chapter 31, which govern dams and Wisconsin Administrative Codes NR 333 and NR 116, which relate to dams and floodplains are often associated with dams, there are there are many regulations that may apply to dams and fish passage projects.

Table 2-1 lists possible statutes, codes and ordinances that may apply to a fish passage at a dam project. These citations may not cover all relevant requirements and each description is a basic summary included to only provided a general understanding of the code statute.

Table 2-1, Regulations That May Apply to Fish Passage at Dams Projects

Specific Action	Statute or Code	Description
Wisconsin State Statutes and Administrative Codes		
Conservation – Invasive Species	Wis. Stat. § 23.22 (1)(c)	Defines “Invasive species” to mean non-indigenous species whose introduction causes or is likely to cause economic or environmental harm or harm to human health.
Endangered and Threatened Species Protected	Wis. Stat. § 29.604	The legislature finds that certain wild animals and wild plants are endangered or threatened and are entitled to preservation and protection as a matter of general state concern.
Scientific Collectors Permit	Wis. Stat. § 29.614 and Wis. Admin. Code NR 19.11	Permit is needed to collect or salvage from wild live fish for scientific purposes.
Fish Stocking Permit	Wis. Stat. § 29.736 and Wis. Admin. Code NR 19.05	Permit is needed to stock fish in Wisconsin waters.

Navigable Waters, Harbors, and Navigation	Wis. Stat. § 30	Permits are needed for most work in navigable waters, including placing, removing, or modifying structures on the bed of navigable waterways, dredging or grading the beds and banks of navigable waterways and change stream courses. These authorizations require the department to consider the public interests and rights in navigable waters emanating from the WI Constitution.
Navigable Waters, Harbors, and Navigation – Transportation of aquatic plants and animals; placement of objects in navigable waters	Wis. Stat. §.30.07 and Wis. Admin. Code NR 19.055	Restrict the movement of aquatic plants, aquatic animals, and by vehicles between waterbodies on highways.
Direct Regulation of Dams	Wis. Stat. § 31	The department may require dam owners to comply with conditions the department determines are reasonably necessary "to preserve public rights in navigable waters, to promote safety and to protect life, health and property." Public rights include fishing, natural scenic beauty, and environmental quality. Ch. 31 permit may eliminate the need to obtain a NR 40 permit.
Ordering Fish Passages	Wis. Stat. § 31.02(4)(c), 31.02(4)(g) and 31.02(4)(r)	4(c) With good and sufficient fishways or fish ladders, or in lieu thereof the owner may be permitted to enter into an agreement with the department to pay for or to supply to the State of WI annually such quantities of game fish for stocking purposes as may be agreed on by the owner and the department. 4(g) The department may not impose the requirement under sub. (4)(c) on an owner of the dam unless all of the following apply: (a) the rules promulgated under sub. (4r) are in effect. (b) federal government or the state implements a program to provide a cost-sharing grants to owners of dams for equipping dams with fishways or fish ladders and a grant is available to the dam owner under the program. 4(r) The department must promulgate rules "specifying the rights held by the public in navigable waters that are dammed," including "provisions on the rights held by the public that affect the placement of fish ways or fish ladders that are dammed." NR 40 considerations should be incorporated into this rule.
Historic Preservation Program	Wis. Stat. § 44.40	"Each state agency shall consider whether any proposed action of the state agency will affect any historic property…" and directs each agency to cooperate with the Wisconsin Historical Society in its efforts to identify and protect the State's cultural resources. (Compliance with this State Statute is done through a Memorandum of Agreement between the State Historical Society of Wisconsin and the department.)
Burial Site Preservation	Wis. Stat. § 157.70	Focuses on the identification and protection of human burial areas including those located on either public or private property and/or otherwise not associated with public cemeteries.
Regulation of Public Utilities	Wis. Stat. § 196.49	For "public utilities" significant facility investments must be approved by the Public Service Commission of Wisconsin (PSCW)

Regulations of Public Utilities	Wis. Stat. § 196.49(3)(b)(1) and (2); and 196.491(3)(d)	The PSCW reviews the investments made in generation resources to determine, among other things, if such investments satisfy the needs of the public for an adequate supply of electric energy, and to determine if the investment is in the public interest "considering alternative sources of supply, alternative locations or routes, individual hardships, engineering, economic, safety, reliability, and environmental factors.
Water Quality Standards	Wis. Stat. § 281.15(1)	The department shall promulgate rules setting standards for water quality to be applicable to the waters of the state, recognizing that different standards may be required for different waters or portions thereof. Water quality standards shall consist of the designated uses of the water portions thereof and the water quality criteria for those waters based upon the designated use. Water quality standards shall protect the public interest, which include the protection of the public health and welfare and the present and prospective future use of such waters for public and private water systems, propagation of fish and aquatic life and wildlife, domestic and recreational purposes and agriculture, commercial, industrial and other legitimate uses. In all cases where the potential uses of water are in conflict, water quality standards shall be interpreted to protect the general public interest.
Inland Fisheries Management	Wis. Admin. Code NR 1.02(7)	The department is charged with the identification and classification of trout streams to ensure adequate protection and proper management of the resource.
Possession, Transport, and Transfer of Live Fish	Wis. Admin. Code NR 19.05(3) and 40.05(3)	General permit required to possess, transport, and transfer live, rough fish, live established nonnative fish species, or live commercial fish (excluding all species of Asian carp).
Fish Refuges	Wis. Admin. Code NR 26	Areas where it is unlawful to take, disturb, catch, capture, kill, or fish for fish in any manner at any time listed in NR 26.
NR 40 Invasive Species Regulation	Wis. Admin. Code NR 40	Where a barrier prevents the upstream movement of a non-native fish species, "removal" of the barrier **may** constitute an "introduction" of the species, which is a regulated activity under NR 40. BMP's could be developed to exempt this provision. Staff should work with Legal Services when considering NR 40. Other permits or approvals may exempt the need to obtain a NR 40 permit.
Invasive Species Regulation – Prohibited Category	Wis. Admin. Code NR 40.04(3) and 40.05(3)	Prohibit the movement of listed invasive species. A person is not subject to a violation, however, if the movement is incidental or unknowing, and not due to the person's failure to take reasonable precautions.
Invasive Species Regulation - Transportation	Wis. Admin. Code NR 40.06(7)	A person who holds a permit or approval issued by the department under another chapter or a statute other than Wis. Stat. § 23.22, is not required to hold a permit under this chapter to transport, possess, transfer, or introduce a prohibited or restricted invasive species listed in Wis. Admin. Code NR 40.
Water Quality Standards	Wis. Admin. Code NR 102, NR 104	Clean Water Act Use Designations and Classifications, Outstanding and Exceptional Waterways.

Use and Designated Standards	Wis. Admin. Code NR 104.24(3)	The department has, by rule, recognized that the Brule and Menominee Rivers are used for hydropower production.
Wisconsin Floodplain Management Program	Wis. Admin. Code NR 116	Provide a uniform basis for the preparation and implementation of sound floodplain regulations for all WI municipalities.
Wisconsin Environmental Analysis and Review Procedures	Wis. Stat. § 1.11 and Wis. Admin. Code NR 150	Establishes the procedures for environmental analysis of department actions.
River Protection Grants	Wis. Admin. Code NR 195	Establish procedures for implementing a river protection grant program.
FERC Dams: Water Quality Certification for Federally Licensed Dam Projects and additional department involvement	401 Water Quality Certification (Wis. Admin. Code NR 299.04)	Dam owner must obtain a Water Quality Certification (NR 299.04) from the department. This requires the department to consider the public interests and rights delineated in Wis. Stat. § 30 and 31. A federally authorized tribe may also require a Water Quality Certification.
Dam design and Construction	Wis. Admin. Code NR 333	Ensure that dams are designed, constructed and reconstructed so as to minimize the danger to life, health and property.
Introduction of Fish or Eggs into the Waters of the State	Wis. Admin. Code ATCP § 10.63	A Fish Health Certificate (FHC) is required when fish or eggs are introduced into the “waters of the state” from another state, or private source. The project applicant should work with the DATCP to determine if their proposed project requires a certificate.
Reintroduction of Fish or Eggs into Original Wild Source	Wis. Admin. Code ATCP § 10.655(1)	A FHC is not required when fish/eggs are collected from and later reintroduced into the same lake or at the same point or a downstream point on a river/stream.
State Executive Order #39		Issued February 27, 2004 details protocols and policy for agency and tribal relations. Affirms the government-to-government relationship between the State of Wisconsin and the Indian Tribal Governments located within the State.
Department Guidelines, Procedures, and Manual Codes		
Department Reference Materials		WDNR Fish Passage Guidance. January 2014. Establishes criteria staff should use when reviewing regulated activities that have the potential to increase the distribution of aquatic invasive species (AIS) of fish pathogens.
		Guidelines for Evaluating Habitat of Wadeable Streams, WDNR, June 2002
		SURFACE WATER ASSESSMENT TEAM Guidelines and Procedures for Continuous Temperature Monitoring, WDNR, 2005 (Draft-Version 3)
		Guidelines for Deployment of Continuous Dissolved Oxygen Meters, Data Evaluation, & Data Storage, WDNR, 2007

	A) Nutrient Chemistry Grab Sampling (V3.2) DNR Water Quality Monitoring Program WDNR-PUB-WY-019-2015 B) Low Level Metals – Method for Clean Sampling ("Clean Hands/Dirty Hands Technique") Version 2.4FPM 101.2, WDNR Water Quality Monitoring Program WDNR PUB-WY-022-2015
	Flow Monitoring in Wadeable Streams Version 1.0 WDNR Water Quality Monitoring Program
	Guidelines for Collecting Macroinvertebrate Samples from Wadeable Streams, WDNR, June 2000
	Large River Macroinvertebrate Sampling (V2.0), DNR Water Quality Monitoring Program, WDNR PUB-WY-080-2015
	Lyons, J., R.R. Piette, and K.W. Niedermeyer 2001. Development, validation, and application of a fish based Index Biotic Integrity for Wisconsin's large warmwater rivers. Transactions of the North American Fisheries Society. 130:1077-1094.
Waterbody Information Databases	The Surface Water Integrated Monitoring System (SWIMS): A data system designed to ensure that staff and management have access to high quality surface water, sediment, and aquatic invasive species data in an accessible format. The SWIMS System is interrelated with other data systems at the department and outside the agency.
	Fisheries Management Database (FMDB): Data collected as part of statewide fisheries and habitat sampling and fisheries stocking activities are stored in the Fishery and Habitat Biology Database (FHDB). The Fish Database is a centralized internet transactional and warehouse system deployed in January 2001, and is accessible to all department staff. Propagation summaries are accessible to the public. The database serves as the central repository of all fish stocking, and fish and habitat survey information collected in the state.
	The Register of Waterbodies (ROW) and 24K Hydrolayer: The official department surface water inventory database. It contains waterbody name, waterbody ID code (WBIC) and various physical characteristic data such as size, depth, substance composition and shoreline length.
	Surface Water Data Viewer (SWDV): A GIS-based mapping tool for water data display and integration. It was originally developed for displaying standards data (Impaired Waters, Outstanding & Exceptional Waters), but Dams and Floodplain viewer applications merged into SWDV in 2005. It contains map features for Wetland, Waterway Protection, Dam and Floodplains, Surface Water Quality, Fisheries, Aquatic Invasive Species, Monetary Grants, Surface Water Outfalls, Hydrography and Watersheds.
	Water Assessment Tracking and Electronic Reporting System (WATERS): WATERS supports water quality standards and assessment work, Division's Goals Reporting, and Watershed Electronic Watershed Planning. WATERS holds decisions and information regarding the status of rivers, streams, and lakes, as well as Great Lakes shoreline miles including a variety of use designation, assessment, management uses, and linkages to documents or reports supporting decisions about a waterbody.

		Waterbody Type: All waterbodies are assigned their modeled Waterbody Type by default, until/unless enough data are available to verify whether the modeled Type is correct and to make corrections if needed. Verifying the Type before assessing whether or not a waterbody is attaining its criteria is a critical first step since some of the waterbody's applicable criteria depend on which Waterbody Type is assigned to it. For streams, Waterbody Type verification is done through verification of the fish Natural Community (NC) subcategory. This verification requires a minimum of one fish community survey (of all species, not gamefish only). This is routinely collected as part of the department's monitoring program sampling regimen, so every site that is sampled should have its Waterbody Type verified as the first step in assessment. Additional fish surveys from multiple years or from upstream/downstream reaches are also helpful. Descriptions of the NC categories, the abundances of fish from different temperature and stream size guilds and the NC verification process are found in: Methodology for Using Field Data to Identify and Correct Wisconsin Stream "Natural Community" Misclassifications, Version 5 (Lyons 2015).
Historic Preservation	Manual Code (MC)1810.1	Outlines the departments actions to meet Section 44.40 of Wisconsin Statutes
Boat, Gear and Equipment Decontamination and Disinfection Protocol	MC 9183.1	Applies to all department employees moving boats, gear, and equipment between waterbodies and/or crossing a barrier while moving from downstream to upstream on the same waterbody or a connected waterbody.
Federal Statutes and Regulations		
Fish and Wildlife Coordination Act	48 Stat. 401; 16 U.S.C. § 661 et seq.	This Act provides for a basic procedural framework for the orderly consideration of fish and wildlife conservation and enhancement measures in Federally constructed, permitted, or licensed water development projects. The Act provides that, whenever any water body is proposed to be controlled or modified "for any purpose whatever" by a Federal agency or by any "public or private agency" under a Federal permit or license, the action is required first to consult with the wildlife agencies, "with a view to the conservation of fish and wildlife resources in connection with that project." The Act authorizes preparation of reports and recommendations by the Secretary of the Interior (and/or Commerce) and the head of the State agency responsible for the administration of fish and wildlife resources, to be submitted to the action agency.
Endangered Species Act	87 Stat. 884, 16 U.S.C. § 1531 et seq.	Under Section 7(a)(2) of the Act, Federal agencies are required to consult with the FWS and/or the National Marine Fisheries Service to ensure that any Federal action is not likely to jeopardize the continued existence of any threatened or endangered species, or adversely modify critical habitat designated for those species. If a proposed agency action may affect a listed species or critical habitat, consultation with the FWS is required under Section 7 of the Act.
Anadromous Fish Conservation Act	16 U.S.C. § 757a-757g; 79 Stat. 1125	Authorizes the Secretaries of the Interior and Commerce to enter into cooperative agreements with the States and other non-Federal interests for conservation, development, and enhancement of anadromous fish, including those in the Great Lakes, and to contribute up to 50% as a Federal share of the cost of the carrying out of such agreements.

Federal Regulation and Development of Power	16 U.S.C. § 799 et seq	FERC licenses are issued for periods of 30-50 years pursuant to the Federal Power Act
Regulation of Water Power and Resources - General powers of Commission	16 U.S.C. § 797(e)	In licensing hydropower projects, FERC is required to give equal consideration to environmental values, including fish and wildlife resources, visual resources, cultural resources, recreational opportunities, and other aspects of environmental quality.
Operation of navigation facilities; rules and regulations; penalties.	16 U.S.C. § 811 & 16 U.S.C. § 803(j)	The FERC license must contain any fishway prescriptions (mandatory conditions) required by the Secretaries of Commerce and the Interior. Any federal and state fish and wildlife agencies recommendations submitted pursuant to the Fish and Wildlife Coordination Act that are needed to adequately and equitably protect, mitigate damages to, and enhance fish and wildlife, including spawning grounds and habitat.
Clean Water Act	33 U.S.C. §1251 et seq. (1972)	Establishes the basic structure for regulating discharges of pollutants into the waters of the United States and regulation quality standards for surface waters.
National Environmental Policy Act of 1969	83 Stat. 852; 42 U.S.C. § 4321 et seq.	NEPA is a systematic interdisciplinary approach, which integrates natural and social sciences and environmental design for planning and decision making, to ensure environmental resources are given appropriate consideration in project planning and decisions.
Federal Power Act	18 C.F.R § 4.38(a) and 18 C.F.R. 5.1(d)	Section 4(e) allows land management agencies to require license conditions to ensure adequate protection and utilization of Federal reservations Section 10(a) requires the FERC to consider recommendations from resource agencies and Indian Tribes to ensure projects are “best adapted” to the comprehensive development of the waterway. Section 10(j) requires fish and wildlife recommendation to be included in the project license, unless inconsistent with other Federal law. Section 18 directs FERC to require construction, maintenance, and operation by a licensee at its own expense of such fishways as may be prescribed by the Secretary of Interior of the Secretary of Commerce. Section 30 (c) requires mandatory fish and wildlife conditions for projects exempted from licensing.
Federal Historic Preservation Act	PL89-665	National Historic Preservation Act of 1966. Established a national historic preservation policy; created the National Register of Historic Places and the Cabinet Level Advisory Council on Historic Preservation; and established the Section 106 process, which requires a consideration of cultural resources for undertakings that are federally funded, licensed, permitted, or occur on federal or tribal lands. WHS/State Historical Preservation Office (SHPO) acts on behalf of respective federal agencies such as FERC for the purposes of Section 106.
Federal Environmental Policy Act	PL91-190	National Environmental Policy Act of 1969. Requires that archaeological and other historic resources be considered during a federal environmental assessment process and in environmental impact studies.

Federal Archeology Resource Protection Act	PL96-95	Archeological Resource Protection Act of 1979. Establishes criminal and civil penalties for disturbing prehistoric and historic archaeological sites on Federal and Indian lands, and for sale, transport or receipt of archaeological resources excavated or removed from public lands or Indian lands or in violation of State or local law (i.e., theft of private property).

3 Types of Fish Passage

3.1 Overview

(Editor's Note: Much of the information in this section comes from the California Department of Water Resources" report *Technologies for Fish Passage at Large Dams* (CDWR 2013).)

Fish passage technology has strengths and weaknesses and may only be suitable for certain sites and species. Fish passage through or around a barrier is either upstream or downstream, active or passive, and any combination of these (*e.g.*, upstream-active, downstream-passive). Active passage occurs through mechanized structures such as fish elevators, locks, and capture and transfer. Passive passage occurs through static structures such as fish ladders and natural bypass river channels, often with few moving parts. Various active and passive technologies are used to pass fish at dams.

Volitional types of passage let the fish choose when to move past a dam by providing a constant hydraulic connection between the upstream reservoir and the river downstream of the dam. It is common for volitional passage to operate seasonally or year-round. Examples of these technologies are fish ladders and nature-like bypass channels.

Non-volitional technologies rely on people or machines to provide assistance in the passing of fish around a dam. Examples of these technologies are lifts, locks, and collection and transport. These technologies do not have a constant hydraulic connection, and may take hours for one load of fish to be moved.

Fish passage structures have existed at several dams since the early days of water resources development in Wisconsin. See Table 1-1 for a list of Wisconsin dams with fish passage projects. From 1908 to 1912, fishways were evaluated on the St. Croix River at St. Croix Falls, the Kilbourn Dam on the Wisconsin River, the Eureka Dam on the Fox River, and the Weyauwega Dam on the Wolf River. The Prairie du Sac Dam on the Wisconsin River had a fish ladder installed in 1941. The ladder was designed to require fish to jump and since Wisconsin River fish species do not jump, the dam personnel decided to remove it.

In Wisconsin and in other states, dams were constructed without upstream or downstream fish passage. Fish hatcheries, fish stocking, and habitat improvement projects are various options to compensate negative impacts from dams.

3.2 Upstream Fish Passage Technologies

The main goal of upstream fish passage is to attract migrating fish species to a specified point in the river downstream of the structure and to induce them or make them move upstream through a waterway, or by collecting and transporting them upstream (Marmulla 2001). Two important aspects of design include the needed hydraulic characteristics of the facility and the fish species of concern. Examples of target fish species could include endangered resources, specific species that require migration, or mussel host species. Biological and hydraulic criteria for designing fish passage facilities vary with species and sizes of fish (Katopodis 1992).

According to Larinier (2000), there are several types of fish passage that have been well developed for passage of anadromous species, which are born in rivers or streams, spend most of their lives in open water, and return to spawn. These technologies include:

- Fishways (ladders and nature-like channels)
- Fish lifts and locks
- Collection and transport facilities

Fish ladders have been used most often in North America and Europe. FERC (2004) reported that within the United States, lifts, locks, and fish ladders are used most often in the Northeast, and pool type ladders are more common in the West/Northwest. Nature-like fishways such as roughened channels have also been used because they provide diverse hydraulic conditions, mimic natural channels, and blend in better with their surroundings. Each passage technology has strengths and weaknesses and may only be suitable for certain sites and species.

3.2.1 Fishways (Passive)

Fishways provide volitional fish passage, as they are constantly hydraulically connected. They can be divided into three main categories:

- Pool-type / ladders – Series of pools at consecutively higher elevations.
- Baffle-type – Series of baffles designed to slow water velocity to allow fish to pass.
- Nature-like – Designed to mimic a natural channel.

The type of design chosen is primarily based on hydraulic criteria such as flow, velocity, turbulence, and drop height (California Department of Fish and Game [CDFG] 2009). The behavior and swimming ability of the target species determines the hydraulic criteria used in the design. If juvenile fish will be passed, more stringent hydraulic criteria need to be used. Large water level differences between pools, excessive flow velocities and turbulence, large eddies, and velocities and depths which are too low can create barriers for fish. In addition, fish are sensitive to other environmental factors such as the level of dissolved oxygen, temperature, noise, light, and odor which can negatively affect migration. This applies particularly if the quality of the water feeding the fishway is different than that passing across the dam (Larinier 2000).

A fishway can be full channel width, partial width, or a bypass around a structure outside of the main channel.

- The full width fishway is advantageous in that fish have no problem finding the entrance to it and it can be constructed completely downstream of the barrier with the upper end of the fishway at the barrier.
- The partial width fishway can be on either side of the channel, or in the middle. To be effective, the entrance should be near the barrier, so the fishway may need to cut through the barrier and have its exit upstream, possibly complicating construction and the hydraulics of the fishway.
- The bypass fishway is isolated hydraulically from the channel and usually has the smallest project footprint. As with the partial width fishway, the entrance should be at the barrier and auxiliary water may be needed to provide the necessary attraction flow. The determination of the entrance location can be difficult because of varying hydraulics at the barrier during different flow regimes. One advantage of the bypass fishway is that,

since it is isolated, most of the construction and maintenance can proceed in dry conditions outside of the channel (CDFG 2009).

Pool-Type Fishways

Pool-type fishways, often called fish ladders, are a series of pools at consecutively higher elevations. Water flows over weirs, through orifices, or through slots to move from pool to pool. Fish must be able to easily overcome the water surface differential between pools by swimming or leaping. The water volume in the pool dissipates the water's energy before reaching the drop to the next downstream pool (CDFG 2009).

The entrance configuration and attraction flow are important features of pool-type fishways. Attraction flow mimics the turbulence and water movement of the river and encourages adults to enter and ascend the ladder (Clay 1995). Improper flows can mean that fish cannot find the ladder entrance and migration is delayed.

Pool-type fishways are seldom used to overcome a maximum hydraulic head of more than 100 feet, although some have been used for higher applications.

The three major pool-type fishways are:

- Pool and weir
- Pool and chute
- Vertical slot

Pool and Weir Fishways

Pool and weir fishways (Figure 3-1) historically have been used most often for passage at low head dams. The fishway is an open channel, usually constructed with concrete, with pools that are separated by weirs. The weirs are typically horizontal, but can be sloped or have notches in them. Sometimes the fishway has one or more orifices in the weirs, which allow fish to swim from pool to pool instead of leaping over the weirs. The amount of flow, the geometric characteristics of the fishway, and the water surface differential between pools determine how water will behave as it flows down the fishway (CDFG 2009).

The pools in the fishway offer resting areas for fish and ensure adequate energy dissipation of water (Larinier 2000). The normal flow regime in the fishway is a plunging circulation pattern. Water passing over the upstream weir plunges toward the fishway floor, moves downstream along the floor, then rises along the upstream face of the downstream weir and either drops over the weir or moves back upstream along the surface of the pool. As the flow in the fishway increases, the depth of water over the weirs increases and the flow transitions to a streaming flow regime (CDFG 2009).

Dimensions of the pools of the fishway depend on the style of fishway, target species, scale of the river, and degree of flow control. Pools can be very small when dealing with smaller fish, but typically are in the range of four by six feet to eight by twelve feet. Typical pool depths for these ladders vary from three feet in streams and smaller rivers to eight feet or more in large rivers (CDFG 2009).

Debris can be a problem in pool and weir fishways, as it can catch on weirs, notches, or orifices. In addition, sediment accumulation can affect the performance of the fishway by filling in pools and thus reducing their energy dissipation capability.

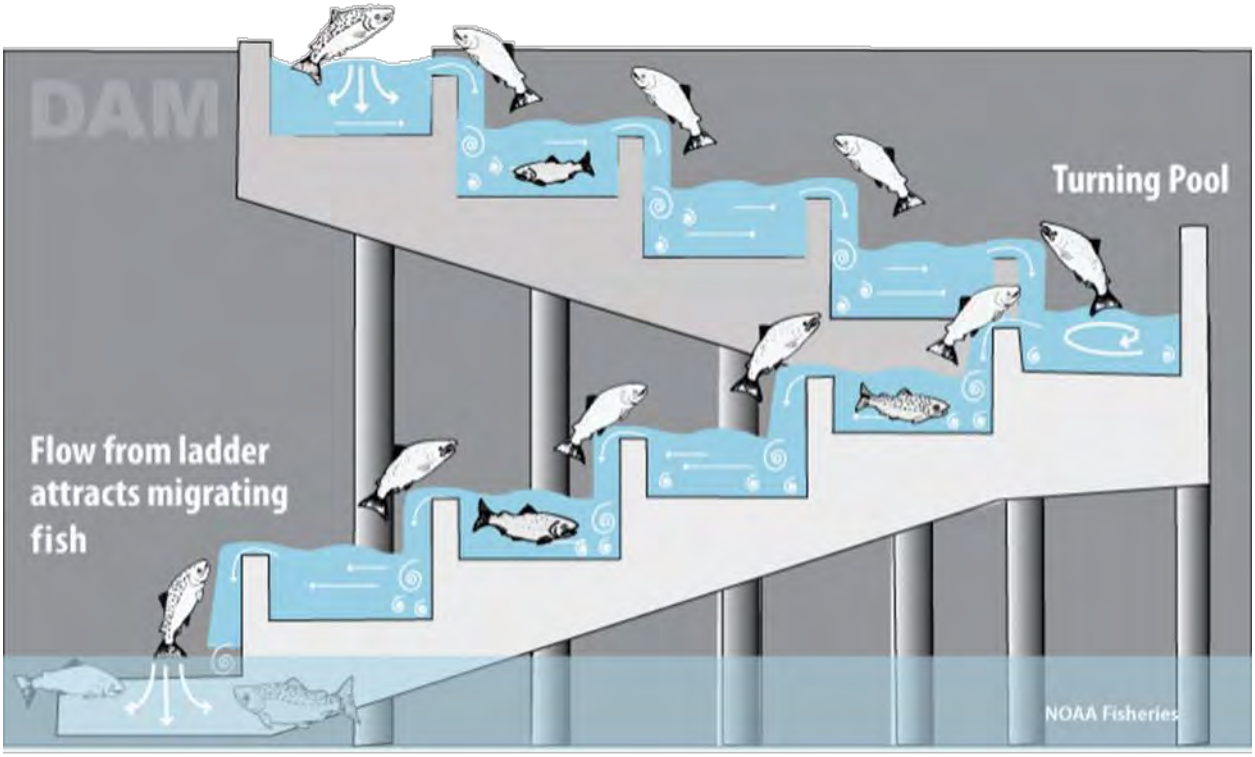

Figure 3-1, Pool and Weir Fishway, Source: NOAA Fisheries

Pool and Chute Fishways

The pool and chute fishway (Figure 3-2) is similar to the pool and weir fishway in that water flows over a weir from pool to pool. The difference is that a pool and chute fishway has a center notch and sloping weirs that extend to the fishway walls.

At low flows, the fishway behaves like a pool and weir fishway, with water only passing through the center notch and spilling over the horizontal weir.

At moderate to high flows, parts of the fishway operate in both plunging and streaming flow regimes simultaneously (CDFG 2009). Water spreads across the fishway and up the sloping weirs, creating plunging flow at the flow margins. Under this condition, high velocity streaming flow exists in the center of the fishway. The fishway should be designed so that the high fish passage design flow doesn't quite cover the entire width of the sloping weirs (at least 2 feet from the wall is recommended). Orifices can be included at the floor to help stabilize the flow and provide a submerged swimming option for fish (Powers 2001).

The pool and chute fishway has many benefits:

- For smaller applications, all of the flow can be contained in the fishway and the fishway creates a strong jet, making it very attractive to migrants.
- Large fishway flows can scour sediment and debris from the fishway, reducing maintenance.

- Several passage routes are available to fish moving upstream and the size of the pools can be smaller than a pool and weir fishway for the same range of flows (CDFG 2009).

The pool and chute fishway also has some disadvantages:

- The fishway must be aligned in a straight line without bends, since it has high velocities down the center at moderate to high flows. The high velocities can cause erosion downstream of the fishway if the channel is narrow or if the fishway is aligned towards a bank.
- Because the hydraulics and biological effectiveness of the pool and chute fishway have yet to be extensively evaluated, the California Department of Fish and Game (CDFG) recommends that "no more than five or six feet of head differential should be taken through a pool-and-chute because of the uncertainties of stability with the high energy in the fishway and the limited hydraulic verification done" (CDFG 2009, pg. XII-123).

The pools for the pool and chute fishway are typically wider and shorter than those for a pool and weir fishway.

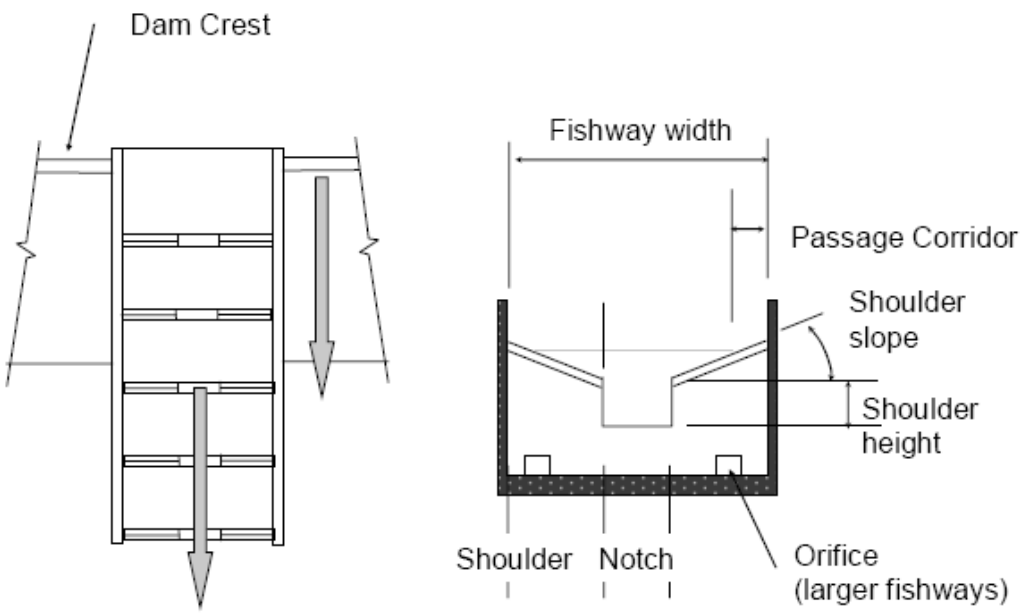

Figure 3-2, Pool and Chute Fishway, Source: CDWR 2013

Vertical Slot Fishways

Vertical slot fishways (Figure 3-3) do not have overflow weirs as do the previous pool-type fishways. Hydraulic control and fish passage are provided by full-depth slots between the pools.

A benefit of the vertical slot design is that it is self-regulating and operates throughout the entire range of design flows without adjustment. That means that the water surface elevation difference between the tailrace and forebay will be divided equally between all of the fishway slots. The fishway automatically compensates for any change in forebay or tailrace water surface elevation. The vertical slot fishway's full depth slots also allow fish passage at any depth (CDFG 2009).

Energy is dissipated by the water jet through the slot mixing with the water in each pool (Katopodis 1992). Pool depths increase as flows increase, creating additional pool volume and thereby maintaining the needed energy dissipation (CDFG 2009).

Since fish must swim the entire length of the fishway, the vertical slot fishway is not the best choice for species that need overflow weirs for passage. The vertical slot fishway gives them no opportunity to leap (Katopodis 1992).

It is critical to the stability of flow in the vertical slot fishway that the design uses the dimensions described by Bell (1991), unless it is known, from studies or experience that other configurations will work. Changes from the standard dimensions can cause unstable flow conditions and water surging in the fishway. Shallow depths can cause hydraulic problems in the fishway, as the water jet through the slot shoots across the pool and to the next slot. Sills at the bottom of the slot should be added if the pool upstream of the slot is to be operated at depths less than 5 feet (CDFG 2009).

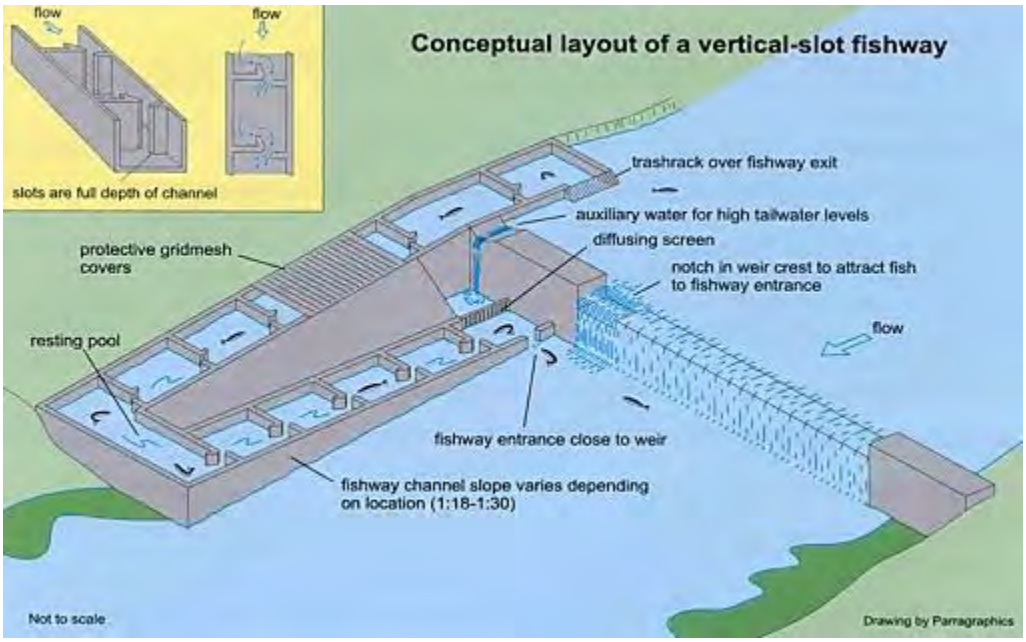

Figure 3-3, Vertical-Slot Fishway, Source: NWS DPI 2016

Baffle-Type Fishways

The two common styles of baffle-type fishways are the Denil (Figure 3-4) and Alaska Steep pass, which are fabricated flumes constructed out of aluminum, steel, or wood with angled baffles. The baffles create roughness which controls the velocity in the fishway, even at high slopes (CDFG 2009). They are narrow fishways, typically less than 5 feet in width, which in combination with the baffles make them very susceptible to debris blockages. Both types require a consistent headwater pool elevation upstream to be effective, as variations of more than a foot will create passage difficulties (Bates 2000).

Since fish must pass through these fishways without stopping, longer fishways may exceed the limits of their endurance. Therefore, resting pools should be constructed between fishway

sections (Larinier 2000). Both types of fishways have been used throughout the world for passage at smaller barriers, but are not the best choice of fishway for settings where debris, sediment, and weak-swimming fish are to be passed.

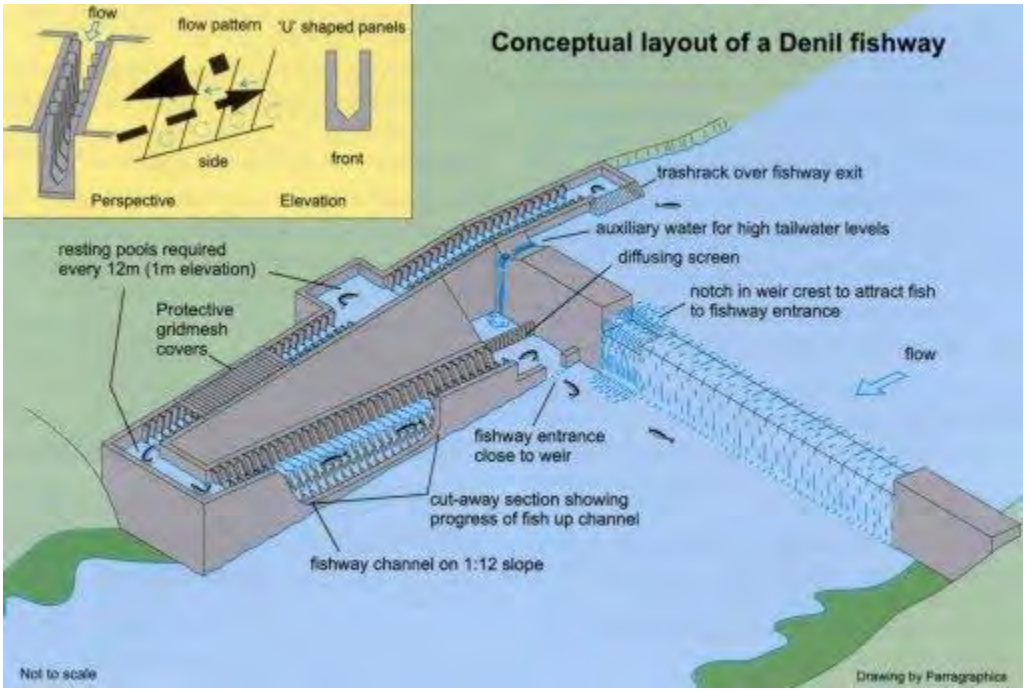

Figure 3-4, Baffle-Type Fishway, Source: NWS DPI 2016

Nature-Like Fishways

The nature-like fishway (Figure 3-5) is designed to mimic a natural channel and provide suitable conditions for passage over a range of flows for fish and other aquatic organisms. The fishway is designed to recreate pools, riffles, steps, and/or cascades using natural materials. This type of fishway is usually used at low-head barriers and can be a full channel width, partial channel width, or bypass type design. Nature-like fishways are constructed mainly with rock, with the smaller particles, such as sand and gravel, filling the voids between the larger ones (Katopodis et al. 2001).

The advantages of nature-like fishways as follows:

- Suitable for a variety of aquatic species
- Enriched habitat for aquatic species that prefer faster moving water
- Low construction, operation, and maintenance costs compared to traditional fish passage technologies
- Can handle a wide range of flows
- Allows for movement of sediment through the fishway
- Flexible construction allows for modifications
- Allows for easy integration into the landscape
- Greater aesthetic value

Unlike traditional (concrete) fishways, nature-like designs have not been developed using extensive hydraulic research (EPRI 2002). Most nature-like fishways have been designed

intuitively to be heterogeneous and meet the requirements for fish passage at a specific site. The design process is based on the fish community present and the characteristics of the natural channels in which these fish are found (Parasiewicz et al. 1998). Successful projects have demonstrated that nature-like fishways provide fish passage and aquatic habitat, and are often inexpensive to construct and reasonable to maintain (Wildman et al. 2002).

Many nature-like fishways have been constructed throughout the world and this type of fishway has come to the forefront as a recommended design for passage at low-head structures. Since they are fairly new and the design methods have not been extensively tested, monitoring of projects is especially important (CDFG 2009).

Common configurations of nature-like fishways include rock ramps spanning a part or the full width of the channel, step-pool or cascade-pool sequences, and bypass channels around dams or drop structures.

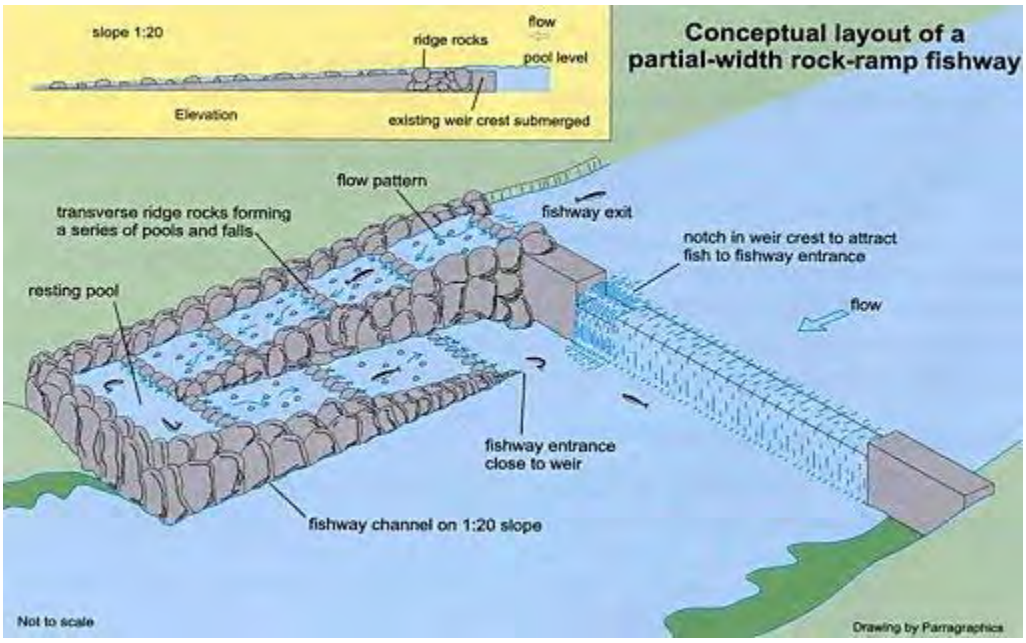

Figure 3-5, Nature-Like Fishway, Source: NSW DPI 2016

3.2.2 Fish Lifts and Locks (Active)

Fish lifts and locks are generally used for sites where vertical passage heights are excessive or for passing species that do not readily use fish ladders. They have the capability of moving fish vertically over high dams as well as reducing the physical demands on fish (California Energy Commission 2005). In addition, space requirements, construction costs, and flow requirements are usually less than traditional fishways for high head dams (Travade and Larinier 2002, FAO 2002).

Fish lifts move fish over a barrier by mechanical means. Fish locks are devices that raise fish over dams, similar to the way that boats are raised in a navigation lock.

Both lifts and locks have a much shorter history than fishways. Fish lifts and locks were first constructed in the 1920s, coinciding with the building of higher dams (Clay 1995). Lower Baker Dam (285 feet high) in Washington State was completed in 1927 and included an 800-foot-long cableway fish lift to transport collected fish in small steel tanks to the top of the dam. In reference to this cableway, Clay (1995) states that, “this contrivance was hailed at the time as the answer to the problem of passing fish over all high dams.” But in the late 1950s, the combination of the construction of Upper Baker Dam (312 feet high), the deterioration of the upstream passage facilities, and the inability of the facilities to handle the large numbers of upstream migrants caused the abandonment of the facilities and a decision to move to a trap and truck system.

In the late 1930s and early 1940s, fish lifts were developed for fish passage at high dams in the United States and Canada (Clay 1995). Fish lock development accelerated in Europe in the 1950s.

Fish Lifts

A fish lift (Figure 3-6) is a mechanical system that first traps the migrating fish in a hopper of water located at the base of an obstruction, and then raises and empties it into the upstream reservoir (Travade and Larinier 2002).

There are two main types of fish lifts:

- The first type attracts fish into a hopper (tank, trough) which has a v-shaped entrance. Once the hopper is loaded with fish, it is then lifted to the top of the dam and dumped into the dam forebay.
- The second type is for dams where large numbers (hundreds of thousands) of fish need passage. A large pool is used to hold the fish, which are then loaded into the lift using a mechanical crowder (Larinier 1998).

Like other fish passage systems, the efficiency of the fish lifts depends on their ability to attract fish into the collection chamber and lifting mechanism. In North America, fish lifts (elevators) have been preferably used over fish locks to pass fish over high dams (Clay 1995). A fish elevator may provide the ability for operators to handle and sort fish for passage.

The primary advantages of this type of technology are:

- It can be used at high head sites where traditional fishways would be very expensive (OTA 1995).
- Other advantages lie in the construction cost, which is practically independent of the height of the dam
- Their small overall footprint
- Their low sensitivity to variations in forebay water level
- They are also considered to be more efficient than traditional fishways for some fish species, such as shad (Larinier 1998)

The primary disadvantages are:

- Greater cost of operation and maintenance,
- Comprised of complex mechanical equipment with many moving parts and also metal parts that are partially or fully submerged in water.

- Breakdowns or periods of malfunction may occur frequently and/or last a long time.
- Fish lifts need regular inspection
- Upkeep of mechanical and electronic parts (hoists, sluices, screens, and machinery)
- Cleaning of screens (Travade and Larinier 2002)
- Intermittent operation of a fish lift, and its potential to delay fish at the base of the project (OTA 1995)

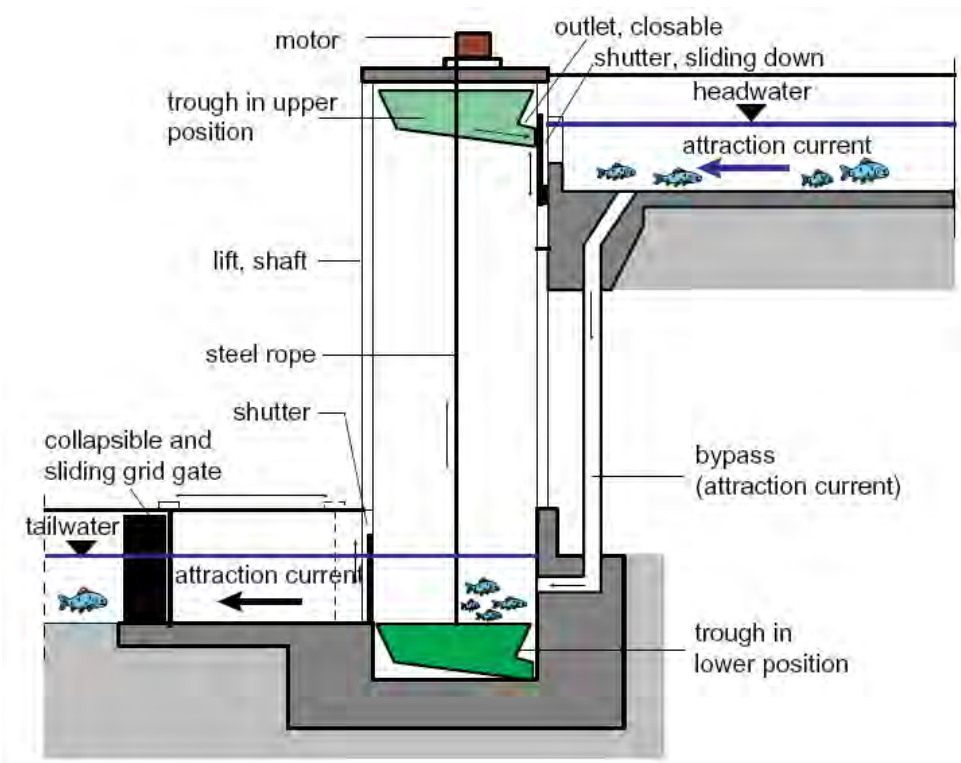

Figure 3-6, Fish Lift for Large Numbers of Fish, Source: FAO 2002

Fish Locks

The Irish engineer J. H. T. Borland developed the first fish lock (Figure 3-7) as a scale model around 1949. The design was then constructed at Leixlip Dam in Ireland, and numerous other locks.

In general, a fish lock attracts fish into the bottom of a vertical or inclined chamber and then fills the chamber with water to the level of the dam reservoir. As the chamber fills, the fish follow the rising water level and then leave the lock by swimming into the reservoir (Clay 1995, Larinier 2000).

The operating cycle can be summarized as follows (Travade and Larinier 2002):

- **Attraction phase:** The downstream sluice gate is open and the upstream sluice gate controls the flow into the fishway. Water flows into the pool formed by the upper chamber, then through the central conduit of the chamber towards the lower holding chamber, and finally out of the holding chamber into the tailwater of the dam. The flow attracts the fish into the lower holding chamber.

- **Filling and exit phase:** After an attraction period lasting for a specified period of time, the downstream sluice gate closes and the lock fills up with water. The fish follow the surface of the water in the central conduit, rising and reaching the upstream pool when the lock is full. Fish are encouraged to exit by the attraction flow created when a bypass is opened in the lower chamber and the upstream sluice gate is partially lowered.
- **Emptying phase:** After a specified period of time, the upstream sluice is closed. The lock is gradually emptied by means of the still open bypass. When the chamber is almost empty and the head on the downstream sluice is low enough, the downstream sluice is re-opened. Emptying the lock by means of the bypass prevents high velocities occurring at the entrance to the lock, which might repel any fish that are in the vicinity of the entrance.

The duration of a cycle generally takes between 1 and 4 hours.

Like other fish passage technologies, the efficiency of the lock depends on the ability to attract fish.

- The entrance location must be considered in relation to the powerhouse tailrace and/or spillway.
- In addition, auxiliary water may be needed to enhance the attraction capability of the lock entrance (Travade and Larinier 2002).

The main disadvantage of fish locks is their limited capacity in terms of the number of fish that can be handled compared to that of a pool-type fishway. This is due to the discontinuous nature of their operation and the limited volume of the lower chamber. Since no significant flow is available to attract fish during the filling and exit phase, any fish arriving at the lock during this phase may leave the entrance area before the cycle returns to the attraction phase. Fish that do enter the downstream chamber during the attraction phase may also leave before the attraction phase ends and the filling of the lock begins (Travade and Larinier 2002).

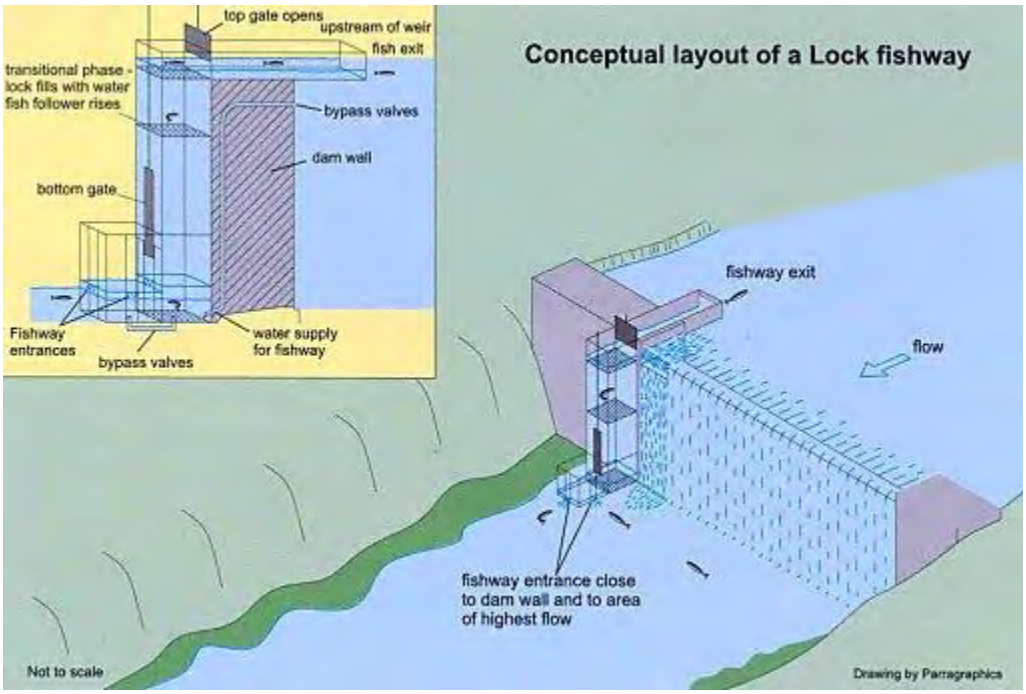

Figure 3-7, Fish Lock, Source: NWS DPI 2016

Navigation Locks

The passage of migratory fish through navigation locks is usually accidental. Fish are generally not attracted to navigation locks because the locks are located in relatively calm areas of the river to enable boats to maneuver (Travade and Larinier 2002).

Nevertheless, studies have shown that navigation locks may be useful as a back-up fish passage facility or a viable alternative to the construction of a new fish passage facility at existing sites, providing that the navigation locks' operation is modified to enhance fish passage. However, the need to operate the locks to pass boats will generally keep these locks from being efficient fish passage facilities, because the operational methods used for passing boats are often incompatible with those used for passing fish (Larinier 2000).

3.2.3 Collection and Transport (Active)

Collection and transport operations (Figure 3-8) have been used successfully for moving adults upstream of long reservoirs or multiple reservoirs. This technology has been used for interim passage until construction of other passage technologies, such as ladders or lifts, is completed (California Energy Commission [CEC] 2005).

Collection and transport has also been used as a long-term fish passage measure at high head dams where the construction of a traditional fishway would be difficult, or where a series of dams intercept a reach void of valuable spawning habitat (Larinier 2000). Other reasons include a lower initial cost compared to constructing fishways, locks, or lifts and the concern that these methods may not be successful, especially at high head dams. At high head dams, collecting and transporting adult migrants may be the only feasible passage method (CEC 2005).

The success of a collection and transport operation depends mainly on the efficiency of collecting and handling fish. Separation of fish may be required to prevent the transport of non-target species. A potential benefit of this type of system is that it needs much less flow than pool-type ladders, which may make it the most feasible fish passage option for low-flow periods in California (CEC 2005).

However, this method of fish passage can be controversial and there are concerns that handling and transporting migrating fish will have negative effects on their health and behavior. Potential adverse impacts include:

- Migration delay,
- Interruption of the homing instinct,
- Disorientation, disease, and mortality (OTA 1995).

The general concept of the collection and transport system is to:

- Block the passage of upstream migrating fish,
- Attract them into a fishway or holding pool,
- Trap them and sort them,
- Load them into a truck (typically) for transport upstream.

The collection and transport system can be used in conjunction with a fish hatchery as well. At dams where developing a suitable entrance would be extremely expensive or physically impossible to build, a barrier can be built downstream which will guide the fish to the entrance (Larinier 2000).

Several previously mentioned technologies, such as fishways, fish lifts, and fish locks, can be used to raise the fish up to a fish collection facility.

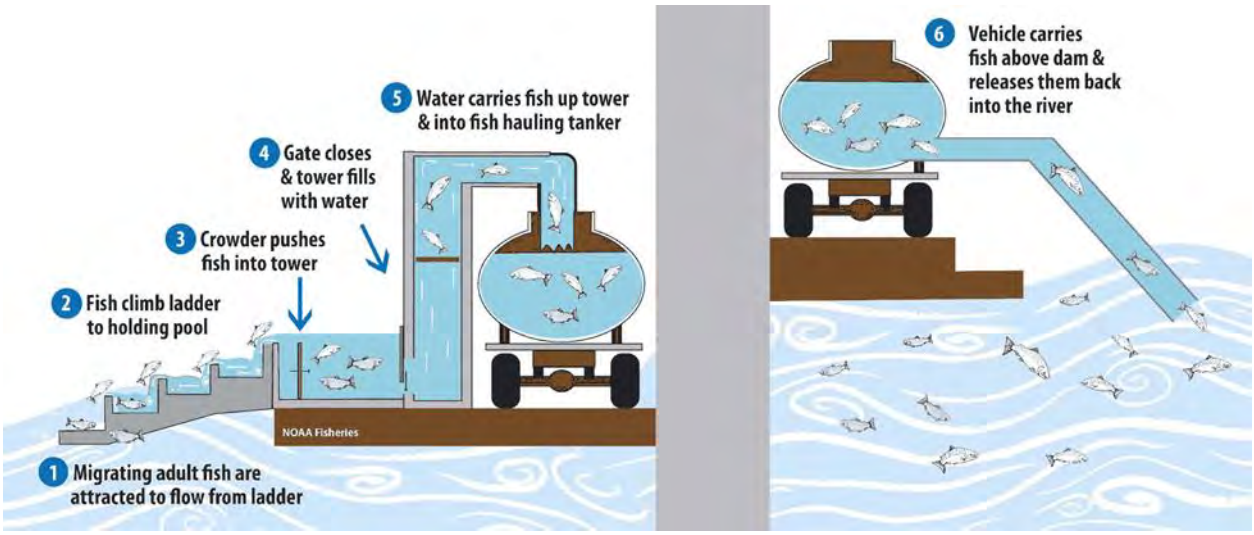

Figure 3-8, Collection and Transport, Source: NOAA Fisheries

3.3 Downstream Fish Passage Technologies

Downstream passage (Figure 3-9) occurs when fish either swim with or are carried by the water current through or over a water control structure. Effective downstream passage minimizes stress and physical injury to the fish while providing a conduit from which fish can migrate to downstream rearing habitat(s) and refugia.

For fish migrating downstream, dams and reservoirs present alternative conditions to the riverine environment. In the reservoirs where the water is deep and slow moving, fish may alter their swimming and feeding behaviors, which can delay migration. In addition, juvenile fish can be exposed to reservoir-dwelling piscivorous fishes for a significant period of time. At the dam, turbines and spillways can injure or kill fish, although injury and death rates can be highly variable depending on the spillway or turbine configuration. After fish pass through or over the dam, fish can be exposed to predatory birds or can continue migrating downstream, unharmed.

When considering downstream fish passage at hydropower facilities, common goals include:

1) To prevent fish from entering into turbine intakes;
2) To allow fish to move safely downstream past the facility; and
3) To move fish, in a timely and safe manner, through the project reservoir.

The first two are applicable to all hydropower facilities, but the third generally applies only to dams with larger reservoirs. Compared to upstream passage, there are generally more options

available for downstream passage, but no downstream passage method is appropriate for all situations.

Typically, downstream migrants can pass a dam by three methods:

- Turbines
- Spillways
- Bypass systems

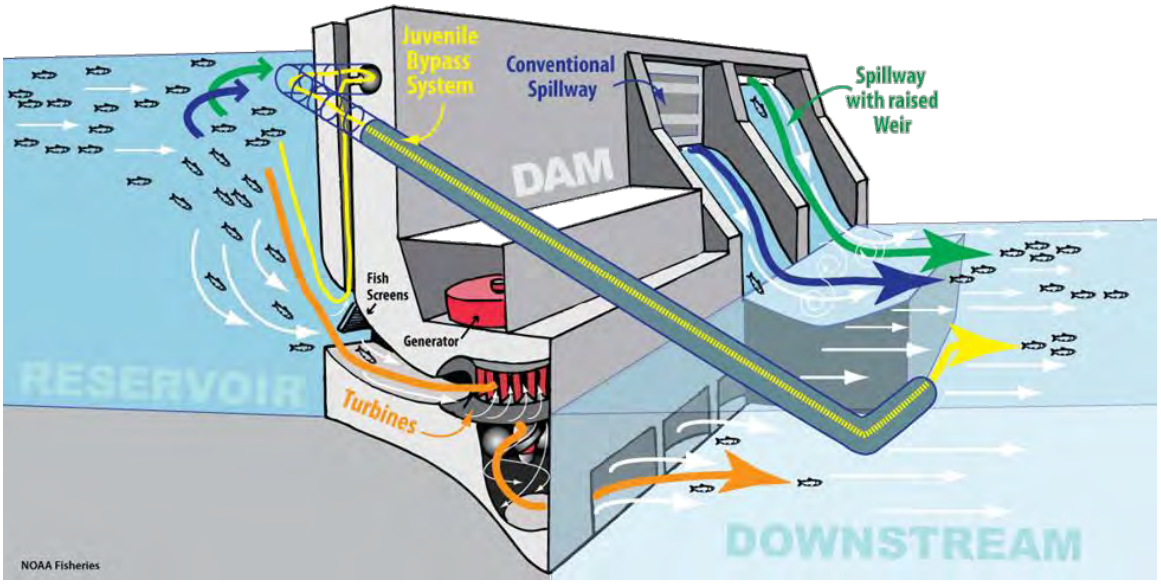

Figure 3-9, Down Stream Fish Passage Methods, Source: NOAA Fisheries

3.3.1 Turbines (Passive)

Dam powerhouses contain large generators for producing electricity. Water stored in the reservoir passes through intakes and penstocks to reach the turbines in the powerhouse. As the turbines turn, the connected generators produce electricity.

Studies of juveniles have shown that fish reluctantly, after delays in the forebay, enter the turbines intakes. Even then, these fish seek refuge in the gatewells, slots used for inserting solid barriers which keep water from entering the turbines during maintenance (Coutant et al. 2006).

Fish that do pass through turbines (Figure 3-10) can become injured or die by a number of mechanisms including:

- Rapid and large pressure changes,
- Shear stresses,
- Cavitation,
- Turbulence,
- Collision with turbine parts, and
- Squeezing through narrow openings between moving and fixed parts (Cada 2001).

The survival of fish during turbine passage is influenced by:

- Size and type of turbine,
- Speed of revolution,
- Mode of operation,
- Characteristics of the fish, such as species, size, life-stage, and condition (CEC 2005).

Two types of turbines are generally used at large dams, Francis and Kaplan. Studies show that a correlation exists between peripheral turbine blade velocity and fish mortality for the Francis design but not the Kaplan design (Eicher Associates, Inc. 1987). Fish size also affects mortality rate; as larger fish have a greater chance of colliding with turbine parts.

Effort to improve fish passage through turbines has been ongoing. Over the last 15 to 20 years, for example, the U. S. Army Corps of Engineers developed and implemented a multiple-phase Turbine Survival Program. Phase 1 was completed in 2004 with the following objectives:

- Evaluate and recommend operational criteria to improve the survival of fish passing through the Kaplan turbine units.
- Identify the biological design criteria for the design of modifications to the existing turbines.
- Investigate modifications to the existing designs that have the potential to increase survival of fish passing through the Kaplan turbine units.
- Recommend a course of action for turbine rehabilitation or replacement that incorporates improvements for fish passage survival.

By 2011 the Turbine Survival Program found:

- 'Quality flow' can be improved by how we operate the turbines to reduce fish injury & mortality
- The most efficient (+/-1%) operation is not necessarily the best range for safe fish passage
- Operating above the upper 1% efficiency range may be good for both fish and power generation for some turbines
- Leading edge strike is not likely the primary source of injury
- Most turbine induced mortality is likely from injuries leading to predation or latent mortality
- Predation in the tailrace can be a significant factor in mortality rates of passing smolts
- Turbine survival estimates are likely biased low based on tag effects

The Phase 2 report described turbine operations that optimize the total turbine passage survival by minimizing causes of both direct and indirect mortality of all fish passing through the turbines (USACE 2013). In addition, Phase 2 specifically noted that delayed and/or indirect effects of turbine passage can be as, if not more, significant than the direct effects (USACE 2013).

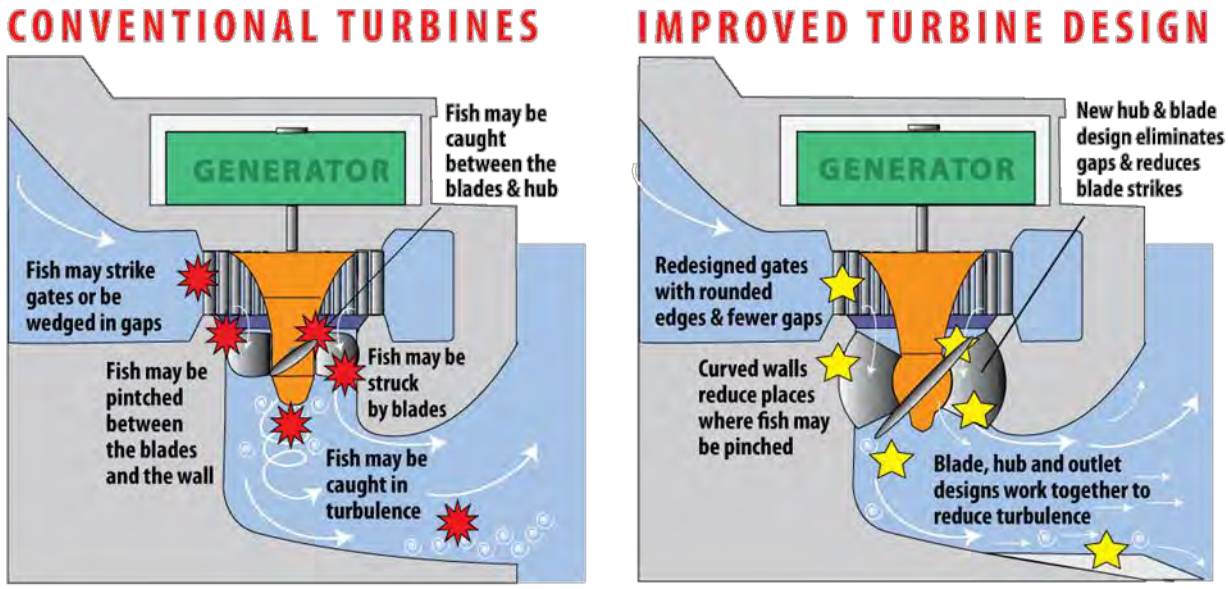

Figure 3-10, Fish Passage Through Dam Turbines, Source: NOAA Fisheries

The department participated in a study to track and document the movement of juvenile sturgeon upstream of Balsam Row and Shawano Paper Mill Dams on the Wolf River. Natural reproduction is occurring above the Balsam Row Dam, and the young sturgeon are assumed to be moving downstream as they return to the Winnebago System. Survival of these young sturgeon through the dams has been a concern. This particular study observed sturgeon survival and mortality over a 48-hour period, and documented injury rates, and types of injury associated with the hydro turbines. The results indicated that the survival rate of the sturgeon through the Shawano Paper Mill Dam was over ninety percent, conservatively.

Turbine design is continually advancing. The Alden Turbine Design is another example of technology that is considered to have less impacts to fish as compared to traditional designs.

3.3.2 Spillways (Passive)

A spillway is one channel or a series of channels along the top of the dam that allow water to pass over the dam (Figure 3-11). Water is passed through the spillway to release excess flows and to assist in fish migration. Spillways use by hydroelectric projects is fairly common, due to the lack of water storage availability in their reservoirs. At these projects, typically any flow in the river above their designed hydraulic capacity (flow through the turbines) is spilled. In larger water storage and flood control projects spillways are rarely used, generally only to release water when the reservoir is full.

Spillway passage is the simplest way to keep fish away from turbines and move them past a hydropower dam. It can also be cost effective when the migration period is short, when migration happens during higher flows events, or where spillway releases are needed for other reasons. However, spill during the low-flow periods of July and August (for late-migrating fall-run fish) is economically expensive. That being said, spillway passage is thought to be an effective means for passing fish around turbines at hydroelectric projects.

There are risks associated with using spillways for fish passage, which include:

- *Gas Supersaturation*: Spilling water entrains air as it plunges into the tailwater of the dam, causing higher levels of gas supersaturation, which can be harmful to fish, as well as adult migrants and other aquatic species. Flow deflectors can help fish passage by producing a more horizontal spill pattern and limiting the depth of the plunge into the tailwater of the dam.
- *Direct Injury or Mortality*: Direct injury or mortality at spillways can have several causes including shear effects, abrasion against the spillway, turbulence in the basin at the base of the dam, sudden velocity and pressure changes as fish enter the stilling basin, and impacts against energy dissipaters.
- *Indirect Mortality*: Indirect mortality can occur at the base of the dam, where turbulence causes disorientation and increased susceptibility to predation.

In addition to these risks, fish must find the spillway passage route. Two technologies that address the problem are the Removable Spillway Weir and the Temporary Spillway Weir (Figure 3-11).

Removable Spillway Weirs

A removable spillway weir (RSW) is a steel structure that is installed upstream of the existing spillway. It has been used to pass fish over a raised spillway crest, similar to a waterslide. A RSW can reduce migration delays and provides a less stressful dam passage route by allowing them to pass the dam near the water surface at lower water velocities and pressures.

As its name suggests, a RSW is designed to be removable, and can be lowered to the bottom of the dam forebay. Removing the RSW allows the permanent spillway to return to its original flow capacity during major flood events.

The advantages of the removable spillway weirs are (USACE 2009):

- Less stressful passage conditions and higher survival
- Greater fish passage efficiency (more fish per unit of flow)
- Delay reduction
- Reduced flow which lowers gas supersaturation and increases power generation
- Removal capability for increasing flow during flood events

Temporary Spillway Weirs

A temporary spillway weir (TSW) is smaller than a RSW, but provides a similar benefit by raising the spillway crest and creating a surface fish passage route. It has a low relative cost, is easier to install than the RSW, and allows more flexibility in biological testing. In contrast to the RSW, the TSW cannot be lowered into the forebay during high flows, but it can be removed by lifting it using an existing gantry crane.

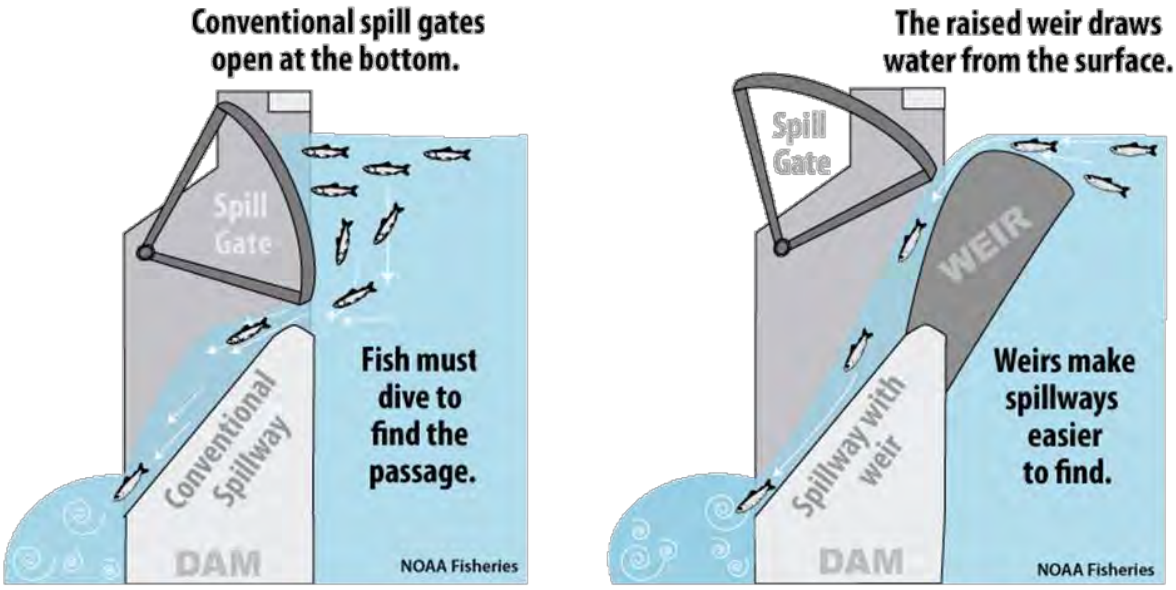

Figure 3-11, Spillway and Weirs, Source: NOAA Fisheries

3.3.3 Bypass Systems (Passive)

Bypass systems allow fish to pass a dam without going through a turbine or over a spillway. These systems can generally be placed into one of two categories:

- Bypass flumes/pipes to the river downstream of the dam, or
- Collection and transport to the river downstream.

The method of guidance into the bypass facility can be the same for both categories. This system screens fish up into a gate well where they pass through orifices into channels that run the length of the dam. The channels route fish into a transport holding area or to the river below the dam.

<u>Bypass to Downstream of Dam</u>

The fish are screened into a bypass pipe (Figure 3-12) which dumps the fish into the river downstream of the dam. Use of this bypass reduces the need to use the spillways for fish passage, so that water can be used for generating electricity.

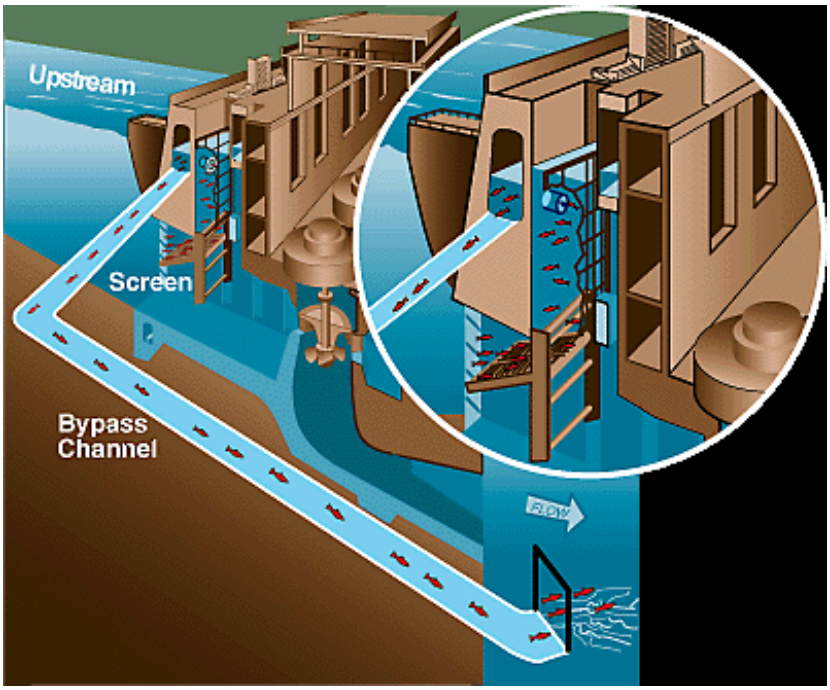

Figure 3-12, Downstream Bypass, Source: CDWR 2013

Collection and Transport

Downstream passage by transport encompasses both trap and truck operations and barging. This method of passing fish around hydropower facilities is used for numerous reasons:

- To mitigate the loss of fish in reservoirs behind dams.
- To avoid the impacts of nitrogen supersaturation that may be associated with spilling water.
- To avoid the impacts of contaminated water.
- To help avoid turbine entrainment, predation, delay, and other issues associated with passing fish downstream of dams.

Trucks are used to move fish downstream to decrease the time it takes for fish to move through the system. After being trucked downstream, the fish are released below the lowest dam, thereby avoiding turbine entrainment and exposure to predators at intervening dams and reservoirs.

Survival can be high for fish transported. However, depending on flow rates, points of collection, holding time, and points of release, fish may experience delay in their migration. Delay can have a negative effect on their physiological development critical to their survival. Exposure to diseases, stress, and disorientation may also occur. The amount of the effect is dependent on the life stage, the transportation method, and the distance between rearing and release sites.

In the Winnebago System, lake sturgeon migrate up the upper Fox and Wolf Rivers, and tributaries, to locate and utilize available spawning habitat. The majority of adult fish migrate back downstream to lentic (still water) environments of Lake Winnebago and the Upriver Lakes (Butte des Morts, Winneconne, and Poygan) following spawning, and the cycle renews.

In 2011 the department entered into a Memorandum of Understanding (MOU) with the Menominee Indian Tribe of Wisconsin (MITW) to increase the number of sturgeon moved around the Shawano Paper Mill and Balsam Row dams. The MOU specified a transfer 100+ sturgeon around the dams. The sturgeon are collected using electrofishing boats in the Wolf River below the Shawano Paper Mill dam, loaded into fish distribution hauling trucks and transported to the reservation.

Figure 3-13, Newly Hatched Lake Sturgeon Larvae, Source: WI DNR

In 2013 the capture of larval Lake Sturgeon below Keshena Falls demonstrated successful reproduction of sturgeon in the mainstream of the Upper Wolf River. As a result of transferring gravid, pre-spawn fish, the timeline to achieve successful reproduction was drastically shortened over that of traditional recovery times to meet Lake Sturgeon population recovery goals.

Rates of downstream movement through the dams by transferred fish are quite high, as fish migrate back downstream to more suitable habitat and food sources. However, a small percentage of fish take up residence of at least multiple years above the Balsam Row Dam; and at some point, in time this population may reach capacity. Thus, annual transfer of migrant sturgeon upstream would be necessary for the foreseeable future to maintain target densities. None the less, the program has shown good success and a shortened timeline while being relatively low cost. The total cost to capture, move and stock adult sturgeon under this MOU is roughly $100.00 per fish.

The timing of when fish are transferred was shown to also play a significant role in determining the likelihood of fish to both spawn and stay and take up residence, at least for a time, after transfer. Telemetry data from fish implanted with hydroacoustic tags showed that the gravid sturgeon transferred pre-spawn in spring were the most likely to spawn above the Balsam Row dam and had the longest retention time above the dam before moving back downstream. Sturgeon transferred during the early fall period (late Sept. through early Oct.) showed the strongest likelihood to take up residence in the riverine sections of the study area. However, much greater sampling time and effort was required to collect sturgeon from the Wolf River below the Shawano Paper Mill dam because the density of the fish in the river are much lower at this time. This is prior to the upstream movement of gravid fish in late fall.

Figure 3-14, PIT Tagging Adult Lake Sturgeon, Source: WI DNR

Based on these experiences, capture and transfer provided a cost effective relatively easy way to meet a number of management goals. Additionally, it may present an alternative to constructing fish passage structures.

3.3.4 Downstream Screening and Guidance Technologies (Passive)

For downstream passage of fish screening and guidance technologies consist of:

- *Physical Barriers*: Physical barriers are the most commonly used technology for protection of fish, and include many kinds of screens that exclude fish and protect them from entrainment. They provide a positive barrier, not allowing any fish to pass. Barrier nets are included in this type of screening.
- *Structural Guidance Devices*: Structural guidance devices, such as angled bar racks or louvers are used to guide fish by eliciting a response to specific hydraulic conditions. Since these devices have arrays of vertical slats or bars with spacing larger than the width of the target fish, they do not create a 100% effective barrier. They use the turbulence created by water moving along the slats to keep fish from moving between the slats
- *Behavioral barriers*: The use of behavioral barriers, such as lights or sound continues to be explored. These devices have not been proven to perform successfully under a wide range of conditions. Therefore, they considered to be much less reliable than properly designed and maintained physical barriers.

All of these technologies have the capability to guide fish away from turbines intakes, water diversions, and spillways (or in some cases to spillways), and into a bypass or collection facility.

Physical Barriers

Physical barrier screens are installed in order to prevent entrainment or impingement of fish passing downstream through a dam. Design criteria vary, but generally address approach and sweeping velocities, size of screen openings, and types of materials. Designs must be customized to an individual site and the target fish species. Screens can be

- flat or curved
- vertical or inclined

- stationary or moving

These screens can be made of many different materials such as:

- perforated steel plate
- metal bars
- wedgewire
- plastic mesh

Debris is commonly one of the biggest problems at fish screens and associated bypass facilities. Debris loads can disrupt flow through a screen, creating high velocity areas, or can cause injury to fish as they move along a screen.

In addition, for screen facilities with fish bypasses, a partially blocked bypass entrance can reduce fish passage efficiency and cause injury or mortality. A screen cleaning system will help alleviate screen debris loading. Automatic, mechanical cleaning systems are preferable over manual ones and are generally more reliable, provided they are working properly. However, automatic cleaning systems can be costly. Regular inspections, to ensure proper operation of the facility, are important to increase effectiveness.

The sections below have descriptions of some specific designs of a variety of physical barrier screens.

- Gate well screens, or turbine intake screens, are used at large hydropower facilities. The screen is placed in the turbine intake and blocks only the upper portion of the intake. Therefore, their best use is at sites with large intakes where fish are concentrated in the upper portion of the intake.
- The rotary drum screen is frequently used in the Pacific Northwest. It is a screen-covered, rotating cylinder placed in a diversion channel with the cylinder axis oriented horizontally. A facility can consist of one or a series of drum screens placed end-to-end across the flow section, usually with a fish bypass at the downstream end of the screen(s). Seals are placed between the screen and bottom and end surfaces. The advantage of the screen is that as it rotates, it continuously removes debris by carrying it over the screen and passively cleaning it off the screen as it submerges on the downstream side. Screen rotation can be achieved by a motor or paddlewheel.

The main disadvantage of the drum screen is, because of its movement, leakage or failure of the side and bottom seals can result in fish entrainment or impingement. Therefore, the seals must be frequently monitored and require greater maintenance in comparison to other types of screens. Another disadvantage of the drum screen is the narrow range of water levels within which it can operate.

Fixed Flat Plate Screens

Fixed flat-plate screens consist of a series of screen panels placed vertically, horizontally, or at an incline. The main benefit of these types of screen is that they have a continuous smooth face which minimizes obstacles to fish passage and simplifies cleaning. The screens are set at a slight angle to converge at the bypass at the downstream end of the channel to keep sweeping velocities relatively uniform along the screen face as water is diverted through the screen. Advantages of the fixed flat-plate screen are that they are easy to seal and, because there are no moving parts, are mechanically simple. However, debris removal is an important design

consideration for these screens and generally a mechanical cleaning system is required for debris removal. There are several types of fixed flat-plate screens including:

- Horizontal and Sloping Fixed Flat-Plate Screens
- Horizontal Flat-plate Screens
- Downward Sloping Fixed Flat-plate Screens
- Coanda Screens
- Upward Sloping Fixed Flat-plate Screens
- Non-Fixed Flat-Plate Screens
- Eicher Screens
- Modular Inclined Screens
- Traveling Screens
- Seasonally used Barrier Nets

Structural Guidance Devices

Angled bar racks (trash racks) and louvers generally consist of numerous vertical slats placed on a diagonal across a channel and are used to guide juvenile fish toward fish bypasses. The spaces between the slats are larger than the fish of interest, so they are not a physical barrier. Instead, they create turbulent conditions that fish avoid, causing the fish to move along the structure with the sweeping flow into a bypass system (USBR 2006). Angled bar racks have slats directed into the flow, typically 90 degrees to the structure to which they are attached, while louvers have slats at a 90-degree angle to flow. The success of these systems is dependent on how well they perform under changing hydraulic conditions and for the range of fish using the facility (OTA 1995).

Structural guidance devices are an appealing fish exclusion option because they are fairly inexpensive and the spacing between slats is relatively large, allowing for sediment and debris passage. These facilities can also operate at higher velocities than typical fish screens, which allows for a smaller overall structure footprint. They often can be an effective exclusion option for stronger swimming fish and can provide a less expensive option at sites where 100 percent fish exclusion is not required (USBR 2006).

Disadvantages of structural guidance devices are that they are not a physical barrier and therefore do not provide 100 percent exclusion. In addition, mechanical equipment is required for cleaning and debris handling. Depending on debris type and quantity, cleaning and debris handling demands may be substantial. Further, some fibrous aquatic plants and woody plants can intertwine in the bars, which lead to difficult debris removal and cleaning.

Behavioral Barriers

Behavioral guidance devices provide various stimuli that are used to guide fish through facilities. At downstream passage facilities, some stimuli are natural, such as flow velocity and depth, ambient light, channel shape, and water temperature. Behavioral guidance devices provide other stimuli, such as:

- **Lights** can be used either to drive fish away from water diversions and intakes or to attract fish to a desired location. Devices generating wide ranges of intensity, wave band

frequency, and duration have been applied. Lights offer a low capital and operation and maintenance cost option for fish guidance. They can be used at sites that are very large, pass large flows that would be difficult or expensive to screen, or that are inaccessible. Lights might also be used at sites where high-cost would preclude the installation of a fish screen (USBR 2006). The primary disadvantage of lights is their inconsistency in excluding or guiding fish. They have been proven effective at some sites which have specific fish species and life stages, but are ineffective at other sites. The performance of lights is strongly influenced by the ambient lighting conditions, which may dominate over artificial lighting. Consequently, when applied at shallower sites, lights are typically effective only at night.

- **Sound** is used to either drive fish away from diversions or intakes, or to guide fish to a desired location using a wide range of sound magnitude and frequency, including: mechanical devices, such as a fishpulser, fishdrone, and poppers; transducer systems which use speaker-like equipment to generate frequencies ranging from less than 100 Hz to 190 kHz; and infrasound generators, which use either an oscillating piston or a rotating valve with openings to generate frequencies less than 100 Hz (typically 10 to 60 Hz) (USBR 2006). As with lights, sound offers a low-cost fish control option. They can be used at sites that are very large or that are inaccessible. Sound can also be used at sites where high cost would preclude the installation of a fish screen. The primary disadvantage of using sound is its inconsistency in generating fish exclusion and guidance. As with lights, sound has been proven effective at some sites with specific fish species and life stages and ineffective at other sites or other species and life stages.

- **Air bubbles** are used to establish curtain-like barriers and to redirect fish. Manifolds are used to release a series of compressed air-driven bubble plumes to form a bubble curtain (USBR 2006). Studies on the effectiveness of bubble curtains, however, have been limited and inclusive and there is a lack of data on their potential effectiveness (OTA 1995).

- **Electrical fields** are used to cause an avoidance response by fish and guide them to a preferred location. However, they have not been proven successful in guiding fish and have had limited success as barriers. Issues such as balancing the power of the electrical field depending on fish size and fish fatigue near the electrical field have not been resolved. Wilkins Slough Pumping Plant (Sacramento River) and USBR personnel worked with various suppliers to test acoustical and electrical fish fields for over four years to try to develop a more cost-effective barrier than a physical barrier fish screen. Although there was considerable and valuable data gathered, these types of systems did not prove to be as effective as positive barrier screens, and in most cases, are not accepted as proven fish barriers by fishery resource agencies (USBR 2006).

3.4 Stocking, Passage and Hatcheries

Dams constructed without fish passage structures often prompted the development of fish propagation programs. This was common in the Pacific Northwest's Columbia River during the early 20th century, where tens of thousands of migratory Salmonids could not pass the dams (Harrison 2008). Artificial propagation may require new buildings, roads, vehicles, and connections to water sources to bolster fish numbers in the river. Many of Wisconsin's Lake Sturgeon populations are currently being restored through stocking, including the Lake Superior population, whose spawning fish could not pass the 80-foot tall Fond du Lac Dam. Additionally,

Lake Sturgeon have been reared at streamside rearing facilities on the Milwaukee and Kewaunee Rivers in efforts to restore sturgeon stocks to Lake Michigan tributaries since 2006. Fingerling and yearling Lake Sturgeon have also been reared at the Wild Rose State Fish Hatchery and stocked throughout the Wisconsin, Mississippi and Lake Michigan watersheds. Rather than provide upstream fish passage, resource agencies stocked various strains from Michigan's Upper Peninsula and eastern Wisconsin. In addition, agencies modified the spawning habitat downstream from the dam to encourage natural reproduction.

Assuming a hatchery or rearing facility already exists, the cost of fish stocking is likely less than building fish passage structures. This is particularly true for rivers with a series of dams without fish passage structures. Under this process invasive species can be more effectively and selectively controlled. The drawbacks of stocking fish include:

- The population of adult fish must be adequate for consistent capture.
- Resource managers specifically select the fish, rather than allowing natural selection.
- Artificial propagation can influence genetic instability of fish. As previously noted, fish stocking often requires physical buildings to raise fish and vehicles to transport fish, both of which can be of significant cost.

4 Fish Migration

Fish populations strongly depend on the ability of individual fish to fulfill critical life stage requirements, particularly access to preferred aquatic habitats (Marmulla 2001). Throughout Wisconsin, game and non-game fish migrate in riverine and lacustrine environments. Adult spawning migrations are commonly recognized, yet juvenile and adult movements to rearing and refuge areas also occur statewide.

Fish migrate varying distances and during various times of the year. Migration distances may vary depending on several factors such as species, water temperature and habitat suitability. Migration time scales range from daily, annually or longer and distance can range from a few meters to thousands of kilometers (Lucas and Baras 2001). These are just a few examples of fish migration in Wisconsin:

- Adult Shovelnose Sturgeon, Lake Sturgeon, and Paddlefish travel the Mississippi River.
- Walleye and Lake Sturgeon traveling Lake Superior's south shore access the spawning habitat in the St. Louis River nearly 20 miles upstream from the river mouth.
- Lake Sturgeon from Lake Michigan heavily use the lower Menominee River.
- Channel Catfish traverse the Wisconsin and Mississippi rivers.
- Salmonids such as Chinook Salmon, Rainbow Trout (Steelhead), and Coho Salmon of Lakes Superior and Michigan migrate dozens of miles from the Lakes to tributaries, including small headwater channels with suitable spawning substrates.
- Yearling and two-year-old Salmonids out-migrate to the Lakes from their natal streams to recruit to adulthood.
- White Sucker, Longnose Sucker, and Silver Redhorse inhabit waters throughout the state and actively migrate to and from spawning grounds.

Migration timing or "periodicity" has important implications for how and when fish passage facilities are designed, constructed, and operated. Periodicity is generally a function of season, commonly observed in spring and fall (Table 4-1), although summer migration also occurs as fish seek thermal refugia or alternative prey bases (UMRCC 2004). Water temperature, river flow, and photoperiod are some of the primary factors that influence fish migration.

A dam can prohibit or delay upstream migration and lead to a decline in fish populations (Marmulla 2001). In some cases, it may result in the extirpation of species that depend on habitat only present upstream of the barrier. Even a temporary delay in passage above an obstacle during an important migratory period can have significant impacts on a fish population. In addition, some fish attempting to migrate downstream may experience mortality when passing over a spillway or through turbines to reach downstream habitat, while other fish move through unharmed. Additionally, if host species for mussels are not able to pass a barrier mussel reproduction and movement may be affected.

In addition to being a full or partial barrier to migration, a dam can alter the flow regime of a river system up and downstream of the structure. A change in the stream flow during the migratory period can alter the dynamics of migration. For instance, a reduction in river discharge during the migratory period can diminish the attraction flow and reduce the number of spawning fish (Marmulla 2001). A potential fish passage design may need to consider the attraction flow during the migratory period of the target species (Marmulla 2001).

Table 4-1, Approximate Spawning Periodicity of Fishes in the Upper Mississippi River (UMRCC 2004)

Species	February	March			April			May			June			July			August			September		
	Late	Early	Mid	Late	Early	Mid	Late	Early	Mid	Late	Early	Mid	Late	Early	Mid	Late	Early	Mid	Late	Early	Mid	Late
Lake Sturgeon																						
Shovelnose Sturgeon																						
Paddlefish																						
Goldeye																						
Mooneye																						
Alabama Shad																						
Skipjack Herring																						
Bigmouth Buffalo																						
Smallmouth Buffalo																						
Blue Sucker																						
White Sucker																						
Spotted Sucker																						
Blue Catfish																						
Channel Catfish																						
Flathead Catfish																						
Northern Pike																						
White Bass																						
Yellow Bass																						
Largemouth Bass																						
Smallmouth Bass																						
Walleye																						

Species	February	March			April			May			June			July			August			September		
	Late	Early	Mid	Late	Early	Mid	Late	Early	Mid	Late	Early	Mid	Late	Early	Mid	Late	Early	Mid	Late	Early	Mid	Late
Sauger																						
Freshwater Drum																						
Shortnose Gar																						
Longnose Gar																						
American Eel																						
Muskellunge																						
Common Carp																						
Black Redhorse																						
Rock Bass																						
Striped Bass																						
Yellow Perch																						
Silver Lamprey																						
Pallid Sturgeon																						
Highfin Carpsucker																						
Golden Redhorse																						
Silver Redhorse																						
Shorthead Redhorse																						
Northern Hogsucker																						
Quillback																						

5 Fish Health

Fish, just like humans and other animals, contract pathogens and parasites and suffer from disease. Fish can contract diseases from viral, bacterial, fungal and parasitic infections and these can be a significant cause of mortality within populations. Fish experiencing stressors such as pollution, lack of food, or abnormal water temperature can be more likely to exhibit significant effects to their health and populations from disease. Dams that act as barriers may help control the spread of diseases upstream.

Some fish diseases may be widespread and/or have been occurring in local populations for a long time. Adverse impacts to fish include impacts to size, observable abnormalities and occasionally mass kills. However, fish populations can often recover from these impacts. Fish populations may be more susceptible to more recently introduced diseases such as Viral Hemorrhagic Septicemia (VHS), as populations may not have developed immunity or responses to these diseases. The department and DATCP adopted statutes and internal policies in 2008 aimed at preventing the spread of VHS (see below for discussion on VHS regulations).

Department fish health veterinarians and fish biologists monitor fish for disease in state waters and in department fish hatcheries. Fish diseases such as infectious pancreatic necrosis (IPN) or infectious hematopoietic necrosis (IHN) can be serious when present in fish populations. DATCP maintains a list of reportable diseases at Chapter ATCP 10 Appendix B. Diagnosis or evidence of the fish diseases in this list need to be reported to DATCP within 10 days.

See also Chapter 9.2 for a discussion of the economic costs associated with AIS.

5.1 VHS in Wisconsin

Viral Hemorrhagic Septicemia (VHS) is a deadly fish virus that poses a serious threat to Wisconsin's aquatic communities. Because the VHS virus is not native to the Great Lakes region, it is considered an invasive species. However, the manner in which the virus arrived is not known. It is possible the virus was introduced by fish migrating from the Atlantic Coast; alternatively, the virus may have "hitch-hiked" in ballast water from ships traveling from other regions.

VHS was first detected in Wisconsin in 2007 in fish from the Lake Winnebago and Lake Michigan systems (Figure 5-1). To date, VHS has only been detected in fish from the Lake Winnebago system, Lake Superior, Lake Michigan, and Green Bay. The fact that the disease is geographically contained highlights the importance of management practices designed to control and combat the spread of VHS to the remainder of Wisconsin's lakes and rivers, where it could prove a serious threat to a broad range of native fish.

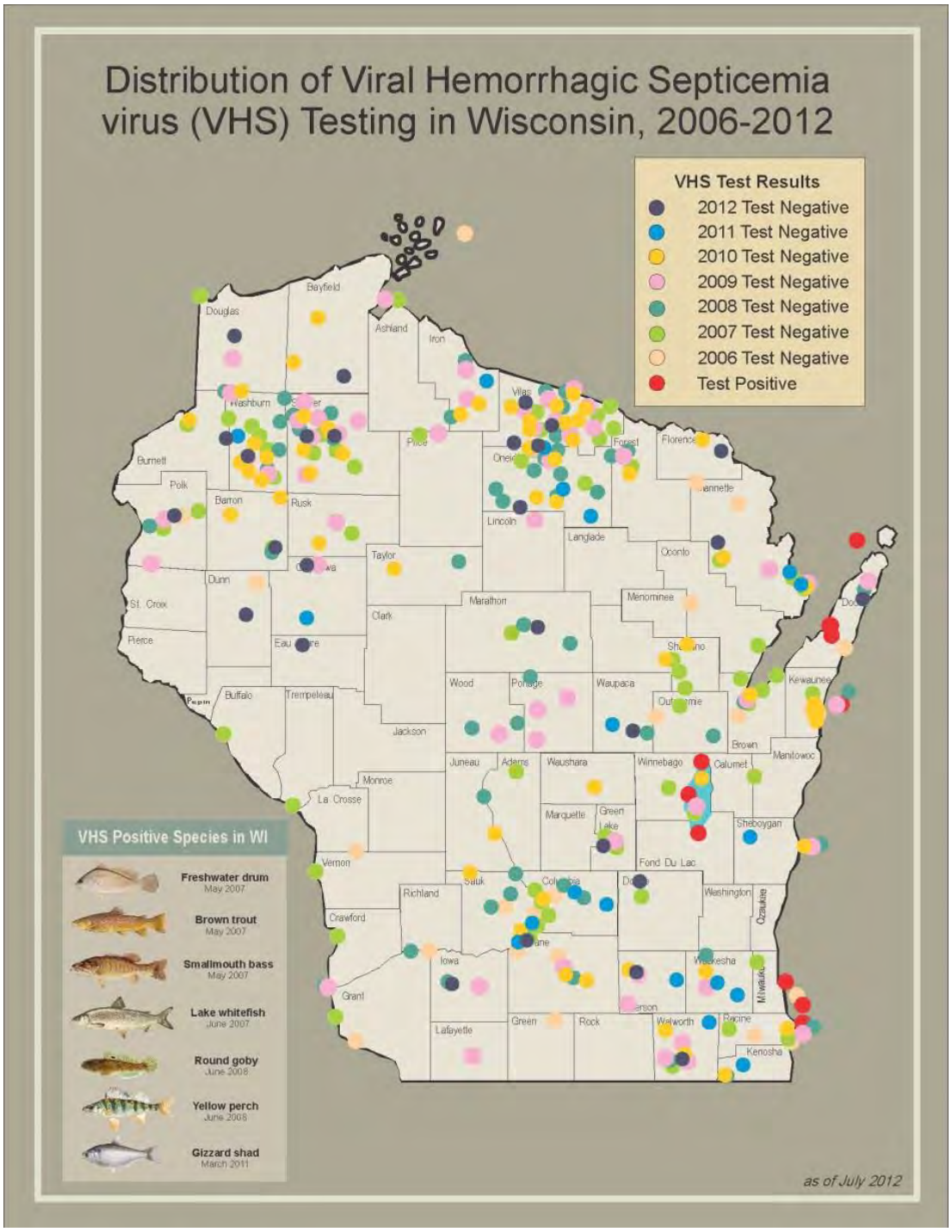

Figure 5-1, VHS Testing Efforts and Results - 2006 to 2012, Source: WI DNR

While VHS is not a threat to people who handle infected fish or want to eat their catch, it poses a significant threat to 28 species of fish in Wisconsin that have been identified as susceptible to the disease—a list that includes 19 sport fish species. For a list of VHS-susceptible fish see Table 17.1 in Appendix C. This is the first time a fish virus has affected so many different species from so many fish families in the Great Lakes.

Current biosecurity and disinfection protocols for VHS also protect fisheries from other known fish pathogens. Department fish hatcheries follow USFWS disinfection, isolation and quarantine guidelines including Iodophor disinfection of fish eggs, which mitigates the disease threat of vertically transmitted (parent to offspring) pathogens (USFWS 2016). Department Manual Code # 9183.1 Boat, Gear and Equipment Decontamination and Disinfection Protocol, helps protect against pathogen transmission between waterbodies by requiring all department employees, agents and service providers, and some permitees to take steps to decontaminate boats, gear and equipment. The Fish Health Inspection and Certification requirement also helps protects waterways from other known fish pathogens.

5.2 Fish Health Regulations

5.2.1 Fish Health Certificate

In order to prevent the spread of VHS, DATCP regulates the movement of fish species which are susceptible to the disease. A fish health certificate is required any time fish are manually handled (sorted) to be moved upstream of a barrier or into new water. For a list of drainage waters covered by VHS rules see Table 17.2 in Appendix C. Moving fish downstream of a barrier does not require a fish health certificate, provided the fish will be returned to the water within the same river system. The fish health certificate must be issued by a qualified fish health inspector. Under current DATCP regulations, fish health certificates cannot be issued for fish species on the VHS susceptible list without necessary tissue culture testing. Under this process, a sample of fish must be euthanized to collect tissue samples for testing and the remaining fish in the lot must be quarantined until the culture results come back negative. New fish may not be added to the lot of quarantined fish at any time. A visual inspection process can be conducted to issue fish health certificates for fish species not susceptible to the VHS virus (lake sturgeon, for example). The inspection process typically includes observation of the eyes, gills, mouth, and surfaces (dorsal, lateral, and ventral) of the body for signs of disease or infection. Fish that do not pass the inspection process may not be moved upstream of the barrier.

5.2.2 Circumstances in Which a Fish Health Certificate May Be Required

In order to permit or engage in the movement of fish to waters above a dam, the DATCP determines whether a fish health certificated is required. These regulations are found in Chapter ATCP 10 of the Wisconsin Administrative Code.

<u>Introduction of Fish into the Waters of the State</u>
A fish health certificate is always required when fish are introduced into the “waters of the state.” Wis. Admin. Code ATCP § 10.63. This requirement applies to any movement of fish, including stocking.

Reintroduction of Fish into Original Wild Source

A fish health certificate is not required when fish are removed from and later reintroduced into the same waterbody from which they were collected, or to the same point or a downstream point in the same river system from which they were collected, but only if all of the following criteria are met:

- Reintroduction is designed to increase or rehabilitate a population of desirable sport fish species;
- The fish are reintroduced within 30 days of collection, or within 30 days of offsite hatching, whichever is later; and
- The fish are not comingled with fish from any other source.

A fish health certificate is required for upstream reintroduction, including situations where fish are removed from water and redeposited upstream by active means, such as upstream trucking, sorting for elevator lifts, and hand carrying above a dam.

6 Invasive Species and Nuisance Species

An “invasive species” is defined by Wis. Stat. § 23.22(1)(c) as a nonindigenous species whose introduction causes or is likely to cause economic or environmental harm or harm to human health. Wis. Admin. Code NR 40.02(24) further defines invasive species as nonnative species including hybrids, cultivars, subspecific taxa, and genetically modified variants whose introduction causes or is likely to cause economic or environmental harm or harm to human health, and includes individual specimens, eggs, larvae, seeds, propagules, and any other viable life-stages of such species.

There are many State Statutes and State Administrative Codes that regulate invasive and nuisance species. Chapter 2, Regulatory Framework and Department Procedures and Guidelines, provides a list of relevant State Statutes and State Administrative Codes.

For a list of current regulated invasive species see the Wis. Admin. Code Ch. NR 40 Invasive Species webpage at: http://dnr.wi.gov/topic/invasives/classification.html.

Together, these regulations and the department’s Fish Passage Guidance discussed in Chapter 6.2 detail the restrictions and guidance to the movement of invasive plants and animals via waterways.

6.1 Impacts of Invasive Species

Invasive species can be introduced unintentionally or purposefully to new areas. Below are some examples of ways aquatic invasive species (AIS) can be introduced to new areas:

- Moving watercraft between different waterbodies
- In bait buckets
- Ballast water
- During flood events
- Passive or active fish passage projects if proper protocols are not followed.
- Construction activities that take place around water

Lack of natural predators for invasive species may allow them to reproduce and grow. This population growth can result in a displacement of native species which cannot compete effectively for resources such as food, nutrients, light, and habitat. Population growth may also result in a reduction in species diversity from a loss of native species.

Additional environmental effects of invasive species are the impacts on the quality of our recreational experience by clogging waterways (i.e., Eurasian Watermilfoil), reducing game fish (i.e., Sea Lamprey) or by causing waterfowl mortality (i.e., Faucet snail/parasite). These effects can reduce user satisfaction of a waterway, which may lead to an adverse economic impact.

Economic impact of invasive species doesn’t end at the water’s edge, but can be felt nationally, regionally, locally and even individually. Across the nation, units of

government are working together and investing significant resources for the prevention and control of invasive species. This includes budget initiatives, research, rapid response, and long term management and prevention. At the local level, citizens and businesses have to accept the impacts of AIS. Examples of economic impacts caused by AIS include:

- The presence of invasive species has increased the cost of outdoor recreation such as the increased price of bait fish due to VHS requirements that bait distributors certify that their bait is VHS free.
- Power companies, wastewater treatment, and water intake industries which use water in their processes often have to clean their intake pipes of invasive mussels (Zebra/Quagga Mussels) to prevent their systems for becoming clogged. The cost of this is estimated to be in the millions annually in the Great Lakes region.

Fish passage projects at dams have to consider the potential of terrestrial and AIS passage and must comply with state and federal regulations. The risk of AIS may preclude the use of certain types of passage such as passive fish passage options. This may result in additional expenditures in planning, design and operation of projects in order to reduce the risk of AIS transfer (i.e. sorting facilities and fish health inspections/certificates).

6.2 Invasive Species Best Management Practices and Guidance

Preventing the introduction of invasive species to new un-infested areas is preferred in lieu of trying to eliminate a species after it has become established in an area. Best management practices (BMPs) and regulations have been developed to prevent and minimize the spread of invasive species. For example, in 2016, the department updated the agency's manual code for disinfection and decontamination to ensure that staff and its contractors is not a vector in the movement of AIS around the state. Invasive species BMPs can be found at the department's invasive species BMP webpage at http://dnr.wi.gov/topic/Invasives/bmp.html.

The department established a Fish Passage Guidance that went into effect on January 1, 2014 to reduce the potential of AIS movement upstream of a dam (WDNR 2014). This guidance established criteria that department staff should use when reviewing regulated activities that have the potential to increase the distribution of AIS.

The department's guidance recommends consideration of the following factors when making a determination of a regulated activity that could result in the passage, movement or transfer of aquatic invasive species upstream of an existing barrier:

- Determine the AIS of concern
- Determine the proximity of AIS of concern to the barrier in question
- Determine if the AIS of concern can survive transit to the barrier
- Determine if the AIS of concern can become established at the barrier
- Determine if the AIS can cross the barrier
- Determine if the AIS can become established above the barrier
- Determine the impact of all species (native and AIS) transferred above the barrier will have on public interests (ecological, economic, recreation, and aesthetic)

The department's Fish Passage Guidance further identifies criteria that will aid staff in determining if the risk of passing AIS is considered low, medium or high. Determining criteria for low, medium or high risk include:

- High Risk:
    - AIS that are already common in the basin with the barrier in question
    - AIS that can survive transit to the barrier
    - AIS that can become established year-round at the barrier
    - Proposed modification increases or maintains AIS passage at a frequent occurrence (1 – 10-year flood event)
    - AIS that are able to establish a reproducing, sustainable population upstream of barrier
- Medium Risk:
    - AIS that are in the basin but not broadly
    - AIS that can survive transit to the barrier seasonally
    - AIS that can become established temporarily or seasonally at the barrier
    - Proposed modifications result in an increase, decrease or maintains AIS passage at an infrequent occurrence (10 – 99-year event)
    - AIS that are able to survive but not establish a sustaining population upstream of the barrier
- Low Risk:
    - AIS not present in the basin
    - AIS that cannot survive transit to the barrier
    - AIS that cannot become established at the barrier
    - Proposed modifications result in the elimination of AIS passage or maintains no passage
    - AIS that are unable to survive or become established upstream of the barrier

Determining if the AIS of concern has the ability to cross a barrier may be a complex and difficult assessment. A proposed fish passage project may increase or decrease the frequency of AIS passage. This change in frequency determines the level of risk of a specific AIS. There are three categories of risk, all based upon the frequency AIS or pathogens are able to pass a barrier (USACE 2014).

- Low - The barrier is not passable even at the 100-year flood event.
- Medium - A barrier is passable by AIS or pathogens during the 10- 99-year flood event.
- High – A barrier is passable by AIS or pathogens during flooding events less than 10-year event.

A significant amount of information should be known about the barrier. The following information would be important to adequately assess the ability of AIS or pathogens to cross the barrier and become established:

- Flood capacity of the barrier
- Barrier height
- Tail water elevation
- Depth of scour pool and other critical physical characteristics that may influence a species ability to cross the barrier

While there are no quantitative standards to assess the impact a proposed fish passage project will have on the public's interests, there are several considerations that are part of a complete evaluation of a proposed project:

- Commercial and recreational navigation
- Water quality and habitat
- Fishing and hunting
- Swimming
- Enjoyment of natural scenic beauty
- Other recreational enjoyment
- Effects the proposed fish passage project would have on the economics associated with the waterway

A decision on department regulated activities should be made based upon the potential of passing high and medium risk AIS and the impact on the ecology of the waterway, economy, aesthetics, and recreational value.

Having adequate quantifiable, objective and scientific information to make accurate assessments of risk and impact of the AIS is critical in this process. The physical, chemical and biological needs of every life stage should be considered. The AIS ability to swim, leap, and climb should also be considered. In addition to the physical abilities of the species, the barrier or barriers in question should also be thoroughly researched.

7 Assessing the Aquatic Environment for Fish Passage

This section describes the tools the department uses for assessing the aquatic environment, but may not specifically capture the information needs when assessing a river for fish passage. Physical, water quality, and biological characteristics are examples of parameters used by biologists to evaluate upstream habitat suitability. The limits of upstream and downstream assessment from the dam may be dependent on the biologist's professional judgment of the habitat needs for all life stages of the target fish species. Determining suitable habitat involves describing the physical, water quality, and biological characteristics of a water body.

- Physical characteristics include: Stream width and depth, flow volume, sinuosity, riffle and bend ratios, substrate identification, canopy cover, and available cover.

- Water quality characteristics include: Temperature, dissolved oxygen, pH and specific conductance, total phosphorus, total suspended solids, and nitrogen.

- Biological characteristics that are important for fish passage include: Macroinvertebrate Index of Biotic Integrity (M-IBI), Fishery IBI, and natural community designation, and carrying capacity.

To a large degree, successful fish passage is dependent on the presence of, or access to, specific ecological characteristics and habitats needed to support all life stages of the target fish species. The following is the type of information the department gathers when documenting or assessing the waterbody characteristics above and below a dam:

- Macroinvertebrate Indices of Biological Integrity: Data derived from aquatic macroinvertebrate samples, combined with stream habitat and fish assemblages, provide valuable information on the physical, chemical and biological condition of streams. Most aquatic macroinvertebrates live for one or more years in streams, reflecting various environmental stressors over time. Since the majority of aquatic invertebrates are limited in mobility, they are good indicators of localized conditions, upstream land use impacts and water quality degradation. The department uses the M-IBI developed by Weigel (2003) to assess wadeable streams. The M-IBI is composed of various metrics used to interpret macroinvertebrate sample data. The M-IBI was developed and validated for cold and warm water wadeable streams and cannot be used as an assessment tool for non-wadeable rivers or ephemeral streams.

- River Biocriteria: The department monitors and assesses large river (i.e. non-wadeable) biologic communities using a similar strategy as wadeable streams. The department uses one river macroinvertebrate IBI and one river fish IBI, sampled with established protocols and index periods, to assess the health of the biologic communities to infer water quality (Lyons et al. 2001, Weigel and Dimick 2011).

- Fish Community Characteristics: Fish indices of biotic integrity (IBIs), developed for Wisconsin's streams, provide valuable measures of stream integrity,

productivity, and the quality of sport fisheries. Standard field protocols, designed and calibrated for Wisconsin's cold and warmwater streams, are used for sampling fish communities in streams. This effort consists of daytime electrofishing of a stream assessment reach 35 times the mean stream width, during base flow conditions in the spring. Fish data collections from this effort are sufficient to compute stream IBI and gamefish population metrics.

The goals of having fish move around a barrier are tied to population viability and fishery/resource management. Assessing habitat availability in relation to habitat requirements is critical to estimating carrying capacity of streams and flowages and evaluating the importance of fish passage at that barrier. It is imperative for resource managers to have biological data to evaluate project need and determine which combination of projects will provide the greatest benefits to targeted fish populations. Further, this same knowledge is needed to determine how a population is performing relative to its potential in a given basin. A water body's carrying capacity has long been applied as a foundation of assessments and strategies for managing fish populations. The traditional approach for estimating carrying capacity has been to fit a relationship between adult recruits and the number of parents that spawned them.

It is important to have accurate data to facilitate the establishment of a fish passage project. Adequate data for resource planning and decision making may exist in various databases and files. These databases may be used in resource planning and decision making. Characterization of aquatic resources is important for determining whether the species will be able to survive in a specific habitat. Most preferred are current data in cases with little or no anthropogenic or natural changes to the watershed or the waterbody for an extended period of time.

7.1 Databases and Community Descriptions

The following is a summary of department databases with data and information about waterbodies:

- The Surface Water Integrated Monitoring System (SWIMS): This is a data system designed to ensure that staff and management have access to high quality surface water, sediment, and aquatic invasive species data in an accessible format. The SWIMS is interrelated with other data systems at the department and outside the agency.

- Fisheries Management Database (FMDB): Data collected as part of statewide fisheries and habitat sampling and fisheries stocking activities are stored in the FMDB. The Fish Database is a centralized internet transactional and warehouse system deployed in January 2001, and is accessible to all department staff. Propagation summaries are accessible to the public. The database serves as the central repository of all fish stocking, and fish and habitat survey information collected in the state.

- Register of Waterbodies (ROW) and 24K Hydrolayer: This is the official department surface water inventory database. It contains waterbody name, waterbody ID code (WBIC) and various physical characteristic data such as size, depth, substance composition and shoreline length.

- Surface Water Data Viewer (SWDV): This is a GIS-based mapping tool for water data display and integration. It was originally developed for displaying standards data (Impaired Waters, Outstanding & Exceptional Waters), but Dam and Floodplain viewer applications were merged into SWDV in 2005. The SWDV contains map features for wetland, waterway protection, dam and floodplains, surface water quality, fisheries, aquatic invasive species, monetary grants, surface water outfalls, hydrography and watersheds.

- Water Assessment Tracking and Electronic Reporting System (WATERS): The WATERS supports water quality standards and assessment work, Watershed goals reporting, and Watershed electronic watershed planning. The WATERS holds decisions and information regarding the status of rivers, streams, and lakes, as well as Great Lakes shoreline miles including a variety of use designation, assessment, management uses, and linkages to documents or reports supporting decisions about a waterbody.

- Natural Communities of Streams and Rivers: Currently, streams and rivers are being evaluated for placement in a revised aquatic life use classification system, in which the new fish and aquatic life use subclasses are referred to as Natural Communities. Natural Communities are defined for streams and rivers using model-predicted flow and temperature ranges associated with specific fish and/or macroinvertebrate communities. This model, developed by the USGS and department research staff, generates proposed stream natural communities based on a variety of base data layers at various scales. The Natural Communities data layer for Wisconsin rivers and streams identifies which fish index of biological integrity to apply when assessing state surface waters.

- Waterbody Type: As stated above, all waterbodies are assigned their modeled waterbody type by default, until/unless enough data are available to verify whether the modeled type is correct and to make corrections if needed. Verifying the Type before assessing whether or not a waterbody is attaining its criteria is a critical first step since some of the waterbody's applicable criteria depend on which Waterbody Type is assigned to it.

For streams, Waterbody Type verification is done through verification of the fish Natural Community (NC) subcategory. This verification requires a minimum of one fish community survey (of all species, not gamefish only). This is routinely collected as part of the department's monitoring program sampling regimen, so every site that is sampled should have its Waterbody Type verified as the first step in assessment. Additional fish surveys from multiple years or from upstream/downstream reaches are also helpful. Descriptions of the NC categories, the abundances of fish from different temperature and stream size guilds and the NC verification process are found in: Methodology for Using Field Data to Identify and Correct Wisconsin Stream "Natural Community" Misclassifications, Version 5 (Lyons 2015).

7.2 Department Data Gathering Protocol and Guidance

When resource data is not available, further studies and data collection may be needed. New data should be gathered through the implementation of current monitoring protocols to characterize the physical, water quality, and biological characteristics of a water body. The following is a list of resources used in evaluating waterway characteristics:

- Guidelines for Evaluating Habitat of Wadeable Streams, WDNR, June 2002.
- Surface Waters Assessment Team Guidelines and Procedures for Continuous Temperature Monitoring, WDNR, 2005 (Draft-Version 3).
- Guidelines for Deployment of Continuous Dissolved Oxygen Meters, Data Evaluation, & Data Storage, WDNR, 2007.
- A) Nutrient Chemistry Grab Sampling (V3.2) DNR Water Quality Monitoring Program WDNR-PUB-WY-019-2015.
  B) Low Level Metals – Method for Clean Sampling ("Clean Hands/Dirty Hands Technique") Version 2.4FPM 101.2, WDNR Water Quality Monitoring Program WDNR PUB-WY-022-2015.
- Guidelines for Collecting Macroinvertebrate Samples from Wadeable Streams, WDNR, June, 2000.
- Large River Macroinvertebrate Sampling (V2.0), DNR Water Quality Monitoring Program, WDNR PUB-WY-080-2015.
- Lyons, J., Piette, R.R. and Niedermeyer, K.W. 2001. Development, validation, and application of a fish based Index Biotic Integrity for Wisconsin's large warmwater rivers. Transactions of the North American Fisheries Society. 130:1077-1094.
- Methodology for Using Field Data to Identify and Correct Wisconsin Stream "Natural Community" Misclassifications, Version 5 (Lyons 2015).
- Weigel, B.M. and J.J. Dimick. 2011. Development, validation, and application of a macroinvertebrate-based index of biotic integrity for non-wadeable rivers of Wisconsin. Journal of the North American Benthological Society 30:665-679.

8 Dam Safety and Operational Considerations

Dam safety is an important factor in fish passage projects. Fish passage structures are considered part of the dam infrastructure, and therefore subject to all state and federal dam safety regulations, as applicable. The portion of the dam designed to pass fish is just as susceptible to seepage and stability issues as well as public safety concerns as any other part of the dam infrastructure.

Structural changes to any dam require approved plans from a dam safety engineer. The Wisconsin State Statute governing dams in the state is Chapter 31. Wisconsin Administrative Codes NR 333 and NR116 relate to dams and floodplains. Specific regulatory requirements for dam safety are different between the state and federal agencies that provide oversight of dam safety and security (see Chapter 2, Regulatory Framework and Department Procedures and Guidelines).

If fish passage is going to include modifications to any portion of the existing dam infrastructure or its operations and water flows, several topics may need to be addressed by stakeholders.

- During the design process engineers and biologists work together to develop a design that is both biologically and technologically feasible. The design must enable the dam to pass water through the dam and include any associated fish passage features while maintaining the dams structural and hydraulic integrity. The design must recognize the unique ecological conditions and needs above and below the dam that passage is intended to augment. In addition, the design might consider hydraulic capacity, debris management, and effects from scour and erosion.

- Dam safety also includes providing safe access to the fish passage. Public access to certain areas of dams may be prohibited, or access may be restricted. Access can also be limited simply by the location of a fish passage.

- Loss of water is commonly associated with both upstream and downstream fish passage. This happens through reduction in the efficiency of gates. For hydroelectric dams, loss of water equates to loss of generation. Any water not going through the turbines may be lost revenue to a hydro dam owner. Dams commonly maintain stable water levels and flows that may be regulated through operating orders. Changes to water levels may impact fish passage operations.

- Protection devices, such as trash racks, reduce the hydraulic capacity and become an operation and maintenance issue requiring a more hands-on operation and higher project costs.

- Depending on the fish passage design there could be an increase in the operation and maintenance costs associated with the dam, as well as changes to FERC license requirements. In the case where the passage is incorporated into an existing dam by using gate openings in the design there may be the need to operate remaining gates more often to maintain water levels upstream.

9 Economic Considerations

This section discusses the major economic considerations of fish passage at dams, based on available data and research. The overarching question is whether, and to what extent, the economic benefits of fish passage facilities outweigh their costs and how these are distributed. Stakeholders include dam owners and operators, contractors, governmental units, tribes, commercial and recreational fisherman, and electrical rate-payers, as well as the general public. Experience in Wisconsin and elsewhere suggests that the economic impacts of individual fish passage projects are context-specific and highly variable, depending in part on dam type and size, the type of fish passage facilities implemented and the species targeted (Francfort et al. 1994), as well as hydrologic and ecological conditions, including the presence or risk of transporting aquatic invasive species and fish diseases (McLaughlin et al. 2013).

Ideally, decisions regarding potential fish passage projects will rely on a thorough consideration of all of the different costs and benefits associated with each available option (McLaughlin et al. 2013). Numerous researchers and managers, however, have commented on the difficulty of simply measuring project costs and benefits, starting with the lack of meaningful and consistent data on the biological effectiveness of different types of facilities (e.g., Noonan et al. 2012; Bunt et al. 2016; Kemp 2016; Gutowsky et al. 2016). There is significant information regarding dam removal and river restoration. However, there is limited information on economic impacts associated with fish passage projects. Given this limitation, we do not have a clear picture of the economic impacts of fish passage in Wisconsin. Studies conducted elsewhere, however, may help to fill-in some of the gaps. A number of these are discussed below.

9.1 Economic Benefits

9.1.1 Sales, Income and Employment Related to Construction

As with other types of infrastructure, the development of fish passage facilities generates direct economic impacts in the form of sales, income and employment within the construction industry. This in turn stimulates indirect and induced impacts in other sectors. While these impacts have not been evaluated for fish passage projects in particular, a study commissioned by the Associated General Contractors of Wisconsin evaluated the impacts of similar infrastructure projects (Clark and Crane 2015). Using Wisconsin-specific economic multipliers for the construction sub-sector that includes water treatment plants, dams, reservoirs and other water-related infrastructure, the authors estimated that every $1 million in spending on such projects supports seven full-time construction jobs. According to the Wisconsin Department of Workforce Development, these jobs pay just over $50,000 a year on average. The study authors further estimate that each $1 million in construction spending stimulates an additional $960,000 in sales and another seven full-time employees in industries that provide goods and services to construction companies and their employees. Similar estimates of direct, indirect and induced impacts were reported for spending on comparable infrastructure projects in California (Sacramento Regional Research Institute 2009).

9.1.2 Commercial and Sport-Fishing

Depending on which species are targeted, fish passage projects can have long-term benefits related to commercial and sport fishing, including sales, income and employment within these and related industries, such as travel and tourism (e.g., Loomis 2006). Michigan's Department of Natural Resources has stated that the $15 million construction of fish passage facilities at five dams along the St. Joseph River, which extended the migratory range of salmon and trout in that Lake Michigan tributary by 40 miles, has generated an "economic benefit… to local Michigan and Indiana communities… estimated at several million dollars annually" (Michigan Department of Natural Resources 2017).

A more detailed study estimated the economic impact on Michigan's chinook salmon sport-fishery brought about by improved passage at two hydroelectric dams on the Manistee River (Kotchen et al. 2006). The fish passage project addressed in the economic impact study by Kotchen et al. (2006) was operational rather than engineered. Specifically, the two hydro-electric dams were converted from peak-demand to a more migration-friendly run-of-river flow. The fish passage efforts at these dams were based on operational changes only. The findings and methods of this economic impact study are potentially informative. The researchers used the survey-based "Michigan Recreational Angling Demand Model" (Lupi et al. 2001) to estimate the impact of increased salmon populations on the number of salmon fishing days (trips) and associated consumer surplus (increased economic value) under the low, medium, and high population scenarios derived from post-project monitoring. The estimated annual consumer surplus generated by the dam conversions ranged from $300,000 (for the low population estimate) to $1 million per year (for the high estimate).

9.1.3 Eco-Tourism

Fish passage projects have the potential to benefit other types of outdoor recreation as well, such as viewing spawning fish at dams. Each spring, sturgeon spawning events draw large numbers of visitors to sites like the Wolf River Sturgeon Trail in Waupaca County. Surveys conducted at spawning events in 2002 confirmed that "sturgeon viewers" typically purchase meals and other goods and services during these trips (Stoll et al. 2009). Similar studies have yet to be conducted at fish passage facilities at dams, which are typically not designed to include features that accommodate visitors.

9.1.4 Property Values

Increases in fish populations and related recreational opportunities along a stretch of river may have a positive effect on nearby property values. In order to isolate the effect that such amenities have on property values, economists sometimes conduct what are known as "hedonic analyses." In these analyses, housing sales and other historical data are used to estimate the premium (or penalty) of being located within various distances of a particular amenity (or dis-amenity), while controlling for other factors related to property values, such as lot size, building size and various social and economic characteristics (e.g., Lewis and Landry 2017). The department could not locate studies specific to property values and fish passage at dams. Based on the lack of information

research may be useful to determine the economic impact of fish passage at dams on property values.

9.1.5 Non-Market Values

The types of economic benefits discussed above involve quantifiable market values. In addition, a number of so-called “non-use” values have been associated with the restoration of fish passage in river systems (Bergstrom and Loomis 2017). While such values are more difficult to measure, they nevertheless represent economic benefits and should be considered when using cost-benefit analysis to evaluate fish passage projects. Sanders et al. (1990) group non-use values into three categories:

1) “Option Values” (i.e., the value of maintaining or restoring a fish population for possible use in the future);
2) “Existence Values” (i.e., the satisfaction of knowing that a particular fish population exists and will continue to exist in the future), and
3) “Bequest Values” (i.e., the satisfaction of knowing that other people, such as sport fisherman, can or will be able to utilize a particular fish population in the future).

Because non-use values are not reflected in market prices, economists have developed survey-based methods to quantify them. Data collected through contingent valuation surveys and “choice experiments” may be used to estimate the average and aggregate “willingness-to-pay” for an additional unit of resource protection, among individuals or households within a particular group, geographic area or jurisdiction. For example, King et al. (2016) conducted an online choice experiment among randomly-selected adults from across Great Britain to estimate their relative willingness to pay for increased fish populations and diversity through a one-time local tax levy.

While the department routinely conducts surveys on issues related to fish and wildlife management, no such surveys have been conducted on the potential non-market values of fish passage at dams. The closest study conducted to date, by researchers at UW-Green Bay, focused on unspecified protection efforts rather than fish passage at dams. In a narrow study of visitors at lake sturgeon spawning events in 2002, the researchers found that the average “sturgeon viewer” expressed a willingness to pay $99 a year to maintain sturgeon populations at current levels (Stoll et al. 2009). Because respondents were drawn from a self-selected group, it is likely that they valued protecting sturgeon more than the average household in the state.

9.2 Project Costs

<u>Financial Costs Associated with Planning and Construction of Fish Passage</u>

The cost of developing fish passage facilities at dams includes various pre-construction costs, such as planning, design and in some cases land acquisition, as well as the capital cost of materials and construction. As reported in Table 9-1, the cost of developing fish passage facilities in Wisconsin has ranged from $50,000 for a project to modify the streambed and abutment of a dam on the Lac du Cours Creek in Ozaukee County, to upwards of an estimated $20 million for a proposed fish lift at Prairie Du Sac hydroelectric dam on the Wisconsin River.

Table 9-1, Wisconsin Dams with Fish Passage Project Costs

Project	County & River	Status	Targeted Species	Complete Barrier	Facility Type	Project Cost X $1000	Cost Includes Planning, Engineering, and Design	Cost Includes Dam (Re-) Construction
Bois Brule (State owned)	Douglas Brule River	Completed (1986)	Trout and Salmon	Yes	Ladder	$ 387	X	X
Eureka Dam	Winnebago Fox River	Completed (1993)	Lake Sturgeon, Walleye	No	Ladder/ Rock Rapids	*n/a*		
Beckman Mill	Rock Raccoon Creek	Completed (2000)	Forage Species	Yes	Bypass Pool-and-Weir	*n/a*		
Jefferson Dam	Jefferson Rock River	Completed (2005)	Walleye, Sauger; Various species	No	Fish Ladder	$ 254		
Thiensville Dam	Ozaukee Milwaukee River	Completed (2010)	Northern Pike; Various species	No	Bypass Nature like	$ 1,050	X	
Lac du Cours Dam	Ozaukee Lac du Cours Creek	Completed (2011)	Various species	No	Modified Abutment/Streambed	$ 50	X	
Winter Dam	Sawyer East Fork Chippewa	Completed (2011)	Lake Sturgeon, Greater Redhorse	Yes	Seasonal Bypass	$ 450	X	
Montello Dam (State owned)	Marquette Fox River	Completed (2014)	Walleye, Lake Sturgeon, Flathead Catfish	No	Fish Ladder	$ 6,000 ($400 fish passage only)	X	X
Park Mill Dam	Marinette Menominee River	Completed (2016)	Lake Sturgeon	Yes	Bypass	$ 3,000	X	
Menominee Dam	Marinette Menominee River	Completed (2017)	Lake Sturgeon	Yes	Fish Elevator, electroshock & transport, trap and sort and downstream bypass	$ 9,400	X	
Princeton Dam (State owned)	Green Lake Fox River	Planned	Various species	No	Fish Ladder	$ 200 (2016 est.)	X	
Balsam Row Dam	Shawano Wolf River	Planned	Lake Sturgeon	Yes	Pool and weir, with trap and sort	$ 1,250 (2016 est.)	X	
Prairie Du Sac	Sauk Wisconsin River	Planned	Lake Sturgeon, Paddlefish, Blue Sucker	Yes	Fish Elevator with trap and sort	$ 20,000 (2015 est.)	X	
Mullet Marsh (State owned)	Fond Du Lac Mullet River	Proposed	Northern Pike	No	Fish ladder	$ 150 (2016 est.)		
Grand Rapids Dam	Marinette Menominee River	Proposed	Lake Sturgeon	Yes	Fish Elevator with trap and sort	$ 5,200 (2012 est.)	X	
Chalk Hill Dam	Marinette Menominee River	Proposed	Lake Sturgeon	Yes	Fish Elevator with trap and sort	$ 9,000 (2015 est.)	X	
White Rapids Dam	Marinette Menominee River	Proposed	Lake Sturgeon	Yes	Fish Elevator with trap and sort	$ 9,000 (2015 est.)	X	
Kletzsch Park Dam	Milwaukee Milwaukee River	Planned	Native Species	No	Ramp and Pool	$ 750 (2016 est.)	X	X

Note: For projects listed as "Completed," the year refers to when the final phase of construction or reconstruction (in the case of the Bois Brule and Eureka Dam facilities) was completed. Projects listed as "Planned" have engineering plans or are otherwise required under FERC licensing or contractual agreements. Projects listed as "Proposed" are under consideration but do not have engineering plans and are not otherwise required. The Bridge Street Dam fish ladder, which is listed as "Withdrawn," had an engineering plan and an application submitted to the department for construction, but the risk of spreading AIS and consequent requirement for active sorting led the applicant (the Town of Grafton) to withdraw the project.

These costs generally vary with the size and type of the dam, and the type of fish passage installed. Bypass channels developed at low-to-medium head dams represent a middle range, from perhaps $100,000 to slightly over $1 million.

Similar ranges have been reported elsewhere in North America:

- In a Canadian review, Katopodis (1992) reported that the cost of constructing Denil fish ladders at low-head dams ranged from $15,000 to $125,000 Canadian dollars ($27,000 to $206,000 in 2017 U.S. dollars).

- Francfort et al. (1994) reviewed cost information provided by FERC-licensed hydroelectric dams around the U.S. and found that the capital cost of individual fish lifts ranged from $1.8 to $11.8 million ($3 to $20 million in 2017 dollars), the most expensive of which was constructed at the 90 ft. Conowingo hydroelectric dam on the Susquehanna River in Maryland.

- Francfort et al. (1994) reported that the capital cost of downstream passage and protection facilities – including various types of bar racks, nets, screens, bypasses and other turbine-avoidance systems – ranged from $580 to $1 million (approximately $1,000 to $1.7 million in 2017 dollars).

When considering project costs reported in older studies, it is important to note that regulatory changes over the past two decades may have increased the cost of fish passage projects, such that the costs reported may not be entirely reflective of current costs, even after adjusting for inflation.

Pre-construction costs themselves can be substantial. In their review of fish passage facilities at FERC-licensed dams, Francfort et al. (1994) reported that “study costs” ranged from $1,360 to $87,000 ($2,300 to $150,000 in 2017 dollars).

- In Wisconsin, pre-construction engineering and design for the channel bypass constructed around the Winter hydroelectric dam on the East Branch of the Chippewa River in Sawyer County, accounted for one-third ($150,000) of the overall development cost.

- In another Wisconsin example, the planning costs for a proposed overhaul of the Bridge Street Dam on the Milwaukee River in Ozaukee County, which would have included a fish ladder, totaled $250,000.

Additional factors influencing the cost of developing fish passage facilities at dams include site conditions, design specifications, construction techniques, fabrication methods, and contract considerations (Katopodis 1992; Francfort et al. 1994). Alsberg (2014) noted that “excessive construction costs and the need for additional equipment and machinery” contributed to higher-than-expected costs to develop fish passage facilities at the Menominee and Park Mill hydroelectric Dams on the Menominee River in Marinette County. For projects involving bypass channels, land acquisition may present another substantial cost.

A final consideration with respect to facility planning and construction is timing within the overall life-span of the dam. Significant cost savings can be achieved by incorporating

fish passage facilities into a dam's initial construction, replacement, or a major overhaul, as opposed to adding them to existing dams as stand-alone retrofits (Katopodis 1992). An example of this opportunistic approach is the inclusion of a fish ladder in the $5.3 million overhaul of the state-owned Montello Dam on the Fox River in Marquette County. The cost of this fish ladder cannot easily be broken-out of the overall project cost. As with most construction projects, constructing fish passage as part of a larger construction project is typically less costly than retrofitting.

In Wisconsin projects that are associated with a public utility may need multiple approvals from the Public Service Commission (PSC). PSC processes are triggered when a project construction cost is expected to exceed $10 million. This approval process includes an evaluation of project need, project impact, and project costs. Additionally, the process may require an environmental review.

The utilities may also need approvals from the PSC to offset the cost of the project through a rate payer increase. If the PSC does not approve a rate payer increase the utility would have to bear the cost themselves. Further information can be found in Wis. Stats. §196.49 and Wis. Admin. Code PSC 112 and 4.

Costs associated with Fish Protection at Hydroelectric Dams

Hydroelectric dam owners and operators use devices such as trash racks to prevent trash or other material from damaging the turbines. These devices can also be used to reduce or prevent mortality or injury to fish. Resource agencies and non-profit organizations have pursued modifications to the existing trash racks, such as reducing the clear spacing to one inch. Other fish protection devices can include fish nets, which discourage fish from getting too close to turbines or trash racks.

The costs of the fish protection devices and their maintenance vary depending upon location, size of the device, type and size of the dam and, the river system. The department contacted several hydroelectric dam owners and operators in Wisconsin to gather estimated current or proposed costs for different types of fish protection devices, which is summarized in Table 9-2 below.

Table 9-2, Cost of Downstream Protection Devices

Type	Cost of Device	Maintenance Cost Per Year	Labor (Hours)
Fish net	$400,000 to $500,000 for installation plus $200,000 replacement (every 10 years)	$20,000	Variable
Automated raking system for a 1" trash rack	Greater than $1 million	Not Available	10 to 20 per week ($20,000 to $50,000 per year)
Angled bar rack	$2 million	Not Available	Not Available
1" Trash rack and new rake	$5 to 9 million	$5,000 to $10,000	3 to 10 per week ($10,000 to $30,000 per year)

Costs associated with Fish Collection and Transportation

The department conducts collect and transport of Lake Sturgeon around the Shawano Paper Mill Hydroelectric and the Balsam Row Hydroelectric dams in Shawano County on the Wolf River as part of an agreement with the Menominee Indian Tribe of Wisconsin. Table 9-3 summarizes costs associated with this activity.

Table 9-3, Cost for Collect and Transport of Lake Sturgeon in the Wolf River

Year	Volunteer Hours	FTE Hours	LTE Hours	Non-wage Cost	LTE Wages	Total Costs	Fish Moved	Cost per Fish
2015-2016	139.5	267.5	164	$5,757.00	$1,968.00	$7,725.00	138	$55.98
2014-2015	99	198	132	$3,228.45	$1,584.00	$4,812.45	134	$35.91
2013-2014	99	198	132	$5,472.20	$1,584.00	$7,056.20	154	$45.82
2012-2013	99	198	132	$3,443.20	$1,584.00	$5,027.20	98	$51.30
2011-2012	99	198	132	$2,537.20	$1,584.00	$4,121	97	$42.49

Sources of Funding

Given the high cost of many fish passage projects, the availability of funding is a fundamental consideration. For smaller projects, dam owners may be able to provide most or all of the funding for developing fish passage facilities at their dams. For large projects, dam owners are more likely to provide only a portion of the funding, often as matching funds for federal grants. Examples of dam owners funding all or part of fish passage projects include:

- The Friends of Beckman Mill designed and constructed a fish bypass around its dam on the Raccoon Creek in Rock County entirely with volunteer labor and donated materials. Actual cost is unknown.
- The Village of Thiensville in Ozaukee County provided roughly $80,000 in non-federal matching funds for a bypass channel around its dam on the Milwaukee River. This constituted less than 10% of the overall project cost.
- Eagle Creek Renewable Energy, fish passage phases 1, 2, and 3 combined are approximately $12 million. Of the $12 million, $5.8 million was from grant funding from the EPA and National Fish and Wildlife Foundation. Also, the project received a grant from Great Lakes Restoration Initiative (GLRI) for $80,000 for monitoring fish. (Radzikinas 2017)

As of 2017, ten fish passage projects have been constructed in Wisconsin at a combined cost of $20 million (see Table 12-1). Roughly one-third of this overall cost was covered by federal grants and cost share, including:

- $6 million in Great Lakes Restoration Initiative grants administered by EPA and the U.S. Fish and Wildlife Service.

- $500,000 in American Recovery and Reinvestment Act grants from NOAA.
- $100,000 in Coastal Zone Management funding administered by the Wisconsin Coastal Management Program.
- $150,000 in cost-share provided by the U.S. Forest Service.

Other sources of funding have included:

- $100,000 in matching funds provided by the department for various fish passage projects from the State's portion of the Great Lakes Protection Fund.
- $5.3 million of Knowles-Nelson Stewardship funds was used to re-construct the state-owned Montello Dam, including a fish ladder.
- Wis. Admin. Code NR 195, River Protection Grants, is for partners to use to support assessments and planning for fish passage and fish passage construction and dam and fish barrier removal.
- Additional financial support has come from the Great Lakes Fishery Commission and the Wisconsin Great Lakes Trout and Salmon Stamp program.

Operation and Maintenance

Once developed, the long-term cost of operating and maintaining fish passage facilities can be substantial. These costs are typically borne by dam owners and may include equipment, personnel and outside contractors, as well as increased insurance premiums and other administrative costs. Operation and maintenance (O&M) can be particularly costly for fish lifts, which require continuous mechanical operation, upkeep, monitoring, and in some cases, the manual sorting of fish.

Francfort et al. (1994) reported that O&M costs for a pair of fish lifts at the Conowingo hydroelectric dam in Maryland were $650,000 a year ($1.1 million in 2017 dollars). Totaled over twenty years, this O&M accounted for 41% of the overall project cost. By contrast, the authors reported that O&M for a vertical-slot fish ladder at the Buchanan hydroelectric dam on the St. Joseph River in Michigan averaged just over $10,000 a year ($17,000 in 2017 dollars) for equipment and part-time staffing provided by the Michigan Department of Natural Resources. Totaled over twenty years, this O&M accounted for just 4.5% of the overall project cost.

For the various types of downstream protection devices, Francfort et al. (1994) analyzed data from 23 hydroelectric dams and found that annual O&M ranged from:

- $500 per year ($845 in 2017 dollars) for angled bar racks, to
- $56,000 a year ($95,000 in 2017 dollars) for a bypass system combined with bar racks, with an average O&M cost of $8,270 per year ($14,500 in 2017 dollars).

For fish passage facilities that require active sorting, staffing is a particularly important component of O&M. The availability of qualified personnel, training and oversight from appropriate natural resource agencies can significantly affect O&M costs. This was illustrated when a proposal to add a passive fish ladder to the municipally-owned Bridge Street Dam on the Milwaukee River in Grafton. This project application was withdrawn after departments concerns over fish disease and AIS, which changed the project from a passive ladder to a trap-and-sort facility, which required active fish sorting.

Lost Power Generation

For fish passage projects implemented at hydroelectric dams, lost power generation represents an additional long-term impact, which is primarily borne by dam owners. The degree to which fish passage reduces power generation at dams depends on how much river flow is diverted from the turbines to create conditions that enable targeted fish to locate the facility and successfully pass through it. For upstream-passage facilities, including fish lifts, studies conducted on salmonid species suggest the need for diversions of up to 5% of flow that would otherwise power turbines. However, diversions of 10% or more may be needed to ensure high rates of passage (Larinier et al. 2005; Linnansaari et al. 2015). In some cases, special turbines may be added to generate power from diverted flows, although this entails additional up-front costs. Impacts from lost generation can be minimized by operating the passage when there are high flows with surplus water.

Francfort et al. (1994) estimated the annual cost of lost power generation at several hydroelectric dams with fish passage facilities. On the low end, the installation of a fish ladder at the 4-megawatt Buchanan Dam on the St. Joseph River in Michigan resulted in a 3% loss in generation, which translated to $33,000 a year in lost revenues ($56,000 in 2017 dollars). On the high end, a pair of fish ladders and downstream passage features at the 15-megawatt Leaburg Dam on the McKenzie River in Oregon was estimated to cost $130,000 a year in lost generation ($220,000 in 2017 dollars).

For low-capacity hydroelectric dams, the long-term cost of lost generation is an important consideration when weighing fish passage projects against dam removal (Doyle et al. 2003; Lewis et al. 2008). In either event, lost generation must be offset by power generated by other sources to meet consumer demand. This in turn can have additional overall economic costs, including increased utility rates and external costs associated with emissions fuel-burning power plants (Whitelaw and Macmullan 2002; Kosnik 2010).

Potential Cost of Aquatic Invasive Species and Fish Disease

As discussed in the Policy Alternatives and Considerations section, fish passage projects can have unintended consequences (McLaughlin et al. 2013). The most significant of these, in both ecological and economic terms, is the unintended passage of aquatic invasive species (AIS) or fish disease through fish passage facilities at dams that would otherwise present barriers to their movement. While statewide estimates do not exist for Wisconsin, Pimentel (2005) estimated that AIS within the Hudson River system cost New York State's commercial and sport-fishing industry a combined $400 million a year in damages and control costs.

It is important to note that not all dams act as barriers to AIS or fish disease. As defined by the department's 2014 Fish Passage Guidance, a dam is considered to be a "complete barrier" if it "does not allow the migration of [any] aquatic organisms upstream [under normal or flood conditions] up to the 100-year event." In the absence of fish passage facilities or other human interventions, such dams are assumed to "pose an impassible barrier" to the upstream spread of AIS and disease.

The fact that Wisconsin straddles the boundary between the Mississippi and Great Lakes watersheds greatly increases the potential risk of unintentional AIS passage at

dams. This concern over AIS movement is a common discussion for fish passage projects in Wisconsin (USACE 2014). To date, efforts to prevent Asian carp from invading the Great Lakes have cost over $400 million, nationwide. Failure to prevent this invasion would have major economic consequences for the estimated $7 billion Great Lakes fishery, as well as boating, beach-going and other activities that provide economic benefits across the region (Hayder 2014; Stern et al. 2014).

The total cost of the 180+ non-native species that are already in the Great Lakes has been estimated at $4.5 billion a year (Pimentel 2005). Sea lampreys have been particularly harmful to lake trout, ciscoes, whitefish and other species that are, or were, commercially important in the state. Historically, dams on tributary rivers where sea lampreys spawn have aided control efforts by limiting their migration and concentrating larval populations for the targeted application of chemical lampricides (WDNR 2015). More recently, the fish disease Viral Hemorrhagic Septicemia (VHS) has become a concern for numerous native species in the Great Lakes and its tributaries.

9.3 Leveraging Fish Passage and AIS Control

Located 9 miles from the mouth of the Brule River in Douglas County, the Bois Brule Lamprey Barrier is an example of a combined dam and fish-passage facility built for the express purpose of controlling AIS while maintaining desirable fish populations. Completed in 1986 at a cost of $387,000, the roughly 5 ft. dam includes a special fish ladder that allows valuable steelhead and salmon to migrate freely, while passively trapping harmful sea lampreys before they spawn. During the facility's first twenty years of operation, nearly 45,000 lamprey were trapped and prevented from reproducing, with an annual peak of 9,300 in 2005 (WDNR 2015). While the specific features of this facility are not necessarily transferable to other projects, the project presents a conceptual model of how fish passage and AIS- control efforts might be strategically leveraged to reduce the long-term costs of AIS while increasing, or at least maintaining, the long-term economic benefits of desired species.

10 Wildlife Considerations and Impacts

Due to the limited information regarding wildlife effects associated with fish passage, it is plausible to assume that effects on wildlife are minimal. However, there may be some direct or indirect impacts to wildlife related to fish passage infrastructure and its management.

10.1 Wetlands

Dams may have a direct or indirect effect of creating shallow lake/deep marsh habitat for wetland dependent wildlife by creating desirable conditions necessary for aquatic plant communities. If the creation and maintenance of wetland wildlife habitat has been established as a priority above the dam, water level manipulation that favors optimal wetland plant conditions is often a primary management strategy. The establishment of fish passage may require water flow management changes that are seasonally in conflict with the preferred strategy for wetland management.

Wetlands are important for duck and amphibian reproduction, and are often more advantageous for these species if the wetlands are devoid of fish. Small fish that feed on aquatic insects can reduce the available food supply for duck broods, and also prey on newly hatched amphibians. Larger fish like northern pike are efficient predators on young waterbirds. Certain wetland habitat management projects above dams are desired to be kept free of common carp, which degrade water quality and aquatic plant communities. If fish passage is established for other species, but also allow carp into the system, it will likely be in conflict with wildlife management plans.

Other considerations regarding wetlands and fish passage are:

- Re-establishment of fish populations to upriver stretches of riverine ecosystems may restore food web connections that enhance wildlife carrying capacity by diversifying food sources for aquatic foraging wildlife species.

- Consideration for fish passage design that may also allow aquatic wildlife (especially herptiles) to move up and downstream could enhance the carrying capacity and population stability for those species.

10.2 Foraging Areas for Birds

Dams often concentrate fish, which can concentrate fish-eating birds. Some birds feed on fish from the surface by diving from the air, like bald eagles, osprey, gulls, terns and kingfishers. They are typically adept at avoiding obstacles that they may encounter while feeding, however consideration could be made during design to avoid creating a strike hazard for them.

Other species like herons, egrets, and pelicans feed from the surface of the water. If a fish passage creates attractive foraging conditions for them, consideration must be taken to prevent structures that may be entanglement risks. Collision risks like wires and cables in the vicinity must also be considered where these birds enter and exit the area.

Cormorants, mergansers, and loons pursue fish while underwater. They may follow fish into a structure and not be able to find their way back out. Physical barriers that allow fish through, but not swimming birds, may be required at the entry of the passage.

11 Endangered Resource Considerations and Impacts

A species at risk of extinction due to human activities, biological or environmental factors may be listed as an endangered or threatened species by the department. The department's Bureau of Natural Heritage Conservation (NHC) maintains a database of state and federal endangered resources called the Natural Heritage Inventory (NHI) and all department programs are responsible for following state and federal endangered species regulations. The list of species tracked in this database is found on the Wisconsin Natural Heritage Working List along with natural communities native to Wisconsin. It includes species legally designated as "endangered" or "threatened" as well as species in the advisory "special concern" category. This list is meant to be dynamic and is updated as new information becomes available.

Wisconsin's fish included in the NHI vary from small shiners and darters to large lake sturgeon and paddlefish. Information on their basic ecology, life history, and habitats is well known. Although extensive surveys have not been conducted statewide for all the listed fish species, the department has information on their general distribution. Listed mussels and herptiles occur throughout the state.

Fish passage implementation can provide both positive and negative effects on a variety of endangered species. The department is required to evaluate endangered resources for any activity that it conducts, permits, or approves. All persons are required to follow endangered resource laws, which includes a prohibition against take unless the person has an Incidental Take Permit, regardless of whether the department conducts, funds, or approves the activity. Regulations require evaluation of impacts from construction, operation, and maintenance on listed species during all life stages. Habitat for rare species or rare or unique natural communities may also be considered. Monitoring may be included in a fish passage project to determine if listed species or their habitats may be impacted.

Incidental take refers to the take (destruction) of individual endangered or threatened animals, or plants on public land, that occur incidental to carrying out an otherwise lawful activity. In many cases, projects that have the potential to take a threatened or endangered species, where avoidance measures are not possible, may be allowed through an Incidental Take Permit or Incidental Take Authorization (ITP/A), provided the project does not put the overall population of the species at risk. The ITA is needed for activities that are conducted, funded or approved by the department or another state agency. The ITP is used for activities not conducted by the department or another state agency. An endangered resources review is required prior to applying for an ITP/A. The review provides the applicant with information needed to comply with Wisconsin's endangered species law and other laws and regulations protecting endangered resources. If potential impacts exist, then project modification to avoid potential impacts should be explored. If impacts cannot be avoided, then an ITP/A would be necessary.

Fish passage may restore aquatic pathways for movement of or provide connectivity for native threatened or endangered fish, herptiles and fresh water mussels (via their host fish) upstream. Fish passage may also provide safe downstream passage for listed fish, mussels and some herptiles species. The ability to move around a barrier can provide benefits to endangered species by restoring the previous range of a species. Extending the habitat range can result in connecting separated populations and allow for genetic

exchange or reestablishing species that were extirpated above the structure. Aquatic species diversity can be reduced above a dam, with some species completely extirpated upstream of the structure. Reconnecting and expanding endangered species populations is one of the recovery goals for many aquatic endangered species. Expanding genetic exchange is another recovery goal accomplished by expanding and connecting populations. Another benefit of restoring a species range through fish passage is to allow access to a diversity of seasonally important habitats for all life stages that were previously unavailable.

Connecting riverine habitats to lake habitats may not result in the desired outcome if the species requires flowing water conditions and cannot get to the riverine section upstream of the impoundment. In addition, water quality can be different upstream and downstream of a dam and it may need to be determined if conditions would be favorable or detrimental to listed species if they are passed.

Dams can provide a barrier to the upstream movement of aquatic invasive species (AIS). AIS have been demonstrated to have deleterious impacts on listed species. Upstream fish passage could result in impacts to listed species upstream of the dam from AIS known or likely to occur downstream if AIS are able to pass along with target species. Passage may not be an appropriate outcome if the risks are greater than the benefits for NHI listed or other aquatic resources.

Although the distribution of fish has been studied, their proximity to any particular dam structure may not be known and the distribution of listed mussels and herptiles may not have been well documented. Conducting species surveys up and downstream of a dam prior to consideration of fish passage is beneficial.

- Surveys below the reservoir would provide information on species known to occur below the structure either seasonally or year-round.
- Surveys within the reservoir would provide information on species known to occur in both lentic (still water) and lotic (flowing water) conditions.
- Surveys extending upstream beyond the impounded section of the river would help evaluate whether species occur within the riverine sections above and below the impoundment, and guide design decisions.

Depending on the purpose of the fish passage, this information could address potential effects on listed fish or herptiles and the extent to which they could benefit from fish passage, as well as the distribution of host fish for listed mussel species. The extent of impingement and entrainment has not been well documented for rare fish species and rare herptiles (e.g., turtles are often caught on trash racks), and may be taken into consideration for downstream passage.

Information is lacking on how effective different types of fish passage would be for the various NHI listed fish or fish hosts for listed mussel species. Game and commercial species have been studied with regard to swimming ability, burst speeds, tolerance of velocities, attraction to flows, and similar features required for active fish passage. However, many rare and nongame species have not been studied to the same extent:

- It is not known how unstudied or understudied species would respond if rare or nongame species were the purpose of fish passage. If not the purpose of passage, then it is unknown what the impacts might be to the rare species from

the operation of the fish passage for other species. Different fish passage types may provide different effects with regard to listed fish.

- If the purpose of fish passage is to extend the range of listed mussel species, the occurrence of fish hosts for those species, and the impacts of possible fish passage on those species would need to be determined.
- Not all mussel host species are known. Identifying such missing information would be an important element of the analysis of a passage project.
- Response of herptiles, primarily mudpuppies and turtles, has not been studied with regard to passage, be it active or passive. An evaluation of fish passage methods could provide information on whether these species would be impacted or would benefit from various types of passage.

It may be appropriate to consider transport of listed species around a barrier, especially when the success of, or impacts from, active passage are unknown for a species, or the risks from AIS downstream do not warrant actively connecting downstream to upstream. Transport of rare and non-game fish may be a viable option for species not likely to 'swim upstream' in an active fishway. Mussels can be transported upstream by either transporting host fish upstream or augmenting populations upstream through release of host fish infested with mussel glochidia or release of juvenile or adult species upstream. Fish and herptile species can also be propagated and released upstream. Release of propagated individuals for any of these species accomplishes the goal or range extension, but does not accomplish goals of genetic exchange or increase in seasonal habitat availability by species downstream.

Overall, effects to listed species need to be accounted for in consideration of fish passage options including upstream, downstream, during construction and long-term ecological alterations for all life stages. Listed species should be considered with determining the purpose of passage the species which are the focus of passage, and the secondary impacts on non-focal species.

12 Cultural Considerations and Tribal Relations

Dams have been part of the Wisconsin landscape for decades and can have effects on historic and cultural resources. Many of the dams in Wisconsin are eligible for historic property designation and some may affect other natural and cultural resources. When fish passage is being considered, it is necessary to consider these resources as part of the planning process. Various options to achieve movement around a dam can have widely different effects on cultural resources.

Historic properties (including prehistoric and historic archaeological sites), historic structures (such as buildings, bridges, and dams that are 50 years old or older), and other cultural resources are afforded protection by federal, state, and local legislation and policies.

Wisconsin State Statutes require that state agencies work with the State Historic Preservation Office of the Wisconsin Historical Society (WHS) to identify and protect historic properties that are listed on WHS's inventory. This means that prior to impacting such sites or structures, the presence, integrity, and significance of such properties must be determined, and that such effects be avoided or otherwise mitigated if the property has been determined eligible for the National or State Registers of Historic Places (NRHP and SRHP).

Similarly, and in advance of project implementation of federal projects, all state agencies must consider WHS-recorded sites and structures, but must also undertake investigations to identify *unrecorded* sites and structures that may be present within the project's disturbance footprint. As per the state process, such properties would need to be evaluated and potentially mitigated if present.

FERC regulated dams are required to manage historic and archeological resources through a Programmatic Agreement with the Michigan and Wisconsin State Historical Preservation Office (SHPO), FERC and the Advisory Council on Historic Preservation. The Programmatic Agreement requirements are used to develop Cultural or Historic Resource Management Plans. These plans detail how licensees will complete cultural resource studies prior to ground disturbing activity, define the project types that would require SHPO consultations for NRHP impacts, and specify how and when to implement dispute resolution. The conditions of a Cultural or Historic Resource Management Plan must be satisfied prior to project implementation.

Efforts to identify the presence of project-related historic properties early in the project development process may reduce potential added project costs and significant project delays from evaluating the importance or potential mitigation of historic properties.

An overview of related regulations is located in Chapter 2, Regulatory Framework and Department Procedures and Guidelines.

12.1 Tribal Relations

The department takes its responsibilities towards and relationships with the tribes of the state seriously. The department acknowledges and respects the sovereignty of each

Tribe and strives to work proactively with them on environmental, fish, wildlife and other natural resource matters. To do so, the department follows protocols, policies, and Executive Order #39. Executive Order #39 affirms the government-to-government relationship between the State and Indian Tribal Governments located within the State. Wisconsin has eleven federally recognized tribes with elected or appointed Tribal governments; this allows for high-level coordination between the two governing bodies.

These resources, along with a consultation policy, guide the department on respectful and cooperative discussion designed to occur prior to a decision being made or an action being taken.

The topic of fish passage at dams is a concern that has been brought to the attention of the department by some tribes in Wisconsin. As a sovereign nation, each Tribe has the ability to regulate activities that occur on land owned by or held in trust for the Tribe. When an activity occurs outside these lands, the Tribe lacks regulatory authority over the activity, state and/or local regulations would apply. Even though an activity may not be regulated by a Tribe, the activity may still impact the tribes' interests. In these situations, the Tribe can request formal consultation with the department so that the State and the Tribe can discuss the issue(s) on a government-to-government level. The Tribe can also take advantage of opportunities made available to the general public to provide feedback to the department. In addition, there may be instances when a federal agency, such as the Bureau of Indian Affairs or US Fish & Wildlife Service, is involved with fish passage. In these instances, the federal agencies involved may have tribal policies they must follow. The department works collaboratively with the federal agency(s) and the tribes to work towards common ground.

13 Policy Alternatives and Considerations

Fish passage projects at dams are complex and may be controversial. As described in previous sections, projects can take years to complete, cost millions of dollars and have mixed or inconclusive results. Many different issues affect regulatory decisions of a fish passage project. Developing a clear and transparent process for considering these issues could help decision makers make more timely and consistent decisions. This section is intended to explore some broad policy alternatives and identify their potential effects. It should be noted that these policy alternatives could conflict with federal policies and decisions. The alternatives described below could be combined and/or modified as conditions warrant. This section also explores specific topics that the department may wish to consider when developing future policies and/or guidelines that affect fish passage at dams.

13.1 Policy Alternatives

Free movement of aquatic species at all dams
A policy that maximizes free movement of aquatic species at all dams in Wisconsin would attempt to provide habitat connectivity for as many species as possible where it is technically feasible. This may be done by creating natural fishways around the structure that do not restrict movement or by other methods on the dam that do not involve active sorting or restricting any species attempting to pass. This policy may provide greater regulatory certainty to dam owners and the public as all dams would need fish passage. This policy would allow the unfettered passage of undesirable species and invasive species across the barrier and would eliminate a tool that can help restrict the distribution of these species. The technological feasibility may depend on the size of the dam and on the surrounding landscape. Dam safety could be affected and this policy may result in economic impacts for dam owners and operators, recreation, property ownership, and the public

No new fish passage at dams
This policy would maintain the separation of aquatic populations at dams that do not already have fish passage facilities, while maintaining fish passage at those dams that do. Desirable fish and invasive species may be prevented from reaching habitat across a dam that do not have fish passage facilities and that are not otherwise vulnerable to being overtopped or bypassed during flood events. This alternative would not eliminate the risk of invasive species being transported by people or wildlife, or passing upstream of dams that are not complete barriers. Such a policy would provide greater regulatory certainty and maintain investments for current fish passage projects. There would likely be economic impacts for dam owners and operators and to public recreation.

No fish passage at all dams (remove all existing fish passage)
A policy to prevent fish passage at all dams would halt all fish passage projects in the state and remove or shut down all existing fish passage operations. This policy would maintain existing separate aquatic populations and separate connected fish populations using existing fish passage facilities. Desirable fish and invasive species may be prevented from passing upstream of dams that are not otherwise vulnerable to being bypassed or overtopped during flood conditions. This alternative would not eliminate the risk of invasive species being transported by people or wildlife, or passing upstream of

dams that are not complete barriers. Such a policy would provide greater regulatory certainty; however, it would entail costs for removing existing fish passage facilities and would negatively impact those fisheries that currently benefit from them.

Fish passage only where no invasive species are present
A policy to only provide fish passage where no invasive species are known to exist at the time of a project proposal would attempt to minimize or prevent the risk of spreading AIS. Such a policy would significantly limit potential future projects and may result in a loss of investments in existing infrastructure. There may also be an increase in regulatory uncertainty and risk should AIS be identified in a waterway where a fish passage project is being considered or is already in place.

Fish passage where invasive species is present, but BMPs are used
A policy to pursue fish passage where invasive species are or may be present, provided best management practices (BMPs) are used, would allow for greater flexibility and professional judgment. The effectiveness may vary depending on the type of fish passage selected, whether and what type of AIS are known to exist at or downstream of the dam, and the efficacy of BMPs at minimizing the risk of their spread. The higher level of uncertainty would require determining the level of risk for dam owners and operators, regulatory agencies and the public. Clear guidance, research and site specific knowledge may be important to the success of a project or the minimization of risk. This policy alternative could potentially be combined with the alternatives described below.

Economically driven fish passage decisions
A policy to pursue economically driven fish passage decisions would attempt to do a thorough cost-benefit analysis for a project, with a value placed on fish passage benefits such as populations reconnected or individual fish passed. These values would be compared to the costs of the fish passage project. A cost or increased risk of passing AIS may also need to be calculated and included to determine if a project is a success or failure. Sport fish, recreation or costs to the dam owner and operator may be emphasized over ecosystem connectivity or integrity in an economically driven decision. The most economical fish passage design may be selected, even if fewer individual fish or fish species are moved past the structure.

Ecologically driven fish passage decisions
A policy to pursue ecologically driven fish passage decisions would emphasize natural resources and maximizing benefits to fisheries and the aquatic environment, regardless of the direct or readily-measurable economic costs and benefits. The risk of spreading AIS would be measured against other ecological goals, requiring clear guidance based on ecological knowledge. Additional research may be needed. Such a policy would likely increase regulatory uncertainty and increase costs to dam owners and operators.

13.2 Policy Considerations

This section presents several general considerations for policy-making about fish passage at dams. The more specific considerations follow in the sections below.

General Considerations
Fish passage projects tend to have similar issues that arise during planning and development.

Policy Considerations:

- Developing best management practices in partnership with hydroelectric industry.
- Developing quantifiable standards for assessing impacts to public interest.
- Developing expectations, deliverables, and decision-making principles for fish passage.
- Creating process transparency for project evaluation and decision making such as maintaining all guidance and requirements on a department website.

Invasive Species
Invasive Species can be transported in a variety of ways. Whether it is transported via boats, bait buckets, animals, or other means, the spread of invasive Species can be detrimental to a waterway. The possible pathways for invasive species transport can be minimized or reduced. Evaluation of type of invasive species movement, habitat needs of invasive species upstream of a barrier, and options to incorporate best management practices are aspects of decision making that can minimize or reduce transport and impacts associated with invasive species. Additionally, proper education in identifying and handling of invasive species is key to inadvertently causing risk to the resource.

Policy Considerations:

- Training of individuals who may operate or assist in a fish passage project.
- Maintaining up-to-date best management practices to reduce risk of invasive species transport.
- Determining the likelihood of the invasive species of concern being transported above the barrier in question by means other than the proposed.
- Determining units of measurement for the economical, ecological, and aesthetic and recreational parameters for a public interest analysis.
- Updating and incorporating the 2014 AIS Fish Passage Guidance into the new fish passage guidance.
- Identifying what level of risk would be considered acceptable to the department.
- Defining the department's tolerance for risk when evaluating projects with the potential to open new pathways for AIS/VHS and outlining alternatives approaches.
- Identifying a process to incorporate monitoring results in order to determine invasive species concern and proximity to a barrier.
- Identifying parameters used to make a determination of whether invasive species can survive transit to the barrier in question and cross the barrier in question. Such identification may require a literature review or species-specific studies for a detailed analysis of each invasive species, including their swimming, leaping, and climbing capabilities in relation to the specific physical characteristic of each barrier, such as structure height, wetted surface and sour pool depths.
- Determining if the invasive species of concern pose any direct threat to the sustainability of native fish populations and whether the potential threat truly outweighs the documented negative effects of habitat fragmentation.

Dam Safety
Anytime a dam is modified either structurally or operationally, there is a potential to have an impact on dam safety. Impact may include, but are not limited to, staffing, additional infrastructure, lighting, site access and layout. Access of non-employees onto the property may be a consideration for safety and security. Maintenance and repairs can be costly, and may require special skills.

Policy Considerations:

- Developing a cost-benefit process that incorporates both the activities associated with fish passage construction, but also takes into consideration any fish protection devices, and post construction operational needs. These costs should be weighed against the justification and need for fish passage.
- Determining roles and responsibilities of dam owners and operators to effectively comply with any fish passage requirements.

Communications
Effective communication is a crucial part of any project development. For the purposes of fish passage, the process of who communicates to whom can be an intricate balance. For example, a failure to clearly identify roles and responsibilities and agency requirements can lead to failure before the project is fully developed.

Policy Considerations:

- Developing a process for decision making and formal communication
- Determining what type/scale of project would require a public process
- Engaging stakeholders in the development of a department guidance or policy
- Defining expectations and deliverables of department and dam owners
- Defining decision-making principles and quantifiable criteria for decision making

Engineering & Design
To maximize the successful passage of fish, the design of a fish passage must often take into account a combination of biological factors, structural needs, and professional judgment and experience. These factors extend beyond the actual passage, and often include aspects such as lighting, road improvements and access, manipulation of existing operations, and additional electrical. The level of design and engineering may be dependent upon the amount of use, time of year for operations, or species requirements.

Policy Considerations:

- Insufficient data on the success of fish passage from a biological determination. More research is needed on the biological improvements to the fishery.
- Defining how the concepts of upstream and downstream movements apply to fish passage.

Fish, Macro-invertebrates, Mussels and Threatened & Endangered Species
Impacts associated with fish passage occur beyond a single target species. Not only can a project directly impact a species, but it may also indirectly impact the species by

changing habitat or resulting in the introduction or loss of predators and food sources. Policy can be crafted to minimize and reduce adverse impacts and to increase benefits.

Policy Considerations:

- Evaluation and monitoring of species that are passed over a barrier are important elements to understanding impacts to target and non-target species.
- Determining how impacts can be evaluated based on habitat needs, predators, ability to achieve management goals.
- Determining how to evaluate the potential for species inability to adapt to new environment.
- Determining how to increase populations of protected species.
- Determining how to evaluate a species response to a new environment.

Entrainment & Mortality

Impacts to fish may occur in a variety of ways when passing through a dam. Most commonly, fish can be injured or killed when they are pinned against trash racks or they move into the equipment of a hydro dam. The impacts associated with a resource can be viewed at a very small scale, or may be viewed at a larger watershed scale. Trash racks and the spacing of the racks are frequently discussed at the time of a fish passage discussion. Protection devices and passage are frequently discussed jointly.

Policy Considerations:

- More research is needed to determine the impacts of fish entrainment, and if those impacts are having an adverse effect on the resource.
- Defining criteria on when the department would require a change to the existing trash rack spacing, and asses the financial and operational impacts.
- Determining acceptable costs due to additional operation and maintenance costs associated with decreased trash rack spacing.

Literature Reviews

Finding useful publications and literature on fish passage, or a specific aspect of fish passage can be challenging. Limited information is available for the Midwest in terms of biological effectiveness, designs for various size rivers and species specific attributes. The gap in existing literature may require additional pre/post construction and implementation studies. Additionally, locating information can be difficult. There is no central clearing house or library system to store research, surveys, or studies related to fish passage. Having more literature available for a desktop review, would result in more efficient use of time, save costs associated with similar field studies, and provide insight into challenges and solutions.

This gap was acknowledged in the Wisconsin Power and Light (WPL) letter dated 2016. It stated, “A recent paper by Roscoe and Hinch (#26) reviewed the scientific literature from 1960-2008 reporting on effectiveness of fish passage facilities. There is a lack of rigorously collected data evaluating the operational performance of fish passage facilities. Their study found that 90% of the studies conducted in North America examined only the mechanistic efficiency of passing fish, whereas the vast majority did not consider or assess whether passage had negative effects on fitness. Further, they conclude that the lack of monitoring is a major reason why many fishways have failed to mitigate the population reduction effects of barriers (Pelicice and Agostinho 2008). This

lack of monitoring information only contributes to the uncertainty surrounding the operational risks of fish passage alternatives (Oldani 2007)."

Policy Considerations:

- Determining when research is needed and how it would be funded.
- Working with dam owners to develop research projects for pre- and post-construction of fish passage facilities, to develop a better understanding of positive and negative impacts that can occur from changes to the management of a resource.
- Extending research beyond the mechanics of fish passage, but also include items such as the impacts of AIS and VHS, changes to species populations and density, the ability to move both upstream and downstream.

Establishing Goals and Objectives

A key to success is meeting goals and objectives. Goals and objectives of the various stakeholders may differ by resource needs, regulations, and owner/operator impacts. Goals can be as simplistic as getting the project built, may expand to achieving passing of fish, or may be complex such as re-establishment of species. Goals should take into account biological and cost effectiveness and should be supported by a clear funding plan.

Policy considerations:

- Determining target species and how to most appropriately move them across the barrier. Determine the processes and factors used to justify cost vs goal-setting and target species.
- Identifying a process for determining when and what type of fish passage is appropriate.
- Determining which species should drive the design if any one design cannot accommodate all desired species.
- Determining how target goals should be set for all dam owners in an equitable manner.
- Determining how effectiveness of a structure should be measured and when/what criteria should be used to determine if it is good enough.
- Defining criteria for a successful or unsuccessful project. For example, if viable populations of non-target species expand above and below the dam but target species do not – would this be deemed a successful or an unsuccessful project?
- Identify timelines to meet performance objectives or achieve goals.
- Establishing who is responsible for the cost of ongoing research to determine if goals have been met.
- Setting target species goals and conducting appropriate studies to support establishing appropriate measure for achieving overall success.
- Prioritizing projects that have clear goals and objectives and underlying river/ecosystem and species management plans.

Local, State, Federal Regulations

For any fish passage project there is a litany of permits, approvals, and regulations that must be followed. Each project is unique and may require federal, state, or local permits or approvals. Like many complex projects there may be differences of opinion, or conflicting viewpoints. Resolution to these challenges is not a one size fits all approach.

Project planning can take a significant amount of time, and project planning may need to be adaptive to changes in requirements or regulations.

Policy Considerations:

- Specific to FERC regulated dams, there are multiple federal agencies involved with decision making related to fish passage. Department consideration of its decision-making process include:
    - The role of the department with FERC, other agencies, and the licensee, to promote a fair and balanced collaborative approach.
    - Options for the department to consider how to best use and improve the FERC process. FERC has primary jurisdiction and responsibility to regulate FERC-licensed hydroelectric dams, and the need for fish passage is an issue that is commonly addressed at the time of relicensing. In many cases the U.S. Fish and Wildlife Service maintains authority for mandatory conditioning that FERC is required to include in a new license.
    - Aspects of jurisdiction in boundary waters, and multiple agency oversight.
- Rules Promulgation to implement Chapter 31 criteria for the development of fish passage at state regulated dams.

Fish Health

Fish health is a common concern when looking at improving the overall health of a resource. Although VHS is the most commonly known fish virus in Wisconsin, it is not the only one of concern. Statues, regulations and policies involving fish health are administered by two separate state agencies (DATCP and DNR).

Policy Considerations:

- A clear process to determine when a fish health certificate or a fish inspection is required, and how the two state agencies will oversee a fish passage project.

Habitat Suitability

Habitat suitability for the target and other aquatic species may vary above and below dams. Knowledge of the habitat needs of the species that may use a fish passage device as well as the habitat types above and below the dam may help decision-makers of a fish passage project.

Policy Considerations:

- Since the habitat may differ between upstream and downstream, will the habitat change affect sensitive species that are not suited to stagnant versus running water conditions?
- What happens if/when AIS do cross a barrier (dam) thus potentially rendering the habitat unsuitable both above and below the dam after fish passage has been installed?
- How is installation of fish passage justified given the potential for eventual habitat degradation if/when AIS becomes an issue?
- Hydraulic connectively is just one of the many components that contribute to the biological, physical, and chemical integrity of river ecosystems. An assessment

should consider water quality and trophic structure above a dam, to ensure that it will support the development of viable populations for the target species.

- An emphasis on only restoring connectively without sufficient attention to improving sediment, water quality and other environmental factors can result in negative outcomes on survival. Studies have drawn attention to the unexpected negative consequences of fish passage, especially when the habitats made available may function as ecological traps (Blank 2016). This may be especially true when fish are allowed safely go up stream, but have no assistance going downstream.
- Industry wants to see a process to identify target species. Non-targeted species impacts should also be discussed with some degree of matrix to evaluate a holistic approach, with discussion on impacts for a variety of species.
- Recommend incorporating Wis. Admin. Code NR40 but also the program management priorities (fisheries), Clean Water Act 303d listed (impaired) water bodies for nutrient or pollution management priorities.
- Including a thorough discussion on the negative impacts of habitat fragmentation and the numerous benefits of connected watersheds.

Public Rights and Interest

Engagement of the public and interested parties is a necessary step in the development of a fish passage project. The department has a variety of communication tools, and regulatory requirements that provide opportunity for the public to provide feedback on a project.

Policy Considerations:

- Developing criteria to be applied to ensure that all stakeholders have an opportunity to understand, and provide comments on the proposed project. This task may need to be applied at various times thorough the planning of a project.
- Establishing criteria on how to evaluate the input of various stakeholders.

Financial Considerations

The financial aspects of a fish passage project extend well beyond the cost of construction. Long-term operation and maintenance, the availability of grant funding, the need for monitoring, uncertainty regarding the potential for success, and the risk of unintended consequences are all important considerations.

Policy Considerations:

- Developing qualifications and requirements for fish passage operations.
- Who pays for the cost of fish passage installation?
- Planning for ongoing and unseen expenses such as operations, repairs and maintenance.
- Developing criteria to determine when economic costs outweigh the resource benefits.
- How should the associated financial investments for a fish passage project be quantified and justified?

Economic Costs and Resource Benefits

To date, the direct costs associated with fish passage projects in Wisconsin have ranged from hundreds-of-thousand to over $15 million; however, the benefits are not well documented and may take years to identify. Ideally, managers and decision-makers will

have reliable information on the various costs and benefits of a proposed fish passage facility. Currently the fish passage literature provides limited information on many of the potential economic costs and resource benefits, as it can take years of in-depth study to determine whether and to what extent the benefits of a project outweigh the costs.

Policy Considerations:

- Considering implementation of the least cost option available to meet the goals of a resource management concern.
- Providing scientific reasoning to require fish passage, fish protection, or other alternatives to address the resource concern.
- Requiring each project to apply a cost-benefit analysis, in similar fashion to what the Wisconsin Public Service Commission requires.
    - Example: The PSC reviews investments the public utility makes in generation resources, to determine, if such investments satisfy the needs of the public and are in the public interest. This process includes considering alternatives. These requirements are noted under Wis. Stats. §196.49(3)(b)(1) and (2), and §196.491(3)(b).
- Requiring literature reviews may provide insight on project design and implementation.
- Requiring post construction studies to evaluate if the costs of the project and operation are worth the benefit to the resource.

Unintended Consequences of Unsuccessful Projects

Fish passage projects can have unintended consequences that could impact cost, natural resources, and project development. Based on a review of fish passage evaluation studies, McLaughlin et al. (2013) identified six consequences that can result from poorly planned, poorly implemented or otherwise unsuccessful projects. These include:

1) "Passage delays" — whereby fish spend excessive time and energy to locate passage facilities, reducing their fitness for survival and reproduction.
2) "Species interactions at the dam location" – whereby delays in fish passage lead to increased densities around dams, creating hotspots of predation and disease-transfer.
3) "Fallback" — whereby migrating fish reverse course during or after upstream passage and subsequently are unable to continue their migration.
4) "Ecological traps" — whereby facilities encourage fish to migrate into stretches of river that are less suitable for their survival and reproduction.
5) "Selective passage" — whereby the particular group of species or individuals capable of passing through a facility negatively affect the ecology of newly-accessible areas.
6) "Unwanted introductions" — whereby aquatic invasive species or diseases pass through facilities at dams that would otherwise act as barriers.

Some of these consequences may also occur at dams without fish passage.

Policy Considerations:

- Halting the fish passage project and re-evaluating design or operations.

- Developing metrics and procedures to evaluate project performance and resource impacts.
- Establishing clear processes for decision making.

Liability and Risk

Concerns for liability and risk have made recent fish passage discussions take a harder look at who, what, where, and when a liability or risk may arise.

Policy Considerations:

- Clear identification of roles and responsibilities of department staff, from the aspects of planning, design, and operational responsibility. Consultants play a critical role in planning and design, including operations.
- Developing a process where a consultant can submit plans and design based on information provided by the department, as opposed to having department staff attend numerous meetings to help plan and design the project.
- Requiring that all fish passage projects at dams obtain an approval from a dam safety engineer.
- Risks include financial implications. Consider clear identification of all financial aspects of a project should for the life of the project, including planning, construction, implementation, resource management, and maintenance and repair.

The department is using the strategic analysis process to engage the public and assess scientific, natural resource and socio-economic information relating to fish passage at dams. These policy alternatives and considerations and the information contained in this Strategic Analysis are intended to be used by the department to inform development of a consistent approach for fish passage proposals throughout Wisconsin.

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15 Appendix A - Terms and Definitions

Active Fish Passage: A constructed pathway which can be used by fish with assistance from humans to move around a (manmade or natural) barrier (*e.g.*, capture and transfer).

Active screen: A self-propelled fish exclusion device that removes debris and maintains ideal fish exclusion characteristics. These devices typically exclude small adult-size fishes. *Synonym: Traveling screen*

Anadromous: A fish born in fresh water that spends most of its life in salt water and then returns to spawn in fresh water.

Approach velocity: The vector component of channel velocity that is perpendicular to and upstream of the vertical projection of the screen face. It is calculated by dividing the maximum screened flow by the effective screen area. An exception to this definition is for end-of-pipe cylindrical screens, where the approach velocity is calculated using the entire effective screen area. Approach velocity should be measured as close as physically possible to the boundary layer turbulence generated by the screen face.

Apron: A flat, usually slightly inclined slab below a flow control structure that provides for erosion protection and produces hydraulic characteristics suitable for energy dissipation or in some cases fish exclusion.

Attraction flow: A velocity and/or volume of water that encourages fish or other aquatic life to swim toward a specific point, such as a fish ladder or other passive passage structure. Attraction flows typically exceed any other flows near the specific point and consist of gravity flow from the passage structure. Attraction flows for upstream fish passage can also include an auxiliary water system that releases water near at the outlet of the passage structure.

Auxiliary water system: A source of water and its transmissive configuration other than the gravity source water from the waterbody.

Backwater: A condition whereby a hydraulic drop is influenced or controlled by a water surface control feature located downstream of the hydraulic drop.

Baffles: Physical structures placed in the flow path designed to dissipate energy or to re-direct flow for the purpose of achieving more uniform flow conditions.

Bank full: The river or stream bank height inundated by an approximately 1.2 to 1.5 year (maximum) average recurrence interval and may be estimated by morphological features such as the following: (1) a topographic break from vertical bank to flat *floodplain*; (2) a topographic break from steep slope to gentle slope; (3) an observable change in vegetation composition; (4) a textural change of depositional sediment; (5) the

elevation below which no finer debris occurs; and (6) a textural change of matrix material between cobbles or rocks.

Bank full width: A measurement across a stream where the water surface would exist when the stream is at its bank full elevation.

Bifurcation (Trifurcation) pools: Two or three low-velocity sections of fish ladders that divide into separate routes.

Burst speed: A rate of movement at which a fish can sustain over a period of one to two seconds. *Synonym: Darting speed*

Bypass reach: The portion of the river between the point of flow diversion and the point of flow return to the river.

Bypass system: The component of a downstream passage facility that diverts water and fish around fish entrainment or impingement hazards, like hydropower turbines. System components may include a bypass entrance, transport or conveyance structure, and a safe outfall back to the river.

Capture and transfer: An upstream or downstream active fish passage method to capture and retain fish for manual transfer around a fish passage barrier. *Synonyms: Trap and truck, Trap and haul, Collection and Transport*

Complete Barrier – A man made or natural structure which does not allow the migration of aquatic organisms upstream up to the 100-year event.

Conceptual design: Otherwise referred as “Preliminary” or “Functional” design. An initial idea developed according to the site conditions and biological needs of the species intended for passage.

Crowder: A combination of static and/or movable picketed and/or solid leads installed in a fishway for the purpose of moving fish into a specific area for sampling, counting, brood stock collection, or other purposes.

Cruising speed: Rate of movement at which a fish can sustain over a period of several hours.

Design discharge (or flow): A quantity (rate) of water that is expected at a certain point as a result of a design storm or a specific low flow condition.

Diffuser: Typically, a set of horizontal or vertical bars designed to introduce flow into a fishway in a nearly uniform fashion. Other means are also available that may accomplish this objective.

End of pipe screen: A cover affixed to a diversion or industrial plant water intake pipe to prevent fish from entering the pipe while allowing water to enter the pipe. It is typically designed for juvenile fishes.

Entrainment: The downstream movement of fish through a turbine. Typically, young-of-year or other juvenile fish that pass through the spacing of the trash racks at the entrance to the turbine bays.

Exclusion barriers: Upstream passage facilities that prevent upstream migrants from entering areas with no upstream egress or areas that may lead to fish injury.

Exit control section: The upper portion of an upstream passage facility that serves to provide suitable passage conditions to accommodate varying forebay water surfaces, through means of pool geometry, weir design, and the capability to add or remove flow at specific locations.

False weir: A device that adds vertical flow to an upstream fishway, usually used in conjunction with a distribution flume that routes fish to a specific area for sorting or to continue upstream passage.

Fish ladder: The structural component of an upstream passage facility that dissipates the potential energy into discrete pools, or uniformly dissipates energy with a single baffled chute placed between an entrance pool and an exit pool or with a series of baffled chutes and resting pools.

Fish lift (fish elevator): A mechanical component of an upstream passage system that provides fish passage by lifting fish in a water-filled hopper or other lifting device into a conveyance structure that delivers upstream migrants past the barrier.

Fish passage: Movement of fish upstream or downstream past a manmade or natural barrier with active or passive assistance from humans.

Fish passage season: The calendar-day timeframe(s) for migratory species to be actively or passively passed based on data or professional and stakeholder consensus.

Fish weir (also called picket weir or fish fence): A device with closely spaced pickets to allow passage of flow, but preclude upstream passage of adult fish. Normally, this term is applied to the device used to guide fish into an adult fish trap or counting window.

Fishway: A facility, structure, device, measure, and operational protocol that together constitute an active or passive structural upstream or downstream fish ladder or passage system.

Fishway entrance: The component of an upstream fishway facility that discharges attraction flow into the tailrace, where upstream migrating fish enter (and flow exits) the fishway.

Fishway exit: The component of an upstream fishway facility where flow from the forebay enters the fishway, and where fish enter the forebay upstream of the passage barrier.

Fishway entrance pool: The pool immediately upstream of the fishway entrance(s), where fish ladder flow combines with any remaining auxiliary water system flow to form the attraction flow.

Fishway trap: A device for safely capturing upstream migrating fish in or adjacent to a fishway. The trap can be managed to allow active or passive upstream passage, or for other fishery assessment or management purposes.

Fishway weir: The partition that passes flow between adjacent pools in a fishway.

Flood frequency: The time interval, at which a particular river flow has the probability of recurring, based on historic flow records. For example, a "100-year" frequency flood refers to a flood flow of a magnitude likely to occur on the average of once every 100 years, or, has a one-percent chance of being exceeded in any year. Although calculation of possible recurrence is often based on historical records, there is no guarantee that a "100-year" flood will occur within the 100-year period or that it will not recur several times.

Flow duration curve: A graphical representation of the relationship between the magnitude of daily flow and the percentage of the time period for which that flow is likely to be equaled or exceeded.

Flow egress weir: A structure used to route excess flow (without fish) from a fishway.

Forebay: The water body impounded immediately upstream of a dam.

Freeboard: The height of a structure that extends above the maximum water surface elevation.

Head loss: The loss of energy through a hydraulic structure.

Hopper: A mechanical device used to lift fish (in water) from a collection or holding area, for release upstream of a river flow barrier.

Hydraulic drop: The energy difference between an upstream and downstream water surface, considering potential (elevation) and kinetic energy (velocity head), and pressure head. For fishway entrances and fishway weirs, the difference in kinetic energy and pressure head is usually negligible and only water surface elevation differences are considered when estimating hydraulic drop across the structure. As such, staff gages that indicate hydraulic drop over these structures must be suitably located to avoid the drawdown of the water surface due to flow accelerating through the fishway weir or fishway entrance.

Impingement: Contact with a structure such as a screen or bar rack caused by water flow velocity that exceeds the swimming capability of a fish.

Incomplete Barrier: A man made or natural structure which allows the migration of aquatic organisms upstream during events less than the 100-year event.

Invasive Species: nonindigenous species whose introduction causes or is likely to cause economic or environmental harm or harm to human health.

Lentic: Still water such as a lake or pond.

Lotic: Flowing water such as a river or stream.

Migration: Movement from one area or region to another. It is often seasonal and/or often for the purpose of reproduction.

Migratory Fishes: Fish species that naturally migrate as part of their life cycle.

Minimum Flow: The smallest instantaneous release of water occurring during a specific period of time.

Mitigation: Actions taken to replace or compensate for losses of fish or fishery habitat caused by project operation.

Mitigation In-Kind: Mitigation involving restoration of fish or fish habitat in area not affected by the project. Usually resulting from uncorrectable impacts or irretrievable fish or habitat losses.

Native Species: A species is considered native if its presence in that area is the result of only natural process without human intervention. Also known as indigenous species.

Naturalized Species: Intentionally or unintentionally introduced non-native species that has adapted to and reproduces successfully in its new environment (i.e. carp). The species has become part of the local flora or fauna.

Non-native/exotic species: A species living outside of its native distributional range, which has arrived there by human activity, either deliberate or unintentional.

Passive Fish Passage: A constructed pathway which can be used by fish to move freely upstream around an existing (manmade or natural) barrier without human assistance (*e.g.*, Fish ladder).

Passive screen: A non-automated device or structure designed to prevent juvenile or adult fish from entering an intake.

Peaking project: Downstream releases are adjusted to maximize power generation during certain times when electricity can be sold for higher prices.

Picket leads or Pickets: A set of vertically inclined flat bars or circular slender columns (pickets), designed to exclude fish from a specific point of passage (also, see trash racks).

PIT tag: Passive integrated transponder. A device inserted in the flesh of fish that emits an electromagnetic signal and detected by an electronic device, such as a PIT tag reader.

PIT tag reader: An electronic instrument that detects passive integrated transponder (PIT) tags.

Plunging flow: Flow over a weir that falls into the receiving pool with a water surface elevation below the weir crest elevation. Generally, surface flow in the receiving pool is in the upstream direction, downstream from the point of entry into the receiving pool.

Porosity: The open area of a mesh, screen, rack or other flow area relative to the entire gross area.

Potadromous fishes: Fish species with life histories entirely within fresh water, often migratory to tributaries from lakes and rivers. Many of Wisconsin's migratory fishes are referred as "anadromous." However, unless migrating from the Atlantic Ocean or the Gulf of Mexico, Wisconsin's migratory fishes are more appropriately defined as potadromous.

Project Review Team: A team of department staff needed to determine the risk and impact a proposed regulated activity will have on the public interests of the waterway. The team may consist of a Water Management Specialist, Fishery Biologist, Wildlife Biologist, Water Resource Management Specialist, Endangered Resources Specialist, and others.

Q7,10: The smallest stream flow that occurs during a 7 consecutive day period with a frequency of once in 10 years.

Ramping: Manual or automated manipulation of river flow or outflow from a structure or device. Ramping is typically conducted at a particular rate and expressed as inches per hour or feet per day.

Rating curve: A graphical representation of the relationship between water surface elevation and river flow volume.

Re-regulation project: Downstream releases that are adjusted to compensate for peaking flows from upstream projects.

Run-of-river projects: Downstream releases that are the same amount of water as it received in inflow on an instantaneous basis.

Storage project: Downstream releases that are adjusted to increase or decrease reservoir water storage capacities on a seasonal basis.

Streaming flow: Flow over a weir which falls into a receiving pool with water surface elevation above the weir crest elevation. Generally, surface flow in the receiving pool is in the downstream direction, downstream from the point of entry into the receiving pool.

Sustained Speed: A rate of movement at which a fish can maintain over the period of a few minutes.

Tailrace: A manmade channel or flume that carries water away from a water wheel or turbine.

Tailwater: The body of water that flows below a dam.

Total project head: The difference in water surface elevation from upstream to downstream of an in-channel structure or natural falls. Total project head is often based on a range of river flows and/or the operation of flow control devices.

Thalweg: The river flow path following the deepest parts of a stream channel and contain the highest percentage of river flow.

Training wall: A physical structure designed to direct flow to a specific location or in a specific direction.

Transport channel: A hydraulic conveyance designed to allow fish to swim between different sections of a fish passage facility.

Transport velocity: The velocity of water within the migration corridor of a fishway, excluding areas with any hydraulic drops greater than 0.1 feet.

Trap and sort: An upstream active fish passage method (typically through a fish weir constructed within a fishway) for capturing and sorting desirable fish species for manual transfer around a barrier and preventing AIS or other undesirable fish or other aquatic organisms from moving upstream past the barrier.

Trash rack: A rack of vertical bars with spacing designed to filter debris from the water surface and column and preclude it from entering the fishway, while providing sufficient opening to allow fish passage.

Turbine mortality: Death to fish caused by passage through the project generation facility.

Upstream passage facility: A system designed for volitional passage or non-volitional passage.

Velocity head (hv): The kinetic energy of flow contained by the water velocity, calculated by the square of the velocity (V) divided by two times the gravitational constant (g) (hv = V2/2g).

Volitional passage: Continuously available upstream or downstream passive fish passage.

Wasteway: A conveyance which returns water originally diverted from an upstream location back to the diverted stream.

Weir: An enclosure of pickets or other such structure set in a stream or river, or associated with a fishway that is designed to trap upstream migrating fish for passage and or other fishery management purposes.

16 Appendix B - Acronyms

AIS – Aquatic Invasive Species

AOC - Area of Concern

AOP – Aquatic Organism Passage

APHIS – Animal Plant and Health Inspection Service

ATCP – Agriculture, Trade, and Consumer Protection

BMP - Best Management Practice

CFR – Code of Federal Regulations

CFS - Cubic Feet per Second

CWA – Clean Water Act

CZMA - Coastal Zone Management Act

DA – Division Administrator

DATCP – Department of Agriculture, Trade and Consumer Protection

DNR – Department of Natural Resources

EIS - Environmental Impact Statement

EPA - U.S. Environmental Protection Agency

ESA – Endangered Species Act

FERC – Federal Energy Regulatory Commission

FHC – Fish Health Certificate

FMDB - Fisheries Management Database

FHDB – Fishery Habitat Biology Database

FM Board - Fish Management Board

FPA - Federal Power Act

FPS - Feet per Second

FWCA - Fish and Wildlife Coordination Act

GIS – Geographical Information System

GLFT - Great Lakes Fisheries Trust

GLRI - Great Lakes Restoration Initiative

GP – General Permit

IBI – Index of Biotic Integrity

IHN – Infectious Hematopoietic Necrosis

IP – Individual Permit

IPN – Infectious Pancreatic Necrosis

ITA – Incidental Take Authorization

ITP – Incidental Take Permit

MC – Manual Code

MITW – Menominee Indian Tribe of Wisconsin

MOU – Memorandum of Understanding

NHC – Natural Heritage Conservation

NHI – Natural Heritage Inventory

NR – Natural Resources

NRHP – National Registers of Historic Places

PL – Public Law

PSC – Public Service Commission

ROW - Register of Waterbodies

RSW – Removable Spillway Weir

SA – Strategic Analysis

SRHP – State Registers of Historic Places

SWDV – Surface Water Data Viewer

SWIMS – Surface Water Integrated Monitoring System

TSW – Temporary Spillway Weir

USACE – U.S. Army Corps of Engineers

USC – United States Code

USFWS - United States Fish and Wildlife Service

VHS – Viral hemorrhagic septicemia

WATERS – Water Assessment Tracking and Electronic Reporting System

WBIC – Waterbody Identification Code

WHS – Wisconsin Historical Society

WQC – Water Quality Certification

17 Appendix C - VHS Information

Table 17-1, VHS Susceptible Live Fish Through the Midwest

2008 APHIS updated list of VHS-susceptible live fish including fish from waterways through the Midwest. (Source: APHIS 2014)	
Common Name	**Scientific name**
Black crappie	*Pomoxis nigromaculatus*
Bluegill	*Lepomis macrochirus*
Bluntnose minnow	*Pimephales notatus*
Brown bullhead	*Ictalurus nebulosus*
Brown trout	*Salmo trutta*
Burbot	*Lota*
Channel catfish	*Ictalurus punctatus*
Chinook salmon	*Oncorhynchus tshawytscha*
Emerald shiner	*Notropis atherinoides*
Freshwater drum	*Aplodinotus grunniens*
Gizzard shad	*Dorosoma cepedianum*
Lake whitefish	*Coregonus clupeaformis*
Largemouth bass	*Micropterus salmoides*
Muskellunge	*Esox masquinongy*
Shorthead redhorse	*Moxostoma macrolepidotum*
Northern Pike	*Esox lucius*
Pumpkinseed	*Lepomis gibbosus*
Rainbow trout	*Onchorhynchus mykiss*
Rock bass	*Ambloplites rupestris*
Round goby	*Neogobius melanostomus*
Silver redhorse	*Moxostoma anisurum*
Smallmouth bass	*Micropterus dolomieu*
Spottail shiner	*Notropis hudsonius*
Trout-Perch	*Percopsis omiscomaycus*
Walleye	*Sander vitreus*
White bass	*Morone chrysops*
White perch	*Morone americana*
Yellow perch	*Perca flavescens*

17.1 VHS Symptoms

Common signs of VHS infections in fish include hemorrhaging (bleeding), bulging eyes, unusual behavior, anemia, bloated abdomens and rapid onset of death. However, because these symptoms are associated with many different fish diseases, the actual presence of the VHS virus must be confirmed by lab tests. Additionally, some infected

fish may not show any signs of disease, but nonetheless have potential to spread the disease to others.

17.2 VHS Transmission and Environmental Factors

Infected fish shed the VHS virus in their urine and reproductive fluids. The virus can survive in water for at least 14 days. Virus particles in the water infect gill tissue first, and then move to the internal organs and the blood vessels. The blood vessels become weak, causing hemorrhages in the internal organs, muscle and skin. Fish can also contract the virus when they eat an infected fish.

Fish that survive the infection develop antibodies to the virus. These antibodies protect the fish against new VHS virus infections for a period of time. However, the concentration of antibodies in the fish will decrease over time, allowing the fish to become reinfected and begin the virus-shedding process anew. This may create a cycle in which fish mortality events occur on a regular basis.

The VHS virus grows best in fish when water temperatures are 37-54°F. Most infected fish will die when water temperatures are between 37 and 41°F, but rarely die when water temperatures are above 59 °F. Stress is an important factor in VHS outbreaks. Stress suppresses the immune system, causing infected fish to become symptomatic. Stressors include spawning hormones, poor water quality, lack of food, or excessive handling of fish.

Table 17-2, Drainage Waters Covered by VHS Rules

Lake Michigan Drainage Waters Covered by the VHS Rules (includes their tributaries upstream to the fist dam or barrier impassable to fish, as of April 29, 2009)			
Drainage Basin	**Waterbody**	**County**	**Barrier**
Lake Michigan	Pine Creek	Manitowoc	Upstream – Center Rd
	Manitowoc River	Manitowoc	Clarks Mills
	West Twin River	Manitowoc	Shoto
	East Twin River and Tribs	Manitowoc	
	Ahanapee River	Kewaunee	Forestville
	Silver Creek	Kewaunee	Breumerville
	East Twin and Kewaunee River, and their Tribs	Kewuanee	
	Red River	Kewuanee	Perched culvert
	Heins, Creek, Piel Creek, Kangaroo Lake, Whitefish Bay Creek, Clark Lake, Logan Creek, Logan Creek, Lost Lake	Door	
	Pike River	Kenosha	
	Root River	Racine	Horlick Dam
	Oak Creek	Milwaukee	Oak Creek Millpond Dam
	Milwaukee River	Milwaukee	Bridge Street Dam (Grafton)
	Menominee River	Milwaukee	Lepper Dam (Men. Falls)
	Kinnikinnic River	Milwaukee	Concrete Weir (7th Street)
	Sauk Creek	Sheboygan	Ozaukee Nature Preserve
	Sheboygan River	Sheboygan	Walderhaus Dam (Kohler)
	Pigeon River	Marinette	Hattie Street Dam
	Little River	Marinette	
	Peshtigo River	Marinette	Peshtigo Dam
	Oconto River	Oconto	Stiles Dam
	Pensaukee River, Kirchner Creek, Tibbet Creek	Oconto	
	Little Suamico, Suamico River, East River, Baird Creek	Brown	
	Barkhausen/Rainbow Creek	Brown	Barkhausen Wildlife Area
	Duck Creek	Brown	Pamperin Park Dam
	Fox River	Brown	Rapide Croche Dam

Lake Michigan Drainage Waters Covered by the VHS Rules (includes their tributaries upstream to the fist dam or barrier impassable to fish, as of April 29, 2009)			
Lake Winnebago Drainage Basin	**Waterbody**	**County**	**Headwaters / Barrier**
Fox River and Tribs	Mecan River	Marquette	Germania Marsh Dam
	Montello River	Marquette	Montello Dam
	White River	Marquette	Neshkoro Dam
	Neenah Creek	Marquette	Oxford Mill Pond Dam
	Grand River	Green Lake	Kingston Dam
	Black Creek, Barnes Creek, Snake Creek	Green Lake	
	Puchyan River	Green Lake	Green Lake Outlet Dam
	Fox River from L. Winnebago	Brown	Green Bay
Lake Poygan and Tribs	Willow Creek	Waushara	Auroraville Dam
	Pine River	Waushara	Poy Sippi Dam
	Pumpkinseed Creek	Waushara	
	Alder Creek	Winnebago	
Lake Winneconne and Tribs	Arrowhead River	Winnebago	
Lake Butte des Morts and Tribs	Spring Creek, Daggets Creek, Sawyer Creek	Winnebago	
Lake Winnebago and Tribs	Fond du Lac River, East Branch Fond du Lac River, West Branch Fond du Lac River, Parsons Creek, Campground Creek	Fond du Lac	
	30 small streams/springs	Calumet and Fond du Lac	
Wolf River and Tribs	Rat River and Tribs	Winnebago	Shawano Dam
	Walla Walla Creek and Tribs	Waupaca	Spencer Lake
	Waupaca River and Tribs	Waupaca	Wayauwega Dam
	Little Wolf River	Waupaca	Manawa Dam
	Spiegelberg Creek, Thiel Creek, Bear Lake, Peterson Creek, Sannes Creek, Grenlie Creek, Skunk Lake,	Waupaca	
	South Branch L Wolf River	Waupaca	Scandanavia Dam
	N Fork S Branch L Wolf River	Waupaca	Ogdensburg Dam
	Pigeon River	Waupaca	Clintonville
	Embarrass River	Shawano	Pella Dam
	Mill Creek and Tribs, Rose Brook, Small Un-named Tribs	Shawano	
	Schoenik Creek	Shawano	Schoenick Lake
	Black Otter Creek	Outagamie	Black Otter Lake Dam
	Bear Creek, Shioc River Watershed	Outagamie	

Drainage Waters Covered by the VHS Rules (includes their tributaries upstream to the fist dam or barrier impassable to fish, as of June 1, 1997)			
Mississippi River Drainage Area	**Waterbody**	**County**	**Headwater/Barrier**
St. Croix River and Tribs	St. Croix River and Tribs		St Croix Falls Dam
	Apple River	St. Croix	Dam near Somerset
	Osceola Creek	Pierce	
	Willow River	Pierce	Hudson Dam
	Kinnickinic River	Pierce	River Falls Dam
	Barkey Coulee		
Chippewa River and Tribs	Chippewa River and Tribs	Eau Claire	Eau Claire Dam
	Lowes Creek, West Creek, Sherman Creek, Elk Creek, Muddy Creek, Cranberry Creek, Duscham Creek, Fall Creek, Rock Creek	Dunn	
	Bear Creek, Little Plum Creek	Pepin	
	Eau Galle River	Pepin	Eau Galle Dam
	Plum Creek	Pepin	Nugget Lake Dam
Red Cedar River and Tribs	Red Cedar River and Tribs		Lake Menominee Dam
	Gilbert Creek, Irving Creek, Little Elk Creek	Dunn	
Black River and Tribs	Black River and Tribs		Black River Falls Dam
	Squaw Creek, Spring Creek, Pine Grove Creek, Trout Run Creek, Robinson Creek, Roaring Creek, Wolf Creek, Wilson Creek, Mill Creek, Sand Creek, Douglas Creek, Davis Creek	Jackson	
	Perry Creek	Jackson	Cranberry Flowage
	Big Creek	Monroe	
	Fleming Creek	La Crosse	
	Hardies Creek, Grant Creek	Trempeleau	
	Beaver Creek	Trempeleau	Lake Marinuka Dam
La Crosse River and Tribs	La Crosse River and Tribs		Lake Neshonic Dam
	Neshonic Creek, Larson Coulee, Gill Coulee, Bostwick Creek, Smith Valley Creek, Pleasant Valley Creek	La Crosse	

Drainage Waters Covered by the VHS Rules (includes their tributaries upstream to the fist dam or barrier impassable to fish, as of June 1, 1997)			
Mississippi River Drainage Area	**Waterbody**	**County**	**Headwater/Barrier**
Wisconsin River and Tribs	Wisconsin River and Tribs		Prairie du Sac Dam
	Roxbury Creek, Dunlap, Marsh Creek	Dane	
	Wilson Creek, Otter Creek, Honey Creek	Sauk	
	Blue Mound Creek, Mill Creek, Lowery Creek, Rush Creek, Otter Creek, Morrey Creek	Iowa	
	Bear Creek, Pine Creek, Indian Creek, Mill Creek, Byrds Creek, Richland Creek, Knapp	Richland	
	Richland Creek, Clear Creek, Little Kickapoo River, Bush Creek, Gran Grae Creek	Crawford	
	Kickapoo River	Crawford	Gay Mills
	Blue River, Sanders Creek, Crooked Creek, Big Green River, Little Green River, Millville Creek, Dutch Hallow Creek, Lane Creek	Grant	
Mississippi River and Tribs	Mississippi River and Tribs		
	Pine Coulee Creek, Dry Run Coulee Creek, Big River, Morgan Coulee Creek, Wing River, Hope Coulee Creek, Trimbelle River, Isabella Creek, Rush River, Pine Creek	Pierce	
	Bogus Creek, Lost Creek, Hicks Valley Creek	Pepin	
	By Golly Creek, Deer Creek, Spring Creek, Iron Creek, Rose Valley Creek, Waumandee Creek, Eagle Creek	Buffalo	
	Buffalo River and Tribs	Buffalo	Below Strum
	Trempeleau River and Tribs	Buffalo	Lake Henry Dam
	Halfway Creek, Pammel Creek, Mormon Creek	La Crosse	
	Chipmunk Creek, Coon Creek, Spring Coulee Creek, Genoa Creek, Bad Axe River and Tribs, Battle Hallow Creek	Vernon	
	Rush Creek, Sugar Creek, Buck Creek, Copper Creek, Kettle Creek, Lynxville Creek, Leitner Coulee Creek, DuCharme Creek, Picatee Creek, Mill Creek, Limery Creek, Camp Coulee Creek	Crawford	
	Wyalusing Creek, Gasner Creek, Ready Creek, Glass Creek, Dry Hallow Creek, Sandy Creek, Chase Creek, Spring Branch, Muddy Creek, Furnace Branch, Mill Branch, McCartney Branch, Grant River and Tribs, Potosi Creek, Platte River and Tribs, Sinnippee Creek	Grant	

18 Appendix D – Public Comment Summary

Commenter	Page Number of FPSA	Comment	Response
Wisconsin Electric Company		Each dam is unique	Noted.
Wisconsin Electric Company		Department must remain flexible in approach to FP	Noted.
Wisconsin Electric Company		Review at a project level, and not adapt programmatic policy objectives that constrain analysis or presume a policy outcomes	Noted. Policy issue.
Wisconsin Electric Company		Do not believe there exists any "one size fits all" policy alternatives for fish passage	Noted. Policy issue.
Wisconsin Electric Company		Decisions should be made on the basis of known and measurable costs and benefits of a reasonable range of alternatives, and these decisions need to equitably balance competing interests as a means to achieve net benefits for the public.	Noted. Policy issue.
Wisconsin Electric Company		First step of analysis is a thorough and credible assessment on the need of passage	Noted. Policy issue.
Wisconsin Electric Company		Assessments must be based upon reliable and peer reviewed science	Noted. Policy issue.
Wisconsin Electric Company		**see the detailed bullets of the letter**	
Wisconsin Electric Company		For FERC regulated dams, follow the FERC licensing process	Noted. Policy issue.
Wisconsin Electric Company	Page 7	suggest changing "been proposed" to "draft detailed planning report"	No change.
Wisconsin Electric Company	Page 9	Statement of authority is not accurate. FERC has authority to supersede state regulations (letter, page 6)	Changes made to page 9.
Wisconsin Electric Company	Page 11-16, Table 2-1	Insert a sentence above Table 2-1 to explain that these citations may not cover all relevant requirements and that each description is a basic summary included to only provide a general understanding of the code or statute.	Changes made to Table 2-1.
Wisconsin Electric Company	Chapter 6	Information is dated. Need to keep up with new technologies and science.	Changes made to Chapter 6.1.

Commenter	Page Number of FPSA	Comment	Response
Wisconsin Electric Company	Chapter 6	The question of what constitutes fish passage must be a current and broad inquiry and should focus upon the most efficient and cost effective way to improve passage …	Noted. Policy issue.
Wisconsin Electric Company	Chapter 6	Implementation policies need to identify a process to determine target species that may be considered…. And non-targeted species that could be impacted all need to be considered…	Noted. Policy issue.
Wisconsin Electric Company	Page 30	Concern for the Department not to prejudge this method … based upon historical concerns that may no longer apply	Noted. No change.
Wisconsin Electric Company	Page 32	Turbine discussions do not account for new developments in fish friendly turbines.	Noted. Refer to policy discussions to incorporate technology and literature reviews. Also, added comments on page 34.
Wisconsin Electric Company	Page 44	Recommend additional information regarding known migration distances of appropriate species of interest be included as part of Table 4-1	Specific to resource access to habitat. Many variables. Policy consideration to look at species and resource specific migration issues. Sentence added to page 44.
Wisconsin Electric Company	Page 44	Request additional reference regarding passage survival to provide a balanced discussion.	Noted. Changes made to page 44.
Wisconsin Electric Company	Pages 47-50	Discussion should state that dams prevent the spread of disease….	Changes made to page 47.
Wisconsin Electric Company	Pages 52-53	More discussion on the spread of invasive that are not classified as AIS.	Changes made to Section 6.1.
Wisconsin Electric Company	Dam Safety, Chapter 8	Costs, feasibility, and changes to operations associated with dam safety must be considered. FERC processes and stakeholder engagement should be considered.	Noted. Policy issue. Changes made to page 59.
Wisconsin Electric Company	Page 59, First Bullet	Revisions to clarify intent	Changes made to page 59.
Wisconsin Electric Company	Page 59, third bullet	Revisions to clarity intent	Noted.

Commenter	Page Number of FPSA	Comment	Response
Wisconsin Electric Company	Page 59, last sentence	Revision to clarify intent	Changes made to page 59.
Wisconsin Electric Company	Page 59, fourth bullet	Revisions to clarify intent	Comment is too specific. No changes made.
Wisconsin Electric Company	Chapter 9	Recommended text to clarify PSC role and permitting processes	Changes made to clarify.
Wisconsin Electric Company	Page 64	include costs as part of policy	Noted. Policy issue.
Wisconsin Electric Company	Table 9-1 page 63	suggest changing "proposed" to "draft detailed planning report", and make changes to Chalk Hill and White Rapids Costs	Noted. Changes made to costs.
Wisconsin Electric Company	Table 9-2 page 65	Corrections to fish net costs, and trash rack costs	Changes made.
Wisconsin Electric Company	Page 68	Recommend additional costs of AIS to landowners	Noted. No changes made.
Wisconsin Electric Company	Page 70	Concerns for adverse impacts to wildlife	Noted. No Change
Wisconsin Electric Company	Page 71	Increasing fish concentrations	Noted. In history section, also a policy issue.
Wisconsin Electric Company	Page 75	Add a paragraph detailing the FERC and SHPO Programmatic Agreement information.	Additional information added to the section.
River Alliance of Wisconsin	General	The FPSA that they will now use, along with the previously issued FPG to evaluate the merits of any new … fish passage projects	This is not an accurate statement. No response needed.
River Alliance of Wisconsin	General	Concerned that an analysis could delay a project	Noted. Policy issue.
River Alliance of Wisconsin	General	Reconnecting rivers and streams by dam removal or fish passage structures should receive equal consideration.	Beyond the scope of the FPSA.
US Fish and Wildlife Service	General	Clearly Define "Complete Barrier"	Defined in definition appendix and added to Table 1-1.
US Fish and Wildlife Service	General	Consider Management Plans and/or Species Recovery Strategies	Noted. Policy consideration.
US Fish and Wildlife Service	General	Describe Volitional vs Non-Volitional Passage	Refer to Policy team and Fishery Program.
US Fish and Wildlife Service	General	Consider Maintaining Flexibility	Noted. Policy issue.

Commenter	Page Number of FPSA	Comment	Response
Great Lakes Fishery Commission and UWFWS Sea Lamprey Control	General	Add text emphasizing that local policy and actions can regional consequences	Noted. Policy issue.
Great Lakes Fishery Commission and UWFWS Sea Lamprey Control	General	Add a timeline for updating the document	Noted. Policy issue.
Great Lakes Fishery Commission and UWFWS Sea Lamprey Control	General	Add link to regulations and protocols	Noted. Policy issue.
Great Lakes Fishery Commission and UWFWS Sea Lamprey Control	Executive Summary	Dams have been used by the department to slow the spread of fish/AIS, ad to segregate the populations of valued fish	Unclear. Dam removal processes are policy.
Great Lakes Fishery Commission and UWFWS Sea Lamprey Control	Chapter 1	Consider adding subheading. Keep this section up to date.	Comment on formatting noted. Keeping up with technology is a policy issue.
Great Lakes Fishery Commission and UWFWS Sea Lamprey Control	Chapter 2, Regulatory Framework	Identify which agency Division is responsible for each regulation.	Policy issue.
Great Lakes Fishery Commission and UWFWS Sea Lamprey Control	General	Provide hyperlinks to all websites	Noted. No changes made.
Great Lakes Fishery Commission and UWFWS Sea Lamprey Control /Whoosh	Chapter 3	Information is dated. Need to keep up with new technologies and science.	Noted. Discuss with leadership. Policy issue.
Great Lakes Fishery Commission and UWFWS Sea Lamprey Control	Chapter 3	Add a new section on emerging technologies	Noted. Discuss with leadership.
Great Lakes Fishery Commission and UWFWS Sea Lamprey Control	Chapter 3	Increase the information on behavior barriers.	Noted. Discuss with leadership.
Great Lakes Fishery Commission and UWFWS Sea Lamprey Control	Chapter 3	More discussion on fish sorting.	Noted. No additional provided. Intent unclear.
Great Lakes Fishery Commission and UWFWS Sea Lamprey Control	Chapter 5	Figure resolution is poor	Noted. No changes made.
Great Lakes Fishery Commission and UWFWS Sea Lamprey Control	Chapter 6, Page 52	Add a sentence about the need for inter-agency consultation at the bottom of page 52, and that additional criteria should include risk of failure and structural deficiencies	Noted. Policy issue. Changes made to page 59.
Great Lakes Fishery Commission and UWFWS Sea Lamprey Control	Chapter 6	Consider lamprey status during risk assessment	Noted. Policy issue.

Commenter	Page Number of FPSA	Comment	Response
Great Lakes Fishery Commission and UWFWS Sea Lamprey Control	Chapter 7	Who can use and access the agency database information. How to access the data	Noted. Policy issues.
Great Lakes Fishery Commission and UWFWS Sea Lamprey Control	Chapter 7	Recommend we add sea lamprey control information	Noted. No changes made.
Great Lakes Fishery Commission and UWFWS Sea Lamprey Control	Chapter 7	Provide hyperlinks to all websites	Noted. No changes made.
Great Lakes Fishery Commission and UWFWS Sea Lamprey Control	Chapter 7	Recommend genetic testing	Noted. Policy issue.
Great Lakes Fishery Commission and UWFWS Sea Lamprey Control	Chapter 7	Too much focus on upstream, Recommend more discussion on up and down stream movement	Noted. No changes made.
Great Lakes Fishery Commission and UWFWS Sea Lamprey Control	Chapter 9	Mention specific funding mechanisms	Noted. No changes made.
Great Lakes Fishery Commission and UWFWS Sea Lamprey Control	Chapter 13	Discuss impacts beyond the state of Wisconsin.	Unclear. Policy issue.
Peter Haug	General	Questions about policy. Questions and statements about a specific project.	Noted. Policy issues. Project Specific Comments are not relevant to scope of the Strategic Analysis.
Menominee Tribe of Wisconsin		Policy questions and statements. Comments associated with Tribal concerns.	Noted. Follow up with Tribe. Comments are beyond the scope of this Strategic Analysis, and somewhat specific to a specific fish passage project.
General	General	A few people provided research papers	Noted. No changes made.

19 Appendix E – Public Comments

Comments received during the public comment period are attached below.

19.1 Wisconsin Electric Company

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October 16, 2017

Submitted Electronically:
DNRFISHPASSAGE@wisconsin.gov

Mr. Jim Doperalski
Wisconsin Department of Natural Resources

Re: WDNR's Draft Strategic Analysis for Fish Passage at Dams – Wis. Admin. Code NR 150.10 Public Review of Analysis

Dear Mr. Doperalski:

Wisconsin Electric Power Company, d.b.a. We Energies, ("We Energies") and Wisconsin Public Service Corporation ("WPS"), subsidiaries of WEC Energy Group, Inc. (collectively the "Companies") submit these comments in response to the Wisconsin Department of Natural Resources ("WDNR" or "Department") notice of public comment period on the Department's draft Fish Passage at Dams Strategic Analysis, dated August 28, 2017 ("Strategic Analysis"). The Companies appreciate the opportunity to offer these comments.

The Companies serve more than 1.5 million electric customers in Wisconsin and Michigan's Upper Peninsula and 1.4 million natural gas customers in Wisconsin. We are the largest electric and gas provider in the state of Wisconsin, and our generation facilities provide half of the electricity to the residents of Wisconsin. The Companies' combined hydroelectric generation system provides 188 megawatts (MW) of capacity and typically over 800,000 megawatt hours (MWh) of annual generation. This system is comprised of 30 facilities located in three main river systems, the Menominee, Wisconsin and Peshtigo Rivers. Nearly all of these facilities operate under licenses issued by the Federal Energy Regulatory Commission (FERC). In addition, significant facility investments must be approved by the Public Service Commission of Wisconsin (PSCW).[1] The plants have operated for decades, and range from about 63 years to over 100 years old.

The Companies' hydroelectric facilities are operated to balance several objectives including economic operations to meet customer needs, protection of associated land and water resources, production of low-cost renewable energy, enhancement of recreational opportunities, and protection of the river basin and fish and wildlife resources. Maintaining this balance is important and in the public interest.

[1] Wis. Stat. § 196.49

I. Summary of Comments

The Companies acknowledge and commend the Department's effort to take an in-depth look at the facts and circumstances surrounding the need for, and the opportunities to provide, fish passage at existing dams in Wisconsin. Healthy and robust fish populations, and the habitat needed to sustain these populations, are valued resources.

As an owner and operator of 30 dams on three river systems, our overriding comment is that dams have unique characteristics and do not present uniform opportunities for fish passage, and in some cases, fish passage may simply not be practical. Environmental conditions, both manmade and natural, greatly influence fish habitat and the ability to sustain and enhance viable fish populations.

We emphasize that the issues surrounding fish passage are often driven or determined by site-specific conditions. Therefore, if the Department moves forward with any one or more of the identified policy alternatives, we think that the Department must remain flexible in its approach to fish passage. The Companies urge the Department to carefully and objectively assess the need and opportunities for fish passage at a project level, and not to adopt programmatic policy objectives that constrain analysis or presume outcomes.

The Companies offer further comment below concerning some of the policy considerations called out in the Strategic Analysis. The Companies also acknowledge, as does the Strategic Analysis, that that FERC has primary jurisdiction and responsibility to regulate FERC-licensed hydroelectric dams, and that the need for fish passage is addressed at the time FERC issues a license (or when a license is renewed). As a resource agency, the Department is well positioned to play a leadership role during a FERC licensing process and work with licensees, other resource agencies, tribes and other stakeholders to promote fair and balanced collaborative solutions and incentives as a means to advance the Department's fish passage goals and objectives.

Finally, the Companies offer some detailed comments that pertain to some of the specifics of the Strategic Analysis. We hope that our comments are helpful to the Department's further consideration of these issues. We offer our continued support as a resource to the Department in developing a further understanding of fish passage issues, and with the formulation of any policies that the Department may wish to consider in the future.

II. Policy Considerations

The Companies understand that the purpose of the Strategic Analysis is to provide an "informational document for the public and policy makers to better understand the topic and aid in the crafting of future policy." We offer our perspective on the "Policy Considerations" and "Policy Alternatives" contained in Section 16 of the draft Strategic Assessment, as well as the priorities that underlie policy considerations.

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The explanation in the introduction to Section 16, and the subsequent discussion of *seventeen* types of underlying "Policy Considerations" – including up to ten specific issues to be contemplated for each, very clearly illustrates the complexity of the topic of fish passage projects at dams. We acknowledge the effort of compiling and presenting all of these relevant elements, interests, and trade-offs. This comprehensive information is appropriate to include in this Strategic Assessment. Based on this wide range of considerations, Section 16 goes on to articulate seven discrete "Policy Alternatives", and notes that these could be combined and or modified as conditions warrant. Having considered these discrete alternatives, the Companies do not endorse any single one of them because we do not believe that there exists any "one size fits all" policy alternative for fish passage.

In lieu of any of the suggested "Policy Alternatives," the Companies believe that the Department should carefully and objectively assess the need and opportunities for fish passage at a project level, and not adopt programmatic policy objectives that constrain analyses or presume outcomes. Project-level assessment of the need and opportunities for fish passage should be undertaken in collaboration with federal and state agencies, tribal governments, dam owners and operators, and other stakeholders. Fish passage decisions should be made on the basis of known and measurable costs and benefits of a reasonable range of alternatives, and these decisions need to equitably balance competing interests as a means to achieve net benefits for the public at large. In striking this balance, the Companies offer further comment on some of the key policy considerations:

- *Cost Benefit Analysis:* The first step in this analysis should be a thorough and credible assessment of the need for passage. If fish passage is needed, then the next step is to assess the efficiency and effectiveness of any passage technologies that are needed, and the likely outcomes if any of these technologies are employed. If there is a need for passage, and technologies are available to address this need, the next step is to consider the various interests affected by a decision to implement fish passage. The decision should strike an equitable balance among competing interests, and a determination of the course of action that is most likely to achieve net benefits for the public at large.

- *Sound Science:* When assessing the costs or benefits of a decision to a given species or its associated habitat, this assessment must be based upon reliable and peer-reviewed science. The wellbeing of other species that thrive in the existing condition should not be discounted or assumed to continue unaffected by the implementation of passage technology. Dollars spent on improvements are inherently more valuable than dollars spent to study improvements. That said, dollars spent on pursuing speculative outcomes are, more frequently than not, dollars wasted. Any policy the Department adopts should place a premium on research and the development of technologies that work. Technologies that address the cost-benefit and sound science objectives identified above are the result of research that can take decades to complete and even longer to effectively implement.

- *Our Customers:* Modifications to a dam may require expensive capital improvements and may add significant and ongoing operation and maintenance costs. Fish passage facilities can also

reduce or impede generation, resulting in a need to replace lost generation – often from non-renewable sources. These are significant costs. The Department should consider these costs from the perspective of the members of the public who will be asked bear these costs. Are these prudent expenditures? Are these expenditures necessary and cost effective? These are questions that utilities must answer in the context of the public service obligations that we owe our customers. These are question that we think the Department must also consider in formulating its fish passage policies.

- *Dam Safety:* Dam safety is of paramount importance and cannot be compromised to support fish passage. Understanding the cost and consequences of meeting dam safety requirements is an important element of understanding the interface of fish passage technology with impoundment structures, and in determining the feasibility and expense of any such improvements.

- *Habitat Suitability:* A threshold consideration to any passage decision should be whether upstream or downstream access will create conditions that will sustain or enhance healthy fish populations. If passage provides access only to marginal habitat, other alternatives need to be considered, including habitat enhancements and fish propagation measures. This analysis must be undertaken with no bias towards a particular outcome.

- *Regulatory Certainty.* Most of the Companies' hydroelectric projects are licensed by FERC. FERC licenses are issued for periods of 30 to 50 years. Long-term licenses provide regulatory certainty, which in turn provides an incentive for investment in projects that provide public benefits. Regulatory certainly should be a pillar of any policy adopted by the Department to implement fish passage measures. We are a willing partner in pursuing the goal of healthy fish populations, but we must recognize existing licenses that have already considered multiple factors and provide regulatory certainly.

III. FERC Jurisdiction.

For FERC jurisdictional projects, the FERC licensing (and relicensing) process provides the context as well as the window of opportunity for determining the need for any fish passage measures to be required of the licensee.[2] The Strategic Analysis acknowledges that FERC has primary jurisdiction and responsibility to regulate FERC-licensed hydroelectric dams. The regulatory mechanisms to provide for fish passage in the FERC process fully engage federal and state resources agencies.[3] It

[2] The scope of FERC's preemptive authority was decided by the United States Supreme Court in *First Iowa Hydro-Electric Cooperative v. Federal Power Commission*, 328 U.S. 152 (1946) (the Federal Power Act, 16 U.S.C. 791 et seq. vests the FERC with broad authority to regulate hydroelectric facilities and that state and local regulation of matters to be decided by FERC with respect to such hydroelectric facilities is preempted by operation of the Supremacy Clause of the U.S. Constitution). The question was revisited and these principles were upheld by the Supreme Court forty-four years later in *California v. FERC,* 495 U.S. 490 (1990).

[3] The license must contain any fishway prescriptions (mandatory conditions) required by the Secretaries of Commerce and the Interior (National Marine Fisheries Service and U.S. Fish and Wildlife); *16 U.S.C. § 811*; any federal and state

is difficult to perceive any regulatory gap or insufficiency in the FERC process to assess the need for, and in the appropriate case, to require a licensee to provide fish passage at a FERC licensed dam. If the Department wishes to align its fish passage policies with the FERC process, there are two important regulatory considerations that we think the Department should consider. These are:

- *Equal Consideration*: FERC is required to give equal consideration to environmental values, including fish and wildlife resources, visual resources, cultural resources, recreational opportunities, and other aspects of environmental quality. The balance of interests reflected in our FERC licenses have been carefully crafted, with the full involvement and participation of all stakeholders. We urge the Department to explore and consider developing its fish passage goals and objectives within policy parameters that embrace a balancing of interests as a means to achieve net benefits for the public at large.

- *Collaboration:* A FERC licensing process can take many years to complete, especially if it becomes an adversarial process. When this occurs, benefits (like fish passage or other improvements) are delayed, if not jeopardized, by uncertain outcomes and potentially disappointing decisions. Better results are achieved, in a timelier manner, when the parties are able to find a common ground. As a resource agency, the Department is well positioned to advance its fish passage goals and objectives by taking a leadership role during a FERC licensing process. This is the opportunity to work with licensees, other resource agencies, tribes and other stakeholders to promote fair and balanced collaborative solutions.

IV. Detailed Comments

The Companies offer the following detailed comments with respect to the referenced portions of the Strategic Analysis.

A. History of Fish Passage at Dams Policy in Wisconsin (Section 4)

Page 7 - History of Fish Passage at Dams Policy in Wisconsin

In the second paragraph the sentence reads: "Currently there are 17 dams where fish passage projects have been completed or area being planned *or have been proposed* in Wisconsin". To clarify, there are 17 dams where fish passage projects have been completed, *proposed or have a draft detailed planning report.*

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fish and wildlife agencies recommendations submitted pursuant to the Fish and Wildlife Coordination Act that are needed to "adequately and equitably protect, mitigate damages to, and enhance fish and wildlife (including spawning grounds and habitat);" *16 U.S.C. § 803(j)*; and in the appropriate case, measures needed to protect aquatic resources required by Section 7(a)(2) of the Endangered Species Act, or any measures needed to protect aquatic resources that may be required by Section 40l(a)(l) of the Clean Water Act.

[3] Wis. Stat. §§ 196.49(3)(b)(1) and (2), and 196.491(3)(d

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Page 9 - History of Fish Passage at Dams Policy in Wisconsin

The fifth paragraph reads: "*FERC regulated dams must comply with state regulations* and those conditions imposed by the FERC or other federal resource agencies." This statement is not accurate. FERC has broad authority to regulate hydroelectric facilities, and the state and local regulation of matters to be decided by FERC is preempted by federal law. *See footnote 2 above.* FERC may decide, in a given case, that an applicant must comply with local requirements that will not interfere with the applicant's ability to carry out the Commission's orders. However, it is within the Commission's sole discretion to determine the extent to which such compliance will be required. Also, the Public Service Commission of Wisconsin (PSCW) has a role to play in areas not preempted by FERC's authority, such as setting retail rates, which includes reviewing the reasonableness of costs, and policies related to the Companies' retail customers (see section H., below).

B. Regulatory Framework and Department Procedures and Guidelines (Section 5)

Pages 11-16 - Table 5-1- Regulations That May Apply to Fish Passage at Dams

The Companies appreciate the difficulty in compiling a comprehensive summary of all of the federal and state laws that may have bearing on any policies to be developed by the Department. Table 5-1 is a useful tool to begin this inquiry. Our suggestion is that the Department inserts a sentence above table 5-1 to explain that these citations may not cover all relevant requirements and that each description is a basic summary included to only provide a general understanding of the code or statute.

C. Types of Fish Passage (Section 6)

This section provides a good summary of fish passage technologies that have been deployed in the past in the United States and internationally. However, some of this information is dated. It is important that all parties interested and involved with fish passage issues keep up with new developments. At any given time, the question of what constitutes "fish passage" must be a *current* and broad inquiry and should focus upon the most efficient and cost effective way to improve passage in those circumstances where passage is required.

This section of the Strategic Analysis also highlights a concern that we raised in our prior comments. Fish passage technology has strengths and weaknesses and may only be suitable for certain sites and species. The Strategic Analysis is not specific to any species. Implementation policies need to identify a process to determine target species that may be considered for any given river system. Non-targeted species that could be secondarily impacted by imposition of fish passage for targeted species also need to be considered.

At page 30, the Strategic Analysis mentions historic concerns about "potential adverse impacts" associated with collection and transport operations, referring to a study done in 1995. In the ensuing years, there have been many trap and haul systems implemented that have been very

successful. The Companies urge the Department not to prejudge this method of providing fish passage based upon historical concerns that may no longer apply.[4]

The discussion of turbine design at pages 32 through 34 does not account for new developments in fish friendly turbines. *See "Development Status of the Alden "Fish-Friendly" Turbine" at Alden Turbine Design.*

The discussion of fish propagation and habitat enhancement programs brings to light the importance of these alternative means to sustain or enhance healthy fish populations. As with collection and transport operations, progress has been made in addressing the "drawbacks of stocking fish as compensatory mitigation" that are mentioned in the Strategic Analysis.

D. Fish Migration (Section 7)

Page 44

This section references fish migration time scales and provides some information about distance ranges. We recommend that additional information regarding known migration distances of appropriate species of interest be included. This would give further context to the discussion of planned or proposed passage projects Presenting this in a table to complement the existing Table 7-1 containing spawning periodicity would be helpful.

In paragraph 4, Marmulla, 2001 is cited regarding significant mortality occurring through downstream migration. An additional reference here regarding passage survival should also be included in order to provide a balanced discussion of fish migration.

E. Fish Health (Section 8)

Pages 47-50

The discussion of fish health should acknowledge how dams prevent the spread of disease, particularly upstream. This acknowledgement would provide a more balanced discussion.

F. Invasive Species and Nuisance Species (Section 9)

Pages 52-53

There is a good discussion regarding aquatic invasive species (AIS), their effects, factors to consider in making passage decisions, criteria for determining risk of passing AIS, etc. Additional consideration should be given to the passage and spread of other state/federal regulated invasive terrestrial or wetland species not classified as AIS. Plant propagules of these types of invasive species can, and do, also spread through waterways. Many wetland invasive species that are not

[4] See for example, a recent article published by NOAA Fisheries referring to a recently installed collection system as "the next generation of fish passage technology See *http://www.westcoast.fisheries.noaa.gov/stories/2014/23_06232014_baker_update.html*

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classified as AIS have just as much an opportunity to spread through waterways as a result of passage as do AIS.

G. Dam Safety and Operational Considerations (Section 11)

The following points should be incorporated into this section.

FERC licensed hydroelectric projects are subject to stringent dam safety regulations. These requirements would be impacted by fish passage technologies that require structural modifications to impoundment structures or other project works. FERC reviews and approves plans, specifications, and quality control inspection programs associated with structural modifications. To ensure dam safety, these reviews frequently require additional studies to identify the need for additional engineering and/or construction measures. These requirements must be considered in assessing the feasibility of any modification of a project (including fish passage facilities) as well as the cost of such modifications and the time it takes to implement them.

Apart from dam safety, operational changes necessary to implement fish passage measures implicate FERC requirements. For example, changes in operations that affect minimum flows or headwater elevations, because of the installation of fish passage, may require the licensee to amend their current FERC license and any state issued Water Quality Certification. Modifications to a hydroelectric facility to accommodate fish passage will result in a need to amend a FERC approved Exhibit F - General Design Drawings and could also require an amendment to an Exhibit G - Exhibit Project Boundary Figure. Changes to hydroelectric operations necessary to accommodate fish passage will also result in the need to amend an Exhibit A - Project Description.

Changes to hydro operations necessary to accommodate fish passage may also require an amendment to FERC license articles.[5] Proposed amendments to FERC license articles will require consultation with stakeholders identified in the license articles or through the licensing process. This can include, but is not limited to: state departments of natural resources, the U.S Fish and Wildlife Service, National Park Service, Bureau of Land Management, Army Corp of Engineers, Native American Tribes, and State Historic Preservation Office. Once the stakeholder consultation has been completed and the licensee has addressed comments, an amendment request can be submitted to FERC. FERC would then make a decision to approve, modify or deny the amendment request.

[5] FERC license articles needed to the amendment may include: Operations Monitoring Plan; Water Quality Management Plan; Fisheries Management Plan; Drawdown Management Plan; Woody Debris Management Plan; Invasive Species Management Plan; Threatened and Endangered Species Management Plan; Wildlife Management Plan; Historic Resource Management Plan; Land Management Plan; Recreation Management Plan; Soil Erosion and Sediment Control Plan.

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Page 59

Please revise first bullet as follows: During the design process engineers and biologists work together to develop a design that is both biologically and technologically feasible. The design must enable water to pass through the dam and any associated fish passage features while maintaining the dam's structural and hydraulic integrity. The design must recognize the unique ecological conditions and needs above and below the dam that passage is intended to augment.

Please clarify third bullet to explain what is meant by – "This happens through reduction in the efficiency of gates."

Please revise last sentence as follows: Lowering of the water level below the crest of the fish passage will render the passage unusable by fish, and could result in a violation of minimum discharge requirements. This could be caused by large swings in headwater elevation from peaking, re-regulation, or drawdown operations. FERC regulates these activities closely and requires deviation reporting if such swings are outside license constraints.

Please clarify the fourth bullet and please add the following to the fifth bullet at the end of the sentence: Modifying gates may adversely impact the hydraulic capacity of the hydro project making it unable to pass the design flow that is used to determine if a project meets strict criteria set forth by the FERC. This could result in very costly hydraulic capacity studies and potentially the construction of additional spillway capacity.

H. Economic Considerations (Section 12)

As further context for this section the Companies would add the following explanation addressing economic considerations for regulated utilities: The Public Service Commission of Wisconsin (PSCW) sets allowable rates that establish charges to customers so that a regulated utility is able to recover its cost of service, including prudent expenses, through customer rates. In addition, there are cost thresholds for larger capital projects that define when PSCW approval is required ahead of construction. Therefore, costs for fish passage capital projects and any associated increased operating and maintenance costs are only recovered in customer rates once approved by the PSCW. Rates are fixed between rate case filings, so an increase in costs outside of a rate case generally means that a regulated utility is unable to recover those costs.

Therefore, utilities subject to PSCW financial requirements may not always be in a position to unilaterally determine a course of action for fish passage. We ask that the Strategic Analysis recognize the role that the PSCW plays in evaluating utility costs and regulating customer rates.

Page 64

We note the statement: "When considering project costs reported in older studies, it is important to note that regulatory changes over the past two decades may have increased the cost of fish passage projects, such that the costs reported may not be entirely reflective of current costs, even after

adjusting for inflation." We agree and believe that the cost information provided in Section 12 may not accurately reflect current costs. Additionally, reasonable and accurate cost estimates are driven by site or project specific conditions, and we would urge the Department to address cost, as a policy consideration, as a matter to be determined as a project specific inquiry.

Table 12-1 on page 63 (corrections):
For Grand Rapids Dam, Chalk Hill Dam and White Rapids Dam, please replace "Proposed" with "Draft Detailed Planning Report."

Project Costs for Chalk Hill & White Rapids are not correct. Per the February 2015 Draft Detailed Project Report assembled by the USACE, the combined cost of Chalk Hill & White Rapids is $18M, and should be shown in Table 12-1 as $9M each since the systems are essentially identical.

Table 12-2 on page 65 (corrections):
Fish net – cost of device: The $200k every 10 years reflects replacing a worn net. However the initial infrastructure installation cost of $400-500k is missing and should be reflected in the table. 1" trash rack and new rake – we suggest showing a range of $5-9M for the cost of this device.

Page 68:
In the discussion of the potential cost of AIS, the discussion should be inclusive of other invasive species that are not AIS. For example, there are significant costs to landowners who are maintaining their properties for general quality, habitat integrity, wildlife value, bank stability, and viewsheds by conducting land management for introduced woody invasive species.

I. Wildlife Considerations and Impacts (Section 13)

Page 70:
Passage could attract some aquatic species to move through passageways to their detriment and into less hospitable or inhospitable environments (could be related to substrate, water flow, forage/prey availability, water quality, etc.). Once there, it is likely individuals would seek to move back toward the environment they came from. However, they may not have the mechanism and/or ability to do so. This can create an unintended population sink and result in population impacts.

Page 71:
Fish concentration could be promoted by installing passage. The Department may need to consider refuges to reduce overharvest of game species where concentrations result from passage.

J. Cultural Considerations and Tribal Relations (Section 15)

Page 75:
Please add a fourth paragraph, as follows:

Most Wisconsin hydroelectric projects with a FERC issued license are required to manage historic and archeological resources through a Programmatic Agreement with the Michigan and Wisconsin State Historic Preservation Office (SHPO), FERC and the Advisory Council on Historic Preservation. The Programmatic Agreement requirements are used to develop Cultural or Historic Resource Management Plans. These plans detail how licensees will complete archeological studies prior to ground disturbing activity, the determination on project types that would require SHPO consultation for NRHP impacts, and how and when to implement dispute resolution. The conditions of a Cultural or Historic Resource Management Plan must be satisfied prior to project implementation.

K. Policy Alternatives and Considerations (Section 16)

Pages 77-79:
The several references to AIS do not account for other invasive species that are not AIS.

* * * * * *

Thank you once again for the opportunity to comment, and to convey the interests of our companies and our customers. For additional information, please contact Dave Lee, by telephone at (414) 221-2158 or by e-mail at david.lee@we-energies.com.

Sincerely,

Bruce W. Ramme, Ph.D., P.E.
Vice President – Environmental

cc: Cheryl Laatsch, FERC Coordinator, WDNR
Dave Siebert, Director, Bureau of Energy, Transportation & Environmental Analysis, WDNR

#463283

19.2 River Alliance of Wisconsin

October 6, 2017

Mr. Jim Doperalski Jr.,
Environmental Analysis and Review Specialist
Wisconsin DNR
2984 Shawano Avenue
Green Bay, WI 54313

Re: Wisconsin DNR's Fish Passage at Dams Strategic Analysis, September 2017

Dear Mr. Doperalski:

The River Alliance of Wisconsin has reviewed the Wisconsin DNR's draft *Fish Passage at Dams Strategic Analysis* (FPSA) document and hope that the Department seriously considers our comments on it before it is finalized.

In January 2014, the Wisconsin DNR issued a *Fish Passage Guidance* (FPG) document for DNR staff to use when reviewing proposed fish passage projects at federally regulated or state regulated dams in Wisconsin. The guidance focused heavily on using evaluation criteria to ascertain potential and risk of a fishway to spread *Aquatic Invasive Species* (AIS) upstream. The FPG described alternative strategies to handle AIS issues. Since issuing that document, we were informed that DNR wanted a much more detailed analysis conducted of a proposed fish passage project before DNR endorsed the action and gave approval to it. Consequently, DNR staff produced the *Fish Passage Strategic Analysis* (FPSA) that they will now use, along with the previously issued FPG, to evaluate the merits of any new (and possibly) any ongoing fish passage project in Wisconsin.

Although the Alliance believes the FPSA is a very through, informative and useful document, complete with a wealth of information about the DNR Water Regulation Program, recreational values of a river, fish and wildlife species life history and the habitats upon which they depend, and more, we are concerned that the detailed department by department analysis within DNR as described in the FPSA for each fish passage project could easily delay a project for years and as such, the "grant window" for eligibility for applicants to apply for grant funds to cost share with a fish passage project could easily be lost. In addition, we are concerned that there are countless ways a project could fail the test of the numerous criteria for upstream passage listed in to the FPSA. Consequently the Department using one or more of them could easily not approve a fish passage project, in spite of the fact that other resource agencies and other Stakeholders may support the project because they believe that the overall benefits of the project outweigh its possible negatives affects. The adverse effects of dams on fish, mussels, and other aquatic life by habitat fragmentation is well understood by the scientific community. We strongly believe that the merits of reconnecting rivers and streams by dam removal or installing fish passage

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structures, depending on what option makes sense, receive equal consideration by the Department as it implements it's FPSA in review of proposed fish passage projects on Wisconsin rivers and streams.

We appreciate the opportunity to comment on this document.

Sincerely,

Raj Shukla
Executive Director

Cc: Nick Utrup, U.S. Fish and Wildlife Service, Bloomington, MN
Robert Elliot, USFWS, Green Bay, WI
Cheryl Laatsch, Wisconsin DNR, Horicon, WI
Elle Gulotty, Michigan DNR, Marquette, MI
Jim Schramm, Michigan Hydro Relicensing Coalition, Pentwater, MI
Angela Tornes, National Park Service, Milwaukee, WI
Doug Cox, Menominee Indian Tribe, Keshena Falls, WI
Jim Fossum, JDEnvironmental Consulting, Winona, MN

19.3 US Fish and Wildlife Service

United States Department of the Interior
FISH AND WILDLIFE SERVICE
Ecological Services
Minnesota-Wisconsin Field Office
4101 American Boulevard East
Bloomington, Minnesota 55425-1665

October 10, 2017

Mr. Jim Doperalski
Wisconsin Department of Natural Resources
Green Bay Service Center
2984 Shawano Avenue
Green Bay, Wisconsin 54313-6727

Re: Comments on WDNR's Draft Fish Passage at Dams Strategic Analysis

Dear Mr. Doperalski:

Thank you for the opportunity to provide input on your draft strategic analysis for fish passage at dams. The U.S. Fish and Wildlife Service (FWS) is dedicated to working with our partners, including WDNR, using a science-based approach, to conserve, restore and enhance fish and other aquatic resources. As such, we often play an active role in Federal project reviews that involve potential impacts to wetlands and waterways and are typically the lead Federal agency responsible for reviewing and coordinating comments on hydroelectric projects licensed by the Federal Energy Regulatory Commission (FERC).

Because of our role in the FERC process, we would like to provide some input on your draft strategic analysis, to better integrate our roles in project planning and resource management. Our comments follow.

1. Clearly Define "Complete Barrier"

You currently define a Complete Barrier as – "*A man made or natural structure which does not allow the migration of aquatic organisms upstream up to the 100-year event.*" You may want to consider using some qualifiers in the definition, such as "*....does not allow for the volitional movement of fish upstream up to the 100-year flood event*". We would also recommend highlighting, either in the text or as a footnote, that a complete barrier to volitional upstream movement of aquatic organisms does not mean a complete barrier to the spread or movement of organisms (such as AIS) by other vectors (e.g., bait buckets, trailers, terrestrial/avian wildlife, etc.). Some aquatic organisms are far more mobile than fish in the presence of a barrier (such as amphibians), and could potentially move upstream of what you consider a "complete barrier". The word "complete" in this definition may need to be reevaluated or defined more specifically.

2. Consider Management Plans and/or Species Recovery Strategies

We recognize that you have written individual sections devoted to endangered resources or aquatic wildlife, however, it may be beneficial to incorporate a section that considers fish passage relative to management plans (e.g., Menominee River Fisheries Plan) or overarching strategies (e.g., Wisconsin Wildlife Action Plan). Also, Endangered Species Recovery Priorities, developed in coordination between the FWS and WDNR, should be considered when developing any policy regarding fish passage at dams as it my impact our collective ability to address recovery needs for certain species (e.g., how dams may impact recovery of mussels).

3. Describe Volitional versus Non-volitional Passage

You identify active versus passive fishways and describe some of the advantages and disadvantages of each. We recommend you further describe these advantages and disadvantages in how the fishway may influence volitional movement of fish. For several species of fish, such as lake sturgeon, we have found a difference between fish that are actively migrating upstream to spawn and those that may just be milling below a dam. As such, it may be a significant disadvantage if we were to move "non-migratory" individuals rather than target actively migrating individuals. For example, an active passage system that uses attraction flow to lure and trap lake sturgeon that are actively migrating would be more advantageous than an active system that collects lake sturgeon without an attraction flow.

4. Consider Maintaining Flexibility

As you continue to develop this strategy, and ultimately consider policy, we recommend that you consider each dam to be unique with a variety of issues that influence the need for fish passage at a site (e.g., management plans, cultural needs, multi-stakeholder input). Currently, each relicensing goes through its own public review process through FERC (typically independent from other dam projects). As such, it is recommended that fish passage decisions be site specific based on applied technology and resource management objectives.

Flexibility is key when considering how stakeholders address the complex issue of fish passage. As with fish passage technologies, it is good to have many options available when considering fish passage as a management recommendation at a dam.

We appreciate having the opportunity to provide these comments and look forward to working with you as you continue to develop this strategic analysis. If you have any questions, or if you would like to coordinate further on this matter, please contact Mr. Nick Utrup, of my staff, at (952) 252-0092, extension 204.

Sincerely,

Peter Fasbender
Field Supervisor

19.4 Great Lakes Fishery Commission and USFWS Sea Lamprey Control

Great Lakes Fishery Commission and US Fish and Wildlife Service Sea Lamprey Control Program comments on the Wisconsin Department of Natural Resources' Strategic Analysis of Fish Passage at Dams

October 11, 2017

This document is a unique and practical guide to those considering a fish passage project, and can also serve the department by maintaining consistency through staff turnover. We appreciate that the document points out the need to consider carrying capacity and all life stages of aquatic species, and that it discusses the need for specific ecological conditions upstream to enhance successful fish passage. Throughout the document, consider adding text emphasizing that local policies and actions can have regional consequences. If the intent is to keep this document relevant into the future, consider adding a sentence in the Forward about expected timeline for updating. Lastly, we suggest a final proofread and addition of links to regulations, databases and protocols if this is to be made available online.

The *Executive Summary* is well written and provides a good overview of the problem. Consider mentioning that dams have been used by the department to slow the spread of fish/aquatic diseases and have been used to segregate populations of valued fishes (sturgeon, brook trout).

Section 4: History of Fish Passage at Dams Policy in Wisconsin – consider adding sub-headings to better direct the user. It's critical that this section stays up to date if regulations change. The first paragraph on p. 9 "Nationwide, most experiments with fish passage at dams…" doesn't seem to fit with the rest of this section. We suggest moving it to Section 6 in the overview describing types of fish passage, and possibly mentioning the FishPass project that is moving to change this trend: http://www.glfc.org/fishpass.php.

Section 5: Regulatory Framework and Department Procedures and Guidelines – capturing all relevant regulations in a single table is a great idea. Users would appreciate more information on which division is responsible for administering each section of code (i.e. do requests go to fisheries or to water regulations and zoning?), which sections have permitting authority, links to policy, procedure, and guidelines for implementing each section of code, and links to the statutes and codes. While the table does a good job of listing Wisconsin statutes and codes that affect fish passage at dams, understanding how these are enacted through policy, procedure, and guidelines would be very useful.

Section 6: Types of Fish Passage - This section provides a lot of detail for many different types of passage scenarios. The most recent citation is approximately 10 years old so it is likely that much of the information could be updated with more recent and more local studies. The Overview section tells readers that fishways were evaluated during 1908-1912, but doesn't tell us the results of that evaluations.
An emerging technologies section would be good to fit in somewhere and the amount of text spent on Behavior Barriers could be increased. Finally, most of the discussion focuses around not necessarily sorting fish, but moving them.

Section 8: Fish Health and AIS – Figure 8-1 please increase resolution, the figure was difficult to interpret both on a screen and when printed.

Section 9: Invasive Species and Nuisance Species – This was well written to generally describe the risk of all invasive species. We suggest adding a sentence about the need for inter-agency consultation at the bottom of p. 52, and that an additional evaluation criteria might be structural deficiencies or risk of failure (i.e. structurally deficient dams are a higher priority for attention). Additionally, for lakes Superior and Michigan, as a part of the lake committee structure, abundance and wounding thresholds for sea lamprey have been established to allow for achievement of shared Fish Community Objectives for these lakes. Current status of sea lamprey in each of these lakes and expected contribution to lakewide abundance and wounding could also be considered in evaluations of risk associated with the potential for passing sea lamprey at a barrier.

Section 10: Assessing the Aquatic Environment for Fish Passage – Who is able to use the databases described and how do they access the information? This area of the document seems to be written more for internal departmental use. If some of these datasets are available to general users, it would be helpful to include links on where to access them. We suggest including the addition of Sea Lamprey Control Program data on pg. 56, and recently developed visualization and decision support tools might also be worth mentioning:

- Sea Lamprey Control Map – http://data.glfc.org
- Fishwerks – https://greatlakesconnectivity.org/
- Fish Habitat Decision Support Tool – http://www.fishhabitattool.org/
- FishTail – https://ccviewer.wim.usgsu.gov/fishtail
- FishVis – https://ccviewer.wim.usgs.gov/FishVis

If the protocols described in Section 10.2 are available online, it would be helpful to provide link to those documents.
We suggest discussing the role of genetics when assessing community/assemblage health; genetics are often noted as a reason to support fish passage, but are rarely studied or documented in monitoring programs. We also note that this section is focused in a single direction (downstream -> upstream), rather than bi-directionally. Assessments downstream of barriers, including changes in the Great Lakes, are also worth evaluating.

Section 12: Economic Considerations - This section was well written and provided some good discussion on trade-offs. Under "Sources of Funding", we suggest mentioning specific funding programs that are supported by the Great Lakes Restoration Initiative such as the Great Lakes Fishery and Ecosystem Restoration fund and the Great Lakes Basin Fish Habitat Partnership.

Section 16: Policy Alternatives and Considerations – This section is well thought out and well written. In section 16.1, it would be useful to add a sentence or two that describes potential impacts outside of the state of Wisconsin under relevant alternatives.

The GLFC and the USFWS SLCP appreciate the opportunity to comment on this strategic analysis, and would like to remain involved in this effort as Wisconsin's policy for fish passage is developed.

19.5 Peter Haug

05 September 2017

Mr. Jim Doperalski Jr.
Environmental Analysis and Review Specialist
2984 Shawano Avenue
Green Bay, 54313

Dear Mr. Doperalski:

Thank you for releasing the FPSA for public review and comment. I have spent my career designing dam modifications for fish passage along the Columbia and Snake River dams and later for much smaller dams in Iowa and Wisconsin. As a long-term advocate for appropriate fish passage around well-maintained dams, I must admit I find much angst in the latest trend for the Wisconsin DNR to demand complete barriers for some proposed fish passage improvement projects in the name of protecting sport fish and against a preponderance of habitat connectivity benefits.

First, while this strategic document claims to only pertain to active dams (not dam removals or culverts per the Foreword), such a narrow strategic analysis will certainly run into legal challenges. Will owners of existing dams be required to maintain into perpetuity their dams simply because a (present or future?) threat of invasives is determined? Or if dam owners claim rights to remove the dam (today or in twenty years?), are they then exempt from NR 40 and ATCP 10 provisions? What if a dam owner puts a culvert through an embankment – are culverts in dam embankments covered by this policy while culverts in highway sections are not? Without much legislative authority and legal precedent elsewhere, the state appears to have a very narrow and tenuous interpretation of NR 40 if dam removal or breach constitutes an introduction of invasive species. How about the Federal Highway policy to accommodate aquatic organism passage where environmentally warranted? What about how National Marine Fisheries continues to force fish passage on some federally-licensed dams in the name of environmental stewardship but yet Wisconsin's FERC dams are told by the DNR that they cannot use environmental stewardship to justify fish passage? By starting with dam removal as one extreme and moving toward grayer areas (partial breach, seasonal breach, culvert options, unregulated vs regulated passage of fish), the same interpretation challenges remain, and merely stating that this strategic analysis does not address dam removal or culvert issues ignores an imminent onslaught of legal challenges to this policy.

Second, the state has chosen to preserve an economic benefit (population support for more than a dozen sport fishing species) at detriment to natural diversity and river health. How can the state "take" the existing dam (private property maintained without state funds) or passage benefits (tribal fishing opportunities, social justice even) without compensating the affected party while the state benefits off the takings? I would argue that the state's desire to preserve public fishing is overriding the federal protections on private property and takings limitations. As a real specific example to this, has anyone done the math at Balsam Row to determine that passing unrestricted species around this dam will create even a net loss to the state economy? The state admits they have insufficient data and no plan to obtain data to make such a computation. Would the sturgeon comeback (tourism, river's carrying capacity, even tribal dignity and sense of community) outweigh the distant (no VHS is below the dam now) risk that VHS will take out sport fish in the two miles of river outside the Menominee lands? I agree with those who divide the project cost by the number of fish expected to be transported and shutter that the cost to preserve the state's sport fishing must be borne by others – for example, why do the Menominee have to pay $600,000 for a trap and sort to preserve the 1000 (or even 10,000) sport fish that the state thinks (but hasn't proven) are upstream of the proposed fish passage project? By not

installing the trap and sort and even if VHS were to arrive at Balsam Row in the future, the current artificially-supported sport fishery can be replaced by sturgeon and other VHS-resistant species. While the state claims a cost of $100 per sturgeon to truck and transport, what is the real cost of doing only truck and transport? That cost must include the high fallback percentage, the knowledge that 100 or 1000 fish per year will not sustain original populations, the lost opportunity for future generations to see high populations. In a similar myopic view, the state has placed a valuation on sport fish (fishing licenses, tourism) but has not evaluated the natural system's value without sport fish. Again, the state is "taking" from non-sport species (restricting sturgeon and other fish passage through the sorting station) and their benefactors (the Menominee and others who care about habitat connectivity) to "subsidize" sport fish population protections.

Third, applying ATCP 10.63 to nature-like fishways that have no human to fish contact (i.e. sorting and handling) is clearly an interpretative stretch of a code designed primarily for fish farming, and such a narrow view is unsupported even by the ATCP state veterinarian. Only by circular reasoning can the state prohibit unrestricted (no handling) fish passage via the nebulous interpretations of NR 40 and ATCP 10.63 and then force dam owners to get health certificates for the fish handled in these inefficient trap and sort facilities (and thus now subject to NR 40 and ATCP 10.63). For nature-like fishways, fish are not handled (so ATCP codes are not applicable) and fish are naturally re-introduced to their original habitat capacity (so NR 40 does not apply). There is no new "introduction" of native species – fish had the opportunity to be introduced upstream before dams and are now allowed to have that same opportunity again via fish passage. In other words, dam owners are not responsible for "introducing" fish to previous habitats during nature-like fishway passage improvements any more than humans could be held responsible for the natural westward migration of invasive English sparrows.

Fourth, how can the Department of Natural Resources not consider "natural resources" in the bulleted risk discussion of this report? Natural resources include the benefits of unrestricted movement for native species, the impact of native species movement on tribal groups who were here long before dams and fish ladders, and the restoration of interconnected Wisconsin streams rather than promotion of isolated reaches that hold (some might argue unnaturally high?) concentrations of sport fish. Risks include – if we do not allow fish passage, what may happen: dwindling native species populations, slowness of species to adapt to AIS challenges, lack of diversity? I know that these natural resources are hard to quantify, but have we humans ever improved anything long-term by micromanaging one aspect of nature without first understanding the much larger picture? I have heard biologists admit that dams don't spread AIS more than boaters, birds, and other transport mechanisms (is this proven either way?) and certainly there are 1000s times more culverts that pass AIS than dams that do – but we do know for a fact that trap and sort facilities severely bottleneck native species movement, especially species that aren't fast, large, highly visible sportfish. It seems like the state has chosen to pick on one component of AIS transport because 1) those advocates of dams are few and 2) those benefits of sport fish are easily quantified – but in choosing this path, the state ignores the vast value of other natural resources. I wonder: are we simply choosing to restrict fish passage through dams because we in all actuality can do little to slow AIS movement and we don't have the time to figure out the true benefits of fish passage?

Finally, there are some issues with material within the document. In Table 12-1 and other tables throughout the report: If complete barrier means that no species will get through other than selected individual species, Winter is not a complete barrier (no trap and sort) and the Bois Brule Lamprey Barrier is also not a complete barrier. Yes the Lamprey Barrier prevents lamprey but because fish are not individually sorted, but the DNR cannot claim that other (even future unknown invasives) species cannot also pass because the barrier only excludes lamprey. Yes, Winter Dam has a gate that closes most

(seems like all now) of the year, but all species in the river can pass at all times when the gate is open. Both of these dams would fail to meet the "complete barrier" standard imposed on Balsam Row Dam or Park Mill Dam (all fish must be handled and inspected). If Winter is indeed "a complete barrier" then Balsam Row's design team immediately requests the same design standard be applied to Balsam Row as to Winter.

My last caution to decision makers approving this path forward without a more comprehensive review is that several issues appear challengeable by the courts, particularly when the strategic analysis does not address the more comprehensive issues of dam removal, culvert aquatic organism passage, and promotion of sportfish over native species by the state's natural resources department. Given the number of naturalists (concerned about more than just warm water sportfish), large tribal communities, and masses of outdoors enthusiasts within Wisconsin, issue advocates will certainly feel shorted by this abbreviated FPSA (long on extraneous words but short on position justification). For example, we see the Ninth US Circuit Court of Appeals taking up cases on whether the federal government can force the western states to create aquatic organism passage through culverts impacting tribal fishing rights, and yet ironically in Wisconsin we see the state preventing aquatic organism passage through a dam and thereby preventing re-establishment of historical tribal fishing opportunities. But even federal/state vs. tribal rights aside, there are many other challengeable issues for Wisconsin if the status quo of restricting fish passage continues – particularly in the areas of dam removal / culvert gray areas, "takings" law, fish farm regulations applied to native passage, responsibility of the DNR to be an environmental steward for more than gamefish. As a professional engineer with a long career ahead in the dam and riverine structure field, I look forward to a second draft of the FPSA that addresses the larger picture beyond sportfish protections.

Sincerely,

9/5/2017

Pete Haug, PE
326 330th Street
Knapp, WI 54749

19.6 Menominee Tribe of Wisconsin

MENOMINEE INDIAN TRIBE OF WISCONSIN
P.O. Box 910
Keshena, WI 54135-0910

October 10, 2017

Jim Doperalski Jr.
Environmental Analysis and Review Specialist
WDNR Green Bay Service Center,
2984 Shawano Ave.,
Green Bay, WI 54313

RE: MITW Comments on Wisconsin Department of Natural Resources proposed *Fish Passage at Dams Strategic Analysis* dated August 27, 2017

Dear Mr. Doperalski

The Menominee Indian Tribe of Wisconsin (MITW or Tribe) provides the following input and comments on the Wisconsin Department of Natural Resources' (WDNR) proposed *Fish Passage at Dams Strategic Analysis* (Strategic Analysis). MITW fully supports fish passage and/or dam removal projects in Wisconsin. The following background is helpful in understanding why this issue is of critical importance to MITW.

Long before any of the following occurred, the Menominee understood the importance of water and its connection to all things living:

1. Wisconsin's earliest natural resource law promulgated by the territorial legislature in 1839 requiring the construction of fish passage structures on navigable waterways;
2. Wisconsin Fish Commission reports from the late 1800s and early 1900s documenting public concerns about impeded movement of fish;
3. The 1917 Water Power Law regulating dams and bridges affecting navigable waters; and/or
4. The concept of Wisconsin's Public Trust Doctrine requiring the state to intervene to protect public rights in the commercial or recreational use of navigable waters.

When the United States tried to remove Indians from their ancestral lands through treaties in the late 1800s, Chief Oshkosh and fellow Chiefs fought hard to keep the current Menominee Reservation in Northeast Wisconsin. They reasoned that Keshena Falls was the most important area because of the value of the Celebration of Spring Lake Sturgeon Ceremony held each spring as the fish migrate back to Keshena Falls. This ceremony represented fresh beginnings each spring for the Menominee people who endured very long harsh winters. The annual spawning of the Lake Sturgeon at Keshena Falls in the Wolf River represented and continues to represent replenishment for all living things, including the Menominee people. But this ancestral

knowledge and tradition is dependent on passable waterways for the Lake Sturgeon to be able to migrate up river.

Indeed, the United States Supreme Court found that:

> The lands covered by the Wolf River Treaty of 1854 were selected precisely because they had an abundance of game . . . . The essence of the Treaty of Wolf River was that the Indians were authorized to maintain on the new lands ceded to them as a reservation their way of life which included hunting and fishing.

Menominee Tribe v. United States, 391 U.S. 404, 406 (1968).

Over the past century, the United States has led the world in dam building – blocking and harnessing rivers for a variety of purposes, including hydropower, irrigation, flood control, and water storage. While dams can benefit society, they also cause considerable harm to rivers and the ecosystems. Dams have depleted fisheries, seriously affected riverine ecological processes, and diminished Tribal Treaty Rights across the Nation. Today, many dams are old, unsafe or no longer serve their intended purposes.

How do dams damage rivers? (http://www.americanrivers.org/initiatives/dams/why-remove/)

1. **Dams block rivers**: Dams prevent the flow of plants and nutrients, impede the migration of fish and other wildlife, and block recreational use. Fish passage structures can enable a percentage of fish to pass around a dam, but multiple dams along a river make safe travel unlikely.
2. **Dams slow rivers**: Many fish species, such as trout species, depend on steady flows to flush them downriver early in their life and guide them upstream years later to spawn. Stagnant reservoir pools disorient migrating fish and significantly increase the duration of their migration.
3. **Dams alter water temperatures**: By slowing water flow, most dams increase water temperatures. Other dams decrease temperatures by releasing cooled water from the reservoir bottom. Fish and other species are sensitive to these temperature irregularities, which often destroy native populations.
4. **Dams alter timing of flows**: By withholding and then releasing water to generate power for peak demand periods, dams cause downstream stretches to alternate between no water and powerful surges that erode soil and vegetation, and flood or strand wildlife. These irregular releases destroy natural seasonal flow variations that trigger natural growth and reproduction cycles in many species.
5. **Dams hold back silt, debris, and nutrients**: By slowing flows, dams allow silt to collect on river bottoms and bury fish spawning habitat. Silt trapped above dams accumulates heavy metals and other pollutants. Gravel, logs and other debris are also trapped by dams, eliminating their use downstream as food and habitat.
6. **Dam turbines hurt fish**: Following currents downstream, fish can be injured or killed by turbines. When fish are trucked or barged around the dams, they experience increased stress and disease and decreased homing instincts.

In 1892, the Shawano Paper Mill Dam and later, in 1926, the Balsam Row Dam, blocked the unrestricted Wolf River. While the Tribe and its members may not have understood the effects of a blocked river on their livelihood at the time of construction of the dams, the Tribe understands now. Specifically, since construction of the Balsam Row and the Shawano Paper Mill dams, the negative effects on and around the Tribe's Reservation include, but are not limited to, the following:

1. Obstuction of passage of Lake Sturgeon to the traditional spawning grounds within the Reservation that deprives the Tribe of a significant resource for which their rights were reserved by the Treaty of 1854. *See Menominee Tribe v. United States*, 391 U.S. at 404 (recognizing reservation to include exclusive hunting and fishing rights, to maintain their way of life);

2. Formation of a barrier to the passage of other fish species, such as walleye, smallmouth bass, muskellunge, northern pike, thereby preventing their access to the Reservation and thus interfering with the Tribe's full enjoyment of its rights and with the intended use of the Reservation; and

3. Entrainment and mortality of fish resources that might otherwise be available at the Reservation for harvest by the Tribe, in fulfillment of Treaty rights and Reservation purposes.

All of this equates to loss to the Tribe of its Treaty rights.

The Tribe recognizes that fish passage includes the ability of fish to move upstream and downstream to find suitable habitat and breeding grounds. The Tribe also recognizes the fact that by creating a free-flowing stream there may be a chance aquatic invasive species, undesirable species and fish diseases may be introduced. This issue would be there with or without dams being present. The Tribe sees much more cultural value in re-establishing a wild free-flowing river. The Tribe has a natural resource department that is capable of handling fish management concerns.

The Tribe has numerous partners that have worked on fish passage projects over time and have vast experience in the field of river restoration, dam removals and fish passage. The Tribe has attached some of those partners' comments and fully supports those comments by resubmitting those as part of the formal record.

The Tribe has the following specific comments on the Strategic Analysis:

Chapter 2 Forward

1. While the Tribe finds the 2nd and 4th paragraphs conflicting with respect to the intended use of the Strategic Analysis, the Tribe is pleased to learn that this is not the final policy and that even if the final policy is identical to the Strategic Analysis, all stakeholders, including the Tribe, will have an opportunity to comment on the draft policy before it is finalized and approved.

Chapter 3 Executive Summary

2. Page 6, 3rd and 4th paragraphs. There is reference to the Public Trust Doctrine and Wisconsin citizens' rights, but there is no mention of Tribal Treaty Rights. All Tribes in Wisconsin have signed Treaties with the United States Government and in effect have inherent rights which are acknowledged by respective Treaties. Treaties have acknowledged Tribal rights to hunt, fish, and gather in specific parts of Wisconsin and must be clearly stated in this policy as there will be direct implications as a result of fish passage limitations at dams.

3. Page 6, 9th paragraph. This paragraph discusses the question of economic benefits versus ecological benefits. Tribal processes have long entertained the aspects of restoration and ecological goals in our philosophy to work on the land. The cost of the projects are simply one of the steps to caring for our future and should not be used to deter from the ever important end goal of environmental health and restoration of these heavily impacted systems. It appears that the WDNR is not objectively addressing this issue but rather taking a stance on the issue. The Tribe requests that the WDNR modify the following passage by adding:

> "An overarching question is whether, and to what extent, the economic benefits of fish passage facilities outweigh their costs and how these are distributed. Experience in Wisconsin and elsewhere suggests that the economic impacts of individual fish passage projects are context-specific and highly variable, depending in part on dam type and size, the type of fish passage facilities implemented and species targeted (Francfort, et al., 1994), as well as hydrologic and ecological conditions, including the presence or risk of transporting aquatic invasive species and fish diseases (McLaughlin, et al., 2013)." <u>However, the importance of restoration cannot be viewed lightly. Moreover, if the parties involved have agreed to implementation of fish passage to uphold the federal government's mandate to impose terms and conditions on a project license necessary for the adequate protection and utilization of a reservation, then that mandate must be given great weight in the analysis.</u>

Chapter 4 History of Fish Passage at Dams Policy in Wisconsin

4. Page 8, Table 4-1. The Tribe contends that this table does not adequately describe the Balsam Row Dam or its facility type. FERC identifies this project as the Shawano Hydro Electric Project #710-000. Although the design for this facility contains a trap and sort feature, the facility is designed to be opened up into a nature-like fishway in the future.

5. Page 9, 5th paragraph. The Tribe notes that there is a description and discussion related to "public rights" to the exclusion of any discussion about Tribes. Specifically, this section

should be qualified to address that lands within the Menominee Indian Reservation are not for public access as described in this paragraph. The Tribe has explicit reserved Treaty Rights within the boundary of the Menominee Reservation and those cannot be interrupted by outside interference, including under the public rights doctrine of Wisconsin. There is some discussion of this in Section 15 that should be reiterated in this section.

6. Page 9, 5th paragraph, last sentence. The Tribe comments that there is a statement regarding FERC dams compliance with state regulations and FERC imposed conditions. Clarification must be added regarding conditions relevant to the lands occupied by the Menominee Indian Tribe of Wisconsin, which are held in trust status by the United States on behalf of the Tribe. Specifically, there should be an accurate description of how FERC and DOI impose conditions to protect the intent of these Federally designated lands, which is for the benefit of the Tribe. The Federal Power Act (FPA), Section 4(e) allows for mandated conditions to be imposed that protect and benefit the intent of all Federal Lands. In the case of Balsam Row, those conditions are imposed to benefit the Menominee Tribe and include fish passage. The Tribe recommends this section be amended to address this issue.

7. Page 9, 6th paragraph. The Tribe notes that the document references a January 1, 2014 Fish Passage Guidance, but no link or attachment is provided. The Tribe recommends that the document be hyperlinked or included in the document's appendix for transparency and easy access.

8. Page 10, 1st paragraph. The Tribe comments that the document references a Fisheries Ad Hoc Task Group. The Tribe recommends that for transparency the individual task force members be identified in the document. The Tribe also requests that the Fisheries Ad Hoc Task Group be open to Tribal participation and that the Tribe be allowed to designate a member.

9. As a general comment regarding Chapter 4, there needs to be some mention of the success of fish passage. While the chapter provides examples of the fishways that were considered unsuccessful, it fails to provide a single example of a successful fishway. Winters Dam and Thiensville are two of those examples.

Chapter 5 Regulatory Framework and Department Procedures and Guidelines

10. Page 11. The Tribe recommends that the language should be corrected; see comments above regarding "Public Rights." The Menominee Indian Reservation is reserved by Treaty for the sole benefit of the Menominee Tribe and its members. All lands within the Menominee Reservation are reserved rights of the Tribe and held in trust for the benefit of the Tribal Members per the rights granted through the Treaty of the Wolf River, 1854. The Tribe recommends this section be amended to address this issue.

11. Page 11, Table 5-1. This section has several citations to WI Statutes and Codes that are in direct conflict with Tribal Governmental Authorities that are granted by Federal

Authorizations or specifically defined through Federal Legislation. These need to be clearly identified in those sections that conflict. We have attached a marked up version outlining comments to the table, including the section on Federal Regulations.

Chapter 6 Types of Fish Passage

12. Pages 25-26. The Tribe comments that to the detriment of the document, there is no reference to successful nature-like fishways operating in Wisconsin. As stated in paragraph 9 above, the Tribe recommends that this document identify successful nature-like fishways. Examples should include Winters and Thiensville Dams, among others.

13. Page 30, part 6.2.3. The Tribe comments that this section does not accurately reflect a full analysis of collection and transport methods. There is no reference to the inability of this method to effectively move "all" species and ages of fish that may be in a management goal. This method only targets adults and to a minor extent, sub-adults of a single species. The Tribal goals for passage include meeting Treaty obligations, as well as restoration of the ecological systems that have been impacted by prevention of natural movements of "all" fish species.

14. Page 38, 1st paragraph. The Tribe comments that the references to the Memorandum of Understanding between the Tribe and WDNR fails to provide important historical information of why the parties ended up entering into the MOU. The MITW proposed language to address the failures in the original 1995 plan and amendments that included the addition of fish passage as a primary objective to meet the goals of the plan. This proposal was rejected by the State. Thus the Tribe recommends that the first sentence be revised as follows: "In 2011 the department entered into a Memorandum of Understanding (MOU) with the Menominee Indian Tribe of Wisconsin (MITW) to increase the number of sturgeon moved around the Shawano Paper Mill and Balsam Row dams because the State refused to agree to MITW's proposal to amend the original 1995 management plan."

15. Page 38, 2nd paragraph. The Tribe comments that there is a reference to the success of the transfers resulting in accelerated "population recovery goals", but there is no mention of how this relates to the goals of the Menominee Tribe and its culture. The Tribal goal is not a singular population recovery target. Rather it is primarily based on a Traditional Ecological approach to resource management, which is much broader than only one aspect of a single population.

16. Page 38, 3rd paragraph. The Tribe suggests that if there is going to be a discussion on the economics of the trap and transfer program, it be moved out of this paragraph into a separate discussion about overall feasibility of trap and transport to meet the goals of fish passage and not in the context of describing activities surrounding the MOU. The Tribe comments that this section also suffers from a narrow focus on the cost to move lake sturgeon and should be expanded to include all fish species. Furthermore, the Tribe comments that this section fails to recognize that this alternative method is only feasible if ALL parties agree that this is the best alternative to meet the goals identified. In the

intent of the nature like fishway, and thereby the DATCP ATCP and the NR40 rules would not apply. The Menominee has consulted with DATCP and they concur with the Tribe's interpretation (see attached September 10, 2015 letter from DATCP to Tribe).

Chapter 9. Invasive Species and Nuisance Species

20. Page 51, Sections 9 and 9.1. The Tribe comments that the current regulations on invasive species movements are certainly critical to protecting our riverine environments from the impacts of "new" invasive species. Unfortunately, much like the DATCP ATCP regulations, the WDNR is implementing these regulations with a very narrow view of system dynamics or the ability to adapt based on system-by-system conditions. A case example would be the Wolf River common carp situation, where there is a known population that has existed in the River for many years and there have been no known measurable impacts to the wild fish populations. In fact, WDNR has for those same years seen a considerable success in both lake sturgeon and walleye populations in the face of this invasive species co-existing in the riverine system. The WDNR has not made efforts to remove common carp from the Wolf River based on concerns over impacts to the fishery. Yet, if there were concerns about movement above the upper barrier, the Tribe has yet to be approached by WDNR on how we would manage common carp if they were present. The Tribe comments there seems to be an inconsistency with approaches on this issue that is not fully addressed in this section. The Tribe recommends that these sections be amended to include a broader view of system dynamics and the ability to adapt based on system-by-system conditions.

21. Page 52, Section 9.2. The Tribe comments that this section does not address tribal consultation within its identified best management practices. The Tribe recommends this section be amended to include a provision giving considerable weight to consultation with the Tribal Governments effected by the decision to evaluate passage based on NR 40. There should also be criteria to evaluate the requirements placed on the project as part of a FPA provision like Section 4(e) or Section 18. The Tribe further recommends that if there are Federal Agencies that would require DNR to consult before decisions are made, this should be clearly identified in this section.

Chapter 11. Dam Safety and Operational Considerations

22. Page 59. Some description should be added to indicate that instances that include a FERC license condition requiring fish passage will include a full dam safety analysis and Probability Failure Mode Analysis to be conducted by FERC and design Engineers. The fishway project cannot be approved without this authorization by FERC.

Chapter 12. Economic Considerations

23. Page 60, Section 12. Although the chapter does have a significant amount of discussion related to the economic benefits/drawbacks regarding fish passage projects, it is only really assessing the "sport fishery" component. There is a lack of information on the importance of fish to the Tribal Peoples of Wisconsin or anywhere else for that matter.

In comment 16 above the Tribe has detailed the specifics of how the Menominee view its cultural and traditional ties to the resources and why economic valuations do not fit in those Traditional ways of life or our values.

24. Page 66. Table 12-3 and the preceding paragraph. The Tribe notes that the table and accompanying paragraph are detailing costs at the expense of the Tribe, as the Tribe has not been consulted in regard to establishing the estimates, nor does it appear the table accounts for any costs the Tribe incurred as part of the Trap and Transport Program. For this reason the Tribe suggests that the table be updated to add our costs to the totals or that the table be removed altogether.

Chapter 15. Tribal Relations

25. Page 75, Sections 15 and 15.1. This discussion falls short of the theme used throughout the entire document of providing some analysis of the benefits and drawbacks related to passage. The section on Tribal Relations only details the States Executive Order #39 and how it requires the State to consult with Tribes on a government-to-government basis. The last paragraph only makes a brief attempt at outlining the issue of impacts to Tribes, but again fails in its specificity. Wisconsin Tribes have legally binding agreements known as Treaties that give specific legal rights to Tribes that include access to the resources that meet the purposes for which the Reservations were created. In all cases this purpose includes the rights to hunt, fish and gather, which would mean fish must have unimpeded access from manmade barriers to reservation waters. There is no discussion or analysis of this within the Chapter or anywhere else in this document.

In conclusion, the Menominee Indian Tribe of Wisconsin (MITW) would like to thank the State of Wisconsin for this opportunity to provide input on the *Wisconsin Department of Natural Resources Fish Passage at Dams Strategic Analysis* dated August 28, 2017. Additionally, MITW requests that the State of Wisconsin engage with the Tribe in a face-to-face meeting to further discuss our comments and concerns regarding the proposed fish passage policies that will have significant impacts on our Nation.

Sincerely,

Gary Besaw

Mr. Gary Besaw, Tribal Chairman
Menominee Indian Tribe of Wisconsin
cc: Doug Cox
Starlyn Tourtillott
M. Catherine Condon
Encl.
MITW Previous Comment Letters
September 10, 2015 DATCP Letter to Tribe
Comments submitted by Peter Haug, P.E.

19.7 Whooshh

Comments on "Fish Passage at Dams Strategic Analysis" Wisconsin DNR

On page 4 of the document is the statement "The purpose of a strategic analysis is to inform decision-makers and the public about alternative courses of action related to an issue or topic" and on page 5 of the document is the statement "This Strategic Analysis is intended (to) provide the department with current and pertinent information on fish passage at dams."

Given these statements an additional section is warranted that includes information about advancements and emerging technologies. The descriptions of fish passage solutions cited only include those which have been in use for a very long time. Having a section that names some of the new approaches, explains how and/or why new approaches may better address fish passage challenges in certain situations, how the definition of active and passive, volitional and non-volitional may be skewed as new approaches to the problem of fish passage have shifted the perspective, in addition to acknowledging that published works represent a substantial time delay between when the data is generated and when the publication is available in print or on-line. Emerging technologies often work on much more aggressive timelines and the private sector may be restrained from publishing some materials to protect intellectual property rights. Thus, to consider the most current advancements in fish passage, a straight literature search will yield valuable but dated findings. Engagement of participants in annual fish passage conferences is an active way to become informed as to the cutting-edge advances and the significant changes in the approach to fish passage that are emerging.

An example of such a section is detailed below.

6.XX Advancements: Emerging Technologies

The traditional types of active and passive, volitional and non-volitional, upstream and downstream fish passage described in Sections 6.1-6.4 have proven to be reasonably effective for some species at some sites but have been shown to have limited effectiveness for other species and sites. What is clear is that each species and each site has unique fish passage challenges and there is no silver bullet, no single fish passage solution that will provide effective fish passage for all species at all sites unless it can be adaptable. Advances have been made that are changing the current fish passage definitions. What has been traditionally termed active transport, systems employing mechanized structures requiring human labor, may be reclassified as passive transport if new innovations are automated such that mechanical systems are triggered by the fish, passage is volitional and does not require human labor intervention.

Emerging fish passage technologies are taking up the challenge of safe, timely, efficient and effective fish passage by paying attention to fish behavior, asking questions and developing fish passage that integrates fish behavior into the solution. In an effort to remain current and pertinent, as is the directive of the Strategic Analysis, additional newer technologies that utilize species sizing and identification together with modular and in-river engineering to address passage of multiple species and/or prohibiting passage of invasive species are discussed.

- Whooshh Fish Transport System

- Floating Surface Collectors
- Others

Whooshh Fish Transport System

The Whooshh Fish Transport System (WFTS) is an innovative new take on volitional fish passage. WFTS is a novel technology that utilizes localized pressure differentials to transport fish through a soft, flexible tube over barriers. The fish can enter volitionally and are rapidly transported via misted tube travel which maintains a minimal hydraulic connectivity. The WFTS can be designed and installed to enable volitional entry, and automated scanning, sorting and passage or used as a mobile, temporary unit in which captured fish are hand-fed into the tube for transport over a barrier or to a desired location ie., hatchery raceway or truck and haul vehicle.

Traditionally, fish passage has been termed passive if there was hydraulic connectivity, a liquid connection, from the above the dam (barrier) to below the dam (barrier) through which the fish swim by their own choice. Fish passage through these systems require a very active swimming role for the fish, but represents a passive role for man; no human/mechanical controlled intervention is required, as is necessary for active fish passage like fish lifts and locks in which man and machine dictate when and how fish passage occurs. The WFTS utilizes automated mechanical intervention that is triggered by the fish. Once in the system, there is no requirement for the fish to swim, they are provided a rapid glide.

Addressing fish passage at high head dams, those with substantial vertical barriers, traditionally has presented additional fish passage challenges. Substantial land and water management requirements to maintain passable ladders or fishways and the potential of diminishing fish energy reserves during fish passage, the reduction of which may impact energy reserves available for reproductive fecundity, need to be considered. The WFTS is adaptable to a specific site with the suspended tube supports readily integrated into or adjacent to current dam structures. As the system does not need to support water flow, vertical distance and water pressure has no impact on design or passage. Individual fish glide rapidly, effortlessly up through the tube and exit into the water on the other side of the barrier.

As an emerging technology the WFTS is malleable. The WFTS has modular components, utilizes fish-friendly flexible and lightly misted tubing for transport that has versatility in addressing the length and height requirements of a given barrier site and is adaptable as it can be designed for volitional, passive swim-in entry for a permanent installation or for non-volitional, active hand-fed entry in a mobile temporary installation. In the volitional passive installation, as the fish enter the WFTS they are dewatered and slide through a scanning system which automatically informs the direction of sorting to either an appropriate sized transport tube for Whooshh transport, or to be returned to the river or directed for removal as may be the case for invasive species. Fish are lightly misted with water throughout the system to ensure gills remain moist and to aid in a comfortable, lubricated glide through the WFTS. Whooshh tube directed fish will pass through a chamber wherein a differential pressure of approximately 1 psi across the fish will be established pushing the fish through the tube in a smooth, rapid glide up the length of the Whooshh tube in seconds. On long passage installations sensors are installed to enable fish passage tracking through the tube and, as the fish approaches the exit, to trigger a deceleration sequence releasing

pressure to slow the fish down for a smooth exit into the water allowing the fish to immediately swim away without need for rest or delayed recovery.

As has been stated elsewhere, the entrance configuration and attraction flow are important features of fish passage. The fish need to be able to find the entrance to enable fish passage. In a permanent installation, the WFTS begins as fish volitionally pass over a false weir. Downstream of the false weir the fish are attracted to an attraction flow that mimics the turbulence and water movement of the river and encourages adults to enter as described by Clay (1995). Site specifications will dictate the best option for the entrance location to attract fish to the false weir with possibilities ranging from a short floating Denil, a partial channel, or bypass type design. In some cases, a few pool and weir steps, short Denil or steeppass may be used to direct the fish from the flow of the river toward the false weir for WFTS entry.

The WFTS uses very little water compared to traditional fishways, however, it does require electrical power. The scanning system records multiple images without restraint or handling of the fish. The data captured informs an immediate sorting decision directing the fish based on measurements. The system counts the fish as they pass through and has the potential for species identification. Fish passage occurs in seconds (Whooshh, 2017) verses the minutes, to hours, to days, that passage up traditional fishways can take. The health, well-being, and reproductive potential of WFTS-transported fish has been well studied (Whooshh, 2017). Reduction of energy reserves during fish passage are a significant concern for agencies and restoration efforts as depletion can impact the ability of the fish to reach spawning habitats and fecundity. Although well studied, there is no evidence of fish stress or injury associated with WFTS transport (Whooshh, 2017) and WFTS rapid transport requires minimal energy expenditure during fish passage. WFTS transported fish have been shown to swim further faster after WFTS passage than fish utilizing a fish ladder for passage up the same vertical distance (Whooshh, 2017).

There is no hydraulic head restriction dictating the use of the WFTS. The WFTS uses minimal quantities of water to mist the tube and to generate attraction flow near the entry of the system but does not require any spill or constant streaming water such as is the case in other fishways. This significantly reduces the amount of water required for fish passage. The criteria for WFTS passage are limited to the size of the fish (to assign the fish to the appropriately sized tube) and air pressure differentials across the fish. The criteria for design of traditional fishways which include water flow, velocity, turbulence, drop height, and swim ability of species are only relevant to Whooshh transport with respect to the initial attraction component, bringing the fish to the WFTS, but do not play any role in WFTS fish passage. The WFTS can address short, long, low and high head barriers. The Whooshh tube is suspended from a cable which can be mounted alongside exiting dam infrastructure enabling installation times on the order of months verse years which the planning, excavation and structure construction, required for some fishways, impose.

The advantages of the WFTS are as follows:

- Modular, sorting chutes and tube sizes
- Scanning, enables accurate sorting and counting (potential species identification)
- Suitable for a variety of aquatic species
- Requires very little water
- Can accommodate water level changes via floating entry and/or exit structures

- Low construction, operation, and maintenance costs compared to traditional fish passage technologies
- High flow rates and movement of sediment have little to no impact on the ability to passage fish
- Occupies a small footprint, limited space, compares to other fishways, minimizing land resource requirements
- Flexible materials allow for ease of site integration and installation
- Selective passage via hands-free fish sorting; allowing for invasive species removal
- Capacity to address low and high head barriers

To date fifteen different live species of fish have been successfully transported through the WFTS (Whooshh, 2017). These range from Chinook, the King salmon of the Pacific Northwest, to American Shad in Maine and the Northeast, to Walleye, Common White Sucker and Sturgeon of the Midwest. With multiple tubes sizes available and the ease of gliding through the tube, the WFTS can accommodate the fish passage needs of a wide variety of aquatic species across an assortment of barriers.

In many cases, especially in temporary installations, migrating fish are trapped in river. The fish are manually sorted and hand transported by way of boot or tote to the transport truck. This process requires significant effort, time, manpower and coordination over the course of the migration run and presents safety concern for both man and fish. Mobile, temporary hand-fed WFTS installations have been used to facilitate the efficiency of handling the fish by rapidly transporting them directly from traps in the river to transport trucks reducing time, effort, manpower and safety concerns.

The Mobile WFTS has also the potential for use in cases of fish rescue, in situations on small rivers with greatly fluctuating flows, in limited seasonal fish passage needs and in combination with dam or river traps for manual sorting of wild verse hatchery stocks with selected stocks WFTS transported directly from dam or mid river traps to transport trucks (Whooshh, 2016 and Whooshh, 2017) or hatchery raceways. Mobile, temporary WFTS typically address needs that require transport generally of a few hundred feet with a moderate vertical rise resulting in transport times in the 10's of seconds or less. Additionally, WFTSs have been designed to accommodate distances and vertical rises of 1,100 ft and 100 ft and 1,780 ft and 165 ft with individual fish transport times of just ~35 to ~60 seconds (Whooshh, 2016b and Whooshh, 2017b).

Compared to many traditional fish passage solutions which can be cost prohibitive, the WFTS is considerably less expensive in terms of material costs, installation time, manpower, management and water use. Installations occur in a matter of months not years, the footprint on environment is quite small, it is modular, adaptable and provides safe, timely, effective and efficient fish passage.

Floating Surface Collector

(we are not experts on this technology and have not provided text however it is an advancing technology worth mentioning)

Other Emerging Tech.

References:

Whooshh. (2016). Video: Whooshh live fish transport Washougal and Buckley. Whooshh Innovations. Retrieved from https://www.youtube.com/watch?v=Jjwh03_3mvE

Whooshh. (2016b). Video: 2016 Long Tube Transport. Whooshh Innovations. Retrieved from https://www.youtube.com/watch?v=1AUjD37DLLc

Whooshh. (2017) Studies. Whooshh Innovations. Retrieved from http://www.whooshh.com/studies.html

Whooshh. (2017). Video: Sockeye Salomon Over Cle Elum Dam. Whooshh Innovations. Retrieved from https://www.youtube.com/watch?v=uCxNC5cJuOo&feature=youtu.be

19.8 General Comments

There was one additional comment submitted via email, which is below, as well as three more emails which attached research papers.

From: [redacted]>
Sent: Monday, October 16, 2017 8:00 PM
To: DNR FISH PASSAGE
Subject: Fish Passages

I'm against wholesale installation of passages to, what appears to me as a .....nice to do this goal.....w/o always having a real benefit. The potential results of altered water levels (esp. lowering) can inflict severe summer hardships (can't get boats off lifts, increase under water hazards, impede travel via channels between lakes in a chain) on boaters and esp. property owners.

Thanks for the opportunity to comment on this.

Russ Schroeder
Park Falls, WI