NATURAL RESOURCES CONSERVATION SERVICE
MONTANA CONSERVATION PRACTICE STANDARD

STRUCTURE FOR WATER CONTROL (NUMBER)

CODE 587

DEFINITION

A structure in a water management system that conveys water, controls the direction or rate of flow, maintains a desired water surface elevation, measures water, **or prevents fish and other aquatic species of concern from unintentional entry into, and injury to an aquatic species from a surface water diversion.**

PURPOSE

The practice may be applied as a management component of a water management system to control the stage, discharge, distribution, delivery or direction of water flow. **The practice may also be applied to protect fish and other aquatic species of concern from entrainment, injury, mortality, and/or accidental escapement resulting from the placement, operation, and management of structures and/or pumps.**

CONDITIONS WHERE PRACTICE APPLIES

This practice applies wherever a permanent structure is needed as an integral part of a water-control system to serve one or more of the following functions:

- Convey water from one elevation to a lower elevation within, to or from a water conveyance system such as a ditch, channel, canal or pipeline designed to operate under open channel conditions. Typical structures: drops, chutes, turnouts, surface water inlets, head gates, pump boxes and stilling basins.
- **Wherever diversion, withdrawal, or drawdown of water from a fish-bearing stream or water body occurs.**
- Control the elevation of water in drainage or irrigation ditches. Typical structures: checks, flashboard risers and check dams.
- Control the division or measurement of irrigation water. Typical structures: division boxes and water measurement devices.
- Keep trash, debris or weed seeds from entering pipelines. Typical structure: debris screen.
- Control the direction of channel flow resulting from tides and high water or back-flow from flooding. Typical structures: tide and water management gates.
- Control the water table level, remove surface or subsurface water from adjoining land, flood land for frost protection or manage water levels for wildlife or recreation. Typical structures: water level control structures, flashboard risers, pipe drop inlets and box inlets.
- Convey water over, under or along a ditch, canal, road, railroad or other barriers. Typical structures: culverts, flumes, inverted siphons and long span pipes.
- Modify water flow to provide habitat for fish, wildlife and other aquatic animals. Typical structures: fish ladders and screens, chutes, cold water release structures and flashboard risers.
- Provide silt management in ditches or canals. Typical structure: sluice.
- Supplement a resource management system on land where organic waste or commercial fertilizer is applied.
- Create, restore or enhance wetland hydrology.

NRCS, MT
April 2014

Conservation practice standards are reviewed periodically and updated if needed. To obtain the current version of this standard contact the Natural Resources Conservation Service.

NOTE: This type of font **(AaBbCcDdEe 123..)** indicates NRCS National Standards.
This type of font (AaBbCcDdEe 123..) indicates Montana Supplement.

CRITERIA

General Criteria Applicable to All Purposes

Structures shall include an evaluation of the need to install fish screens in accordance with "Criteria Applicable to Fish Screens" within this Standard to protect fish species from entrainment.

Structure designs shall be based on site surveys, required hydraulic functions, and site soils and foundation investigations that clearly define the effects and needed size of the structure.

Materials. Structures may be constructed from a variety of materials including reinforced concrete, steel, wood, aluminum, and wire mesh baskets (gabions). All materials shall have the strength, durability and workability required to meet the installation and operational conditions required for the site, and shall conform to the requirements listed in the applicable Montana Construction Specification. The selection of the material to be used shall take into account the required life of the structure. The required length of life for Structure for Water Control is 20 years.

Concrete Structures

Concrete used in water control structures is expected to have long life and low maintenance. It must have the durability to resist anticipated exposure conditions. The most destructive weathering factor in Montana is freezing and thawing cycles. Deterioration is caused by freezing of water and subsequent expansion in the paste, aggregate particles, or both. Concrete paste that is air-entrained and has a low water cement ratio will help to protect the concrete from freeze-thaw damage. The Structural Design portion of this Standard and Montana Construction Specification, Reinforced Concrete (MT-106), gives specific requirements to assure a 20-year service life.

Steel Structures

Steel structures shall be protected against corrosion. Accepted paint systems for the type of environment shall be as specified in Montana Construction Specification, Metal Fabrication and Installation (MT-113). Paint systems include options for structures that may or may not be submersed, or those subject to dry or saturated soil conditions. For buried steel structures, the coatings specified in MT-113 apply only when the soil resistivity is greater than 10,000 ohm-cm. When soil resistivity is less than 10,000 ohm-cm:

1. **Cathodic protection shall be provided in addition to applying a paint system that is resistant to saturated soil conditions.**
2. **Galvanized steel may be used when the soil resistivity is greater than 4000 ohm-cm.**
3. **Aluminized steel may be used when the soil resistivity is greater than 1500 ohm-cm and the soil pH is between 5 and 9.**

All metal to metal connections such as starter couplings, risers, bends, and tees should be of similar metals. If dissimilar metals are used, the fittings shall be protected against galvanic corrosion (e.g., separate dissimilar metals with rubber or plastic insulator).

Wood Structures

Wood structures for Agricultural purposes shall be treated with an environmentally safe preservative that meets the requirements of the American Wood Protection Association (AWPA). AWPA Standard U1 specifies applicable use categories. Wood structures for agricultural purposes in fresh water will typically fall in Use Category UC4B. For guidance in determining the applicable use category refer to the AWPA Standard U1 at http://www.awpa.com.

The drawings or specifications shall list the type of wood, AWPA Use Category, and a statement stating "Treated wood used in this project shall be produced in compliance with "Best Management Practices for the Use of Treated Wood in Aquatic and other Sensitive Environments" (BMP Manual) published by the Western Wood Preservers Institute.

Allowable preservatives include Chromated Copper Arsenate (CCA), Alkaline Copper Quat Type C (ACQ-C), Alkaline Copper Quat Type D, Carbonate formulation (ACQ-D Carbonate), and Copper Azole Types A and B (CBA-A and CA-B), however CCA is the dominant preservative in Montana for full dimension lumber.

Douglas fir, (interior) treated with CCA, shall be treated with a minimum 2.1% solution strength and to a 4-hour pressure cycle, or to refusal. For all other species use AWPA Use Category UC4b. For larger projects, consider requiring a mill certification from the supplier that the wood products meet this requirement.

When designing wood structures, keep in mind that obtaining adequate treatment with CCA can be a problem with difficult-to-treat species such as

Douglas fir even when incised. Consider pine species such as ponderosa pine that is readily treatable with waterborne preservatives.

To minimize impacts on species of concern, federally listed species, and/or designated critical habitat, schedule the project installation during times when salmonids are less likely to be spawning. Large wood structures such as diversions or headgates may have to be evaluated on a case by case basis to assure they are installed with minimal impacts. Examples may include, treating only the structure and not the checkboards, and installation during certain time periods.

Do not use aluminum in direct contact with treated wood. Galvanized bolts, washers, nuts, nails, and other hardware in contact with treated wood shall meet ASTM Specifications A153 for fasteners and A653 Class G185 sheet metal for connectors.

Capacity. Structures shall have the capacity to carry the design flow, remain stable, control downstream erosion, and keep the upstream and downstream water surfaces within the limits allowed.

Foundation. Foundation investigations must be made to assure the following items can be addressed by the design:

1. **Bearing Capacity**
2. **Sliding**
3. **Overturning**
4. **Uplift or Settlement**
5. **Piping Potential.**

The extent of foundation investigations shall be based on the size and importance of the structure, geology of the area, and water table considerations.

Foundation materials shall have adequate bearing strength to support the structure without undesirable and/or differential settlement unless specific structural design considerations and/or foundation treatment are included in the design.

Index tests of site soil may allow correlation with similar soils for which test data is available. If no test data is available, presumptive bearing strength values for assessing actual bearing pressures may be obtained from NEH-8, Engineering Geology, Table 7.2, or USBR, Design of Small Dams, Table C-1.

Foundation materials shall have adequate resistance to prevent piping. Structure cutoffs, drainage and/or foundation treatment shall be included in the design as needed. Cut-off requirements for structures shall be determined by using NEH, Section 11, Lane's Theory of Weighted Creep, or flow net procedures described in NRCS, Soil Mechanics, Note 5, "Flow Net Construction and Use".

Structural Loading. Structures for water control shall be designed to withstand the anticipated loads including internal and external loading, hydrostatic uplift, surcharge loads, surface and impact loads, water pressure due to seasonally high water tables, frost and ice pressures.

The lateral earth pressures should be calculated from soil strength values determined from the results of appropriate soil tests. Lateral earth pressures can be calculated using the procedures outlined in TR-74. If soil strength tests are not available, the presumptive lateral earth pressure values in Table 3 of Practice Standard, Waste Storage Facility (Code 313), or Table 6.2-1, NEH, Section 6, Structural Design.

Structural Design. Reinforced concrete structures, except for channel linings, shall have a minimum thickness of six (6) inches. The minimum reinforcement for shrinkage and temperature steel in a 6-inch wall shall be ½-inch diameter (No. 4) rebar located on 12-inch centers each way. Two mats of steel are required in concrete sections 10 inches thick and greater. Reinforcing and temperature steel shall be designed in accordance with NRCS, Technical Release 67, "Reinforced Concrete Design, or NEH, Section 6, Structural Design, or Code Requirements for Environmental Engineering Concrete Structures (ACI 350).

The minimum compressive strength of concrete for small turnouts or inlet structures, checks, and headgates shall be 3,000 psi. The USBR, Concrete Manual indicates soil with a water soluble sulfate concentration of >0.2% or water with a sulfate content >1,500 mg/l is detrimental to the cement paste. The minimum design compressive strength for concrete exposed to this soil, water, or difficult construction conditions shall be 4,000 psi. Unless otherwise specified, concrete mixtures shall be designed to use a maximum coarse aggregate size of 1-1/2 inches, an air content by volume of 5 to 8 percent, and a slump at the time of placement of 3 to 5 inches.

For steel structures, the steel shall meet the structural requirements of the job. The steel thickness will be determined for the specific loading conditions. The minimum gage for corrugated metal riser type structures for various fill heights

are found in Montana Practice Standard, Ponds (Code 378).

References for steel design include the "Manual of Steel Construction", American Institute of Steel Construction, and the "Handbook of Steel Drainage and Highway Construction Products", American Iron and Steel Institute.

Wood used in structures shall meet the structural requirements of the job. Member thickness is determined using design values and adjustment factors found in the National Design Specification for Wood Construction, and Supplement, Design Values for Wood Construction. Typically in Montana, full dimension Douglas fir is used and attached with galvanized ring shank nails or lag screws. Boards should be attached on the soil side, or load side of the structure.

For gabion wire mesh baskets and mattresses, Construction Specification 64 of the National Engineering Handbook, Part 642 is the National Construction Specification that may be used. To allow drainage and prevent the migration of fine material into the wire mesh baskets or mattress, a non-woven geotextile shall be used. If an impermeable layer is required such as an upstream cutoff or headwall, a reinforced polypropylene membrane or similar material shall be used.

Trash Racks. Trash racks are needed when there is a possibility that debris will plug the structure or pipeline. When properly designed, installed, and maintained, trash racks:

- **Prevent debris from clogging critical portions of the pipe.**
- **Capture debris in such a way that is relatively easy to remove.**
- **Provide a safety system that prevents humans and animals from being drawn into the structure.**

Inclined vertical racks are effective. Debris will ride up the trash rack as the water level increases. This design also allows for removal with a rake while standing on the structure.

The spacing of bars must be proportioned to the size of the smallest outlet protected.

Trash racks can be easily attached to the structure using angle iron and bolts anchored into the concrete with epoxy adhesive. Bars shall be designed to carry the weight of water above the screen in the event it becomes plugged.

Screens. Screens are needed when there is the possibility that debris will plug sprinkler nozzles.

General screen criteria are as follows:

- **The maximum velocity through the screen openings should be between 0.5 and 1.0 foot per second.**
- **Account for the percent open area to determine intake velocity. An open area of 40-50% is common, however most manufacturers provide this information.**
- **Consider the need for additional screen area should partial plugging occur. A plugged screen will also affect the stability (uplift) of the structure.**

Horizontal Screens with Check Structures

It has been found that horizontal screens set 6 to 12 inches above the channel bottom offer screening flexibility and protection from bedload and debris. The screen is offset to the side of the canal allowing it to be isolated from the main flow. Checkboards in the canal raise the water surface to direct flow over the screen. Checkboards can be gapped (approx. ¼- to ½-inch) at the bottom to allow sediment to sluice under the elevation of the screen. This type of structure allows flexibility to draw water from the desired elevation in the stream profile. If needed, checkboards can also be placed on the upstream side of the screen to create turbulence and help wash off debris. Rock riprap should be placed below the screen to allow excess water back to the canal without erosion.

Rotating Drum Screens

Optimum performance is achieved when the drum is submerged approximately 75%. This allows debris to be picked up on the drum and passed downstream. It also provides room to adjust the spray bar for optimum cleaning.

Travelling Screens

This type of screen is typically constructed off-stream near the supply canal. The top of the structure shall be constructed above the high water anticipated in the supply canal to protect the structure from overtopping if the screen plugs.

Turbulent Fountains

Depending on the inlet pipe configuration, a typical turbulent fountain screen installation requires 1 to 2 feet of elevation difference between the water surface in the ditch and the top of the riser pipe. Adequate turbulence is generated if an exit velocity of 2.5 to 3 feet per second is maintained in the riser pipe. These structures can be constructed directly in the canal or off-stream. Structures constructed off-stream requires a pipe or overflow ditch to be constructed to allow excess water to flow back to the ditch or other safe location. Provisions may also be needed to keep the trash from falling back into the outflow stream.

Vegetation complying with Critical Area Planting standard (Code 342) shall be established on all disturbed earth surfaces. Where soil, climate or site specific conditions preclude establishing permanent vegetation, other protective means such as mulches or gravels, shall be used.

The structure shall be fenced, if necessary, to protect the vegetation.

Structures shall not be installed that have an adverse effect on septic filter fields.

Structure installations upslope of personal property could be considered a safety issue. Designs shall consider measures of safety and breaching potential of canals. Excavations through embankments shall be sloped to assure proper compaction. Protective measures such as filter diaphragms shall be considered to provide a defense against piping and seepage. Top widths used for roadways shall be wide enough to allow safe equipment travel and operation.

The water level upstream of water control structures shall not be raised on adjacent landowners without their permission.

CRITERIA APPLICABLE TO FISH SCREENS

General Criteria Applicable to All Purposes

NRCS must determine if the proposed installation will affect any federal, tribal, or state-listed species or their habitat during the planning process. This determination is generally accomplished through completion of the Environmental Evaluation Worksheet (see the National Environmental Compliance Handbook for more information). In Montana, this process also may involve the use of species-specific habitat determination screens and/or on-line databases (e.g., Montana Fisheries Information System, Montana Natural Heritage Program).

Fish screens shall be designed to meet specific site conditions and the physiological and behavioral characteristics of the relevant aquatic species at the time of their life history in which the screen is operating. In Montana, the following biological information shall be provided in writing to the engineering screen design team for all target species: species name, life stage(s) at target location, timing of migration (where applicable), and spawning location.

Fish screens shall be designed on an individual basis to meet job site conditions and functional requirements. Designs must meet the requirements of Federal, State, or Tribal fish screening criteria developed to accommodate the requirements of species for which the screen is providing protection. If such criteria are not available, the structure shall be designed in accordance with National Engineering Handbook (NEH), Part 654, Technical Supplement 14N, Fish Passage and Screen. Design and screen criteria will adhere to Chapter 11 of the NOAA document titled *Anadromous Salmonid Passage Facility Design* available at: http://www.nwr.noaa.gov/Publications/Reference-Documents/Passage-Refs.cfm

A properly designed fish screen will account for the following:

a. **Behavioral characteristics of targeted species**
b. **Slot opening size relative to targeted species**
c. **Approach velocity**
d. **Appropriate location within the stream cross section**
e. **Allowable impingement time for exposed fish on a traveling screen.**

Criteria for these elements and others should include input from a Biologist, found in the references included in this Standard, or other published documents relative to the targeted species.

In Montana, when NRCS' environmental evaluation process indicates that a fish species is listed by the U.S. Fish and Wildlife Service (USFWS) as Threatened (T) or Endangered (E) and may be negatively affected by the proposed action, screening is required. In addition, the screen must meet the requirements of the USFWS as determined through programmatic, informal, or formal consultation.

Fish Screen Criteria Applicable to Water Diversion Sites

Provisions of gravity flow fish screens will include return of the target organisms to the stream or water body in a manner which insures their survival.

Water diversion facilities that include bypasses must provide adequate cover and depth in the bypass to minimize predation by birds and other predators during recovery periods.

When practical, screens shall be designed for convenient removal from the water as needed for operations and maintenance.

When applicable, screen designs shall include a pump safety shutoff mechanism, or bypass, with instrumentation to determine the status of the system.

Criteria Applicable to Draw-down Sites

Water control structures that allow passive drawdown of flooded natural or enhanced wetlands shall be designed and operated to allow juvenile fish using the wetland for seasonal habitat to migrate to the stream at will and not be trapped in the wetland beyond the time in which they would normally be expected to migrate.

Provide a screen at all conduits used to draw down constructed farm ponds and aquaculture facilities, to assure organisms intentionally contained therein will not enter a natural stream, floodplain wetland, or river.

CONSIDERATIONS

When planning, designing, and installing this practice, the following items should be considered:

- **Consider drains in structures to prevent ice damage to the structure, screen, pipe, and gates.**
- **Consider a sluice upstream or to the side of screening structures to reduce sediment from plugging the screen.**
- Effects on the water budget, especially on volumes and rates of runoff, infiltration, evaporation, transpiration, deep percolation and ground water recharge.
- Potential for a change in the rate of plant growth and transpiration because of changes in the volume of soil water.
- Effects on downstream flows or aquifers that would affect other water uses or users.
- Effects on the field water table to ensure that it will provide a suitable rooting depth for the anticipated crop.
- Potential use for irrigation management to conserve water.
- Effect of construction on aquatic life.
- Effects on stream system channel morphology and stability as it relates to erosion and the movement of sediment, solutes and sediment-attached substances carried by runoff.
- Effects on the movement of dissolved substances below the root zone and to groundwater.
- Effects of field water table on salt content in the root zone.
- Short term and construction-related effects of this practice on the quality of downstream water.
- Effects of water level control on the temperatures of downstream waters and their effects on aquatic and wildlife communities.
- Effects on wetlands or water-related wildlife habitats.
- Effects on the turbidity of downstream water resources.
- Existence of cultural resources in the project area and any project impacts on such resources.
- Conservation and stabilization of archeological, historic, structural and traditional cultural properties when appropriate.

Design alternatives presented to the client should address economics, ecological concerns and acceptable level of risk for design criteria as it relates to hazards to life or property.

FISH SCREEN CONSIDERATIONS

Federal Candidate (C) Species and State/Tribal Listed Species: Although there are no existing legal requirements in Montana to screen fish in this category, screening may be applicable. When NRCS' environmental evaluation process indicates that a fish species within one of these categories may be adversely affected, NRCS will attempt to fulfill its National Environmental Policy Act (NEPA) requirements (GM Title 190, Part 410.22) using a collaborative approach. In the instance of a Candidate species, NRCS should solicit written screening requirement input from the USFWS. In the instances of state or tribal-listed species, NRCS should solicit written screening requirement input from Montana Fish, Wildlife and Parks and/or Native American Tribes, as appropriate.

Non-Listed Species: Although there are no existing legal requirements in Montana to screen fish in this category, screening may be applicable. When NRCS' environmental evaluation process indicates that the target species is a non-listed species, NRCS should solicit written screen requirement input from Montana Fish, Wildlife and Parks and/or Native American Tribes, as appropriate. Additional written input may also be solicited from non-governmental organizations or citizen groups.

Other Considerations (all species):

Diversion or withdrawal of water from streams will affect habitat at and downstream of the site. Maintain in-stream flows to the greatest degree possible to protect stream function and aquatic species habitats.

When determining where to install a fish screen, it is usually preferred to keep fish within the body of water they are presently occupying.

Consider the watershed management context of the site, structure maintenance, and operational costs before deciding on whether to construct in-stream or off-stream exclusion structures.

Sediment, debris loads, algae, leaves, and other suspended material will dictate the types of cleaning and debris systems required on fish screens.

The site for installing a fish screen facility can limit the types of screens, O&M capabilities of the design, and capital and maintenance costs. Careful consideration of the screen location can lead to simplification of the structure, and reduction of stress to fish, as well as reduction in maintenance demands and overall costs to the **operator.**

Required easements for construction and O&M at the site should not be overlooked in the planning process. Include easements for the fish screening site, O&M access, and power and other utility lines.

PLANS AND SPECIFICATIONS

Plans and specifications for installing structures for water control shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose.

The plan shall specify the location, grades, quantities, dimensions, materials, and hydraulic and structural requirements for the individual structure. Provisions must be made for necessary maintenance. Care must be used to protect the surrounding visual resources. If watercourse fisheries are important, special precautions or design features may be needed to facilitate continuation of fish migrations.

OPERATION AND MAINTENANCE

An operation and management plan shall be provided to and reviewed with the land manager. The plan shall be site specific, **document needed actions, provide specific instructions for operating and maintaining the system, and require prompt repair or replacement of damaged components to ensure that practices perform adequately throughout their expected life. It shall** include but not be limited to the following: Structures will be checked and necessary maintenance, including removal of debris, shall be performed after major storms and at least semi-annually. Water level management and timing shall be adequately described wherever applicable. T**he plan shall include the following provisions where applicable:**

- **Inspect the structure(s) periodically to ensure that the structure functions as planned.**
- **Inspect the structures for deterioration and capacity. Remove blockage of trash and debris that could affect flows through the structure. Repair or replace materials that have deteriorated, including rock used for outlet protection.**

- **Determine and eliminate causes of settlement or cracks in the earthen sections and repair damage.**

- **Periodic cleaning and re-grading of collection facilities (ditches, pipes, structures) to maintain proper flow lines and functionality.**

- **Prevent surface ponding by grading area adjacent to structures to remove depressions.**

- **Make sure that all structural drains are functional.**

- **Repair spalls, cracks and weathered areas in concrete surfaces.**

- **Repair or replace rusted or damaged metal and paint.**

- **Check all valves, gates, and other appurtenances for proper functioning. If worn or damaged, repair or replace.**

- **Replace weathered or displaced rock riprap to constructed grade.**

- **Check all timber or lumber sections for decay and other damage, especially sections in contact with earth. Promptly repair any damaged sections and apply protective coatings as needed.**

- **Limit livestock usage to periods that permit use without damage to the structures and appurtenances.**

- **Inspect for safety of people or animals using the area near the structure.**

- **Inspect for excessive vegetation on earthfills. Mow when vegetative growth becomes excessive.**

- **Repair and/or fertilize damaged vegetation as needed.**

- **Eradicate or otherwise remove all rodents or burrowing animals that have or may potentially damage any part of the structure. Immediately repair any damage caused by their activity.**

- **Immediately repair any damage resulting from vandalism, vehicles, or livestock.**

- **Fish screens will be operated and maintained to meet the life history requirements of the targeted species.**

- **Fish screens will be checked routinely and necessary maintenance, including removal of debris, shall be performed as required to allow the screen to function properly.**

- **Water level management and timing of control shall be adequately described wherever applicable.**

STRUCTURES FOR WATER CONTROL REFERENCES

Engineering Field Handbook

National Engineering Handbook:

Sections 5, Hydraulics
Section 6, Structural Design
Section 11, Drop Spillways

Technical Release 67, Reinforced Concrete Strength Design

Code Requirements for Environmental Engineering Concrete Structures (ACI 350)

Technical Release 74, Lateral Earth Pressures

Design Note 15, Submerged Weir Flow

Design Note 22, Design of Rock Chutes

Design of Small Canal Structures, USBR

Design and Control of Concrete Mixtures, Portland Cement Association

Civil Engineering Reference Manual, M.R. Lindeburg

Handbook of Steel Drainage and Highway Construction Products (AISI)

AWWA Steel Pipe-A Design Guide for Design and Installation

King's Handbook of Hydraulics

American Forest and Paper Association, National Design Specification for Wood

Construction and Supplement, Design Values for Wood Construction

AWPA – American Wood Protection Association

WWPI - Western Wood Preservers Institute, Best Management Practices

FISH SCREEN REFERENCES

1. General References:

Fish Protection at Water Diversions, USDI, Bureau of Reclamation, Chapters I and II Fish Protection at Water Diversions

Gale, S. B and Zale, A. V. 2005. Evaluation of entrainment losses of westslope cutthroat trout at private irrigation diversions and the efficiency of fish screens on Skalkaho Creek, Montana. Montana Cooperative Fishery Research Unit, USGS, Department of Ecology, Montana State University, Bozeman, Montana 59717. Evaluation of Entrainment Losses of Westslope Cutthroat

NRCS, General Manual, Title 190, Part 410.22 Endangered and Threatened Species and Species of Concern. Amendment 16: October 2009.

USGS, MTFWP, USFWS. Sampling Larval Pallid Sturgeon in Large Rivers: Maximizing the Likelihood of Catch Based on Vertical Sampling Location in the Water Column, Net Design, and Lateral Sampling Location.

2. Technical Design References:

NRCS NEH 654: Technical Supplement, TS14N, Fish Passage and Screen Design, can be found in the Technical Supplements. Fish Screening and Screening Design

USBR, Fish Protection at Water Diversions. April, 2006. Chapters VII-VIII: Operation and Maintenance http://www.usbr.gov/pmts/hydraulics_lab/pubs/manuals/fishprotection/Fish%20chapters%20VII,VIII,B iblio,Appendices.pdf

USBR, Fish Protection at Water Diversions. April, 2006. Chapter III: Overview of Fish Exclusion http://www.usbr.gov/pmts/hydraulics_lab/pubs/manuals/fishprotection/Fish%20chapter%20III.pdf

NMFS, Northwest Region. Anadromous Salmonid Passage Facility Design. February 2008. http://www.nwr.noaa.gov/Publications/Reference - Documents/Passage-Refs.cfm

USBR, Intake Diversion Dam Fish Screens: Evaluation of Fish Screens for Protecting Early Life Stages of Pallid Sturgeon. September 2008.