NRCS Natural Resources Conservation Service

Fish Passage

Alaska Conservation Practice Job Sheet 396

Sucker River debris obstruction.

Fifty-inch hanging culvert on Sitkinak Island.

Definition

Modification or removal of barriers that restrict or impede movement or migration of fish or other aquatic organisms.

Purposes

Improve or provide upstream and downstream passage for fish and other aquatic organisms.

Where Used

This practice applies to all watercourses and outlets and connections of ponds, lakes and wetlands where barriers impede desired fish passage, especially upstream passage.

Fish passage barriers can be natural (e.g., waterfalls, beaver dams) or artificial (e.g., road culverts, surface water diversions). Native fish have evolved around the presence of natural barriers – in many circumstances they should be left in place. Beaver dams, for example, may block weak-swimming fish at all flows or strong swimmers during only extreme flows, yet they create very diverse habitat for fish and numerous other species of aquatic and terrestrial wildlife. Evaluations of natural barriers in some cases may indicate opportunities for reconnection of previously existing aquatic habitat and fish passage, when stable stream and ecological conditions will persist.

Artificial barriers where possible, on the other hand, should be completely removed, or the stream should be rerouted around them, or obstruction be otherwise modified, to avoid installing expensive, high-maintenance fishways (fish ladders). However, for some surface-water diversion dams or weirs, a fishway may be the only alternative. A concurrent “passage” problem at these diversion structures is the loss of fish that become entrained in the diverted flow. This problem is best addressed by installing screens, using Structure for Water Control (587).

Resource Management System

This practice is commonly applied concurrently with Practice 395 - Stream Habitat Improvement and Management as part of a resource management system for a conservation management unit.

Often, artificial barriers (especially culverts) are associated with unstable stream conditions. When this occurs, the Fish Passage practice should be part of a long-range goal to restore geomorphic stability to the entire stream by combining it with Channel Stabilization (584) and Streambank and Shoreline Protection (580). If system or stream section instabilities exist beyond those caused specifically by the artificial barrier, barrier replacement or

Bean Creek hanging culvert coho juvenile passage problems.

Bean Creek after install supports juvenile fish passage during low flow periods.

rehabilitation may not be warranted until other stability concerns are addressed. Site visits by NRCS Engineering and Technical Sciences staff are mandatory to assist in these determinations.

Structures installed under this practice must be designed not only for upstream passage of fish, but also for downstream passage of high flows, bedload, and woody debris. The Alaska Department of Natural Resources requires that road crossings maintain their structural integrity during a minimum 50-year flow event.

Fish Passage Criteria

There are 23 native species of anadromous and resident fish that use Alaska State streams (Nancy Ihlenfeldt AKDNR, personal communiqué). Their ability to negotiate instream obstructions varies by species and by size of individual fish within a species. This practice will follow the passage criteria for culvert design established in the August 2001 MOA between the Alaska Department of Fish and Game (ADF&G) and the Alaska Department of Transportation and Public Facilities (ADOTPF) (see practice standard references) for the roughly 19 native species of salmon, trout, whitefish and lamprey migratory species. Also, additional criteria may be required by federal agencies for fish that are protected under the Endangered Species Act.

This job sheet is to be prepared and provided to the landowner as a documentation package describing the use and application of the specifications and parameters outlined in the August 2001 MOA between ADF&G and the ADOTPF. Additional site specific engineering and hydraulic designs/ calculations, and the 396 Fish Passage checklist should also be present in the documentation package.

A primary requirement for successful installation of the Fish Passage conservation practice is the coordination between NRCS planners, engineers, biologists and landowners with the Alaska Department of Fish and Game and the Department of Natural Resources-Office of Habitat Management and Permitting (DNR-OHMP). Interaction between these individuals and groups is necessary to fulfill legal and technical obligations as well as insure the best possible chance of success for the project. Planners should begin consultation with the technical NRCS specialists, ADF&G and OHMP as early in the process as possible to determine site location and design parameters, identify water body presence on any established lists, and the fish species, life stages and the migration schedules which must be considered in the projects design and planned construction schedule.

CULVERT INSTALLATION

Maximum allowable velocities for upstream passage through culverts are based on the sustained (red- muscle use) swimming speed of the "design" fish. Passage should be designed for the weakest fish in the system. Unless otherwise designated by the OHMP, a culvert installation project will utilize weak-swimming fish design calculations represented by the adult Arctic grayling (*Thymallus arcticus*; 60mm-400mm total length). Swimming performance for Class 1, low-performance fish (Table 1), are found in the MOA between ADF&G and AKDOTPF.

Table 1 Class I Fish. Low-performance swimmers.

Arctic Grayling

Long-nose Sucker

Northern Pike

Stickleback

Whitefish

Burbot

Sheefish

Smelt

Sculpin

Dolly Varden/ Arctic Char

Upstream migrant salmon fry

Bridge and culvert installations and maintenance for fish-bearing streams require permitting by the DNR-OHMP. The permitting procedure recognizes a three-tiered system, where design and analysis is based on site location and complexity of conditions, stream gradient and hydrologic parameters. Review and consider the information in the MOA between the ADF&G and AKDOTPF (hyperlink in the Additional Help section) to determine if your projects fits within the Tier Categories, and a permit application is required. Request from OHMP, the design fish species and length, the time (s) of the year fish passage is required, a list of species and habitat present, and identified in-stream construction time windows.

Tier I

Stream Simulation is a culvert design technique that attempts to replicate natural channel conditions within the culvert. Sediment transport, flood and debris conveyance, and fish passage are designed to function as they would in a natural channel. Stream Simulation Design is used at sites where the channel slope is between 0% and 6%. Stream widths are relatively narrow and incised (less than 20' at OHW). Here, the culvert width at the ordinary high water stage (OHW) waterline must be greater than the .9 x OHW width. The culvert grade should approximate the channel slope, but in no instance deviate more than 1% from the natural grade (e.g. a 4% channel grade with an installed 3% culvert). In stream channel with slopes less than 1%, culverts may be installed at slopes less than .5% with culvert widths greater than .75% x OHW

Within the culvert barrel substrate should remain dynamically stable at all flood discharges up to and including the 50-year flood stage. If gravel retention baffles are used, they should have a weir height of .5 times the culvert invert burial depth. If needed, outlet aprons should be extended 3 culvert widths downstream or as required based on site conditions.

Different culvert shapes have varying physical and hydraulic design impacts at a given site. Where feasible bridges, bottomless culverts or arch culverts can often be more applicable/ efficient in stream simulation designs, and should be given priority for choice as a treatment alternative. Invert burial depths for Tier I circular culverts should be at least 40% of the culvert diameter. Invert depths for arch pipes should be at least 20% of the rise.

If the above criteria are followed, it is assumed that fish passage is met for all species and life stages. Further hydraulic analysis to support fish passage is not required. If Tier I fish passage is desired, document that these parameters have been satisfied, in the following table and the attending engineering culvert and hydraulic design. The Tier I

category can also apply to any fish passage projects in which a fish barrier is removed and not replaced or modified or when a culvert barrier is replaced by a bridge.

Tier II

This design category is used when retrofitting existing structures or new installations where Tier I conditions cannot be met or are not preferred. This method requires hydrologic and hydraulic analysis and evaluation of biological parameters based on field documented power/ energy capabilities of some Alaskan fish species.

Culverts designed for Tier II use a combination of traditional hydraulic engineering methods and either the Alaska Interagency Fish Passage Task Force's 1991 "FISHPASS" computer modeling program (see Additional Help Section for hyperlink), or the U.S. Forest Services "FISHXING Ver.2" modeling program (see Additional Help section for the hyperlinks). The FISHPASS computer modeling program and background documentation is published in;

Behlke C., Kane D., McLean R., and Travis M. 1991 Fundamentals of culvert design for passage of weak swimming fish. AKDOT&PF Facil. Rpt. No. FHWA-AK-RD-90-10. Fairbanks, AK (see Additional Help Section for hyperlink).

Culvert design using the FISHPASS or FISHXING computer program must be evaluated for design discharge for the fish (Q_{fish}), the design flood hydraulic capacity and effects on the upstream and downstream channel. Appropriate treatments will be investigated if needed to address outlet perching or upstream effects (e.g. headcutting due to conditions where the slope at the installation point is not matched with the slope of the stream).

Some site conditions which lend themselves to Tier II analysis requirements are;

- Sites where narrower culverts than allowed in Tier I are required/ desired.
- Sites with low to moderate gradient slopes potentially suitable for culverts without baffles.
- Sites with gradients less than or equal to 10%, where baffles are to be considered.
- Sites where focus fish species, lengths, age class, and time of migration are required information.
- Sites where any size watershed or length of pipe could be needed and more detailed analysis is warranted or required.

Tier III

This design category is for use where site-specific conditions preclude the use of Tier I or Tier II culvert design methodologies. This type of design requires more detailed evaluation of the hydraulic and hydrologic and biological parameters. Professionally recognized hydraulic engineering methods will be used to insure fish passage in the culvert. DNR-OHMP permit review is proportionately more complex.

Some situational requirements for Tier III design settings are;

- Detailed design and review process.
- Must be used for all baffled culverts when the installation slope is greater than 10%.
- Appropriate for use when installation includes downstream weirs or other tail water control structures.
- Use with Tier I design to evaluate bed stability when slopes are greater than 6%.

Tier II and Tier III Designs

Baffles are used in combination to create a roughened channel that slows the velocity throughout the length of the culvert so a fish can swim through without resting – using prolonged swimming speed. Fishways and baffles both require extensive maintenance. Roughened channels and fishways can be used in combination with No-slope culverts.

The most common fishway is the pool-and-weir design. Fish jump or swim over each weir using burst speed (high energy, sustainability measured just a few in seconds). Since fish

can rest at each pool, fishway length is not critical. Weir height and drop height allowances at each weir are closely correlated with fish species, age, potential power and fish length. Insure design fish lengths are factored into culverts or structures featuring weirs, baffles or step pools (Technical Notes section, ADF&G/ AKDOT&PF MOA).

Other Obstructions/ Impasses

In many situations planktonic species (e.g. phytoplankton and zooplankton) that rely on the presence of water or water flow will not be impacted by obstructions which impair fish passage. Fish may be obstructed by natural or manmade structures or events which require debris removal or modification to channel features (e.g. bed, banks, sediment load, vegetation components). Fish passage can necessitate the use of selected engineering-based components *which require specific site designs and application* to achieve habitat treatment goals. These practices will be engineered and applied according to their own standards and specifications. Ecological and biological considerations must be integrated into the application of the engineering components/ practices.

Reclamation or recovery of streambanks often requires bank or landscape vegetation/ revegetation. Principles and practices shall be applied utilizing recognized bioengineering methods and can be found in *Streambank, Revegetation and Protection, Guide for Alaska, 2005*, Alaska Department of Fish and Game; *and Stream Corridor Restoration, Principles, Processes, and Practices*, The Federal Interagency Stream Restoration Working Group, 1998.

Determine needs and designs where required and document features and specifications.

Operation and Maintenance Specifications
Site specific specifications and management and operation plans are to be prepared in accordance with the NRCS Field Office Technical Guide and Practice Standard 396 (Fish Passage).

NRCS
Natural Resources Conservation Service

FISH PASSAGE

Conservation Practice Jobsheet 396

April, 2007

Customer		Company/ Org.		Date			
Landowner address		Borough		SWCD			
Program	WHIP Select	Contract #		Plan completion date			
Practice location	Farm #	Tract #		Field #		HUC #	
GPS Coordinates	Select	Coord. system	Select	Latitude	deg.	Longitude	deg.
Legal description	Township N	Range	Select	Section		¼ Section	Select
Stream Name		Catalog #		Receiving water			
Species present	Ki ☐ Co ☐ Cm ☐ So ☐ Pk ☐ Rt ☐ Ct ☐ St ☐ Other Select	Site Concerns	Select	Streambed	Select		
Design fish, length, passage periods	Select	DNR-OHMP Permit #		In-stream Work period			

BARRIER DESCRIPTION

Measurements made in meter Listed as barrier by ADF&G Select Miles to next barrier

1A. EXISTING CULVERT (For multiple culverts: copy, paste and enter data in the first two lines as many times as the number of culverts)

Number 5 Shape Select	Material Select	Span	Rise	Outfall	Length	% Slope	
Bed material ☐	Apron Select	Fill depth	Tidegate Select	Water velocity	Damaged Select		
Downstream gradient (%)	Upstream gradient (%)	Invert Elevations: inlet	outlet	Average bankfull width	Angle of stream to inlet of culvert (degrees)	Angle of stream to outlet of culvert (degrees)	

1B. CULVERT SOLUTION

Replaced with	Replaced with Select	Shape Select	Material Select	Span	Rise	Length	% Slope	Embedded Depth Inlet	Outlet
Downstream Bed Controls Type Select	Select	Upstream Bed Controls Type Select	Selec	Retrofitted in Place ☐	Baffles Installed Type Select	# Select	Weirs Installed no	Selec	Fish Screen Needed No

2A. EXISTING DAM (WEIR)

Height	Face	Base	Plunge Pool Depth	Construction/Form	Reservoir Depth
	Select	Select		select	

2B. DAM SOLUTION

Select

3A. OTHER CONDITION/ OBSTRUCTION

Site Condition/ Passage Issue	Passage Treatment Goal	Other Information
Select	Select	

3. SIGNATURES:

I agree to apply these practices as planned and designed.

Customer _____ Date _____

I have determined that these practices have been properly applied, based on: site inspection

Planner _____ Date _____

4. ADDITIONAL HELP:

- MOA Alaska Department of Fish and Game/ Alaska Department of Transportation and Public Facilities - Design, Permitting and Construction of Culverts for Fish Passage
- Fundamentals Of Culvert Design for Passage Of Weak-Swimming Fishes
- FishXing software (free)
- Fishpass program FISHPASS.EXE (free) - Executable program to calculate fish passage requirements for culvert installations. FISHPASS program software documentation.

- AK Department of Natural Resources, OHMP Title 41 permitting contact points:

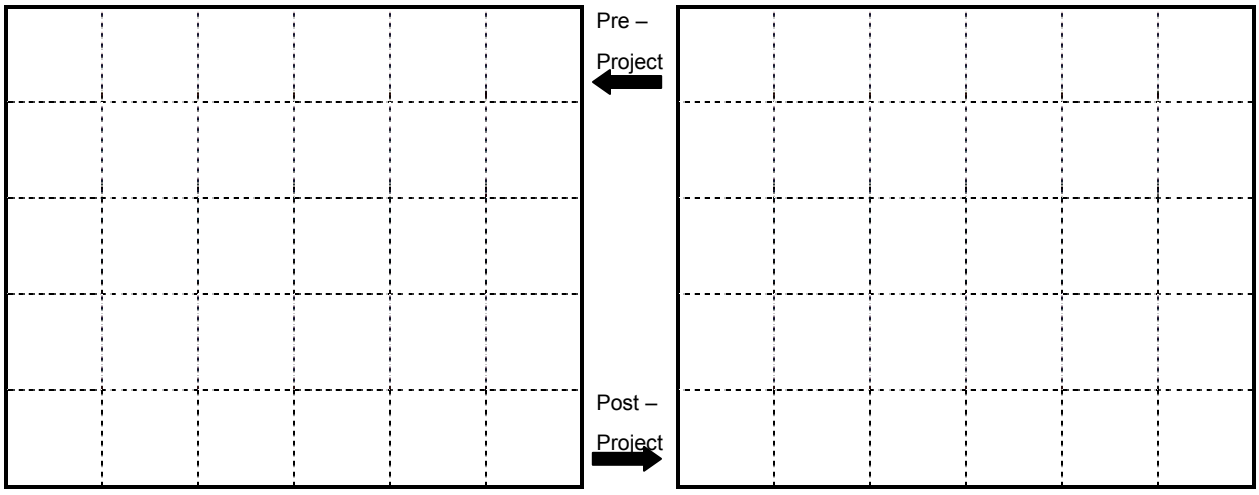
Anchorage	**Craig**	**Douglas**	**Fairbanks**	**Palmer**	**Soldotna**
Alaska Department of Fish and Game Division of Habitat 333 Raspberry Rd, Suite 2068 Anchorage, AK 99518 267-2342 phone 267-2499 fax	Alaska Department of Fish and Game Division of Habitat Westwind Plaza, Suite 302 Craig, AK 99921 826-2560 phone 826-2562 fax	Alaska Department of Fish and Game Division of Habitat 802 3rd Street, Room 209 Douglas, AK 99824-5412 465-4105 phone 465-4759 fax	Alaska Department of Fish and Game Division of Habitat 1300 College Road Fairbanks, AK 99701-1551 459-7289 phone 459-7303 fax	Alaska Department of Fish and Game Division of Habitat 1800 Glenn Highway, Suite 6 Palmer, AK 99645-6736 861-3200 phone 861-3232 fax	Alaska Department of Fish and Game Division of Habitat 514 Funny River Road Soldotna, AK 99669-8255 714-2475 phone 260-5992 fax

Fish Passage – Preliminary Job Sketch and Associated Practices (*This page cannot be used to satisfy required documentation to acquire DNR-OHMP permits. Signed and stamped final engineering designs are to be provided to the landowner for permit applications. Landowner signature on this jobsheet constitutes acceptance of these final engineering design.*)

Scale 1/2"=_____ ft. (NA indicates sketch not to scale: grid size=1/2" by 1/2")

Stream Longitudinal Profile: Sketch the longitudinal stream profile, including the fish barrier (culvert(s) or dam. Show height of dam or rise of culvert(s); depth and length of outfall pool; downstream control point; size, shape, and slope of apron and/or face of dam; slope of culvert(s); slope, depth and composition of bed material in culvert(s) or behind the dam.

Stream Cross Section: Sketch a cross section from bank to bank, looking upstream at the barrier. Show height and shape of dam; rise, span and shape of culvert(s); height of culvert invert above pool surface; bank erosion and armoring.



Additional Specifications, Complementary Practices, Photos, and Notes:

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