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Memo

To:	Randall Lee, CENWP		
From:	Jeffrey Blank, HDR	Project:	*Bonneville Dam Spillway and Stilling Basin Reconfiguration for Fish Passage Alternative Study*
Copy:	Ron Mason, HDR Don Erickson, CENWP	Contract No:	W9127N-08-D-0006 Task Order 0002
Date:	November 7, 2008		
Re:	**30% Deliverable: Alternative Evaluation Criteria Technical Memorandum**		

Purpose

The purpose of this memo is to set forth a detailed list of the criteria used throughout the *Bonneville Dam Spillway and Stilling Basin Reconfiguration for Fish Passage Alternative Study*. The criteria will be used to qualitatively evaluate each alternative and recommend the best alternatives for further development. Because this alternatives study represents one of the first steps in evaluating the improvements needed at Bonneville Dam's spillway, some of the criteria proposed in this document may change as the project evolves. Consequently, this memo is intended to be a living document that will be updated as new and/or better information becomes available. Criteria values that are unspecified (TBD) in this document will be completed after subsequent meetings with Corps staff.

Background

The purpose of the *Bonneville Dam Spillway and Stilling Basin Reconfiguration for Fish Passage Alternative Study* is to recommend alternatives that will aid in the passage of juvenile migrant salmonids past Bonneville Dam at the Spillway. The alternatives will be developed in conjunction with long-term plans to repair the spillway and stilling basin. To ensure an equal treatment of each alternative, a consistent set of assumptions, constraints, and criteria are required at the outset. The criteria are separated into specific disciplines, including hydraulic, biological, geotechnical, structural, electrical, mechanical, permitting, and operational. Also considered in the evaluation of each alternative are cost, constructability and safety.

Each alternative has been selected for evaluation because of its potential to improve downstream juvenile fish passage. The adjustable flow deflectors can improve total dissolved gas concentrations at varying tailwater elevations. Spillway pier modifications can minimize lateral flow within the stilling basin and improve fish egress. Spillwalls can improve fish egress and minimize spilling rates by focusing more flow downstream. Behavioral guidance systems can encourage migrating fish to pass over the spillway at specific locations, thereby decreasing spilling rates increasing fish egress.

For the alternatives analysis, the North American Datum of 1983 (NAD83) horizontal datum projected to the State Plan Coordinate System, Oregon North Zone with units in International feet will be used. The vertical datum will be the National Geodetic Vertical Datum of 1929 through the 1947 adjustment (NGVD29/47).

1.0 Design Life

The alternatives considered in this project will have an estimated design life of 50 years.

2.0 Hydraulic Criteria

2.1 General

The hydraulic criteria list the water levels and flows used as the constraints in developing the concept designs for each alternative. The flows and water levels are divided into two types: maximum design and operating. The maximum design values are those used in designing the alternative and assessing the stability and forces acting upon it. These will focus on the Probable Maximum Flood (PMF) and/or the 100-year event. The operating values are those for which the alternative is designed to operate and perform its intended purpose. These can include both minimum and maximum values. The 7Q10 flow is defined as the highest average seven consecutive day flow with an average recurrence frequency of once in ten years as determined statistically

2.2 Flows

The following are the flow rates for which the alternatives are evaluated.

Maximum Design Flow

Probable Maximum Flood:	1,600,000 cfs (89,000 cfs per spillbay)
100-year Flood (Total River):	700,000 cfs
100-year Flood (Total Spillway):	TBD
7Q10 (Total River):	471,000 cfs
7Q10 (Total Spillway):	283,000 cfs (15,700 cfs per spillbay)

Operating Flows

April 10—June 30:	100,000 cfs (day and night)
July 1—August 31:	75,000 cfs (day), minimum 50,000 cfs (night)

The selected alternative must be able to function under varied conditions. Flow requirements for optimal fish passage operations vary due to the interaction of head and tailwater conditions. The headwater elevation varies over 7 feet and the tailwater elevation varies over 28 feet. The varying tailwater dictates the total drop over the spillway, and consequently influences other factors important for the survival rate of migrating juvenile salmonids, such as total dissolved gas values and egress rates.

Figure 1 presents the tailwater stage duration curve for the calendar year. The period of record is 1974 – 1999. This figure depicts the percent of the time a given tailwater elevation was exceeded during the time period evaluated.

Figure 2 depicts the forebay stage duration curve for the calendar year. The period of record is 1974 – 1999. This figure depicts the percent of the time a given headwater elevation was exceeded during the time period evaluated.

2.3 Water Levels

The following forebay and tailrace water surface elevations apply to all alternatives unless otherwise noted.

- Maximum Operating Reservoir Level Elevation = 77 ft
- Maximum Pool Elevation (at maximum inflow) = 87.5 ft
- Minimum Operating Reservoir Level Elevation = 71.0 ft
- Maximum Operating Tailwater Elevation = 35.0 ft
- Minimum Operating Tailwater Elevation = 7.0 ft
- Normal Headwater Elevation = TBD
- Normal Tailwater Elevation = TBD
- Maximum Operating Differential Head = 80.5 ft
- Minimum Operating Differential Head = 36.0 ft
- 500-Yr Flood Head Water Elevation = TBD
- 500-Yr Flood Tail Water Elevation = TBD

2.4 Spill Periods

The 2008 Fish Passage Plan was written by the Corps and documents the operational procedures for ensuring fish passage (juvenile and adult) at Corps projects. According to the 2008 Fish Passage Plan, spill planning dates for juvenile fish passage have a start date of April 10 and end date of August 31. These are planning dates and are flexible according to specific requirements relating to fish abundance. During spring through the end of June, the day and night spill amount is 100,000 cfs. From July 1 through August, the daytime spill amount is 75,000 cfs, and the nighttime spill amount is a level that entrains gas up to the 120% gas cap without exceeding it. The NMFS 2004 BiOp sets a minimum spill level of 50,000 cfs.

2.5 Navigation Conditions

The selected alternative will not impede the current navigation conditions and procedures used at Bonneville Dam.

2.6 Erosion

The selected alternative will not increase the current rate of erosion to the spillway or stilling basin, or create erosion problems at other locations at the site. Alternatives that reduce or minimize erosive potential may be preferable when determining the final recommended alternative.

2.7 Flow Patterns

The selected alternative will create flow patterns that best facilitate successful juvenile passage. Structures added in the forebay and/or tailrace will address the following:

- Create spillway approach flow conditions that guide fish to specific spillbays and minimize delay in the approach channel
- Minimize eddies that entrain fish and cause fish passage delays
- Promote spillway discharge flows that aid in fish egress by minimizing rapid flow expansions and cross flows
- Minimize localized non-uniform flow or boundary layer conditions that may be created by the addition of structures

2.8 Alternative Specific Criteria

2.8.1 Deflectors

- Deflectors shall be designed for the 7Q10 flow. 7Q10 is defined as the highest average seven consecutive day flow with an average recurrence frequency of once in ten years as determined statistically.
- Tailrace water surface elevations for design purposes range from 7 to 35 ft (note that the 7Q10 flow coincides with a 35 ft WSEL)
- Deflectors shall be designed to provide stilling basin flow conditions that have been previously shown to meet the state water quality criterion of 120% for TDG (the waiver allowed by the states of Oregon and Washington) at other Columbia/Lower Snake River projects.
- Flow deflectors shall reduce TDG up to the 7Q10 at this site, which is 471,000 cfs with two powerhouses operating at a total of 188,000 cfs. The spillway 7Q10 flow is therefore 283,000 cfs**.**
- Flow deflectors shall be structurally stable at any elevation for all discharges reasonably expected.
- Should the deflectors fail, the event will not jeopardize stability or safety of the spillway monolith.

2.8.2 Spillwalls

- Design flows for the spill wall alterative range from TBD to TBD.
- The spill wall may be overtopped at TBD flow.
- The spill wall must be structurally stable for all spillway releases up to the PMF, but may sustain minor damage above the 100-year event.

2.8.3 Behavioral Guidance System

- Structure location and design will allow for spillway flows of TBD cfs without moving the structure.
- Structure location and bay operation restrictions will not impact TDG in the tailrace.
- Structure must have the capability of being either easily removed from the spillway approach channel during a TBD cfs spillway flow or designed such that it sinks or realigns so the corresponding flood flow is not impacted.

2.8.4 Spillway Pier Modifications

- Modified piers shall minimize lateral flow between spillway bays and to the extent possible within the stilling basin.

3.0 <u>Biological Criteria</u>

3.1 General

This section deals with biological and behavior characteristics of migrating juvenile fish species. The criteria stated below deal with seasonality of passage and project operational criteria. In general, the alternatives will be designed to minimize total dissolved gas values and maximum egress rates.

3.2 Juvenile Passage Period

3.2.1 Seasonal Timing

Table 1 shows the time frame for juvenile fish migration at the Bonneville Dam as given in the Bonneville Dam section of the 2008 Fish Passage Plan.

3.3 Juvenile Passage Criteria

3.3.1 Total Dissolved Gas (TDG) Limits

The state and federal water quality standards require that TDG concentrations do not exceed 110% up to the 7Q10 discharge; however, the states have granted “fish passage waivers” to balance the risk of high TDG levels with the benefits of fish passage. In the past, these annual waivers have increased the criterion to 120% at Bonneville during the fish passage season. A value greater than 120% may be harmful to juveniles salmonids.

3.3.2 Egress

The selected alternative will maximize the egress of juveniles downstream of the spillway.

3.3.3 Residence Time

Outmigrating juvenile fish will spend as little time as possible in the forebay prior to locating and using the spillway passage route. Alternative designs will facilitate downstream movement of outmigrating juvenile fish following passage through the spillway. Fish entrapment in eddies or reverse flow patterns which would hold them near the dam and prolong outmigration time or expose them to high TDG levels multiple times will be minimized.

3.3.4 Maximize Direct Survival

Direct survival through the spillway will be maximized by considering the potential for direct impact of fish on spillway structures (e.g. ogee, gates, piers, baffle blocks, flow deflectors, etc.). The alternative designs will help to minimize the potential for gas bubble disease as a result of rapid pressure changes or prolonged exposure to excessive TDG.

Figure 1. Bonneville Project Annual Tailwater Duration Curve

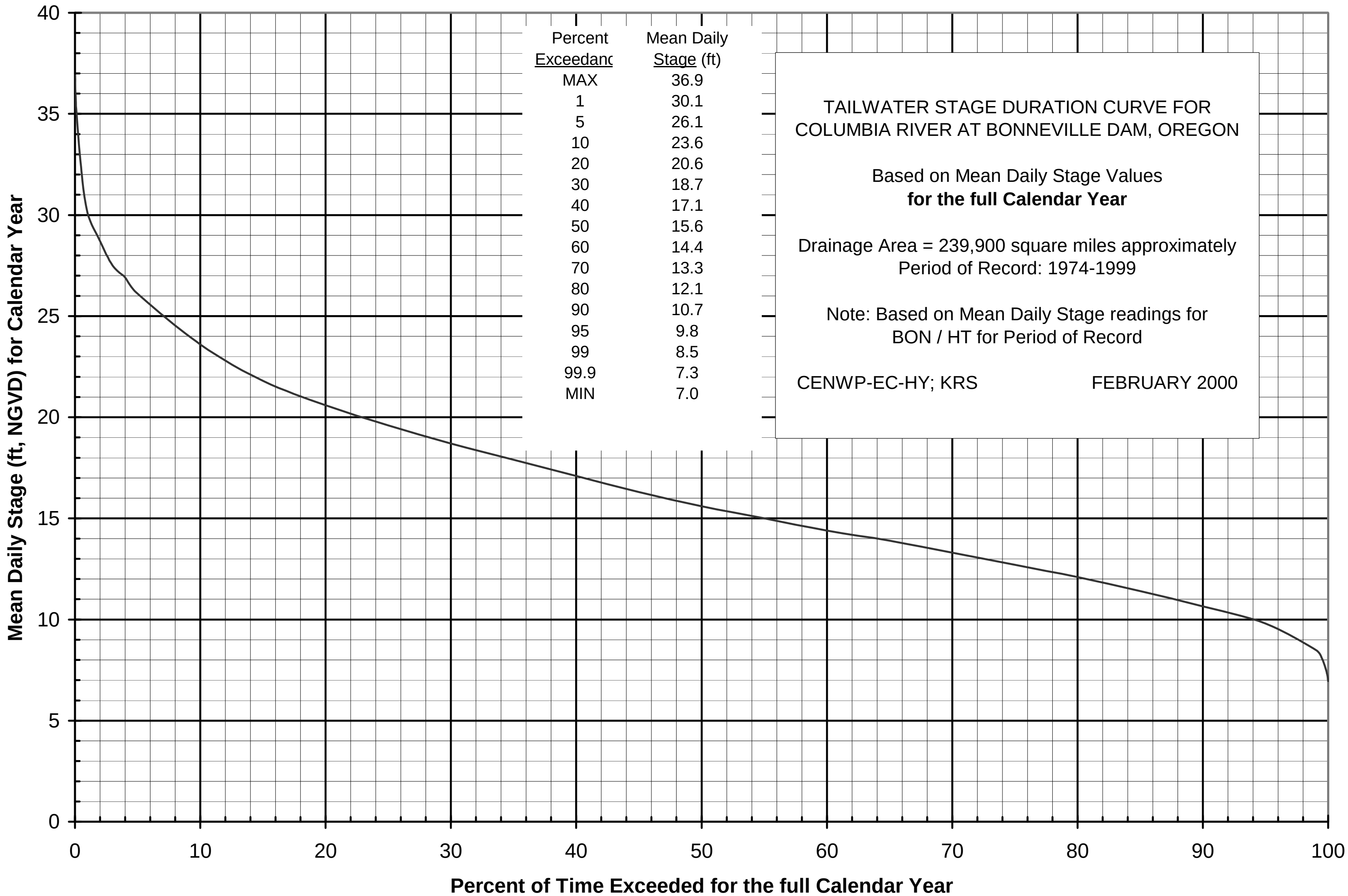

Figure 2. Bonneville Project Annual Headwater Duration Curve

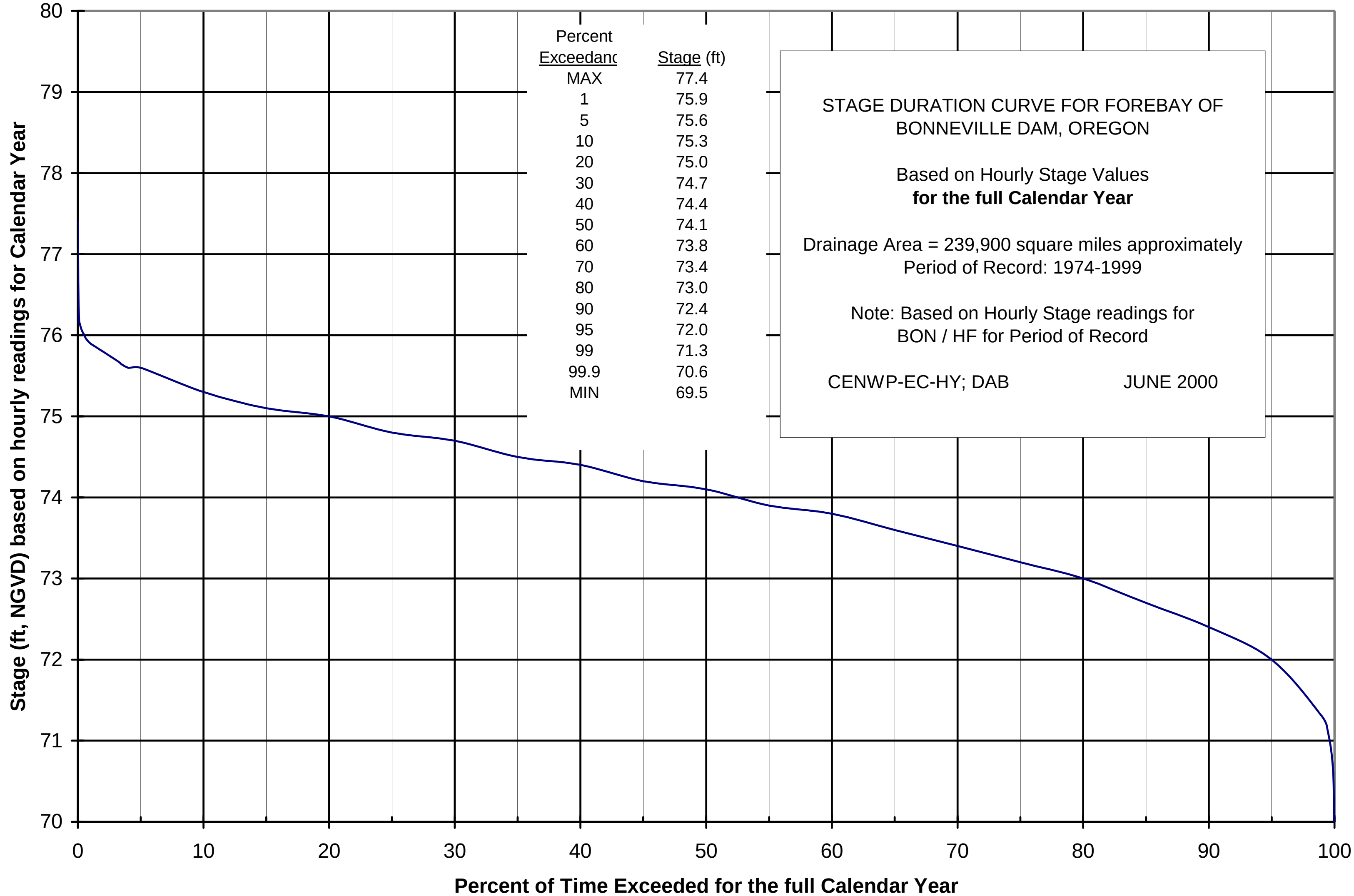

Table 1. Juvenile Fish Migration Passage Dates for Bonneville Dam.

Yearling Chinook	10 %	50%	90 %	# of Days
2000	Apr 23	May 17	Jun 01	40
2001	Apr 26	May 11	Jun 06	42
2002	Apr 25	May 18	Jun 01	38
2003	Apr 22	May 14	May 31	40
2004	Apr 17	May 04	May 30	44
2005	Apr 19	May 7	May 25	37
2006	Apr 16	May 9	May 21	36
2007	Apr 20	May 11	May 23	34
MEDIAN	Apr 21	May 11	May 30	41
MIN	Apr 16	May 04	May 21	34
MAX	Apr 26	May 18	Jun 06	44

Subyearling Chinook	10 %	50%	90 %	# of Days
2000	Jun 06	Jun 22	Jul 19	44
2001	Jun 07	Jul 09	Aug 15	70
2002	Jun 21	Jul 03	Jul 20	30
2003	Jun 15	Jul 01	Jul 19	35
2004	Jun 10	Jun 28	Jul 14	35
2005	Jun 15	Jun 28	Jul 20	36
2006	Jun 16	Jun 29	Jul 15	30
2007	Jun 19	Jul 08	Jul 22	34
MEDIAN	Jun 15	Jun 30	Jul 19	36
MIN	Jun 06	Jun 22	Jul 14	30
MAX	Jun 21	Jul 09	Aug 15	70

Unclipped Steelhead	10 %	50%	90 %	# of Days
2000	Apr 23	May 16	Jun 01	40
2001	May 02	May 18	Jun 09	39
2002	May 01	May 27	Jun 09	40
2003	May 03	May 27	Jun 09	38
2004	Apr 17	May 16	May 31	45
2005	Apr 23	May 11	May 29	37
2006	Apr 24	May 07	May 29	36
2007	Apr 29	May 16	Jun 03	36
MEDIAN	Apr 26	May 16	Jun 02	38
MIN	Apr 17	May 07	May 29	36
MAX	May 03	May 27	Jun 09	45

Clipped Steelhead	10 %	50%	90 %	# of Days
2000	Apr 28	May 18	Jun 04	38
2001	May 07	May 20	Jun 12	37
2002	May 02	May 27	Jun 11	41
2003	May 07	May 30	Jun 11	36
2004	Apr 30	May 16	May 27	28
2005	Apr 26	May 15	May 30	35
2006	Apr 27	May 08	May 29	33
2007	May 08	May 17	Jun 04	28
MEDIAN	May 01	May 17	Jun 04	35
MIN	Apr 26	May 08	May 27	28
MAX	May 08	May 30	Jun 12	41

Coho	10 %	50%	90 %	# of Days
2000	May 06	May 22	Jun 03	29
2001	May 15	May 24	Jun 03	20
2002	May 06	May 19	Jun 06	32
2003	Apr 29	May 16	Jun 09	42
2004	Apr 18	May 05	May 27	40
2005	Apr 22	May 9	May 27	36
2006	Apr 27	May 17	May 27	31
2007	Apr 26	May 13	May 31	36
MEDIAN	Apr 28	May 16	Jun 01	32
MIN	Apr 18	May 05	May 27	20
MAX	May 15	May 24	Jun 09	42

Sockeye (Wild & Hatchery)	10 %	50%	90 %	# of Days
2000	May 05	May 25	Jun 07	34
2001	Jun 03	Jun 10	Jun 25	23
2002	May 13	May 23	Jun 09	28
2003	May 12	May 20	Jun 05	25
2004	May 21	Jun 01	Jun 15	26
2005	May 15	May 23	Jun 1	18
2006	May 10	May 19	May 31	22
2007	May 16	May 25	Jun 7	23
MEDIAN	May 14	May 24	Jun 07	25
MIN	May 05	May 19	May 31	18
MAX	Jun 03	Jun 10	Jun 25	34

[1] Includes upriver brights only (excludes influence by Spring Creek NFH Tules).

3.3.5 Maximize Indirect Survival

Indirect survival through the spillway will be maximized by limiting fish disorientation that can result in increased risk for predation or extended residence times. The designs will also limit injuries such as removal of slime layer or descaling which can result in infection or disease and damage to sensory systems such as the lateral line or eyes.

3.3.6 Adult Attraction Flow

The selected alternative will not reduce the attraction flow for adult fish, such as salmonid, lamprey, and sturgeon. Upstream migration success will remain the same or be improved.

4.0 Geotechnical Criteria

4.1 Surface and Subsurface Assumptions:

- Bedrock under the Spillway, spillway apron, and for at least 500 feet upstream and downstream of the structure consist of a soft to moderately hard sedimentary rock locally identified as the Weigle Formation. Rock types in this formation very considerably and consist of siltstones, sandstones, and agglomerates
- All overburden was removed from beneath the spillway and spillway apron during construction.
- Downstream of the spillway apron overburden was either removed or has been eroded and will not be found in significant quantities.
- Several tens of feet of overburden will likely be found upstream of the spillway. This material will likely consist of relatively dense sands and gravels, and recent deposits of soft sands and silts.

4.2 Geotechnical Assumptions:

- Bedrock materials will be sufficiently strong to support relatively heavy structures.
- No test anchor data for the Wiegle materials are available. Anchor capacity will be generated from standard tables and charts. It is assumed that sufficient capacity will be available for most alternatives.
- The structures will be designed for no damage during the operational based earthquake (OBE), with a no collapse criteria for the Maximum Credible Earthquake (MCE). The peak horizontal acceleration for the MCE will be about 0.3g. The peak vertical acceleration for the MCE will be about 0.1g.
- Flow velocities downstream of the spillway are presently capable of eroding the bedrock materials. The erosion potential of the bedrock will be a consideration in the development of alternatives.

4.3 Geotechnical Construction Assumptions:

- Any construction upstream or downstream of the spillway will likely require cofferdams or in-water construction.
- In-water construction will likely be the most economical option.

- In-water construction will only be permitted during the winter in-water work season.
- Alternatives will need to be evaluated based upon the ability to construct in-water and during a relatively short winter construction season.

5.0 Structural Criteria

5.1 General

For conceptual design of structures considered in the study, stability analyses and general structural computations are required. To be consistent with the Corps' design criteria and other structures at the Bonneville Project, the following criteria are initially planed for use in this study. Due to the complexity of each alternative, more criteria than may be necessary are listed below.

5.2 Codes, Standards, and References

- American Concrete Institute, ACI 318-05 or latest edition, Building Code Requirements of Reinforced Concrete and Commentary on Building Code Requirements for Reinforced Concrete.
- American Society of Civil Engineers (ASCE), Minimum Design Loads for Buildings and Other Structures, Revision of ASCE 7-05.
- International Building Code – IBC 2006.
- American Institute of Steel Construction (AISC), Steel Construction Manual 13th Edition (2005)
- American Concrete Institute, ACI 350/350R-05 or latest edition, Code Requirements for Environmental Engineering Concrete Structures and Commentary
- USACE Engineer Manuals, EM 1110-2-1603, Hydraulic Design of Spillways
- USACE Engineer Manuals, EM 1110-2-2100, Stability Analysis of Concrete Structures
- USACE Engineer Manuals, EM 1110-2-2104, Strength Design for Reinforced-Concrete Hydraulic Structures
- USACE Engineer Manuals, EM 1110-2-2105, Design of Hydraulic Steel Structures

5.3 Computer Programs

The purpose of this subsection is to identify the computer programs that may be used in the analysis of the aforementioned structure if required.

- RISA 3D, a finite element program for structural analysis.

5.4 Design Materials

5.4.1 Concrete

- fc' = 3000 psi. Fill concrete and minor structure
- fc' = 4000 psi. Structures at grade with foundations not deeper than 10 feet below finish grade.

- Cement – ASTM C150, Type II.
- Possolan – ASTM C618. Class M, C, or F.
- Grout – ANSI/ASTM C50
- Sand and Coarse Aggregate – ANSI/ASTM C33

5.4.2 Steel

- Reinforcing Steel, Deformed Bars ASTM A615, Grade 60 or ASTM A615, Grade 60 or ASTM A706, Grade 60, where required or where welding of rebar is permitted by Engineer.
- Structural Shapes and Plate (unless noted otherwise on Drawings):
- All W-shapes and WT-shapes: ASTM A572, Grade 50
  - ASTM A992
- Plate and Bar: ASTM A36
- Pipe: ASTM A53 Grade B (Type E or S (Fy = 35).
- Hollow Structural Sections (HSS):
  - Round: ASTM A500, Grade B (Fy = 42).
  - Square or Rectangular: ASTM A500, Grade B (Fy = 46)
- Welding Electrodes (AWS):
  - Shield metal arc: AWS A5.1 or AWS A5.5, E70XX or E801X-X.
  - Submergers arc: AWS A5.17 or A5.23, F7XX-EXXX or F8XX-EXXX-XX.
  - Gas metal arc: AWS A5.18, E70S-X or EOU-1 or AWS A.528 ER805-XX, E80C-XX.
  - Flux cored arc: ASW A5.20, E7XT (except 2, 3, 10, GS) AWS A5.29, E7XT-X or E8XTX-X, E8XTX-XM.

5.4.3 Existing Material Properties

- Concrete Ogee Spillway
  - Unit Weight = 145 lb/ft^3
  - Compressive Strength = 3000 psi (core testing may be required to determine actual strength)
  - Modulus of Elasticity = 3155 ksi
  - Allowable Tensile Stress = $1.7(f'c)^{2/3}$ = 353 psi
- Concrete Pier Spillway
  - Unit Weight = 150 lb/ft^3
  - Compressive Strength = 4000 psi
  - Modulus of Elasticity = 3834 ksi
  - Allowable Tensile Stress = $1.7(f'c)^{2/3}$ = 428 psi
- Steel Unit Weight = 490 lb/ft^3
- CDF Unit Weight = Varies

5.5 External Loads Below Grade

Groundwater elevation should be assumed to be located at the ground surface unless noted otherwise in the Geotechnical report. Uplift will equal the hydraulic head multiplied by the equivalent fluid density of 62.4 lb/ft^3.

- Wind (if necessary): TBD
- Seismic:
  - Seismic Design Category = TBD
  - Operating Basis Earthquake Peak Acceleration (Horiz.) = 0.3g
  - Operating Basis Earthquake Peak Acceleration (Vert.) = 0.0g
  - Max. Credible Earthquake Peak Acceleration (Horiz.) = 0.3g
  - Max. Credible Earthquake Peak Acceleration (Vert.) = 0.1g

- Soils
  - Upstream Soil Friction Angle = 35.0 degrees
  - Upstream Soil Unit Weight (Submerged) = 65 pcf
  - Active Lateral Pressure Coefficient = 0.27
  - Passive Lateral Pressure Coefficient = 3.69
  - Downstream Soil Friction Angle = 30.0 degrees
  - Downstream Soil Unit Weight (Dry) = 0 pcf
  - Downstream Soil Unit Weight (Submerged) = 65 pcf
  - Passive Lateral Soil Pressure on Downstream Concrete = TBD
  - Uplift Pressure = TBD
  - Lateral Hydrodynamic Pressure = TBD
  - Allowable Bearing Pressure = 10 ksf
  - Shear Strength (Cohesion Resistance) = TBD
  - Underlying Foundation Material Angle of Friction = 35 degrees
- Vehicle Surcharge TBD
- Seismic Soil Loads
  - Active Lateral Seismic Soil Pressure = TBD
  - Allowable Bearing Pressure = 12 ksf

5.6 External Loads Above Grade

- Wind (if necessary): TBD
- Seismic:
  - Seismic Design Category = TBD
  - Operating Basis Earthquake Peak Acceleration (Horiz.) = 0.3g
  - Operating Basis Earthquake Peak Acceleration (Vert.) = 0.0g
  - Max. Credible Earthquake Peak Acceleration (Horiz.) = 0.3g
  - Max. Credible Earthquake Peak Acceleration (Vert.) = 0.1g
  - F_v = TBD
  - S_s 0.2 sec = 125.00 %g
    - S_1 1.0 sec = 50.00 %g
    - I_w = TBD
- Ice Load (if necessary):
  - Thickness of Ice = TBD
- Snow Load (if necessary):
  - Drift snow load = TBD
  - I_s = TBD
  - C_e = TBD
  - C_t = TBD

  - Slab on Grade = TBD
- Live Loads
  - Operating/Equipment Floors = 250 psf
  - Stairs, Landings, Walkways = 100 psf
  - Grating & Covering Plates – Same as adjacent floors areas, but not less than 100 psf. Deflection shall not exceed ¼" inch of 1/360 clear span, whichever is smallest.
- Equipment Dead Loads
  - Actual dead load of equipment
- Hydrodynamic Loads
  - Lateral = TBD
  - Vertical = TBD
- Lateral Loads
  - Loads and load diagrams shall be taken as the greater combination of seismic load, hydrostatic load, hydrodynamic load, and wind load.
- Uplift Loads
  - Normal Conditions – factor of safety against buoyancy = 1.3 min.
  - 100 year flood conditions – factor of safety against buoyancy = 1.10.

5.7 Spillway Specifications

- Bay Width = 60.0 ft
- Crest Elevation = 25.16 ft
- Downstream Apron Elevation = -10.00 ft
- Width of Section Between Piers = 60.0 ft
- Width of Pier = 10.0 ft
- Width of Foundation from Heel to Toe = 190.0 ft

5.8 Structural Analysis

The following methods shall be used in the structural analysis:

- Concrete – Strength Design (Load Factor)
  - ACI 318-05
  - ACI 350-05
- Metals – Working Stress Design (ASD)
  - AISC Steel Construction Manual 13th Edition
- USACE Engineer Manuals, EM 1110-2-2100, Stability Analysis of Concrete Structures

6.0 <u>Electrical Criteria</u>

The alternative designs shall conform to the latest edition of the following applicable standards and codes:

- National Electrical Code (NEC-2008 edition)
- Life Safety Code (NFPA-101 2009 edition)
- National Electric Safety Code (ANSI C2 2007 edition)
- American National Standards Association (ANSI)
- Illuminating Engineering Society (IES)

- National Electrical Manufacturers Association (NEMA)
- Institute of Electrical and Electronic Association (IEEE)
- Instrument Society of America (ISA)
- Insulated Cable Engineers Association (ICEA)
- Occupational Safety and Health Act (OSHA)
- Underwriters Laboratory (UL)

7.0 Mechanical Criteria

7.1 General

For conceptual design of structures considered in the study, an effort will be made to keep the design approach simple. This will minimize the number of moving parts, simplify operation and maintenance requirements, and reduce the likelihood of a mechanical component failure. The conceptual designs will use conventional concepts and materials.

7.2 Considerations

The following mechanical concepts and requirements will be used during the conceptual evaluation and design of each alternative.

- Multiple deflector types will be examined
- Multiple operating equipment types will be considered. This includes electric motor driven, hydraulic, and pneumatic equipment.
- Various building and operational materials will be considered, including reinforced concrete, stainless steel, elastomerics (seals), and protective coatings.
- Various modes of operation will be examined. Operations such as adjustability, locking mechanisms, and time requirements for adjustments will be considered.
- Maintenance requirements will be minimized.
- To reduce maintenance:
    - In-water bearings will be self-lubricating
    - Moveable parts will be minimized in the spillway
    - There will be no interference with existing spillway operations and maintenance
    - Biodegradable hydraulic fluid will be used
    - Mechanical components will be managed from existing local controls.

8.0 Permitting Criteria

The proposed alternatives being analyzed and developed would be subject to environmental review and approval. Dependent upon the refinement and continued understanding of the potential impacts to the human and natural environmental each alternative could have low to high levels of effort to meet environmental compliance. Below is a scale ranking from low to high describing the potential level of effort for environmental review and compliance proposed alternatives may be subject dependent upon potential impacts.

Low

- The alternative would meet the categorical exclusion (CE) requirements for National Environmental Policy Act (NEPA) documentation.
- Effects of individual habitat actions are determined to meet the conditions and site-specific effects to listed species as addressed in the 2008 Biological Opinion.
- State Historic Preservation Office (SHPO) Concurrence and No Effect Determination could be obtained.
- Federal regulatory permitting would meet the requirements of Clean Water Act Section 404 Nationwide Permits.

Medium

- The alternative would meet the Environmental Assessment (EA) requirements for NEPA documentation.
- Effects of individual habitat actions are determined to meet the conditions and site-specific effects to listed species as addressed in the 2008 Biological Opinion.
- SHPO Concurrence and Effect Determination could be obtained.
- Federal regulatory permitting would meet the requirements of Clean Water Act Section 404 Individual Permits.

High

- The alternative would meet the Environmental Impact Statement (EIS) requirements for NEPA documentation.
- There would be individual actions in the selected alternative that require additional consultation because the effects of the proposed action were not addressed in the 2008 Biological Opinion, and USACE will need to consult with NMFS and USACE to supplement the 2008 Biological Opinion.
- SHPO Concurrence and Effect Determination could be obtained.
- Federal regulatory permitting would meet the requirements of Clean Water Act Section 404 Individual Permits

9.0 Cost Criteria

A conceptual level cost estimate for each investigated alternative will be produced. Cost data will be based on the previously prepared cost estimates at The Dalles Lock and Dam Spillway and other similar projects in the Pacific Northwest. If and when detailed cost information is not readily available, estimates will be developed for significant components using standard cost estimating methodologies. Each completed cost estimate will be compared to similar Corps projects to determine if the alternative costs are reasonable.

10.0 Constructability

Each alternative will be evaluated for constructability. Issues impacting an alternative's constructability may include, but are not limited to, dewatering requirements, construction safety, the necessity to use divers, depth of diving, and the availability of prefabricated materials will be considered. Alternatives that are more easily constructible will be scored higher in determining the final recommended alternative.

11.0 Operation and Maintenance

The ease of operation and maintenance will be considered with each alternative. Alternatives that have easier operation and maintenance may be more preferable when determining the final recommended alternative. Elements to be considered for operation and maintenance may include anticipated life span, ease of part replacement, the inclusion of static versus dynamic elements, and the use of non-proprietary prefabricated materials will be considered.

12.0 Safety

Safety is an important consideration when evaluating each alternative. Both public safety and the safety of Corps personnel will be evaluated. Factors influencing safety may include the use of automated systems versus manual adjustments, personnel risk during emergency operations, and the proximity of personnel to potential risk. An alternative that is deemed inherently unsafe will not be moved forward without discussion on ways to mitigate safety risks. An alternative that is evaluated to be more safe than other less safe alternatives will be preferable.