Klamath River Renewal Project

Fall Creek Fish Hatchery—Design Documentation Report

50% Design Submittal

DRAFT
Revision No. 0

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Revision Log

Revision No.	Date	Revision Description
0	June 1, 2020	Initial Draft - 50% Design

1.0 Introduction and Background

1.1 Purpose

The purpose of this report is to present the design documentation associated with development of the Fall Creek Fish Hatchery Project.

1.2 Background

1.2.1 Location

The Project is located in Siskiyou County northwest of Iron Gate Dam near Yreka, California. The Project is located at the existing Fall Creek Fish Hatchery site adjacent to Fall Creek.

1.2.2 Project Description

1.2.2.1 Fall Creek Fish Hatchery

The Klamath River Renewal Project includes the removal of four dams along the Klamath River. As part of the overall Project, the existing Iron Gate Fish Hatchery (IGFH) production will be moved to the Fall Creek Hatchery site. The Fall Creek Hatchery site will be modified to upgrade existing facilities and construct new facilities for Coho (*Oncorhynchus kisutch)* and fall-run Chinook salmon (*O. tshawytscha)* production. California-Oregon Power Company (Copco) built the Fall Creek Fish Hatchery (FCFH) in 1919 as compensation for the loss of spawning grounds due to the construction of Copco No. 1 Dam. FCFH was operated by the California Department of Fish and Wildlife (CDFW) to raise approximately 180,000 Chinook salmon yearlings in continuous operation between 1979 and 2003, when it ceased operations and hatchery production on the Klamath River was consolidated at IGFH. The National Marine Fisheries Service (NMFS) and CDFW have determined the priorities for fish production at FCFH under the proposed Fish Hatchery Plan. As a state- and federally listed species in the Klamath River, Southern Oregon Northern California Coastal (SONCC) Coho Distinct Population Segment (DPS) production is the highest priority for NMFS and CDFW, followed by Chinook salmon, which support tribal, sport, and commercial fisheries. Steelhead (*O. mykiss)* production is the lowest priority. Due to limited water availability and rearing capacities at the two facilities, and recent low hatchery steelhead returns, NMFS and CDFW have determined that steelhead production will be discontinued. Table 1-1 summarizes the NMFS/CDFW goals for fish production at FCFH (data compiled from CDFW information).

Table 1-1. Fall Creek Hatchery – Fish Production Goals

Species (Juvenile Life History)	Adult Return*	Incubation Start Date	Incubation Start Number	Target Release Dates	Release Number	Release Size
Coho (Yearling)	Oct. – Dec.	Oct. – Mar.	120,000	Mar. 15 – May 1	75,000	10 fpp

Species (Juvenile Life History)	Adult Return*	Incubation Start Date	Incubation Start Number	Target Release Dates	Release Number	Release Size
Chinook (Sub-Yearling)	Oct. – Dec.	Oct. – Mar.	4.5M**	Pre-Mar. 31	1,250,000	520 fpp
Chinook (Sub-Yearling)	Oct. – Dec.	Oct. – Mar.	-	May 1 – June 15	1,750,000	90-100 fpp
Chinook (Yearling)	Oct. – Dec.	Oct. – Mar.	-	Oct. 15 – Nov. 20	250,000	10 fpp

*Adult trapping period from Iron Gate Fish Hatchery data

** Estimated Total Green Egg Requirement at Spawning

fpp = fish per pound

Since ceasing operations in 2003, the FCFH raceways remain and CDFW continues to run water through the raceways. The facility has retained its water rights, but substantial infrastructure improvements will be required to achieve the fish production goals following dam removal. FCFH improvements will occur within the existing facility footprint to minimize environmental and cultural resource disturbances, and the facility must be in operation prior to the drawdown of Iron Gate Reservoir. The water rights and maximum available flow for the Project are set at 10 cubic feet per second (cfs). This water right is non-consumptive and water must be returned to Fall Creek, with final designs addressing National Pollutant Discharge Elimination System (NPDES) water quality permit considerations. The proposed Fish Hatchery Plan requires CDFW to employ Best Management Practices to minimize pollutants and therapeutants being discharged to Fall Creek during hatchery operations.

1.3 Report Organization

This DDR is a record of the design effort for the Project and specifically describes the details of the design process and work effort. The DDR consists of a summary of the design elements, criteria, methods and approach, engineering calculations, and pertinent references. The major report sections and intended purpose are presented in Table 1-2.

Table 1-2. Major Report Sections and Purpose

Section	Description	Purpose
1	Introduction and Background	Presents the authorization, scope, background, a description of the overall Project, and the report organization.
2	Design Criteria	Summarizes the basic design criteria that are used as the basis for the design of the Fall Creek Fish Hatchery.
3	Project Description	Describes the Fall Creek Fish Hatchery Project.
4	Hydraulic Design	Presents the hydraulic analysis of the piping systems, fish ladder, and fish barrier systems.
5	Civil Design	Includes information related to the civil design of the Fall Creek Fish Hatchery and associated access around the site.

Section	Description	Purpose
6	Structural Design	Includes information related to the structural design of the FCFH buildings, concrete raceways and holding ponds, fish ladder, and barrier.
7	Mechanical Design	Includes information related to the mechanical design of the FCFH facility including supply water, internal building plumbing, and HVAC design.
8	Electrical Design	Includes information related to the electrical design of the FCFH facility.
9	Instrumentation and Controls	Includes information related to the instrumentation and control components of the FCFH facility.
11	Operation	Includes a summary of the anticipated FCFH facility operation.
10	References	Documents the references used in developing the design.
Appendices		
A	Hydraulic Design Calculations	Presents the detailed calculations related to hydraulic design.
B	Civil Design Calculations	Presents the detailed calculations related to civil design.
C	Biological Design Calculations	Presents the detailed calculations related to biological design.
D	Structural Design Calculations	Presents the detailed calculations related to structural design.
E	Mechanical Design Calculations	Presents the detailed calculations related to mechanical design.
F	Electrical Design Calculations	Presents the detailed calculations related to electrical design.

2.0 Design Criteria

2.1 Pertinent Data

Pertinent data for the Project include the assumed survey datum, topographic mapping, and references as described below.

2.1.1 Survey Datum

The Project data provided by the Klamath River Renewal Corporation (KRRC) were supplied in reference to the North American Vertical Datum of 1988 (NAVD88, Geoid 12B). This is the vertical datum that will be used on all drawings and in all calculations submitted as deliverable for the Project. The horizontal coordinate system is the California Coordinate System of 1983, Zone 1 North American Datum of 1983 (NAD83) in feet.

2.1.2 Topographic Mapping

Topographic data was supplied by CDM Smith and includes (1) Light Detection and Ranging (LiDAR) and sonar survey performed in 2018 by GMA Hydrology, Inc. for the entire site, and (2) a river transect and existing structure survey completed by the River Design Group.

2.2 References and Data Sources

A wide range of data sources and references was used in developing this TM. Specific data related to the conceptual design of the FCFH were obtained from the various technical analyses and memoranda prepared by CDM Smith, which include the following:

- CDM Smith. 2019. Basis of Design Report.
- CDM Smith. 2019. Geotechnical Data Report.
- CDM Smith. 2019. Klamath River Renewal Project Geotechnical Data Report.

Additional data sources, including publicly available aerial imagery, U.S. Geological Survey (USGS) maps, USGS streamflow gaging station data, soils maps, as-constructed drawings, and standard engineering reference documents, were used.

2.3 General Design Criteria and Standards

2.3.1 Standard List of Terms and Abbreviations

ACI	American Concrete Institute
ADM	Aluminum Design Manual
AISC	American Institute of Steel Construction
ANSI	American National Standards Institute
ASCE	American Society of Civil Engineers
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
ASME	American Society of Mechanical Engineers

ASTM	American Society of Testing and Materials
AWS	American Welding Society
CBC	California Building Code
CCOR	California Code of Regulations
CDFW	California Department of Fish and Wildlife
cfs	cubic feet per second
CGP	Construction General Permit
DI	density index
DO	dissolved oxygen
DPS	Distinct Population Segment
ECP	Erosion Control Plan
FCFH	Fall Creek Fish Hatchery
FI	flow index
ft^3	cubic feet
fpp	fish per pound
GBR	Geotechnical Baseline Report
gpm	gallons per minute
HDPE	high-density polyethylene
HEC-RAS	Hydrologic Engineering Center River Analysis System
HMI	Human Machine Interface
hp	horsepower
HVAC	Heating, Ventilation, and Air Conditioning
IBC	International Building Code
IEEE	Institute of Electrical and Electronic Engineers
IESNA	Illuminating Engineering Society of North America
IGFH	Iron Gate Fish Hatchery
ISA	Instrument Society of America
ksf	kips per square foot
KRRC	Klamath River Renewal Corporation
kW	kilowatts
lb/cf/in	pounds of fish per cubic foot of rearing volume per inch of fish length
lbs/ft^3	pounds of fish per cubic foot of rearing space
LED	Light-Emitting Diode
LiDAR	Light Detection and Ranging survey
mA	milliamperes (or milliamps)
MDD	maximum dry density
mg/L	milligrams per liter
ml/L	milliliter per liter
mm	millimeter
mm/ctu/day	millimeters per centigrade temperature unit per day
NAD	North American Datum

NAVD	North American Vertical Datum
nd	no date
NEC	National Electrical Code
NEMA	National Electrical Manufacturers Association
NESC	National Electrical Safety Code
NFPA	National Fire Protection Association
NHC	Northwest Hydraulic Consultants
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
PLC	Programmable Logic Controller
Project	Fall Creek Hatchery Project
pcf	pounds per cubic foot
psf	pounds per square foot
PVC	polyvinyl chloride
RWQCB	Regional Water Quality Control Board
SS	Structural Fill
SONCC	Southern Oregon Northern California Coastal
SCADA	Supervisory Control and Data Acquisition
TM	Technical Memorandum
TSS	total suspended solids
UL	Underwriters Laboratories
USACE	United States Army Corps of Engineers
USACE EMs	United States Army Corps of Engineers Engineer Manuals
USBR	United States Bureau of Reclamation
US DOE	United States Department of Energy
USGS	United States Geological Survey
UV	Ultraviolet
V	Volts (alternating current, if not stated otherwise)
Vac	Volts (alternating current)
Vdc	Volts (direct current)

2.4 Biological

Key biological information used in the development of design criteria are based on a biological program (bioprogram) schedule developed in conjunction with CDFW Fisheries staff. The preliminary bioprogram schedule is included with this document as Figure 2-1; biological design criteria addressed below will be discussed in reference to Figure 2-1.

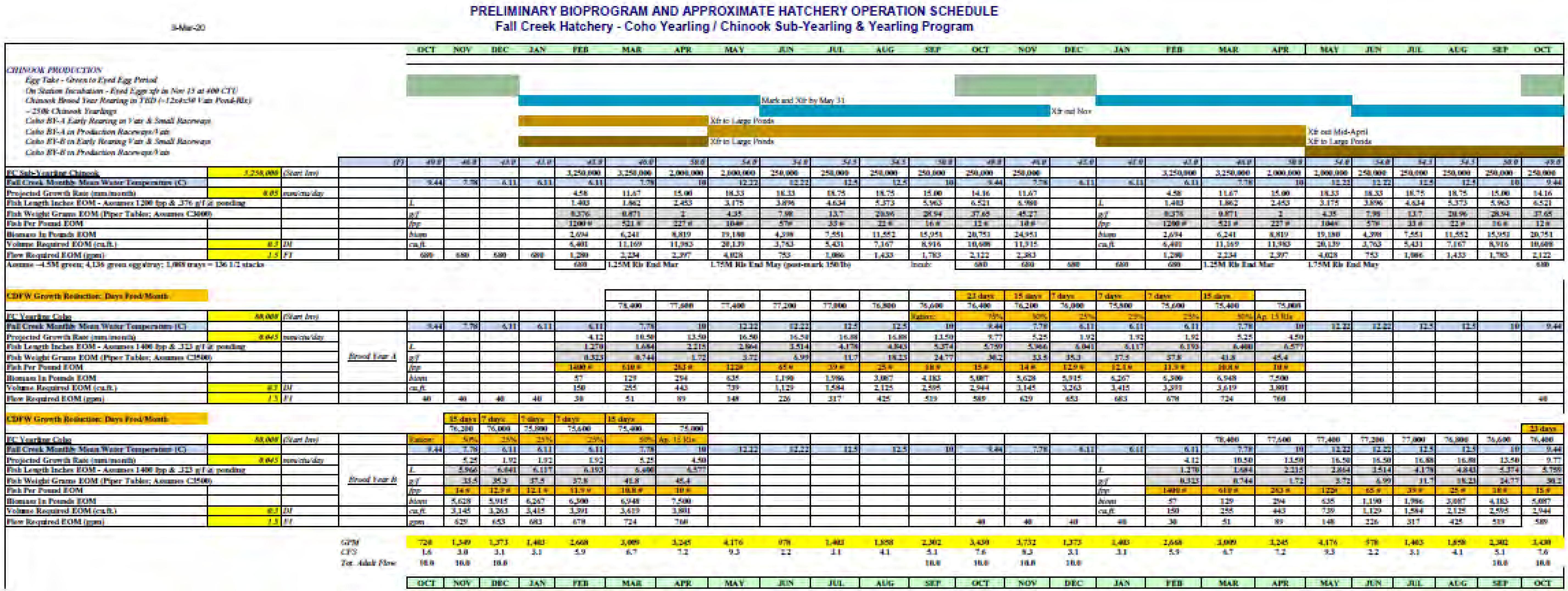

Figure 2-1. Biological Program Schedule – Fall Creek Fish Hatchery

2.4.1 Fish Development Cycle

The colored bars across the top section of Figure 2-1 depict the timing of adult spawning and resulting egg incubation, juvenile fish rearing, and a general approach to fish transfer based on marking and release (“first-feeding” vessels and “grow-out” vessels). The adult holding/spawning process is assumed to mirror current adult holding and spawning at the IGFH and occurs from October through December. Egg/alevin incubation is initiated at the onset of adult spawning and generally runs through March. Egg incubation activities are assumed to be flexible in the initial years of the program as eggs may be sourced from one or more CDFW egg production stations and/or sourced from the most appropriate natural anadromous brood sources. Early rearing will begin as first-feeding fry are ponded, and this period will generally extend until the marking/tagging is completed. The ultimate marking/tagging dates and numbers will be determined after further input from CDFW. Early-rearing tanks/vessels will be designed and sited with consideration for fish collection through the marking trailer, as well as differentiating between marked/tagged and non-marked/tagged groups. Final grow-out rearing will provide adequate rearing space and collection/release methods for fish at release.

2.4.2 Biological Variables

The primary biological variables used in the preparation of the preliminary operations schedule include water temperature, species-specific condition factor/growth rates, fish weight/length targets, and density and flow indices.

2.4.2.1 Water Temperature

Water temperature is a primary determining factor in the development and growth rate of fish. Figure 2-1 (row 2 for each cohort group) provides mean water temperature data that are used to estimate the rate of fish growth, which is also tied to feed rate. Temperature profiles for the Fall Creek source water are considered ideal for the culture of Pacific salmon. CDFW’s prior rearing experience at the Fall Creek facility with Chinook salmon demonstrate that rearing conditions are favorable for the production of high-quality juvenile salmon. CDFW-provided mean monthly water temperature data for Fall Creek is presented below in Figure 2-2.

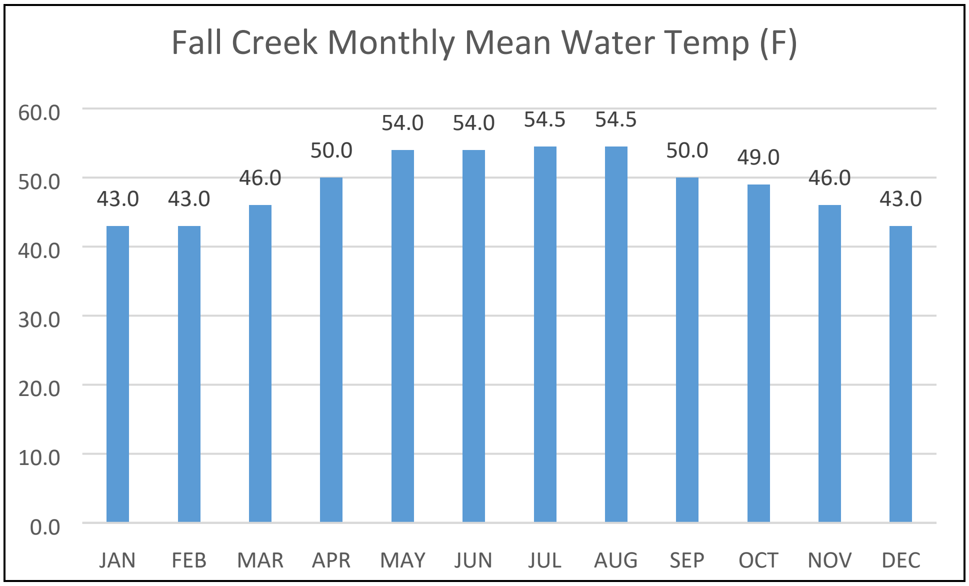

Figure 2-2. Mean Monthly Fall Creek Rearing Temperature Data (Data from L. Radford, CDFW)

2.4.2.2 Expected Growth Rates

The projected monthly growth rate shown in Figure 2-1 (row 3 for each cohort group) is 0.045 and 0.05 millimeters per centigrade temperature unit per day (mm/ctu/day) for Coho and Chinook, respectively. Growth rates are applied to mean water temperatures to develop an estimate of total growth (millimeters per month), which is tied directly to feed rate. Within an ideal water temperature range for salmonids and in the absence of feed modulation, fish will grow faster at higher water temperatures than at lower temperatures (increased daily/monthly growth in millimeters at elevated water temperature range). CDFW does not plan to use chilled water (i.e., water chiller units) for incubation and/or grow-out rearing strategies. For the new facility, CDFW will rely on ambient Fall Creek water temperature profile.

2.4.2.3 Fish Weight and Length

Row 4 of each cohort group shown in Figure 2-1 depicts the cumulative fish length in inches, which is determined by adding the growth per month to the fish length at the end of the preceding month. The mean weight of individual fish in grams is shown in the row below the length (row 5); mean weights are obtained from Piper et al. (1982) Length-Weight Tables for the specific condition factor of fish in culture (Coho C3500, Chinook C3000; $Cx10^{-7}$).

2.4.2.4 Density Index

Density index (DI) is a function of pounds of fish per cubic foot of rearing volume per inch of fish length (lbs fish/cf volume/length [inch]). CDFW staff have agreed to rear fish at a maximum DI of 0.3 for the Coho and Chinook programs at Fall Creek; 0.3 is a conservative DI that is reflective of similar conservation/recovery programs for anadromous Pacific salmon juveniles throughout the Pacific Northwest.

The DI is then used to calculate the total volume of rearing space required in terms of cubic feet. Figure 2-1 (row 8) shows the rearing volume required at the end of each month as fish size increases from left to right. The total volume is then divided by the cubic foot volume of individual rearing tanks/vessels to determine the total number of rearing units required.

2.4.2.5 Flow Index

Flow index (FI) is a function of pounds of fish divided by fish length in inches times flow in gallons per minute (gpm). Flow index is an indication of how much oxygen is available for fish metabolism and is adjusted based on the elevation of the project site and water temperature, both of which affect the amount of oxygen in the water supply at saturation. CDFW staff have agreed to rear fish at a maximum FI of 1.50 for the Coho and Chinook programs at Fall Creek; 1.50 is a conservative FI that is reflective of similar conservation/recovery programs for anadromous Pacific salmon juveniles throughout the Pacific Northwest (at similar elevations and water temperature profiles).

2.4.3 Egg Take and Fish Survival

Current rearing production program scenarios plan for a total of 75,000 Coho salmon and approximately 3.25 million Chinook salmon at various release dates. Mean survival rate estimates provided by CDFW for the IGFH program suggest a green egg to ponding (first-feeding) survival rate of approximately 73 percent. Based on the 73 percent survival estimates, approximately 120,000 green eggs will be required for the Coho program and approximately 4.5 million green eggs will be required for the Chinook program. Acknowledging improved incubation water quality at Fall Creek (vs. poorer Iron Gate water quality) and reduced tray loading densities, survival rates are anticipated to increase as the program develops rearing techniques that favor increased survival.

2.4.4 Incubation and Rearing Facilities

This section provides a brief summary of the incubation and rearing flows, as well as rearing volumes depicted in Figure 2-1.

2.4.4.1 Incubation

Incubation systems currently at IGFH will be used for egg/alevin incubation at Fall Creek. A total of 130 incubation stacks are currently available for future rearing needs. The existing incubation units are vertical stack incubators with a double-stack arrangement with 15 useable trays per stack (full-stack/with the top tray used as sediment tray). Water flow requirements are modeled at 5 gpm, per manufacturer’s recommendations, which is an industry standard, regardless of eight-tray or 16-tray configuration.

Early hydraulic modeling efforts indicated that egg incubation systems (vertical stack incubators) would require auxiliary pumping if full-stack arrangements were required (16-tray configuration). In stressing the importance of gravity-flow systems to the extent possible, CDFW staff elected for an eight-tray (half-stack) configuration for all incubation systems at FCFH. Additionally, CDFW staff acknowledge that reducing the tray loading densities for the Chinook program will likely result in increased survival. The current design efforts will assume approximately 50 to 55 ounces of Chinook eggs per tray rather than current approximately 100 ounces/tray currently used at IGFH.

Incubation requirements based on new loading densities for Chinook are approximately 136 half-stack incubators (1,088 trays) requiring approximately 680 gpm. Chinook incubator units are proposed as eight-tray loading with an extra incubation tray on top of the unit acting as a sediment tray (ninth tray without screening used to settle sediment). Incubation requirements for the Coho program are unchanged from the original planning efforts and require six half-stack incubators (approximately 40 trays required) using approximately 30 gpm of water. Coho incubator units have the flexibility (tray space) to accommodate a seven-tray loading configuration with the eighth tray (top) used as a sediment tray.

2.4.4.2 Early Rearing

First-feeding and early-rearing vessel requirements are based on fish size estimates from the bioprogram for the period of ponding through the marking stage of rearing. Maximum bioprogram requirements for rearing space and water flow resulted in approximately 3,850 cubic feet of rearing space and approximately 760 gpm for Coho and approximately 20,200 cubic feet and 4,050 gpm for Chinook. Acknowledging the maximum space and flow required at peak production for each species, the estimated rearing space required for early-rearing through marking phases are identified below:

- Coho Early-Rearing: Total rearing required at mark size of about 150 fish per pound (fpp) – 650 ft^3
- Chinook Early-Rearing: Total rearing required at mark size of about 150 fpp – 16,000 ft^3

Total early-rearing space provided for Coho is approximately 825 ft^3 of fiberglass vat rearing and an additional 1,200 ft^3 available in renovated concrete raceways; the renovation of the concrete raceways provides a total of eight individual rearing containers that can be used to maximize the population compartmentalization of the listed Coho stock. Total early-rearing space provided for Chinook is approximately 19,200 ft^3 and provides maximum compartmentalization for cohort groups of between 204,000 (16 rearing units) and 408,000 (eight rearing units) fish, depending on mean fish size.

The maximum production/flows for Coho occur at mid-April release and the maximum biomass/flows for Chinook occur at late-May release, as shown in. Coho brood cohorts (first-feeding fry and smolt program) will overlap from early-ponding through smolt release; Coho production for the second cohort is assumed to require approximately 650 ft^3 of rearing space (the four fiberglass vats) and 90 gpm from first-feeding through late-April transfer to larger production ponds (post-smolt release).

2.4.4.3 Juvenile Rearing

Grow-out vessel requirements based on Figure 2-1 result in a maximum grow-out rearing need of 3,800 ft^3 of Coho rearing space (April release) and approximately 20,200 ft^3 of Chinook rearing space (May release) based upon the bioprogram. Total rearing volume provided in the facility design is 4,190 ft^3 for Coho and 20,340 ft^3 for Chinook. Raceway drains for both Coho and Chinook units have been designed to allow for volitional emigration of fish directly to Fall Creek; volitional water supply routing is described later in this document.

2.4.4.4 Adult Holding

Adult holding and spawning ponds have been designed per CDFW recommendations and align with NOAA guidelines for anadromous adults as closely as possible. The existing raceway series currently on-site (south of Copco Road) will be retained, renovated, and will provide sufficient space to hold the requested 100 Coho and 200 Chinook pre-spawn adults. One of the four existing raceways will act as a primary trapping and handling pond, with two ponds renovated to act as longer-term holding for pre-spawn Coho and Chinook adults. The remaining pond will be used as a settling pond and is described later in the report. All non-cleaning (effluent) flow, which will be a maximum of 10 cfs, will be routed to the adult ponds and used for adult holding and fish ladder attraction flows when required, which is assumed between September and December.

The three adult rearing ponds will be renovated with screen and stoplog keyways (and adequate quiescent zones; effluent collection) to allow for the potential short-term rearing of juvenile Chinook that would have otherwise been released early because of space limitations in the Chinook rearing raceway complex. Flow to the holding ponds is second-pass, untreated water from the Coho and Chinook rearing facilities. However, the second pass water should be of sufficient quality and oxygen levels for surplus juvenile Chinook because of the conservative density and flow indices used in the biological program. Assuming three raceways with approximately 2,500 ft^3 of vacant space per unit (12.5’W x 50’L x 4’D useable space; 7,500 ft^3 total), serial reuse flows from the upper production units, and using a 0.3 density index, the maximum permissible weight of 3.175-inch fish (about 104 fpp) would be approximately 7,100 pounds (about 740,000 fish at 104 fpp). Drains have been designed to provide volitional emigration of fish to Fall Creek; volitional water supply routing from this series is described later in this document.

2.4.5 Peak Water Demand

Appendix A provides a water budget for an entire calendar year with a peak water demand of 9.3 cfs projected for May of each year immediately prior to Chinook sub-yearling releases and when juvenile Coho are in early rearing containers. The projected annual water budget by month is also provided below in Table 2-1.

Table 2-1. Fall Creek FH Water Requirements – Full Production

Month:	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Total Juv. CFS	3.1	5.9	6.7	7.2	9.3	2.2	3.1	4.1	5.1	7.6	8.3	3.1
Total Ladder CFS	-	-	-	-	-	-	-	-	10.0	10.0	10.0	10.0

2.5 Civil

2.5.1 Erosion Control Plan

The contractor will be required to obtain a Construction Storm Water General Permit from the California State Water Resources Control Board prior to construction. Construction General Permits (CGPs) are required for construction projects that result in greater than 1 acre of soil disturbance. The CGP requires temporary and post-construction Best Management Practices to prevent erosion and reduce sediment discharges from construction sites.

Prior to permit issuance by Siskiyou County, submittal of an Erosion Control Plan (ECP) to the appropriate Director at Siskiyou County is required. The ECP shall include methods for controlling runoff, erosion, and sediment movement.

2.5.2 Hatchery Effluent Discharge

The California Regional Water Quality Control Board (RWQCB) requires hatchery facilities that discharge effluent to obtain an NPDES permit to regulate the hatchery effluent discharge. It is assumed that the waste stream from FCFH will be required to meet effluent limitations included in the California Regional Water Quality Control Order No. R1-2015-0009, General NPDES CAG131015, Waste Discharge Requirements for Cold Water Concentrated Aquatic Animal Production Facility Discharges to Surface Waters.

2.5.3 Stormwater Control

The federal Clean Water Act requires facilities that discharge stormwater runoff to obtain an NPDES permit to regulate the discharge of stormwater into surface waters such as Fall Creek. The design of the FCFH site will minimize the addition of impervious areas. The addition of impervious areas will be limited to rooftops and gravel surfacing around the site. The drainage from new impervious areas will not be hydraulically connected to Fall Creek and will be treated through on-site ground infiltration.

2.5.4 Grading

According to the California Building Code adopted by the County of Siskiyou design standards, slopes shall be no steeper than 2 horizontal (H) to 1 vertical (V). Steeper slopes may be allowed if the Building Official determines they will be stable or if a geotechnical engineer certifies that the site has been investigated and that the proposed deviation will be and will remain structurally stable.

2.5.5 Site Access

Modeling to simulate site access conditions was performed using AutoTurn software and the following design vehicles:

- Standard pickup truck (2019 Ford F-450, Crew Cab).
- Marking and tagging trailer for access and egress from the Coho and Chinook rearing ponds (43.0-foot-long Newmar X-Aire 2009, on a 21.85-foot-long design truck, based on typical marking trailers used by the U.S. Fish and Wildlife Service).
- Septic pump truck for access and egress from the settling pond (33.6-foot-long design truck).

2.6 Hydraulic

The proposed hydraulic engineering criteria are presented in the tables below. A brief description of the contents of each table is as follows:

- **Table 2-2.** Hydraulic Standards, References, and Standards of Practice
- **Table 2-3.** Governing Hydrological Criteria for Adult Salmon Facilities

- **Table 2-4.** Inlet Structure Hydraulic Criteria
- **Table 2-5.** Supply Piping Hydraulic Criteria
- **Table 2-6.** Drain Piping Hydraulic Criteria
- **Table 2-7.** Volitional Fish Release Pipe Hydraulic Criteria
- **Table 2-8.** Coho Rearing Hydraulic Criteria
- **Table 2-9.** Chinook Rearing Hydraulic Criteria
- **Table 2-10.** Adult Holding Hydraulic Criteria
- **Table 2-11.** General NPDES CAG131015 Effluent Limitations
- **Table 2-12.** Settling Pond Hydraulic Criteria
- **Table 2-13.** Fish Ladder Hydraulic Criteria
- **Table 2-14.** Fish Barrier Hydraulic Criteria

2.6.1 Applicable Codes and Standards

The following codes, standards, and specifications will serve as the general design criteria for the hydraulic design of the FCFH facilities.

Table 2-2. Hydraulic Standards, References, and Standards of Practice

Standard	Reference
ASCE, 1975	American Society of Civil Engineers (ASCE). 1975. *Pipeline Design for Water and Wastewater*. ASCE: New York, NY.
CDFW, 2004	California Department of Fish and Wildlife (CDFW). 2004. *California Salmonid Stream Habitat Restoration Manual.* March 2004.
Chow, 1959	Chow, V.T. 1959. *Open Channel Hydraulics*. McGraw-Hill Book Company: New York, NY.
Idaho DEQ, nd	Idaho Department of Environmental Quality. nd. *Idaho Waste Management Guidelines for Aquaculture Operations.*
Lindeburg, 2014	Lindeburg, M.R. 2014. *Civil Engineering Reference Manual, Fourteenth Edition.* Professional Publications, Inc.: Belmont, CA.
Miller, 1990	Miller, D.S. 1990. *Internal Flow Systems.* The Fluid Engineering Centre, BHRA: Cranfield, UK.
NMFS, 2011	National Marine Fisheries Service (NMFS). 2011. *Anadromous Salmonid Passage Facility Design*. National Oceanic and Atmospheric Administration, NMFS, Northwest Region: Portland, OR.
NOAA Atlas 14	National Oceanic and Atmospheric Administration (NOAA). 2014. *Precipitation-Frequency Atlas of the United States, Volume 6 Version 2.3: California.* NOAA, National Weather Service: Silver Spring, MD.
Rossman, 2000	Rossman, L.A. 2000. EPANET2, User's Manual. U.S. Environmental Protection Agency (USEPA), Office of Research and Development, National Risk Management Research Laboratory: Cincinnati, OH.
Tullis, 1989	Tullis, J.P. 1989. *Hydraulics of Pipelines: Pumps, Valves, Cavitation, Transients*. John Wiley & Sons, Inc.

Standard	Reference
USFWS, 2017	U.S. Fish and Wildlife Service (USFWS). 2017. *Fish Passage Engineering Design Criteria*. USFWS, Northeast Region RG, Hadley, MA.
USBR, 1987	U.S. Bureau of Reclamation (USBR). 1987. *Design of Small Dams*. U.S. Department of the Interior, USBR: Washington, D.C.

2.6.2 Fall Creek Hydrology

USGS Gage Station No. 11512000 was used to estimate the hydrology of Fall Creek near the proposed FCFH site. This gage station is located approximately two-thirds of a mile downstream from the existing lower raceway bank at the site, and therefore provides the best representation of flows at the site. The data record consists of daily average discharge, and extends from 1933 to 1959, and then from 2003 to 2005. Table 2-3 below presents the governing hydrological criteria used as the basis of the design for adult collection facilities at FCFH.

Table 2-3. Governing Hydrological Criteria for Adult Salmon Facilities

Criteria	Units	Value	Comments
Period of Anadromous Fish Present at Site	-	Oct – Dec	See Bioprogram
95% Exceedance Streamflow (Fish Passage Low Flow)	cfs	23.4	NMFS, 2011; for period when anadromous fish are present at the site
50% Exceedance Streamflow (Fish Passage Typical Flow)	cfs	30.1	NMFS, 2011; for period when anadromous fish are present at the site
5% Exceedance Streamflow (Fish Passage High Flow)	cfs	46.8	NMFS, 2011; for period when anadromous fish are present at the site
1% Exceedance Streamflow (Fish Passage High Flow)	cfs	71.9	CDFW, 2004; alternative high flow definition, for period when anadromous fish are present at the site
1% Exceedance Streamflow (Juvenile High Flow)	cfs	76.9	High flow for maximum flow month during juvenile release (March)
2-year Flood Event Streamflow	cfs	115.3	Adjusted from downstream USGS Gage 11512000
100-year Flood Event Streamflow	cfs	756.2	Adjusted from downstream USGS Gage 11512000
2-year, 24-hour Precipitation Depth	in	1.94	NOAA Atlas 14, Volume 6, Version 2
10-year, 24-hour Precipitation Depth	in	2.88	NOAA Atlas 14, Volume 6, Version 2
100-year, 24-hour Precipitation Depth	in	4.43	NOAA Atlas 14, Volume 6, Version 2

2.6.3 Fall Creek Intake Structure

A non-consumptive water diversion from Fall Creek will support hatchery operations by construction of a new intake structure at Dam A. Water demand for facility operations will vary to meet biological criteria for various life stages of fish development. Table 2-4 below summarizes the design criteria used to support the design of the intake structure at Dam A on Fall Creek.

Table 2-4. Intake Structure Hydraulic Criteria

Criteria	Units	Value	Comments
Design Flow	cfs	10	FCFH Water Right and Proposed Maximum Diversion Flow from Fall Creek to Project Site
Design Water Surface Elevation	ft	2510.4	Elevation of Dam A at crest
Trash Rack Percent Open Area	%	50	Typical, subject to screen manufacturer specifications
Maximum Allowable Trash Rack Occlusion	%	40	Assumed, conservative for an automatically cleaned screen
Pipe Entrance Loss Coefficient, K_e	-	0.7	USBR, 1987; Maximum for open pipe with downstream isolation valve
Screen Cleaning System	-	See Comment	Automatic active system.

2.6.4 Supply Piping

The supply piping network was analyzed using EPANET2 software (Rossman, 2000) to determine the head at the design locations, and to size the water supply pipes in the network. The supply piping consisted of four main distribution networks: (1) the Coho building distribution piping, (2) the Chinook raceway distribution piping, (3) the Chinook Incubation Building distribution piping, and (4) the adult holding pond distribution piping. These constituted four separate models in the EPANET2 software. Table 2-5below summarizes the supply piping hydraulic criteria used to develop the EPANET2 model.

Table 2-5. Supply Piping Hydraulic Criteria

Criteria	Units	Value	Comments
Pipe Hazen-Williams Coefficient	-	120	ASCE 1975; Small diameter of good workmanship or large diameter of ordinary workmanship. Schedule 80 PVC material.
Minor Loss Coefficient – 90° Bend	-	0.24	Tullis, 1989
Minor Loss Coefficient – 45° Bend	-	0.10	Tullis, 1989
Minor Loss Coefficient – 22.5° Bend	-	0.06	Tullis, 1989
Minor Loss Coefficient – Butterfly Valve (Open)	-	0.2	Tullis, 1989
Minor Loss Coefficient – Tee (Branch Flow)	-	1.0	Miller, 1990; Approx. 60%-40% Flow Split
Minor Loss Coefficient - Tee (Line Flow)	-	0.2	Miller, 1990; Approx. 60%-40% Flow Split
Minor Loss Coefficient - Reducer	-	See Comment	Calculated based on relative pipe size according to Tullis 1989

2.6.5 Drain Piping

The online drain pipeline will convey effluent from the rearing vessels to the adult holding ponds and will ultimately be discharged into Fall Creek via the new fish ladder. All outlet pipes and trunk lines were sized to maintain open-channel flow. Table 2-6 below summarizes the drain piping hydraulic criteria used to develop the open-channel hydraulic calculations.

Table 2-6. Drain Piping Hydraulic Criteria

Criteria	Units	Value	Comments
Gravity Flow – Maximum Flow Depth	%	75	Prevent pressurizing of pipe for presence of waves, etc. Generally less than 70%
Minimum Self-Cleaning Velocity	ft/s	1.5	Typical, Sewer Design
Typical Self-Cleaning Velocity	ft/s	2.0	Typical, Sewer Design
Gravity Flow Pipe Manning's Roughness Coefficient, n	-	0.013	Maximum; Plastic Pipe
Pressure Pipe Relative Roughness	in	$6.0\text{x}10^{-5}$	Lindeburg, 2014; Plastic Pipe
Minor Loss Coefficient – 90° Bend	-	0.24	Tullis, 1989
Minor Loss Coefficient – 45° Bend	-	0.10	Tullis, 1989
Minor Loss Coefficient – Tee (Branch Flow)	-	1.0	Miller, 1990; Approx. 60%-40% Flow Split
Minor Loss Coefficient - Tee (Line Flow)	-	0.2	Miller, 1990; Approx. 60%-40% Flow Split
Orifice Discharge Coefficient	-	0.62	Lindeburg, 2014; Sharp-Edge

2.6.6 Volitional Fish Release Pipes

The volitional fish release pipes will convey juvenile fish from the rearing raceways to various discharge points in Fall Creek. Pipe design was subject to design criteria from NMFS (2011) for fish bypass pipes. Table 2-7 below summarizes the fish release piping hydraulic design criteria.

Table 2-7. Volitional Fish Release Pipe Hydraulic Criteria

Criteria	Units	Value	Comments
Gravity Flow – Maximum Flow Depth	%	75	Prevent pressurizing of pipe for presence of waves, etc. NMFS, 2011; Section 11.9.3.2 Generally less than 70%
Gravity Flow – Minimum Flow Depth	%	40	NMFS, 2011; Section 11.9.3.9
Minimum Bend Radius R/D	-	5.0	NMFS, 2011; Section 11.9.3.4 Greater for supercritical flows; Bend radius 5 times the pipe diameter

Criteria	Units	Value	Comments
Typical Access Port Spacing	ft	150	NMFS, 2011; Section 11.9.3.5
Maximum Pipe Velocity	ft/s	12.0	NMFS, 2011; Section 11.9.3.8
Minimum Pipe Velocity	ft/s	6.0	NMFS, 2011; Section 11.9.3.8 Generally less than 6.0 ft/s, absolute minimum of 2.0 ft/s
Minimum Pipe Diameter	in	10	NMFS, 2011; Table 11-1
Plunge Pool Maximum Impact Velocity	ft/s	25.0	NMFS, 2011; Section 11.9.4.2
Plunge Pool Minimum Depth	ft	4.0	USFWS, 2017; Reference Plate 9-2 Up to an equivalent drop height of 16', then ¼ of the equivalent drop height

2.6.7 Rearing Facilities

Based upon the biological design criteria summarized above, Table 2-8, Table 2-9, and Table 2-10 below summarize the hydraulic criteria, flow, and volume requirements for each of the rearing facilities at FCFH.

Table 2-8. Coho Rearing Hydraulic Criteria

Criteria	Units	Value	Comments
Maximum Rearing Volume Requirement	ft^3	3,850	See Bioprogram
Maximum Flow Requirement	gpm	765	See Bioprogram; Flow to rearing raceways only, additional flow to first-feeding vessels
Cleaning Method	-	See Comment	Vessels to be cleaned using vacuum system
Cleaning Maximum Flow	gpm	200	Assumed. Two vessels cleaned at one time. Intermittent flow.

Table 2-9. Chinook Rearing Hydraulic Criteria

Criteria	Units	Value	Comments
Maximum Rearing Volume Requirement	ft^3	20,190	See Bioprogram
Maximum Flow Requirement	gpm	4,040	See Bioprogram
Cleaning Method	-	See Comment	Vessels to be cleaned using vacuum system
Cleaning Maximum Flow	gpm	200	Assumed

Table 2-10. Adult Holding Hydraulic Criteria

Criteria	Units	Value	Comments
Chinook Holding Capacity	#	200	See Bioprogram
Coho Holding Capacity	#	100	See Bioprogram
Adult Chinook Weight	lbs	12	Estimated, CDFW
Adult Coho Weight	lbs	8	Estimated, CDFW
Minimum Holding Volume	ft^3/lb-biomass	0.75	NMFS, 2011; long-term holding: Holding > 72 hours, 0.75 x Weight of Fish: If temperature exceeds 50°F, reduce pounds of fish by 5% for each degree over 50°F
Minimum Adult Holding Flow	gpm/fish	2 (long-term holding)	NMFS, 2011; 0.67 gpm per fish for short-term holding. Increase three times for fish held over 72 hours.
Jump Protection Height	ft	5.0	NMFS, 2011; to meet jump minimization criterion, alternatively nets, coverings, or sprinklers may be used

2.6.8 FCFH Wastewater Treatment

Flow-through water through the rearing facilities will be discharged to the adult holding ponds and ultimately through the fish ladder without treatment. Wastewater flows consisting of solids collected through vacuuming rearing vessels and flows treated with therapeutants will be discharged to a new settling pond for treatment. The downstream end of the settling pond will be equipped with an overflow structure that will divert overflows into the fish ladder to be mixed with the adult holding pond overflows and ultimately to Fall Creek.

The east-most pond in the existing lower concrete raceway bank will be repurposed as a settling pond that will be used to settle out any biosolids or other solid waste from cleaning of the upstream facilities. This pond will be refurbished and parsed into two distinct chambers such that solids can be dried. It is assumed that the waste stream from FCFH will be required to meet effluent limitations included in the California Regional Water Quality Control Order No. R1-2015-0009, General NPDES CAG131015, and Waste Discharge Requirements for Cold Water Concentrated Aquatic Animal Production Facility Discharges to Surface Waters. The General NPDES CAG131015 effluent limitations and the hydraulic criteria used to design the settling basin are summarized in Table 2-11 and Table 2-12 below.

Table 2-11. General NPDES CAG131015 Effluent Limitations

Criteria	Units	Value	Comments
Average Monthly Total Suspended Solids (TSS)	mg/L	8	Net Increase Over Influent Limitations
Maximum Daily TSS	mg/L	15	Net Increase Over Influent Limitations
Average Monthly Settleable Solids	ml/L	0.1	Net Increase Over Influent Limitations
Maximum Daily Settleable Solids	ml/L	0.2	Net Increase Over Influent Limitations

Criteria	Units	Value	Comments
pH	-	7 to 8.5	Receiving water shall not be depressed below or above the pH values identified. If the influent exceeds a pH of 8.5, the pH of the effluent shall not exceed the pH of the influent.
Receiving Water Dissolved Oxygen (DO) Non-Spawning	mg/L	≥7.0	Effluent shall not cause the dissolved oxygen (DO) of the receiving water to be depressed below 7.0 mg/L during non-spawning and egg incubation periods.
Receiving Water DO during Critical Spawning and Egg Incubation Periods	mg/L	≥9.0	Effluent shall not cause the DO of the receiving water to be depressed below 7.0 mg/L during spawning and egg incubation periods.
Turbidity	%	20	Effluent shall not cause receiving waters to be increased more than 20% above naturally occurring background levels.
Temperature	ºF	≤5	Net Increase above natural temperature of receiving water.

Table 2-12. Settling Pond Hydraulic Criteria

Criteria	Units	Value	Comments
Design Discharge	gpm	200	Only water used during vacuum cleaning routed through the settling pond. Intermittent flow.
Design Settling Velocity	ft/s	1.51×10^{-3}	Idaho DEQ, nd; Settling velocity is the maximum overflow rate from the settling pond
Overflow Weir Discharge Coefficient	-	3.33	Assumed

2.6.9 FCFH Fish Ladder

A concrete fish ladder will be constructed from Fall Creek up to the existing concrete outlet structure at the lower raceway bank. The ladder will terminate at the finger weir at the downstream end of the trapping and sorting pond and will convey fish into the pond for sorting. The fish ladder will be of the Denil steeppass type as described in the NMFS (2011) guidelines, and will have two pools separated by a weir at the top for turning into the pond structure. The design criteria used to design the fish ladder, so that the fish ladder is passable to the target fish with available flow, are included in Table 2-13 below.

Table 2-13. Fish Ladder Hydraulic Criteria

Criteria	Units	Value	Comments
Fish Ladder Type	-	See Comment	Denil Steeppass
Design Discharge	cfs	10	Full water right
Minimum Attraction Flow	cfs	4.7	NMFS, 2011; Section 4.2.2.3; 10% Fish Passage High Flow
High Tailwater Elevation	ft	2,484.77	Modeled in HEC-RAS
Typical Tailwater Elevation	ft	2,484.27	Modeled in HEC-RAS
Low Tailwater Elevation	ft	2,484.12	Modeled in HEC-RAS
Debris Characterization		See Comment	NMFS, 2011; Section 4.10.2.1; Very little debris is expected as this is the downstream extents of the facility and water will have been screened multiple times
Maximum Slope	%	20	NMFS, 2011; Section 4.10.2.1
Maximum Average Chute Velocity	ft/s	5	NMFS, 2011; Section 4.10.2.1
Maximum Horiz. Distance between Rest Pools	ft	25	NMFS, 2011; Section 4.10.2.1
Minimum Flow Depth	ft	2	NMFS, 2011; Section 4.10.2.1
Minimum Flow Depth over Weir	ft	1.0	NMFS, 2011; Section 4.5.3.2
Energy Dissipation Factor	ft-lbs/s/ft^3	4.0	NMFS, 2011; Section 4.5.3.5

2.6.10 FCFH Fish Barriers

A system of fish exclusion barriers will be constructed that will (1) exclude adult and juvenile fish passage upstream of existing Dams A and B year-round, and (2) direct adult fish into the fish ladder during the trapping season. The fish barrier system will consist of three components: (1) a high-velocity concrete apron on the downstream side of Dam A, (2) a high-velocity concrete apron on the downstream side of Dam B, and (3) a set of removable picket panels on a concrete apron immediately upstream of the fish ladder. The NMFS requirements and design criteria for both velocity barriers at Dams A and B, and for a picket barrier at the fishway entrance are presented in Table 2-14 below.

Table 2-14. Fish Barrier Hydraulic Criteria

Criteria	Units	Value	Comments
Fishway Entrance (Trapping Only)			
Fish Barrier Type	-	-	Picket Barrier
Adult Fish Passage High Flow	ft^3/s	71.9	1% Exceedance during months of October - December
Adult Fish Passage Low Flow	ft^3/s	23.4	95% Exceedance during months of October - December
Juvenile Fish Passage High Flow	ft^3/s	76.9	1% Exceedance during March (max release month)
Juvenile Fish Passage Low Flow	ft^3/s	23.4	95% Exceedance during May (min release month)
Maximum Picket Clear Spacing	in	1.0	NMFS, 2011; Section 5.3.2.1
Maximum Average Velocity Through Barrier	ft/s	1.0	NMFS, 2011; Section 5.3.2.2; Discharge evenly distributed over gross wetted area
Maximum Head Differential (over clean picket condition)	ft	0.3	NMFS, 2011; Section 5.3.2.3
Minimum Picket Freeboard on Fish Passage High Flow	ft	2.0	NMFS, 2011; Section 5.3.2.6
Minimum Submerged Depth at Fish Passage Low Flow	ft	2.0	NMFS, 2011; Section 5.3.2.7; often relaxed in smaller drainages such as this
Minimum Picket Porosity	%	40	NMFS, 2011; Section 5.3.2.8
Sill/Apron Construction	-	See Comment	Picket barrier sill shall consist of a concrete sill with cutoff walls
Dams A & B (Year-Round)			
Fish Barrier Type	-	-	Velocity Barrier
Dam A High Flow	ft^3/s	50.0	Maximum powerhouse discharge
Dam A Low Flow	ft^3/s	15.0	Minimum flow requirement downstream of Dam A
Dam B Juvenile High Flow	ft^3/s	62.1	1% Exceedance during March (max release month); adjusted to Dam B reach
Dam B Fish Passage High Flow	ft^3/s	56.9	1% Exceedance during months of October – December; adjusted to Dam B reach
Dam B Fish Passage Low Flow	ft^3/s	8.4	95% Exceedance during months of October – December; adjusted to Dam B reach
Minimum Weir Height	ft	3.5	NMFS, 2011; Section 5.4.2.1
Minimum Apron Length	ft	16	NMFS, 2011; Section 5.4.2.2
Minimum Apron Slope	ft/ft	1 / 16	NMFS, 2011; Section 5.4.2.3
Maximum Weir Head	ft	2.0	NMFS, 2011; Section 5.4.2.4

Criteria	Units	Value	Comments
Downstream Apron Elevation	-	-	Above fish passage high flow tailwater

2.7 Geotechnical

To support final engineering efforts, the following geotechnical criteria will be required:

- Soil Bearing Pressure
- Water Table Height
- Active/Passive Lateral Earth Pressure
- Passive Soil Pressure (Lateral)
- Soil Weight
- Soil Friction Factor
- Site Class as Defined by ASCE 7-16 Table 3.13
- Frost Depth
- Minimum Footing Bearing Depth
- Minimum Footing Width
- Anticipated Total Settlement
- Anticipated Differential Settlement

CDM Smith and AECOM Technical Services, Inc. prepared a Geotechnical Data Report for KRRC in June 2019. Two borings, B-13 and B-14, were drilled near Fall Creek Bridge by Gregg Drilling between September 25 and October 18, 2019, with a truck-mounted Mobile B-53 drill rig. The borings reached depths of 21 feet (B-13) and 29 feet (B-14) below ground surface.

The Project site is mapped as Quaternary (Qv) and Tertiary (Tv) volcanic rock with nearby landslide deposits (Qls) associated with steep slopes on the east side of Fall Creek and just south of the Project site. Cobble- and boulder-sized rocks were observed on the ground surface at the proposed hatchery site and will likely need to be cleared to support construction. The borings advanced in the Project vicinity indicate approximately 18 inches of fill (road base) overlying slightly to completely weathered basalt. Based on the presence of sand, clay, and root structures at depth, we interpreted the deposit to be colluvium consisting of cobbles and boulders within a clay/sand matrix. Colluvium was interpreted to extend to the depths explored in boring B-13 and to a depth of 13 feet in boring B-14. Highly weathered andesite was observed below the colluvium in boring B-14 and extended to the depth explored (29 feet).

2.8 Structural

The design criteria apply to all design procedures to be implemented during the Project design phase. Structural design considerations listed in this section—including detailing of structural components, material selection, and design requirements—are intended to be incorporated into Project design. The structural facilities consists of 11 main systems: (1) the intake structure, (2) the Dam A velocity barrier,

(3) the Dam B velocity barrier, (4) the Coho building, (5) the Chinook raceways, (6) the Chinook Incubation Building, (7) the Spawning Building, (8) the adult holding ponds, (9) the meter vault, (10) the fish ladder, and (11) the temporary picket barrier.

2.8.1 Applicable Codes and Standards

The following codes, standards, and specifications will serve as the general design criteria for the structural design of the facilities. The applicable version of each document is the latest edition in force unless noted otherwise. References to the specific codes and standards will be included in the applicable technical specifications as the final design documents are prepared.

The structural design, engineering, materials, equipment, and construction will conform to the codes and standards listed in Table 2-15.

Table 2-15. Structural Codes and Standards

Code	Standard
2018 IBC	2018 International Building Code
2019 CBC	2019 California Building Code
SEI/ASCE 7-16	Minimum Design Loads for Buildings and Other Structures, 2016 Edition
ANSI/AISC 360-16	Specification for Structural Steel Buildings, 2016 Edition
AISC 341-16	Seismic Provisions for Structural Steel Buildings, 2016 Edition
ACI 318-14	Building Code Requirements for Structural Concrete
ACI 350-06	Code requirements for Environmental Engineering Concrete Structures
ACI 350.4R-04	Design Considerations for Environmental Engineering Concrete Structures
ADM1-2015	Aluminum Design Manual, 2015 Edition
AWS D1.1-2020	Structural Welding Code – Steel, 2020 Edition
AWS D1.2-16	Structural Welding Code – Aluminum, 2016 Edition

The following references are used in development of the structural design elements of the Project:

- American Institute of Steel Construction (AISC) (2017). "Steel Construction Manual," Fifteenth Edition.
- County of Siskiyou Building Code – Design Information, https://www.co.siskiyou.ca.us/building/page/design-information.

2.8.2 Materials

The material properties assumed for preparation of the design and engineering are listed in Table 2-16.

Table 2-16. Structural Material Properties

Structural Stainless Steel	
Bars and Shapes	ASTM A240, Type S31600
Plates	ASTM A240, Type S31600

Hollow Sections	ASTM A312, Type S31600
Structural bolts	ASTM F593 Type 316
Nuts and washers	ASTM F593 Type 316
Anchor bolts	ASTM F593 Type 316
Miscellaneous	
Grating	Fiberglass reinforced plastic (FRP)
Access stairs	Fiberglass reinforced plastic (FRP)
Handrails	Fiberglass reinforced plastic (FRP)
Aluminum alloy shapes	6061-T6
Aluminum alloy plates	5052-H32
Concrete	
Concrete	4,500 psi normal weight
Rebar	ASTM A615, Grade 60

2.8.3 Design Loads

The general loads considered in the design of the facilities are summarized in this section. All loads will be combined per the requirements of ASCE 7 for the various loading conditions to assess factors of safety. The actual design loads for each structure are included on the structural drawings.

2.8.3.1 Dead Load

The structural system for all Project elements will be designed and constructed to support all dead loads, permanent or temporary, including but not limited to self-weight, pipe systems, fixed mechanical and electrical equipment, stairs, walkways, and railings.

2.8.3.2 Live Load

Live loads during construction and operation consist of workers on the structures, temporary stored materials or equipment on the Project elements, impact, and construction equipment and vehicles. In-stream structures will be designed to resist impact loads from logs and other debris carried in the river system. Live loads on the access stairways will be superimposed as per the IBC codes.

2.8.3.3 External Hydrostatic Loads

A triangular distribution of static water pressure is assumed to act normal to the upstream faces of all screen panels, stop logs, and gate structures.

2.8.3.4 Buoyancy Loads

Structures will be designed to resist upward hydrostatic pressures from high groundwater or river levels. Design factors of safety follow ACI 350.4R Section 3.1 guidelines recommending a factor of safety of 1.1 for groundwater to the top of wall, not considering soil, and 1.25 considering soil and groundwater elevations below the top of wall.

2.8.3.5 Earthquake Loads

Earthquake loads have been selected based on the IBC related maps and tables. S_s=0.584g, S_1=0.304g. The buildings will be designed for Risk Category II with an importance factor of 1.0 and assuming Site Class D or worse. Using Site Class D: S_{DS}=0.519g, C_V=1.089. The Seismic Design Category classification for the Project is D.

2.8.3.6 Earth Loads

Below-grade structures and water-holding basins will be designed for worst-case load combinations of full height of backfill plus a minimum 2-foot soil surcharge with tanks empty. Additional surcharge loads will be applied to account for unique conditions due to adjacent structure proximity and traffic or equipment loading.

2.8.3.7 Snow Loads

The structures will be designed to carry the applicable snow load. The flat roof snow load at this site is 40 pounds per square foot (psf) in accordance with the County of Siskiyou Building Code. Design snow loads include effects from drift surcharge loads and unbalance snow load requirements. Grating area will be treated as impervious surface with no reductions applied for the open area of the grating surface.

2.8.3.8 Wind Loads

Wind loads will be applied in the design of the buildings and elevated structures. For structures, wind loads will be computed per the IBC using an ultimate design wind speed of 115 miles per hour and a minimum design wind pressure of 20 psf, exposure category C, Risk Category II, and an importance factor of 1.0. Wind loads will be compared to the earthquake forces and the controlling load will be used.

2.8.3.9 Temperature Loads

Temperature changes for expansion and contraction will be considered based on the site location.

2.8.4 Frost Depth

The design minimum frost depth is 12 inches in accordance with the County of Siskiyou Building Code.

2.9 Mechanical

2.9.1 Applicable Codes and Standards

The following references will serve as the basis for preparation of the mechanical design elements:

- American Society of Testing and Material (ASTM)
- American National Standards Institute (ANSI)
- American Society of Mechanical Engineers (ASME)
- American Welding Society (AWS)
- American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE)

- National Fire Protection Association (NFPA)

2.9.2 Materials

The material properties assumed for preparation of the preliminary design are listed in Table 2-17. Yellow metals and galvanized systems that would come in contact with fish production water supply will not be allowed.

Table 2-17. Mechanical Materials

Component	Materials
Gates	Cast iron, Stainless Steel, Aluminum
Buried Piping	PVC, Ductile Iron
Exposed Piping	PVC, Carbon Steel, Ductile Iron
Valves	Stainless Steel, PVC
Hardware	Stainless, PVC
Ductwork	Galvanized Sheet Metal, Aluminum for high humidity areas
Transport Flumes	Aluminum, stainless steel
Fish Transport Pipes	PVC
Intake Fish Screens	Stainless steel, Mild Steel
Incubation Trays	Fiberglass, Plastic

2.9.3 Design Loads

The mechanical loads are listed in Table 2-18.

Table 2-18. Mechanical Loads

Load	Description
Pump Loads	Net Positive Suction Head Required and Net Positive Suction Head Available will be determined to size all pumps to prevent cavitation.
Intake Screens	Differential pressure and approach velocity will be determined to size all screens to meet hydraulic requirements.
Piping Loads	Piping and fittings will be designed to the working pressure of the fluid and the pipe wall thickness will be designed for a sufficient bursting pressure.
Gate Loads	Load calculations for deflection for gates at the maximum expected head.
Valve Loads	Valves will be designed for expected maximum pressure and expected maximum differential pressure.
Debris Screens	Debris screens will be designed for a maximum differential pressure of 3-ft of water across the upstream and downstream faces.
Building Cooling	Cooling will not be provided; air circulation will be provided by large high-volume wall mount fans to allow airflow across the building space.

Load	Description
	The ventilation system will be designed based on a maximum summer ambient temperature of 97°F.
Building Heating	The heating system will be designed to maintain building space temperature above freezing (40°F). Heating system will be designed based on a minimum winter ambient temperature of 15.9°F.

2.9.4 HVAC

Heating and ventilation will be provided to the Coho Rearing Building, Chinook Incubation Building, and the Spawning Building. Heating in all buildings will be provided by wall- or ceiling-mounted electric unit heaters. Cooling will not be provided.

2.9.5 Plumbing

No sanitary waste collection system or domestic water distribution system is included in the project. An outdoor vault toilet with a sealed inground tank will be provided on site.

2.9.6 Fire Protection

Automatic fire sprinklers are not required. A fire extinguisher will be provided according to applicable building codes and NEPA standards at all buildings.

2.10 Electrical

The electrical design criteria apply to all design procedures to be implemented during the Project design phase. Electrical design considerations listed in this section, including detailing of electrical components, material selection, and design requirements, are intended to be incorporated into Project design.

2.10.1 Applicable Codes and Standards

The following references and design standards will serve as the general design criteria for the electrical design of the Project. The applicable version of each document is the latest edition enforced, unless noted otherwise. References to the specific codes and standards are included in the applicable technical specifications. The electrical design, materials, equipment, and construction will conform to the codes and standards listed in Table 2-19.

Table 2-19. Electrical Codes and Standards

Code	Standard
ANSI	American National Standards Association
CARB	California Air Resources Board
CCOR Title 24	California Code of Regulations
CPUC GO 128	California Public Utilities Commission – General Order No. 128: Construction of Underground Electric Supply and Communication Systems
IEEE	Institute of Electrical and Electronics Engineers
IESNA	Illuminating Engineering Society of North America – Lighting Application Handbook
ISA	Instrument Society of America
NEMA	National Electrical Manufacturers Association
NETA ATS	International Electrical Testing Association Acceptance Testing Specifications
NFPA 70	National Electrical Code (NEC)
NFPA 70E	Standard for Electrical Safety in the Workplace
NFPA 101	Life Safety Code
NFPA 110	Standard for Emergency and Standby Power Systems
OSHA	Occupational Safety and Health Act
UL	Underwriters Laboratory

2.10.2 Materials

The materials assumed for preparation of the preliminary design and applicable for engineering of the Project are listed in Table 2-20.

Table 2-20. Electrical Materials

Material	Standard
Panelboards	NEMA PB 1, UL 67
Transformers, Dry Type	NEMA ST 1, UL 1561, 10 CFR – Part 431 DOE 2016
Circuit Breakers	NEMA AB 1, UL 489
Switches	NEMA KS 1, UL 98
PLCs	NEMA ICS 1, UL 508
Terminal Blocks	UL 1059
Instrumentation Cable: THWN Copper	ASTM B8, NEMA WC 57, UL 13, UL 83, UL 1277
Power Conductors/Cable:	ASTM B3, ASTM B8, ASTM B496, NEMA WC 70, UL 83

Material	Standard
THWN Copper; XHHW-2 Copper	
Splices, Connectors, and Terminations	UL 486A-486B, UL 486C, UL 510
Grounding: Copper	UL 467
Boxes and Enclosures: NEMA 1, 12, 3R, & 4	NEMA 250, UL 514A
Raceway: Rigid Galvanized Steel; Intermediate Metal Conduit; PVC Schedule 80; Liquid-tight Flexible Metal Conduit	NEMA C80.1, NEMA C80.6, NEMA RN 1, UL 6, UL 360, UL 514B, UL 651, UL 1242
Propane Standby Generators	NEMA MG 1, UL 508, UL 1236, UL 2200
Transfer Switches	NEMA ICS 1, NEMA ICS 2, UL 1008
Motors: TEFC or submersible	IEEE 112, NEMA MG 1, UL 2111
Motor Controls	NEMA ICS 2
Wiring Devices	NEMA WD 1, NEMA WD 6
Luminaires: LED	IESNA HB-9, IESNA LM-80, IEEE C62.41.1, UL 1598, UL 2108, UL 8750, U.S. DOE Energy Star
Surge Protective Devices	UL 1449

2.10.3 Design Loads

All currently anticipated electrical loads are summarized in Table 2-21.

Table 2-21. Electrical Loads

Load	Description
Booster Pumps	480V, 3-phase, 3 hp, 3 ea.
Intake Traveling Screens and Pumps	208V, 3-phase, 1 hp, 2 screens ea., 1.5 hp, 2 pumps ea.
Existing Conveyor Belt	208V, single-phase, 1.5 hp
Existing Fish Lift Hoist	120V, single-phase, 2 hp (assumed)
Existing Electro-Anesthesia Tank and Hoist	120V, single-phase, 2 hp (hoist), 1.92 kVA (electro-anesthesia tank)
Coho Building Unit Heater	480V, 3-phase, 20 kW
Chinook Incubation Building Unit Heater	480V, 3-phase, 15 kW
Spawning Building Unit Heater	480V, 3-phase, 10 kW

Load	Description
Coho Building Radiant Heaters	208V, 3-phase, 3 kW, 2 ea.
Chinook Incubation Building Radiant Heaters	208V, 3-phase, 3 kW, 2 ea.
Spawning Building Radiant Heaters	480V, 3-phase, 4.5 kW, 1 ea.; 208V, 3-phase, 3 kW, 2 ea.
Electrical Room Split AC Unit	208V, single-phase, 2.08 kVA
Exhaust Fans	120V, single-phase, 3/4 hp, 2 ea., 1/2 hp, 3 ea., 1/4 hp, 1 ea., 1/6 hp, 1 ea., 1/20 hp, 1 ea.
Motorized Dampers	120V, single-phase, 100 VA, 5 ea.
Meter Vault Sump Pump	120V, single-phase, 1 hp
Tagging Trailer Receptacle, 100A	240V, single-phase, 19.2 kVA
Tagging Trailer – Fish Pump Receptacle, 60A	240V, single-phase, 11.5 kVA
RV Trailer Receptacle, 50A	240V, single-phase, 9.60 kVA
RV Trailer Receptacle, 30A	120V, single-phase, 2.88 kVA
Lighting, LED	120V, single-phase, 4.27 kVA
Convenience Receptacles	120V, single-phase, 180 VA, 39 ea.
Standby Generator Loads	208V, single-phase, 2.50 kVA (block heater); 120V, single-phase, 400 VA (battery heater), 100 VA (battery charger)
SCADA Panel	120V, single-phase, 400 VA
Cameras	120V, single-phase, 100 VA, 5 ea.
Instrumentation	120V, single-phase or 24 Vdc, 4-20 mA
Intrusion Detection	120V, single-phase

2.11 Instrumentation and Controls

2.11.1 Applicable Codes and Standards

The following references and design standards will serve as the general design criteria for the instrumentation and control design of the Project. The applicable version of each document is the latest edition enforced, unless noted otherwise. References to the specific codes and standards are included in the applicable technical specifications. The instrumentation and control design, materials, equipment, and construction will conform to the codes and standards listed in Table 2-22.

Table 2-22. Instrumentation and Control Codes and Standards

Code	Standard
IEEE	Institute of Electrical and Electronics Engineers
ISA 5.1	Instrumentation Symbols and Identification
NEMA	National Electrical Manufacturers Association
NFPA 70	National Electrical Code (NEC)
UL	Underwriters Laboratory

3.0 Project Description

3.1 General Description

The general site layout is depicted in Figure 3-2, with the major components of the layout summarized in Table 3-1, as well as in the following sections.

3.2 Intake Structure and Meter Vault

A hatchery intake structure will be located along the southeast bank of Fall Creek directly adjacent to Dam A and opposite the City of Yreka intake structure (see Figure 3-1). The intake will be constructed of concrete and will divert flows up to 10 cfs from Fall Creek. A buried 24-inch-diameter pipe will supply the site and will divide flows into four buried water supply pipes to deliver flow to the various hatchery facilities. A debris screening system will be added at the entrance to the new intake structure to prevent large sediment, detritus, and other debris from entering the intake chamber. The debris screening system will be equipped with an automated screen-cleaning system that will operate at regular intervals or based on an acceptable head differential across the screen. Behind each screen will be stop log guide slots for isolation of the pipeline, or closure of one of the screen slots for general maintenance.

Inside the intake structure, the 24-inch-diameter supply line will be set in the concrete wall at a sufficient depth to preclude significant air entrainment at the pipe entrance. After the flow split, the four hatchery facility supply pipelines will be equipped with magnetic flow meters and isolation valves located in a concrete vault that will transmit flow rates to a programmable logic controller (PLC) located in the electrical room connected to the Chinook Incubation Building (see below). The intake will also be equipped with a sediment sluiceway outside of the intake chamber, for bypassing sediment and bedload that may accumulate at the toe of the intake screens.

Figure 3-1. Intake Structure Location and City of Yreka Intake (Source: McMillen Jacobs)

Table 3-1. Major Facilities Schedule

Facility	Species	Required Capacity / Volume	Rearing Volume Provided	Flow Requirement	Total Dimensions (Rearing Dimensions)	Comments
Intake Structure	-	-	-	10 ft^3/s	8’ (W) x 8.9’ (L) x 8.5’ (H)	Concrete Structure
Meter Vault	-	-	-	-	13’ (W) x 15’ (L) x 6.4’ (H)	Concrete In-Ground Vault
Coho Building	Coho	-	-	-	53’ (W) x 65’ (L)	Pre-engineered Metal Building
Incubators	Coho	48 trays	48 trays	40 gpm	25” (W) x 25” (L) x 34.5” (H) (per stack)	Existing, from IGFH
Incubation Working Vessel	Coho	150 ft^3	150 ft^3	30 gpm	(2) 2’ (W) x 15’ (L) x 3’ (H)	Existing, from IGFH
First-Feeding Vessel	Coho	750 ft^3	825 ft^3	150 gpm	(2) 4’ (W) x 16’ (L) x 3’ (H), Existing (3’ W x 15’ L x 2.5’ Depth) Existing	Existing, from IGFH
					(2) 6’ (W) x 21’ (L) x 4’ (H), New (5’ W x 20’ L x 3’ Depth) New	Fiberglass Vat
Rearing Ponds	Coho	3,850 ft^3	5,400 ft^3	764 gpm	(2) 11’ (W) x 40’ (L) x 3.8’ (H), Existing (11’ W x ~38’ L x 3’ Depth) Existing	Existing Concrete Raceway
					(2) 12.0’ (W) x 34.8’ (L) x 5’ (H), New (12.0’ W x 30’ L x 4’ Depth) New	Concrete Raceway
Chinook Incubation Building	Chinook	-	-	-	50’ (W) x 60’ (L)	Pre-engineered Metal Building
Incubators	Chinook	1,088 trays	1,088 trays	680 gpm	25” (W) x 25” (L) x 34.5” (H) (per stack)	Existing, from IGFH
Incubation Working Vessel	Chinook	290 ft^3	290 ft^3	60 gpm	(4) 2.5’ (W) x 14.5’ (L) x 2.5’ (H)	Existing, from IGFH
Chinook Rearing Ponds	Chinook	20,200 ft^3	23,040 ft^3	4,040 gpm	(8) 12’ (W) x 64.8’ (L) x 5’ (H) (12’ x 60’ L x 4’ Depth)	Concrete Raceway
Trapping/Sorting Pond	Coho/Chinook	3,350 ft^3	3,350 ft^3	200 gpm	12.6’ (W) x 66.3’ (L) x 5’ (H)	Concrete Raceway (1495 gpm provided)
Chinook Adult Holding Pond	Chinook	1,800 ft^3	3,350 ft^3	400 gpm	12.6’ (W) x 66.3’ (L) x 5’ (H)	Concrete Raceway (1495 gpm provided)
Coho Adult Holding Pond	Coho	600 ft^3	3,350 ft^3	200 gpm	12.6’ (W) x 66.3’ (L) x 5’ (H)	Concrete Raceway 1495 gpm provided
Spawning Building	Coho/Chinook	-	-	-	25’ (W) x 35’ (L)	Pre-engineered Metal Building
Settling Pond	-	3,200 ft^3	3,200 ft^3	-	(2) 12.6’ (W) x 31.8’ (L) x 5’ (H)	Concrete Pond (2 Bays)
Fish Ladder	Coho/Chinook	-	-	10 ft^3/s	2.5’ (W) x 24.6’ (L)	Denil Type (Concrete)
Fish Barrier (Dam A)	Coho/Chinook	-	-	-	29’ (W) x 16’ (L)	Velocity Apron (Concrete)
Fish Barrier (Dam B)	Coho/Chinook	-	-	-	11.5’ (W) x 20’ (L)	Velocity Apron (Concrete)
Fish Barrier (Fishway)	Coho/Chinook	-	-	-	17.3’ (W) x 8’ (L) x 4.5’ (H)	Picket Panels on Concrete Sill

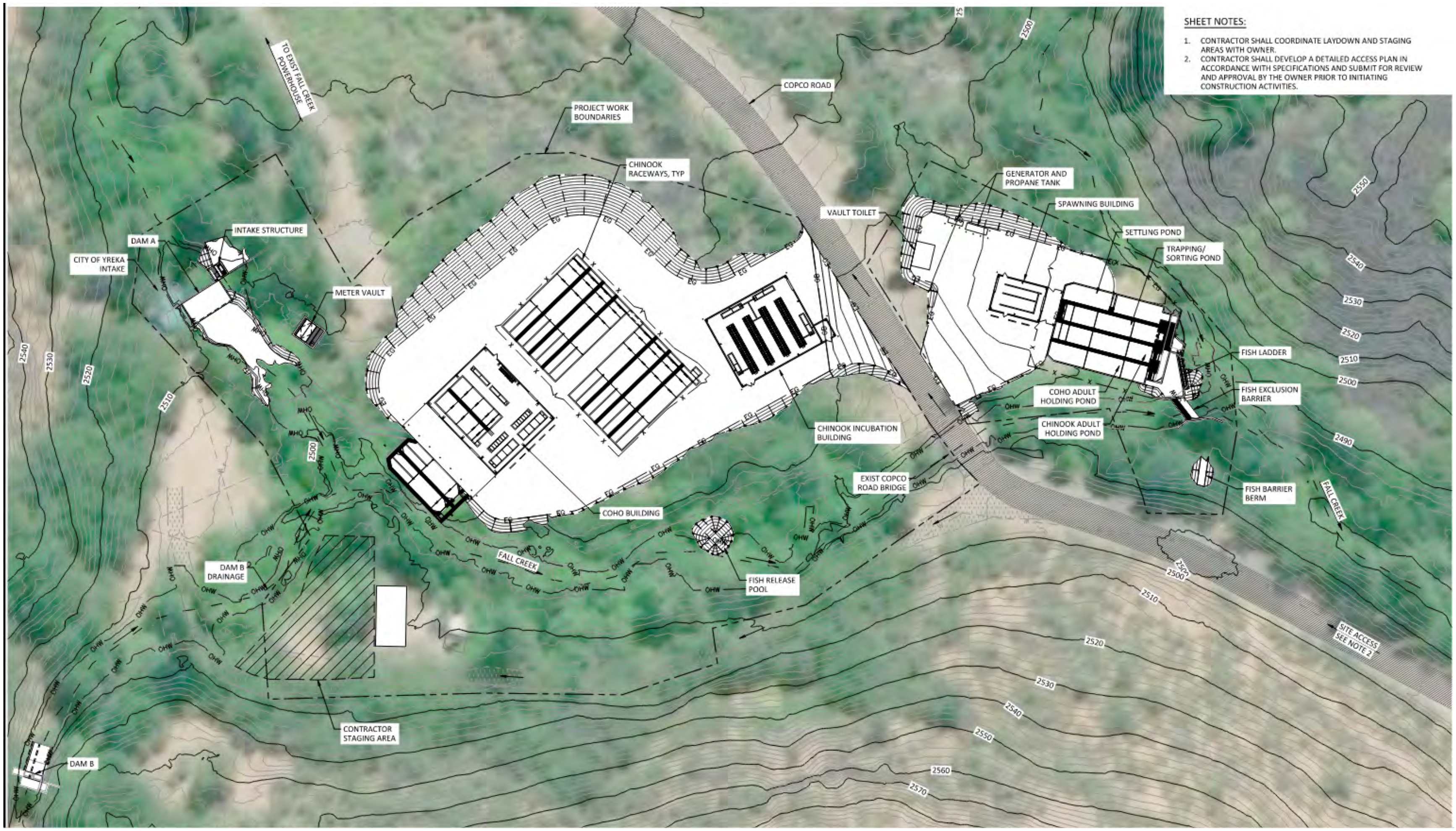

Figure 3-2. General Site Layout

3.3 Coho Building

The Coho Building will be located at the north end of the Project site at pad elevation 2503.0 (North American Vertical Datum [NAVD] 88), and will house all Coho incubation, grow-out, and rearing infrastructure Coho production facilities. The Coho Building will be a pre-engineered metal building with interior dimensions of 53 feet wide by 65 feet long.

Existing incubation stacks and trays will be reused from IGFH (see Figure 3-3), and will be configured in a row of six half-stacks (i.e., eight trays per stack) along the southwest wall. This will accommodate the 120,000 Coho green eggs discussed in the bioprogram at 2,500 eggs per tray. A water flow rate of 5 gpm will be provided to each of the incubation stacks via a head tank located above the stacks. The intent of a head tank design is to protect against any potential flow interruption. Water will flow downward through the stacks to a floor drain that discharges to a production drain system, with flows diverted to one of two systems (adult ponds as online flow; effluent ponds as effluent flow). The incubation stacks will be supplemented with two working vessels (egg picking, enumeration) that will be reused from IGFH (see Figure 3-3).

Figure 3-3. Existing IGFH Incubators (Left) and Working Vessels (Right) (Source: McMillen Jacobs)

Four first-feeding vessels will be provided for initial ponding of the Coho fry consisting of two existing vats from IGFH and two new fiberglass aquaculture vats, providing a total of 825 ft^3 of ponding volume. First-feeding vessels will be equipped with screen guides, such that a quiescent zone can be maintained at the downstream end of the vessel. These vessels will operate in a flow-through condition with a 150-gpm (total) renewal rate, and online overflows will pass through a standpipe in the quiescent zone that flows into the drain system and then routed to the adult holding ponds; effluent will be conveyed to the effluent pond (or holding tanks if designed) via an effluent standpipe adjacent to the vats in the floor, which will discharge to the effluent drain system.

Grow-out and rearing space will be provided in part in the existing upper raceway bank (see Figure 3-4). There are two existing concrete raceways (approximately 11 feet wide by 40 feet long by 3.8 feet deep) adjacent to Fall Creek that will be just outside of the Coho building. These will be rehabilitated with a surficial mortar layer and resurfaced with an epoxy liner for use in Coho grow-out and rearing. This raceway bank will be covered with a roof above and predator netting and fencing provided along the sides of the site. The existing flume that feeds these raceways will be demolished and replaced with pipe manifolds that provide a maximum of 210 gpm to each of the existing raceways. The raceways will be further subdivided by two 20-foot-long pony walls, equipped with dam boards and fish screen slots. This will provide approximately 1,300 ft^3 of early rearing volume for use prior to fish tagging/marking. After fish have been tagged/marked, the dam boards and fish screens can be removed, allowing the full 2,500 ft^3 of rearing space to be used.

Figure 3-4. Existing Upper Raceway Bank (Source: McMillen Jacobs)

At the downstream end of the existing raceways, dam boards and fish screens will be installed upstream of the outlet works. Additionally, a set of dam boards will be installed in the existing concrete outlet flume, and pond overflow will be directed into a production drain pipe that will convey flow to the adult holding ponds. When fish are to be released from these raceways, a gate will be closed on the production drain pipe, and dam boards will be lowered in the existing concrete flume to allow fish to pass over the dam boards and directly into Fall Creek.

Further rearing space will be provided by two additional constructed concrete raceways 12 feet wide by about 35 feet long by 5 feet deep, located approximately 20 feet from the existing raceways inside the Coho Building. A roadway will pass under the roof structure between the existing and the new. At tagging and marking, the trailer will pull between the existing and new raceways and the roll-up doors on the Coho Building will be opened. Newly tagged/marked fish can then be distributed among the four raceways as required by rearing volume.

Overflow from the new concrete raceways will discharge to an approximately 2-foot-wide exit channel that will direct flows to a production drain pipe in the concrete wall. In addition, there will be in the exit channel a 2-foot by 2-foot box behind a set of dam boards leading to the volitional fish release pipe. If it is desired that fish be volitionally released from these ponds, the gate on the production drain pipe can be closed and dam boards can be removed at the volitional fish release box. Fish will volitionally go over the dam boards and enter a 10-inch-diameter fish release pipe that will convey fish to the existing concrete flume on the discharge end of the existing Coho rearing raceways, and ultimately out to Fall Creek.

Finally, because production periods will overlap and all Coho infrastructure, with the exception of the existing upper raceways, will be housed in the same building, biosecurity will be maintained by curtain systems between the respective areas of the Coho Building (e.g., incubation, first-feeding, rearing/grow-out).

3.4 Chinook Incubation Building

The Chinook Incubation Building will be located immediately north of Copco Road at pad elevation 2,503.0 (NAVD 88) and will house only the Chinook egg incubation operations. The Chinook Incubation Building will be a pre-engineered metal building with interior dimensions of 50 feet wide by 60 feet long.

Existing incubation stacks and trays will be reused from IGFH and will be configured in eight rows of 17 half-stacks, for a total of 136 stacks or 1,088 trays. Incubation trays will accommodate the 4.5 million Chinook green eggs discussed in the bioprogram at an approximate loading density of 4,150 eggs per tray. Rows of incubation stacks will maintain a 7.5-foot buffer on other rows to mitigate any cross-contamination from splashing. A flow of 5 gpm will be routed to each of the incubation half-stacks via head tank above, as in the Coho Building, and water will flow to the drain system in the floor.

Four incubation working vessels will be reused from IGFH and will be positioned around the inside perimeter of the building for hatchery operations.

3.5 Chinook Raceways

Eight concrete raceways will be constructed in two raceway banks north of the Chinook Incubation Building at pad elevation 2,503.0 (NAVD 88), with the pond invert set 3 feet below the pad elevation (2,500.0 NAVD 88). Raceways will be constructed with 26-foot-long pony walls and fish screen guide slots and stop log slots at intervals along the length of the structure, such that ponding volumes can be incremented based on fish development. The eight raceways provide a total rearing volume of 23,040 ft^3. Bioprogram requirements for tagging and marking assume Chinook will be marked at 150 fpp with a required rearing volume of 16,045 ft^3. CDFW staff have indicated that Chinook sub-yearling cohort releases will begin immediately after marking has been completed. If required, the total rearing volume available (23,040 ft^3) provides adequate rearing flexibility for CDFW staff to rear fish up until approximately 104 fpp before approaching the recommended 0.3 density index maximum.

Chinook rearing raceways will be operated in a flow-through condition, with manifolds at the upstream end of the pond supplying a maximum of 500 gpm to each of the ponds, and dam board overflows draining to a sloped concrete exit channel that connects the two raceway banks. The concrete exit channel will be equipped with two open concrete boxes at the southwest end of the channel containing the production drain pipe and the volitional fish release pipe, respectively. During normal operations, dam boards will be in place to isolate the volitional fish release pipe, such that all water is directed to the production drain pipe and on to the adult holding ponds.

During volitional fish release, it is anticipated that the adult holding ponds may be used for raising fish on second-pass water, and therefore flow through the Chinook raceways will need to be divided between the production drain system and the volitional fish release pipe. At volitional fish release, fish screens in each of the raceways will be removed and a fish screen will be installed in front of the production drain box. Dam boards in front of both pipe boxes will be adjusted for the desired distribution between the two pipes, while maintaining a pool in the exit channel for fish that volitionally leave the raceways. Fish will be contained in the exit channel until they volitionally pass over the dam boards into the volitional fish release pipe. The volitional fish release pipe will convey fish entrained flows in an open channel condition to a constructed plunge pool adjacent to Fall Creek, approximately 150 feet upstream of the existing Copco Road bridge.

Predator netting and security fencing will be supplied to protect the Chinook rearing raceways. Predator netting will be connected to an exterior security fence with a metal frame structure that will allow personnel to stand and move around in the enclosure for access to the ponds. The security fence will generally be maintained 1 foot from edge of concrete, such that feed vehicles could drive close to the ponds, as needed. The security fence will be equipped with man gates and double-leaf gates between the raceway banks such that vehicles could access the 12-foot-wide center aisle between the raceway banks. At tagging/marking, it is anticipated that the tagging/marking trailer will pull into the center aisle for best access to the raceways.

3.6 Adult Holding Ponds

The existing lower concrete pond bank consists of four ponds approximately 12.5 feet wide by 70 feet long, with a concrete outlet structure at the downstream end (see Figure 3-5). Three of these ponds will be refurbished for use as adult holding ponds: one for trapping and sorting, one for Coho holding, and one for Chinook holding. Existing pond concrete walls are in poor structural condition, and will require demolition and reconstruction. Reconstructed walls will be equipped with walkways between each of the ponds and neoprene jump panels above the pond walls.

Based on estimates of holding 200 Chinook and 100 Coho at any given time and estimated adult weights (Chinook – 12 lbs, Coho – 8 lbs), NMFS guidance (2011) dictates a minimum of 1,800 ft^3 of pond volume for Chinook and 600 ft^3 of storage for Coho. Each individual pond is estimated to have approximately 3,350 ft^3 of storage, which provides ample capacity for adult holding. Because of the available capacity in the reconstituted ponds, these ponds may additionally be used for raising fish on second-pass water at the option of CDFW. Therefore, the ponds will be retrofitted with fish screen slots for partitioning, as needed operationally.

The adult holding ponds will be fed by a supply pipe from the intake structure, but will also be fed by the fish production drain system, such that at any given time (aside from nominal losses to cleaning) the adult ponds will be fed with the full water right of 10 cfs. In the Coho and Chinook holding ponds, during normal operations, the water supply will flow over a set of dam boards at the downstream end and through a floor diffuser into the fish ladder. The trapping-and-sorting pond will be equipped with a finger weir at the downstream end through which pond outflow will be routed. This will then serve as the trap at the end of the fish ladder. As fish go over the weir, they will remain in the trapping-and-sorting pond until they are transferred into their respective holding ponds. The trapping-and-sorting pond will be equipped with a fish crowder to aid in sorting and transfer of the respective species.

The adult holding ponds have been designed with fish screen keyways that will allow for culture and effluent collection for a limited number of Chinook juveniles during the periods when adult Coho and Chinook are not present. Acknowledging that the water source will be serial reuse from upper facility fish rearing systems (Coho and Chinook production raceways), the conservative density and flow indices used in the program should provide second-pass water of sufficient quality and oxygen levels to support serial reuse for a limited number of surplus juvenile Chinook. If juvenile fish are to be raised in these ponds, the Coho and Chinook holding pond outflow can be isolated from the fish ladder with a set of dam boards to full height. A fish release pipe with another set of dam boards in the exit channel provides the option of volitional release from these ponds. The fish release pipe will convey fish to the pool at the toe of the fish ladder. Furthermore, the adult holding ponds will be connected by dam boards that may be removed such that fish can be directed into any of the three ponds.

Figure 3-5. Existing Lower Raceway Bank Ponds (Source: McMillen Jacobs)

The lower raceway bank will be surrounded by an enclosure consisting of perimeter fencing and predator netting. Sufficient clearance to the perimeter fencing will be maintained around the ponds, such that personnel will be able to access the ponds and associated infrastructure. Predator netting and security fencing will tie into the Spawning Building at the north end of the pond.

3.7 Spawning Building

Immediately north of the adult holding ponds at pad elevation 2491.5 (NAVD 88) will be the Spawning Building. The Spawning Building will be a pre-engineered metal building with interior dimensions of 25 feet wide by 35 feet long and will house equipment relocated from IGFH. A roll-up working door will be located on the southeastern wall of the building, providing direct access to the head of the sorting/trapping raceway. Within the sorting/trapping raceway, the existing fish lifting basket and hoist will be provided to transfer fish from the raceway to an electro-anesthesia tank for fish sedation or euthanasia. A sorting table will be placed immediately outside of the roll-up door to sort and transfer sedated fish into the Spawning Building through removable troughs.

Within the Spawning Building, a holding table and air spawning table are provided for egg retrieval. The existing egg rinsing table and water hardening table will be relocated from IGFH for egg processing prior to incubation. A conveyor belt will be provided for transferring fish carcasses to a collection bin located outdoors. Additional return pipes are to be provided along the southeastern wall of the building for returning fish to either the trapping/sorting pond or the Chinook holding pond.

Excess space is provided within this structure for storage of hatchery supplies, as needed. Additional workspace is provided for any collaborator activities.

3.8 Settling Pond

The final pond in the existing lower concrete raceway bank (eastern-most pond) will be used as a settling pond to settle out any biosolids or other solid waste from cleaning of the upstream facilities discharged to a waste drain. The effluent treatment is discussed in greater detail in Section 10.4. This pond will be refurbished and parsed into two distinct bays such that solids can be dried and removed as necessary over the life of the facility, while the waste drain system remains in operation.

The settling pond will be located in the same exclosure as the adult holding ponds, to prevent water fowl from landing on the pond and stirring up the settled solids. The predator netting along the eastern edge of the settling pond will be weighted and connected to eye-bolts in the concrete that may be easily disconnected. When cleaning of the settling pond is required, a septic pump truck will access the pond from the adjacent pad, the predator netting can be disconnected from the eye-bolts, and the solids can be vacuumed out of the pond.

The downstream end of each of the settling pond bays will be equipped with an overflow structure that will divert flow-through water into the fish ladder (see below) for mixing with the adult holding pond flows and release to Fall Creek.

3.9 Fish Ladder

The fishway is a baffled chute which is a type of roughened chute designed to meet the NMFS criteria. The baffled chute type is a Denil fishway. The Denil fishway is 2.5-foot-wide by approximately 25-foot-long. The entrance to the fishway will be located just downstream of the picket barrier at the upstream terminus to maximize fish passage efficiency. The fishway will ascend to the constructed concrete outlet structure at the lower raceway bank and will terminate at the finger weir at the downstream end of the trapping and sorting pond to convey fish into the pond for sorting. The fish ladder will consist of 15 standard baffles in total and will be of the Denil-type, as described in the NMFS (2011) guidelines (see Figure 3-6). At the top of the Denil ladder will be a pool for fish to turn into the constructed outlet structure. This turning/resting pool is sized to provide adequate energy dissipation characteristics and will be equipped with a dam board weir for fish to enter the constructed outlet structure.

The uppermost pool in the constructed outlet structure will be fed by the flow over the finger weir, and by flow from the Coho and Chinook holding ponds through a floor diffuser. The finger weir is sized according to recommendations from the U.S. Army Corps of Engineers *Fisheries Handbook* (Bell, 1991), and maintains approximately 3.5 inches above the fingers of the finger weir.

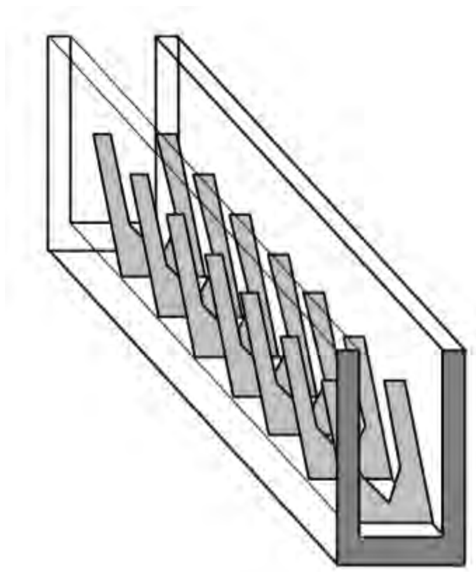

Figure 3-6. Perspective of Denil-Type Fish Ladder with Single-Plane Baffles (Source: NRCS, 2007)

3.10 Fishway Picket Fish Barrier

A removable fish exclusion picket barrier will be constructed with the fish ladder that will guide fish to the fish ladder entrance pool and ultimately up to the trap. The fish barrier will consist of a set of aluminum pickets with 1-inch-maximum clear spacing that will be installed on a permanent concrete sill and removed each year at the beginning and end of the trapping season. The sill will have side walls and a 6-inch-tall curb across the bottom that the picket panels will be able to seal against, forming a continuous barrier across the stream. The sill and removable pickets will be oriented at an angle of approximately 30 degrees to the stream transect, such that an anadromous fish moving upstream will encounter the barrier and be directed toward the stream’s east bank, where the fish ladder entrance pool is situated. The typical fish ladder flow of 10 cfs will act as an attraction flow to the anadromous fish. NMFS (2011) recommendations for attraction flow in smaller streams are typically greater than 10 percent of the design high flow during the fish passage season. In this case, 10 cfs is approximately 20 percent of the design high flow and will provide effective attraction flow. The orientation of the picket barrier will also aid in reducing approach velocities at the barrier.

The picket framing will consist of ultra-high molecular weight (UHMW) stringer bars with penetrations for the aluminum pickets to slide in. UHMW stringer bars will be overlapped at installation to tie the individual picket panels together. These picket panels will rest at the bottom against the concrete sill, with a 6-inch-tall curb to prevent fish from passing underneath the panels. The picket panels will then be connected to a stand that will be secured to the concrete sill. A small walkway will be cantilevered from the framing/stringer bars above the high water level, such that access may be maintained to the whole length of the barrier without entering the stream (see Figure 3-7).

When debris or bedload accumulates on the pickets, the pickets will need to be manually cleaned to ensure that less than 0.3 feet of additional headloss on the clean picket condition is maintained (per NMFS, 2011). This can be performed by raising and lowering individual pickets through the stringer bars to allow the accumulated debris or bedload to be washed downstream. This will be performed from the small access way, and will only need to be performed during the trapping season, as the pickets will be removed from the creek at all other times.

Figure 3-7. Temporary Picket Barrier for Adult Fish Trap (Source: McMillen Jacobs)

3.11 Dam A Velocity Barrier

Immediately downstream of existing Dam A, a 16-foot-long by 29-foot-wide sloped concrete apron will be constructed from the downstream face of Dam A. The apron will be sloped at 16H:1V (about 6.3 percent), resulting in high velocities and shallow flow depths. The combined high-velocity apron and the jump required to pass upstream of Dam A will effectively bar passage to both juvenile and adult anadromous fish for the anticipated creek flow range expected during juvenile fish release, adult migration, and up to larger flood events. This barrier follows design guidance from NMFS (2011).

3.12 Dam B Velocity Barrier

Immediately downstream of existing Dam B, a 20-foot-long by 11.5-foot-wide sloped concrete apron will serve as a similar velocity barrier to preclude fish from approaching the Dam B reservoir and exclude juvenile fish passage upstream. This barrier likewise follows design guidance from NMFS (2011).

4.0 Hydraulic Design

The facility hydraulic design consists of four main piping systems:

1. Water supply piping system
2. Production drain system
3. Waste drain system
4. Volitional fish release pipes

The design also includes three fish passage/trapping elements:

1. Fish Ladder
2. Finger Weir
3. Fish Barriers

The design also includes the effluent treatment system. Hydraulic calculations for each of these elements can be found in Appendix A of this DDR, and each is discussed in detail below.

4.1 Supply Piping System

The supply piping system consists of four primary pipelines from the intake structure to the major production facilities, which include: (1) the Coho Building, (2) the Chinook rearing raceways, (3) the Chinook Incubation Building, and (4) the adult holding ponds. All pipes were assumed to be schedule 80 PVC, which are typical in hatchery applications, and present considerable cost savings over alternatives. The site is relatively constrained in terms of hydraulic head. The assumed water surface at the intake structure is at elevation 2,510.4 (NAVD 88), and the pad for the majority of the site is at elevation 2,503.0 (NAVD 88), providing only about 7.4 feet of hydraulic head across much of the site. For this reason, pipes were conservatively sized to minimize dynamic head losses through the piping system. At the same time, pipes were sized to maintain a minimum velocity of 1.5 feet per second (ft/s) and a typical velocity of approximately 2.0 ft/s such that they would be self-cleaning, and would not settle out any sediment, detritus, or other material in suspension.

Modeling of the supply piping system using EPANET software (Appendix A) demonstrates that there is sufficient hydraulic head to provide conveyance to the entire site without the use of pumps. Due to the hydraulic head constraint, infrastructure was kept as low as possible including the use of half-stacks for incubation. In addition, pressurized cleanouts are provided at intervals along the supply pipelines such that water may be blown out and pipes cleaned if fouling of the pipe or accumulation of fine sediments occurs. The supply pipes will be screened at the upstream end, and these cleanouts are provided as a contingency feature to ensure that the hydraulic head is not impacted over time. Pipe sizes are shown in the Drawing package accompanying this document.

4.2 Production Drain System

The production drain system is the primary drain system for all hatchery infrastructure and drains to the adult holding ponds and out to Fall Creek through the fish ladder. The production drain system consists of lateral lines that convey flow from individual hatchery elements to larger trunk lines that collect and convey flows to their terminus. The system was designed to convey flows primarily in a gravity flow regime, such that pipes would not pressurize and hydraulically connect the ponds. Pipes were sized such that at maximum flow rates the pipes would flow at most 70 percent full, which is typical for the design of open-channel drain piping.

In the lower portion of the production drain system, riser pipes distribute flows into the three adult holding ponds, and therefore, the trunk line in the lower portion of the site will pressurize. Calculations demonstrate that this lower pressurization of the pipe occurs well below the invert elevation of all the upstream pond and raceway systems, and therefore no impacts will be conveyed to those design elements. This transition from gravity flow to pressure pipe flow will require the pipe to have adequate venting to provide the necessary air flow into the pipe to accommodate the transition.

While the production drain system is expected to have minimal solids content due to the outlet configurations of the upstream ponds, the pipes were designed to maintain minimum self-cleaning velocities such that accumulation of biosolids or suspended sediment would not occur in the pipeline. Thus, it is expected that biofouling will occur over the 8-year life of the facility. Regularly spaced cleanouts are provided to the ground surface such that these pipes can be cleaned at intervals and operations are not inhibited. Calculations in support of the production drain system hydraulics can be found in Appendix A, and pipe sizing information can be found on the Drawings accompanying this document.

4.3 Waste Drain System

The waste drain system will be used when cleaning the facilities, and significant content of biosolids is anticipated in the effluent. The waste drain system conveys biosolid-laden flows from each of the hatchery vessels or raceways to the settling pond located adjacent to the adult holding ponds. At each of the hatchery vessels or raceways, a riser pipe will be provided to the ground surface with a cam-lock fitting on the end. When cleaning the ponds or vessels, hatchery operators will vacuum waste to these riser pipes that will then discharge to the waste drain system. Because this system is fed by vacuum cleaning flows only, the system has a uniform design flow of approximately 200 gpm, under the assumption that only one to two of the raceways or vats will be cleaned simultaneously.

The waste drain system was designed similar to the production drain system to operate in a gravity flow regime, and pipes were sized to flow at most 70 percent full at the maximum design flow. These pipes, however, will maintain an open channel regime all the way to their outlet at the settling pond. The waste drain system will have cleanouts to grade at regular intervals for cleaning, as necessary. Calculations associated with the waste drain system are provided in Appendix A, and pipe sizes are summarized in the Drawings accompanying this document.

4.4 Volitional Fish Release Pipes

The volitional fish release pipes are provided from the Coho rearing raceways, the Chinook rearing raceways, and from the adult holding ponds where there is potential for raising juvenile fish to various outlet points in Fall Creek. Volitional fish release pipes were subject to more stringent criteria than the other pipe systems, because of the entrained fish in the flow. Design criteria are summarized in Section 2.6 above and follow guidance from NMFS (2011) for fish bypass pipes. All volitional fish release pipes will be butt-welded HDPE and will have any internal weld beads or burrs removed for fish safety.

For the Coho rearing raceways, flow-through rates were limited, and therefore at volitional release the entirety of the flow is to be directed through the volitional release pipe to the existing concrete flume and ultimately out to Fall Creek. This location appears to have been previously used for fish release, and therefore was deemed appropriate and the most cost-effective solution due to the proximity of the existing raceways to Fall Creek. The drop into Fall Creek is relatively limited, and therefore impact velocities will be well below the maximum threshold recommended by NMFS. Because fish are released in a juvenile state, and generally not during the trapping period, fish released to Fall Creek will have free egress down from the hatchery site to the lower reaches of Fall Creek and into the Klamath River.

For the Chinook rearing raceways, the majority of the hatchery water right will be flowing through the Chinook raceways at volitional release, and therefore, the flow needs to be distributed between the volitional release pipe and the production drain system that supplies water to the lower raceway bank. Due to the constraints on the volitional release pipe (depth in pipe greater than 40 percent full, but less than 70 percent full), the pipe will only be able to accommodate a limited range of flows. A flow range from 2.6 cfs to 4.5 cfs (about 25 to 50 percent of the Chinook pond outflow) was selected for the volitional release pipe, allowing a majority of the water to supply the lower site. Outside of the defined flow range, the volitional release pipe will not operate as intended. The fish ladder is not anticipated to be in operation during volitional fish release, and therefore, the flow diverted to the lower raceway bank will be required strictly for any juveniles being raised in the adult holding ponds on second-pass water.

The Chinook volitional release pipe will convey fish to a constructed plunge pool in the east overbank area adjacent to Fall Creek, approximately 150 feet upstream of the existing Copco Road bridge. The pipe invert at the plunge pool will be approximately 1.1 feet above the high tailwater level in Fall Creek, and approximately 1.6 feet above the low tailwater level. The plunge pool will be excavated such that it is approximately 4.5 feet deep at high tailwater and 4.0 feet deep at low tailwater. This results in impact velocities at the low water surface of approximately 12 ft/s and at the bottom of the pool of approximately 19 ft/s. Both of these values are within the 25 ft/s recommended by NMFS (2011), and the plunge pool was deemed appropriate.

Finally, the adult holding volitional release pipe will convey the entirety of the flows through the Coho and Chinook adult holding ponds, and possibly the flow through the sorting/trapping pond, as well. This results in a design flow range from 6.7 cfs to 10 cfs. The adult holding volitional release pipe is located less than 20 ft from the fish ladder entrance pool, and therefore will only convey fish a short distance.

Further details regarding the design of the volitional fish release pipes and the plunge pools can be found in the calculations in Appendix A. Pipe design and sizing are summarized in the Drawing package accompanying this report.

4.5 Fish Ladder

The Denil fish ladder was designed according to standard Denil geometry, as provided by USFWS (2017), and according to the guidance provided by NMFS (2011). It was assumed that during the trapping season, when the fish ladder is in operation, the full water right (10 cfs) would be directed to the adult holding ponds (either through the production drain system or the supply pipe) and out through the fish ladder, with only occasional, minimal losses to cleaning and utility water. The slope of the fish ladder was selected to minimize the slope and resultant turbulence in the ladder, while avoiding the introduction of turns and rest pools. It was found that at the design flow, a 2.5-foot-wide ladder at 18 percent slope would result in flow depths in excess of 2.0 feet and cross-section average velocities less than 2.0 ft/s. This was within guidance for these structures and provided flow characteristics that would be passable to both adult Chinook and Coho. The rating curve calculated in association with the designed fishway is presented in Figure 4-1.

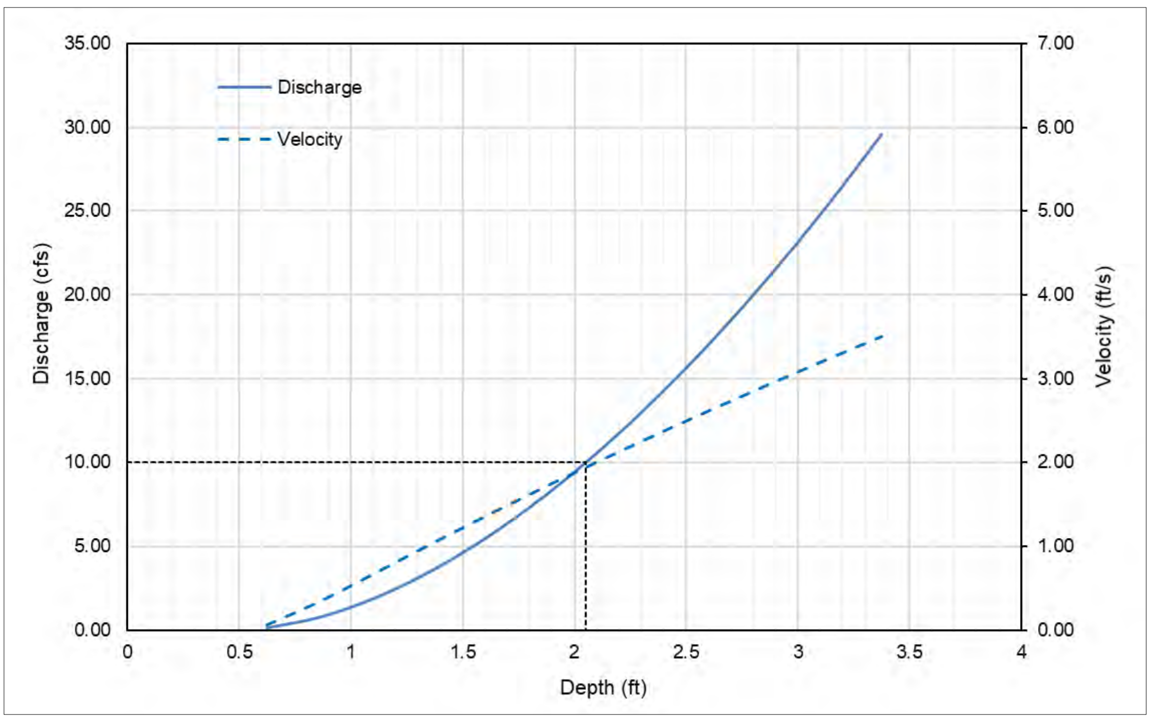

Figure 4-1. Denil Fish Ladder Rating Curve

At the top of the Denil fish ladder will be a resting and turning pool with a set of dam boards that will allow fish to pass into the adult holding raceway outlet structure and on to the finger weir. The turning and resting pool provides an energy dissipation factor of 2.8 ft-lbs/s-ft^3, which is below the maximum value recommended by NMFS (2011) of 4.0 ft-lbs/s-ft^3.

4.6 Finger Weir

After passing the fish ladder, a 1-foot drop will be maintained across a finger weir coming out of the trapping and sorting pond. The finger weir was designed according to the hydraulic guidance provided by the U.S. Army Corps of Engineers (Bell, 1991), to maintain 2 to 6 inches of water depth above the fingers of the weir. The finger weir will be attached to a gate that will allow for raising and lowering of the weir based on the desired water surface level in the pond. This water surface will need to be coordinated with the downstream set of dam boards, such that the hydraulic control in the pond is maintained at the finger weir.

4.7 Fish Barrier

The fish barrier system consists of three components. Dam A and Dam B will be modified to serve as permanent velocity barriers to preclude both juvenile and adult fish passage to the impoundments above the dams. At the fishway, a removable picket barrier with a concrete sill will be installed to direct adult fish to the fishway during the trapping season. The hydraulic design of each of these barriers is discussed below.

4.7.1 Dam A and Dam B Velocity Barriers

NMFS (2011) recommended velocity barriers consist of two components: (1) a downstream high-velocity apron, and (2) an upstream weir. The combination of these two components produces a shallow flow depth and a high velocity on the apron, which makes the jump for an adult anadromous fish impassable over the weir. The design of the Dam A and Dam B velocity barriers use the existing dams as the weir portion of the barrier and need only to be amended with a downstream steep concrete apron to form an impassable barrier to adult fish.

Downstream aprons were provided in accordance with NMFS (2011) recommendations and maintain a minimum length of 16 feet and a slope of about 6.3 percent (16H:1V). Open-channel flow calculations with an assumed Manning's roughness of 0.015 (concrete, float finish; Chow, 1959) were performed for the flows on the aprons to ensure flows were shallow and fast such that the jump over the dams would be impassable. Table 4-1 summarizes the calculated depths and velocities.

Table 4-1. Velocity Apron Depths and Velocities

Location	Flow Condition	Flow (cfs)	Depth (in)	Velocity (ft/s)
Dam A	High Flow	50.0	2.4	8.5
	Low Flow	15.0	1.2	5.3
Dam B	Juvenile High Flow	62.1	4.9	13.1
	Adult High Flow	56.9	4.7	12.7
	Adult Low Flow	8.4	1.5	6.0

The velocity barriers will also be equipped with vent pipes located under the overflow nappe with risers built into the concrete walls. The pipe risers will be open to the atmosphere above the high water elevation at the weir overflow. These vent pipes will ensure an aerated nappe which decreases upstream water surface elevations and minimizes the potential for fish jumping past the barrier.

4.7.2 Removable Picket Barrier

The removable picket barrier to be installed yearly at the beginning of the trapping period was designed according to typical guidance from NMFS (2011) for picket barrier systems. Approach velocities were calculated through the pickets based on the gross area of picket panels and adjusted for the rotation about the stream transect and the rotation about vertical. Table 4-2 summarizes the calculations through the picket barrier.

Table 4-2. Picket Barrier Flow Characteristics

Flow Condition	Flow (cfs)	Depth (ft)	Approach Velocity (ft/s)	Head Loss Across Pickets (in)
Fish Passage High Flow	71.9	1.7	2.0	4.0
Fish Passage Low Flow	23.4	1.1	1.0	1.0

The picket barrier is not able to meet the picket approach velocity criterion of 1 ft/s for the design high flow. Meeting the 1 ft/s picket velocity criterion, however, has proven challenging in the setting of small mountain streams across the Pacific Northwest, such as Fall Creek. It is not anticipated that the 1 ft/s picket velocity criterion will be met by this design; however, it is not expected that the picket barrier will pose a fish impingement concern for the following reasons:

1. The fish habitat above this barrier is very limited, and fish (especially anadromous fish) are not anticipated upstream of the picket barrier where impingement could occur.
2. The exposure window when the pickets will be in place is limited to the period of trapping. At all other times, the pickets will be removed, and the stream will flow through naturally.
3. The screen is oriented at an angle to the stream transverse, increasing the wetted area of the picket panels and decreasing average velocities through the pickets to the greatest degree possible.
4. Natural flow velocities in the stream around this location are as high as 4.5 ft/s under high-flow conditions. The flow through the pickets will be much less than the natural surrounding stream, due to the orientation of the barrier, and effects of the sill on the stream hydraulics.

Likewise, it may be observed that the minimum submerged picket depth at the barrier of 2 feet is not attained under any of the design flows. This is to be expected as the natural flow depth in this portion of the stream is only about 9 inches at low flow. Meeting the minimum submerged picket depths would require significant deviation about the natural channel flows. Therefore, the current design meets the intent of the picket barrier guidelines and criteria, though, like many other sites on small mountainous streams, it is unable to meet the values specified.

4.8 Effluent Treatment

Primary effluent concerns for the FCFH will be settleable solids (see *TM 002 – Design Criteria* for a complete listing of NPDES requirements), and particularly biosolids produced in the hatchery vessels. As discussed above, biosolids will be cleaned from all vessels and ponds via vacuum to the waste drain system, where they will be deposited in the settling pond. Idaho DEQ (nd), which has been widely used in aquaculture applications across the Pacific Northwest, recommends that a settling pond be sized based on a settling velocity of 0.00151 ft/s, such that the overflow velocity is less than the settling velocity ($V_o < V_s$). It was found that the existing pond in the lower raceway bank provided approximately 2.6 times the surface area required for settling of the biosolids, or if the pond is split into two chambers, each would maintain approximately 1.3 times the surface area required. This could be supplemented with a drum screen or overflow weir as needed to ensure that biosolids are sufficiently removed before release.

The other effluent concern for the facility will be the use of therapeutants or inorganics that could occasionally be required for treatment of fish. Use of such therapeutants is not anticipated due to the high quality of the intake water and the short design life of the facility. If it is determined that therapeutants will be required, the use of therapeutants used for fish treatments can be addressed operationally by using the 3,200 ft^3 of effluent holding provided by the effluent pond. While use would depend on flow rates supplied to each individual rearing unit, the effluent ponds provide short-term storage of up to 24,000 gallons of therapeutant laden flow that could then be pumped to appropriate storage tanks and transferred to approved off-site disposal areas, or discharged to Fall Creek after a prescriptive residence time.

5.0 Civil Design

5.1 General Description

This section presents the civil design elements at each of the Project structures and summarizes the design of the overall site layout.

5.2 Erosion and Sediment Control

The Contractor is required to install, monitor, and maintain erosion and sediment control measures as identified within the Project Drawings, and prepare the required documents discussed in Section 2.5 as determined by the various regulatory agencies. The erosion control measures shall be maintained for the duration of the construction project.

The Contractor will be required to install specified permanent post-construction measures as required for the Project. The permanent measures are designed to protect the exposed slopes until the vegetation is fully established. Following construction, the disturbed areas of the Project site will be revegetated with native plant mixes. The Contractor will be required to submit a Notice of Termination (NOT) to the State Water Resources Control Board (SWRCB) after completing the Project. This is required to be relieved from the Construction General Permit requirements. Final soil stabilization throughout the proposed Project area must be achieved prior to the SWRCB approval of the NOT.

5.3 North Site

The North Site, or the Project site north of existing Copco Road, consists of a pad at elevation 2503 (NAVD88) that was designed to support the Coho Building and infrastructure, the Chinook raceways, and the Chinook Incubation Building and supporting infrastructure. The pad elevation was selected such that sufficient hydraulic head would be maintained from the intake structure at elevation 2510.4 (NAVD88) to the design elements, while minimizing earthworks quantities.

Pad limits were determined to maintain a footprint within previous work boundaries, to the extent possible. The pad maintains sufficient space for access and egress around structures such that the whole site is accessible via standard pickup truck. The site layout also maintains access for an assumed tagging and marking trailer to locations near the Coho rearing raceways and the Chinook rearing raceways. A swept path analysis was performed to ensure site access, and discussion of design vehicles, clearances, and swept path results can be found in Appendix B.

5.3.1 Fencing

Per direction from CDFW, perimeter fencing around the entirety of the North Site will not be required. Fencing will be required, however, around the Chinook rearing raceways as part of the predator exclusion system. Fencing will be 8-foot-tall chain link fence with three strands of barbed wire oriented at 45 degrees outward to prevent larger predators from climbing over the fence. The fencing layout will be as indicated on the Drawings, and will have man-gates and vehicular access double-leaf gates in the locations indicated.

5.3.2 Grading

Site grading at the North Site will generally be a flat pad at elevation 2503 (NAVD88) but will be graded at slopes (0.02 ft/ft) away from all buildings and structures. Cut-and-fill slopes will be graded at a maximum slope of 2H:1V in accordance with the Project civil design criteria. The pad will be surfaced with a 4-inch-thick ¾-inch-maximum Type Granular Fill per specifications, and an 8-inch-thick Type Aggregate Subbase material per specifications beneath.

5.3.2.1 Site Drainage

Drainage from all impervious area will be collected at the perimeters of the pad in concrete swales and directed to a series of catch basins. From these catch basins, storm drain pipes will convey flows to an infiltration basin where water will be stored, treated, and slowly infiltrate into groundwater.

5.3.3 Intake Structure and Dam A Velocity Barrier Modifications

5.3.3.1 Cofferdam and Dewatering

It is anticipated that a cofferdam will be required to aid construction of the intake and Dam A velocity barrier modifications and will need to be staged with construction. The Contractor will review the hydrology and hydraulics of the powerhouse canal (Specification 01 12 00) and determine the elevations required for any cofferdam system. Dewatering pumps will be placed inside the cofferdam and the intake construction area to collect seepage and pump it over the cofferdam to the Dam A impoundment. Staging of the cofferdam must maintain water to the City of Yreka intake at all times. Therefore, it is expected that the cofferdam will be in place along the southwest bank of the powerhouse canal for construction of the intake structure and appurtenances, and a portion of the velocity barrier modifications. The cofferdam will then need to be moved to the northwest portion of the stream for the remaining construction of the velocity barrier modifications. While the cofferdam is in place on the northwest portion of the stream, flows must be maintained to the City of Yreka intake. It is expected that the cofferdam will exclude overflow for a segment of Dam A, and a downstream cofferdam will be maintained around the working area.

5.3.3.2 Excavation and Backfill

Around the intake structure, a pad at elevation 2512.4 (NAVD88) will be constructed to exclude water behind the intake. The pad will be constructed from available on-site fill materials, in accordance with the specifications, and will be lined with riprap available from the North Site pad grading excavation. A 25-foot-long sheet pile wall will be installed down to elevation 2502.3 (NAVD88) from the back end of the intake structure to mitigate any seepage that may occur from the Dam A impoundment.

Under the intake, a 6-inch-thick layer Type Drain Rock, Graded (DRG) will be placed to mitigate any pore water pressure that may develop on the bottom of the structure.

The Dam A concrete velocity apron will likewise be constructed over a 6-inch-thick layer of free-draining graded drain rock and will have trench drains on either side of the apron to relieve any pressure. Trench drains will consist of a coarse drain rock backfill, surrounding a perforated pipe that will outlet to the powerhouse channel immediately downstream of the velocity barrier.

5.3.3.3 Fencing

Fencing will be provided around the intake structure for safety and for protection of equipment such as the traveling screens and gates from theft or vandalism. The intake structure enclosure will be accessed through a double leaf gate such that vehicles can access the structure for maintenance or for hauling away accumulated debris from the traveling screens. Fencing will be 8-foot-tall chain link fence with three strands of barbed wire oriented at 45 degrees outward.

5.3.4 Dam B Velocity Barrier Modifications

5.3.4.1 Cofferdam and Dewatering

It is anticipated that a cofferdam will be required to aid construction of the Dam B velocity barrier modifications. The Contractor will review the hydrology and hydraulics of Fall Creek (Specification 01 12 00) and determine the elevations required for any cofferdam system. Dewatering pumps will be placed inside the cofferdam and construction area to collect seepage and pump it downstream into Fall Creek beyond the limits of construction. The Dam B velocity barrier modifications will span a portion of the creek at this location, but will maintain flows to the City of Yreka Dam B intake. A bypass pipe will need to be installed to maintain flows past the construction area.

5.3.4.2 Excavation and Backfill

The concrete velocity apron will be constructed above grade on the downstream side of Dam B. After clearing and grubbing, and scarifying and recompacting the subgrade, the concrete subgrade will be built up on Type Structural Fill (SF) compacted to 95 percent maximum dry density as determined by ASTM D 1557, to 6 inches below the bottom of the concrete, as depicted on the Drawings. The structural fill will be overlaid with a 6-inch-thick layer of Type DRG fill, per specifications, that will drain to trench drains on either side of the concrete velocity apron. Any in-stream disturbance will be replaced with natural cobbles removed during clearing and grubbing of the site.

5.3.5 Coho Building

The Coho Building will be located at the northern extent of the North Site pad grading. The pre-engineered metal building will consist of one room that houses Coho infrastructure from incubation, through first-feeding, and grow-out. The building will be accessible via man-door on the south side of the building, or through one of three roll-up doors (two on the north side of the building, one on the south side). To the north of the building, the concrete slab will extend approximately 22 feet from the outside face of the building to the two existing Coho rearing raceways. The roof from the building will extend out over the existing rearing raceways, and predator netting connected to the roof will form an exclosure around the outdoor rearing raceways. Bollards will be located at all building corners, and along the length of the existing raceways at 10-foot spacing to ensure that a 5-foot offset is maintained by vehicles at all times.

5.3.5.1 Excavation and Backfill

In order to provide a consistent subgrade below the Coho Building, the subgrade will be over-excavated to a minimum of 6 inches and will be back-filled with Type SF material per specifications, which is a readily compacted, crushed rock with 1.5-inch-maximum aggregate. The Type SF fill should extend a minimum of 6 inches beyond the edge of the footings. The structural fill should be compacted to 95 percent maximum dry density as determined by ASTM D 1557.

5.3.6 Chinook Raceways

The Chinook raceways will be outdoors and will consist of two banks of four ponds. These raceways will all discharge to a common exit channel, and the exit channels between the two raceway banks will be connected by a 2.5-foot-wide by 3.0-foot-tall buried box culvert. The two raceway banks will have a 12-foot center aisle running between them for vehicular access. The ponds will be surrounded by fencing and predator netting (see Section 5.3.1 above) that will maintain a minimal offset from the pond concrete, such that feed vehicles on the outside of the exclosure can still access the ponds from outside the fence.

The pond inverts will be located at elevation 2500 (NAVD88) and the pond walls will extend 2 feet above grade to elevation 2505 (NAVD88).

5.3.6.1 Excavation and Backfill

The ponds will be excavated 3 ft below the pad elevation (2503 NAVD88) and will be over-excavated an additional 6 inches. The subgrade shall be scarified and recompacted, and a 6-inch layer of Type DRG, per specifications, will be placed and compacted to form a suitable subgrade for the ponds.

5.3.7 Chinook Incubation Building

The Chinook Incubation Building is located at the southern extent of the North Site adjacent to the existing Copco Road. The pre-engineered metal building will house all Chinook incubation infrastructure, including incubation stacks and working vessels. The building will be accessed on the west side through a set of double doors, or on the south side of the building through a roll-up door for equipment access.

Along the southern edge of the building, a separate room will house the site's electrical infrastructure. The electrical room will be accessed through a man-door on the west side of the building. Around the outside of the building, the building corners will be protected by bollards.

5.3.7.1 Excavation and Backfill

In order to provide a consistent subgrade below the Chinook Incubation Building, the subgrade will be over-excavated to a minimum of 6 inches and will be back-filled with Type SF material per specifications, which is a readily compacted, crushed rock with 1.5-inch-maximum aggregate. The Type SF fill should extend a minimum of 6 inches beyond the edge of the footings. The structural fill should be compacted to 95 percent maximum dry density as determined by ASTM D 1557.

5.4 South Site

The South Site, or the Project site south of existing Copco Road, consists of a pad extending down from the existing road to elevation 2491.5 (NAVD88) designed to support the Spawning Building. In addition, the South Site contains the vault toilet, the genset and propane tank, the adult holding ponds, the settling pond, the fish ladder, and the removable fish barrier.

The South Site was designed to provide vehicular access to the Spawning Building and to the settling pond by the design vehicles. A swept path analysis was performed for this area, and the design vehicles have access and egress to the design points. The swept path analysis is summarized in Appendix B.

5.4.1 Fencing

Fencing is provided around the majority of the South Site, to preclude unhindered access to the Spawning Building equipment, the holding ponds, and the settling pond. Fencing will be 8-foot-tall chain-link fence with three strands of barbed wire oriented at 45 degrees outward to prevent larger predators from climbing over the fence. The fencing layout will be as indicated on the Drawings and will have man-gates and vehicular access double-leaf gates in the locations indicated.

5.4.2 Grading

Grading of the area was primarily driven by the elevation of the Spawning Building and existing concrete raceways and the elevation of Copco Road. Grades were maintained from Copco Road (about elevation 2496 [NAVD88]) down to this lower site (about elevation 2491.5 [NAVD88]) at no greater than 8 percent for vehicular access. At elevation 2491.5 (NAVD88), the pad flattens out and remains at or slightly below that elevation. The pad is primarily in cut, and maximum cut slopes of 2H:1V were maintained.

The pad will be surfaced with a 4-inch-thick ¾-inch-maximum Type Granular Fill per specifications, and an 8-inch thick Type Aggregate Subbase material per specifications beneath.

5.4.2.1 Site Drainage

Due to the grading constraints, the pad is naturally graded toward the Spawning Building. Concrete swales will collect water around the Spawning Building and will direct any surface runoff to catch basins located around the South Site pad grading. Catch basins will direct flows through the storm drain system to an infiltration trench at the perimeter of the site. This will allow stormwater to drain freely and infiltrate into the groundwater system.

5.4.3 Spawning Building

The Spawning Building is located at the north end of the existing lower raceway bank, approximately 10 feet 3 inches from the outside face of the concrete. The pre-engineered metal building will house all infrastructure necessary for spawning activities, including the egg-rinsing table, water hardening table, holding table, air spawning table, fish chutes, fish conveyors, collection bins, etc. To the south, the Spawning Building will have an awning that will be used to keep personnel out of the elements during spawning activities and collection of fish from the adult holding ponds.

The Spawning Building will have access from the east and the west by man-doors, and will have roll-up doors to the north and south for equipment access. A parking area will be maintained on the west side of the building, and all building corners will be protected by bollards.

5.4.3.1 Excavation and Backfill

In order to provide a consistent subgrade below the Spawning Building, the subgrade will be over-excavated to a minimum of 6 inches and will be back-filled with Type SF material per specifications, which is a readily compacted, crushed rock with 1.5-inch-maximum aggregate. The Type SF fill should extend a minimum of 6 inches beyond the edge of the footings. The structural fill should be compacted to 95 percent maximum dry density as determined by ASTM D 1557.

5.4.4 Fish Ladder and Temporary Picket Barrier

The fish ladder and temporary picket barrier will be located at the southern end of the existing raceway bank, and in the adjacent stretch of Fall Creek. The temporary picket barrier will be placed yearly at the beginning of the trapping period; however, a concrete sill and walls will be permanently in the stream. Both the fish ladder and the sill will be concrete structures, as depicted in the plans. In addition, some localized grading will be provided around these structures.

5.4.4.1 Cofferdam and Dewatering

It is anticipated that a cofferdam will be required to aid construction of both the fish ladder and the temporary picket barrier sill. The Contractor will review the hydrology and hydraulics of Fall Creek (Specification 01 12 00) and determine the elevations required for any cofferdam system. Dewatering pumps will be placed inside the cofferdam and construction area to collect seepage and pump it downstream into Fall Creek beyond the limits of construction. The concrete sill will span the entire creek at this location, and therefore a bypass pipe will need to be installed to maintain flows past the construction area.

5.4.4.2 Excavation and Backfill

After the area is cleared and grubbed and topsoil is stripped from the site, the fishway will be excavated into the eastern bank of Fall Creek. The fish ladder will be over-excavated an additional 6 inches and after the subgrade is scarified and recompacted, a 6-inch layer of Type DRG material per specifications will be placed and compacted to form a suitable subgrade for the concrete construction.

For the concrete sill, a similar process will be performed with a 6-inch-thick layer of Type DRG material underlaying the concrete construction. Following completion of the concrete work in this area, the natural creek bed will be restored with any material or cobbles that were removed during the initial clearing of the site.

6.0 Geotechnical Design

6.1 Engineering Soil Properties

Engineering soil properties were selected based on the subsurface conditions described in the Geotechnical Data Report. Anticipated ranges in soil properties are provided below.

Table 6-1. Soil Properties

Soil Unit	Total Unit Weight (pcf)	Friction Angle, ϕ (deg)	Cohesion, c (psf)
Existing Fill	140	38	0
Colluvium	115-120	26-30	50 - 200
Alluvium	120	28-32	0

6.2 Shallow Foundations

The Coho Building, Hatchery Building, and Chinook Raceways will be supported on shallow foundations. Recommendations for shallow foundations are provided in the following sections.

6.2.1 Bearing Surface Preparation

Based on available geotechnical data, structures will bear primarily within colluvium soils. Footings bearing in colluvium should be supported on an 18-inch to 24-inch section of imported structural fill (SF) foundation base material. The bearing surface should be inspected prior to placement of SF and should be clear of deleterious material and standing water. If soft, pumping soils are observed at the bearing elevation, an additional 6- to 12-inches of colluvium should be removed from below the footing. A non-woven geotextile consisting of Mirafi RS280i or equivalent, should be placed at the base of the footing excavation for added stability.

Structural fill should be placed in loose lifts of 6- to 8-inches and compacted to 95 percent of maximum dry density (MDD).

6.2.2 Bearing Resistance

Structures bearing on soils prepared as outlined in the previous section may be design using an allowable bearing resistance of 2 kips per square foot (ksf). This allowable bearing resistance applies to the total of dead and long-term live lads and may be increased by up to one-third for wind or seismic loads.

6.2.3 Lateral Resistance

Lateral forces on shallow foundation may be resisted by passive resistance on the side of footings and by friction on the base of the footings. Frictional resistance may be computed using an allowable coefficient of friction of 0.49 for cast-in-place foundations and 0.39 for precast concrete foundations applied to vertical dead load forces.

Passive pressure acting at the side of the shallow foundation can be estimated using an equivalent fluid density of 400 pounds per cubic foot (pcf) (triangular distribution).

The above coefficients of friction and passive equivalent fluid density values incorporate a FS of 1.5.

6.3 Lateral Earth Pressures

Lateral earth pressures are needed for design of the raceways and adult holding ponds. The raceways and holding ponds are restrained against deflection; therefore, at-rest earth pressures are recommended for use in design. At-Rest earth pressure coefficients are presented below.

Table 6-2. At-Rest Earth Pressure Coefficients

Soil Unit	At-Rest, K_O	At Rest + Seismic, K_{OE}
Colluvium	0.53	0.91

7.0 Structural Design

7.1 General Description

The structural facilities consists of 11 main systems: (1) the intake structure, (2) the Dam A velocity barrier, (3) the Dam B velocity barrier, (4) the Coho building, (5) the Chinook raceways, (6) the Chinook incubation building, (7) the Spawning Building, (8) the adult holding ponds, (9) the meter vault, (10) the fish ladder, and (11) the temporary picket barrier. Structural calculations for these systems can be found in Appendix D of this DDR.

7.2 Intake Structure

The intake structure measuring approximately 10 feet by 10 feet is situated at the south end of Dam A. Portions of the existing dam will need to be demolished in order to construct the intake structure, as the bottom of the intake structure extends below the bottom of the dam. The dam would therefore be undermined during the construction of the intake structure. The intake structure is composed of reinforced concrete walls with a concrete wingwall measuring 8 feet long, travelling screens with stainless steel support system, and FRP grating across the top providing access to the screens. The new intake structure walls and slab will tie into the existing Dam A at the interface with drilled epoxy dowels. Retrofit waterstops will be provided at all joints between new and existing concrete.

The new intake structure has a positive effect on the overall stability of Dam A. The intake structure consists of a considerable amount of additional concrete, increasing the overall weight and base width of the structure. This will increase the factor of safety of the dam due to sliding and overturning.

7.3 Dam A Velocity Barrier Modifications

In addition to the demolition work at the south end of the dam, the toe of the dam for the entire width of the proposed downstream velocity barrier apron will need to be demolished. The velocity barrier apron consists of a reinforced concrete apron slab measuring approximately 30 feet wide by 16 feet long with vertical retaining walls at both canal banks. The apron and retaining walls will tie into the existing Dam A concrete with drilled epoxy dowels. Retrofit waterstops will be provided at all joints between new and existing concrete.

The new velocity barrier has a positive effect on the overall stability of Dam A. The velocity barrier consists of a considerable amount of additional concrete, increasing the overall weight and base width of the structure. This will increase the factor of safety of the dam due to sliding and overturning, while also reducing bearing pressures at the toe.

7.4 Dam B Velocity Barrier Modifications

The velocity barrier apron consists of a reinforced concrete apron slab measuring approximately 11 feet wide by 20 feet long with vertical retaining walls at both canal banks. The apron and retaining walls will tie into the existing Dam B concrete with drilled epoxy dowels. The existing stoplog slots will be replaced with shorter slots on top of a concrete platform, effectively raising the sill elevation of the stoplogs. Retrofit waterstops will be provided at all joints between new and existing concrete.

The new velocity barrier has a positive effect on the overall stability of Dam B. The velocity barrier consists of a considerable amount of additional concrete, increasing the overall weight and base width of the structure. This will increase the factor of safety of the dam due to sliding and overturning, while also reducing bearing pressures at the toe.

7.5 Coho Building

The Coho Building is the largest of three buildings on the Project. The building consists of a fully enclosed portion measuring approximately 54 feet by 66 feet, and a roof-only portion measuring approximately 50 feet by 66 feet. The roof of the fully enclosed building continues over the roof-only portion for a seamless transition. The building itself is a pre-engineered metal building with insulated metal panels. All exposed steel surfaces of the building will be hot dip galvanized. Flooring will consist of a 6-inch concrete slab. The foundation system consists of cast-in-place (CIP) reinforced concrete stem walls and spread footings for the enclosed portion and four individual column footings for the roof-only portion.

The enclosed portion of the building houses new concrete Coho raceways and various incubation and feeding vessels. The raceways will consist of two ponds measuring approximately 38 feet by 12 feet each. The ponds will consist of 8-inch cast-in-place reinforced concrete walls with embedded stainless guide slots for the existing aluminum fish screens and new aluminum dam boards, and a 2-foot-wide FRP walkway on top of all interior walls. Hinged sections of grating allow access to the guide slots underneath.

Directly adjacent to the building under the roof only portion will be a 20-foot-wide concrete drive-through area for the fish tagging and marking trailer. This area is designed for a 250 psf uniform vehicular surcharge pressure.

The existing concrete raceways will also be under the roof of this structure, directly adjacent to the drive-through. The existing raceway walls and slabs will remain in place, while all of the walls aside from the south wall will be raised to finish-floor elevation. The new wall extensions will be tied to the existing walls with drilled epoxy dowels. The existing raceways will be retrofitted with new reinforced concrete pony walls, stainless steel guide slots, FRP walkways, aluminum dam boards and fish screens, and a fish-friendly polyurethane coating. Hinged sections of grating allows access to the guide slots underneath. Predator netting extending down from the roof framing to grade will protect the Coho ponds from birds of prey.

7.6 Chinook Raceways

The new Chinook raceways are located just south-east of the Coho Building. The raceways will consist of two banks of four ponds each, with a 12-foot drive-through between the two. Each pond measures approximately 70 feet by 12 feet. The ponds will consist of 8-inch cast-in-place reinforced concrete walls with embedded stainless guide slots for the existing aluminum fish screens and new aluminum dam boards, and a 2-foot-wide FRP walkway on top of all interior walls. Hinged sections of grating allow access to the guide slots underneath.

Chain-link fencing around the perimeter of the Chinook raceways will prevent large predators from entering. A predator netting support structure consisting of stainless steel hollow structural section (HSS) and cable wire-rope will be mounted to the top of the exterior walls. The netting will run across the top of the support structure and connect to the chain-link fencing to provide complete protection from birds of prey.

7.7 Chinook Incubation Building

The Chinook Incubation Building is fully enclosed, measuring approximately 63 feet by 53 feet with a 12-foot by 10-foot electrical room attached to the south corner. The main building and electrical room both have an eave height of 15 feet. The building is a pre-engineered metal building with insulated metal panels. All exposed steel surfaces of the building will be hot dip galvanized. The building houses incubation vessels and tray storage. Flooring will consist of a 6-inch concrete slab. The foundation system consists of a CIP reinforced concrete thickened slab around the perimeter of the building.

7.8 Spawning Building

The Spawning Building is the smallest of three buildings on the Project. The building consists of a fully enclosed portion measuring approximately 37 feet by 27 feet and a roof-only portion measuring approximately 10 feet by 27 feet. The roof of the fully enclosed building continues over the roof-only portion for a seamless transition. The enclosed portion of the building houses various worktables used for collecting eggs from adult salmon. Flooring will consist of a 6-inch concrete slab. The foundation system consists of CIP reinforced concrete perimeter-grade beam for the enclosed portion, and two individual column footings for the roof-only portion. The roof-only portion will exhibit a limestone surfacing and provide shelter for the electro-anesthesia (EA) tank and hatchery workers.

7.9 Adult Holding Ponds

The adult holding ponds are located directly adjacent to the roof-only portion of the Spawning Building. The holding ponds will consist of four ponds measuring approximately 70 feet by 12 feet. The ponds will consist of 8-inch cast-in-place reinforced concrete walls with embedded stainless guide slots for new aluminum fish screens and new aluminum dam boards, and a 2-foot-wide FRP walkway on top of all interior walls. Hinged sections of grating allow access to the guide slots underneath. Jump prevention netting will be provided at all interior walls along the walkway to prevent fish from jumping between ponds. Floor diffusers located at the north end of the ponds provide an obstacle-free path on that side of the ponds. For egg collection, hatchery workers can crown the fish to the north end of the sorting pond into a hoist that will lift the fish into the EA tank.

Chain-link fencing around the perimeter of the adult holding ponds ties into the Spawning Building and will prevent large predators from entering. A predator netting support structure consisting of stainless steel HSS and cable wire-rope will be mounted to the top of the exterior walls. The netting will run across the top of the support structure and connect to a cable running along the top of the walls to provide protection from birds of prey. There will be some small openings in the netting along the southern side where the netting crosses the ponds.

7.10 Meter Vault

The meter vault will house various flow meters and mechanical valves for the intake piping for the Project. The vault will consist of cast-in-place reinforced concrete slab and walls, with an aluminum access hatch measuring 8 feet 13 feet and covered FRP grating for a roof. The inside dimensions of the vault are approximately 13 feet by 15 feet.

Due to the close proximity to Fall Creek, the meter vault will need to be designed to resist buoyant forces due to water pressure beneath the slab. This will be accomplished with rock anchors strategically placed at various locations across the slab.

7.11 Fish Ladder

The fish ladder structure connects the adult holding ponds to Fall Creek downstream of the facility. Adult salmon will travel up the fish ladder and be sorted into the various ponds during spawning season. The fish ladder consists of CIP reinforced concrete with Denil-style baffle sections supported by stainless steel embed guides.

7.12 Temporary Picket Barrier

The temporary picket barrier prevents fish from travelling farther upstream Fall Creek and directs the fish into the Denil fish ladder. The barrier is removeable and will only be in place during spawning season. It consists of aluminum rods spaced with 1-inch clear that are strung through several aluminum stringers that connect adjacent panels. The panels can be set in place in their location in the channel in a relatively short amount of time due to their light weight and simple design. A CIP reinforced concrete apron measuring approximately 8 feet by 17 feet will serve as a uniform sill surface for the temporary barrier to sit on. The apron will span between CIP reinforced concrete retaining walls at each bank.

8.0 Mechanical Design

8.1 General Description

This section presents a narrative description of the mechanical elements at each of the Project facilities and provides details on the mechanical design of each component.

8.2 Intake Structure

The mechanical components of the intake structure include debris screens, a sluicing gate, isolation valves, vacuum breaker valves, and flow meters. The design, sizing, and operation of these components are discussed in the following subsections.

8.2.1 Debris Screens

The debris screens at the intake of the hatchery will consist of two vertically oriented traveling screens located in guide slots immediately upstream of the hatchery supply piping inlet. The debris screens will serve to filter out larger debris and detritus from entering the facility to minimize the risk of clogging small piping and valves. The screens will have 1-inch clear openings and will be mobilized such that any debris captured on the upstream face is lifted out of the water to a spray wash system, where any material caught on the screen will be dislodged and fall into a debris trough. The debris trough will rest on the operator’s platform atop the intake structure and will be cleaned out periodically by operations and maintenance staff.

The screen and spray wash system can have three different modes of operation:

- The screen and spray wash may be set to automatically operate at time intervals defined by hatchery personnel, based on site experience.
- The screen and spray wash may be set to automatically operate when a set head differential is measured across the screen by the surrounding level sensors.
- The screen and spray wash may be set by manual actuation, as necessary, by hatchery personnel.

The spray wash will consist of a pump and piping system that draws water from the downstream side of the screen and conveys it to a spray bar with nozzles that will extend across the screen above the debris trough. It is expected that when the spray wash system is engaged, there will be some minor losses to evaporation and aberrant sprays, but these losses are expected to be minimal.

8.2.2 Intake Sluice Gate

As flow passes over the concrete lip at the entrance of the intake structure, some debris is anticipated to settle out of the flow immediately upstream of the debris screens. An aluminum sluice gate with self-contained frame will be located on the upstream face of Dam A, intended to discharge any collected debris from the intake structure though a new 12-inch-diameter penetration through the dam. This gate is anticipated to be normally closed and opened via a handwheel-actuated rising stem by hatchery personnel as part of routine maintenance activities.

8.2.3 Isolation Valves

Immediately downstream of the intake structure the intake piping branches into four individual supply pipes and enters a metering vault. Within this vault, each pipe will be provided an isolation gate valve to allow shutting off of flow to any of the structures within the hatchery. The valves are anticipated to be normally open and are intended to be closed during major maintenance activities or whenever a complete dewatering of the facility is required. Each valve will be a flanged, ductile iron, resilient seated gate valve with a manual 2-inch square nut actuator.

8.2.4 Air/Vacuum Valves

An air/vacuum valve will be located downstream of the isolation valves within the valve vault on each supply pipeline. These valves will allow air to be released from the pipeline during initial filling and prevent vacuum formation within the line during a dewatering event. The combination air release/vacuum breaker valve is anticipated to be 2-inch diameter, of cast iron construction, and located at the crown of each supply pipeline.

8.2.5 Flow Meters

Each supply line will be equipped with an inline magnetic flowmeter for reliable flow measurement to each structure in the hatchery. The flowmeters will be located a sufficient distance upstream of the isolation valves to minimize flow disturbance and ensure accurate flow measurement readings. Each meter will be of steel or cast-iron construction and contain a polyurethane liner. The flow meters will be sized based on the design criteria shown in Table 8-1.

Table 8-1. Flow Meter Design Criteria

Equipment ID	Description	Flow Range (GPM)	Accuracy
FE-200	Coho Building Supply	0 - 1000	±5%
FE-201	Adulting Holding Pond Supply	0 - 4500	±5%
FE-202	Chinook Rearing Supply	0 - 4500	±5%
FE-203	Chinook Incubation Supply	0 - 750	±5%

8.3 Coho Building

The mechanical components within the Coho Building include the rearing raceway banks, incubation head tank, incubation working vessels, feeding vessels, waste drain system, plumbing system, and building HVAC. The design, sizing, and operation of these components are discussed in the following subsections.

8.3.1 Rearing Raceways

Two sets of raceways exist within the Coho Building:

- A pair of existing raceways, located outdoors underneath the building awning, and;
- A pair of new raceways located within the building structure

Each raceway will contain segmented bays for varying the allocated space requirement of the juvenile Coho salmon. The bays will be separated by the removable aluminum fish screens currently in use at the Iron Gate Hatchery facility. To facilitate use of the existing fish screens, piers will be installed down the centerline of each raceway allowing for two 5 foot -3/8-inch screens to be inserted and removed by hatchery personnel.

At the head of each raceway, flow is controlled with a 6-inch PVC ball valve, manually throttled to achieve the desired flow rate. At the downstream end of each raceway, flows pass over a dam board weir, set to a height required to achieve necessary flow depth for fish rearing. An aluminum stop gate is located at the inlet to the drainage piping, which shall be installed to divert flow through the fish release pipe during volitional fish releases to Fall Creek.

8.3.2 Coho Incubation Head Tank

Incubation stacks will be re-used from the Iron Gate Hatchery to facilitate Coho egg incubation. The incubation head tank/stack design will consist of an aluminum tray stand with adjustable feet supporting six stacks of eight trays. Approximately 5 gpm will be supplied to each stack through a head trough, with a 1-inch PVC ball valve at each stack used for flow regulation and isolation purposes. The head trough will be supported from the wall of the Coho Building and will be equipped with an overflow standpipe, providing a constant head for easier adjustment of the flow rate into each stack.

8.3.3 Coho Incubation Working Vessels

Existing fiberglass tanks will be re-used from the Iron Gate Hatchery as working vessels for the Coho incubation area. These vessels are anticipated to be used for egg picking and enumeration purposes. A 3-inch ball valve will be provided at the head of each working vessel for flow regulation and isolation purposes. Flow will be drained through a removable standpipe at the downstream end of each vessel.

8.3.4 Coho Feeding Vessels

Four feeding vessels will be located within the Coho building, two of which are re-used from the Iron Gate Hatchery, and two will be newly fabricated for the Fall Creek Hatchery. The new feeding vessels will be of fiberglass construction with a width of 5 feet 1 inch and a length of 20 feet. The feeding vessels will be segmented into quarters, with fish screen slots to facilitate insertion of the existing aluminum fish screens from the Iron Gate Hatchery. Flow will be regulated by a 3-inch PVC ball valve at the upstream end and drained by a removable standpipe at the downstream end.

8.3.5 Waste Drain System

A waste drain system will be provided within the Coho Building and adjacent to the outdoor raceways to facilitate removal of fish fecal matter and uneaten food from the ponds. The waste drain system will consist of 2-inch-diameter pipe protrusions from the floor with a stainless-steel cam locking-type quick disconnect for attaching a waste removal vacuum attachment during regular cleaning cycles. All waste will be conveyed through this piping to the settling pond, where it will be collected and removed from the facility.

8.3.6 Plumbing System

Non-potable utility water will be provided within the Coho Building to supply washdown water through numerous hose bibs located internally and externally throughout the structure. A booster pump will tap off the adult holding pond supply line to fill and pressurize two 80-gallon hydropneumatic tanks located at the eastern corner of the building. The hydropneumatic tanks are anticipated to provide a flow at a relatively constant pressure to the hose bib system located throughout the building.

8.4 Chinook Rearing Area

Mechanical design elements at the Chinook rearing area consist of components within the Chinook rearing raceways and the waste drain system.

8.4.1 Rearing Raceways

Eight raceways are provided for the rearing of Chinook salmon. Each raceway will contain segmented bays for varying the allocated space requirement of the juvenile fish. The bays will be separated by the removable aluminum fish screens currently in use at the Iron Gate Hatchery facility. To facilitate use of the existing fish screens, piers will be installed down the centerline of each raceway allowing for two 5 foot-3/8-inch screens to be inserted and removed by hatchery personnel.

At the head of each raceway, flow is controlled with a 6-inch PVC ball valve, manually throttled to achieve the desired flow rate. At the downstream end of each raceway, flow passes over a dam board weir, set to a height required to achieve necessary flow depth for fish rearing purposes. Additional dam board slots are provided upstream of the fish release and drain pipelines for diversion of flow during volitional release operations.

8.4.2 Waste Drain System

A waste drain system will be provided around the Chinook rearing raceways to facilitate removal of fish fecal matter and uneaten food from the ponds. The waste drain system will consist of 2-inch-diameter pipe protrusions from the floor with a stainless-steel cam locking-type quick disconnect for attaching a waste removal vacuum attachment during regular cleaning cycles. All waste will be conveyed through this piping to the settling pond, where it will be collected and removed from the facility.

8.5 Chinook Incubation Building

The mechanical components within the Chinook Incubation Building include the incubation head tanks, incubation working vessels, plumbing system and building HVAC. The design, sizing, and operation of these components are discussed in the following subsections.

8.5.1 Chinook Incubation Head Tank

Incubation stacks will be reused from the Iron Gate Hatchery to facilitate Chinook egg incubation. The incubation head tank/stack design will consist of an aluminum tray stand with adjustable feet supporting 17 stacks of eight trays. Approximately 5 gpm will be supplied to each stack through a head trough feeding back to back rows of incubation trays (34 stacks total), with a 1-inch PVC ball valve at each stack used for flow regulation and isolation purposes. The head trough will be equipped with an overflow standpipe, providing a constant head for easier adjustment of the flow rate into each stack. The Chinook Incubation Building will house four back-to-back rows of incubation trays, for a total of 136 incubation tray stacks.

Each tray will discharge into a drainage trench located within the concrete underneath the centerline of each head tank. The end of the drainage trench will contain two 8-inch-diameter standpipes, one leading to the adult holding ponds (drain) and the other leading to the settling ponds (waste drain). During normal operations, the water will be directed into the drain directing flow to the adult holding ponds. Hatchery personnel will have the option of pulling the waste drain standpipe and diverting all flow to the settling pond during cleaning operations.

8.5.2 Chinook Incubation Working Vessels

Existing fiberglass tanks will be reused from the Iron Gate Hatchery as working vessels for the Chinook Incubation Building. These vessels are anticipated to be used for egg picking and enumeration purposes. A 3-inch ball valve will be provided at the head of each working vessel for flow regulation and isolation purposes. Flow will be drained through a removable standpipe at the downstream end of each vessel.

8.5.3 Plumbing System

Non-potable utility water will be provided within the Chinook Incubation Building to supply washdown water through numerous hose bibs located internally and externally throughout the structure. A booster pump will tap off the adult holding pond supply line to fill and pressurize two 80-gallon hydropneumatic tanks located at the southern corner of the building. The hydropneumatic tanks are anticipated to provide a flow at a relatively constant pressure to the hose bib system located throughout the building.

8.6 Spawning Building

Mechanical design elements within the Spawning Building include the fish lift/electro-anesthesia tank system, egg rinse/water hardening stations, conveyor belt, and building plumbing.

8.6.1 Fish Lift/Electro-Anesthesia System

A fish lift and electro-anesthesia system will be located at the head of the trapping/sorting pond for the purposes of collecting and anesthetizing fish for sorting and spawning purposes. Both devices are existing elements that will be reused from the Iron Gate Hatchery. The fish lift consists of a 6-foot by 4-foot basket with hoisting system for trapping fish in the raceway and raising them to the level of the electro-anesthesia tank located on the ground surface at the head of the pond. Fish are deposited into the electro-anesthesia tank where they are sedated or euthanized, depending on the operation being performed. The electro-anesthesia tank is additionally equipped with a separate hydraulic hoist where fish are raised and deposited on a sorting table for further processing.

8.6.2 Egg Rinse/Water Hardening Station

An existing egg rinsing table and water hardening table will be relocated from the Iron Gate Hatchery to the Spawning Building. Both units will be located against the northeastern wall of the structure and provided with water from the adult holding ponds supply line. Water is discharged through the tables into a drainage trench where it is drained to the settling pond.

8.6.3 Conveyor Belt

The existing motorized conveyor belt at the Iron Gate Hatchery will be relocated to the Spawning Building. The conveyor belt contains multiple sections and may be connected to an approximate 100-foot length. This system is primarily intended to be used for transporting fish carcasses to a collection bin located outside the northern wall of the structure.

8.6.4 Plumbing System

Non-potable utility water will be provided within the Spawning Building to supply washdown water through numerous hose bibs located internally and externally throughout the structure. A booster pump will tap off the adult holding pond supply line to fill and pressurize two 80-gallon hydropneumatic tanks located at the eastern corner of the building. The hydropneumatic tanks are anticipated to provide a flow at a relatively constant pressure to the hose bib system located throughout the building. One hose bib shall be located on a retractable hose reel above the holding table to provide washdown water and a wetted surface during fish sorting/spawning operations.

8.7 HVAC Design

8.7.1 Winter Heating

The Coho Building, Chinook Incubation Building, and Spawning Building heating systems will consist of a single downflow electric unit heater located in the middle of the building. Supplemental heating will be provided by electric radiant heaters at the locations recommended for personnel comfort.

8.7.2 Building Fresh Air Requirements

Fresh air ventilation will be provided by the use a single inline fresh air fan and louver in each building. The fan will provide continuous ventilation through the year. The fresh air requirements for each building will be per American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) 62.1-2019.

8.7.3 Summer Cooling

The Coho Building and Chinook Incubation Building cooling systems will consist of two wall-mount propeller fans with two fresh air louvers that will provide free air cooling. The fan flow rate is designed for six air changes per hour to minimize condensation build-up and provide air circulation through the building space. The wall-mount fans will be controlled via an on/off switch.

The Spawning Building's cooling system will consist of a single wall-mount propeller fans with a fresh air louver that will provide free air cooling. The fan flow rate is designed for six air changes per hour to minimize condensation build-up and provide air circulation through the building space. The wall-mount fans will be controlled via an on/off switch.

The electrical room located within a separate room attached to the Chinook Incubation building will require cooling. The cooling system will consist of a 1-ton mini split wall-mount unit and condenser unit. The condenser unit will be mounted on a small support stand to protect it from snow and water build-up. The electrical equipment heat output in the room is anticipated to be 2.5 kW. Mechanical heating will not be required due to the high heat output of the electrical equipment in the room.

9.0 Electrical Design

9.1 Utility Power Service

Power from a locally available source will need to be conveyed to the site. Initial examination suggests that the nearest likely power source would be from the three-phase power utility lines to the east owned by PacifiCorp. The distance from the existing utility lines to the proposed site is approximately 520 feet. The installation contractor will coordinate with PacifiCorp to provide a new power utility service drop for the site location. The service voltage required is 480 volt, three-phase power, connected in wye-ground configuration. Preliminary calculations place the service transformer size at 225 kVA, or three 75 kVA single-phase cans.

9.2 Facility Power Distribution

Service equipment will be located on the exterior of the Chinook Incubation Building due to its proximity to potential utility sources. The Chinook Incubation Building will house the majority of electrical equipment in an electrical room, which is isolated from the main room due to the presence of splashing and spraying water during normal operations. The Chinook Incubation Building will subfeed the Coho Building and Spawning Building, with the Intake Structure subfed from the Coho Building. The general distribution arrangement for the majority of loads at each building will consist of a 480V, three-phase panel, a step-down transformer, and a 208V/120Y, three-phase panel. The 480V panelboards will serve the large motor loads and HVAC equipment, while the 208/120V panelboard will serve lights, convenience receptacles, instrumentation, SCADA, and small HVAC and motor loads. Detailed load calculations are included in the panel schedules on the drawings. Additionally, a step-down transformer and 240/120V, single-phase panel will be provided to feed loads that require 240V, including the tagging trailer and fish pump receptacles. Power receptacles will also be provided north of the site for hook-up of a RV trailer.

9.3 Propane Standby Generator

The existing 100 kW generator set has been assessed for reuse at this facility to provide standby power to all critical loads for the facility. Generator sizing calculations were performed using Kohler's generator sizing software, and are included in Appendix E. While this design includes methods for automatic load-stepping of equipment starting and disabling/ignoring non-critical loads during a power outage to avoid procuring a larger generator, the current running load assumed to be required during an outage exceeds 100 kW. Preliminarily, this design is proposing a new 130 kW generator to feed the facility based on this calculation; however, future iterations of the design will consider other alternatives, such as reducing total heating load or instituting manual load-shedding procedures during power outages, in order to attempt to reuse the existing generator instead.

The generator will be designed to run on liquid propane (LP) stored in an on-site tank. Based on the 130 kW generator noted above, a 500-gallon above-ground cylindrical tank is calculated to be required to meet the minimum capacity requirement of 24 hours of power.

9.4 Lighting Design

High bay lighting will be provided at each building, and switched lights will be provided above building exterior doors and at the intake structure for maintenance purposes. Lighting will conform to the requirements of the California Energy Code and will be exclusively LED-based fixtures. Excluding the electrical room, interior lighting will be provided primarily by skylight refraction tubes during the day, with high bay fixtures providing auxiliary illumination to each building during night operations and other times when natural light is limited. Lighting level calculations for each room have been provided under Appendix E.

The underlying design assumption for each building is that high intensities of light (88 ft-c and greater) will act as a lethal agent to Coho and Chinook salmon eggs, as found by Eisler (1958). Further, dimmable lighting levels may be desirable to the facility operators to limit adult and juvenile salmon exposure to light to a natural, circadian schedule. Under those assumptions, both the skylight refraction tubes and high bay fixtures will be controlled by manual dimmer switches to allow the operators to dim lighting as much as necessary to prevent premature egg mortality, but also provide lighting necessary for natural salmon growth rates. Preliminary lighting levels for the Coho and Chinook Incubation Buildings are designed to provide 40 ft-c on average from skylight refraction tubes and 20 ft-c on average from high bay lighting. For the Spawning Building, both skylight refraction tubes and high bay lighting levels are designed to provide 20 ft-c on average. The lighting fixtures as specified will allow dimming down to 10 percent illumination for the high bays, and 2 percent for the skylight refraction tubes. Options for further dimming are available, if desired. No occupancy sensors, photocell control, or other intelligent lighting control is planned for the facility.

10.0 Instrumentation and Controls

10.1 General Description

All instrumentation and controls will be mustered to a single SCADA cabinet located in the Chinook Incubation Building electrical room. The SCADA cabinet will house PLC, UPS, alarms, relays, terminal blocks, and other components required for a complete system. There will be no SCADA or remote control of the facility; all subsystems will be controlled locally through manual or sensor-based actuation.

PLCs used in the Project will be Allen Bradley, Emerson, Schneider Electric, or equal models. The SCADA cabinet will have a UPS to maintain operability of critical monitoring functions at the fish hatchery for a short duration, with the on-site standby generator providing up to 24 hours of backup power to the facility. In the event of a primary PLC failure, the facility will alert operators of the loss.

Telemetry communication for system visibility to the operators will be achieved using an automatic cellular alarm dialer (autodialer). The autodialer will call site operators when an alarm occurs, and will allow for multiple sequential alarm dial-out numbers and alarm acknowledgement from remote phones. The autodialer will be equipped with automatic battery backup, in addition to being backed up by the SCADA UPS and the standby generator. Communication design will be refined in subsequent design deliverables.

The water surface elevation sensors will be submersible pressure transducers in heated stilling wells. The raw water flowmeters will be magnetic, inline type, as described above in Section 7.2.5. The dissolved oxygen/temperature sensor will be either optical or galvanic cell type. The level switches in the meter vault, one for the sump and one for vault high-level alarm, will be the conductive, non-moving type. Intrusion switches will be standard magnetic type.

10.2 Intake Structure

Instrumentation at the Intake Structure will consist of intake water surface elevation sensors (for measurement of differential pressure across the screen), raw water supply piping flowmeters located in a vault, a dissolved oxygen/temperature sensor, level switches in the meter vault, and a vault intrusion detection switch. The traveling screens and spray wash pumps will be controlled locally from the control panel only, either automatically or manually as described above in Section 7.2.1. Status I/O points will be sent to SCADA from the traveling screens control panel and the transmitters, analyzers, and switches.

10.3 Coho Building

Instrumentation at the Coho Building will consist of a level switch in the incubator head tank and door intrusion detection switches. Status I/O points will be sent to SCADA from each of the switches. No other instrumentation and control are planned for this building.

10.4 Chinook Raceways

Instrumentation and control are not planned for this feature.

10.5 Chinook Incubation Building

Instrumentation at the Chinook Incubation Building will consist of a level switch in each of the incubator head tanks and door intrusion detection switches. Status I/O points will be sent to SCADA from each of the switches. No other instrumentation and control are planned for this building.

10.6 Spawning Building

Instrumentation at the Spawning Building will consist of a foot-pedal safety switch for the electro-anesthesia unit and door intrusion detection switches. Status I/O points will be sent to SCADA from each of the intrusion switches. The safety switch will be used for local control of the electro-anesthesia unit only. No other instrumentation and control are planned for this building.

10.7 Adult Holding and Settling Ponds

Instrumentation and control are not planned for this feature.

10.8 Fish Ladder

Instrumentation at the fish ladder will consist of a dissolved oxygen/temperature sensor at the water outlet. Status I/O points will be sent to SCADA from the analyzer. No other instrumentation and control are planned for this building.

11.0 Operations

11.1 General Description

The following subsections discuss general operations of the Fall Creek Hatchery. The information is intended to be high-level for this design phase and will be further defined through discussions with KRRC and CDFW in future design phases.

11.2 Water Distribution and Collection Systems

The intake located at Dam A for the Project is intended to operate autonomously, with self-cleaning screens set to initiate a cleaning cycle based on pre-set head differential or time interval. Debris removed from the screens will be collected in a trough, which will require occasional removal by hatchery personnel. The isolation valves on each of the four (4) supply pipelines are intended to be normally open, with all flow being controlled in the downstream distribution systems.

Supply piping will generally be operated by valves located at each of the raceways, vessels, or working spaces. Flows through each of the supply pipelines will be monitored by the flow meters located in a below grade vault with flow rate estimates transmitted to the PLC. To maintain the 10 cfs water right, the PLC will be programmed to alert hatchery personnel if the water right is exceeded. There has been a 0.5 cfs contingency built within the FCFH bioprogram to ensure that the water right is not exceeded while hatchery production goals are achieved.

Flow to individual rearing raceways or vessels will be adjusted by operating the supply manifold valve and estimating flow at the overflow discharge. The production drain piping system will simply convey the rearing raceway and vessel drain flows to the adult holding ponds. There are no control valves on the drain piping system. Clean-outs have been provided on all pipelines throughout the facility to allow hatchery staff to flush the pipelines, as needed, if flow disturbances are observed.

Under typical operations, water will return to Fall Creek after being routed through the drain piping system, through the adult holding ponds and ultimately through the fish ladder downstream of the adult holding ponds.

During times of fish release, water can also return through any of the three (3) volitional release pipes located at the Coho Raceways, Chinook Raceways, or the adult holding pond discharge channel. Stop gates or dam boards shall be placed in front of the raceway drain, diverting all flow through the fish release piping after those respective dam boards have been removed. The volitional release pipes will only be in operation when hatchery staff release fish to Fall Creek throughout the year.

11.3 Waste Management

Waste management will be performed with a vacuum system that discharges to the waste drain system. Quiescent zones will be maintained near the downstream end of the raceways and rearing vessels, where biosolids will settle. Vacuums, as depicted in Figure 11-1, will be used to suction out the solids, and discharge into the waste drain system. The waste drain system will discharge the solids with a transport water flow to the settling pond.

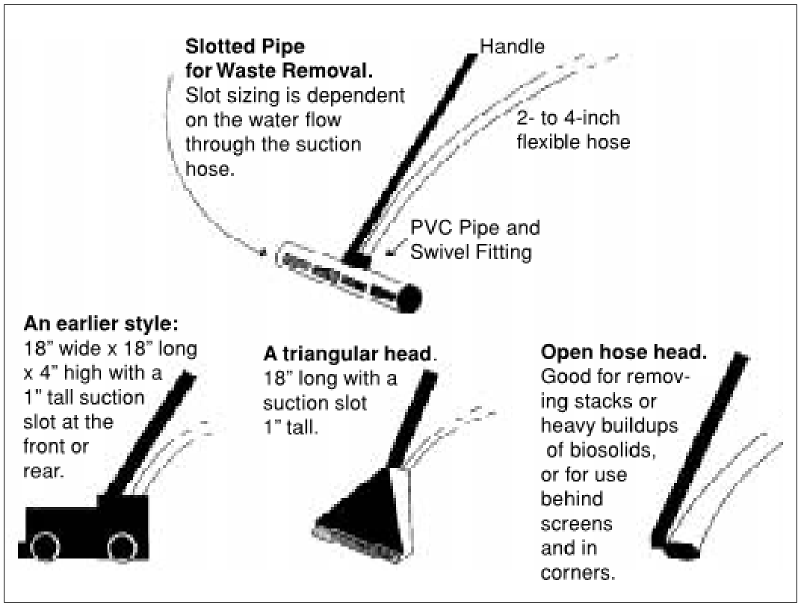

Figure 11-1. Typical Vacuum Removal of Solids (Source: Idaho DEQ, nd)

The settling pond will be partitioned into two sections with the flow from the waste drain system directed to one or the other of these partitions by a valve. One of these subdivisions will collect flows from the upstream cleaning of the ponds, while the water content in the other is allowed to evaporate. Once the drying partition is sufficiently dry, biosolids will be removed and disposed of. The valve will be adjusted to direct flows to the now empty partition, and the water content in the other partition will be allowed to evaporate.

The downstream end of each of the settling pond bays will be equipped with an overflow structure that will divert flow-through water into a pipe that discharges into the fish ladder. The fish ladder will be the primary outfall from the hatchery.

11.3.1 NPDES Sampling

Water quality samples will be required to be sampled at fish ladder downstream of the settling pond discharge location to verify the effluent is within the allowable parameters set by the NPDES permit. CDFW is in the process of negotiating the NPDES permit for the Project. At this design phase, it is assumed that the waste stream from FCFH will be required to meet effluent limitations included in the California Regional Water Quality Control Order No. R1-2015-0009, General NPDES CAG131015, and Waste Discharge Requirements for Cold Water Concentrated Aquatic Animal Production Facility Discharges to Surface Waters. The General NPDES CAG131015 effluent limitations are summarized in Table 2-11. This NPDES design criteria for the Project will be updated once an NPDES permit has been issued for the site.

11.3.2 Treatment of Therapeutants

Another effluent concern for the facility will be the use of therapeutants or inorganics that could occasionally be required for treatment of fish. Use of such therapeutants is not anticipated due to the high quality of the intake water and the short design life of the facility. However, if therapeutants are used for treatment of fish operationally hatchery staff can isolate and direct the flow to the waste drain system and utilize the 3,200 ft^3 of effluent holding provided by the effluent settling pond. While use would be dependent on flow rates supplied to each individual rearing unit, the effluent settling ponds provide short-term storage of up to 24,000 gallons of therapeutant laden flow that could then be pumped to appropriate storage tanks and transferred to approved off-site disposal areas, or discharged to Fall Creek after the required residence time.

11.4 Adult Holding and Spawning

11.4.1 Trapping/Sorting

Adult salmon will be guided to the base of the fish ladder by the fish exclusion picket barrier located adjacent to the holding ponds on Fall Creek. At the head of the fish ladder, adult salmon will pass over a dam board weir and enter the holding pond outflow structure where attractant flows will guide them over a finger weir trap into the sorting/trapping pond. A manual crowding screen will be placed by hatchery personnel to guide fish to the head of the pond and into the fish lift, where they may be hoisted into the electro-anesthesia tank for temporary sedation. Sedated fish will be raised to a sorting table, where adult Chinook are placed in their respective pond through a removable pipe and adult Coho are processed and placed in a separate pond by hatchery personnel.

11.4.2 Spawning

During Chinook spawning operations, the dam boards separating the Chinook holding pond from the sorting/trapping pond will be removed, and a fish screen will be installed in the upper quarter of the trapping pond. The manual fish crowder will be placed by hatchery personnel in the Chinook pond to guide fish into the sorting pond and into the fish lift, where they may be hoisted into the electro-anesthesia tank for sedation. At the sorting table, males and females will be separated and transferred to the holding table within the spawning building. Female salmon eggs will be gathered on the air spawning table, where they will be rinsed, water hardened, and prepared for incubation. If male salmon are to be used more than once during the spawn season, stripped males will be manually returned to their respective rearing containers (raceways for Chinook and spawning tubes for Coho). Fish carcasses will be placed on the conveyor belt and deposited in a collection bin outside, where they will be periodically gathered and processed by hatchery personnel.

11.5 Incubation

Incubation trays are provided in the Coho and Chinook buildings for egg/alevin incubation within the hatchery. Multiple ½-stack incubators (8 trays per stack) are provided in both buildings and hold eggs during incubation, with the water supply provided by a constant head tank feeding each row. Hatchery personnel will be required to perform periodic cleaning of the trays during the incubation period, and working vessels are provided for egg picking and enumeration purposes.

11.6 Juvenile Rearing

Rearing of juvenile salmonids is anticipated to take place in the Coho and Chinook raceway banks. Additionally, the adult holding ponds are provided with dam boards and fish screen slots to allow for juvenile rearing if elected by hatchery personnel. Each raceway contains segmented bays, with the total rearing volume configurable by insertion of removable fish screens. A final screened bay shall be used for initial settling of waste, to be periodically cleaned by hatchery personnel through the waste drain system.

Each raceway bank is equipped with a volitional release piping system, returning juvenile salmon to Fall Creek at the end of the rearing season. Stop gates or dam boards shall be placed in front of the raceway drain, diverting all flow through the fish release piping after those respective dam boards have been removed.

12.0 References

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U.S. Fish and Wildlife Service (USFWS). 2017. *Fish Passage Design Criteria*. USFWS, Northeast Region R5, Hadley, MA

Appendix A
Hydraulic Design Calculations

Calculation Cover Sheet

Project: Fall Creek Hatchery

Client: Klamath River Renewal Corporation **Proj. No.** 20-024

Title: Hydraulic Calculations - 50% Design

Prepared By, Name: Andrew Leman

Prepared By, Signature: **Date:** 6/1/2020

Peer Reviewed By, Name: Vincent Autier, P.E.; Nathan Cox, P.E.

Peer Reviewed, Signature: **Date:** 6/1/2020

6/1/2020

SUBJECT:	Klamath River Renewal Corporation	BY:	A. Leman	CHK'D BY:	V. Autier/N. Cox
	Fall Creek Hatchery	DATE:	6/1/2020		
	Hydraulic Calculations - 50% Design	PROJECT NO.:	20-024		

Table of Content

Hydraulics **Page**

SUBJECT:	Klamath River Renewal Corporation	BY:	A. Leman	CHK'D BY:	V. Autier
	Fall Creek Hatchery	DATE:	6/1/2020		
	Streamflow	PROJECT NO.:	20-024		

Purpose

The purpose of this calculation sheet is to identify design streamflows throughout the site.

References

- *Gotvald, A.J., Barth, N.A., Veilleux, A.G., and Parrett, Charles, 2012, Methods for determining magnitude and frequency of floods in California, based on data through water year 2006: U.S. Geological Survey Scientific Investigations Report 2012–5113, 38 p., 1 pl., available online only at http://pubs.usgs.gov/sir/2012/5113/.*

- *FERC (Federal Energy Regulatory Commission). 2007. Klamath Hydroelectric Project, FERC Project No. 2080-027, Oregon and California: Environmental Impact Statement. U.S. Dept of Energy: FERC. Washington, D.C.*

- *NMFS (National Marine Fisheries Service). 2011. Anadromous Salmonid Passage Facility Design. NMFS, Northwest Region, Portland, Oregon.*

- *CDFW (California Department of Fish and Wildlife). 2004. California Salmonid Stream Habitat Restoration Manual, Vol. II: Fish Passage Evaluation at Stream Crossings. State of California, California Dept. of Fish and Game, Wildlife and Fisheries Division. March 2004.*

- *USGS (U.S. Geological Survey). 2019. Guidelines for Determining Flood Flow Frequency: Bulletin 17C. Version 1.1. U.S. Dept. of the Interior, U.S. Geological Survey, Washington, D.C. May 2019.*

Method

The following design streamflows were identified as necessary for the design of Fall Creek hatchery and appurtenant facilities:

1. 100-year flood - This information will be used to ensure that facilities are protected against large storm events, and outside of the floodway.

2. 2-year flood - The 2-year flood is often associated with the bankfull flow condition in natural streams and rivers. This information will be collected for reference in determining bank locations. This also provides a more frequent flooding event that is very likely to be encountered during the life of the facility.

3. Fish Passage 95% Exceedance - This is designated as a design flow by NMFS (2011), and represents a low design flow during the period that the barrier, fish ladder, and trap are in operation, and anadromous fish are present at the site.

4. Fish Passage 50% Exceedance - This information is collected as a reference value for what would be expected as a typical flow at the site during the period that the barrier, fish ladder, and trap are in operation, and anadromous fish are present at the site.

5. Fish Passage 5% Exceedance - This is designated as a design flow by NMFS (2011), and represents a high design flow during the period that the barrier, fish ladder, and trap are in operation, and anadromous fish are present at the site.

6. Fish Passage 1% Exceedance - This is designated as the high design flow by CDFW (2004) for stream crossings, and was applied as the high flow design criteria for consistency with other elements of the project as a whole.

7. Juvenile Release 1% Exceedance - This was selected as the peak flow month (March) in which juveniles would be released from the hatchery. While it is not typical behavior for them to migrate upstream, the barriers at Dam A and Dam B were designed to preclude passage based on this design flow. The 1% exceedance probability was selected based on CDFW criteria for fish passage (see above).

The following locations of streamflow were identified as necessary for modeling flows in Fall Creek:

1. Powerhouse Channel - This reach is fed by flows diverted to the upstream powerhouse and will be the location of the intake for the hatchery as well as the intake for the City of Yreka, at Dam A.

2. Upper Reach - This reach is the main branch of Fall Creek, and is fed by a waterfall upstream of Dam B (not shown on Figure 1).

3. Middle Reach - Downstream of the confluence of the penstock channel and the upper reach, will be the reach that flows past much of the site including the Copco road bridge, and the fish barrier and trap.

4. Unnamed Drainage - This drainage flows toward the southwest past the existing lower pond battery and combines with the main stream of Fall Creek. This is the drainage into which the existing lower raceway battery currently discharges.

5. Lower Reach - Downstream of the confluence of the middle reach and the unnamed drainage is the lower reach of Fall Creek that continues on to the Klamath River.

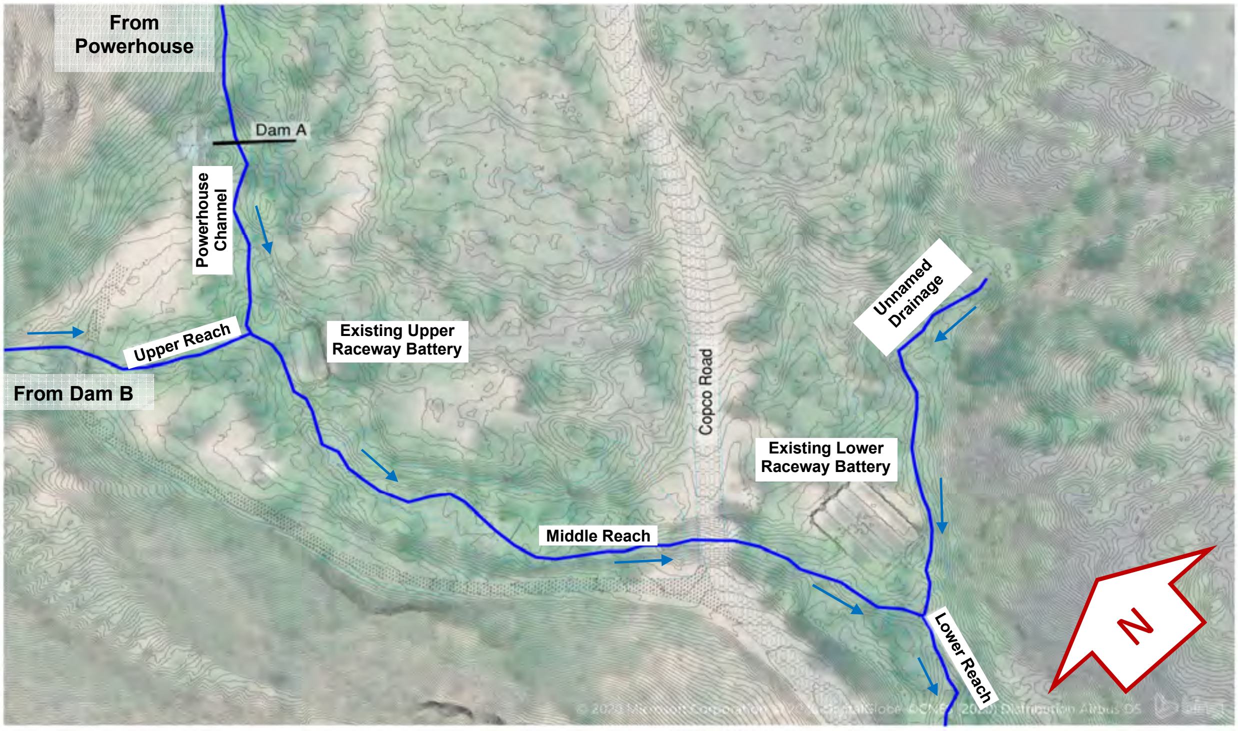


Figure 1. Stream Network Schematic

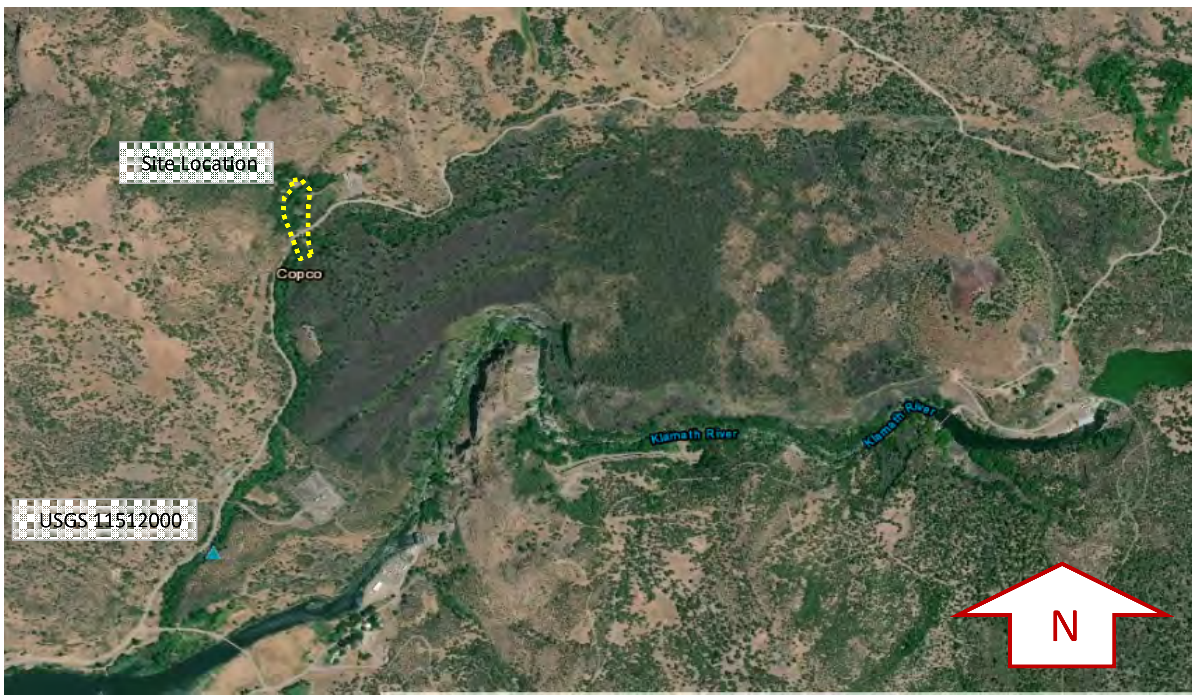


Figure 2. USGS Gage Location Map

The following data sources were identified for evaluation of streamflows at the above locations:

1. USGS Gage Station 11512000 - This gage station is located approximately 2/3 mile downstream from the existing lower raceway bank (see Figure 2), and therefore provides the best representation of flows at the site. The data record consists of daily averaged discharge, and extends from 1933 to 1959, and then from 2003 to 2005. While this does not represent the most recent 25 years (per NMFS, 2011), it is the best available data and does represent a 28 year record.

2. Gotvald et al, 2012 - This report from the USGS provides regional regression relationships by which streamflow can be estimated for ungaged stream locations. This is the method employed by the USGS StreamStats software in the state of California.

3. USGS StreamStats Software - The drainage areas at the points of interest were delineated using the USGS StreamStats software which utilizes the USGS 3DEP (3D Elevation Program) topography.

4. FERC Environmental Impact Statement (2007) - The flows diverted to the Fall Creek powerhouse from Spring Creek and Fall Creek were collected from the FERC environmental impact statement for the Klamath Hydroelectric Project.

The method employed in these calculations will be as follows:

Fish Passage Flows

1. Develop a flow exceedance curve for the downstream gage station 11512000 during the months when fish are present at the site (adults: October - December; juveniles: Mar - May).

2. Determine the fish passage and juvenile design criteria flows (1%, 5%, 50%, and 95% exceedance) from the flow exceedance curve.

3. Adjust the flow rates at the USGS gage to the locations of interest.

a. The regression relationships of Gotvald et al (2012) identify three primary variables of interest to the streamflow: (1) drainage area, (2) precipitation, and (3) elevation. Because of the proximity of the USGS gage to the project site, both precipitation and elevation are expected to be similar. Therefore, the adjustment from the USGS gage station to the project site can be performed based on the ratio of drainage areas. Therefore, the adjustment from the USGS gage station to the project site will follow the equation:

$$Q_{site} = Q_{USGS}\left(\frac{A_{site}}{A_{USGS}}\right)$$

b. In the case of the powerhouse channel, flows are dictated by the diversion to the powerhouse and therefore are human-influenced more than based on a natural regime. Furthermore, the withdrawals by the City of Yreka will be variable and unknown.

c. Therefore, an estimation of the division of the middle branch flows is required between the upper reach and powerhouse channel flows. A constant flow was applied to the powerhouse channel that is equal to the minimum flow requirement (15 cfs) downstream of Dam A. The following should be noted when considering this assumption:

i. There is relatively little contributing area to upper reach drainage and it will therefore be primarily human-influenced.

ii. The barrier located at Dam A will be designed for the full range of anticipated powerhouse flows (15 cfs - 50 cfs). All other in-stream design points are either in the adjacent drainage or well downstream of this point, and impacts to the stream model from this assumption will be limited.

iii. For flooding evaluation, the remainder of the flow will be contributed from the Upper Reach of Fall Creek, which meets up with the powerhouse channel near the existing upper pond battery. There will be no infrastructure (with the exception of the intake) upstream of this location, and therefore the flooding limits will not be unduly influenced by this assumption.

Flooding Flows

1. Collect peak flow statistics from the USGS StreamStats online software for the USGS gaging station 11512000.

2. Adjust the flow rates to the project location based on drainage area, according to the drainage area scaling discussed above.

a. The same assumption with respect to the Fall Creek upper reach will be made as for the fish passage flows.

Calculations

Fish Passage Flows

Data collected from USGS Station 11512000 was processed to eliminate all data that was not approved for published use, and was limited to the months of October through December (adult fish present at the site). This is summarized in the exceedance curve below:

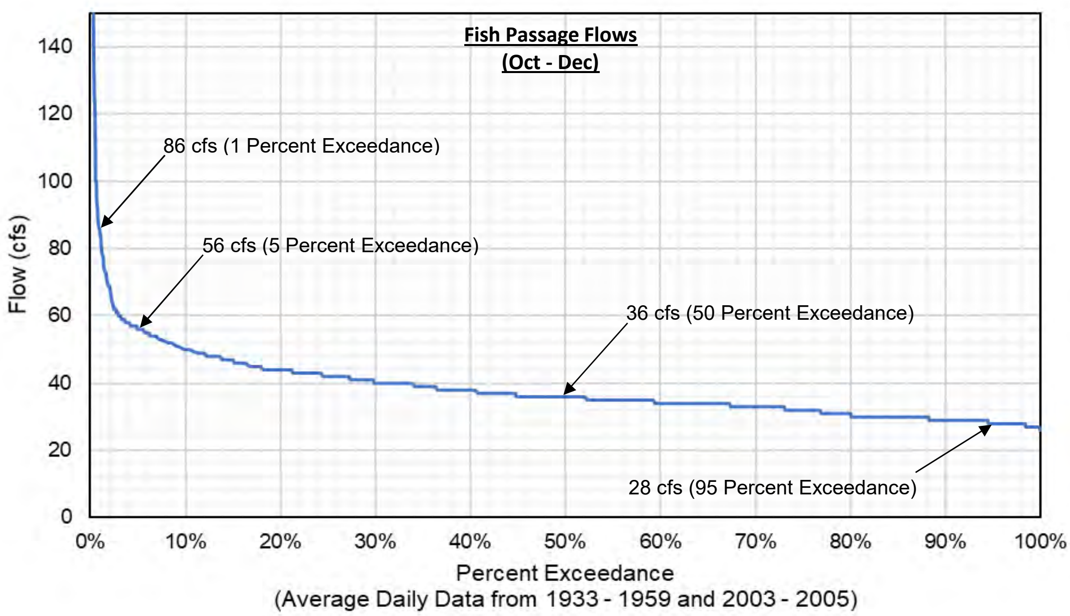


Figure 2. Exceedance Curve for USGS Station 11512000 (October - December)

Exceedance Criterion	Flow (cfs)
1% Exceedance	86
5% Exceedance	56
50% Exceedance	36
95% Exceedance	28

Drainage areas were collected from StreamStats for each of the points of interest and for the USGS gage station:

Location	Drainage Area mi^2
USGS Gage Station	14.6
Powerhouse Channel	0.1
Upper Reach	12.1
Middle Reach	12.2
Unnamed Drainage	2.2
Lower Reach	14.4

From which the adjusted fish passage flows could be calculated:

Location	95% cfs	50% cfs	5% cfs	1% cfs
Powerhouse Channel	15.0	15.0	15.0	15.0
Upper Reach	8.4	15.1	31.8	56.9
Middle Reach	23.4	30.1	46.8	71.9
Unnamed Drainage	4.2	5.4	8.4	13.0
Lower Reach	27.6	35.5	55.2	84.8

Juvenile Flows

Data collected from USGS Station 11512000 was processed to eliminate all data that was not approved for published use, and was limited to the month of March, the peak month when fish will be released from the site. This is summarized in the exceedance curve below:

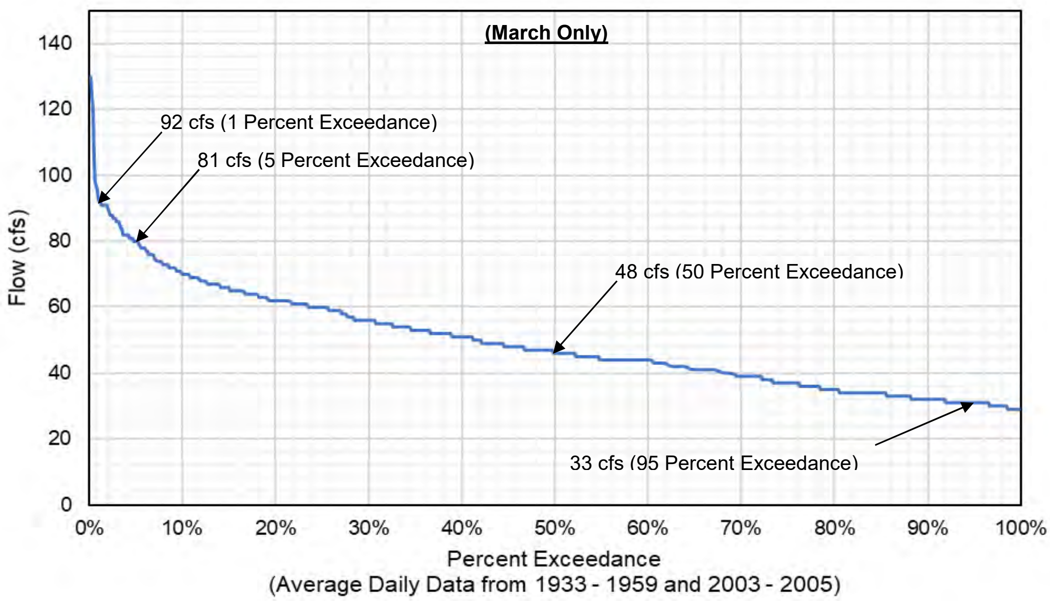


Figure 3. Exceedance Curve for USGS Station 11512000 (March Only)

Exceedance Criterion	Flow (cfs)
1% Exceedance	92
5% Exceedance	81
50% Exceedance	48
95% Exceedance	33

The juvenile design flow was then determined using the drainage area weighting as discussed above to determine the juvenile design high flow:

Location	1% cfs
Powerhouse Channel	15.0
Upper Reach	61.9
Middle Reach	76.9
Unnamed Drainage	13.9
Lower Reach	90.7

Flood Flows

The flood flows for the USGS gaging station were collected from the USGS StreamStats online software.

Return Period	Flow (cfs)
2-yr Flood	138
100-yr Flood	905

These values were checked against the methods of Bulletin 17C (USGS, 2019), and were found to be within 2% of each other, with the reported values slightly higher than those calculated by the methods of Bulletin 17C. Therefore, the reported values were accepted.

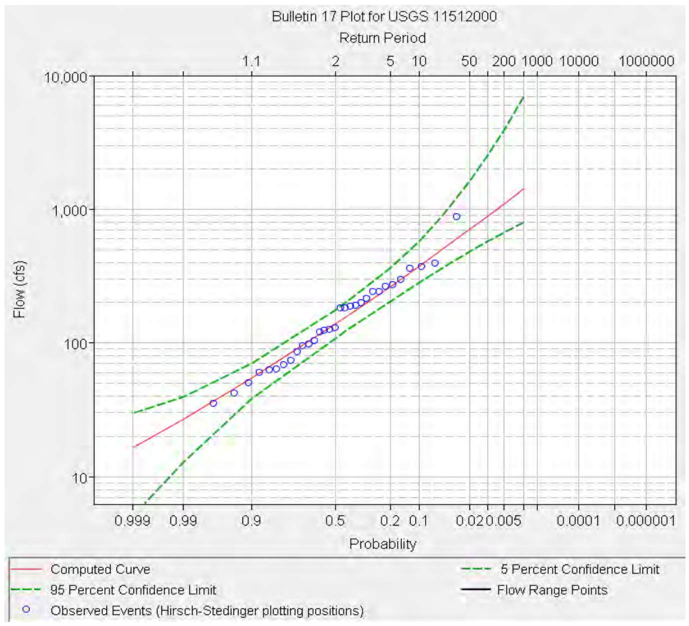


Figure 4. Frequency Analysis Results (Bulletin 17C)

These were then adjusted to the project site according to the drainage area scaling:

Location	2-yr cfs	100-yr cfs
Powerhouse Channel	15.0	15.0
Upper Reach	100.3	741.2
Middle Reach	115.3	756.2
Unnamed Drainage	20.8	136.4
Lower Reach	136.1	892.6

Conclusions

The streamflows for Fall Creek were determined from nearby USGS gage station 11512000 and adjusted to the site based on the relative drainage areas at each location. The streamflows are summarized below, and will serve as boundary conditions for the hydraulic model (see Tailwater calculations):

Location	Adult Fish Passage				Juvenile	Extreme Events	
	95% cfs	50% cfs	5% cfs	1% cfs	1% cfs	2-yr cfs	100-yr cfs
Powerhouse Channel	15.0	15.0	15.0	15.0	15.0	15.0	15.0
Upper Reach	8.4	15.1	31.8	56.9	61.9	100.3	741.2
Middle Reach	23.4	30.1	46.8	71.9	76.9	115.3	756.2
Unnamed Drainage	4.2	5.4	8.4	13.0	13.9	20.8	136.4
Lower Reach	27.6	35.5	55.2	84.8	90.7	136.1	892.6

SUBJECT:	Klamath River Renewal Corporation	BY:	A. Leman	CHK'D BY:	V. Autier
	Fall Creek Hatchery	DATE:	6/1/2020		
	Tailwater	PROJECT NO.:	20-024		

Purpose

The purpose of this calculation sheet is to demonstrate the calculations of water surface elevations along the length of Fall Creek.

References

- *Chow, V.T. 1959. Open Channel Flow. McGraw Hill: New York.*

- *Gotvald, A.J., Barth, N.A., Veilleux, A.G., and Parrett, Charles, 2012, Methods for determining magnitude and frequency of floods in California, based on data through water year 2006: U.S. Geological Survey Scientific Investigations Report 2012–5113, 38 p., 1 pl., available online only at http://pubs.usgs.gov/sir/2012/5113/.*

- *Hydrologic Engineering Center (HEC). 2016. HEC-RAS: River Analysis System Hydraulic Reference Manual, Version 5.0. U.S. Dept. of the Army, Army Corps of Engineers, Hydrologic Engineering Center: Davis, CA. February 2016.*

Method

The tailwater elevation at the fishway entrance was calculated by 1-dimensional HEC-RAS modeling along Fall Creek. Model characteristics are summarized below:

Geometry

- Model geometry was collected from surveyed transects including both ground shots and stream bathymetry at approximately 50' spacing.
- Channel banks were surveyed as part of the transects, and were used to differentiate channel and overbank regions and their associated hydraulic roughness and conveyance.
- Manning's roughness coefficients of 0.035 were assigned uniformly to the channel, consistent with mountain streams with gravel bottoms (Chow, 1959).
- Manning's roughness coefficients of 0.060 were assigned to the overbank regions, consistent with floodplains with moderate brush (Chow, 1959).
- Levees were introduced at locations to contain flows within the channel in locations of depressions in the overbank areas and where there would be no upstream/downstream connectivity of the depression in the floodplain.
- Ineffective areas were introduced at locations of depression in the overbank areas where there is upstream/downstream connectivity, however the depression would not add to the cross-section conveyance (i.e. storage only).
- A flat section was introduced as a temporary measure at the fishway and exclusion barrier, and the roughness was adjusted to 0.015 for the concrete sill and abutments.
- Cross-sections were interpolated at 5-ft spacing according to the default HEC-RAS algorithm to ensure that changes in the energy grade line would be small and minimize errors in the calculations.

Hydrology

- See "Streamflow" calculations for assumptions regarding hydrology and flow boundary conditions. Seven flow conditions were evaluated:
    - Fish passage low flow (95% exceedance)
    - Fish passage typical flow (50% exceedance)
    - Fish passage high flow (NMFS Definition, 5% exceedance)
    - Fish passage high flow (CDFW Definition, 1% exceedance)
    - Juvenile high flow (1% exceedance, March only)
    - Flooding Flow - 2 year
    - Flooding Flow - 100 year

Boundary Conditions

- The boundary condition at Dam A was assumed to be critical.
- The boundary conditions in the two tributaries and at the downstream of the model extents was assumed to be normal flow with local bed slopes measured from the transect data or the LiDAR data as appropriate to the location.

Modeling Assumptions

- HEC-RAS solves the energy equation for each cross-section using the iterative process of the standard step method (HEC, 2016).
- The model was run as a steady model ($dQ/dt = 0$) at the peak discharge for each of the flow conditions listed above.
- The model was run for mixed regime, in order to allow for variations between subcritical and supercritical flow.
- Junctions were modeled using the energy equation, as is the HEC-RAS default, as the energy loss across the junction was not expected to be significant.

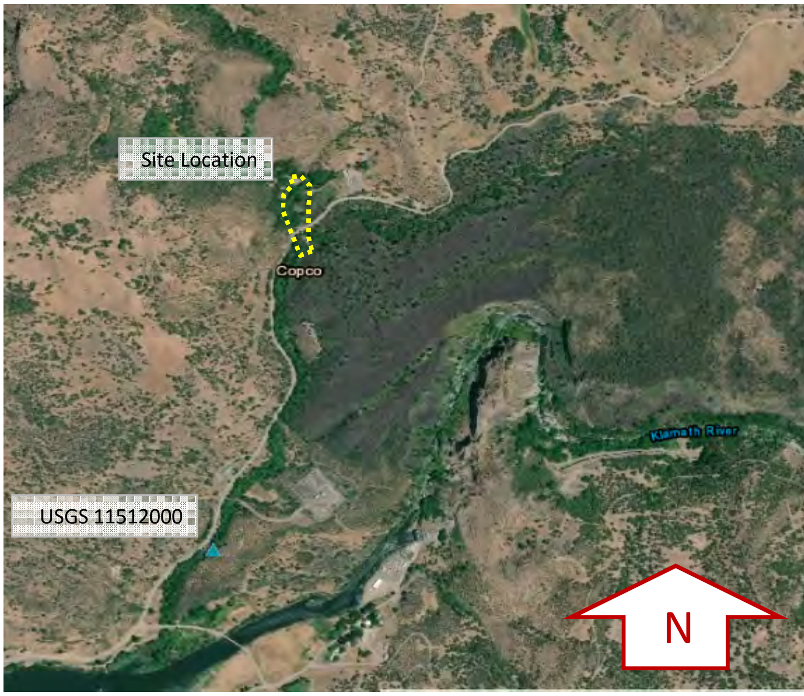
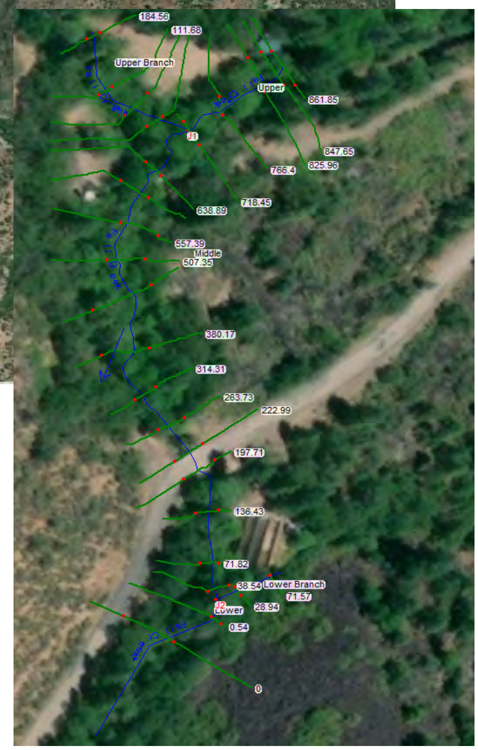


Figure 1. Gage Location



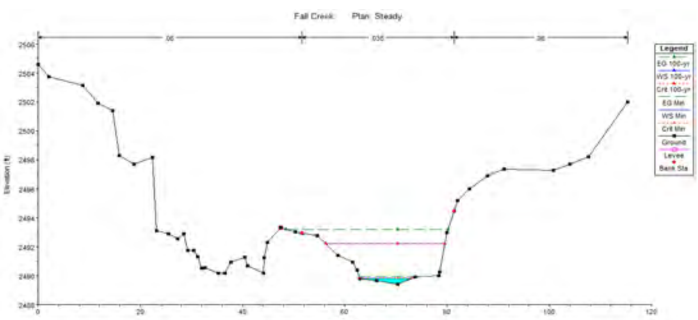


Figure 3. Typical Cross-Section

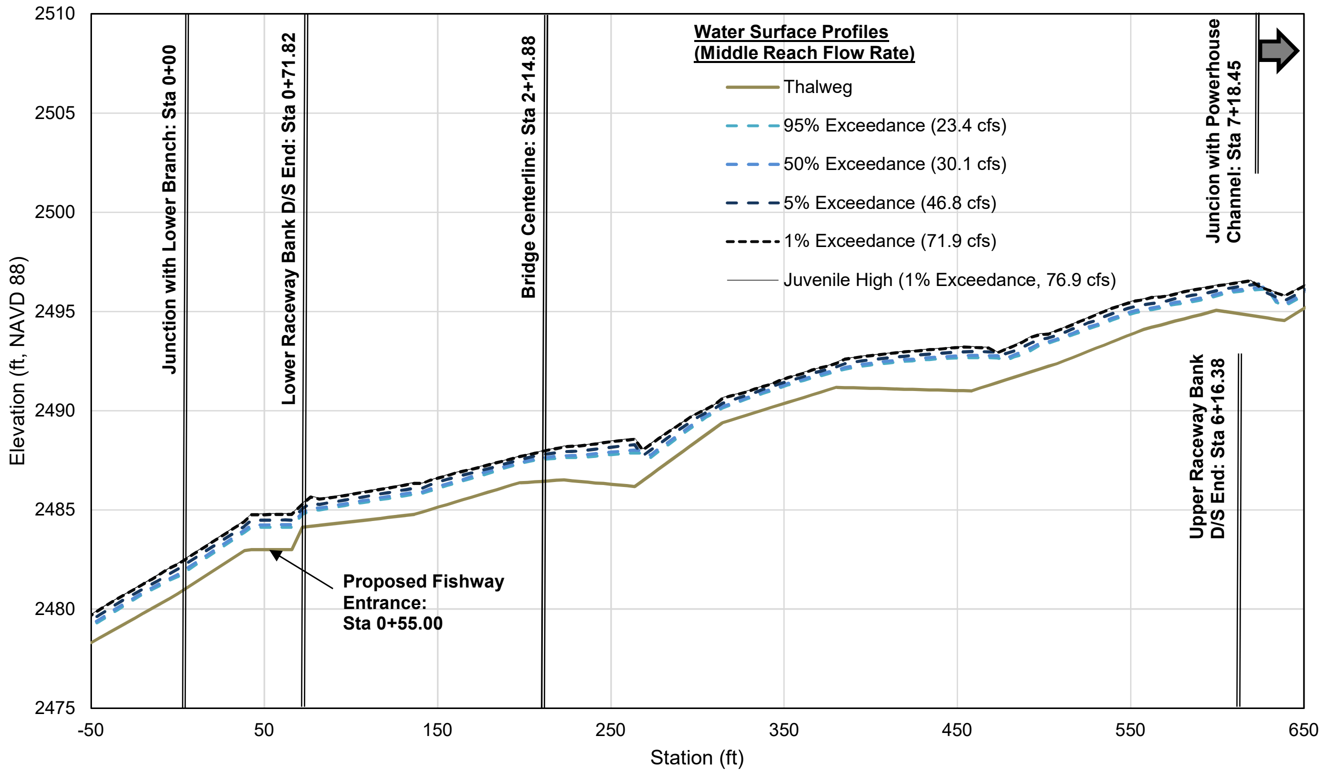
Figure 2. Model Geometry

Flow Change Location	Low Flow cfs	Typical cfs	High Flow (5%) cfs	High Flow (1%) cfs	Juvenile High cfs	2-yr cfs	100-yr cfs
Powerhouse Channel	15	15	15	15	15	15	15
Upper Reach	8	15	32	57	62	100	741
Middle Reach	23	30	47	72	77	115	756
Unnamed Drainage	4	5	8	13	14	21	136
Lower Reach	28	36	55	85	91	136	893

Table 1. Flow Change Locations
(Reference Streamflow Calculations)

Results

The results of the HEC-RAS modeling for the juvenile and adult fish passage flows are summarized in the longitudinal profile along Fall Creek, in Figure 4 below:



Bas

Figure 4. Longitudinal Profile

Conclusions

Water surface profiles in Fall Creek were calculated for each of the design flows using a 1-dimensional HEC-RAS model and available topography and bathymetry surveyed at the site. These water surface profiles were used in the design of in-stream structures, as well as to determine flooding extents and elevations for extreme event design flows. One location of critical interest to the site, was the proposed fishway entrance and temporary barrier, for fish trapping. The table below summarizes water surface elevations and depths at this location. Other locations were queried from the model, directly.

Flow Condition	Flow cfs	WSEL ft msl	Depth ft
Low - 95% Exceedance	23.40	2484.12	1.12
Typ - 50% Exceedance	30.08	2484.24	1.24
High - 5% Exceedance	46.79	2484.48	1.48
High - 1% Exceedance	71.86	2484.77	1.77
Juvenile Hi - 1% Exc.	76.88	2484.82	1.82
2-year	115.32	2485.13	2.13
100-year	756.23	2487.21	4.21

McMILLEN JACOBS ASSOCIATES

SUBJECT: Klamath River Renewal Corporation | **BY:** A. Leman | **CHK'D BY:** N. Cox
Fall Creek Hatchery | **DATE:** 6/1/2020
Intake Losses | **PROJECT NO.:** 20-024

Purpose

The purpose of this calculation sheet is to determine hydraulic head losses through the intake.

References

- *Tullis, J. Paul. (1989). Hydraulics of Pipelines, Pumps, Valves, Cavitation, Transients. New York: John Wiley & Sons.*
- *U.S. Bureau of Reclamation (USBR). 1987. Design of Small Dams. Third Edition. U.S. Dept. of the Interior, Bureau of Reclamation: Washington, D.C.*

Method

The head losses through the intake structure were considered to consist of two components: (1) debris screen losses and (2) pipe entrance losses. Elsewhere, the velocity is to be maintained 1 ft/s or less and therefore minor losses and friction losses were considered negligible.

Debris Screen
USBR, 1987; Section 10.15, Eq 11

Debris screen losses are evaluated according to the equation presented in the *Design of Small Dams* (USBR, 1987; see also Creager & Justin, 1963). The losses through the debris screen are a function of the percent opening (net screened area divided by gross area):

$$K_s = 1.45 - 0.45\frac{A_n}{A_g} - \left(\frac{A_n}{A_g}\right)^2$$

$$A_n = (1 - R_D)R_0 A_g$$

$$h_s = K_s\left(\frac{v_n^2}{2g}\right)$$

where:
- $K_s =$ Screen loss coefficient
- $h_s =$ Screen head losses, ft
- $A_n =$ Net screen area (less screen and occlusions), ft^2
- $A_g =$ Gross screen area, ft^2
- $v_n =$ Net velocity (through net screen area), ft/s
- $g =$ Gravitational constant, 32.2 ft/s^2
- $R_D =$ Ratio of debris coverage
- $R_o =$ Ratio of open area (clean bars)

Pipe Entrance Losses
Tullis, 1989; Table 1.4 and USBR, 1987; Table 10.1

Entrance loss coefficients have been tabulated by a number of sources, including Tullis (1989) and the USBR (1987). The USBR provides a range of coefficients based on a survey of texts and technical papers.

$$h_e = K_e\left(\frac{v_p^2}{2g}\right)$$

where:
- $h_e =$ Entrance head losses, ft
- $K_e =$ Entrance loss coefficient
- $v_p =$ Pipe velocity, ft/s

<Other parameters as previously defined>

TABLE 1.4 Minor Loss Coefficients

Item	K_t Typical Value	K_t Typical Range
Pipe inlets		
Inward projecting pipe	0.78	0.5 to 0.9
Sharp corner—flush	0.50	
Slightly rounded	0.20	0.04 to 0.5
Bell mouth	0.04	0.03 to 0.1

FIGURE 1. Typical Entrance Loss Coefficients (Tullis, 1989)

	Discharge coefficient, C			Loss coefficient, A		
	Max.	*Min.*	*Avg.*	*Max.*	*Min.*	*Avg.*
(a) Gate in thin wall – unsuppressed contraction	0.70	0.60	0.63	1.80	1.00	1.50
(b) Gate in thin wall – bottom and sides suppressed	.81	.68	.70	1.20	0.50	1.00
(c) Gate in thin wall – corners rounded	.95	.71	.82	1.00	.10	0.50
(d) Square-cornered entrances	.85	.77	.82	0.70	.40	.50
(e) Slightly rounded entrances	.92	.79	.90	.60	.18	.23
(f) Fully rounded entrances ($r/D \geq 0.15$)	.96	.88	.95	.27	.08	.10
(g) Circular bellmouth entrances	.98	.95	.98	.10	.04	.05
(h) Square bellmouth entrances	.97	.91	.93	.20	.07	.16
(i) Inward projecting entrances	.80	.72	.75	.93	.56	.80

FIGURE 2. USBR Entrance Loss Coefficients (USBR, 1987)

Inputs

Geometric

The geometric inputs are summarized below:

Intake

Min. WSE:	2510.4	ft msl	[Dam A crest elevation]
Intake Bottom El:	2506.3	ft msl	[Design value, per City of Yreka sluice gate invert]
Intake Width:	6.0	ft	[2 x 3.0' wide screens]
Intake Min. Depth:	4.10	ft	
Open Area Ratio, R_o:	50%		[Assumed, subject to screen manufacturer]

Pipe

Prelim. Nom Dia:	24.0	in	
Inner Dia:	21.418	in	[Sched 80 PVC]
	1.78	ft	

Hydraulic

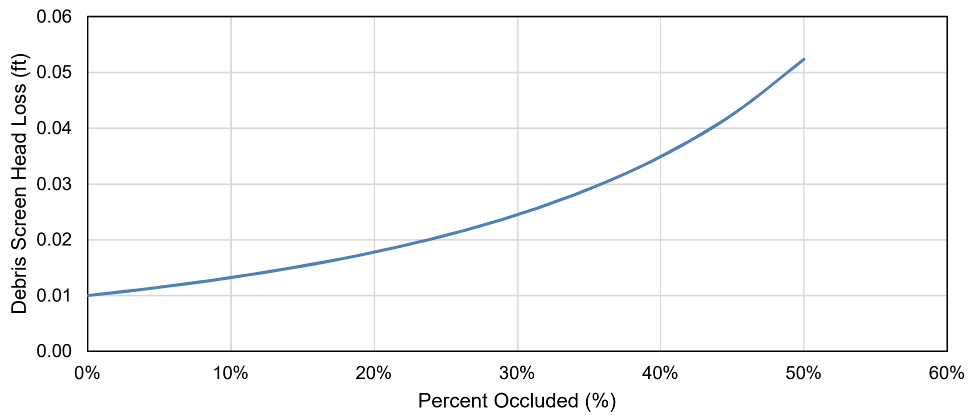
The hydraulic inputs are summarized below:

Max Screen Occlusion:	50%		[Max recommended by USBR, 1987]
Typ/Max Demand:	10	cfs	

Calculations

Debris Screen Losses

Percent Occluded, R_D	Ratio of Open Area, R_o	Gross Area, A_g (ft^2)	Net Area, A_n (ft^2)	Ratio of Net to Gross Area, A_n/A_g	Loss Coeff, K_s	Net Velocity, V_n (ft/s)	Velocity Head, h_v (ft)	Head Loss, h_s (ft)
0%	50%	24.6	12.30	50%	0.98	0.81	0.01	0.01
5%	50%	24.6	11.68	48%	1.01	0.86	0.01	0.01
10%	50%	24.6	11.07	45%	1.05	0.90	0.01	0.01
15%	50%	24.6	10.45	43%	1.08	0.96	0.01	0.02
20%	50%	24.6	9.84	40%	1.11	1.02	0.02	0.02
25%	50%	24.6	9.22	38%	1.14	1.08	0.02	0.02
30%	50%	24.6	8.61	35%	1.17	1.16	0.02	0.02
35%	50%	24.6	7.99	33%	1.20	1.25	0.02	0.03
40%	**50%**	**24.6**	**7.38**	**30%**	**1.23**	**1.36**	**0.03**	**0.03**
45%	50%	24.6	6.76	28%	1.25	1.48	0.03	0.04
50%	50%	24.6	6.15	25%	1.28	1.63	0.04	0.05



Entrance Losses

Pipe entrance losses were calculated for a variety of conditions, for use in the design process. It was ultimately elected that no gate would be present at the intake structure, but rather isolation would be performed using a downstream isolation valve in the meter vault. Therefore, the open pipe values were used.

Entrance	Condition	Pipe Nom. Dia, D in	Pipe Inner Dia, D_i in	Pipe Velocity, V_p ft/s	Velocity Head, h_v ft	Loss Coeff, K_e	Head Loss, h_e ft
Gate	Max (unsuppressed gate)	24.0	21.418	4.00	0.25	1.8	0.45
	Avg (unsuppressed gate)	24.0	21.418	4.00	0.25	1.5	0.37
	Min (unsuppressed gate)	24.0	21.418	4.00	0.25	1.0	0.25
	Improved (corners round)	24.0	21.418	4.00	0.25	0.5	0.12
Open Pipe (D/S Isolation Valve)	**Max (square corners)**	**24.0**	**21.418**	**4.00**	**0.25**	**0.7**	**0.17**
	Avg (square corners)	24.0	21.418	4.00	0.25	0.5	0.12
	Min (square corners)	24.0	21.418	4.00	0.25	0.4	0.10
	Improved (slightly round)	24.0	21.418	4.00	0.25	0.23	0.06

Conclusions

The above calculations demonstrate that the head losses through the intake under worst case conditions, i.e. 50% screen occlusion and unimproved entrance conditions at the pipe, would be approximately 0.22 ft (2.6 in). This is not expected to be the case, however, as the screens will be actively cleaned and it is not expected that occlusion will reach 50%. As a design value, a conservative screen occlusion of 40% was assumed, however, resulting in a maximum loss through the intake of 0.21 ft. This value was used as a boundary condition to the head modeling performed for the supply piping (see "Supply Hydraulics" calculations).

SUBJECT:	Klamath River Renewal Corporation	**BY:** A. Leman	**CHK'D BY:** N. Cox
	Fall Creek Hatchery	**DATE:** 6/1/2020	
	Supply Hydraulics	**PROJECT NO.:** 20-024	

Purpose

The purpose of this calculation sheet is to demonstrate the hydraulic calculations associated with the supply piping.

References

- *Miller, D.S. 1990. Internal Flow Systems, Second Edition. Cranfield, UK: BHRA, The Fluid Engineering Centre.*
- *Rossman, L.A. 2000. EPANET2, User's Manual. U.S. Environmental Protection Agency (USEPA), Office of Research and Development, National Risk Management Research Laboratory: Cincinnati, OH.*
- *Tullis, J. Paul. (1989). Hydraulics of Pipelines, Pumps, Valves, Cavitation, Transients. New York: John Wiley & Sons.*

Method

The supply piping network was analyzed using EPANET2 software (Rossman, 2000) during the preliminary stages of design. It was found that adequate head was available to deliver water to each of the design points at the site, despite the limited nature of the hydraulic head. Subsequent changes were made to the mechanical piping configurations, and interior mechanical piping head losses are now incorporated into the mechanical design of the facility. The following calculations represent head losses associated with the civil yard piping only. Yard piping head losses account for friction losses and minor losses:

Friction Losses

Friction losses were calculated according to the Hazen-Williams equation:

$$h_{f,ft} = \frac{10.44 L_{ft} Q_{gpm}^{1.85}}{C^{1.85} d_{in}^{4.87}}$$

where:

$h_{f,ft} =$ Friction head losses, ft
$L_{ft} =$ Length of pipe run, ft
$Q_{gpm} =$ Discharge, gpm
$C =$ Hazen-Williams coefficient
$d_{in} =$ Pipe diameter, in

Minor Losses

Minor losses were calculated according to the standard minor loss formulation:

$$h_L = K\left(\frac{V^2}{2g}\right)$$

where:

$h_L =$ Minor head losses, ft
$K =$ Composite minor loss coefficient
$V =$ Pipe average velocity, ft/s
$g =$ Gravitational constant, 32.2 ft/s^2

Assumptions

The following assumptions were made in the development of the pipe network model:

(1) Composite minor loss coefficients were collected from the pipe distribution layout as shown in the Drawings, and typical values (see Section 'Inputs') collected from Tullis (1989) and Miller (1990).

(2) Pipes were assumed to be new PVC pipe, with smooth interior. Given the short life of the facility and the low presence of suspended material in the existing piping system, it was assumed that a Hazen-Williams coefficient of 120 could be applied as representative.

(3) Pipe sizes were selected to maintain velocities within the desired range of 1.5 feet per second (fps) - 5.0 fps, such that pipes would be self-cleaning (lower bound), but head losses would not be excessive and abrasion potential would be mitigated (upper bound). 1.5 fps was treated as an absolute minimum, and generally pipe velocities were maintained around 2.0 fps.

(4) The upstream condition for all four distribution models assumed a 40% occluded trash rack with the maximum recommended loss coefficient for a pipe entrance (total 0.21 ft). Furthermore, it was assumed that the water surface elevation was at the Dam A crest elevation, 2510.4 ft, as a minimum value. This provided some measure of conservatism, as the intake will have an automated cleaning mechanism and the actual water surface elevation will always be above the Dam A crest elevation. The head at the intake, accounting for these losses, used as the upstream boundary condition in each of the models was 2510.19.

(5) Demand at the model nodes were based on the bioprogram, and the critical (i.e. maximum) flow requirements. This provides some measure of conservatism, as well, as it is generally not expected that each demand node will be operating simultaneously.

Inputs

Upstream Boundary Condition

Dam A Crest Elev:	2510.4	ft
Intake Head Loss:	0.21	ft
U/S Boundary Condition:	2510.19	ft

Minor Loss Coefficients

Coefficient K	90° Bends	45° Bends	22.5° Bends	Butterfly Valve (Open)	Tee (Branch)	Tee (Line)	Reducer - Contraction*
	0.24	0.1	0.06	0.2	1	0.2	

from Tullis, 1989 and Miller, 1990.

** Reducer losses were calculated based on the equation:* $K = \left(1/C_c - 1\right)^2$

A_2/A_1	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
C_c	0.624	0.632	0.643	0.659	0.681	0.712	0.755	0.813	0.892
K	0.363	0.339	0.308	0.268	0.219	0.164	0.105	0.053	0.015

Other Inputs

Gravitational Constant 32.2 ft/s^2

Calculations

Supply Line 1 - Coho

Station	Description	Discharge, Q gpm	Pipe Nom. Diameter in	Pipe I.D. in	Hazen-Williams Coeff, C	Length ft	Velocity ft/s	Velocity Head ft	Composite Minor Loss Coeff, K
0+00	24" x 16" Red Tee	954							
1+55	16" Tee	954	16	14.213	120	154.7	1.93	0.06	1.99
1+78	8" x 4" Red Tee	534	8	7.565	120	23.8	3.81	0.23	1.20
1+91	8" x 4" Red Tee	362	8	7.565	120	12.7	2.58	0.10	0.20
2+01	6" Tee	190	6	5.709	120	9.4	2.38	0.09	0.28
2+18	90deg Bend	40	3	2.864	120	17.8	1.99	0.06	0.42

Station	Description	Friction Losses ft	Minor Losses ft	Total Losses ft	EGL ft	HGL ft
0+00	24" x 16" Red Tee				2510.19	
1+55	16" Tee	0.18	0.11	0.30	2509.89	2509.84
1+78	8" x 4" Red Tee	0.21	0.27	0.48	2509.42	2509.19
1+91	8" x 4" Red Tee	0.05	0.02	0.07	2509.34	2509.24
2+01	6" Tee	0.05	0.02	0.07	2509.27	2509.18
2+18	90deg Bend	0.14	0.03	0.17	2509.10	2509.04

Supply Line 2 - Chinook Rearing

Station	Description	Discharge, Q gpm	Pipe Nom. Diameter in	Pipe I.D. in	Hazen-Williams Coeff, C	Length ft	Velocity ft/s	Velocity Head ft	Composite Minor Loss Coeff, K
0+00	24" Tee	4040							
2+30	Raceway 1A	4040	24	21.418	120	230.0	3.60	0.20	2.74
2+36	Raceway 1B	3787.5	24	21.418	120	6.3	3.37	0.18	0.20
2+43	Raceway 2A	3535	24	21.418	120	6.3	3.15	0.15	0.20
2+49	Raceway 2B	3282.5	24	21.418	120	6.3	2.92	0.13	0.20
2+55	Raceway 3A	3030	24	21.418	120	6.3	2.70	0.11	0.20
2+62	Raceway 3B	2777.5	24	21.418	120	6.3	2.47	0.09	0.20
2+68	Raceway 4A	2525	24	21.418	120	6.3	2.25	0.08	0.20
2+74	Raceway 4B	2272.5	24	21.418	120	6.3	2.02	0.06	0.20
2+86	24" x 16" Red	2020	24	21.418	120	11.7	1.80	0.05	0.20
2+98	Raceway 5A	2020	16	14.213	120	12.0	4.08	0.26	0.13
3+04	Raceway 5B	1767.5	16	14.213	120	6.3	3.57	0.20	0.20
3+11	Raceway 6A	1515	16	14.213	120	6.3	3.06	0.15	0.20
3+17	Raceway 6B	1262.5	16	14.213	120	6.3	2.55	0.10	0.20
3+23	Raceway 7A	1010	16	14.213	120	6.3	2.04	0.06	0.20
3+30	Raceway 7B	757.5	16	14.213	120	6.3	1.53	0.04	0.20
3+36	Raceway 8A	505	16	14.213	120	6.3	1.02	0.02	0.20
3+42	Raceway 8B	252.5	16	14.213	120	6.3	0.51	0.00	0.20

Station	Description	Friction Losses ft	Minor Losses ft	Total Losses ft	EGL ft	HGL ft
0+00	24" Tee				2510.19	
2+30	Raceway 1A	0.53	0.55	1.08	2509.11	2508.91
2+36	Raceway 1B	0.01	0.04	0.05	2509.06	2508.89
2+43	Raceway 2A	0.01	0.03	0.04	2509.02	2508.87
2+49	Raceway 2B	0.01	0.03	0.04	2508.98	2508.85
2+55	Raceway 3A	0.01	0.02	0.03	2508.95	2508.84
2+62	Raceway 3B	0.01	0.02	0.03	2508.93	2508.83
2+68	Raceway 4A	0.01	0.02	0.02	2508.90	2508.83
2+74	Raceway 4B	0.01	0.01	0.02	2508.89	2508.82
2+86	24" x 16" Red	0.01	0.01	0.02	2508.87	2508.82
2+98	Raceway 5A	0.06	0.03	0.09	2508.78	2508.52
3+04	Raceway 5B	0.02	0.04	0.06	2508.72	2508.52
3+11	Raceway 6A	0.02	0.03	0.05	2508.67	2508.52
3+17	Raceway 6B	0.01	0.02	0.03	2508.64	2508.54
3+23	Raceway 7A	0.01	0.01	0.02	2508.62	2508.55
3+30	Raceway 7B	0.00	0.01	0.01	2508.60	2508.57
3+36	Raceway 8A	0.00	0.00	0.01	2508.60	2508.58
3+42	Raceway 8B	0.00	0.00	0.00	2508.60	2508.59

Supply Line 3 - Incubation Building

Station	Description	Discharge, Q gpm	Pipe Nom. Diameter in	Pipe I.D. in	Hazen-Williams Coeff, C	Length ft	Velocity ft/s	Velocity Head ft	Composite Minor Loss Coeff, K
0+00	90deg Bend	740							
4+16	16" x 10" Red	740	16	14.213	120	416.0	1.50	0.03	2.71
4+19	Incubation Building	740	10	9.493	120	3.0	3.35	0.17	0.12

Station	Description	Friction Losses ft	Minor Losses ft	Total Losses ft	EGL ft	HGL ft
0+00	90deg Bend				2510.19	
4+16	16" x 10" Red	0.31	0.09	0.40	2509.79	2509.76
4+19	Incubation Building	0.02	0.02	0.04	2509.75	2509.58

Supply Line 4 - Adult Holding

Station	Description	Discharge, Q gpm	Pipe Nom. Diameter in	Pipe I.D. in	Hazen-Williams Coeff, C	Length ft	Velocity ft/s	Velocity Head ft	Composite Minor Loss Coeff, K
0+00	24" Tee	4570							
6+76	24" x 12" Red Tee	4570	24	21.418	120	675.9	4.07	0.26	3.68
6+76	24" x 12" Red Tee	3070	24	21.418	120	0.0	2.73	0.12	0.20
6+89	90deg Bend	1570	12	11.294	120	13.1	5.03	0.39	0.60

Station	Description	Friction Losses ft	Minor Losses ft	Total Losses ft	EGL ft	HGL ft
0+00	24" Tee				2510.19	
6+76	24" x 12" Red Tee	1.96	0.95	2.91	2507.29	2507.03
6+76	24" x 12" Red Tee	0.00	0.02	0.02	2507.26	2507.15
6+89	90deg Bend	0.12	0.24	0.36	2506.91	2506.51

Conclusions

It was found in the preliminary analysis that the velocities could be maintained within the desired 1.5 fps - 5.0 fps range while still maintaining positive head at each of the design points. Locally, velocities may be lowered below the 1.5 fps threshold based on the pipeworks costs, however cleanouts will be provided to address any potential for accumulated sediment. The calculations above were performed for the civil yard piping, and further losses are accounted for in the mechanical piping design inside of the buildings/areas. The following is a summary of the critical energy locations:

Location	HGL ft	EGL ft
Coho Area - Flow Split	2509.84	2509.89
Coho Building - To Incubation Stacks	2509.04	2509.10
Chinook Raceways - Final Pond	2508.59	2508.60
Incubation Building	2509.58	2509.75
Trapping/Sorting Pond	2506.51	2506.91

SUBJECT:	Klamath River Renewal Corporation	**BY:** A. Leman	**CHK'D BY:** N. Cox
	Fall Creek Hatchery	**DATE:**	6/1/2020
	Drain Hydraulics	**PROJECT NO.:**	20-024

Purpose

The purpose of this calculation sheet is to determine the hydraulics of the drain piping system.

References

- *Lindeburg, Michael R. 2014. Civil Engineering Reference Manual, Fourteenth Edition. Professional Publications, Inc. Belmont, CA.*
- *FHWA (Federal Highway Administration). 2012. Hydraulic Design Series Number 5, Hydraulic Design of Highway Culverts, Third Edition. U.S. Department of Transportation, FHWA. Washington, D.C. January 2012.*

Method

The drain pipeline will convey effluent from the ponds and vats to the adult holding ponds. All outlet pipes and trunk lines will be sized to maintain open-channel flow. Open channel flow calculations followed the equations below (Lindeburg, 2014), and were calculated iteratively using a Newton-Raphson iterating scheme:

$$\theta_{deg} = 2\cos^{-1}\left(\frac{\frac{D}{2} - d}{\frac{D}{2}}\right) \qquad R_h = \frac{A}{P} \qquad \frac{n}{n_{full}} = 1 + \left(\frac{d}{D}\right)^{0.54} - \left(\frac{d}{D}\right)^{1.2}$$

$$A = \left(\frac{D}{2}\right)^2 \frac{\theta_{rad} - \sin\theta_{deg}}{2} \qquad V = \left(\frac{1.486}{n}\right) R_h^{2/3} S^{1/2}$$

$$P = \frac{D\theta_{rad}}{2} \qquad Q = AV$$

where:

$\theta =$ Internal angle of water surface
$D =$ Pipe inner diameter, ft
$d =$ Flow depth, ft
$A =$ Flow area, ft^2
$P =$ Wetted perimeter, ft
$R_h =$ Hydraulic radius, ft
$V =$ Average flow velocity, ft/s
$n =$ Manning's roughness coefficient
$S =$ Pipe bed slope, ft/ft
$Q =$ Discharge, cfs
$n_{full} =$ Pipe-full roughness coefficient

At the adult holding ponds, the orifices will cause the pipe to pressurize such that sufficient head is built up to convey the flow into the ponds. The design head on the orifice will be calculated according to the orifice equation:

$$Q = C_D A_0 \sqrt{2gh}$$

$$h = \left(\frac{Q}{C_D A_0}\right)^2 \Big/ 2g$$

where:

$Q =$ Design discharge, cfs
$C_D =$ Discharge coefficient
$A_0 =$ Orifice aperture, ft^2
$g =$ Gravitational constant, 32.2 ft/s^2
$h =$ Orifice head, ft

In addition to the design head on the orifice, head losses in the pressure pipe must be accounted for. Friction losses will be calculated according to the Darcy equation:

$$h_f = f\frac{L}{D}\frac{V^2}{2g}$$

where:

$h_f =$ Friction head losses, ft
$f =$ Friction factor
$L =$ Length of full pipe run, ft
$D =$ Pipe inner diameter, ft
$V =$ Pipe average velocity, ft/s
<all other values as previously defined>

The friction factor is calculated according to the Colebrook-White equation:

$$\frac{1}{\sqrt{f}} = -2\log_{10}\left(\frac{\frac{\epsilon}{D}}{3.7} + \frac{2.51}{Re\sqrt{f}}\right)$$

where:

$\epsilon =$ Surface roughness, ft
$Re =$ Reynolds Number, VD/ν
$\nu =$ Kinematic viscosity, ft^2/s
<all other values as previously defined>

Minor losses are also accounted for in the headloss, according to the equation:

$$h_L = K\left(\frac{V^2}{2g}\right)$$

where:
$h_L =$ Minor head losses, ft
$K =$ Composite minor loss coefficient
<all other values as previously defined>

The location that the pipe starts to flow full pressure is at the elevation of the orifice plus the orifice head and all friction and minor losses:

$$z_{press} = z_o + h + h_f + h_L$$

where:
$z_{press} =$ Elevation pressure flow begins, ft
$z_o =$ Orifice elevation (free discharge), ft
<all other values as previously defined>

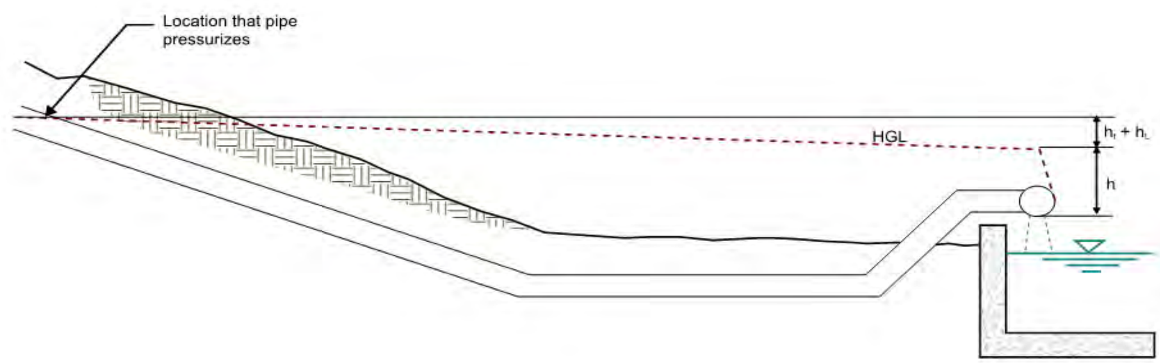


Figure 1. Pipe Downstream Schematic

Finally, the inlets were checked at the three major drain locations to determine the headwater condition at the upstream end of the pipe. Headwater depth was calculated according to Equations A.1 and A.3 from Appendix A of the FHWA Hydraulic Design Series Number 5 (HDS5; 2012), with the constants enumerated in Appendix A.

unsubmerged, circular; A.1

$$\frac{HW}{D} = \frac{H_c}{D} + K\left[\frac{K_u Q}{AD^{0.5}}\right]^M + K_s S$$

submerged, circular; A.3

$$\frac{HW}{D} = c\left[\frac{K_u Q}{AD^{0.5}}\right]^2 + Y + K_s S$$

where:
$HW =$ Headwater, ft
$D =$ Pipe inner diameter, ft
$H_c =$ Specific energy at critical depth, ft
$A =$ Culvert (full) barrel area, ft^2
$S =$ Culvert slope, ft/ft
$K_u =$ Unit conversion, 1.0 for USCS units
$K_s =$ Slope correction, -0.5
$K, M, c, Y =$ Constants, based on entrance conditions
<all other values as previously defined>

Assumptions

The following assumptions are made in these calculations:

(1) In order to allow for sufficient airflow, and to prevent periodic pressurization of the pipe where unintended, the pipe size is designed to convey the flow in an open-channel condition with the depth less than 70% of the inner diameter of the pipe, and a maximum of 75% full.

(2) The pipe is assumed to be plastic or some other smooth interior pipe, and non-profile wall pipe. Accordingly, a conservative roughness coefficient of 0.013 was applied.

(3) Based on standard sewer design, the pipe is considered self-cleaning if the velocity is greater than 2.0 ft/s. Above 1.5 ft/s is acceptable if occasional flushing flows are expected. The pipes were designed to meet this criterion.

Inputs

General Parameters

Gravitational constant, g	32.2	ft/s^2	
Kinematic Viscosity, ν	1.41E-05	ft^2/s	[@ 50 F]
Orifice Discharge Coefficient, C_D	0.62		[Lindeburg, 2014; sharp-edged, conservative]

Orifice Data

Orifice Diameter, D_o	4	in	
Orifice Diameter, D_o	0.33	ft	
Number of Ponds, N_p	3		
Number of Orifices per Pond, N	4		
Total Number of Orifices, N_0	12		
Orifice Elevation, z_o	2491.75	ft	[T.O.C. plus 3 inches]

Calculations

Gravity Pipeline

Location I.D.	Description	Discharge, Q gpm	Pipe Nom. Diameter in	Pipe Inner Diameter ft	Slope ft/ft	Roughness Coeff, *n*	Flow Depth, d ft	<70% Full?
DR1	Trunk Drain - Reach 1	420	12	0.94	0.005	0.013	0.49	53%
DR2	Trunk Drain - Reach 2	420	18	1.33	0.005	0.013	0.43	32%
DR3	Trunk Drain - Reach 3	805	18	1.33	0.005	0.013	0.60	45%
DR4	Trunk Drain - Reach 4	850	18	1.33	0.005	0.013	0.62	46%
CH1	Chinook Drain - Reach 1	4040	24	1.78	0.022	0.013	0.85	47%
DR5	Trunk Drain - Reach 5	4190	24	1.78	0.005	0.013	1.33	75%
DR6	Trunk Drain - Reach 6	4190	24	1.78	0.005	0.013	1.33	75%

Location I.D.	Description	Internal Angle, θ deg	Flow Area, A ft^2	Flow Velocity, V ft/s	Self-Cleaning?
DR1	Trunk Drain - Reach 1	186	0.37	2.53	OK
DR2	Trunk Drain - Reach 2	138	0.39	2.43	OK
DR3	Trunk Drain - Reach 3	169	0.61	2.93	OK
DR4	Trunk Drain - Reach 4	172	0.64	2.98	OK
CH1	Chinook Drain - Reach 1	174	1.17	7.69	OK
DR5	Trunk Drain - Reach 5	239	2.01	4.65	OK
DR6	Trunk Drain - Reach 6	239	2.01	4.65	OK

Orifice Head/Pressure Pipe

While the anticipated flow rate through the drain pipe system is equal to that of Trunk Drain Reach 6 above, the pressure pipe portion was designed for the full water right of 10 cfs, as it is critical that the pressure section not attain the elevation of the upstream ponds. Therefore, the following calculations were performed using a design discharge of 10 cfs.

Discharge, Q cfs	Orifice Aperture, A_0 ft^2	Number of Orifices, N_0	Discharge Coefficient, C_D	Head Req'ment, h ft	HGL ft
10	0.09	12	0.62	3.68	2495.43

Piping Losses

Discharge, Q cfs	Pipe Nom. Diameter in	Pipe Inner Diameter[1] in	Pipe Full Area ft^2	Velocity ft/s	Velocity Head ft	Reynolds Number	Surface Roughness in	Friction Factor[2], f
10	24	21.418	2.50	4.00	0.25	5.06E+05	6.00E-05	0.0132

Pipe Length[3] ft	Composite Minor Loss Coefficient[4] K	Major Losses ft	Minor Losses ft	Total Losses ft	HGL ft	
200	2.28	0.37	0.57	0.93	**2496.37**	<----- Location of pipe full

[1] Pipe inner diameter and surface roughness based on Schedule 80 PVC pipe.
[2] Friction factor calculated according to the Colebrook-White Equation.
[3] Pipe length is the length of pipe flowing full, based on the orifice head. This was rounded up to the nearest 100 ft based on the pipe alignment and profile.
[4] Composite minor loss coefficient was based on drain pipe layout, and includes (2) x 90 bends, (2) x 45 bend, (2) x tee (line flow), (1) x tee (branch flow), and (1) x open valve.

Inlet Control?

Location I.D.	Description	Discharge, Q gpm	Discharge, Q cfs	Nominal Diameter in	Inner Diameter ft	Culvert Barrel Area, A ft^2	Culvert Barrel Slope, S ft/ft
C1	Existing Coho	420	0.9	12	0.94	0.70	0.005
C2	Coho Raceway Bank 2	345	0.8	12	0.94	0.70	0.005
CH1	Chinook Raceways	4040	9.0	24	1.78	2.50	0.022

Location I.D.	Description	Critical Depth, d_c ft	Critical Spec Energy, H_c ft	Unit Conversion K_u	Slope Correction K_s	Constant[1] K	Constant[1] M	Constant[1] c	Constant[1] Y
C1	Existing Coho	0.41	0.62	1	-0.5	0.0078	2.0	0.0379	0.69
C2	Coho Raceway Bank 2	0.37	0.56	1	-0.5	0.0078	2.0	0.0379	0.69
CH1	Chinook Raceways	1.11	1.66	1	-0.5	0.0078	2.0	0.0379	0.69

Location I.D.	Description	Headwater Ratio, HW/D	Sub-merged?	>70%?	Sub-merged HW/D
C1	Existing Coho	67%	NO	NO	-
C2	Coho Raceway Bank 2	60%	NO	NO	-
CH1	Chinook Raceways	98%	NO	YES	-

[1] *Constants taken from HDS-5 Appendix A, Table A.1 based on circular pipe in headwall.*

Conclusions

The above calculations provide a set of flow, slope, and pipe size conditions that will maintain gravity flow in the drain pipes. It is likewise found that the orifice is expected to back flow up to elevation 2496.37, which is well below the lowest pond elevation and should not pose a concern for backing up the ponds. This elevation also provides an expected location upstream of which venting of the drain pipe will be required.

Finally, the entrance conditions were checked at the three major inlets to the drain system. It was found that the headwater was less than 70% of the pipe diameter for the Coho inlets, and therefore no modifications would be required. The Chinook raceways, on the other hand, have a headwater nearly equal to the pipe diameter, and therefore a vent pipe will be needed downstream if the pipe to provide adequate airflow downstream of the entrance condition.

SUBJECT: Klamath River Renewal Corporation
Fall Creek Hatchery
Waste Drain Hydraulics

BY: A. Leman CHK'D BY: N. Cox
DATE: 6/1/2020
PROJECT NO.: 20-024

Purpose

The purpose of this calculation sheet is to determine the hydraulics of the waste drain piping system.

References

- *Lindeburg, Michael R. 2014. Civil Engineering Reference Manual, Fourteenth Edition. Professional Publications, Inc. Belmont, CA.*

Method

The waste stream pipeline will convey flushing flows from the ponds and vats to the settling pond in the existing lower raceway bank. All outlet pipes will be sized to maintain open-channel flow. Open channel flow calculations followed the equations below (Lindeburg, 2014), and were calculated iteratively using a Newton-Raphson iterating scheme:

$$\theta_{deg} = 2\cos^{-1}\left(\frac{\frac{D}{2} - d}{\frac{D}{2}}\right) \qquad R_h = \frac{A}{P} \qquad \frac{n}{n_{full}} = 1 + \left(\frac{d}{D}\right)^{0.54} - \left(\frac{d}{D}\right)^{1.2}$$

$$A = \left(\frac{D}{2}\right)^2 \frac{\theta_{rad} - \sin\theta_{deg}}{2} \qquad V = \left(\frac{1.486}{n}\right) R_h^{2/3} S^{1/2}$$

$$P = \frac{D\theta_{rad}}{2} \qquad Q = AV$$

where:

$\theta =$ Internal angle of water surface
$D =$ Pipe inner diameter, ft
$d =$ Flow depth, ft
$A =$ Flow area, ft^2
$P =$ Wetted perimeter, ft
$R_h =$ Hydraulic radius, ft
$V =$ Average flow velocity, ft/s
$n =$ Manning's roughness coefficient
$S =$ Pipe bed slope, ft/ft
$Q =$ Discharge, cfs
$n_{full} =$ Pipe-full roughness coefficient

Assumptions

The following assumptions are made in these calculations:

(1) In order to allow for sufficient airflow, and to prevent periodic pressurization of the pipe where unintended, the pipe size is designed to convey the flow in an open-channel condition with the depth less than 70% of the inner diameter of the pipe, and a maximum of 75% full.

(2) The pipe is assumed to be plastic or some other smooth interior pipe, and non-profile wall pipe. Accordingly, a conservative roughness coefficient of 0.013 was applied.

(3) Based on standard sewer design, the pipe is considered self-cleaning if the velocity is greater than 2.0 ft/s. Above 1.5 ft/s is acceptable if occasional flushing flows are expected. The pipes were designed to meet this criterion.

Inputs

It is assumed that each raceway/pond/vat will be cleaned using a vacuum system that will connect to a riser pipe for each of the design points, via cam-lock. As such, the maximum flow in any pipe (outlet or trunk line) at any given time will be 200 gpm.

Design Discharge, Q	200	gpm
	0.45	cfs

Calculations

Because the design discharge is the same for all of the pipes, design pipe sizes were determined as a function of the slope condition, such that the drain pipe sizing could be calculated for any given location:

Description	Discharge, Q gpm	Pipe Nom. Diameter in	Pipe Inner Diameter ft	Slope ft/ft	Roughness Coeff, *n*	Flow Depth, d ft	<70% Full?
0.5% Slope	200	8	0.630	0.005	0.013	0.40	63%
1.0% Slope	200	8	0.630	0.010	0.013	0.33	52%
1.5% Slope	200	8	0.630	0.015	0.013	0.29	46%
2.0% Slope	200	6	0.476	0.020	0.013	0.31	66%
2.5% Slope	200	6	0.476	0.025	0.013	0.29	61%
3.0% Slope	200	6	0.476	0.030	0.013	0.28	58%
4.0% Slope	200	6	0.476	0.040	0.013	0.26	54%
5.0% Slope	200	6	0.476	0.050	0.013	0.24	50%
10.0% Slope	200	6	0.476	0.100	0.013	0.20	42%

Description	Internal Angle, θ deg	Flow Area, A ft^2	Flow Velocity, V ft/s	Self-Cleaning?	Top Width, T ft	Froude Number
0.5% Slope	211	0.21	2.14	OK	0.61	0.64
1.0% Slope	185	0.16	2.72	OK	0.63	0.94
1.5% Slope	172	0.14	3.13	OK	0.63	1.16
2.0% Slope	216	0.12	3.61	OK	0.45	1.22
2.5% Slope	206	0.11	3.90	OK	0.46	1.38
3.0% Slope	199	0.11	4.15	OK	0.47	1.53
4.0% Slope	188	0.10	4.59	OK	0.47	1.79
5.0% Slope	181	0.09	4.96	OK	0.48	2.01
10.0% Slope	161	0.07	6.33	OK	0.47	2.88

Conclusions

The above pipe sizes were calculated for the waste drain pipes used for cleaning the ponds and vats which report to the settling pond in the lower bank of existing raceways. Appropriate pipe sizes that maintain gravity flow and are self-cleaning, were calculated for slopes from 0.5% to 10% as a design aid for sizing the drain pipes based on profile requirements.

SUBJECT:	Klamath River Renewal Corporation	**BY:** A. Leman	**CHK'D BY:** V. Autier
	Fall Creek Hatchery	**DATE:** 6/1/2020	
	Volitional Release Pipes	**PROJECT NO.:** 20-024	

Purpose

The purpose of this calculation sheet is to document the design of the three (3) fish volitional release pipes.

References

- *NMFS (National Marine Fisheries Service). 2011. Anadromous Salmonid Passage Facility Design. NMFS, Northwest Region, Portland, Oregon.*
- *USFWS (U.S. Fish and Wildlife Service). 2017. Fish Passage Engineering Design Criteria. USFWS, Northeast Region R5, Hadley, MA.*

Design Criteria

The NMFS (2011) criteria for a fish bypass pipe are summarized below:

NMFS Guidelines	Value		Comments
Flow Regime	Open-Channel		NMFS 11.9.3.2 and 11.9.3.3
	No Hydraulic Jump		NMFS 11.9.3.12
Minimum Bend Radius (R/D)	5.0		NMFS 11.9.3.4 (greater for super-critical velocities)
Minimum Pipe Diameter	10.0	in	NMFS Table 11-1
Typical Access Port Spacing	150	ft	NMFS 11.9.3.5
Minimum Bypass Flow	5%		NMFS 11.9.3.7 (5% of diverted flow)
Maximum Pipe Velocity	12	ft/s	NMFS 11.9.3.8
Minimum Pipe Velocity	2	ft/s	NMFS 11.9.3.8 (6 ft/s recommended, 2 ft/s absolute where sedimentation is a concern)
Minimum Depth (d/D)	40%		NMFS 11.9.3.9 (percentage of pipe diameter); absolute > 2 in
Valves	None		NMFS 11.9.3.10

The NMFS (2011) criteria for a bypass outfall are summarized below:

NMFS Guidelines	Value		Comments
Location	Minimizes Predation		NMFS 11.9.4.1
	No eddies, reverse flow, predators		NMFS 11.9.4.1
Minimum Ambient River Velocities	4	ft/s	NMFS 11.9.4.1
Pool Depth	Not impact bottom		NMFS 11.9.4.1
Maximum Impact Velocity	25	ft/s	NMFS 11.9.4.2
Must be designed to avoid adult attraction			NMFS 11.9.4.3

Method

Open Channel Hydraulics

Fish pipe hydraulics were calculated according to standard open channel flow equations in a circular pipe:

$$\theta_{deg} = 2\cos^{-1}\left(\frac{\frac{D}{2} - d}{\frac{D}{2}}\right)$$

$$\frac{n}{n_{full}} = 1 + \left(\frac{d}{D}\right)^{0.54} - \left(\frac{d}{D}\right)^{1.2}$$

$$A = \left(\frac{D}{2}\right)^2 \frac{\theta_{rad} - \sin\theta_{deg}}{2}$$

$$P = \frac{D\theta_{rad}}{2}$$

$$R_h = \frac{A}{P}$$

$$V = \left(\frac{1.486}{n}\right) R_h^{2/3} S^{1/2}$$

$$Q = AV$$

where:

$\theta =$ Internal angle of water surface
$D =$ Pipe inner diameter, ft
$d =$ Flow depth, ft
$A =$ Flow area, ft^2
$P =$ Wetted perimeter, ft
$R_h =$ Hydraulic radius, ft
$V =$ Average flow velocity, ft/s
$n =$ Manning's roughness coefficient
$S =$ Pipe bed slope, ft/ft
$Q =$ Discharge, cfs
$n_{full} =$ Pipe-full roughness coefficient

Calculations were performed iteratively using a Newton-Raphson iterating scheme.

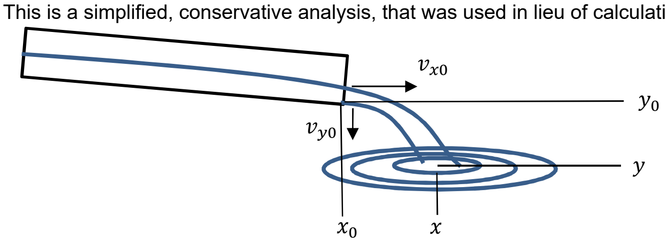
Fish Bypass Pipe

• The fish bypass pipe was sized to meet the minimum depth criterion (40% of the inner diameter), while also ensuring that the pipe would not pressurize. In order to ensure open channel flow, the water surface was generally maintained less than 70% of the pipe diameter, and strictly less than 75%.
• The Coho fish release pipes have a much smaller flow-through discharge and therefore, it was assumed that the full discharge through the Coho raceways would be directed to Fall Creek at volitional fish release.
• The Chinook fish release pipes will be operated while still maintaining flow down to the adult holding ponds at volitional fish release. Therefore, an operational flow range was selected that would be diverted to fish release, and the remainder will be directed to adult holding ponds, based on the placement/removal of stoplogs (see "Chinook Outlet" calculations). The operational flow range was maintained within the same 40% - 75% of the pipe inner diameter for volitional release.

• The adult holding fish release pipe will be operated to drain the Coho and Chinook holding ponds. These can be hydraulically connected to the trapping and sorting pond, and therefore could see a range of flows from 6.6 cfs - 10 cfs. This is considered the operational range for the volitional release pipe. The operational flow range was maintained within the same 40% - 75% of the pipe inner diameter for volitional release.
• Velocities were subsequently checked to ensure that they are maintained within the NMFS guidelines for fish bypass pipes.

Plunge Pool

• The plunge pool impact velocity was calculated according to basic kinematic equations. The impact velocity was calculated at the water surface, and at the bottom of the pool. If both of these locations are less than the critical impact velocity, it was deemed that the criterion was met. This is a simplified, conservative analysis, that was used in lieu of calculating hydraulics of the jet in the plunge pool.



$$y = y_0 + v_{y0}t_i + \frac{1}{2}a_y t_i^2$$
$$x = x_0 + v_{x0}t_i$$

where:

$a_y =$ Acceleration in y-direction, 32.2 ft/s^2
$t_i =$ Time to impact, s

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Inputs

The following inputs were used for the design of the fish bypass pipe and outfall:

Inputs (Chinook)	Value		Comments
Maximum outflow	4.5	cfs	50% of the Chinook pond outflow
Minimum outflow	2.6	cfs	~25% of the Chinook pond outflow
Outfall Pipe Invert Elevation	2494.0	ft	Selected, 1-ft above High TW
Pool Bottom Elevation	2489.4	ft	Selected, Min pool depth 3.0'
100-year Tailwater Elevation	2494.5	ft	HEC-RAS Model
High Tailwater Elevation	2492.9	ft	March 1% Exceedance Flow
Low Tailwater Elevation	2492.4	ft	May 95% Exceedance Flow
Pipe Material	HDPE		butt welded for smooth interior
Pipe Dimension Ratio	26		From Civil Calculations
Gravitational Constant	32.2	ft/s^2	

Inputs (Coho)	Value		Comments
Outflow (New ponds)	0.77	cfs	2 ponds x 172 gpm/pond
Outflow (New ponds + Exist)	1.70	cfs	New ponds + 2 ponds x 210 gpm/pond
Existing Conc Flume Width	4	ft	Measured in survey
Pool Bottom Elevation	2494.93	ft	Measured in survey
100-year Tailwater Elevation	2498.26	ft	HEC-RAS Model
High Tailwater Elevation	2496.46		March 1% Exceedance Flow
Low Tailwater Elevation	2495.98		May 95% Exceedance Flow
Pipe Material	HDPE		butt welded for smooth interior
Pipe Dimension Ratio	26		From Civil Calculations

Inputs (Adult Holding)	Value		Comments
Maximum outflow	10	cfs	Full flow - 3 ponds
Minimum outflow	6.6	cfs	Full flow - 2 ponds
100-year Tailwater Elevation	2487.21	ft	HEC-RAS Model
High Tailwater Elevation	2484.77	ft	March 1% Exceedance Flow
Low Tailwater Elevation	2484.12	ft	May 95% Exceedance Flow = Oct-Dec Fish Passage Low Flow
Pool Bottom Elevation	2482.07	ft	See Denil Fishway Calculations
Pipe Inlet Elevation	2486.5	ft	See Denil Fishway Calculations
Pipe Outlet Elevation	2485.99	ft	Input
Pipe Material	HDPE		butt welded for smooth interior
Pipe Dimension Ratio	26		From Civil Calculations

McMILLEN JACOBS ASSOCIATES

Calculations

Chinook Fish Release

Bypass Pipe Calculations

The following table was used as a design aid for the fish release pipe design:

Pipe Nominal Diameter (in)	Pipe Inner Diameter (ft)	Manning's Rough Coefficient	Discharge (cfs)	Slope (ft/ft)	Flow Depth (ft)	% Full	Flow Velocity (ft/s)	Froude Number
20	1.54	0.013	4.5	0.005	0.94	61%	3.80	0.75
20	1.54	0.013	2.6	0.005	0.69	45%	3.22	0.78
16	1.23	0.013	4.5	0.01	0.87	71%	5.00	0.98
16	1.23	0.013	2.6	0.01	0.63	51%	4.22	1.05
16	1.23	0.013	4.5	0.015	0.77	63%	5.75	1.25
16	1.23	0.013	2.6	0.015	0.57	46%	4.87	1.30
14	**1.08**	**0.013**	**4.5**	**0.02**	**0.77**	**71%**	**6.49**	**1.36**
14	**1.08**	**0.013**	**2.6**	**0.02**	**0.56**	**52%**	**5.48**	**1.45**
14	1.08	0.013	4.5	0.03	0.68	63%	7.46	1.73
14	1.08	0.013	2.6	0.03	0.50	46%	6.31	1.80
12	0.98	0.013	4.5	0.04	0.66	67%	8.36	1.93
12	0.98	0.013	2.6	0.04	0.48	49%	7.07	2.03
12	**0.98**	**0.013**	**4.5**	**0.06**	**0.58**	**59%**	**9.62**	**2.43**
12	**0.98**	**0.013**	**2.6**	**0.06**	**0.43**	**44%**	**8.15**	**2.51**
12	0.98	0.013	4.5	0.07	0.56	57%	10.14	2.65
12	0.98	0.013	2.6	0.07	0.41	42%	8.61	2.72
10	0.83	0.013	4.5	0.1	0.55	67%	11.79	2.97
10	0.83	0.013	2.6	0.1	0.40	49%	9.97	3.13
10	0.83	0.013	4.5	0.15	0.49	59%	13.56	3.74
10	0.83	0.013	2.6	0.15	0.36	44%	11.49	3.86
10	0.83	0.013	4.5	0.2	0.45	55%	14.98	4.37
10	0.83	0.013	2.6	0.2	0.34	41%	12.73	4.47

** red indicates outside of 40% - 70% full range, and only occurs where standard pipe sizes above the minimum cannot accommodate the operational flow range within those recommended water depths.*

Plunge Pool Calculations

Scenario	Pipe Outfall Velocity, V (ft/s)	Initial Velocity, V_x (ft/s)	Initial Velocity, V_y (ft/s)	Pipe Elevation (ft)	Tailwater Elevation (ft)	Drop Height (ft)	Drop to Bottom of Pool (ft)
Lo Release, Lo TW	5.48	5.48	0.11	2494.0	2492.4	1.6	4.6
Lo Release, Hi TW	5.48	5.48	0.11	2494.0	2492.9	1.1	4.6
Hi Release, Lo TW	6.49	6.49	0.13	2494.0	2492.4	1.6	4.6
Hi Release, Hi TW	6.49	6.49	0.13	2494.0	2492.9	1.1	4.6

Scenario	Time to Impact WSEL (s)	Time to Impact Bottom* (s)	Impact Velocity at WSEL (ft/s)	Impact Velocity at Bottom* (ft/s)	x-distance to WSEL Impact (ft)
Lo Release, Lo TW	0.3	0.5	11.53	18.06	1.71
Lo Release, Hi TW	0.3	0.5	10.04	18.06	1.41
Hi Release, Lo TW	0.3	0.5	12.05	18.39	2.02
Hi Release, Hi TW	0.3	0.5	10.63	18.39	1.67

**Note: impact velocity calculated at the bottom of the pool as the maximum possible impact velocity. It is demonstrated, that the bypass flow does not impact the bottom, but rather the water surface a minimum of 3.0' above the pool bottom.*

Coho Fish Release

Bypass Pipe Calculations

The following table was used as a design aid for the fish release pipe design:

Pipe Nominal Diameter in	Pipe Inner Diameter ft	Manning's Rough Coefficient	Discharge cfs	Slope ft/ft	Flow Depth ft	% Full	Flow Velocity ft/s	Froude Number
10	0.83	0.013	0.77	0.005	0.47	57%	2.42	0.69
10	**0.83**	**0.013**	**0.77**	**0.01**	**0.39**	**47%**	**3.09**	**0.99**
10	0.83	0.013	0.77	0.015	0.35	42%	3.56	1.22
10	0.83	0.013	0.77	0.02	0.32	39%	3.94	1.42
10	0.83	0.013	0.77	0.025	0.30	37%	4.27	1.59
10	0.83	0.013	0.77	0.04	0.27	33%	5.05	2.01
10	0.83	0.013	0.77	0.06	0.24	29%	5.83	2.46

** red indicates outside of 40% - 70% full range, and only occurs where standard pipe sizes above the minimum cannot accommodate the operational flow range within those recommended water depths.*

The bypass pipe will terminate in the existing concrete outlet flume on the existing upper concrete raceways, which will convey fish to Fall Creek. The water surfaces of interest in this area are as follows:

Existing Conc Flume Invert	2498.4	ft
Pipe Invert Elevation	2499.61	ft
100-year Flood Elevation	2498.26	ft
Dam Board Normal Elevation	2502.2	ft
Dam Board Vol Release Elevation	2499.35	ft

Plunge Pool Calculations

The release to the stream will be at the location of existing fish release from the existing facility. No constructed plunge pool is expected for this site.

Adult Holding Fish Release

Bypass Pipe Calculations

The following table was used as a design aid for the fish release pipe design:

Pipe Nominal Diameter in	Pipe Inner Diameter ft	Manning's Rough Coefficient	Discharge cfs	Slope ft/ft	Flow Depth ft	% Full	Flow Velocity ft/s	Froude Number
30	2.31	0.013	6.60	0.005	0.96	41%	4.03	0.84
30	2.31	0.013	10.00	0.005	1.20	52%	4.56	0.82
24	1.85	0.013	6.60	0.01	0.87	47%	5.29	1.13
24	1.85	0.013	10.00	0.01	1.10	60%	6.00	1.10
24	1.85	0.013	6.60	0.015	0.78	42%	6.10	1.40
24	1.85	0.013	10.00	0.015	0.98	53%	6.91	1.37
20	1.54	0.013	6.60	0.02	0.79	51%	6.91	1.54
20	1.54	0.013	10.00	0.02	1.00	65%	7.85	1.48
18	**1.38**	0.013	**6.60**	**0.03**	**0.74**	**53%**	**8.07**	**1.85**
18	**1.38**	0.013	**10.00**	**0.03**	**0.94**	**68%**	**9.18**	**1.76**
18	1.38	0.013	6.60	0.04	0.68	49%	8.93	2.15
18	1.38	0.013	10.00	0.04	0.86	62%	10.13	2.08
18	1.38	0.013	6.60	0.06	0.61	44%	10.30	2.66
18	1.38	0.013	10.00	0.06	0.77	55%	11.66	2.60
18	1.38	0.013	6.60	0.07	0.59	42%	10.87	2.88
18	1.38	0.013	10.00	0.07	0.74	53%	12.30	2.83
16	1.23	0.013	6.60	0.1	0.56	46%	12.50	3.36
16	1.23	0.013	10.00	0.1	0.71	57%	14.17	3.28
14	1.08	0.013	6.60	0.15	0.53	50%	14.66	4.00
14	1.08	0.013	10.00	0.15	0.67	63%	16.64	3.86
14	1.08	0.013	6.60	0.2	0.49	46%	16.22	4.64
14	1.08	0.013	10.00	0.2	0.62	58%	18.38	4.53

** red indicates outside of 40% - 70% full range, and only occurs where standard pipe sizes above the minimum cannot accommodate the operational flow range within those recommended water depths.*

Plunge Pool

The adult holding fish release pipe will discharge to the entrance pool at the toe of the Denil fishway. The following calculations are performed for the impact velocity at this location.

Scenario	Pipe Outfall Velocity, V ft/s	Initial Velocity, V_x ft/s	Initial Velocity, V_y ft/s	Pipe Elevation ft	Tailwater Elevation ft	Drop Height ft	Drop to Bottom of Pool ft
Lo Release, Lo TW	8.07	8.07	0.16	2486.0	2484.12	1.9	3.9
Lo Release, Hi TW	8.07	8.07	0.16	2486.0	2484.77	1.2	3.9
Hi Release, Lo TW	9.18	9.18	0.18	2486.0	2484.12	1.9	3.9
Hi Release, Hi TW	9.18	9.18	0.18	2486.0	2484.77	1.2	3.9

Scenario	Time to Impact WSEL s	Time to Impact Bottom* s	Impact Velocity at WSEL ft/s	Impact Velocity at Bottom* ft/s	x-distance to WSEL Impact ft
Lo Release, Lo TW	0.3	0.5	13.62	17.82	2.71
Lo Release, Hi TW	0.3	0.5	11.99	17.82	2.18
Hi Release, Lo TW	0.3	0.5	14.31	18.35	3.08
Hi Release, Hi TW	0.3	0.5	12.76	18.35	2.47

Conclusions

The above calculations document the design of the fish release pipes and plunge pools in Fall Creek, and demonstrate that the fish release pipes follow recommendations/guidelines from NMFS. It should be noted, however, that both the Chinook volitional release pipe and the adult holding volitional release pipe were designed for a specific flow range, and should only be operated within those parameters at fish release.

SUBJECT: Klamath River Renewal Corporation | BY: A. Leman | CHK'D BY: V. Autier
Fall Creek Hatchery | DATE: 6/1/2020
Chinook Outlet | PROJECT NO.: 20-024

Purpose

The purpose of this sheet is to document the design of the Chinook outlet for splitting flows to the volitional release pipe and the production drain.

References

- *NMFS (National Marine Fisheries Service). 2011. Anadromous Salmonid Passage Facility Design. NMFS, Northwest Region, Portland, Oregon.*

Method

The outlet of the Chinook raceways will feed a single exit channel, that will typically be operated to direct flows to the production drain system. During volitional fish release, however, flows will need to be diverted to both the production drain system (and on to the adult holding ponds, as "second pass" water) and to the volitional release pipe. The calculations below document the following:

Overflow Dam Boards

These calculations determine the weir overflow depth, and consequently the elevation of the dam boards at the end of the Chinook raceways. Calculations are based on the weir equation with pier contractions as given in HDC 111-3 (USACE, 1977). The discharge coefficient was determined according to the Rehbock equation:

$$Q = \frac{2}{3} C_1 \sqrt{2g} \left(L' - 2\left(NK_p\right)H_e\right) H_e^{3/2}$$

$$C_1 = \left(0.6035 + 0.0813\frac{H_e}{Y} + \frac{0.000295}{Y}\right)\left(1 + \frac{0.00361}{H_e}\right)^{3/2}$$

where:
$Q =$ Discharge, cfs
$C_1 =$ Discharge coefficient
$L' =$ Net Length of crest, ft
$N =$ Number of piers
$K_p =$ Pier contraction coefficient, ft
$H_e =$ Energy head, ft
$Y =$ Weir height, ft

Volitional Release Dam Boards

These calculations determine the elevation at which the volitional release dam boards need to be set to maintain a minimum pool depth, such that fish that drop into the exit channel do not drop onto concrete. These calculations will also set the water surface in the exit channel for determining the flow split between the production drain and the volitional release pipe.

$$Q = \frac{2}{3} C_1 \sqrt{2g} L H_e^{3/2}$$

where:
$L =$ Crest length, ft

Volitional Release Pipe

Volitional release pipe calculations are performed on the "Volitional Pipe Release" sheets.

Fish Screen

During volitional release, the production drain will have a fish screen in place to prevent fish from being entrained in the production drain system. The fish screen will be brought over from IGFH and will be of the type that is currently in use by CDFW. The fish screen was sized such that approach velocities would be less than 0.4 ft/s per NMFS 11.6.1.1. Active screen values were used as this is not in the stream, but is downstream of the ponds and has already been screened multiple times before this point. There will also be significant sweeping velocities along the length of the screen from the draw at the volitional release dam boards.

$$A = W \times d$$

$$V_a = \frac{Q}{A}$$

where:
$W =$ Screen width, ft
$A =$ Screen area, ft^2
$V_a =$ Approach velocity, ft/s

Production Drain

The production drain will be operated, during volitional release by another set of dam boards. These will be placed to direct the remainder of the flow (not going to the volitional release pipe) to the production drain system.

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Inputs

Parameter	Units	Value	Description
Total Flow	cfs	9	
Flow per Pond	cfs	1.125	Total, divided by 8 ponds
Volitional Release Min Flow	cfs	2.6	see "Volitional Release Pipes" calculations
Volitional Release Max Flow	cfs	4.5	see "Volitional Release Pipes" calculations
Pond Floor Elevation	ft	2500	
Pond Water Surface Elevation	ft	2504	
Pond Depth	ft	4	Design Value
Pond Width	ft	12	Design Value
Exit Channel Width	ft	2.5	Design Value
Exit Channel Floor Elevation (@ Volitional Rel)	ft	2498.93	Design Value
Volitional Release Min Pool Depth	ft	3	Design Value
Pier Width	ft	1.5	Design Value
Number of Piers per pond		1	
Pier Contraction Coefficient, K_p		0.1	Assumed, conservative
Gravitational Constant	ft/s^2	32.2	

Calculations

Overflow Dam Boards

Q cfs	H_e ft	Y ft	L' ft	C_1	Q_{calc} cfs	Goal Seek to 1.0
1.125	0.10	3.90	10.5	0.64	1.126	1.00

Overflow dam board crest elevation: 2503.90 ft

Volitional Release Dam Boards

Q cfs	H_e ft	Y ft	L ft	C_1	Q_{calc} cfs	Goal Seek to 1.0
9	1.08	1.92	2.5	0.65	9.006	1.00
6.4	0.89	2.11	2.5	0.64	6.647	1.04
4.5	0.68	2.32	2.5	0.63	4.502	1.00

Discharge to Production Drain cfs	Discharge to Volitional Release cfs	Production Drain Dam Boards Crest El ft	Volitional Release Dam Boards Crest El ft	WSEL ft
2.6	6.4	2501.64	2501.04	2501.93
4.5	4.5	2501.51	2501.25	2501.93

Volitional Release Pipe

See "Volitional Release Pipe" calculations.

The Chinook volitional release pipe was sized for a flow range from:

$Q_{max} =$ 4.5 cfs [50% total flow]
$Q_{min} =$ 2.6 cfs [~25% total flow]

Fish Screen

Q cfs	d ft	W ft	A ft^2	V_a ft/s
4.5	3.0	5	15	0.30
6.4	3.2	5	16	0.40

**use 5.0' b/c of existing screens at IGFH*

Conclusions

The above calculations document the design of the Chinook outlet channel for diverting water to the production drain and the volitional release pipe. During normal operations, the dam boards at the volitional release pipe will be full height, and all water will be drained to the production drain system. During volitional release, a 3.0' deep pool will be maintained in the exit channel, based on the crest elevation of the volitional release pipe dam boards. The production drain will have a fish screen that meets NMFS criteria for a range of flows from 4.5 cfs to 6.4 cfs. Behind the fish screen will be another set of dam boards that will control the amount of flow diverted to the production drain system. See the drawings for details.

SUBJECT:	Klamath River Renewal Corporation	BY:	A. Leman	CHK'D BY:	V. Autier
	Fall Creek Hatchery	DATE:	6/1/2020		
	Fish Barrier	PROJECT NO.:	20-024		

Purpose

The purpose of this sheet is to design the fish exclusion system in Fall Creek.

References

- *Brater, E.F., King, H.W., Lindell, J.E., Wei, C.Y. 1976. Handbook of Hydraulics, 7th Edition* . McGraw-Hill.
- *NMFS (National Marine Fisheries Service). 2011. Anadromous Salmonid Passage Facility Design. NMFS, Northwest Region, Portland, Oregon.*

Method

The fish exclusion system in Fall Creek is intended for several main purposes:

(1) To exclude anadromous adults from the upstream reaches above Dam A and Dam B where they can pose a concern for the intake structures and for disease to the hatchery water supply.

(2) To exclude juvenile hatchery fish being released in the Spring from the same areas.

(3) To direct anadromous adults toward the fishway entrance and ultimately to the fish trap.

During the design process it was identified by NOAA that the habitat between Dam A/Dam B and the fishway is to be maintained. Therefore, in order to provide a barrier during trapping that will direct fish into the fishway, but will remain open during other seasons or after the closure of the hatchery, a 3-part barrier system is provided.

(1) **Lower Barrier** - In the lower portion of the site, adjacent to the fishway and trap, a removable picket barrier will be provided which will be placed at the start of each trapping season on a concrete sill. The pickets can then be removed at the end of the trapping season to allow unimpeded passage. The lower barrier sill will be oriented at an angle to the natural channel direction, such that fish will be directed toward the fishway entrance pool.

(2) **Dam A Barrier -** In order to prevent fish from accessing the reach containing the hatchery intake structure and City of Yreka intake building, Dam A will be modified with a steep apron to constitute a NMFS standard velocity barrier. This steep apron will convey natural Dam A overflows at shallow depths and high velocities into the stream below, such that an anadromous fish could not swim up the apron, or if it did, depths would not be sufficient for the fish to jump over Dam A.

(3) **Dam B Barrier -** In order to prevent fish from accessing the reach containing the City of Yreka intake structure in the Dam B reach, Dam B will likewise be modified with a steep apron to constitute a NMFS standard velocity barrier.

The design of each of the barrier systems is described below.

Criteria

The NMFS (2011) criteria for the two barrier types under consideration are summarized below:

NMFS Guidelines (Pickets)	Value		Comments
Picket Clear Spacing	1	in	NMFS 5.3.2.1, max
Maximum River Velocity	1.25	ft/s	NMFS 5.3.2.2
Average River Velocity	1	ft/s	NMFS 5.3.2.2, gross picket area
Maximum Head Differential	0.3	ft	NMFS 5.3.2.3, on the clean picket condition
Debris and Sediment	-		NMFS 5.3.2.4, debris and sediment removal must be considered
Picket Barrier Orientation	-		NMFS 5.3.2.5, direct fish toward fishway
Minimum Picket Freeboard	2	ft	NMFS 5.3.2.6 (during fish passage)
Minimum Submerged Depth	2	ft	NMFS 5.3.2.7, for 10% of cross-section; low design flow
Minimum Percent Open	40%		NMFS 5.3.2.8
Picket Materials	-		NMFS 5.3.2.9, Flat or round, steel, aluminum, or durable plastic
Picket Sill	-		NMFS 5.3.2.10, Uniform concrete sill

NMFS Guidelines (Velocity)	Value		Comments
Minimum Weir Height	3.5	ft	NMFS 5.4.2.1, relative to maximum apron elevation
Minimum Apron Length	16.0	ft	NMFS 5.4.2.2
Minimum Apron Slope	0.06	ft/ft	NMFS 5.4.2.3, 16H:1V
Maximum Weir Head	2.0	ft	NMFS 5.4.2.4
Downstream Apron Elevation	-		NMFS 5.4.2.5, must be greater than tailwater at high design flow
Flow Ventilation	-		NMFS 5.4.2.6, fully ventilated nappe flow

Inputs

Hydrologic Inputs

Barrier 1 (Lower)	Value		Comments
Adult Fish Passage High Flow	71.86	ft^3/s	1% Exceedance Probability for Oct - Dec (CDFW Definition)
Adult Fish Passage Low Flow	23.40	ft^3/s	95% Exceedance Probability for Oct - Dec
Extreme Event: 2-year Flood	115.32	ft^3/s	See "Streamflow" Calculations
Extreme Event: 100-year Flood	756.23	ft^3/s	See "Streamflow" Calculations

Barrier 2 (Dam A)	Value		Comments
Powerhouse High Flow*	50.00	ft^3/s	Klamath Hydroelectric Project, EIS 2007
Powerhouse Low Flow*	15.00	ft^3/s	Klamath Hydroelectric Project, EIS 2007

**Note: Flows in the Dam A drainage are predominantly anthropogenic, from the powerhouse. The drainage area reporting to this area is very limited, and these two design flows will be representative of the flow regime in the Dam A drainage.*

Barrier 3 (Dam B)	Value		Comments
Juvenile High Flow	62.14	ft^3/s	1% Exceedance Probability for the peak month of juvenile release (Mar)
Adult Fish Passage High Flow	56.86	ft^3/s	1% Exceedance Probability for Oct - Dec
Adult Fish Passage Low Flow	8.40	ft^3/s	95% Exceedance Probability for Oct - Dec
Extreme Event: 2-year Flood	100.32	ft^3/s	See "Streamflow" Calculations
Extreme Event: 100-year Flood	741.23	ft^3/s	See "Streamflow" Calculations

Other Inputs

Barrier 1 (Lower)	Value		Comments
Natural Channel Width	15.00	ft	Measured from upstream and downstream transects
Broad-Crested Weir Coefficient	2.65		Brater et al., 1976; 5.0-ft wide crest; ~ 1.0 - 2.0 overflow
Floodplain Weir Elevation	2488.00	ft	
Floodplain Weir Crest Length	30.00	ft	Measured in CAD
Sill Crest Elevation	2483.00	ft	
Screen Angle to Horiz	60.00	deg	
Adult High Flow WSEL	2484.77	ft	See 'Tailwater' Calculations
Adult Low Flow WSEL	2484.12	ft	See 'Tailwater' Calculations
2-year Flood WSEL	2485.13	ft	See 'Tailwater' Calculations
100-year Flood WSEL	2487.21	ft	See 'Tailwater' Calculations

Barrier 2 (Dam A)	Value		Comments
Apron Width	29.00	ft	City of Yreka Intake Bldg to Hatchery Intake

Barrier 3 (Dam B)	Value		Comments
Apron Width	10.00	ft	Estimated from photograph of existing Dam B

Calculations

Barrier 1 (Lower) Calculations

Picket Flow Depths & Velocities

The flow depths through the pickets were calculated from the backwater HEC-RAS calculations. These flow depths were then used to determine velocities by rotation angle about the stream transect and the vertical angle of the screens. Only adult fish passage flows were used, as this barrier will only be in operation during trapping periods.

Rotation Angle about Stream	Adult High Flow			Adult Low Flow		
	Discharge	Flow Depth	Flow Velocity	Discharge	Flow Depth	Flow Velocity
(°)	cfs	ft	ft/s	cfs	ft	ft/s
0	71.86	1.77	2.34	23.40	1.12	1.21
5	71.86	1.77	2.34	23.40	1.12	1.20
10	71.86	1.77	2.31	23.40	1.12	1.19
15	71.86	1.77	2.26	23.40	1.12	1.17
20	71.86	1.77	2.20	23.40	1.12	1.13
25	71.86	1.77	2.12	23.40	1.12	1.09
30	**71.86**	**1.77**	**2.03**	**23.40**	**1.12**	**1.04**

Upstream Water Surface Elevation / Head Loss

Water surface elevations at the fish barrier were calculated in HEC-RAS via backwater calculations. These calculations, however, do not include the additional head losses accounting for the picket barrier. Therefore head losses were calculated across the barrier using the screen head loss equations (USBR, 1987):

$$K_s = 1.45 - 0.45\frac{A_n}{A_g} - \left(\frac{A_n}{A_g}\right)^2$$

$$A_n = (1 - R_D)R_0A_g$$

$$h_s = K_s\left(\frac{v_n^2}{2g}\right)$$

where:

$K_s =$ Screen loss coefficient
$h_s =$ Screen head losses, ft
$A_n =$ Net screen area (less screen and occlusions), ft^2
$A_g =$ Gross screen area, ft^2
$v_n =$ Net velocity (through net screen area), ft/s
$g =$ Gravitational constant, 32.2 ft/s^2
$R_D =$ Ratio of debris coverage
$R_o =$ Ratio of open area (clean bars)

It is assumed that the removable pickets will maintain 2.0' of freeboard above the upstream elevation of the fish passage high flow water surface with an additional 0.3' for screen occlusions.

Event	Discharge	Backwater Elevation	Gross Screened Area	% Open	Net Screened Area	Ratio An/Ag
	cfs	ft	ft^2		ft^2	
Adult Fish Passage High Flow	71.86	2484.77	30.7	50%	15.3	50%
Adult Fish Passage Low Flow	23.40	2484.12	19.4	50%	9.7	50%
Extreme Event: 2-year Flood	115.32	2485.13	36.9	50%	18.4	50%

Event	Loss Coeff	Net Velocity	Net Velocity Head	Head Loss	Clean Picket U/S Elev	Occluded Screen U/S Elev	Top of Picket Elevation
		ft/s	ft	ft	ft	ft	ft
Adult Fish Passage High Flow	0.975	4.69	0.34	0.33	2485.10	2485.4	**2487.40**
Adult Fish Passage Low Flow	0.975	2.41	0.09	0.09	2484.21	2484.5	-
Extreme Event: 2-year Flood	0.975	6.25	0.61	0.59	2485.72	2486.0	-

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100-year Flood Elevation

It is conservatively assumed that for the 100-year flood, the pickets are in place and not able to be removed. They furthermore are assumed to be fully occluded with debris. Thus all flows will act as weir flow over the occluded pickets and the overflow weir in the floodplain. Calculations of the weir flow at the 100-year flood are provided below for setting the grade on the east bank of the stream.

Event	WSEL ft	Depth @ OF Weir ft	Length of OF Weir ft	OF Weir Discharge Coeff	OF Weir Discharge cfs
Extreme Event: 100-year Flood	2490.26	2.26	30.00	2.65	461

Event	Depth over occluded barrier ft	Length of occluded barrier ft	Height of Occluded Barrier ft	Rehbock Discharge Coeff	Barrier Discharge cfs	OF Weir Discharge cfs	Total Discharge cfs
Extreme Event: 100-year Flood	2.86	17.32	4.40	3.52	295	461	756

Given the conservative assumptions of the barrier remaining in place and being fully occluded by debris, a 7" freeboard was maintained on all walls, and 4" of freeboard was maintained on the elevation at either bank.

Wall Elevation	2490.85
Bank Elevation	2490.60

Barrier 2 (Dam A) Calculations

Apron Depths & Velocities

The depths and flow velocities on the Dam A high velocity apron were calculated according to a normal flow assumption. The aim of the high velocity apron is to provide a section that will be too shallow and too fast for an adult to jump from over Dam A. Velocities and flow depths were calculated for powerhouse high and low flows.

Design Flow cfs	Slope ft/ft	Width ft	Roughness Coeff, n	Normal Flow Depth in	Velocity ft/s	Apron Length ft	Drop ft
50.00	0.0625	29.00	0.015	2.4	8.48	16	1
15.00	0.0625	29.00	0.015	1.2	5.26	16	1

Barrier 3 (Dam B) Calculations

Apron Depths & Velocities

The depths and flow velocities on the Dam B high velocity apron were calculated according to a normal flow assumption. The aim of the high velocity apron is to provide a section that will be too shallow and too fast for an adult to jump from over Dam B. Velocities and flow depths were calculated for juvenile high flows and adult high and low flows.

Design Flow cfs	Slope ft/ft	Width ft	Roughness Coeff, n	Normal Flow Depth in	Velocity ft/s	Apron Length ft	Drop ft
62.14	0.0625	11.50	0.015	4.9	13.10	16	1
56.86	0.0625	11.50	0.015	4.7	12.66	16	1
8.40	0.0625	11.50	0.015	1.5	6.00	16	1

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Discussion

Based on the foregoing calculations, there remain two guidelines/criteria that are unmet by the design of the lower picket barrier (Barrier 1). These will be discussed in turn:

NMFS 5.3.2.2 - Picket Velocities

High picket velocities can pose a concern for impingement of fish upstream of the barrier on screens or picket panels. Meeting the 1 ft/s picket velocity criterion, however, has proven challenging in the setting of small mountain streams across the Pacific Northwest, such as Fall Creek. It is not anticipated that the 1 ft/s picket velocity criterion will be met by this design. However, it is not expected that the picket barrier will pose a fish impingement concern, because of the following mitigating factors:

- The fish habitat above the FCFH exclusion barrier is very limited, and fish are not anticipated upstream of the picket barrier where impingement could occur.
- The exposure window when the pickets will be in place is limited to the period of trapping. At all other times the pickets will be removed, and streamflow will flow through naturally.
- The screen will be oriented at an angle to the stream transverse, increasing the wetted area of the picket panels and decreasing the average velocities through the pickets.
- Natural flow velocities in the stream around this location are as high as 4.5 ft/s under high flow conditions. The flow through the pickets will be much less than the natural surrounding stream, due to the orientation of the barrier, the backwater caused by the picket head losses, and the local shallowing of the slope for the concrete sill.
- In the language of the NMFS guidelines, this is not a "criterion" but is meant to serve as a "guideline." Given all of the site-specific mitigating factors above, it is expected that the current design is within the spirit of the guideline.

NMFS 5.3.2.7 - Minimum Submerged Picket Depth

The minimum submerged depth at the picket barrier is a criterion that is also challenging to meet in the setting of the FCFH barrier, and in other similar locations across the Pacific Northwest. It is not anticipated that this criterion will be met for the FCFH exclusion barrier. Similar reasons for relaxation of this criterion apply as those given above. In addition, it may be noted:

- The natural flow depth through this region is only about 9 inches deep at low flow. Meeting the minimum submerged picket depths would require significant deviation about the natural channel flows.
- The current design will cause a backwater that will raise the water surface elevations as high as possible. Further modifications would require drastic alteration of the natural stream environment.
- No alternative locations at the site are anticipated to be significantly more confined than the location selected, and therefore the water surface elevations at other locations about the site should not show much improvement in meeting this criterion.

It is therefore deemed that, while these represent exceptions to the NMFS guidelines and/or criteria, these are common exceptions required in small stream/tributary settings such as this one. The design meets the spirit of the NMFS (2011) guidelines to the extent possible in such a setting.

Conclusions

The above calculations and discussion detail the design of the exclusion barrier system at the FCFH site. It was elected that 3-part barrier system be constructed, with a temporary picket barrier system that is used for trapping of adults only, and a velocity barrier system at Dam A and Dam B that uses existing infrastructure to the greatest possible extent. As is the case with many sites on small streams, such as Fall Creek, some of the NMFS criteria are unattainable due to site specific constraints. These are discussed in detail above.

SUBJECT:	Klamath River Renewal Corporation	**BY:** A. Leman	**CHK'D BY:** V. Autier
	Fall Creek Hatchery	**DATE:** 4/2/2020	
	Denil Fishway	**PROJECT NO.:** 20-024	

Purpose

The purpose of this calculation sheet is to size the Denil fishway for the design flow.

References

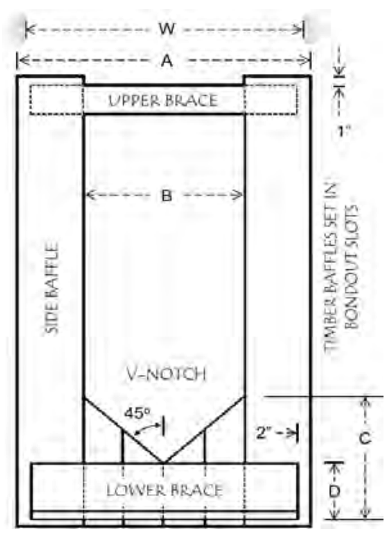
- *NMFS (National Marine Fisheries Service). 2011. Anadromous Salmonid Passage Facility Design. NMFS, Northwest Region, Portland, Oregon.*
- *NRCS (Natural Resources Conservation Service). 2007. Technical Supplement 14N: Fish Passage and Screening Design. National Engineering Handbook. USDA: NRCS. August 2007.*
- *Odeh, M. 2003. Discharge Rating Equation and Hydraulic Characteristics of Standard Denil Fishways. Journal of Hydraulic Engineering, 129(5), 341-348.*
- *Slatick, E. 1975. Laboratory Evaluation of a Denil-Type Steeppass Fishway with Various Entrance and Exit Conditions for Passage of Adult Salmonids and American Shad. Marine Fisheries Review, 37.*
- *USFWS (U.S. Fish and Wildlife Service). 2017. Fish Passage Engineering Design Criteria. USFWS, Northeast Region R5, Hadley, MA.*

Design Criteria

The NMFS (2011) criteria for a Denil fishway are summarized below:

NMFS Guidelines	Value		Comments
Debris Characterization	-		Must be low/no debris accumulation, NMFS 4.10.2.1
Maximum Slope	20%		NMFS 4.10.2.1
Maximum Avg. Chute Velocity	5	ft/s	NMFS 4.10.2.1
Max Horiz. Distance b/w Rest Pools	25	ft	NMFS 4.10.2.1
Minimum Flow Depth	2	ft	NMFS 4.10.2.1

Standard Denil baffle sizes used by the USFWS Region 5 (Northeast; 2017) were used for reference:



STANDARD DENIL GEOMETRY *

W **	A	B	C	D	S ***
4' - 0"	4' - 3"	2' - 4"	2' - 0"	1' - 0"	2' - 6"
3' - 6"	3' - 9"	2' - 0"	1' - 9"	10½"	2' - 4"
3' - 0"	3' - 3"	1' - 9"	1' - 6"	9"	2' - 0"
2' - 6"	2' - 9"	1' - 5½"	1' - 3"	7½"	1' - 8"
2' - 0"	2' - 3"	1' - 2"	1' - 0"	6"	1' - 4"

* U.S. Fish and Wildlife Service criteria
** Denil channel width denoted by W; typically inside width of concrete channel
*** Horizontal (longitudinal) spacing of baffles in channel denoted by S

No standard design guidance or requirements were found from CDFW, or USFWS Region 8.

Method

A rating curve will be calculated to determine appropriate geometries of a Denil fishway, according to the equations of Odeh (2003):

$$Q = (1.34 - 1.84S_0)h_u^{1.75}B^{1.75}\sqrt{gS_0}$$

$$h_u = H - D\sin(45° + \tan^{-1}(S_0))$$

where:

$Q =$ Design discharge, cfs
$S_0 =$ Bed slope, ft/ft
$h_u =$ Depth above V-notch, ft
$B =$ Width through baffle, ft
$g =$ Gravitational constant, 32.2 ft/s^2
$H =$ Depth above invert, ft
$D =$ Height of V-notch above invert, ft

This rating curve can then be converted to an average velocity basis (for comparison with NMFS criterion), by dividing the flow rate by the flow area:

$$V_{avg} = \frac{Q}{WH}$$

where:

$W =$ Chute width, ft
<all other values as previously defined>

This was calculated on the gross chute area because it is called an "average chute design velocity" in the NMFS (2011) criteria. As flows pass down the chute, the angled baffles will result in variable flow areas along the entire length.

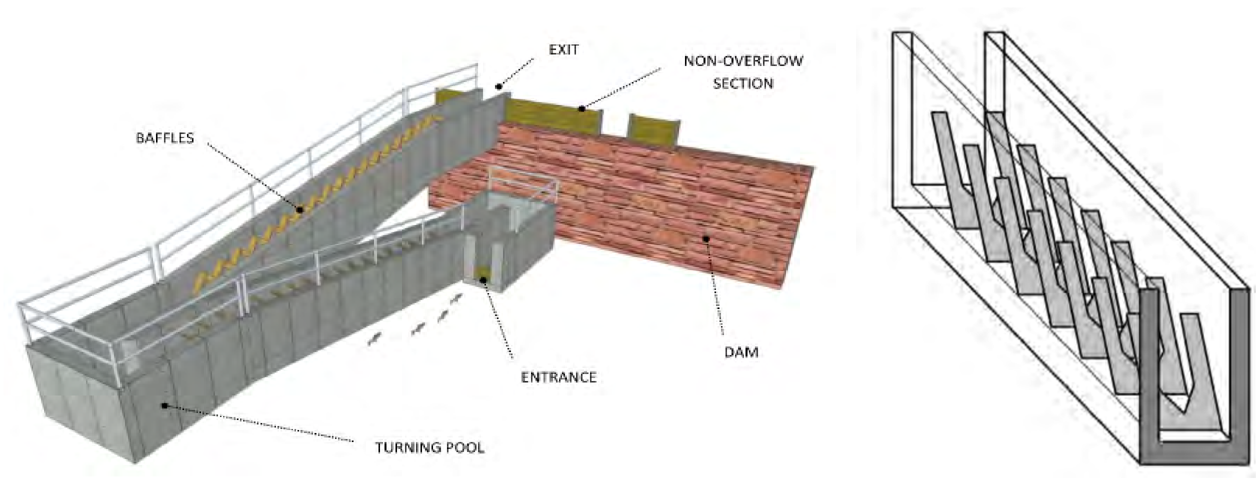


Figure 1. Denil Fishway Schematics (Left Source: USFWS, 2017; Right Source: NRCS, 2007)

Inputs

The following inputs were used for calculation of the Denil fishway rating curve:

Hydraulic Parameters	Value		Comments
Design Discharge	10	cfs	Typical for operation of the fish ladder
Tailwater Parameters	**Value**		**Comments**
High Tailwater	2484.77	ft msl	from Tailwater calculations
Typical Tailwater	2484.24	ft msl	from Tailwater calculations
Low Tailwater	2484.12	ft msl	from Tailwater calculations
Streambed Elevation	2483.00	ft msl	from Tailwater calculations
Upper Pool Parameters	**Value**		**Comments**
Denil Crest Elevation	2486.50	ft msl	Based on desired water surface
Fishway Parameters (User Inputs)	**Value**		**Comments**
Fishway Width, W	2.5	ft	Sized for for flow using standard Denil sizes
Baffle Inner Width, B	1.4583	ft	Standard, W = 2.5
Baffle V-Notch Bottom Height, D	0.625	ft	Standard, W = 2.5
Baffle Spacing, S	1.67	ft	Standard, W = 2.5
Bed Slope, S_0	0.18	ft/ft	Determined to meet depth requirements
Baffle Angle, α	45	deg	Standard

Calculations

Rating Curves

	Total Depth, H	Depth Over Baffle, h_u	Discharge, Q	Avg Velocity, V
	ft	ft	cfs	ft/s
	0.625	0.11	0.10	0.06
	0.88	0.36	0.79	0.36
	1.13	0.61	1.99	0.71
	1.38	0.86	3.62	1.05
	1.63	1.11	5.66	1.39
	1.88	1.36	8.07	1.72
	2.13	1.61	10.84	2.04
	2.38	1.86	13.95	2.35
	2.63	2.11	17.39	2.65
	2.88	2.36	21.15	2.94
	3.13	2.61	25.22	3.23
	3.38	2.86	29.59	3.51
DESIGN	2.05	1.54	10.00	1.95

Velocity	**1.95**	**< 5 ft/s**
Depth	**2.05**	**> 2 ft**

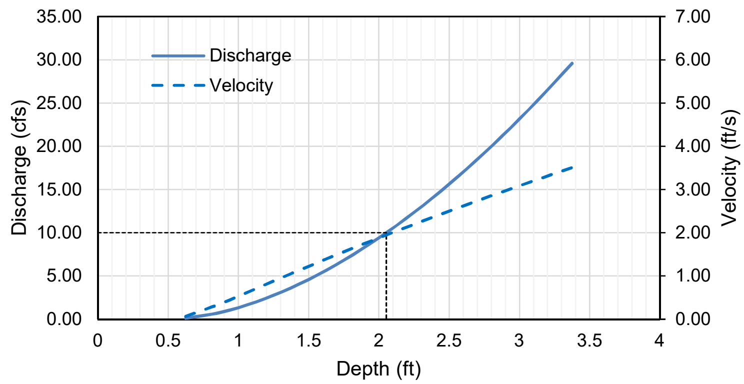


Figure 2. Denil Fishway Rating Curve

Fishway Length

Denil Crest El	2486.50	ft msl	
Denil Bottom El	2482.07	ft msl	[Low Tailwater less calculated flow depth]
Elevation Difference	4.43	ft	
Slope	0.180	ft/ft	
Required Length	**24.6**	**ft**	
Intermediate Rest Pools?	0	#	
Number of Baffles	15	#	

Conclusions

A Denil fishway is designed above for conveyance of Chinook and Coho to the trap. It is found that adequate hydraulics (per NMFS, 2011 criteria) can be provided for a bedslope of 0.20 ft/ft and with the baffle geometry summarized below in Figures 3 and 4. Given the steepness of the structure and the small vertical distance that needs to be traversed, the Denil fishway could maintain a single run with no intermediate resting pools.

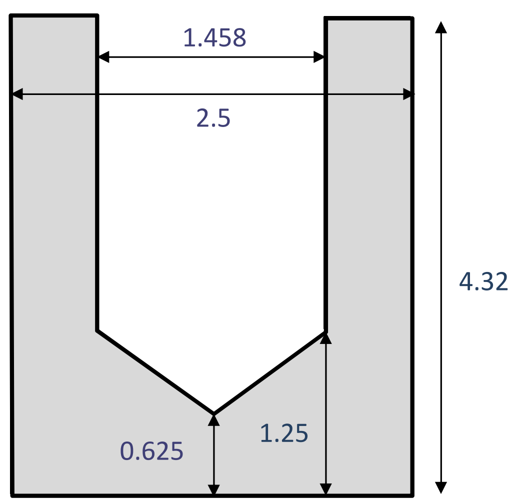


Figure 3. Baffle Geometry Summary

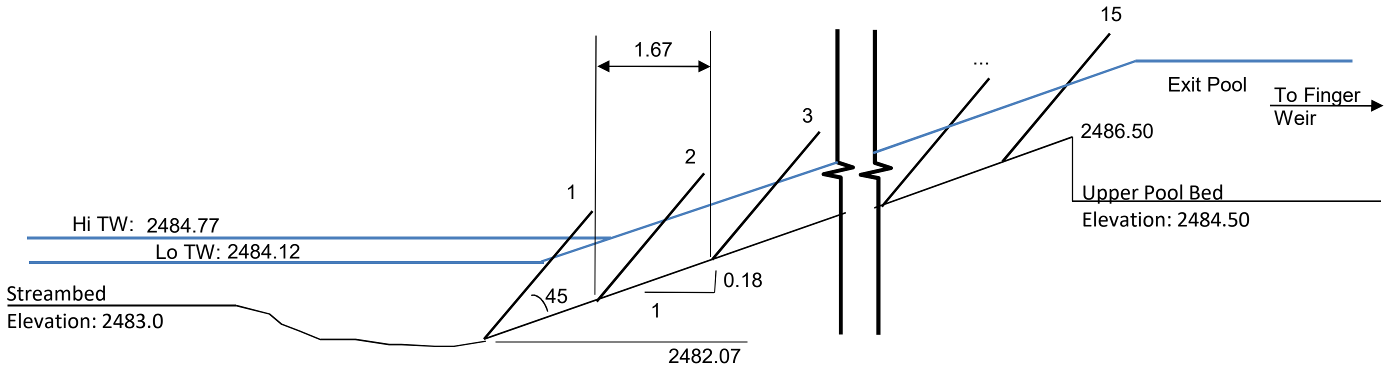


Figure 4: Denil Fishway Profile Summary

Purpose

The purpose of this calculation sheet is to size the length of the finger weir.

References

- *Bell, M. 1991. Fisheries handbook of engineering requirements and biological criteria. U.S. Dept. of the Army, Army Corps of Engineers, North Pacific Division, Fish Passage Development and Evaluation Program.*
- *Miller, E. 1968. Flow and Cavitation Characteristics of Control Valves. J Inst Water Eng. Vol 22, No. 7, pp 512-533. Oct 1968.*
- *Tullis, J. Paul. 1989. Hydraulics of Pipelines, Pumps, Valves, Cavitation, Transients. New York: John Wiley & Sons.*

Method

The finger weir will be mounted so as to adjust the height of the weir to provide 2 to 6 inches of flow depth over the fingers per the fisheries handbook (Bell, 1991).

Weir Flow

The flow over the weir will be calculated according to the equation:

$$Q = C_w C_v L H_w^{1.5}$$

where:
$Q =$ Design discharge, cfs
$C_w =$ Weir discharge coefficient
$C_v =$ Villemonte submerged weir coefficient
$L =$ Weir crest length, ft
$H_w =$ Weir head, ft

Discharge Coefficient

The discharge coefficient will be calculated according to the following equation:

$$C_w = C_c \frac{2}{3}\sqrt{2g}$$

where:
$C_c =$ Sharp crested weir coefficient, 0.62
$g =$ Gravitational constant, 32.2 ft/s^2

This is modified for the rounded crest of the finger weir, by applying a factor from Miller (1968) for rounded edge orifices:

$$K_s = \frac{1}{C_c^2}$$ [Tullis, 1989; Eq 4.7] for free discharge valves

$$K_r = K_s C_{rad}$$ [Miller, 1968]

$$C_{c,r} = \sqrt{\frac{1}{K_r}}$$

where:
$K_s =$ Sharp crest loss coefficient
$K_r =$ Rounded crest loss coefficient
$C_{rad} =$ Rounded edge coefficient
$C_{c,r} =$ Rounded crest weir coefficient

Submerged Weir Discharge Coefficient

The coefficient for submerged weir flow is calculated as follows:

$$C_v = \left(1 - \left(\frac{H_d}{H_w}\right)^{3/2}\right)^{0.385}$$

where:
$H_d =$ Downstream head on weir, ft

Head Loss Through Fingers

The head on the weir is equal to the head upstream of the weir and fingers less the head losses through the finger slots:

$$H_w = H_u - h_L$$

where:
$H_w =$ Head at the weir, ft
$H_u =$ Head upstream of weir and fingers, ft
$h_L =$ Head loss through finger slots, ft

And the head loss through the finger slots can be calculated as:

$$h_L = K_f \frac{(PQ/A)^2}{2g}$$

where:
$K_f =$ Finger slot loss coefficient, ft
$P =$ Proportion of flow through the finger slots, %
(i.e. not the 2-6 inches over the top)
$A =$ Flow area through the finger slots, ft^2

And finally, the flow area through the finger slots can be calculated as:

$$A = LB \cos\theta$$

where:
$B =$ Chord length of fingers, ft
$\theta =$ Angle of finger chord to vertical, degree

Inputs

The following parameters were adopted for these calculations

Parameter	Units	Value	Description
Design discharge	cfs	**3.33**	Water right, divided equally to 3 ponds
(Max) +15%	cfs	2.8	
(Min) -15%	cfs	3.8	
Sharp Crested Weir Coeff, Cc		**0.62**	from Rouse
Rounded Edge Coeff, Crad		**0.72**	Miller, 1968; Assume orifice dia = 1.0', Rounded edge radius 1"
Finger Loss Coefficient, Kf		**0.67**	Miller, 1968; B.C. Cook 8/17/07 estimates
Proportion of Flow thru Fingers, P		**87.5%**	Assumed
Chord Length of Fingers, B	ft	1.00	Assumed, to produce 2" - 6" over fingers
Finger Chord Angle to Vert, θ	deg	70	Assumed
Gravitational Constant, g	ft/s^2	32.2	
Upstream Head, Hu	ft	0.66	Assumed, 8"
Downstream Head, Hd	ft	0.0	

Calculations

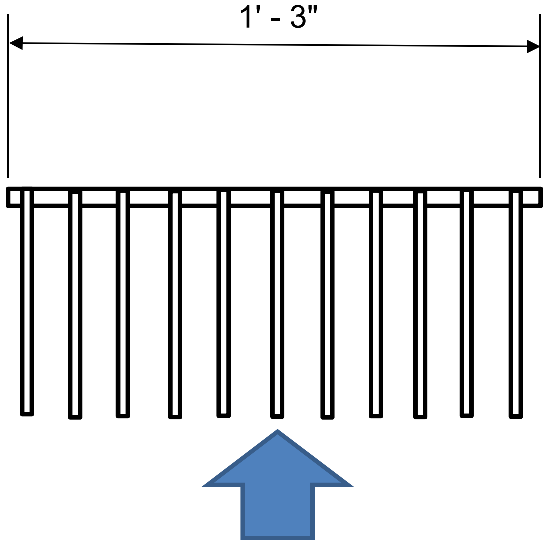
The required weir length was calculated iteratively according to the equations above. The following scenarios were run:

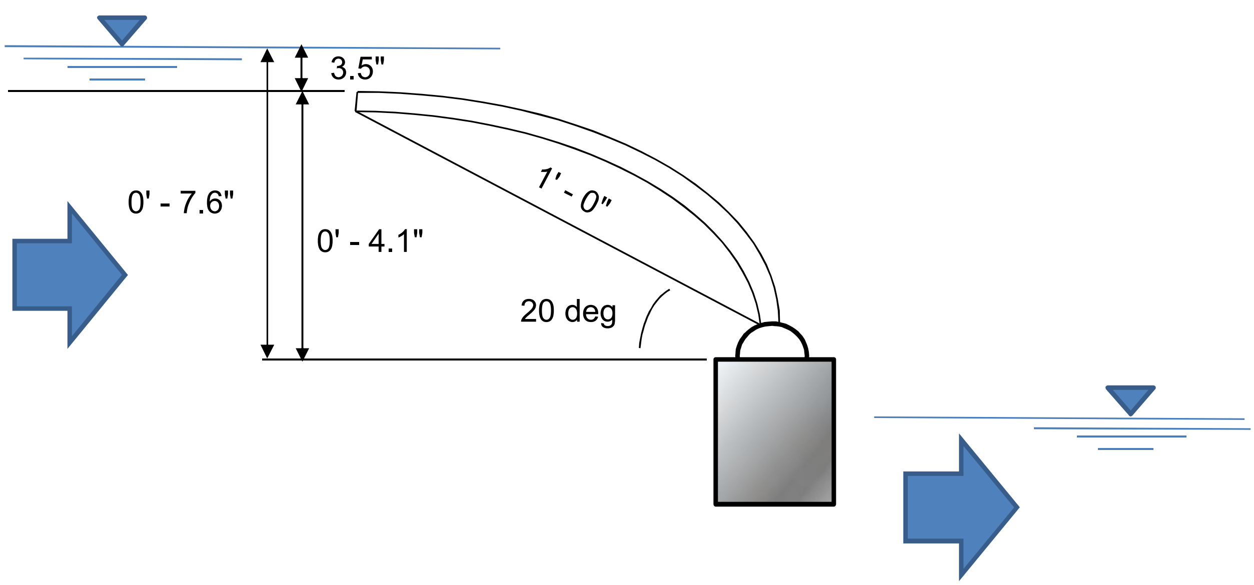
1. **Normal -** calculates the required weir length, based on the design upstream head.
2. **Rounded** - calculates the upstream head based on the weir length to a rounded value.
3. **Flow sensitivity (low) -** calculates the upstream head based on a low flow (-15%).
4. **Flow sensitivity (high) -** calculates the upstream head based on a high flow (+15%).
5. **Coefficient sensitivity (low) -** calculates the upstream head based on a low weir coefficient (-20%).
6. **Coefficient sensitivity (high) -** calculates the upstream head based on a high weir coefficient (+20%).

Scenario	Q cfs	L ft	H_u ft	$C_{c,r}$	C_w	A ft^2	h_L ft	H_w ft	Q_{calc} cfs	Depth above Fingers in
Normal	3.33	1.23	0.66	0.731	3.909	0.42	0.500	0.160	3.33	3.8
Rounded	3.33	1.25	0.63	0.731	3.909	0.43	0.483	0.147	3.33	3.5
Q - 15%	2.8	1.25	0.40	0.731	3.909	0.43	0.342	0.062	2.80	0.7
Q + 15%	3.8	1.25	0.91	0.731	3.909	0.43	0.629	0.284	3.80	6.9
Cw - 20%	3.33	1.25	0.93	0.731	3.127	0.43	0.483	0.448	3.33	7.1
Cw + 20%	3.33	1.25	0.54	0.731	4.691	0.43	0.483	0.059	3.33	2.4

Conclusions

The finger weir crest length and finger orientation were sized such that the recommended depth of 2-6 inches would be maintained above the fingers for the design flow. The orientation is summarized below:





These above orientation was subjected to sensitivity analysis on both the flow over the finger weir and the weir coefficient. It was found that for low flows, some nominal depth would be maintained over the fingers, however the fingers would remain submerged. This was deemed acceptable given that there will be control of the flow through the ponds via valves at the head of the ponds.

For high flows, it was found that the 6 inch recommendation was exceeded by less than one inch. This is not expected to result in any escapement, however, if this becomes a concern the flow to the pond may be adjusted. It is not expected that more than 3.3 cfs will report to this pond.

If the weir coefficient is found to be overestimating by 20%, the depth above the fingers are found to be 1.1 inches above the recommended range. This could be controlled via flow through the pond, as in the case above, or by allowing the fingers to rotate such that the desired depths above the fingers are attained.

Therefore, the finger weir orientation depicted above is expected to meet the design intent.

SUBJECT:	Klamath River Renewal Corporation	**BY:** A. Leman	**CHK'D BY:** N. Cox
	Fall Creek Hatchery	**DATE:** 6/1/2020	
	Settling Pond	**PROJECT NO.:** 20-024	

Purpose

The purpose of this calculation sheet is to check the size of the settling pond meets typical criteria for settling solids.

References

- *Idaho Department of Environmental Quality (Idaho DEQ), nd. Idaho Waste Management Guidelines for Aquaculture Operations. Published online: https://www.deq.idaho.gov/media/488801-aquaculture_guidelines.pdf, Accessed March 2020.*

- *Lindeburg, Michael R. 2014. Civil Engineering Reference Manual, Fourteenth Edition. Professional Publications, Inc. Belmont, CA.*

Method

This sheet will check that the overflow rate is less than the accepted values of settling velocity for aquaculture waste (Idaho DEQ, nd). The overflow rate is defined as:

$$V_o = \frac{Q}{A_s} < V_s$$

where:
$V_s =$ Settling velocity, ft/s
$V_o =$ Overflow velocity, ft/s
$A_s =$ Settling pond surface area, ft^2
$Q =$ Discharge, cfs

These calculations will also determine the weir elevation for setting the water surface through the settling pond according to the equation:

$$Q_w = C_D L \sqrt{2g} h^{3/2}$$

where:
$Q_w =$ Weir overflow, cfs
$C_D =$ Discharge coefficient
$L =$ Weir length, ft
$g =$ Gravitational constant, 32.2 ft/s^2
$h =$ Head over the weir, ft

Assumptions

The above formulation for settling is standard calculation for wastewater settling basins, and is based on a plug flow assumption through the basin.

Inputs

General Parameters	Value		Comments
Gravitational Constant	32.2	ft/s^2	
Settling Velocity	0.00151	ft/s	Idaho DEQ, nd; minimum

Hydraulic Parameters	Value		Comments
Design Discharge, Q	200	gpm	
Weir Discharge Coefficient	3.33		Typical

Settling Pond Parameters	Value		Comments
Pond Width	12.5	ft	Client supplied CAD linework
Pond Bay Length	31.8	ft	2 bays
Pond Bottom Elevation	2486.5	ft	X-Section Survey
Pond Depth	3.5	ft	Idaho DEQ, nd; recommended for monthly cleanout
Weir Length	5.0	ft	

Calculations

Settling Velocity

Discharge, Q cfs	Settling Pond Area, A_s ft^2	Settling Velocity, V_s ft/s	Overflow Velocity, V_o ft/s	Ratio V_s/V_o
0.45	396.875	0.00151	0.00112	1.34

Overflow Weir

Discharge, Q cfs	Weir Length, L ft	Discharge Coefficient, C_D	Weir Head, h ft	Weir Crest Elevation ft
0.45	5.00	3.33	0.09	2489.91

Conclusions

It was found that the pond in the existing lower battery of raceways provides sufficient area per Idaho DEQ standards for aquaculture solid waste management when divided into 2 bays. The two bays will allow for drying of one of the bays, while keeping the waste drain system online.

Appendix B
Civil Design Calculations

Calculation Cover Sheet

McMILLEN JACOBS ASSOCIATES

Project: Fall Creek Hatchery

Client: Klamath River Renewal Corporation **Proj. No.** 20-024

Title: Civil Calculations - 50% Design

Prepared By, Name: Andrew Leman

Prepared By, Signature: **Date:** 6/1/2020

Peer Reviewed By, Name: Jodi Burns, P.E.; Vincent Autier, P.E.

Peer Reviewed, Signature: Jodi L Burns **Date:** 6/1/2020

Date: 6/1/2020

SUBJECT:	Klamath River Renewal Corporation	**BY:** A. Leman	**CHK'D BY:** J. Burns/V. Autier
	Fall Creek Hatchery	**DATE:** 6/1/2020	
	Civil Calculations - 50% Design	**PROJECT NO.:** 20-024	

Table of Content

Civil **Page**

SUBJECT: Klamath River Renewal Corporation | BY: A. Leman | CHK'D BY: J. Burns/V. Autier
Fall Creek Hatchery | DATE: 6/1/2020
Vehicle Tracking | PROJECT NO.: 20-024

Purpose

The purpose of this calculation sheet is to document the design vehicles for the site and determine the swept path for facility layout.

References

- *Transoft Solutions. 2020. Autoturn Online [software]. Online at https://www.autoturnonline.com, Accessed February 2020.*
- *U.S. Fish and Wildlife Service (USFWS). 2013. Great Lakes Mass Marking Program. Published online at https://www.fws.gov/midwest/greenbayfisheries/documents/Mass-Marking2013.pdf, Accessed February 2020.*

Method

The swept path analysis was performed using AutoTurn online software and the site layout. The site layout was developed iteratively with the swept path analysis. Where possible (or not otherwise constrained) the site sought to maintain a 2.0 ft (min.) buffer on the swept path to any structures, ponds, buildings, etc.

Inputs

Design Vehicles

Marking/Tagging Trailer

The marking and tagging trailer was the largest of the design vehicles for the site, and needed access and egress from both the Coho rearing ponds and the Chinook rearing ponds. The design vehicle used for the swept path analysis was a 43.0-ft long Newmar X-Aire 2009, on a 21.85-ft long design truck. This selection was based on typical marking trailers used by the U.S. Fish and Wildlife Service (see Figures 1 and 2).

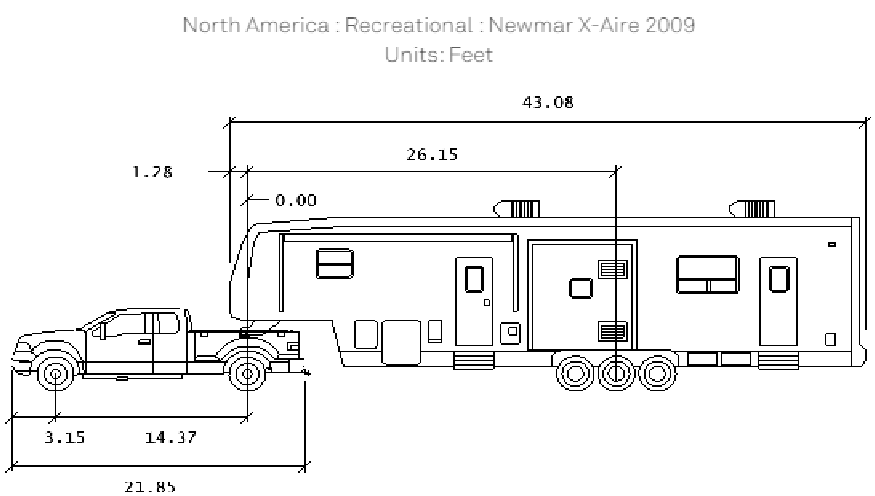


Figure 1. Design Marking/Tagging Trailer (Transoft Solutions, 2020)

Figure 2. U.S. Fish and Wildlife Tagging and Marking Trailer (USFWS, 2013)

Standard Pickup Truck

A standard pickup truck was treated as the design vehicle for typical use at the site, and therefore would be required to access every portion of the site. A 2019 Ford F-450 Crew Cab was used for the design truck.

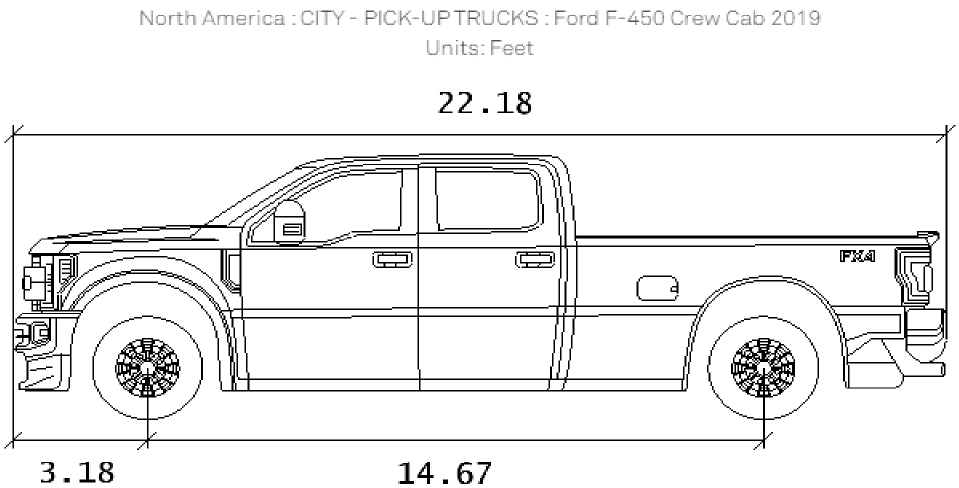


Figure 3. Ford F-450 Dimensions (Transoft Solutions, 2020)

Pump Truck

A pump truck will be required to access the settling pond for removal of accumulated waste. No pump truck was available in the AutoTurn online vehicle library, so a truck of comparable size, number of axles, configuration, etc. was used.

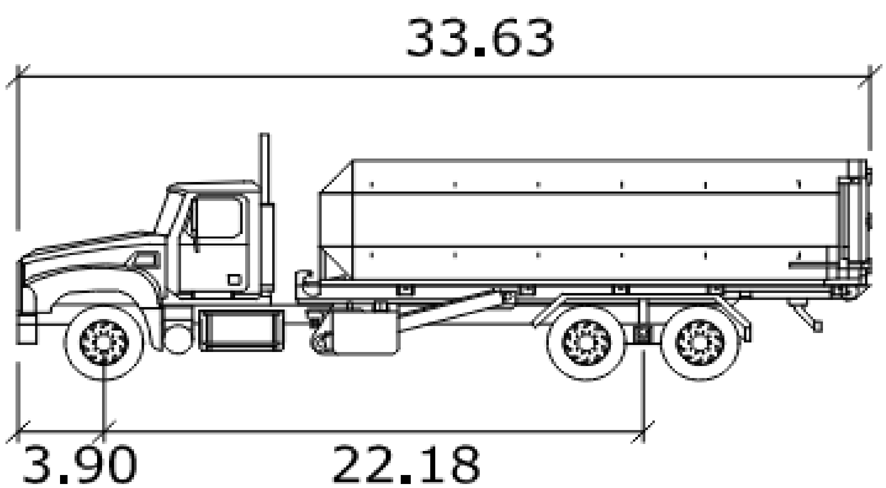


Figure 4. Pump Truck (Similar) Dimensions (Transoft Solutions, 2020)

Site Layout

The site layout that was utilized represents the site layout as defined in the current design phase.

Results

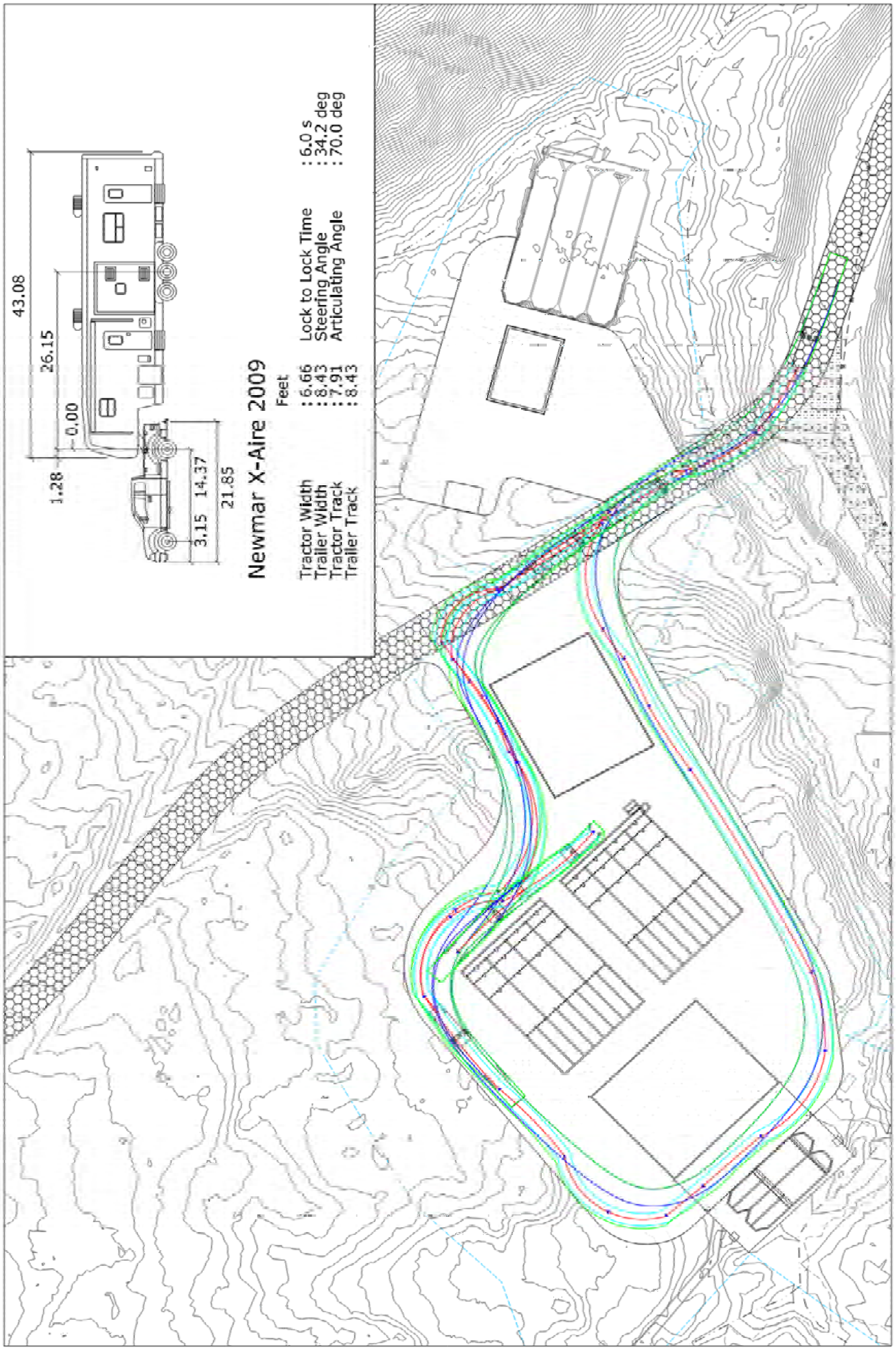


Figure 5. Marking/Tagging Trailer Swept Path

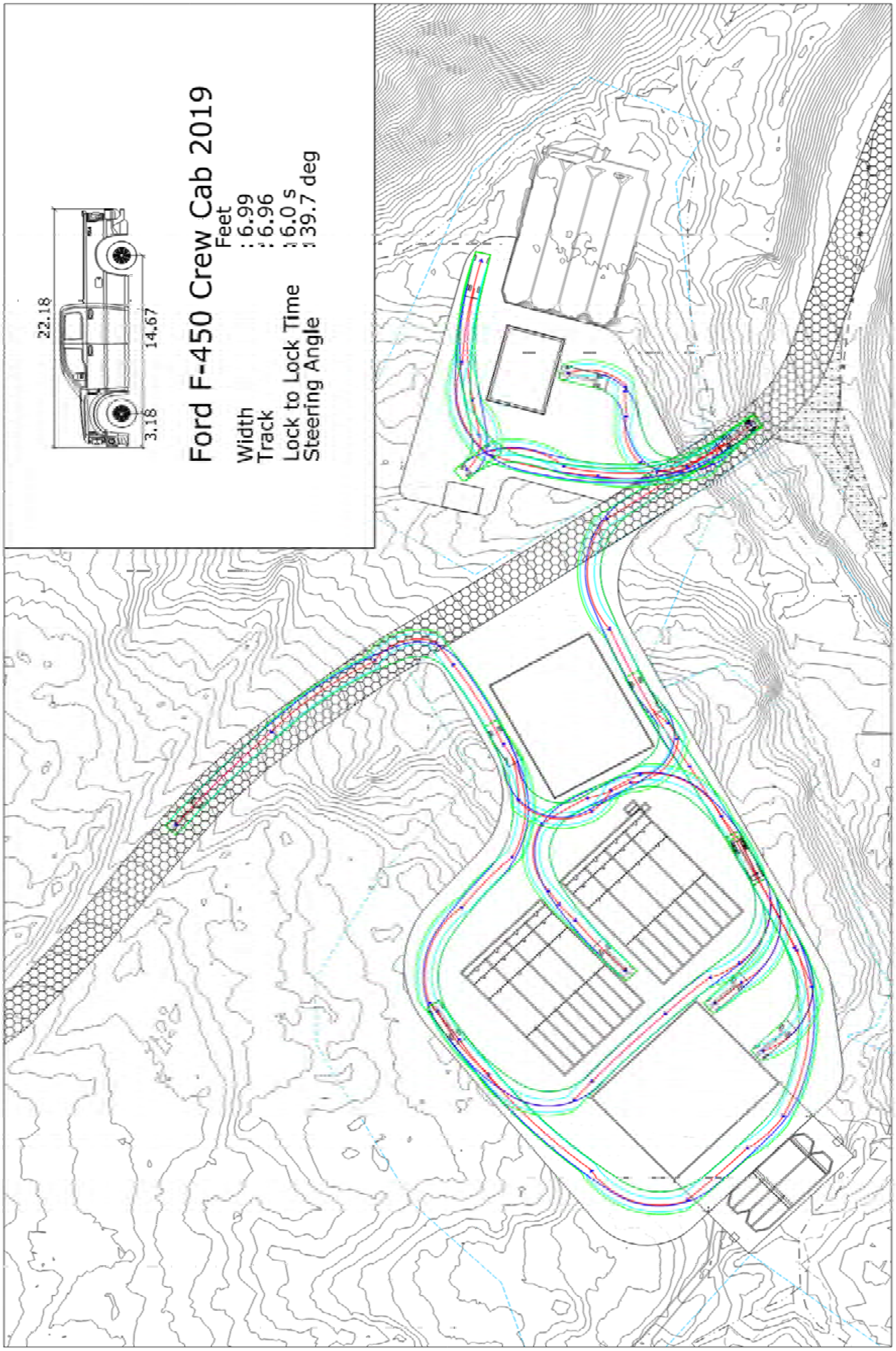


Figure 6. Design Pickup Truck Swept Paths

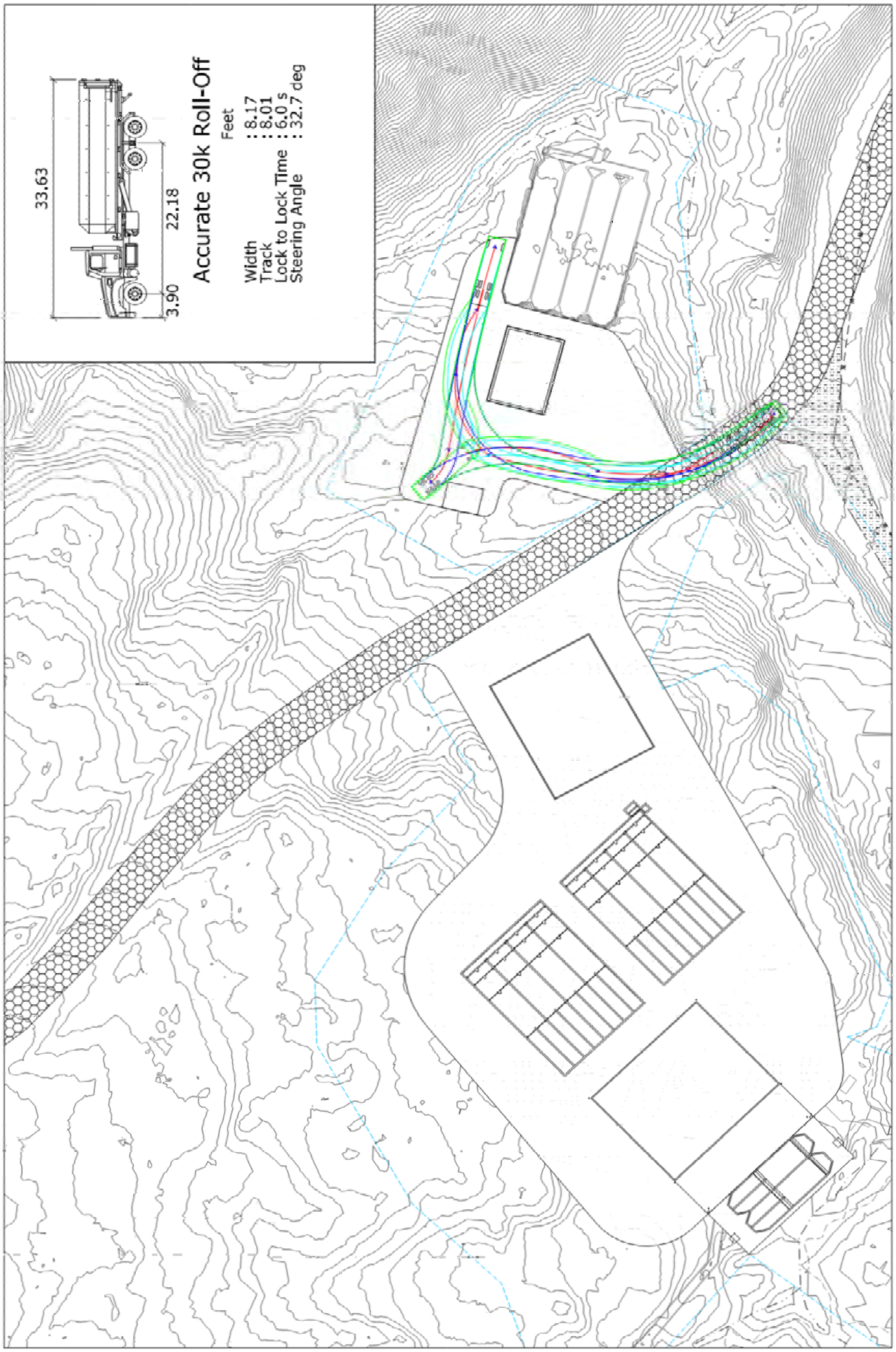


Figure 7. Design Pump Truck Swept Path

Conclusion

A swept path analysis has been run to ensure site access and egress is maintained on this relatively constrained site. Three (3) design vehicles were used for the swept path analysis: (1) a tagging and marking trailer that will need access and egress to the Coho and Chinook rearing ponds, (2) a design pickup truck that will need access to the majority of the site, (3) and a pump truck (similar) that will need to access the settling ponds. It was found that the preliminary site layout maintained sufficient space that all of the design vehicle requirements could be met, however, in some cases with relatively small margin. This is due to the constrained nature of the site, and was primarily a problem for the less frequently used tagging and marking trailer. Therefore, the current layout is deemed sufficient given the short design life of the facility.

SUBJECT: Klamath River Renewal Corporation
Fall Creek Hatchery
Earthworks

BY: A. Leman **CHK'D BY:** J. Burns/V. Autier
DATE: 6/1/2020
PROJECT NO.: 20-024

Purpose

The purpose of this calculation sheet is to document the earthworks for the current pad layout.

References

- *Autodesk. 2018. AutoCAD Civil 3D 2018 [software]. Autodesk, Inc. San Rafael, CA.*

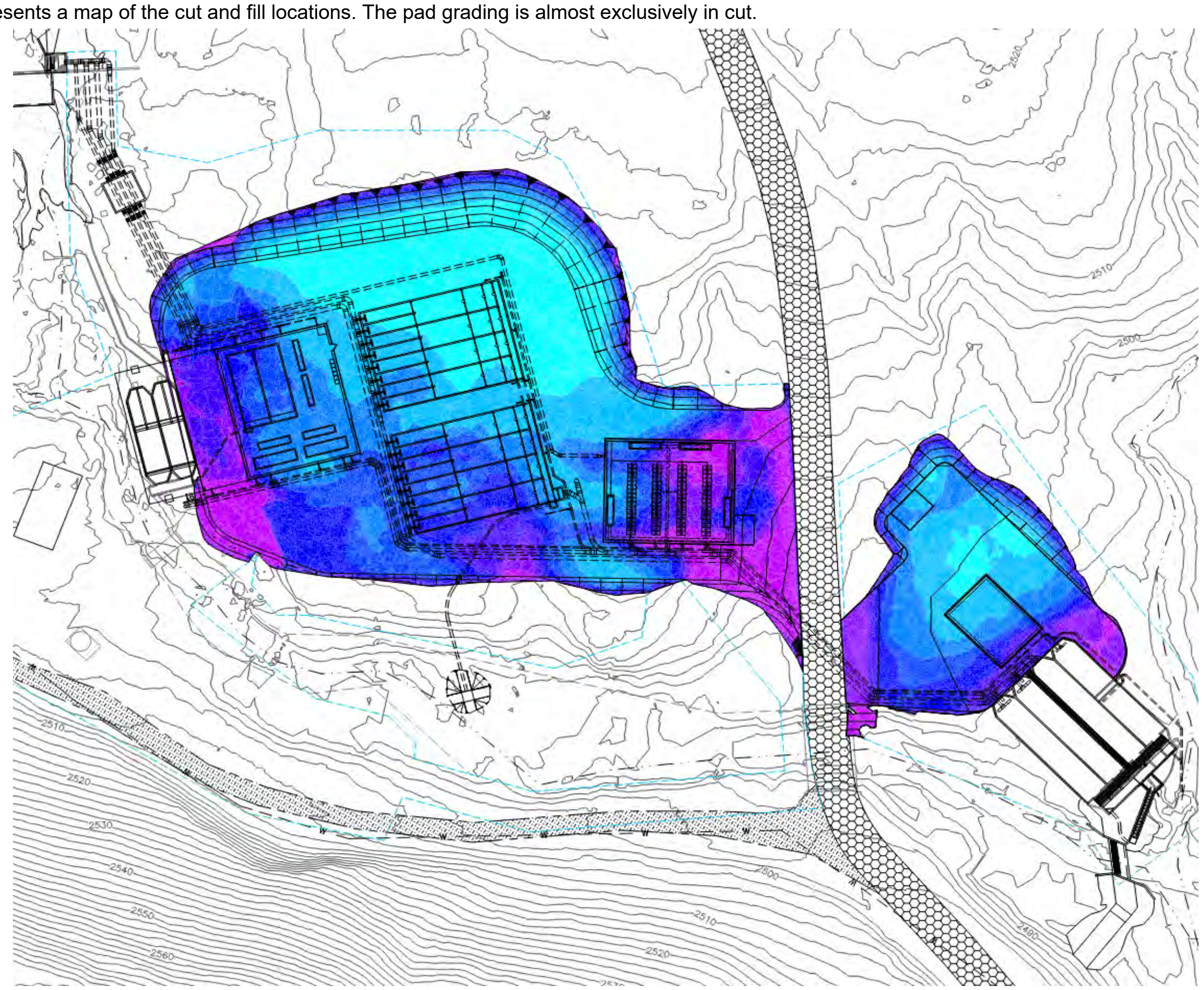
- *CDM Smith. 2019. Klamath River Renewal Project Geotechnical Data Report. Prepared for Klamath River Renewal Corp.*

Information - Input

Pad grading for earthwork volumes was based on the layout of the facility as represented in the current design phase. Pad grading was compared against a composite existing ground triangular irregular network (TIN) consisting of the following in order of precedence (greatest precedence to least):

- *Site structure and ground shot survey*
- *River transect survey*
- *LiDAR and Sonar prepared by GMA Hydrology, Inc. (2018)*

Figure 1 presents a map of the cut and fill locations. The pad grading is almost exclusively in cut.



MIN		MAX	
-13.667	to	-6.452	ft
-6.452	to	-4.449	ft
-4.449	to	-2.884	ft
-2.884	to	-1.79	ft
-1.790	to	-0.85	ft
-0.850	to	-0.15	ft
-0.150	to	0.408	ft
0.408	to	6.215	ft

Figure 1. Cut-Fill Map of North and South Pad Grading

Geotechnical data available for the preliminary analysis consists of two borings located near the Copco Road bridge (CDM Smith, 2019):

Figure 2. Boring Locations (Source; CDM Smith, 2019)

Boring data was derived from the same source:

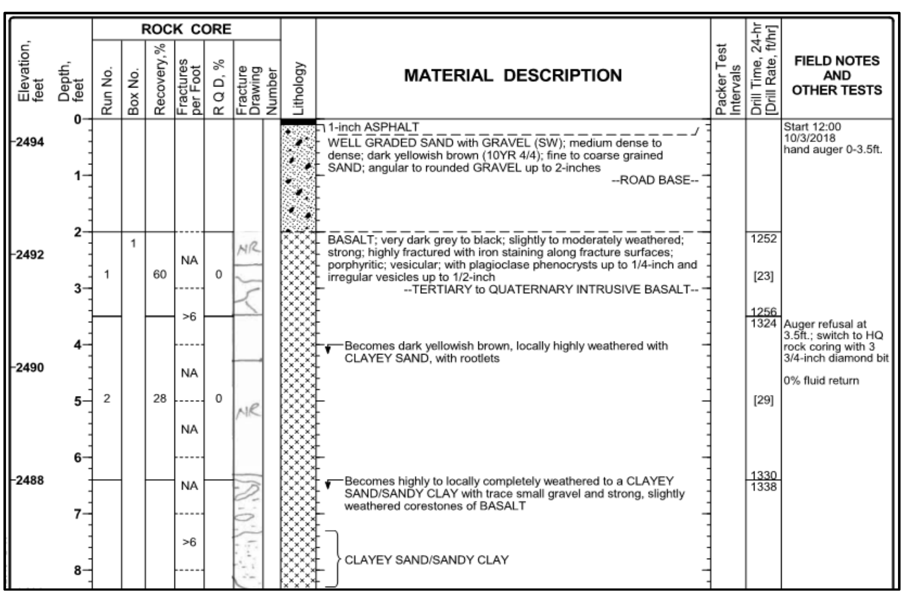


Figure 3. Boring B-13 Log (Source; CDM Smith, 2019)

The boring reached hand auger refusal at approximate elevation 2491 ft (NAVD 88). Both pads were kept above this elevation, however further geotechnical information may be required to determine whether there will be significant rock excavation associated with the current arrangement.

Calculation

Cut and fill volumes were determined using AutoCAD Civil 3D 2018 (Autodesk, 2018). All volumes are reported **in bank condition**. The following table summarizes the cut and fill volumes associated with the preliminary design.

Location	Description	Cut (yd^3)	Fill (yd^3)	Net (yd^3)
North Pad	Pad Grading North of Copco Road	7,125	250	6,875
South Pad	Pad Grading South of Copco Road	1,323	16	1,307

Conclusion

Cut and fill quantities were determined for the pad grading at the Fall Creek Fish Hatchery. Quantities were determined from AutoCAD Civil 3D 2018 and were based on a composite existing ground surface consisting of ground survey, LiDAR, and Sonar. It was found that a total net excavation of approximately 8,000 cubic yards (bank) is required for the current pad configuration. Limited geotechnical boring information suggests that bedrock is below the pads, however the bedrock elevation could fluctuate significantly across the site, and further geotechnical information would support decisions and cost estimating related to rock excavation.

McMILLEN JACOBS ASSOCIATES

SUBJECT:	Klamath River Renewal Corporation	BY:	ASL	CHK'D BY:	J. Burns/V. Autier
	Fall Creek Hatchery	DATE:	6/1/2020		
	Pipe Crushing	PROJECT NO.:	20-024		

Purpose

The purpose of this calculation sheet is to determine whether sufficient cover is maintained on the buried pipelines for HS20 traffic loads.

References

• PPI (Plastics Pipe Institute), 2019. *Handbook of PE Pipe, 2nd Edition* . Published online at https://plasticpipe.org/publications/pe-handbook.html. Accessed Sept. 2019.

• American Lifelines Alliance. 2001. *Guidelines for the Design of Buried Steel Pipe.* American Society of Civil Engineers (ASCE) and Federal Emergency Management Agency (FEMA).

• Spangler, M.G. 1941. The Structural Design of Flexible Pipe Culverts, Bulletin 153, Iowa Engineering Experiment Station, Ames, IA.

Information - Input

The following parameters were used in the development of the pipe crushing calculations.

General Parameters	Value	Units	Comments
Backfill Dry Unit Weight	140	lb/ft^3	Conservative
Unit Weight of Water	62.4	lb/ft^3	Standard, T = 50 F
Bedding Factor, K_{bed}	0.1		Typical
Deflection Lag Factor, L_{DL}	1.25		Typically, 1.0-1.5 (Spangler, 1941)
Modulus of Soil Rxn, E'	1000	psi	Assume Type SC @ 90% Compaction, see Tables below
Trench Width Ratio, B/D_o	2		Maintain one radius either side of pipe
Native Modulus of Soilo Reaction, E'_N	700	psi	Assume soft cohesive, conservative
Soil Support Factor, F_s	0.85		See Tables below

PVC Pipe Parameters	Value	Units	Comments
PVC Modulus of Elasticity, E	280,000	psi	@ 73 F, reduced ~20% for long term
Pipe Nominal Diameter	24	in	Maximum pipe size used at site, limiting case
Pipe Pressure Rating	Sched 80		

HDPE Pipe Parameters	Value	Units	Comments
HDPE Modulus of Elasticity, E	60,000	psi	@73 F, for 24 hour sustained load, PE4710
Pipe Nominal Diameter	10	in	Case of interest, under Coho slab
Pipe Pressure Rating	Determined in analysis below		

Method

Calculations were performed according to the Handbook of PE Pipe, 2nd Edition, using data associated with PVC pipe. The Handbook of PE Pipe method follows Spangler's modified Iowa equation for pipe deflection, which is typical for PVC pipe as well as HDPE pipe.

Live Load
HS20 Soil Pressure Table (Table 3-4)

The live load was determined from Table 3-4 of the Plastic Pipe Institute (2019) Handbook of PE pipe. This is applicable to PVC pipe as well as PE pipe, and represents an unpaved or flexible pavement condition. The tabulated values do not include an impact factor, which will be applied in subsequent calculations based on the cover condition.

Unpaved or Flexible Pavement		
Depth of Cover	Soil Pressure	
ft	psf	psi
1.5	2000	13.9
2	1340	9.3
2.5	1000	6.9
3	710	4.9
3.5	660	4.6
4	600	4.2
6	310	2.2
8	200	1.4
10	140	1.0

Dead Load
Soil Prism (Eq 3-1)

Dead load was calculated according to a modification on the standard soil prism equation, to account for the water table above the pipe crown (American Lifelines Alliance, 2001). This is summarized below:

$$\sigma_{DL} = \gamma_d H \left(1 - \frac{1}{3}\frac{h_W}{H}\right) + \gamma_W H$$

where:

$\sigma_{DL} =$ Dead load pressure, psf
$\gamma_d =$ Dry weight of soil, lb/ft^3
$\gamma_w =$ Unit weight of water, lb/ft^3
$H =$ Cover over pipe crown, ft
$h_w =$ Height of water table above crown, ft

Pipe Deflection / Ovality
Modified Iowa Equation (Eq 3-10)

The pipe deflection/ovality was calculated according to the modified Iowa equation (PPI, 2019), following the work of Spangler (1941).

$$\frac{\Delta y}{D_M} = \frac{K_{bed}L_{DL}\sigma_{DL} + K_{bed}\sigma_{LL}}{\frac{2E}{3}\left(\frac{1}{D_o/_t - 1}\right)^3 + 0.061F_s E'}$$

where:

$\Delta y =$ Vertical deflection
$D_M =$ Mean pipe diameter
$D_o =$ Outside pipe diameter
$K_{bed} =$ Bedding factor
$L_{DL} =$ Lag deflection factor
$E =$ Pipe modulus of elasticity, psi
$t =$ Pipe wall thickness, in
$F_s =$ Soil Support Factor
$E' =$ Modulus of Soil Reaction, psi
<other values as previously defined>

Tables for selecting soil values are summarized below:

Modulus of Soil Reaction					
Type of Soil	Depth of Cover ft	Modulus of Soil Reaction, E'			
		<85%	90%	95%	100%
Fine-grained soils with < 25% sand	0	500	700	1000	1500
	5	600	1000	1400	2000
	10	700	1200	1600	2300
	15	800	1300	1800	2600
Coarse-grained soils with fines (SM,	0	600	1000	1200	1900
	5	900	1400	1800	2700
	10	1000	1500	2100	3200
	15	1100	1600	2400	3700
Coarse-grained soils with little or no	0	700	1000	1600	2500
	5	1000	1500	2200	3300
	10	1050	1600	2400	3600
	15	1100	1700	2500	3800

Native Soil Modulus of Soil Reaction				
Granular		Cohesive		E'_N (psi)
Std. Penetration ASTM D1586	Description	Unconf. Compress. Strength (tsf)	Description	
>0 -1	v. v. loose	>0 - 0.125	v. v. soft	50
1-2	very loose	0.125 - 0.25	very soft	200
2-4	very loose	0.25 - 0.50	soft	700
4-8	loose	0.50 - 1.00	medium	1,500
8-15	slight.comp.	1.00 - 2.00	stiff	3,000
15-30	compact	2.00 - 4.00	very stiff	5,000
30-50	dense	4.00 - 6.00	hard	10,000
> 50	very dense	> 6.00	very hard	20,000
Rock	-	-	-	50,000

E'$_N$/E'	Soil Support Factor Ratio of Trench Width to Pipe Outer Diameter, 1.5	2.0	2.5	3.0	4.0	5.0
0.1	0.15	0.30	0.60	0.80	0.90	1.00
0.2	0.30	0.45	0.70	0.85	0.92	1.00
0.4	0.50	0.60	0.80	0.90	0.95	1.00
0.6	0.70	0.80	0.90	0.95	1.00	1.00
0.8	0.85	0.90	0.95	0.98	1.00	1.00
1.0	1.00	1.00	1.00	1.00	1.00	1.00
1.5	1.30	1.15	1.10	1.05	1.00	1.00
2.0	1.50	1.30	1.15	1.10	1.05	1.00
3.0	1.75	1.45	1.30	1.20	1.08	1.00
5.0	2.00	1.60	1.40	1.25	1.10	1.00

Safe Deflection Limits - Pressure Pipe DR	%
7.3	3.00%
9.0	4.00%
13.5	6.00%
17.0	6.00%
21.0	7.50%
26.0	7.50%
32.5	7.50%

Pipe Wall Buckling
Luscher Equation (Eq 3-15)

The pipe wall buckling contraint is calculated according to Luscher's equation for constrained pipe wall buckling:

$$\sigma_{b,allow} = \left(\frac{1}{SF}\right)\sqrt{\frac{32RB'E'E}{12\left(D_0/_t - 1\right)^3}}$$

$$B' = \frac{1}{1 + 4e^{-0.065H}}$$

$$R = \left(1 - \frac{1}{3}\frac{h_W}{H}\right)$$

where:
$\sigma_{b,allow}$ = Allowable constrained buckling pressure, psi
SF = Safety Factor, >2 recommended
R = Buoyancy Reduction Factor
B' = Soil Support Factor
<other values as previously defined>

Calculations

The following calculations demonstrate that at 2.0' of cover above the crown of the pipe, the pipes are adequately protected against ovality and pipe wall buckling for HS20 traffic loads.

PIPE Pipe Material	Pressure Rating	Nominal Pipe Diameter in	Wall Thickness in	Pipe Outer Diameter in	Pipe Mean Diameter in	Pipe Inner Diameter in	Pipe Moment of Inertia in^4/in	Pipe Modulus of Elast., E psi
PVC	Sched 80	24	1.218	24	22.782	21.564	0.1506	280,000
HDPE	DR26.	10	0.413	10.75	10.337	9.924	0.0059	60,000

LOADS Pipe Material	Pressure Rating	Burial Depth (to Crown), H ft	Backfill Dry Unit Weight, γ_d lb/ft^3	Height of Water Table above Pipe Crown, h_w ft	Live Load Type	Impact Factor, F'	Dead Load Pressure, σ_{DL} psi	Live Load Pressure, σ_{LL} psi	Total Pressure, σ_T psi
PVC	Sched 80	2.0	140	0	HS20	1.35	1.94	12.56	14.51
HDPE	DR26.	2.0	140	0	HS20	1.35	1.94	12.56	14.51

Deflection Pipe Material	Pressure Rating	Bedding Factor, K_{bed}	Deflection Lag Factor, L_{DL}	Modulus of Soil Rxn, E' psi	Soil Support Factor, F_s	% Deflection, $\Delta y/D_m$	Acceptable Deflection %	Deflection OK?
PVC	Sched 80	0.1	1.25	1000	0.85	1.87%	7.01%	OK!
HDPE	DR26.	0.1	1.25	1000	0.85	2.76%	7.50%	OK!

Pipe Wall Buckling							
Pipe Material	Pressure Rating	Soil Support Factor, B'	Buoyancy Reduction Factor, R	Allowable Buckling Press, σ_b (FS = 2) psi	Actual Pressure	Calculated FS	Buckling OK?
PVC	Sched 80	0.22	1.00	79.5	14.51	11.0	OK!
HDPE	DR26.	0.22	1.00	23.8	14.51	3.3	OK!

Conclusion

Calculations demonstrate that a 24" nominal diameter Schedule 80 PVC pipe with 2.0' of cover above the crown of the pipe is well within the limits for acceptable ovality and pipe wall buckling. Similar preliminary calculations show that acceptable factors of safety are available for ring thrust and through-wall bending as well. Therefore, a minimum cover of 2.0' will be applied to all pipes across the site, as this is the limiting case. Where pipes are buried less than 1 diameter below finished grade in traffic rated areas, controlled low-strength material, or some alternative engineered solution will be used to protect the pipes against crushing.

Appendix C
Structural Design Calculations

Calculation Cover Sheet

Rev. 0

McMILLEN JACOBS ASSOCIATES

Project: Fall Creek Fish Hatchery

Client: KRRC **Proj. No.** 20-024

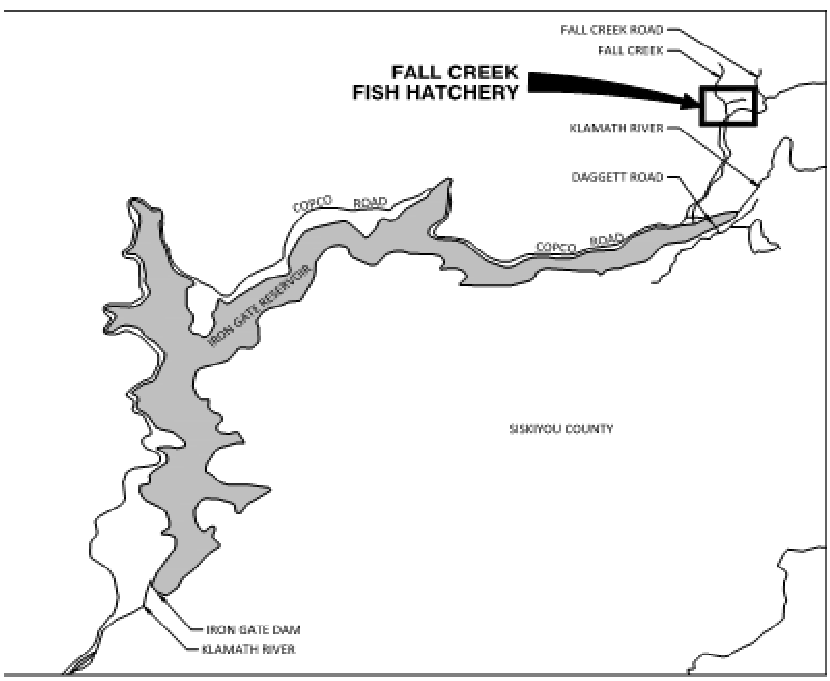
Title: Structural Calculations

Prepared By, Name: Zachary Autin

Prepared By, Signature: **Date:** 5/27/2020

Peer Reviewed By, Name: Taylor Bowen

Peer Reviewed, Signature: **Date:**



SUBJECT:	KRRC	**BY:** Zachary Auti	**CHK'D BY:** Taylor Bowen
	Fall Creek Fish Hatchery	**DATE:** 5/27/2020	
	Structural Calculations	**PROJECT NO.:** 20-024	

Purpose

Present general structural design information relevant to all calculations including:

- *References, Codes, and Standards*
- *General Information*
- *Load Combinations*
- *Design Basis*

References

- *ACI 318-14: Building Code Requirements for Structural Concrete*
- *ACI 350-06: Code Requirements for Environmental Engineering Concrete Structures*
- *AISC 341-16: Seismic Provisions for Structural Steel Buildings*
- *AISC 360-16: Specification for Structural Steel Buildings*
- *AISC Steel Construction Manual, 15th Edition*
- *AISC Steel Design Guide 27: Structural Stainless Steel*
- *AWS D1.1: Structural Steel Welding Code -- Steel*
- *ASCE 7-16: Minimum Design Loads and Associated Criteria for Buildings and Other Structures*
- *2019 California Building Code (CBC) as amended by Siskiyou County*
- *BEFS 2019: Nonresidential Compliance Manual for the 2019 Building Energy Efficiency Standards, Title 24, Part 6*
- *PCA PL279.01D: Portland Cement Association - Reinforcing Bar Specifications - 1911 through 1968*

General Information

Material Properties

Specific Weights

γ_w =	**62.4**	lb/ft^3	*Unit weight of Water*
γ_s =	**490**	lb/ft^3	*Unit weight of Steel*
γ_{SST} =	**500**	lb/ft^3	*Unit weight of Stainless Steel*
γ_c =	**150**	lb/ft^3	*Unit weight of Concrete*
γ_{native}=	**125**	lb/ft^3	*Unit weight of Native Soil*
γ_a =	**172.8**	lb/ft^3	*Unit weight of Aluminum*

Steel Properties

E_s =	**29000**	ksi	*Elastic Modulus*

Wide Flanges (W Shapes)

Grade:	**A992**		*High-Strength Low-Alloy Steel*
F_y =	**50**	ksi	*Yield Strength*
F_u =	**65**	ksi	*Tensile Strength*

Channels, Angles, Plates and Bars

Grade:	**A36**		*Carbon Steel*
F_y =	**36**	ksi	*Yield Strength*
F_u =	**58**	ksi	*Tensile Strength*

Rectangular HSS

Grade:	**A500 Gr. B**		*Carbon Steel*
F_y =	**46**	ksi	*Yield Strength*
F_u =	**58**	ksi	*Tensile Strength*

Round HSS

Grade:	**A500 Gr. B**		*Carbon Steel*
F_y =	**42**	ksi	*Yield Strength*
F_u =	**58**	ksi	*Tensile Strength*

Pipe

Grade:	**A53 Gr. B**		*Carbon Steel*
F_y =	**35**	ksi	*Yield Strength*
F_u =	**60**	ksi	*Tensile Strength*

Stainless Steel Properties

E_s =	28000	ksi	*Elastic Modulus*

Bars and Shapes

Grade:	A276		*316 Austenitic Stainless Steel*
F_y =	30	ksi	*Yield Strength*
F_u =	75	ksi	*Tensile Strength*

HSS

Grade:	A312		*316 Austenitic Stainless Steel*
F_y =	30	ksi	*Yield Strength*
F_u =	75	ksi	*Tensile Strength*

Plate

Grade:	A240		*316 Austenitic Stainless Steel*
F_y =	30	ksi	*Yield Strength*
F_u =	75	ksi	*Tensile Strength*

Aluminum Properties

E_a =	10100	ksi	*Elastic Modulus*

Sheet and Plate (B209)

Grade:	6061-T6		
Fty =	35	ksi	*Yield Strength*
Ftu =	42	ksi	*Tensile Strength*
Ftyw =	11	ksi	*Yield Strength*
Ftuw =	24	ksi	*Tensile Strength*
Fcy =	31.5	ksi	*Yield Strength*
Fsu =	25.2	ksi	*Tensile Strength*
Fsy =	21	ksi	*Yield Strength*
Fcyw =	11	ksi	*Yield Strength*
Fsuw =	14.4	ksi	*Tensile Strength*
Fsyw =	6.6	ksi	*Yield Strength*

New Concrete Properties

fc' =	4.5	ksi	*Compressive strength*
fy_bar =	60	ksi	*Yield Strength of steel reinforcement*
fu_bar =	90	ksi	*Ultimate strength of steel reinforcement*
Es =	29000	ksi	*Modulus of elasticity of steel reinforcement*

Existing Concrete Properties

fc' =	2.5	ksi	*Compressive strength*
fy_bar =	33	ksi	*Yield Strength of steel reinforcement*
fu_bar =	55	ksi	*Ultimate strength of steel reinforcement*
Es =	29000	ksi	*Modulus of elasticity of steel reinforcement*

	Structural	Intermediate	Hard	Cold-twisted
Yield min., psi (MPa)	33,000 (228)	40,000 (276)	50,000 (345)	55,000 (379)
Tensile, psi (MPa)	55,000 (379) to 70,000 (483)	70,000 (483) to 85,000 (586)	55,000 (379) min.	n/a

Soil Properties - Structural Fill

mu_CIP =	0.73		*Soil friction coefficient - cast in place*
mu_precast =	0.58		*Soil friction coefficient - precast*
Pa =	2000	psf	*Allowable Bearing Pressure*

Soil Properties - Native Soil

Es =	600	ksf	*Elastic modulus*
phi =	30	degrees	*Internal angle of friction*
	0.523598776	radians	
c =	200	psf	*Cohesion*
Ka =	0.29		*Active Pressure Coefficient*
Ko =	0.5		*At-rest Pressure Coefficient*
Ke =	0.35		*Seismic pressure coefficient*

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Load Cases

Dead Loads

Siskiyou County Building Department has the following requirements;

Design Information

The County's Minimum Elevation is 1,000 feet and the Maximum Elevation is 14,152 feet. The following design elements must be considered for all projects in Siskiyou County.

1. **Roof design loads for site above 5,000 feet elevation** - Must be obtained from the Building Division.
2. **Flat roof snow load below 5,000 feet elevations -** McCloud, Mt. Shasta, Dunsmuir, Weed and Happy Camp, 60 pounds per square foot. All Other areas, 40 pounds per square foot.
3. **Basic Wind Speed** - VASD 90 mph with VULT 115 mph: All areas, 20 pounds per square foot.
4. **Earthquake** - the Seismic Design Category is determined by the Design Professional.
5. **Soils Site Class** - Based on soils investigation
6. **Climate Zone 16** - for Energy compliance
7. **Frost Depth** - 12 inch minimum

Dead Loads

Equipment loading per Mechanical

Roof dead = 5.5 psf

Live Loads

Sidewalks, vehicular driveways, and yards subject to trucking

(ASCE 7-16 Table 4.3-1)
250 psf
8,000 lbs concentrated

Pedestrian

(ASCE 7-16 Table 4.3-1)
Corridors = 100 psf
Walkways and Elevated Platforms = 60 psf

Roof

(ASCE 7-16 Table 4.3-1)
Roof Live = 20 psf
Collateral = 3 psf

Hydrostatic Loads

Loads due to hydrostatic pressure increase linearly with depth (y).

Phs = γ_w*y

Earth Loads

Lateral earth pressures are calculated based on equivalent fluid earth pressure values given above. Earth pressures increase linearly with depth (y).

Ph = EFP*y

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Wind Loads

Governed by Siskiyou County requirements.

V =	**115**	mph
Iw =	**1**	
Surface Roughness =	**B**	
Gcpi =	**0.18**	psf
Gcpi =	**-0.18**	psf

ASCE

ASCE 7 Hazards Report

Address: No Address at This Location		**Standard:**	ASCE/SEI 7-16	**Elevation:**	2504.85 ft (NAVD 88)
		Risk Category:	II	**Latitude:**	41.984436
		Soil Class:	D - Default (see Section 11.4.3)	**Longitude:**	-122.362037

Wind

Results:

Wind Speed:	95 Vmph
10-year MRI	66 Vmph
25-year MRI	72 Vmph
50-year MRI	77 Vmph
100-year MRI	81 Vmph
Data Source:	ASCE/SEI 7-16, Fig. 26.5-1B and Figs. CC.2-1–CC.2-4
Date Accessed:	Mon Feb 24 2020

Value provided is 3-second gust wind speeds at 33 ft above ground for Exposure C Category, based on linear interpolation between contours. Wind speeds are interpolated in accordance with the 7-16 Standard. Wind speeds correspond to approximately a 7% probability of exceedance in 50 years (annual exceedance probability = 0.00143, MRI = 700 years).

Site is not in a hurricane-prone region as defined in ASCE/SEI 7-16 Section 26.2.

Mountainous terrain, gorges, ocean promontories, and special wind regions should be examined for unusual wind conditions.

Seismic Loads

Ss =	**0.584**	g
S1 =	**0.304**	g
Sms =	**0.778**	g
Sm1 =	**0.608**	
Sds =	**0.519**	g
Sd1 =	**0.405**	
Fa =	**1.333**	g
Fv =	**2**	
Tl =	**16**	
Ts =	**0.78**	
Ta =	**0.1**	
PGA =	**0.264**	g
PGAm =	**0.353**	g
Fpga =	**1.336**	g
Ie =	**1**	g
Cv =	**1.089**	g
SDC =	**D**	Tables 11.6-1 and 11.6-2
Steel Ordinary Moment Frames		Table 12.2-1
R =	**3.5**	
Omega-o =	**3**	
Cd =	**3**	Tables 11.6-1 and 11.6-2
Cs =	**0.15**	Ta<Ts -> Use Eqn. 12.8-2 per 11.8.4
Steel Ordinary Concentrically Braced Frame		Table 12.2-1
R =	**3.25**	
Omega-o =	**2**	
Cd =	**3.25**	Tables 11.6-1 and 11.6-2
Cs =	**0.16**	

Seismic

Site Soil Class: D - Default (see Section 11.4.3)

Results:

S_S :	0.584	S_{D1} :	N/A
S_1 :	0.304	T_L :	16
F_a :	1.333	PGA :	0.264
F_v :	N/A	PGA_M :	0.353
S_{MS} :	0.778	F_{PGA} :	1.336
S_{M1} :	N/A	I_e :	1
S_{DS} :	0.519	C_v :	1.089

Ground motion hazard analysis may be required. See ASCE/SEI 7-16 Section 11.4.8.

Data Accessed: Mon Feb 24 2020

Date Source: USGS Seismic Design Maps

Snow Loads

pf =	**40**	psf
Is =	**1**	
Ce =	**1**	Table 7.3-1
Ct =	**1**	Table 7-3.2
pg = pf/(.7*Ce*Ct*Is) =	**57.14**	psf

This is a prescribed "case-study" area per ASCE 7-16. Roof snow load was given by the coutny. This can be considered a "case-study" for purposes of design. Ground snow load was back-calculated assuming exposure and temperature coefficients of 1.0.

Snow

Results:

Elevation:	2504.8 ft
Data Source:	ASCE/SEI 7-16, Table 7.2-8
Date Accessed:	Mon Feb 24 2020

In "Case Study" areas, site-specific case studies are required to establish ground snow loads. Extreme local variations in ground snow loads in these areas preclude mapping at this scale.

Ground snow load determination for such sites shall be based on an extreme value statistical analysis of data available in the vicinity of the site using a value with a 2 percent annual probability of being exceeded (50-year mean recurrence interval).

Values provided are ground snow loads. In areas designated "case study required," extreme local variations in ground snow loads preclude mapping at this scale. Site-specific case studies are required to establish ground snow loads at elevations not covered.

Load Combinations

As described previously, the following load effects will be considered:

Label	Description
D	Dead
L	Live
W	Wind
E	Seismic
S	Snow
H	Earth
Hs	Hydrostatic

The following load combinations will be considered for all structures per the intent of ASCE 7-16

Combo	Type	γD	γL	γW	γE	γS	γH*	γHs	
1	Basic	1.4	-	-	-	-	1.6/0.9	1.4	
2	Basic	1.2	1.6	-	-	0.5	1.6/0.9	1.2	
3a	Basic	1.2	1	-	-	1.6	1.6/0.9	1.2	
3b	Basic	1.2	-	0.5	-	1.6	1.6/0.9	1.2	
4	Basic	1.2	1	1	-	0.5	1.6/0.9	1.2	
5	Basic	0.9	-	1	-	-	1.6/0.9	-	
6	Seismic	1.2	1	-	1	0.2	1.6/0.9	1.2	
7	Seismic	0.9	-	-	1	-	1.6/0.9	0.9	

Design Basis

Concrete

The required strength of reinforced concrete elements will be determined in accordance with ACI 318-14. Structural elements will satisfy Load Factor and Resistance Design methodology based on the equation below:

$$\sum \gamma_i L_{ni} \leq \varphi R_n$$

where:

γ_i = ASCE 7-16 load factors

L_{ni} = loads

Φ = resistance factor from ACI 318

R_n = nominal resistance from ACI 318

Steel

The required strength of structural steel elements will be determined in accordance with AISC 360-16. Structural elements will satisfy Load Factor and Resistance Design methodology based on the equation below:

$$U = \sum \gamma_i L_{ni} \leq \alpha \phi R_n$$

where:

U = required strength

γ_i = ASCE 7-16 load factors

L_{ni} = loads

α = 1.0 for non-hydraulic structures, 0.9 for hydraulic structures

Φ = resistance factor from AISC

R_n = nominal resistance from AISC

SUBJECT: KRRC
Fall Creek Fish Hatchery
Structural Calculations

BY: Zachary Autin CHK'D BY: Taylor Bowen
DATE: 5/27/2020
PROJECT NO.: 20-024

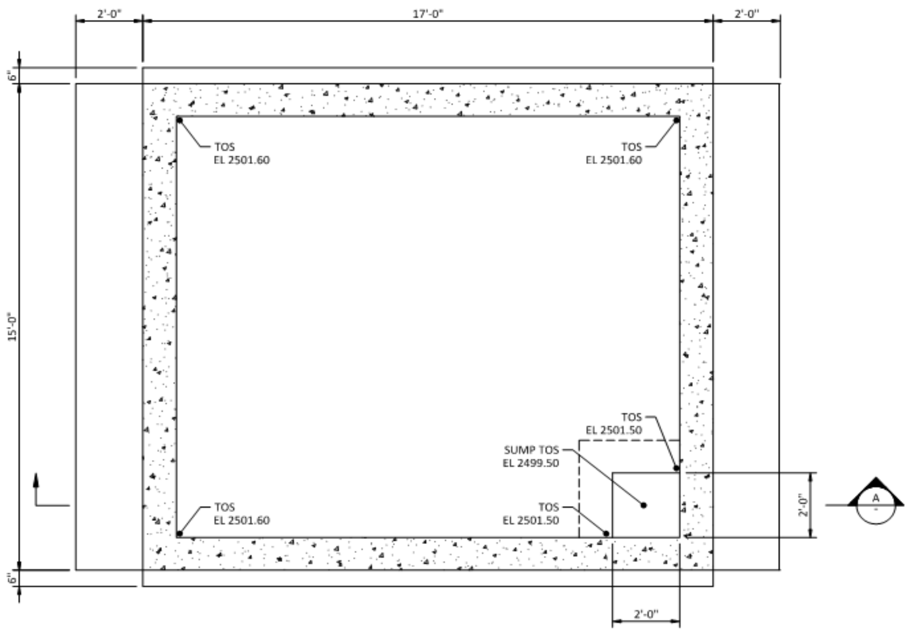
Purpose

Design of the CIP concrete meter vault.

Information

gamma_s =	125	pcf	Unit weight soil
gamma_w =	62.4	pcf	Unit weight water
gamma_c =	150	pcf	Unit weight concrete
fc'_ex =	2.50	ksi	Compressive strength
fy,bar_ex =	33.00	ksi	Yield Strength of steel reinforcement
fu,bar_ex =	55.00	ksi	Ultimate strength of steel reinforcement
Es =	29000.00	ksi	Modulus of elasticity of steel reinforcement
Ka =	0.29		Active Pressure Coefficient
Ko =	0.50		At-rest Pressure Coefficient
Ke =	0.35		Seismic pressure coefficient
t_slab =	8.00	in	Thickness of slab
LL_surcharge =	250.00	psf	Live load surcharge

Figures



Calculations: Buoyancy - Extreme

EL_top =	2508.00 ft	Elevation top of meter vault	
EL_tos =	2501.60 ft	Elevation top of slab	
EL_w =	2508.00 ft	Elevation of ground water	
t_slab =	2.50 ft	Thickness of slab	
EL_sump =	2499.60 ft	Elevation of top of sump slab	
t_walls =	1.00 ft	Thickness of walls	
B =	17.00 ft	Width	
L =	15.00 ft	Length	

Volumes

V_c =	1094.30 cf	Volume of concrete	
V_mv =	2389.50 cf	Volume of water displaced	
Fb =	149.10 kips	Buoyancy force	
Wc =	164.15 kips	Weight of concrete	
FOS =	1.10	Factor of Safety for Flotation	
CHECK	GOOD	Check if FOS >/= 1.3	USACE EM 1110-2-2100 Section 3-8

3-8. Factors of Safety for Flotation

A factor of safety is required for flotation to provide a suitable margin of safety between the loads that can cause instability and the weights of materials that resist flotation. The flotation factor of safety is defined by equation 3-2. The required factors of safety for *flotation* are presented in Table 3-4. These flotation safety factors apply to both *normal* and *critical* structures and for all site information categories.

$$FS_f = \frac{W_S + W_C + S}{U - W_G} \tag{3-2}$$

where

W_S = weight of the structure, including weights of the fixed equipment and soil above the top surface of the structure. The moist or saturated unit weight should be used for soil above the groundwater table and the submerged unit weight should be used for soil below the groundwater table.
W_C = weight of the water contained within the structure
S = surcharge loads
U = uplift forces acting on the base of the structure
W_G = weight of water above top surface of the structure.

Table 3-4 Required Factors of Safety for Flotation – All Structures

	Load Condition Categories		
Site Information Category	**Usual**	**Unusual**	**Extreme**
All Categories	1.3	1.2	1.1

Calculations: Buoyancy - Usual

EL_top =	2508.00 ft	Elevation top of meter vault	
EL_tos =	2501.60 ft	Elevation top of slab	
EL_w =	2504.50 ft	Elevation of ground water	
t_slab =	1.17 ft	Thickness of slab	
EL_sump =	2499.60 ft	Elevation of top of sump slab	
t_walls =	1.00 ft	Thickness of walls	
B =	17.00 ft	Width	
L =	15.00 ft	Length	

Volumes

V_c =	754.30 cf	Volume of concrete	
V_mv =	1157.00 cf	Volume of water displaced	
Fb =	72.20 kips	Buoyancy force	
Wc =	113.15 kips	Weight of concrete	
FOS =	1.57	Factor of Safety for Flotation	
CHECK	GOOD	Check if FOS >/= 1.3	USACE EM 1110-2-2100 Section 3-8

SUBJECT:	KRRC	**BY:** Zachary Autin	**CHK'D BY:**	Taylor Bowen
	Fall Creek Fish Hatchery	**DATE:** 5/27/2020		
	Structural Calculations	**PROJECT NO.:** 20-024		

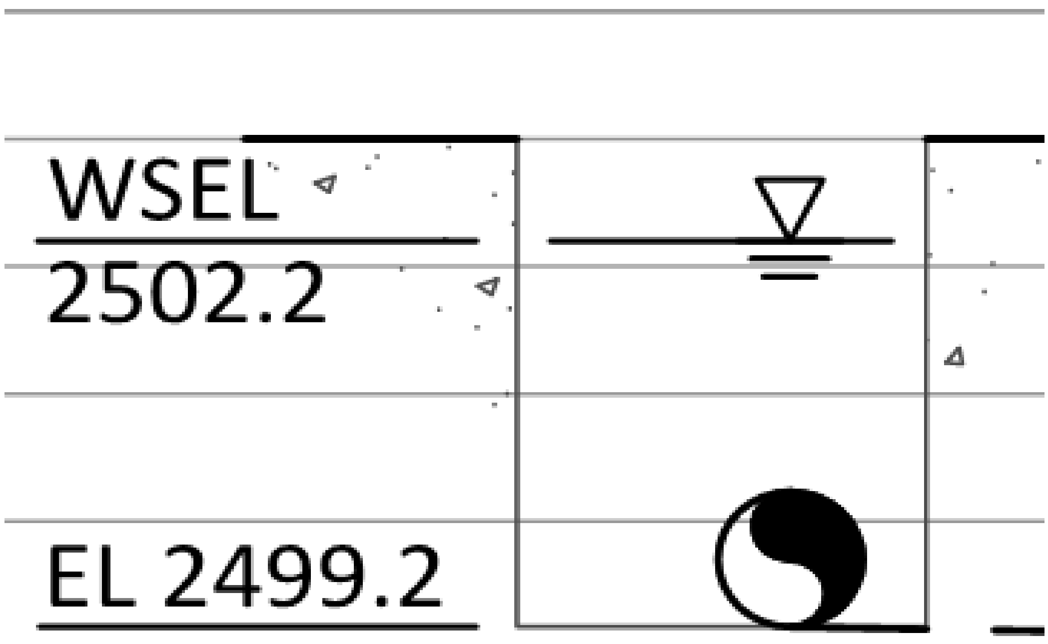
Purpose

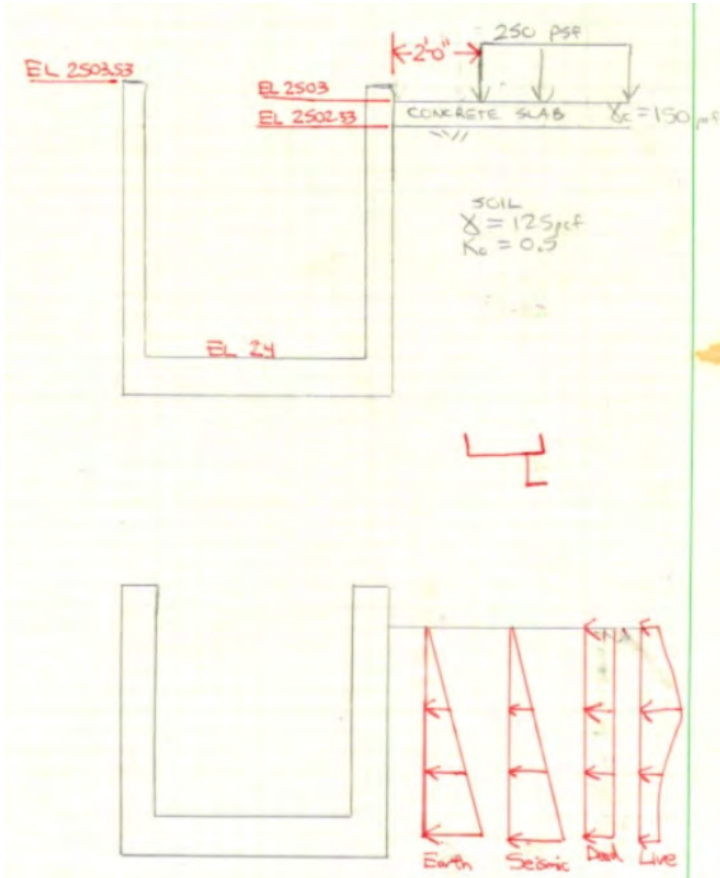
Design the walls for the rearing ponds

Information

gamma_s =	125	pcf	Unit weight soil
gamma_w =	62.4	pcf	Unit weight water
gamma_c =	150	pcf	Unit weight concrete
fc'_ex =	2.50	ksi	Compressive strength
fy,bar_ex =	33.00	ksi	Yield Strength of steel reinforcement
fu,bar_ex =	55.00	ksi	Ultimate strength of steel reinforcement
Es =	29000.00	ksi	Modulus of elasticity of steel reinforcement
Ka =	0.29		Active Pressure Coefficient
Ko =	0.50		At-rest Pressure Coefficient
Ke =	0.35		Seismic pressure coefficient
t_slab =	8.00	in	Thickness of slab
LL_surcharge =	250.00	psf	Live load surcharge

Figures





250 psf
2'-0"
EL 2503.53
EL 2503
EL 2502.53
CONCRETE SLAB
γ_c = 150 pcf
SOIL
γ = 125 pcf
K_o = 0.5
EL 24
Earth
Seismic
Dead
Live

Calculations: Loads

EL_bot =	2499.20	ft	Elevation top of slab
EL_top =	2503.53	ft	Elevation top of wall
EL_w =	2502.00	ft	Diameter of bar
EL_soil =	2502.33	ft	Elevation top of soil
EL_c =	2503.00	ft	Elevation top of driveway
EL_fix =	2498.78	ft	Elevation center of slab

Lateral Earth Pressure

P1 =	0.00	psf	Soil pressure top of wall
P2 =	0.00	psf	Soil pressure top of slab
P3 =	0.00	psf	Soil pressure top of soil
P4 =	195.83	psf	Soil pressure bottom of soil
Fh =	0.31	k	Resultant force
y_h =	1.46	ft	Distance of resultant from base
M_h =	0.45	k-ft	Max moment in wall

Seismic Earth Pressure

P1 =	0.00	psf	Seismic earth pressure top of wall
P2 =	0.00	psf	Seismic earth pressure top of slab
P3 =	0.00	psf	Seismic earth pressure top of soil
P4 =	137.08	psf	Seismic earth pressure bottom of soil
Fe =	0.21	k	Resultant force
y_e =	1.46	ft	Distance of resultant from base
M_e =	0.31	k-ft	Max moment in wall

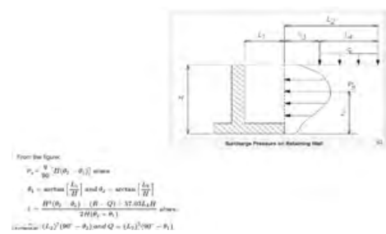
Lateral Dead Load Pressure

P1 =	0.00	psf	Concrete slab pressure top of wall
P2 =	0.00	psf	Concrete slab pressure top of slab
P3 =	50.00	psf	Concrete slab pressure top of soil
P4 =	50.00	psf	Concrete slab pressure bottom of soil
Fd =	0.16	k	Resultant force
y_d =	1.98	ft	Distance of resultant from base
M_d =	0.31	k-ft	Max moment in wall

Live Load Surcharge Pressure

q =	250.00	psf	Live load surcharge
L1 =	0.00	ft	
L2 =	19.50	ft	
L3 =	4.50	ft	
L4 =	15.00	ft	
H =	3.13	ft	Height of wall
theta-1 =	55.15	degrees	
theta-2 =	80.87	degrees	
Ps =	0.22	kips	Resultant force
R =	3471.10		
Q =	705.70		
z_bar =	1.46	ft	Distance of resultant from base
M_l =	0.33	k-ft	Max moment in wall

https://epg.modot.org/index.php/751.24_LFD_Retaining_Walls



Calculations: Load Combinations

Flexure

LC1 =	1.15	k-ft	Load combination 1 (see design criteria)
LC2 =	1.61	k-ft	Load combination 2 (see design criteria)
LC6 =	1.73	k-ft	Load combination 6 (see design criteria)
Mmax_f =	1.73	k-ft/ft	Maximum factored moment in wall

Shear

LC1 =	0.71	k	Load combination 1 (see design criteria)
LC2 =	1.04	k	Load combination 2 (see design criteria)
LC6 =	1.12	k	Load combination 6 (see design criteria)
Vmax_f =	1.12	k	Maximum factored shear in wall

Calculations: Wall Design

Calculations: Flexure

Twall =	8.00	in	Wall thickness
size bar =	5.00		Bar size
dbar =	0.63	in	Diameter of bar
Cover =	N/A	in	Bar cover (center reinforcement)
d = Twall/2 - dbar*0.5 =	3.69	in	Depth to tension reinforcement
Spacing =	18.00	in	Spacing of bars
Abar =	0.31	in2	Area of 1 bar
As =	0.20	in2/ft	Area of flexural steel
Beta1 =	0.85		
rho-b = 0.85*Beta1*fc'/fy*(87/(87+fy)) =	0.04		Balanced % steel
rho-max =	0.025		Max % steel
As,max =	1.11	in2/ft	Max area of flexural steel
rho-min =	0.003		Min % steel (Table 7.12.2.1)
As,min =	0.13	in2/ft	Min area of steel
a = As*fy/(0.85*fc'*b) =	0.26	in	
phi =	0.90		
Mn = As*fy*(d-a/2) =	24.00	k-in	Nominal Moment
Mn =	2.00	k-ft	
Phi*Mn =	1.80	k-ft	
Mmax_f =	1.73	k-ft/ft	
Check	GOOD		*D/C Ratio = 0.96*

Calculations: Longitudinal Steel

rho-min =	0.01		Min % steel (Table 7.12.2.1)
As,min =	0.27	in2/ft	Min area of steel
size bar =	5.00		Bar size
dbar =	0.63	in	Diameter of bar
Spacing =	12.00	in	Spacing of bars
Abar =	0.31	in2	Area of 1 bar
As =	0.31	in2/ft	Area of flexural steel

Calculations: Shear

Lambda =	1.00	kips	Normalweight concrete
Vc = 2*lambda*sqrt(fc')*b*d =	4.43	k/ft	Nominal shear strength
phi =	0.75		Reistance factor - shear
phi*Vc =	3.32	k/ft	Ultimate shear strength
Vmax_f =	1.12	k/ft	
CHECK	GOOD		*D/C Ratio = 0.34*

Appendix D
Mechanical Design Calculations

Calculation Cover Sheet

Project: Fall Creek Hatchery

Client: Klamath River Renewal Corporation **Proj. No.** 20-024

Title: Mechanical Calculations - 50%

Prepared By, Name: Sean Ellenson, P.E.

Prepared By, Signature: **Date:** 5/22/2020

Peer Reviewed By, Name: Kyle DeSomber, P.E.

Peer Reviewed, Signature: **Date:** 5/22/2020

McMILLEN JACOBS ASSOCIATES

SUBJECT:	Klamath River Renewal Corporation	**BY:**	S. Ellenson	**CHK'D BY:**	K.DeSomber
	Fall Creek Hatchery	**DATE:**	5/22/2020		
	Mechanical Calculations - 50%	**PROJECT NO.:**	20-024		

Table of Content

SUBJECT:	Klamath River Renewal Corporation	**BY:** S. Ellenson	**CHK'D BY:** K. Desomber
	Fall Creek Hatchery	**DATE:** 5/22/2020	
	Coho Building Supply Piping Design	**PROJECT NO.:** 20-024	

Purpose

The purpose of this calculation sheet is to determine whether sufficient hydraulic head exists for the features within the Coho building

References

- *Miller, D.S. 1990. Internal Flow Systems, Second Edition. Cranfield, UK: BHRA, The Fluid Engineering Centre.*

- *Rossman, L.A. 2000. EPANET2, User's Manual. U.S. Environmental Protection Agency (USEPA), Office of Research and Development, National Risk Management Research Laboratory: Cincinnati, OH.*

- *Tullis, J. Paul. (1989). Hydraulics of Pipelines, Pumps, Valves, Cavitation, Transients. New York: John Wiley & Sons.*

Method

The supply piping network within the Coho Building was analyzed using EPANET2 software (Rossman, 2000) to determine the head at the design locations, and to size the pipes in the network. The supply piping was based on the 50% layout of the Coho Building.

The EPANET model was set to calculate pipe friction losses according to the Darcy-Weisbach formula:

$$h_{f,ft} = f\frac{L}{d}\frac{v^2}{2g}$$

where:
$h_{f,ft} =$ Friction head losses, ft
$L_{ft} =$ Length of pipe run, ft
$v =$ velocity (ft/s)
$f =$ friction factor
$d_{in} =$ Pipe diameter, in
$g =$ Gravitational constant, 32.2 ft/s^2

Minor losses were calculated according to the equation:

$$h_L = K\left(\frac{V^2}{2g}\right)$$

where:
$h_L =$ Minor head losses, ft
$K =$ Composite minor loss coefficient
$V =$ Pipe average velocity, ft/s
$g =$ Gravitational constant, 32.2 ft/s^2

Assumptions

The following assumptions were made in the development of the pipe network model:

(1) Composite minor loss coefficients were collected from the preliminary pipe distribution layout, and typical values (see Section 'Inputs') collected from Tullis (1989) and Miller (1990).

(2) Pipes were assumed to be new PVC pipe, with smooth interior. Pipe roughness 0.005 micro-feet

(3) Pipe sizes were selected to maintain velocities within the desired range of 1.5 feet per second (fps) - 5.0 fps, such that pipes would be self-cleaning (lower bound), but head losses would not be excessive and abrasion potential would be mitigated (upper bound). 1.5 fps was treated as an absolute minimum, and generally pipe velocities were maintained around 2.0 fps.

(4) Demand at the model nodes were based on the critical (i.e. maximum) flow requirements for each feature in the facility

Inputs

Upstream Boundary Condition

Supply Piping HGL: 2509.9 ft

Minor Loss Coefficients

Coefficient K	90° Bends	45° Bends	22.5° Bends	Ball Valve (Open)	Tee (Branch)	Tee (Line)	Reducer - Contraction*
	0.24	0.1	0.06	0.05	1	0.2	

from Tullis, 1989 and Miller, 1990.

** Reducer losses were calculated based on the equation:* $K = \left(1/C_c - 1\right)^2$

A_2/A_1	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
C_c	0.624	0.632	0.643	0.659	0.681	0.712	0.755	0.813	0.892
K	0.363	0.339	0.308	0.268	0.219	0.164	0.105	0.053	0.015

Pipe Inputs

Coho Building

Pipe I.D.	90° Bends	45° Bends	22.5° Bends	Ball Valve (Open)	Tee (Branch)	Tee (Line)	Reducer - Contraction*	K_{tot}	Length (ft)	Roughness (micro-ft)	Nominal Diameter (in)	Actual Diameter (in)
P1	-	-	-	-	-	-	-	0.000	1	0.005	16	14.213
P2	-	-	-	-	1	-	0.268	1.268	11.5	0.005	8	7.565
P3	1	-	-	-	-	-	-	0.240	9	0.005	8	7.565
P4	1	-	-	-	-	-	-	0.240	1	0.005	8	7.565
P5	-	-	-	-	-	1	-	0.200	4	0.005	8	7.565
P6	-	-	-	-	-	1	-	0.200	8.5	0.005	8	7.565
P7	-	-	-	-	-	1	-	0.200	4	0.005	8	7.565
P8	2	-	-	-	1	-	-	1.480	10.5	0.005	4	3.786
P9	2	-	-	-	1	-	-	1.480	10.5	0.005	4	3.786
P10	2	-	-	-	1	-	-	1.480	10.5	0.005	4	3.786
P11	2	-	-	-	1	-	-	1.480	10.5	0.005	4	3.786
P12	-	-	-	-	1	-	0.268	1.268	23	0.005	8	7.565
P13	-	-	-	1	1	-	-	1.050	17	0.005	4	3.786
P14	3	-	-	-	1	-	-	1.720	4.5	0.005	4	3.786
P15	3	-	-	-	1	-	-	1.720	4.5	0.005	4	3.786
P16	-	-	-	-	-	1	-	0.200	12	0.005	8	7.565
P17	-	-	-	1	1	-	-	1.050	17	0.005	4	3.786
P18	3	-	-	-	1	-	-	1.720	4.5	0.005	4	3.786
P19	3	-	-	-	1	-	-	1.720	4.5	0.005	4	3.786
P20	-	-	-	-	-	1	0.164	0.364	10	0.005	6	5.709
P21	-	-	-	-	-	1	0.339	0.539	18	0.005	3	2.864
P22	1	-	-	-	-	-	-	0.240	20.5	0.005	3	2.864
P23	5	-	-	1	-	-	-	1.250	14	0.005	3	2.864
P24	-	-	-	-	1	-	-	1.000	25	0.005	6	5.709
P25	-	-	-	-	1	-	-	1.000	5	0.005	3	2.864
P26	2	-	-	1	1	-	-	1.530	10	0.005	3	2.864
P27	2	-	-	1	1	-	-	1.530	10	0.005	3	2.864
P28	-	-	-	-	-	1	-	0.200	27	0.005	6	5.709
P29	1	-	-	-	-	-	-	0.240	5.5	0.005	6	5.709
P30	1	-	-	-	-	-	-	0.240	3	0.005	6	5.709
P31	2	-	-	1	2	-	-	2.530	8	0.005	3	2.864
P32	2	-	-	1	2	-	-	2.530	8	0.005	3	2.864
P33	-	-	-	-	-	1	-	0.200	8	0.005	6	5.709
P34	2	-	-	1	2	-	-	2.530	8	0.005	3	2.864
P35	2	-	-	1	2	-	-	2.530	8	0.005	3	2.864

Results

A summary image of the model results are provided in the following figure:

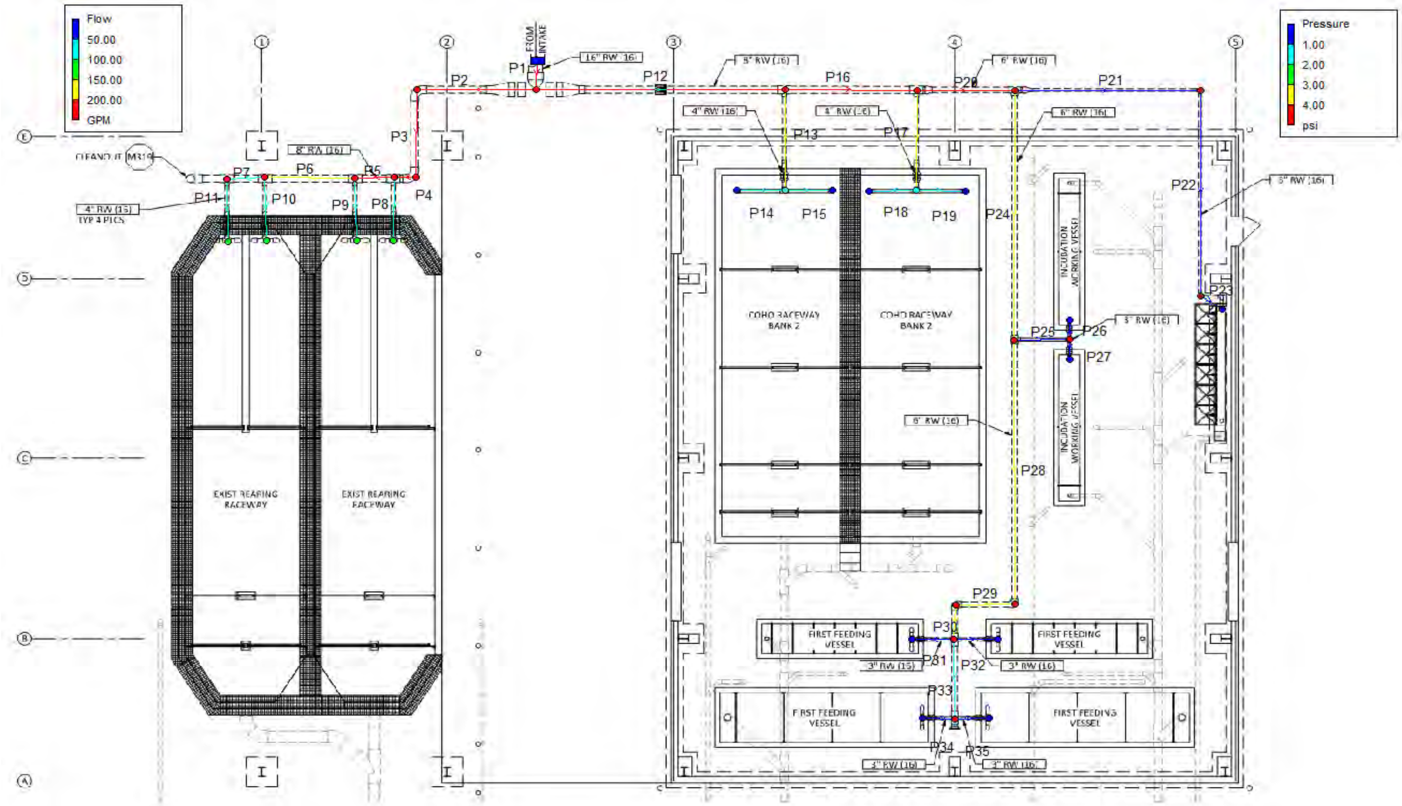


Figure 1. Coho Building Supply Piping

Table 1. Modeling Results

Node ID	Elevation (ft)	Flow Rate (gpm)	Hydraulic Grade (ft)	Pressure (psi)	Head Loss (ft)
Entrance	2499	-	2509.9	4.7	0
Existing Raceway A	2503.5	181	2509.39	2.5	-0.5
Existing Raceway B	2503.5	181	2509.35	2.5	-0.6
New Raceway A	2506	181	2508.26	1.0	-1.6
New Raceway B	2506	181	2508.2	1.0	-1.7
Working Vessel	2507	15	2509	0.9	-0.9
Exist Feeding Vessel	2507	37.5	2508.79	0.8	-1.1
New Feeding Vessel	2508	37.5	2508.78	0.3	-1.1
Incubation Head Tank	2508	40	2508.82	0.4	-1.1

Conclusions

- The available head at The Coho building provides sufficient driving head to supply each raceway/vessel at the maximum permissible flow rate.

SUBJECT:	Klamath River Renewal Corporation	**BY:**	S. Ellenson **CHK'D BY:** K. Desomber
	Fall Creek Hatchery	**DATE:**	5/22/2020
	Chinook Building Supply Piping Design	**PROJECT NO.:**	20-024

Purpose

The purpose of this calculation sheet is to determine whether sufficient hydraulic head exists for the features within the Chinook building

References

- *Miller, D.S. 1990. Internal Flow Systems, Second Edition. Cranfield, UK: BHRA, The Fluid Engineering Centre.*
- *Rossman, L.A. 2000. EPANET2, User's Manual. U.S. Environmental Protection Agency (USEPA), Office of Research and Development, National Risk Management Research Laboratory: Cincinnati, OH.*
- *Tullis, J. Paul. (1989). Hydraulics of Pipelines, Pumps, Valves, Cavitation, Transients. New York: John Wiley & Sons.*

Method

The supply piping network within the Chinook Building was analyzed using EPANET2 software (Rossman, 2000) to determine the head at the design locations, and to size the pipes in the network. The supply piping was based on the 50% layout of the Chinook Building.

The EPANET model was set to calculate pipe friction losses according to the Darcy-Weisbach formula:

$$h_{f,ft} = f\frac{L}{d}\frac{v^2}{2g}$$

where:
$h_{f,ft} =$ Friction head losses, ft
$L_{ft} =$ Length of pipe run, ft
$v =$ velocity (ft/s)
$f =$ friction factor
$d_{in} =$ Pipe diameter, in
$g =$ Gravitational constant, 32.2 ft/s^2

Minor losses were calculated according to the equation:

$$h_L = K\left(\frac{V^2}{2g}\right)$$

where:
$h_L =$ Minor head losses, ft
$K =$ Composite minor loss coefficient
$V =$ Pipe average velocity, ft/s
$g =$ Gravitational constant, 32.2 ft/s^2

Assumptions

The following assumptions were made in the development of the pipe network model:

(1) Composite minor loss coefficients were collected from the preliminary pipe distribution layout, and typical values (see Section 'Inputs') collected from Tullis (1989) and Miller (1990).

(2) Pipes were assumed to be new PVC pipe, with smooth interior. Pipe roughness 0.005 micro-feet

(3) Pipe sizes were selected to maintain velocities within the desired range of 1.5 feet per second (fps) - 5.0 fps, such that pipes would be self-cleaning (lower bound), but head losses would not be excessive and abrasion potential would be mitigated (upper bound). 1.5 fps was treated as an absolute minimum, and generally pipe velocities were maintained around 2.0 fps.

(4) Demand at the model nodes were based on the critical (i.e. maximum) flow requirements for each feature in the facility

Inputs

Upstream Boundary Condition

Supply Piping HGL: 2509.75 ft

Minor Loss Coefficients

Coefficient K	90° Bends	45° Bends	22.5° Bends	Ball Valve (Open)	Tee (Branch)	Tee (Line)	Reducer - Contraction*
	0.24	0.1	0.06	0.05	1	0.2	

from Tullis, 1989 and Miller, 1990.

** Reducer losses were calculated based on the equation:* $K = \left({}^{1}/_{C_c} - 1 \right)^2$

A_2/A_1	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
C_c	0.624	0.632	0.643	0.659	0.681	0.712	0.755	0.813	0.892
K	0.363	0.339	0.308	0.268	0.219	0.164	0.105	0.053	0.015

Pipe Inputs

Coho Building

Pipe I.D.	90° Bends	45° Bends	22.5° Bends	Ball Valve (Open)	Tee (Branch)	Tee (Line)	Reducer - Contraction*	K_{tot}	Length (ft)	Roughness (micro-ft)	Nominal Diameter (in)	Actual Diameter (in)
P1	-	-	-	-	-	-	-	0.000	6.75	0.005	10	9.493
P2	-	-	-	-	1	-	-	1.000	18.5	0.005	3	2.864
P3	1	-	-	-	-	-	-	0.240	3	0.005	3	2.864
P4	3	-	-	1	-	-	-	0.770	10	0.005	3	2.864
P5	-	-	-	-	-	1	-	0.200	3.5	0.005	10	9.493
P6	-	-	-	-	1	-	-	1.000	4.5	0.005	3	2.864
P7	3	-	-	1	-	-	-	0.770	10	0.005	3	2.864
P8	-	-	-	-	-	1	-	0.200	3	0.005	10	9.493
P9	-	-	-	-	1	-	-	1.000	1.5	0.005	6	5.709
P10	3	-	-	1	-	-	-	0.770	11	0.005	6	5.709
P11	-	-	-	-	-	1	-	0.200	12	0.005	10	9.493
P12	-	-	-	-	1	-	-	1.000	1.5	0.005	6	5.709
P13	3	-	-	1	-	-	-	0.770	11	0.005	6	5.709
P14	-	-	-	-	-	1	0.268	0.468	12	0.005	6	5.709
P15	-	-	-	-	1	-	-	1.000	1.5	0.005	6	5.709
P16	3	-	-	1	-	-	-	0.770	11	0.005	6	5.709
P17	-	-	-	-	-	1	-	0.200	12	0.005	6	5.709
P18	-	-	-	-	1	-	-	1.000	1.5	0.005	6	5.709
P19	3	-	-	1	-	-	-	0.770	11	0.005	6	5.709
P20	-	-	-	-	-	1	-	0.200	2.5	0.005	6	5.709
P21	-	-	-	-	1	-	-	1.000	4.5	0.005	3	2.864
P22	3	-	-	1	-	-	-	0.770	10	0.005	3	2.864
P23	-	-	-	-	-	1	0.339	0.539	3.5	0.005	3	2.864
P24	1	-	-	-	-	-	-	0.240	19	0.005	3	2.864
P25	1	-	-	-	-	-	-	0.240	3	0.005	3	2.864
P26	3	-	-	1	-	-	-	0.770	10	0.005	3	2.864

Results

A summary image of the model results are provided in the following figure:

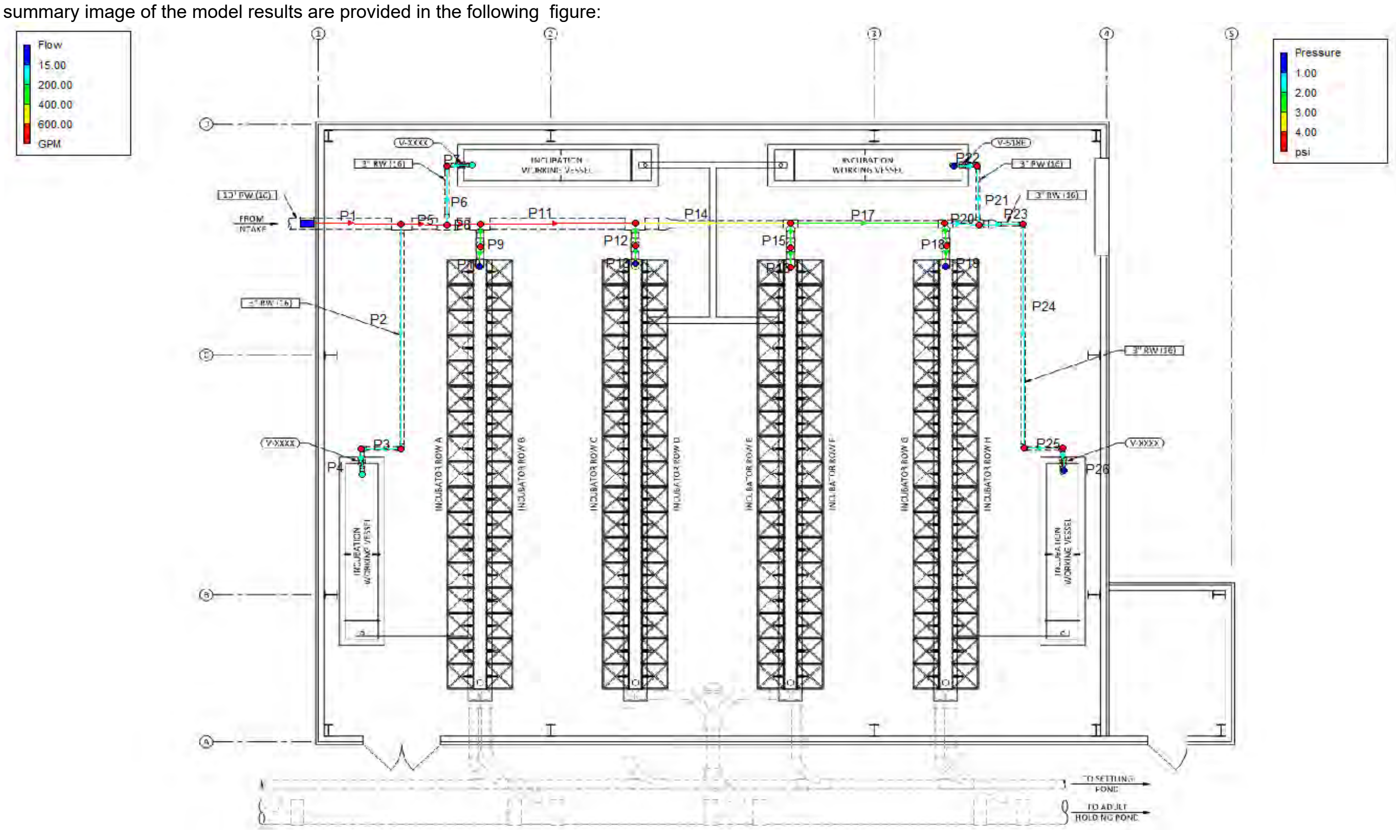


Figure 1. Chinook Building Supply Piping

Table 1. Modeling Results

Node ID	Elevation (ft)	Flow Rate (gpm)	Hydraulic Grade (ft)	Pressure (psi)	Head Loss (ft)
Entrance	2499	-	2509.75	4.7	0
Working Vessel A/B	2507	15	2509.67	1.2	-0.1
Working Vessel C/D	2507	15	2509.63	1.1	-0.1
Working Vessel E/F	2507	15	2509.03	0.9	-0.7
Working Vessel G/H	2507	15	2509.01	0.9	-0.7
Head Tank A/B	2508	204	2509.37	0.6	-0.4
Head Tank C/D	2508	204	2509.31	0.6	-0.4
Head Tank E/F	2508	204	2508.92	0.4	-0.8
Head Tank G/H	2508	204	2508.83	0.4	-0.9

Conclusions

- The available head at The Chinook building provides sufficient driving head to supply each head tank/vessel at the maximum permissible flow rate.

SUBJECT:	Klamath River Renewal Corporation	**BY:** S. Ellenson	**CHK'D BY:** K. DeSomber
	Fall Creek Hatchery	**DATE:** 5/22/2020	
	Coho Building Drainage Piping Design	**PROJECT NO.:** 20-024	

Purpose

The purpose of this calculation sheet is to size the drainage piping within the Coho Building.

References

- *Lindeburg, Michael R. 2014. Civil Engineering Reference Manual, Fourteenth Edition. Professional Publications, Inc. Belmont, CA.*

Method

Raceway, working vessels, and building drains discharge raw water to the adult holding ponds after interconnecting with the primary drain piping outdoors. Open channel flow calculations followed the equations below (Lindeburg, 2014), and were calculated iteratively using a Newton-Raphson iterating scheme:

$$\theta_{deg} = 2\cos^{-1}\left(\frac{\frac{D}{2}-d}{\frac{D}{2}}\right) \qquad R_h = \frac{A}{P} \qquad \frac{n}{n_{full}} = 1 + \left(\frac{d}{D}\right)^{0.54} - \left(\frac{d}{D}\right)^{1.2}$$

$$A = \left(\frac{D}{2}\right)^2 \frac{\theta_{rad} - \sin\theta_{deg}}{2} \qquad V = \left(\frac{1.486}{n}\right) R_h^{2/3} S^{1/2}$$

$$P = \frac{D\theta_{rad}}{2} \qquad Q = AV$$

where:

$\theta =$ Internal angle of water surface
$D =$ Pipe inner diameter, ft
$d =$ Flow depth, ft
$A =$ Flow area, ft^2
$P =$ Wetted perimeter, ft
$R_h =$ Hydraulic radius, ft
$V =$ Average flow velocity, ft/s
$n =$ Manning's roughness coefficient
$S =$ Pipe bed slope, ft/ft
$Q =$ Discharge, cfs
$n_{full} =$ Pipe-full roughness coefficient

The following assumptions are made in these calculations:

(1) In order to allow for sufficient airflow, and to prevent periodic pressurization of the pipe where unintended, the pipe size is designed to convey the flow in an open-channel condition with the depth less than 70% of the inner diameter of the pipe.

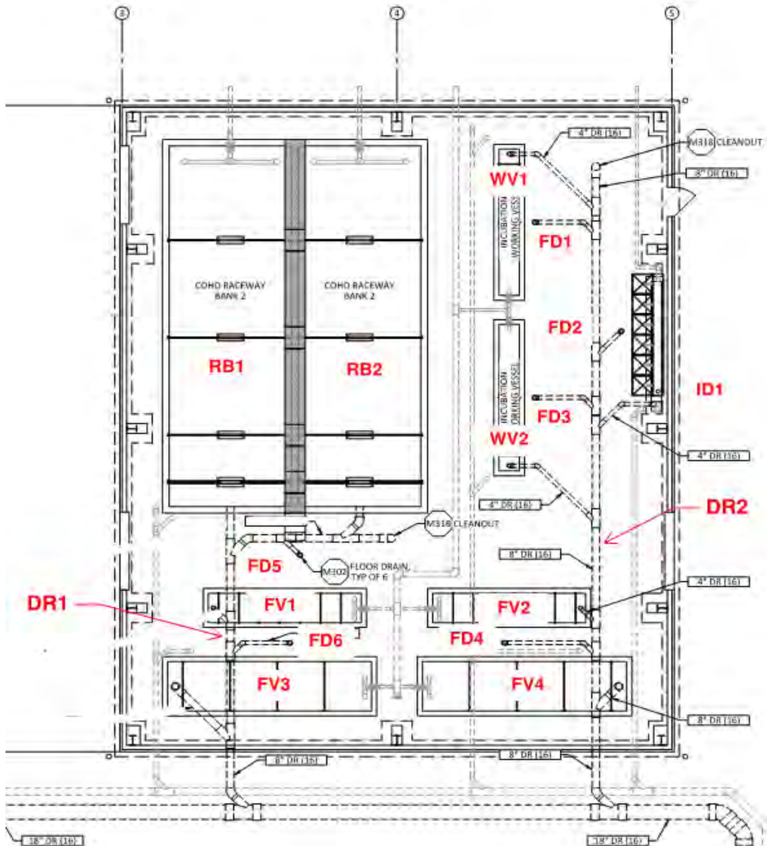
(2) The pipe is assumed to be plastic or some other smooth interior pipe, and non-profile wall pipe. Accordingly, a conservative roughness coefficient of 0.015 was applied (note: C900 pipe manufacturers report roughness values of 0.009). If the pipe varies from this assumption, these hydraulics will need to be reconsidered.

(3) Based on standard sewer design, the pipe is considered self-cleaning if the velocity is greater than 2.0 ft/s. Above 1.5 ft/s is acceptable if occasional flushing flows are expected. The pipes were designed to meet this criterion.

Inputs

General Parameters

Gravitational constant, g	32.2	ft/s^2	
Kinematic Viscosity, ν	1.41E-05	ft^2/s	[@ 50 F]



Location I.D.	Description	Discharge, Q gpm	Comments
WV1	Working Vessel #1	15	
WV2	Working Vessel #2	15	
FV1	Feeding Vessel #1	37.5	
FV2	Feeding Vessel #2	37.5	
FV3	Feeding Vessel #3	37.5	
FV4	Feeding Vessel #4	37.5	
ID1	Incubation Stack Drain	40	6 Stacks @ 5 gpm + 10 gpm standpipe waste
FD1	Floor Drain #1	10	Estimated
FD2	Floor Drain #2	10	Estimated
FD3	Floor Drain #3	10	Estimated
FD4	Floor Drain #4	10	Estimated
FD5	Floor Drain #5	10	Estimated
FD6	Floor Drain #6	10	Estimated
RB1	Coho Raceway Bank #1	181	
RB2	Coho Raceway Bank #2	181	
DR1	Drainage Header #1	457	RB1+RB2+FV1+FV3+FD5+FD6
DR2	Drainage Header #2	185	WV1+WV2+FV2+FV4+ID1+FD1+FD2+FD3+FD4

McMILLEN JACOBS ASSOCIATES

Calculations

Gravity Pipeline

Location I.D.	Description	Discharge, Q gpm	Pipe Nom. Diameter in	Pipe Inner Diameter ft	Slope ft/ft	Roughness Coeff, *n*	Flow Depth, d ft	<70% Full?
WV1	Working Vessel #1	15	4	0.3155	0.015	0.015	0.11	34%
WV2	Working Vessel #2	15	4	0.3155	0.015	0.015	0.11	34%
FV1	Feeding Vessel #1	37.5	4	0.3155	0.015	0.015	0.17	55%
FV2	Feeding Vessel #2	37.5	4	0.3155	0.015	0.015	0.17	55%
FV3	Feeding Vessel #3	37.5	4	0.3155	0.015	0.015	0.17	55%
FV4	Feeding Vessel #4	37.5	4	0.3155	0.015	0.015	0.17	55%
ID1	Incubation Stack Drain	40	4	0.3155	0.015	0.015	0.18	57%
FD1	Floor Drain #1	10	4	0.3155	0.015	0.015	0.09	27%
FD2	Floor Drain #2	10	4	0.3155	0.015	0.015	0.09	27%
FD3	Floor Drain #3	10	4	0.3155	0.015	0.015	0.09	27%
FD4	Floor Drain #4	10	4	0.3155	0.015	0.015	0.09	27%
FD5	Floor Drain #5	10	4	0.3155	0.015	0.015	0.09	27%
FD6	Floor Drain #6	10	4	0.3155	0.015	0.015	0.09	27%
RB1	Coho Raceway Bank #1	181	12	0.9412	0.005	0.015	0.34	36%
RB2	Coho Raceway Bank #2	181	12	0.9412	0.005	0.015	0.34	36%
DR1	Drainage Header #1	457	12	0.9412	0.005	0.015	0.56	60%
DR2	Drainage Header #2	185	8	0.6304	0.015	0.015	0.30	48%

Location I.D.	Description	Internal Angle, θ deg	Flow Area, A ft^2	Flow Velocity, V ft/s	Self-Cleaning?
WV1	Working Vessel #1	142	0.02	1.44	N/A
WV2	Working Vessel #2	142	0.02	1.44	N/A
FV1	Feeding Vessel #1	192	0.04	1.88	N/A
FV2	Feeding Vessel #2	192	0.04	1.88	N/A
FV3	Feeding Vessel #3	192	0.04	1.88	N/A
FV4	Feeding Vessel #4	192	0.04	1.88	N/A
ID1	Incubation Stack Drain	197	0.05	1.92	N/A
FD1	Floor Drain #1	126	0.02	1.28	N/A
FD2	Floor Drain #2	126	0.02	1.28	N/A
FD3	Floor Drain #3	126	0.02	1.28	N/A
FD4	Floor Drain #4	126	0.02	1.28	N/A
FD5	Floor Drain #5	126	0.02	1.28	N/A
FD6	Floor Drain #6	126	0.02	1.28	N/A
RB1	Coho Raceway Bank #1	148	0.23	1.78	N/A
RB2	Coho Raceway Bank #2	148	0.23	1.78	N/A
DR1	Drainage Header #1	203	0.43	2.35	OK
DR2	Drainage Header #2	176	0.15	2.77	OK

Conclusions

The above calculations provide a set of flow, slope, and pipe size conditions that will maintain gravity flow in the drain pipes within the Coho Building.

SUBJECT:	Klamath River Renewal Corporation	**BY:** S. Ellenson	**CHK'D BY:** K. DeSomber
	Fall Creek Hatchery	**DATE:** 5/22/2020	
	Chinook Building Drainage Trench Design	**PROJECT NO.:** 20-024	

Purpose

The purpose of this calculation sheet is to size the drainage piping within the Chinook Building.

References

- *Lindeburg, Michael R. 2014. Civil Engineering Reference Manual, Fourteenth Edition. Professional Publications, Inc. Belmont, CA*

Method

Working Vessels and Incubation Stacks discharge raw water to the adult holding ponds after interconnecting with the primary drain piping outdoors. Open channel flow calculations followed the equations below (Lindeburg, 2014), and were calculated iteratively using a Newton-Raphson iterating scheme:

$$P = B + 2d$$

$$A = B * d$$

$$R_h = \frac{A}{P}$$

$$\frac{n}{n_{full}} = 1 + \left(\frac{d}{D}\right)^{0.54} - \left(\frac{d}{D}\right)^{1.2}$$

$$V = \left(\frac{1.486}{n}\right) R_h^{2/3} S^{1/2}$$

$$Q = AV$$

where:

$\theta =$	Trench Width
$h =$	Trench Depth
$d =$	Flow depth, ft
$A =$	Flow area, ft^2
$P =$	Wetted perimeter, ft
$R_h =$	Hydraulic radius, ft
$V =$	Average flow velocity, ft/s
$n =$	Manning's roughness coefficient
$S =$	Trench slope, ft/ft
$Q =$	Discharge, cfs
$n_{full} =$	Trench roughness coefficient

Assumptions

The following assumptions are made in these calculations:

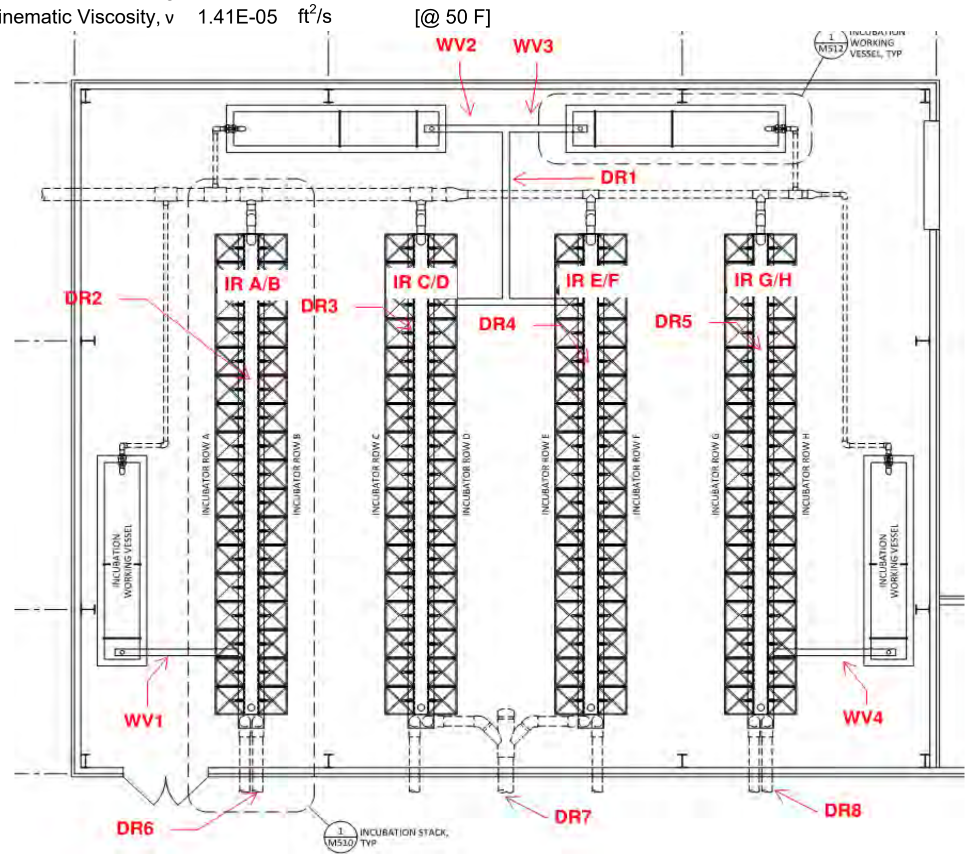
(1) The trench is intended to be formed within the concrete floor slab. Accordingly, a conservative roughness coefficient of 0.015 was applied.

(2) Based on standard sewer design, the trench is considered self-cleaning if the velocity is greater than 2.0 ft/s. Above 1.5 ft/s is acceptable if occasional flushing flows are expected. The pipes were designed to meet this criterion.

Inputs

General Parameters

Gravitational constant, g	32.2	ft/s^2	
Kinematic Viscosity, ν	1.41E-05	ft^2/s	[@ 50 F]



Location I.D.	Description	Discharge, Q gpm	Comments
WV1	Working Vessel #1	15	
WV2	Working Vessel #2	15	
WV3	Working Vessel #3	15	
WV4	Working Vessel #4	15	
IR A/B	Incubation Stack Row A/B	204	34 Stacks @ 5 gpm + 1 gpm waste per stack (34 gpm
IR C/D	Incubation Stack Row C/D	204	34 Stacks @ 5 gpm + 1 gpm waste per stack (34 gpm
IR E/F	Incubation Stack Row E/F	204	34 Stacks @ 5 gpm + 1 gpm waste per stack (34 gpm
IR G/H	Incubation Stack Row G/H	204	34 Stacks @ 5 gpm + 1 gpm waste per stack (34 gpm
DR1	Trench Drain #1	30	WV2+WV3
DR2	Trench Drain #2	219	IR A/B+WV1
DR3	Trench Drain #3	219	IR C/D+WV2
DR4	Trench Drain #4	219	IR E/F + WV3
DR5	Trench Drain #5	219	IR G/H+WV4
DR6	Pipe Drain #1	219	DR2
DR7	Pipe Drain #2	438	DR3+DR4
DR8	Pipe Drain #3	219	DR4

Calculations

Gravity Trenches

Location I.D.	Description	Discharge, Q gpm	Trench Width in	Slope ft/ft	Roughness Coeff, *n*	Flow Depth, d in
WV1	Working Vessel #1	15	6	0.020	0.015	0.52
WV2	Working Vessel #2	15	6	0.020	0.015	0.52
WV3	Working Vessel #3	15	6	0.020	0.015	0.52
WV4	Working Vessel #4	15	6	0.020	0.015	0.52
IR A/B	Incubation Stack Row A/B	204	22	0.020	0.015	1.11
IR C/D	Incubation Stack Row C/D	204	22	0.020	0.015	1.11
IR E/F	Incubation Stack Row E/F	204	22	0.020	0.015	1.11
IR G/H	Incubation Stack Row G/H	204	22	0.020	0.015	1.11
DR1	Trench Drain #1	30	6	0.020	0.015	0.81
DR2	Trench Drain #2	219	22	0.020	0.015	1.16
DR3	Trench Drain #3	219	22	0.020	0.015	1.16
DR4	Trench Drain #4	219	22	0.020	0.015	1.16
DR5	Trench Drain #5	219	22	0.020	0.015	1.16

Gravity Piping

Location I.D.	Description	Discharge, Q gpm	Pipe Nom. Diameter in	Pipe Inner Diameter ft	Slope ft/ft	Roughness Coeff, *n*	Flow Depth, d ft	<70% Full?
DR6	Pipe Drain #1	219	8	0.6304	0.015	0.015	0.33	53%
DR7	Pipe Drain #2	438	12	0.9412	0.015	0.015	0.41	43%
DR8	Pipe Drain #3	219	8	0.6304	0.015	0.015	0.33	53%

Conclusions

The above calculations provide a set of flow, slope, trench size, and pipe size conditions that will maintain gravity flow in the drain pipes within the Chinook Building.

McMILLEN JACOBS ASSOCIATES

SUBJECT:	Klamath River Renewal Corporation	**BY:** C. Gregory	**CHK'D BY:** K. DeSomber
	Fall Creek Hatchery	**DATE:** 5/22/2020	
	Coho Building HVAC Calculations	**PROJECT NO.:** 20-024	

Purpose

The purpose of this calculation sheet is to determine the heating and cooling loads within the Coho Building

Calculations

Total Building Skin Heat Loss During Winter Time

FORMULAS **Q = U * A * DT**

Length (ft)	Width (ft)	Height (ft)		
65	55	18		
outdoor temp (F)	**indoor temp (F)**	**Avg OutdoorTemp Range (F)**		
15.9	50	35.3		
Wall Area (ft^2)	**Roof Pitch**	**Wall Area below Roof Pitch (ft^2)**	**Roof Area (ft^2)**	**Floor Area (ft^2)**
4672	0.083	352.08	3647	240
R-value Walls (ft2·°F·h) / BTU	**R-value Roof (ft2·°F·h) / BTU**	**R-value Floor (ft2·°F·h) / BTU**		
17	25	0.73		
Infiltration Rate (ACH) (Ft^3/Hr)				
0.6				
Heat Loss Walls (Btu/hr)	**Heat Loss Roof (Btu/hr)**	**Heat Loss Floor (Btu/hr)**	**Heat Loss Infiltration (Btu/hr)**	
9372	4974	11211	23699	
TOTAL Heat Loss (Btu/hr)	**TOTAL Heat Loss (kW)**			
49255	14.43			

Total Building Skin Heat Gain During Summer Time

FORMULAS **Q = U * A * DT**

Length (ft)	Width (ft)	Height (ft)
65	55	18

outdoor temp (F)	indoor temp (F)	Avg OutdoorTemp Range (F)
97.0	75	35.3

Wall Area (ft^2)	Roof Pitch	Wall Area below Roof Pitch (ft^2)	Roof Area (ft^2)	Floor Area (ft^2)
4672	0.083	352.08	3647	240

R-value Walls (ft2·°F·h) / BTU	R-value Roof (ft2·°F·h) /	R-value Floor (ft2·°F·h) / BTU
17	25	0.73

Infiltration Rate (ACH) (Ft^3/Hr)
0.6

Heat Gain Walls (Btu/hr)	Heat Gain Roof	Heat Gain Floor (Btu/hr)	Heat Gain Infiltration (Btu/hr)
6046	3209	7233	15290

TOTAL Heat Gain
31778

	Wall Type (#1)								Roof type (#2)
Wall Area (ft^2)		990		1170		990		1170	
Hour Of The Day	N	NE	E	SE	S	SW	W	NW	Roof
1	5	5	5	5	5	7	8	8	2
2	3	3	3	3	3	4	5	4	0
3	2	2	2	2	2	2	3	2	-2
4	0	0	0	0	0	1	1	1	-4
5	-1	-1	-1	-1	-1	0	0	-1	-5
6	-2	-2	-1	-2	-2	-1	-1	-2	-6
7	-1	2	2	0	-2	-2	-2	-2	-4
8	3	13	15	8	-1	0	0	-1	4
9	7	26	32	20	2	2	2	2	17
10	9	36	47	33	7	5	5	5	32
11	11	39	55	43	14	9	9	9	48
12	14	37	57	50	24	13	13	13	62
13	18	33	52	53	33	20	17	17	74
14	21	31	44	51	42	30	23	21	82
15	24	29	38	45	47	41	33	25	86
16	26	29	34	39	48	53	46	32	85
17	27	29	32	35	46	61	59	41	80
18	28	28	30	31	40	65	69	51	70
19	28	26	27	28	33	62	73	57	56
20	27	23	23	24	27	53	66	54	39
21	22	18	19	19	21	39	50	42	25
22	17	14	14	14	15	27	34	29	15
23	12	10	11	11	11	17	22	19	9
24	8	7	8	8	8	11	14	12	5

Corr. Wall CLTD									Corr. Roof CLTD	
Wall Area (ft^2)		990		1170		990		1170		Total Delta T of Heat Gain from Solar Radiation
Hour Of The Day	N	NE	E	SE	S	SW	W	NW	Roof	
1	2	2	2	2	2	4	5	5	-1	26
2	0	0	0	0	0	1	2	1	-3	4
3	-1	-1	-1	-1	-1	-1	0	-1	-5	-9
4	-3	-3	-3	-3	-3	-2	-2	-2	-7	-25
5	-4	-4	-4	-4	-4	-3	-3	-4	-8	-35
6	-5	-5	-4	-5	-5	-4	-4	-5	-9	-43
7	-4	-1	-1	-3	-5	-5	-5	-5	-7	-33
8	0	10	12	5	-4	-3	-3	-4	1	17
9	4	23	29	17	-1	-1	-1	-1	14	86
10	6	33	44	30	4	2	2	2	29	155
11	8	36	52	40	11	6	6	6	45	213
12	11	34	54	47	21	10	10	10	59	259
13	15	30	49	50	30	17	14	14	71	293
14	18	28	41	48	39	27	20	18	79	321
15	21	26	35	42	44	38	30	22	83	344
16	23	26	31	36	45	50	43	29	82	368
17	24	26	29	32	43	58	56	38	77	386
18	25	23	27	28	37	62	66	48	67	386
19	25	23	24	25	30	59	70	54	53	366
20	24	20	20	21	24	50	63	51	36	312
21	19	15	16	16	18	36	47	39	22	231
22	14	11	11	11	12	24	31	26	12	155
23	9	7	8	8	8	14	19	16	6	98
24	5	4	5	5	5	8	11	9	2	57

Solar Radiation Delta T for different hours of the day										
Hour Of The Day	**N**	**NE**	**E**	**SE**	**S**	**SW**	**W**	**NW**	**Roof**	**Total Heat Gain from radiation on walls and roof**
1	0	137	0	162	0	253	0	368	-95	825
2	0	20	0	24	0	79	0	93	-387	-171
3	0	-38	0	-45	0	-38	0	-45	-678	-843
4	0	-154	0	-182	0	-96	0	-114	-970	-1516
5	0	-213	0	-251	0	-154	0	-251	-1116	-1985
6	0	-271	0	-320	0	-213	0	-320	-1262	-2385
7	0	-38	0	-182	0	-271	0	-320	-970	-1781
8	0	603	0	368	0	-154	0	-251	197	762
9	0	1360	0	1194	0	-38	0	-45	2093	4564
10	0	1942	0	2089	0	137	0	162	4281	8611
11	0	2117	0	2777	0	370	0	437	6615	12315
12	0	2000	0	3259	0	603	0	712	8657	15231
13	0	1767	0	3465	0	1010	0	988	10407	17638
14	0	1651	0	3328	0	1593	0	1263	11574	19408
15	0	1535	0	2915	0	2233	0	1538	12157	20378
16	0	1535	0	2502	0	2932	0	2020	12012	21000
17	0	1535	0	2226	0	3398	0	2639	11282	21081
18	0	1360	0	1951	0	3631	0	3328	9824	20093
19	0	1360	0	1745	0	3456	0	3741	7782	18083
20	0	1185	0	1469	0	2932	0	3534	5302	14423
21	0	894	0	1125	0	2117	0	2708	3260	10104
22	0	661	0	781	0	1418	0	1814	1801	6475
23	0	428	0	575	0	836	0	1125	926	3890
24	0	253	0	368	0	486	0	644	343	2094

Equipment Heat Gain

Item	Raw Load (kW)	Qty	Total Raw Load (kW)	Heat Gain %	Total Heat Gain (Btu/hr)
Misc. Electrical load	0.000	0	0.00	100%	0
	0.000	0	0.00	100%	0
	0.000	0	0.000	100%	0
			0.00		0

Heating and Cooling Load Summary

Cooling Load Summary

Category		Heat Gain (Btu/hr)
Radiation Heat Gain (Btu/hr)		21081
Envelope Heat Gain (Btu/hr)		31778
Equipment Heat Gain (Btu/hr)		0
Total Required Cooling	Total (Btu/hr)	52858
	Total (Tons)	4.4

Heating Load Summary

Category		Heat Loss (Btu/hr)
Envelope (Btu/hr)		49255
Electrical Equip Heat Output (Btu/hr)		0
Total Required Heating	Total (Btu/hr)	49255
	TOTAL (kW)	14.4

SUBJECT:	Klamath River Renewal Corporation	**BY:** C. Gregory	**CHK'D BY:** K. DeSomber
	Fall Creek Hatchery	**DATE:** 5/22/2020	
	Chinook Building HVAC Calculations	**PROJECT NO.:** 20-024	

Purpose

The purpose of this calculation sheet is to determine the heating and cooling loads within the Chinook Incubation Building

Calculations

Total Building Skin Heat Loss During Winter Time

FORMULAS $Q = U * A * DT$

Length (ft)	Width (ft)	Height (ft)		
61	51	12		
outdoor temp (F)	**indoor temp (F)**	**Avg OutdoorTemp Range (F)**		
15.9	50	35.3		
Wall Area (ft^2)	**Roof Pitch**	**Wall Area below Roof Pitch (ft^2)**	**Roof Area (ft^2)**	**Floor Area (ft^2)**
2998	0.083	310.08	3173	224
R-value Walls (ft2·°F·h) / BTU	**R-value Roof (ft2·°F·h) / BTU**	**R-value Floor (ft2·°F·h) / BTU**		
17	25	0.73		
Infiltration Rate (ACH) (Ft^3/Hr)				
0.6				
Heat Loss Walls (Btu/hr)	**Heat Loss Roof (Btu/hr)**	**Heat Loss Floor (Btu/hr)**	**Heat Loss Infiltration (Btu/hr)**	
6014	4328	10464	13749	
TOTAL Heat Loss (Btu/hr)	**TOTAL Heat Loss (kW)**			
34554	10.12			

Total Building Skin Heat Gain During Summer Time

FORMULAS Q = U * A * DT

Length (ft)	Width (ft)	Height (ft)		
61	51	12		
outdoor temp (F)	**indoor temp (F)**	**Avg OutdoorTemp Range (F)**		
97.0	75	35.3		
Wall Area (ft^2)	**Roof Pitch**	**Wall Area below Roof Pitch (ft^2)**	**Roof Area (ft^2)**	**Floor Area (ft^2)**
2998	0.083	310.08	3173	224
R-value Walls (ft2·°F·h) / BTU	**R-value Roof (ft2·°F·h) / BTU**	**R-value Floor (ft2·°F·h) / BTU**		
17	25	0.73		
Infiltration Rate (ACH) (Ft^3/Hr)				
0.6				
Heat Gain Walls (Btu/hr)	**Roof (Btu/hr)**	**Heat Gain Floor (Btu/hr)**	**Heat Gain Infiltration (Btu/hr)**	
3880	2792	6751	8870	
Gain (Btu/hr)				
22293				

	Wall Type (#1)								Roof type (#2)
Wall Area (ft^2)		612		732		612		732	
Hour Of The Day	**N**	**NE**	**E**	**SE**	**S**	**SW**	**W**	**NW**	**Roof**
1	5	5	5	5	5	7	8	8	2
2	3	3	3	3	3	4	5	4	0
3	2	2	2	2	2	2	3	2	-2
4	0	0	0	0	0	1	1	1	-4
5	-1	-1	-1	-1	-1	0	0	-1	-5
6	-2	-2	-1	-2	-2	-1	-1	-2	-6
7	-1	2	2	0	-2	-2	-2	-2	-4
8	3	13	15	8	-1	0	0	-1	4
9	7	26	32	20	2	2	2	2	17
10	9	36	47	33	7	5	5	5	32
11	11	39	55	43	14	9	9	9	48
12	14	37	57	50	24	13	13	13	62
13	18	33	52	53	33	20	17	17	74
14	21	31	44	51	42	30	23	21	82
15	24	29	38	45	47	41	33	25	86
16	26	29	34	39	48	53	46	32	85
17	27	29	32	35	46	61	59	41	80
18	28	28	30	31	40	65	69	51	70
19	28	26	27	28	33	62	73	57	56
20	27	23	23	24	27	53	66	54	39
21	22	18	19	19	21	39	50	42	25
22	17	14	14	14	15	27	34	29	15
23	12	10	11	11	11	17	22	19	9
24	8	7	8	8	8	11	14	12	5

	Corr. Wall CLTD								Corr. Roof CLTD	
Wall Area (ft^2)		612		732		612		732		**Total Delta T of Heat Gain from**
Hour Of The Day	**N**	**NE**	**E**	**SE**	**S**	**SW**	**W**	**NW**	**Roof**	
1	2	2	2	2	2	4	5	5	-1	26
2	0	0	0	0	0	1	2	1	-3	4
3	-1	-1	-1	-1	-1	-1	0	-1	-5	-9
4	-3	-3	-3	-3	-3	-2	-2	-2	-7	-25
5	-4	-4	-4	-4	-4	-3	-3	-4	-8	-35
6	-5	-5	-4	-5	-5	-4	-4	-5	-9	-43
7	-4	-1	-1	-3	-5	-5	-5	-5	-7	-33
8	0	10	12	5	-4	-3	-3	-4	1	17
9	4	23	29	17	-1	-1	-1	-1	14	86
10	6	33	44	30	4	2	2	2	29	155
11	8	36	52	40	11	6	6	6	45	213
12	11	34	54	47	21	10	10	10	59	259
13	15	30	49	50	30	17	14	14	71	293
14	18	28	41	48	39	27	20	18	79	321
15	21	26	35	42	44	38	30	22	83	344
16	23	26	31	36	45	50	43	29	82	368
17	24	26	29	32	43	58	56	38	77	386
18	25	23	27	28	37	62	66	48	67	386
19	25	23	24	25	30	59	70	54	53	366
20	24	20	20	21	24	50	63	51	36	312
21	19	15	16	16	18	36	47	39	22	231
22	14	11	11	11	12	24	31	26	12	155
23	9	7	8	8	8	14	19	16	6	98
24	5	4	5	5	5	8	11	9	2	57

Solar Radiation Delta T for different hours of the day										
Hour Of The Day	**N**	**NE**	**E**	**SE**	**S**	**SW**	**W**	**NW**	**Roof**	**Total Heat Gain from radiation on walls and roof**
1	0	85	0	101	0	157	0	230	-83	490
2	0	13	0	15	0	49	0	58	-336	-202
3	0	-23	0	-28	0	-23	0	-28	-590	-693
4	0	-95	0	-114	0	-59	0	-71	-844	-1184
5	0	-131	0	-157	0	-95	0	-157	-971	-1512
6	0	-167	0	-200	0	-131	0	-200	-1098	-1797
7	0	-23	0	-114	0	-167	0	-200	-844	-1349
8	0	373	0	230	0	-95	0	-157	171	522
9	0	841	0	747	0	-23	0	-28	1821	3358
10	0	1201	0	1307	0	85	0	101	3725	6419
11	0	1309	0	1737	0	229	0	273	5756	9304
12	0	1237	0	2039	0	373	0	446	7533	11627
13	0	1093	0	2168	0	625	0	618	9056	13559
14	0	1021	0	2082	0	985	0	790	10072	14949
15	0	949	0	1824	0	1381	0	962	10580	15695
16	0	949	0	1565	0	1813	0	1264	10453	16043
17	0	949	0	1393	0	2101	0	1651	9818	15911
18	0	841	0	1221	0	2245	0	2082	8549	14936
19	0	841	0	1092	0	2137	0	2340	6772	13181
20	0	733	0	919	0	1813	0	2211	4614	10289
21	0	553	0	704	0	1309	0	1694	2837	7096
22	0	409	0	489	0	877	0	1135	1568	4476
23	0	265	0	360	0	517	0	704	806	2651
24	0	157	0	230	0	301	0	403	298	1388

Equipment Heat Gain

Item	Raw Load (kW)	Qty	Total Raw Load (kW)	Heat Gain %	Total Heat Gain (Btu/hr)
Misc. Electrical load	0.000	0	0.00	100%	0
	0.000	0	0.00	100%	0
	0.000	0	0.000	100%	0
			0.00		0

Heating and Cooling Load Summary

Cooling Load Summary

Category		Heat Gain (Btu/hr)
Radiation Heat Gain (Btu/hr)		16043
Envelope Heat Gain (Btu/hr)		22293
Equipment Heat Gain (Btu/hr)		0
Total Required Cooling	Total (Btu/hr)	38336
	Total (Tons)	3.2

Heating Load Summary

Category		Heat Loss (Btu/hr)
Envelope (Btu/hr)		34554
Electrical Equip Heat Output (Btu/hr)		0
Total Required Heating	Total (Btu/hr)	34554
	TOTAL (kW)	10.1

SUBJECT: Klamath River Renewal Corporation
Fall Creek Hatchery
Spawning Building HVAC Calculations

BY: C. Gregory **CHK'D BY:** K. DeSomber
DATE: 5/22/2020
PROJECT NO.: 20-024

Purpose

The purpose of this calculation sheet is to determine the heating and cooling loads within the Spawning Building

Calculations

Total Building Skin Heat Loss During Winter Time

FORMULAS **Q = U * A * DT**

Length (ft)	Width (ft)	Height (ft)		
34	24	12		
outdoor temp (F)	**indoor temp (F)**	**Avg OutdoorTemp Range (F)**		
15.9	50	35.3		
Wall Area (ft^2)	**Roof Pitch**	**Wall Area below Roof Pitch (ft^2)**	**Roof Area (ft^2)**	**Floor Area (ft^2)**
1488	0.083	96.33	832	116
R-value Walls (ft2·°F·h) / BTU	**R-value Roof (ft2·°F·h) / BTU**	**R-value Floor (ft2·°F·h) / BTU**		
17	25	0.73		
Infiltration Rate (ACH) (Ft^3/Hr)				
0.6				
Heat Loss Walls (Btu/hr)	**Heat Loss Roof (Btu/hr)**	**Heat Loss Floor (Btu/hr)**	**Heat Loss Infiltration (Btu/hr)**	
2985	1135	5419	3606	
TOTAL Heat Loss (Btu/hr)	**TOTAL Heat Loss (kW)**			
13146	3.85			

Total Building Skin Heat Gain During Summer Time

FORMULAS Q = U * A * DT

Length (ft)	Width (ft)	Height (ft)		
34	24	12		
outdoor temp (F)	**indoor temp (F)**	**Avg OutdoorTemp Range (F)**		
97.0	75	35.3		
Wall Area (ft^2)	**Roof Pitch**	**Wall Area below Roof Pitch (ft^2)**	**Roof Area (ft^2)**	**Floor Area (ft^2)**
1488	0.083	96.33	832	116
R-value Walls (ft2·°F·h) / BTU	**R-value Roof (ft2·°F·h) / BTU**	**R-value Floor (ft2·°F·h) / BTU**		
17	25	0.73		
Infiltration Rate (ACH) (Ft^3/Hr)				
0.6				
Heat Gain Walls (Btu/hr)	**Heat Gain Roof (Btu/hr)**	**Heat Gain Floor (Btu/hr)**	**Heat Gain Infiltration (Btu/hr)**	
1926	732	3496	2327	
TOTAL Heat Gain (Btu/hr)				
8481				

	Wall Type (#1)								Roof type (#2)
Wall Area (ft^2)		288		408		288		408	
Hour Of The Day	NE	N	SE	E	SW	S	NW	W	Roof
	NE	N	SE	E	SW	S	NW	W	Roof
1	5	5	5	5	5	7	8	8	2
2	3	3	3	3	3	4	5	4	0
3	2	2	2	2	2	2	3	2	-2
4	0	0	0	0	0	1	1	1	-4
5	-1	-1	-1	-1	-1	0	0	-1	-5
6	-2	-2	-1	-2	-2	-1	-1	-2	-6
7	-1	2	2	0	-2	-2	-2	-2	-4
8	3	13	15	8	-1	0	0	-1	4
9	7	26	32	20	2	2	2	2	17
10	9	36	47	33	7	5	5	5	32
11	11	39	55	43	14	9	9	9	48
12	14	37	57	50	24	13	13	13	62
13	18	33	52	53	33	20	17	17	74
14	21	31	44	51	42	30	23	21	82
15	24	29	38	45	47	41	33	25	86
16	26	29	34	39	48	53	46	32	85
17	27	29	32	35	46	61	59	41	80
18	28	28	30	31	40	65	69	51	70
19	28	26	27	28	33	62	73	57	56
20	27	23	23	24	27	53	66	54	39
21	22	18	19	19	21	39	50	42	25
22	17	14	14	14	15	27	34	29	15
23	12	10	11	11	11	17	22	19	9
24	8	7	8	8	8	11	14	12	5

	Corr. Wall CLTD								Corr. Roof CLTD	
Wall Area (ft^2)		288		408		288		408		Total Delta T of Heat Gain from
Hour Of The Day	NE	N	SE	E	SW	S	NW	W	Roof	
1	2	2	2	2	2	4	5	5	-1	26
2	0	0	0	0	0	1	2	1	-3	4
3	-1	-1	-1	-1	-1	-1	0	-1	-5	-9
4	-3	-3	-3	-3	-3	-2	-2	-2	-7	-25
5	-4	-4	-4	-4	-4	-3	-3	-4	-8	-35
6	-5	-5	-4	-5	-5	-4	-4	-5	-9	-43
7	-4	-1	-1	-3	-5	-5	-5	-5	-7	-33
8	0	10	12	5	-4	-3	-3	-4	1	17
9	4	23	29	17	-1	-1	-1	-1	14	86
10	6	33	44	30	4	2	2	2	29	155
11	8	36	52	40	11	6	6	6	45	213
12	11	34	54	47	21	10	10	10	59	259
13	15	30	49	50	30	17	14	14	71	293
14	18	28	41	48	39	27	20	18	79	321
15	21	26	35	42	44	38	30	22	83	344
16	23	26	31	36	45	50	43	29	82	368
17	24	26	29	32	43	58	56	38	77	386
18	25	23	27	28	37	62	66	48	67	386
19	25	23	24	25	30	59	70	54	53	366
20	24	20	20	21	24	50	63	51	36	312
21	19	15	16	16	18	36	47	39	22	231
22	14	11	11	11	12	24	31	26	12	155
23	9	7	8	8	8	14	19	16	6	98
24	5	4	5	5	5	8	11	9	2	57

Solar Radiation Delta T for different hours of the day										
Hour Of The Day	**NE**	**N**	**SE**	**E**	**SW**	**S**	**NW**	**W**	**Roof**	**Total Heat Gain from radiation on walls and roof**
1	0	40	0	56	0	74	0	128	-22	277
2	0	6	0	8	0	23	0	32	-88	-19
3	0	-11	0	-16	0	-11	0	-16	-155	-208
4	0	-45	0	-64	0	-28	0	-40	-221	-397
5	0	-62	0	-88	0	-45	0	-88	-255	-537
6	0	-79	0	-112	0	-62	0	-112	-288	-652
7	0	-11	0	-64	0	-79	0	-112	-221	-486
8	0	175	0	128	0	-45	0	-88	45	216
9	0	396	0	416	0	-11	0	-16	478	1263
10	0	565	0	728	0	40	0	56	977	2367
11	0	616	0	968	0	108	0	152	1510	3354
12	0	582	0	1136	0	175	0	248	1976	4118
13	0	514	0	1208	0	294	0	344	2375	4736
14	0	480	0	1160	0	463	0	440	2642	5186
15	0	446	0	1016	0	650	0	536	2775	5424
16	0	446	0	872	0	853	0	704	2742	5618
17	0	446	0	776	0	989	0	920	2575	5707
18	0	396	0	680	0	1056	0	1160	2242	5535
19	0	396	0	608	0	1005	0	1304	1776	5090
20	0	345	0	512	0	853	0	1232	1210	4153
21	0	260	0	392	0	616	0	944	744	2957
22	0	192	0	272	0	413	0	632	411	1921
23	0	125	0	200	0	243	0	392	211	1172
24	0	74	0	128	0	141	0	224	78	646

McMILLEN JACOBS ASSOCIATES

Equipment Heat Gain					
Item	Raw Load (kW)	Qty	Total Raw Load (kW)	Heat Gain %	Total Heat Gain (Btu/hr)
Misc. Electrical load	0.000	0	0.00	100%	0
	0.000	0	0.00	100%	0
	0.000	0	0.000	100%	0
			0.00		0

Heating and Cooling Load Summary

Cooling Load Summary

Category		Heat Gain (Btu/hr)
Radiation Heat Gain (Btu/hr)		5707
Envelope Heat Gain (Btu/hr)		8481
Equipment Heat Gain (Btu/hr)		0
Total Required Cooling	Total (Btu/hr)	14188
	Total (Tons)	1.2

Heating Load Summary

Category		Heat Loss (Btu/hr)
Envelope (Btu/hr)		13146
Electrical Equip Heat Output (Btu/hr)		0
Total Required Heating	Total (Btu/hr)	13146
	TOTAL (kW)	3.9

SUBJECT: Klamath River Renewal Corporation
Fall Creek Hatchery
Electrical Room HVAC Calculations

BY: C. Gregory **CHK'D BY:** K. DeSomber
DATE: 5/22/2020
PROJECT NO.: 20-024

Purpose

The purpose of this calculation sheet is to determine the heating and cooling loads within the electrical room.

Calculations

Total Building Skin Heat Loss During Winter Time

FORMULAS Q = U * A * DT

Length (ft)	Width (ft)	Height (ft)		
13	10	12		
outdoor temp (F)	**indoor temp (F)**	**Avg OutdoorTemp Range (F)**		
15.9	50	35.3		
Wall Area (ft^2)	**Roof Pitch**	**Wall Area below Roof Pitch (ft^2)**	**Roof Area (ft^2)**	**Floor Area (ft^2)**
566	0.083	14.08	133	46
R-value Walls (ft2·°F·h) / BTU	**R-value Roof (ft2·°F·h) / BTU**	**R-value Floor (ft2·°F·h) / BTU**		
17	25	0.73		
Infiltration Rate (ACH) (Ft^3/Hr)				
0.6				
Heat Loss Walls (Btu/hr)	**Heat Loss Roof (Btu/hr)**	**Heat Loss Floor (Btu/hr)**	**Heat Loss Infiltration (Btu/hr)**	
1135	181	2149	575	
TOTAL Heat Loss (Btu/hr)	**TOTAL Heat Loss (kW)**			
4040	1.18			

Total Building Skin Heat Gain During Summer Time

FORMULAS **Q = U * A * DT**

Length (ft)	Width (ft)	Height (ft)		
13	10	12		
outdoor temp (F)	**indoor temp (F)**	**Avg OutdoorTemp Range (F)**		
97.0	75	35.3		
Wall Area (ft^2)	**Roof Pitch**	**Wall Area below Roof Pitch (ft^2)**	**Roof Area (ft^2)**	**Floor Area (ft^2)**
566	0.083	14.08	133	46
R-value Walls (ft2·°F·h) / BTU	**R-value Roof (ft2·°F·h) / BTU**	**R-value Floor (ft2·°F·h) / BTU**		
17	25	0.73		
Infiltration Rate (ACH) (Ft^3/Hr)				
0.6				
Heat Gain Walls (Btu/hr)	**Heat Gain Roof (Btu/hr)**	**Heat Gain Floor (Btu/hr)**	**Heat Gain Infiltration (Btu/hr)**	
733	117	1386	371	
TOTAL Heat Gain (Btu/hr)				
2606				

	Wall Type (#1)								Roof type (#2)
Wall Area (ft^2)		120		156		120		0	
Hour Of The Day	N	NE	E	SE	S	SW	W	NW	Roof
1	5	5	5	5	5	7	8	8	2
2	3	3	3	3	3	4	5	4	0
3	2	2	2	2	2	2	3	2	-2
4	0	0	0	0	0	1	1	1	-4
5	-1	-1	-1	-1	-1	0	0	-1	-5
6	-2	-2	-1	-2	-2	-1	-1	-2	-6
7	-1	2	2	0	-2	-2	-2	-2	-4
8	3	13	15	8	-1	0	0	-1	4
9	7	26	32	20	2	2	2	2	17
10	9	36	47	33	7	5	5	5	32
11	11	39	55	43	14	9	9	9	48
12	14	37	57	50	24	13	13	13	62
13	18	33	52	53	33	20	17	17	74
14	21	31	44	51	42	30	23	21	82
15	24	29	38	45	47	41	33	25	86
16	26	29	34	39	48	53	46	32	85
17	27	29	32	35	46	61	59	41	80
18	28	28	30	31	40	65	69	51	70
19	28	26	27	28	33	62	73	57	56
20	27	23	23	24	27	53	66	54	39
21	22	18	19	19	21	39	50	42	25
22	17	14	14	14	15	27	34	29	15
23	12	10	11	11	11	17	22	19	9
24	8	7	8	8	8	11	14	12	5

	Corr. Wall CLTD								Corr. Roof CLTD	
Wall Area (ft^2)		120		156		120		0		Total Delta T of Heat Gain from
Hour Of The Day	N	NE	E	SE	S	SW	W	NW	Roof	
1	2	2	2	2	2	4	5	5	-1	23
2	0	0	0	0	0	1	2	1	-3	0
3	-1	-1	-1	-1	-1	-1	0	-1	-5	-13
4	-3	-3	-3	-3	-3	-2	-2	-2	-7	-29
5	-4	-4	-4	-4	-4	-3	-3	-4	-8	-39
6	-5	-5	-4	-5	-5	-4	-4	-5	-9	-47
7	-4	-1	-1	-3	-5	-5	-5	-5	-7	-37
8	0	10	12	5	-4	-3	-3	-4	1	13
9	4	23	29	17	-1	-1	-1	-1	14	82
10	6	33	44	30	4	2	2	2	29	151
11	8	36	52	40	11	6	6	6	45	209
12	11	34	54	47	21	10	10	10	59	255
13	15	30	49	50	30	17	14	14	71	289
14	18	28	41	48	39	27	20	18	79	317
15	21	26	35	42	44	38	30	22	83	340
16	23	26	31	36	45	50	43	29	82	364
17	24	26	29	32	43	58	56	38	77	383
18	25	23	27	28	37	62	66	48	67	382
19	25	23	24	25	30	59	70	54	53	362
20	24	20	20	21	24	50	63	51	36	308
21	19	15	16	16	18	36	47	39	22	227
22	14	11	11	11	12	24	31	26	12	151
23	9	7	8	8	8	14	19	16	6	94
24	5	4	5	5	5	8	11	9	2	53

Solar Radiation Delta T for different hours of the day										
Hour Of The Day	**N**	**NE**	**E**	**SE**	**S**	**SW**	**W**	**NW**	**Roof**	**Total Heat Gain from radiation on walls and roof**
1	0	13	0	17	0	28	0	0	-6	53
2	0	-1	0	-1	0	6	0	0	-16	-12
3	0	-8	0	-10	0	-8	0	0	-27	-53
4	0	-22	0	-28	0	-15	0	0	-38	-103
5	0	-29	0	-38	0	-22	0	0	-43	-131
6	0	-36	0	-47	0	-29	0	0	-48	-160
7	0	-8	0	-28	0	-36	0	0	-38	-110
8	0	70	0	45	0	-22	0	0	5	98
9	0	162	0	155	0	-8	0	0	74	383
10	0	232	0	274	0	13	0	0	153	673
11	0	253	0	366	0	42	0	0	238	899
12	0	239	0	430	0	70	0	0	312	1052
13	0	211	0	458	0	119	0	0	376	1164
14	0	197	0	440	0	190	0	0	418	1245
15	0	183	0	384	0	268	0	0	440	1275
16	0	183	0	329	0	352	0	0	434	1299
17	0	183	0	293	0	409	0	0	410	1295
18	0	162	0	256	0	437	0	0	355	1209
19	0	162	0	228	0	416	0	0	281	1086
20	0	140	0	192	0	352	0	0	190	875
21	0	105	0	146	0	253	0	0	116	621
22	0	77	0	100	0	169	0	0	63	409
23	0	49	0	72	0	98	0	0	31	251
24	0	28	0	45	0	56	0	0	10	138

Equipment Heat Gain

Item	Raw Load (kW)	Qty	Total Raw Load (kW)	Heat Gain %	Total Heat Gain (Btu/hr)
Misc. Electrical load	2.500	1	2.50	100%	8533
	0.000	0	0.00	100%	0
	0.000	0	0.000	100%	0
			2.50		8533

Heating and Cooling Load Summary

Cooling Load Summary

Category		Heat Gain (Btu/hr)
Radiation Heat Gain (Btu/hr)		1299
Envelope Heat Gain (Btu/hr)		2606
Equipment Heat Gain (Btu/hr)		8533
Total Required Cooling	Total (Btu/hr)	12438
	Total (Tons)	1.0

Heating Load Summary

Category		Heat Loss (Btu/hr)
Envelope (Btu/hr)		4040
Electrical Equip Heat Output (Btu/hr)		0
Total Required Heating	Total (Btu/hr)	4040
	TOTAL (kW)	1.2

SUBJECT: Klamath River Renewal Corporation
Fall Creek Hatchery
Ventilation Calculations

BY: C. Gregory **CHK'D BY:** K. DeSomber
DATE: 5/22/2020
PROJECT NO.: 20-024

Purpose

The purpose of this calculation sheet is to determine the ventilation requirements in each of the hatchery buildings.

Calculations

Hatchery Ventilation Requirements

Description	Area (sf)	Height (ft)	Density	P_z	R_p	R_a	V_{bz}	E_z	V_{oz}	1 CFM/SF	6 ACH	Design
Coho Buildin	3575	18	10.00	35.8	5	0.06	393	1	393	3,575	6,435	393
Incubation Bu	3,111	12	10.00	31.1	5	0.06	342	1	342	3,111	1,244	342
Spawning Bu	816	12	10.00	8.2	5	0.06	90	1	90	816	326	90
Total	7,502								825	7,502	8,006	825

Appendix E
Electrical Design Calculations

Calculation Cover Sheet

Project:	Fall Creek Fish Hatchery		
Client:	Klamath River Renewal Corporation (KRRC)	**Proj. No.:**	20-024
Title:	Electrical Calculations		
Prepared By, Name:	Mitchell Skelton		
Prepared By, Signature:		**Date:**	6/1/2020
Peer Reviewed By, Name:	John Bakken		
Peer Reviewed, Signature:		**Date:**	6/1/2020

SUBJECT:	Klamath River Renewal Corporation (KRRC)	**BY:** M. Skelton	**CHK'D BY:** J. Bakken
	Fall Creek Fish Hatchery	**DATE:** 06/01/2020	
	Electrical Calculations - Table of Content	**PROJECT NO.:** 20-024	

Table of Content

Electrical **Page**

SUBJECT:	Klamath River Renewal Corporation (KRRC)	**BY:** M. Skelton	**CHK'D BY:** J. Bakken
	Fall Creek Fish Hatchery	**DATE:** 06/01/2020	
	Lighting Level Calcs	**PROJECT NO.:** 20-024	

Purpose

The purpose of this calculation sheet is to analyze the required fixture and lumen count to achieve a desired light level for a given room or area.

Information - Input

Room/Area: Coho Building

Design footcandle (ave. maintained), F: 20 fc

Luminaire H1 manuf.: LITHONIA
Luminaire H1 Cat. No.: JCBL 18000LM ACCR ACRFGL MVOLT GZ10 40K 80CRI E10WCP DWHXD

Luminaire H2 manuf.: LITHONIA
Luminaire H2 Cat. No.: JCBL 24000LM ACCR ACRFGL MVOLT GZ10 40K 80CRI E10WCP DWHXD

	Fixture H1:		Fixture H2:	
Lamp type:	LED		LED	
Total lumens for fixture, Lf:	17018	lumens	22090	lumens

Room Shape:		Rectangular		
Room/Area dimensions:	Length, L =	65	ft.	
	Width, W =	50	ft.	
	Fixture mounting height (highest), H =	14	ft.	
	Work plane, P =	2.5	ft.	
	Area, A =	3250	sq. ft.	
	Perimeter, P =	230	ft.	
	Cavity Depth, D =	11.5	ft.	*D=(H-P)*

Fixture maintenance factor, M: 0.93

Reflectances:	Ceiling:	80	%
	Walls:	50	%
	Floors:	20	%

Calculation

Room cavity ratio calculation:						*RCR (Rectangular Rooms) = (5*D*(L+W))/A*
	RCR=	2.03				*RCR (Irregular Rooms) = (2.5*D*P)/A*
Coefficient of Utilization from table:						
	CU=	0.39				
Required total lumens for room:		65000	lumens			*Lr = (F*A)*
Minimum no. of fixtures required		Fixture A:		Fixture B:		
to achieve desired footcandles:		10.5	fixtures	8.1	fixtures	*N = (Lr)/(Lf*M*CU)*

Conclusions

Choice #1 -					
Alternate no. of fixtures used, n1:	12	fixtures	9	fixtures	
Footcandles produced, f1:	22.8	fc	22.2	fc	*f1=(F*n1)/N*
Choice #2 -					
Alternate no. of fixtures used, n2:	16	fixtures	12	fixtures	
Footcandles produced, f2:	30.4	fc	29.6	fc	*f2=(F*n2)/N*

Choices #1 and #2 provide reasonable illumination to the area for night-time working conditions.
Select Choice #1 for a cost-effective illumination capacity and dimmability range.

McMILLEN JACOBS ASSOCIATES

SUBJECT:	Klamath River Renewal Corporation (KRRC)	**BY:** M. Skelton	**CHK'D BY:** J. Bakken
	Fall Creek Fish Hatchery	**DATE:** 06/01/2020	
	Lighting Level Calcs	**PROJECT NO.:** 20-024	

Purpose

The purpose of this calculation sheet is to analyze the required fixture and lumen count to achieve a desired light level for a given room or area.

Information - Input

Room/Area: Chinook Incubation Building

Design footcandle (ave. maintained), F: 20 fc

Luminaire H1 manuf.: LITHONIA
Luminaire H1 Cat. No.: JCBL 18000LM ACCR ACRFGL MVOLT GZ10 40K 80CRI E10WCP DWHXD

Luminaire H2 manuf.: LITHONIA
Luminaire H2 Cat. No.: JCBL 24000LM ACCR ACRFGL MVOLT GZ10 40K 80CRI E10WCP DWHXD

	Fixture H1:		Fixture H2:	
Lamp type:	LED		LED	
Total lumens for fixture, Lf:	17018	lumens	22090	lumens

Room Shape:		Rectangular		
Room/Area dimensions:	Length, L =	60	ft.	
	Width, W =	50	ft.	
	Fixture mounting height (highest), H =	12	ft.	
	Work plane, P =	2.5	ft.	
	Area, A =	3000	sq. ft.	
	Perimeter, P =	220	ft.	
	Cavity Depth, D =	9.5	ft.	*D=(H-P)*
Fixture maintenance factor, M:		0.93		
Reflectances:	Ceiling:	80	%	
	Walls:	50	%	
	Floors:	20	%	

Calculation

Room cavity ratio calculation:						*RCR (Rectangular Rooms) = (5*D*(L+W))/A*
	RCR=	1.74				*RCR (Irregular Rooms) = (2.5*D*P)/A*
Coefficient of Utilization from table:						
	CU=	0.4				
Required total lumens for room:		60000	lumens			*Lr = (F*A)*
Minimum no. of fixtures required		Fixture A:		Fixture B:		
to achieve desired footcandles:		9.5	fixtures	7.3	fixtures	*N = (Lr)/(Lf*M*CU)*

Conclusions

Choice #1 -					
Alternate no. of fixtures used, n1:	10	fixtures	8	fixtures	
Footcandles produced, f1:	21.1	fc	21.9	fc	*f1=(F*n1)/N*
Choice #2 -					
Alternate no. of fixtures used, n2:	12	fixtures	9	fixtures	
Footcandles produced, f2:	25.3	fc	24.7	fc	*f2=(F*n2)/N*

Choices #1 and #2 provide reasonable illumination to the area for night-time working conditions.
Select Choice #2 for a cost-effective illumination capacity and dimmability range, and practical layout.

SUBJECT:	Klamath River Renewal Corporation (KRRC)	**BY:** M. Skelton	**CHK'D BY:** J. Bakken
	Fall Creek Fish Hatchery	**DATE:** 06/01/2020	
	Lighting Level Calcs	**PROJECT NO.:** 20-024	

Purpose

The purpose of this calculation sheet is to analyze the required fixture and lumen count to achieve a desired light level for a given room or area.

Information - Input

Room/Area: Chinook Incubation Building - Electrical Room

Design footcandle (ave. maintained), F: 20 fc

Luminaire manuf.: LITHONIA
Luminaire Cat. No.: MSL 8000LM L/LV 120 GZ10 40K 80CRI E10WLCP WH

Lamp type: LED
Total lumens for fixture, Lf: 8733 lumens

Room Shape: Rectangular

Room/Area dimensions:			
Length, L =	12	ft.	
Width, W =	9	ft.	
Fixture mounting height (highest), H =	12	ft.	
Work plane, P =	2.5	ft.	
Area, A =	108	sq. ft.	
Perimeter, P =	42	ft.	
Cavity Depth, D =	9.5	ft.	*D=(H-P)*

Fixture maintenance factor, M: 0.91

Reflectances:		
Ceiling:	80	%
Walls:	50	%
Floors:	20	%

Calculation

Room cavity ratio calculation:
RCR= 9.24

*RCR (Rectangular Rooms) = (5*D*(L+W))/A*
*RCR (Irregular Rooms) = (2.5*D*P)/A*

Coefficient of Utilization from table:
CU= 0.185

Required total lumens for room: 2160 lumens *Lr=(F*A)*

Minimum no. of fixtures required to achieve desired footcandles: 1.5 fixtures *N=(Lr)/(Lf*M*CU)*

Conclusions

Choice #1 -
Alternate no. of fixtures used, n1: 2 fixtures
Footcandles produced, f1: 27.2 fc *f1=(F*n1)/N*

Choice #2 -
Alternate no. of fixtures used, n2: 3 fixtures
Footcandles produced, f2: 40.8 fc *f2=(F*n2)/N*

Choice #1 provides reasonable illumination to the area for general working conditions. Choice #2 provides exceptional illumination to the area. Select Choice #1 for a cost-effective illumination capacity.

McMILLEN JACOBS ASSOCIATES

SUBJECT:	Klamath River Renewal Corporation (KRRC)	**BY:** M. Skelton	**CHK'D BY:** J. Bakken
	Fall Creek Fish Hatchery	**DATE:** 06/01/2020	
	Lighting Level Calcs	**PROJECT NO.:** 20-024	

Purpose

The purpose of this calculation sheet is to analyze the required fixture and lumen count to achieve a desired light level for a given room or area.

Information - Input

Room/Area: Spawning Building

Design footcandle (ave. maintained), F: 20 fc

Luminaire H1 manuf.: LITHONIA
Luminaire H1 Cat. No.: JCBL 18000LM ACCR ACRFGL MVOLT GZ10 40K 80CRI E10WCP DWHXD

Luminaire H2 manuf.: LITHONIA
Luminaire H2 Cat. No.: JCBL 24000LM ACCR ACRFGL MVOLT GZ10 40K 80CRI E10WCP DWHXD

	Fixture H1:		Fixture H2:	
Lamp type:	LED		LED	
Total lumens for fixture, Lf:	17018	lumens	22090	lumens

Room Shape: Rectangular

Room/Area dimensions:			
Length, L =	35	ft.	
Width, W =	25	ft.	
Fixture mounting height (highest), H =	14	ft.	
Work plane, P =	2.5	ft.	
Area, A =	875	sq. ft.	
Perimeter, P =	120	ft.	
Cavity Depth, D =	11.5	ft.	*D=(H-P)*

Fixture maintenance factor, M: 0.93

Reflectances:		
Ceiling:	80	%
Walls:	50	%
Floors:	20	%

Calculation

Room cavity ratio calculation:
RCR= 3.94
*RCR (Rectangular Rooms) = (5*D*(L+W))/A*
*RCR (Irregular Rooms) = (2.5*D*P)/A*

Coefficient of Utilization from table:
CU= 0.3

Required total lumens for room: 17500 lumens *Lr = (F*A)*

	Fixture A:		Fixture B:		
Minimum no. of fixtures required to achieve desired footcandles:	3.7	fixtures	2.8	fixtures	*N = (Lr)/(Lf*M*CU)*

Conclusions

Choice #1 -					
Alternate no. of fixtures used, n1:	4	fixtures	3	fixtures	
Footcandles produced, f1:	21.7	fc	21.1	fc	*f1=(F*n1)/N*
Choice #2 -					
Alternate no. of fixtures used, n2:	6	fixtures	4	fixtures	
Footcandles produced, f2:	32.6	fc	28.2	fc	*f2=(F*n2)/N*

Choice #1 provides reasonable illumination to the area for night-time working conditions. Choice #2 provides exceptional illumination to the area.

Project information

Project name: Fall Creek Fish Hatchery
Customer's name: Klamath River Renewal Corporation

Site requirements

Voltage:	277/480
Phase:	3
Frequency:	60Hz
Alt. Temp. Rise Duty:	130°C Standby
Qty of Gensets:	1
Fuel type:	LP Vapor
Country :	United States

Application:	Construction
Emissions Requirement:	Stationary emergency (US EPA)
Altitude:	2589 Feet
Max. Ambient Temp.:	100 Degrees F
Min. Genset Loading :	10 %
Max. Genset Loading :	100 %

Site load requirements summary

Running kW:	92.95
Running kVA:	94.37
Running P.F.:	0.98

Max. Starting kW:	122.71 in step 1
Max. Starting kVA:	132.23 in step 1

Generator selection

Genset Model:	180REZXB
Engine:	Doosan 11.1L
Emission level:	EPA Certified
BHP:	302.00
Displacement:	674.00
RPM:	1800

Alternator:	4S13X
Alternator Leads:	12
Alt. Starting kVA **at 35% V dip**:	570.00
Cal Alt Temp rise with site loads:	80C
Excitation System :	PMG

Rated kW :	130.00
Site Rated kW :	119.52
Seismic Certified	
UL 2200 Certified	

Generator Performance Summary

Voltage Dip Limit:	15.00 %
Frequency Dip Limit:	10.00 %
Harmonic Distortion Limit:	10.00 %

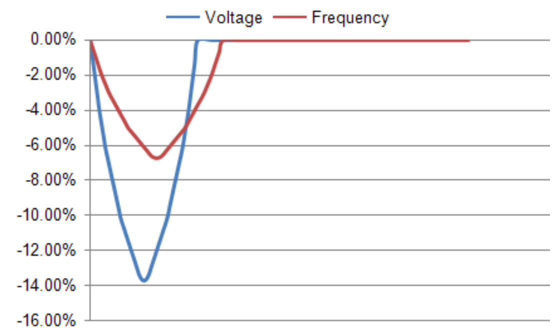
Calculated Voltage Dip:	13.69 %
Calculated Frequency Dip:	6.71 %
Calculated Harmonic Distortion:	0.42 %
Calculated Genset % Loaded:	77.77 %

Software version: 1.0033.5.99

Model : 180REZXB, Alternator : 4S13X

Load Profile

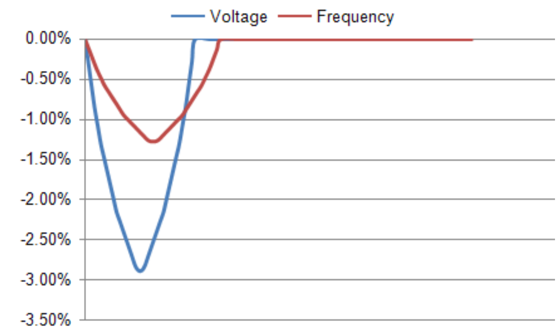
Step # 1	Qty	Run			Start			Volt Dip %	Freq Dip %	Volt. Dist. %
		kW	kVA	PF	kW	kVA	PF			
Misc. Linear Load **480V Heating Loads** **3 Phase**	1	49.50	49.50	1.00	49.50	49.50	1.00			
Motor **Traveling Screens** **1.00 HP** **3 Phase** **Motor code : L** **Loaded** **NEMA Design** **across the line**	2	1.99	2.84	0.70	12.92	19.00	0.68			
Motor **Traveling Screen Pumps** **1.50 HP** **3 Phase** **Motor code : L** **Loaded** **NEMA Design** **across the line**	2	2.98	4.14	0.72	17.96	28.50	0.63			
Misc. Linear Load **208V Heating Loads** **3 Phase**	1	18.00	18.00	1.00	18.00	18.00	1.00			
Motor **Split AC Unit - Elec Rm** **1.54 HP** **Phase B-C** **Motor code : L** **Loaded** **NEMA Design** **across the line**	1	1.50	2.08	0.72	9.19	14.59	0.63			



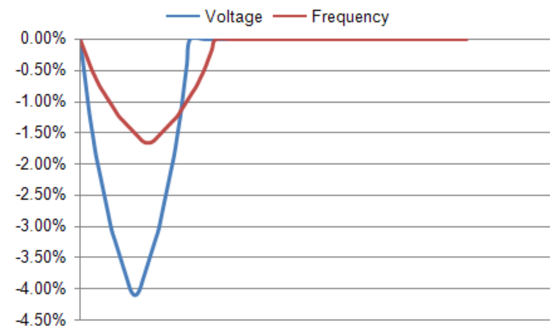
Software version: 1.0033.5.99

Step # 1	Qty	Run			Start			Volt Dip %	Freq Dip %	Volt. Dist. %
		kW	kVA	PF	kW	kVA	PF			
Motor **Sump Pump** **1.00 HP** **Phase B-N** **Motor code : L** **Loaded** **NEMA Design** **across the line**	1	0.99	0.99	1.00	9.50	9.50	1.00			
Lighting **Lighting** **Evenly distributed** **LED** **Filtered Ballast**	1	3.84	4.27	0.90	3.84	4.27	0.90			
Misc. Linear Load **Convenience Receptacles** **3 Phase**	1	5.62	7.02	0.80	0.80	0.80	1.00			
Misc. Linear Load **SCADA** **3 Phase**	1	1.00	1.00	1.00	1.00	1.00	1.00			
Step Total		85.42	86.32	0.99	122.71	132.23	0.93	13.69	6.71	0.42
Cum.Total		85.42	86.32	0.99						

Step # 2	Qty	Run			Start			Volt Dip %	Freq Dip %	Volt. Dist. %
		kW	kVA	PF	kW	kVA	PF			
Motor **Conveyor Belt** **1.50 HP** **Phase A-B** **Motor code : H** **Loaded** **NEMA Design** **across the line**	1	1.47	1.77	0.83	10.05	10.05	1.00			
Motor **Fish Lift Hoist, EA Tank Hoist, or EA Unit** **2.00 HP** **Phase A-N** **Motor code : J** **Loaded** **NEMA Design** **across the line**	1	1.90	2.14	0.89	15.10	15.10	1.00			
Step Total		3.37	3.90	0.86	25.15	25.15	1.00	2.88	1.27	0.42
Cum.Total		88.80	89.96	0.99						



Step # 3	Qty	Run			Start			Volt Dip %	Freq Dip %	Volt. Dist. %
		kW	kVA	PF	kW	kVA	PF			
Motor **Coho Exhaust Fans** **0.75 HP** **Phase B-N** **Motor code : L** **Loaded** **NEMA Design** **across the line**	2	1.55	1.55	1.00	14.25	14.25	1.00			
Motor **Chinook Exhaust Fans** **0.50 HP** **Phase C-N** **Motor code : L** **Loaded** **NEMA Design** **across the line**	2	1.08	1.35	0.80	9.50	9.50	1.00			
Motor **Spawn Bldg Exhaust Fan** **0.50 HP** **Phase C-N** **Motor code : L** **Loaded** **NEMA Design** **across the line**	1	0.54	0.67	0.80	4.75	4.75	1.00			
Motor **Misc Duct Fans** **0.17 HP** **Phase C-N** **Motor code : L** **Loaded** **NEMA Design** **across the line**	3	0.59	0.73	0.80	4.85	4.85	1.00			



Step # 3	Qty	Run			Start			Volt Dip %	Freq Dip %	Volt. Dist. %
		kW	kVA	PF	kW	kVA	PF			
Motor **Motorized Dampers** **0.08 HP** **Phase C-N** **Motor code : L** **Loaded** **NEMA Design** **across the line**	5	0.40	0.50	0.80	3.06	3.82	0.80			
Step Total		4.15	4.59	0.91	36.40	36.47	1.00	4.09	1.66	0.42
Cum.Total		92.95	94.37	0.98						
Grand Total		92.95	94.37	0.98				13.69	6.71	0.42

Appendix F
Biological Design Criteria Technical Memo

Technical Memorandum 001

To:	Klamath River Renewal Corporation California Department of Fish and Wildlife	Project:	Fall Creek Fish Hatchery
From:	Jodi Burns, Project Manager Derek Nelson Jeff Heindel	cc:	Mort McMillen, P.E. – McMillen Jacobs File
Date:	March 11, 2020	Job No.:	20-024
Subject:	Technical Memo 001 – Fall Creek Fish Hatchery Biological Design Criteria, Rev 02		

Revision Log

Revision No.	Date	Revision Description
0	02/27/2020	Initial Draft
1	03/02/2020	KRRC Comments Addressed
2	03/11/2020	CDFW Comments Addressed; Final

1.0 Introduction

Technical Memorandum (TM) No. 001 summarizes the biological design criteria that will be used as the basis for the development of the California Department of Fish and Wildlife's (CDFW) Fall Creek Fish Hatchery (FCFH) project (Project). The criteria presented within this TM provide key water supply and fish culture facility programming information that will serve as the foundation for the Alternatives Analysis to evaluate potential modifications to the existing fish hatchery facility, as well as the selected alternative design development.

The following acronyms and abbreviations are used within this TM:

CDFW	California Department of Fish and Wildlife
cfs	cubic feet per second
CTU	Celsius temperature unit
CWT	coded-wire tag
DI	density index
D.O.	dissolved oxygen
FCFH	Fall Creek Fish Hatchery
FI	flow index
fpp	fish per pound
ft^3	cubic feet
gpm	gallons per minute
HRT	hydraulic retention time

IGFH	Iron Gate Fish Hatchery
lb/cf/in	pounds of fish per cubic foot of rearing volume per inch of fish length
lbs/ft^3	pounds of fish per cubic foot of rearing space
mm	millimeter
NPDES	National Pollutant Discharge Elimination System
Project	Fall Creek Fish Hatchery Project
R	water turnovers per hour
TM	Technical Memorandum

2.0 Background

The Klamath River Restoration Project includes removal of four (4) dams along the Klamath River and a new hatchery to provide salmon mitigation production for a period of eight (8) years. The original 50 percent design package was developed by CDM Smith as a subconsultant to AECOM. The 50 percent design included proposed modifications to FCFH with the capability of rearing the current Coho Salmon *Oncorhynchus kisutch* yearling target (~ 75,000 yearlings at ~ 10 fish per pound [fpp]; ~ May release [age-1+]), ~ 115,000 Chinook Salmon *O. tshawytscha* yearlings (~ 10 fpp; November release [age-1+]), and approximately 2,885,000 Chinook sub-yearlings (~ 90 fpp; May release [age-0+]) using mixed-size, dual-drain circular tanks. The design included incubation and spawn-building structures, a concrete pad for ball-and-hitch camper (single-resident temporary housing), and a clarifier to handle increased effluent demands. Limited impacts to the existing facility "footprint" were considered throughout the design process. The design included facilities and land-disturbing activities on both the east and west sides of Fall Creek.

During the technical review of the 50 percent design package (CDM Smith, 2019), several areas of the proposed FCFH design were identified that could benefit from a refined analysis and design approach. The analysis started with the basic input parameters of the hatchery bioprogram with the goal of achieving an optimum rearing configuration considering fish numbers, rearing flow, and rearing densities. The refined bioprogram is presented within this TM. Once the proposed program has been reviewed and approved by CDFW, the FCFH layout will be updated to reflect the final rearing unit numbers, type, water supply piping, and effluent treatment.

3.0 Proposed Facility Upgrades

Site layout and land-disturbing activities/areas were generally addressed in the 50 percent drawing package. Moving forward with continued facility design alternatives, CDFW acknowledged that both ongoing and future permitting discussions dictate that future changes to the design/layout will not deviate from the impact areas provided in the previous design. The previous design suggested major facility upgrades on both the east and west sides of Fall Creek with recommendations to remove all existing infrastructure (e.g., old fish production raceways); initial site investigations conducted by McMillen Jacobs staff on January 28, 2020 suggest that future design is likely possible exclusively on the east side of Fall Creek (minimal to no infrastructure upgrades on west side) and that existing raceways (2 north of Copco Road, 4 south of Copco Road) could be retained (renovated) to minimize the need for "new" aquaculture rearing space.

Initial bio-programming efforts will determine an "optimum" number of fish to be reared over a calendar year based on CDFW guidelines. The total number of fish that can be reared to a certain size (biomass) are directly linked to the key variables of total water flow available (gallons per minute [gpm] and cubic feet per second [cfs]) and total rearing space available (cubic feet of rearing space). Bio-programming analysis presented within this TM will result in determination of a total flow and rearing space requirements to arrive at optimized aquaculture tank/rearing vessels and sizes to meet CDFW aquaculture operational requirements. These preliminary values will be refined as the design is advanced.

The water rights and maximum available flow for the Project are set at 10 cfs. This water right is non-consumptive and water must be returned to Fall Creek with the facility design addressing National Pollutant Discharge Elimination System (NPDES) water quality permit considerations. Facility water treatment designs will be determined after critical aquaculture variables are addressed. Future water treatment design efforts will prioritize the development of systems that maximize water quality/discharge to receiving water bodies (Fall Creek) while minimizing the technological and operational costs of these systems.

4.0 Production Goals

Discussions with CDFW Fish Production staff on January 27, 2020 resulted in a "priority" list of fish species, life stages, and numbers to aid in future design efforts:

- 75,000 Coho yearlings at approximately 10 fpp at release (top priority)
- Adult holding capacity for 100 Coho Salmon adults and 200 Chinook Salmon adults (ideally spawned at Fall Creek facility once production releases return adults to Fall Creek)
- Up to 3M Chinook sub-yearlings at approximately 90 fpp at release (at minimum, 1.5M coded-wire tag [CWT] groups would be ideal for monitoring and evaluation)
- Approximately 115,000 Chinook yearlings at approximately 10 fpp at release (lowest priority)

Table 4-1 provides a high-level overview of fish production goals for the proposed FCFH Program (data compiled from CDFW information):

Table 4-1. Fall Creek Hatchery – Fish Production Goals

Species (Juvenile Life History)	Adult Return*	Incubation Start Date	Incubation Start Number	Target Release Dates	Release Number	Release Size
Coho (Yearling)	Oct. – Dec.	Oct. – Mar.	120,000	Mar. 15 – May 1	75,000	10 fpp
Chinook (Sub-Yearling)	Oct. – Dec.	Oct. – Mar.	4.5M**	Pre-Mar. 31	1,250,000	520 fpp
Chinook (Sub-Yearling)	Oct. – Dec.	Oct. – Mar.	-	May 1 – June 15	1,750,000	90-100 fpp
Chinook (Yearling)	Oct. – Dec.	Oct. – Mar.	-	Oct. 15 – Nov. 20	250,000	10 fpp

*Adult trapping period from Iron Gate Fish Hatchery data

** Estimated Total Green Egg Requirement at Spawning

5.0 Biological Variables

The primary biological variables generally used to develop a preliminary fish hatchery operations schedule include water temperature, species-specific condition factors, growth rates, feed conversion rates, as well as density and flow indices. Understanding that CDFW has prior culture history with the target aquaculture species (Coho, Chinook) and rearing cycles (growth and feed rates relative to period of culture) for the program, the initial bio-programming analysis will identify high-level fish condition factor and growth rate assumptions, provide summary water temperature profile data for the facility, and present recommendations on industry-standard (State/Federal/Tribal conservation programs for Pacific salmon) density and flow indices. These variables will serve as general guidelines for assuring rearing units and water conveyance systems are sized appropriately.

5.1 Fish Condition Factor and Growth Rate

Fish condition factors provide fish culturists with a hypothetical "ideal" condition value of various fish species (body types) that is tied directly to mean fish weight and length. For the purpose of modeling growth and size (total length and/or total weight), a Coho Salmon condition factor of C3500 and a Chinook Salmon condition factor of C3000 are assumed. Coho of a given size (either length or weight) will generally have a higher condition factor than Chinook; for example, Coho juveniles compared to similarly-sized (fish per pound or grams per fish) Chinook juveniles will generally be *shorter* (total length) and *heavier* (mean weight) and have a resulting *higher* condition factor.

Fish growth rate was initially modeled at 0.035 millimeters (mm) per Celsius temperature unit (CTU) per day (0.035 mm/CTU/day) in the original hatchery bio-program documents. Actual growth rates for similar species of fish in similar rearing conditions (water temperature profiles) suggest that this rate is lower than actual rates of growth using conventional fish food diets. CDFW provided actual growth rate data from previous rearing events at FCFH (calendar year 2003 rearing history) that demonstrated that actual growth rates are closer to 0.05 mm/CTU/day for Chinook Salmon. CDFW identified that actual growth rates are controlled by hatchery feeding guidelines and fish may be restricted (growth slowed) during colder periods of rearing (lower metabolic requirements) to target specific release sizes. Fish growth modeling efforts assume a growth rate of 0.045 and 0.05 mm/CTU/day for Coho and Chinook rearing, respectively.

5.2 Water Temperature

Water temperature is a primary determining factor in the development and growth rate of fish. The Fall Creek Fish Hatchery water supply includes a 10 cfs year-round water right from Fall Creek. The Fall Creek water source has a demonstrated history of water temperature ranges (and assumed water *quality* based on prior positive rearing history) that generally favor the growth and development of anadromous salmonids. Figure 5-1 provides mean monthly rearing temperature data (degrees Fahrenheit) for the water source currently supplying the abandoned Fall Creek facility. Additional water chemistry testing is to be completed on source water, with the results described in future TMs.

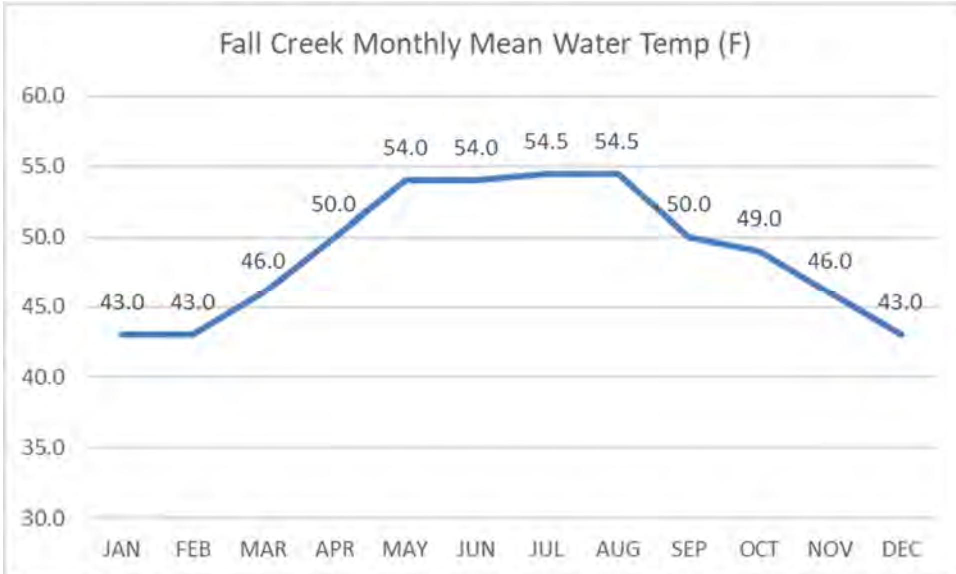


Figure 5-1. Mean Monthly Fall Creek Rearing Temperatures (Data from L. Radford, CDFW)

The proposed facility upgrades will use the existing Fall Creek source as the sole source for water supply to the facility (no groundwater well development planned). The water source, water rights, and general flow rates at the facility will remain unchanged for the proposed project design.

5.3 Density Index

Density index (DI) is a common method for estimating maximum carrying capacity in a rearing vessel. DI is a function of pounds of fish per cubic foot of rearing volume, per inch of fish length (lb/cf/in). The DI used for Pacific salmon species in a raceway (flow-through) environment is typically in the 0.2 to 0.3 range (Heindel, 2020), but can be highly variable depending on species, rearing goals, fish performance, and water quality. Additional information specific to DI is provided in the example below (adapted from Piper et al., 1982) and in Table 5-1:

"A common method for estimating maximum carrying capacity in a tank/raceway is the Density Index (DI). D.I. is a factor which, when multiplied by container volume in CUBIC FEET (V) and by fish length in inches (L) will give the maximum allowable weight of fish (W). A general rule of thumb for salmonids (Pacific salmon in this case) is DI should be from 0.2 to 0.5 (pounds of fish per cubic foot of tank space); fish densities should be no greater than 0.2 to 0.5 times their length in inches (for Pacific salmon)".

Table 5-1. Key DI Calculations

Design Question	Calculation
What is permissible weight of fish?	$W = D * V * L$
What is Density Index (D.I.)?	$D = \frac{W}{(L * V)}$

Design Question	Calculation
What Volume is Required at Certain D.I.?	$V = \frac{W}{(D * L)}$

Where: W = Weight in lbs. (biomass); D = Density Index; V = Volume of Unit in ft^3; L = Fish Length in Inches

"Example: If DI of 0.2 is used, 2-inch fish could be held at a density of 0.4 pounds per cubic foot (0.2 x 2 = 0.4) / If DI of 0.5 is used, 2-inch fish could be held at a density of 1 pounds per cubic foot (0.5 x 2 = 1). Note: DI is useful in estimating carrying capacity but only considers SPACE, not flow!"

CDFW staff generally employ aquaculture rearing guidelines that focus on pounds of fish per cubic foot of rearing space (lbs/ft3) and the rate of water exchange through a given sized vessel. The water exchange is identified as water turnovers per hour (R) and/or hydraulic retention time (HRT) in water exchanges every "X" minutes. Acknowledging that historic survival from green egg through release at Iron Gate Hatchery is extremely variable based on previous survival data provided by CDFW (sub-yearling and/or yearling Chinook and Coho), FCFH rearing volume estimates provided below will assume a maximum DI of 0.3.

It is important to note that conservative rearing values should always be utilized in designing new hatchery facilities. While higher DIs are possible in some circumstances and with some species/stocks of fish, the values used in the current design are considered a prudent starting point providing the greatest number of fish with the highest level of fitness and smolt quality. Production of high-quality juveniles should translate into higher downstream survival of anadromous emigrants with a corresponding increase in adults returning from original hatchery production efforts.

The DI is used to calculate the total volume of rearing space required in terms of cubic feet. Table 5-2 reflects the rearing volume required for the Coho yearling program proposed at the FCFH using density indices of 0.3 and a mean fish size of 10 fpp at release based on current production goals. The total volume can then be divided by the volume of individual rearing units in order to show the total number of rearing units required per scenario. The number of rearing units will vary with fish species, fish size, and management requirements.

Table 5-2. FCFH Coho Bio-Program – DI and Rearing Unit Calculations

75,000 Coho @10 fpp, 6.57" mean, 45.1 g/f mean (C3500 Piper)						
Number Fish	**Fish Size Out (fpp)**	**Fish Size Out (L inches)**	**Fish Size Out (g/f)**	**End Biomass (lbs)**	**D.I. (lb/cf/in)**	**Tank Space Req (cu ft)**
75,000	10	6.570	45.4	7,500	0.3	3,805

The bio-program assumes that CDFW staff will manipulate feed rates (and resulting growth profile) during colder months to achieve the 10 fpp target release size. Based on the fish number and size in Table 5-2, the total maximum rearing volume for Coho yearlings is approximately 3,805 cubic feet. When considering a rearing buffer volume, a total rearing volume of 4,000 cubic feet would be required.

The fish rearing tank numbers and sizes will be discussed with CDFW to select the optimum configuration to meet fish marking, tank changes, and fish health management objectives.

Table 5-3 reflects the rearing volume required for the Chinook sub-yearling/yearling program proposed at the FCFH using density indices of 0.3 and a mean fish size at release based on current production goals. Discussions with CDFW Fish Managers suggest that the new design parameters should consider maximizing full use of the available water (10 cfs). Table 5-3 presents a rearing scenario that was developed to maximize Chinook production at the facility with the following guidelines:

- Initial ponding of approximately 3,250,000 first-feeding fry;
- Rear 3.25M through end of March and release ~ 1.25M sub-yearlings at ~ 520 fpp/0.871 g/f mean size;
- Rear remaining ~ 2.0M through end of May and release ~1.75M sub-yearlings at ~ 104 fpp/4.35 g/f mean size;
- Rear remaining ~250,000 yearlings and release ~ end of November at ~ 10 fpp/45.27 g/f mean size.
- Marking and tagging strategies will be determined at a later date.

Table 5-3. FCFH Chinook Bio-Program – DI and Rearing Unit Calculations

3,250,000 Chinook @521 fpp, 1.862" mean, 0.87 g/f mean (C3000 Piper)						
Number Fish	**Fish Size Out (fpp)**	**Fish Size Out (L inches)**	**Fish Size Out (g/f)**	**End Biomass (lbs)**	**D.I. (lb/cf/in)**	**Tank Space Req (cu ft)**
3,250,000	521	1.862	0.87	6,241	0.3	11,170

2,000,000 Chinook @104 fpp, 3.175" mean, 4.35 g/f mean (C3000 Piper)						
Number Fish	**Fish Size Out (fpp)**	**Fish Size Out (L inches)**	**Fish Size Out (g/f)**	**End Biomass (lbs)**	**D.I. (lb/cf/in)**	**Tank Space Req (cu ft)**
2,000,000	104	3.175	4.35	19,231	0.3	20,190

250,000 Chinook @10 fpp, 6.98" mean, 45.27 g/f mean (C3000 Piper)						
Number Fish	**Fish Size Out (fpp)**	**Fish Size Out (L inches)**	**Fish Size Out (g/f)**	**End Biomass (lbs)**	**D.I. (lb/cf/in)**	**Tank Space Req (cu ft)**
250,000	10	6.980	45.27	25,000	0.3	11,915

The fish rearing tank numbers and sizes will be discussed with CDFW to select the optimum configuration to meet fish marking, tank changes, and fish health management objectives; a follow-up TM will be produced once tank sizes and configuration have been determined.

5.4 Flow Index

Flow index (FI) is a function of pounds of fish per fish length in inches times flow in gallons per minute (gpm). Flow index is an indication of how much oxygen is available for fish metabolism and is adjusted based on the elevation of the project site and water temperature. Both of these variables affect the amount of dissolved oxygen (D.O.) in the water supply at saturation. Additional information specific to FI is provided in the example below (adapted from Piper et al., 1982) and in Table 5-4.

"The Flow Index (FI) describes how rapidly fresh water will replace "used" water (water in which fish have reduced D.O. concentrations and excreted waste products). The FI takes flow rate into consideration when estimating maximum allowable weight of fish that a culture unit can hold."

Table 5-4. Key Flow Index Calculations

Design Question	Calculation
What is Flow Index (F.I.) if you know Weight, Length and Inflow?	$F = \frac{W}{(L * I)}$
What is permissible Weight if you know F.I., Length and Inflow?	$W = F * L * I$
What is Inflow requirement if you know Weight, F.I. and Length?	$I = \frac{W}{(F * L)}$

Where: W = Weight in lbs. (biomass); F = Flow Index; I = Inflow of water in gpm; L = Fish Length in inches

"As a rule of thumb for salmonids (certainly Pacific salmon), FI values should range from 0.5 to 1.5. Actual FI values will depend on several factors, especially the dissolved oxygen concentration of the inflowing water. To correctly estimate the FI for a specific unit, fish are added while water flow is held constant; when enough fish have been added to the system so that the DO level in the outflow has been reduced below ~ 6ppm, the unit is at maximum [fish capacity]."

According to Table 8 in *Fish Hatchery Management* (Piper et al., 1982), the recommended flow index for the FCFH at an elevation of 2,200 feet and a range of actual water temperatures (degrees Fahrenheit) is provided below:

- 40 F = 2.50 FI
- 45 F = 2.10 FI
- 50 F = 1.68 FI
- 55 F = 1.40 FI

Using the conservative design guidelines identified in the DI section above and experience with conservation stocks of both Coho and Chinook salmon (Heindel, 2020), flow considerations modeled below assume an FI of no greater than 1.5. As noted previously, this is a reasonable starting point for a new facility (at stated elevation and water temperature profiles). Rearing experience gained over multiple years will allow operators the opportunity to modify actual FIs based on demonstrated fish performance/survival. Flow indices of 1.5 are applied to the rearing scenarios described previously to establish maximum water requirements for the proposed Coho yearling and Chinook sub-yearling/yearling programs as illustrated in Tables 5-5 and 5-6.

Table 5-5. FCFH Coho Bio-Program – FI and DI Unit Calculations

75,000 Coho @10 fpp, 6.57" mean, 45.1 g/f mean (C3500 Piper)								Single-Pass	
Number Fish	**Fish Size Out (fpp)**	**Fish Size Out (L inches)**	**Fish Size Out (g/f)**	**End Biomass (lbs)**	**D.I. (lb/cf/in)**	**Tank Space Req (cu ft)**	**F.I. (lb/gpm/in)**	**Flow Req (gpm)**	**Flow Req (cfs)**
75,000	10	6.570	45.1	7,500	0.3	3,805	1.50	761	1.70

Table 5-6. FCFH Chinook Bio-Program – FI and DI Unit Calculations

3,250,000 Chinook @521 fpp, 1.862" mean, 0.87 g/f mean (C3000 Piper)								Single-Pass	
Number Fish	**Fish Size Out (fpp)**	**Fish Size Out (L inches)**	**Fish Size Out (g/f)**	**End Biomass (lbs)**	**D.I. (lb/cf/in)**	**Tank Space Req (cu ft)**	**F.I. (lb/gpm/in)**	**Flow Req (gpm)**	**Flow Req (cfs)**
3,250,000	521	1.862	0.87	6,241	0.3	11,170	1.50	2,234	4.98

2,000,000 Chinook @104 fpp, 3.175" mean, 4.35 g/f mean (C3000 Piper)								Single-Pass	
Number Fish	**Fish Size Out (fpp)**	**Fish Size Out (L inches)**	**Fish Size Out (g/f)**	**End Biomass (lbs)**	**D.I. (lb/cf/in)**	**Tank Space Req (cu ft)**	**F.I. (lb/gpm/in)**	**Flow Req (gpm)**	**Flow Req (cfs)**
2,000,000	104	3.175	4.35	19,231	0.3	20,190	1.50	4,028	9.00

250,000 Chinook @10 fpp, 6.98" mean, 45.27 g/f mean (C3000 Piper)								Single-Pass	
Number Fish	**Fish Size Out (fpp)**	**Fish Size Out (L inches)**	**Fish Size Out (g/f)**	**End Biomass (lbs)**	**D.I. (lb/cf/in)**	**Tank Space Req (cu ft)**	**F.I. (lb/gpm/in)**	**Flow Req (gpm)**	**Flow Req (cfs)**
250,000	10	6.980	45.27	25,000	0.3	11,915	1.50	2,383	5.31

The initial flow modeling suggests that the fish numbers and sizes proposed above can be accommodated with the available 10 cfs water right. The analysis indicates that the peak flow of 9.0 cfs for the Chinook group is required about 1 month after the release of the Coho yearling. The maximum flow required for newly-ponded Coho during the same period is 166 gpm with sufficient water available for the proposed rearing and release scenario.

6.0 Incubation and Rearing Facilities

This section provides a brief summary of the incubation and rearing flows and volumes required for the program based on CDFW input. The bio-programming information provided is largely tied to incubation needs in early design.

6.1 Mean Survival Assumptions

Mean survival data by life stage was provided during a meeting with CDFW (CDFW, 2020). The initial sizing of incubation facilities is based on the following survival data provided by CDFW (2020):

- Green egg to eyed survival: 80% (~ 20% loss)
- Eyed egg to ponding survival: 93% (~7% loss)
- Green egg to ponding survival: 73% (~27% loss)
- Ponding inventory to release: 95% (5% loss)

Based on the mean survival data and tied to the rearing scenarios presented above, estimates of total green eggs required for the Project are provided in Table 6-1.

Table 6-1. Starting Inventory at FCFH - Coho and Chinook

Species	Incubation Period	Incubation Start Number	% Survival Green to Pond	Pond Number	Ponding Period
Coho	Oct. – Mar.	120,000	73%	~88,000	~ Jan. – Mar.
Chinook	Oct. – Mar.	4,500,000	73%	~3,250,000	~ Jan. – Mar.

6.2 Incubation

Incubation systems currently at Iron Gate Fish Hatchery (IGFH) will be used for egg/alevin incubation at FCFH. A total of 130 incubation stacks are currently available for future rearing needs. The existing incubation units are vertical stack incubators with a double-stack arrangement (15 useable trays per stack); hydraulic head requirements at Fall Creek dictate that new incubation systems will be reduced to "½" stack design with eight useable trays per incubator (empty tray on top for sediment collection). Water flow requirements are modeled at 5 gpm per manufacturer's recommendations (industry standard). Incubation requirements for Coho and Chinook based on updated tray loading densities are provided in Table 6-2.

Table 6-2. Incubation Loading at FCFH – Coho and Chinook (Proposed Loading Rates)

Species	Green Inventory	Mean # Eggs/Ounce	Ounces/Tray	Total Trays	Total Stacks**	Total Flow (gpm)
Coho	120,000	TBD	TBD	40*	6	30
Chinook	4,500,000	80	50-55	1,088	136	680

*Per CDFW Egg Incubation Data; L. Radford

**8-tray setup (1/2 stack); required because of reduced hydraulic head (no pumping)

Current facility bio-program efforts will assume a maximum incubation need of 40 gpm for Coho incubation and 680 gpm for Chinook incubation. Historic tray loading for the Chinook incubators at Iron Gate often approached ~8,000-10,000 green eggs per tray (100 ounces). Reducing the total number of eggs/tray to ~4,000 (approximately 50 ounces/tray) for the Chinook incubation increases the total footprint and water demand yet should improve survival of resulting eggs/alevins while also reducing the risks associated with disease/fungal infection.

6.3 First-Feeding Vessels

First-feeding vessel requirements will be addressed once the final Program size is determined. Estimates of total rearing volume and flow requirements will be refined at a later date. Coho brood cohorts (first-feeding fry & smolt program) will overlap from early-ponding through smolt release; Coho production for the second cohort is assumed to require approximately 500 ft^3 of rearing space from first-feeding through late-April transfer to larger production ponds (post-smolt release).

6.4 Grow-out Vessels

Grow-out vessel (post-marking and parr/smolt rearing containers/sizes) requirements will be addressed once the final Program size is determined. Estimates of total rearing volume and flow requirements will be refined at a later date. Initial bio-program estimates suggest a maximum grow-out rearing need of 3,800 ft^3 of Coho rearing space (April release) and approximately 20,200 ft^3 of Chinook rearing space (May release).

6.5 Adult Holding Ponds

Adult holding and spawning ponds will be designed per CDFW recommendations for design flows, holding volumes, and fish handling systems; adult flow and holding requirements will align with NOAA guidelines for anadromous adults. Initial site investigations suggest that the four (4) raceways currently on-site (south of Copco Road) could be retained, renovated, and would provide sufficient space to hold the requested 100 Coho and 200 Chinook pre-spawn adults. Early design efforts will assume that all non-cleaning (effluent) flows, which is approximately 10 cfs, will be routed to the adult ponds and used for adult holding and fish ladder attraction flows.

6.6 Peak Water Supply

Peak water demand is modeled based on the rearing scenarios presented within this TM. Considering the design limitation that the total surface water supplies from Fall Creek will not exceed 10 cfs, Table 6-3 provides an overview of the annual water budget based on initial modeling efforts.

Table 6-3. FCFH Water Requirements – Full Production (Concurrent Use of All Facilities)

Month:	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Total Juv. CFS	3.1	5.9	6.7	7.2	9.3	2.2	3.1	4.1	5.1	7.6	8.3	3.1
Total Ladder CFS									10.0	10.0	10.0	10.0

7.0 Effluent Treatment Systems

Effluent treatment system requirements will be addressed once the final Program size is determined; estimates of total effluent treatment will be refined at a later date. We understand that an NPDES permit will be required for the Program and that all design efforts will focus on minimizing downstream water quality impacts to Fall Creek (and beyond).

8.0 Fish Passage Design and Screening Criteria

Fish passage design and screening criteria will be addressed in the Facility Design Criteria Technical Memorandum (TM 002).

9.0 Biological Reference Documents

Biological design criteria presented within this TM were obtained from the following sources/literature:

CDFW (California Department of Fish and Wildlife). 2020. CDFW Staff meeting held in Redding, CA on January 27 & 28, 2020.

CDM Smith. 2019. Basis of Design Report.

Heindel, J. 2020. Personal experience and industry standard rearing values for conservation stocks of Pacific salmon.

NMFS (National Marine Fisheries Service). 2011. Anadromous Salmonid Fish Passage Facility Design. Northwest Region. July 2011.

Piper, R.G., I.B. McElwain, L.E. Orme, J.P. McCraren, L.G. Fowler, and J.R. Leonard. 1982. Fish Hatchery Management. U.S. Fish and Wildlife Service. Washington, D.C.

Wedemeyer, G.A. 1996. Physiology of Fish in Intensive Culture Systems. New York: International Thompson Publishing.

PRELIMINARY BIOPROGRAM AND APPROXIMATE HATCHERY OPERATION SCHEDULE
Fall Creek Hatchery - Coho Yearling / Chinook Sub-Yearling & Yearling Program

9-Mar-20

				OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT
CHINOOK PRODUCTION																												
Egg Take - Green to Eyed Egg Period																												
On Station Incubation - Eyed Eggs xfr in Nov 15 at 400 CTU																												
Chinook Brood Year Rearing in TBD (~12x4x50 Vats Pond-Rls.)												Mark and Xfr by May 31																
~ 250k Chinook Yearlings																		Xfr out Nov										
Coho BY-A Early Rearing in Vats & Small Raceways											Xfr to Large Ponds																	
Coho BY-A in Production Raceways/Vats																							Xfr out Mid-April					
Coho BY-B in Early Rearing Vats & Small Raceways											Xfr to Large Ponds												Xfr to Large Ponds					
Coho BY-B in Production Raceways/Vats																												
			(F)	*49.0*	*46.0*	*43.0*	*43.0*	*43.0*	*46.0*	*50.0*	*54.0*	*54.0*	*54.5*	*54.5*	*50.0*	*49.0*	*46.0*	*43.0*	*43.0*	*43.0*	*46.0*	*50.0*	*54.0*	*54.0*	*54.5*	*54.5*	*50.0*	*49.0*
FC Sub-Yearling Chinook	*3,250,000*	*(Start Inv)*						3,250,000	3,250,000	2,000,000	2,000,000	250,000	250,000	250,000	250,000	250,000	250,000			3,250,000	3,250,000	2,000,000	2,000,000	250,000	250,000	250,000	250,000	250,000
Fall Creek Monthly Mean Water Temperature (C)				9.44	7.78	6.11	6.11	6.11	7.78	10	12.22	12.22	12.5	12.5	10	9.44	7.78	6.11	6.11	6.11	7.78	10	12.22	12.22	12.5	12.5	10	9.44
Projected Growth Rate (mm/month)	*0.05*	*mm/ctu/day*						4.58	11.67	15.00	18.33	18.33	18.75	18.75	15.00	14.16	11.67			4.58	11.67	15.00	18.33	18.33	18.75	18.75	15.00	14.16
Fish Length Inches EOM - Assumes 1200 fpp & .376 g/f @ ponding				*L*				1.403	1.862	2.453	3.175	3.896	4.634	5.373	5.963	6.521	6.980		*L*	1.403	1.862	2.453	3.175	3.896	4.634	5.373	5.963	6.521
Fish Weight Grams EOM (Piper Tables; Assumes C3000)				*g/f*				0.376	0.871	2	4.35	7.98	13.7	20.96	28.94	37.65	45.27		*g/f*	0.376	0.871	2	4.35	7.98	13.7	20.96	28.94	37.65
Fish Per Pound EOM				*fpp*				1200 #	521 #	227 #	104#	57#	33 #	22 #	16 #	12 #	10 #		*fpp*	1200 #	521 #	227 #	104#	57#	33 #	22 #	16 #	12 #
Biomass In Pounds EOM				*biom*				2,694	6,241	8,819	19,180	4,398	7,551	11,552	15,951	20,751	24,951		*biom*	2,694	6,241	8,819	19,180	4,398	7,551	11,552	15,951	20,751
Volume Required EOM (cu.ft.)	*0.3*	*DI*		*cu.ft.*				6,401	11,169	11,983	20,139	3,763	5,431	7,167	8,916	10,608	11,915		*cu.ft.*	6,401	11,169	11,983	20,139	3,763	5,431	7,167	8,916	10,608
Flow Required EOM (gpm)	*1.5*	*FI*		680	680	680	680	1,280	2,234	2,397	4,028	753	1,086	1,433	1,783	2,122	2,383			1,280	2,234	2,397	4,028	753	1,086	1,433	1,783	2,122
Assume ~4.5M green; 4,136 green eggs/tray; 1,088 trays = 136 1/2 stacks								680	**1.25M Rls End Mar**		**1.75M Rls End May (post-mark 150/lb)**				Incub:	680	680	680	680	680	**1.25M Rls End Mar**		**1.75M Rls End May**					680
CDFW Growth Reduction; Days Feed/Month																**23 days**	**15 days**	**7 days**	**7 days**	**7 days**	**15 days**							
									78,400	77,600	77,400	77,200	77,000	76,800	76,600	76,400	76,200	76,000	75,800	75,600	75,400	75,000						
FC Yearling Coho	*80,000*	*(Start Inv)*													Ration:	75%	50%	25%	25%	25%	50%	Ap. 15 Rls						
Fall Creek Monthly Mean Water Temperature (C)				9.44	7.78	6.11	6.11	6.11	7.78	10	12.22	12.22	12.5	12.5	10	9.44	7.78	6.11	6.11	6.11	7.78	10	12.22	12.22	12.5	12.5	10	9.44
Projected Growth Rate (mm/month)	*0.045*	*mm/ctu/day*						4.12	10.50	13.50	16.50	16.50	16.88	16.88	13.50	9.77	5.25	1.92	1.92	1.92	5.25	4.50						
Fish Length Inches EOM - Assumes 1400 fpp & .323 g/f @ ponding				*L*				1.270	1.684	2.215	2.864	3.514	4.178	4.843	5.374	5.759	5.966	6.041	6.117	6.193	6.400	6.577						
Fish Weight Grams EOM (Piper Tables; Assumes C3500)			***Brood Year A***	*g/f*				0.323	0.744	1.72	3.72	6.99	11.7	18.23	24.77	30.2	33.5	35.3	37.5	37.8	41.8	45.4						
Fish Per Pound EOM				*fpp*				1400 #	610 #	263 #	122#	65 #	39 #	25 #	18 #	15 #	14 #	12.9 #	12.1 #	11.9 #	10.8 #	10 #						
Biomass In Pounds EOM				*biom*				57	129	294	635	1,190	1,986	3,087	4,183	5,087	5,628	5,915	6,267	6,300	6,948	7,500						
Volume Required EOM (cu.ft.)	*0.3*	*DI*		*cu.ft.*				150	255	443	739	1,129	1,584	2,125	2,595	2,944	3,145	3,263	3,415	3,391	3,619	3,801						
Flow Required EOM (gpm)	*1.5*	*FI*		40	40	40	40	30	51	89	148	226	317	425	519	589	629	653	683	678	724	760						40
CDFW Growth Reduction; Days Feed/Month					**15 days**	**7 days**	**7 days**	**7 days**	**15 days**																			**23 days**
					76,200	76,000	75,800	75,600	75,400	75,000											78,400	77,600	77,400	77,200	77,000	76,800	76,600	76,400
FC Yearling Coho	*80,000*	*(Start Inv)*		Ration:	50%	25%	25%	25%	50%	Ap. 15 Rls																		
Fall Creek Monthly Mean Water Temperature (C)				9.44	7.78	6.11	6.11	6.11	7.78	10	12.22	12.22	12.5	12.5	10	9.44	7.78	6.11	6.11	6.11	7.78	10	12.22	12.22	12.5	12.5	10	9.44
Projected Growth Rate (mm/month)	*0.045*	*mm/ctu/day*			5.25	1.92	1.92	1.92	5.25	4.50										4.12	10.50	13.50	16.50	16.50	16.88	16.88	13.50	9.77
Fish Length Inches EOM - Assumes 1400 fpp & .323 g/f @ ponding				*L*	5.966	6.041	6.117	6.193	6.400	6.577									*L*	1.270	1.684	2.215	2.864	3.514	4.178	4.843	5.374	5.759
Fish Weight Grams EOM (Piper Tables; Assumes C3500)			***Brood Year B***	*g/f*	33.5	35.3	37.5	37.8	41.8	45.4									*g/f*	0.323	0.744	1.72	3.72	6.99	11.7	18.23	24.77	30.2
Fish Per Pound EOM				*fpp*	14 #	12.9 #	12.1 #	11.9 #	10.8 #	10 #									*fpp*	1400 #	610 #	263 #	122#	65 #	39 #	25 #	18 #	15 #
Biomass In Pounds EOM				*biom*	5,628	5,915	6,267	6,300	6,948	7,500									*biom*	57	129	294	635	1,190	1,986	3,087	4,183	5,087
Volume Required EOM (cu.ft.)	*0.3*	*DI*		*cu.ft.*	3,145	3,263	3,415	3,391	3,619	3,801									*cu.ft.*	150	255	443	739	1,129	1,584	2,125	2,595	2,944
Flow Required EOM (gpm)	*1.5*	*FI*		*gpm*	629	653	683	678	724	760						40	40	40	40	30	51	89	148	226	317	425	519	589
			GPM	720	1,349	1,373	1,403	2,668	3,009	3,245	4,176	978	1,403	1,858	2,302	3,430	3,732	1,373	1,403	2,668	3,009	3,245	4,176	978	1,403	1,858	2,302	3,430
			CFS	1.6	3.0	3.1	3.1	5.9	6.7	7.2	9.3	2.2	3.1	4.1	5.1	7.6	8.3	3.1	3.1	5.9	6.7	7.2	9.3	2.2	3.1	4.1	5.1	7.6
			Tot. Adult Flow	10.0	10.0	10.0									10.0	10.0	10.0	10.0									10.0	10.0
				OCT	**NOV**	**DEC**	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**