US Army Corps
of Engineers
Portland District

The Dalles East Fish Ladder Auxiliary Water System Emergency Backup

Position Paper

June 10, 2011

1. Problem Statement

This position paper provides a recommended plan to develop and initiate a reliable AWS backup if the two fish turbines have an outage.

Providing a backup water supply to the auxiliary water system (AWS) for The Dalles East Fish Ladder (EFL) is critical to the overall success of adult fish passage at The Dalles Dam. Approximately 80 percent of the returning adult salmon approaching The Dalles Dam use the EFL. Spill for juvenile fish impacts the use of the north fish ladder because of the high approach velocities. Therefore, if the east ladder goes out, spill would likely be reduced to enable adults to transit through the spill velocities to the north fish ladder entrance. This would put the regional fish managers in the position of deciding on the fate of adults vs. juveniles. The AWS system does not have a backup source of water in the event the fish turbines unit have an outage.

2. Background

The issue of providing backup auxiliary water has been studied during the 1990’s in several alternative reports. Early concepts in the 1990’s revolved around the juvenile bypass system (JBS) dewatering to provide the backup water. But, in the early 2000’s the JBS concept at The Dalles Dam was abandoned. Therefore, a backup AWS was never implemented at The Dalles Dam.

In 2008, the COE’s Hydroelectric Design Center (HDC) conducted a risk failure analysis and report on the fish turbines units, “The Dalles Fish Water Units Risk Failure Analysis” (November 2008). HDC concluded that there is a 25 percent probability that at least one of the two fish water units will experience a significant failure in the next ten years. Furthermore, the probability of failure of both units at the same time is 1.4 percent in the next ten years.

Subsequently, HDR Engineering, Inc. (HDR), under contract to the COE completed a letter report, “The Dalles East Fish Ladder Auxiliary Water Backup System” (May 2009), that investigated in further detail the concept utilizing the draft tube of a main turbine unit to provide full flow backup water supply of 5000 ft^3/sec for the AWS. The estimated cost of the recommended alternative from the HDR report is much greater than the estimated cost presented in the HDC report. Due to the high cost, and risk of draft tube modifications, this alternative was no longer considered.

Recognizing that providing a full flow backup AWS is cost prohibitive, the COE and the fisheries agencies discussed operational options that would require less flow and still provide good fish passage during an “emergency operation**”** (Appendix A). The group agreed that in the event both fish units failed, the duration of the “emergency operation” is one year. It was also agreed the east fish ladder entrance was the priority and two of the three weirs would remain operational. The south and west entrances would be closed. Based on the east entrance only scenario, the COE estimated 1400 ft^3/sec is needed (Appendix B). With 1400 ft^3/sec established as the minimum hydraulic AWS needs, it was recommended that a brainstorming session be conducted to further develop concepts for this scenario.

and volumes, in concert with perhaps a smaller, cost effective alternative feature(s) that could help meet the hydraulic need for the "emergency operation". The meeting is documented in the report "The Dalles East Fish Ladder Auxiliary Water System Emergency Operation Backup System Alternatives – Brainstorm Meeting Report" (February 2011).

2. Description of Existing Fish Facilities

The adult fish passage facilities at The Dalles Dam consist of the North Fish Ladder and the EFL (Figure 1). This position paper focuses on the EFL. Attraction and transportation flow for the south, west, and east entrances for the EFL is provided by two fish turbine units located on the west end of the powerhouse. Water discharged (5000 ft^3/sec) from the fish turbines enters the auxiliary water conduit (AWC) and is released into the system through diffusers. Water enters the fishway at the junction pool, east entrance, south entrance, west entrance, and transportation channel after passing through diffusers. It can enter the collection channel but these diffusers were closed because fish entrances along the collection channel are not operational. Fish enter the south and west entrances and travel through the transportation and collection channels, respectively, to the East Fishway. (Figure 1 through Figure 3).

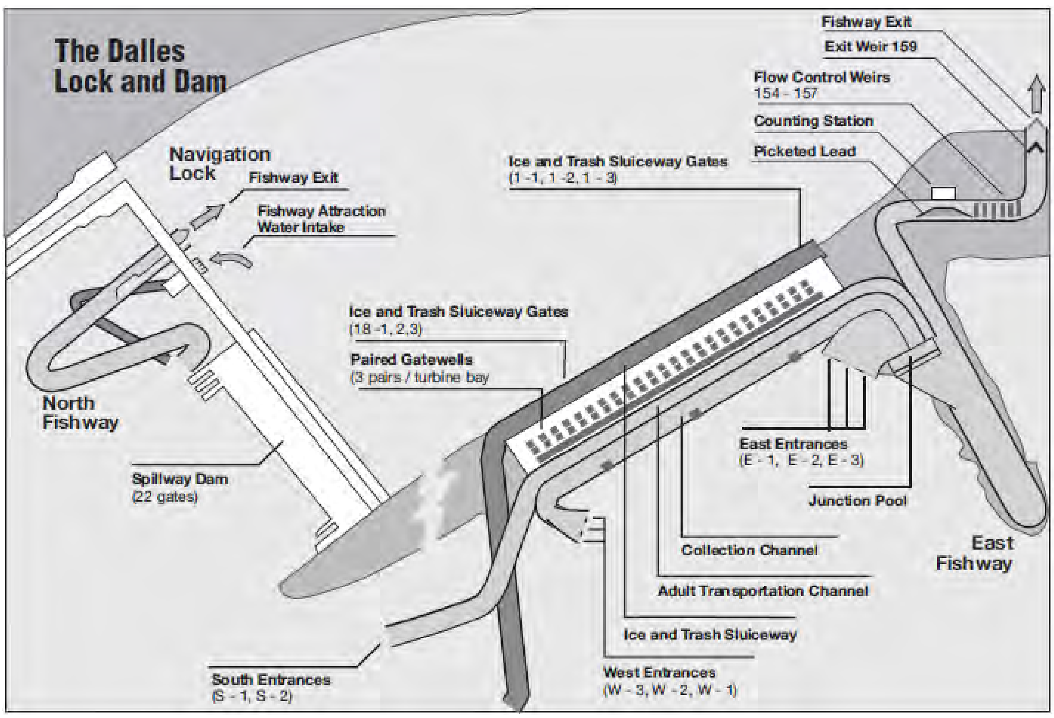


Figure 1. The Dalles Dam Fish Ladder System
(Illustration from the 2008 COE Fish Passage Plan)

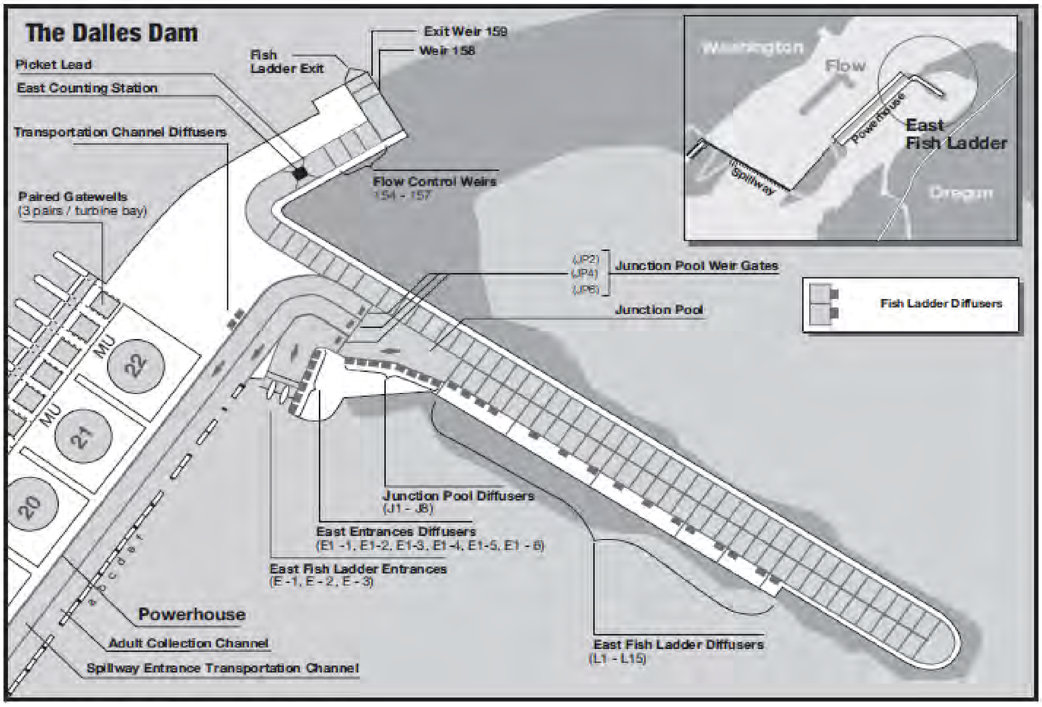


Figure 2. The Dalles Dam East Fish Ladder
(Illustration from the 2008 the COE Fish Passage Plan)

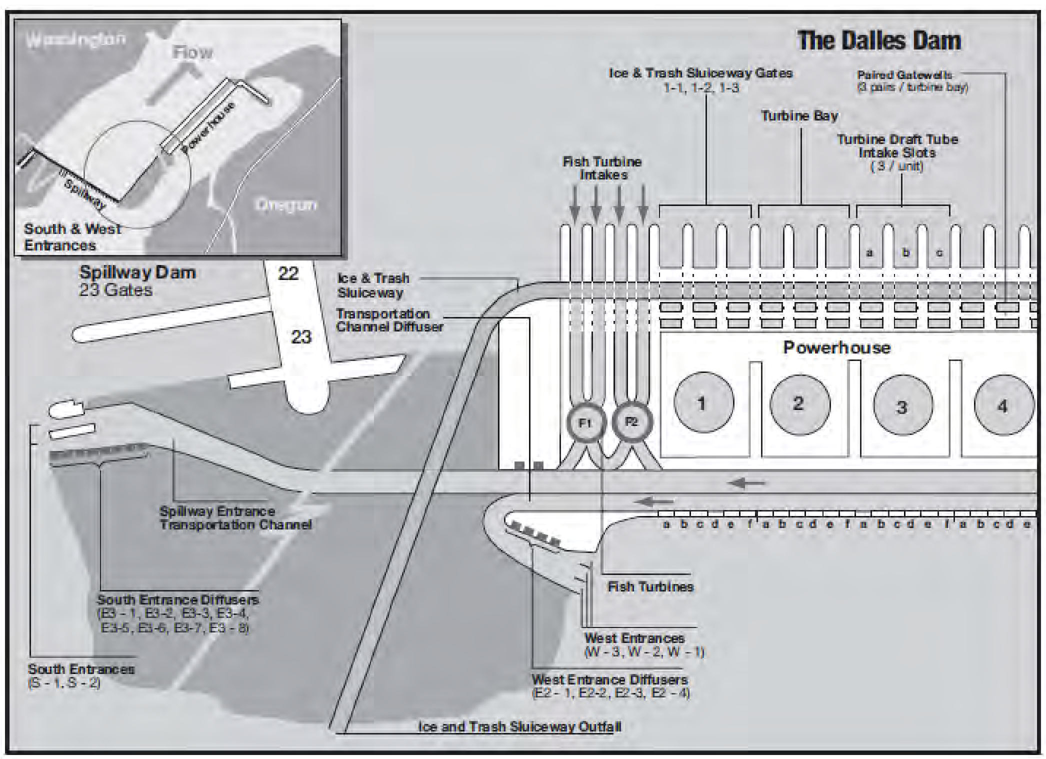


Figure 3. The Dalles Dam West and South Fish Ladders
(Illustration from the 2008 COE Fish Passage Plan)

Fish Unit Turbines

Two fish turbine units (F1 and F2) are located at the west end of the powerhouse. The turbine units have a combined power capacity of 28,000 kilowatts and a maximum flow capacity of 2500 ft^3/sec each. Although the fish turbines function similarly to the power generation units, the discharge from the turbines flows directly into the AWC. The operation and reliability of the fish turbines is critical in maintaining adult fish attraction water. Trash racks spaced one inch apart are installed in the fish turbine intakes.

Auxiliary Water System

As shown on Figure 1 through Figure 3, the AWS consists of the AWC, a fish transport channel, fish collection channel, junction pool, weir gates, and a series of diffusers along the AWC that conveys water to the south, west, and east entrances. Water is supplied to the AWC from the two fish turbines. This system is complex to operate, but an integral part of the overall operation of the EFL system. Prior to water flowing through the EFL entrance, it is sent through a series of diffusers in the junction pool. The junction pool provides water to the fish transportation channel (FTC), which supplies the south entrance, and the fish collection channel (FCC), which supplies the west entrance. The AWS normally operates with a total flow of up to 5000 ft^3/sec.

3. Operational Requirements and Criteria

The alternatives from previous reports that provide a discharge of up to 5000 ft^3/sec have unacceptably high costs. Recognizing this, the COE and the regional fishery managers re-evaluated the operational and flow requirements that would be used to provide options that need less flow while still providing good fish passage. The COE and fishery managers met November 2, 2010 to address this issue (Appendix A). Additionally, new operational and flow requirements were detailed by the COE in a memorandum for record (MFR) (AppendixB).

Operational Requirements

As a result of the meeting and subsequent MFR the operational and flow requirements are:

- The duration of an “emergency operation” is considered to be up to one year. This is assumed to be the time it takes to repair a fish turbine. This is the estimated downtime that is predicated on availability of funds, and expeditious acquisition process and a reduced “long lead time.”
- The east entrance is the primary fish entrance. Two of the three weirs will remain operational.
- The south and west fish entrances will be closed during the operation of the backup system.
- The total discharge required to operate the backup system is 1400 ft^3/sec.

Adult Fish Passage Criteria

Adult fish passage criteria are from the COE’s 2010 Fish Passage Plan.

- Water depth over fish ladder weirs: 1.0 ft. +/- 0.1 ft. During shad passage season 1.3 ft. +/- 0.1 ft.
- Head on all entrances: 1 ft. – 2 ft. (1.5 ft. optimum)
- East Powerhouse Entrance. Operate weirs E2 and E3 to maintain gate crest 8 ft or greater below tailwater.
- Water velocity of 1.5 to 4 ft/sec (2 ft/sec optimum) shall be maintained for the full length of the powerhouse collection channel and the lower ends of the fish ladders that are below tailwater.

4. Previous Studies

The issue of providing backup auxiliary water has been studied from the 1990's in several alternative reports. Below are the 6 studies conducted to date and the corresponding alternatives evaluated.

The Dalles Emergency Fish Attraction Water System Study, U.S. Army Corps of Engineers Hydroelectric Design Center September 1991

The Hydroelectric Design Center developed a conceptual report that generated six alternatives:

1. New Penstock from non overflow monolith to AWS ($8.8M*)
2. Modify fishlock at east end of AWS ($5.94M*)
3. Modify I&T chute to feed into AWS (Not Feas.)
4. ***Modify main unit draft tube (gate in AWS flr.) ($1.78M* Report Rec.)***
5. Modify station service draft tubes, same as No. 4, 1200 cfs only ($0.953M*)
6. Build new fish attraction water pumphouse ($40M*)

* Cost in 1994 dollars from Project Improvements for Endangered Species report

Study of AFA Auxiliary Water Supply, The Dalles Project Improvements for Endangered Species, EBASCO, Bellevue, June 1994

EBASCO under contract to the COE developed and alternatives report for the Passage Improvement for Endangered Species Program. The report showed a total 15 Alternatives (9 new ones and the 6 from HDC report).

1. New penstock from the eastern non-overflow monolith to AWS ($9.8M*).
2. Modify main unit 5 draft tube (gate in roof) ($2.92M*)
3. Bonneted slide gates in main unit scroll case ($2.72M*)
4. Pump station at the south end of East Fish Ladder ($27.5M*)
5. Screened double chambered conduit hanging on non-overflow monoliths with pipe routed near dewatering facility ($16.4M*)
6. Pump station from the east end cul-de-sac ($37.8M*)
7. New penstock from non-over flow monolith using 6 conduits with modular inclined screens ($23.1M*)
8. New fish turbines at main unit bay 22 ($19.0M*)
9. Replacement of runner on main unit 22 ($5.2M*)

*Cost in 1994 dollars

The Dalles Dam Auxiliary Water System Upgrade Alternatives Evaluation, INCA and Associates September 1997

INCA and Associates, under contract to the COE developed two alternatives (A and B).

Alternative A – Forebay Intake with Screen Structure

- Gated intake structure in the fish lock monolith with an elevated V-screen dewatering facility downstream of the east non-overflow dam.
- Cost estimate - $47.9 million (updated 2011)
- Discharge 2500 ft^3/sec

Alternative B – Tailrace Pump Station at East Fishway

- Pumphouse located next to the East Fish Ladder, adjacent to the existing junction pool.
- Cost estimate - $41.6 million (updated 2011)

The Dalles Fish Water Units Risk of Failure Analysis, USACE Hydroelectric Design Center November 21, 2008

The COE Hydroelectric Design Center developed a report that documents their findings of a risk of failure analysis for the two fish turbine units using a simplified methodology similar to that used as part of a Major Rehabilitation Evaluation Report. The conclusions of the analysis are:

- There is a 25 percent probability that a least one of the two fish turbines will experience a significant failure sometime in the next 10 years.
- The probability of failure of both units failing at the same time is 1.4% within the next ten years.
- Probability of failure can be further reduced by increased periodic inspection and maintenance, but some of the equipment is in excess of 50 years old, the probability of failure will increase in time.
- Outage time can be reduced by have critical (long lead time) components on site as spares.

The Dalles East Fish Ladder Auxiliary Water Backup System Letter Report, HDR, Inc. May 4, 2009

Under contract to the COE, HDR, Inc. developed a Letter Report that evaluated two alternatives and recommended one alternative that involve taking water from a main turbine unit draft tube or scroll case. The draft tube option was recommended. The recommended option also requires:

- 2 Main Units to supply water
- 2 seasons to construct

- Cost Estimate – $43.6M =>$27.2M direct + $8.2M KTR profit indirect & OH + $8.2M contingency on direct

The Dalles East Fish Ladder Auxiliary Water System Emergency Operation Backup System Alternatives – Brainstorm Meeting Report, HDR February 3, 2011

Under contract to the COE, HDR, Inc. developed a report, based on the results of a brainstorming meeting held on December 8, 2010.

- 15 alternative ideas generated as potential sources for makeup water: Siphon to Fish Lock, River Wet Trap, Ice and Trash Sluice Water Tap, Fish Lock Direct Tap to Reservoir, Install Concrete Lid on Open Channel Fishway, Stop Log Modifications at Tainter Gate 23, New Third Fish Turbine, Pipe(s) to AWS Culvert, Remove Flow Restrictions on Current System, Single Pump/Pumphouse on East Side, Upstream Intake Tower with Siphon, Floating Plant Pump Station, Fish Turbine Speed No Load, Ice and Trash Sluice Intake Channel Water Tap and Diversion, Siphon with Entrance at Fish Ladder Exit to AWS Conduit.
- Conceptual level evaluation was conducted. Alternatives were ranked and scored based on criteria developed by the participants of the brainstorm meeting.
- The top three ideas that HDR recommended: Fish Turbine speed-no-load operation; a deep intake siphon that feeds directly into AWS conduit, and a siphon that feeds into the fish lock/elevator caisson.

5. COORDINATION

INTERNAL

The COE team met to evaluate and eliminate ideas from the Brainstorm Report that are not practical, feasible or potentially cost prohibitive:

- Eliminated Operating Fish Unit Speed No Load
  - Not realistic for long term operation because of likely bearing/packing burn-out.
  - Too dependent on the failure mode of the fish turbines (ie: failed bearing-no, failed winding-maybe) making the reliability too risky.
  - Discharge may be much less than thought.
- PDT determined that while the siphon alternatives may have viability potential, additional engineering study was necessary.
- AWS flow will most likely come from sources that provide smaller volumes (ie: fish lock modifications, equalizing header, pump, etc.) but collectively meet the flow requirement (1400 ft^3/sec).

FISHERIES AGENCIES

The project has been coordinated with the regional fisheries agencies during regularly scheduled meetings of the Fish Facility Design Review Work Group (FFDRWG). Where additional discussion is needed outside the regularly scheduled FFDRWG meeting for clarification or regional input, special meetings were held. Special meetings were held on November 2, 2010 and May 9, 2011. Meeting minutes can be found in Appendix A.

The purpose of the November 2, 2010 meeting was to come to mutually agree on an operation that did not include a full AWS flow requirement (5000 ft^3/sec). At that meeting all agreed that:

- The duration of an emergency operation is assumed to be one year, and
- Operation of the east fish ladder entrance should be the focus of the emergency operation.

The purpose of the May 9, 2011 meeting was to come to mutually agree on concepts from the Brainstorm Meeting Report to consider in an alternatives report strictly focused on the establishment and agreed 1400 ft^3/sec minimum AWS hydraulic needs.

Concepts from the Brainstorm Meeting Report that were kept for further consideration are:

- Alternative 1 – Siphon (from forebay) to Fish Lock
- Alternative 2 – River Wet Tap
- Alternative 4 – Fish Lock Direct Tap to Forebay
- Alternative 5 – Concrete Lid on Fish Lock Approach Channel

Note: this is not a standalone alternative. It would have to be combined with other alternatives.

- Alternative 8 – Pipe(s) to AWS Culvert (combine with Alternatives 11 and 15)
- Alternative 9 – Remove Flow Restrictions on Current Fish Lock System

Note: this is not a standalone alternative. It would have to be combined with other alternatives.

- Alternative 10 – Single Pumphouse on East Side (cul-de-sac)
- Alternative 11 – Upstream Intake Tower with Siphon

Note: this should be combined with Alternatives 8 and 15.

- Alternative 15 – Siphon With Entrance at Fish Ladder Exit to AWS Conduit

Note: this should be combined with Alternatives 8 and 11 as a “Forebay Intake” alternative

- Alternative 16 – Equalizing Headers (Note: this alternative was identified after the Brainstorm Meeting Report.

6. RECOMMENDATION

Based upon the revised requirements for a backup AWS that focuses on utilizing only the east fish ladder entrance, the COE team is recommending moving forward with a strategy that includes the following activities that can be accomplished in the short term and long term (Figure 4).

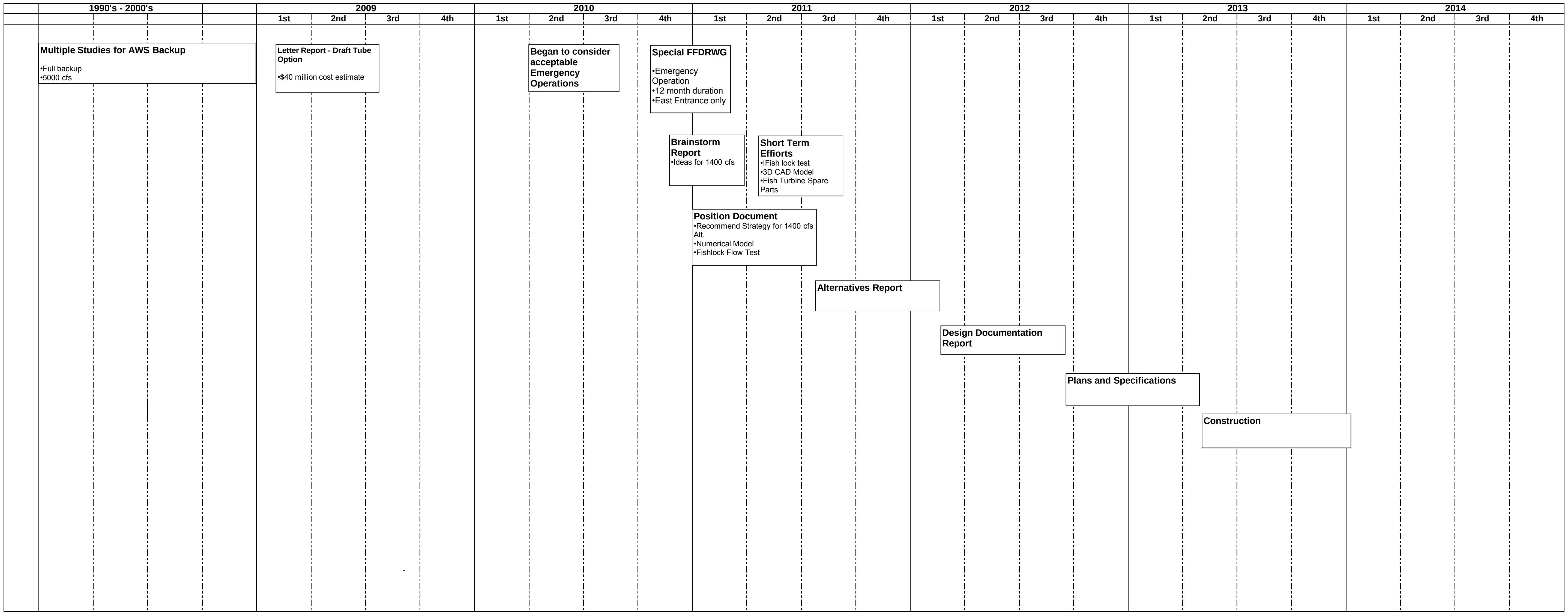
Activities that can be accomplished in the short term are:

- Fish lock flow test (FY11). Determine what is currently available from the existing fish lock. Use ideas from the Brainstorm Report to provide the remaining flow.
- Construct 3D CAD drawing of the AWS and fish lock. The drawing will allow:
  - Communicate clearly the complex AWS system
  - Clear understanding of the fishlock
  - Clear understanding of the equalizing header
- Spare parts for the fish turbines should be purchased, stored and available to limit the outage time for turbine repairs. A list of fish turbine spare parts can be found in Appendix C.

Activities that can be accomplished in the long term are:

- Alternatives Report (early FY 12). Develop ideas from the Brainstorm Report to provide the difference between the required flow (1400 ft^3/sec) and results of the flow test of the existing fishlock as well as other alternatives such as the complete rehabilitation of the fish turbines.
- Design Documentation Report (FY12)
- Plans and Specifications (FY13)
- Construction (FY14)
- The Dalles Project initiate the necessary administrative, planning and acquisition actions necessary to have both turbine units rehabilated.

Figure 4. The Dalles East Fish Ladder Auxiliary Water System Backup Strategy



1. The schedule shown assumes Regional Fishery Agnecy agreement for funding of the proposed actions
2. The flow chart is subject to change based upon information gained throughout the development process1

APPENDIX A – Special FFDRWG Meeting Minutes

CENWP-PM-E **2 November 2010**

MEMORANDUM FOR THE RECORD

SUBJECT: Special FFDRWG – TDA Sluiceway Operations and East Fish Ladder AWS Backup

1. Attendance

Name	**Agency**	**Email**
Chris Peery	USFWS	capeery@gmail.com
Karen Kuhn	USACE – Portland	Karen.a.kuhn@usace.army.mil
Randy Lee	USACE – Portland	Randall.t.lee@usace.army.mil
Sean Tackley	USACE – Portland	Sean.c.tackley@usace.army.mil
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David Wills	USFWS	David_Wills@fws.gov
Natalie Richards	USACE – Portland	Natalie.r.richards@usace.army.mil
Mike Langeslay	USACE – Portland	Mike.j.langeslay@usace.army.mil

2. East Fish Ladder AWS Backup System
   a. Randy Lee presented a background on the AWS backup project
   b. AWS need for various scenarios:
      i. East or West Entrance for Single Weir & TW = 73.6 ft
         1. 460 cfs for 1.0 ft head/8 ft submergence
         2. 570 cfs for 1.5 ft head/8 ft submergence
      ii. South Entrance for Single Weir & TW = 73.6 ft
         1. 1040 cfs for 1.0 ft head/8 ft submergence
         2. 1290 cfs for 1.5 ft head/8 ft submergence
      iii. There are 2 weirs to run at East Entrance, so total would be more like 1200 cfs (for example).
   c. Fredricks: If we want to narrow this down to one entrance for an emergency operation (both fish units out of service), I'd prioritize the East Entrance; maintain the 1.5 ft of head (priority) and 8 ft of head (not as high a priority). Also want to keep signature in tailrace strong (square shape, bulked middle).
      i. Ed Meyer has suggested an insert to improve tailrace signature. Also want to consider shaped weir. The group agreed that this is a good idea.
   d. Cordie noted that they have to keep submergence at 12 ft just to keep head right. Too much water is a problem here. This will have to be part of the HD analysis.

e. Lorz: Is it better to go with one weir at 12’ or two at 8’? Key is to do CFD evaluation on two 8’ weirs vs. single 12’ weir for flow signature. The group agreed that this should be part of the next iteration. Cordie noted that this was discussed for operating the North ladder at one point. It was decided to run a single entrance at 10’ there. CFD work will resolve this question.
f. Sweet: This is something we should consider evaluating in next year’s RT study. The group agreed that the RT study isn’t going to move forward since the BON WA Shore lamprey modifications but that we should consider a block test for various configurations next time we have an RT study.
g. Fredricks doesn’t want a complicated system with multiple sources that might fail. Should prioritize gravity flow systems.
h. Fredricks: Biggest problem with this solution might be for sockeye in June, since passage numbers suggest that they don’t use the North ladder during high flows. Only having a single entrance open (East) might cause significant delay problems.
    i. Sweet noted that we might consider boosting the signature with inductor pumps (Cowlitz example) to solve this potential problem. Group agreed that this should be considered.
i. **Summary:** Group agreed that if we lose both fish units, the emergency operation should focus on operating the East Entrance only. In this operation, the Corps would shut off the junction pool. Corps should reduce leakage as much as possible to maintain system efficiency.
j. **Next steps:** Tackley needs to schedule brainstorming session for this fall/winter. Need to make sure Ed Meyer can attend. Tackley will do a Doodle poll ASAP.

3. TDA Sluiceway Operations – 2011

a. Fredricks described his recommendations, as outlined in a memo submitted to the group:
    i. Research
        1. On/off test is off for this year since Unit 1 is out of service. There is a real research need to determine whether sluiceway can be operated every other day without causing increased passage via turbines.
    ii. Operations
        1. Suggested operation is 24/day for first 2 weeks of December and entire month of March (like study period in FY10; Section 2.4.1.2 of 2010 Fish Passage Plan). This operation would include 4 open sluice gates – 2 at Unit 1 and 2 at Unit 18 (or adjacent units if units are OOS).
        2. During rest of season, operated as described in Fish Passage Plan.
    iii. Credit
        1. NOAA agrees that this can be credited against the 6% survival (Bonneville - Lower Granite) improvement for Snake River B-Run steelhead. This credit is estimated to be 0.5% to 1% over the life of the BiOp.

        a. Final accrediting requires more work to determine proportion of B-run Snake River fish in the population at The Dalles.
        b. Crediting process should be documented in the AA's Kelt Management Plan (RPA 33).
    2. Fredricks noted that MCN is going to require substantial improvements for Snake River steelhead and that this is one of the few things that can be done for steelhead right now, aside from reconditioning.

iv. Sweet: BPA has to consider this along with reconditioning, in terms of credits.

v. Wills: If everyone agrees that the 1% is acceptable and reasonable, do we still need something in place to document/measure this? Fredricks said for now that we need to just estimate, but should look at studies to confirm down the road.

vi. **Summary:** Recommendation from group would be as Fredricks described, with an on/off test needed next fall/winter to get at holding. Hydroacoustic gear will be left in place at TDA to save cost of removal, assuming that the on/off study will likely be needed in FY12. On/off test would be Units 1 and 18.

vii. **Next Steps**:

1. Khan will investigate whether hydroacoustic transducers need to be removed.
    a. Plan for dive work in Fall (FY11 – September) to fix any transducers that need work. Fenton will test units monthly until fall and document equipment status.
    b. Tackley and Richards need to extend PNNL contract through FY11 to allow Fenton to inspect transducers.
2. Sweet and Volkman will discuss Fredricks' proposal and credits with BPA management.
3. Resolution by November 15 is preferred to allow for operations planning.

The Dalles East Fishladder Auxiliary Water System
Emergency Operation Backup
Special FFDRWG Meeting
1-3 pm
May 9, 2011

FINAL MEETING NOTES

1. Introductions

Name	Agency	Email
Sean Tackley	USACE – Portland	Sean.c.tackley@usace.army.mil
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Tom Lorz (on phone)	CRITFC	lort@critfc.org

2. Meeting Objectives (Tackley)
    a. Briefly review the TDA East Ladder AWS backup issue
    b. Review alternatives identified in the HDR brainstorm report
    c. Outline next steps for the design team, including update on ongoing work
    d. Identify biological considerations for various concepts

3. Background/History (Medina)
    a. Purpose is to have a backup system in the event of failure of both fish units
    b. Ongoing issue since mid-1990s
    c. Various design teams have studied alternatives that would provide 100% backup for AWS system, but these have been prohibitively expensive
    d. HDR hosted a brainstorming session to identify potential means to provide 1400 cfs through the AWS to run East Entrance only (as coordinated through FFDRWG); produced report summarizing alternatives discussed.
    e. Need to confirm that we're all on the same page regarding criteria of 1400 cfs (through the AWS).
        i. NOAA (Fredricks) confirmed this was the target.
    f. Team has identified a path forward toward implementation

4. Discussion of Brainstorm Alternatives (All)
    a. Alternative 1: Siphon to Fish Lock (from forebay)
        i. Key issues: Operational – priming and valve; maintenance – pump and valve; fish screens required?
        ii. Combine with other alternatives. Can get water into fish lock, but still need to reduce constrictions in system, pressurize fish lock, etc.
        iii. Ament noted that from an O&M perspective, biggest concern is the pumping required to prime the siphon (Ament).
        iv. Fredricks asked what the cost would be, without screening. HDR rated this as a relatively low cost alternative.
        v. **Actions:** Group agreed we should keep this as an alternative.
    b. Alternative 2: River wet tap
        i. Deep intake pipe supplies water to fish lock
        ii. Key issues: Construction (mining under dam, control valve, energy dissipation); dam safety; fish screens required?
        iii. Ament reiterated the dam safety concern. Meyer asked if we could use the concrete instead (on the other end of the powerhouse) if dam safety is a concern.
        iv. Reiner suggested that this concept could be used at the fish lock instead.
        v. Fredricks noted that this concept is desirable due to the simplicity and added that since the facility we develop is intended only to be used in a very rare emergency and its use would of limited duration, it makes sense to consider granting an exemption to our screening criteria.
        vi. **Actions:** Group agreed to keep this alternative.
    c. Alternative 3: Ice and trash sluice tap
        i. Key issues: Fish screens required; maintenance (fish screen debris); operations (high water velocities, energy dissipation, juvenile fish route)
        ii. **Actions:** Group agreed we should drop this alternative. Surface entrainment of juvenile fish and extensive screening requirements are problematic.
    d. Alternative 4: Fish lock direct tap to forebay
        i. Similar to Alternative 1
        ii. Key issues: Maintenance (control valves), dam safety.
        iii. Would have to be combined with other alternatives
        iv. **Actions:** Group agreed we should keep this alternative.
    e. Alternative 5: Concrete lid on fish lock approach channel
        i. Pressurizing provides higher discharges to AWS
        ii. Need to be combined with other alternatives
        iii. Constructability concerns – new stoplogs needed
        iv. **Actions:** Group agreed we should keep this alternative as a design feature rather than a true "alternative." It needs to be combined with other concepts.
    f. Alternative 6: Stop log modifications to Tainter Gate 23
        i. Modify or build new stop logs on Tainter Gate 23

    ii. Bottom stop log would be modified to pass water to a conduit, then to the AWS
    iii. Tackley noted that this seems highly infeasible, particularly from a screening perspective. Lee noted that there are dam operation concerns.
    iv. **Actions:** Group agreed this alternative should be eliminated due to concerns about fish entrainment, screening, and feasibility.

g. Alternative 7: New third fish turbine
    i. Provide 5,000 cfs
    ii. Key issues: Construction (cost, time, disruption to operations), fish screens required
    iii. Would be screened to meet NOAA criteria (an advantage)
    iv. **Actions:** Group agreed this alternative should be eliminated. This alternative is outside the scope of this design team, as it is a replacement for the existing AWS system.

h. Alternative 8: Pipe(s) to AWS culvert
    i. Construct large diameter pipes (4-7 ft)
    ii. Connect to existing fish lock intake and discharge directly into AWS culvert
    iii. Maintenance of fish screens (if required) is a concern
    iv. May require modification to fish lock system.
    v. **Actions:** Group agreed to keep this alternative and combine with Alternatives 11 and 15.

i. Alternative 9: Remove flow restrictions on current fish lock system
    i. Use in combination with other alternatives
    ii. Not likely to provide required AWS backup flow
    iii. TDA project staff are identifying some of these restrictions
    iv. Cordie added that there is a bottleneck in existing system. Reiner: two 8' x 8' conduits reduce down to 36-in. Could make it a single large conduit/penstock.
    v. **Actions:** Group agreed this is actually a design component for the various fish lock alternatives. Need to keep.

j. Alternative 10: Single pumphouse on east side (cul-de-sac)
    i. Used in combination with other alternatives (9)
    ii. Single pump (Q = 600 cfs)
    iii. Key issues: Construction (cofferdam needed); maintenance; sturgeon considerations; screening.
    iv. Fredricks is concerned about O&M. Mackey noted that maintenance may not get funded due to O&M budget problems and other priorities.
    v. Meyer: Makes sense to put pump in the fishway approach channel. May reduce screening needs and shorten run of pipe.
    vi. Meyer: At Baker, 1000 cfs pump system (4 pumps). Can we apply this same concept here?
    vii. **Actions:** Group agreed to keep this alternative for now, though O&M and reliability is big concern for all.

k. Alternative 11: Upstream intake tower with siphon
    i. Discharge directly into AWS via siphon

    ii. Could be used with other alternatives or stand alone
    iii. Maintenance (gates and valves) is a concern
    iv. Tackley noted that concern about this and other intakes is juvenile fish impacts, etc.
    v. **Actions:** Group agreed that this should be combined with Alternatives 8 and 15.

  l. Alternative 12: Floating pumping plant in cul-de-sac
    i. Similar to Alternative 10
    ii. Fredricks and Tackley agreed that this would not be good for juvenile fish, in addition to O&M concerns
    iii. **Actions:** NOAA advised to drop this alternative due to O&M concerns and potential juvenile fish impacts. Group agreed.

  m. Alternative 13: Fish turbine running speed-no-load
    i. Operate on turbine at speed no load
    ii. 10-20% of the fish turbine operational flow
    iii. Combine with other alternatives
    iv. Operational issue - cannot be used for long term (up to one year)?
    v. Conder asked if it is possible to pull turbine out and let water flow freely through system. This is not feasible and would pose dam safety concerns. Takes approx. 3 months to disassemble unit as well.
    vi. **Actions:** Corps advised that this alternative should be dropped due to operational issues. Group agreed.

  n. Alternative 14: ITS intake channel tap and diversion
    i. Bulkhead between units to divert flow
    ii. Key issues: debris handling, construction (modification to concrete structures for new pipes), energy dissipation
    iii. Fredricks – this is unacceptable impact on juvenile fish.
    iv. **Actions:** Group agreed this alternative should be dropped.

  o. Alternative 15: Siphon with entrance at fish ladder exit to AWS conduit
    i. Similar to Alternative 1
    ii. Discharge directly to AWS conduit (better constructability)
    iii. Key issues: fish screens, possible energy dissipation issues, O&M (priming, valve)
    iv. **Actions:** Group agreed that we should combine with Alternatives 8 and 11 as "forebay intake" alternative.

  p. Alternative 16 (*not in report*): Equalizing headers
    i. Pulls water from scroll cases to fill others (at 14 main units)
    ii. Small piping (4-in) only used to drain units, but may be able to modify to supply AWS.
    iii. Needs further analysis; need to include fish entrainment questions
    iv. **Actions:** Group agreed to keep this alternative, though it would need to be combined with others.

5. Other discussion points
  a. Fredricks reiterated concerns for not having a backup system. North ladder is not effective backup, particularly for smaller fish and at higher flows.

b. Group prefers alternatives with fewest components, such as a direct forebay tap for fish and O&M reasons
c. Group discussed the possibility of deploying rental pumps. Not likely to work, unless used in conjunction with other alternatives and if we only needed to deliver a small portion of the 1400 cfs needed.
d. Deep intakes – how deep should we make intakes?
    i. Can use data from other projects. Need to consider juvenile lamprey as well.
    ii. Fredricks: Since the facility we develop is intended only to be used in a very rare emergency and its use would of limited duration, it makes sense to consider granting an exemption to our screening criteria.
    iii. Lorz: consider eliminating or reducing night operation to avoid lamprey impacts.
    iv. Intake velocity (10 ft/s is concern)
    v. Trash rack screen criteria. Standard is 2 ft/s, likely based on ability to effectively rake. Need a trash rake.
    vi. Is it possible to float debris off the siphon at night by shutting it off? Meyer: Not likely, as deep debris is neutrally buoyant.

6. Ongoing Activities
    a. Currently building 3D CADD model (S. Sipe) to evaluate alternative configurations. Sipe demonstrated the model for the group.
    b. Modifying existing numerical model to allow investigation of alternatives (K. Kuhn)
    c. Confirming flows from various sources
        i. Existing fish lock system
        ii. Equalizing header system
    d. Working on position document - essentially an update on where we are and where we're heading, including decisions made at today's meeting. Complete around June 2011.

7. Next Steps
    a. Eliminated several alternatives and consolidated others into 6 alternatives, based on feasibility, fish impacts, and complexity issues.
    b. Medina reviewed timeline
        i. Brainstorm report (completed)
        ii. Position document (June 2011)
        iii. Alternatives report phase through Winter 2011-12.
        iv. DDR and Plans & Specs phases through mid-2013.
        v. Construction in late 2013, assuming funding is provided.
    c. Fredricks noted that we've compromised in getting 1400 cfs for the system rather than 5000 cfs to get this accomplished, and there may be additional room (such as screening) for compromise. We need a backup system in place. Wants active coordination of planning and alternatives evaluation.
    d. Tackley will schedule meeting for August-September to check in. PDT will update FFDRWG as work evolves.

APPENDIX B – Emergency Operation Flow Requirement Memorandum

CENWP-EC-HD 21 January 2011

MEMORANDUM FOR Randy Lee, CENWP-EC-HD

SUBJECT: The Dalles East Fish Ladder Emergency Backup for the Auxiliary Water Supply System–Minimum Discharge

Objective:

1. This memo will present the rationale for choosing 1400 cfs as the minimum discharge target for emergency backup flow to the Auxiliary Water System (AWS) at The Dalles East Fish Ladder (TDEFL) for the purpose of initial alternatives brainstorming by HDR and USACE Portland District (NWP).

Background:

2. The AWS at TDEFL supplies water to the east, west, and south fish ladder entrances, the fish ladder itself, as well as the transportation and collection channels in order to attract and transport upstream migrating adult fish. Water is currently supplied to the AWS by two fish unit turbines located on the west end of the powerhouse. The AWS normally operates with a total flow of up to 5,000 cfs (2,500 cfs per turbine unit). If both turbines were to fail at the same time, water supplied to the AWS would be severely limited or eliminated.

3. Previous studies have been undertaken to find alternatives to provide a backup supply of water to the AWS for a one-year duration in the event that both fish units fail. For these studies, alternatives have been evaluated assuming that at least 3400 cfs is required to allow the ladder system (including east, west and south entrances) to meet fisheries criteria. Estimated costs for the alternatives that were deemed most promising turned out to be very expensive and consequently impractical.

4. A special Fish Facilities Design Review Work Group (FFDRWG) meeting was held on 2 November 2010 in part for the purpose of discussing the possible reduction of operational constraints for a one-year emergency situation where both fish turbine units were unavailable. Based on discussions at this meeting, it was agreed that the minimum acceptable one-year emergency operation would be to use TDEFL east entrance exclusively.

5. The relative importance of various design criteria was also discussed at the FFDRWG meeting and is shown below in relative order of priority:
   a. Maintain 1.5 ft. of head differential over the entrance weir(s).
   b. Assume operation of two of the three weirs (however, there was additional interest in considering a variable width vertical entrance structure instead with the goal of improved downstream attraction flow properties).
   c. Maintain at least 8 ft. depth at entrance weir(s) (depth from tailwater elevation to top of the weir)

Other operational criterion that were not discussed but need to be considered include:

d. Water velocity of 1.5 to 4 fps (2 fps optimum) maintained for the full length of the lower end of the fish ladder that is affected by tailwater elevation.
e. Water depth over fish ladder weirs: 1.0 ft. +/- 0.1 ft. and 1.3 ft, +/- 0.1 ft, during shad season.
f. Maximum diffuser velocity = 0.5 ft/s

Discussion:

6. Calculations of a single weir discharge at the TDEFL east entrance were made for a range of tailwater elevations with the following equations, criteria, assumptions and constants:
   - Villamonte Equation for Submergence:
     - $Q = (1 - (H2/H1)^{1.5})^{0.385} \cdot CwLH1^{1.5}$
     - H1 = depth from water surface elevation (WSE) to top of weir;
     - H2 = depth from tailwater elevation (TW) to top of weir
   - Rehbock Equation for Weir Coefficient:
     - $Cw = 3.22 + 0.44\, H/P$
     - H = H1; P = weir height
   - Entrance weir head (WSE – TW) at entrance weir(s) of 1.5 ft.
   - Depth of weir (H2) minimum of 8 ft.
   - Entrance weir width of 8.67 ft.
   - Invert elevation at entrance of 60 ft.
   - Entrance channel width just upstream of weir of 34 ft.
   - No pier or contraction losses were used to allow for a more conservative discharge (ie: higher acceptable minimum emergency flow).

7. Tailwater (TW) elevation used in the above equations can markedly influence the estimated minimum flow. Therefore it was necessary to choose a reasonable range for this analysis. Both stage and flow duration curves for the period of record (1974-1999) were used to compile a range of tailwater elevations of note at The Dalles Dam (Table 1). As seen in the table, the forebay of Bonneville Dam can influence the tailrace elevation of The Dalles Dam such that there is a range of possible tailwater levels for any given total river flow. A range of probable flow operations within the fish passage season would be banded by the higher flows in May/June and the lower flows in September/October. For the upper tailwater limit in May/June the 5% exceedance TW elevation range is 85.4 to 86.6 ft. Additionally, within the range of high flows, there is a peak where river flow conditions are such that adult fish will hold rather than travel upstream. Until a more defined estimate can be identified using existing fish passage data, it is estimated that this river discharge is around 400 to 450 kcfs, The corresponding TW elevation range (based on Bonneville forebay) for this condition is 84.7-88.6 ft. or an average of 86.6 ft which coincides with the 5% exceedance for June. Therefore, 86.6 ft. was chosen as the upper TW elevation limit for this analysis. Focusing on lower TW levels, the range of 95% exceedance for September and October is 74.0 to 74.2 ft. These values fall within the TW elevation range for the minimum powerhouse flow of 50,000 cfs (72.6 to 77.6 ft.). Therefore the 95% exceedance TW elevation for October (74.0 ft.) was chosen for the lower TW elevation limit for this analysis.

8. Using the criteria deemed most critical for an emergency operation (the ability to maintain 1.5 ft. entrance weir differential head and a minimum of 8 ft. weir depth) through the range of TW elevations 74.0 to 86.6 ft. results in design flows of 1200 cfs and 1000 cfs respectively. However, if minimum channel velocities are to be maintained at the downstream end of the east entrance, more flow would be needed at the higher TW elevation limit of 86.6 ft. If 1.5 fps (minimum channel velocity criteria) is required at the entrance then the flow would need to be 1400 cfs. For the purposes of this analysis, the upper flow of 1400 cfs has been chosen for the minimum allowable emergency flow for TDEFL east entrance-only condition. When the inflow from the upper ladder flow control section (80-120 cfs) is subtracted, the actual total AWS flow required would be 1320 to 1280 cfs. However, for this level of analysis a conservative AWS discharge of 1400 cfs has been chosen.

9. Considerations that could help maintain and/or reduce the minimum allowable emergency flow required for TDEFL include the potential for reduction of the forebay elevation at Bonneville dam during the higher TW period of an emergency operation. Also, further analyses should include the development of an operational logic for the full range of design TW elevations (ie: prescribing weir depth as a function of TW) as the weir height is pivotal to keeping within the minimum discharge needed for emergency operations.

Conclusions:

10. For this initial analysis, 1400 cfs is determined to be a minimum allowable emergency backup flow for TDEFL based on meeting ladder entrance head and 8 feet of passage depth over 2 of the 3 East entrance weirs. A range of TW elevation conditions were defined and flows approximated given certain fisheries criteria. Ultimately, for future alternative analyses, the hydraulics throughout the ladder system will need to be analyzed to ensure that all internal hydraulic criteria are met in order to maximize fish passage success. Also, as studies progress to a recommended design solution, the impact of system operations (such as the elevation of the Bonneville forebay) on an emergency ladder operation should be discussed and possible emergency operations to improve adult movement should be defined.

Recommendations:

11. For this phase of the comparison of alternatives for supplying emergency backup water to the Auxiliary Water Supply System for The Dalles East Fish Ladder in the case where both fish units are unable to function, we recommend using 1400 cfs.

Karen Kuhn
Hydraulic Engineer

REVIEW PROCESS:

HD – Steve Schlenker

CF:
CENWP-EC-HD - Randy Lee
CENWP-EC-HD – Kyle McCune
CENWP-PM-E – Sean Tackley

Table 1 - Range of Significant River Discharge and Tailwater Conditions for The Dalles Dam*

Condition	Discharge	Approximate Tailwater Range at Powerhouse by Flow **		TW at Powerhouse by Exceedance***
	kcfs	ft	ft	ft
100 year event	680	95.6	97.0	
Maximum Tailwater				92.2
5% Exceedance June***				***86.6***
Max Q for Adult Movement****	400-450	84.7	88.6	
5 % Exceedance May***				85.4
Max Ph w/ 40% spill	430	85.3	88.0	
Max Ph	270	77.8	81.3	
Discharge 100kcfs (92% Flow Exceedance)	100	73.5	78.2	
Min Ph w/40% Spill	85	73.3	78.0	
Min Ph	50	72.6	77.6	
95% Exceedance Sept***				74.2
95% Exceedance Oct***				***74.0***
Minimum Operating Tailwater*****				70.0

*Data Source: Stage exceedance, stage/discharge relationships, and tailwater ranges for the period of record (1974-1999) developed by CENWP-EC-HY October 2000.
**Tailwater range based on forebay fluctuations at Bonneville Dam from 71.5-76.5 ft. Tailwater elevations were adjusted from RM 188.95 to location at TDEFL powerhouse (RM 192.43) using relationships developed in Oct. 2000 study.
***Based on hourly readings at Powerhouse gage.
****Estimate to be verified with fish passage data.
*****From Fish Passage Plan 2010

Note: Highlighted values used in final selection of minimum emergency flow analysis.

APPENDIX C – Fish Turbine Spare Parts List

G2D-20030	ASSEMBLY, BASE, 3 POLE, W-H #1490400, TYPE N, SIZE 3 LINE STARTER CONTACT BASE TDD, JDD
G2D-20035	ASSEMBLY, BASE, 3 POLE, #1490403, SIZE 3, 3 POLE, TDD, JDD
G2D-20086	STUDS, CONTACT, FOR 4,000 AMP GE BREAKER DISCONNECTS (PR 16684)
G2D-20086	STUDS, CONTACT, FOR 4,000 AMP GE BREAKER DISCONNECTS (PR 16684)
G2D-20087	CONTACT, STATIONARY, FOR 4,000 AMP GE BREAKER DISCONNECT
G2D-20100	SNUFFER ASSEMBLY (ARC CHUTE FOR DMB-50-T), TDD
G2D-20105	UPPER STATIONARY ASSEMBLY, DMB-25-IT BREAKER (MAIN CONTACT), TDD
G2D-20106	TRIP ATTACHMENT, SHUNT, FED. PAC. #11550757, TDD
G2D-20120	BARRIER, BOX, COMPLETE, TDD, JDD, GE#61C41662
G2D-20135	BEARING, PMG FU, SKF BRAND #6209-2RSJEM, PELTON GOVERNOR, PM-5365, PMG (G-6)
G2D-20157	BEARING, FAFNIR 206 KDD ONLY. DO NOT SUB!, FOR PELTON TYPE "B"
G2D-20178	BEARING, GENERATOR GUIDE, FU 1-2, TDD
G2D-20190	BEARING, PMG FU, SKF #6208-2RSC3 OR KOYO #6208-2RSC3 , METRIC SINGLE ROW, LIGHT
G2D-20192	BEARING, NSK 626ZZ & FAFNIR 36KDD, FOR FU AND SELSYN SYNCHRONIZE MOTORS, TDD
G2D-20194	BEARING, TORRINGTON B-812X, FOR SPEED ADJUST SHAFT IN GOVERNOR CABINETS, OLD UNITS
G2D-20204	BEARING, FAG OR SKF #6203-2ZJEM, METRIC SINGLE ROW, LIGHT 200 SERIES,
G2D-20240	BLOCK, INSULATING (F.U. F-1, F-2 RTDS),TDD
G2D-20260	BRIDGE ASSEMBLY, MOVABLE, #181474-K1, TDD
G2D-20340	BUSHING, GATE, BRONZE, 4" LONG, F.U. TURBINE, TDD
G2D-20345	BUSHING, BRONZE, BLADE SHANK F1 & F2, 4--3/4"L X 11-1/2" ID, TDD
G2D-20379	CUP, BEARING, TIMKEN #09195, GOVERNOR PARTS
G2D-20690	CLOTH, GLASS, .007 X 36" (50 YD ROLLS), TDD
G2D-21034	FIELD COIL AND POLE FOR EXCITER, F1 & F2
G2D-21035	ASSEMBLY, FIELD COIL, F.U., TDD
G2D-21185	COIL, G.E. #22D151G-41, 125VDC, F1 & F2
G2D-21280	COLLAR, INSULATING, STATOR COILS, (F.U. GENERATOR) TDD
G2D-21690	KIT, CONTACT, SIZE 3, TYPE N CONTROL, 3 POLE, GENERIC FOR WESTINGHOUSE #1625563, ARGO
G2D-21871	SWIVEL, HIGH PRESSURE, ANTI-FRICTION, 1/4", #U997-6, FOR FARVAL GREASE SYSTEM,TURBINE PIT
G2D-21965	COVER, DRIVE SHAFT, PUMP, (F.U. GOVERNOR) TDD
G2D-22242	GASKET, UPPER OIL GUIDE BEARING, M. U. 15-22, SET OF 4 SECTIONS, 79-1/2" OD X 74-3/4" ID
G2D-22249	GASKET, DRAFT TUBE DOOR, FU 1-2, TDD, 24" X 36" RECT ID X 31" X 43" RECT
G2D-2225	FITTING, JIC, FEMALE, SWIVEL, #1AA8FJ6, AEROQUIP HYDRAULIC
G2D-22290	GEAR, SPEED SWITCH, 1-1/2" DIA. FOR 12 POLE PERMANENT MAGNET GENERATOR, 1 EACH OF #1, #2,
G2D-22295	GEAR, SPEED SW #35444-60, 3" DIA., TDD,
G2D-22521	TACH-PAK, AIRPAX, FOR F.U. EXCITERS, #T77430-11
G2D-22522	SENSOR, #H1512-009, FOR F.U. EXCITERS
G2D-22523	SENSOR, #H1522-009, FOR FU EXCITERS
G2D-22756	ASSEMBLY, BEARING TURBINE GUIDE, FU 1-2 TURBINE, 8TH FLOOR B-2, TDD
G2D-22901	MOTOR, BALDOR #VM3538, USED FOR FU AC TURBINE BEARING OIL PUMP, 1/2 HP, 208/230/460 VAC,
G2D-22935	MOTOR, INDUCTION, W-H 220/440 V, 3 PHASE, #77, F1 & F2, TDD
G2D-23018	METER, FLOW, 6,000 PSI, 1/2" PORT, NPTF, 0.5 - 5.0 GPM, #H613B-005. FOR WATER BASED FLUIDS

G2D-23019	METER, FLOW, 6,000 PSI, 1/2" NPTF, 1-15 GPM, #H613B-015, FOR WATER-BASED FLUIDS, BRASS
G2D-23021	PIN, CRANK, SPEED ADJUST, #FM-23392F (SL-17), USED FOR PELTON GOVERNOR FULLER CONTROLS
G2D-23026	SHAFT, RESTORING, #FM-16365AD, (R-2), USED FOR PELTON GOVERNOR PERMANENT MAGNET GENERATOR,
G2D-23027	PIN, CALIBRATION, #FM-16365DF, (R-3) USED FOR PELTON GOVERNOR PERMANENT MAGNET GENERATOR, GROUP
G2D-23028	KEEPER, SPRING, BLADE PV, #FM-24126F, (BR-42), USED FOR PELTON GOVERNOR, GROUP #3, GATE &
G2D-23029	ROD, PUSH, PUMP PV, #DM-3352F, USED FOR PELTON GOVERNOR, FULLER CONTROLS
G2D-23030	PIN, MK #6503 15 KVA SYSTEM FOR F.U. & M.U. GENERATORS, TDD
G2D-23031	SHAFT, GL CLUTCH, #37455-A, USED FOR PELTON GOVERNOR FULLER CONTROLS
G2D-23032	SPINDLE, L.H., #FM-16365BF, (R-6), USED FOR PELTON GOVERNOR, PERMANENT MAGNET GENERTOR, GROUP #5
G2D-23033	LEVER, SPEED ADJUST, SL-16, #FM-23393F,USED FOR PELTON GOVERNOR, FULLER CONTROLS
G2D-23034	CAGE, PILOT VALVE, OIL PUMP, #FM-019497D, USED FOR PELTON GOVERNOR,
G2D-23035	PIN, SHEAR (F.U. TURBINE), TDD
G2D-23038	SHUTTEL, #DM-3372CF, USED FOR PELTON GOVERNOR, FULLER CONTROLS
G2D-23039	KIT, PMG DRIVE MOD, #9 (16" LOCKWIRE #PE-9223 & #12 (1) RET. RING, EXT 1-1/2", #PM-5367, USED FOR
G2D-23040	PISTON, COMPENSATING, #FM-11002BD, (D-14), USED FOR PELTON GOVERNOR, GROUP #2, COMPENSATING
G2D-23041	SPINDLE, R.H., #FM-16365CF, (R-6), USED FOR PELTON GOVERNOR, PERMANENT MAGNET GENERTOR, GROUP #5
G2D-23042	SPRING, COMPENSATING, #FM-11002DF, (D-18), USED FOR PELTON GOVERNOR, GROUP #2, COMPENSATING
G2D-23043	PISTON, POWER, #FM-90167BD (D-5), USED FOR PELTON GOVERNOR, GROUP #2, COMPENSATING DASHPOT
G2D-23044	SPRING, KEEPER, BLADE PV, #FM-24126F, (BR-42), USED FOR PELTON GOVERNOR, GATE & BLADE RELAY VALVE
G2D-23046	PIN, TAPER, #2 X 1-1/2", #PM-5388, (R-16), USED FOR PELTON GOVERNOR, PERMANENT MAGNET GENERATOR
G2D-23050	PIN ASSEMBLY, SPEC., 1-3/4" DIA., X 3-11/16" LONG (F.U. TURBINES) TDD
G2D-23070	PLATE, LOCK, METAL, #27D72911 (F.U. GEN., F-1, F-2) TDD
G2D-23095	PLUG, HEAD COVER JACKING BOLT, F.U. TURBINE (GATE CHAIN ASSEMBLY), TDD (DO NOT REORDER)
G2D-23127	PUMP, (F.U.) B&S PUMP, 2SA, WRV, CCW ROTATION. MOTOR: 1/2 HP, 1725 RPM, 250V DC, TEFC.
G2D-23128	PUMP, (F.U.) B&S #2SA, WRV, CW ROTATION. MOTOR: 1/2 HP, 115/230 VAC, 1 PH, 60 CYCLE TEFC.
G2D-23129	PUMP, COMPLETE, FU, B&S PUMP #2SA, WRV, CW ROTATION, MOTOR: 1/2 HP, 1725 RPM,
G2D-23132	PUMP REPAIR KIT, FOR B&S #2S, FU TURBINE BEARING OIL PUMP
G2D-23400	RINGS, PISTON, 6-58" X 3/8" (F.U. TURBINE CYLINDERS, TDD
G2D-23422	SPOOL, PILOT VALVE, #DM-3081, GOVERNOR PARTS FOR OLD PELTON UNITS AND FU
G2D-23423	CAGE, PILOT VALVE, #DM-3082B, GOVERNOR PARTS FOR OLD PELTON UNITS AND FU
G2D-23424	CAGE, PILOT VALVE, #DM-3114B, GOVERNOR PARTS FOR OLD PELTON FU
G2D-23428	SPOOL, PILOT VALVE, #DM-3081D, GOVERNOR PARTS FOR OLD PELTON FU
G2D-23429	SPRING, BLADE PILOT VALVE, #FM-24125F, GOVERNOR PARTS FOR OLD PELTON UNITS
G2D-23431	SPOOL, PILOT VALVE, OIL PUMP, #FM-016402D, GOVERNOR PARTS FOR OLD PELTON UNITS
G2D-23432	SLEEVE, WEARING, PILOT VALVE, #41373A, FOR OLD PELTON UNITS
G2D-23433	SPOOL, PILOT VALVE, AUX VALVE, #AV-16, FOR OLD PELTON UNITS
G2D-23434	CAGE, PILOT VALVE, AUX VALVE, #AV-16A, FOR OLD PELTON UNITS
G2D-23436	SPOOL, VALVE, BLADE PILOT, #BR-39, FOR OLD PELTON UNITS
G2D-23437	CAGE, GATE LIMIT, #DM-3085B, FOR OLD PELTON UNITS
G2D-23438	SPRING SET, FLYBALL STRAP, #FM-01599F, FOR OLD PELTON UNITS
G2D-23439	CAGE, PUMP PILOT VALVE, #DM-3349D, FOR OLD PELTON UNITS

G2D-23440	ROLLER, BRASS, FOR PRESSURE RELEASE COVER, F.U. TURBINE, TDD(DO NOT REORDER)
G2D-23442	CAGE, PILOT VALVE, SPRING, CONICAL, #H-41366A, FOR OLD PELTON UNITS
G2D-23443	SPOOL, PILOT VALVE PUMP, #DM-3350D, FOR OLD PELTON UNITS
G2D-23444	BUSHING, DRIVE, PMG (G-30) #DM-3072F, FOR OLD PELTON UNITS
G2D-23445	ROTOR, GOVENOR HEAD, F.U. GEN., MAIN UNIT PELTON, TDD
G2D-23447	SPRING, ECHELON CONTROL, OIL PUMP, #FM-24421F, FOR OLD PELTON UNITS
G2D-23448	SUPPORT, UPPER SPRING, #FM-09165D, FOR OLD PELTON UNITS
G2D-23449	SPOOL, GATE LIMIT, #DM-3084D, FOR OLD PELTON UNITS
G2D-23450	SLEEVE, WEARING, (H-63) PILOT VALVE, #DM-3113D, FOR OLD PELTON UNITS
G2D-23451	CAGE, VALVE, BLADE PILOT, #BR-40, FOR OLD PELTON UNITS
G2D-23478	SEAL, BLADE FISH UNIT, 17.00 X 18.50 X 1.440, SEAL CONSISTS OF ONE SET (2) SEALS, OPPOSED
G2D-23478A	SEAL, BLADE FISH UNIT, 17.00 X 18.50 X 0.75", JAMES WALKER M1/D6/SPLIT,
G2D-23485	SEAL, CARBON RING, F.U. (ALLIS-CHALMERS, *NOTE* SET CONSISTS OF TWO RINGS, EACH RING IS
G2D-23493	SEAL, WASHER, PARKER #7500, 5/8", TDD (DON'T REORDER)
G2D-23497	SEAL, MECHANICAL FOR BROWN & SHARP (B&S) #2S PUMP., FU TURBINE BEARING OIL PUMP
G2D-23498	SEAL, OIL #48520 RELIANCE MASTER TYPE SL (FOR BROWN & SHARPE MOTOR DRIVEN ROTARY GEAR PUMP
G2D-23506	SEAL, NATIONAL #470050, USED FOR PELTON GOVERNOR DISTRIBUTION VALVE,
G2D-23516	SEAL, MECHANICAL WITH FLOATING STYLE MATING RING, SIZE1.0125" FOR GOV OIL PUMPS ON FU, MATERIALS
G2D-23608	SLEEVE, TURBINE SHAFT, FU, SEE HARD CARD FOR SPECS AND DRAWINGS, 23609 IS THE MANDREL.
G2D-23609	MANDREL FOR F.U. TURBINE SHAFT SLEEVE, #23608 (SEE 23608 FOR DRAWINGS AND SPECS)
G2D-23640	SPACER, METAL, 1/4" X 1" X 3" (F.U. GEN. F-1, F-2) TDD
G2D-23805	STATOR, GOVENOR HEAD, F.U. GEN., TDD
G2D-23900	SWITCH, SEE HARD CARD.AMMETER, TYPE W, STAYPUT, HEAVY DUTY ROUND HANDLE, ITEM 4-07 (N)
G2D-24261	RUNNER, THRUST GENERATOR BEARING, HALF FU1 & FU2
G2D-24262	SHOES, THRUST BEARING, F.U. (8 BX = 1 SET)
G2D-24263	ASSEMBLY, WICKET GATE, F.U.
G2D-24515	VALVE, PILOT, PC. #41468-A, DWG. C-35443-61-36, (F.U. & M.U. GOVENORS) TDD
G2D-24520	VALVE, RELAY, GATE. 8" (F.U. & M.U. GOVENORS) TDD
G2D-24550	WASHER, IRON, ITEM #3, DWG. 21C4267-1, T
G2D-24555	WASHER, LOCK, S#1240367, (F.U. GEN., F-1, F-2) TDD
G2D-26015	BOLT, SOCKET ALLEN HEAD, 1/2-13 X 1", S.S., FOR FU BLADE SEAL SEGMENT
G2D-27540	BOOSTER CYLINDER, (F.U. BKR, FXJ1), REF: P064-1417, TDD
G2D-27545	BUFFER, (F.U. BKR FXJ1) (REF: PO 64-1517) TDD
G2D-27550	CLAMP, FOR BUFFER, (F.U. BKR, FXJ1) (REF: PO. 64-1517) TDD
G2D-27555	CONTACT, FINGER, PRIMARY, (F.U. BKR) (REF: PO. 64-1517) TDD
G2D-27565	CONTACT, PRIMARY, (F.U. BKR. FXJ1) (REF: PO. 64-1517) TDD
G2D-27575	COVER, (F.U. BKR. FXJ1) (REF: PO. 64-1517) TDD
G2D-27580	FILLER PLATE, ARC RUNNER (UPPER), (F.U. BKR FXJ1) (REF: 64-1517) TDD
G2D-27585	SPACER FOR ARC RUNNER
G2D-27590	SPACER, (F.U. BKR. FXJ1) (REF: 64-1517), TDD
G2D-27595	SPRING, RETAINER, TDD

G2D-27600	SUPPORT, ARC CHUTE, (F.U. BKR, FXJ1) (REF: PO 64-1517) TDD
G2D-27605	COIL, SUPPORT, (F.U. BKR, FXJ1) (REF: PO 64-1517) TDD
G2D-27610	TUBE ASSEMBLY, (F.U. BKR, FXJ1) (REF: PO 64-1517) TDD
G2D-27645	BLOCK, INSULATOR, #MK110, TDD
G2D-27691	BREAKER, AIR CIRCUIT, TYPE FIS1250, PART # 3ACD5340A019, FOR MAIN UNIT EXCITERS, THIS IS
G2D-27933	CONVERTER, SIGNAL, ENTRELEC #1SVR040001R0400
G2D-27934	CONVERTER, SIGNAL, ENTRELEC #1SVR040000R1700
G2D-28000	FLOAT, STAINLESS, FOR TOP PLATE FLOAT SWITCHES, 5" DIA. 1/4" NPT, 550 PSI, MU 15-22
G2D-28120	LINK, F.T.U. GATE, TDD
G2D-28245	BEARING, LOWER GUIDE, W.H, #30D6748 F.U. GENERATORS, TDD
G2D-28250	GUIDE BEARING SHOE, #51P60. S.S. GENERATOR, TDD
G2D-28265	SOLENOID, COMPLETE, 125V, DC #CR9503-209 CAN 5, TDD
G2D-28401	VALVE, PRESSURE REGULATING GLAND WATER, MU 15-22, AND SPILLWAY DECK WASH
G2D-28816	
G2D-36305	THYRISTORS, EXCITER, 5SPT16F2400
G2D-36329	CONTACTOR, AC-3:37KW-400V, AE75-30-11-8711, FIELD FLASHING, FISH WATER EXCITERS