BLACK RIVER NEEDS ASSESSMENT
AND CAPITAL IMPROVEMENT PLANNING

KING COUNTY, WASHINGTON

TASK 2 NEEDS ASSESSMENT
TECHNICAL MEMORANDUM

JANUARY 2015
BLACK RIVER NEEDS ASSESSMENT AND CAPITAL IMPROVEMENT PLANNING

TASK 2 NEEDS ASSESSMENT TECHNICAL MEMORANDUM

JANUARY 2015
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2. NEEDS ASSESSMENT TECHNICAL MEMORANDUM

2.1. INTRODUCTION/EXECUTIVE SUMMARY

The Black River Pump Station (BRPS) is located on a dam that spans the Black River channel, which carries all Springbrook Creek flow to the Duwamish River. The BRPS was constructed in 1972, and includes seven engine-driven flood control pumps. It has been successfully operated and maintained (O&M) by King County Road Services (ROADS) Maintenance Division for 35 years. In 2007 the King County Wastewater Treatment Division (WTD) agreed to provide O&M services to the Water and Land Resources Division (WLRD). Since it was constructed, the BRPS has received only one major capital improvement (the recent upgrade of the diesel fuel system).

This needs assessment has been conducted to provide WLRD and WTD an assessment of the capital improvement needs at the BRPS. WTD staff (mechanical maintenance, engine maintenance, and operations) provided input on equipment issues and operational challenges. This assessment identifies improvements needed to the existing equipment as well as new equipment that could be added to address some of the operational issues.

Task 6 of this project will be an assessment of the various recommendations presented in this technical memorandum (TM) based on a number of criteria (spare parts availability, reliability concerns, improved efficiencies, improved fish migration, etc.). Task 7 of this project develops the higher ranked recommendations into capital needs recommendations, organized to conform to the System Wide Improvement Framework (SWIF) Capital Improvements Program timeframes (e.g., 2 year, 5 year, 10 year, etc.).

Systems analyzed in this BRPS Needs Assessment:
- Flood control pumping system, including diesel engine drives
- Miscellaneous pumps (screen washing, fish ladder, engine cooling)
- Compressed air systems (instrument, service, and engine starting)
- HVAC (for engine combustion/cooling as well as building temperature control)
- Trash rake and conveyor
- Hoisting systems
- Fish migration facilities (downstream and upstream)
- Electrical systems (including backup power)
- Control systems
- Drainage/spill containment
- Structural (including assessing areas of corrosion)

A basic site plan and floor plan for the BRPS are included as Figures 2-1 and 2-2, respectively. These figures were taken from the County’s BRPS Operations Manual (90% draft, December, 2007).
Figure 2-1 Ground Plan
Figure 2-2 Layout of the Pump Building
2.1.1. General Notes

NAVD88 Datum
All elevations referenced in this report are NAVD88, the datum used for recording and managing Green River water levels. However, the design drawings for this station, as well as the BRPS Operations Manual, the station bubblers (for river level sensing), and the station’s pump control system, still use NGVD29.

Conversion of vertical datum from NGVD29 to NAVD88 was determined using Corpscon Version 6.0.1, a U.S. Army Corps of Engineers datum conversion program, for two specific locations - at the location of USGS Gage 12113350 (Green River at Tukwila, WA) and at the location of the Black River Pump Station. To convert an elevation from NGVD29 to NAVD88 at the USGS gage location, add 3.54 feet. To convert an elevation from NGVD29 to NAVD88 at the Black River Pump Station location, add 3.55 feet.

Code Issues
The scope of this assessment did not include a code review, therefore checking the compliance of the BRPS to Occupational Safety and Health Agency (OSHA) and Washington Industrial Safety and Health Act (WISHA) requirements was not performed. Determining compliance of the existing electrical system with the National Electric Code (NEC) also was not performed; however, code compliance may be discussed in the “issues” sections of the electrical equipment items in the Electrical section of this TM.

Format for Recommendations
The format for recommendations for capital improvements are categorized by discipline (e.g., M-1 is the first mechanical recommendation). The recommendation numbers are often not consecutive (i.e., there can be breaks in the numbering system). The various discipline categories include the following:

- M   Mechanical Recommendation
- FM  Fish Migration Recommendation
- E   Electrical Recommendation
- I   Instrumentation and Control Recommendation
- S   Structural Recommendation

2.1.2. Cost Estimates
All cost estimates for the recommended capital improvements are considered planning level cost estimates. For this report, this is defined as being within 25% below to 50% above actual costs.

Engineering cost estimates generally range from 10% to 40% of the estimated construction cost, depending on the engineering effort anticipated to design the recommended improvement (including coordination with the County during the design phase and incorporating County review comments). Engineering costs can be significantly higher for retrofit/rehabilitation projects (as a percentage of construction cost) than for new construction. This is due to the additional effort needed to incorporate the improvement into the existing facility, including developing electronic base drawing files that reflect the as-built configuration of the facility, defining the demolition requirements, and designing the tie-in or interface of the new design with the existing facilities, including modifications to the existing civil, structural, mechanical, electrical, and control systems to fully integrate the needed improvement.

2.1.3. Summary of Recommendations
Table 2-1 shows the various needs recommendations identified and developed in this evaluation. Many of the recommendations are interrelated, and in some cases, a specific recommendation would eliminate the need for other related recommendations. An example would be M-3 or M4, which are a complete
replacement of the Mitsubishi engines. Obviously, this could eliminate M-1 and M-2 as these recommendations deal with improving the reliability and lowering the risk of oil spills of the existing Mitsubishi engines. However, M-3 or M-4 do not eliminate M-5 and M-6, as the new engines would still require acoustical insulation on their exhausts, as well as new exhaust silencers and exterior piping.

Some of these recommendations should be completed prior to other recommendations due to the need to maintain a fully functional BRPS even during construction. Going back to the previous example, M-1 or M-2 (the replacement of the Mitsubishi engines) should be completed prior to M-20 or M-21 (the replacement or overhaul, respectively, of flood control pump P1). The Mitsubishi engines should be replaced to provide a dependable P2 and P4 pumping system prior to the County undertaking the replacement or overhaul of P1.

The interrelationships of these recommendations will be examined more closely in Tasks 6 and 7 mentioned earlier.

Table 2-1 Recommended Actions-Black River Pump Station Needs Assessment

<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>M-1</td>
<td>Obtain a Set of Critical Spare Parts for the Mitsubishi Engines</td>
<td>N/A</td>
<td>$40,000</td>
<td>$40,000</td>
</tr>
<tr>
<td>M-2</td>
<td>Install Crankcase Ventilation Canisters on the Mitsubishi Engines</td>
<td>N/A</td>
<td>$11,000</td>
<td>$11,000</td>
</tr>
<tr>
<td>M-3</td>
<td>Completely Replace the Mitsubishi Engines with New Diesel Engines with Tier 3 Emissions</td>
<td>$60,000</td>
<td>$240,000</td>
<td>$300,000</td>
</tr>
<tr>
<td>M-4</td>
<td>Completely Replace the Mitsubishi Engines with New Diesel Engines with Tier 4 Final Emissions</td>
<td>$60,000</td>
<td>$340,000</td>
<td>$400,000</td>
</tr>
<tr>
<td>M-5</td>
<td>Wrap Exhausts of Mitsubishi Engines with Acoustical Insulation Material</td>
<td>N/A</td>
<td>$13,000</td>
<td>$13,000</td>
</tr>
<tr>
<td>M-6</td>
<td>Replace Existing Exhaust Silencers and Exterior Exhaust Piping for Mitsubishi Engines</td>
<td>$10,000</td>
<td>$50,000</td>
<td>$60,000</td>
</tr>
<tr>
<td>M-10</td>
<td>Obtain a Set of Critical Spare Parts for Waukesha Engines</td>
<td>N/A</td>
<td>$50,000</td>
<td>$50,000</td>
</tr>
<tr>
<td>M-11</td>
<td>Completely Replace All Waukesha Engines</td>
<td>$250,000</td>
<td>$2,750,000</td>
<td>$3,000,000</td>
</tr>
<tr>
<td>M-12</td>
<td>Replace Coolant Manifold Serving Waukesha Engines</td>
<td>$20,000</td>
<td>$45,000</td>
<td>$65,000</td>
</tr>
<tr>
<td>M-13</td>
<td>Clean Out the Heat Exchangers and Coolant Piping Serving Waukesha Engines</td>
<td>Included in M-12</td>
<td>$12,000</td>
<td>$12,000</td>
</tr>
<tr>
<td>M-14</td>
<td>Maintain Coolant Expansion Tanks Serving Waukesha Engines</td>
<td>Included in M-12</td>
<td>$21,000</td>
<td>$21,000</td>
</tr>
<tr>
<td>M-15</td>
<td>Replace the P3 Engine Exhaust Silencer</td>
<td>$8,000</td>
<td>$32,000</td>
<td>$40,000</td>
</tr>
<tr>
<td>M-16</td>
<td>Add Coolant Heaters to the Waukesha Engines</td>
<td>$15,000</td>
<td>$45,000</td>
<td>$60,000</td>
</tr>
<tr>
<td>M-17</td>
<td>Fit the Waukesha Engines for Spin-On Oil Filters</td>
<td>N/A</td>
<td>$17,500</td>
<td>$17,500</td>
</tr>
<tr>
<td>M-18</td>
<td>Replace the Control Panels on the Waukesha Engines</td>
<td>$25,000</td>
<td>$120,000</td>
<td>$145,000</td>
</tr>
<tr>
<td>M-19</td>
<td>Test Waukesha Engines</td>
<td>$22,000</td>
<td>$7,500</td>
<td>$29,500</td>
</tr>
<tr>
<td>M-20</td>
<td>Replace P1 (New Pump and Motor)</td>
<td>$39,000</td>
<td>$361,000</td>
<td>$400,000</td>
</tr>
<tr>
<td>M-21</td>
<td>Overhaul P1 (Overhaul Pump, New Motor)</td>
<td>N/A</td>
<td>$90,000</td>
<td>$90,000</td>
</tr>
<tr>
<td>M-22</td>
<td>Purchase Critical Spare Parts for P1 (Pump only)</td>
<td>N/A</td>
<td>$85,000</td>
<td>$85,000</td>
</tr>
<tr>
<td>M-30</td>
<td>Replace P2 and P4 (Pumps only)</td>
<td>$55,000</td>
<td>$1,100,000</td>
<td>$1,155,000</td>
</tr>
<tr>
<td>M-31</td>
<td>Overhaul P2 and P4 (Pumps only)</td>
<td>N/A</td>
<td>$135,000</td>
<td>$135,000</td>
</tr>
<tr>
<td>M-32</td>
<td>Purchase Critical Spare Parts for P2 and P4 (Pumps only)</td>
<td>N/A</td>
<td>$170,000</td>
<td>$170,000</td>
</tr>
<tr>
<td>M-33</td>
<td>Test P3, P5, P6, P7, and P8</td>
<td>$40,000</td>
<td>$0</td>
<td>$40,000</td>
</tr>
<tr>
<td>M-34</td>
<td>Replace Oilers on P3, P5, P6, P7, and P8</td>
<td>N/A</td>
<td>$50,000</td>
<td>$50,000</td>
</tr>
<tr>
<td>M-40</td>
<td>Replace P9 (New Pump and Motor)</td>
<td>N/A</td>
<td>$83,000</td>
<td>$83,000</td>
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<td>---------</td>
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</tr>
<tr>
<td>M-41</td>
<td>Overhaul P9 (Overhaul Pump and Reuse Motor)</td>
<td>N/A</td>
<td>$45,000</td>
<td>$45,000</td>
</tr>
<tr>
<td>M-42</td>
<td>Install an Automatic Self-Cleaning Strainer on the Spray Water Flow</td>
<td>$15,000</td>
<td>$38,000</td>
<td>$53,000</td>
</tr>
<tr>
<td>M-43</td>
<td>Overhaul P10 (Overhaul Pump, New Motor)</td>
<td>N/A</td>
<td>$30,000</td>
<td>$30,000</td>
</tr>
<tr>
<td>M-44</td>
<td>Provide a New Cooling Water Pump P12</td>
<td>$23,000</td>
<td>$77,000</td>
<td>$100,000</td>
</tr>
<tr>
<td>M-45</td>
<td>Provide Manually Cleaned Strainer on P11 and P12 Discharge</td>
<td>$22,000</td>
<td>$78,000</td>
<td>$100,000</td>
</tr>
<tr>
<td>M-50</td>
<td>Install a New Air Dryer on the Instrument Air Line</td>
<td>$30,000</td>
<td>$45,000</td>
<td>$75,000</td>
</tr>
<tr>
<td>M-51</td>
<td>Inspect and Repair Air Lines</td>
<td>$20,000</td>
<td>$60,000</td>
<td>$80,000</td>
</tr>
<tr>
<td>M-60</td>
<td>Replace Roof-Mounted Ventilation Fans</td>
<td>$12,000</td>
<td>$35,000</td>
<td>$47,000</td>
</tr>
<tr>
<td>M-61</td>
<td>Replace Pneumatic Damper Actuators</td>
<td>$6,000</td>
<td>$14,000</td>
<td>$20,000</td>
</tr>
<tr>
<td>M-62</td>
<td>Install Airlift / Fishway Room Ventilation System</td>
<td>$20,000</td>
<td>$40,000</td>
<td>$60,000</td>
</tr>
<tr>
<td>M-63</td>
<td>Upgrade Electrical Room Ventilation System</td>
<td>$7,000</td>
<td>$13,000</td>
<td>$20,000</td>
</tr>
<tr>
<td>M-64</td>
<td>Clean and Lubricate Hand Operated Damper Near P1</td>
<td>N/A</td>
<td>$1,000</td>
<td>$1,000</td>
</tr>
<tr>
<td>M-65</td>
<td>Inspect and Service Heaters as Required</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>M-70</td>
<td>Replace the Trash Rake and Dolly with a Monorail System</td>
<td>$250,000</td>
<td>$1,150,00</td>
<td>$1,400,00</td>
</tr>
<tr>
<td>M-71</td>
<td>Replace the Trash Conveyor</td>
<td>$9,000</td>
<td>$35,000</td>
<td>$44,000</td>
</tr>
<tr>
<td>M-80</td>
<td>Replace the 3-Ton Electric Trolley Hoist</td>
<td>N/A</td>
<td>$20,000</td>
<td>$20,000</td>
</tr>
<tr>
<td>M-81</td>
<td>Replace the 2-Ton Manual Chain Hoist with an Electric Hoist</td>
<td>$7,000</td>
<td>$13,000</td>
<td>$20,000</td>
</tr>
<tr>
<td>FM-1</td>
<td>Replace the Fish Ladder Bar Rack</td>
<td>$10,000</td>
<td>$25,000</td>
<td>$35,000</td>
</tr>
<tr>
<td>FM-2</td>
<td>Replace SG2, including the Air Cylinder Actuator</td>
<td>$5,000</td>
<td>$13,000</td>
<td>$18,000</td>
</tr>
<tr>
<td>FM-10</td>
<td>Replace Electric Hoists for the Fish Screens</td>
<td>$14,000</td>
<td>$56,000</td>
<td>$70,000</td>
</tr>
<tr>
<td>FM-11</td>
<td>Upgrade Screen Spray Water System</td>
<td>$40,000</td>
<td>$140,000</td>
<td>$180,000</td>
</tr>
<tr>
<td>FM-12</td>
<td>Replace the Airlift Compressor and Airflow Controls</td>
<td>$36,000</td>
<td>$144,000</td>
<td>$180,000</td>
</tr>
<tr>
<td>FM-13</td>
<td>Replace the Weather Cover over the Airlift Compressor</td>
<td>$8,000</td>
<td>$30,000</td>
<td>$38,000</td>
</tr>
<tr>
<td>FM-14</td>
<td>Evaluate and Monitor Airlift Capacity</td>
<td>$33,000</td>
<td>$12,000</td>
<td>$45,000</td>
</tr>
<tr>
<td>FM-15</td>
<td>Replace the Air-Actuator for SG1</td>
<td>$3,000</td>
<td>$7,000</td>
<td>$10,000</td>
</tr>
<tr>
<td>E-1</td>
<td>Replace Standby Generator</td>
<td>$30,000</td>
<td>$140,000</td>
<td>$170,000</td>
</tr>
<tr>
<td>E-2</td>
<td>Replace the Automatic Transfer Switch</td>
<td>$9,000</td>
<td>$17,000</td>
<td>$26,000</td>
</tr>
<tr>
<td>E-3</td>
<td>Replace the Motor Control Center and Main Breaker</td>
<td>$51,000</td>
<td>$190,000</td>
<td>$241,000</td>
</tr>
<tr>
<td>E-4</td>
<td>Provide VFD for P1</td>
<td>$7,000</td>
<td>$20,000</td>
<td>$27,000</td>
</tr>
<tr>
<td>E-5</td>
<td>Provide VFD for Airlift Compressor</td>
<td>$7,000</td>
<td>$15,000</td>
<td>$22,000</td>
</tr>
<tr>
<td>E-6</td>
<td>Replace the 120VAC Panelboard</td>
<td>Included in MCC replacement</td>
<td></td>
<td></td>
</tr>
<tr>
<td>E-10</td>
<td>Replace Pump Room Lighting</td>
<td>$9,000</td>
<td>$29,000</td>
<td>$38,000</td>
</tr>
<tr>
<td>E-11</td>
<td>Replace Forebay Lighting</td>
<td>$9,000</td>
<td>$19,000</td>
<td>$28,000</td>
</tr>
<tr>
<td>E-12</td>
<td>Move Forebay Lighting Switch</td>
<td>Included forebay lighting replacement</td>
<td></td>
<td></td>
</tr>
<tr>
<td>E-20</td>
<td>Replace Exterior Lighting</td>
<td>$9,000</td>
<td>$19,000</td>
<td>$28,000</td>
</tr>
<tr>
<td>E-30</td>
<td>Reconnect Unconnected Ground Tails</td>
<td>$5,000</td>
<td>$10,000</td>
<td>$15,000</td>
</tr>
<tr>
<td>E-31</td>
<td>Tie New Equipment into the Existing Ground Grid</td>
<td>$5,000</td>
<td>$10,000</td>
<td>$15,000</td>
</tr>
<tr>
<td>I-1</td>
<td>Replace Main Control Panel (MCP)</td>
<td>$46,000</td>
<td>$102,000</td>
<td>$148,000</td>
</tr>
<tr>
<td>I-2</td>
<td>Provide Separate Pneumatic Control Panel</td>
<td>$10,000</td>
<td>$22,000</td>
<td>$32,000</td>
</tr>
<tr>
<td>I-3</td>
<td>Provide New PLC system</td>
<td>$10,000</td>
<td>$20,000</td>
<td>$30,000</td>
</tr>
<tr>
<td>I-4</td>
<td>Provide New Ethernet Control System</td>
<td>$6,000</td>
<td>$19,000</td>
<td>$25,000</td>
</tr>
<tr>
<td>I-10</td>
<td>Replace Emergency Lighting Panel</td>
<td>$6,000</td>
<td>$6,000</td>
<td>$12,000</td>
</tr>
<tr>
<td>---------</td>
<td>----------------------------------------------------</td>
<td>---------------------------</td>
<td>---------------------------</td>
<td>----------------------</td>
</tr>
<tr>
<td>I-11</td>
<td>Replace the Fish Screen Spray Control Panel</td>
<td>$20,000</td>
<td>$33,000</td>
<td>$53,000</td>
</tr>
<tr>
<td>I-12</td>
<td>Provide a New Bubbler Panel</td>
<td>$12,000</td>
<td>$20,000</td>
<td>$32,000</td>
</tr>
<tr>
<td>I-20</td>
<td>Provide New Telemetry System</td>
<td>$5,000</td>
<td>$12,000</td>
<td>$17,000</td>
</tr>
<tr>
<td>S-1</td>
<td>Provide Storage Shelves for SPCC Equipment</td>
<td>$3,000</td>
<td>$4,000</td>
<td>$7,000</td>
</tr>
<tr>
<td>S-2</td>
<td>Seal Utility Trench</td>
<td>$20,000</td>
<td>$110,000</td>
<td>130,000</td>
</tr>
<tr>
<td>S-10</td>
<td>Repair Damaged Concrete and Walkway Connection</td>
<td>$7,000</td>
<td>$13,000</td>
<td>$20,000</td>
</tr>
<tr>
<td>S-11</td>
<td>Aluminum Grating for Utility Trench</td>
<td>$10,000</td>
<td>$40,000</td>
<td>$50,000</td>
</tr>
<tr>
<td>S-12</td>
<td>Forebay Walkway Corrosion Protection</td>
<td>$40,000</td>
<td>$200,000</td>
<td>$240,000</td>
</tr>
<tr>
<td>S-13</td>
<td>Fishway and Airlift Rooms Corrosion Protection</td>
<td>$35,000</td>
<td>$150,000</td>
<td>$185,000</td>
</tr>
<tr>
<td>S-14</td>
<td>Crane Support Structure Corrosion Protection</td>
<td>$20,000</td>
<td>$50,000</td>
<td>$70,000</td>
</tr>
<tr>
<td>S-15</td>
<td>Inspect Flap Gates</td>
<td>N/A</td>
<td>$12,000</td>
<td>$12,000</td>
</tr>
<tr>
<td>S-20</td>
<td>Sheet Pile Wall Corrosion Investigation</td>
<td>$40,000</td>
<td>N/A</td>
<td>$40,000</td>
</tr>
</tbody>
</table>

Legend:
- M Mechanical Recommendation
- FM Fish Migration Recommendation
- E Electrical Recommendation
- I Instrumentation and Control Recommendation
- S Structural Recommendation

2.2. DIESEL ENGINES

NC Machinery assisted Tetra Tech in the development of the equipment cost estimates as well as installation cost for most of the new equipment discussed in this section. NC Machinery also provided estimated costs for engine testing assistance.

2.2.1. DIESEL ENGINES (MITSUBISHI)

**DESCRIPTION**

The Mitsubishi Model S6N-PT, turbocharged, radiator cooled, diesel engines are used to power the most heavily used of the engine-driven flood control pumps (P2 and P4), and are critical to the wet-weather operation of the pump station.

Nameplates on the engines say these are 580 hp at 1,800 rpm and were manufactured in March, 1985. Information from submittals provided with the engines say they are rated at 475 hp at 1,800 rpm. It appears that the nameplate information is not accurate and the engines are actually rated for 475 Hp.

These engines have electric starters with batteries. The exhaust systems appear to be finished with heat resisting silicone based aluminum paint.

Mitsubishi pump engine P2:
Total run time of 8,884 hours over 29+ years (equates to about 300 hours per year)
Mitsubishi pump engine P4: Total run time 8,885 hours over 29+ years (equates to about 300 hours per year)

ISSUES
1. It’s hard to get parts for older Mitsubishi engines. Parts have to come from Japan and there isn’t much dealer support. WTD staff suggested that these engines should be replaced. Hatton Marine in Ballard has filters, seals, and gaskets, but metal components are not available if one of them should have a major problem.

2. There is a significant amount of oil leakage from the oil breather tube and defective parts on the Mitsubishi. Absorbent towels are used to catch the leakage. WTD staff will install crankcase ventilation system separators on these to collect the oil and drain it back to the engine.

3. The exhaust piping and exhaust silencers for P2 and P4 exterior to the building are very corroded.

4. With just one of these engines running, it is difficult to communicate inside the building, due to the lack of acoustical wrapping on the exhaust pipes within the pump station for these two engines.

RECOMMENDATIONS

M-1, OBTAIN A SET OF CRITICAL SPARE PARTS FOR THE MITSUBISHI ENGINES
Purchase one complete rebuild kit consisting of belts, gaskets, seals, filters, cylinder heads, turbochargers, water pump, auxiliary water pump fuel injector parts, bearings, cylinder liners, and piston rings to be kept in stock for quick replacement when these engines require servicing.

Cost Estimate: $40,000

M-2, INSTALL CRANKCASE VENTILATION CANISTERS ON THE MITSUBISHI ENGINES
Install crankcase ventilation canisters on the Mitsubishi engines to collect the oil that escapes from the breather tubes. The cost estimate assumes these canisters would be installed on the two Mitsubishi engines by WTD staff.

Cost Estimate: $11,000

M-3, COMPLETELY REPLACE THE MITSUBISHI ENGINES WITH NEW DIESEL ENGINES WITH TIER 3 EMISSIONS
Replace the two Mitsubishi engines with new CAT C18 ACERT industrial power units producing 575 bhp at 1,800 rpm. These are I-6 turbocharged and after-cooled 18.1 L 4-stroke diesel engines with radiators and critical grade mufflers. These engines would meet Tier 3 diesel emissions as established by
the Environmental Protection Agency (EPA) and regulated in this region by the Puget Sound Clean Air Agency (PSCAA).

It is not clear at this level of investigation if these engines could qualify as “emergency use,” and be allowed to meet Tier 3 emission requirements, or if the engines would be considered to be equipment that is operated under normal conditions, and therefore required to meet stricter Tier 4 emission requirements. See the Task 5 Evaluate Natural-Gas-Fired Engines TM for further discussion of this issue.

The cost estimate for each engine includes engineering services for preparation of plans and specifications ($60,000) as well as construction cost, including equipment cost.

Cost Estimate: $300,000

**M-4, COMPLETELY REPLACE THE MITSUBISHI ENGINES WITH NEW DIESEL ENGINES WITH TIER 4 FINAL EMISSIONS**

Replace the two Mitsubishi engines with new CAT C18 ACERT industrial power units producing 575 bhp at 1,800 rpm. These are I-6 turbocharged and after-cooled 18.1-L 4-stroke diesel engines with radiators and critical grade mufflers. These engines would meet Tier 4 Final diesel emissions with no limit to their use (standby or normal service). As mentioned in the previous recommendation, see the Task 5 Evaluate Natural-Gas-Fired Engines TM for further discussion of this issue.

The cost estimate includes engineering services for preparation of plans and specifications ($60,000) as well as construction cost, including equipment cost.

Cost Estimate: $400,000

**M-5, WRAP EXHAUSTS OF MITSUBISHI ENGINES WITH ACOUSTICAL INSULATION BLANKETS**

Wrap the exhaust pipes with acoustical insulation blankets within the pump building. The exhaust piping inside the building consists of about 6 feet of 8-inch exhaust pipe and fittings, transitioning to about 9 feet of 10-inch pipe that passes through the exterior wall. The acoustical insulation will make it necessary to remove the thermocouples that are used to trigger the air actuators for the wall louver and roof exhaust fans. This ventilation equipment should be controlled by the water temperature of the engines. It is assumed that a temperature sensor will be provided on the new engines.

Cost Estimate: $13,000

Figure 2-5 The exhaust piping of the P2 and P4 engines
M-6, REPLACE EXISTING EXHAUST SILENCERS AND EXTERIOR EXHAUST PIPING FOR MITSUBISHI ENGINES

Replace the rusted exterior exhaust piping and silencers for P2 and P4 with new and more effective silencers. The existing exhaust silencers are semi-residential Kittel Model 2072-AST10, 6 feet long and 20 inches in diameter. Replace with a new critical grade stainless steel silencer. Critical grade silencers reduce noise by 30 -35 dBA (approximately 5 dBA higher than semi-residential silencers) and are recommended for use in residential and school areas where noise is a critical factor.

Also replace about 16 feet of vertical 10-inch exhaust pipe and rain cap with new stainless steel pipe and fittings.

The cost estimate includes engineering services for preparation of plans and specifications ($10,000) as well as construction cost, including equipment cost.

Cost Estimate: $60,000

2.2.2. DIESEL ENGINES (WAUKESHA)

DESCRIPTION

Waukesha L5792 DSIU 1,400 HP diesel engines are used to power flood control pumps P3, P5, P6, P7, and P8. Starting air required = 17.73 cfs @ 120 psi. Fuel consumption is approximately 70 gph. They are 42 years old, but each has an average of less than 8 hours per year of run time, and they still run well, as evidenced by the engine tests conducted by the County in 2014.

Table 2-2 Waukesha Engine Test Data, 2014

<table>
<thead>
<tr>
<th>Pump</th>
<th>Hours</th>
<th>Last Run</th>
<th>Oil Press</th>
<th>Oil Temp</th>
<th>Coolant Temp</th>
<th>RPM</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>P3</td>
<td>352</td>
<td>10/07/2014</td>
<td>45 psi</td>
<td>160 deg</td>
<td>160 deg</td>
<td>1,200</td>
<td>Oil sample appears normal.</td>
</tr>
<tr>
<td>P5</td>
<td>197</td>
<td>10/07/2014</td>
<td>40 psi</td>
<td>160 deg</td>
<td>120 deg</td>
<td>1,000</td>
<td>Oil sample appears normal.</td>
</tr>
<tr>
<td>P6</td>
<td>161</td>
<td>10/07/2014</td>
<td>40 psi</td>
<td>160 deg</td>
<td>180 deg</td>
<td>1,300</td>
<td>Oil sample appears normal.</td>
</tr>
<tr>
<td>P7</td>
<td>40</td>
<td>8/27/2014</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>1 K slightly high, Glycol negative, Pb high.</td>
</tr>
<tr>
<td>P8</td>
<td>330</td>
<td>8/27/2014</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>Oil sample appears normal.</td>
</tr>
</tbody>
</table>

1 When the engines were last run, oil samples were taken and analyzed by NC Machinery. The engine for pump P7 has a slightly elevated potassium level in the oil, which may indicate a minor coolant leak. A Glycol test was performed but was negative. The lead is high, which may be related to break-in wear. This engine has only been run 40 hours, so the piston rings are probably not seated yet. Other results are normal.

2 Control panel for P7 is inoperable.

3 Results were not recorded for P8.

ISSUES

1. The lead time for spare parts can extend into months due to the age of the engines, which are no longer being manufactured. This delay for repairs could affect the reliability of the station, especially if a number of engines require repair.

2. The silencer for P3 looks to be completely rusted through from the inside. There is some rust on the other exhausts, but their condition is unknown.

3. The engines are not equipped with heaters and are sometimes difficult to start in cold weather.
4. An outmoded method of replacing the oil filters is time consuming and often results in a small amount of oil being spilled onto the engine stand and floor.

5. The control panels are 42 years old, and spare parts cannot be obtained. The panel for P7 is not operating because parts have been taken from it to use in others. The engine can still be run but it cannot be monitored (oil temperature/pressure, water temperature, overspeed).

6. The cooling pump P11 is located in the P8 pump bay, which is not fitted with fish screens. As a result, P11 pumps a significant amount of sediment and debris that easily passes through the bar screen and enters the pump. WTD staff report that the heat exchangers collect rocks and debris, which lowers their effectiveness, and could eventually completely plug the heat exchangers.

7. There is only one pump (P11) to pump water from the river through the heat exchangers. If that fails, the large pumps cannot be run, leading to overheating and automatic shutdown of the Waukesha engines, which comprise 87% of the total installed pump capacity at this station. A redundant pump would provide a good safety margin for such a critical item.

8. WTD staff report that the interior of the coolant piping serving the Waukesha engines is heavily corroded, based on the condition of some sections of the coolant manifold that were recently replaced. A significant amount of rust and rust deposits were evident in the coolant manifold, which is uncoated Schedule 40 steel pipe located in the utility trench on the west side of the station. This sediment contributes to the clogging of heat exchangers, including the small heat exchangers serving the right angle gear drive, and oil coolers.

**RECOMMENDATIONS**

**M-10, OBTAIN A SET OF CRITICAL SPARE PARTS FOR WAUKESHA ENGINES**

Purchase a set of spare parts consisting of belts, gaskets, seals, filters, two cylinder heads, two turbochargers, water pump, auxiliary water pump fuel injector parts, bearings, cylinder liners, and piston rings to be kept in stock for quick replacement when these engines require servicing.

Cost Estimate: $50,000

**M-11, COMPLETELY REPLACE THE WAUKESHA ENGINES**

Replace the five Waukesha engines with new CAT 3516 industrial power units producing 1,355 bhp at 1,200 rpm. These are V-16 turbocharged and after-cooled 69-L 4-stroke diesel engines with radiators and critical grade mufflers. Standby Use applies to this application, so it has been assumed that these engines will be provided with Tier 3 diesel emissions.
The cost estimate includes engineering services for preparation of plans and specifications ($250,000) as well as construction cost, including equipment cost.

Cost Estimate: $3,000,000

**M-12, REPLACE COOLANT MANIFOLD SERVING THE WAUKESHA ENGINES**

Replace the existing steel coolant manifold with a new corrosion resistant manifold constructed of Schedule 80 PVC pipe. The pipe replacement would extend from the discharge of P11 (the cooling pump at the north end of the station) to P3. The manifold would taper from 8-inch diameter at the upstream end to 4-inch diameter at P3. The existing 3-inch branch connections to the heat exchangers serving the engines would be replaced with new PVC branch connections.

The cost estimate includes engineering services for preparation of plans and specifications ($20,000) as well as construction cost. Note that this engineering services cost includes M-13 and M-14 below.

Cost Estimate: $65,000

**M-13, CLEAN OUT THE HEAT EXCHANGERS AND COOLANT PIPING SERVING THE WAUKESHA ENGINES**

The heat exchangers and the associated piping from pump P11 should be inspected and cleaned out as needed to allow for sufficient flow for cooling the engines effectively.

It is assumed that this would be done in conjunction with the replacement of the existing cooling water manifold discussed previously.

Engineering costs are included in M-12.

Cost Estimate: $12,000

**M-14, MAINTAIN COOLANT EXPANSION TANKS SERVING THE WAUKESHA ENGINES**

Remove the Jacket Water coolant system expansion tanks and send to a radiator shop to be boiled out. Give the engine a good flush to remove rust, scale, and debris. Replace coolant, gaskets and thermostat. It is assumed that this would be done in conjunction with the replacement of the existing cooling water manifold discussed previously.

Engineering costs are included in M-12.

Cost Estimate: $21,000
M-15, REPLACE THE P3 ENGINE EXHAUST SILENCER
The silencer on P-3 is completely rusted through and needs to be replaced. The existing silencers are 20-inch diameter by 7 feet long Kittel Model 2084-AST12. Replace with a new critical grade stainless steel silencer. Critical grade silencers reduce noise by 30 -35 dBA and are recommended for use in residential and school areas where noise is a critical factor.

Also replace about 15 feet of vertical 12-inch exhaust pipe and rain cap with new stainless steel pipe and fittings.

It is assumed that this work will be included with replacement of the exterior exhaust pipe and silencers on the P2 and P4 exhausts. The cost estimate includes engineering services for preparation of plans and specifications ($8,000) as well as construction cost, including equipment cost.

Cost Estimate: $40,000

M-16, ADD COOLANT HEATERS TO THE WAUKESHA ENGINES
The installation of coolant heaters on the Waukesha engines is a needed improvement for reliability, especially in the winter months. The coolant heaters should be on backup power. It is assumed that conduit and wiring will be required from the Control Building to the Waukesha engines.

The cost estimate includes engineering services for preparation of plans and specifications ($15,000) as well as construction cost, including equipment cost.

Cost Estimate: $60,000

M-17, FIT THE WAUKESHA ENGINES FOR SPIN-ON OIL FILTERS
Provide fittings for installing spin-on oil filters that are easier to obtain and can be replaced easily with less chance of spilling oil than the old cartridge type filters. The cost estimate assumes that WTD staff would make the necessary modifications to the Waukesha engines to install the spin-on oil filters.

Cost Estimate: $17,500

M-18, REPLACE THE CONTROL PANELS ON THE WAUKESHA ENGINES
Replace the control panels with modern computerized engine monitoring and control panels such as CAT model EMCP 4.2. These are able to provide engine monitoring, protection, and control for over 20 parameters with real-time diagnostics and event logs available locally and remotely and stored in memory.

The cost estimate includes engineering services for preparation of plans and specifications ($25,000) as well as construction cost, including equipment cost.

Cost Estimate: $145,000
**M-19, Test Waukesha Engines**

Each of the Waukesha engines was uncoupled from its pump and started in 2014 to check that they are ready for operation when needed to prevent flooding. Full operational testing with the pumps under full load should be done after the forebay is cleaned of sediment and debris in 2015. This would ease concerns over the effect of the pumped sediment on the pumps as well as the downstream water quality. Because these pumps can lower the river quickly, it would be best to do the testing during the wet weather season.

NC Machinery has provided a price to provide labor and materials for inspection and analysis services to assist the County with assessment of these engines and related systems.

WTD staff would be on hand to run the engines, monitor the river level, and record data into the County’s CMMS system. To prepare for the testing, the County should shut down pumps P1, P2, and P4 (placed in OFF at the HOA switch on the main control panel, MCP), allowing the water in the forebay to rise to elevation 9.0 feet (NAVD88 datum). To start the Waukesha engines, the following basic steps are performed:

1. Start P11 by turning the HOA switch to HAND on the MCP.
2. Turn the HOA switch for the engine to be tested to HAND on the MCP. (The engine won’t start until manually started at the local control panel).
3. At the local control panel (LCP), turn the control power to ON. Clear and reset any alarms.
4. Use the hand pump to bring the oil pressure up to 50 – 60 pounds. Verify that the starting air line is open. Look for the governor to drop. Bar the engine one full revolution using the bar crank to turn the flywheel.
5. For this test, it should not be necessary to start the diesel transfer pump as the day tank should hold sufficient fuel to run the test.
6. Turn the OFF/MANUAL switch to MANUAL at the LCP.
7. Press and hold the START button until the engine turns over. Release the START button as the engine fires.

Allow the pumps to run for sufficient time for the engines to warm up and come up to full speed. Pump technicians will then run diagnostic tests on the pumps as described in the Flood Control Pump section later in this report.

**Operational Concerns/Cautions:**

- Check that the water pump for the gear box is turning. Stop the engine immediately if the water pump is not turning.
- Check to see that the wall louvers have opened and that the ceiling fan has turned on (requires a heat sensor near the engine exhaust pipe to activate).
- Inspect the engine and piping to look for any fuel leaks.

**Operational Data to be collected:**

- Record the amount of time that the engine turned over before starting.
- Check to see how much the air pressure dropped in the receivers and how long it takes for the compressor to bring the pressure back to the set point.
- Engine technicians should record engine rpm, oil pressure, oil temperature, water temperature, cylinder head temperature, and any other readings that are available on the control panel.
- Take oil, coolant, & fuel samples from each engine and fuel tank for analysis.
The planning level cost estimate for these tests includes the following:

- NC Machinery Testing Assistance: $7,500
- Consultant Engineer (Subcontracts NC Machinery, coordinates the testing, produces test report): $22,000

Cost Estimate: $29,500

2.3. FLOOD CONTROL PUMPS

Sulzer Pump representatives (Salt Lake City, UT, Houston, TX, Edmonton, AB, and Easely, SC) have supported this project by providing budget level cost estimates for critical spare parts, pump overhaul and pump replacement costs for the flood control pumps and for P11, the cooling water pump for the Waukesha engines.

Pump Tech (Bellevue, WA) provided pump overhaul costs and pump replacement costs for P9 (the fish ladder pump) and P10 (the fish screen spray water pump).

2.3.1. PUMP P1

**DESCRIPTION**

P1 is a 200 Hp motor-driven Sulzer propeller style flood control pump, with a 36-inch bowl diameter and 36-inch discharge. The right angle gear box reduces the pump speed to 500 rpm. Design conditions are (TDH=Total Dynamic Head):

- 75 cfs at 13.0 feet TDH, at a speed of 500 rpm.
- 54 cfs at 22.8 feet TDH, at a speed of 500 rpm.

P1 is the lead pump for the BRPS and therefore has significantly more use than any of the other flood control pumps.

WTD staff replaced the oiler (lubricates the shaft seals and bearings) approximately five years ago. The heat exchanger for the right angle gear box was also recently replaced.

**ISSUES**

1. Pump’s upper seal is leaking oil and absorbent towels are used to capture the biodegradable oil for disposal. The pump was rebuilt in 1995; however because this is the lead pump, P1 is on-line continuously, and the pump is due for an overhaul or replacement.

2. The engine driven pumps P2 and P4 pumps must be reliable prior to taking P1 out of service for repair.
3. The motor was rebuilt in 1988, and is currently performing well, however after 26 years of heavy use, the motor should be considered for replacement. Consider keeping the existing motor as a spare.

4. Critical spare parts should be available to minimize the downtime for this pump.

**RECOMMENDATIONS**

**M-20, REPLACE P1 (NEW PUMP AND MOTOR)**
Assumes pump supplier removes and hauls away existing pump, except for the 200 Hp motor, which is retained as a spare. Assumes pump supplier installs and starts up new pump.

The cost estimate includes engineering services for preparation of plans and specifications ($39,000) as well as construction cost, including equipment cost.

Cost Estimate: $400,000

**M-21, OVERHAUL P1 (OVERHAUL PUMP, NEW MOTOR)**
Ship pump to Sulzer Service Center in Salt Lake City, Utah, for overhaul ($37,000). Include new motor ($20,000). Assumes the County hires a mechanical contractor to remove and reinstall the pump and contract with Sulzer for the overhaul. Assumes that the existing motor is retained as a spare. Estimated time for overhaul is approximately 6 weeks after delivery to service center.

Cost Estimate: $90,000

**M-22, PURCHASE CRITICAL SPARE PARTS FOR P1 (PUMP ONLY)**
Purchase replacement bearings, pump shaft, bowl, impeller, head/drive shaft, and miscellaneous bushings, gaskets, hardware and fasteners.

Cost Estimate: $85,000

**2.3.2. PUMPS P2, P4**

**DESCRIPTION**
P2 and P4 are Mitsubishi diesel-powered, Sulzer propeller-style flood-control pumps with 48-inch bowl diameter and 48-inch discharge. The right-angle gear box reduces the pump speed to 400 rpm. Design condition are:

- 150 cfs at 13.9 feet TDH
- 115 cfs at 23.6 feet TDH

P2 and P4 each have approximately 8,800 hours of operation since the pump station went on-line, according to County records, which is an average of approximately 205 hours per year per pump.

WTD staff replaced the oilers on P2 and P4 a few years ago. The heat exchanger for the right angle gear box on each of the pumps was also recently replaced.

![Figure 2-12 The Pump P2 right angle gear drive with the WTD-installed oiler on the right](image-url)
ISSUES
1. The upper seal of both pumps are leaking oil and absorbent towels are used to capture the biodegradable oil for disposal.
2. Although these pumps are used relatively infrequently, it appears that no major maintenance (seals, bearings, etc.) has been performed on these pumps in the approximately 40 years since they first went into service.

RECOMMENDATIONS

M-30, REPLACE P2 AND P4 (PUMPS ONLY)
Assumes pump supplier removes and hauls away existing pumps. Assumes pump supplier installs and starts up new pumps.
The cost estimate includes engineering services for preparation of plans and specifications ($55,000) as well as construction cost, including equipment cost.
Cost Estimate: $1,155,000

M-31, OVERHAUL P2 AND P4 (PUMPS ONLY)
Ship pumps to Sulzer Service Center in Salt Lake City, Utah, for overhaul. Assumes the County hires a mechanical contractor to remove and reinstall the pumps and contract with Sulzer for the overhaul. Estimated time for overhaul is 6 weeks after delivery to the service center.
Cost Estimate: $135,000

M-32, PURCHASE CRITICAL SPARE PARTS FOR P2 AND P4 (PUMPS ONLY)
Purchase a set of replacement bearings, pump shaft, bowl, impeller, head/drive shaft, and miscellaneous bushings, gaskets, hardware and fasteners.
Cost Estimate: $170,000

2.3.3. PUMPS P3, P5, P6, P7, P8

DESCRIPTION
P3, P5, P6, P7, and P8 are Waukesha diesel powered Sulzer propeller style flood control pumps, 72-inch bowl diameter and 96-inch discharge. The right angle gear box reduces the pump speed to 270 rpm.
Design conditions are:
- 514 cfs at 12.7 feet TDH
- 426 cfs at 23.2 feet TDH

These pumps average approximately 215 hours of operation since the pump station went on-line, according to County records, which is an average of approximately 5 hours per year per pump. These pumps were not viewed in operation during this assessment.
**ISSUES**

1. Because of the relatively infrequent use of these pumps, the reliability of these flood control pumps is questionable.

2. Testing these pumps is problematic due to the following issues:
   - The testing must be performed during high river flow conditions, as the high discharge rate of these pumps would otherwise create a significant drawdown in the forebay, leading to increased flow of sediment into the pump, and increased risk of damage occurring to the pumps.
   - The pumped sediment can create highly turbid conditions in the Green River downstream of the station.
   - WLKD’s Sediment Removal Project, to remove approximately 2,900 CY of collected sediment from the forebay area during the summer of 2015, should be completed prior to testing these pumps (during the winter of 2015-2016).

3. These pumps are equipped with their original oilers (for the seals and bearings). These oilers have been affected by the dampness evident in this facility in cold weather conditions and in some cases the oil reservoirs have leaked at corroded seams.

**RECOMMENDATIONS**

**M-33, TEST P3, P5, P6, P7, AND P8**

This is a continuation of the previous discussion of the recommended testing of the Waukesha engines for these pumps. This discussion is focused on the need to plan the pump testing portion of these tests, which is recommended after the completion of WLKD’s Sediment Removal Project.

Sulzer Pumps, who purchased Johnson pumps, the original manufacturer, has the equipment and training to assist WLKD in these tests, including easily installed temporary flow metering equipment on the pump discharge, and monitoring vibration at the right angle gear. It is assumed that the existing level sensors for the forebay as well as downstream of the station will be used to determine the static head during the testing. It may be necessary to stagger the pump tests to allow the forebay level to rise sufficiently to provide a sufficient volume of water to perform a test without creating a significant drawdown in the forebay. The forebay water level should be at least Elevation 9.0 (NAVD88 datum), which is the start elevation for the second follow Mitsubishi pump (P4), according to the Operations Manual. The engine shall be allowed to warm up sufficiently before recording the flow rate and static head for each pump.

The planning level cost estimate for these tests includes the following:

- Sulzer Pump Testing Assistance: $15,000
- Consultant Engineer (Subcontracts Sulzer, coordinates the testing, produces a test report): $25,000

Cost Estimate: $40,000
M-34, REPLACE OILERS ON P3, P5, P6, P7, AND P8

Replace the existing oilers on these pumps with the same style oilers that WTD has installed on P1, P2, and P4. It is assumed that the County will hire a mechanical contractor to install the oilers on P3, P5, P6, P7, and P8 as well.

Cost Estimate: $50,000

2.4. MISCELLANEOUS PUMPS

2.4.1. PUMP P9

DESCRIPTION
P9 is a 25 Hp Worthington electric vertical turbine pump, 12 HK MD-16, 2 stage, 16-inch discharge, to supply water to fish ladder (3,600 gpm @ 38 feet TDH, 875 RPM). P9 operates during the upstream fish migration period (September to February).

Per the Operations Manual, approximately 2,250 gpm (62.5%) of the pump discharge is directed to the fish ladder, 450 gpm (12.5%) flows to the fish chute (to the upstream side of the station), and 900 gpm (25%) is overflow from the box structure for the pump discharge, and is returned to the P1 forebay.

ISSUES
1. Although WTD staff has not reported any maintenance required for this pump, this pump has been in operation approximately 6 months per year since the BRPS was put into service approximately 42 years ago.

2. Any major repair work on this pump must be scheduled from March to August of the year to avoid impacting the upstream migration period.

RECOMMENDATIONS

M-40, REPLACE P9 (NEW PUMP AND MOTOR)
Assumes pump supplier removes and hauls away existing pump. Assumes pump supplier installs and starts up new pump.

Cost Estimate: $83,000

M-41, OVERHAUL P9 (OVERHAUL PUMP AND REUSE MOTOR)
It is assumed that the County would hire Pump Tech to remove P9 at the BRPS, and overhaul this pump in its Bellevue, WA facility. Pump Tech would reinstall the overhauled pump. Estimated time for overhaul is 6 weeks after delivery to the service center.

Cost Estimate: $45,000
2.4.2. **PUMP P10**

**DESCRIPTION**
P10 is a 15 Hp Worthington electric vertical turbine style pump, 8L-15, 7 stage, 3-inch discharge, that provides spray water to clean the fish screens (122 gpm @ 252 feet TDH, 1,760 RPM). The fish screens are in the bays for P1-P4. P10 draws from the P3 bay.

**ISSUES**

1. WTD staff note that the primary deficiency of the screen spray system is the debris in the water, which tends to clog the spray nozzles, and lower the ability to keep the screens clean and able to pass flow. The clogged nozzles create a significant maintenance problem for WTD staff, as the nozzles cannot be removed from the spray headers, and unplugged. This results in high maintenance as WTD staff uses a drill to keep the spray nozzles open, however the nozzles plug again soon after the drilling.

2. Tape on this pump indicates it was overhauled in 1988, therefore it has been in use for approximately 26 years. P10 was operated during the 11/18/2014 site visit, and a pressure gauge a short distance downstream of the pump indicated the pump was producing the design pressure of 252 feet, therefore it appears this pump is still in good shape, however, it is due for an overhaul.

**RECOMMENDATIONS**

**M-42, INSTALL AN AUTOMATIC SELF-CLEANING STRAINER ON THE SPRAY WATER FLOW**
Replace the existing basket strainer on the discharge line from P10 with an automatic self-cleaning strainer. The strainer can capture very fine sediment (40 mesh has been assumed) to protect the spray nozzles from plugging. The strainer automatically backwashes collected sediment and a 1-inch drain line would need to be routed from the strainer to the P1 pump bay, to pump the sediment downstream. The strainer has a ¼ Hp motor.

The cost estimate includes engineering services for preparation of plans and specifications ($15,000) as well as construction cost, including equipment cost.

Cost Estimate: $53,000

**M-43, OVERHAUL P10 (OVERHAUL PUMP, NEW MOTOR)**
Assumes that the County hires Pump Tech to remove P10 and overhaul this pump in its Bellevue, WA facility. Assumes that a new motor would be provided, and the existing motor would be retained as a spare. Pump Tech would reinstall the overhauled pump. Estimated time for overhaul is 6 weeks after delivery to the service center.

Cost Estimate: $30,000
2.4.3. PUMP P11

DESCRIPTION

P11 is a 20 Hp Sulzer electric vertical turbine pump 12 DC single stage with a 6” discharge that supplies cooling water to the heat exchangers serving the Waukesha engines and the right angle gear drives (1,240 gpm @ 51 feet TDH, 1800 RPM). Because of the low use of P3, P5, P6, P7, and P8, this pump also has a very low use.

ISSUES

1. The main drawback of this pump is the fact that it pumps from a bay that is not fitted with a set of screens like the bays of P1-P4, therefore WTD staff report that a significant amount of debris is carried with the cooling water into the heat exchangers serving the Waukesha pumps. The debris collects in the heat exchangers lowering the heat transfer efficiency, and could potentially result in engine shutdown due to high temperature.

2. Another discrepancy is the fact that there is no redundant pump for this service. The loss of this pump would prevent the operation of the five largest flood control pumps in the BRPS.

RECOMMENDATIONS

M-44, PROVIDE A NEW COOLING WATER PUMP P12

Replace the existing pump P12 with a vertical turbine pump to be the new lead pump to provide cooling water to the heat exchangers serving the Waukesha engines and right angle drives. The existing P11 pump would be retained to provide redundancy.

Pump P12 is an abandoned vertical turbine pump located over the P4 pump bay (P12 was used to supply cooling water to the P2 and P4 engines, which were replaced in 1985 with the Mitsubishi engines that are air cooled). Because the P4 pump bay is fitted with a set of fish screens, this would significantly lower the amount of debris currently carried with the cooling water from the P11 pump, assuming the screens were in service. See the Fish Screens section for further discussion of the advantages of operating the fish screens year-round.

The opening in the floor for P12 (approximately 13” diameter) would be enlarged (to approximately 16” diameter), and the greater weight and thrust of the larger pump may require strengthening the floor area around the pump. The 8-inch discharge pipe of the new
P12 would connect with the proposed manually cleaned screen (discussed in the next section). The discharge of the strainer would elbow down into the pipe trough to connect to the new 8-inch cooling water manifold recommended previously (see the Waukesha engine section).

This system will provide significantly increased reliability to the operation of this the cooling water system by limiting the amount of debris that is carried with the cooling water to the heat exchangers serving the Waukesha engines and the right angle gear drives. Reliability is also increased by retaining the existing P11 pump for redundancy. It is recommended that the pressure and flow requirements of the cooling water system be reviewed during the design of the new P12 pumping system.

The cost estimate includes engineering services for preparation of plans and specifications ($23,000) as well as construction cost, including equipment cost.

Cost Estimate: $100,000.

**M-45, PROVIDE MANUALLY CLEANED STRAINER ON P11 AND P12 DISCHARGE**

Install a manually cleaned strainer, sized to minimize head loss, on the 8-inch diameter discharge of P11 and the new cooling water pump P12, to protect the cooling system serving the Waukesha engines. The strainer (30-inches diameter and approximately 5 feet high, with 10” flanged connections) is constructed of stainless steel. The strainer is equipped with a 40-mesh screen, but the surface area of the screen is large, resulting in low head loss and ability to collect a significant amount of sediment.

The unit is equipped with a 1-1/2 inch drain line that can be opened during operation to help flush collected sediment (it is assumed that this drain line would be routed to the tailrace of the BRPS). After the Waukesha pumps stop and the cooling pump is no longer needed, the top of the unit can be removed and the screen can be hosed out. If an extended duration flood event occurs, then the standby cooling pump could be put into service, thus allowing the strainer to be cleaned on the lead cooling pump, P12. An isolation valve is needed downstream of each strainer.

The cost estimate includes engineering services for preparation of plans and specifications ($22,000) as well as construction cost, including equipment cost.

Cost Estimate: $100,000.

**2.4.4. PUMP P14**

**DESCRIPTION**
P14 is an electric sump pump, 160 gpm

**ISSUES**
1. No issues have been reported for this pump.

**RECOMMENDATIONS**
Continue to monitor performance.
2.5. COMPRESSED AIR SYSTEMS

2.5.1. COMPRESSORS

DESCRIPTION

Two compressors provide instrument air, starting air to the Waukesha engines, and service air at various outlets in the BRPS. A 5 Hp Worthington Model ED compressor was rebuilt in 2012. This compressor is used as a backup.

A new 5 Hp Ingersoll Rand Model 2475 compressor was installed in 2010 to replace the other Worthington, and this compressor is primarily used. It puts out 14.1 scfm, according to the nameplate. Marks on the pressure gauge for the receivers shows that the set points for operating the compressor are at 180 psi and 210 psi. The receivers appear to be about 6 feet tall and 2-1/2 feet in diameter, equating to a total of 60 cubic feet for the two receivers.

A manifold leading from the receivers separates the air into different lines for starting air, service air, and instrument air. The instrument air runs through a single tower chemical desiccant type air dryer.

Instrument air is provided to the bubbler system, to air-actuated solenoid valves in the main control panel, and to air-actuated control valves for the fish-screen spray water valves. Instrument air is also distributed to the rotary valve SG1, fishway sluice gate (SG2), and to the cylinder actuators on the ventilation louvers (the needs assessment of this equipment is addressed in a later section).

Service air is supplied to service-air stations around the pump building for connecting air-powered equipment.

ISSUES

1. WTD staff have reported that the air dryer for the compressors is broken. They have purchased a new one (a Van Air Model D-30) but have not yet installed it. The new air dryer, like the existing one, is a single tower deliquescent desiccant type air dryer. This desiccant dissolves as it absorbs moisture, and the spent desiccant is drained frequently and has left a small mess of desiccant on the floor. A non-cycling refrigerated air dryer would provide significantly drier air to the sensitive components using instrument air and would not require regular filling, drainage, and cleanup associated with the desiccant dryer. Refrigerated air dryers are the WTD standard for use at other facilities and would be preferred by WTD staff.
2. The discharge of water from the compressed air equipment to the utility trench along the west side of the facility is problematic in that this trench has no drainage outlet and is fitted with level switches to detect a potential fuel spill. The collected water from the compressed air system can eventually activate the high level alarm for the fuel leak detection system.

3. WTD staff recently completed repairs to the compressed air piping to seal leaks. There are many small diameter air lines serving valve and louver actuators. As will be discussed under the needs assessment for Fish Migration Facilities and for HVAC, many of these actuators are recommended for replacement (corrosion issues primarily). The compressed air distribution system should be given a thorough inspection to identify worn components.

4.Leaks in the compressed air system could compromise the ability of the system to serve the starting air requirements for the Waukesha engines.

**RECOMMENDATIONS**

*M-50, INSTALL A NEW AIR DRYER ON THE INSTRUMENT AIR LINE*

Install a non-cycling refrigerated air dryer such as a Pneumatech AD-25, FS Curtis RNP25, or Quincy QPNC25. The cost of these is approximately $1,300. In addition, 115 volt power would be provided to this unit. A bypass line around the refrigerated dryer should be provided. Consider routing the bypass line through the new desiccant dryer recently purchased by the County, for dryer redundancy.

The drainage from the dryer, as well as from the receivers and the oil/water separator, contains a small amount of lubrication oil from the compressor and requires treatment prior to discharge. It is recommended that the drains from the solenoid drain valves on the receivers and the oil/water separator, and the drain from the proposed refrigerated air dryer, be routed to a new chemical adsorption unit.

This unit employs a proprietary media for primary oil removal, and carbon media for final polishing, for a final effluent rating of less than 10 parts per million volume (ppmv). It has not been confirmed if this would be sufficient to comply with Department of Ecology regulations; however, this does comply with International Organization for Standardization (ISO) 14000.

The chemical adsorption unit (18.5” wide x 10” deep x 16” high) may be able to be located in the existing utility trench (the top of the unit should be below the level of the floor). The discharge from the unit can be routed via a ½-inch pipe through the west wall of the utility trench to the tailrace. This is similar to the routing of the 3-inch diameter discharge pipes from the heat exchangers serving the Waukesha engines.

The chemical adsorption unit has a capacity to capture oil equal to approximately half the weight of the media, or approximately 0.8 gal. The media must be replaced as it reaches capacity. The frequency of replacement is dependent upon the concentration of oil in the condensate. It is recommended that further
investigation be completed during the design phase to determine the oil concentration of the condensate and allow estimation of the media replacement frequency. Also, Department of Ecology regulations should be reviewed to determine if the treated water can be discharged to the Green River.

The cost estimate includes engineering services for arranging for the testing of the condensate and the evaluation of releasing the treated condensate to the Green River. Engineering services (totaling $30,000) also include preparation of plans and specifications. The estimated construction cost ($45,000), assumes that the treated condensate is allowed to be discharged to the Green River, and includes equipment cost.

Cost Estimate: $75,000

**M-51, INSPECT AND REPAIR AIR LINES**

Inspect the compressed air distribution system and replace worn or corroded components. Some of these components (air lines, air actuated solenoid valves, pressure regulation valves, filters, etc.) will be replaced during the replacement of the actuators mentioned in later sections (Fish Migration, HVAC, and Instrumentation and Control). This recommendation covers the inspection and repair of the remaining portions of the compressed air system.

A specific recommendation is to remove the compressed air piping serving the Mitsubishi engines. This piping used to serve the original Waukesha engines, which were air-started (the Mitsubishi engines are battery-started).

The cost estimate includes engineering services for preparation of plans and specifications ($20,000) as well as construction cost.

Cost Estimate: $80,000

**2.5.2. RECEIVERS**

The Waukesha engines for pumps P3, P5, P6, P7 and P8 are normally used only when the combined capacity of the operable P1, P2, and P4 pumps is not sufficient to maintain the desired water level of the Black River. However, if flood conditions exist on the Green River (defined as when flows exceed 9,000 cfs at the Auburn gage), the Green River Management Agreement (GRMA) limits the BRPS discharge to various levels depending upon the Green River flood stage. During flood conditions, the operating strategy of all the flood control pumps in the BRPS switches from maintaining a desired water level in the Black River to maintaining a desired discharge rate from the station, as dictated by the GRMA (See the Task 3 Evaluate Criticality of Systems TM for further discussion).

**DESCRIPTION**

Dual receivers provide compressed air storage primarily for starting air for the Waukesha engines. The receivers appear to provide 30 cubic feet (cf) each in storage volume. The receivers and the oil/water separator each have a Rogers automatic drain valve (recently installed by WTD staff).

The Waukesha engines use Ingersoll Rand Model SM450RB99IA01 air starters that require 17.73 cubic feet per second (cfs) at 120 psi. According to the O&M Manual, the Waukesha engines use 27 cubic feet (cf) of air at 120 psi per start.

**ISSUES**

1. The total 60 cf receiver capacity at 180 psi (the lowest pressure prior to compressor start-up to boost pressure to 210 psi) is sufficient for one, and possibly two Waukesha engine start-ups, depending on the volume of air used in comparison to the manufacturer’s estimate of 27 cf at 120 psi, and the other air demands in the facility (bubblers, air actuators on valves and dampers, etc).
2. Another factor to consider is the amount of air leakage that may be occurring in the compressed air system. No serious air leakage appears to be currently occurring at the BRPS, however WTD staff have recently completed an effort to seal all leaks that were evident in the facility. Recommendation M-51 discussed the inspection and repair of the compressed air lines. This recommendation would therefore increase the reliability of the air-starting system of the Waukesha engines.

3. The compressor (14.1 scfm at 180 psi) would theoretically require approximately 15 minutes to produce the starting air requirement of 27 cf at 120 psi. This is a significant length of time; however, under normal operations, the following Waukesha pump would not be started up until the Black River water level rose another 6 inches, per the BRPS Operations Manual (see the Task 3 TM for further discussion of operating strategy for the Waukesha Pumps). Normal operations are defined as Green River flow of less than 9,000 cfs at the Auburn gauge. The time required for the Black River water level to rise 6 inches while the first Waukesha pump is operating could greatly exceed 15 minutes.

4. Our discussions with WTD staff indicate a time requirement of 15-20 minutes to start-up a single Waukesha engine, due to the operational effort involved in each start-up. This is for the manual labor and checks of proper operation that must be performed (using the hand pump to bring oil pressure up to 50-60 lbs, bar the engine one full revolution, etc.). The procedures for starting up the Waukesha Engines are discussed in detail in Recommendation M-19.

5. All of the Waukesha engines were started in 2014 (see the Diesel Engines (Waukesha) section) indicating that the compressed air system serving the air starters was able to provide sufficient air. There are no plans to add equipment with additional air requirements to this facility.

6. In conclusion, it appears that the existing receivers are adequately sized for the existing demands. If additional air-operated equipment is added to this facility in the future, WTD should reexamine the needed capacity of the compressed air system.

**RECOMMENDATIONS**

No capital improvements are identified for the receivers. The previous discussion of testing procedures for the Waukesha engines included checking the air pressure drop in the receivers during the start-up of the engines, and the length of time required it for the compressor to bring the pressure back to the set point. This would help confirm the adequacy of the receivers.

### 2.6. HVAC System

#### 2.6.1. Ventilation Systems for Engines

**Description**

The following ventilation equipment in the pump building primarily serves the combustion and ventilation needs of the engines for the flood control pumps:

1. (7) 1-1/2 HP roof-mounted Penn panel exhaust fans with louvered penthouses that exhaust 13,600 CFM each to provide space cooling.

2. (7) air-actuated parallel blade dampers for combustion air (88” x 48”). Each combustion air damper is controlled by a single air cylinder actuator.
3. (7) air-actuated dampers for ventilation air (132” x 48”). Each ventilation air damper is controlled by (2) air cylinder actuators.

**ISSUES**

1. Roof ventilator fan RV-1 (over flood control pump P2) is disconnected. Its circuit is currently being used to power the P2 day tank.

2. WTD staff stated that roof ventilator fans RV-2 and RV-3 didn’t have belts. These fans were turned off at the MCC. Associated ventilation louvers didn’t function.

3. Roof ventilator fan RV-4 operates in manual mode. Fan runs strong. Its associated gravity back draft damper opens completely. Its associated ventilation damper opens about 95%.

4. Roof ventilator fan RV-5 operates in manual mode. Fan appears to run slow. Its gravity back draft damper doesn’t open completely. Its associated ventilation damper opens about 95%.

5. Roof ventilator fan RV-6 doesn’t operate. The associated ventilation damper doesn’t open.

6. Roof ventilator fan RV-7 operates. It’s noisy and its belt looks lose. The gravity back draft damper opens partially. Its associated ventilation damper opens about 95%.

7. There does not appear to be a way to test the function of the combustion dampers without operating each engine driven pump, or otherwise heating the thermocouple mounted next to the engine exhaust.

8. Air cylinder actuators on the dampers are original equipment. Not all of the damper sections open completely, but are able to be opened fully by hand, suggesting that the damper actuators may be damaged due to corrosion (this is related to the poor instrument air drying system).

9. The overall condition of the dampers appear to be good despite their age (these get very little use due to the sporadic operation of the engines in the BRPS).

**RECOMMENDATIONS**

*M-60, REPLACE ROOF-MOUNTED VENTILATION FANS*

Replace (7) roof ventilator fans, associated gravity dampers, and discharge hoods. The existing fans are original equipment and past their useful service life.
Engineering costs need to be included for preparation of plans and specifications ($12,000), in addition to the construction cost, including equipment cost.

Cost Estimate: $47,000

**M-61, REPLACE PNEUMATIC DAMPER ACTUATORS**

Replace (21) pneumatic actuators serving combustion and ventilation air dampers. Clean and lubricate the dampers. It is assumed that the existing solenoid valves controlling airflow to these actuators, as well as the existing air lines, can be retained.

Engineering costs need to be included for preparation of plans and specifications ($6,000), in addition to the construction cost, including equipment cost.

Cost Estimate: $20,000

### 2.6.2. VENTILATE THE AIRLIFT / FISHWAY ROOM

**DESCRIPTION**

The fishway room contains the discharge of the fish ladder pump (below the false weir), and the entrance to the sluiceway (with the fish counter) to transport the returning salmon down to the upstream side of the dam. The airlift pump room contains the discharge basins for the two airlift pumps. The pumps release approximately 700 cfm of humid air into this room when they are operating. The only ventilation available to these rooms is through an opening (approximately 2 feet wide x 3 feet tall) for the returning fish to enter the fishway room (and immediately pass over the false weir).

**ISSUES**

1. The Airlift / Fish Way room is poorly ventilated. Because of this moisture condensates on all surfaces. This accumulation of moisture has resulted in significant corrosion of the steel supports for the airlift pump discharge basins, as well as the steel grating in both rooms (see Structural section).

2. The steel door to this room has been corroded and should be replaced (see the Structural section).

**RECOMMENDATIONS**

**M-62, INSTALL AIRLIFT / FISHWAY ROOM VENTILATION SYSTEM**

Install a 1,000 cfm exhaust fan on the outside of the east wall of the airlift pit to mitigate condensation build up (a concrete pad will be poured on the sloped concrete immediately north of the C2 compressor). A 16” x 16” clear opening will be cut through the east concrete wall just above the pit access ladder. The 1,000 cfm exhaust fan requires a weather proof cover, electrical disconnect, and gravity back draft damper. Includes providing electrical service to the fan.

Engineering costs need to be included for preparation of plans and specifications ($20,000), in addition to the construction cost, including equipment cost.

Cost Estimate: $60,000
2.6.3. **VENTILATE THE ELECTRICAL ROOM**

**DESCRIPTION**
The existing electrical room is ventilated by a gravity damper (32” x 48”) that also serves as a ventilation air intake for the existing generator. WTD operators have rigged this damper to be held in an open position, to provide some ventilation to this room.

**ISSUES**
1. WTD facilities usually have fan-ventilated electrical rooms, to provide positive control of room temperature, and prevent high temperatures that could damage electrical equipment.
2. The existing gravity damper is always open, and the heater in the control room is also often on during the winter months, therefore this is an inefficient HVAC system in its current state.

**RECOMMENDATIONS**

**M-63 UPGRADE ELECTRICAL ROOM VENTILATION SYSTEM**
Replace the existing gravity damper in the electrical room with a new gravity damper. Install a 400 CFM exhaust fan to discharge through the south wall of the electrical room, possibly utilizing the existing louver in the south wall currently used for the generator radiator exhaust. This assumes that the existing generator is replaced with a larger skid-mounted unit exterior to the control building (See Recommendation E-1). The exhaust fan would be controlled by a new thermostat, which would turn on the fan when the temperature set-point is exceeded. The fan could also be placed in Manual mode to allow WTD staff to turn on the fan for ventilation whenever desired.

Engineering costs need to be included for preparation of plans and specifications ($7,000), in addition to the construction cost, including equipment cost.

Cost Estimate: $20,000.

2.6.4. **HAND OPERATED DAMPER FOR P1**

**DESCRIPTION**
A hand operated damper (108”x48”) is located immediately west of the electric flood control pump P1.

**ISSUES**
1. This hand operated damper is original equipment (42 years old) and is very difficult to operate.

**RECOMMENDATIONS**

**M-64, CLEAN AND LUBRICATE HAND OPERATED DAMPER NEAR P1**
The overall condition of the damper appears to be good despite its age. It doesn’t appear to have seen much use. It is recommended that routine maintenance be performed on the damper including cleaning and lubricating all its moving parts.

The cost estimate includes construction cost only.

Cost Estimate: $1,000
2.6.5. HEATING SYSTEMS

DESCRIPTION
1. Two 320 MBH output gas heaters in the pump building
2. One 5 kW and one 7.5 kW electric fan powered unit heaters in the control building
3. One wall mounted radiant heater in control building restroom

ISSUES
1. The two 320 MBH output gas heaters in the pump building were both observed to be operating without any issues. These heaters do not appear to be original equipment in the station (i.e., no information was found in the O&M manual or in the original design documents). The exact age of the heaters is unknown. Each heater has been fitted with a new thermostat.
2. The two electric fan powered unit heaters in the control building along with the electric radiant heater in the restroom were observed to be operating without any issues. These heaters appear to be original equipment.

RECOMMENDATIONS

M-65, INSPECT AND SERVICE HEATERS AS REQUIRED
It’s recommended that a furnace service technician evaluate the overall condition of the heaters and perform maintenance and repair as necessary.

2.7. TRASH RAKE AND CONVEYOR SYSTEM

2.7.1. TRASH RAKE AND DOLLY

DESCRIPTION
The pump bays are protected from large debris by bar screens mounted to the front of the piers forming the bays. The bar screens are approximately 40 feet high, from the platform on the east side of the structure supporting the trash rake rails to the floor of the forebay. A dolly with a trash hopper and winch-actuated rake can access the length of the bar screens on the track.

Trash rake—the trash rake traverses down the bar screen, and at the bottom of the exposed screen the teeth of the rake automatically pivot into the screen. The rake returns up the screen and empties the debris into the hopper.

Trash rake dolly—the dolly travels to the south side of the station on the trash rake rails, and empties its contents into a hopper at the base of an inclined conveyor.
ISSUES

1. The equipment is beyond its service life and parts are difficult to obtain.

2. If the rake hits a log or other large object on the way down, the cable sometimes jumps off the pulley. Reinstalling it on the pulley is a difficult and somewhat dangerous job.

3. WTD staff has noted the inability of the trash rake to remove large debris.

4. The settlement and deflection of the tracks for the trash rake between the concrete structure and the screenings conveyor poses a danger of tipping the trash rake dolly.

5. The space between the edge of the building and the edge of the piers on the east side of the station (where the existing tracks are located) is only approximately 9 feet wide. This limited clearance is a constraint on the options available for replacing the trash rake. The following options for replacing the trash rake and dolly were investigated, and eliminated from consideration due to clearance issues:

- Atlas Polar makes a fully automatic system that rides on a monorail installed above the trash rack. It uses a long arm with a rake mounted on the end to reach out and down into the water to the bottom of the trash rack. It then pulls the material to the top of the trash rack and dumps it on the deck or into a trash dolly alongside the trash rake. The manufacturer has determined that there is insufficient clearance between the building and the rake mechanism for the operation of the rake arm to reach all the way to the bottom of the trash rack. They could design a system for the space available, but it would not be able to reach the bottom five feet of the trash rack.
• Ashland Hydro trash rakes are knuckle-style boom devices (similar to a backhoe) designed to reach down into the water at depth up to 50 feet below the deck and rake material up from the trash rack. The system moves along the length of the trash rack on rails mounted to the deck. It has an articulated rake with an opposing thumb at the end of the boom. Material is lifted from the water and can be carried by the machine to a disposal site, or emptied into a trash dolly alongside the trash rake. This system, however, requires a minimum of 15 feet between the edge of the deck above the trash rack and the nearest obstruction, such as the pump building. Only 9 feet is available at this station.

RECOMMENDATIONS

M-70, REPLACE THE TRASH RAKE AND DOLLY WITH A MONORAIL SYSTEM

Completely replace this equipment with a more modern and effective design. Rex and Link-Belt cable style trash rakes are similar to the one currently in service at BRPS. The trash rake is mounted on a dolly with a hopper for holding the debris. A direct replacement would be fairly straight forward and relatively low cost. It would not, however, significantly improve the function over the existing trash rake. This system would cost $260,000, including $45,000 for engineering services for plans and specifications. However, this is not recommended due to the inability of this system to pick up the debris/sediment at the very bottom of the bar screen.

Evoqua makes a grab style rake fitted with a hydraulically actuated bucket that grabs the debris before bringing it to the surface. Once the trash rake/grab bucket has been retrieved, the carriage will traverse to the dump location and discharge the collected debris. This system can be either operator or automatically controlled. Further investigation during the design phase is needed to determine if automatic control would be possible at the BRPS. This equipment would be mounted on an overhead monorail that would traverse to the trash dumpster to discharge the material, possibly directly into the trash dumpster (currently the belt conveyor lifts the debris from the trash hopper into the trash dumpster). Therefore it may be possible that this system could eliminate the trash conveyor.

It will be necessary to relocate the C2 airlift compressor to the southeast of its present location in order to provide sufficient clearance for the new trash rake. The monorail will be in the approximate location of the existing handrail at the top of the bar screens (the handrail would be replaced during the construction of monorail). The C2 compressor could be located southeast of the existing stairs that are adjacent to the east side of the compressor. Because the monorail would have to be installed above the deck and
supported on the existing piers, this system would require some further study to determine the ability of the existing structure to support the monorail.

The additional cost to relocate the airlift compressor is included in the engineering and construction costs below (concrete pad, extending electrical and water service, new compressed air lines from the new location to the connect to the existing lines near the entrance to the Fish Lift Room, etc.).

The cost estimate also includes constructing a concrete pad from the existing slab over the forebay to the trash dumpster pad (i.e., in the area where the existing trash rake rails have deflected due to settlement of the ground supporting the rail ties). The existing trash rake rails would also be removed from the slab over the forebay.

The cost estimate includes engineering services for preparation of plans and specifications ($250,000) as well as construction cost.

Cost Estimate: $1,400,000

### 2.7.2. TRASH CONVEYOR

**DESCRIPTION**

The rails for the trash rake dolly stop at a hopper in the yard south of the trash rack. The storage box on the dolly opens to drop the material into the hopper. A trash conveyor transports the debris from the hopper into a dumpster for disposal.

![Figure 2-27 Trash Rake and Dolly in position at Conveyor](image)

![Figure 2-28 Trash Hopper and Conveyor](image)

**ISSUES**

1. The equipment is beyond its service life, and WTD staff report that replacement chain is unavailable for the debris conveyor. The chain is damaged due to rubbing on a support below the conveyor belt. The support that was rubbing on the chain had to be repaired. New sprockets and chain for the conveyor would cost $14,000 for parts alone.
**RECOMMENDATIONS**

**M-71, REPLACE THE TRASH CONVEYOR**

Completely replace the existing conveyor with a new trash conveyor such as a Gilmore-Kramer Model PC 40-foot long by 24-inch wide conveyor. Note that this recommendation may not be necessary if the monorail system is installed (see the previous recommendation).

The cost estimate includes engineering services for preparation of plans and specifications ($9,000) as well as construction cost.

Cost Estimate: $44,000

**2.8. HOISTING SYSTEMS**

**DESCRIPTION**

1. 10-ton electric bridge crane for general maintenance in the pump house
2. 3-ton electric trolley hoist, pendant operated, used for stop log operations
3. 2-ton manual chain hoist used for removing fish screens out of the forebay. The existing hoist is a Wright Safeway Hand Hoist Model E.

**ISSUES**

1. WTD staff has not noted any concerns with the 10-ton electric bridge crane.
2. The 3-ton electric trolley hoist leaks oil, and replacement parts cannot be found.
3. The 2-ton manual chain hoist is very slow and cumbersome for the operations needed to remove the screens from their places for repairs. The screens must be lifted approximately 22 feet to be removed from the forebay, requiring an extended period of time with the manual hoist.

**RECOMMENDATIONS**

**M-80, REPLACE THE 3-TON ELECTRIC TROLLEY HOIST**

The 3-ton electric trolley hoist should be replaced with a new one that will fit the existing monorail beam and perform the same functions. A 3-ton, two-speed, 480 volt, 3-phase, hoist with a motor driven trolley, capable of a 70-foot lift, with weather proof electrical connections and corrosion resistant features should be specified. The hoist must have the motor and reeve in alignment with the monorail beam for adequate clearance from the screen hoist.
It is assumed that the hoist supplier will complete the installation of the new hoist. The cost estimate includes the equipment and installation cost.

Cost Estimate: $22,000

**M-81, REPLACE THE 2-TON MANUAL CHAIN HOIST WITH AN ELECTRIC HOIST**

The 2-ton manual chain hoist should be replaced with an electric lug-mounted wire rope hoist that will fit the existing monorail beam. The hoist and the trolley would both be motorized. The hoist should be a 2-ton, two-speed, 480 volt, 3-phase hoist, capable of a 50-foot lift, with weather proof electrical connections and corrosion resistant features. As mentioned for the 3-ton electric hoist, this hoist must have the motor and reeve in alignment with the monorail beam for adequate clearance from the exterior wall of the pump station. It will be necessary to provide 480 volt, 3 phase electrical power for the new hoist.

The cost estimate includes engineering services for preparation of plans and specifications, including the new electrical service ($8,000), as well as construction cost, which includes equipment cost.

Cost Estimate: $28,000

**2.9. UPSTREAM FISH MIGRATION FACILITIES**

The upstream migration facilities are operated to permit adult fish migration from September to February. Because of the time of year, all the upstream migration facilities were on-line during this evaluation.

The evaluation of how well the existing fish migration facilities meet current environmental codes and practices, and potential upgrades to improve fish migration is addressed in Task 4 (Fish Migration Facility Review). The following sections discuss the existing upstream fish migration facilities and recommend repairs needed to provide reliability and lower maintenance costs for these facilities.

**2.9.1. FISH LADDER**

**DESCRIPTION**

Fish ladder—an “Alaska Steep-Pass Fishway” with a single resting pool—provides access to the “false weir” at the highest point of the ladder that then drops the upstream migrating fish into the slide into the upper Black River. The ladder is constructed of aluminum plate.

**ISSUES**

1. At the lower end of the fish ladder, a bar rack (2-inch wide x ¼-inch thick galvanized steel bars, on 1-1/4-inch centers) was installed to keep returning salmon from swimming up the P1 discharge channel. The screen originally spanned the width of the channel, and the framework was anchor bolted to the floor and walls of the channel. The bar rack fit around the discharge of the fish ladder, so the fish could only swim up the ladder.
However, this bar rack has largely detached from the wall and floor of the channel, and is currently held in place with a rope.

2. This bar rack would tend to collect debris from the discharge of P1 and if this debris causes sufficient blockage of the bar rack, the P1 discharge could eventually cause the bar rack to fail. It is suspected that this is why the bar rack became detached.

3. Cleaning collected debris from this bar rack would not be possible without removing a section of screen over the channel that is meant to prevent salmon in the fish ladder from jumping out of the ladder and into the P1 discharge channel.

4. The fish ladder itself appears to be in good condition, however the evaluation of the ladder to determine conformance with current fish ladder design criteria is included in the Task 4 Technical Memorandum.

**RECOMMENDATIONS**

**FM-1, REPLACE THE FISH LADDER BAR RACK**

Replace the fish ladder bar rack with an aluminum bar rack. Design the bar rack to withstand hydraulic forces resulting from partial blockage. Provide a hinged gate to allow a diver access to the upstream side of the bar rack for cleaning trapped debris. The dimensions of the bar rack are approximately 9 feet wide x 6.5 feet high, with an opening for the fish ladder (approximately 2’-3” wide x 2’-9” height).

The cost estimate includes engineering services for preparation of plans and specifications ($10,000), as well as construction cost.

Cost Estimate: $35,000

**2.9.2. FISHWAY SLUICE GATE**

**DESCRIPTION**

Fish-way sluice gate (SG2)—this sluice gate (30” x 30”) immediately downstream of the discharge of P9 closes when downstream water levels reach a high point (El 15.55, NAVD88), to prevent backflow of the Green River through the fish-way. SG2 is a cast steel sluice gate with a galvanized frame, and has a 4-inch diameter air cylinder actuator (controls are located in the existing main control panel (MCP) in the control building).
ISSUES
1. The WTD staff report that the sluice gate does not close smoothly, and it is suspected that the air cylinder actuator may not be operating correctly. The cylinder appears corroded.
2. The problems noted with the operation of the sluice gate could also be caused by corrosion of the galvanized steel frame. Industry standards for sluice gates in these harsh conditions are for stainless steel or aluminum construction.

RECOMMENDATIONS

**FM-2, REPLACE SG2, INCLUDING THE AIR CYLINDER ACTUATOR**

Replace SG2 with a fabricated aluminum sluice gate with a new air cylinder actuator. The cylinder actuator should be rated for wet and corrosive areas. Replace all exposed air lines serving the actuator. Replacement of the controls for this gate are included in the Instrumentation and Control Section.

The cost estimate includes engineering services for preparation of plans and specifications ($5,000) as well as construction cost, including equipment cost.

Cost Estimate: $18,000

**2.9.3. FISH COUNTER AND FISH CHUTE**

DESCRIPTION

Fish counter and fish chute—a fiberglass chute transports returning salmon down to the water on the upstream side of the dam. A paddle is mounted over the chute and used to count upstream returning fish. WTD staff recently replaced the paddle with a WTD-fabricated paddle made out of Lexan plate. The plate is mounted to a hinged arm and held in place with a bungee cord. A nail on the arm is used to send a signal to a proximity switch mounted on the fixed portion of the arm.

ISSUES

This existing system is very rudimentary and should be replaced with something more robust.

RECOMMENDATIONS

A new fish counter employing photography and imagery for species identification is recommended for incorporation into a new fishway at the BRPS. See the Task 4 Fish Migration Facility Review TM for further details.
2.10. **DOWNSTREAM FISH MIGRATION FACILITIES**

Downstream fish migration facilities are in operation from April through June. This includes the fish screens, discussed below.

As mentioned previously, the evaluation of how well the existing fish migration facilities meet current environmental codes and practices, and potential upgrades to improve fish migration are addressed in Task 4 (Fish Migration Facility Review). The following sections discuss the existing downstream migration facilities and recommended repairs needed to provide reliability and lower maintenance costs for these facilities.

### 2.10.1. FISH SCREENS

**DESCRIPTION**

Fish screens—Pump bays for P1–P4 pumps are fitted with dual screens (7 pairs of screens total), that are raised/lowered with electric hoists (on a timed cycle), with one screen in the down position, and the other in a raised position. The pumps P1 (lead pump), P2 and P4 (the next two pumps to operate) are predominately used in the BRPS. P3 is a Waukesha pump, and WTD staff operates these pumps (P3, P5, P6, P7, and P8) approximately the same number of hours to spread the wear evenly among these pumps. This makes sense, as the engines need to be operated as frequently as practical to keep them properly exercised and ready to operate during flood conditions.

Keeping the fish screens clean during the downstream fish migration period is a significant operational concern. This is in contrast to the operation of the other fish migration equipment at this station (airlift pump, fish ladder, etc.), which in general would not heavily impact the station’s pumping operation if this equipment were to malfunction.

The screens (approximately 9 feet x 19 feet) are stainless steel mesh fabric attached to a stainless steel frame. WTD staff recently replaced the original galvanized steel screen material (3 x 3 mesh screen with 0.08-inch diameter wire with 0.253-inch square openings, 57% open area) with a significantly finer 304 stainless steel screen material (6 x 6 mesh with 0.08-inch diameter wire with 0.087-inch square openings, 27.2% open area). The galvanized screen frames were largely retained, however the lower portions of some screens were badly corroded and new framework was necessary.

**ISSUES**

1. The electric chain hoists (1 ton capacity, ¾ Hp) are original equipment, and spare parts are no longer available. The loss of a hoist could eventually result in the blinding of the screens and significantly reduced inflow to the P1 – P4 pump bays.

2. WTD staff have installed new electric chain hoists to replace the failed original hoists, however some of the new hoists have failed within a couple of years.

3. The fish screens are only used during downstream migration period. However, there would be a number of advantages in operating the screens year round:
The proposed installation of a new P12 to provide cooling water to the Waukesha engines was discussed previously (See P11 discussion). One of the advantages of locating this pump in the P4 bay is that this bay is equipped with screens.

Pump P9, the fish ladder pump, draws from the P2 bay. Because this pump operates with the screens in the raised position, a significant amount of river debris is picked up by this pump, and this leads to partial clogging of the false weir with pine cones, sticks, and other large debris. The debris gets trapped below the false weir grating. Removing the debris requires that P9 be shut down, and the material being picked out of the false weir grating. Operating the screens year round would significantly lower this maintenance headache.

Operating the screens year round would lower fish mortality of the resident fresh water species due not only to the operation of P1, P2, and P4, but also P9 (fish ladder pump), and P10 (spray water pump). Year round operation would increase the survival of all species both migratory and resident in accommodating the inconsistent timing of the migratory species as well as providing year-round protection to the resident species.

**RECOMMENDATIONS**

**FM-10, REPLACE ELECTRIC HOISTS FOR THE FISH SCREENS**

New 1-ton electric chain hoists would be purchased to replace each of the (14) existing hoists. The hoists should be similar to the existing hoists including the following:

- Power—460V, 3 phase
- Lift and Lifting Speed—20 feet, 8 feet/minute
- Upper and lower limit switches, with reversing magnetic contactor
- Fully rated for harsh exterior exposure

It is assumed that the replacement of the hoists and the screen spray water control panel (See the Miscellaneous Control Panels section for details) will be included in a single project, however this cost estimate is only for the new chain hoists.

Engineering costs need to be included for preparation of plans and specifications ($14,000), in addition to the construction cost, including equipment cost.

Cost Estimate: $70,000
### 2.10.2. Spray Water System

**Description**

As mentioned previously, the P1-P4 pump bays are fitted with dual screens (7 pairs of screens total), that are raised/lowered with electric hoists (on a timed cycle), with one screen in the down position, and the other in a raised position. A high pressure spray system cleans the screens during the raising/lowering cycle. Each of the seven openings between the piers upstream of the P1-P4 pump bays is fitted with two spray headers (one for each screen). The spray headers are 2-1/2-inch diameter Schedule 40 galvanized steel, approximately 8 foot long, fitted with (19) stainless steel spray nozzles. The design flow rate for each pair of spray headers is 122 gpm @ 93 psi (i.e., the same as the design output from the spray water pump).

Flow to each pair of spray headers is controlled by seven 2-inch diameter air-actuated control valves located on a 3-inch diameter steel pipe manifold located above the pump room floor level on the east wall of the station. The air-actuated spray water control valves are controlled by a screen cycle timer in the Screen Spray Control Panel. Both spray headers (for the upstream and downstream fish screens) are in operation throughout the raising/lowering cycle.

**Issues**

1. As mentioned in the discussion of the spray water pump P10, the spray nozzles clog with sediment in the spray water, and the nozzles cannot be removed from the header for cleaning. This results in a significant maintenance effort to drill out the nozzles, however the nozzle often clogs soon after the drilling-out.
2. The spray headers do not have drain/flush valves, to allow flushing out heavy sediment that could collect in the header.
3. WTD Staff have noted a significant amount of corrosion inside the steel spray water piping serving the spray headers. It is likely that rust and scale from the pipe corrosion is partially responsible for the clogging of the spray nozzles.

**Recommendations**

**FM-11, Upgrade Screen Spray Water System**

Replace the 3-inch diameter steel spray water piping manifold as well as the 3-inch diameter drop legs to the spray headers with Schedule 80 PVC. The pipe replacement would begin at the discharge of P-10, and connect to the new automatic strainer discussed under the P-10 recommendations. It appears that the existing air actuated control valves can be retained.

Replace the galvanized steel spray headers with new 2-1/2-inch diameter stainless steel headers fitted with new stainless steel spray nozzles, and drain/flush valves.

As discussed previously, engineering costs need to be included for preparation of plans and specifications ($40,000), in addition to the construction cost, including equipment cost.

Cost Estimate: $180,000.


2.10.3. **AERIFLIFT SYSTEM**

**DESCRIPTION**

Air lift system—Consists of the 100 Hp C2 airlift compressor (695 scfm at 22 psig, 1800 rpm) and the airlift pumps, which lift the juvenile fish up and over the dam to the Green River. The juvenile fish blocked from entering the pump bays by the fish screens described previously are attracted to a current created by the airlift pump through the 6-inch diameter ports on the pier walls on both sides of the screen (one port is at El 5.55 and the other at El 1.55). There are two airlift pumps, each 30-inch diameter fiberglass pipe, with one pump serving the high ports and one pump serving the low ports. Based on an average water level upstream of the BRPS, the airlift pump lifts the flow approximately 13 feet. No information could be found on the water flow rate for the airlift pump under the existing hydraulic conditions, and at the design compressed airflow rate.

The juvenile fish enter the ports and are conveyed through individual 6-inch diameter fiberglass pipes embedded in the pier walls that descend down to an embedded manifold in the concrete floor of the forebay. The manifold leads back to the airlift pumps on the south end of the pump station facility. The rising air bubbles in the airlift pump create the current that draws the water through the system. The airlift pump discharge structure allows the flow to off-gas prior to passing through SG1, an 18-inch rotary valve that will be discussed later in this section, and then through an 18-inch diameter fiberglass pipe to the fish counter.

Although each pier has a high port and a low port, only the high ports are currently in service, apparently due to the inoperability of components on the airlift compressor C2, discussed later in this section. Therefore, only the airlift pump serving the high ports (7 ports total) is in service. The ports are equipped with cast steel sluice gates that are open during the downstream fish migration period of April through June.

Because of the time of year, this system was not in operation during the site visits.

**ISSUES**

1. The C2 airlift compressor is a rotary vane style that was supplied in the original construction (1972), although it was rebuilt by WTD staff in 2007 when WTD took over the operation and maintenance at this station. WTD staff state that many of the replacement parts used during the rebuild were machined locally, as the parts were no longer available from the manufacturer.

2. The loss of this compressor could result in a long-term interruption of the downstream fish migration system.
3. The airlift compressor has served its useful life and it is not cost-effective to keep this compressor in service.

4. Airflow to each of the airlift pumps is controlled by a 3-inch air-actuated three-way flow control valve (FCV-8) immediately downstream of the C2 compressor. This valve is inoperative, and according to the Operations Manual, this valve only supplies air to the airlift pump serving the high ports. Discussions with WTD staff indicate that it appears both airlift pumps appear to be in service, however. This valve, and the associated solenoid valve SV-8, should be replaced.

5. WTD staff indicate that it is difficult to maintain the desired airflow rate from the compressor to the airlift pump. This could be due to an extended warm-up period for the compressor, lack of good control over the cooling system (the unit has a radiator and is water cooled), the lack of positive control over the airflow due to the faulty FCV-8, or a number of other factors.

6. WTD staff have opened the fish ports (both high and low) for the P1 and P2 pump bays, plus a port in the south pier of the P3 pump bay. Therefore the ports serving the bays with the pumps that are primarily used at the station are open. This conforms to fact that downstream migrating fish will naturally follow the current created by the flood control pumps, therefore the ability to capture and convey these fish should be maximized in these bays. However, as mentioned previously, the current control system only allows either the high ports or the low ports to be in service. It appears that at some point the SV-8 was taken out of service and the flow control valve FCV-8 was manually adjusted to allow airflow to both airlift pumps.

7. It was mentioned previously that no information was located on the design flow rate of the airlift pumps, assuming C2 is operating at its design condition (695 scfm at 22 psig). The flow rate must be determined to be able to evaluate the ability of the existing system to attract, intake, and convey juvenile salmon over the BRPS dam.

8. The shelter over C2 is a dilapidated wood structure that should be replaced.

**RECOMMENDATIONS**

**FM-12, REPLACE THE ARLIFT COMPRESSOR AND AIRFLOW CONTROLS**

Replace the existing C2 compressor, including controls to provide constant airflow to each of the airlift pumps concurrently. The airlift compressor should be replaced with a new rotary vane compressor. Other styles of compressors could be considered during the design of the replacement compressor (e.g., a screw compressor), however, it appears that the rotary vane style has the ability to maintain the required airflow (695 scfm @ 22 psig) over long-term operation. Screw compressor performance will degrade as the compressor wears and the clearances between the rotor and stator enlarge.
The new compressor would be similar in design as the existing compressor (complete with a lubrication, cooling, and control system designed for exterior exposure). The new compressor is approximately the same size as the existing, therefore it should fit below the existing weather cover; however, the weather cover should be replaced, as discussed later in this section.

Airflow from the compressor to the airlift pumps needs to be accurately controlled to provide the desired airflow rate to both of the airlift pumps concurrently. As discussed previously, the high and low ports serving the pump bays that are in service should be open to maximize the capture of juvenile salmon. To provide an automated method of controlling and stabilizing the airflow to the airlift pump, it is recommended that a variable frequency drive (VFD) be provided for the 100 Hp motor of the compressor. The speed of the compressor would be modulated to maintain a desired pressure in the two airlines feeding each airlift pump. Pressure is roughly proportional to the airflow in this system given the relatively constant water levels and low head loss in the hydraulics of the airlift system. The pressure set-point should be somewhat lower than the design pressure output of the compressor, to provide adjustability and stability. It is assumed that the VFD would be located in the control room.

Each of the 3-inch diameter air line to its respective airlift pump should have an automatic shut-off valve to allow the airflow to be shut-off if upstream water levels get too low, or if the downstream water level gets too high. This is similar to the function of SV-8 on the current system. It is recommended that the flow control valves be motor-actuated, rather than air-actuated, for simplicity and lower cost (as compared to air-actuated control valves).

It was mentioned in the recommendation for the replacement of the existing trash rake (M-70), that the monorail-style trash rake with the hydraulically actuated bucket would require the relocation of the existing C2 compressor, and that the cost for the relocation (the pad, the utility work, etc.) was included in M-70. Therefore the cost estimate below only includes the replacement equipment costs.

The replacement of the airlift compressor and airflow controls will include design engineering services for preparation of plans and specifications ($36,000), in addition to the construction cost, including equipment cost.

Cost Estimate: $180,000.

**FM-13, REPLACE THE WEATHER COVER OVER THE AIRLIFT COMPRESSOR**

Replace the existing wood frame shelter over the C2 compressor with a new weather cover constructed of galvanized and coated steel framework, with a shed-style roof (sloped for good drainage). The roofing could be galvanized and coated standing seam metal roofing. The dimensions of the weather cover should be coordinated with the space requirements of the new C2 compressor, however it appears that the roof should be approximately 12 feet wide and 15 feet long (assumes the compressor is relocated). It is assumed that the weather cover is pre-engineered, and pre-fabricated.

The replacement of the weather cover will include design engineering services for preparation of plans and specifications ($8,000), in addition to the construction cost.

Cost Estimate: $38,000.

**FM-14, EVALUATE AND MONITOR AIRLIFT CAPACITY**

Evaluate the capacity of the various components of the airlift system, including the C2 compressor, the airlift pumps, and the 6-inch intake ports on the piers of the forebays for P1, P2, P3, and P4. Determine the airflow rate from C2 by installing an insertion style thermal air flow sensor in the 3-inch diameter discharge line upstream of flow control valve FCV-8. Assume power can be provided from the existing C2 control panel (a 120VAC/18 to 30 VDC transformer will be required).
This flow sensor can be easily removed and reinstalled on the discharge line of the new C2 compressor discussed in a previous recommendation. Install a temporary flow meter within Roto-Valve SG1 discussed in the next section to obtain accurate measurement of airlift pump discharge rate (this will require the discharge basin of the airlift pump to be drained to the sump pump).

The test is to be repeated with various configurations of the components (FCV-8 and fish ports, primarily). For each of the tests performed, allow C2 to completely warm up and reach operating temperatures before recording airflow and water flow data. The following tests are recommended:

1. Operate C2 with the current configuration of FCV-8, and the fish ports in their current open/close position.
2. Adjust FCV-8 to direct flow to only the airlift pump serving the high ports (if the current configuration splits the flow between the two airlift pumps). Note that this does not require adjustment of the fish ports.
3. Repeat the above test with all the high ports opened. Return these ports to their original position after the test.
4. Adjust FCV-8 to direct flow to only the airlift pump serving the low ports. Note that this does not require adjustment of the fish ports.
5. Repeat the above test with all the low ports opened. Return these ports to their original position after the test.
6. It is assumed that County WTD operations and maintenance personnel operate the equipment and provide general assistance during the testing.

Record the following for all tests:

1. Airlift pump(s) in service
2. Fish port open/close position
3. Airflow rate (scfm) and pressure (psig)
4. Water flow rate (gpm)
5. Estimate the approximate proportion of flow from each of the two airlift pumps (%)

The planning level cost estimate for these tests includes the following:

1. Installation of airflow meter on C2 discharge air line: $8,000
2. Installation of temporary water flow meter in SG1 (and provide flow meter output data): $4,000
3. Consultant Engineer (Designs the airflow meter installation, subcontracts the installation of the temporary flow meter, coordinates the testing, produces test report): $33,000

Cost Estimate: $45,000

Figure 2-40 The 3-inch discharge from the C2 compressor should be fitted with a flow sensor by tapping the silver colored spool (on the right side of the compressor)
2.10.4. ROTO-VALVE SG1

DESCRIPTION
Roto-Valve SG1 is located immediately downstream of the airlift pump discharge basin, in a concrete vault approximately 16 feet deep. This 18-inch air-cylinder actuated rotary valve closes when upstream water levels are too low (the airlift system is deactivated when Black River water level is El 3.55 NAVD88), or downstream water levels are too high (El 15.55 NAVD88) to prevent the Green River water from reversing flow through the air-lift pump and manifold piping to the upstream side of the dam. The roto-valve is connected to an 18-inch discharge line that leads to the downstream fish counter.

ISSUES
1. The concrete vault is unventilated and is very wet. The air actuator and associated airlines for SG1 are corroded and appear ready for replacement.

RECOMMENDATIONS

FM-15 REPLACE THE AIR-ACTUATOR FOR SG1
Replace the cylinder air-actuator for SG1, including the exposed air lines. The actuator and air lines should be designed for wet and corrosive areas. Replacement of the controls for this valve are included in the Instrumentation and Control Section.

The cost estimate includes engineering services for preparation of plans and specifications ($3,000) as well as construction cost, including equipment cost.

Cost Estimate: $10,000

2.10.5. MISCELLANEOUS DOWNSTREAM MIGRATION EQUIPMENT

DESCRIPTION
Fish port slide gates—these 6” x 6” manually actuated, rising stem, cast steel gates control the openings in the pier walls of the P1 through P4 forebays for downstream fish migration (April – June). The stainless steel operating stems of the gates terminate below the grating that spans over the forebay area between the piers. The gates are actuated with a Tee wrench that fits over the end of the stem. The Operations Manual indicates only the upper gates are in service, however WTD staff operate both the upper and the lower gates of the P1, P2, and one port in the P3 pump bay as discussed previously.

Fish counter— is located in a vault on the 18-inch discharge pipe from the airlift pump, the fish counter detects fish passing to the downstream side of the dam. The fish counter is a Smith Root SR-1601 Fish Counter connected to a four port 2” orifice discharge and overflow weir to the Green River.

ISSUES
1. No issues were identified by WTD staff for the fish port slide gates.
2. No issues were identified by WTD staff for the fish counter, however it was noted that a certain amount of debris is carried with the flow from the fish ports (which are located upstream of the fish screens), and this debris can register as a juvenile fish by the counter. It would not be possible to use a screen to eliminate this debris without interfering with fish migration.

3. On occasion a larger fish (not a juvenile salmon) will enter the fish port and be conveyed to the fish counter, and be trapped in the counter due to the size restriction of the 2-inch ports leading to the downstream side. WTD staff physically remove the fish and release them to the Green River.

**RECOMMENDATIONS**

The fish counter may require updating that will allow larger fish and debris to pass through the counter area. This upgrade could provide for more accurate out-migration fish counts if desired. The upgrade would also allow for a good discrimination of debris versus fish out-migrant counts. This is discussed further in the Task 4 Fish Migration Facility Review TM.

**2.11. ELECTRICAL SYSTEMS**

The needs assessment of the electrical and control systems at BRPS included discussions with County WTD electrical and I&C personnel on maintenance issues, reliability concerns, etc.

The electrical system is supplied power via a 12.5kV/480VAC transformer owned by Puget Sound Energy and mounted in a vault to the west of the control room.

**2.11.1. STANDBY GENERATOR AND AUTOMATIC TRANSFER SWITCH**

**DESCRIPTION**

The standby generator is a 50kW, 60Hz, 480VAC Delco diesel generator. It is located in the control building next the automatic transfer switch and motor control center. It appears to be the original standby generator which would mean that it is approximately 45 years old. It appears to be in working condition. King County personnel has indicated that the current standby generator is undersized. For example, when the standby generator is run, the lights dim and the sump pump cannot be operated without shutting down the air compressor. Due to the short timeframe of the
condition assessment, it is assumed that the new standby generator would double in size to 100kW. The exact size of the new standby generator should be determined in the next phase of work.

The standby generator has a 25 gallon fuel day tank. The day tank was recently upgraded as part of the fuel system upgrade project. Due to the recent replacement, no costs have been included to replace the day tank.

There is a 100 Amp automatic transfer switch which switches between utility power and the standby generator. The automatic transfer switch should also be replaced due to the age of the unit, the availability of replacement parts, and that it would be undersized for the new standby generator.

**ISSUES**

1. Spare parts for the standby generator are very hard if not impossible to find, as Delco no longer makes standby generators.
2. The existing generator is undersized for the loads that are currently served and for future loads that may be added with the recommended capital improvements from this needs assessment.
3. Age of panelboard.

**RECOMMENDATIONS**

**E-1, REPLACE THE STANDBY GENERATOR**

Replace the standby generator with a 100 KW skid-mounted unit with a weather/acoustical enclosure for exterior service. There is insufficient room in the existing electrical room for a larger generator. It is anticipated that the generator will be located west of the control building. The generator will be mounted on a concrete pad, and a security fence will be provided. It is assumed that the new day tank inside the electrical room will remain in service, and fuel supply and return lines will be installed between the day tank and the new generator.

The cost estimate includes engineering services for preparation of plans and specifications ($30,000) as well as construction cost, including equipment cost.

Cost Estimate: $170,000

**E-2, REPLACE THE AUTOMATIC TRANSFER SWITCH**

Replace the automatic transfer switch with a new unit adequately sized for the larger generator.

The cost estimate includes engineering services for preparation of plans and specifications ($9,000) as well as construction cost, including equipment cost.

Cost Estimate: $26,000
2.11.2. MOTOR CONTROL CENTER AND MAIN BREAKER

DESCRIPTION
The motor control center is located in the control building. It was manufactured by General Electric and appears to be the original motor control center which would mean that it is approximately 45 years old. It appears to be in working condition but does not conform to current codes regarding arc flash safety.

The main service disconnect switch/breaker is located in the motor control center. It is the same age and manufacturer as the rest of the motor control center and should be replaced with the rest of the motor control center.

ISSUES
1. Spare parts for the motor control center are very hard if not impossible to find, as General Electric no longer makes motor control centers.
2. Motor control center does not conform to current arc flash safety codes.
3. Based on the fact that new parts are not available for the motor control center, the motor control center would not be able to handle any needs for additional load at the pump station.
4. P1 is a 200 Hp electric flood control pump that is currently equipped with a conventional “across the line” starter located in the MCC. Puget Sound Energy (PSE) will require motors of this size to be equipped with a soft starter or VFD, to prevent “voltage sag” in its distribution system. The replacement of the MCC should include a soft starter or variable frequency drive (VFD) to meet permitting requirements.
5. Similar to the above, the C2 compressor (100 Hp) should be provided with a VFD to comply with PSE requirements, as well as provide improved regulation of airflow to the airlift pump (see the Downstream Fish Migration Facilities section for further discussion).

RECOMMENDATIONS

E-3, REPLACE THE MOTOR CONTROL CENTER AND MAIN BREAKER
It is recommended that the existing motor control center be replaced as it is outdated and cannot handle any additional capacity. Additional or revised loads should be looked at in a future phase to see how much bigger the new motor control center should be. It is anticipated that the existing stand-by generator in the electrical room will be replaced with an exterior unit, therefore there should be adequate room for additional electrical equipment in this room if needed in the future.

The cost estimate includes engineering services for preparation of plans and specifications ($51,000) as well as construction cost, including equipment cost.

Cost Estimate: $241,000
**E-4, PROVIDE VFD FOR P1**
Incorporate a 200 Hp VFD for P1 in the new MCC. A soft starter was considered but it would cost almost as much as a VFD, and the VFD has many advantages in terms of operational strategy and capabilities that cannot be provided by a soft starter.

The cost estimate includes engineering services for preparation of plans and specifications ($7,000) as well as construction cost, including equipment cost.

Cost Estimate: $27,000

**E-5, PROVIDE VFD FOR AIRLIFT COMPRESSOR**
Incorporate a 100 Hp VFD for the C2 Compressor in the new MCC. This will provide the capability to maintain a desired pressure in the compressed air lines to the airlift pumps, resulting in a constant discharge rate for these pumps.

The cost estimate includes engineering services for preparation of plans and specifications ($7,000) as well as construction cost, including equipment cost.

Cost Estimate: $22,000

**2.11.3. 120VAC PANELBOARD**

**DESCRIPTION**
The 120VAC Panelboard is located in the motor control center. It is the same age and manufacturer as the rest of the motor control center and should be replaced with the rest of the motor control center.

**ISSUES**
1. Age of panelboard.
2. Panelboard is integrated into the motor control center.

**RECOMMENDATIONS**

**E-6, REPLACE THE 120VAC PANELBOARD**
If the motor control center is replaced then the replacement of the 120VAC panelboard would also be required as it is part of the motor control center. The size of the panelboard should be looked at during the design phase to see if the present size is adequate or if a larger panelboard is required.

The cost estimate for this recommendation (engineering as well as construction cost), is included in the replacement of the MCC discussed previously in this section.

**2.11.4. INTERIOR LIGHTING**

**DESCRIPTION**
The interior lighting in the main part of the pump station is a series of high bay ceiling mounted fixtures. They appear to be the original lights. Some of the lights were working while others were not. Also, due to the type of lighting, the lights take a long time to come up to full illumination.

The interior lighting in the forebay of the pump station is a series of wall mounted fixtures. They also appear to be the original lights. These lights were not working, possibly due to access issues.
ISSUES
1. The lights in the pump room are mounted too high for easy replacement. Replacement must be done with some type of lift or, where possible, with the overhead crane.
2. The forebay lights did not work at all.
3. The switch for the forebay lights was in an awkward location.

RECOMMENDATIONS

E-10, REPLACE PUMP ROOM LIGHTING
Replace the lighting in the Pump Room preferably with wall mounted units instead of ceiling mounted for easier replacement. It is recommended that Fluorescent or LED be used for better efficiency, longer life, and shorter time to full illumination.

The cost estimate includes engineering services for preparation of plans and specifications ($9,000) as well as construction cost, including equipment cost.

Cost Estimate: $38,000

E-11, REPLACE FOREBAY LIGHTING
Replace the lighting in the forebay preferably with wall mounted units instead of ceiling mounted for easier replacement. It is recommended that Fluorescent or LED be used for better efficiency, longer life, and shorter time to full illumination.

The cost estimate includes engineering services for preparation of plans and specifications ($9,000) as well as construction cost, including equipment cost.

Cost Estimate: $28,000

E-12, MOVE FOREBAY LIGHTING SWITCH
The forebay lighting switch should be moved to a more conspicuous location like the ladder entrance to the forebay. This would allow for easier access to turn on the lights.

The cost estimate for this recommendation is included in the previous recommendation to replace the forebay lighting.

2.11.5. EXTERIOR LIGHTING

DESCRIPTION
The outdoor lighting of the pump station consists of a combination of wall and edge of roof mounted fixtures. They appear to be the original lights.
ISSUES
1. The lights are mounted too high for easy replacement.
   Replacement must be done with some type of lift or very large ladder.
2. Lighting is old and near the end of its life cycle.

RECOMMENDATIONS

**E-20, REPLACE EXTERIOR LIGHTING**
Replace the exterior lighting, preferably with wall mounted units mounted lower on the exterior walls for easier replacement. Also, it is recommended that Fluorescent or LED be used for better efficiency, longer life, and shorter time to full illumination.

The cost estimate includes engineering services for preparation of plans and specifications ($9,000) as well as construction cost, including equipment cost.

Cost Estimate: $28,000

2.11.6. GROUNDING

DESCRIPTION
Grounding appeared adequate although it was noted that some ground connections were disconnected near the eastern exterior of the building, possibly due to the use of the portable cables next to the ground connections.

ISSUES
1. Unconnected ground tails.
2. National Electrical Code requirement for grounding of all electrical equipment.

RECOMMENDATIONS

**E-30, RECONNECT UNCONNECTED GROUND TAILS**
It is a National Electrical Code requirement that all ground tails be connected to the site ground grid to ensure adequate grounding.

The cost estimate includes engineering services for preparation of plans and specifications ($5,000) as well as construction cost, including equipment cost.

Cost Estimate: $15,000

**E-31, TIE NEW EQUIPMENT INTO THE EXISTING GROUND GRID**
It is a National Electrical Code requirement that all new equipment be connected to the site ground grid to ensure adequate grounding.

The cost estimate includes engineering services for preparation of plans and specifications ($5,000) as well as construction cost, including equipment cost.

Cost Estimate: $15,000
2.12. CONTROL SYSTEMS

2.12.1. MAIN CONTROL PANEL & HUMAN MACHINE INTERFACE TOUCHSCREEN

DESCRIPTION
The main control panel (MCP) is located in the control building in a walled off area separate from the stand-by generator and motor control center. It consists of push buttons, selector switches, and pilot lights for control, plus an Allen-Bradley PanelView human-machine interface (HMI) terminal for status. The push buttons, selector switches, and pilot lights appear to be from the original installation, whereas the HMI terminal is a fairly recent addition. There are also pneumatics located inside the panel. Based on the age of the control panel, pneumatics and controls were often combined. The roof ventilation system controls are also located on the front of the main control panel. These would be replaced with the main control panel.

ISSUES
1. Main control panel houses controls and pneumatics.
2. Ability to serve future needs.
3. If the MCP is replaced, it will also be necessary to replace some relatively new equipment that has been incorporated into the MCP (the programmable logic controller (PLC), the Ethernet system, the telemetry system, etc.). It is not possible to incorporate this equipment into a new MCP due to the need to completely fabricate and shop test the MCP prior to delivery to the BRPS for installation. This equipment can be used at other WTD facilities, or used for spare parts.

RECOMMENDATIONS

I-1, REPLACE MAIN CONTROL PANEL (MCP)
It is recommended that the MCP be replaced. Although the existing HMI terminal is fairly new, and could be reused in the new control panel, the need to keep this station fully functional requires that the MCP be changed out quickly, so the new MCP would be provided with a new HMI terminal. The pilot lights and selector switches on the front of the MCP could be replicated on the new control panel if requested by the Black River Pump Station operations personnel, but could also be replicated on the HM terminal if desired.

The cost estimate includes engineering services for preparation of plans and specifications ($46,000) as well as construction cost, including equipment cost.

Cost Estimate: $148,000

Figure 2-48 Main Control Panel
I-2, PROVIDE SEPARATE PNEUMATIC CONTROL PANEL

It is recommended that the pneumatics in the existing control panel (serves SG1, SG2, and FCV-8) be separated from the MCP, and located in a separate pneumatics control panel. SG1 is the rotary valve downstream of airlift pump discharge, SG2 is the fishway sluice gate, and FCV-8 is a valve at the airlift compressor that directs the compressed air to one of the two airlift pumps. As discussed in the in the Airlift System section, it is recommended that FCV-8 be replaced with separate motor actuated valves to control the airflow to each airlift pump.

The cost estimate includes engineering services for preparation of plans and specifications ($10,000) as well as construction cost, including equipment cost.

Cost Estimate: $32,000

2.12.2. PLC CONTROL SYSTEM

DESCRIPTION

The PLC control system is in the rear of the main control panel. It is an Allen-Bradley ControlLogix PLC. The communication platform is Ethernet.

ISSUES

1. Although the existing PLC system is relatively new, a new PLC system should be provided in the proposed new MCP to minimize the time that the station needs to be operated manually during the MCP replacement. As mentioned previously, the PLC could be used at another WTD facility, or used for spare parts.

2. The existing Ethernet system is fine but should also be replaced based on the same issues as those with the PLC system.

RECOMMENDATIONS

I-3, PROVIDE NEW PLC SYSTEM

A new PLC system should be installed into the new main control panel.

The cost estimate includes engineering services for preparation of plans and specifications ($10,000) as well as construction cost, including equipment cost.

Cost Estimate: $30,000

I-4, PROVIDE NEW ETHERNET CONTROL SYSTEM

A new Ethernet control system should be installed in the new main control panel.

The cost estimate includes engineering services for preparation of plans and specifications ($6,000) as well as construction cost, including equipment cost.

Cost Estimate: $25,000
2.12.3. MISCELLANEOUS CONTROL PANELS

DESCRIPTION

EMERGENCY LIGHTING PANEL
The emergency lighting panel is located to the right of the motor control center. It appears to be the original lighting panel which means that replacement parts would be hard to find.

SCREEN SPRAY WATER CONTROL PANEL
The fish screen spray water control panel is located on the inside east wall of the pump station. It appears to be from the original installation which means that replacement parts would be hard to find. This panel should be replace in conjunction with the proposed upgrade of the Spray Water System discussed previously.

BUBBLER LEVEL CONTROL SYSTEM
The Bubbler Level Control System is located on the front of the main control panel. It consists of two lever type controls and two level displays (for the upstream and downstream bubblers). These are the original controls, and the replacement of the MCP will require that a new bubbler control system be provided.

MISCELLANEOUS INSTRUMENTATION AND ALARMS
During the design phase of this project, the alarms for the HMI touchscreen and for the telemetry panel should be discussed to see if there are any additional monitoring or alarming requirements.

MISCELLANEOUS LOCAL CONTROL PANELS
This needs assessment has recommended the replacement of miscellaneous local control panels in conjunction with the replacement of major equipment, or to replace existing panels that have exceeded their useful life, including the following:

1. Trash rake and conveyor system (See Recommendations M-70 and M-71)
2. C2 compressor (See Recommendation FM-12, Replace the Airlift Pump Compressor and Airflow Controls)
3. Waukesha engine control panels (See Recommendation M-18)

See the respective sections of this report for further information on these equipment replacements.

RECOMMENDATIONS

I-10, REPLACE THE EMERGENCY LIGHTING PANEL
It is recommended that the emergency lighting panel be updated when the rest of the motor control center is updated. The emergency lighting panel is old and located right next to the motor control center which means that it might have to move and/or get damaged when the motor control center is replaced.

The cost estimate includes engineering services for preparation of plans and specifications ($6,000) as well as construction cost, including equipment cost.

Cost Estimate: $12,000
I-11. REPLACE THE FISH SCREEN SPRAY CONTROL PANEL
It is recommended that the fish screen spray control panel be replaced with a new panel when the spray water system is upgraded. The fish screen spray control panel is old technology and replacement parts are hard to find.

The cost estimate includes engineering services for preparation of plans and specifications ($20,000) as well as construction cost, including equipment cost.

Cost Estimate: $53,000

I-12. PROVIDE A NEW BUBBLER PANEL
A new bubbler control panel conforming to King County WTD standards should be provided for the upstream and downstream bubblers.

The cost estimate includes engineering services for preparation of plans and specifications ($12,000) as well as construction cost, including equipment cost.

Cost Estimate: $32,000

2.12.4. TELEMETRY SYSTEM

DESCRIPTION
The telemetry system is the main controls communication system between the Pump Station and the South Plant. It consists of an Elpro wireless modem which connects to the Ethernet control system and an antenna mounted on the roof of the control building. The system is still useful but the modem will have to be relocated if the main control panel is updated.

ISSUES
1. Wireless hub is located in main control panel.

RECOMMENDATIONS
I-20, PROVIDE NEW TELEMETRY SYSTEM
Similar to the existing PLC and Ethernet systems, a new telemetry system should be provided in the proposed new MCP to minimize the time that the station will not be able to send alarms and status to the South Plant. The existing telemetry system modem could be used at another WTD facility, or used as a spare once the new system is in place. Additional alarms and data transfer requirements between the Pump Station and the South Plant could also be programmed at that time.

The cost estimate includes engineering services for preparation of plans and specifications ($5,000) as well as construction cost, including equipment cost.

Cost Estimate: $17,000

2.13. DRAINAGE/SPILL CONTAINMENT

DESCRIPTION
The fact that the BRPS includes seven engine-driven flood control pumps, and is located across the Black River channel, indicates that there is a risk that a malfunction of a component on an engine, or similar mechanical failure, could cause a leak of diesel fuel or crankcase oil. Depending on the quantity of fuel and the location of the leak, a spill from the station could leak through available pathways to fall into the
forebay area below the pumps. This could result in the spill being pumped downstream of the station, creating a potentially significant cleanup effort/cost.

Steel angle (2” x 2”) is anchored to the floor around the concrete pads of each of the engines to create a curb that would help contain a spill from the engine and direct the spill to the utility trench along the west side of the station.

Spill containment equipment stored at the station includes, including sorbent booms (New Pig), sorbent pads, granular absorbent (Sea Sweep, manufactured from sawdust) and granular adsorbent (X-Sorb, manufactured from alumina silicate). This material is stored on a table near the northeast corner of the pump building. There is an acid spill response kit stored on top of a cabinet in the control building.

**ISSUES**

1. The recent fuel system upgrade project sealed a number of pipe penetrations in the utility trench to increase the ability of this trench to contain a spill. However, the trench is not coated and therefore cleanup of minor oil leaks is difficult. The County is concerned that leakage may still occur through cracks in concrete. The County intends to coat the utility trench for improved housekeeping as well as fuel spill containment.

2. There are level switches in the pipe service trench intended to detect spills of diesel fuel and to shut down the diesel transfer pump. As discussed previously under the compressed air system section, the discharges of water from the automatic drain valves serving the compressed air system can eventually activate the level switch in the portion of the trench near the compressors. It is recommended that the discharge lines from the automatic drain valves be routed to a chemical adsorption unit to capture the oil in the drainage prior to release to the Green River (See Recommendation M-50 for further details).

3. There is a possibility that an oil spill from the engines would not be contained within the angle iron curb around the engines, such as if a leak was sprayed beyond the curb. The seams and missing bolts in steel plating around the gear boxes could allow a spill to enter the forebay.
4. The gear boxes of the flood control pump, as well as the upper seal and line-shaft bearings use a vegetable oil for lubrication, therefore a leak from these sources does not pose the environmental hazard that the diesel spill does.

**RECOMMENDATIONS**

It is not recommended that the edges of the floor plates around the gear boxes be gasketed, for the following reasons:

1. The steel plates around the gear boxes are bolted directly to the supports below the floor level, and although they are not gasketed, the interface between the plates and the beams is tight and should not allow a high rate of leakage through the floor plate.

2. This project would be relatively expensive (approximately $70,000). If installed, the gasket should be Buna N, for resistance to oils (significantly more expensive than other commonly used gasketing material, such as EPDM or Rubber). This gasketing would be mechanically fastened to the beams with small, flat-headed self-tapping steel screws. The gasketing should be ¼-inch thick to allow the screw heads to be recessed into the gasket. Installing the gaskets would be labor intensive.

3. Adding gaskets would raise the plating above the level of the floor approximately ¼-inch, creating an uneven walking surface, and therefore a tripping hazard.

4. The lack of an even walking surface will also interfere with the movement of equipment within the facility. For example, the removal of an engine from this facility will require that the engine be gradually rolled on steel pipes that are laid on the floor. The pipes would be placed in front of the engine as it rolls the distance to the roll-up door at the north end of the facility. The engine would have to pass over numerous steel plated areas during this process, and if these plated areas are raised ¼-inch, this would be a significant hindrance to this movement (which is difficult under the best of circumstances).

5. As mentioned previously, the oil most likely to spill in the area around the gear drives is vegetable oil, not diesel.

6. It is recommended that all missing bolts in the plating be replaced, as the bolt holes provide a relatively open pathway to the forebay below, as compared to the joints between the plates.

**S-1, PROVIDE STORAGE SHELVES FOR SPCC MATERIALS**

The spill containment equipment that was provided to comply with the revised SPCC plan should be provided with a better and larger storage area. This would allow the SPCC materials to be raised off the ground (some of these materials are laying on the floor below the table) and provide more space for additional materials.
Permanent shelves should be constructed along the east wall of the facility, potentially in the same place where the material is currently stored on the portable shelf. Signage should be provided on the shelves to increase its visibility. A cabinet to hold the SPCC plan should also be available at the storage location.

The cost estimate includes engineering services for preparation of plans and specifications ($3,000) as well as construction cost.

Cost Estimate: $7,000

**5-2, Seal the Utility Trench**

Seal the existing utility trench with a high-build epoxy coating rated for sealing concrete surfaces exposed to diesel fuel. The existing concrete surface of the utility trench would need to be thoroughly cleaned to remove all oil residue. Mechanical methods (grinders, needle guns, etc.) would be used to remove a surface layer of concrete to provide a suitable substrate for coating.

It is anticipated that this coating would be performed in conjunction with replacement of the existing cooling water manifold for the Waukesha engines (see Recommendation M-12). This would allow staged coating of the trench with replacement of the cooling water manifold. Coating the trench in sections would provide greatly increased accessibility in the trench for coating. Temporary piping (located out of the trench) would be used to keep the cooling water manifold in service during the coating operation.

It is also anticipated that this project would be coordinated with the proposed new P12 cooling water pump (see Recommendation M-44). Having the redundant cooling pump installed would make it easier to stage the coating of the trench and simplify the installation of temporary cooling water manifold piping to maintain service to the Waukesha engines.

The cost estimate includes engineering services for preparation of plans and specifications ($20,000) as well as construction cost. The construction cost includes the cost for temporary piping to keep the cooling water manifold for the Waukesha engines in service throughout the coating operation.

Cost Estimate: $130,000

### 2.14. Facility and Structural

The Black River Pump Station was visually inspected for structural deficiencies on September 24th and November 18th. The findings and recommendations are presented below.

#### 2.14.1. Concrete Foundation and Retaining Walls

**Description**

The Pump Station has nine concrete retaining walls identified on the plans. Retaining wall #1 and #2 are on the upstream side of the Pump Station; #1 is located on the North side of the river while #2 is located on the South side of the river. Both walls are approximately 73 feet long. Retaining walls #3 and #4 are downstream of the Pump Station on the North side of the river; they are connected as a continuous retaining wall with an approximate total length of 118 feet. Retaining wall #5 is located on the downstream side of the Pump Station in the middle of the river, with an approximate length of 48 feet. Retaining walls #6A and #6B are on the downstream side of the Pump Station and are located on the South side of the river. Retaining walls #6A and #6B are also the fishway walls; each are approximately 70 feet long. Retaining wall #7 is connected to retaining wall #6B and extends approximately 70 feet downstream from retaining wall #6B. Retaining wall #8 extends from the North side of the Pump Station; it supports one column of the monorail support structure. Retaining walls #1, #2, #3, #4, #6B, and #7 are counterfort retaining walls, while retaining walls #5 and #8 are cantilever retaining walls. Retaining wall #6A is stabilized by beams connecting it to retaining wall #6B.
Figure 2-54 Retaining Wall Locations
A visual inspection of the Pump Station retaining walls #1 through #8, excluding #5, was completed on site. The inspection was limited by access, therefore the full length of each retaining wall, the counterfort buttresses, and the wall and footing below the water line were not inspected. Retaining wall #5 was not inspected as it is located within the river. The retaining walls are located and labeled on sheet S-1 on the plan drawings dated 8/21/69.

**ISSUES**

Retaining walls #6A and #6B are also the fish way walls. It appears the fish way has either slightly settled vertically or globally slid down river. This would not normally be of concern, as the fish way was detailed with appropriate expansion joints. However, the downstream exterior pump station steel walkway was connected on both sides of an expansion joint near gridline R/3, linking both sides of the expansion joint. As the fish way has settled, the connection at the walkway has “pulled” on the settling concrete, causing the concrete to crack and spall.

**RECOMMENDATIONS**

*S-10, REPAIR DAMAGED CONCRETE AND WALKWAY CONNECTION:*

The steel walkway connection to the retaining wall should be redesigned and replaced to prevent further damage to retaining wall #6B. The damaged section of the retaining wall should be removed and repaired.

The cost estimate includes engineering services ($7,000) for preparation of plans, specifications, calculations, and construction support as well as construction cost, including labor and materials.

Cost Estimate: $20,000

**2.14.2. FISH PASSAGE STRUCTURE**

**DESCRIPTION**

The fish passage is located on the downstream side of the structure, on the South side of the river. Retaining walls #6A and #6B are the fishway walls. The fishway is a combination of a fish ladder and pump discharge. It is approximately 50 feet long and 9 feet wide.

**ISSUES**

As noted in the Concrete Retaining Walls section, the fishway has cracking and
spalling at the top of retaining wall #6B due to an inadequate connection at the walkway to concrete interface.

The bar rack at the bottom of the fish ladder has broken loose, allowing fish to travel into the fish pass discharge, rather than directing them into the fish ladder. The picket fence consists of galvanized steel angles and bars, and was originally bolted into the retaining walls with three anchors on each wall.

**RECOMMENDATIONS**

The bar rack at the bottom of the fishway should be repaired in order to prevent fish from entering the pumpway rather than the fish ladder (see the Upstream Fish Migration Facilities section for more detail).

### 2.14.3. PUMP ROOM SUPERSTRUCTURE

**DESCRIPTION**

The Pump Room superstructure is an approximately 160’ long by 37’ wide steel framed one story structure. The lateral system is steel moment frames at each gridline in the transverse direction and two concentrically braced frames on each side in the longitudinal direction. The structural steel beams, columns, base plates, braces, and connections were visually inspected.

**ISSUES**

No structural deficiencies were noted.

### 2.14.4. PUMP ROOM CONCRETE

**DESCRIPTION**

The Pump Room floor consists of concrete floor slabs and beams. The equipment is mostly supported on concrete pedestals while some pieces are supported directly on the concrete floor. The pumps are supported by steel beams which are concealed by metal floor plates. The Pump Room concrete floor slab, beams, walls, equipment pedestals, and column pedestals were visually inspected.

**ISSUES**

1. No structural deficiencies were noted in the concrete or pump support steel beams.
2. The steel grating over the utility trench on the west side of the BRPS is slightly corroded, and removal is difficult due to the weight of the grating sections. Staff noted the 3’-10” wide steel grating covering the trench along gridline 3 was difficult to remove.

**RECOMMENDATIONS**

**S-11, ALUMINUM GRATING FOR UTILITY TRENCH**

Replace the steel grating above the utility trench with aluminum grating. Aluminum grating will reduce the weight of the grating sections as aluminum is approximately one-third the weight of steel. A dielectric separation should be placed between the embedded steel angles and the aluminum grating to preclude galvanic corrosion.

The cost estimate includes engineering services ($10,000) for preparation of plans, specifications, calculations, and construction support as well as construction cost, including labor and materials.

Cost Estimate: $50,000
2.14.5. **Pump Station Forebay**

**Description**

The BRPS forebay consists of eight pump bays. Seven of the bays (P2 through P8) are 22 feet by 22 feet, while the Southernmost bay (P1) is 10 feet by 22 feet. Steel walkways are placed throughout the interior. The walkways vary in width between 3 feet and 2 feet. In the P2 through P8 pump bays the walkways are in a “C” configuration, while in the P1 pump bay the walkway is in an “F” configuration. The walkways consist of steel bar grating supported by steel channels. The channels in turn are supported by steel wide flange members and knee braces bolted to the concrete walls. The ladder and guardrail system are also steel. All steel appears to have been painted and not galvanized.

From the walkways, it is possible to see the pump support steel beams above. The pump support beams consist of painted wide flange steel sections. The steel support beams are bolted to embedded connections in the Pump Room concrete floor beams.

**Issues**

1. Oil staining is evident below the P4 supports. It is unclear if this is residue from a previous leak, such as occurred on the Mitsubishi engine for this pump, or if it is a current leak.

2. The steel walkway beams, ladders, grating, and guardrails in the P1 and P2 pump bays have significant coating loss and are beginning to rust. However, they do not appear to be structurally impacted at this point. The walkways in the remaining bays do not appear to have significant coating loss.

**Recommendations**

5-12, **Forebay Walkway Corrosion Protection**

It is recommended that the steel support beams and knee braces in the P1 and P2 pump bays (between gridlines N and R) be abrasive blasted to remove any existing coating and rust, and be coated with a high build epoxy coating. As the walkways are located above water, protective measures should be taken to avoid polluting the water with debris. This could be achieved by installing the stop logs on the east side as well as the south side of the bays, to isolate the bay being worked on. It is anticipated that temporary scaffolding will be installed.
in these bays to support the workers and contain the debris from the steel preparation and coating. After the coating work has been completed and the scaffolding has been removed, it is recommended that the trapped water in the bay be pumped to the local sewer line for treatment at the South Plant. The stop logs could then be removed and relocated as necessary to isolate the next bay.

The steel grating, guardrails, and ladders in these bays should be replaced with new aluminum grating, guardrail, and ladders. The recommended coating will provide adequate dielectric protection for the aluminum grating to be supported by the steel beams of the walkway structure.

It should be noted that, according to the project specifications, the existing paint is a “Red Lead Base Paint.” Appropriate precautions should be taken to ensure adequate worker safety and environmental protection.

The cost estimate includes engineering services ($40,000) for preparation of plans, specifications, calculations, and construction support as well as construction cost, including labor and materials.

Cost Estimate: $240,000

2.14.6. Fishway and Airlift Rooms

Description
The Fishway Room and the Airlift Room are located south of the P1 pump bay (i.e., south of gridline R). The Fishway Room is approximately 7 feet by 17 feet by 13 feet deep, while the Airlift Room is approximately 15 feet by 16 feet by 70 feet deep. Painted steel walkways connect the two rooms. The construction of the steel walkways is similar to the walkways within the forebay discussed previously. The tank in the Airlift Room is supported by steel beams which are grouted into the concrete wall.

Issues
1. Fishway Room: The pipe supports, grating, guardrail, and supporting steel have significant coating loss and have rusted.
2. Airlift Room: The grating, guardrail, ladder, and supporting steel have significant coating loss and are badly rusted. The steel beams supporting the airlift pump discharge basin have significant coating loss and are badly rusted.

Figure 2-59 Corroded Tank Support Beam at Air Lift
RECOMMENDATIONS

S-13, Fishway and Airlift Rooms Corrosion Protection

In the Fishway and Airlift Rooms, the steel walkway support beams and pipe supports should be prepared and coated in a similar process as described for the forebay steel walkway. The walkway grating and guardrails should be replaced with aluminum grating and guardrail.

This work should not be performed in the Fishway Room during the upstream migration period, or in the Airlift Room during the downstream migration period.

The steel beams supporting the airlift pump discharge basin in the Airlift Room should be prepared and coated as described in the forebay section.

The steel supports in the Airlift Room below the tank support level (such as for the ladder landing) should also be coated, and the steel grating replaced with aluminum grating. During the design phase this area should be inspected to determine the scope of further steel coating and grating replacement from the main landing down to the grating over the sump pump.

As noted previously, the existing paint is a “Red Lead Base Paint” according to the specifications, therefore appropriate precautions should be taken.

The cost estimate includes engineering services ($35,000) for preparation of plans, specifications, calculations, and construction support as well as construction cost, including labor and materials.

Cost Estimate: $185,000

2.14.7. Exterior Steel Walkways, Grating, Ladders, and Guardrails

Description

The Pump Station has steel walkways on both the upstream and downstream sides of the structure. The upstream walkway is approximately 10 feet wide and runs the length of the structure. It consists of steel bar grating resting on embeds in the tops of the concrete piers between the bays.

The downstream walkway is approximately 3 feet wide and runs the length of the structure. The walkway consists of steel bar grating and is supported on wide flange steel sections and WT knee braces. The guardrails are welded pipe with kick plates.

Issues

1. On the downstream exterior walkway there is minor corrosion on the support beams, guardrails, and kick-plate.
2. There is minor corrosion on all exterior guardrails. It appears the paint on the guardrails has peeled off in small patches, leaving the steel exposed and vulnerable to corrosion.

3. On the downstream walkway near gridlines R/3, the steel walkway is connected to the fishway concrete Retaining Wall #6A. As noted in the Concrete Foundation and Retaining Walls section, this connection has damaged concrete due to settling of the retaining wall. In addition, the steel beam and anchor are heavily corroded at the connection to the concrete retaining wall.

4. It should be noted that, according to the project specifications, the paint is a “Red Lead Base Paint.”

**RECOMMENDATIONS**

On the downstream walkway near gridlines R/3, the damaged steel-to-concrete connection should be redesigned and reinstalled to prevent any further damage to the fishway concrete as well as the steel walkway, as discussed in the Concrete Foundation and Retaining Walls section (See Recommendation S-10). It is possible that a portion of the beam will need to be replaced due to section loss from corrosion.

All exterior steel, including grating, walkway beams, and guardrails, should be monitored for excessive corrosion in the future.

**2.14.8. CRANE RAILS**

**DESCRIPTION**

The Pump Station has two exterior monorails and one interior bridge crane. On the exterior of the building, monorail #1 runs the full length of the building and extends to the North and is supported by the Crane Support Structure. Monorail #2 is located next to monorail #1, it runs from gridline J to gridline Q. The interior bridge crane runs the length of the building.

**ISSUES**

No Structural deficiencies were noted with the Crane Rails.
2.14.9. Crane Support Structure at Stop-Log Storage Area

Description
The crane support structure is located to the North of the Pump Station. The structure is one story and open. It is 34 feet by approximately 13 feet and approximately 30 feet tall. The framing consists of six steel wide flange columns connected at the top with wide flange beams. There are knee braces in both of the principle directions at each column. The six columns are supported on concrete piers. Lateral load and uplift are transferred to the foundation by two anchor rods at each column.

Issues
A visual inspection of the columns revealed delamination of the protective coating and corrosion induced pitting of the steel. The base plates, anchor rods, washers, and nuts are similarly affected. We were unable to determine the condition of the beams due to height inaccessibility.

Recommendations
S-14, Crane Support Structure Corrosion Protection
It is recommended that the exposed metal surfaces be abrasive blasted to remove all rust and provide a white metal finish, at which point the members should be measured to determine the amount of section loss. If member section loss has occurred, it is recommended that the structure be analyzed using the smaller member sections to determine if the structure is adequate as is or needs to be replaced. If the structure is found to be structurally adequate, it is recommended that the entire structure be coated with a high performance coating, such as epoxy primer with a topcoat of polyurethane for exterior exposure. If the existing structure is found to be vulnerable to collapse, it is recommended to be replaced with a similar structure framed with galvanized steel.

For the purposes of this report, it has been assumed that the entire structure will be prepared and coated.

It should be noted that, according to the project specifications, the paint is a “Red Lead Base Paint.” Appropriate precautions should be taken to ensure adequate worker safety and environmental protection.

The cost estimate includes engineering services ($20,000) for preparation of plans, specifications, calculations, and construction support as well as construction cost, including labor and materials.

Cost Estimate: $70,000
2.14.10. CONTROL BUILDING

DESCRIPTION
The Control Building is located to the South of the Pump Station. The Control Building is a one story CMU structure, approximately 24 feet by 20 feet by 10 feet tall. The roof system is a built up roof over metal decking supported by metal bar joists.

ISSUES
No structural deficiencies were noted with the Control Building.

2.14.11. FLAP GATE HINGE MOUNTINGS

DESCRIPTION
The Flap Gates are located on the downstream side of the Pump Station. Since they are located in the river way, an inspection of the flap gates was not possible due to inaccessibility (a boat would be required). WTD staff repaired the hinge of the P4 flap gate by accessing the gate in a boat.

RECOMMENDATIONS

S-15, INSPECT FLAP GATES
Inspect the flap gates for P1-P8 to determine if any noticeable defects are apparent. This inspection is primarily focused on the hinges on the gates. The gates for P-2 and P-4 (48” diameter) and for P3, P5, P6, P7, and P-8 (96” diameter) should be accessed by boat; however, it is expected that the inspection will require a ladder resting on the tailrace floor to access the hinges, which on the 8 ft diameter gates is approximately 10 ft higher than the floor.

Accessing the P1 flap gate will be challenging, as it will be necessary for the inspector to be lowered to the top of the screen spanning between the edge of the channel and the fish ladder. The inspector would then have to move closer to the P1 flap gate, where the screen does not cover the channel, to drop down to the channel floor and access the hinges with a ladder.

It is assumed that the County will hire a mechanical contractor to conduct the inspection and produce a report.

Cost Estimate: $12,000

2.14.12. SHEET PILE WALL

DESCRIPTION
The sheet pile wall is a buried structure that is a critical element of the dam structure. The sheet pile wall prevents the river water from circumventing the concrete forebay, as well as anchoring the dam in the river channel. The sheet pile wall extends approximately 470 feet south of the Pump Station and 200 feet north of the Pump Station, as well as extending below the Pump Station.
According to the project specifications, the sheet pile wall was driven with a drop hammer and is a minimum of 1/2” ASTM A328-67 Gr A steel with a minimum weight of 28 psf and a minimum section modulus of 2.5 cubic inches per linear foot of wall. The top of the wall is approximately 4 feet below grade and extends between 20 and 50 feet to the bedrock.

**ISSUES**

1. It is possible the sheet pile wall has been subject to corrosion.
2. Determine the scope and budget for an inspection of the buried sheet pile wall.

**RECOMMENDATION**

**S-20, SHEET PILE WALL CORROSION INVESTIGATION**

The following steps should be taken to evaluate the sheet pile wall:

1. Soil type, oxygen content, and groundwater location have a significant effect on steel corrosion. The soil in the area of the sheet piles should be tested to determine its corrosive potential. Testing could include a soil resistivity measurement using a 4 pin test and performing borings at various locations. Testing should determine the soil type and pH level as well as the minimum and maximum groundwater elevations.

2. Sheet pile walls can be subject to soil corrosion, the diffusion of oxygen from the soil to the steel. Sheet pile walls which stay saturated are not usually subject to soil corrosion, as the water acts as a barrier to soil corrosion. Therefore, corrosion will probably be limited to the portion of the sheet pile wall subject to wetting and drying cycles in areas of high oxygen content. In order to visually inspect the most likely location of corrosion, it is recommended that limited potholing be performed along the length of the sheet pile wall to view the condition of the upper portion on both the upstream and downstream side of the wall.

3. If corrosion is detected, further non-destructive testing may be performed to determine the amount and extent of the potential corrosion. The tests could be either a micrometer or ultrasound measuring.

4. If the corrosion is deemed to be extensive yet not detrimental to the function of the wall, the rate of corrosion could be slowed by use of sacrificial anodes or an impressed current. Sacrificial anodes are strips or blocks of a dissimilar metal which will react and be consumed by corrosion prior to the steel sheet piles. Impressed current protection consists of applying a continuous current to the sheet pile wall which interrupts the galvanic corrosion process.

The cost estimate for the sheet pile wall corrosion evaluation will depend on the extent of testing. A general report consisting of only a single site visit to perform a 4 pin resistivity test could cost as low as $4,000. A visual examination and testing of the buried sheet pile wall, soil sampling, and steel testing could be as much as $60,000. For the planning purposes, a budget of $40,000 is recommended for the sheet pile wall corrosion evaluation. Depending on the results of this analysis, further investigation may be warranted.