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Final Report

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The Pump Station #1 Replacement project feasibility study was a collaborative effort between Redlands Water and Power Company and J-U-B Engineers. Significant effort went in to analyzing various alternatives and determining which alternative was the best fit.

Ultimately, it was determined that the cost effectiveness and functionality of Alternative #2: a slab-on-grade structure adjacent to the Tailrace with water withdrawals from the Power Canal was the best option. With a total project cost estimated at approximately $4,267,000, external funding will be required, likely through a combination of grants and low interest loans.

Efficiency improvements will likely decrease the energy consumption used to pump water to the First Lift Ditch. This provides the opportunity to generate additional revenue or the opportunity to forego some diversion during times of low water while maintaining current levels of energy production and water delivery.

Submitted by: Rae Shannon
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Signature:

Pump Station No. 1
Replacement Feasibility Study

Prepared for:

Redlands Water and Power Company

June 2019

Prepared by: J-U-B ENGINEERS, Inc.

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1.0 EXECUTIVE SUMMARY

The Articles of Incorporation of the Redlands Water and Power Company (RWPC) state that, among other things, the purpose of the Company is, "…to furnish and distribute to the stockholders' water for irrigation and domestic purposes…" Most of the RWPC service area is located on benches high above the diversion on the Gunnison River such that a gravity conveyance system alone cannot provide water to much of the service area. The continued ability to pump water to serve irrigated acreage is the only mechanism RWPC has in order to fulfill its articles of incorporation.

The purpose of Pump Station No. 1 is to supply the First Lift Ditch and Stub Ditch with irrigation water. The entirety of the pumped water is intended for irrigation of the benched lands. Given the purpose of the company and the function of Pump Station No. 1, it is appropriate to classify Pump Station No. 1 as critical and necessary infrastructure within the RWPC system.

The Redlands Water and Power Company Pump Station No. 1 was constructed beginning in 1917. Except for some minor maintenance and modernization efforts over the last 100+ years, most of the original infrastructure is still in use today. The pump station is significantly outdated by today's standards; many aspects of the pump station do not comply with modern building and electrical codes. The rising cost and frequency of repairs coupled with the inefficiencies associated with the outdated equipment have highlighted the need for replacement of the existing facility.

RWPC hired J-U-B Engineers to investigate the feasibility of the replacement or rehabilitation of Pump Station No. 1. The investigation consisted of:

- An existing conditions assessment to identify deficiencies of the pump station and related infrastructure, and to identify limitations and opportunities of the site conditions for new infrastructure
- A collaborative effort with RWPC to weigh various alternatives for new pump station location and operation (Appendices 1-3 of this report)
- A conceptual design, based on the chosen alternative, with a level of detail sufficient to generate appropriate cost estimates
- Potential project phasing with cost estimates for each potential phase
- An investigation into potential revenue increases as a result of the efficiency improvements of the replacement

The existing conditions assessment and alternatives analysis led to a preferred design that provided the needed infrastructure to supply the irrigation water to the first lift ditch, met the site-specific needs of RWPC, and exploited some potential water saving opportunities (by withdrawing pumped water from the Redlands Tailrace). Initial efforts were focused on exploring this option, however, as the conceptual design was refined and costs were estimated, it became apparent that the preferred option was cost prohibitive. Project efforts were redirected to explore a more affordable alternative that withdraws water from the Power Canal rather than the Tailrace. This report acknowledges the original efforts but is focused upon the revised design concept.

The chosen design concept consists of a structure adjacent to the Redlands Tailrace but supplied through a 48" HDPE pipeline from the Redlands Power Canal. The structure houses five horizontal split-case pumps powered by a motor control center containing an Adjustable Speed Drive (ASD). The design allows for pumping up to 70 cfs with four pumps (the fifth pump adds system redundancy); the ASD allows for adjusting the flow rate by varying the speed of a single pump, enabling a user to specify a flow rate. Appurtenant to the proposed Pump Station is the replacement of the pumpline, and the replacement of the penstock and bypass gates. Long-term system functionality requires the replacement of these items.

Project phases were investigated to determine elements of the project that could be independently completed and independently funded to give RWPC maximum flexibility for project implementation. They also provide a general order based on both need and required construction sequencing (please note that exact order in all cases is not mandatory but is recommended). Table 1.0.1 provides phase ordering, description, construction time constraints and estimated cost. **The total for all phases is estimated at $4,037,000**. Potential project scheduling should consider grant and loan acquisition/administration, final design, and possible environmental compliance work in addition to the construction windows provided above.

Table 1.0.1. Project Phasing and Estimated Costs

Phase	Description	Construction Time Constraints	Estimated Cost
1	Pumpline Replacement*	November-March Construction Only	$ 406,000.00
2	Pump Station Structure Construction	None	$ 1,114,000.00
3	Intake Pipe Installation*	November-March Construction Only	$ 142,000.00
4	Pump Station Equipment Purchase and Installation**	None	$ 2,065,000.00
5	Penstock and Turbine Bypass Gate Replacement*	November-March Construction Only	$ 310,000.00
Estimated Project Total***			$ 4,037,000.00

*All or some of the construction requires power plant shutdown resulting in loss of revenue (not accounted for in cost)
**Phase includes purchase of all hydraulic piping and equipment excluding intake pipe and pumpline, includes mechanical/HVAC components, all electrical components
***Funding sources may require NEPA related work. If these sources are pursued, assume estimated cost of Environmental Work at $100,000

Given the high total project cost, funding will likely have to come through a combination of grants and low-interest loans. While this report does not suggest funding mechanisms, it does acknowledge that if a loan were pursued, an increase in power revenue could provide for a portion of debt service. The proposed project will result in less power consumption for an equivalent amount of pumping. The decrease in power consumption would allow for additional power to be sold, thereby increasing power revenue. Initial analysis indicates that an increase of over $24,000 of annual revenue may become available by replacing Pump Station #1.

2.0 EXISTING CONDITIONS ASSESSMENT

The Redlands Water and Power Company (RWPC) diverts water from the Gunnison River approximately 2.4 miles upstream from the confluence with the Colorado River. Diverted water enters the Redlands Power Canal which travels approximately 3.5 miles to the West where it reaches its termination point. The termination point of the Power Canal serves as the forebay for both the RWPC Hydro-Electric Power Plant and Pump Station No. 1.

Pump Station No. 1, which is powered by a portion of the power generated by the hydro-electric power plant, exists to provide irrigation water to the bench lands high above the Colorado and Gunnison Rivers. Water is pumped vertically approximately 128 feet, from the Pump Station to the First Lift Ditch through the "pumpline", a 48-inch diameter, 1550-foot long steel pipe installed in 1944 (some sections were replaced in 2007). According to the 2014 Water Management Plan demand from the pump station varies from 50 to 65 cfs; operations staff have stated that demands to the First Lift Ditch and Stub Ditch have been as high as 70 cfs.

2.1 General Site Layout

The existing site is bounded on the south by the Redlands Power Canal. On the north, the site is bounded by the Redlands Tailrace, which conveys water presumably used for power generation to the Colorado River. The western side of the site is constrained by the confluence of the Power Canal overflow with the Redlands Tailrace. The eastern side of the site is adjacent to a paved walkway, serving as a local trail. The site has a steep northeast to southwest grade. The elevation changes approximately 38 feet between the banks of Power Canal and the bank of the Tailrace.

There are multiple structures on the site. Pump Station No. 1 and the turbine intake are on the south boundary of the site, adjacent to the Power Canal. An old, currently unused, house sits immediately to the north of Pump Station No. 1, while the turbine penstocks travel north from the turbine intake to the power plant. There are two occupied homes on the site for operations staff. A steel building for maintenance related activities is currently under construction to the west of Pump Station No. 1.

2.2 Pumping Plant

Pump Station No. 1, constructed in 1917, sits adjacent to the Redlands Power Canal. Water is withdrawn directly from the power canal via submerged intakes supplying individual pumps behind a common trash rack. Figure 2.2.1 illustrates the exterior configuration of the Pump Station relative to the Power Canal.

Figure 2.2.1 Pump Station Exterior Configuration

Pumping is performed by four horizontal split case pumps with design discharge rates ranging from 26 cfs to 16 cfs, all housed in a below-grade concrete foundation. The motors range in size from 500 HP to 250 HP. Figure 2.2.2 shows the interior of the pumping room. An exterior vertical turbine pump is designed to pump an additional 12 cfs using a 200 HP motor.

Figure 2.2.2. Below-grade Pumping Room Layout

The electric motors are powered by a 2300 V motor control center (MCC) supplied by the hydroelectric plant. The 2300V electricity is transmitted to the MCC directly via a transformer outside of the hydroelectric building. The at-grade portion of the pumping plant houses the motor control centers responsible for powering the pumps, as can be seen in Figure 2.2.3. The RWPC Water Management Plan (2014-2015) states that the current facility needs extensive upgrade to comply with the National Electric Code (NEC).

Figure 2.2.3 Pump Station Control Room

RWPC's 1.6 MW hydroelectric plant generates approximately 1,000,000 kW-hrs per month. During the irrigation season, approximately 700,000 kW-hrs are consumed per month by the pump station. Given that pump rates peak at roughly 50 cfs during many months, analysis indicates that the system is highly inefficient. Section 6.0 explores this idea further and compares potential energy consumption to historic energy use.

At present, RWPC does not have an adjustable speed drive (ASD) for their pumps. Without an ASD, motors are started "across the line" (creating the potential for power surges on the system) and are only able to operate at a single speed. This results in frequent over pumping (RWPC frequently pumps more water than is required due to pump hydraulics). While this practice does not affect water use (the excess water is returned to the Power Canal), it requires significant additional energy at the pumps.

2.3 Pumpline

The current 1550 ft pumpline begins immediately outside of Pump Station No. 1 and is tied directly onto the below-grade pump discharge manifold. The line abruptly turns toward the south in the direction of the First Lift Ditch. Immediately after the turn to the south, the pumpline passes over the Power Canal in an overshot supported by concrete piers. This overshot runs parallel with the culinary waterline for the site. Figure 2.3.1 shows the Power Canal Overshot.

Figure 2.3.1. Power Canal Overshot

The pumpline is comprised of steel pipe of varying sizes, ages, and conditions. The bulk of the pumpline was installed in 1967 and was lined with concrete at a later date. In 2007, approximately 525 feet of the upper end of the pumpline were replaced with new 48-inch steel pipe. To avoid high costs associated with traffic control during construction, the section of pipe replaced under Broadway was sliplined with 44-inch steel pipe. The older sections of the pumpline are in poor condition and require frequent repair. Operations staff are concerned that a major failure may occur if the existing pipe is not replaced.

The pumpline alignment North of Broadway follows a dirt O&M road owned by RWPC. The extent of the pipe replacement that is proposed (highlighted in Exhibit 3) is entirely beneath this road and within RWPC property. Figure 2.3.2 shows a typical section of the pumpline alignment.

Figure 2.3.2. Typical Section of Pumpline Alignment

2.4 Appurtenant On-Site Infrastructure

Site assessment indicates that additional infrastructure is in need of repair or replacement. Specifically, the bypass chute overshot gate and the penstock gates were identified as critical infrastructure in need of replacement. Despite being separate from the pump station, this infrastructure directly impacts pumping operations.

Water surface elevation within the Power Canal is maintained by both a spill gate at the western termination of the Power Canal, and an overshot gate at the mouth of the bypass chute adjacent to the Hydropower Facility. The spill gate at the end of the canal is in operable condition and does not warrant replacement. The overshot gate on the bypass chute, however, appears to be in poor condition and should be replaced. A failure of the overshot gate would drain the Power Canal and inhibit both power production and pumping capabilities. Figure 2.4.1, on the following page, shows the current condition of the overshot gate.

Figure 2.4.1. Current Condition of Overshot Gate on Bypass Chute

Water at the entrance of the turbine penstocks is controlled by two 9-foot by 9-foot slide gates used to isolate the turbines for maintenance and other unforeseen events. The gates have corroded slide channels which prevent them from opening when seated by hydraulic pressure from the canal. The result is that the Power Canal must be drained to open the penstock gates, interrupting pumping operations and extending the downtime of power generation. Figure 2.4.2 shows the two turbine penstock gates within the turbine forebay.

Figure 2.4.2. Penstock Gates in Turbine Forebay

3.0 ANALYZED ALTERNATIVES

To ensure that the chosen conceptual design would appropriately meet the needs of RWPC, J-U-B engaged in a collaborative process with the RWPC staff and board members to examine three different alternatives. The alternatives were developed to provide a broad comparison of varying configurations on the pumping and piping infrastructure for RWPC. The comparisons examined operational, economic, and river flow impacts of the varying configurations. Summaries of the various alternatives are described below; Appendices 1-3 contain memoranda from this evaluation process which elaborate on alternative specifics.

3.1 Alternative #1: Remodel/Rehabilitate Existing Pump Station

Alternative #1 was a remodel/rehabilitation of the existing pump station. This alternative would have utilized the existing pump station structure and intake from the Redlands Power Canal.

Advantages:

- Cheapest alternative as minimal site development would be required and current structure could be utilized
- Favorable operating economics compared to pumping from the Redlands Tailrace, as pumping from the Power Canal requires less energy

Disadvantages:

- Extensive structural rehabilitation would be required to bring current facility in compliance with applicable building codes
- Configuration and size limitations of existing pump pit limit the potential infrastructure that can be utilized
- Rehabilitation of existing location would not allow for utilization of Tailrace water under any circumstances
- Rehabilitation could only occur when irrigation water is not needed in the RWPC service area; rehabilitation would have to be completed in a single off-season to ensure pumping during the next irrigation season

3.2 Alternative #2: Relocate and Rebuild Pump Facility and Continue Intake from Power Canal

Alternative #2 was a relocation and rebuild of the pumping facility to a location adjacent to the Redlands Tailrace, while continuing to intake water from the Power Canal.

Advantages:

- Relocation would allow for significantly larger building footprint, thereby improving on-site operations with shop areas, restrooms, break rooms, etc.
- Favorable operating economics, as water withdrawal would be from the Power Canal. Added friction loss from the extra piping required would make this less economical than Alternative #1, however, use of a pressurized intake manifold would be

significantly more economical than withdrawing water from the Tailrace

- Split-case horizontal centrifugal pumps with flooded suction would not require below-grade sump, therefore, the structure could be slab-on-grade construction

Disadvantages:

- Does not provide for ability to withdraw water from the Redlands Tailrace, which limits operational flexibility

3.3 Alternative #3: Relocate and Rebuild Pumping Facility with Intake from Redlands Tailrace

Alternative #3 was a relocation and rebuild of the pumping facility adjacent to the Redlands Tailrace. Water intake, however, would be from the Tailrace rather than the Power Canal. Utilization of horizontal split-case centrifugal pumps (which is RWPC operations staff preference) would require use of a below-grade "pump bay" to provide flooded suction to the pumps.

Advantages:

- Improved water security as pumping from Tailrace provides opportunity to divert less water during times of scarcity, while maintaining ability to utilize both turbine and pumps
- Relocation would allow for significantly larger building footprint, thereby improving on-site operations with shop areas, restrooms, break rooms, etc.

Disadvantages:

- Below-grade pump bay would significantly add to project cost
- Least favorable operating economics, as cost of pumping from Tailrace would likely not be fully offset from increased power generation and increase in efficiency

3.4 Alternative #4: Relocate and Rebuild Pump Facility with Intake Options from both Power Canal and Redlands Tailrace

Alternative #4 was developed after discussion between RWPC and J-U-B regarding the merits of both Alternative #2 and #3. It combines the ability to utilize the more favorable operating conditions of Alternative #2 with the added water security of Alternative #3. It is a relocation and rebuild of the pumping facility adjacent to the Redlands Tailrace, with intake options out of both the Power Canal and the Redlands Tailrace.

Advantages:

- Improved water security as pumping from Tailrace provides opportunity to divert less water during times of scarcity, while maintaining ability to utilize both turbine and pumps
- Ability to pump with favorable operating economics as water withdrawal could be from

the Power Canal during periods of water surplus

- Relocation would allow for significantly larger building footprint, thereby improving on-site operations with shop areas, restrooms, break rooms, etc.

Disadvantages:

- Most expensive option due to added piping costs from Power Canal and high costs associated with the below-grade pump bay

4.0 CONCEPTUAL PLAN

Initial efforts were focused on exploring the option identified Alternative #4 (a pump station with the capability of withdrawing water from both the Power Canal and the Tailrace). As a conceptual design for Alternative #4 was developed and costs were estimated, it became apparent that the Alternative #4 was cost prohibitive. Alternative #2 (a pump station adjacent to the Tailrace with all water withdrawals from the Power Canal) was identified as a significantly more affordable option. **Discussions with the Board of Directors and operational staff indicated that Alternative #2 would be the chosen conceptual design.** The system description herein is for the chosen alternative, Alternative #2. Appendix 4 contains a brief overview of the Alternative #4 structural design and its associated costs.

4.1 Site Configuration

The preferred pump station is adjacent to the Redlands Tailrace. The combination of the current pump station facility, the turbine forebay, and the new shop facility occupy much of the space on the bank adjacent to the power canal. While the existing pump station will no longer be used, demolition of the structure and a rebuild of a new pump station on its footprint in a single off-season (November-March) would be difficult. This would mean that water users on the Redlands could be without irrigation water for a time, which is unacceptable to the RWPC. Without significant site reorganization, such as moving the operator housing, placement of the facility adjacent to the Redlands Tailrace is ideal.

Being significantly downgrade from the intake from the power canal allows for a flooded suction manifold while keeping the pumps above grade. Placement of the pump station adjacent to the tailrace has the potential to restrict access to the hydroelectric plant facility. This was discussed with RWPC staff who believe that significant work on the hydroelectric facility would require access through the drained Tailrace, regardless of pump station location. Additionally, RWPC staff believes that they could rough grade the hillside base to maintain access to the hydroelectric facility.

Relocation of the pump station away from the water source requires an intake (suction) pipe from the source to the pumps. A concrete screening/intake structure on the northern bank of the Power Canal was anticipated as essential infrastructure for the relocation; the opportunity for double utilization of the urethane trash rack on the turbine forebay was investigated as an alternative. The forebay was surveyed and it was determined that there was adequate space and hydraulic capacity within the forebay to tie the intake pipe into the forebay and eliminate the need for an additional concrete structure as originally anticipated.

The proposed site configuration favors a discharge pipe alignment that would utilize the existing Power Canal overshot location. By proxy, the existing pumpline alignment would likely be maintained upon replacement of the pumpline pipe. Exhibit 2 shows conceptual alignments for the suction and discharge pipes, as well as the pump station location described above.

4.2 Pumpline Replacement

The current condition of the pumpline coupled with its importance within the system, merits its replacement. Due to probable project phasing (discussed in Section 5.0) and for purposes of this report, the "Pumpline Replacement Phase" begins at the upstream end of the existing Power Canal steel overshot.

The proposed pumpline replacement, shown in Exhibit 3, consists of a new 48-inch steel overshot connected via a weld-on flanged fitting to a new 48-inch HDPE line. The replacement will terminate at the recently installed steel pipe (circa 2007), approximately 100 feet north of Broadway. Termination will likely consist of a weld-on steel flange joined to an HDPE flange adapter.

HDPE was deemed preferable for this application because:

- HDPE fusion welds result in a seamless pipe (unlike PVC), thereby minimizing potential leak locations
- HDPE's flexibility decreases the need for fittings where variable grades are present, as is the case with the pumpline
- HDPE is resistant to abrasive fluids, including silt-laden irrigation water
- HDPE is significantly cheaper than steel pipe

HDPE pipe is a commodity-based product whose price is determined by the weight of the resin needed to make the pipe. Product costs can be highly variable with recent resin prices ranging from \$0.90/lb to \$1.40/lb, while the current price is approximately \$1.20/lb (June 2019).

Given the cost of pipe varying by material weight, along with varying pressures expected along the pumpline (with higher pressure rated pipe needed closer to the pump station), the proposed pumpline has varied thicknesses (pressure ratings) along its length. The proposed dimension ratios (which relate to wall thickness) range from DR 21 near the overshot to DR 41 pipe near the outlet at the first lift ditch. Total pumpline cost is provided in Table 4.2.1, and assumes an HDPE cost of \$1.25/lb.

Table 4.2.1. Opinion of Pumpline Replacement Costs

Pumpline Replacement					
Item	Description	Unit	Estimated Quantity	Unit Price	Amount
1	Mobilization	LS	1	$ 15,000.00	$ 15,000.00
2	Furnish and Install 48" DR 21 HDPE	LF	180	$ 224.37	$ 40,400.00
3	Furnish and Install 48" DR 32.5 HDPE	LF	160	$ 162.37	$ 26,000.00
4	Furnish and Install 48" DR 41 HDPE	LF	540	$ 138.28	$ 74,700.00
5	HDPE Mainline Pipe Fittings	LS	1	$ 15,000.00	$ 15,000.00
6	Steel Overshot	LF	100	$ 500.00	$ 60,000.00
7	Overshot Concrete Supports	YD	16	$ 625.71	$ 10,000.00
8	Import Pipe Embedment/Foundation Material	TON	900	$ 41.60	$ 37,400.00
9	Inline Thrust Blocks	EA	2	$ 1,000.00	$ 2,000.00
10	Removal and Disposal of Existing Pipe	LF	900	$ 35.00	$ 31,500.00
Construction Subtotal:			$ 312,000.00		
Construction Contingency (15%):			$ 46,800.00		
Indirect Costs (Engineering, Construction Management, etc)			$ 46,800.00		
Total			**$ 405,600.00**		

4.3 Pumping and Piping

The proposed pump station piping begins at the turbine forebay with a connection to a 170 foot, 48-inch DR 32.5 HDPE suction line. The connection requires an isolation valve/gate at the forebay to isolate the pump station and to allow for repair of the suction line, should the need arise. The connection will require coring into the existing concrete wall of the turbine forebay, using a low-head connection and attaching a flush-mount 48-inch canal gate to the interior wall of the forebay. The low-head connection poses a pull-out risk due to the thermal expansivity of HDPE; an inline HDPE thrust restraint will likely be required to mitigate this risk. The size and material of the suction line should help minimize head loss in the system, thereby decreasing the energy requirements of the pumps.

The suction line will tie directly onto a 48-inch steel pump manifold with 22-inch outlets for the five proposed Horizontal Split Case Centrifugal pumps. Preliminary piping and valving were designed to assist in accurate pump sizing and to increase accuracy of cost estimates. The preliminary pumping and piping infrastructure at the pump station is provided in Exhibit 4: Proposed Pumping and Piping Schematic. Each 22-inch steel manifold outlet will connect to the suction side a proposed pump assembly. The discharge of each pump will convert back into 20-inch steel pipe, each of which will tie onto the proposed 48-inch steel discharge manifold. Through a flanged connection, the steel discharge manifold will attach to a section of 48-inch DR 17 HDPE pipe. The 48-inch HDPE line will travel approximately 185 feet and connect to the pumpline at the base of the Power Canal overshot of the pumpline.

The pumps used in the cost estimates are Pentair Aurora 12x14x15B with 350 HP/460 V electric TEFC motors. Stainless steel impellers, wear sleeves, and wear rings are included in the estimate due to the abrasive nature of the diverted irrigation water. The selected pumps are intended to pump approximately 16.5 cfs each and provide the requisite 127.5 feet of elevation lift between the Power Canal and the First Lift Ditch (the total dynamic head requirements of the system curves were used in sizing pumps to ensure adequate pump capacity and more accurately estimate energy requirements). It is anticipated that three or four pumps will operate in-parallel throughout the irrigation season based on the demand. One of the operating pumps will be controlled by and ASD, allowing for the plant operator to set a specific flowrate for the pumps to achieve. The fifth pump will be a standby pump to be used if an active pump requires shutdown. Further details regarding pump operation and control may be found in Section 4.5 (Electrical).

The opinion of probable cost for pumping equipment and appurtenant piping was generated with using piping material and labor data from comparable projects. Steel piping, fittings and valves cost data was obtained courtesy of Grand Junction Pipe and Supply in Grand Junction, CO. Pump and motor cost data was obtained through direct quotation courtesy of Pentair Industries. The opinion of probable cost for pumping and piping components can be found in Table 4.3.1.

Table 4.3.1. Opinion of Pumping and Piping Costs

Pumping and Piping					
Item	Description	Unit	Estimated Quantity	Unit Price	Amount
1	Mobilization	LS	1	$ 41,000.00	$ 41,000.00
2	Pipe connection to Turbine Forebay (coring, attachment, gate)	LS	1	$ 46,000.00	$ 46,000.00
3	48" DR 32.5 HDPE Pipe from Forebay to Pump Station	LF	170	$ 162.37	$ 27,600.00
4	Steel Piping in Pump Station	LS	1	$ 271,000.00	$ 271,000.00
5	Valves and Appurtenances	LS	1	$ 75,000.00	$ 75,000.00
6	48" DR 17 HDPE to Pumpline	LF	40	$ 264.00	$ 10,600.00
7	48" DR 21 HDPE to Pumpline	LF	145	$ 224.37	$ 32,500.00
8	48" HDPE Fittings	LS	1	$ 25,000.00	$ 25,000.00
9	Pumps and Motors	5	5	$ 66,150.00	$ 330,800.00
Construction Subtotal:			$ 859,500.00		
Construction Contingency (15%):			$ 128,925.00		
Indirect Costs (Engineering, Construction Management, etc)			$ 103,784.63		
Total			**$ 1,092,209.63**		

4.4 Structure

The relocated and rebuilt Redlands Water and Power Pump Station No. 1 structure was preliminarily designed to accommodate the hydraulic and operational needs of RWPC at minimal cost. Both steel and concrete masonry unit (CMU) block buildings were considered. Preliminary estimates indicate that a steel building is likely a cheaper, and therefore, a preferable option. A graphical representation of the proposed design may be found in Exhibit 5: Proposed Pump Station Structure.

The structure is designed to be a slab-on-grade with a small concrete channel containing the intake manifold. The concrete channel allows for the intake manifold to enter the structure while maintaining the requisite pipe bury depth outside of the structure. The concrete channel will be covered by grating for operator safety and to improve access to the pumps for repairs and maintenance. Final design should consider grading the concrete channel and installation of a drain to the Tailrace. Additional equipment protection will be achieved through concrete pedestals beneath the pump and motor assemblies.

Pumped water will exit the structure through piped wall penetrations from each pump discharge. The discharge manifold will be buried outside of the structure footprint. The proposed building footprint shown in Exhibit 2 represents the building and exterior appurtenances (including discharge lines).

The structure has been designed to accommodate maintenance needs that are typical for pump stations of this size, including the ability to remove and repair or replace damaged pumps and motors. A 21-ton top riding double girder (TRDG) bridge crane was preliminarily sized and quoted for the structure to allow lifting and moving of pump assemblies. An exterior roll-up door was added with sufficient interior space beneath the bridge crane to allow loading of pump assemblies on truck or trailer beds.

A separate electrical room is required for the specialized electrical equipment and their specific cooling needs (the equipment is discussed in Section 4.5). The addition of the electrical room allows for the addition of a kitchen and a restroom with a minimal increase to costs. A storage mezzanine was added above the additional rooms to maximize efficient usage of the building footprint and to provide an operationally useful space.

A structural cost estimate was completed for elements of the project that are distinctly related to the structure. The opinion of probable cost was generated using a combination of data from comparable installations and quoted items (such as the bridge crane. Table 4.4.1 provides the opinion of probable costs for the structural component of the project.

Table 4.4.1. Opinion of Structural Costs

Structural					
Item	Description	Unit	Estimated Quantity	Unit Price	Amount
1	Mobilization	LS	1	$ 90,000.00	$ 90,000.00
2	Excavation	CY	328	$ 32.00	$ 10,500.00
3	Granular Base Course	CY	84	$ 35.00	$ 3,000.00
4	Concrete Foundation	CY	420	$ 500.00	$ 210,000.00
5	Metal Building	SF	2808	$ 62.00	$ 174,100.00
6	Metal Stud Wall Structure	SF	992	$ 15.00	$ 14,900.00
7	Roll-up Door	EA	1	$ 6,000.00	$ 6,000.00
8	Man Door (Interior)	EA	4	$ 800.00	$ 3,200.00
9	Man Door (Exterior)	EA	2	$ 2,500.00	$ 5,000.00
10	Window	EA	4	$ 1,000.00	$ 4,000.00
11	Storage Mezzanine	SF	775	$ 45.00	$ 34,900.00
12	OSHA Mezzanine Stairway	EA	1	$ 15,000.00	$ 15,000.00
13	Guardrailing	LF	81	$ 100.00	$ 8,100.00
14	Fixtures and Appliances	LS	1	$ 8,000.00	$ 8,000.00
15	Cabinetry	LF	15	$ 300.00	$ 4,400.00
16	Bridge Cranes	EA	1	$ 101,000.00	$ 101,000.00
Construction Subtotal:			$ 692,100.00		
Construction Contingency (25%):			$ 173,025.00		
Indirect Costs (Engineering, Construction Management, etc)			$ 164,373.75		
Total			**$ 1,029,498.75**		

4.5 Electrical

The conceptual electrical design and opinion of probable cost was performed by NEI Electric Power Engineering, Inc. (NEI) with collaboration from J-U-B Engineers (J-U-B) and RWPC Staff. The information herein is the best interpretation by J-U-B of the information provided by NEI.

To power the pump station, the conceptual electrical system consists of a low voltage (480V) motor control center (MCC) with an adjustable speed drive (ASD) to operate the pumps, the bridge crane, the air conditioning units, fans, and other devices. A transformer will be required on the building exterior to supply the 480V power for the MCCs.

The ASD in the pump MCC will start pumps individually to limit starting current and the resulting voltage drop on the power system (pumps are currently started “across the line” occasionally resulting in costly demand surcharges). During normal operation, when pumps reach full speed, a synchronous transfer control will close a by-pass contactor and remove the ASD from controlling the pump. The ASD will then control subsequent pumps, allowing all pumps to have a controlled “soft” start. The final pump that is brought on-line will remain under the control of the ASD, allowing for variable rates to be pumped by a single motor.

The conceptual design includes sophisticated instrumentation and controls (I&C) for the pump station. These include a distributive control system (DCS), Human-Machine Interface (HMI) Touch Screen, sensors, routers, and flow meters. The proposed control systems can automatically adjust the number of pumps that are online and the speed of a single pump to achieve a flow rate set by the operator. Continuous feedback from the flow and pressure meters on the discharge manifold will be used in user-defined algorithms to match the actual flow rate to the set flow rate. The I&C will have the option to use "local Mode" or "PLC Mode" to control the pumps at the MCC in the electrical room or from a remote computer terminal. The I&C provides equipment protection through process controls that monitor suction pressure, discharge pressure, flow rate, and valve positions. These process controls will notify operators or shut-down equipment to protect pumps and motors from severe damage.

Upgrade of the electrical systems will have multiple benefits, including:

- A modern facility that complies with National Electric Code (NEC) standards
- The ability to minimize power consumption and improve overall efficiency through an Adjustable Speed Drive (ASD).
- The ability to "soft-start" the electric motors, reducing electrical demand charge risks from the electric utility.
- SCADA enabled controls that allow for immediate remote control of pumping operations and eventual automation of pumping rates

Table 4.5.1 provides an Opinion of Probable Costs for the Electrical Components of the project. Note that the electrical cost estimate includes standard electrical costs for the building (receptacles, lighting, fire system).

Table 4.5.1. Opinion of Electrical Costs

Electrical					
Item	Description	Unit	Estimated Quantity	Unit Price	Amount
1	Mobilization	LS	1	$ 60,000.00	$ 60,000.00
2	Conduits	LF	670	$ 67.15	$ 45,000.00
3	Duct Bank	LF	240	$ 133.33	$ 32,000.00
4	Pull Box	EA	1	$ 3,201.00	$ 3,200.00
5	LowVoltage Motor Control Center	LS	1	$ 445,224.10	$ 445,200.00
7	Transformer	EA	1	$ 13,345.00	$ 13,300.00
8	LV Cable	LF	2560	$ 22.92	$ 58,700.00
10	Cable Tray - 24"	LF	100	$ 151.25	$ 15,100.00
11	Ground Loop - Grounding	LS	1	$ 21,500.00	$ 21,500.00
12	Interior Lighting	LS	1	$ 11,374.00	$ 11,400.00
13	Receptacles	EA	12	$ 652.00	$ 7,800.00
14	Exterior Lighting	LS	1	$ 8,000.00	$ 8,000.00
15	Fire System	EA	2	$ 17,750.00	$ 35,500.00
16	Instrumentation and Controls	LS	1	$ 53,681.00	$ 53,700.00
Construction Subtotal:			$ 810,400.00		
Construction Contingency (15%):			$ 121,560.00		
Indirect Costs (Engineering, Construction Management, etc)			$ 149,113.60		
Total			**$ 1,081,073.60**		

4.6 Additional Considerations

Appurtenant canal gate infrastructure replacement and HVAC are both included in the conceptual design. Both are identified as elements required for the Pump Station #1 Replacement and both have significant contribution to the overall project cost.

Grand Mesa Mechanical, Inc. (GMMI) assisted J-U-B Engineers in a budgetary and conceptual design at HVAC and mechanical costs for the structure. Preliminary heat loads for the electrical room were provided by NEI as part of their analysis and used for the conceptual design. GMMI has significant experience on similar pump station installations in the Grand Valley; however, a professional mechanical engineer will be needed for final design to verify all estimated heating and cooling loads.

The electrical room conceptual design requires a SCADA-enabled 15-ton single pack exterior wall mounted AC unit with supply and return ducts/grilles through the wall. The electrical room HVAC design includes an outside air economizer and 15 kW electric strip heating. Due to equipment cost and sensitivity, both high and low temperature alarms are included in the design.

Electric motors and split case pumps are capable of operating at significantly higher temperatures that the MCC in the electrical room. Accordingly, the conceptual design for cooling of the pump room is focused on ventilation without refrigerated air. Preliminarily the pump room will have three 11,000+ cfm roof-mounted exhausted fans ducted down from curbs to the pump room and terminated with expanded metal on plenums. Three 42” x 42” louvers with motorized dampers are planned above the storage mezzanine. Two 8.0 kW electric heaters are also planned.

Heating is anticipated for the breakroom and bathroom with a dual function mini split to provide cooling planned for the breakroom. This should allow for a comfortable space for employees year-round while not introducing excess moisture (as would be the case with an evaporative cooler) that could damage electrical equipment.

Table 4.6.1. provides the opinion of probable cost for the mechanical and HVAC components of the pump station. Material and labor cost estimates are courtesy of GMMI, while contingency and indirect costs were estimated by J-U-B.

Table 4.6.1. Opinion of HVAC/Mechanical Costs

Mechanical					
Item	Description	Unit	Estimated Quantity	Unit Price	Amount
1	Mobilization	LS	1	$ 4,000.00	$ 4,000.00
2	Electric Room	LS	1	$ 42,850.00	$ 42,850.00
3	Pump Room	LS	1	$ 38,350.00	$ 38,400.00
4	Other Occupied Areas	LS	1	$ 8,250.00	$ 8,300.00
Construction Subtotal:			$ 93,550.00		
Construction Contingency (25%):			$ 23,387.50		
Indirect Costs (Engineering, Construction Management, etc)			$ 20,000.00		
Total			**$ 136,937.50**		

Conceptual design includes replacement of the overshot and penstock gates due to their importance to system operation. Gate costs and the requisite electric actuator were quoted courtesy of Hydro Gate. Table 4.6.2 shows the opinion of probable cost for the appurtenant infrastructure.

Table 4.6.2. Opinion of Appurtenant Infrastructure Costs

Appurtenant Infrastructure					
Item	Description	Unit	Estimated Quantity	Unit Price	Amount
1	Mobilization	LS	1	$ 12,000.00	$ 12,000.00
2	Penstock Gate	EA	2	$ 69,057.00	$ 138,100.00
3	Portable Electric Actuator	LS	1	$ 6,357.00	$ 6,400.00
4	Bypass Chute Gate	LS	1	$ 100,000.00	$ 100,000.00
Construction Subtotal:			$ 256,500.00		
Construction Contingency (15%):			$ 38,475.00		
Indirect Costs (Engineering, Construction Management, etc)			$ 14,748.75		
Total			**$ 309,723.75**		

5.0 PROJECT PHASING

Project costs are anticipated to total approximately $4 million, as demonstrated in Section 4.0. This high cost may prove difficult for RWPC to fund as a single project. Project phasing provides a mechanism to complete the project in manageable increments. Phasing requires logical sequencing of discrete tasks that can be completed without adverse impact to operations or the completion of other phases. After significant discussion with the RWPC board and staff, the Pump Station #1 Replacement project has been divided into five phases. The proposed phases are as follows:

- *Phase 1: Pumpline Replacement*
    - Includes all pipe replacement on the pumpline from (and including) the Power Canal Overshot to the connection with the newer steel pipe at the upper end of the pumpline
    - Construction must be done outside of the irrigation season as pumping cannot occur during construction
    - Estimated Cost (2019): $406,000
- *Phase 2: Pump Station Structure Construction*
    - Includes all elements of the Structural Cost Estimate (Table 4.4.1) and electrical costs associated with general building electricity (Line items 11-14 of Table 4.5.1)
    - Construction can occur at any time, must occur prior to Phase 3 & 4
    - Estimated Cost (2019): $1,114,000
- *Phase 3: Intake Pipe Installation*
    - Includes 48” DR 32.5, a 48” Canal gate in the turbine forebay, turbine forebay coring and anticipated design and installation costs

- Construction must be done outside of the irrigation season as Power canal must be drained for construction
- Estimated Cost (2019): $142,000 + lost power revenue

- *Phase 4: Pump Station Equipment Purchase and Installation*
  - Includes all elements of the Pumping and Piping OPC (Table 4.3.1 – excluding the Intake Pipe costs), the HVAC for the structure (Table 4.6.1), electrical equipment excluding that used for general building electricity (Table 4.5.1 excluding line items 11-14)
  - Construction can occur at any time, however, must occur after Phase 2
  - Estimated Cost (2019): $2,065,000
- *Phase 5: Penstock and Turbine Bypass Gate Replacement*
  - Includes all elements presented in Table 4.6.2.
  - Construction must be done outside of the irrigation season as the Power Canal must be drained for construction
  - Estimated Cost (2019): $310,000 + lost power revenue

Phase information is summarized in Table 1.0.1 in the Executive Summary.

6.0 ANTICIPATED ENERGY SAVINGS

The improved and modernized equipment of the Pump Station #1 Replacement project will result in significant energy efficiency improvements. While relocation of the pump station will result in minor additional hydraulic head (energy) loss, improved efficiencies are expected to outweigh the energy loss and result in decreased overall energy consumption. Since the energy supplied to Pump Station #1 comes from the hydroelectric plant, a decrease in energy consumption by the Pump Station allows for more energy to be sold by RWPC. Alternatively, a decrease in energy consumption could enable RWPC to bypass water to the lower reach of the Gunnison River during times of low flow while maintaining current revenue from energy generation. Significant further study is required to quantify the potential water that could be bypassed, the effects on the RWPC system, and the legal ramifications and mechanisms for bypassing during times of low water. The remainder of this section assumes that efficiency improvements will be used to increase energy revenue for RWPC.

Power consumption by electric motors on pumps is a product of the flow rate and required pumping head (a combination of lift and friction losses), adjusted by the overall system efficiency. Overall system efficiency is a product of all inefficiencies from the power source to the energy imparted on the pumped fluid. Lower overall system efficiency requires that more power must be supplied to the system for the same output (flow rate and hydraulic lift). Since efficiencies in the current system are largely unknown an analysis of historic energy consumption versus historic pumping rates was conducted. Data for 2017 (considered by RWPC staff to be a typical water year) was provided to J-U-B and was used for analysis. The data used for the analysis includes:

- Monthly volumes of water diverted by RWPC according to the Colorado Department of Natural Resources (obtained on the Colorado Decision Support System Website)
- Daily flume readings from the First Lift Ditch, provided by RWPC
- Quantity of power (and resultant revenue) sold to the power utility, provided by RWPC

Monthly pumped volumes were calculated as the sum of RWPC flow readings in the First Lift Ditch and an assumed 2.5 cfs rate in the Stub Ditch (Stub Ditch water is also pumped from Pump Station #1 and shares the same starting point as the First Lift Ditch). The quantity of water used for power generation was assumed to equal the diverted volume minus the volume of pumped water and the volume of water deliveries prior to the pump station (assumed to be 10% of pumped volume). Historical power consumption for the pump station is assumed to be the difference of the amount of generated power and the quantity of power sold to the power utility. Since the total power generated during the irrigation season is not recorded, power generation was linearly extrapolated from months where pumping did not occur, based on the previously calculated quantity of water used for power generation. Table 6.0.1 provides estimated historical power generation and pumping power consumption for months entirely within the irrigation season.

Table 6.0.1. Estimated 2017 Power Generation and Pumping Power Consumption

	2017				
	May	June	July	August	September
Reported Power Sold (kW-Hr)	416,217	388,041	341,809	364,911	424,296
Estimated Power Generation (kW-Hr)	1,084,196	1,072,650	1,003,721	1,099,552	1,102,496
Estimated Pump Power Consumption (kW-Hr)	667,979	684,609	661,912	734,641	678,200
Average Pumping Rate (cfs)	43.6	45.1	47.1	48.1	46.2

Using assumed efficiencies and the system curve for the proposed pump station and manifold, power consumption can be determined for various flow rates. The proposed adjustable speed drive (ASD) allows for pumps to run at various speeds, eliminating the concern of over pumping (pumping more water than is required due to pump size constraints). This simplifies energy use analysis. The pump efficiency was obtained from the pump curve for the selected pump, while the motor efficiency is likely conservative based on available data. Electrical transmission efficiency, from hydropower generation to the pump motors, was estimated by NEI Electric Power Engineering. Table 6.0.2 provides assumed efficiencies for the energy savings analysis. Table 6.0.3 shows estimated power consumption requirements at rates consistent with the monthly average rates of 2017.

Table 6.0.2. Estimated Efficiencies for Proposed Pump Station #1

Assumed Efficiencies	
Pump	86%
Motor	95%
Electrical	95%

Table 6.0.3. Estimated Pumping Power Consumption of New Equipment at 2017 Avg. Rates

Rate (cfs)	43.6	45.1	47.1	48.1	46.2
Estimated Power Consumption (kW-Hr)	499,079	515,791	538,684	550,818	528,840

A comparison between estimated power consumption and historical power consumption at typical monthly rates gives an indication about the potential for more power revenue. Revenue and power consumption analysis assumes the following:

- RWPC will continue to sell all generated power for $0.31/kW-Hr
- Future pumping rates are consistent with those of 2017
- The efficiencies listed in Table 6.0.2 will remain constant with time

Figure 6.0.1 provides the results of the comparison between estimated power consumption of the proposed Pump Station #1 and historical power consumption from 2017. The figure illustrates the ability to generate more revenue if future pumping rates are consistent with 2017 operation. The comparison indicates that an average of $4,900 per month of additional revenue may be realized between the months of May and September. Note that because pumping does not occur for the full months of April and October, they were excluded from the analysis.

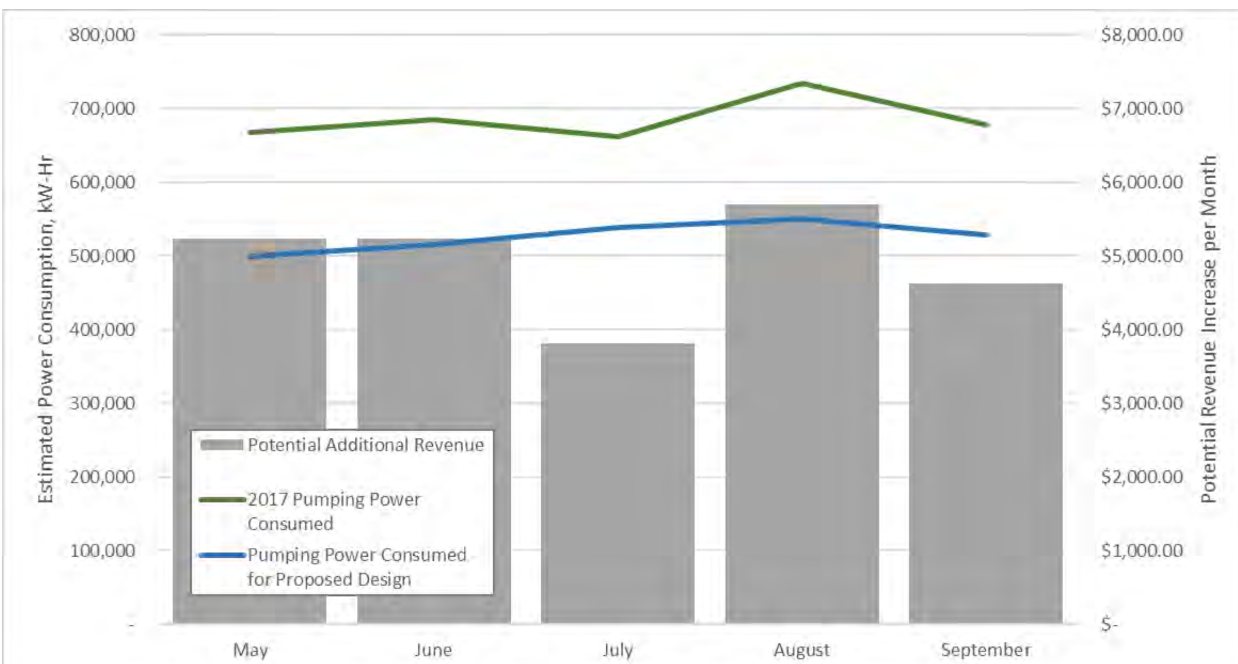


Figure 6.0.1. Potential Additional Revenue from Pump Station #1 Replacement

The Pump Station #1 Replacement project costs will likely require a strategic funding plan and may require RWPC to incur low-interest debt. Most agencies that provide low-interest loans require a loan feasibility study which include a financial plan that outlines how the loan will be repaid. While this report does not intend to suggest any potential repayment strategies (if loans are pursued), an increase of energy to sell provides a mechanism to assist in loan repayment. The analysis suggests annual increases in power revenues could be in excess of $24,000.

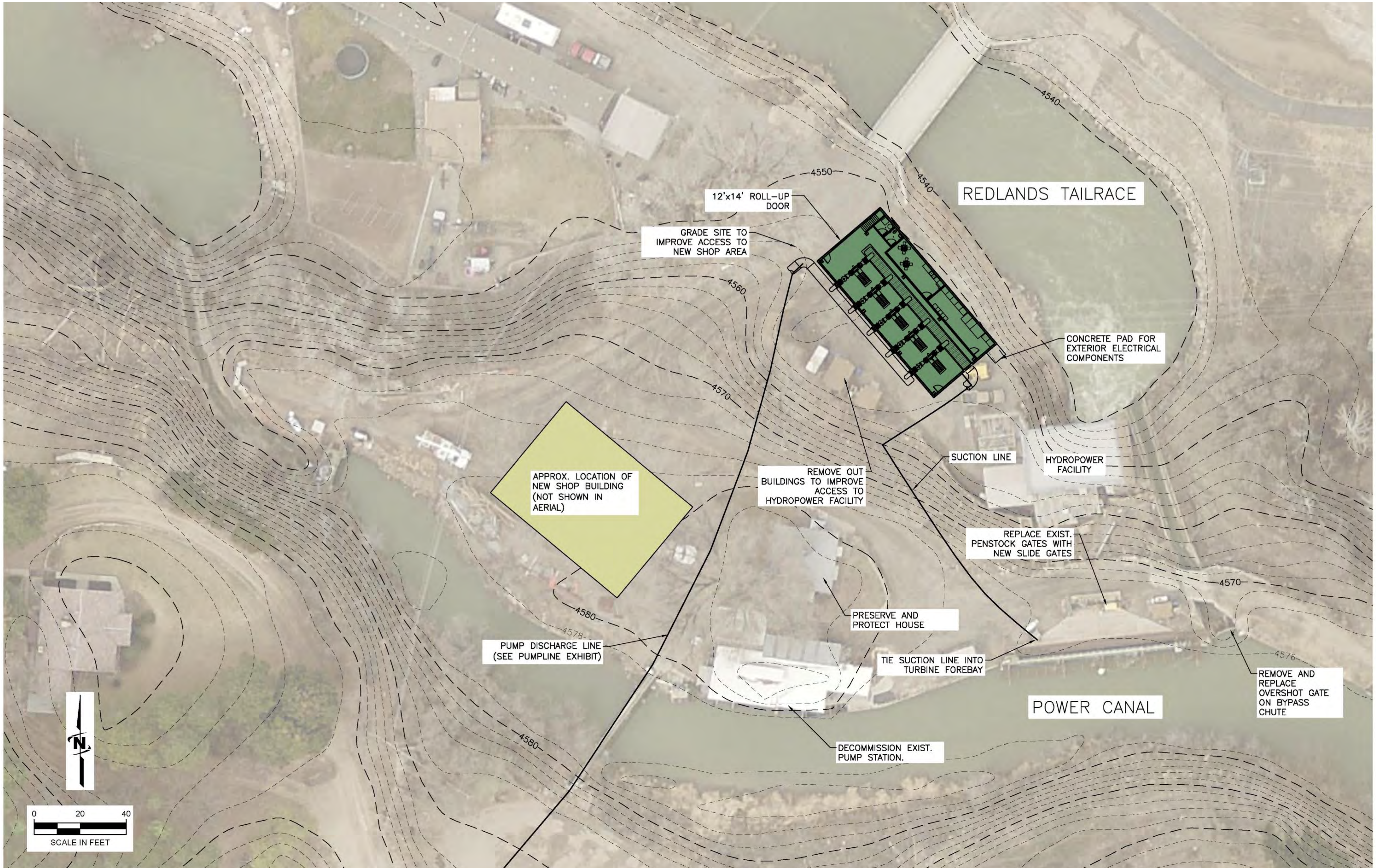
7.0 SUMMARY AND NEXT STEPS

The Pump Station #1 Replacement project feasibility study was a collaborative effort between J-U-B Engineers and Redlands Water and Power Company. Significant effort went in to analyzing various alternatives and determining which alternative was the ideal fit for RWPC. Ultimately, it was determined that the cost effectiveness and functionality of Alternative #2: a slab-on-grade structure adjacent to the Redlands Tailrace with water withdrawals from the Power Canal was the best option for RWPC. With a total project cost estimated at approximately $4,267,000, external funding will be required, likely through a combination of grants and low interest loans. Efficiency improvements will likely decrease the energy consumption used to pump water to the First Lift Ditch. This provides the opportunity to generate additional revenue or the opportunity to forego some diversion during times of low water while maintaining current levels of energy production and water delivery.

The cost estimates that have been provided were done so with the best available data to J-U-B Engineers at the time this report was written.

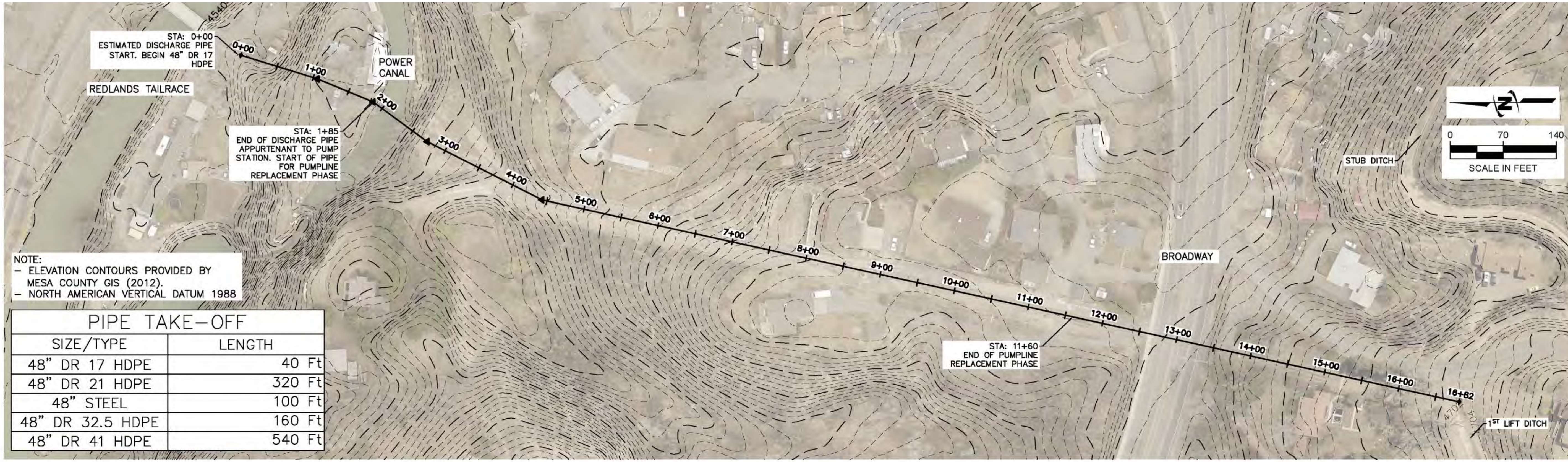
EXHIBIT 1 – EXISTING SITE LAYOUT

EXHIBIT 2 – PROPOSED SITE LAYOUT



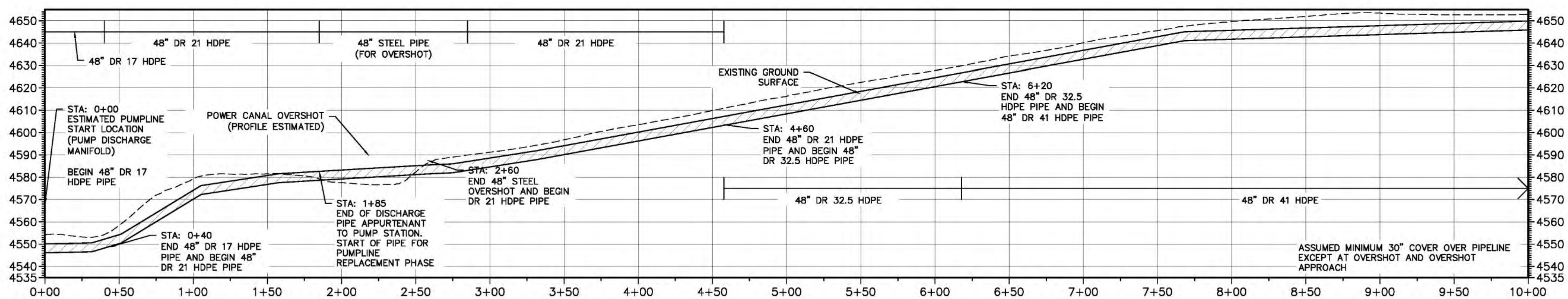
J·U·B ENGINEERS, INC.

EXHIBIT 3 – PROPOSED PUMPLINE PLAN AND PROFILE



PIPE TAKE-OFF

SIZE/TYPE	LENGTH
48" DR 17 HDPE	40 Ft
48" DR 21 HDPE	320 Ft
48" STEEL	100 Ft
48" DR 32.5 HDPE	160 Ft
48" DR 41 HDPE	540 Ft



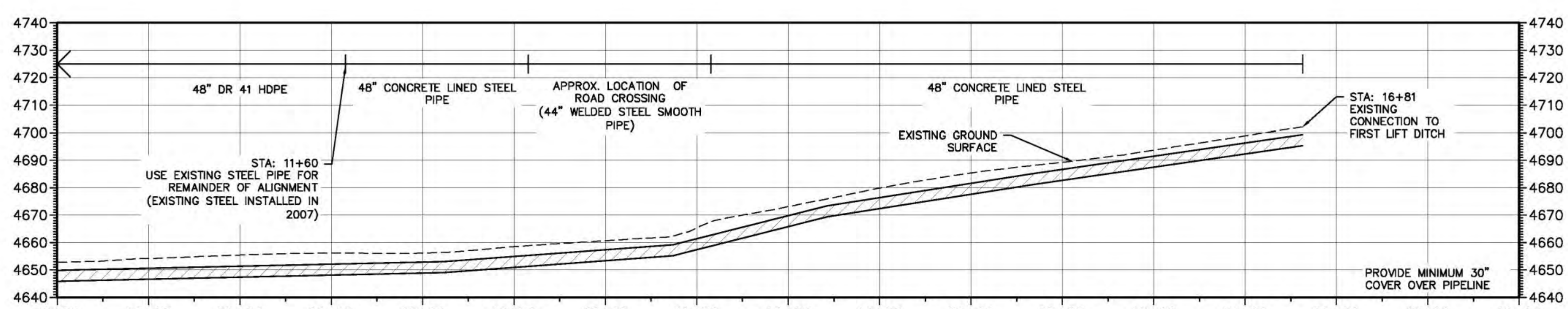
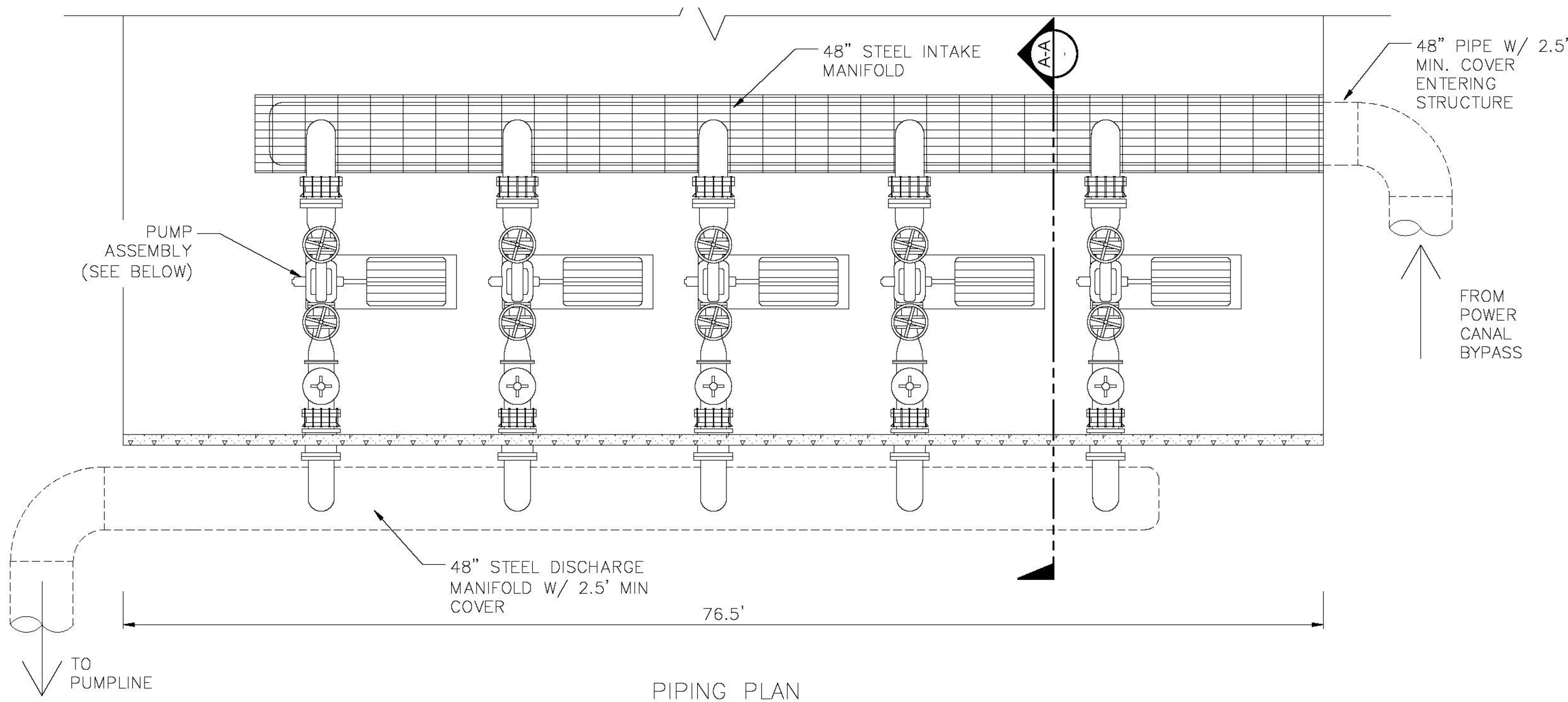
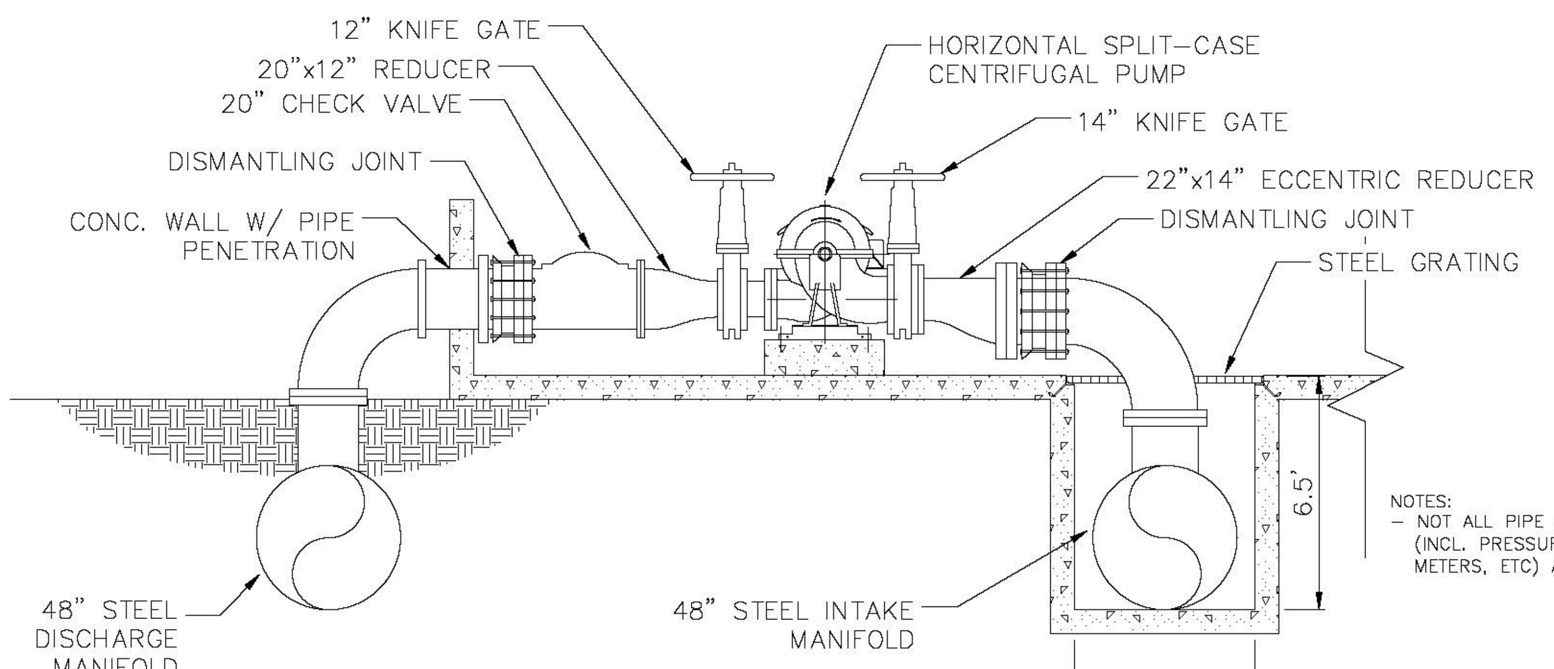


EXHIBIT 4 – PROPOSED PUMPING AND PIPING SCHEMATIC

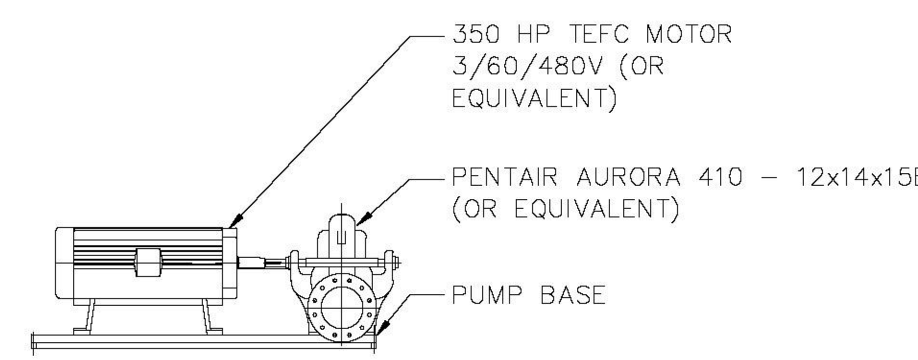


PIPING PLAN



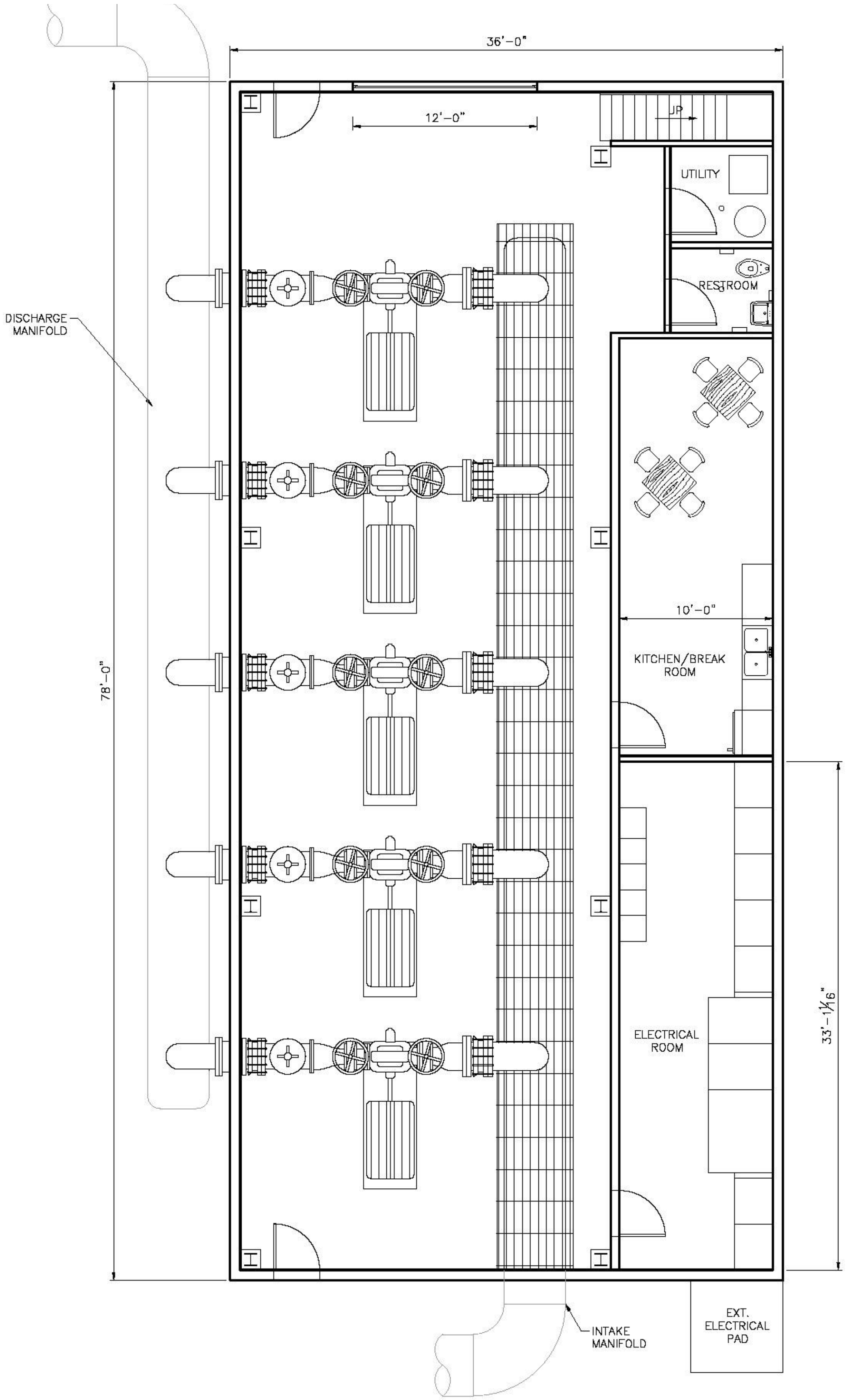
NOTES:
– NOT ALL PIPE APPURTENANCES (INCL. PRESSURE GAGES, FLOW METERS, ETC) ARE SHOWN

SEC. A–A

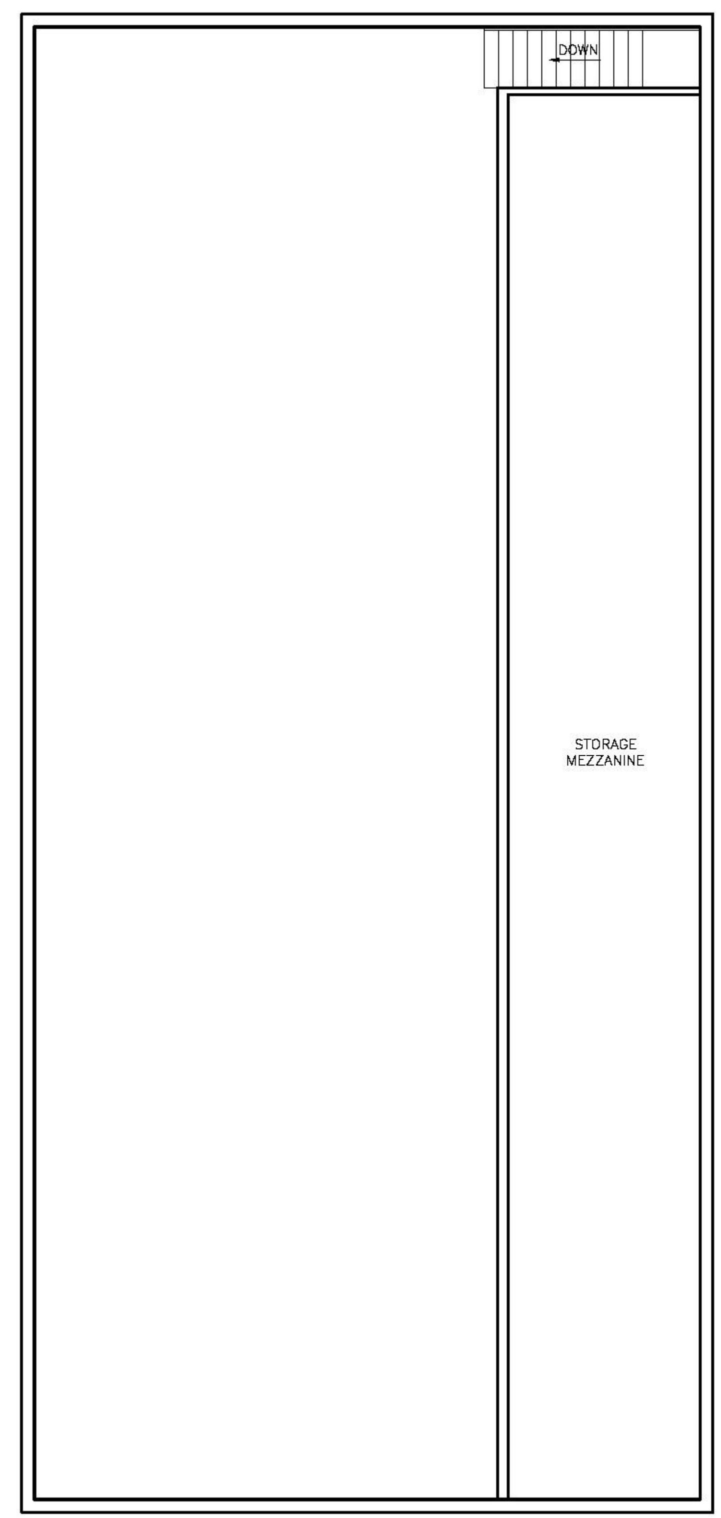


PUMP DETAIL

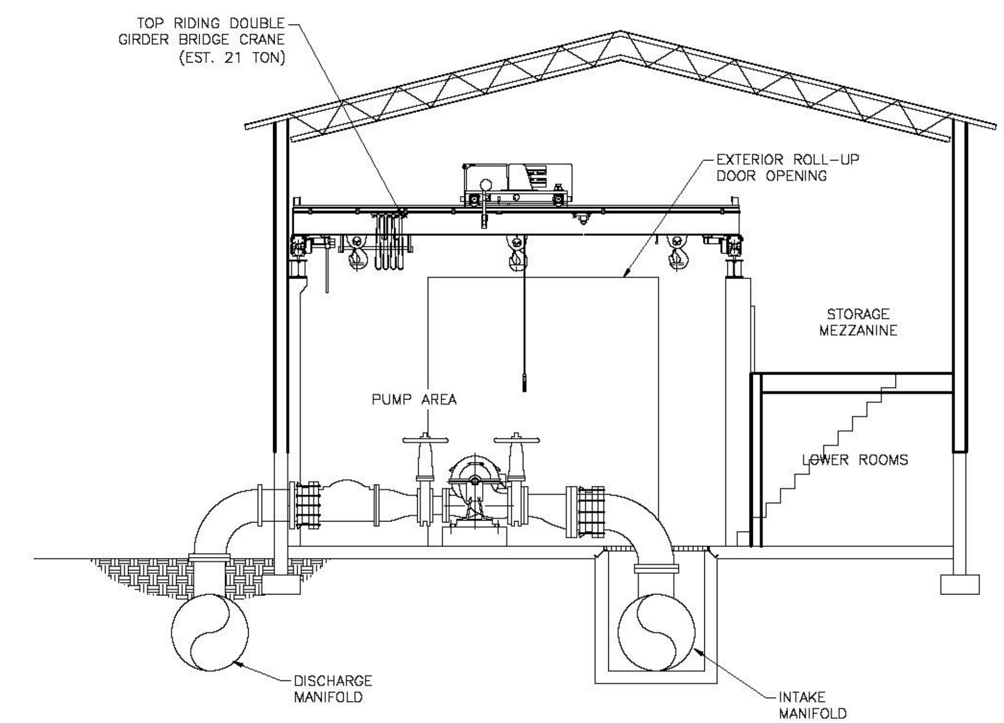
EXHIBIT 5 – PROPOSED PUMP STATION STRUCTURE



LOWER FLOOR – PLAN



UPPER FLOOR – PLAN



INTERIOR PROFILE

APPENDIX 1 Alternatives Memorandum 1

J-U-B ENGINEERS, INC.

J-U-B COMPANIES THE LANGDON GROUP GATEWAY MAPPING INC.

MEMORANDUM

DATE: 10/19/2018

TO: Redlands Water and Power Company

CC: Bret Guillory, PE; Nick Emmendorfer, PE

FROM: Luke D. Gingerich, PE

SUBJECT: RWPC Pumping Plant – Memo #1

The project to rehabilitate the RWPC Pump Station #1 was kicked off on August 14, 2018. Luke Gingerich and Bret Guillory of J-U-B Engineers met at the site with members of the RWPC advisory committee and operations and management staff. This is to be the first of three follow-up memoranda to establish a mutual understanding with the Redlands Water and Power Company on:

1.) RWPC Pump Station #1 system and RWPC needs and concerns
2.) Limitations and considerations of alternatives for pumping plant rehabilitation.

Ultimately, with these memoranda, we will explore three potential design alternatives for Pump Station #1 rehabilitation and provide sufficient information so that the RWPC and J-U-B can proceed with design of the chosen alternative.

Pump Station #1 - System Overview:

The Redlands Power Canal (Colorado WDID 4200541) is a trans basin diversion that diverts approximately 750 cfs of water from the Gunnison River and discharges most of that water into the Colorado River Basin. After diversion, the Redlands Power Canal traverses the Grand Valley South of the Colorado River and West of the Gunnison River to irrigate a number of fields and parcels near the valley floor.

Approximately 3.5 miles downstream of the diversion from the Gunnison River, the Company owns a hydroelectric power plant with an estimated drop of 34 ft (2012 Mesa County 2 ft contour data) which generates the electricity to power Pump Station #1. At Pump Station #1, approximately 60 cfs of water is pumped uphill 127.5 ft from the power plant to the 1st Lift Ditch and Stub Ditch. Water used in the turbine is discharged into the Redlands Tailrace, which ultimately flows to the Colorado River. Figure 1, below, illustrates the current system and Pump Station #1.

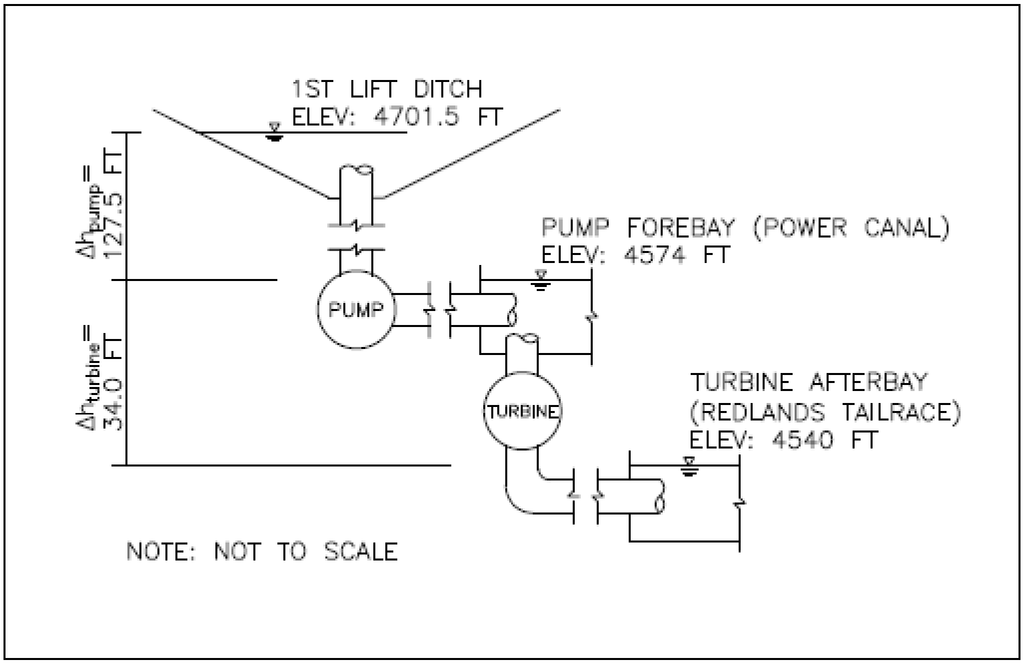


Figure 1. Pump Station #1 System Overview

Hydraulics of Current System:

Power generation from a turbine is dependent upon flow rate, available head across the turbine, and turbine efficiency. The current system set-up provides approximately 34 feet of head across the turbine and all but 60 cfs of the diverted flow (for this analysis it is assumed that 690 cfs of flow is run through the turbine).

Similar to power generation, pumping power requirements are also dependent upon desired flow rate, the total lift provided by the pump, and efficiency of the pump. The required lift in the current configuration is estimated at 127.5 feet with a pumping rate of 60 cfs. RWPC staff has indicated that the current pump is approximately 50% efficient, and it is the understanding of JUB Engineers that the ~ 100% of the power generated by the turbine during the irrigation season is used at Pump Station #1.

Using the above assumptions, the efficiency of the turbine can be estimated. Preliminary analysis indicates an efficiency of approximately 65% for the turbine/generator system. This efficiency is assumed constant for all alternative scenarios, as no alternatives propose an upgrade to the turbine/generator.

Description of Alternatives:

RWPC has proposed three alternatives for rehabilitation of Pump Station #1. While each alternative has multiple nuances, the alternatives can be summarized as:

Alternative #1: Remodel the existing pump station. Within the existing structure, this would likely be the least cost option.

Alternative #2: Construct a new pump station with pump intake remaining in (or near) the existing pump forebay. The exact location of the pump station could be at a location convenient to RWPC (described in more detail below).

Alternative #3: Construct a new pump station with intake moved to the turbine afterbay. Irrigation water to be passed through turbine, then pumped to the 1st Lift Ditch. This would require an additional 34 feet of pumping lift.

Hydraulics of Alternative #1 and Alternative #2:

From a broad hydraulics perspective, Alternative #1 and Alternative #2 behave similarly. Both alternatives propose the continued withdrawal of water from the Power Canal rather than the Redlands Tailrace. Additionally, both alternatives will continue to provide and require the same flow rates and elevation heads across the pump and turbines as the existing system. From a broad perspective, the only change from the current system would be an improved pump efficiency. Modern pump/motor systems properly sized for a system should be capable of 75%-80% efficiency (78% efficiency is used in this analysis). The increase in efficiency would result in a lesser power requirement for the pump, meaning that power could be sold during the irrigation season to help offset the power requirements of the other RWPC pumping facilities.

Location of Alternative #2 Pump Station: Construction of a new pump station in Alternative #2 could be located wherever it is convenient for RWPC so long as the intake is still within the Power Canal. By maintaining the intake location and keeping the intake flow in pressurized conduit, the station could be located adjacent to the Redlands Tailrace without the need for additional pumping head. Figure 2, below, demonstrates this concept.

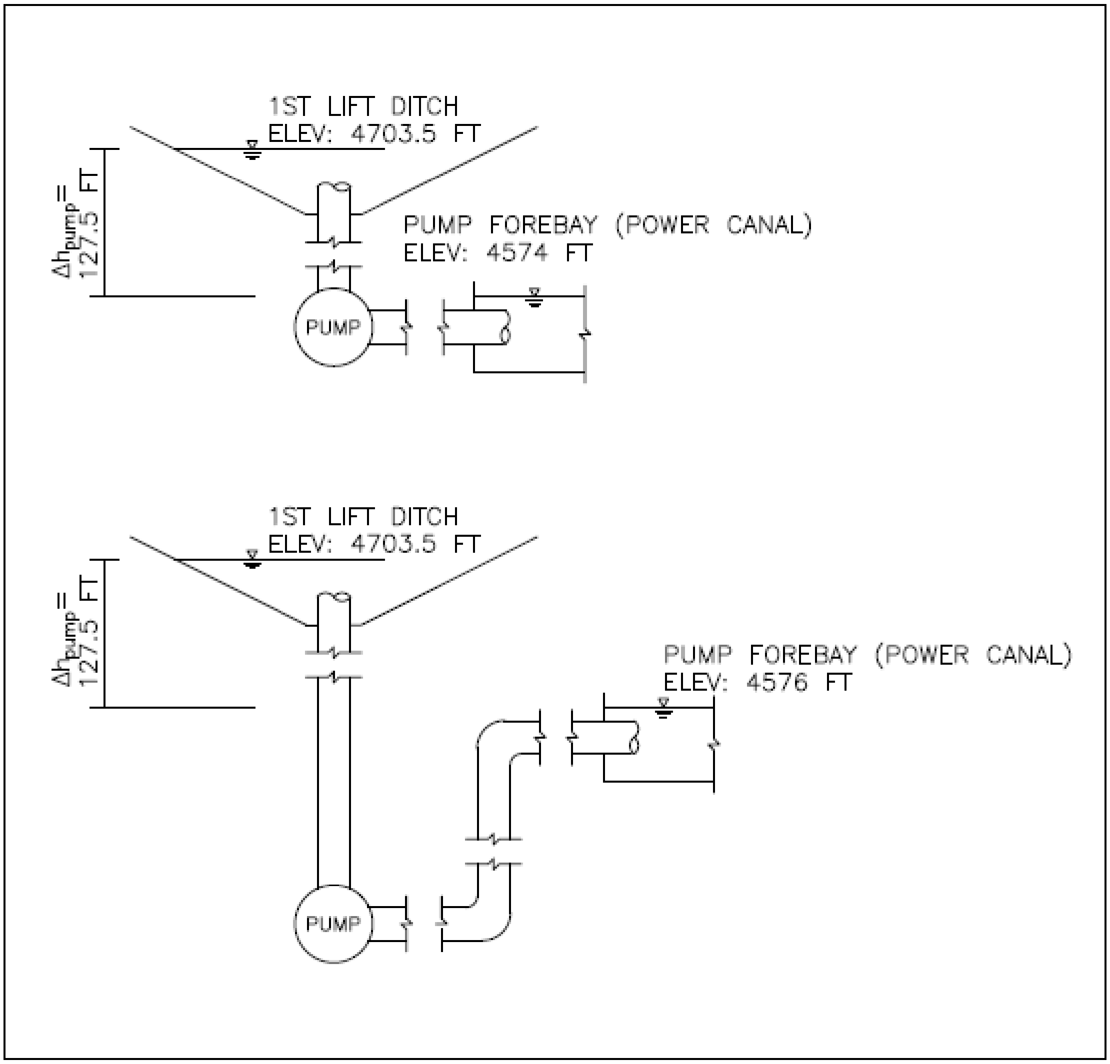


Figure 2. Demonstration of Ability to Relocate Pump Station #1 in Alternative #2

Hydraulics of Alternative #3:

By running all of the irrigation water through the turbine, Alternative #3 would have the potential to generate more power (it is assumed that efficiency would remain at 65% for this scenario). While more power would be generated, additional power would be required to lift the 60 cfs of irrigation water the extra 34 feet, since the pump intake would be located in the Redlands Tailrace. A pump for this scenario could presumably be sized to provide approximately 78% efficiency as well. Figure 3 demonstrates the additional pumping head requirement of Alternative #3

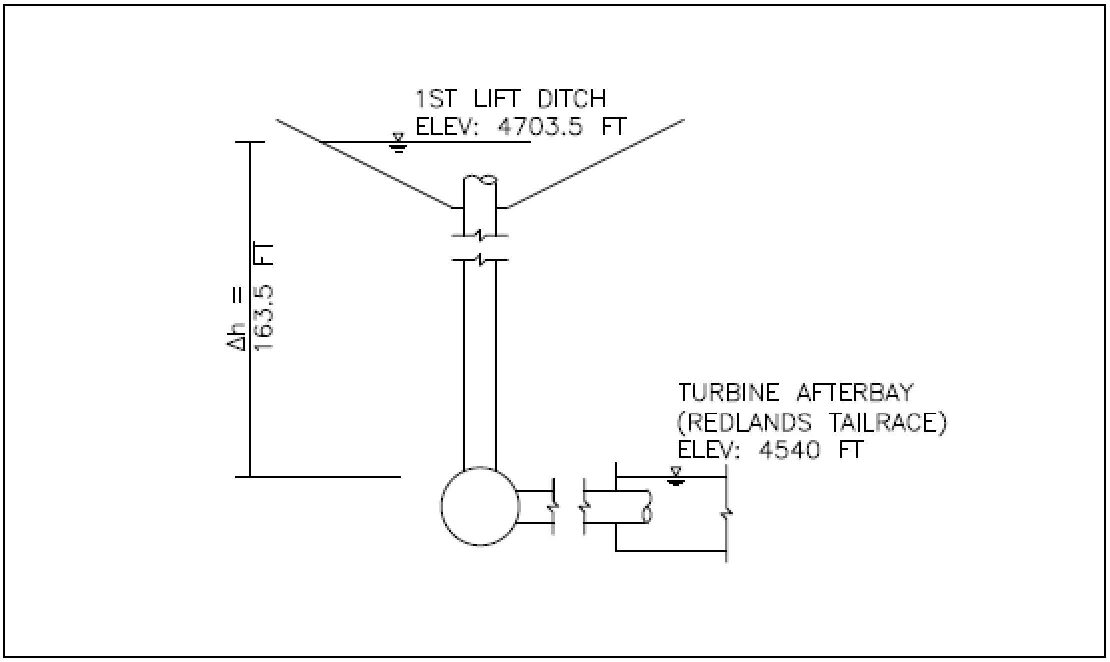


Figure 3. Pumping Head Requirement of Alternative #3

Hydraulic and Economic Comparison of Alternatives

Using the hydraulic information of the preceding sections, alternatives were compared based on net power requirements. For this analysis, net power requirement is the power needed to provide 60 cfs of irrigation water to the 1st Lift Ditch and Stub Ditch minus the potential power generation through the turbine/generator. Concordantly, a negative value implies more power generation potential than power consumption requirements by the pump(s). Table 1 provides the results of the comparison.

Table 1. New Power Requirement Comparison of Alternatives

		Current System	Alternative #1	Alternative #2	Alternative #3
Turbine	Est. Flow Through Turbine (cfs)	690	690	690	750
	Est. Head Across Turbine (ft)	34	34	34	34
	Turbine/Generator Assumed Efficiency	65%	65%	65%	65%
	Potential Power Generation (kW)	1295.6	1295.6	1295.6	1408.3
Pump	Est. Flow Through Pump (cfs)	60	60	60	60
	Required Lift (ft)	127.5	127.5	127.5	161.5
	Pump Assumed Efficiency	50%	78%	78%	78%
	Estimated Power Requirement (kW)	1295.6	830.5	830.5	1052.0
Est. Net Power Requirement (kW)		**0.0**	**-465.1**	**-465.1**	**-356.3**

As illustrated by Table 1, Alternative #1 and Alternative #2 will provide more excess power than Alternative #3. If steady flow to the power plant is assumed for the duration of the irrigation season (April 15 through October 15) potential total power and thereby revenue can be extrapolated from the analysis. Table 2 provides estimated potential revenue from the alternatives assuming the ability to sell power for $0.04/kWH.

Table 2. Estimated Potential Revenue from Alternatives

	Est. Avg. Power Available (kW)	Est. Total Power Available During Irrigation Season (kWH)	Est. Potential Additional Revenue ($)
Alternative #1	465.1	2,000,000	$ 80,000.00
Alternative #2	465.1	2,000,000	$ 80,000.00
Alternative #3	356.3	1,600,000	$ 64,000.00

In addition to potential power revenues from the proposed alternatives, cost of construction/implementation should also be considered. Continued withdrawal of irrigation water from the Power Canal allows for continued use of centrifugal pumps in both Alternative #1 and Alternative #2. Withdrawal of irrigation water from the Redlands Tailrace (see Alternative #3) may require vertical turbine pumps to pull the water from below grade, or require a significant construction/excavation effort to continue use of centrifugal pumps. For this reason, Alternative #3 likely has more expensive construction and implementation costs.

Conclusions and Next Steps

When looking at power generation, Alternative #1 and Alternative #2 offer the greatest potential benefit to RWPC. Project cost would likely also be less with Alternatives #1 and #2 with Alternative #1 having the least cost. Table 3 provides a summary of the principal differences between the alternatives, as well as the anticipated economic differences between the projects.

Table 3. Economic Summary of Proposed Alternatives

	Alternative #1	Alternative #2	Alternative #3
Pump Intake	Power Canal	Power Canal	Redlands Tailrace
Pump Location	Existing Location	RWPC Choice	Near Tailrace
Anticipated Relative Cost	Lowest	Middle	Highest
Potential Additional Revenue	$ 80,000.00	$ 80,000.00	$ 64,000.00

While Alternative #3 appears to be the least economically favorable, RWPC may have specific needs or concerns that make Alternative #3 a preference. These concerns likely merit further investigation before choosing a preferred alternative. In addition to any concerns voiced by RWPC, other issues that deserve further analysis are:

- Environmental benefits/drawbacks of alternatives
- Effects of potential water curtailment on alternatives, weighed against likelihood of water curtailment (based on climate forecasts, and historic records)
- Impacts of construction on supplying interim irrigation water
- Safety concerns of Pump Station #1 locations

J-U-B Engineers eagerly awaits further discussion on the three alternatives. Multiple assumptions were made in the presented analysis, and we believe that results and conclusions could be refined through the application of more accurate data. Receipt of information on the following could help to refine our analysis:

- Records about flow through the power plant versus power generation
- Records on power consumption by Pump Station #1
- Records on irrigation water supplied to the 1st Lift Ditch
- Information about the RWPC agreement for selling power to Xcel Energy

Through a collaborative effort, we believe we RWPC and J-U-B can iterate to a preferred alternative. Please feel free to call or email me with any questions or concerns that you may have.

Sincerely,

Luke D. Gingerich, PE

APPENDIX 2 Alternatives Memorandum 2

J-U-B ENGINEERS, INC.

J-U-B COMPANIES THE LANGDON GROUP GATEWAY MAPPING INC.

MEMORANDUM

DATE: 1/07/2019

TO: Redlands Water and Power Company

CC: Bret Guillory, PE; Nick Emmendorfer, PE

FROM: Luke D. Gingerich, PE

SUBJECT: RWPC Pumping Plant – Memo #2

We have recently received your feedback regarding “RWPC Pumping Plant – Memo #1” in which you provided clarification on some of the issues facing the Redlands Water and Power Company (RWPC). In Memo #1 three potential alternatives were identified and reviewed for engineering feasibility; they can be summarized as:

Alternative #1: Remodel the existing pump station
Alternative #2: Construct a new pump station with the intake to remain in the Power Canal
Alternative #3: Construct a new pump station with the intake moved to the Redlands Tailrace (turbine afterbay)

Memo #1 focused on an economic evaluation of the proposed systems under “Normal Operating Conditions”. There was assumed to be no curtailment of any RWPC water rights. With the 2018 water year in the rearview mirror, it is clear that “Normal Operating Conditions” are not guaranteed.

This memorandum will focus on the effects of the flow in the Gunnison River on Pump Station #1 operations. The memo will examine RWPC Water Rights, Environmental Considerations, and Turbine Operations under less-than-ideal conditions. Ultimately, the analysis will point to Alternative #3 being preferential, despite its economic disadvantages under normal operating conditions.

Overview of Water Rights:

The Redlands Power Canal possesses three water rights of varying priority and decreed use. These rights are summarized in Table 1, below.

Table 1. RWPC Water Rights Summary

WATER RIGHTS SUMMARY					
ADMINISTRATION NUMBER	DECREED AMOUNT (CFS)	APPROPRIATION DATE	ADJUDICATION DATE	ADJ. TYPE	COMMENTS
22283.20300	670.0	1905-07-31	1912-07-22	Absolute	60 cfs decreed to irrigation, 610 cfs decreed for commercial use
34419.33414	80.0	1941-06-26	1959-21-7	Absolute	Decreed for Irrigation, Commercial, Domestic, and Stock
52869.00000	100.0	1994-10-1	1994-12-31	Absolute	Decreed for Power Generation
TOTAL WATER DECREE (CFS):	850.0				

The relatively late appropriation date of the RWPC Junior Right for 100 cfs suggests that in most years it is only available during spring runoff. The two more senior rights, however, are rarely curtailed. According to data on the “Colorado Decision Support System” (CDSS) provided by the Colorado Department of Water Resources, the 80 cfs decreed right has been out of priority only 1.22 percent of the time since the year 2000. All instances being in 2002.

Geographically, the Redlands Power Canal is the last major diversion on the Gunnison River (there are 4 downstream points of diversion, though they are largely junior and insignificant in scale). Additionally, the Colorado River west of the confluence with the Gunnison has no diversions before the state line. This puts the Power Canal in a unique position to set the call on the Gunnison with their more senior rights.

The Bureau of Reclamation’s Aspinall Unit (which includes a number of reservoirs in the Upper Gunnison Basin) is often able to satisfy the water needs of upstream uses while leaving enough in-stream flow at the Redlands Diversion Dam to allow 750 cfs of diversion at most times. Strategic releases from the Aspinall Unit allow the RWPC to divert without often setting the call.

Redlands Diversion Dam Environmental Considerations:

Environmental flows downstream of the Redlands Diversion Dam are typically set at 300 cfs for the duration of the irrigation season. This flow is maintained by either natural stream flow (if available) or through environmental releases from the Aspinall Unit. During many years, RWPC is able to divert between 850 to 750 cfs while maintaining the 300 cfs environmental flow downstream of the diversion.

The distance between the Redlands Diversion Dam and the Aspinall Unit coupled with diurnal flow fluctuations on the Gunnison River occasionally result in periods in which the flow below the Redlands Diversion Dam drops below 300 cfs. Recent negotiations with the Federal Energy Regulatory Commission (155 FERC ¶ 62,054) allow for flows to vary within 5% of the negotiated 750 to 300 cfs split at the diversion dam to allow RWPC to maintain a continuous 750 cfs flow while not damaging fish and wildlife resources. This allowable fluctuation allows the RWPC to optimally operate their system most years.

During very dry years, as was the case in WY2018, the Bureau of Reclamation has the authority to decrease Aspinall Unit releases such that flows downstream of the Redlands Diversion are only 140 cfs as described in their "Record of Decision for the Aspinall Unit Operations Final Environmental Impact Statement"(2012). This allows for the continued operation of the Fish Ladder (40 cfs) and the Fish Screen (100 cfs) at their normal operating points. As non-consumptive uses, operation of the Fish Ladder and Fish Screen result in downstream flows.

During WY2018 (with a 140 cfs flow requirement downstream of the Redlands Diversion Dam), there were numerous occasions in which RWPC needed to borrow 20-30 cfs from the fish ladder and fish screen to maintain 750 cfs in the Power Canal. It is not clear if the agreement from "155 FERC ¶ 62,054" allows for 5% variance of flow rate during the dry year scenario of reduced environmental target flow. This potential likely merits exploration as it could pose operational issues to RWPC in the future. Regardless of if it applies, however, any variance from 140 cfs should be avoided if possible during dry years for the benefit of the endangered fish.

Turbine Operations During Low Flow Conditions:

Previous conversations with RWPC have implied that operations of the turbine suffer at flows below 750 cfs in the Power Canal. At flows below 750 cfs, there begins to be insufficient head in the power canal to efficiently operate the turbine. Occurrence of this condition requires one of the following operational adjustments:

1) Pump less than 65 cfs to the first lift ditch
2) Purchase power at premium rates from Xcel Energy to continue to operate the pumps at 65 cfs.

Neither option is suitable to the RWPC. Mitigating this risk is of high priority to the board and can be achieved through Alternative #3. Alternative #3, which pumps water from the Redlands Tailrace, would allow all water to pass through the turbine, increasing power production and decreasing the pre-turbine drawdown caused by the current configuration of the pump in the Power Canal.

Benefits to Alternative #3:

As described above, the primary benefits of Alternative 3 are:
1) Mitigation of potential operational issues
2) Minimization of disruption to Environmental Flows below Redlands Diversion Dam

In addition to the principal benefits listed above, ongoing conversations with RWPC have brought to light additional operational benefits. Some of these benefits are as follows:

- Double utilization of trash rake on the turbine penstock. This could reduce the cost of construction of the new pump station, as well as operational costs.
- Access to "sediment free" water in the Redlands Tailrace. Currently RWPC struggles with large amounts of sediment in the Redlands Power Canal downstream of the power plant intakes.
- Operationally superior pump station location.
- Increased turbine efficiency due to more head at intake

Conclusions:

Memo #1 outlined the economic impacts resulting from the three pump station alternatives. While Alternatives #1 and #2 were economically superior during "Normal Operating Conditions", they may not be ideal for RWPC. Other considerations at this time appear to outweigh the economic considerations.

The RWPC believe that there is a high likelihood of increasing frequency of dry years in the Colorado River Basin and its tributaries. A system that remains functional and maintains downstream environmental flows in dry years will be critical. In many respects, Alternative #3 is preferred in dry years.

While there is no direct comparison between the economic benefit from Alternatives #1 and #2 to the environmental benefits of Alternative #3, ongoing conversations with RWPC indicate that #3 is preferred by the Board of Directors, for the reasons outlined in this memo.

Memo #3 will take a final, more in-depth look at the economic and operational feasibility of Alternative #3. It will seek to ensure that the desired benefits of Alternative #3 do not result in unintended economic or operational consequences.

APPENDIX 3 Alternatives Memorandum 3

MEMORANDUM

DATE: 2/11/2019

TO: Redlands Water and Power Company

CC: Bret Guillory, P.E.; Nick Emmendorfer, P.E.

FROM: Luke D. Gingerich, P.E.

SUBJECT: RWPC Pumping Plant – Memo #3

Upon discussion with the RWPC Board, it has become clear that “Alternative 3”, construction of a new pump station with the intake located in the Redlands Tailrace, is the alternative preferred by the Board. The reasons for its favorability, particularly the water security provided by pumping from the Tailrace, are outlined in Memo #2.

Recent conversations, however, have indicated the need for future rehabilitation of the turbine and its appurtenant infrastructure. If the turbine were offline, the spill adjacent to the turbine likely does not have the capacity to convey the full irrigation right, thus any irrigation water would need to come directly from the Power Canal. Instances like this (there may be other unforeseen occasions in which pulling out of the Power Canal may be necessary) highlight the need for the ability to pump irrigation water out of the Power Canal as well as the Tailrace.

This memo will propose a final option, “Alternative #4” that will allow for maximum flexibility of the pumping plant infrastructure to allow for RWPC to supply irrigation water to the First Lift Ditch from both the power canal and the tailrace.

Alternative #4

The previous two memoranda have outlined the advantages and drawbacks of the original 3 alternatives. Memo #1 outlined the potential economic advantages of pumping directly from the Power Canal, whereas Memo #2 discussed the long term security attained from pumping from the Tailrace instead of the Power Canal. Our proposal is to design a pumping plant that allows for pumping from both sources, so the system can be optimally operated under multiple conditions or water supply availability.

Alternative #4 will consist of a pumping plant adjacent to the Redlands tailrace, in a more operationally convenient location than the existing facility. It will have a sunken concrete pump vault to provide submerged pump intake from the tailrace. The pump vault will contain a manifold supplied by intake pipes from both the Power Canal and the Redlands Tailrace. Figure 1, below, illustrates the location and intakes of the pumping plant as described above.

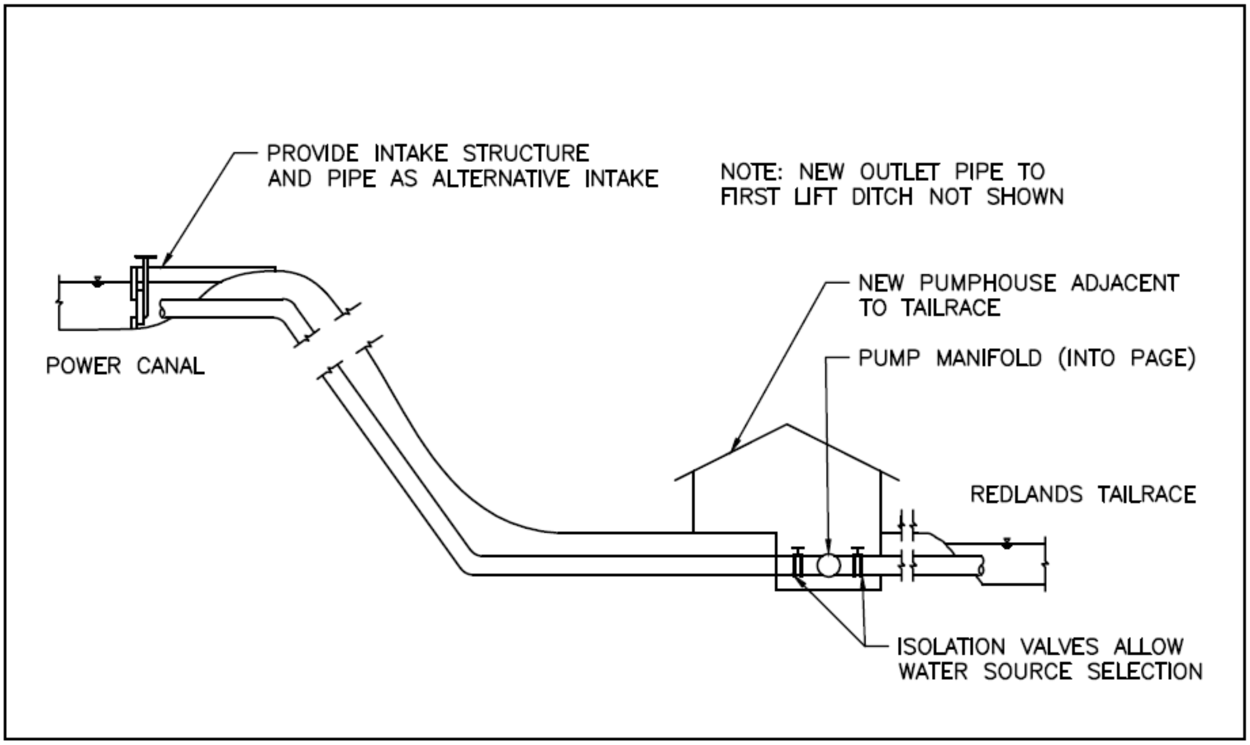


Figure 1. Alternative #4 Pumping Plant Schematic

As shown in Figure 1, Alternative #4 will have isolation valves to select the water source (either power canal or tailrace) from which to supply the pump manifold. The pump manifold will consist of three pumps. To provide 100% redundancy while maximizing efficiency, the pump configuration would be as follows:

- Pump 1 – Sized to pump 60 cfs from **Tailrace** intake to 1st Lift Ditch at high efficiency
- Pump 2 - Sized to pump 60 cfs from **Power Canal** intake to 1st Lift Ditch at high efficiency
- Pump 3 – Utilizing a VFD, will be capable of pumping 60 cfs from either source to 1st Lift Ditch and adjusting frequency to meet maximum demand of lift ditch #1 from either source.

Figure 2, below, illustrates the pump manifold configuration for Alternative #4. Map 1, attached to the memo, provides a summary of appurtenant infrastructure requirements for Alternative #4.

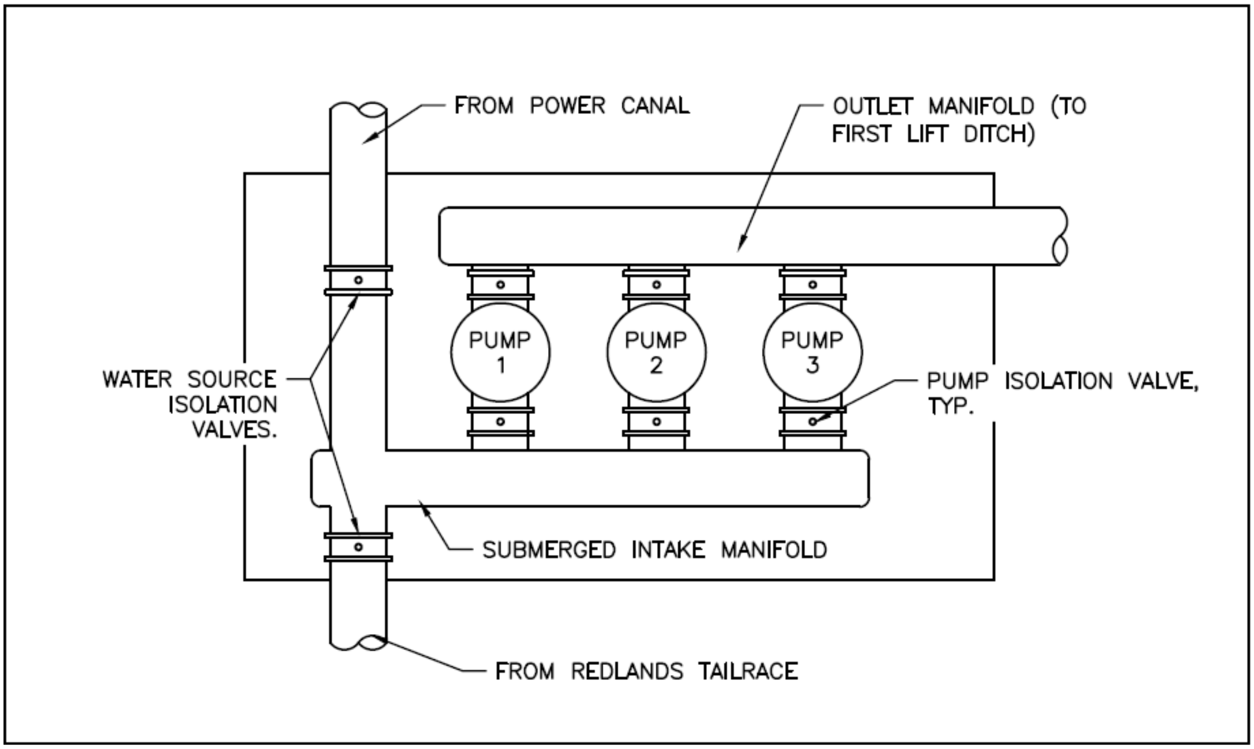


Figure 2. Alternative #4 Pump Manifold Configuration

Summary of Benefits – Alternative #4:

We believe that Alternative #4 provides numerous benefits that make it the ideal conceptual plan. Some of the benefits are as follows:

- Economics: Ability to optimize efficiency of pumping (and thereby power revenues) depending on operational scenario
- Security: Ability to draw water from Tailrace during periods of low water availability
- Environmental Sustainability: Operations during periods of low water availability will allow system flexibility so that fish ladder and fish screen operations are maintained.
- Operational flexibility & Convenience: New location will provide additional space to make operations and maintenance of pumping plant more feasible for operations staff as well as provide flexibility to choose the water source for pumping based on numerous factors.

The multiple benefits associated with alternative 4 make it a preferable alternative to the other 3 alternatives analyzed. The increased operational capacity and ability to pump water from either the power canal or tailrace provide economic benefit, security, environmental benefit, and operational flexibility. In addition the increased efficiency of the pumped system will allow RWPC to re-coup the cost of re-habilitation sooner.

Next Steps

Upon receipt of this memo we recommend a follow-up meeting to ensure that our proposed conceptual design is acceptable to the RWPC board and operations staff. Once the conceptual design is accepted we will begin a more detailed conceptual plan and cost estimate. We hope this will continue to be a collaborative process with RWPC as operators and staff have specific insight that will likely lead to better design.

Completion of our series of memoranda have highlighted many of the intricacies associated with a project to replace the pump station and many of the opportunities for improved efficiency and operation. Design will require a thorough, iterative process to create the most efficient and effective system possible. We previously suggested a design-build process for this project, however, knowing what we do now, we feel that the nature of this project is best suited for a design-bid-build process.

We look forward to meeting with the Board to discuss the alternatives that we have outlined in these memoranda and to discuss our proposed change in strategy for project design and implementation. Please feel free to contact us with any questions you may have.

Thank you,

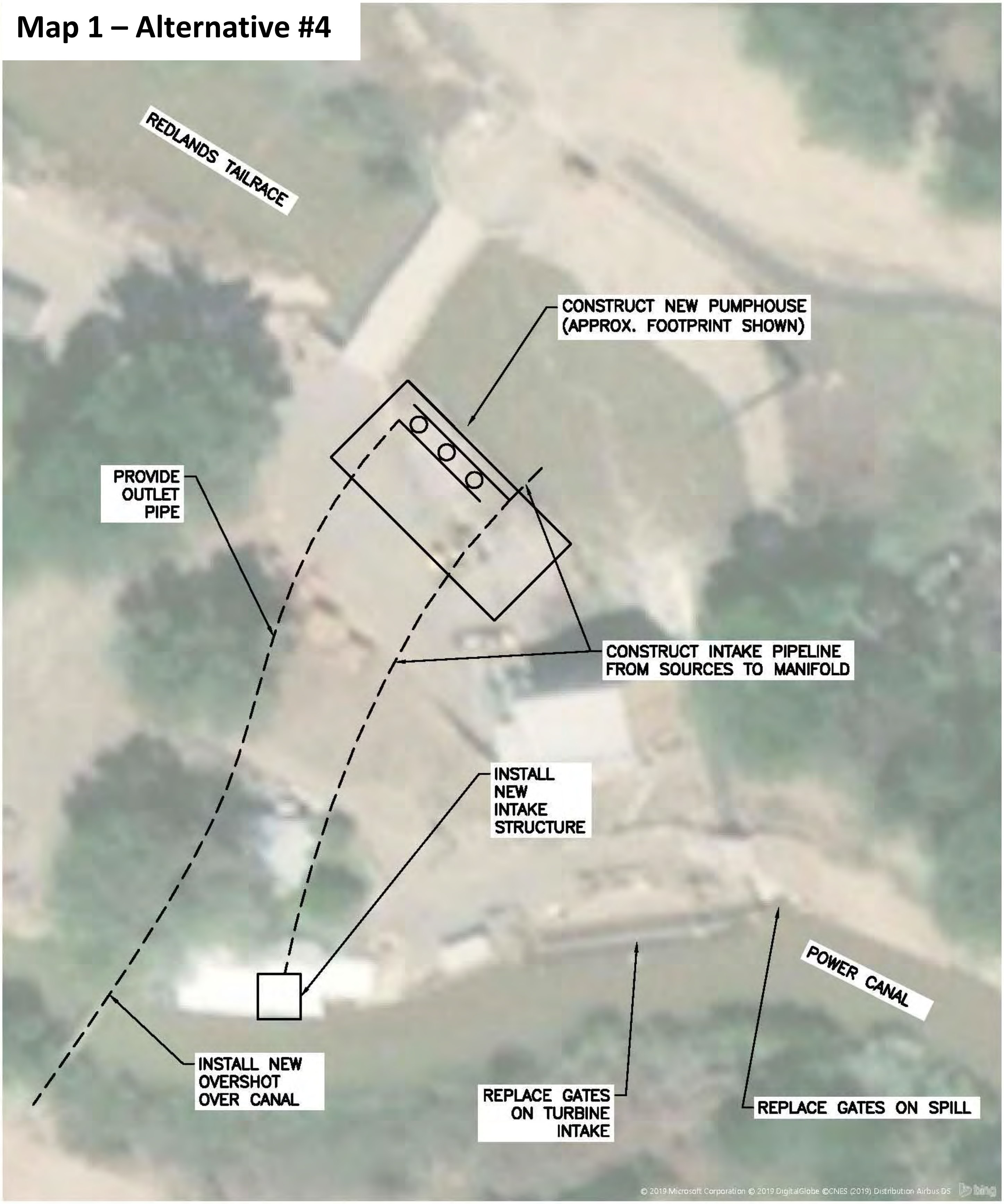
Luke Gingerich

Attached: Map 1

J-U-B ENGINEERS, INC.

J-U-B COMPANIES | THE LANGDON GROUP | GATEWAY MAPPING INC.

Map 1 – Alternative #4



APPENDIX 4 Overview of Alternative #4 Conceptual Design

APPENDIX 4 – OVERVIEW OF ALTERNATIVE #4 CONCEPTUAL DESIGN

Alternative #4 was initially chosen as the preferred design by Redlands Water and Power. After significant design and a thorough investigation into costs, it was deemed to not be cost effective. Alternative #2 (presented in Memorandum 1) was chosen as the eventual design and was presented in the body of the report. Alternative #4 was estimated to cost in excess of $5,245,000. Some of the larger infrastructure differences of Alternative #4 compared to the chosen design were:

- Large below grade pump area requires significantly more concrete and excavation. Structural costs were estimated at $1,900,000
- Larger pumps with larger motors (450 HP) were required. The pump and motor combined quote was $477,700
- The larger motors required a separate medium voltage MCC (a low voltage MCC could be utilized but cable costs for low voltage/high power were excessive). The electrical estimate was $100,000 more than the estimate presented for the chosen alternative

As with the structure for Alternative #2, the structure for Alternative #4 was derived from site conditions, RWPC needs, and operational requirements. A collaborative process was utilized in the design. Figures A4.1 and A4.2, below provide plan and profile views of the proposed structure from Alternative #4, respectively.

Should Alternative #4 be reconsidered as the chosen alternative, it is recommended that new cost estimates be generated. The design requires significant concrete and steel, both of which are commodity products that can vary significantly with time.

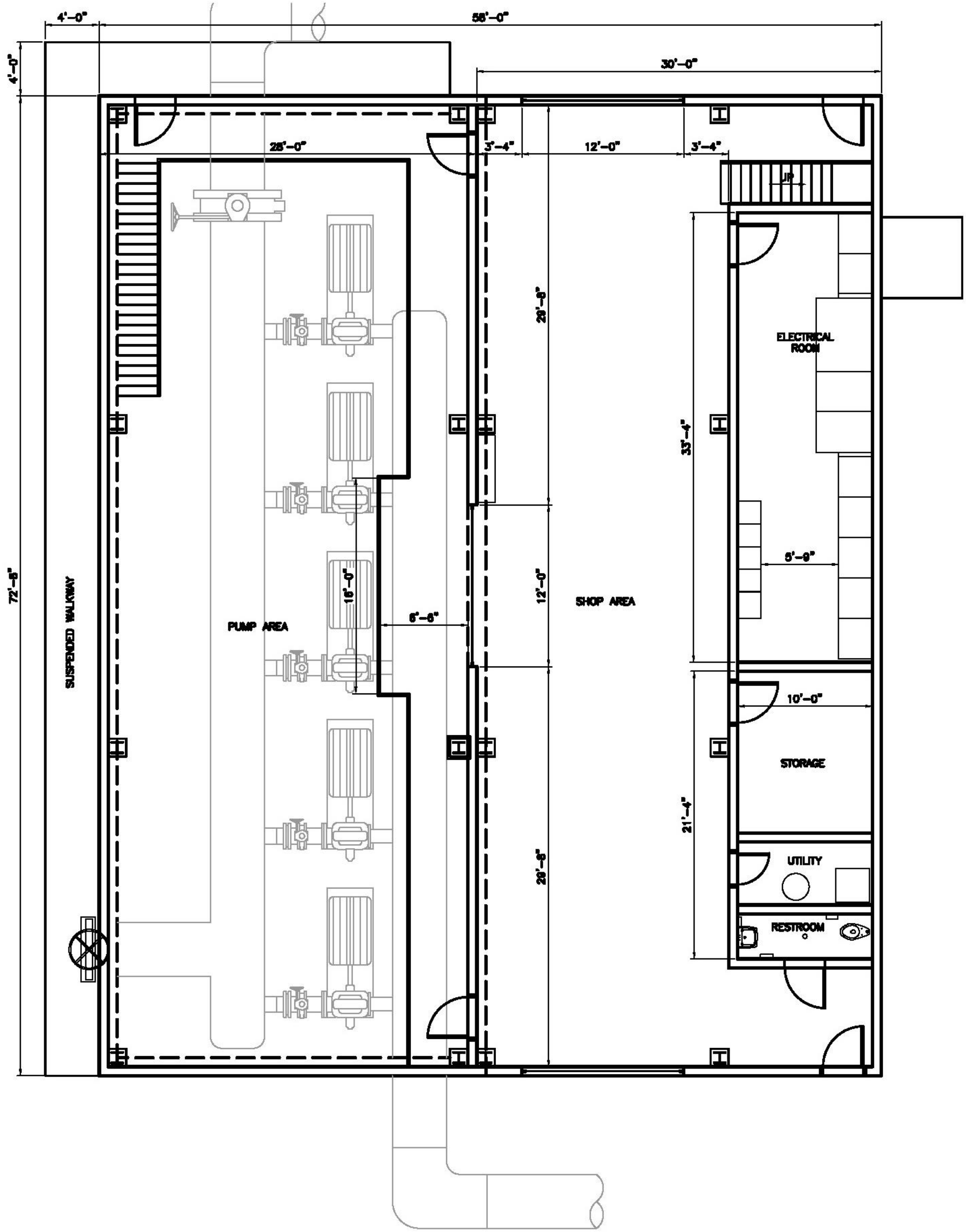


Figure A.4.1. Plan View of Alternative #4 Structure

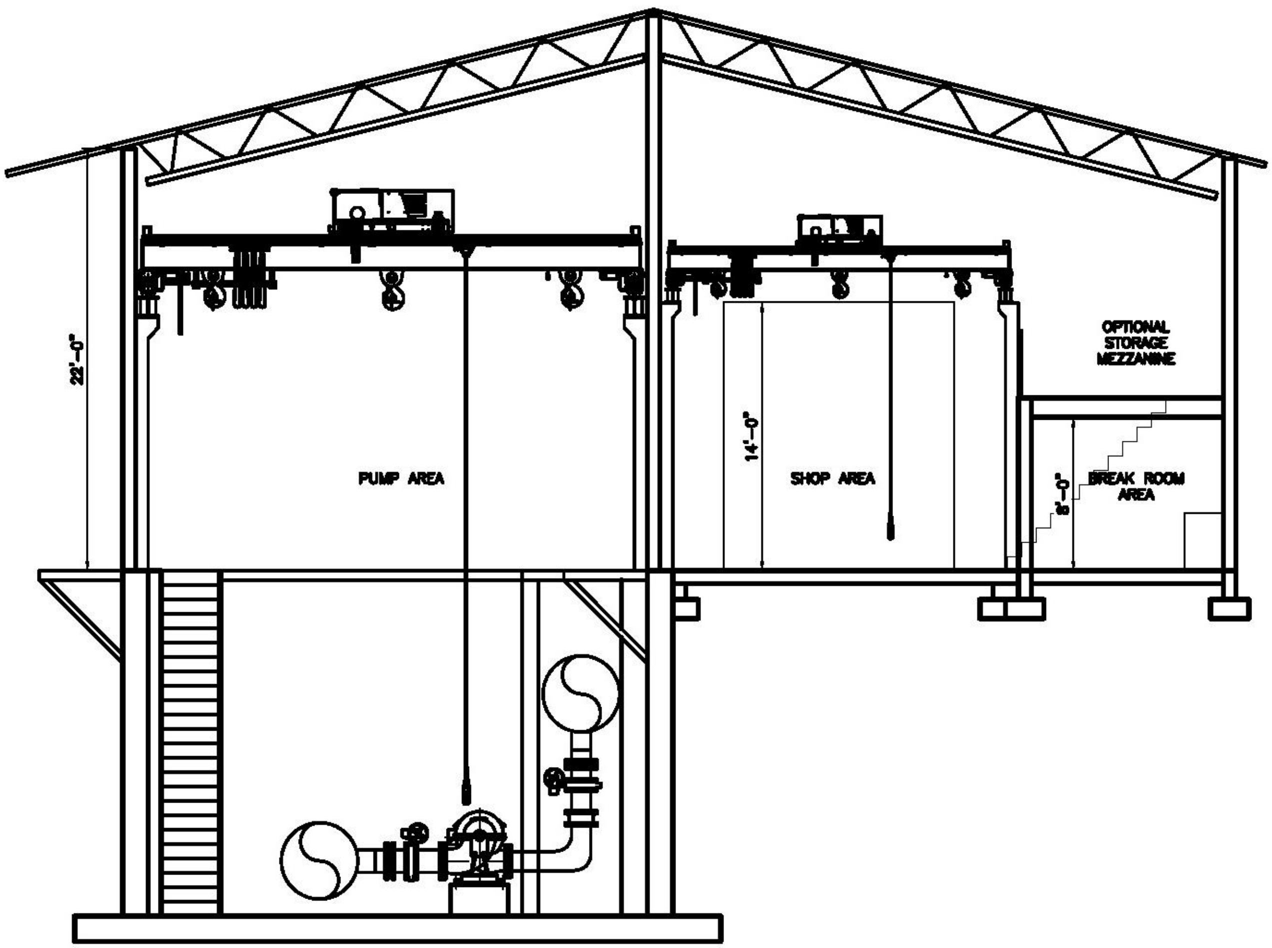


Figure A.4.2. Profile View of Alternative #4 Structure