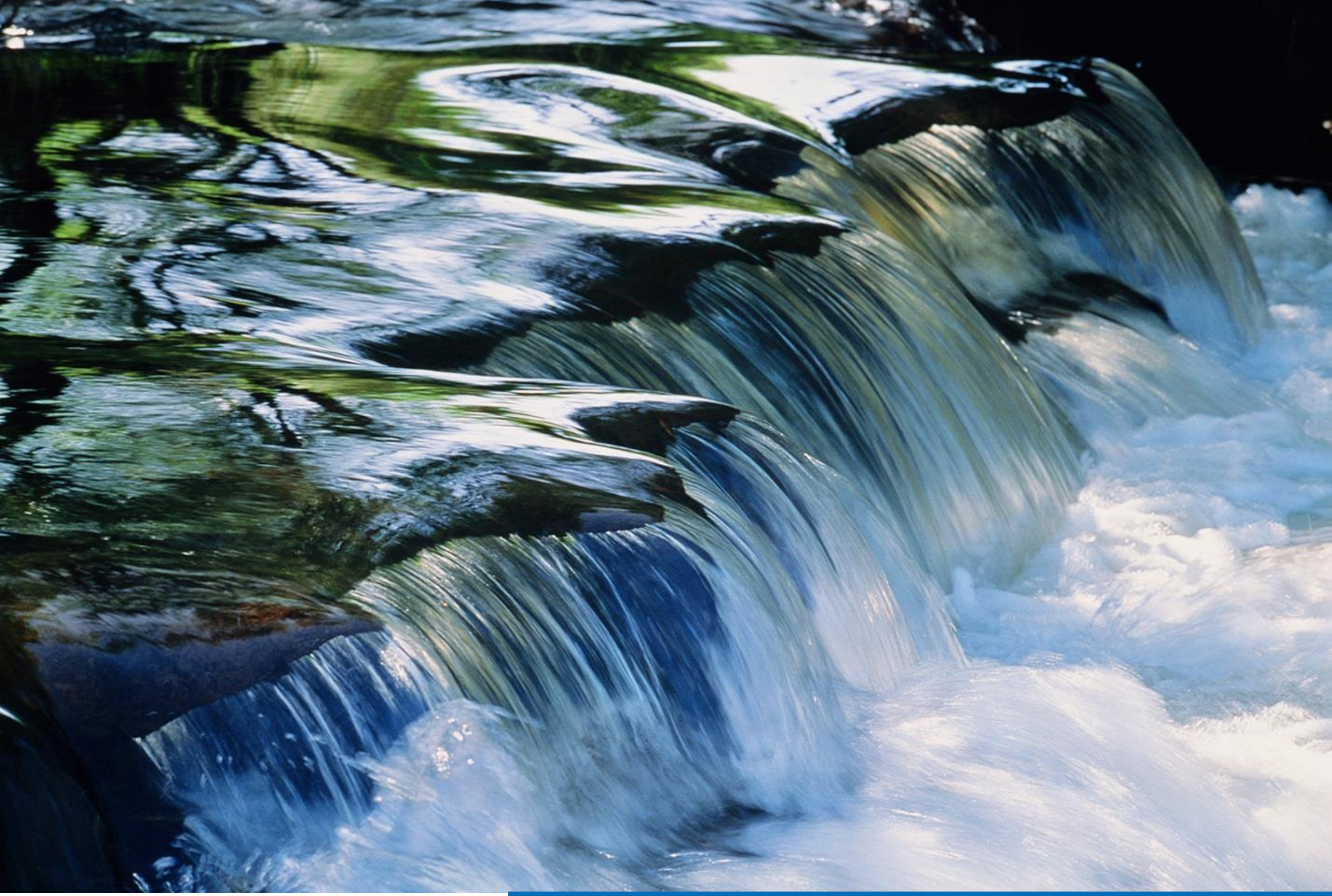

JORDAN VALLEY WATER
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Jordan Valley Water Conservancy District
Jordan Valley Water Treatment Plant

PRETREATMENT EXPANSION UPDATE

FINAL | August 2021

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PRETREATMENT EXPANSION UPDATE

FINAL | August 2021

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08/31/21
STATE OF UTAH

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Section 1

EXECUTIVE SUMMARY

The 2016 Jordan Valley Water Treatment Plant (JVWTP) Capacity and Site Optimization Study (2016 Study) evaluated alternatives to expand the JVWTP to 255 million gallons per day (mgd). The 2016 Study assumed the existing plant successfully operates at 180 mgd. Two alternatives were recommended for further study: construct new open basins (Alternative 2) or construct a new 75 mgd treatment facility (Alternative 4). The alternative to retrofit the 1985 basins with plate settlers (Alternative 1) was not recommended because it was approximately $20 million more expensive than constructing new open basins (Alternative 2).

In the summer of 2017, JVWTP experienced its most challenging raw water quality and the pretreatment facilities performance suffered above 140 mgd. This recent operational experience indicates that the flocculation and sedimentation (floc/sed) design criteria at 180 mgd may be too aggressive, particularly if the Jordan Valley Water Conservancy District (JVWCD or 'District') re-rates the JVWTP filters to higher filtration rates.

The District has recently focused on Alternatives 1 or 2 from the 2016 Study in conjunction with rerating the filters to expand plant capacity. It will soon be replacing and/or repairing the aging sludge removal equipment in all of the basins.

The purpose of this Pretreatment Expansion Update is to:

- Evaluate the existing pretreatment and update its design criteria considering the 2017 challenges and the planned higher filtration rates.
- Reconfigure Alternatives 1 and 2 of the 2016 Study based on revised criteria and identify impacts to the planned sludge equipment replacement project.
- Develop costs for the reconfigured Alternatives 1 and 2.

1.1 Existing Pretreatment Evaluation

Based on the paper study evaluation of the flocculation and sedimentation basin facilities, we recommend the following:

- The existing flocculation basins have a reliable capacity of 187.5 mgd based on a 30-minute flocculation time.
- The existing sedimentation basins have a reliable capacity of 140.5 mgd based on a 0.75-gallon per minute per square foot (gpm/ft^2) loading rate.
- The existing reliable pretreatment capacity under challenging conditions is therefore 140.5 mgd.
- The following modifications are recommended to improve both existing and expanded pretreatment performance:
  - Replace of all flocculators in the 1985 and older basins with new units with the correct diameter impellers and shaft lengths.
  - Replace existing flocculation baffle walls 2 and 3 to achieve better hydraulic characteristics.

  - Implement the use of an anionic/nonionic polymer in the second stage of flocculation as a flocculant aid (developing costs for this improvement is beyond the scope of this project).
  - Install longitudinal baffles in the 1985 sedimentation basins to improve hydraulic and process performance (unless plate settlers are installed).
  - If hoseless sludge collectors are used in new open basins, install a transverse baffle in both the 1985 and new basins to mitigate density currents.
  - Modify the flocculation basin inlet gates to allow for automatic adjustment to split flow equally.

1.2 Updated Pretreatment Expansion Alternatives

Alternatives 1 (retrofit 1985 basins with plates) and 2 (construct new open basins) have been updated to reflect the downrated existing plant capacity and the more conservative loading rates. Both alternatives remain viable for ultimate expansion to 255 mgd, and Alternative 2 (open basins) remains the low-cost alternative. Relevant features of each alternative are summarized below:

- *Alternative 1 - Adding Plates to the Existing 1985 Sedimentation Basins*
  - A more conservative surface loading rate and increased clearance under the plates for an operator friendly installation significantly increases the basin area equipped with plate packs.
  - Hoseless collectors are recommended over chain and flight collectors to create a safer, more operator friendly installation. The 2016 Study also assumed hoseless collectors.
  - The increased plate area significantly increases the building size such that it is more practical to enclose the entire 1985 floc/sed basins. A tension fabric building covering is recommended to compensate for the added cost of a larger building.
  - If Alternative 1 is selected, the Sludge Collection Equipment Replacement project should replace the equipment with hoseless collectors.
- *Alternative 2 - Constructing Additional Open Flocculation/Sedimentation Basins*
  - The revised alternative includes extending the 1985 basins to take advantage of surplus flocculation time.
  - The two additional basins will match the width and length of the extended 1985 basins.
  - The JVWTP site does accommodate the extended and new basins but will require particular attention in some areas:
    - On the north side, the new basin will be on fill and is close to the Reclaim Basins.
    - On the northeast side, the extended basins encroach into the overflow embankment.
    - On the southeast side the chlorine dioxide piping and a portion of the raw water have to be relocated.
  - If Alternative 2 is selected, the Sludge Collection Equipment Replacement project will not be impacted.
- Both Alternatives 1 and 2 will expand capacity to 233 mgd.
  - Expansion to 250 mgd can be achieved by extending the original basins and/or operating at a higher loading rate.

- The original basins can be improved by replacing the circular sludge collectors with hoseless collectors and installing longitudinal collectors.

1.3 Implementation Costs

The low-cost alternative to expand JVWTP to a firm, reliable 233 mgd is Alternative 2 at $23.8 million. At $38.6 million, Alternative 1 is more expensive by $14.8 million – 60 percent more expensive. These costs are generally in line with the 2016 Study, despite a more conservative design criteria.

The estimated costs for the additional recommendations to the existing pretreatment is $7.8 million, excluding floc aid.

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Section 2

INTRODUCTION

The JVWTP is jointly owned by JVWCD and the Metropolitan Water District of Salt Lake and Sandy (MWDSLS) and is operated by JVWCD. The plant, located in Herriman, Salt Lake County, Utah, was designed in 1971 (constructed in 1972) as a 42-mgd plant and was originally used seasonally as a peaking plant to meet high summer demands.

JVWTP was expanded to 60 mgd in 1979, and to 138 mgd (180 mgd hydraulic capacity) in 1985. In 2002, plant capacity was expanded to 180 mgd with improvements to the flash mix and by pushing the treatment process flows beyond their original design criteria, i.e., a 30-minute floc time compared to 40-minute, a 1.0 gpm/ft^2 surface loading rate compared to 0.75 gpm/ft^2, while still meeting water quality objectives. The plant currently operates year-round and frequently operates at or near its 180 mgd capacity during summer months to meet peak day demands.

The District has had longstanding plans to expand the JVWTP to 255 mgd. In 2016 Carollo Engineers, Inc. (Carollo) completed the JVWTP 2016 Study for the District, which developed and analyzed four alternatives for that expansion:

- Alternative 1: convert the four existing 1985 basins to high rate using plate settlers.
- Alternative 2: construct two additional open floc/sed basins.
- Alternative 3: construct two additional high-rate basins.
- Alternative 4: construct a new 75-mgd treatment facility west of the existing plant.

All four alternatives assumed the existing 180-mgd plant capacity and corresponding floc/sed design criteria. The two alternatives recommended for further consideration were: construction of new open basins (Alternative 2), or construction of a new 75-mgd treatment facility (Alternative 4). Alternative 1 was not recommended for further consideration at that time because installing plates in the existing basins (Alternative 1) was approximately $20 million more expensive than constructing new open basins (Alternative 2).

The 2016 Study identified that the existing filter configuration has the sufficient filter box depth and available head to accommodate deeper media and operate at higher filtration rates. The District is planning to rerate the filters to achieve 255 mgd filtration capacity. Successful operations at higher filtration rates demand high quality settled water. As such, it will be more important that the pretreatment expansion to 255 mgd reliably produces high quality, low turbidity settled water.

In the summer of 2017, the JVWTP experienced its most challenging raw water quality. These conditions stressed the pretreatment facilities, and their performance suffered at production levels greater than 140 mgd. Under these conditions, settled water quality exceeded 2 Nephelometric turbidity units (NTU) and the resulting solids loading onto the filters created short filter runs and excessive backwashes. This recent operational experience indicates that the more aggressive floc/sed design criteria at 180 mgd that was previously assumed for all expansion scenarios in the 2016 Study may be too aggressive and may not reliably produce acceptable water quality particularly required by higher filtration rates.

The District has recently become more interested in pretreatment expansion by retrofitting the existing 1985 basins with plates (Alternative 1 from the 2016 Study) and is separately planning to replace the aging sludge removal equipment in the four (1985) basins prior to any expansion project. Given that timing, it is important to understand how the Sludge Collection Equipment Replacement project and the expansion project impact each other before the design of either project begins.

The purpose of this Pretreatment Expansion Update is to:

- Evaluate the existing pretreatment and update its design criteria considering the 2017 challenges and the planned higher filtration rates.
- Reconfigure Alternatives 1 and 2 of the 2016 Study based on revised criteria and identify impacts to the planned Sludge Collection Equipment Replacement project.
- Develop costs for the reconfigured Alternatives 1 and 2.

Section 3

EXISTING PRETREATMENT EVALUATION

Design criteria for the JVWTP Expansion Project (1985) pretreatment facilities are presented below.

Table 3.1 JVWTP Expansion Project (1985) Design Criteria

Description	Units	Value
Plant Criteria		
Design Flow	mgd	138
Hydraulic Flow	mgd	180
Flocculation Basins		
Type: Compartmentalized, Vertical Shaft Flocculators		
Mixing Energy G (variable) First Two Stages	sec^{-1}	10-60
Second Two Stages	sec^{-1}	10-20
Flocculator Power		
Existing, each	hp	2
New, each	hp	3
Existing, Total	hp	48
New, Total	hp	96
Existing, per compartment	hp	6
New, per compartment	hp	6
Number of Basins		
Existing	no.	2
New	no.	4
Number of Compartments		
Existing and New	no.	4
Compartment Inside Dimensions		
Existing	feet by feet (ft x ft)	26 x 85
New	ft x ft	30 x 60
Average Water Depth		
Existing	feet	10
New	feet	12
Compartment Volume		
Existing, each	cubic feet (ft^3) gallons (gal)	22,100 165,300
New, each	ft^3 gal	21,600 161,600
Total Flocculation Time		
Design Flow	minutes (min)	40
Hydraulic Flow	min	30

Table 3.1 JVWTP Expansion Project (1985) Design Criteria (continued)

Description	Units	Value
Sedimentation Basins		
Type: Rectangular Horizontal Flow		
Number		
Original	no.	2
1985 Basins	no.	4
Basin Inside Dimensions		
Original	ft x ft	85 x 257
1985 Basins	ft x ft	60 x 360
Basin Volume, each		
Original	ft^3 gal	218,000 1,634,000
1985 Basins	ft^3 gal	260,000 1,939,000
Total Volume		
Original	ft^3 gal	437,000 3,268,000
1985 Basins	ft^3 gal	1,037,000 7,755,000
Total Sedimentation Time at Design Flow, Existing and New		
Original	min	102
1985 Basins	min	120
Surface Loading Rate at Design Flow		
Original	gpm/ft^2	0.73
1985 Basins	gpm/ft^2	0.74
Weir Overflow Rate		
Original	gallons per minute per foot (gpm/ft)	15.6
1985 Basins	gpm/ft	269
Sludge Equipment Type		
Original		Circular Collector
1985 Basins		Chain and Flight
Sludge Pumps		
Number	no.	2
Capacity, each	gpm	800

The 1985 expansion modified the original two floc/sed basins and constructed four new floc/sed basins (1985 basins) based on a process design capacity of 138 mgd and a hydraulic capacity of 180 mgd. At the 138-mgd process design capacity, each flocculation basin provided 40 minutes detention time and the rectangular, horizontal-flow sedimentation basins would operate at 0.75 gpm/ft^2 surface loading rate.

The 1985 design accommodated future process expansion to the 180 mgd hydraulic capacity by one of two options:

- Construct additional floc/sed basins.
- Provide additional capacity within the 1985 basins.

Additional basin construction was accommodated with provisions in the footings and walls for future common-wall construction with a new basin on both the north and south sides of the 1985 basins (refer to Figure 3.1).

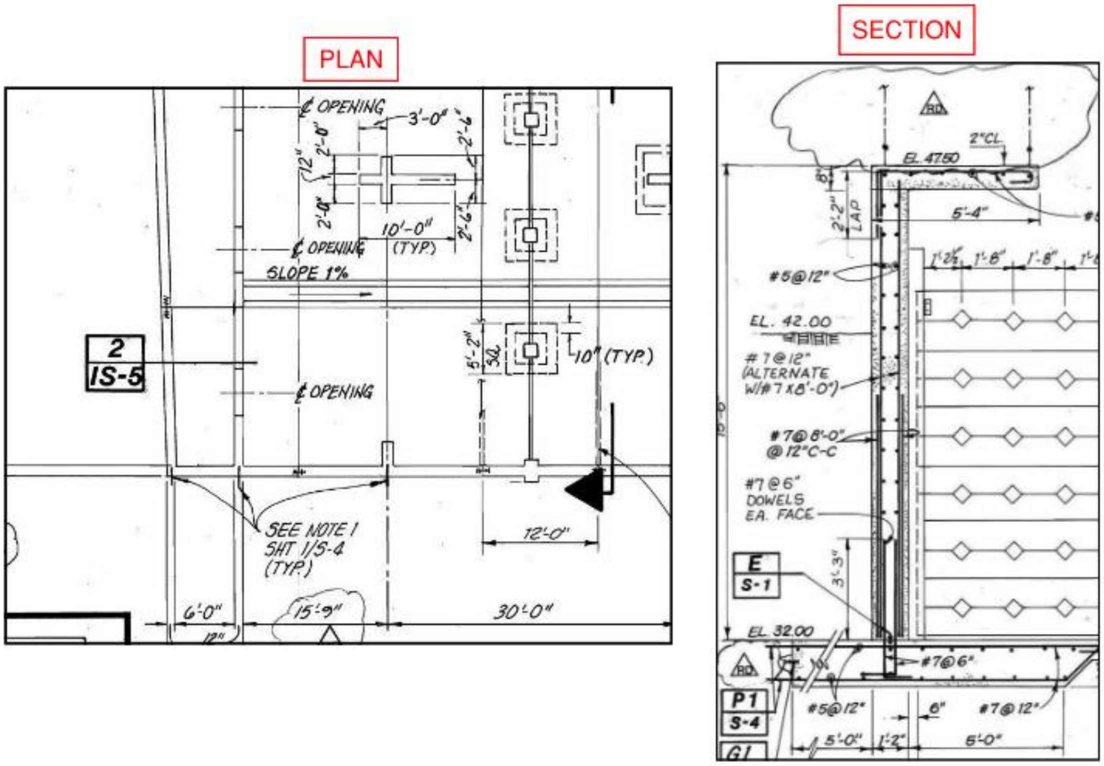


Figure 3.1 Provisions for Common Wall Construction

Additional capacity within the 1985 basins was accommodated with surplus flocculation time and provisions to install future tube packs to increase settling surface area. The flocculation basins were sized in 1985 to provide 40 minutes of detention time at 138 mgd so that at future higher flows it would be reduced to an acceptable 30 minutes at 180 mgd. Future installation of tube settlers was structurally accommodated with corbels along the sedimentation basin walls and support steel in the slab to anchor future columns to support the tube packs (refer to Figure 3.2). The excessive cost of plate settlers in 1985 made tubes more attractive than plate settlers for high-rate sedimentation in these large basins.

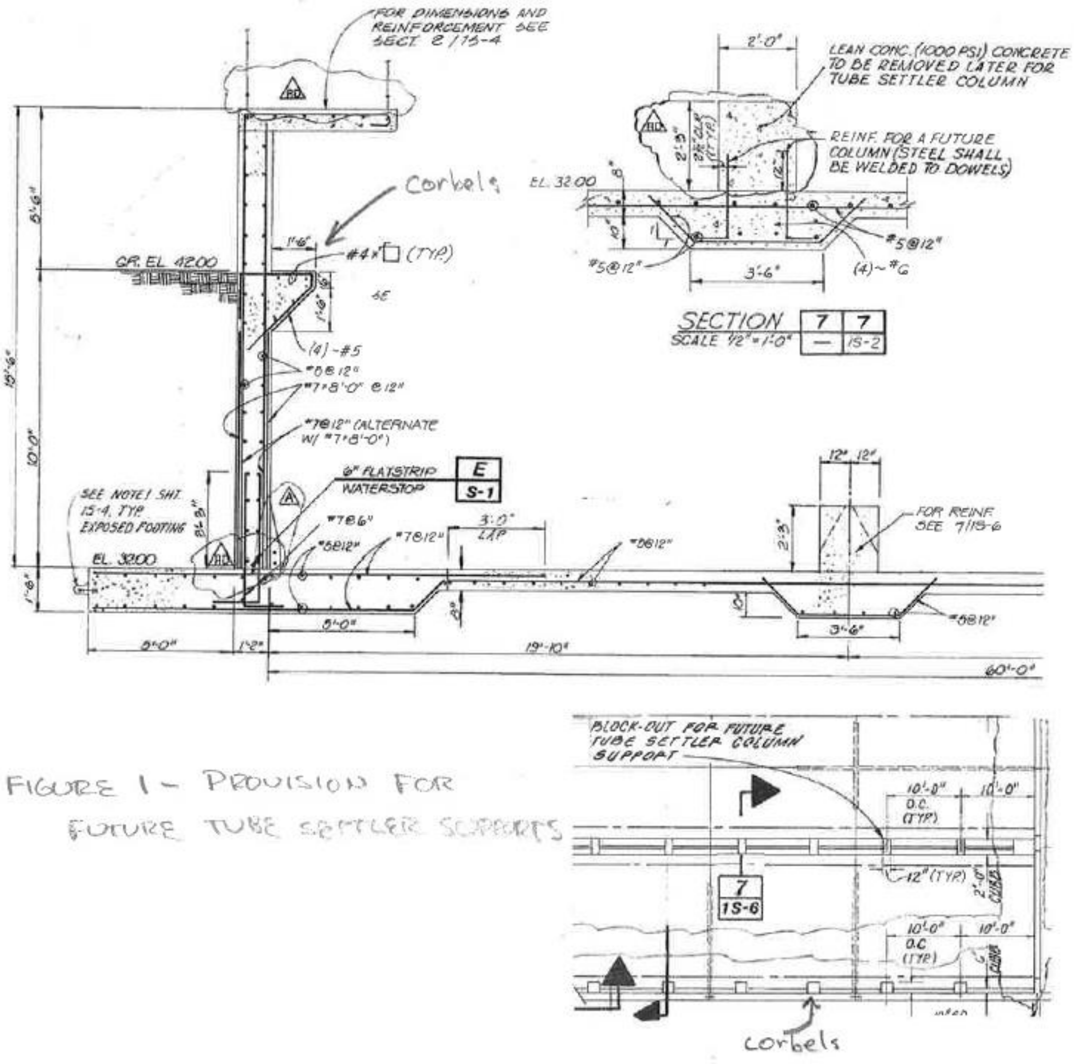


Figure 3.2 Provision for Future Tube Settler Supports

3.1 Flocculation

Figure 3.3 is a photo of the existing flocculators, baffle walls, and stator baffles, and Table 3.2 presents a review of the existing flocculation basins as designed and constructed in comparison with recommended design criteria. Based on this table, there are several improvements that we recommend when these facilities are expanded or upgraded.

Figure 3.3 Existing Flocculator, Baffle Walls, and Stator Baffles

Table 3.2 JVWTP Flocculation Design Criteria

<table>
<tr><th>Criteria</th><th colspan="3">As Constructed</th><th>Recommended[1]</th></tr>
<tr><td>Flocculation Detention Time</td><td colspan="3">40 minutes @ 138 mgd</td><td>30 Minutes Minimum</td></tr>
<tr><td>Flocculator Type</td><td colspan="3">vertical shaft, 45° pitched-blade turbines (PBTs) with two-speed motors</td><td>Appropriate</td></tr>
<tr><td>Flocculation Compartment Dimensions</td><td colspan="3">30 ft x 30 ft x 12 ft depth (1985)
26 ft x 28 ft x 10 ft depth (original)</td><td>>22 feet in L or W requires upward pumping flocculators as furnished</td></tr>
<tr><td>Flocculator D/T Ratio (Diameter Impeller/Width Tank) > 0.35</td><td colspan="3">PBTs 84 to 94-inch diameter</td><td>120 inch (Original)
144 inch (1985)
diameter</td></tr>
<tr><td>Flocculator Impeller Location Above Basin Floor</td><td colspan="3">78 inch</td><td>1/2 Impeller Diameter Max for Upward Pumping</td></tr>
<tr><td>Flocculator Tip Speed</td><td colspan="3">6.2 - 6.8 feet per second (fps) Max Stg 1
5.4-5.6 fps Max Stg 2
4.0-4.4 fps Max Stg 3/4</td><td>< 8 fps Stg 1 Appropriate
Appropriate
< 2 fps Stg 4</td></tr>
<tr><td>Flocculator Energy Input (1/G)</td><td colspan="3">40-62 sec^{-1} Stg 1

31-48 sec^{-1} (1985) Stg 2
32-49 sec^{-1} (Original)
20-31 sec^{-1} Stg 3/4</td><td>Appropriate for 2-spd Motors
VFD Recommendation
20-60 sec^{-1} Stgs 1-3
10-30 sec^{-1} Stg 4</td></tr>
<tr><td>Stator Baffles</td><td colspan="3">1/12 compartment width</td><td>Appropriate</td></tr>
<tr><td rowspan="4">Baffle Walls (max velocity - fps)</td><td></td><td>138 mgd</td><td>180 mgd</td><td>Max Recommended</td></tr>
<tr><td>Stg 1</td><td>1.3</td><td>1.7</td><td>1.8 Stg 1</td></tr>
<tr><td>Stg 2/3</td><td>0.9</td><td>1.2</td><td>1.5 Stg 2/3</td></tr>
<tr><td>Stg 4</td><td>0.6</td><td>0.8</td><td>0.8 Stg 4</td></tr>
</table>

Note:
(1) Integrated Design of Water Treatment Facilities. Susumu Kawamura, 1991.

3.1.1 Flow Split into Flocculation

Current flow to each floc/sed basin is split with downward opening slide gates manually set to a position established by the mechanical position indicators (refer to Figure 3.4). Typically, the gate position is not adjusted based on flow, there is no indication for the operator to determine if the gates are properly positioned, and there is often no way to ensure that the gate was returned to its prior position following basin cleaning. This configuration is typical for many installations and often leads to poor flow split which in turn results in poor basin performance.

Figure 3.4 1985 Basins Slide Gates

The poor flow split results from minor variations in gate levels that translate to large variations in flow over the weir gates. For example, computational fluid dynamics (CFD) modeling on a tapered inlet channel like the channel supplying the 1985 basins has shown that a 1-inch variation in gate level can increase maldistribution from the acceptable 6 percent variation to more than 24 percent variation between basin flows. This means that if two basins are supposed to each be operating at their 1.0 gpm/ft^2 design criteria, one is operating at 1.1 gpm/ft^2 while the other is operating at only 0.9 gpm/ft^2. The basin with the higher flow is operating beyond its design criteria and its performance will suffer.

In addition to the gates, the configuration of the flow split between the original and the 1985 basins could result in maldistributed flow between the northern 1985 basins, the original basins and the southern 1985 basins. CFD modelling has improved significantly since 1985 and is a powerful tool to evaluate and correct hydraulic flow split issues.

Recommendation. We recommend CFD modeling to evaluate flow split between all basins for the existing or for any expansion alternative. CFD modeling may identify some baffling in inlet channel. In addition, the existing slide gates at JVWTP could be retrofitted with in channel level sensors along with mechanical stem positioners that operate automatically to closely control weir levels and flow rates to the basins.

3.1.2 Flocculation Time

As discussed in the previous section, the 40-minute flocculation time at 138 mgd is longer than 30 minutes recommended by Susumu Kawamura. There is surplus flocculation capacity built into these basins that could be utilized to achieve reliable flocculation at higher capacities.

Recommendation. We recommend a 30-minute flocculation time for effective flocculation.

3.1.3 Flocculators

Table 3.2 shows that the flocculators are fitted with impellers that are smaller than recommended. Ideally, the impellers would have 120-inch diameter in the original basins and 144-inch diameter in the 1985 basins. While they are upward pumping as required for the large flocculation compartments, they are mounted too high off the basin floor for optimum performance. Ideally these flocculators would be mounted 60 inches and 72 inches above the floor for the original and 1985 basins, respectively. Lastly, Stage 4 flocculation tip speed is too high and could lead to floc shear. The maximum tip speed for Stage 4 should not exceed 2 fps. These less-than-ideal characteristics of the existing flocculators reduce the effectiveness of the flocculation process. In addition, the 2-speed motors provide some flexibility in mixing energy, but variable frequency drives (VFDs) provide additional optimization.

Recommendation. At 35 years old, the existing flocculators are reaching their useful life and we recommend they be replaced with flocculators that have optimized characteristics and VFD drives.

3.1.4 Baffles

Figure 3.5 shows the details of the baffle walls between flocculation stages and the stator baffles within each stage. The recommended maximum baffle wall velocity in Table 3.2 is based on an optimized tradeoff between hydraulic efficiency and floc shear. Table 3.2 shows the maximum velocities through the second and third baffle walls are low at 180 mgd, and all of the baffle wall velocities are low at 138 mgd. The lower velocities could contribute to hydraulic inefficiencies which would reduce effective flocculation time and compromise floc quality.

The stator baffles are appropriately sized for effective flocculation.

Recommendation. For basins operating at a maximum flow rate of 180 mgd, we recommend the baffle walls 2 and 3 be modified to have less orifice area to operate at 1.5 fps at 180 mgd. For basins that will operate at a maximum flow rate of 138 mgd, we recommend all four baffle walls be modified to have less orifice area.

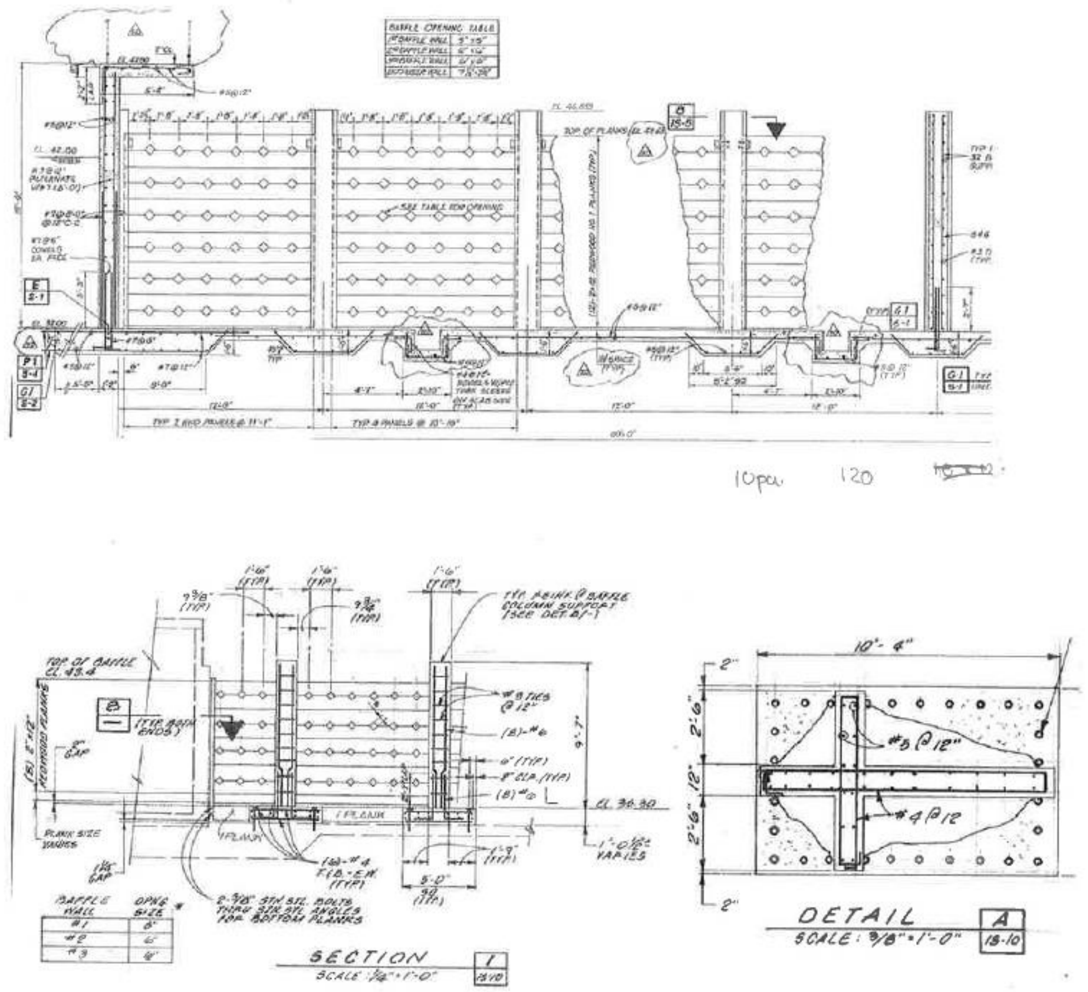


Figure 3.5 Baffle Wall and Stator Baffle Details

3.1.5 Flocculant Aid

Floc aid optimizes the flocculation process for many water quality conditions. Figure 3.6 shows jar testing results for Weber Basin Water Conservancy District (WBWCD)'s Weber South Water Treatment Plant (WTP) where floc aid reduced settled water turbidity from 2.04 to 0.63 NTU at 12.8 mg/L alum dose, and from 1.68 to 0.65 NTU at 16.0 mg/L and 0.65 floc aid is best added in the second stage using small diameter piping routed to the mixing zone for each flocculator impeller. Floc aid can be particularly effective at lowering settled water turbidity during periods requiring higher coagulant doses and high flowrates. We understand floc aid was piloted for a short period of time around 2009 using temporary piping and equipment (refer to Figure 3.7), with inconclusive results. However, the equipment setup was unreliable and difficult to operate, and the brief testing may not have captured the potentially significant benefits that could be realized under different water quality and flow conditions.

Recommendation. We recommend that floc aid be implemented at JVWTP for the existing facility and for any expansion scenario.

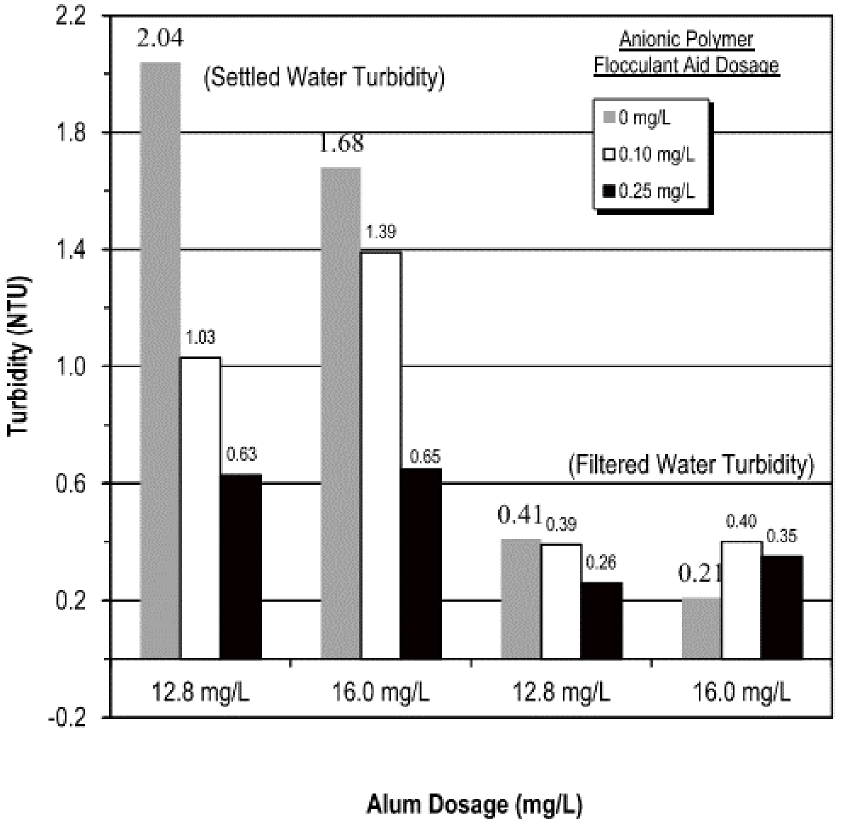


Figure 3.6 Effect of Anionic Polymer as Flocculant Aid on Turbidity in Jar Testing (WBWCD)

Figure 3.7 Temporary Flocculant Aid Piping at JVWTP (circa year 2009)

3.2 Sedimentation

Table 3.3 presents a review of the existing sedimentation basins as designed and constructed with recommended design criteria.

Table 3.3 JVWTP Sedimentation Design Criteria

Criteria	As Constructed	Recommended[1]
Sedimentation Type	Rectangular Horizontal Flow	Appropriate
Water Depth	10 ft (Original)(2) 12 ft (1985)	Appropriate for open basins
Length to Width Ratio	3:1 (Original) 6:1 (1985)	4:1 Minimum 6:1 Recommended
Surface Loading	0.75 / 1.0 gpm/ft^2 @ 138 / 180 mgd	0.75 gpm/ft^2
Reynolds Number	20,700 / 27,000 (Original) @ 138 / 180 mgd 25,900 / 33,800 (1985) @ 138 / 180 mgd	<20,000 <18,000 if possible
Froude Number	6.7x10^{-6} / 1.1x10^{-5} (Original) @ 138 / 180 mgd 8.8x10^{-6} / 1.5x10^{-5} (1985) @ 138 / 180 mgd	> 1.0x10^{-5}
Water Depth/Length	1:25 (Original) 1:30 (1985)	Minimum 1:15
Width/Water Depth	8.5:1 (Original) 5:1 (1985)	6:1 Maximum 3:1 Recommended
Horizontal Velocity	2.5/3.3 fpm (Original) @ 138/180 mgd 3.0/3.9 fpm (1985) @ 138/180 mgd	1-3.5 gpm

Note:
(1) Integrated Design of Water Treatment Facilities, Susumu Kawamura, 1991.
(2) 10 ft is listed depth. Actual depth appears to vary from 10.7 to 14.2 ft due to sloped floor to circular sludge collectors.

With effective coagulation and flocculation, properly designed rectangular horizontal sedimentation basins are generally preferred in water treatment given their simplicity and ability to tolerate both hydraulic and shock loadings without degrading the quality of the settled water. Although uncovered basins are vulnerable to wind and temperature-driven density currents, many larger basins are uncovered due to high building costs. In these situations, basin configuration and geometry become even more critical to optimize to obtain the best sedimentation basin performance. Uncovered basins that properly address these issues operate effectively, even in the colder Utah climates.

3.2.1 Surface Loading Rate and L:W Ratio

The two most important criteria for sedimentation basin performance are the surface loading rate and the length-width ratio (L:W ratio). Rectangular horizontal sedimentation basins perform best when the maximum surface loading rate is limited to 0.75 gpm/ft^2 and the basin L:W ratio is a minimum of 6:1. The 1985 basins were designed to meet this recommended criteria at

138 mgd. The original basins operate at the same surface loading rate but have a significantly insufficiently low 3:1 L:W ratio. The very low L:W ratio means that even at the 138 mgd design capacity, the 1985 basins will outperform the original basins. This performance difference will be exaggerated at 180 mgd and 1.0 gpm/ft^2. Sedimentation basins can adequately operate 1.0 gpm/ft^2 but only during low turbidity and coagulant demand periods in warmer weather, and only when other parameters discussed below are optimized.

Recommendation. We recommend a surface loading rate of 0.75 gpm/ft^2 for effective sedimentation.

3.2.2 Other Ratios and Basin Flow Characteristics

Besides the L:W ratio, other aspects of basin geometry impact sedimentation basin performance. Table 3.3 shows the width-to-depth is exceeded in the original basins by over 40 percent, which when coupled with the poor L:W ratio will impact performance at both 138 mgd and 180 mgd. The horizontal velocity criteria in the 1985 basins at 180 mgd is approximately 10 percent higher than recommended.

The flow characteristics of the sedimentation basins can be characterized by the Reynolds (Re) and Froude (Fr) numbers - dimensionless numbers used in fluid mechanics to control turbulent and critical flow. The Reynolds number increases from 20,700 (within 5 percent of the acceptable 20,000) at 138 mgd to 27,000 at 180 mgd for the original basins, and from 25,900 to 33,800 for the 1985 basins. The high Reynolds numbers at 180 mgd are sufficiently high to impact basin performance. The Froude number is slightly off for both the original and the 1985 basins at 138 mgd but improves at the higher flows.

Recommendation. If the 1985 basins remain as open basins, we recommend improving both the Reynolds and Froude numbers by installing longitudinal, intra-basin baffles on top of the pony walls between the sludge collectors to trifurcate each basin. Installation of the longitudinal baffle walls could be readily accomplished given provision for tube settler support columns in the slab on grade during construction of the 1985 expansion as previously discussed. This work is recommended to be done with the flocculation basin baffle wall replacement because both types of baffling could use the same FRP technology (refer to Figure 3.8) and there would be significant economies of scale.

In addition, if the existing chain and flight sludge removal equipment is replaced with a hoseless system, a transverse baffle is recommended midway along these long basins to intercept and reduce density currents. A transverse baffle would not be effective with chain and flight collectors because the openings to accommodate the chain and flight collectors would be too large to create an effective transverse baffle.

Figure 3.8 FRP Structural Baffle Wall System

The original basins have additional configuration challenges resulting from the circular sludge collector configuration. Rectangular sedimentation basin performance relies on uniform wall of water proceeding steadily down the length of the basin with minimal velocity gradients normal to the flow. However, the original basins have a cross section that changes significantly along their length, varying in depth from 10.7 to 14.2 feet and back again three times (refer to Figure 3.9). This creates a 33 percent variation in horizontal velocity and introduces a vertical velocity component both of which could work to resuspend floc that is trying to settle. The circular sludge removal mechanisms in the original basins also prohibit the installation of longitudinal baffles that would correct the L:W ratio. Replacing the circular mechanisms with a different technology would eliminate the variability in basin cross section and accommodate longitudinal baffles. Such a project would require significant structural, mechanical, and electrical modifications.

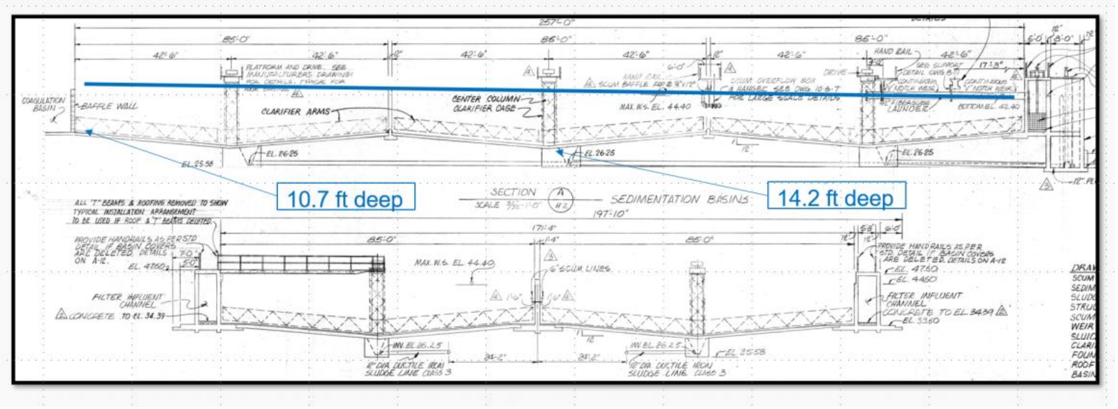


Figure 3.9 Cross Section of the Original Sedimentation Basins

Recommendation. If the circular mechanisms are replaced in the future with a different technology, we recommend installing longitudinal baffle walls with that project. A potential concept is presented Section 4 of this report.

3.3 Overall Pretreatment Capacity

For the remainder of this report, the term reliable capacity will refer to the sustainable maximum flow that could successfully treat raw water with high total organic carbon (TOC) (higher than the 2017 challenges) and turbidites in the hundreds. Properly designed rectangular horizontal sedimentation basins have successfully treated such water. For example, several water treatment plants have successfully treated Colorado River at flood stage with raw water turbidities ranging from 1,000 - 2,000 NTU. While historically JVWTP has not had to treat such high turbidity, it is prudent to plan for poorer water qualities given the potential impacts to watersheds from natural disasters such as earthquakes, landslides, and forest fires. Utilities in recent years throughout the west have had to shut down or substantially reduce production long after forest fires have ravaged watersheds due long-term, fire-related impacts. Recently, Central Utah Water Conservancy District's Duchesne WTP has suffered dramatic water quality changes due to a major forest fire in its watershed. Although they were spared extreme turbidity increases, they suffered major impacts to their water quality more severe than had been previously imagined from their reservoir supply. As a result, they have made significant and costly improvements to reliably treat more the more challenging water that has become their new reality.

Based on our desktop study of the existing design criteria compared to the recommended design criteria, we suggest the following reliable capacities for the existing JVWTP pretreatment. These capacities are summarized in Table 3.4:

- The existing flocculation basins have a reliable capacity of 187.5 mgd based on the recommended 30 minutes of flocculation time. Their performance could be improved by addressing some of the deficiencies identified in this section.
- The existing sedimentation basins have a reliable capacity of 140.5 mgd based on the recommended loading rate of 0.75 gpm/ft^2. Their performance at this loading rate may be stressed during challenging conditions but could be improved by addressing the deficiencies identified in this section. We would not expect the sedimentation basins, particularly the original basins, to perform well at loading rates approaching 1.0 gpm/ft^2.
- Considering that JVWCD is intending to re-rate the downstream filters to higher loading rates, it is imperative that they be provided with the best settled water possible to ensure efficient operations and a manageable number of daily backwashes. Consequently, the existing, reliable pretreatment capacity under challenging conditions is 140.5 mgd.

Table 3.4 Pretreatment Capacities (mgd)

	Flocculation	Sedimentation
Original Basins (Basins 1,2)	63.5	47.2
1985 Basins (Basins 3, 4, 5, 6)	124	93.3
Totals	**187.5**	**140.5** ←

3.4 Supporting Operational Data

Recent operational data, including the 2017 challenges while treating difficult water quality, confirm our desktop analysis conclusions. Figure 3.10 shows plant flowrate, north and south settled water channel applied turbidity, and daily filter backwashes (along with TOC and chemical dose) for both a normal year (2016) and the challenging water quality that occurred in 2017. In 2017, settled water turbidity exceeded 3 NTU when plant flowrates were approximately 160 mgd, and this unacceptable turbidity created an excessive number of filter backwashes. The settled water turbidity would have been higher still had the plant operated at 180 mgd. Furthermore, it is unlikely that re-rated filters could successfully operate above the currently permitted 5.9 gpm/ft^2 when presented with such high turbidity water.

Figure 3.10 also shows that at our proposed 140.5-mgd firm, reliability capacity, the settled water turbidity was an acceptable 2 NTU whether treating normal raw water quality of 2016 or challenging raw water quality of 2017. Although 2 NTU is acceptable, an optimized floc/sed facility will produce settled water turbidities below 1 NTU during normal water quality conditions at design flowrates. Improving the flocculation and sedimentation deficiencies we have identified in this report would significantly improve pretreatment performance at the firm, reliable 140.5 mgd capacity.

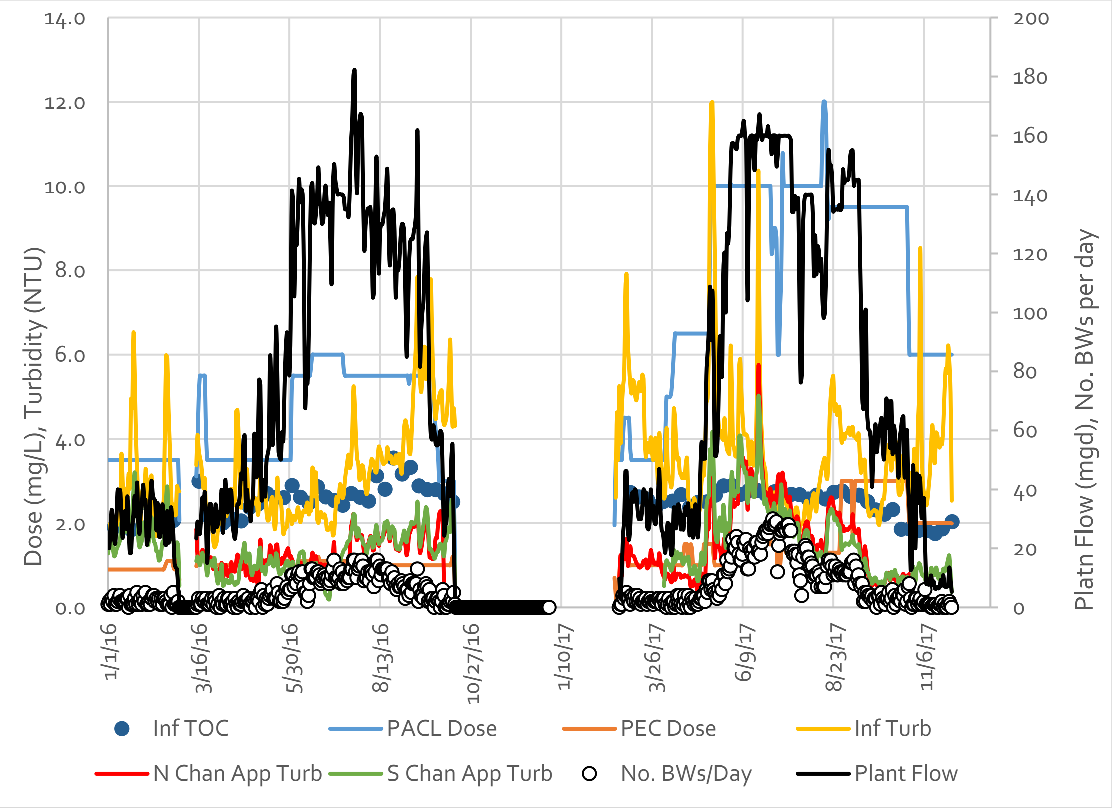


Figure 3.10 2016-2017 Plant Flow, Applied Turbidity, Daily Backwashes, TOC and Chemical Dose

Figure 3.11 is a map that shows basin numbering, and Figure 3.12 provides individual basin performance from June 2020 to February 2021 using new instruments installed in June 2020. The data in this figure represent 24-hour running averages of hourly data. The black curve is plant flow, the red and orange curves are the original Basins 1 and 2, the blue and green curves are the 1985 Basins 3 through 6. The dashed curves are the outboard basins 3 and 6. The summer data at high plant flowrates clearly show that all four 1985 basins outperform the original basins, producing turbidities approximately half of the original basins. The original basin's low L:W ratio, exacerbated by their high Reynolds number and the variable cross section, are responsible for their significantly poorer performance.

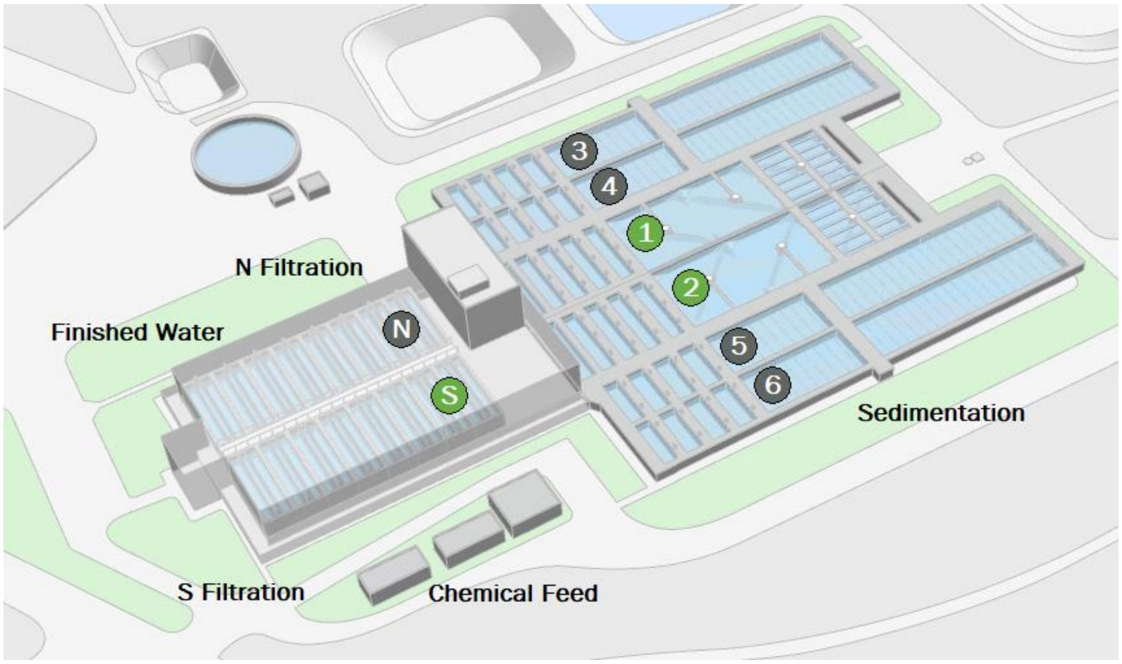


Figure 3.11 Map of JVWTP Floc/Sed Basin Numbering

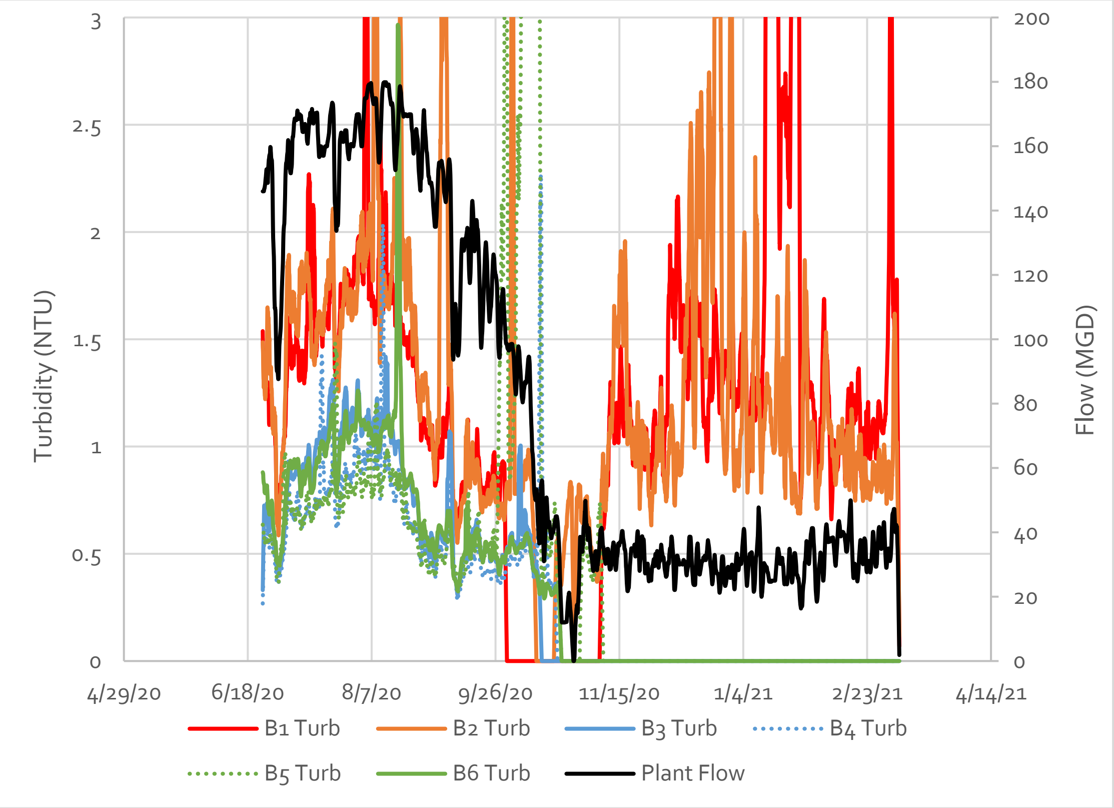


Figure 3.12 Individual Basin Settled Water Turbidity: Summer and Winter

Figure 3.13 shows the same data as Figure 3.12 but zoomed in on 7 days of high plant flow and the data is 4 hour running averages of hourly data. In addition to showing the poor performance of the original basins, Figure 3.13 provides evidence of the flow split concerns that were discussed previously in this report. Basins 4 and 5 -- the inboard 1985 basins -- outperform the outboard Basins 3 and 6. This could result from inadequate flow split that sends more water into the end basins. This situation could result from improper gate positions or could result from the momentum in the inlet channel carrying water proportionately more water past the upstream gates.

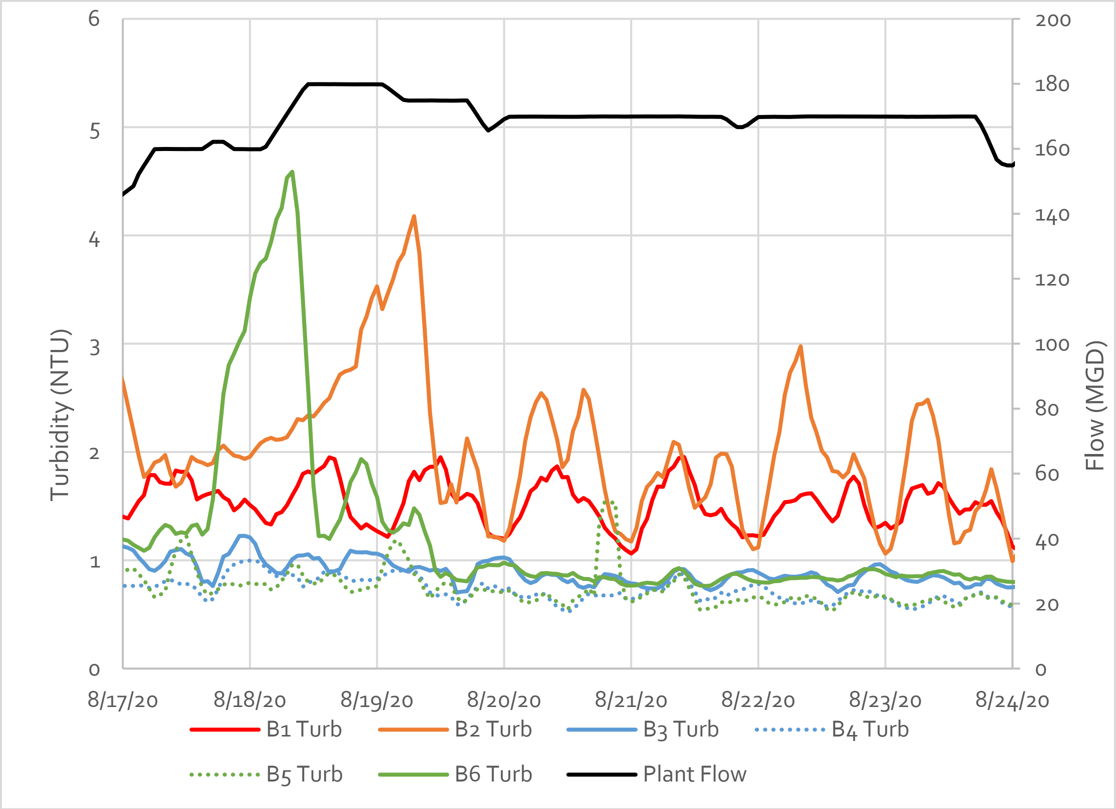


Figure 3.13 Individual Basin Settled Water Turbidity: High Plant Flows

Section 4

UPDATED PRETREATMENT EXPANSION ALTERNATIVES

4.1 Alternatives from the 2016 Study

The 2016 Study developed four alternatives for expanding the plant capacity to 255 mgd. These included:

- Alternative 1 - Adding plates to the existing 1985 sedimentation basins.
- Alternative 2 - Constructing new open floc/sed basins.
- Alternative 3 - Constructing new shorter floc/sed basins with plate settlers.
- Alternative 4 - Constructing a new parallel plant offsite.

The 2016 Study recommended Alternatives 2 and 4 for further consideration by the District, noting that:

- Alternative 2 - Constructing new open floc/sed basins -- would be the least cost alternative.
- Alternative 4 - Constructing a new parallel plant offsite -- offered the opportunity of increasing water production redundancy in case of emergency.

With the 2017 treatment challenges, the District has recently developed a new interest in Alternative 1, due in part to the improved pretreatment performance through the 1985 basins and the for the new 75 mgd capacity. All other alternatives in that report provided improved pretreatment for only the additional 75 mgd capacity. The District has also become less interested in Alternative 4 because the separate treatment train complicates operations and can be avoided by re-rating the filters if suitable settled water can be provided by expanding pretreatment.

This Section 4 updates the previous Alternatives 1 and 2 to address the previous section conclusions that downrates the reliable, firm existing pretreatment capacity from 180 mgd to 140.5 mgd.

4.2 Plant Hydraulics and Improvements Common to Both Alternatives

We have refined and updated the plant hydraulics from the raw water reservoir through the new finished water reservoir to confirmed that the JVWTP can pass 255 mgd with reasonable headloss for filtration. The updated hydraulics indicate the following:

- The 60-inch piping in the raw water meter vault must be replaced with larger pipe, as identified in the 2016 Study (refer to Figure 4.1)
- With media improvements and proper attention to detail by the design engineer, the plant can accommodate 255 mgd through the filters with sufficient available head for filtration. Although sufficient, the available headloss is on the low end of what is

acceptable, and optimized pretreatment will be required to ensure efficient filter operations at high rate.

- The configuration of the new finished water reservoir (FWR) requires that the second 12.5-million-gallon (MG) reservoir be constructed to accommodate flows beyond 180 mgd, which is consistent with District expectations. Without the second reservoir, headloss in the inlet and outlet piping at flows greater than 180 mgd severely limits the allowable operating range of within the reservoir. Figure 4.2 shows the schematic for the current configuration and with the future 12.5 MG reservoir. Figure 4.3 shows the hydraulic grade line for the current configuration at 180 (blue line) and 255 mgd (red line), and with the future reservoir at 255 mgd (green line) with the 12.5 MG reservoir at its maximum operating level. The red line is not viable because it would have to shift down enough to match the other conditions at the outlet structure, which leaves insufficient operating range for both the 12.5 and 8 MG reservoirs when operating in series. The existing configuration could not support flows much greater than approximately 200 mgd.

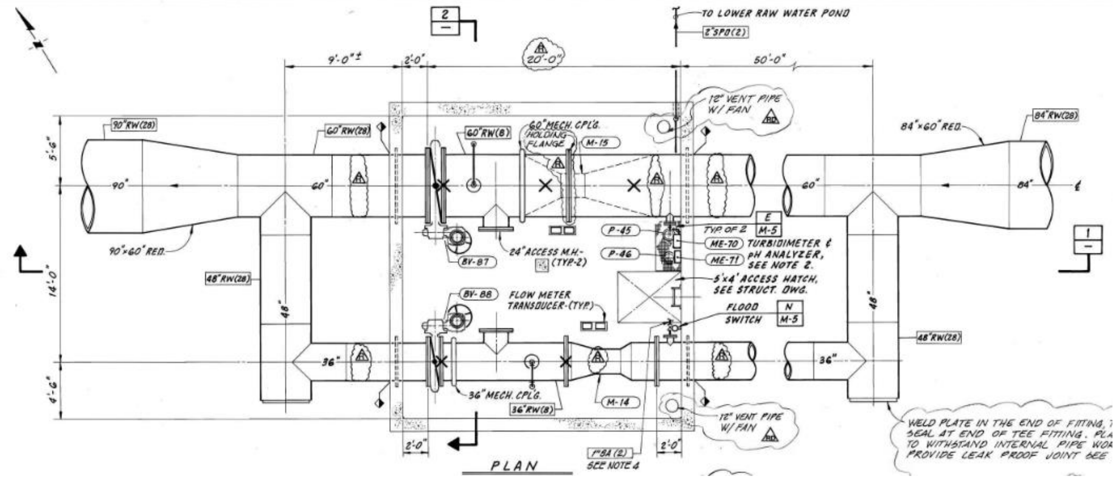


Figure 4.1 Raw Water Meter Vault 60-inch Pipe Must be Replaced

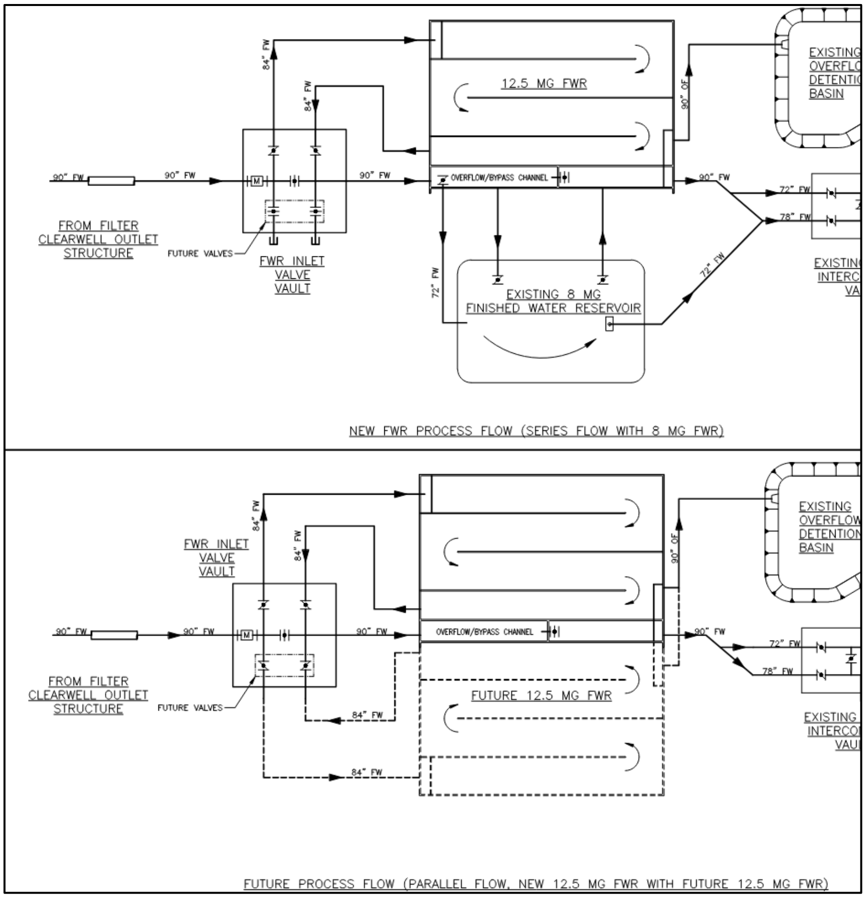


Figure 4.2 Existing and Future Flow Schematic for Finished Water Reservoir

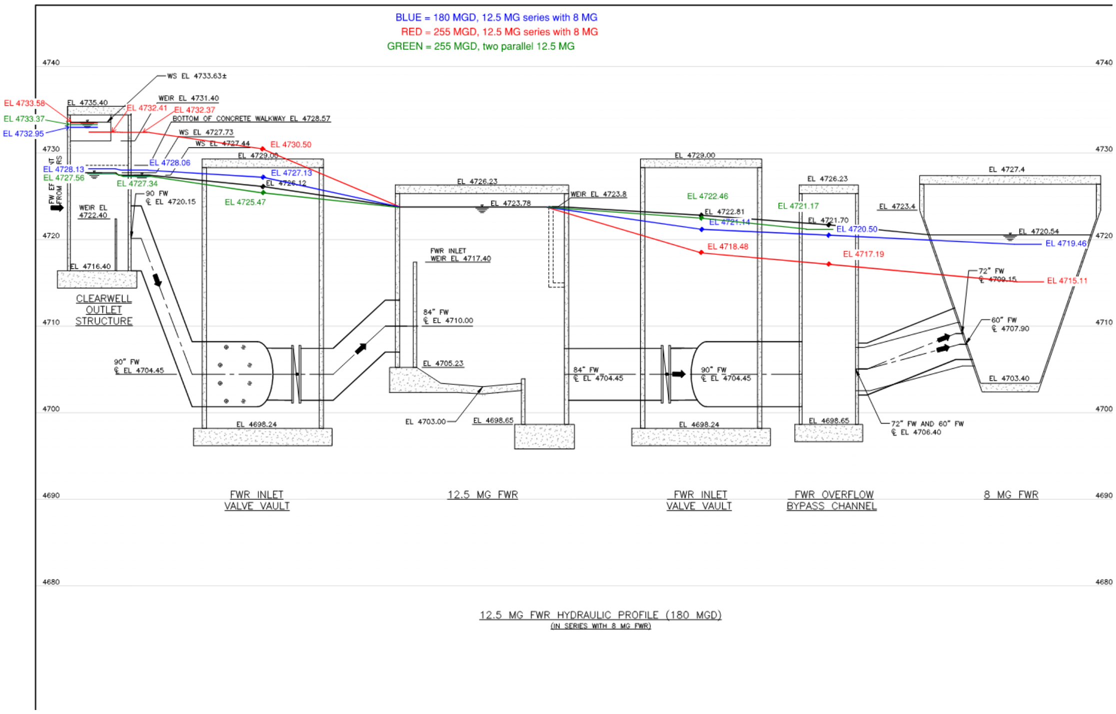


Figure 4.3 Hydraulic Profile for Finished Water: With and Without the Future 12.5 MG

This update is focused only on the flocculation and sedimentation facilities. Any improvements to the filters, chemical building or residuals handling is beyond the scope of this update.

4.3 Alternative 1 - Adding Plates to the Existing 1985 Sedimentation Basins (Expansion to 233 mgd)

Adding plate settlers to an open sedimentation basin significantly increases sedimentation capacity and greatly improves hydraulic stability within the same footprint. Figure 4.4 shows a cross section of a basin equipped with plate settlers to demonstrate plate settler operations. Flocculated water enters the sedimentation basin through a perforated wall, enters the plate pack along the bottom and lower sides, flows upwards between the plates where sedimentation occurs, and settled water is collected at the top of the plates and flows into troughs. Floc settles by gravity within the plate pack until it hits a plate. Accumulated sludge slides down the inclined plate and drops to the floor where it is collected by sludge removal equipment. The figure shows low profile hoseless collectors, but chain and flight collectors are also commonly used underneath plates.

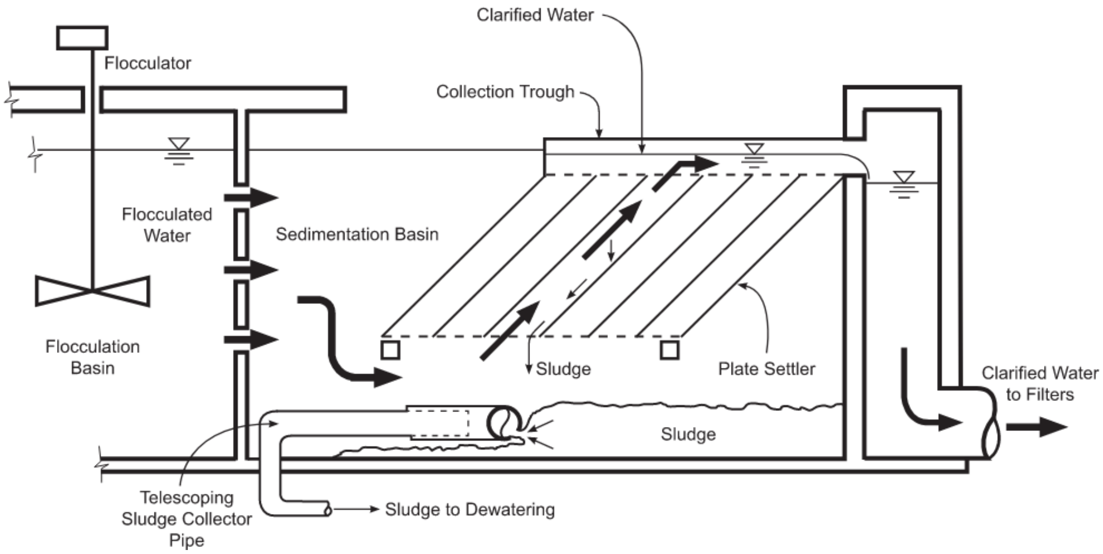


Figure 4.4 Cross Section of a Typical Plate Settler Installation

There are several challenges that must be addressed when retrofitting existing basins with plates. How these challenges are addressed can have significant impact on the ultimate maximum capacity of the basin, the capital cost, the O&M cost, and the operator-friendliness of the facility. We describe our recommended approach to the following issues that impact cost and operability in the following subsections, and highlight any revisions from the 2016 plate settler alternative:

- Flocculation time
- Effective loading rate.
- Clearance under the plates for cleaning operations.
- Breaking up continuous plate pack rows
- Sludge collection equipment
- Clearance in front of the plates
- Existing cross channel
- Building enclosures
- Structural modifications
- Alternative Summary

The goal of this Alternative 1 is to maximize the pretreatment capacity of the four 1985 basins within their existing capacity. Based on these evaluations, this revised Alternative 1 will increase the firm, reliable capacity pretreatment capacity of the four 1985 basins from 93.3 mgd to 186 mgd. Together with the 47.2-mgd firm, reliable capacity of the unmodified existing basins, the alternative descried below will obtain a total pretreatment capacity of 233 mgd.

Future expansion from 233 mgd to 255 mgd will be identical for both Alternatives 1 and 2 and is presented in its own subsection.

4.3.1 Flocculation Time

Additional flocculation basin volume is required to achieve 30-minute flocculation time at the new 186-mgd capacity. This additional volume will be provided by converting the first 60 feet of the sedimentation basins to two additional stages of flocculation. This is easily accomplished but does reduce the overall sedimentation basin length to 300 feet.

Revisions from the 2016 Study. This matches the assumptions of the 2016 Study.

4.3.2 Effective Loading Rate

Plate settler design criteria is based on a surface loading rate expressed in terms of flow rate per effective square foot, or gpm/esf. The effective square foot is the sum of the horizontally projected area of all plates discounted by an efficiency factor that accounts for inefficient flow up through the plates.

Plate efficiency is an assumed value that represents the percentage of total area that we allow to be used in the surface loading rate calculation. Consequently, it impacts the total amount of plate area required to achieve a particular loading rate. For a particular plate pack configuration, a lower loading rate assuming a higher efficiency will require the same number of plates and have identical performance as a higher loading rate assuming a lower efficiency. Plate efficiency has become a matter of semantics because CFD modelling of well-designed, modern plates demonstrate a higher efficiency than plate settlers of the past. In Utah installations, we have preserved a somewhat outdated 80 percent efficiency and maintained consistency across large installations, to simplify discussions with Utah Division of Drinking Water. Any loading rate applied to well-designed plate packs with an assumed efficiency can be converted to an identical loading rate at a different assumed efficiency.

Operating data at multiple plants demonstrate that settled water turbidity produced by plate settlers increases as basin flow and surface loading rate increase. Proper selection of the design surface loading rate is critical, and we offer the following perspective:

- We designed the first three plate settler installations in Utah at 0.3 gpm/esf assuming an 80 percent plate efficiency, generally on the lower end of plate manufacturer's recommended range. These rates were selected based on historical water quality, and all three installations perform very well with settled water turbidities less than 1.0 NTU at design flowrates.
- We designed the Duchesne installation, currently under construction, for a more conservative 0.25 gpm/esf at 80 percent because of the recent fire impacts and need to operate at full capacity in the winter.
- Recent cold-water installations with severe water quality challenges suggest that a plate loading rate of 0.23 gpm/esf at 80 percent efficiency may be more equivalent to an overflow rate of 0.75 gpm/ft^2 in an open basin.
- Across the west, forest fire frequency and intensity have increased, resulting in higher turbidities and TOC in the watersheds they impact. We have seen this in Utah, and it appears the trend will continue. Although Jordanelle and Deer Creek reservoirs will dampen high turbidity in the watershed, there are many examples, including Central Utah Water Conservancy District at Duchesne, where significant turbidity impacts persist to reservoir outlets.

- JVWCD is investigating rerating the JVWTP to operate at higher filtration rates. To successfully operate at the higher rates, it will be critical to maximize solids removal through pretreatment.

Given the 2017 challenges and the perspective above, we recommend a plate settler design surface loading rate of 0.25 gpm/esf to achieve reliable capacity.

Based on this firm capacity rate, each of the existing four 1985 sedimentation basins would have to be covered a length of 264 feet in plates.

Revisions from the 2016 Study. The current recommended 0.25 gpm/esf loading rate is more conservative than the 0.33 gpm/esf selected for the 2016 Study. Consequently, the updated alternative requires significantly more plate area than the 2016 Study.

4.3.3 Clearance Under the Plates for Cleaning Operations

The 12-foot depth of the 1985 sedimentation basins at JVWTP is shallow for plate settlers, which makes their installation difficult from the standpoint of operators working below. Susumu Kawamura recommends a minimum of 6.5 feet clear under plates or tubes to facilitate operator access with a hard hat and work boots, and the two lowest-clearance installations in Utah have 6.7 feet and 7.0 feet. Operators would still have to duck under support beams spaced approximately every 20 feet along the basin length and the step over sludge equipment and short divider walls while dragging hoses for cleaning operations.

Alternative 1 in the 2016 Report was focused on keeping the plate packs on the downstream side of the cross channel to minimize structural impacts. To accomplish this, it used longer plates with only 5 feet of clearance under the plates, and used a less common concealed beam that would not extend below the plate packs (refer to Figure 4.5).

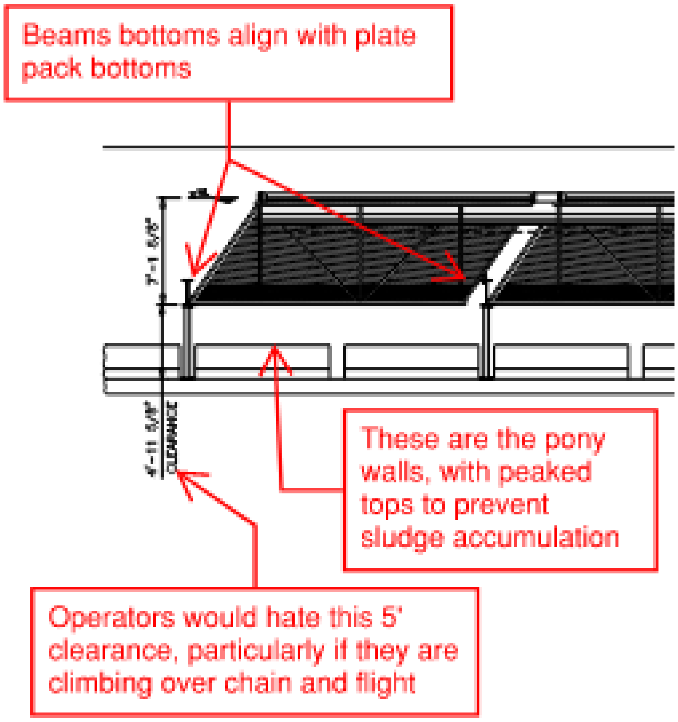


Figure 4.5 Cross Section of the Plate Settlers from the 2016 Report

Upon further review, we now suggest that this low clearance was overly aggressive for the size and extent of the plate settler coverage and will complicate O&M activities and increase safety concerns. The only locations an operator could stand up during washdown activities would be under the approximate 2-foot-wide troughs between rows of plate packs (Figure 4.6, right photo). Many large installations, such as Sunol WTP in California, have been installed with very little clearance. But in Sunol's case (Figure 4.6, left photo), the very large clearance between the rows of plate packs that are free of troughs significantly improve accessibility for washdown. The modern plate settler configuration is lot more congested configuration.


Sunol WTP - Old style plate settles with plenty of space between plate pack rows.

Modern plate packs with narrower space between plate packs that are filled with troughs.

Figure 4.6 Old-style and Modern Plate Pack Installations

We recommend providing a minimum of 6.5 feet under the plates for operator friendly and safe washdown activities. With the 12-foot basin depth and assuming 4 inches of water over the plates, there are only 5.17 feet of vertical space available for plate packs, which translates to a 6.3-foot plate length. This is possible, but plate packs are least expensive when they use the standard 10-foot-long plate. Shorter plates require more plates and proportionally more support frames which significantly increase the required basin area covered by plates, and the cost of the plates.

Revisions from the 2016 Study. The currently recommended 6.5 feet of clearance under the plates is larger than the 5 feet clearance selected or the 2016 Study. This reduces the plate length and consequently requires that more basin area be covered by plate packs.

4.3.4 Breaking Up Continuous Plate Pack Rows

In addition, the 2016 Study covered 170 feet of length in each basin across its entire 60-foot width with uninterrupted plate packs (refer to Figure 4.7). Covering large basins continuously with plates without occasional open spaces for access and light does is not operator friendly: it creates long exit distances and a claustrophobic environment for an operator washing down the basin. We recommend that individual plate pack rows are broken up into sections ranging from 60- to 80-foot lengths with 8- to 10-foot open areas separating the sections.

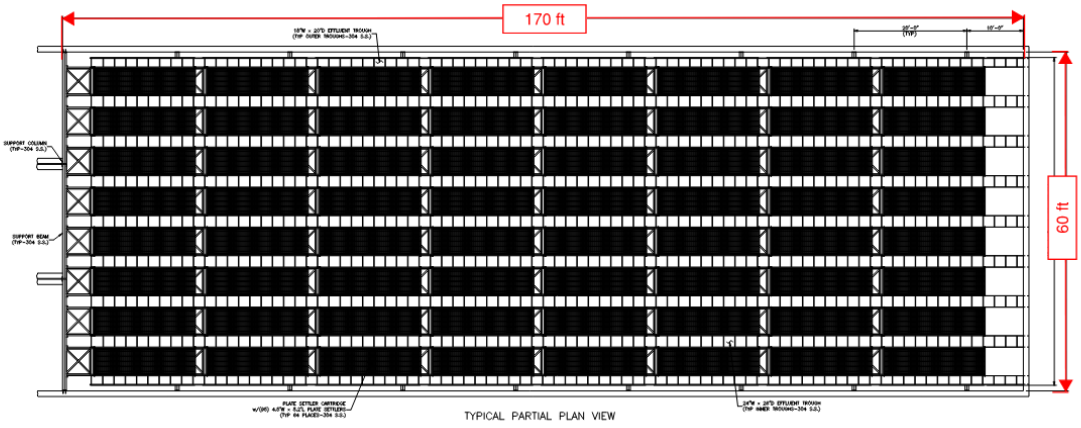


Figure 4.7 Plan View of the Plate Settlers from the 2016 Report

Revisions from the 2016 Study. The current recommendation creates periodic spaces along the length of the plate packs to provide a safer more operator friendly space for washdown. This will add an additional 16 to 20 feet to the length of the basins covered by plate packs.

4.3.5 Sludge Collection Equipment

Refer to Figure 4.8. Low profile sludge removal equipment is recommended over chain and flight with only 6.5 feet clearance under the plates. We typically recommend additional clearance when using chain and flight equipment to facilitate access and washdown - stepping over the return flights every 10 feet with minimal headroom, particularly at beams, becomes extremely cumbersome for the operator washing down the basin. Both low-clearance (6.7 feet and 7.0 feet) installations in Utah use the low-profile MRI hoseless collectors and operations staff reports they appreciate not having to deal with the chain and flight in the confined area. This is particularly true for large basins. The lowest-clearance installation in Utah with chain and flight has an 8.0-foot clearance under the bottom of the plate packs.

Figure 4.9 provides some perspective on how large the 1985 basins are for basin washdown to reinforce how challenging it would be for an operator to wash down these basins if he had only 6.5 feet of headroom across the entire basin - or only 5 feet based on the 2016 Study -- and had to navigate over chain and flight equipment. If operator access is not user friendly, safety policies and operator concerns may prevent annual cleaning, which could create long term operational problems.

Revisions from the 2016 Study. There are no revisions. Although not stated in the 2016 report, Alternative 1 was based on using low profile sludge removal equipment and not chain and flight.

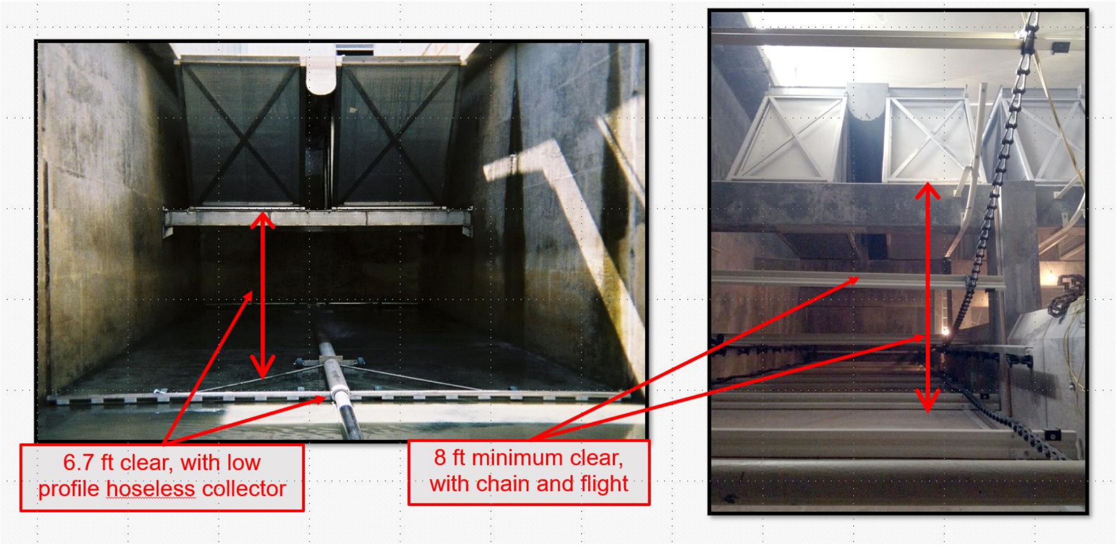


Figure 4.8 Clearance Comparison for Hoseless and Chain and Flight Collectors

Figure 4.9 Cleaning 1985 Basins/Repairing Broken Chain and Flights

4.3.6 Clearance in Front of the Plates

Basins equipped with plate settlers are routinely (weekly) washed down from above to remove accumulated floc-carryover and to help ensure that sludge is not building up between the plates (refer to Figure 4.10). The plate packs can support the weight of a man to facilitate access for routine washdown from the top of the plates. Ideally, the first 25 percent of a basin equipped with plates is left open because 70 percent of floc in well-coagulated water settles in the first

25 to 30 percent of basin. If the entire basin is covered with plates, the front plates may become overloaded and could require significantly more frequent washing from above compared to the remainder of plates. Overloaded plates that are not properly maintained could become clogged or create excessive floc carry over into the launders.

The 2016 Report alternative had surplus open area in front of the plate packs. For the revised current alternative, the more conservative loading rate, shorter plates, and periodic openings every 60 to 80 feet require substantially more area for the plate packs. As shown in the final alternative configuration at the end of this subsection, the recommended 25 percent of open area in front of the plate packs cannot be achieved and operations staff should plan for increased washdown maintenance of the front plate packs during periods of high flows and/or solids production. There is a minimum open area in front of the plate packs to provide stable hydraulics, operator/equipment access and to accommodate sludge removal equipment. This minimum space in front of the plates is accommodated in this alternative.

Revisions from the 2016 Study. The revised alternative has limited open basin in front of the plate packs. Consequently, additional plate pack washdown from above may be required for the front plate packs. The 2016 Alternative had plenty of open basin and no such issues.

Figure 4.10 Routine Plate Cleaning from Above

4.3.7 Existing Cross Channel

The 2016 Report alternative placed all the required plate packs downstream of the existing cross channel, allowing the cross channel to remain in place as well as the upstream chain and flight. For the current revised alternatives, the more conservative loading rate, shorter plates, and periodic openings every 60 to 80 feet require substantially more area for the plate packs.

Consequently, the packs extend through the cross channel to the upstream section of the basin. Consequently, the existing cross channel must be abandoned, and deck removed. Fortunately, the decision to use hoseless collectors means that a cross channel is no longer needed. The existing channel must be filled in there is no need to construct a new one. The proposed plate settler configuration is shown later in this subsection.

Revisions from the 2016 Study. The revised alternative requires the existing cross channel to be filled in and its deck removed. The 2016 Study alternative did not need to abandon the cross channel.

4.3.8 Building Enclosures

Covering flocculation and sedimentation basins of any type is always best practice to eliminate wind effects and wind-blown debris and to minimize surface temperature changes that create density currents. Unfortunately, the cost of covering large open basins is very expensive and often cost prohibitive. Hence, large open basins like those at JVWTP are usually left uncovered, even in cold weather climates.

In cold weather climates, basins equipped with plate settlers must be enclosed to prevent icing of all the equipment at the air water interface. The enclosure provides the operator easy access to observe the process and wash down the plate packs on a regular basis. Consequently, a simple concrete deck is not an option.

We explored the use of structurally supported retractable covers (refer to Figure 4.11) to avoid the high cost of a full building. These enclosures could be left open during warm months and closed during winter if desired. The construction cost for retractable covers is estimated at $2.5 million to cover just the sedimentation basins (300 LF). Although this low cost is attractive, retractable covers are not recommended. When placed, they prevent visual observation of the process, and snow load in the winter will make their removal difficult. In addition, walking in the plates for washdown in winter conditions create additional safety challenges.

Two other building types were considered- a traditional block building with standing seam roof and a tension fabric building (Figure 4.12). The block building would have an estimated construction cost of approximately $8.0 million to cover just the sedimentation portion of the basins and $11.6 million to cover both the flocculation and sedimentation sections.

Figure 4.11 Structurally Supported Retractable Covers

Sprung Structures, located in West Jordan, is one of several manufacturers providing tension fabric buildings worldwide. Several hundred of these have been erected in the Salt Lake City area, including one currently used at the JVWTP for equipment storage. Estimated costs for fully insulated facilities complete would be approximately 40 percent less expensive than a conventional block building. For costing purposes herein, we have used construction costs for a tension fabric building covering the entire flocculation/sedimentation 1985 basins - $6.3 million.

Based on the cost savings associated with the tension fabric building, and high percentage of the floc/sed facility that requires enclosure, we recommend that this alternative include a tension fabric building over the entire 1985 floc/sed basins.

Figure 4.12 Tension Fabric Building

Revisions from the 2016 Study. The 2016 Study alternative installed plate settlers in a much smaller section of the sedimentation basins. Consequently, it included a concrete masonry unit (CMU) building only over the portion of the sedimentation basins downstream of the cross channel. The revised alternative requires a larger area equipped with plate settlers. To save costs, the revised alternative includes a tension fabric building over the entire 1985 floc/sed facilities.

4.3.9 Structural Modifications

The plate packs and tension fabric building will add significant load to the existing basin walls that must be addressed. The plate packs add approximately 650,000 pounds in each basin at an average height of over 9 feet above the slab on grade - seismic design must be carefully considered. Most of the vertical load would be carried by the support columns located along each pony wall but significant seismic lateral loading will be carried by the basin walls. The tension fabric building also adds significant vertical and lateral loads to the top of the existing concrete basin walls. The top deck strips in the flocculation area strengthen and support the top of the walls but these deck strips cannot be added to the sedimentation basins because they would interfere with maintenance of the plate packs. Consequently, concrete buttresses will be needed along the outer-perimeter, cantilevered walls of the sedimentation basins as shown in Figure 4.13. Concrete buttresses are not required on the interior perimeter walls of the 1985 basins because the filter inlet channel provides the necessary support.

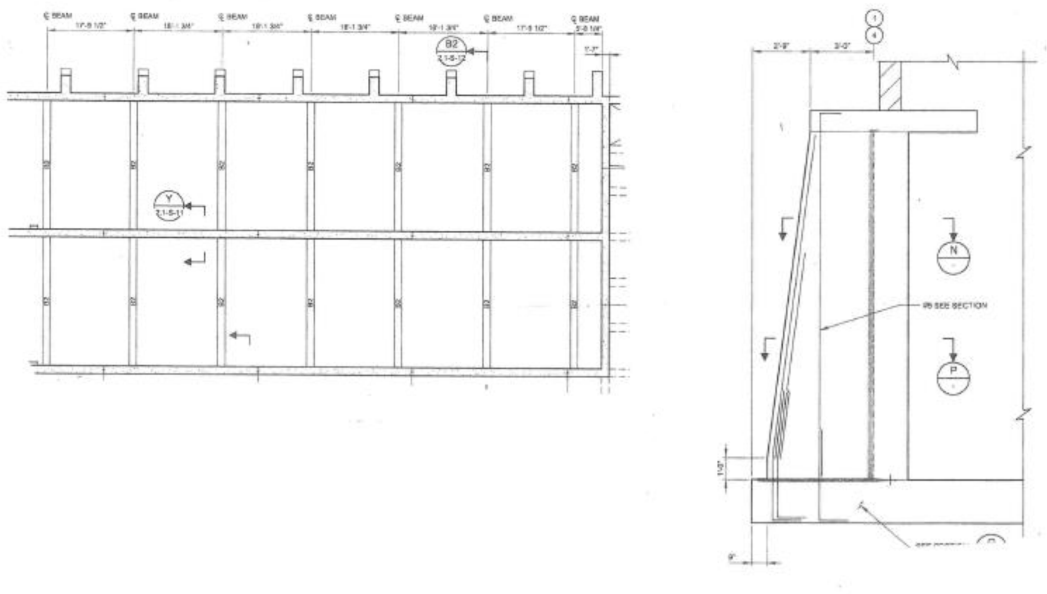


Figure 4.13 Basin Concrete Wall Buttressing

Revisions from the 2016 Study. The 2016 Study alternative included buttresses for the outer perimeter walls where plates packs are installed. However, the revised alternative requires buttresses for the entire sedimentation basin.

4.3.10 Alternative Summary and Impacts to the Sludge Collection Equipment Replacement Project

The revised Alternative 1 incorporating all the items above is shown on Figures 4.14 through 4.17. Alternative 1 as shown will provide a reliable, firm capacity of 233 mgd as shown in Table 4.1. Future expansion from 233 mgd to 255 mgd will be identical for both alternatives and is presented in its own subsection.

Potential Impacts to Sludge Collection Equipment Replacement Project. If revised Alternative 1 is the preferred alternative, we recommend the existing chain and flight be replaced with hoseless collectors. Chain and flight will not be compatible with this plate settler installation.

Table 4.1 Pretreatment Capacities with Plates - 1985 Basins (mgd)

	Flocculation	Sedimentation
Original	63.5	47.2
1985 w/ Plates	186	186
Totals	**249.5**	**233.2** ←

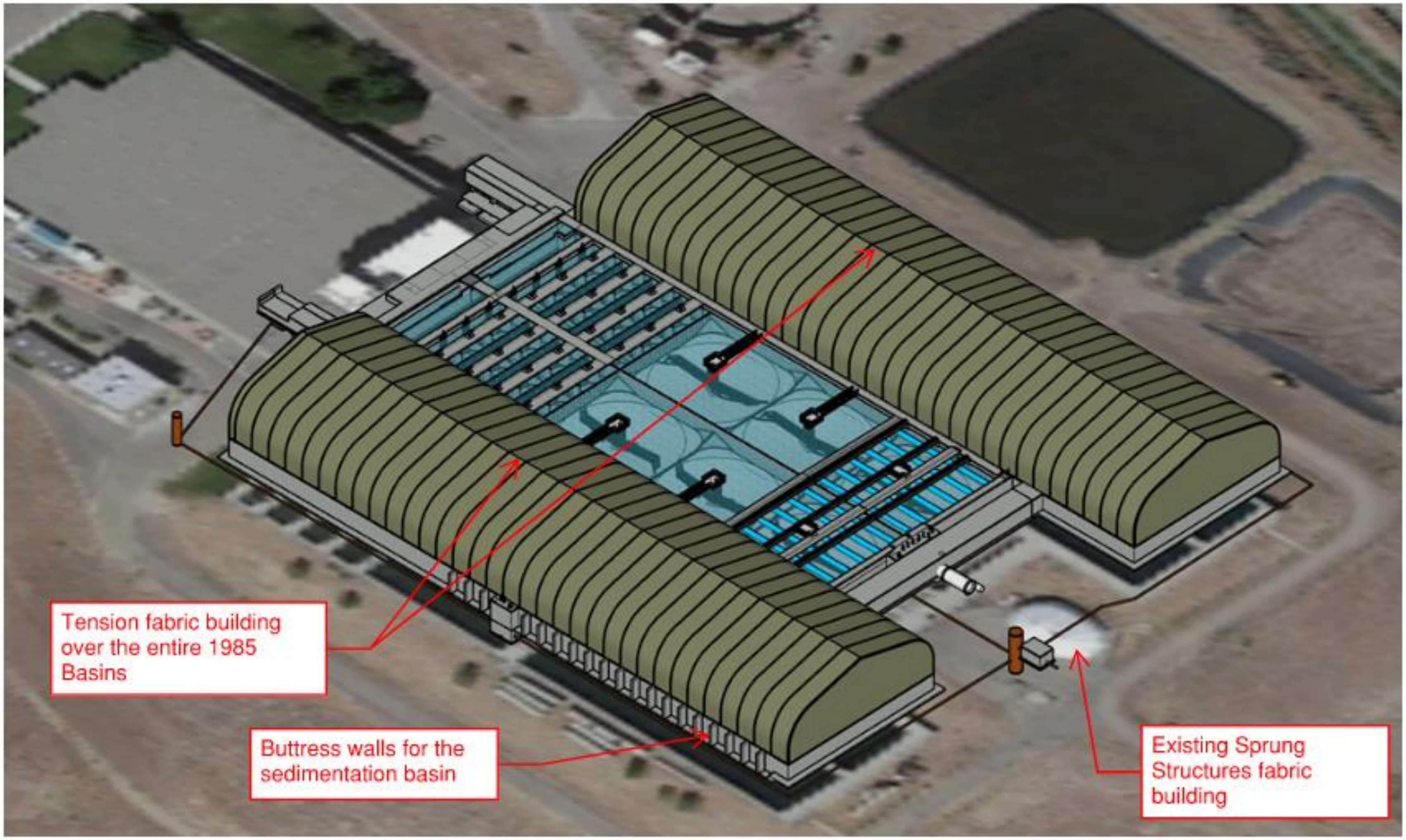


Figure 4.14 Alternative 1: Overview

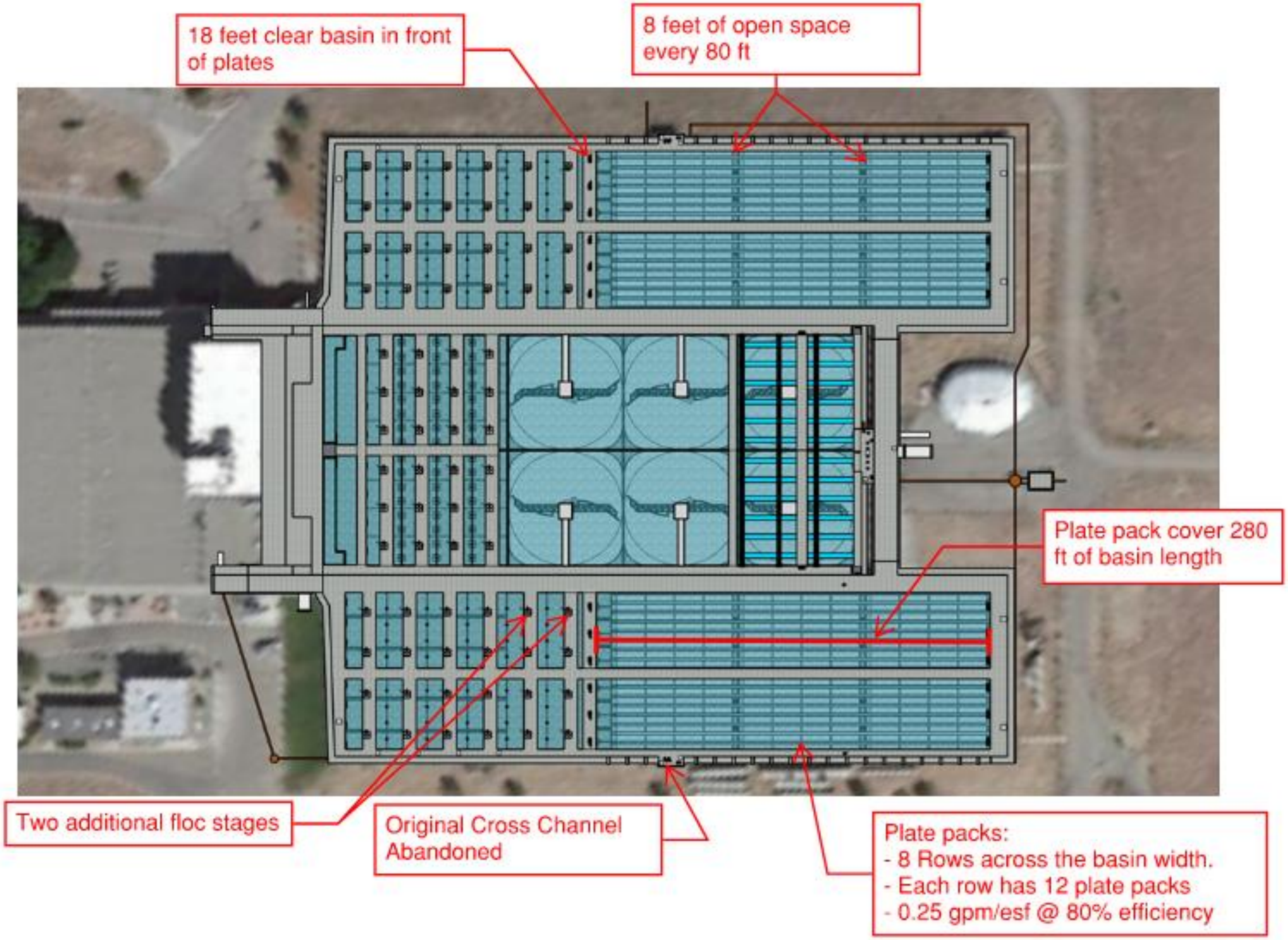


Figure 4.15 Alternative 1: Plan

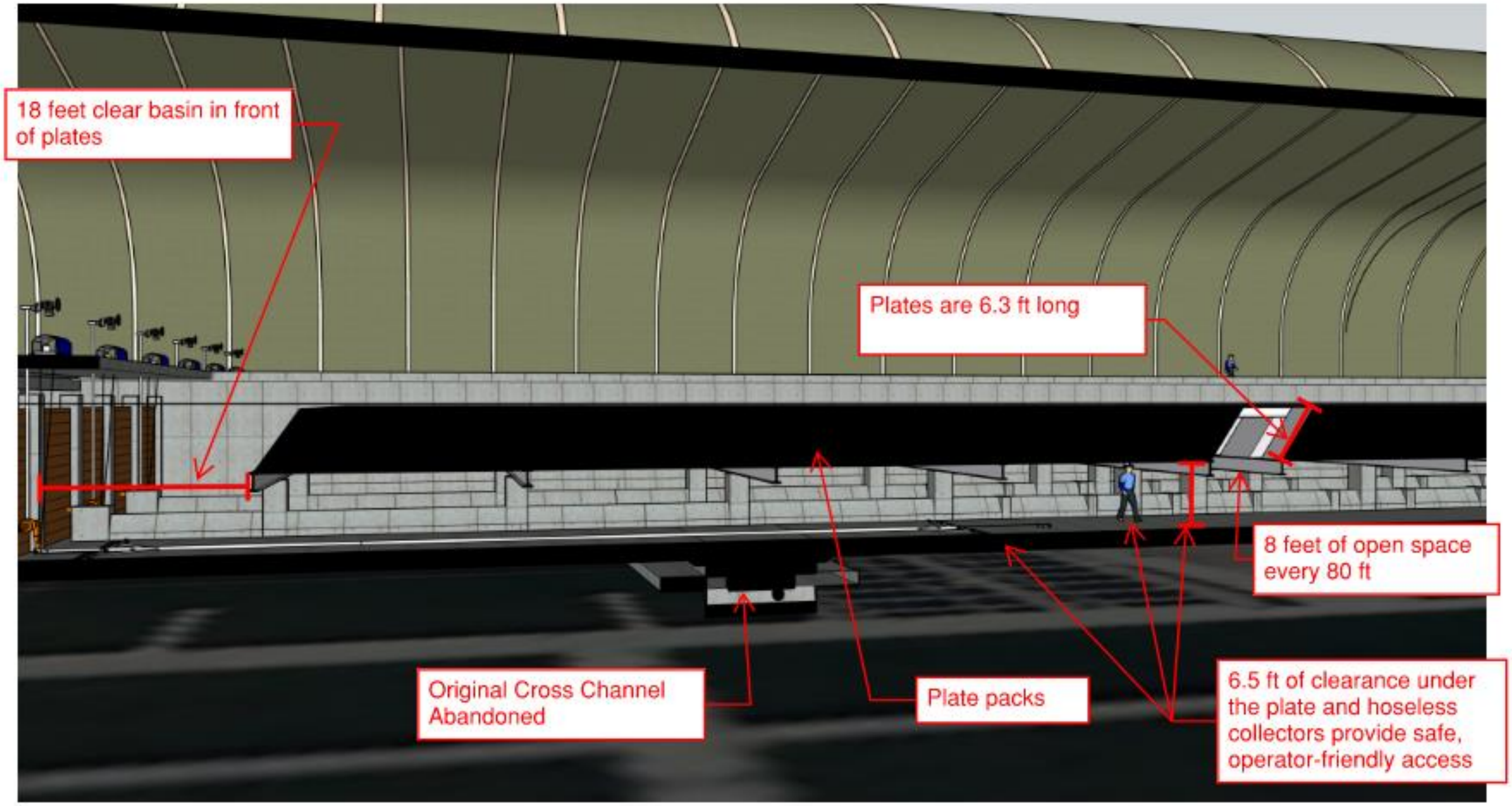


Figure 4.16 Alternative 1: Longitudinal Section

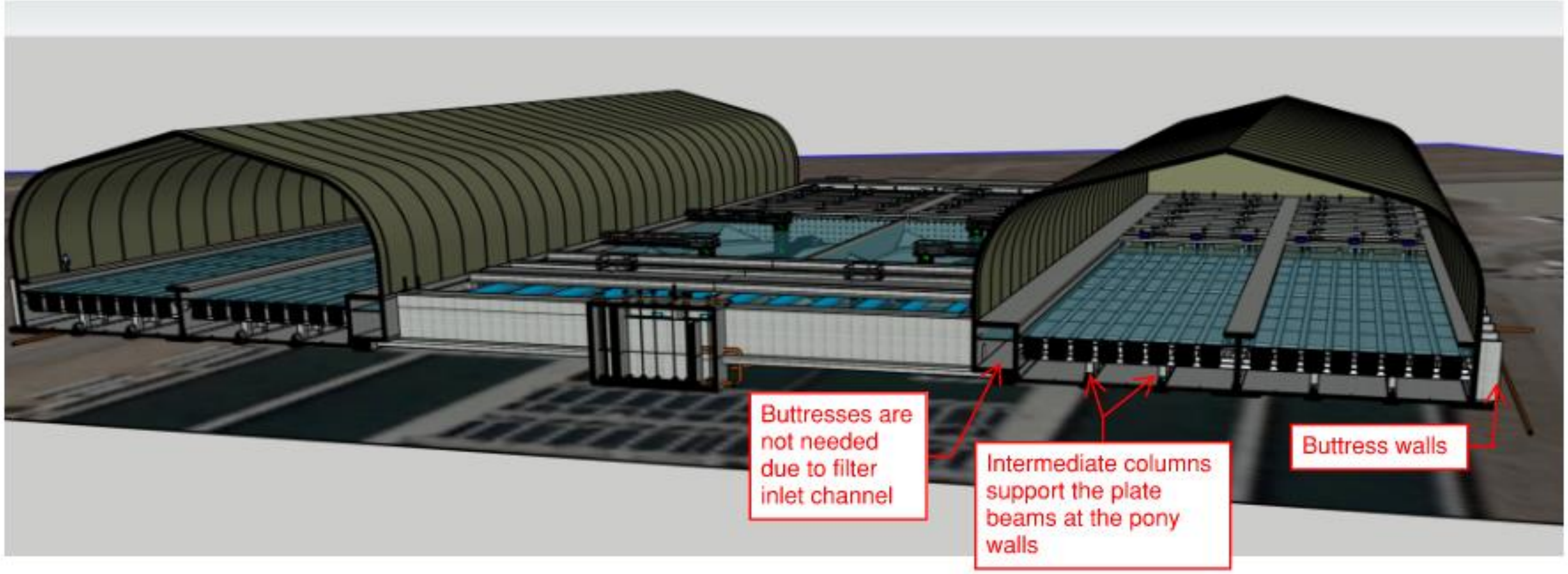


Figure 4.17 Alternative 1: Cross Section

4.4 Alternative 2 - Constructing Additional Open Flocculation/Sedimentation Basins (Expansion to 233 mgd)

The 0.75 gpm/ft^2 reduced surface loading rate impacts Alternative 2 by requiring more sedimentation area and limiting the expansion capacity achievable with two new basins. However, there is sufficient available space on site to achieve the full 255 mgd ultimate capacity with open basins.

The four 1985 basins at JVWTP have a combined flocculation capacity of 124 mgd at the recommended flocculation detention time of 30 minutes but a sedimentation capacity of only 93.3 mgd at the recommended overflow rate of 0.75 gpm/ft^2. The revised alternative extends these basins to provide additional sedimentation area to take advantage of their stranded surplus flocculation capacity. This alternative also adds two new basins identical to the extended basins as shown in Table 4.2 and Figure 4.18 to achieve a firm, reliable capacity of 233 mgd.

Future expansion from 233 mgd to 255 mgd will be identical for both Alternative 1 and 2 and is presented the next subsection.

Table 4.2 Pretreatment Capacities with Expanded 1985 Basins Plus 2 New Open Basins

	Flocculation	Sedimentation
Original Basins (Basins 1,2)	63.5	47.2
Extended 1985 Basins (Basins 3, 4, 5, 6)	124	124
2 Additional Open Basins	62	62
Totals	**249.5**	**233.2** ←

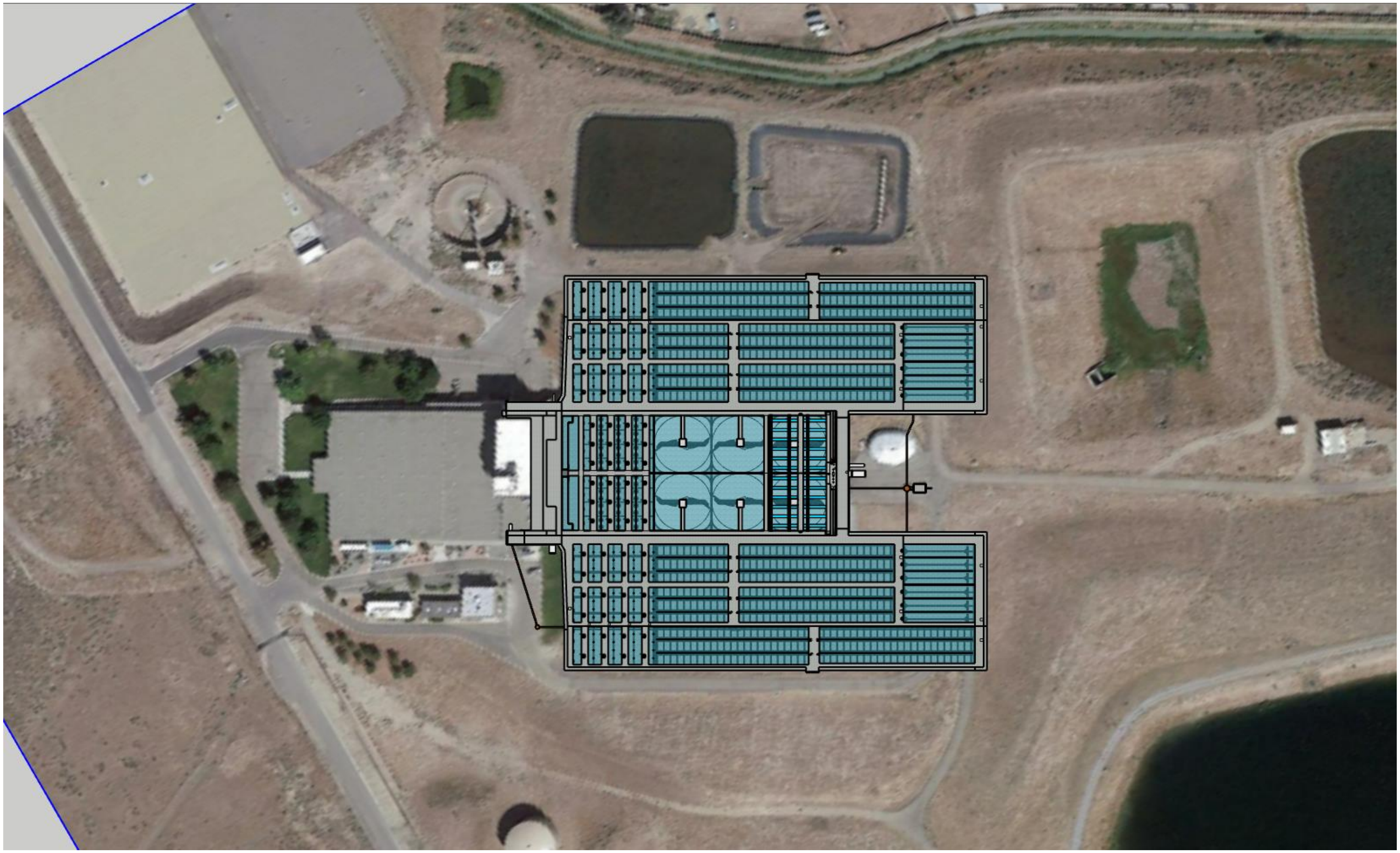


Figure 4.18 Revised Alternative 2: Plan

There is sufficient space on site to accommodate the extended 1985 basins and the two additional basins. However, there are several issues that we address in the subsections below.

4.4.1 Structural Considerations

Extending the basins will require demolishing the eastern settled water channels and relocating them to the end of the extended basins.

As shown previously in Figure 3.1, the 1985 basins included provisions for common-wall construction with future basins to their north and south. New construction may take advantage of that; however, the new basins will be on fill and common wall construction may create settlement challenges. There could be available space in the layout to accommodate separate structures and an additional wall has been included in the costs to cover different implementation scenarios.

The east and west sludge vaults must be relocated if common wall construction is implemented. These vaults may be able to remain in place and serve the new basin if separate structures are implemented.

4.4.2 Civil Challenges for the Northern Basins

Figure 4.19 shows the extended and new building perimeter as it relates to the Reclaim Basins, existing grade, yard piping, and a new 14" BWR line installed with the 2020/2021 Reclaim Water and Solids Handling Improvement Project. The east-west portion of that line has been relocated as shown. The east wide of the new and extended northern basins will cut into the existing embankment for the overflow pond. Three viable options exist for dealing with this interference:

- Relocate the embankment to the east, reducing the size of the overflow pond. This overflow has never been required for plant overflow and is only used for routine basin draining. It can be downsized without impact to operations.
- Construct the east end of the basins to act as a retaining wall and relocate that access road.
- Construct a separate retaining wall that preserves the overflow pond and access road.

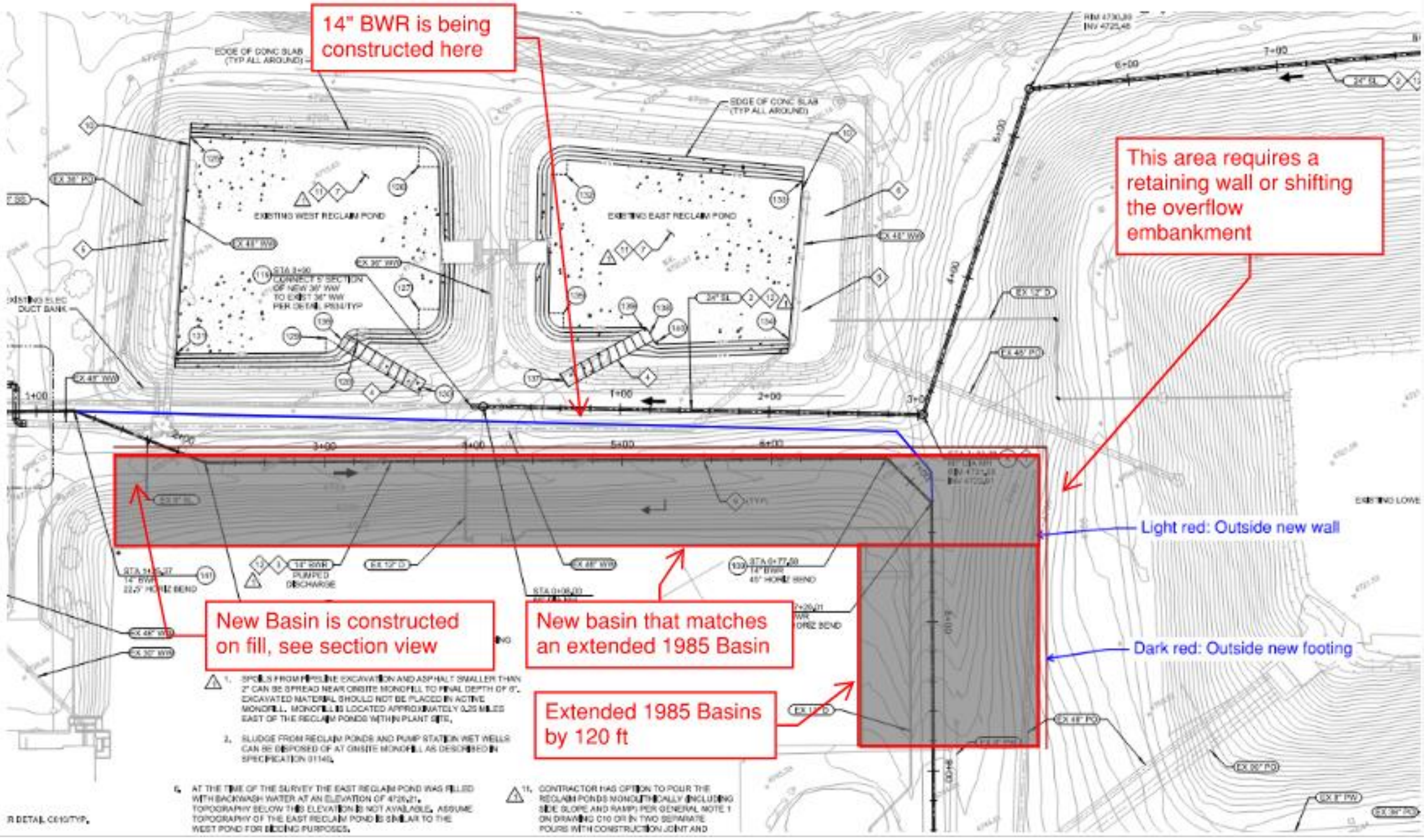


Figure 4.19 Civil Challenges for the Northern Basins

The new northern basin will be built on fill as shown on Figure 4.20. Special provisions will be required to address settlement and either a retaining wall or relocating the access will be required.

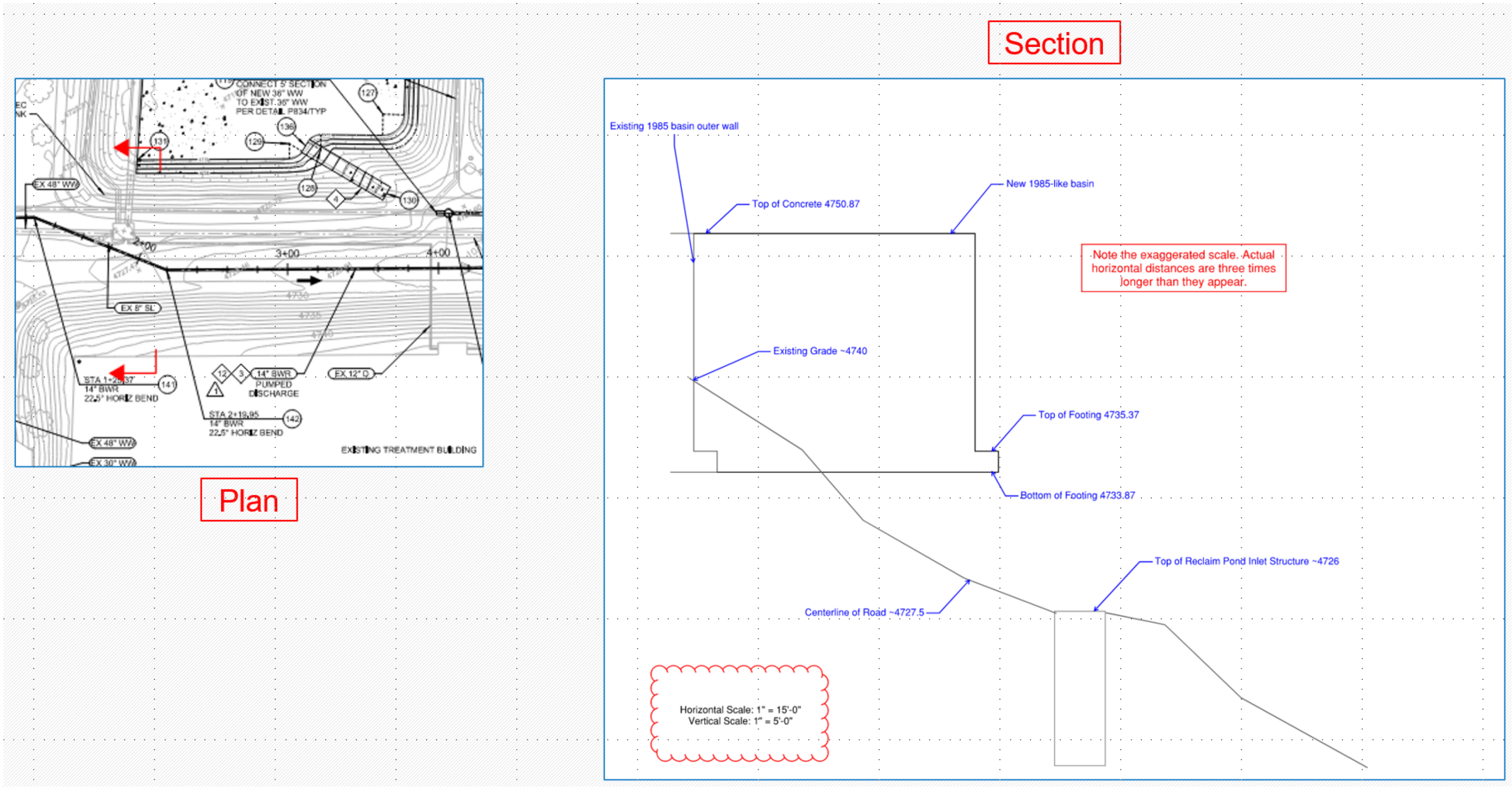
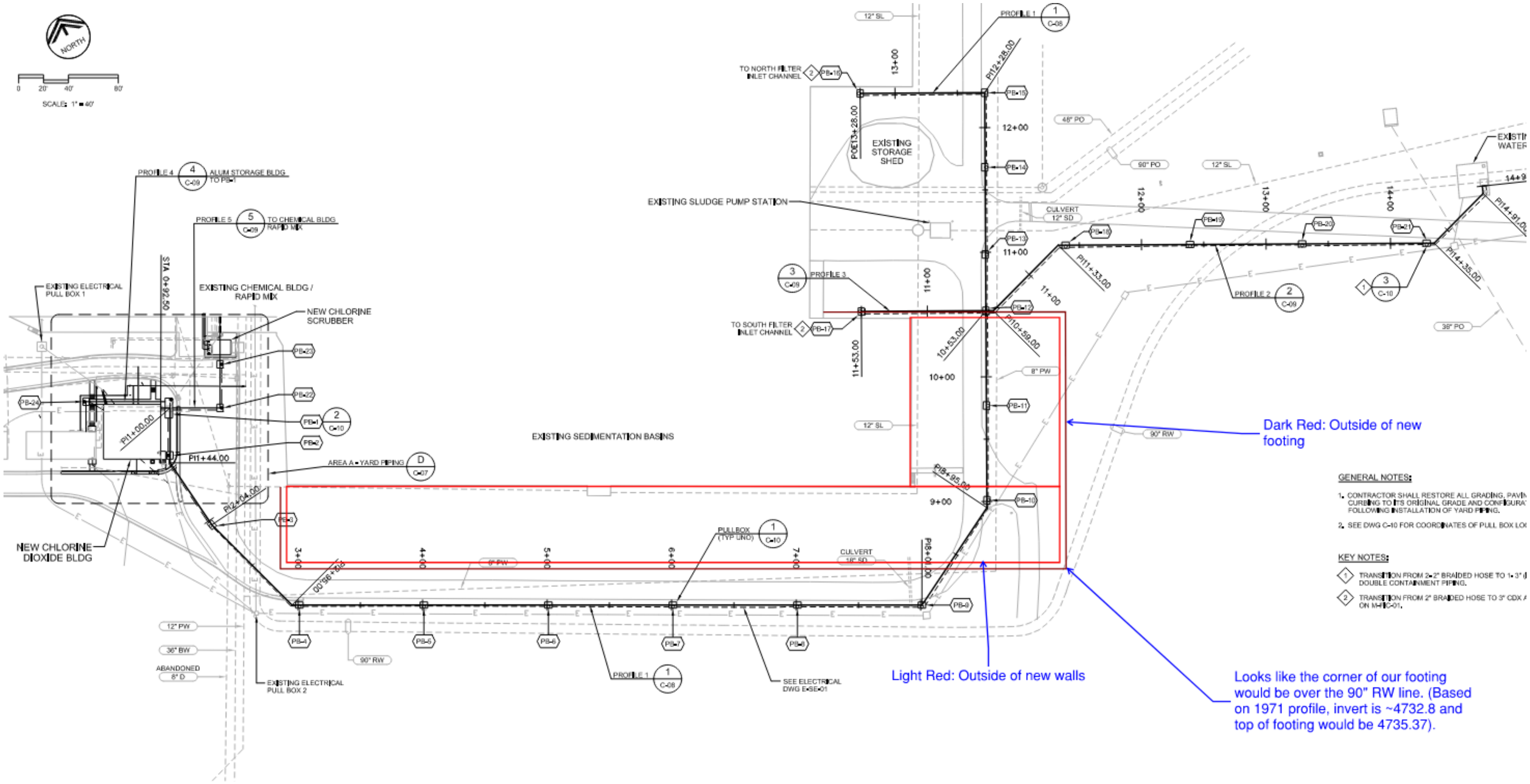


Figure 4.20 Section View for the Northern Basins

4.4.3 Civil Challenges for the Southern Basins

Figure 4.21 shows the civil challenges associated with the southern basins. Extending the southern basins will require relocating the chlorine dioxide double contained piping system and the access road. In addition, the new basin is likely to encroach on the 90" raw water line which may need to be relocated to accommodate the full basin.



Dark Red: Outside of new footing

Light Red: Outside of new walls

Looks like the corner of our footing would be over the 90" RW line. (Based on 1971 profile, invert is ~4732.8 and top of footing would be 4735.37).

Figure 4.21 Civil Challenges for the Southern Basins

4.4.4 Impacts to the Sludge Collection Equipment Replacement Project

Revised Alternative 2 has no impact on the planned Sludge Collection Equipment Replacement project. The 1985 basin chain and flight can be replaced with either chain and flight or hoseless collectors, and either can remain operational when the basins are extended. The extended basins could be equipped with hoseless collectors or chain and flight. The later would require a second cross channel and additional costs.

4.5 Expansion from 233 mgd to 255 mgd

The two original basins at JVWTP have a combined flocculation capacity of 63.5 mgd at the recommended flocculation detention time of 30 minutes but a sedimentation capacity of only 47.2 mgd at the recommended overflow rate of 0.75 gpm/ft^2. Table 4.3 shows that either Alternative 1 or 2 can be expanded to 249 mgd by extending the original basins to provide additional sedimentation area to take advantage of their stranded surplus flocculation capacity. The basins can be extended by 33 percent and installing a fourth circular sludge collector. Figure 4.22 provides a visual comparison of the existing JVWTP, and what it would look like after implementing Alternative 1 and extending the original basins to achieve 249 mgd.

Once the original basins are extended, expanding the pretreatment capacity to 255 mgd can be accomplished by operating at design criteria that is only 2.4 percent more aggressive: 0.77 gpm/ft^2 surface loading rate and 29.3 minutes flocculation time. The process impacts of this slight change during only the highest plant production would be negligible.

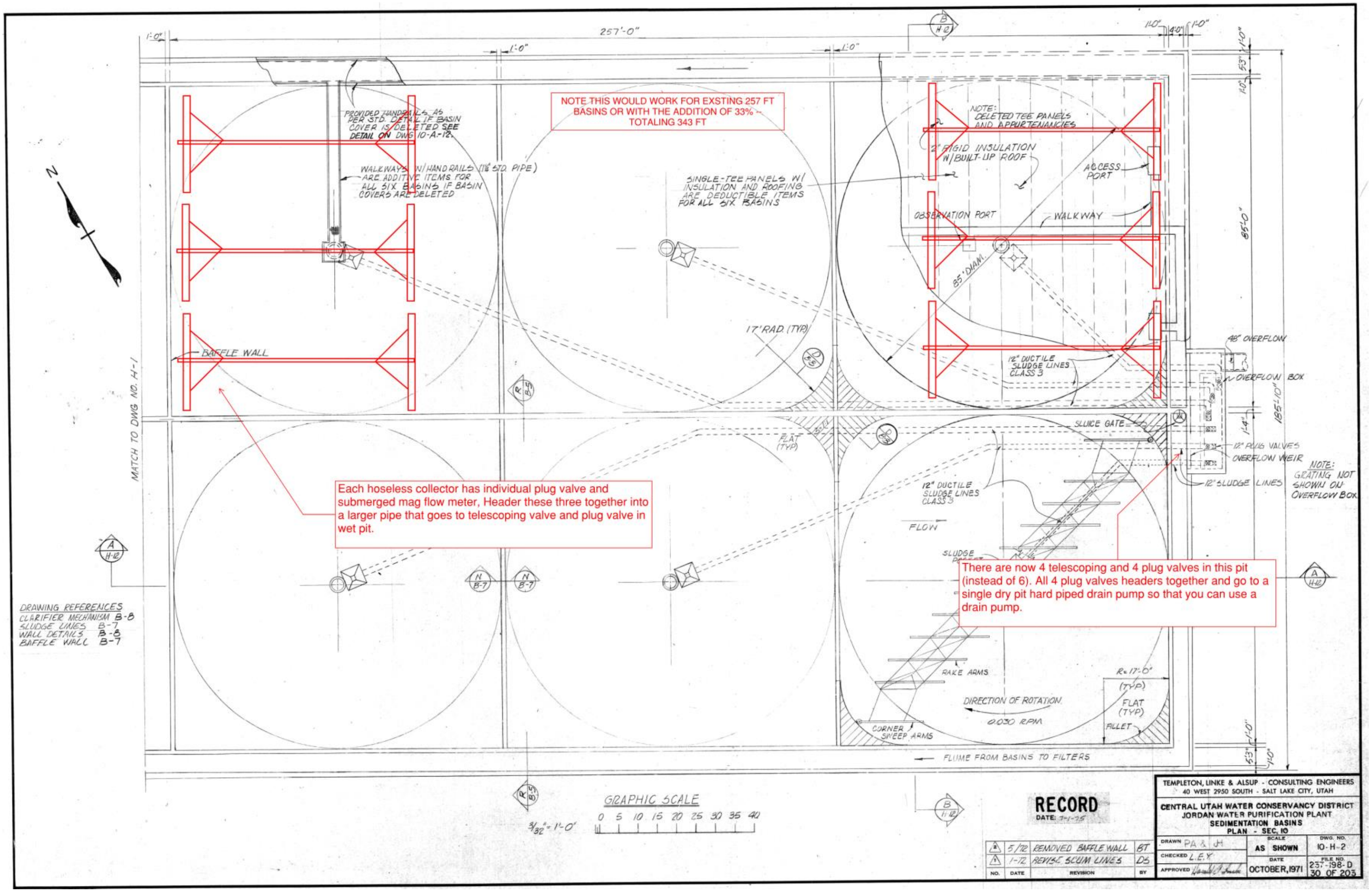
Table 4.3 Pretreatment Capacities with Expanded 1985 Basins Plus 2 New Open Basins

	Flocculation	Sedimentation
Extended Original Basins (Basins 1,2)	63.5	62.8
Alt 1 (1985 Basins with Plates) -- OR -- Alt 2 (Extended 1985 plus 2 new Basins)	186	186
Totals	**249.5**	**248.8** ⟵

Figure 4.22 Existing Plant vs Revised Alternative 1 with Extended Original Basins

Extending the original basins is feasible but will be more complicated and expensive compared to extending the 1985 basins due to the east sludge vault, overflow channel, and cross over channels. The cost may not be worth the additional capacity. An alternate expansion strategy maybe to simply operate the entire plant at a more aggressive loading rate. For example, operating the 233 mgd firm capacity facility at 255 mgd would result in a surface loading rate of 0.82 gpm/ft^2, substantially lower than the 1.0 gpm/ft^2 loading rate of the existing facility at 180 mgd.

Under this scenario, it is possible and may be more practical to improve the original basin performance by retrofitting the original basins with hoseless collectors. In so doing, longitudinal baffles can be installed to trifurcate each basin and improve its L:W ratio to 9:1. This, coupled with a uniform basin cross section, would dramatically improve the original basin performance at any surface loading rate. Figures 4.23 and 4.24 show this concept. This would require a major project, but it could be applied to extended basins as well.



NOTE THIS WOULD WORK FOR EXSTING 257 FT BASINS OR WITH THE ADDITION OF 33% -- TOTALING 343 FT

Each hoseless collector has individual plug valve and submerged mag flow meter, Header these three together into a larger pipe that goes to telescoping valve and plug valve in wet pit.

There are now 4 telescoping and 4 plug valves in this pit (instead of 6). All 4 plug valves headers together and go to a single dry pit hard piped drain pump so that you can use a drain pump.

Figure 4.23 Hoseless Collector Retrofit Concept for Original Basins: Plan

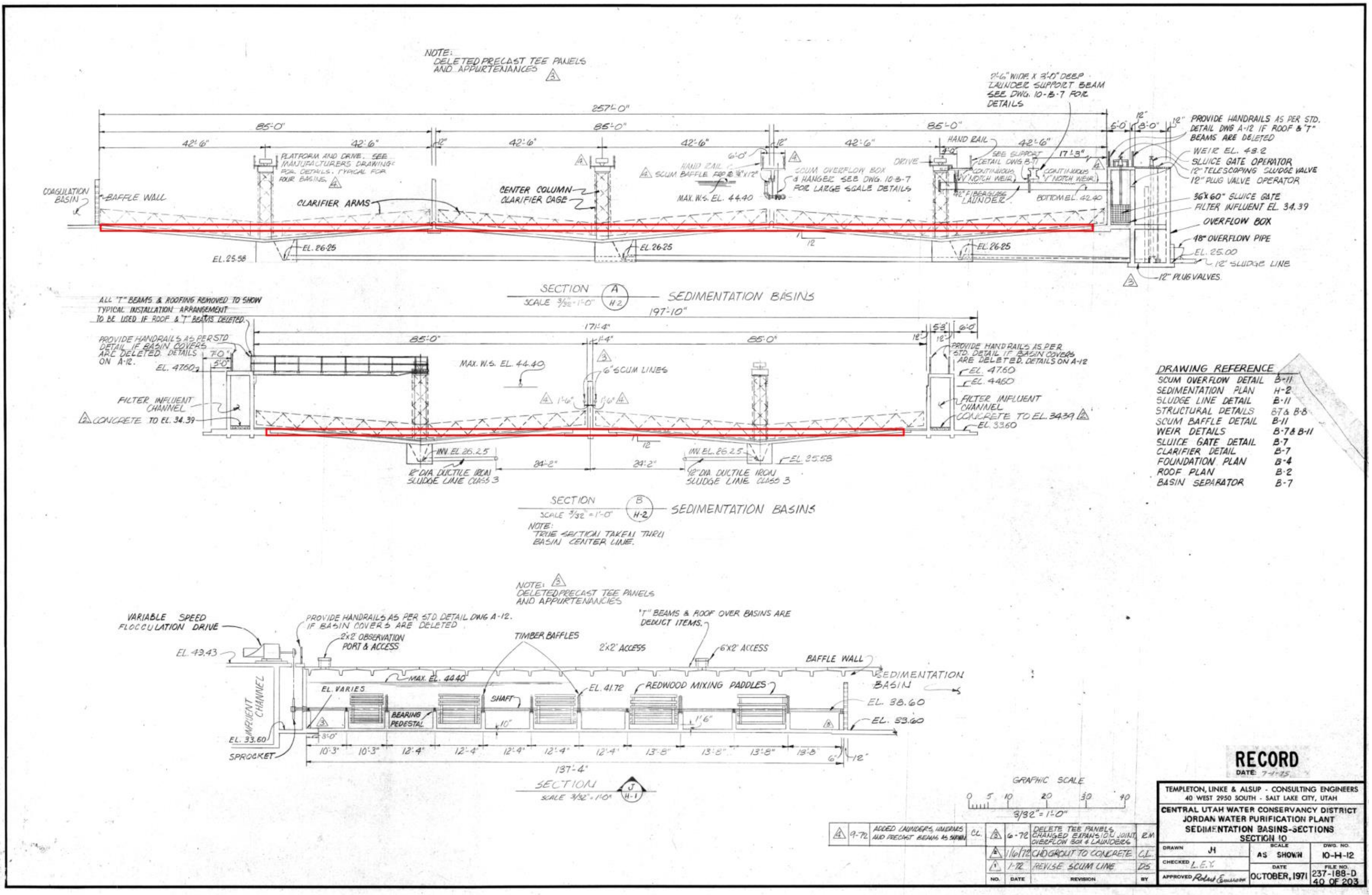


Figure 4.24 Hoseless Collector Retrofit Concept for Original Basins: Section

Section 5

IMPLEMENTATION COSTS

This section presents updated cost estimates for implementing the two alternatives discussed in Section 2, Alternative 1 - Adding Plates to the Existing 1985 Sedimentation Basins and Alternative 2 - Constructing Additional Open Flocculation/Sedimentation Basins.

5.1 Alternative 1 - Adding Plates to the Existing 1985 Sedimentation Basins

Table 8 from the JVWCD Jordan Valley Water Treatment Plant Capacity and Site Optimization Study completed in April 2016 is included as Table A.1 in Appendix A for reference. This estimate included all modifications to facilities necessary for future expansion to a capacity of 255 mgd including those to filters, disinfection, sludge, and FWW and the addition of ozone. Herein we have confined our analysis to only those costs associated with modifying/expanding the flocculation/sedimentation basins.

5.1.1 Demolition

While this alternative seems much simpler on the surface - just adding plates to the existing basins, there is still demolition and repair work inside the basins that would be necessary. This includes removal of existing sludge removal equipment and removal and repair of concrete corbels to allow for installation of the plate settler modules. With the additional plate packs, this alternative now requires filling in the cross channel and removing its concrete deck.

5.1.2 Flocculation Addition

Two additional flocculation stages are required to provide 30 minutes flocculation time at higher capacities. This work would include constructing baffle walls, stator baffles, overhead walkways to support the flocculators, and installing flocculators.

5.1.3 Plate Settler Addition

Each plate pack would be approximately 22 feet long by 5 feet wide and weigh over 6,000 pounds. For each 60-foot-wide basin, eight plate packs would be installed across the basin width with 24-inch wide launders separating plate packs. The launders would terminate at and discharge through the basin end wall which would have to be cutout and patched to fit each launder.

For the four 1985 sedimentation basins, 384 plate packs would be needed - 96 plate packs per basin arranged 8 wide by 12 long. To illustrate the size of the job necessary to install these, two crews each with four personnel and a crane operator can unload and set approximately ten units per day. The plate packs will be supported on beams which will be supported on stainless steel columns at the one third and two third's points across the 60-foot-wide basins, corresponding to the existing short wall lines separating the chain and flight sludge collectors. The stainless steel beams and short support columns would be supplied by the plate manufacturer.

The 1985 design anticipated future addition of tube settler modules and additional steel was installed in the basin slab on grade to anchor the support columns at 10 feet spacing. Unfortunately, at a little over 22 feet in length, the plate packs cannot take advantage of these provisions. The existing short wall would have to cut down to a flat base for the columns at the correct spacing, anchors drilled into the slab and anchor plates installed with double nuts to allow for leveling of the support beams. Following installation of all the plate packs the manufacturer would provide a crew to level all the launders.

5.1.4 Sludge Equipment Replacement

Six hoseless collector units would be used in each basin to allow the three shorter units at the head of basins to operate more often to deal with heavier buildup there. As described in Section 4, hoseless collectors are recommended due to the shallow clearance under the plates. Hoseless collectors also less expensive than chain and flight equipment. For comparison purposes, construction costs (materials, labor, contractor overhead and profit) for replacing the JVWTP chain and flight collectors is $3.8 million for chain and flight equipment and $2.2 million for hoseless collectors.

5.1.5 Basin Enclosure

A tension fabric enclosure over the entire 1985 floc/sed basins has been assumed in the cost estimate

5.1.6 Estimated Flocculation/Sedimentation Basin Costs

Table 5.1 presents estimated construction costs for revised Alternative 1 - Adding Plates to the Existing 1985 Sedimentation Basins. The estimated construction cost for the alternative is $38.6 million (present day costs) not including contingencies and engineering/legal/ administration. This compares to the estimated cost of $33.5 million from the JVWTP 2016 study ($26,400,000 for floc/sed basins shown in Table A.1 of Appendix A plus general conditions and electrical/I&C allowances).

The approximate $5 million increase in the current estimate for Alternative 1 is primarily due to the additional plate settler area needed to provide the more conservative loading and increased clearance under the plate packs.

Table 5.1 Updated JVWTP Expansion Alternatives - Construction Cost Estimates

Description	Alternative 1: Plates in 1985 Basins	Alternative 2: New Open Basins	Comments
Demolition	$300,000	$800,000	
Flocculation Addition (2-Stgs)	$1,500,000		
Plate Settler Addition	$16,500,000		
Sludge Equipment Replacement	$1,700,000	$2,700,000	Hoseless Collectors
Basin Covering	$6,300,000		Tension Fabric
Concrete	$500,000	$7,500,000	Alt 1: buttressing
Civil/Sitework	-	$1,000,000	Includes sheet piling
Yard Piping	-	$100,000	
Flocculators	-	$1,100,000	
Misc. Equipment	-	$1,050,000	Gates, Valves, Grading, Baffling
SUBTOTAL	$26,050,000	$14,250,000	
Electrical/I&C	$2,700,000	$4,000,000	
SUBTOTAL	**$29,650,000**	**$18,250,000**	
Contractors O&P/General Conditions (30%)	$8,900,000	$5,500,000	
TOTAL	**$38,550,000**	**$23,750,000**	

5.2 Alternative 2 - Constructing Additional Open Flocculation/Sedimentation Basins

5.2.1 Sitework

As shown in Figure 4.5, additional flocculation/sedimentation basins and extended sedimentation basins have been located to minimize interference with existing major pipelines and utilities. The new basins constructed to the east will have to be sheet piled to protect the adjoining filter waste washwater facilities and additional earthwork is required on the east end to either build a retaining wall into the overflow basin slope or to reduce the size of the overflow basin itself. Allowances for these additional costs have been included in the cost estimate.

5.2.2 Demolition

Required demolition for this alternative would be more extensive. The existing sedimentation basin effluent channel on the south would have to be demolished and replaced. The existing cross collector pump wells would have to be relocated.

5.2.3 Estimated Costs

Table 5.1 presents estimated construction costs for revised Alternative 2 - Constructing Additional Open Flocculation/Sedimentation Basins. The estimated construction cost for the alternative is $23.8 million (present day costs) not including contingencies and engineering/legal/administration. This compares to the estimated cost of $21.9 million for the floc/sed basins in the 2016 Study ($15.0 million for the floc/sed basins in Table 4 of the 2016 Study report plus adjustments for electrical/I&C and general conditions).

5.3 Recommendations

As shown in Table 5.1, the low-cost alternative to expand JVWTP to a firm, reliable 233 mgd constructs new open basins and extends the 1985 sedimentation basins to provide more settling area. It is possible to achieve the same firm, reliable capacity by installing plates within the existing 1985 basins, but this alternative is 60 percent more expensive, adding $14.8 million of capital cost.

Additional expansion to 255 mgd is possible with significant modifications to the original Basins 1 and 2 and by operating at slightly more aggressive loading rates as described in Section 4. Developing the costs for these modifications was beyond the scope of this project.

5.4 Costs for Recommended Modifications to Improve Process Performance

As detailed in Section 3, several modifications to the existing floc/sed basins are recommended to improve floc/sed process performance. These modifications will improve both the existing plant performance and the performance of either alternative. We recommend implementing these improvements as soon as possible - many can be implemented with the Sludge Equipment Replacement Project or as standalone projects. The recommended modifications include the following:

- Replace of all flocculators in the 1985 and older basins with new units with the correct diameter impellers and shaft lengths.
- Replace existing flocculation baffle walls 2 and 3 to achieve better hydraulic characteristics.
- Implement the use of an anionic/nonionic polymer in the second stage of flocculation as a flocculant aid (developing costs for this improvement is beyond the scope of this project).
- Install longitudinal baffles in the 1985 sedimentation basins to improve hydraulic and process performance (unless plate settlers are installed).
- If hoseless sludge collectors are selected for replacing the existing chain and flights and Alternative 2 New Open Basins is pursued, install a transverse baffle in both the 1985 and new basins to mitigate density currents.
- Modify the flocculation basin inlet gates to allow for automatic adjustment to split flow equally.

Table 5.2 presents estimated construction costs for the additional recommended improvements at JVWTP.

Table 5.2 JVWTP Expansion Additional Recommended Improvements Construction Cost Estimates

Description	Construction Cost
Flocculator Replacement	$3,400,000
Flocculation Baffle Replacement	$400,000
Implement Floc Aid	(TBD)
Longitudinal Baffles (1985 Basins)	$1,250,000
Transverse Baffle (1985 Basins)	$100,000
Inlet Gate Retrofit	$500,000
Subtotal	**$5,650,000**
Electrical/I&C	$350,000
Subtotal	**$6,000,000**
Contractor O&P/General Conditions (30%)	$1,800,000
Total	**$7,800,000**

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Appendix A

TITLE TABLE 8 FROM THE JVWCD JORDAN VALLEY WATER TREATMENT PLANT CAPACITY AND SITE OPTIMIZATION STUDY COMPLETED IN APRIL 2016

Table A.1 Previous JVWTP Expansion Alternatives: Capital Cost Estimates (Table 8 JVWTP Capacity and Site Optimization Study)

Description	Alt.1: Plates in '85 Basins	Alt. 2: New Basins	Alt. 3: New Short Basins	Alt. 4: New 75 mgd WTP	Comments
General Conditions	$10,600,000	$9,700,000	$10,100,000	$11,500,000	Not included in total cost See Section 6.2 15 MG FWR
Civil/Site Work	$900,000	$1,600,000	$1,400,000	$2,900,000	
RWR, 75 MG	$2,900,000	$2,900,000	$2,900,000	$2,900,000	
Yard Piping	$4,000,000	$4,100,000	$4,100,000	$6,000,000	
Landscaping	$150,000	$200,000	$200,000	$500,000	
Plant Inlet Structure	$0	$0	$0	$250,000	
Floc/Sed Basins	$26,400,000	$15,000,000	$20,000,000	$19,200,000	
Filters	$15,600,000	$15,600,000	$15,600,000	$16,500,000	
UV Disinfection	$0	$0	$0	($7,200,000)	
Ozone	$37,500,000	$37,500,000	$37,500,000	$37,500,000	
FWR	$14,000,000	$14,000,000	$14,000,000	$14,000,000	
Chemical Feed Facilities	$5,000,000	$5,000,000	$5,000,000	$10,000,000	
Operations Building	$0	$0	$0	$3,000,000	
Backwash Supply Facilities	$3,000,000	$3,000,000	$3,000,000	$3,000,000	
FWW Basin and PS	$2,500,000	$2,500,000	$2,500,000	$3,000,000	
FWW Clarifiers, PS	$4,500,000	$4,500,000	$4,500,000	$4,500,000	
Sludge Lagoons	$3,000,000	$3,000,000	$3,000,000	$3,000,000	
Electrical	$19,600,000	$17,800,000	$18,600,000	$21,800,000	
Instrumentation	$4,000,000	$3,600,000	$3,800,000	$4,400,000	
Construction Estimate	**$153,650,000**	**$140,000,000**	**$146,200,000**	**$163,960,000**	
Contingency (30%)	$46,100,000	$42,000,000	$43,860,000	$49,190,000	
Escalation to Midpoint	$3,850,000	$3,500,000	$3,660,000	$4,100,000	
Eng. Admin, Legal (20%)	$20,730,000	$28,000,000	$29,240,000	$32,790,000	
TOTAL COST (with ozone)	**$234,400,000**	**$213,500,000**	**$223,000,000**	**$250,100,000**	
TOTAL COST (without ozone)	**$177,200,000**	**$156,400,000**	**$165,800,000**	**$203,900,000**	

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