6975 Union Park Center, Suite 490
Midvale, UT 84047-4135

T: 801.316.9800

Expansion Options Evaluation

Prepared for: Jordan Valley Water Conservancy District

Project Title: JVWTP Expansion Options Evaluation

JVWCD PO No.: 20220687 - 00

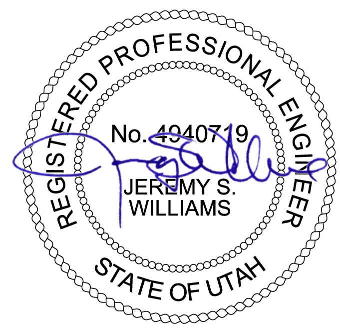
BC Project No.: 157490

Technical Memorandum [No. 1] – Pretreatment Supplement

Date: November 29, 2021

To: David McLean, P.E., Project Manager

From: Jeremy Williams, P.E., Project Manager



Prepared by: Jeremy Williams, P.E.

Reviewed by: Tyler Bird, P.E., Brown and Caldwell

Jason Curl, P.E., Hazen and Sawyer

Limitations:

This document was prepared solely for Jordan Valley Water Conservancy District in accordance with professional standards at the time the services were performed and in accordance with the contract between Jordan Valley Water Conservancy District and Brown and Caldwell dated September 21, 2021. This document is governed by the specific scope of work authorized by Jordan Valley Water Conservancy District; it is not intended to be relied upon by any other party except for regulatory authorities contemplated by the scope of work. We have relied on information or instructions provided by Jordan Valley Water Conservancy District and other parties and, unless otherwise expressly indicated, have made no independent investigation as to the validity, completeness, or accuracy of such information.

Table of Contents

List of Figures

List of Tables

Executive Summary

Jordan Valley Water Conservancy District has planned extensively to expand the Jordan Valley Water Treatment Plant from 180 mgd to 255 mgd. JVWCD also recently completed a draft Hazard Mitigation Plan that identified structural deficiencies in Sedimentation Basins 1&2 as one of the Top 5 mitigation projects to improve system resilience. Additional effort under the Solids Equipment Replacement Project identified a structural deficiency in Sedimentation Basins 3-6 that could be mitigated as part of that project.

The existing plant has a firm capacity of 138 mgd and a hydraulic capacity of 180 mgd. Plant operators notice a drop in settled water performance when operating at flows approaching 180 mgd. This adversely affects filter performance, and expansion plans need to address poor basin performance.

This report supports the following recommendations to phase pretreatment expansion:

- Hydraulics:
  - Move flow split to the end of each basin using the weirs on the plate-settler troughs.
- Flocculation:
  - Improve flocculation in each basin (1-6) by replacing the existing flocculators with new properly designed flocculators, by improving baffling between stages, and by adding provisions for floc aid. Modifications are estimated at approximately $1M per basin.
- Sedimentation:
  - Retrofit sedimentation Basins 1&2 with four additional stages of flocculation and plate settlers; cover the final stage of flocculation and the plates. Use 0.35 gpm/sf @ 80% effective area for plate design.
  - Retrofit sedimentation Basins 3-6 with one additional stage of flocculation and plate settlers; continue to take Basins 3-6 offline each winter, do not cover the plates. Use shorter plates for packs that are 2-ft shorter than in Basins 1&2 and use 0.35 gpm/sf @ 80% effective area for plate design.

Recommendation	Timeframe	Cost
Select plate settlers for Basins 3-6 and select 0.35 gpm/sf @ 80% effective area for plate design in all basins; no cover	November 2021	NA
Include supports in the Solids Removal Equipment Replacement Project for future plate-pack installation in Basins 3-6	December 2021	Design cost only
Install supports in Basins 3-6 for future plate packs, to support the 4-axle chain & flight layout, and as a seismic retrofit	October 2022 – March 2023	$7M
Install plates in Basins 3-6; take Basins 1&2 offline for the retrofit project and convert to downstream flow split; improve all existing flocculation basins; add floc aid	October 2023 – March 2024	$12.3M
Rebuild Basins 1&2 and install plate settlers, including a building covering the plate settlers and final stage of flocculation	October 2023 – April 2025	$26.4M
Total		$45.7M

Figure ES-1 shows Basins 1-6 after pretreatment expansion is complete.

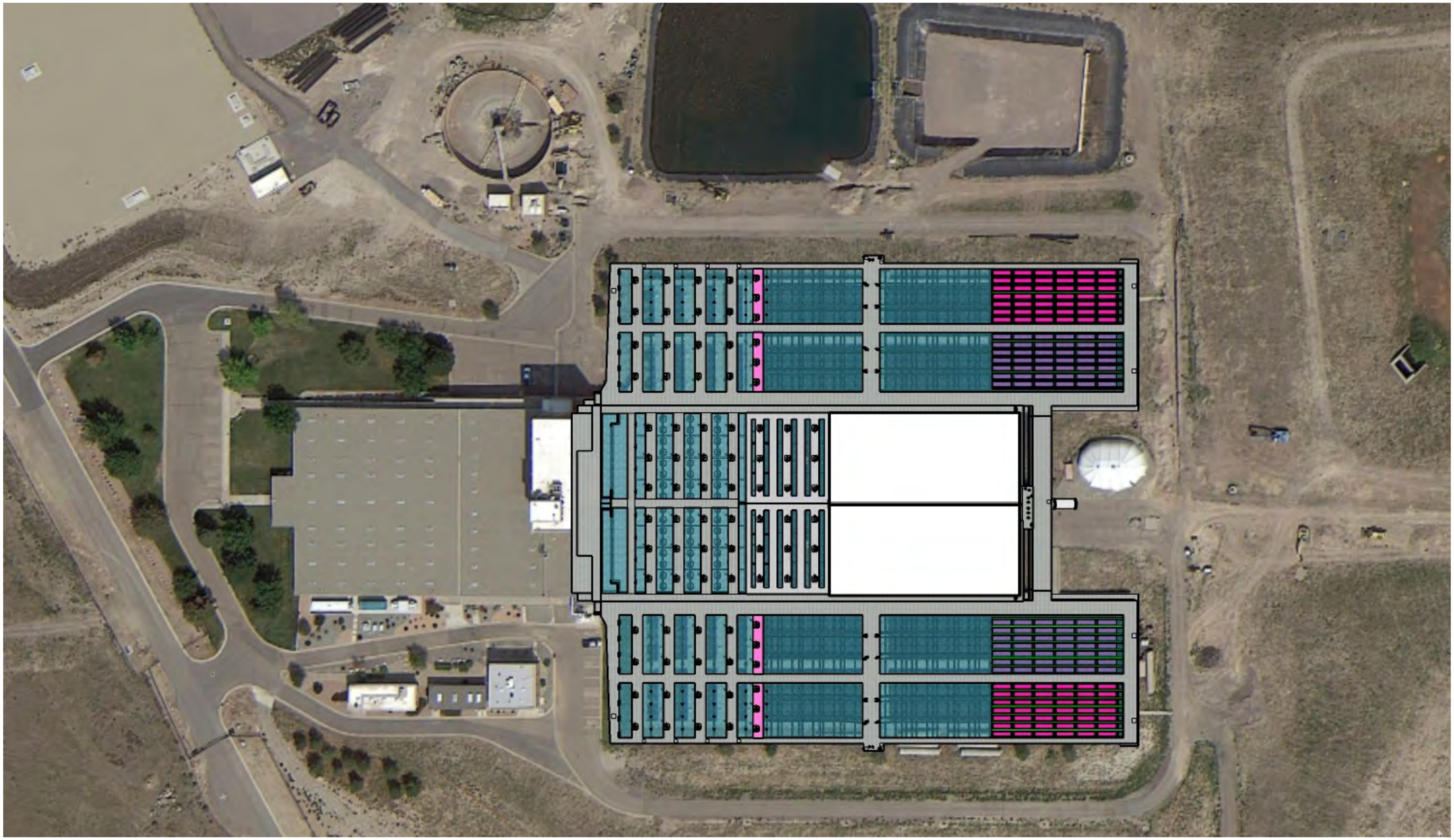


Figure ES-1. Basins 1-6 After Pretreatment Expansion is Complete

Section 1: Introduction

1.1 Purpose

Jordan Valley Water Conservancy District (JVWCD) intends to expand the Jordan Valley Water Treatment Plant (JVWTP) from 180 mgd to 255 mgd. Several alternatives have already been developed and presented to JVWCD. The purpose of this project is to present an additional expansion alternative that retrofits Basins 1-6 to increase capacity and improve process and seismic performance.

This project will:

- Compare design considerations for open basins (current JVWTP configuration) to plate settlers (Basins 1-6) or tube settlers (Basins 3-6),
- Recommend design criteria to support the expansion goal of 255 million gallons per day (mgd), and
- Provide planning-level cost estimates for the recommended alternative.

1.2 Background

JVWCD has planned extensively to expand the JVWTP to 255 mgd, completing the JVWTP Capacity and Site Optimization Study ([Study] Carollo, July 2015) with Supplements 1, 2, and 3 (Carollo, April 2016) followed by the Pretreatment Expansion Update ([Update] Carollo, August 2021). The previous Study and Update evaluated plate settlers in Basins 3-6, new open basins as Basins 7&8, and building a new plant.

JVWCD recently completed a draft Hazard Mitigation Plan (HMP) that identified structural deficiencies in Basins 1&2 as one of the Top 5 mitigation projects to improve system resilience. JVWCD also submitted a grant application through the Federal Emergency Management Agency's (FEMA) Building Resilient Infrastructure & Communities (BRIC) program. If successful, the BRIC grant will fund a significant portion of an upgrade to Basins 1&2 that is described in this Technical Memorandum No. 1 (TM1).

1.3 Plant History

The JVWTP is jointly owned by JVWCD and the Metropolitan Water District of Salt Lake & Sandy (MWDSLS), and is operated by JVWCD. The plant, located in Herriman, Salt Lake County, Utah, was designed in 1971 (constructed and brought online in 1974) as a 42 mgd plant. The original design and construction included two flocculation and sedimentation basins and six tri-media filters.

The JVWTP was expanded to 60 mgd in 1979 by rerating existing processes, and was expanded again to 138 mgd (180 mgd hydraulic capacity) in 1985 by constructing ten additional filters and four additional flocculation & sedimentation basins (Basins 3, 4, 5, and 6). Plant capacity was "expanded" to 180 mgd by pushing the treatment process flows beyond their original design criteria, and with improvements to the flash mix system in 2002. The tube settlers intended for later installation in Basins 3-6 were never installed.

1.4 Gross vs. Net Capacity

A water treatment plant's (WTP) rated capacity can either refer to its gross capacity (output + recycle) or its net capacity (output only). Recycle rates vary from 5-percent to 10-precent. For example, MWDSLS's Little Cottonwood Water Treatment Plant (LCWTP) has a gross capacity of 150 mgd and a net capacity of 142.5 mgd assuming a recycle rate of 5-percent. MWDSLS is actively preparing a Site Optimization Study to rebuild the LCWTP, and the planning team decided to reconcile net capacity as 145 mgd to match delivery (output) requirements, retained the 5-percent recycle rate based on past filter performance, and will plan all processes around a gross capacity of 152 mgd. Salt Lake City Department of Public Utilities (SLCDPU) City Creek Water Treatment Plant (CCWTP) recently completed a Basis of Design Report that selected 10-percent as the recycle rate based on past creek diversions during peak runoff. The planning team decided to reconcile net capacity as 16 mgd to match historical creek flows, applied the 10-percent recycle rate based on raw water turbidity and temperature, and is designing all processes around a gross capacity of 17.6 mgd.

Source water characteristics (e.g., river diversion vs. reservoir outlet) can influence plant performance and therefore recycle rates. Clarification and filtration processes generate a liquid stream to convey solids to solids handling facilities. The JVWTP sends solids removed in the sedimentation basins to one of three solids drying beds. Decant from the beds is returned to the head of the plant (recycled), and treated. Waste backwash water (WBW) is sent to one of two WBW drying beds; a scalping project is currently underway to ‘intercept’ the first few minutes of each backwash while solids concentration is above a certain turbidity value, and send that flow to one of the three solids drying beds for clarification and recycle.

The Update cited 2017 as a particularly challenging year that led to excessive filter backwashes because of poor pretreatment performance and the resulting high settled water turbidity. It is more efficient (i.e., uses less water) to remove solids in the sedimentation basin than to perform more frequent backwashes to remove carryover solids on the filters. Unit Filter Run Volume (UFRV) is a measure of filter efficiency; UFRV is measured in volume treated by a filter divided by the area, or gallons/square-foot. Lower UFRVs indicate lower efficiency and therefore higher recycle rates. UFRVs were very low in 2107.

Recycle rate directly impacts a plant’s ability to produce the ‘rated’ capacity. The typical design range for recycle flows is 5% - 10%. Past plant performance suggests that the JVWTP operates at a recycle rate closer to 10-percent than 5-percent when operating at or near maximum capacity (the real-time recycle rate decreases as flow decreases because process performance improves). Aging facilities, like leaking backwash valves, drain valves, solids removal valves, etc., all contribute to recycle flows and further reduce inefficiencies. The recommended expansion alternative should improve pretreatment performance to promote high UFRVs (e.g., > 10,000 gal/sf), so a 5-percent recycle rate would be more appropriate.

Table 1 summarizes flow rates suggested as design criteria for the existing and expanded JVWTP:

Table 1. Recommended Recycle Rate and Associated Plant Production Rate

Criterion	Existing	Expanded
Net Production, mgd	162	255
Recycle Rate at Max Capacity, %	10	5
Gross Capacity, mgd	180	268

Section 2: Open Basin Design Considerations

Large, open sedimentation basins are commonly used for clarification at WTPs across the world. Industry standards typically focus on four main design criteria:

- Surface loading rate (gpm/sf)
- Detention time (hours)
- Cross-basin velocity (ft/min)
- Length-to-width ratio (L:W)

This section summarizes various industry guidelines for the above criteria, provides examples from peer agencies, and summarizes current and projected JVWTP design and operating criteria.

2.1 Literature Review

There are several reference documents commonly used to guide WTP design in Utah:

- The American Society of Civil Engineers (ASCE) Water Treatment Plant Design, 5th Edition, 2012
- MWH's Water Treatment Principles and Design, 3rd Edition, 2012
- Susumu Kawamura's Integrated Design and Operation of Water Treatment Facilities, 2nd Edition, 2000
- Great Lakes and Upper Mississippi River Board's (GLUMRB) Ten States Standards for Water Works, 2018
- Utah Administrative Code (UAC) R309. Environmental Quality, Drinking Water

Table 2 summarizes listed design criteria for open sedimentation basins (no high-rate equipment) from each standard. Note that UAC does not codify surface loading rate (SLR).

Table 2. Sedimentation Design Criteria for Open Basins by Standard

	Source				
Criterion	**ASCE**	**MWH**	**Susumu**	**Ten States**	**UAC 309**
SLR, gpm/sf	0.55 – 0.83[a]	0.5 – 1.0	0.34 – 1.0		
Detention Time, hrs	1.5 – 2.0	1.5 – 4.0	1.5 – 3.0	4	4
Velocity, fpm	2.0 – 4.0[b]	2.0 – 4.0		< 0.5	< 0.5
L:W Ratio	3:1 – 5:1	4:1[c]	5:1[c]		

a. *Assumes warmer water, 10 - 20° C*

b. *Points out that shallower basins are more susceptible to short-circuiting from density and wind currents and to floc carryover as solids accumulate*

c. *Minimum, no maximum given*

As shown in the above table, design criteria for the State of Utah are loosely based on Ten States Standards and are mostly silent to specific design criteria for basin dimensions and loading rate. Detailed design is left to the experience of the owner and/or the designer. For example, the Metropolitan Water District of Southern California (MWD) owns and operates five large surface water treatment plants. All were initially constructed with varying design criteria based on the original designer's opinion. Through decades of experience, MWD has standardized on a surface loading rate of 1.0 gpm/sf based on their raw water quality and corresponding finished water quality goals (MWD, Uniform Approach to Filtration Plant Design Criteria, May 1989).

2.2 Benchmarking JVWTP Basin Performance

Table 3 summarizes JVWTP design criteria at 180 mgd:

Table 3. JVWTP Design Criteria @ 180 mgd

Criterion	Basins 1&2	Basins 3-6	Comments
Basin Flow, mgd	30	30	1985 intended design flows: 23/33.5 respectively, with tube settlers in Basins 3-6
SLR, gpm/sf	0.95	0.96	This should be adequate given warmer temperatures at peak flow and low raw water turbidity; however, the 1985 design intent was to operate Basins 1&2 at 0.74 gpm/sf and operate Basins 3-6 with tube settlers at 2.0 gpm/sf (tube SLR, not basin SLR)
Detention Time, hrs	1.3	1.6	This is low per UAC, but acceptable
Velocity, fpm	3.3	3.8	This is high, and is a result of the shallow basins
L:W Ratio	3:1	6:1	ok

With a surface loading rate of just less than 1.0 gpm/sf, the JVWTP sedimentation basins should function well at peak flow given that peak flow occurs in summer months with warmer water and that the large raw water pond dampens raw water turbidity spikes. For example, Weber Basin Water Conservancy District (WBWCD) intends to expand their Davis North Water Treatment Plant (DNWTP) from 46 mgd to 60 mgd and their Weber South Water Treatment Plant (WSWTP) from 32 mgd to 40 mgd. Table 4 summarizes select sedimentation design criteria and basin dimensions in comparison to JVWTP's Basins 3-6.

WBWCD performed full-scale flow tests at the DNWTP in July 2012 and again in September 2014, and at the WSWTP in September 2014 concurrent with the retest at the DNWTP. Both plants saw raw water turbidity between 20 – 40 NTU with corresponding coagulant doses of 14 – 50 mg/L. WBWCD met their settled water turbidity goals of < 2 NTU for raw water > 10 NTU, and decided to expand by rerating sedimentation basins to surface loading rates equal to or greater than what the JVWTP has found to be insufficient. This was decided with raw water quality significantly worse than what JVWCD experienced in 2017.

Table 4. Comparison of JVWTP Basins to WBWCD's Full-Scale Demonstration Tests

	JVWTP		WSWTP[a]		DNWTP[a]			
Criterion	Basins 1&2	Basins 3-6	Existing	Expanded	Existing, 1-6	Expanded, 1-6	Existing, 7-8 [b]	Expanded, 7-8 [b]
SLR, gpm/sf	0.95	0.96	0.88	1.10	0.41	0.53	0.74	0.96
Detention Time, hrs	1.3	1.6	2.4	1.9	3.0	2.3	2.0	1.5
Velocity, fpm	3.3	3.8	1.5	1.9	1.0	1.3	1.9	2.5
L:W Ratio	3:1	6:1	5:1	5:1	4:1	4:1	6:1	6:1
Depth, ft	10	12.2	16	16	10	10	12	12

a. *Source: Weber South and Davis North Capacity Optimization Study, Carollo, January 2013*

b. *Each basin has a longitudinal baffle wall that doubles the effective L:W ratio*

The previous table suggests that basin velocity – the cross-sectional velocity – plays a large part in basin performance. JVWTP's Basins 3-6 are proportionally almost identical to DNWTP's Basins 7&8 (both are classic Susumu designs), but note that while JVWTP's basins are proportionally larger in length and width, they are the same depth, so area does not increase proportionally. This results in significantly higher basin velocity through the JVWTP's basins than through the DNWTP's basins even though surface loading rate is equal. ASCE's manual seems to agree with this observation:

> "*In theory, basin depth should not be an important parameter either, because settling is based on overflow rates. However, in practice, basin depth is important because it affects flow-through velocity. Flow-through velocities must be low enough to minimize scouring of the settled floc blanket. . . Basin depth may also play a role in allowing greater opportunity for flocculent particle contact. Additional flocculation that takes place as particles settle allows for growth of heavier floc and the formation of a sludge blanket that may be less susceptible to resuspension. The formation of this blanket helps increase the solids content of the residuals withdrawn by removal equipment*." – (4th Edition, Part 7.4)

JVWTP staff have commented that the basins perform well at flows less than 140 mgd, which corresponds to basin SLR of < 0.75 gpm/sf. The 1985 design intent was to install tube settlers in Basins 3-6 for flows above 140 mgd. Without the tube settlers and because of high basin velocity, JVWTP's sedimentation basins may be acting more like basins with a SLR of 1.25 gpm/sf or higher when operating at 180 mgd, and when derated to 0.75 gpm/sf the basins may still be acting like a deeper basin would at 1.0 gpm/sf or higher. This is an important correlation to understand when 'translating' open-basin design criteria to high-rate processes like tube settlers and/or plate settlers.

Section 3: Tube Settler Design Considerations

Basins 3-6 were designed in 1985 with thickened footings, starter columns, and corbels for beams to install tube settlers in the future, see Figure 1. Tube settlers are made from expanded plastic to create tubes at a 60-degree angle within a plastic pack. The tubes improve settling by shortening the length a particle has to travel before it drops out of suspension, increasing the settling area (and capacity) of the basin.

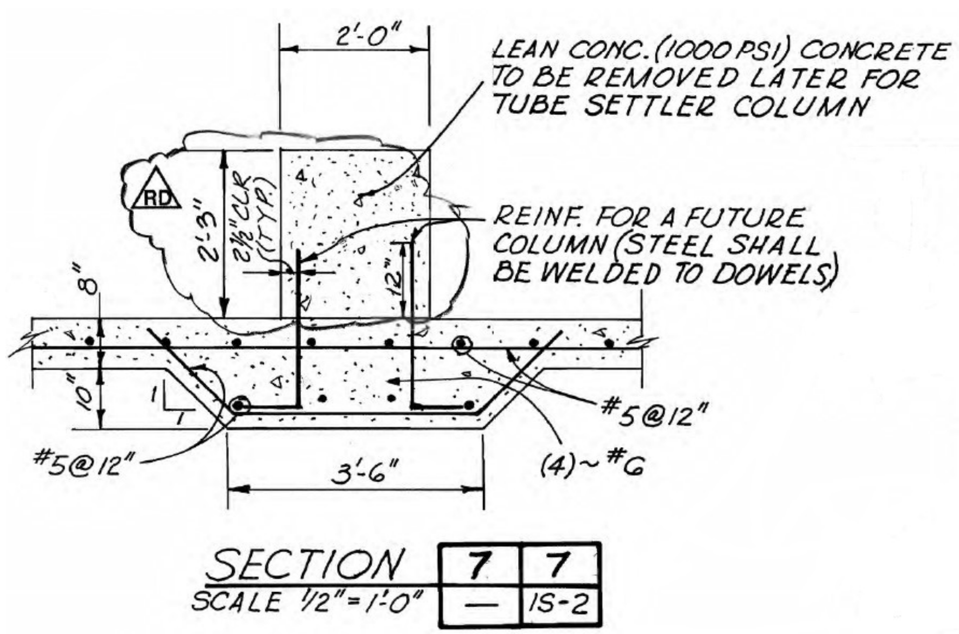


Figure 1. Thickened Footing with Temporary Concrete for Future Column

Tubes are lightweight and could be installed over stainless steel columns and support grid, with either stainless or fiberglass troughs. There are two primary tube settler manufacturers: Brentwood Industries, and MRI; JMS typically supplies supports for Brentwood. Table 5 shows Brentwood's tube-settler product line with associated details.

Table 5. Brentwood Industries Tube Settler Information

Brentwood Product	Vertical Height, inches	Tube Length, inches	Application Rate
IFR-6024	24.0	27.71	2.0 gpm/ft2
IFR-6030	30.0	34.64	2.5 gpm/ft2
IFR-6036	36.0	41.57	3.0 gpm/ft2
IFR-6041	41.0	47.34	3.5 gpm/ft2

3.1 Literature Review

Similar to open-basin design, Table 6 summarizes listed design criteria from each standard.

Table 6. Literature Review of Tube Settler Design Recommendations

	Source				
Criterion	ASCE	MWH	Susumu	Ten States	UAC 309
Derated to, %					
SLR, gpm/sf	1.5 – 3.0	2.5 – 6.25[a]	1.5 – 3.0	</= 2.0	</= 2.0[b]
Fraction of basin covered, %		< 75			

a. *Basin area before the settlers are installed*

b. *Based on 24-inch long 60-degree tubes or 39.5-inch long 7.5-degree tubes*

Note that the State of Utah follows Ten States Standards, and that the recommendation for </= 2.0 gpm/sf is based on a specific tube length. The shorter 2-foot pack is likely what the original design considered, but raising the basin water surface elevation (WSE) provides an opportunity to negotiate with the State to install a deeper tube pack that will cover less area to reduce cost. A deeper tube pack may be necessary to optimize tube area and the corresponding launder length in Basins 3-6 with plate settler trough lengths in Basins 1&2 to better match hydraulics across all basins to optimize flow split.

3.2 Tubes in Basins 1 & 2

Tubes were not considered for Basins 1&2 because tubes cannot provide the target capacity of 70 mgd, each basin.

3.3 Tubes in Basins 3 – 6

Tubes can provide the target capacity of 32 mgd, each basin, for Basins 3-6. Tables 7 and 8 show design criteria for tubes in Basins 3-6 assuming a 3-foot tube pack @ 3.0 gpm/sf.

Table 7. Flocculation, Basins 3-6 with Tubes				
Description	**Units**	**Existing**	**Modified**	**Comments**
Type: Vertical shaft, parallel flow				
1985 Basins	No.	4	4	
Flow Rate, each	mgd	30	32	Increase for 5% recycle
Number of Stages	No.	4	4	
Length	ft	30	30	
Width	ft	60	60	
L:W Ratio		2	2	
Water Depth	ft	12.10	13.50	Raise WSE for Downstream flow split
Volume, Each Basin	gal	652,000	728,000	
Flocculation Time	min	31	33	

Table 8. Sedimentation, Basins 3-6 with Tubes				
Description	**Units**	**Existing**	**Modified**	**Comments**
Flow Rate, each	mgd	30	32	
Length	ft	360	360	
Width	ft	60	60	
L:W Ratio		6.0	6.0	
Water Depth	ft	12.10	13.50	
Volume, each	gal	1,956,000	2,182,000	
Sed Basin Detention Time	min	94	98	
Sed Basin Flow-Through Velocity	ft/min	3.8	3.7	
Surface Area, each	ft2	21,600	21,600	
Nominal Surface Loading Rate	gpm/ft2	0.96	1.03	
Tubes				
effective loading rate	gpm/sf		3.0	Loading rate selected to reduce pack area
required surface area	sf		7,403	
total pack length	LF		124	Length is similar to plates in 1&2
pack end-wall height	ft		6.0	
underflow height	ft		7.5	
underflow velocity	ft/s		0.11	Slightly above Brentwood's 0.10 goal

Figure 2 shows a comparison of an existing basin (upper basin) to a modified basin with tube settlers (lower basin).

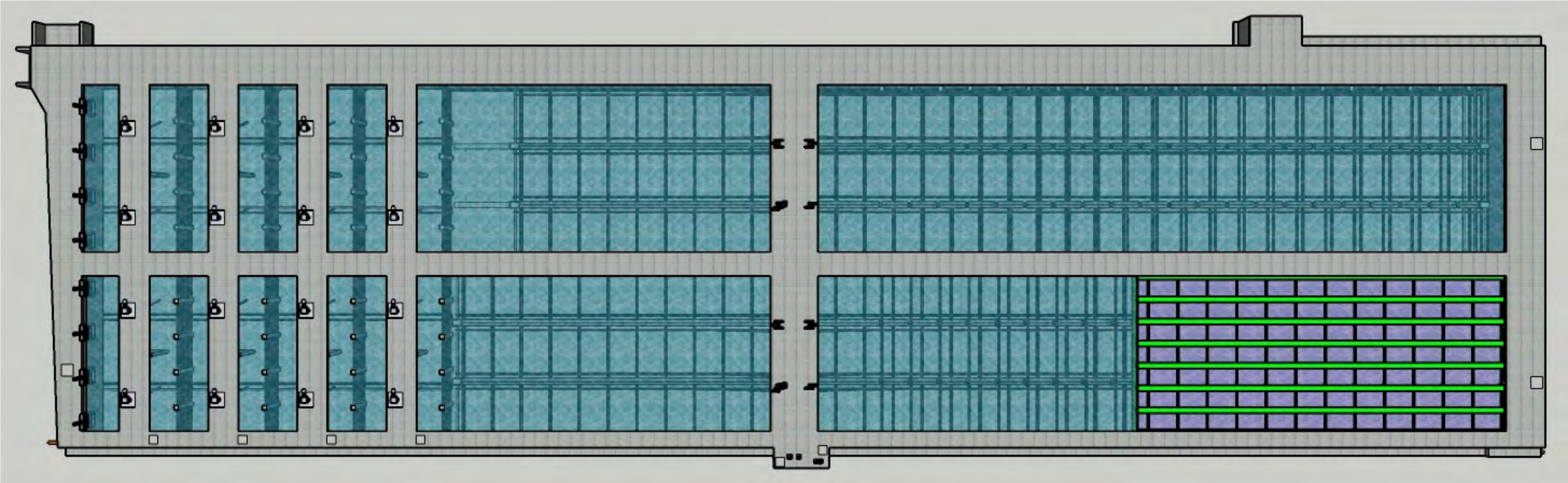


Figure 2. Outer Basin Comparison with 3-ft Tubes @ 3.0 gpm/sf, 32 mgd

3.4 Cover Considerations

The Ten States Standards and most industry literature recommend a cover over tube settlers, primarily for maintenance considerations and because weather events can stir up floc particles that have settled on the tubes and produce a temporary settled water turbidity spike. However, it is not uncommon to see tube settlers in uncovered basins in climates like the Pacific Northwest, Southwest, South, and Southeast regions of the United States. Washington County Water Conservancy District's Quail Creek Water Treatment Plant (QCWTP) in St. George, Utah, has a 20-mgd flocculation/sedimentation train with tube settlers that are not covered. The tubes were installed as part of the original plant construction in 1989 and are nearing the end of their useful life. St. George does not see the same climate and weather conditions as the Salt Lake area, but much more severe ultraviolet (UV) exposure. At 32 years, the tubes have far exceeded their design life.

There are tube settlers at three plants in the Salt Lake area (Parleys WTP, Southeast Regional WTP, and the Don A Christiansen Regional WTP's filter waste washwater recycle plant); all three WTPs have covers over their tubes; however, many installations of tube settler in uncovered basins are found in colder climates like the Midwest and the Northeast. In Aurora, Colorado, the Binney WTP has a treatment train with tube settlers in uncovered basins that runs parallel to a treatment train with plate settlers that are also uncovered. The train with tube settlers has operated uncovered for over ten years without impacts to basin performance. The plant has seen hail damage from extreme weather events common on the western edge of the Great Plains, but the plant has no plans to cover the tubes.

Brentwood also manufactures a protective surface grating they call AccuGrid made from high-density-polyethylene (HDPE) that covers the tube packs, see Figure 3. The AccuGrid system allows operators to walk on the tubes for inspection and O&M activities. It is much easier and cleaner to wash down tubes from the top than from the bottom, and this option greatly improves end-of-season activities when basins are taken offline for the winter. The grating also provides some UV protection.

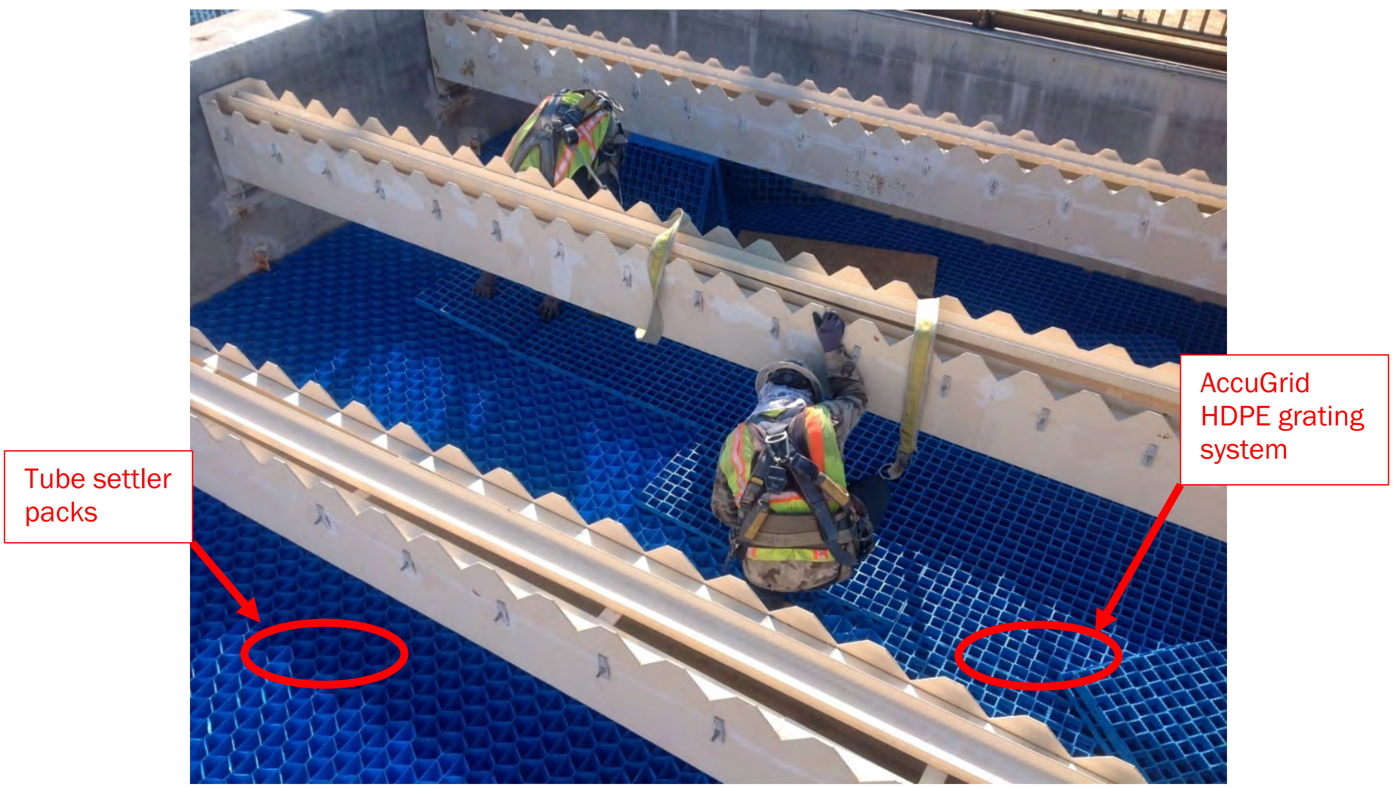


Figure 3. Brentwood Tube Settlers with AccuGrid at the Binney WTP

3.5 Additional Tube Settler Considerations

The Salt Lake area does not see frequent extreme weather events, like tornados and large-diameter hail, as Colorado's Front Range does. The Salt Lake area's UV exposure is also less than in St. George, and with the Binney WTP and QCWTP as reference points, JVWTP's Basins 3-6 do not need to be covered if tube settlers are installed, although a grate like Brentwood's AccuGrid option should be included for O&M considerations and for additional UV protection. The tube settlers are plastic, and while UV inhibitors help to extend service life, JVWCD should program tube settler replacement for 20-year intervals.

Section 4: Plate Settler Design Considerations

Plate settlers are constructed by 'stacking' thin plates at an angle inside a frame to create a 'pack'. Standard plates are 10-feet long and laid at a 55-degree angle; packs can contain over 100 plates, and are generally 5-feet wide, 8-feet tall, and 18-20-feet long. The packs are easily customized for both height and length.

Plate settler area is calculated based on the total projected surface area and then typically derated to account for inefficiencies. For example, a standard 10-foot-long by 4.5-foot-wide plate, installed at an angle of 55-degrees from horizontal, projects an area of 25.8 sf or a little over half of the plate's actual 45 sf. The 25.8 sf, derated for effective area (also called efficiency, typically between 80 percent and 95 percent), is the value used to determine how many plates are needed. A pack with 100 plates provides 2581-sf of projected area while only covering 100-ft of basin area.

4.1 Literature Review

Similar to open-basin design, Table 9 summarizes listed design criteria from each standard. UAC is silent to plate-settler design criteria. Detailed design is left to the experience of the owner and/or the designer.

Table 9. Plate-Settler Design Criteria by Standard

	Source				
Criterion	ASCE	MWH	Susumu	Ten States	UAC 309
Derated to, %				80	
SLR, gpm/sf	0.3 – 0.7	2.5 – 6.25[a]		</= 0.50	
Fraction of basin covered, %		< 75			

a. *This value is for the entire basin area, not for the projected plate area*

4.2 Regional Examples

Four WTPs in Utah have been constructed with plate settlers in the last 15 years: MWDSLS's Point of the Mountain Water Treatment Plant (POMWTP), Central Utah Water Conservancy District's (CUWCD) Ashley Valley Water Treatment Plant (AVWTP) in Vernal, UT, Duchesne Valley Water Treatment Plant (DVWTP) in Duchesne, UT, and Don A Christiansen Regional Water Treatment Plant (DCRWTP) in Orem, UT. The following table summarizes listed design criteria for each WTP with comments on the selected plate loading rate. The first three plants in Utah (POMWTP, AVWTP, DCRWTP) were designed within a fairly narrow range: 0.30 to 0.34 gpm/sf @ 80% effective area. The fourth (DVWTP) was designed to a much lower SLR (i.e., 20-percent more plates) because the plant delivers peak capacity in January under cold-water conditions when particles settle more slowly and require more settling area.

There are two more WTPs in Utah currently in design that will include plate settlers: SLCDPU's CCWTP and Big Cottonwood WTP (BCWTP). Both plants are run-of-the-river plants with short intakes immediately off their respective creek. Because both WTPs are in design, and have not yet been constructed, they are not listed in the table. CCWTP is in design as 0.30 gpm/sf @ 80% effective area because historical raw water turbidity is quite low, coagulant dose is quite low, temperature averages 7-degrees C at peak flow, peak flow occurs for just two weeks on average, and the conservative recycle rate of 10% adds a layer of conservatism. BCWTP will likely be designed to the same surface loading rate even though peak flow is much longer and both turbidity and coagulant dose are higher. The design team will include a grit basin, similar to the grit basin at the LCWTP, to act as a pretreatment buffer under extreme runoff events.

Table 10 summarizes plate-settler design criteria for four Utah WTPs that are in operation or in construction. Considering the information in the table, plate-settler design criteria for the JVWTP is recommended to be on the higher end of the range (e.g., 0.35 gpm/sf) for two reasons:

1. Part of the JVWTP's supply is a turnout off the very end of the 21.5-mile Provo River Aqueduct (PRA). With a capacity of 612 cubic-feet-per-second (cfs), the PRA supplies irrigation water to many turnouts before flow reaches JVWTP's turnout, and acts as a giant settling basin. This shields the JVWTP from large turbidity spikes like those experienced at the DCRWTP.
2. The JVWTP has a 180-million-gallon (MG) raw water storage pond on site. The JVWTP's other source, the Jordan Aqueduct, shares the same Provo River diversion as the DCRWTP, but the JVWTP does not see the same large turbidity spikes because flow is blended with the PRA and pre-settled in the raw water storage pond. Industry guidelines suggest that raw water ponds with at least twelve hours of storage can provide up to 50-percent turbidity removal.

Table 10. Plate-Settler Design Criteria for Utah WTPs

	POMWTP	AVWTP	DCRWTP	DVWTP
Plant Capacity, mgd (current/expanded or future)	70/121 or 151	15/20/30	80/100 (120)	8/12
Reservoir, Y/N	N	Y	N	Y
Raw Water Pond, Y/N	Y	N	N	N
Peak Demand, month	July	July	July	January/July
Derated to, %	80	80	80	80
SLR, gpm/sf	0.30/0.32[a]	0.34/0.45[b]	0.30/0.375[c]	0.25/0.25[d]

a. *The POMWTP will add either 2 or 3 sedimentation basins to expand to the desired capacity, and the plate loading rate will increase slightly based on total plate area installed*

b. *The AVWTP rerated from 15 mgd to 20 mgd in 2012 by rerating filters after sedimentation was installed but without installing more pretreatment. If the AVWTP expands to 30 mgd as planned, more pretreatment will be added and the SLR will reduce to 0.34 to match the original design.*

c. *The DCRWTP rerated from 80 mgd to 100 mgd in 2015 by rerating filters after sedimentation was installed but without installing more pretreatment. If the DCRWTP expands to 120 mgd as planned, more plate settlers will be added and the SLR will reduce to 0.30 to match the original design.*

d. *The DVWTP was designed with a more conservative SLR to improve cold-water settling performance to deliver peak plant flow in January at water temperatures approaching 0-degrees C.*

A post-fire turbidity event in August 2018 illustrates this point. After a wildfire in July, heavy rains in the Provo River watershed produced sediment loads that quickly spiked the river to over 600 NTU. CUWCD monitors the Olmstead Diversion as it is the source for their DCRWTP and JVWCD's JVWTP, and started to prepare as turbidity spiked the night of August 22, 2018, peaking at over 450 NTU at the DCRWTP in the early morning of August 23, 2018 (Note: the lab's benchtop reading was only 227 NTU).

Table 11 shows water quality data at the DCRWTP, MWDSLS's Point of the Mountain Water Treatment Plant (POMWTP), and the JVWTP. Note that the DCRWTP saw a short but extremely high turbidity spike that was over in approximately 24 hours, while the POMWTP and JVWTP saw muted spikes with the turbidity working its way through the PRA and the raw water ponds over several days. The POMWTP saw even lower raw water turbidity than the JVWTP because the PRA is the POMWTP's only source and the POMWTP also has a raw water storage pond. The JA likely carried significant turbidity to the JVWTP's raw water pond before blending with the PRA. These assets – blending the PRA with the JA in the raw water pond – offer significant source protection for the JVWTP, and these assets should not be ignored when selecting process design criteria like SLR. The existing JVWTP basins struggle to treat even mild turbidity events like the plate experienced in 2017, and again after the post-fire event in August 2018, because the basins are so shallow and high basin velocity scours settled particles; however, basins with plate settlers will perform very well if properly designed.

Table 11. Post-Fire Raw Water Quality Comparison at Three Utah WTPs

	Raw Water Turbidity, NTU		
Date	**DCRWTP**	**POMWTP**	**JVWTP**
August 22, 2018	6.2	3.5	4.0
August 23, 2018	**452**	3.9	4.6
August 24, 2018	3.0	**20.0**	**49.2**
August 25, 2018	2.4	17.9	33.0
August 26, 2018	2.6	9.5	15.8
August 27, 2018	6.9	8.8	8.9

4.3 Industry Guidelines

There are two primary plate-settler manufacturers: Meurer Research, Inc. (MRI, now owned by Parkson), and Jim Myers & Sons, Inc. (JMS). Both suppliers offer exceptional support during planning and design. JMS makes a general recommendation of a plate loading rate in the range of 0.20 gpm/sf to 0.50 gpm/sf for water treatment. There are no industry guidelines or technical literature that correlate open-basin design with plate settler design, but Table 12 summarizes JMS's comparison to design criteria for open basins. In general, the lower range (0.25 gpm/sf) is more appropriate for colder water, while the upper range (0.40 gpm/sf) is more appropriate for warmer water.

JMS defines 'difficult' and 'easy' as follows:

- Difficult: Pin floc formation, low density particles, slower settling speed
- Easy: Large floc formation, medium density particles, faster settling speeds

Table 12. Industry Guidelines to Compare Open-Basin and Plate-Settler Design Criteria

Open Basin			Plate Settlers			
SLR, gpm/sf	Detention Time, hrs	Side-Water Depth, ft	SLR – Difficult, gpm/sf	SLR – Easy Water	Eff. Factor, %	Side-Water Depth, ft
0.50	4	>/= 15	</= 0.25	</= 0.30	80	>/= 15
0.75	3	>/= 15	</= 0.30	</= 0.35	80	>/= 15
1.0	2	>/= 15	</= 0.35	</= 0.40	80	>/= 15

The JVWTP uses a polyaluminum chloride coagulant (PACL) at very low doses (3-8 mg/L) to treat what is normally very high-water quality (< 10 NTU, TOC </= 2.5 mg/L). At times, this does lead to pin-floc formation with low-density particles that settle slowly. This would classify as 'difficult'. As noted in the Update, flocculation improvements need to be made, including dosing flocculant aid at stage 2. Improving flocculators, improving baffling between stages, and dosing flocculant aid should be a priority to improve pretreatment performance. These improvements will also shift the JVWTP from 'difficult' to 'easy' on the previous table.

As summarized in Table 10, three of the four WTPs in Utah with plate settlers were designed between 0.30 gpm/sf and 0.35 gpm/sf, which correlates well with Table 4 and the listed WTPs in Utah with open basins designed at 0.75 and rerated to 1.0 gpm/sf. This supports the manufacturer's comparison in Table 12.

4.4 Recommended Plate-Settler Design Criteria for the JVWTP

The following summary of the previous discussion helps shape the recommended plate-settler design criteria for the JVWTP:

- Understanding that Basins 1-6 function more as an open basin with a surface loading rate of 1.0 even when operating at 0.75 gpm/sf (i.e., the basins underperform), and
- Knowing that the PRA and raw water pond provide a significant buffer against turbidity events, and
- Knowing that flocculation improvements will improve settling characteristics, and
- Applying Table 12 guidelines for plate settlers:
  - open basin @ 1.0 gpm/sf & 'difficult' → plates @ </=0.35 gpm/sf
  - open basin @ 0.75 gpm/sf & 'easy' → plates @ </=0.35 gpm/sf

  Then:

- Plate settlers at the JVWTP should be designed with a surface loading rate of 0.35 gpm/sf at 80-percent effective plate area.

4.5 Plates in Basins 1 & 2

Planned seismic improvements for Basins 1&2 provide an opportunity to add four more stages of flocculation, deepen the remaining sedimentation portion, and install plate settlers over hoseless solids collectors. Each basin could be expanded up to 70 mgd assuming 30-minutes of flocculation time and plate settlers at 0.35 gpm/sf at 80-percent effective plate area.

Tables 13 and 14 show flocculation and sedimentation design criteria, respectively.

Table 13. Flocculation, Basins 1 & 2 After Seismic Upgrade

Description	Units	Value	Comments
Type: Vertical shaft, parallel flow			
Old Basins - existing floc	No.	2	
Flow Rate, each	mgd	70	
Number of Existing Stages	No.	4	
Length	ft	26.25	
Width	ft	85.0	
L:W Ratio		1.2	
Water Depth	ft	11.4	Assumes flow split is moved from upstream to downstream so max WSE can be raised by at least one foot
Volume, Each Basin	gal	762,000	
Flocculation Time	min	16	Existing stages provide half of required time
Old Basins - new floc	No.	2	
Flow Rate, each	mgd	70	
Number of new Stages	No.	4	Total of 8 stages
Length	ft	26.25	
Width	ft	82.0	Basins narrow because of sister walls
L:W Ratio		1.3	
Water Depth (average)	ft	12.5	Basin slopes to deeper sedimentation
Volume, Each Basin	gal	806,000	
Flocculation Time	min	17	New stages provide half of required time
Flocculation Time, total	min	32	Rounded, meets required 30-minute minimum

Table 14. Sedimentation, Basins 1 & 2			
Description	**Units**	**Value**	**Comments**
Type: Rectangular, hoseless collectors			
Old Basins	No.	2	
Flow Rate, each	mgd	70	
Length	ft	143.0	
Width	ft	82.0	
L:W Ratio		1.7	
Water Depth	ft	15	
Volume, each	gal	1,316,000	
Sedimentation Detention Time	min	27	
Sedimentation Flow-Through Velocity	ft/min	5.3	Higher velocity is ok when using plates, the packs diffuse the velocity
Surface Area, each	ft2	11,726	
Nominal Surface Loading Rate	gpm/ft2	4.14	Higher basin SLR is ok when using plates, the packs provide the settling area
Plates			
effective loading rate	gpm/sf	0.35	
plate efficiency factor	%	80%	Typical values range from 80% - 95%
required surface area	sf	173,500	
projected area per plate	sf	25.81	
required number of plates	No.	6,722	
plates per plate pack	No.	97	
area per plate pack	sf	2,504	
packs required	No.	70	10 rows, 7 per row (based on similar MRI layouts)

Figures showing the entire construction sequence are included in Appendix A. Figure 4 shows a comparison of an existing basin (Basin 1) to a modified basin (Basin 2). After construction is complete, both basins would be the same.

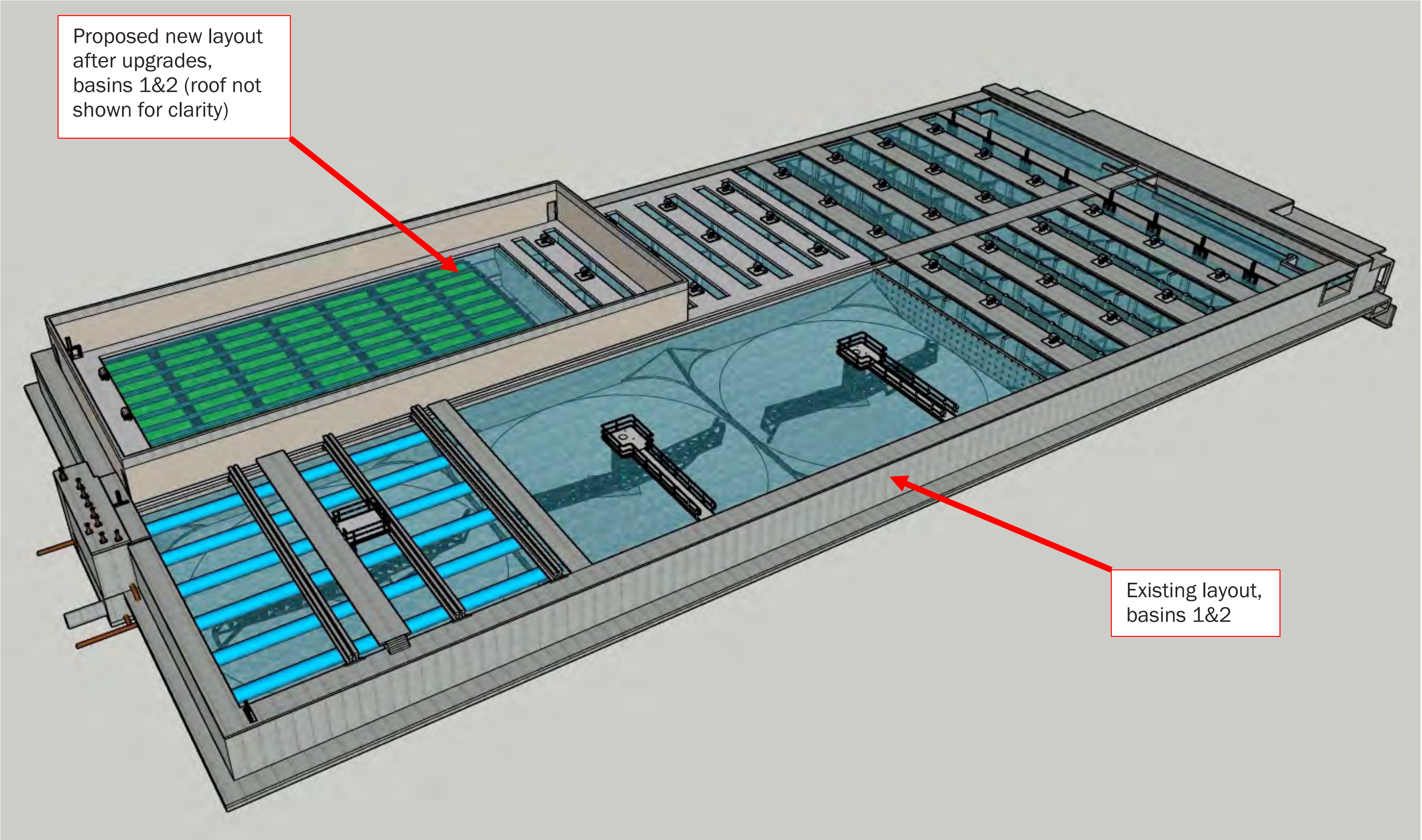


Figure 4. Center Basin Comparison, Existing vs New with Plates @ 0.35 gpm/sf, 70 mgd

4.6 Plates in Basin 3 – 6

Basins 3-6 were designed in 1985 with accommodations (thickened footings for columns and corbels for beams) to install tube settlers in the future. The tube settlers were never installed, but the thickened footings could be used to support concrete or steel columns at 20-feet on-center with steel beams. Plate packs can easily be fabricated to be 20'–0" long to match column spacing; however, Basins 3-6 are quite shallow. With a 12.10-ft side-water depth (see 1985 record drawings, sheet 1M-4), a standard 8-foot-tall plate pack would leave only 4 feet under the plates to access solids removal equipment for operations and maintenance (O&M) or for routine basin cleaning.

There are two options to resolve this clearance issue:

1. Use custom plate packs that are only 6-feet tall – Custom packs will cost more than standard packs because more packs will be required to achieve the needed surface area, but the increased cost is minor compared to the O&M benefits of more room under the packs.
2. Move flow split from upstream to downstream – The JVWTP currently uses four weirs just after flash mix for proportional flow spilt: two weirs of equal length send flow to Basins 1&2, and two longer weirs of equal length send flow to Basins 3&4 and 5&6, respectively. The hydraulic profile @ 180 mgd (1985 Drawing G-2, see Appendix B) shows a drop in WSE of over two feet from the proportional flow split weirs (WSE 4746.20, weir el. 4745.40) to the basin (WSE 4744.10). This headloss is necessary to split flow across the basins because the inlet channel has momentum effects that would favor Basins 1&2 because Basins 1&2 are in line with and immediately downstream of flash mix, while a long tapered channel conveys flow to Basins 3&4 to the north and 5&6 to the south.

   The same headloss could be moved to the downstream side of the basins if the influent channel were modified and plate settlers with troughs were installed in all basins to act as flow-split weirs. Assuming a freeboard of 12-inches below top of wall, the new maximum WSE in the flocculation inlet channel could be as high as 4745.83, or more than 1.5-feet higher than the current WSE.

Both options could (and should) be combined to provide as much clearance under the plates as possible for O&M benefits. Tables 15 and 16 compare current and proposed design criteria for Basins 3-6.

Table 15. Flocculation, Basins 3-6 with Plates

Description	Units	Existing	Modified	Comments
Type: Vertical shaft, parallel flow				
1985 Basins	No.	4	4	
Flow Rate, each	mgd	30	32	Increase for recycle
Number of Stages	No.	4	4	
Length	ft	30	30	
Width	ft	60	60	
L:W Ratio		2	2	
Water Depth	ft	12.10	13.50	Downstream flow split
Volume, Each Basin	gal	652,000	728,000	
Flocculation Time	min	31	33	

Brown AND Caldwell

Table 16. Sedimentation, Basins 3-6 with Plates				
Description	**Units**	**Existing**	**Modified**	**Comments**
Flow Rate, each	mgd	30	32	
Length	ft	360	360	
Width	ft	60	60	
L:W Ratio		6.0	6.0	
Water Depth	ft	12.10	13.50	
Volume, each	gal	1,956,000	2,182,000	
Sedimentation Detention Time	min	94	98	
Sedimentation Flow-Through Velocity	ft/min	3.8	3.7	Higher velocity is ok when using plates, the packs diffuse the velocity
Surface Area, each	ft2	21,600	21,600	
Nominal Surface Loading Rate	gpm/ft2	0.96	1.03	Higher basin SLR is ok when using plates, the packs provide the settling area
Plates				
effective loading rate	gpm/sf		0.35	Reduces to 0.32 with full grid
plate efficiency factor	%		80%	Typical values range from 80% - 95%
required surface area	sf		79,314	
projected area per plate	sf		19.36	Assumes a 6-ft plate
required number of plates	No.		4,097	
plates per plate pack	No.		102	
area per plate pack	sf		1,975	
packs required	No.		40	Install 42 packs to complete the grid (7 rows x 6 packs per row)

Figure 5 shows a comparison of an existing basin to a modified basin with plates. Note that the figure shows seven rows with six packs per row for a total of 42 plate packs. This results in an as-installed effective loading rate of 0.32 gpm/sf. Plate-pack layout could ignore the existing starter columns to install only the required plate area, reducing the total number of plates and packs to meet the design SLR of 0.35 gpm/sf. If this layout is preferred, the area covered by plates in the figure would be less than shown.

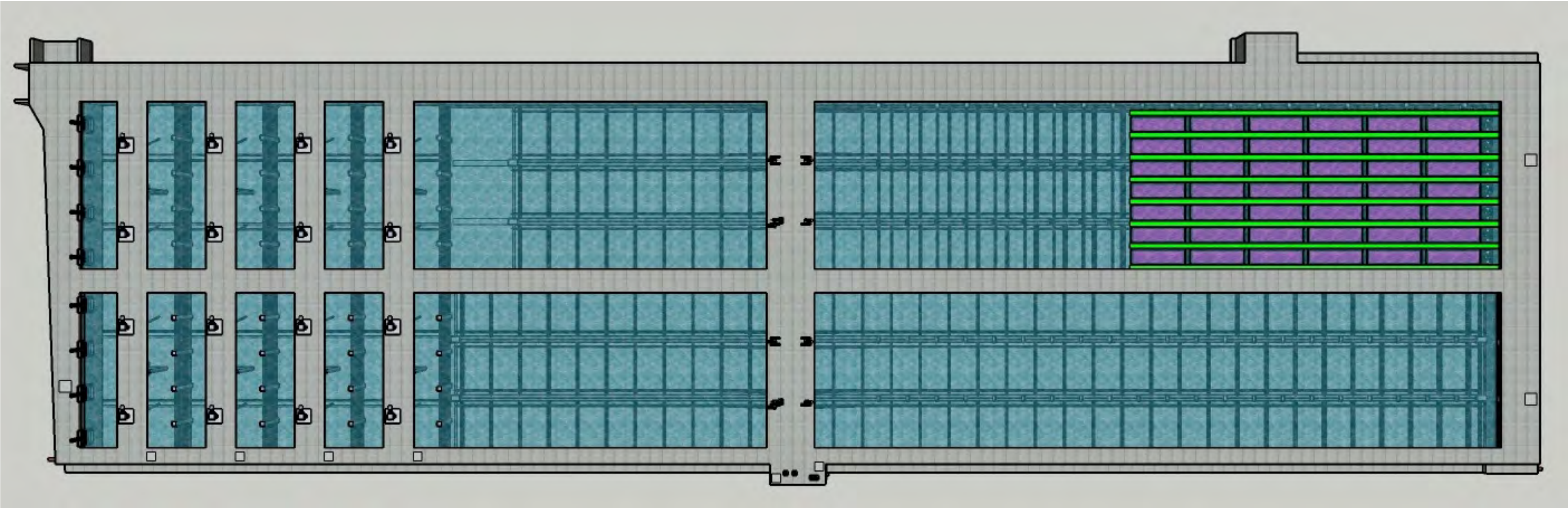


Figure 5. Outer Basin with Plates @ 0.32 gpm/sf, 32 mgd (upper) Compared to Existing (lower)

4.7 Cover Considerations

The Ten States Standards and most industry literature recommend a cover over plate settlers, primarily for maintenance considerations and because weather events can stir up floc particles that have settled on the plates and produce a temporary settled water turbidity spike. However, it is not uncommon to see uncovered basins with plate settlers in climates like the Pacific Northwest, Southwest, South, and Southeast regions of the United States. The Joint Water Commission's JWCWTP near Portland, Oregon (OR), recently retrofit several existing basins with plates and did not install a cover, and Portland Water Bureau's Bull Run Program is currently under design for their Filtration Facility as a greenfield WTP with uncovered sedimentation basins with plate settlers.

All WTPs in Utah with plate settlers are covered with a building, but there are many uncovered installations in the eastern US in cold climates (see Appendix C), and there are several uncovered installations in the Denver, Colorado (CO), area (e.g., Binney WTP, Broomfield WTP) that see similar winter conditions as the JVWTP. One example is the Binney WTP located approximately 25 miles east of Denver, CO, owned and operated by Aurora Water. The basins were built without a cover to reduce construction cost, and the basins have remained uncovered for the last ten years. Discussions with the plant manager suggest that basin performance has not suffered by not having a cover, but operations have suffered, and the plant has started a project to cover the basins for maintenance reasons. Ice on the hoseless collector reel has derailed the cable several times, and taking the basins offline for cleaning or routine maintenance in cold Colorado winters is difficult.

The JVWTP typically only runs Basins 1&2 during the winter and takes Basins 3-6 offline from November to March. Based on feedback from plants in Colorado that see similar climate and weather as the Salt Lake area, if plate settlers are installed, then Basins 1&2 must be covered, but Basins 3-6 do not need to be covered.

4.8 Additional Plate-Settler Considerations

Plates, plate-pack frames, and troughs are fabricated from stainless steel and are more robust and more UV-resistant than tube settlers. Staff can operate Basins 3-6 in the winter if needed, or staff can continue their current practice of draining Bains 3-6 each winter and using Basins 1&2. This supports covering Basins 1&2 but not covering Basins 3-6; JVWCD should program plate settler replacement for 40- to 50-year intervals.

Plate settlers are recommended for Basins 1-6 for the following reasons:

- Consistency across all basins
- Easier to maintain
- Longer design life

Section 5: Additional Expansion Alternatives

Retrofitting Basins 1&2 with additional flocculation, and plate settlers in a building, will require an approximately 18-month construction schedule. This means that the project would reduce the JVWTP's pretreatment capacity to 120 mgd gross with only Basins 3-6 online. All the filters will still be available, and filtration rate will be less than at full plant flow, so it may be safe to assume a 5-percent recycle rate for a net plant production of 114 mgd. This will not be sufficient to meet peak summer demand.

There is enough sedimentation area in Basins 3-6 to construct additional flocculation on the short side and install additional plate settlers on the long side to expand those basins to meet a higher interim capacity.

5.1 Temporary Expansion of Basins 3-6

Basins 3-6 are taken offline each winter, providing an easy opportunity to install plate settlers to improve settled-water performance when Basins 1&2 are offline, and potentially expand Basins 3-6 to meet a target minimum capacity of at least 160 mgd net (168 mgd gross), or 40 mgd per basin net (42 mgd gross).

For example, adding one additional flocculation stage to Basins 3-6 would increase flocculation detention time to maintain the State's minimum flocculation time at a gross flow of 42 mgd for each basin. This additional stage should be 20-ft-long and be divided into three 20-ft compartments with three mixers (one in each compartment). This would reduce the short side of sedimentation from 113'-1" to approximately 93' (1985 Drawing 1S-2); this will have no adverse effect on sedimentation.

Assuming a higher plate SLR of 0.40 to 0.50 gpm/sf for one summer to avoid over-installing plates, the same amount of plates required for 32 mgd could be pushed to 0.44 gpm/sf. This rate may not meet JVWCD's settled water turbidity goal of < 1.0 NTU when raw water turbidity is < 10 NTU, but would likely be similar to current plant performance, which may be acceptable for one more summer until the expansion project is complete. One additional row of plate packs could be installed to reach a SLR of 0.38 gpm/sf, and an additional half row could be installed to reach 0.35 gpm/sf at 42 mgd each basin.

Tables 17 and 18 summarize temporary high-rate design criteria for Basins 3-6 if an additional flocculation stage is installed, but no additional plate packs are installed:

- Existing – open basins @ 30 mgd
- Modified – raise side-water depth by 1.4 ft; install plate settlers for 32 mgd at 0.35 gpm/sf @ 80%
- Expanded, Temporary (this is the temporary condition for one summer while Basins 1&2 are out of service) – raise side-water depth by 1.4 ft; construct a 5th stage of flocculation to maintain code minimum of 30 minutes detention time at 42 mgd; install plate settlers for 32 mgd at 0.35 gpm/sf @ 80%, but operate at 0.44 gpm/sf @ 80% for one summer
- Expanded, Permanent (this is the permanent condition after Basins 1&2 are rebuilt and flow through Basins 3-6 is reduced) – maintain side-water depth increase; 5th stage of flocculation installed for 42 mgd increases flocculation time at 32 mgd; operate plate settlers at 32 mgd at 0.35 gpm/sf @ 80%

Table 17. Flocculation, Basins 3-6 with Additional Capacity

Description	Units	Existing	Modified	Expanded, Temporary	Expanded, Permanent
Type: Vertical shaft, parallel flow					
1985 Basins	No.	4	4	4	4
Flow Rate, each	mgd	30	32	42	32
Number of Stages	No.	4	4	***5*** [a]	***5*** [a]
Water Depth	ft	12.10	13.50	13.50	13.50
Volume, Each Basin	gal	652,000	745,000	850,000	850,000
Flocculation Time	min	31	34	32	38

a. Additional floc stage is 20-ft long and has three mixers per stage, one per compartment; compartments are 20'x20' to match the thickened footings in the short side of the sedimentation basins to reduce structural impacts (existing compartments are 30'x30' with two mixers each stage)

Table 18. Sedimentation, Basins 3-6 with Additional Capacity					
Description	**Units**	**Existing**	**Modified**	**Expanded, Temporary**	**Expanded, Permanent**
Flow Rate, each	mgd	30	32	42	32
Length	ft	360	360	340	340
Width	ft	60	60	60	60
L:W Ratio		6.0	6.0	5.7	5.7
Water Depth	ft	12.10	13.50	13.50	13.50
Volume, each	gal	1,956,000	2,182,000	2,061,000	2,061,000
Sedimentation Detention Time	min	94	101	71	93
Sedimentation Flow-Through Velocity	ft/min	3.8	3.6	4.8	3.7
Surface Area, each	ft2	21,600	21,600	20,400	20,400
Nominal Surface Loading Rate	gpm/ft2	0.96	1.03	1.43	1.09
Plates					
effective loading rate	gpm/sf		0.35	0.44	0.35
plate efficiency factor	%		80%	80%	80%
required surface area	sf		79,314	82,807	79,314
projected area per plate	sf		19.36	19.36	19.36
required number of plates	No.		4,097	4,277	4,097
plates per plate pack	No.		102	102	102
area per plate pack	sf		1,975	1,975	1,975
packs required	No.		40	42	40
packs installed	No.		42	42	42
actual effective loading rate	gpm/sf		0.33	0.44	0.33

Figure 6 shows a comparison of the footprint for plate settlers rated for 32 mgd at 0.35 gpm/sf @ 80% (Basin 6) to the footprint for plate settlers rated for 42 mgd at 0.35 gpm/sf @ 80% (Basin 5), including the required stage-5 flocculation addition. Substantial savings can be realized if the plates are pushed to 0.44 gpm/sf for one summer.

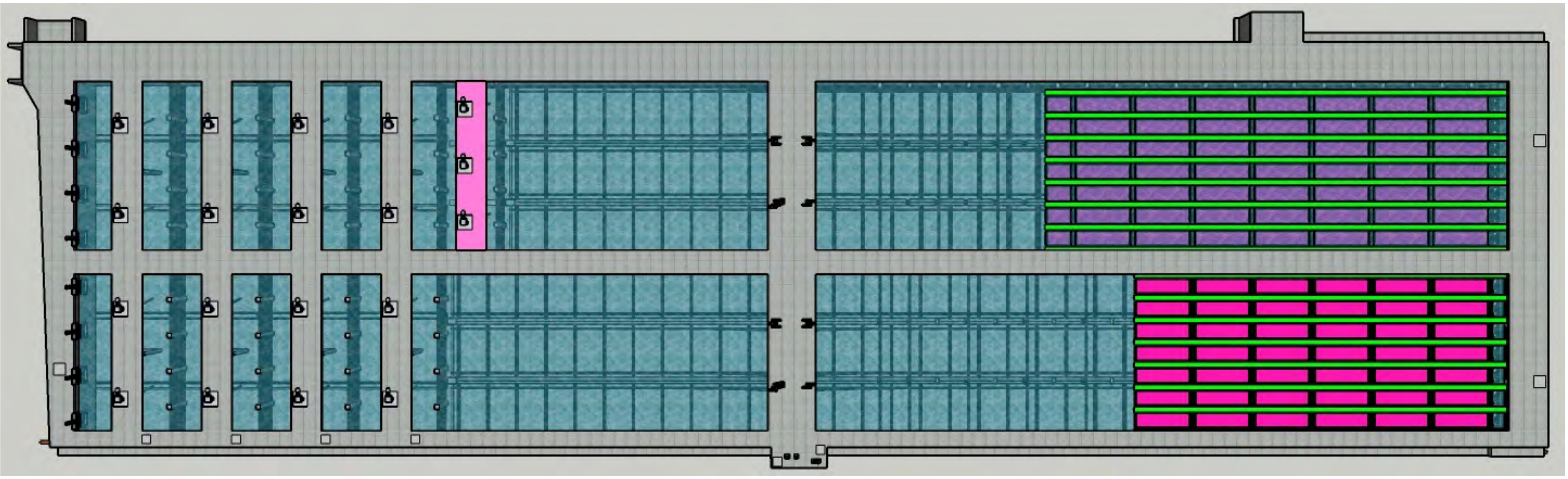


Figure 6. Comparison of Plate Settler Footprints for 42 mgd (upper) and 32 mgd (lower)

5.2 Seismic Considerations for Basins 3-6

Sedimentation Basins 3-6 are 360-feet long with exterior and interior longitudinal walls that are 14'-8" tall. The current water surface is 12.1-feet, leaving 2.57-feet of freeboard below the 8-inch-thick walkway. The walkway on the exterior wall is 5'-4", including the portion over the 1'-2" wall. The walkway over the interior wall is 8-feet wide, centered over the 1'-2" wall.

There is a cross-collector channel that divides Basins 3-6 into a 'short side' and a 'long side' with a 1/3 - 2/3 split. On the short side, the walls are 113'-1" long with no buttresses, perpendicular walls, or suspended slabs to stiffen the wall. On the long side, the walls are 228'-2" without any additional support. See Drawing 1S-2 from the 1985 record set. The walkway over the wall adjacent to Basin 1 (Basin 4) or Basin 2 (Basin 5) forms the top of the settled water channel that braces the wall adjacent to the original basins; this wall is supported, only the outer exterior wall and interior basin divider wall are unsupported.

Figure 7 shows the reinforcement in each outer exterior wall; the reinforcement is similar in the interior basin-divider wall. Note that the corbel shown in the section is intermittent; it is only 18-inches wide on 10-foot centers, and only appears on the long side of each basin. The corbels were intended to support future tube settlers that have not been installed.

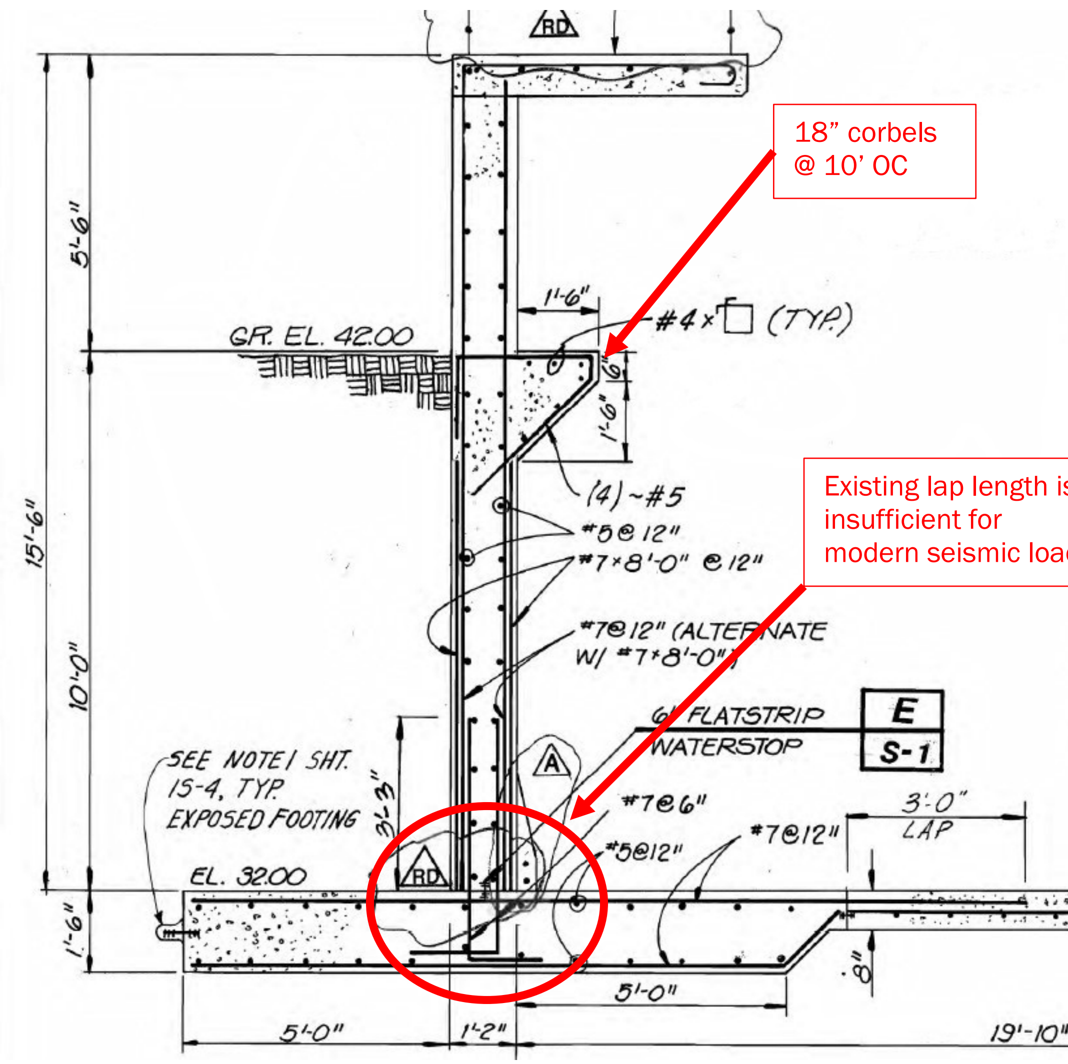


Figure 7 Typical Wall Reinforcement, Basins 3-6 Exterior and Interior Divider Walls

The walls act as cantilever walls with a fixed base and free top where the flexural moment is maximum at the base of the wall. There is a deficiency in the original design that only provided a 3'-3" lap length of the #7 rebar @ 6-inches on-center, and the proper lap length for #7 bars to meet current seismic code is 4'-6". The reinforcement is inadequate for the existing soil load and current water surface elevation under seismic conditions.

In a seismic event, the base joint is expected to fail in flexure from ground shaking, with the walls rotating out of plumb, leaning towards the non-loaded (water-bearing) side. Horizontal cracking at the base of the wall is expected, with potential for large cracks at the base where the wall and floor created a 'hinged' effect.

There are two viable options to seismically upgrade Basins 3-6:

- Struts: Installing steel or concrete struts across the basins at certain intervals would provide the required bracing, and JVWCD has experience with this mitigation method from a previous retrofit project in the Filter Building.

- Elevated Slabs: The flocculation basins have an elevated slab, or walkway, that spans the basins. This provides stiffness and support similar to a strut, and could be added to the sedimentation basins in similar fashion on similar spacing.

The design for a strut system would look almost exactly like the support system required for plate settlers. This means that if seismic loads are added to the design criteria for plate settler supports, and similar supports are installed throughout the long and short sides of each sedimentation basin, this expansion option would also accomplish the seismic upgrade for Basins 3-6.

5.3 Coordination with the Solids Equipment Replacement Project

Installing plate settlers in Basins 3-6 requires demolishing the temporary columns to expose the dowels in the floor to then either place concrete columns or cut off the dowels and install steel columns to support steel beams. This demolition should occur with chain & flight removed, which means fall of 2022 is an opportunity to install plate settler supports while the existing equipment is removed for replacement.

Installing the plate settler supports as part of Solids Removal Equipment Project will also provide supports for a 4-axle chain & flight layout that will improve basin access. This option is discussed in more detail in the predesign report (Brown and Caldwell, October 2021).

Basins 3-6 will need to operate in the winter for two years while Basins 1&2 are rebuilt. Flights currently rise out of the water as they return down the basin, and operators have commented that they have issues with ice buildup near the head shaft that interferes with the flights. The head shafts should be lowered so that flights are six inches below the max WSE to support occasional winter operations. The WSE could be raised as part of plate or tube installation, which would reduce the distance that the head shafts need to be lowered, thereby reducing structural modifications to the support walls.

5.4 Conclusions

The decision to install plate settlers in Basins 3-6 should be made as soon as possible to coordinate with the Solids Removal Equipment Replacement Project so that:

1. Supports can be installed in the basins while the chain & flight equipment is removed, and
2. To minimize structural modifications to the chain & flight head shaft support walls.

Section 6: Opinion of Probable Construction Costs

Brown and Caldwell prepared an Opinion of Probable Construction Cost (OPCC) for two scenarios:

- Seismic upgrade of Basins 1&2, including deepening the basins and installing plate settlers to improve resilience for wildfire and drought by improving basin performance under a broader range of raw water quality, and
- Process and seismic upgrade of Basins 3-6 to install a 5th flocculation stage, plate settlers with supports in the entire sedimentation area (short and long sides), and a 4-axle chain & flight system.

6.1 Class of Estimate

This is an "Order of Magnitude" estimate. An Order of Magnitude estimate is defined as a Conceptual Level or Project Viability Estimate. Typically, engineering is from 0 to 2 percent complete. Order of Magnitude estimates are used to prepare planning-level cost scopes or to evaluate alternative schemes for long-range capital outlay planning.

Expected accuracy for Order of Magnitude estimates typically ranges from -50 to +100 percent, depending on the technological complexity of the project, appropriate reference information, and the inclusion of an appropriate contingency. In unusual circumstances, ranges could exceed those shown. This Opinion of Probable Construction Cost (OPCC) is made based on the experience, qualifications and judgement of the cost estimators. Brown and Caldwell cannot and does not guarantee that proposals, bid or actual construction costs will not vary from this or subsequent estimates.

6.2 Estimating Methodology

This estimate was prepared using quantity take-offs, vendor quotes, and equipment pricing furnished either by the project team or by the estimator. The estimate includes direct labor costs and anticipated productivity adjustments to labor and equipment. Where possible, estimates for work anticipated to be performed by specialty subcontractors have been identified.

Construction labor crew and equipment hours were calculated from production rates contained in documents and electronic databases published by R.S. Means, Mechanical Contractors Association (MCA), National Electrical Contractors Association (NECA), and Rental Rate Blue Book for Construction Equipment (Blue Book).

6.3 Cost Summary

Table 19 summarizes the OPCCs to seismically upgrade Basins 1&2 and install plate settlers in a covered building, and to install plate settlers in Basins 3-6 as a process and seismic upgrade with no cover.

The Update recommended flocculation improvements that included flocculator replacement, modifications to improve baffling, and implementing floc aid. Flocculation improvements were estimated at $1.000,000 per basin, and additional supports in Basins 3-6 to act as seismic bracing were estimated at $750,000 per basin; these costs are also included in the table.

With the projects summarized in the table: seismic upgrade of Basins 1&2, process improvements with plate settlers in Basins 3-6, flocculation improvements to all basins, and seismic upgrades to Basins 3-6, JVWCD can improve pretreatment performance and can expand the JVWTP's pretreatment capacity to 255 mgd (net) with a 5-percent buffer for recycle flows (268 mgd gross) for approximately $45,650,000.

Table 19. Opinion of Probable Construction Costs

Item	Basins 1&2 Upgrade	Basins 3-6 Upgrade with Plates
Demolition	$1.7M	$0.3M
Civil	$0.4M	NA
Structural	$7.3M	NA
Mechanical	$15.7M	$11.5M
Electrical & Instrumentation	$1.3M	$0.5M
OPCC Total	***$26.4M***	***$12.3M***
Lower Bound (-20%)	$21.1M	$8.0M
Upper Bound (+30%)	$34.3M	$16.0M
Additional Improvements		
Flocculation Improvements	Included above	$4.0M
Additional Supports	NA	$3.0M
Project Total, Capital Cost in Q2 2021 Dollars		***$45.7M***

Section 7: Recommendations

The existing JVWTP has a firm capacity of 138 mgd and a hydraulic capacity of 180 mgd. JVWCD notices a drop in settled water performance when operating the JVWTP at flows approaching 180 mgd, especially when the typical raw water turbidity and total organic carbon climb, requiring more coagulant and polymer to treat. This adversely affects filter performance, and expansion plans need to address poor existing flocculation and sedimentation basin performance.

This report supports the following recommendations to phase pretreatment expansion:

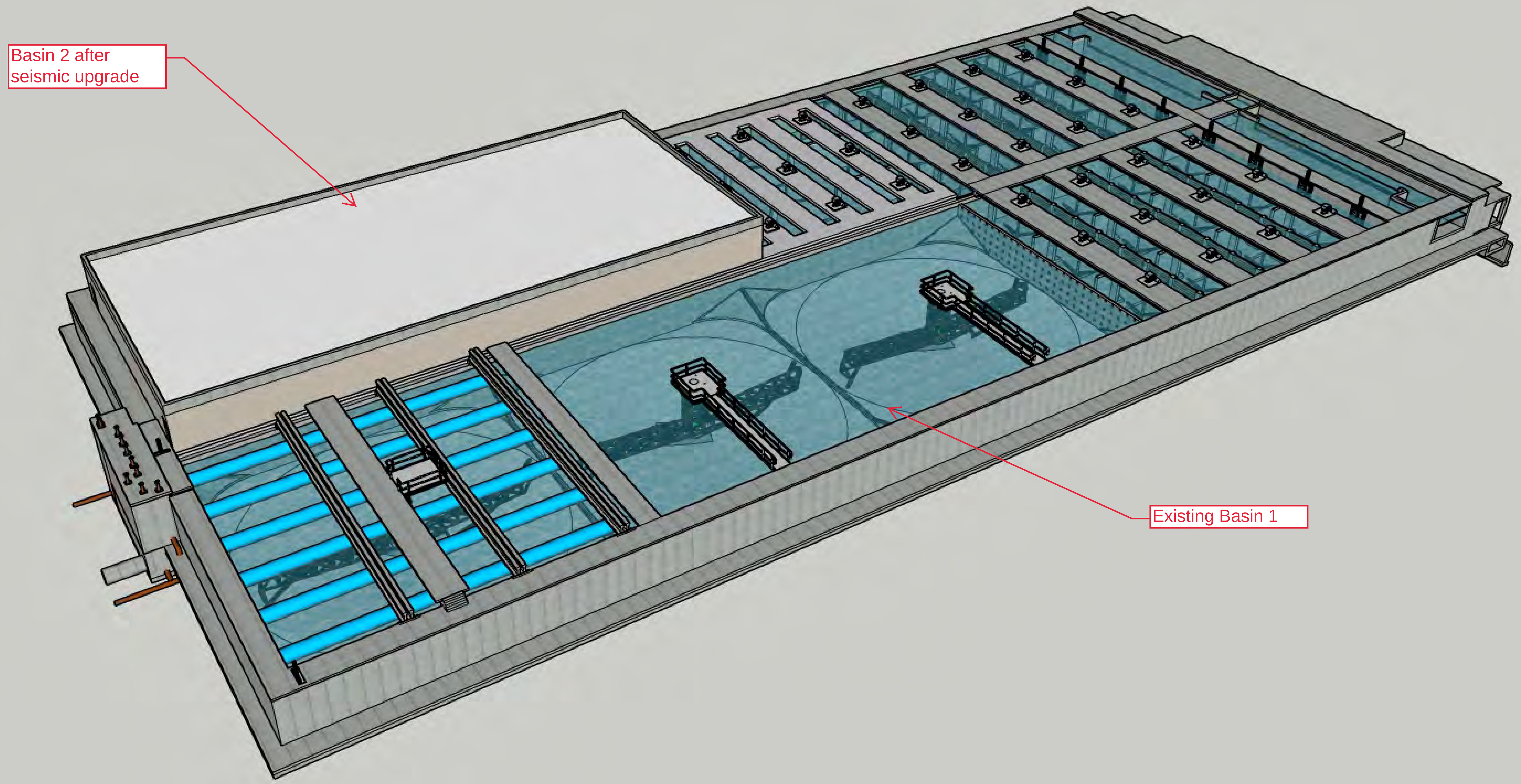
- Hydraulics:
  - Move flow split, and the associated headloss, from just after flash mix to the end of each basin using the weirs on the plate-settler troughs.
- Flocculation:
  - Improve flocculation in Basins 1-6 by replacing the existing flocculators with new properly designed flocculators, by improving baffling between stages, and by adding provisions for flocculant aid polymer. Modifications are estimated at approximately $1M per basin.
- Sedimentation:
  - Retrofit existing sedimentation Basins 1&2 with four additional stages of flocculation and plate settlers; cover the final stage of flocculation and the plates. Use 0.35 gpm/sf @ 80% effective area for plate design.
  - Retrofit sedimentation Basins 3-6 with one additional stage of flocculation and plate settlers; continue to take Basins 3-6 offline each winter, do not cover the plates. Use shorter plates for packs that are 2-ft shorter than in Basins 1&2 and use 0.35 gpm/sf @ 80% effective area for plate design.

Table 20 summarizes each recommendation with its associated timeframe and cost.

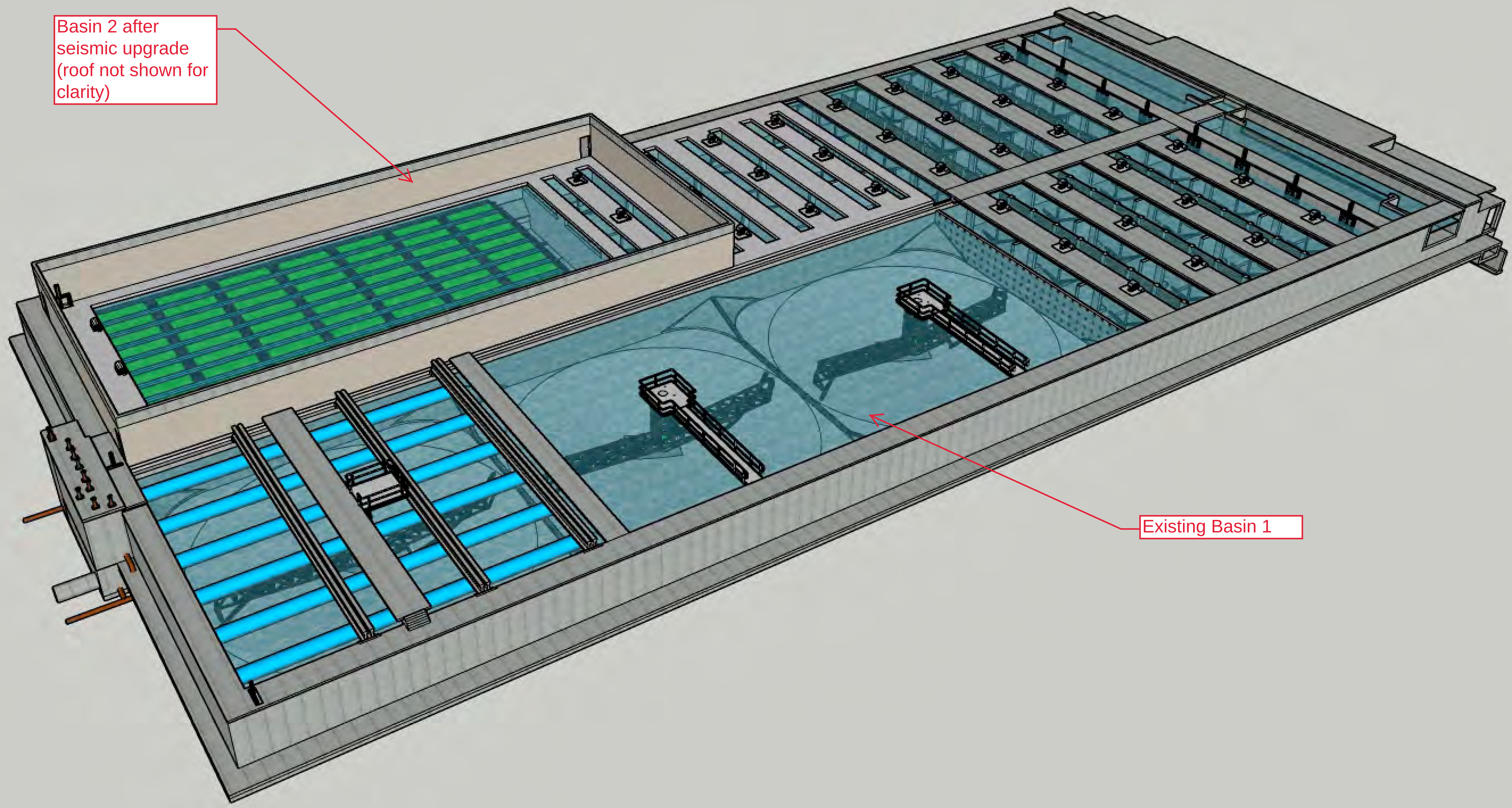
Table 20. Recommended Improvements with Schedule and Cost

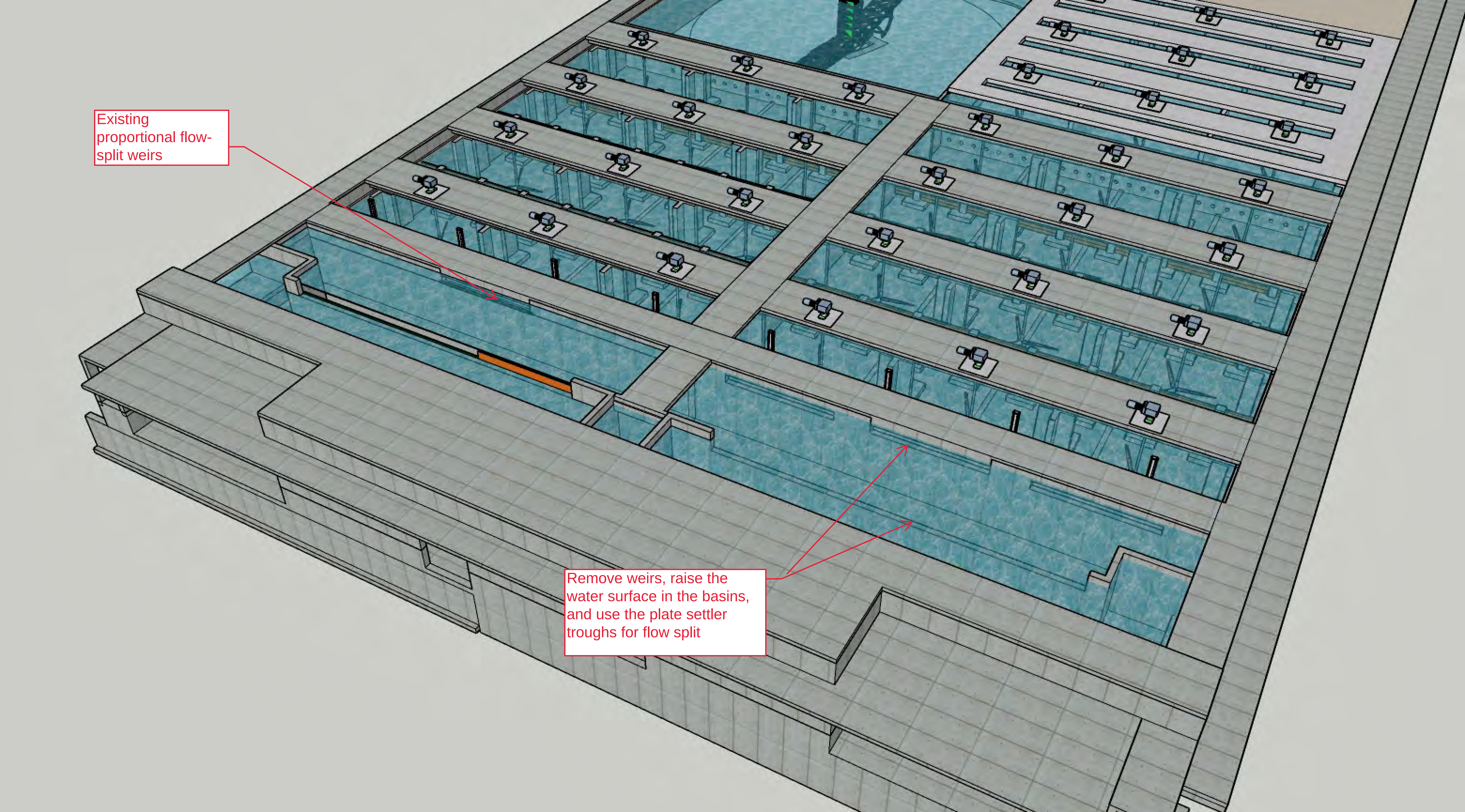
Recommendation	Timeframe	Cost
Select plate settlers for Basins 3-6 and select 0.35 gpm/sf @ 80% effective area for plate design in all basins; no cover	November 2021	NA
Include supports in the Solids Removal Equipment Replacement Project for future plate-pack installation in Basins 3-6	December 2021	Design cost only
Install supports in Basins 3-6 for future plate packs, to support the 4-axle chain & flight layout, and as a seismic retrofit	October 2022 – March 2023	$7M
Install plates in Basins 3-6; take Basins 1&2 offline for the retrofit project and convert to downstream flow split; improve all existing flocculation basins; add floc aid	October 2023 – March 2024	$12.3M
Rebuild Basins 1&2 and install plate settlers, including a building covering the plate settlers and final stage of flocculation	October 2023 – April 2025	$26.4M
Total		$45.7M

Attachment A: Basins 1&2 Retrofit Construction Sequence

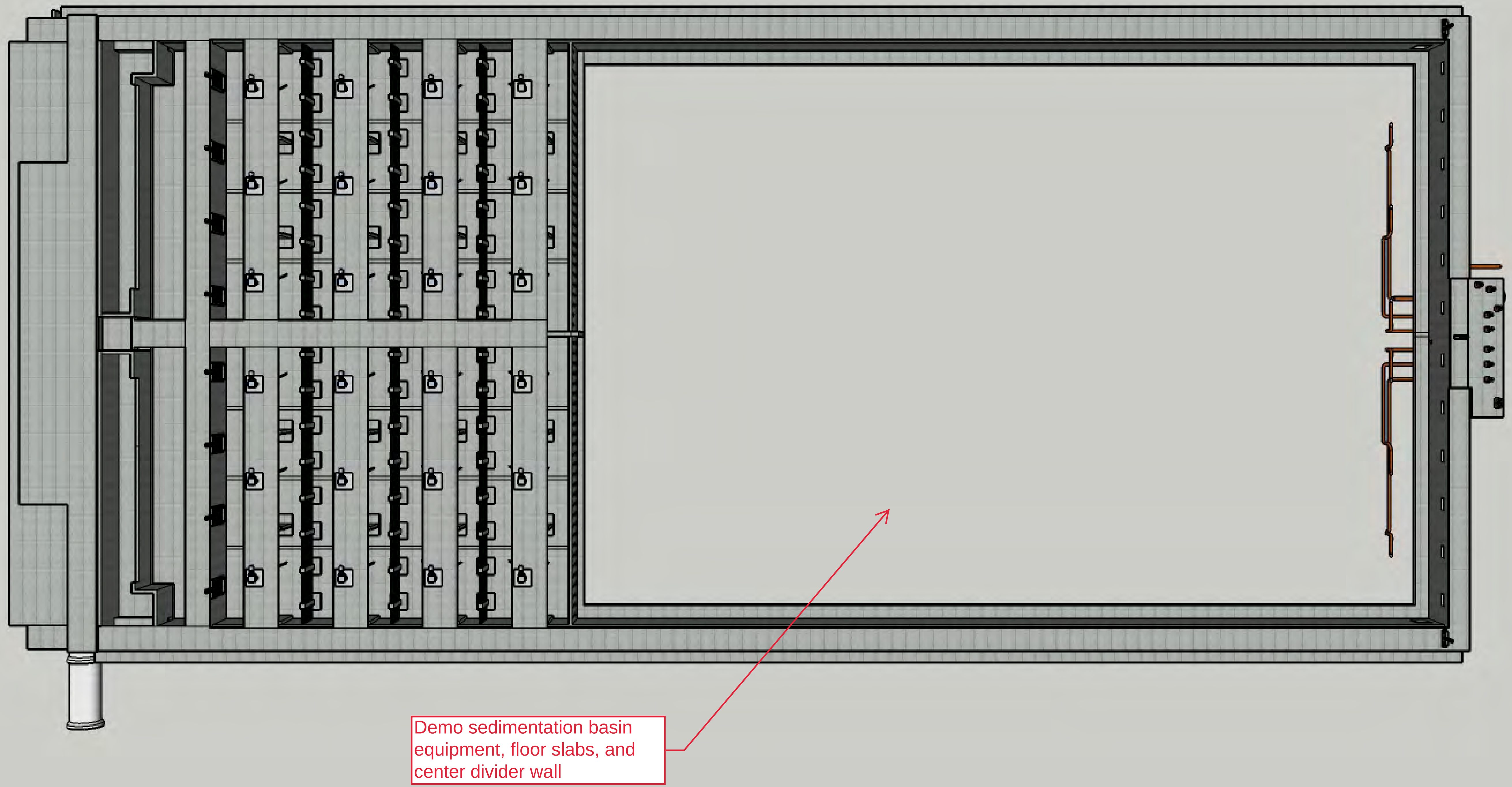


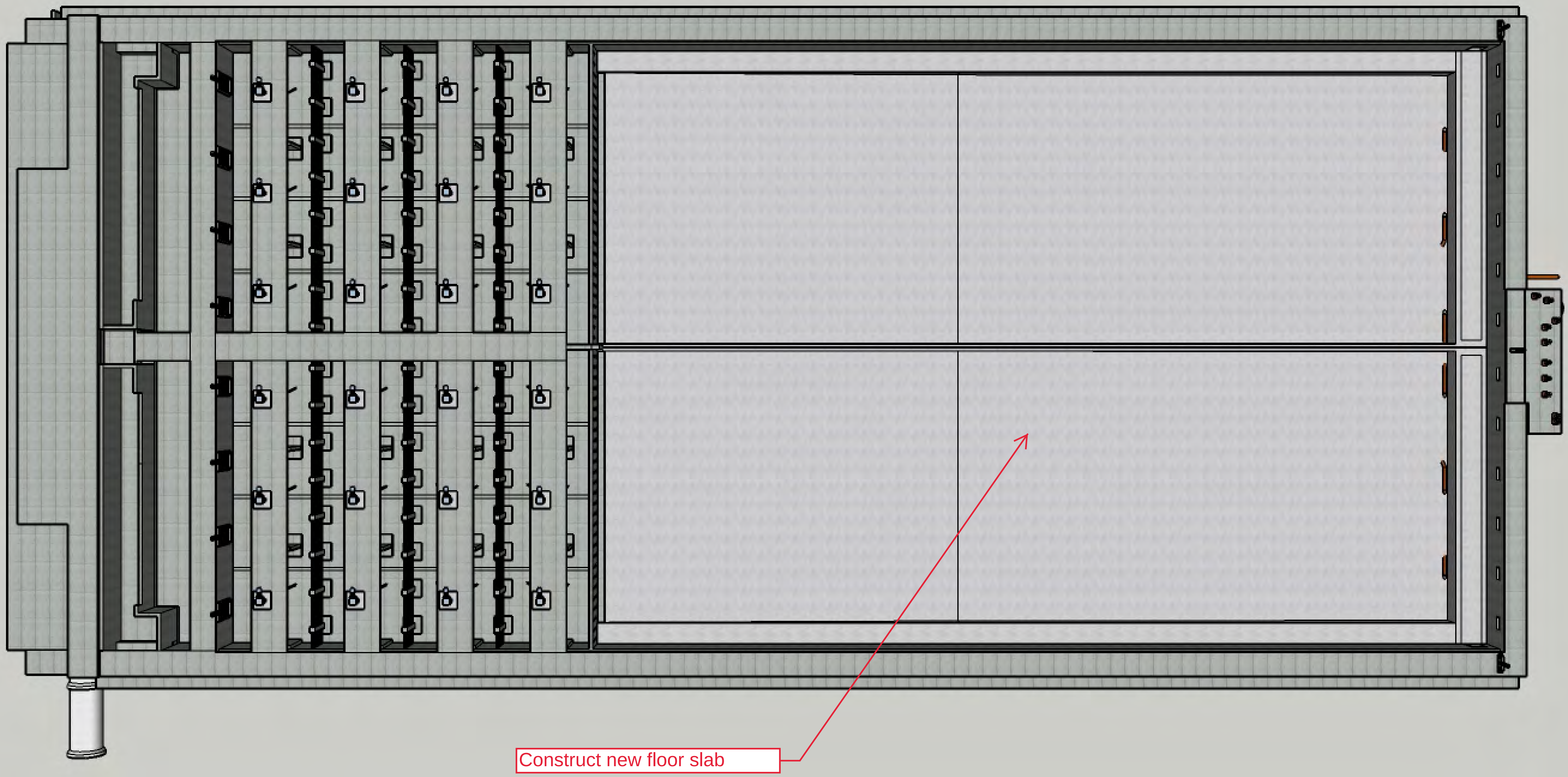
Basin 2 after
seismic upgrade
Existing Basin 1

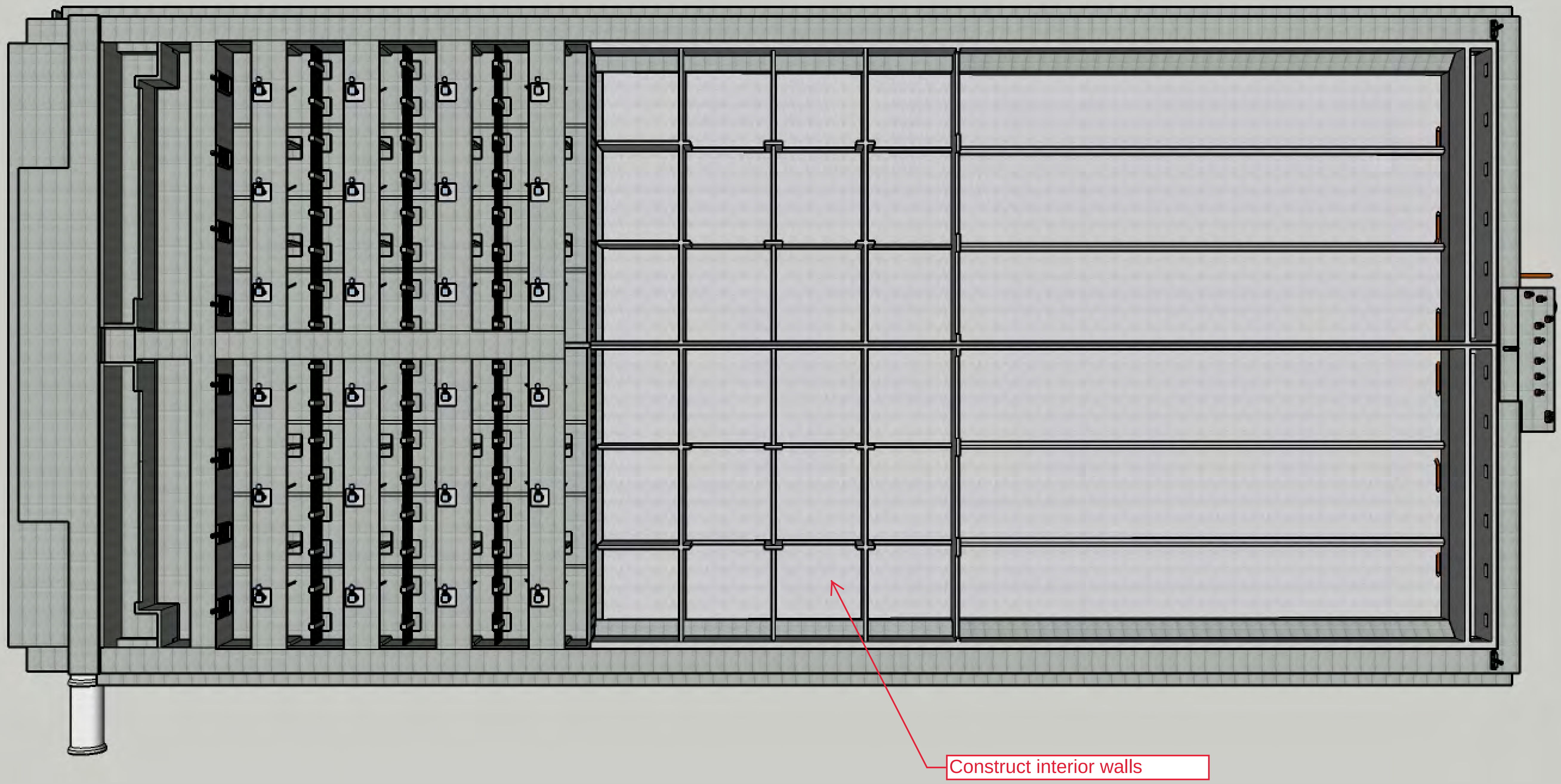

Basin 2 after seismic upgrade (roof not shown for clarity)
Existing Basin 1

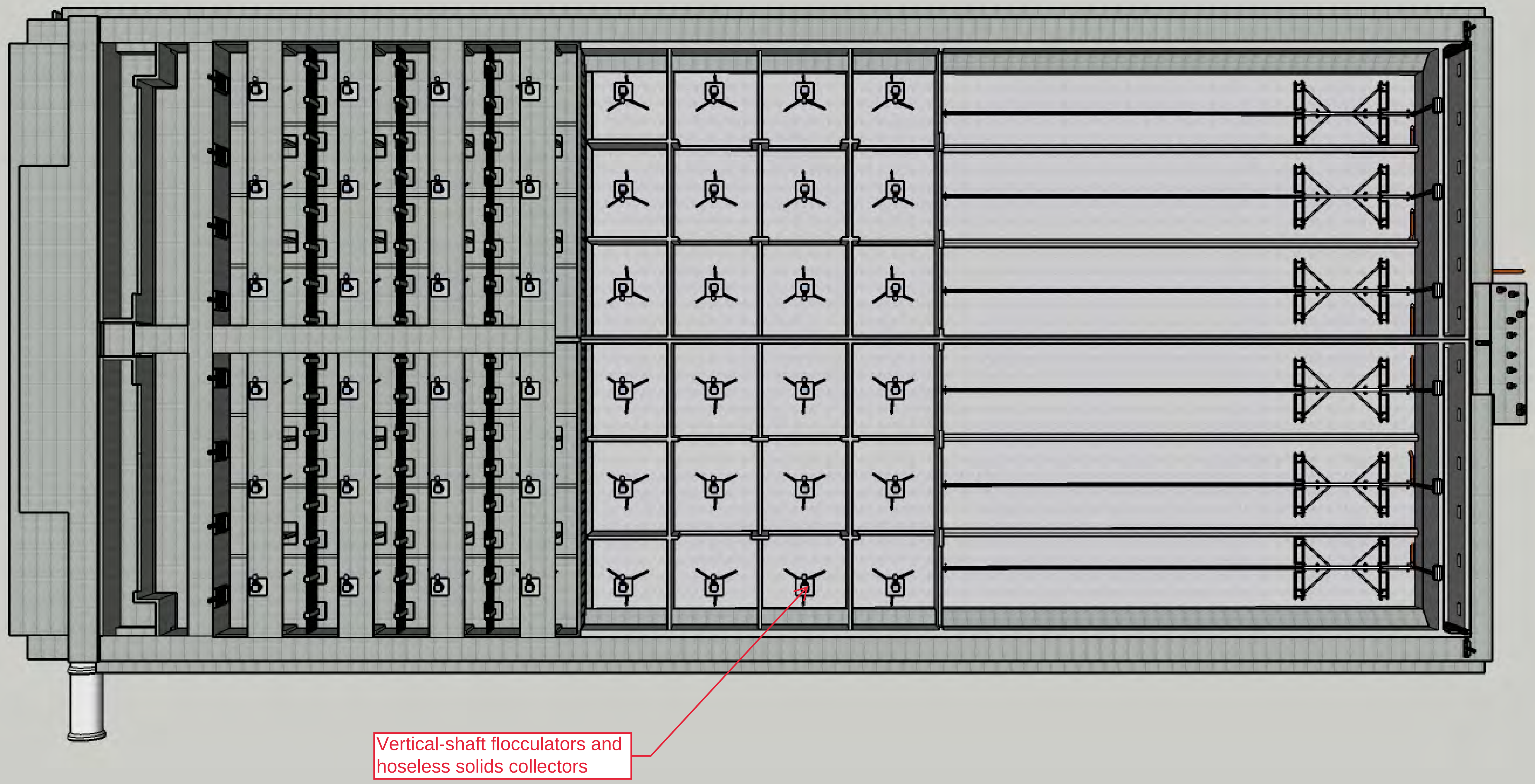


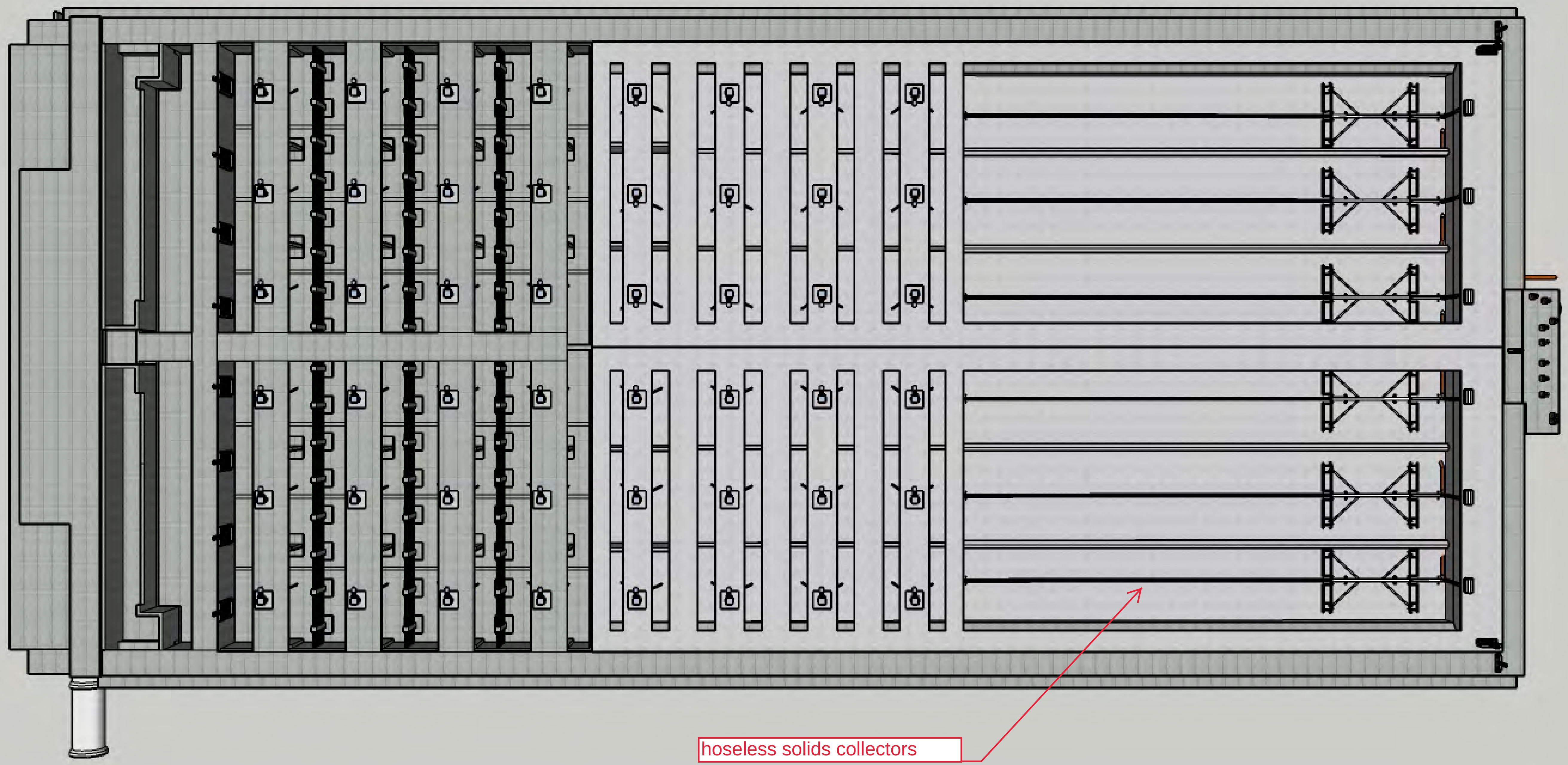
Existing proportional flow-split weirs
Remove weirs, raise the water surface in the basins, and use the plate settler troughs for flow split


Demo sedimentation basin
equipment, floor slabs, and
center divider wall


Construct new floor slab


Construct interior walls


Vertical-shaft flocculators and
hoseless solids collectors



hoseless solids collectors

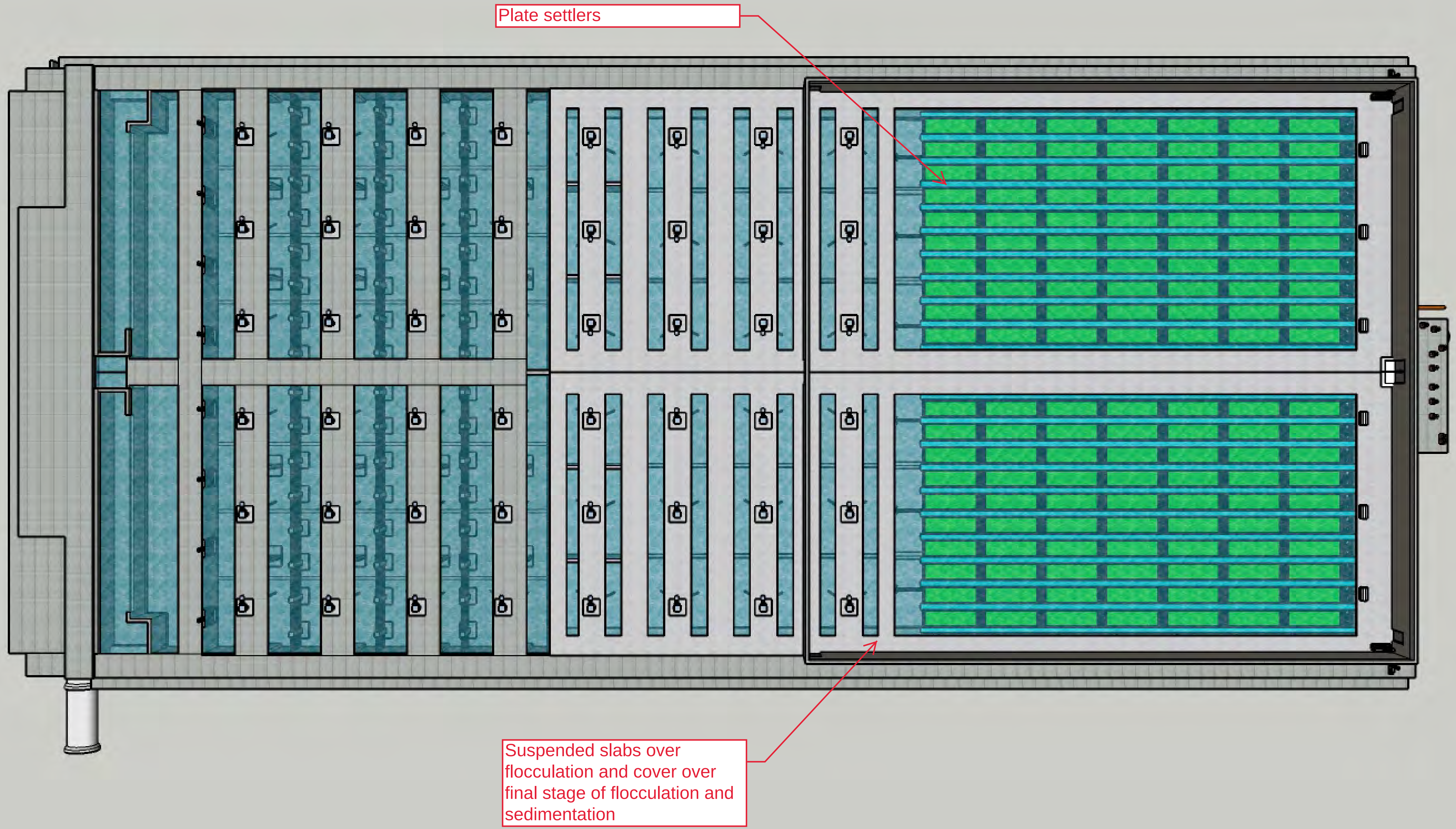
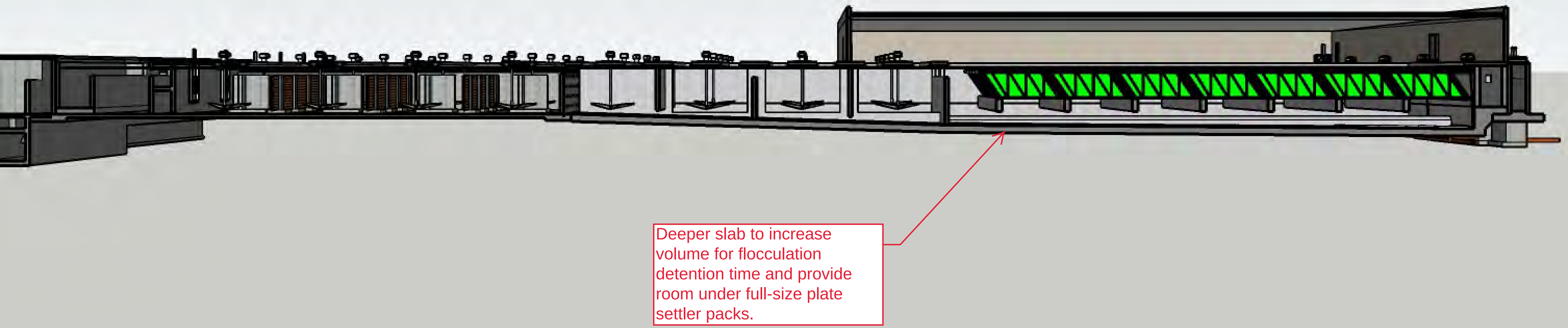
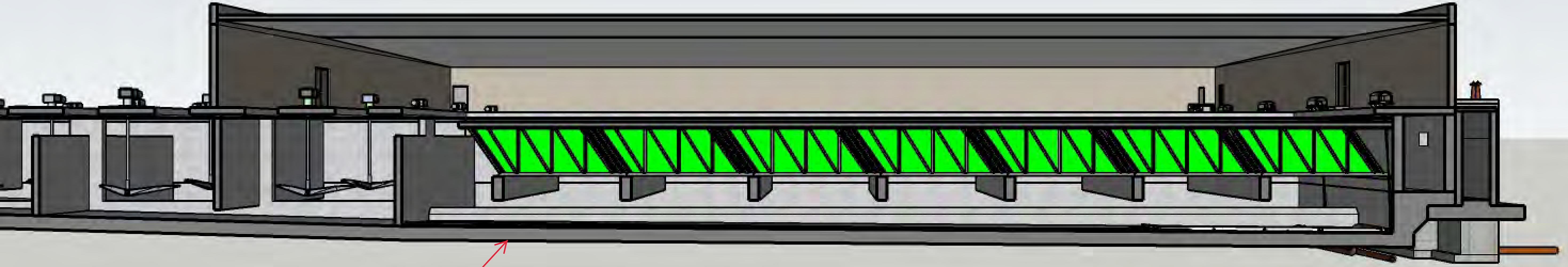


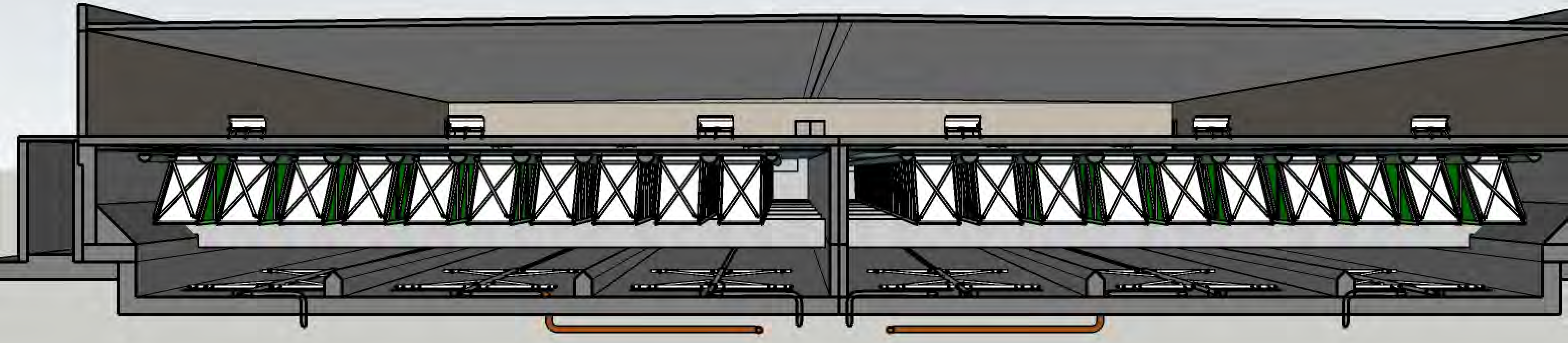
Plate settlers
Suspended slabs over flocculation and cover over final stage of flocculation and sedimentation

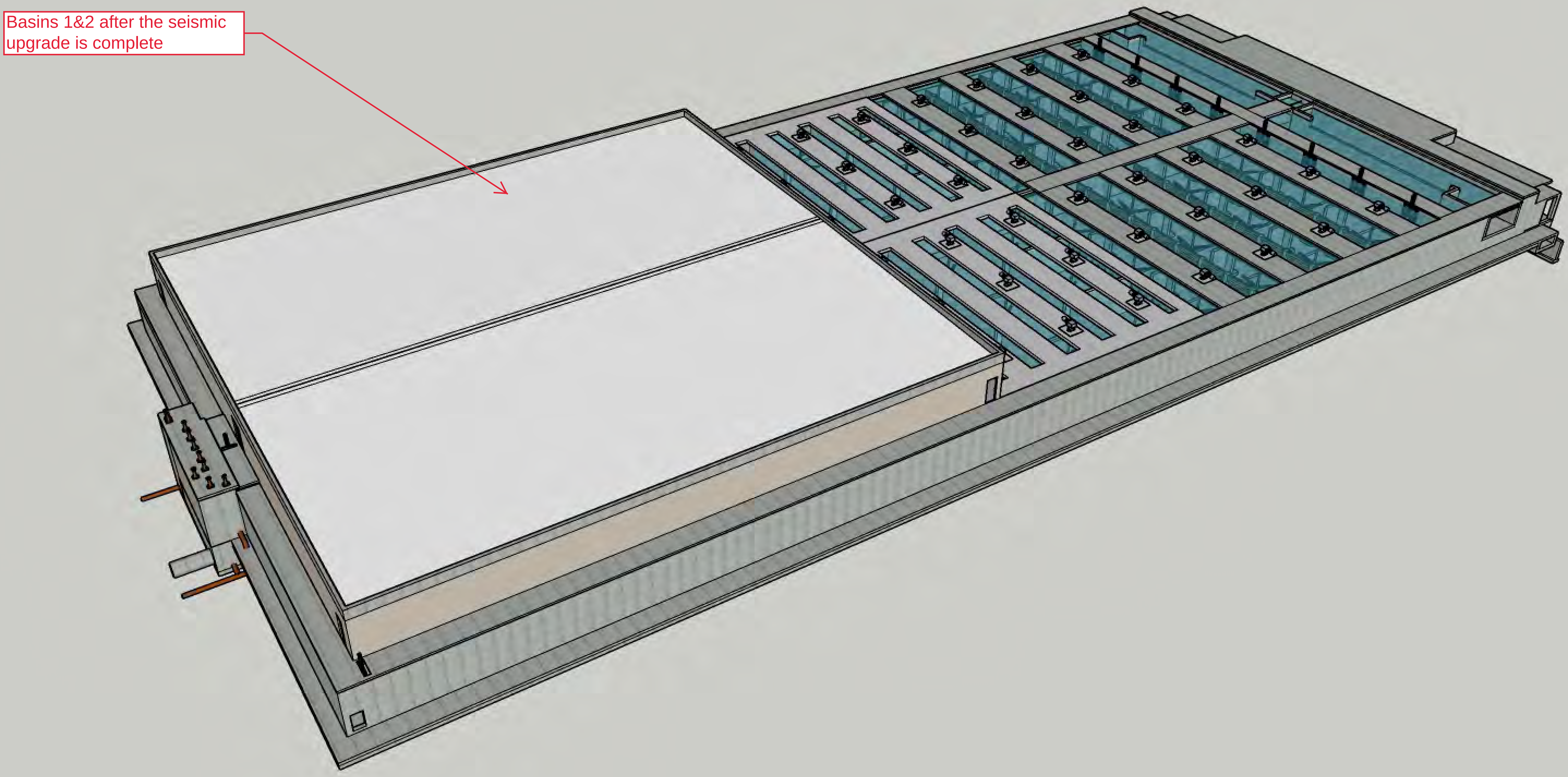

Cover


Deeper slab to increase volume for flocculation detention time and provide room under full-size plate settler packs.

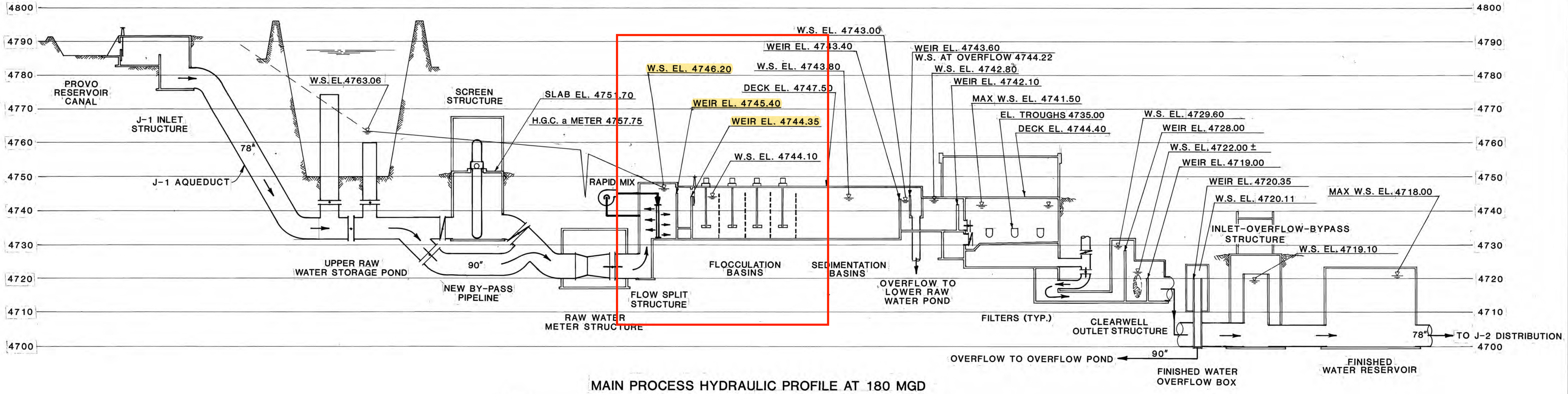


Deeper slab to increase volume for flocculation detention time and provide room under full-size plate settler packs.




Basins 1&2 after the seismic upgrade is complete

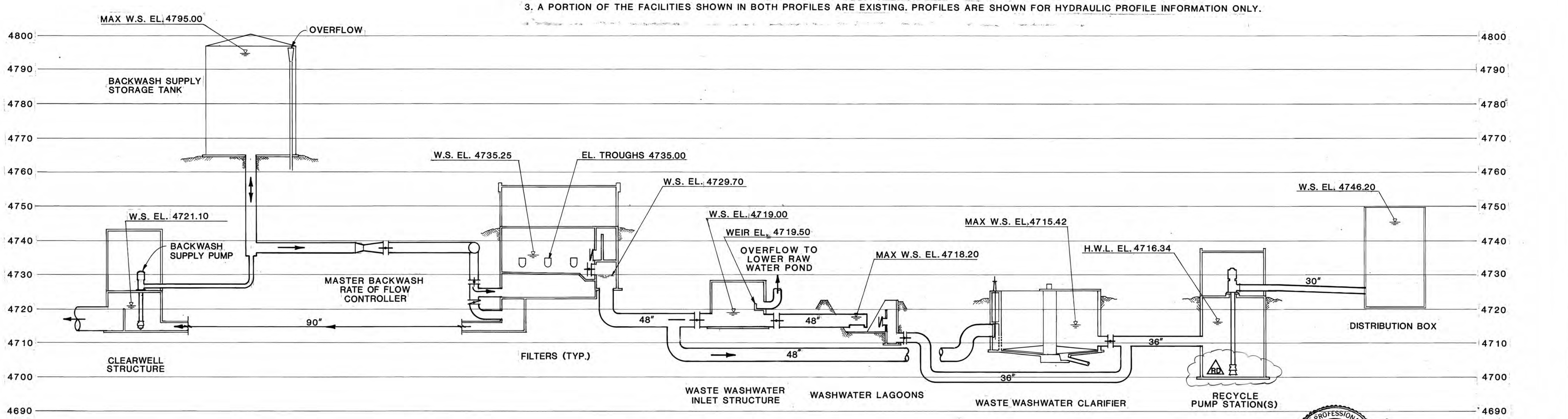
Attachment B: Referenced Record Drawings



MAIN PROCESS HYDRAULIC PROFILE AT 180 MGD

NOTES:

1. PROFILE CALCULATED WITH SCREEN STRUCTURE BYPASSED.
2. OVERFLOWS AND SUBSEQUENT ELEVATIONS THROUGH THE MAIN PROCESS HAVE BEEN CALCULATED AT A FLOW RATE OF 180 MGD.
3. A PORTION OF THE FACILITIES SHOWN IN BOTH PROFILES ARE EXISTING. PROFILES ARE SHOWN FOR HYDRAULIC PROFILE INFORMATION ONLY.



FILTER BACKWASH HYDRAULIC PROFILE

NOTES:

1. PROFILE SHOWN ASSUMES LAGOONS AND CLARIFIER OPERATED IN SERIES
2. BACKWASH FLOW IS 26,750 GPM, RECYCLE FLOW IS 12,500GPM.

SCHEDULE VARIES

REGISTERED PROFESSIONAL ENGINEER No. 7307 Gary J. Wohlgemuth STATE OF UTAH

RECORD DRAWING

This record drawing has been prepared based upon information provided by others. The Engineer has not verified the accuracy of such information and shall not be responsible for any errors or omissions which have been incorporated herein as a result.

REV	DATE	BY	DESCRIPTION
RD	5/6/85		RECORD DRAWING

SCALE: VERTICAL: 1" = 15 FT. HORIZONTAL: NONE

DESIGNED B. BENCH
DRAWN H. P. Cline
CHECKED G. WOHLGEMUTH

SUBMITTED — PROJECT ENGINEER — 7307 R.C.E. NO. — 7-31-85 DATE

RECOMMENDED — JAMES M. MONTGOMERY CONSULTING ENGINEERS, INC. — 4960 R.C.E. NO. — 7-31-85 DATE

JAMES M. MONTGOMERY CONSULTING ENGINEERS, INC.
12200 E. ILIFF AVE., SUITE 108, AURORA, COLORADO 80014

APPROVED Don A. Christiansen 7-31-85 DATE
APPROVED Matthew R. Marshall 7-31-85 DATE

CENTRAL UTAH WATER CONSERVANCY DISTRICT
JORDAN VALLEY WATER PURIFICATION PLANT EXPANSION
HYDRAULIC PROFILE

SHEET G-5 OF SHEETS

JOB NO. FILE CC 7/79

PROJECT NO. 86-19A

ALL WORK IN FLOC/SED BASINS NO.3&4 (WHICH ARE MIRROR IMAGE TO THAT SHOWN) INCLUDING NORTH & SOUTH INFLUENT CHANNELS IS SCHEDULE 2

NOTE:
1. FOUNDATION PROJECTION NOT SHOWN FOR CLARITY.
2. WATERSTOPS ARE AT ALL WALL CONSTRUCTION JOINT LOCATIONS.

RECORD DRAWING
This record drawing has been prepared based upon information provided by others. The Engineer has not verified the accuracy of such information and shall not be responsible for any errors or omissions which have been incorporated herein as a result.

REGISTERED PROFESSIONAL ENGINEER No. 7307 Garry J. Wohlgemuth STATE OF UTAH

REV	DATE	BY	DESCRIPTION
A	10/85	JMM	ADDENDUM 1-5
RD	11/29/88	M.T.S	RECORD DRAWING

SCALE: 3/32" = 1'-0"

DESIGNED DMH/RSG — DRAWN D.S. — CHECKED D.M. Harley

SUBMITTED: PROJECT ENGINEER — 7307 R.C.E. NO. — 7-31-85 DATE
RECOMMENDED: JAMES M. MONTGOMERY CONSULTING ENGINEERS, INC. — 4960 R.C.E. NO. — 7-31-85 DATE

JAMES M. MONTGOMERY CONSULTING ENGINEERS, INC.
12200 E. ILIFF AVE., SUITE 108, AURORA, COLORADO 80014

APPROVED: Don A. Christiansen — 7-31-85 DATE
APPROVED: Matthew R. Marshall — 7-31-85 DATE

CENTRAL UTAH WATER CONSERVANCY DISTRICT
JORDAN VALLEY WATER PURIFICATION PLANT EXPANSION
FLOCCULATION/SEDIMENTATION BASINS PLAN

SHEET 1S-2

JOB NO. 568.0205

ALL WORK THIS SHEET IS SCHEDULE 2 AND/OR 6

RECORD DRAWING

This record drawing has been prepared based upon information provided by others. The Engineer has not verified the accuracy of such information and shall not be responsible for any errors or omissions which have been incorporated herein as a result.

REGISTERED PROFESSIONAL ENGINEER No. 7307 Garry J. Wohlgemuth STATE OF UTAH

REV	DATE	BY	DESCRIPTION
A	10/85	JMM	ADDENDUM 1-5
RD	11/3/86	MTS	RECORD DRAWING

SCALE: AS SHOWN

DESIGNED DMH
DRAWN R.S. Garcia
CHECKED D.N. Hardy

SUBMITTED — PROJECT ENGINEER — 7307 R.C.E. NO. — 7-31-85 DATE
RECOMMENDED — JAMES M. MONTGOMERY CONSULTING ENGINEERS, INC. — 4960 R.C.E. NO. — 7-31-85 DATE

JAMES M. MONTGOMERY CONSULTING ENGINEERS, INC.
12200 E. ILIFF AVE., SUITE 108, AURORA, COLORADO 80014

APPROVED Don A. Christiansen — 7-31-85 DATE
APPROVED Matthew R. Marshall — 7-31-85 DATE

CENTRAL UTAH WATER CONSERVANCY DISTRICT
JORDAN VALLEY WATER PURIFICATION PLANT EXPANSION
FLOCCULATION/SEDIMENTATION BASINS
SECTION & DETAILS

SHEET 1S-7 OF SHEETS

JOB NO. 568.0205

PROJECT NO: 86C196A

Attachment C: Cold-Weather, Uncovered-Basin Plate Settler Install List

Cold-Weather, No-Cover Install List for Plate Settlers

JMS (Note – this is NOT a complete list)

1. Tacoma, WA
2. Elkins, WV
3. Charles Town, WV
4. Woonsocket, RI

MRI

1. Binney WTP – Aurora, CO
2. Maple Grove WTP (Consolidated Mutual Water) – Lakewood, CO
3. Broomfield WTP – Broomfield, CO
4. Durango WTP – Durango, CO
5. Sid Copeland WTP – Louisville, CO
6. Howard Berry WTP – Louisville, CO
7. Kennewick, WA
8. Ferndale, WA
9. Ashtabula, OH
10. North Jersey, NJ
11. Pequannock, NJ (BWW)
12. Beaver Falls WTP - Eastvale, PA
13. Chester WTP, PA
14. Carlisle WTP, PA
15. York WTP, PA
16. Aqua PA – Bristol, PA
17. Aqua PA – Crum Creek, PA
18. Aqua PA – Pickering Creek, PA
19. Richmond WTP, VA
20. Crozet WTP, VA
21. Broadway WTP, VA
22. Atlantic City, NJ
23. Capital City Water, PA
24. Red Lion, PA
25. Frederick, MD