



Special Board Meeting Agenda

July 7, 2017 at 10:00 a.m.

156 S. Broadway, Turlock, CA, Second Floor, Yosemite Conference Room

*Chair, Gary Soiseth
Vice Chair, Chris Vierra
Director, Amy Bublak
Director, Ken Lane*

*Interim General Manager, Michael Brinton
Interim Legal Counsel, Phaedra A. Norton
Board Secretary, Tish Foley*

NOTICE REGARDING NON-ENGLISH SPEAKERS: The Stanislaus Regional Water Authority (SRWA) meetings are conducted in English and translation to other languages is not provided. Please make arrangements for an interpreter if necessary.

EQUAL ACCESS POLICY: If you have a disability which affects your access to public facilities or services, contact the Board Secretary. The Board is committed to taking all reasonable measures to provide access to its facilities and services. Please allow sufficient time for the Board to process and respond to your request.

NOTICE: Pursuant to California Government Code Section 54954.3, any member of the public may directly address the Board on any item appearing on the agenda, including Consent Calendar and Scheduled Matters, before or during the Board's consideration of the item.

AGENDA PACKETS: Prior to the Stanislaus Regional Water Authority Board meeting, a complete Agenda Packet is available for review on the SRWA's website at www.stanrwa.org and in the Board Secretary's Office at 156 S. Broadway, Suite 270, Turlock, during normal business hours. Materials related to an item on this Agenda submitted to the Board after distribution of the Agenda Packet are also available for public inspection in the Board Secretary's Office. Such documents may be available on the SRWA's website subject to staff's ability to post the documents before the meeting.

1. A. CALL TO ORDER
- B. SALUTE TO THE FLAG
2. RECOGNITION, APPOINTMENTS, ANNOUNCEMENTS & PRESENTATIONS: None
3. A. SPECIAL BRIEFINGS: None
- B. STAFF UPDATES
 1. Interim General Manager Updates (*Brinton*)
 2. Finance Director Report (*Lorenzi*)
- C. CONSULTANT UPDATES
 1. West Yost Associates will provide the Board with a project status update. (*Nakano*)
- D. PUBLIC PARTICIPATION: This time is set aside for members of the public to address the Board concerning any item that has been described in the notice for the meeting, including Consent Calendar items, before or during consideration of that item. You will be allowed five (5) minutes for your comments. If you wish to speak regarding an item on the agenda, you may be asked to defer your remarks until the Board addresses the matter.

4. DECLARATION OF CONFLICTS OF INTEREST AND DISQUALIFICATIONS

- 5. CONSENT CALENDAR:** Information concerning the Consent items listed below has been forwarded to each Board member prior to this meeting for study. Unless the Chair, a Board member, or member of the audience has questions concerning the Consent Calendar, the items are approved at one time by the Board. The action taken by the Board in approving the Consent items is set forth in the explanation of the individual items.

A. *Motion:* Accepting minutes of Regular Meeting of May 25, 2017

6. PUBLIC HEARINGS: None

7. SCHEDULED MATTERS

- A. Request to consider supporting the Association of California Water Agencies' Policy Statement on Bay-Delta Flow Requirements. (*Smith*)

Recommended Action:

Resolution: Supporting the Association of California Water Agencies (ACWA) Policy Statement on Bay-Delta flow requirements.

- B. Request to concur with the Executive TAC and TAC's recommendation to proceed with further evaluation of a conventional water treatment process featuring ozonation and granular media filters, and allowing consideration of such processes by proposers for the future design and construction of the water treatment plant. (*Smith*)

Recommended Action:

Motion: Concurring with the Executive TAC and TAC's recommendation to proceed with further evaluation of a conventional water treatment process featuring ozonation and granular media filters, and allowing consideration of such processes by proposers for the future design and construction of the water treatment plant.

- C. Request to declare intention to seek reimbursement for expenditures paid prior to the issuance of the obligations or the approval by the State Water Board (Drinking Water State Revolving Fund (SRF) Program) for the SRWA Surface Water Supply Project (Project) funds in the maximum principal amount of \$275,654,000. (*Smith*)

Recommended Action:

Resolution: Declaring intention to seek reimbursement of water supply project expenditures from the Drinking Water State Revolving Fund Program.

- D. Request to adopt the Annual Budget for the Stanislaus Regional Water Authority for the 2017-18 Fiscal Year and adopting a minimum cash reserve target for 2017-18. (*Lorenzi*)

Recommended Action:

Resolution: Adopting the Annual Budget for the Stanislaus Regional Water Authority for the 2017-18 Fiscal Year and Adopting a minimum cash reserve target for 2017-18

8. MATTERS TOO LATE FOR THE AGENDA

9. BOARD ITEMS FOR FUTURE CONSIDERATION

10. BOARD COMMENTS: Board members may provide a brief report on notable topics of interest. The Brown Act does not allow discussion or action by the legislative body.

11. NEXT MEETING DATE: July 27, 2017 - Regular Meeting

12. ADJOURNMENT

The foregoing meeting is hereby called by Chair Soiseth at the above mentioned date and time pursuant to California Government Code §54956.



Gary Soiseth, Chair



To: SRWA Board

From: Michael Brinton, Interim General Manager

Subject: Interim General Manager Report

The members of the Technical Advisory Committee (TAC) have continued to meet and work closely with West Yost Associates and their sub-consultants on various items in preparation of the design of the raw water supply infrastructure, water treatment facility, treated water transmission mains and local distribution systems. The items covered since the last SRWA Board meeting includes the following:

- Completed tax questionnaire as part of the SRF financial application package
- Made modifications to the Treatment Process Alternative Technical Memorandum 2
- Continued discussions with Stanislaus County Building Department
- Continued to coordinate and work with CVFPW representatives on the issue of the seasonal construction constraints for the wet well construction
- Continued preparation of Streambed Alteration Agreement permit application for CDFW
- Continued collection of raw water samples and laboratory testing analysis of samples
- Updated construction cost estimates for the alternative 15 mgd and 30 mgd treatment plant sizes.
- Updated the potential monthly average customer bill impact for the 30 mgd treatment plant option
- Developed permitting schedule for treatment plant and pipeline construction
- Met with property owner regarding access to Nazareno property
- Completed work on new, refreshed SRWA Logo
- Prepared letter regarding wetland delineation to USACE
- Completed review of draft IS/MND
- Sent letter to property owners regarding on site surveys
- Developed milestone Project schedule summary
- Prepared permit application package for CVFPB
- Prepared documents for DVFPB detailing project phasing and construction methods

Ms. Smith will provide a more in depth review of these items. I will be happy to answer any questions.



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1. **A. CALL TO ORDER:** Chair Soiseth called the meeting to order at 10:10 a.m.
PRESENT: Director Bublak, Director Lane, Chair Soiseth
ABSENT: Vice Chair Vierra

B. SALUTE TO THE FLAG
 2. **RECOGNITION, APPOINTMENTS, ANNOUNCEMENTS & PRESENTATIONS:**
 - A. Chair Soiseth announced that on May 3, 2017, Agenda Item 7B entitled "Request to concur with the TAC's recommendation to proceed with further evaluation of two treatment process alternatives..." was continued to May 25, 2017; however, the presenter has requested more time to develop their report, therefore, this item will be heard at a later date.
 3. **A. SPECIAL BRIEFINGS:** None

B. STAFF UPDATES:
 1. Interim General Manager Mike Brinton provided an update of items discussed at recent Technical Advisory Committee (TAC) meetings, including:
 - Completed internal QA/QC review of 90% documents for the Raw Water Wet Well
 - Coordinated with Horizon regarding wet well constraints and fisheries analyses
 - Presented updated wet well permitting matrix to the TAC
 - Provided findings regarding existing ROW across Hudelson property along John Fox Road
 - Incorporated environmental schedule updates into overall schedule
 - Provided TID with updated Project milestones for presentation to their Board
 - Prepared and distributed meeting notes from coordination meeting between SRWA/TID representatives discussing how water rights would be addressed in the CEQA document
 - Updated O&M cost and expandability information for preferred treatment trains
 - Continued preparation of wetland delineation and permit applications. Submitted scoping summary report for TAC review
 - Completed permit application letter to DVFPB
 - Finalized appraisal map for permanent pipeline easement through state property
 - Reviewed revised design/build legislation
 - Preparation of Streambed Alteration Agreement permit application
 - Updated property acquisition portion of master project schedule
 - Filled out tax questionnaire as initial piece of financial SRF application package
 - Continued analysis of raw water samples
 - Prepared NDA for easement through State property, sent to Department of Fish and Wildlife.
 - Prepared updated cost estimate of 30 mgd Water Treatment Plant
 2. Marie Lorenzi, Interim Finance Director, deferred comments to Scheduled Matters, Item 7B.

C. CONSULTANT UPDATES:

1. Lindsay Smith of West Yost Associates provided a project status update including the following:
 - Treatment train(s) for further evaluation
 - Initial Project capacity, cost estimates and customer billing impacts
 - Senate approval of SB 373 to authorize use of design-build procurement process
 - SRWA logo refresh
 - Wet Well progress
 - Planning for Phase 2, anticipated to start July 2017
 - Property acquisition progress

D. PUBLIC PARTICIPATION: None

4. DECLARATION OF CONFLICTS OF INTEREST AND DISQUALIFICATIONS: None

5. CONSENT CALENDAR:

Action: Motion by Director Bublak, seconded by Director Lane, to adopt the consent calendar and approve the minutes of the Special Meeting of May 4, 2017. Motion carried 3/1 by the following vote:

| | | | |
|---------------|-----------------|-------------------|---------------|
| Director Lane | Director Bublak | Vice Chair Vierra | Chair Soiseth |
| Yes | Yes | Absent | Yes |

A. Motion accepting minutes of Special Meeting of May 4, 2017.

B. Motion accepting the Stanislaus Regional Water Authority’s audited Financial Statements for the fiscal year ended June 30, 2016 and related reports

C. Resolution 2017-0016 adopting a Retention Schedule for the Stanislaus Regional Water Authority Board

6. PUBLIC HEARINGS: None

7. SCHEDULED MATTERS:

A. Michael Cooke presented the report on behalf of the Technical Advisory Committee regarding the recommendation of the Executive TAC and TAC to officially adopt a new SRWA logo to replace the existing “water drop” logo.

Discussion: The logo depicts a bridge over graphics resembling either water or agriculture. The colors are warmer and the font is more readable in a landscaped format.

Chair Soiseth opened public participation. There being no public response, Chair Soiseth closed public participation.

Action: Motion by Director Bublak, seconded by Director Lane, to accept the recommendation of the Executive TAC and TAC to officially adopt a new SRWA logo to replace the existing “water drop” logo. Motion carried 3/1 by the following vote:

| | | | |
|---------------|-----------------|-------------------|---------------|
| Director Lane | Director Bublak | Vice Chair Vierra | Chair Soiseth |
| Yes | Yes | Absent | Yes |

- B. Marie Lorenzi presented the report of projected expenses for the remainder of the fiscal year and provide direction to staff regarding cash reserve balances for the Stanislaus Regional Water Authority.

Discussion: Marie presented the refined numbers gathered from the consultants and their contracts. Non-contractual items were averaged for the balance of the year. \$2.6 million is projected and the overall budget is \$3.5 million for the current fiscal year. The TID expenses are included and will be further detailed. Non-expended funds will carry over to next fiscal year. Invoices will be sent to the Participating Cities.

As the JPA agreement states the need to maintain a cash reserve, a recommendation will be brought to a future meeting for the Board’s consideration.

Chair Soiseth opened public participation. There being no public response, Chair Soiseth closed public participation.

Action: Motion by Director Lane, seconded by Director Bublak, to accept the report of projected expenses for the remainder of the fiscal year and provide direction to staff regarding the cash reserve levels to be maintained by the Authority going forward. Motion carried 3/1 by the following vote:

| | | | |
|---------------|-----------------|-------------------|---------------|
| Director Lane | Director Bublak | Vice Chair Vierra | Chair Soiseth |
| Yes | Yes | Absent | Yes |

- 8. **MATTERS TOO LATE FOR THE AGENDA:** None
- 9. **BOARD ITEMS FOR FUTURE CONSIDERATION:** None
- 10. **BOARD COMMENTS:** None
- 11. **NEXT MEETING DATE:** June 22, 2017 - Regular Meeting
- 12. **CLOSED SESSION:** None
- 13. **ADJOURNMENT:** Motion by Director Bublak, seconded by Director Lane, to adjourn at 10:35 a.m. Motion carried 3/1.

Respectfully submitted,
DRAFT

Tish Foley, Board Secretary



From: Michael Cooke, TAC Member

Prepared by: Lindsay Smith, Program Management Team

1. ACTION RECOMMENDED:

Resolution: Supporting the Association of California Water Agencies (ACWA) policy statement on Bay-Delta flow requirements.

2. DISCUSSION OF ISSUE:

SRWA became an ACWA member in late 2016 in order to stay informed on the latest California water policies in California, be represented in the legislative and regulatory arenas in Sacramento and Washington, D.C., and to learn from other ACWA members who have embarked on similar surface water projects. ACWA is the largest coalition of public water agencies in California. ACWA is recommending that its members adopt a resolution to support its Bay-Delta flow requirements policy statement. The key points of ACWA's policy statement include:

- a. The State Water Resources Control Board's (State Water Board's) "unimpaired flow" approach for the San Joaquin River and its tributaries is not the path to achieve the desired ecological outcomes. Furthermore, the State Water Board's approach is inconsistent with established state policies, such as the California Water Action Plan, the coequal goals defined in the Delta Reform Act of 2009, the Sustainable Groundwater Management Act of 2014, and the Human Right to Water Act.
- b. The State Water Board's proposal would undermine investments in storage, adversely impact the drinking water quality of disadvantages communities, increase groundwater overdraft in a part of the state where groundwater basins are already out of balance, and put large amounts of agricultural land out of production.
- c. The State Water Board should set aside the percentage of unimpaired flow approach and heed Governor Jerry Brown's call for negotiated agreements. Negotiated agreements historically have achieved desired ecological outcomes while maintaining water supply reliability.
- d. The State Water Board should embrace a collaborative process to develop water quality objectives that incorporate the best available science, utilize comprehensive solutions that address multiple variables, align with established state policies, considers economic impacts, and ensures that Bay-Delta Plan decisions enable, rather than obstruct, implementation of the California Water Action Plan.

More than 80 ACWA members have already taken action to support ACWA's policy statement. Approving this resolution will show SRWA's solidarity with other water agencies in the region and state.

3. FISCAL IMPACT / BUDGET AMENDMENT:

No direct fiscal impact is associated with this resolution.

4. INTERIM GENERAL MANAGER'S COMMENTS:

Recommend approval.

5. ENVIRONMENTAL DETERMINATION: N/A

6. ALTERNATIVES:

The alternatives are to: 1) pass a modified version of this resolution, or 2) not pass this resolution. No direct consequence to the SRWA is expected with either approach.



BEFORE THE BOARD OF THE STANISLAUS REGIONAL WATER AUTHORITY

**IN THE MATTER OF STATING THE STANISLAUS
REGIONAL WATER AUTHORITY'S SUPPORT OF
THE ASSOCIATION OF CALIFORNIA WATER
AGENCIES' POLICY STATEMENT ON BAY-DELTA
FLOW REQUIREMENTS**

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RESOLUTION NO. 2017-xxx

WHEREAS, California is facing a defining moment in water policy that will be substantially impacted by the State Water Resources Control Board's approach to water quality objectives under the Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta; and

WHEREAS, the State Water Board has the responsibility for updating the Bay-Delta Plan in a manner that establishes water quality objectives that ensure the reasonable protection of all beneficial uses of water in a way that is consistent with the coequal goals of improving water supply reliability and protecting, restoring and enhancing the Delta ecosystem and with respect to the commitments made in the California Water Action Plan; and

WHEREAS, the State Water Board staff's current proposal, which focuses singularly on an "unimpaired flow" approach, is irreconcilable with a policy of coequal goals of improving both water supply reliability and ecosystem health; it is also inconsistent with the broader water policy objectives of the Brown Administration; and

WHEREAS, the ACWA Board of Directors has unanimously adopted a strong policy statement that calls for a better approach that can more effectively achieve ecological objectives while maintaining water supply reliability. The statement calls on the State Water Board to set aside its "unimpaired flow" approach and heed Governor Jerry Brown's call for negotiated agreements, which have been successful on many rivers and tributaries in California; and

WHEREAS, the ACWA statement notes that to be successful, the State's flow policy must be consistent with the principles of collaboration, comprehensive solutions, science, functional flows, economic considerations, consistency with State policy and leadership; and

WHEREAS, California's local urban and agricultural water managers are united in their vision for a future that includes a vibrant California economy as well as

healthy ecosystems and fish populations, and believe that vision is best achieved through a comprehensive, collaborative approach.

NOW, THEREFORE, BE IT RESOLVED, that the Board of the Stanislaus Regional Water Authority hereby supports ACWA's Policy Statement on Bay-Delta Flows and encourages the State Water Resources Control Board to embrace the approach articulated in ACWA's Policy Statement.

PASSED AND ADOPTED at a Special Meeting of the Board of the Stanislaus Regional Water Authority this ___ day of _____, 2017, by the following vote:

AYES:

NOES:

NOT PARTICIPATING:

ABSENT:

ATTEST:

Tish Foley, Board Secretary



From: West Yost Program Management Team
Prepared by: Andy Smith, West Yost Associates

1. ACTION RECOMMENDED:

Motion: Concurring with the Executive TAC and TAC's recommendation to proceed with further evaluation of a conventional water treatment process featuring ozonation and granular media filters, and allowing consideration of such processes by proposers for the future design and construction of the water treatment plant.

2. DISCUSSION OF ISSUE:

The TAC and Project Management (PM) Team have continued to refine and evaluate available water treatment processes for the SRWA Surface Water Supply Project, which were initially documented in *Available Treatment Process Alternatives Technical Memorandum 1 (TM 1)*. After TM 1 was finalized in September 2016, source water sampling and bench-scale testing efforts began in October 2016, allowing a number of information gaps to be filled. Based on these initial sampling and testing activities, *Draft Treatment Process Alternatives Technical Memorandum 2 (TM 2)* was drafted on March 28, 2017, and provided expanded discussion, comparison, planning-level cost information and evaluation of treatment processes (including construction costs and operation and maintenance costs). The TAC and PM Team participated in workshops on March 30, 2017 and May 16, 2017 to discuss TM 2 and make recommendations regarding which treatment processes should be considered for further evaluation. Based on TAC feedback from these workshops, a revised draft of TM 2 was completed on June 15, 2017 (attached).

A summary of major topics discussed in TM 2 and during the workshops, as well as an outline of the TAC and PM Team's findings, is provided below.

Initial Source Water Sampling and Bench Testing Results

A total of 11 raw water sampling events took place between October 31, 2016 and March 30, 2017. From those events, TM 2 summarizes results for a variety of parameters, including general water quality parameters, nutrients, disinfection byproducts, iron and manganese, microbiological parameters, pesticides and other synthetic organic chemicals. Similarly, TM 2 summarizes results from a total of five (5) bench testing events which took place between November 28, 2016 and March 13, 2017, including coagulation jar tests, ozone demand tests, simulated distribution system disinfection byproduct tests and manganese removal tests. The results of both

sets of tests provide valuable information about the applicability of a variety of treatment processes and trains for this source water. Notable results include the need to remove organic carbon during portions of the year and the likelihood that SRWA will be subject to pathogen treatment requirements greater than regulatory minimums for unimpaired waters. TM 2 acknowledges that certain parameters have yet to be detected (e.g., algal toxins and most pesticides), potentially due to the lack of sampling events from periods when specific constituents may be more likely to be present, if at all.

Winter 2017 and Historical Tuolumne River Flows

TM 2 provides a summary of recent and historical flows in the Tuolumne River below La Grange Dam, and discusses the correlation of recent high flows (namely January through March 2017) with measurements for turbidity and total organic carbon (TOC). Using the recent flow and water quality data as a guide, the historical flow data indicate that the selected SRWA treatment train will need to be capable of handling seasonally elevated concentrations of TOC in order to restrict formation of disinfection byproducts.

Development of Refined Treatment Train Alternatives

TM 2 presents seven (7) treatment train alternatives developed and refined based on anticipated minimum requirements for pathogen treatment and previous input from TAC representatives. The updated list of alternatives includes trains with and without ozone, trains with and without direct filtration, and trains with and without membranes, as discussed below:

1. Conventional treatment with pre-ozonation
2. Conventional treatment with intermediate ozonation
3. Conventional treatment without ozone
4. Direct filtration with ozone
5. Direct filtration without ozone
6. Membrane filtration with ozone
7. Membrane filtration without ozone

Comparison of Unit Processes and Treatment Trains

TM 2 describes and compares key unit processes on the basis of typical components, advantages, disadvantages, likelihood of meeting regulatory requirements and SWRA treatment goals, and planning-level construction cost estimates. Construction cost information for overall treatment trains, including processes and facilities which would be common to any of the identified alternatives, are presented for each of the seven trains. Operations and maintenance costs were also estimated.

Risk Assessment and Recommendations

The PM Team identified four issues, or areas of risk, associated with the performance of the treatment train alternatives evaluated:

1. Exceedance of regulatory limits for disinfection byproducts with use of free chlorine as a secondary disinfectant
2. Taste and odor complaints and/or inadequate treatment of algal toxins (if present)
3. Inadequate treatment of pesticides (if present)
4. Inadequate control of manganese (if present)

The PM Team provided assessments of the relative probability of such issues arising under each alternative. Based on TAC and PM Team discussion of these risks, in conjunction with comparison of planning-level cost information, the TAC identified the following treatment process requirements:

1. Select a treatment train that utilizes ozone treatment
2. Select a treatment train that utilizes free chlorine for secondary disinfection (i.e., do not utilize chloramines)
3. Do not pursue direct filtration further

Based on TAC feedback on March 30, 2017, two treatment train alternatives (conventional treatment with pre-ozonation [Train 1], and membrane filtration with ozonation [Train 6]) were initially identified for further consideration, including an assessment of estimated operation and maintenance costs and a more detailed evaluation of the risks of exceeding regulatory limits for disinfection byproducts. The PM Team then developed additional information which indicated that treatment Train 6 could present significant risks associated with compliance with regulatory limits for disinfection byproducts, in addition to having higher estimated operation and maintenance costs than Train 1. After presentation and discussion of this information on May 16, 2017, the TAC and PM Team agreed that further evaluation of treatment processes should include Train 1 and Train 2 (which differs from Train 1 only in the relative sequence of ozonation in the treatment process) and variants thereof. Such evaluation will include the development of preliminary design criteria, site layouts and construction schedules; and development of refined cost estimates for operation and maintenance.

3. FISCAL IMPACT / BUDGET AMENDMENT:

The estimated water treatment plant capital costs of the two alternatives initially recommended for further evaluation (Trains 1 and 6) are within approximately four percent (4%) of one another. Monthly single family water bills for the same alternatives were estimated to be within approximately one percent (1%) of one another.

Although narrowing the acceptable alternatives to Trains 1 and 2 necessarily limits the types of proposals which may be developed by Design-Build proposers, it is expected that ongoing source water sampling and bench testing activities will identify acceptable variations of Trains 1 and 2 that will encourage innovation and price competition among proposers.

4. INTERIM GENERAL MANAGER'S COMMENTS:

The interim General Manager supports moving forward with the continued evaluation of Train Nos. 1 and 2, and recommends the Board concur with the recommendations of the Executive TAC, TAC and PM Team.

5. ENVIRONMENTAL DETERMINATION: N/A

6. ALTERNATIVES:

The Board may consider any of the other five treatment train alternatives described in Technical Memorandum 2.



TECHNICAL MEMORANDUM

DATE: March 28, 2017 (DRAFT)
June 15, 2017 (REVISED DRAFT) Project No.: 693-20-16-01
SENT VIA: EMAIL

TO: SRWA Technical Advisory Committee

FROM: Andy Smith, West Yost Associates, PE, RCE #74673
Elaine Howe, Trussell Technologies, PE, RCE #21477 (New Mexico)
Fred Geringer, Trussell Technologies, PE, RCE #67467

REVIEWED BY: Rhodes Trussell, Trussell Technologies, PE, RCE #25107
Gerry Nakano, West Yost Associates, PE, RCE #29524
Lindsay Smith, West Yost Associates, PE, RCE #72996

SUBJECT: Treatment Process Alternatives Technical Memorandum No. 2

1.0 INTRODUCTION

The Stanislaus Regional Water Authority (SRWA) is planning to construct a new surface water treatment plant (WTP) as part of a Surface Water Supply Project (Project) to provide a new, supplemental drinking water supply to the cities of Ceres and Turlock (Cities). To facilitate identification of a preferred treatment train by the SRWA Technical Advisory Committee (TAC), a variety of workshops were scheduled and two Technical Memoranda (TMs) were requested to develop and evaluate viable treatment options. The first workshop was held June 30, 2016 and included a robust discussion of treatment technologies and processes, and was followed by a TM titled "Treatment Process Alternatives, TM 1, Part 1" (Trussell Technologies [Trussell], September 6, 2016), referred to henceforth as TM 1. A second workshop was held January 12, 2017 and focused on the results of initial source water sampling and bench testing of potentially available treatment alternatives. The third workshop will be held on March 30, 2017.

This TM builds on information presented in TM 1. The draft version of this TM 2 (published in March 2017) was intended to aid the TAC in the ongoing evaluation and refinement of available treatment process alternatives, and to help guide discussion of this information at the March 30, 2017 TAC workshop. This revised draft of the TM reflects discussion at that workshop, as well as additional discussion at a subsequent TAC workshop on May 16, 2017.

This TM is organized as follows:

1. Introduction
2. Background and Purpose

3. Summary of Early Source Water Sampling and Bench Testing Results
4. Development of Refined Treatment Train Alternatives
5. Non-Cost Comparison of Unit Processes
6. Construction Cost Comparison of Unit Processes and Treatment Trains
7. Risk Assessment, Recommendations and Supplemental Evaluation Information
8. Next Steps
9. References

2.0 BACKGROUND AND PURPOSE

This section provides a summary of previous work completed by the Program Management (PM) Team (West Yost Associates [West Yost] and Trussell) and TAC, and describes the intended outcome of this TM. Previous work referenced herein includes the development of treatment performance goals and the first phase of evaluation of available treatment process alternatives.

2.1 Overview of Treatment Performance Goals

On May 12, 2016, the PM Team and TAC conducted a workshop to identify performance goals for the treatment and delivery of surface water to the Cities of Ceres and Turlock. The results of this workshop were captured in a TM titled “Treatment Performance Goals” (Trussell, July 21, 2016) and presented to the SRWA Board on August 10, 2016. As presented in the TM, the performance goals can be condensed as follows:

- **Employ a Reasonably Robust Treatment Train:** The treatment train should be robust to accommodate “normal” raw water quality variability, and to accommodate nighttime unmanned facility operations. Plant shutdown is acceptable under extreme water quality conditions, since groundwater will remain available.
- **Use Proven Processes:** Choose processes that are successfully operating at other plants. Demonstration testing will be required for membrane filtration, if selected.
- **Minimize Disinfection Byproduct (DBP) Formation:** Choose disinfection and total organic carbon (TOC) removal options that result in lower DBP concentrations. Chloramines will be considered for final disinfection, but only if upstream processes are not expected to sufficiently reduce DBP formation potential.
- **Design for Unmanned Night Operations:** Treatment process complexity and instrumentation and monitoring should be considered in meeting the goal of unmanned facility night operations.

The performance goals have established a general framework for evaluating a range of available treatment process alternatives to date, and will be returned to during discussion of the relative advantages and disadvantages of the treatment trains and unit processes presented in subsequent sections of this TM.

2.2 Overview of Treatment Process Alternatives TM No. 1

After the development of the treatment performance goals described above, and upon completion of a review of available historical Tuolumne River raw water quality data, the PM Team began the first phase of evaluating available treatment process alternatives for the Project. This first evaluation phase included a TAC workshop conducted by West Yost and Trussell on June 30, 2016 and culminated in TM 1.

The objectives and conclusions of TM 1 are summarized below:

- **Describe drivers expected to shape the TAC's evaluation of available alternatives.** Expected drivers included potential contamination sources, source water quality, treatment performance goals and input from Division of Drinking Water (DDW) staff.
- **Describe alternative treatment *processes* for achieving regulatory compliance and SRWA's adopted treatment performance goals.** Processes described include pretreatment (generally), direct filtration, conventional clarification and filtration, granular media filtration, membrane filtration, disinfection (generally), and ozone treatment.
- **Summarize and compare alternative treatment *trains* deemed potentially capable of achieving regulatory compliance and SRWA's adopted treatment performance goals.** Five treatment trains were developed. Three included the use of direct filtration and two included conventional clarification and filtration. In terms of disinfection, two trains included the use of ozone as a primary disinfectant and three trains assumed that primary disinfection is provided by free chlorine, ultraviolet light, or both. One of the trains included the use of membrane filters; the remaining trains relied on granular media filtration.
- **Identify information gaps affecting refinement of the list of potentially viable alternatives.** Information gaps identified in the TM include performance of the infiltration gallery, source water TOC concentrations at the infiltration gallery location, incidence of pesticide contamination in source water, incidence of algae-related taste and odors and/or toxins, TOC removal characteristics via enhanced coagulation, and ozone demand of raw and clarified source water.
- **Identify next steps in the alternatives evaluation process, including necessary TAC recommendation points.** Principal recommendation points identified in the TM include the recommendation of whether or not to include ozone and biologically active filters in the treatment train, and whether or not to include direct filtration.

Following the finalization of TM 1, a staff report was prepared for the SRWA Board to summarize key elements of the TM and to seek Board approval to proceed with the further evaluation of treatment trains including ozone and biologically active filters, and to further evaluate the feasibility of direct filtration. Board action concurred with the TAC's recommendation.

2.3 Purpose of Treatment Process Alternatives TM No. 2

This TM, referred to herein as TM 2, builds on the documents and SRWA Board actions described above. The purpose of TM 2 can be broadly summarized as follows:

- **Update the TAC on the results of source water sampling and bench-scale testing efforts** completed since TM 1 was finalized, and describe the impacts of these results on information gaps and preliminary recommendations described in TM 1.
- **Document discussion and TAC direction provided during a TAC workshop held on January 12, 2017.** This workshop included a brief summary of source water sampling and bench-scale testing activities to date and renewed discussion of previously identified treatment trains and their ability to achieve regulatory compliance and SRWA's treatment performance goals.
- **Provide a more detailed description and comparison of key treatment processes** that comprise the treatment trains which remain under consideration, including capital and operating cost information, to facilitate the TAC's evaluation of relative benefits of each potential treatment train.
- **Document treatment train recommendations** reached by the TAC, based on source water quality and bench-scale testing results to date and the comparative benefits and cost information presented herein.

3.0 SUMMARY OF EARLY SOURCE WATER SAMPLING AND BENCH TESTING RESULTS

This section summarizes the results of source water sampling and bench-scale testing activities conducted between October 2016 and February 2017. These results are representative of only a portion of the planned sampling period, which is intended to evaluate seasonal trends and changes. These sampling and testing periods capture a portion of the impacts from significant precipitation events in January and February 2017.

3.1 Source Water Quality

Table 1 presents a comparison of select historical water quality parameters at the infiltration gallery location with current water quality from the SRWA sampling program, which started in October 2016. These data cover a four-month period from October 31, 2016 to February 27, 2017; the majority of the sampling campaign will occur over a 12-month period ending in October 2017. It should be noted that when a series of "atmospheric river" precipitation events in the area began in January 2017, sample collection frequency for TOC, dissolved organic carbon (DOC), iron and manganese was increased from once per month to once every two weeks, in order to facilitate a better understanding of the nature and duration of storm-related impacts on these key parameters. Other key parameters that could influence process train selection (e.g., total coliform, *E. coli*, turbidity and pH) are already being monitored once every two weeks.

Table 1. Comparison of SRWA Tuolumne River Sampling Results with Historical Water Quality Data, for Select Parameters

| Water Quality Parameter | Statistic | Waterford Road CEDEN (8/09 – 8/12) Upstream | Fox Grove CEDEN (8/09 – 8/12) Upstream | Infiltration Gallery TID (5/06 – 10/08) | Infiltration Gallery SRWA (10/16 - ongoing) | TID Pilot Study TID (9/06 – 4/07) Downstream |
|--|-----------------------------------|--|---|---|---|---|
| Alkalinity, mg/L as CaCO ₃ ^(a) | Range | No data | No data | 23 - 80 | 16 - 28 | 27 - 36 |
| | Average | | | 37 | 22 | 32 |
| | Median | | | 37 | 24 | 32 |
| | N ^(b) | | | 40 | 6 | -- |
| Bromide, µg/L | Range | No data | No data | <0.1 - <0.1 ^(c) | 7.3 – 8.8 | No data |
| | Average | | | <0.1 | 8.2 | |
| | Median | | | <0.1 | 8.4 | |
| | N | | | 30 | 3 | |
| Dissolved Oxygen, mg/L, Field | Range | 7.05 – 7.27 | 7.09 – 17.60 | 7.93 – 14.49 | 9.3 – 11.7 | 7.40 – 18.50 |
| | Average | 7.16 | 9.42 | 10.60 | 10.5 | 10.33 |
| | Median | 7.16 | 7.85 | 10.53 | 10.7 | 7.71 |
| | N | 2 | 7 | 66 | 9 | 4 |
| Organic Carbon, Dissolved, mg/L ^(a) | Range | No data | No data | 1.3 – 4.0 | 1.9 – 3.9 | 1.5 – 2.3 |
| | Average | | | 2.5 | 2.8 | |
| | Median | | | 2.4 | 2.4 | Not reported |
| | N | | | 47 | 6 | Not reported |
| Organic Carbon, Total, mg/L ^(a) | Range | No data | No data | 1.4 – 6.5 | 1.9 – 7.3 | 1.5 – 2.3 |
| | Average Average ^(d) | | | 3.3 | 3.66 2.81 ^(d) | 1.8 |
| | Median | | | 3.0 | 2.6 ^c | Not reported |
| | N | | | 47 | 6 | Not reported |
| Specific Conductance, µmho/cm, Lab | Range | 30 - 60 | 30 - 190 | 33 - 201 | 52 - 76 | No data |
| | Average | 43 | 88 | 90 | 66 | |
| | Median | 40 | 75 | 77 | 68 | |
| | N | 5 | 10 | 67 | 4 | |
| Specific Conductance, µmho/cm, Field | Range | | | | 47.8 – 68.2 | |
| | Average | | | | 59.3 | |
| | Median | | | | 61.1 | |
| | N | | | | 9 | |
| SUVA, L/mg-m ^(a) | Range | Not reported | Not reported | Not reported | 2.5 – 3.0 | Not reported |
| | Average | | | | 2.8 | |
| | Median | | | | 2.8 | |
| | N | | | | 6 | |

Table 1. Comparison of SRWA Tuolumne River Sampling Results with Historical Water Quality Data, for Select Parameters

| Water Quality Parameter | Statistic | Waterford Road CEDEN (8/09 – 8/12) Upstream | Fox Grove CEDEN (8/09 – 8/12) Upstream | Infiltration Gallery TID (5/06 – 10/08) | Infiltration Gallery SRWA (10/16 - ongoing) | TID Pilot Study TID (9/06 – 4/07) Downstream |
|------------------------------------|-----------|---|--|---|---|--|
| Turbidity, NTU, Lab ^(a) | Range | 0.89 – 1.08 | 1.33 – 3.56 | 0.62 – 7.32 | 0.65 - 12 | 0.75 – 8.70 |
| | Average | 0.96 | 2.33 | 2.25 | 3.9 | 2.8 |
| | Median | 0.96 | 1.62 | 2.25 | 1.3 | Not reported |
| | N | 3 | 7 | 72 | 9 | Not reported |
| Turbidity, NTU, Field | Range | | | | 0.59 – 15.43 | |
| | Average | | | | 6.1 | |
| | Median | | | | 2.4 | |
| | N | | | | 9 | |
| Ammonia, mg/L | Range | No data | No data | <0.1 ^(c) | <0.05 – 0.059 ^(c) | No data |
| | Average | | | <0.1 | <0.05 | |
| | Median | | | <0.1 | -- | |
| | N | | | 11 | 3 | |
| Nitrate, mg/L as N | Range | No data | No data | 0.3 – 0.9 | 0.17 – 0.49 | No data |
| | Average | | | 0.5 | 0.323 | |
| | Median | | | 0.4 | 0.315 | |
| | N | | | 19 | 4 | |
| Iron, Dissolved, mg/L | Range | No data | No data | No data | 0.021 – 0.098 | No data |
| | Average | | | | 0.067 | |
| | Median | | | | 0.073 | |
| | N | | | | 5 | |
| Iron, Total, mg/L | Range | No data | No data | <0.05 – 6.5 ^(c) | 0.14 – 0.67 | 0.11 – 0.35 |
| | Average | | | 0.188 | 0.398 | 0.17 |
| | Median | | | <0.10 | 0.4 | Not reported |
| | N | | | 94 | 5 | Not reported |
| Manganese, Dissolved, mg/L | Range | No data | No data | No data | <0.002 – 0.0044 ^(c) | No data |
| | Average | | | | <0.002 | |
| | Median | | | | <0.002 | |
| | N | | | | 5 | |
| Manganese, Total, mg/L | Range | No data | No data | <0.01 – 0.850 ^(c) | 0.013 – 0.028 | 0.014 – 0.085 |
| | Average | | | 0.0294 | 0.018 | 0.04 |
| | Median | | | 0.017 | 0.015 | Not reported |
| | N | | | 95 | 5 | Not reported |

Table 1. Comparison of SRWA Tuolumne River Sampling Results with Historical Water Quality Data, for Select Parameters

| Water Quality Parameter | Statistic | Waterford Road CEDEN (8/09 – 8/12) Upstream | Fox Grove CEDEN (8/09 – 8/12) Upstream | Infiltration Gallery TID (5/06 – 10/08) | Infiltration Gallery SRWA (10/16 - ongoing) | TID Pilot Study TID (9/06 – 4/07) Downstream |
|------------------------------------|-----------|--|---|---|---|---|
| <i>E. coli</i> , MPN/100 mL | Range | 12.1 – 172.3 | 3 – 461.1 | 0 - 160 | 6.3 - 460 | No data |
| | Average | 60.8 | 75.9 | 24.0 | 108 | |
| | Median | 26.2 | 29.0 | 12.7 | 41 | |
| | Average | | | | 108 | |
| | N | 5 | 10 | 24 | 9 | |
| Total Coliform, MPN/100 mL | Range | 866 - >2420 | 816 – >2420 | 4 - >1600 | 820 - >2420 | No data |
| | Average | 1728.4 | 1876.8 | 282 | 1851 | |
| | Median | 1732.9 | 1986.3 | 130 | 1700 | |
| | N | 5 | 8 | 73 | 9 | |
| <i>Cryptosporidium</i> , oocysts/L | Range | 0 | 0 – 0.258 | 0 - 09 | 0 - 1 | No data |
| | Average | | 0.052 | 0 | 0.0025 | |
| | Median | | 0 | 0 | 0 | |
| | N | 1 | 5 | 24 | 4 | |
| <i>Giardia</i> , cysts/L | Range | 0.195 | 0 – 0.129 | 0 – 2.00 | 0.1 – 0.4 | No data |
| | Average | | 0.026 | 0.33 | 0.225 | |
| | Median | | 0 | 0 | 0.2 | |
| | N | 1 | 5 | 12 | 4 | |

(a) Eurofins and Trussell Tech (TT) data were merged into one dataset when analysis frequency was increased for this Project. When samples for a specific collection date were analyzed by both Eurofins and TT, only Eurofins data was included in dataset.

(b) "N" = number of samples

(c) When the dataset included measurements below the detection limit, the detection limit was used in calculating the average and median.

(d) The TOC measured by Eurofins on Feb 13, 2017 was 7.3 mg/L. The DOC measured for this same sample was 2.8 mg/L. For all prior samples, the DOC was > 94% of the TOC. Additionally, the TOC of water collected this same day for bench testing was 3.07 mg/L. Therefore, the TOC measurement of 7.3 mg/L is considered an outlier and was excluded from the indicated statistics.

Most parameters in this sampling campaign are analyzed by the State-certified laboratory, Eurofins. Dissolved oxygen, conductivity, pH, temperature, and turbidity are also measured in the field at the time of sample collection. TOC, DOC, ultraviolet (UV)-254¹, pH, turbidity and alkalinity are also measured in the Trussell laboratory when river water samples are received for bench testing. Measurements from all three sources are included in Table 1.

Statements about how these recently collected data compare with historic data, along with preliminary implications for treatment train selection, are discussed below.

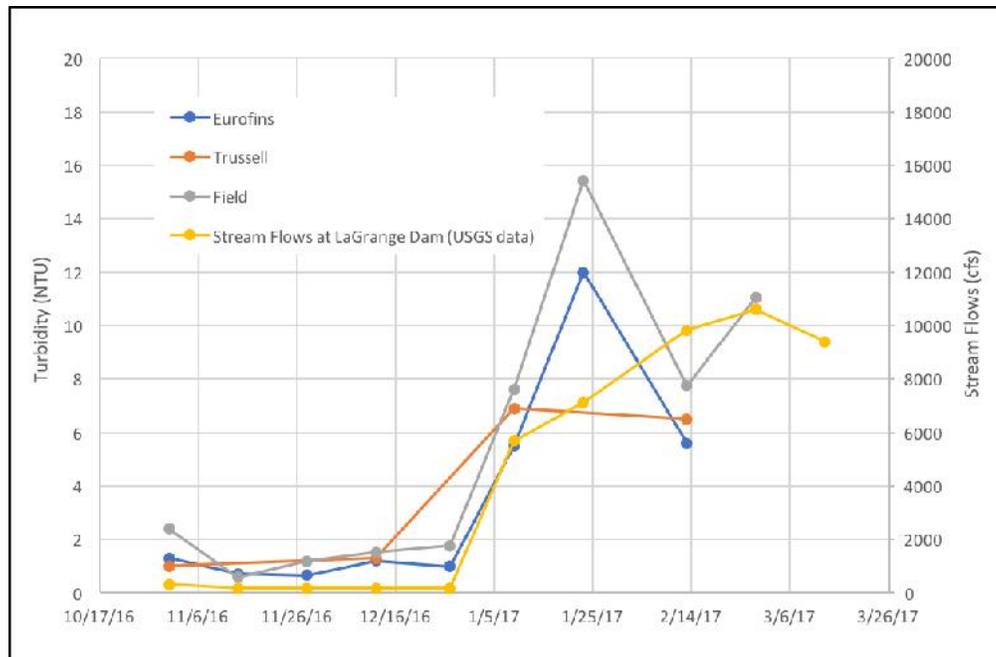
3.1.1 General Water Quality Parameters

General water quality parameters include alkalinity, color, pH, turbidity, sodium, chloride, conductivity, dissolved oxygen, temperature, calcium, and magnesium. Noteworthy observations are summarized below:

- **Alkalinity** ranged from 16-28 milligrams per liter (mg/L) as CaCO₃, which is a slightly lower than nearby historical measurements.
- **Turbidity** measured in the lab ranged from 0.65-12 nephelometric turbidity units (NTU), while field turbidity ranged from 0.59-15.43 NTU. These numbers are in line with the historical data, but the maximum measured during this monitoring program is slightly higher than the maximum historical measurements. As shown on Figure 1 turbidity increased in relation to the winter storm events and higher releases from Don Pedro Reservoir. The infiltration gallery intake will likely dampen the storm related turbidity “spikes.” Even without accounting for the assumed turbidity reduction provided by the infiltration gallery, these raw water turbidity values do not preclude the use of direct filtration or membrane filtration (which generally requires that raw water turbidity is consistently less than 10 NTU).

¹ UV-254: The amount of UV light that is absorbed by the sample at a wavelength of 254 nanometers (nm).

Figure 1. Turbidity Levels in the Tuolumne River at the Infiltration Gallery Location in Relation to Releases from Don Pedro Reservoir



3.1.2 Nutrients

The parameters considered in the nutrient category are ammonia, nitrite, nitrate, and phosphorus². Noteworthy observations are summarized below:

- **Ammonia** was below the minimum reporting limit (MRL) of 0.05 mg/L in three out of four samples. The one time it was detected the concentration was 0.059 mg/L, just slightly above the MRL.
- **Nitrite** was never detected.
- **Nitrate** concentrations were lower than the historical data, with a maximum measured concentration of 0.49 mg/L as N and an average concentration of 0.32 mg/L as N. The average nitrate concentration from the historical data was 0.5 mg/L as N. Nitrate concentrations measured during the on-going monitoring program decreased in relation to the Dec-Feb storm events and large releases from Don Pedro Reservoir, likely due to dilution.

² To date, phosphorus test results have not been received from the laboratory. We are following up with the lab to locate the missing data.

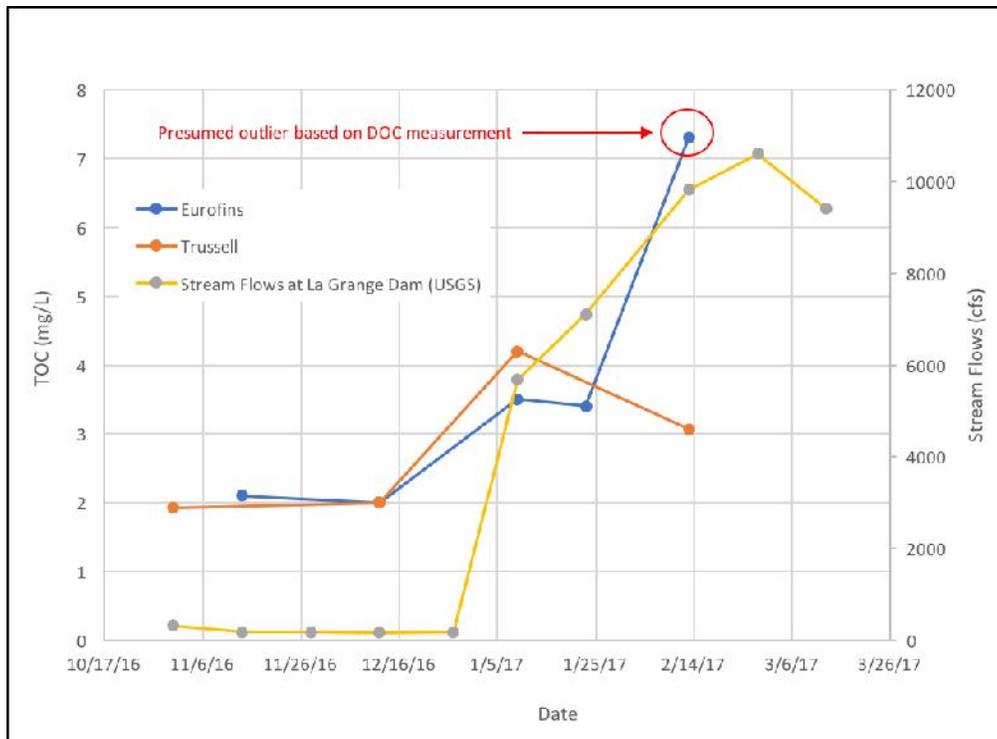
3.1.3 Disinfection By-Product Related Parameters

Water quality parameters that fall into the DBP-related category include TOC, DOC, UV-254, specific ultraviolet absorbance (SUVA), and bromide. Noteworthy observations are summarized below:

- **Bromide** concentrations remained very low, with a maximum concentration of 0.0088 mg/L. Bromate can form during ozonation when bromide concentrations are high enough (typically at concentrations greater than 0.10 mg/L (Song, et al., 1997 in USEPA, April 1999)). The maximum contaminant level (MCL) for bromate is 0.010 mg/L. Based on experience, the bromide limit for exceeding the bromate MCL with ozone is typically 0.1 to 0.3 mg/L, more than an order of magnitude higher than measured concentrations. Thus, bromate formation during ozonation of this source water should not be a concern.
- **Natural organic matter (NOM)** in the water is the precursor material for the chlorination DBPs. TOC concentrations (a measure of NOM) measured to date as part of this SRWA monitoring program have been consistent with historical concentrations. The average TOC concentration measured between 2006 and 2008 at the infiltration gallery location was 3.3 mg/L, and the average from current monitoring is 2.8 mg/L (excluding a presumed outlier³ of 7.3 mg/L).
- **TOC** concentrations in the Tuolumne River increased in relation to winter storm events and higher stream flows (see Figure 2).
- As discussed in the Section 3.2 of this TM, the TOC concentrations of this source water are expected to be high enough at times that DBP formation will exceed regulatory limits with free chlorine as a final disinfectant, unless sufficient TOC is removed during treatment or chloramines are used for final disinfection.
- **DOC** concentrations are consistently > 94 percent of the TOC concentrations, meaning that most of the organic carbon is dissolved rather than particulate.

³ This reported TOC concentration is considered an outlier and disregarded because (a) for the same sample the DOC was measured by the laboratory to be 2.8 mg/L, (b) the DOC has consistently been between 94 percent and 112 percent of the TOC and if the TOC was truly 7.3 mg/L then the DOC would have been only 38 percent of the TOC, and (c) Trussell Tech measured the TOC of a different sample, but collected the same day, to be 3.07 mg/L.

Figure 2. TOC in the Tuolumne River at the Infiltration Gallery Location in Relation to Releases from Don Pedro Reservoir



3.1.4 Iron and Manganese

As part of the on-going monitoring program, both total and dissolved iron and manganese have been measured. The historical dataset includes only total iron and manganese concentrations. Recent SRWA monitoring data indicates manganese is present in the Tuolumne River at the infiltration gallery location, at total manganese concentrations ranging from 14 to 28 micrograms per liter ($\mu\text{g/L}$). In four of seven samples to date, the dissolved manganese concentration was below $2 \mu\text{g/L}$, which is the method reporting limit. These data indicate that dissolved manganese from the Tuolumne River (as Mn^{2+}) may not be a concern for this WTP unless there is another source of Mn^{2+} or ozone produces a manganese colloid that is not effectively removed. Also, it is good to keep in mind that we are only partway through the sampling campaign, so there may be additional raw water samples in the future with Mn^{2+} . Based on experience with infiltration galleries (and other types of sub-surface collectors like Ranney collectors, etc.) and water treatment plant design, manganese can show up when the full-scale facility starts up or has been operating some time, even if it is not measured in the Tuolumne River samples (Trussell and Snoeyink, 2017). Ideally, the WTP design will be flexible enough to address manganese removal if needed. The finished water goal for total manganese should be $\leq 10 \mu\text{g/L}$ to avoid potential aesthetic issues related to manganese that may pass through the treatment plant and into the distribution system.

Iron and manganese are important because of the potential for aesthetically unpleasant colored water in the distribution system, as well as potential health impacts. Currently, both iron and

manganese have a secondary MCL but neither has a primary MCL. Manganese has been included on the latest Contaminant Candidate List (CCL4) and Unregulated Contaminant Monitoring Rule (UCMR4) lists because of potential neurological effects in children and infants. Therefore, a pMCL may be forthcoming in the future for manganese.

3.1.5 Microbiological

Microbiological parameters that were measured during this on-going sampling program include *E. coli*, total coliform, *Giardia* and *Cryptosporidium*. Noteworthy observations are summarized below:

- **Total coliform** numbers measured during this sampling program are in line with those reported for the upstream Waterford Road and Fox Grove locations, as well as the downstream historical sampling locations. However, the numbers are higher than measured by Turlock Irrigation District at the infiltration gallery location between 2006 and 2008 as part of the Watershed Sanitary Survey.
- On average, the *E. coli* numbers measured during the ongoing sampling campaign are higher than the historical data.
- As discussed in Section 4.2 of this TM, the total coliform and *E. coli* levels may lead DDW to require higher-than-minimum pathogen treatment for *Giardia* and viruses (minimum treatment requires 3-log and 4-log reduction, respectively).
- *Cryptosporidium* samples analyzed to date (four out of the 24 required samples) indicate this source water falls in Bin 1, requiring only 2-log removal per regulations. DDW, however, may require 3-log removal based on total coliform and *E. coli* results.

3.1.6 Pesticides and other Synthetic Organic Chemicals (SOCs)

The pesticides and SOC's included in this sampling program include the following:

- Constituents with a primary or secondary maximum contaminant level (pMCL or sMCL).
- Constituents detected above the analytical detection limit in the available historical data.
- Constituents with high application rates (>5,000 lbs/yr or applied to >10,000 acres) in the watershed.

Of the 189 parameters analyzed, only two were detected: diuron and simazine. Diuron has a Health Advisory level of 1 mg/L and was measured at 66 nanograms per liter (ng/L), or 0.000066 mg/L, which is roughly 4 orders of magnitude less than the Health Advisory Level. Simazine has a pMCL of 0.004 mg/L and was measured at a concentration of 93 ng/L (or 0.000093 mg/L), or roughly two orders of magnitude below the pMCL. Neither of these are on the list of high-use pesticides for the Lower Tuolumne River watershed. However, both pesticides were previously detected in historical sampling between La Grange Dam and Modesto.

3.2 Bench Test Results

To help answer questions regarding the treatability of the source water, and to aid in the development of preliminary design doses for certain treatment chemicals, a series of bench tests are being conducted as part of a year-long monitoring program (November 2016 through October 2017). The bench tests conducted to date, and the questions they have attempted to answer, are summarized below:

- **Coagulation jar tests** were conducted to evaluate TOC removal with three commonly used coagulants as a function of coagulant dose and pH. In conjunction with these jar tests, DBP formation with free chlorine and chloramines has been evaluated as a function of contact time, using the simulated distribution system disinfection by-product (SDSDBP) test procedure.
- **Ozone demand tests** were conducted to evaluate the ozone dose required for ozonation of both raw water (i.e., pre-ozonation) and coagulated/settled water (i.e., intermediate ozonation). Bromate formation, a regulated ozonation by-product, was determined as a function of ozone dose. Ozone demand tests are being conducted monthly to evaluate seasonal changes in ozone demand and to accurately select a design dose.
- **Manganese removal jar tests** were conducted to evaluate whether reduced manganese (Mn^{2+}) could be effectively removed if ozone were included in the treatment train. Mn^{2+} concentrations measured thus far in this source water have been very low, with only three of seven samples having a measurable concentration above the laboratory's method reporting limit. There are other potential sources of manganese for SRWA's treatment plant, however: (a) manganese as a component of a ferric chloride coagulant (if used); (b) reduction of particulate manganese through the infiltration gallery or an unanticipated contribution by groundwater to infiltration gallery influent; and (c) dissolved manganese in the decant stream from sludge storage basins and drying beds. Experience indicates that reduced manganese can show up in the influent to the WTP even if it was not measured during the source water characterization program, and the WTP design should be flexible to accommodate manganese removal if needed (Trussell and Snoeyink, 2017). Ineffective removal of Mn^{2+} can result in colored water that is aesthetically unappealing to consumers. In addition, a pMCL is being considered for manganese because of potential neurological effects in children and infants.

Key preliminary findings of these bench tests are summarized in the subsections below. The discussion is organized in terms of the questions each bench test was intended to answer. A separate, standalone report will be prepared to provide detailed discussion of all bench test results; this report is expected to be published in April 2017.

3.2.1 Enhanced Coagulation and DBP Formation

The Disinfectants and Disinfection Byproducts (D/DBP) Rule requires a specified percentage of raw water TOC to be removed through a process known as “enhanced coagulation⁴”, depending on raw water TOC concentration and alkalinity. The TOC removal requirements are summarized in Table 2. Per the regulations, enhanced coagulation requirements apply to conventional treatment, while direct filtration and membrane filtration treatment trains are exempt. The reason is because a low coagulant dose (e.g., ≤ 5 mg/L) is used in direct filtration and membrane filtration, which typically provides little or no TOC removal. So, the regulations do not force a direct filtration plant to add sedimentation to accommodate the higher required coagulant dose, but they still require that the plant is compliant with the DBP standards for drinking water. Therefore, regardless of whether enhanced coagulation is required, the finished water must meet the total trihalomethanes (TTHM) and haloacetic acids (HAA5) MCLs of 80 $\mu\text{g/L}$ and 60 $\mu\text{g/L}$, respectively, as measured in the distribution system.

| Source Water TOC (mg/L) | Source Water Alkalinity (mg/L as CaCO ₃) | | |
|-------------------------|--|---------|------|
| | 0-60 | >60-120 | >120 |
| >2.0 – 4.0 | 35% | 25% | 15% |
| >4.0 – 8.0 | 45% | 35% | 25% |
| >8.0 | 50% | 40% | 30% |

Because DBP formation is largely a function of DBP precursor concentration (i.e., TOC), the D/DBP Rule includes “Alternative Compliance Criteria” which are alternate means of complying with this Rule. In brief, the Alternative Compliance Criteria applicable to the Tuolumne River state that the specified TOC removals do not have to be met if (1) raw water TOC is <2.0 mg/L, (2) treated water TOC is <2.0 mg/L, (3) raw water SUVA is <2.0 L/mg-m, or (4) treated water SUVA is <2.0 L/mg-m.

Three coagulants were tested to compare their effectiveness for both TOC removal and turbidity removal: ferric chloride (ferric), aluminum sulfate (alum), and polyaluminum chloride (PACl). These are conventional coagulants used widely in water treatment. Aluminum chlorohydrate ($\text{Al}_n\text{Cl}_{(3n-m)}(\text{OH})_m$) or ACH, another long-chain aluminum-based coagulant, was not tested as part of this study. ACH and PACl are similar chemicals; neither reduces pH or consuming as much alkalinity as alum.

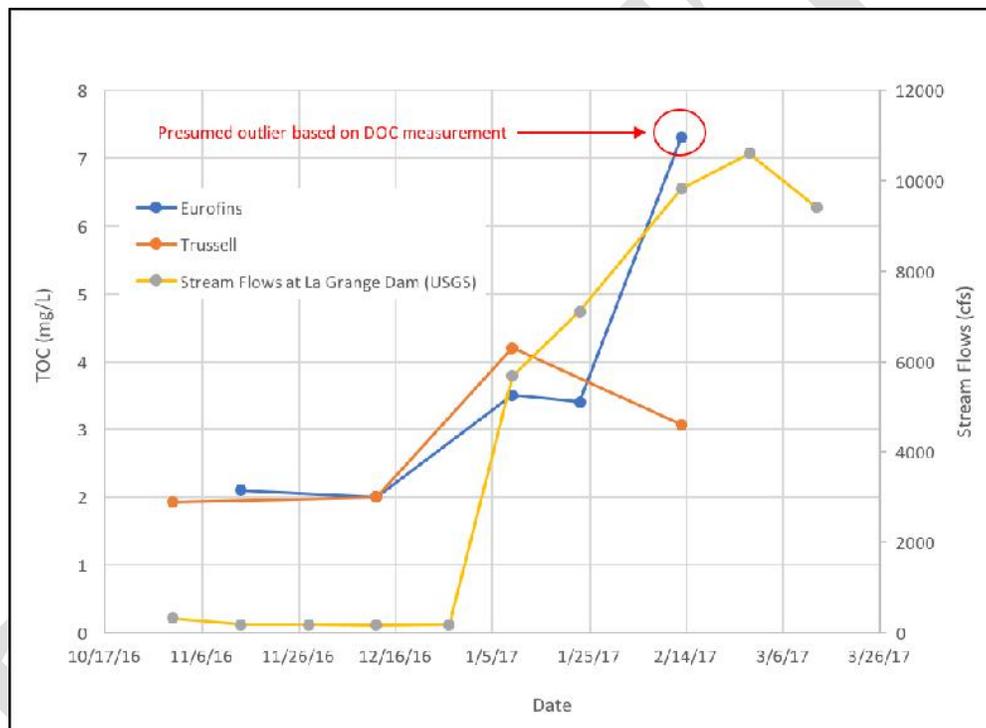
Results from these enhanced coagulation jar tests are discussed below in terms of key questions the tests were designed to answer.

⁴ Enhanced coagulation typically entails the precipitation of humic compounds present in raw water by coagulation, flocculation and settling.

3.2.1.1 Will Enhanced Coagulation be required for this source water, or will one of the Alternative Compliance Criteria be applicable?

The raw water TOC has been variable since monitoring began at the end of October, with concentrations ranging from 1.9 mg/L to 4.2 mg/L (the max TOC of 7.3 mg/L was excluded as an outlier). The TOC was ≤ 2.1 mg/L from the start of the sampling campaign through mid-December when the “atmospheric river” storm events began, such that only a small coagulant dose would be required to reduce the TOC below 2.0 mg/L. From mid-December 2016 to early March 2017, TOC levels have been well above 2.0 mg/L such that enhanced coagulation would be required for conventional treatment. This variability in raw water TOC is shown on Figure 2 (and repeated below as Figure 3 for ease of reference) in relation to stream flows.

Figure 3. Raw Water TOC Concentrations Over Time and as a Function of Stream Flows



The SUVA for this source water has consistently been above 2.0 L/mg-m, ranging from 2.5 to 3.0 L/mg-m. SUVA is an indicator of the humic content of the water. Humic organic material is more amenable to removal through coagulation than non-humic organic material. SUVA is calculated by dividing the UV-254 measurement by the DOC concentration. Waters with a low SUVA contain primarily non-humic organic material which are not amenable to enhanced coagulation. Waters with a high SUVA are generally amenable to enhanced coagulation. Thus, the raw water for this treatment plant should be amenable to effective TOC removal through enhanced coagulation.

ANSWER: For a conventional treatment facility, enhanced coagulation (i.e., use of a higher coagulant dose to meet regulated TOC removal) will be required some portion of the year. A conventional treatment facility is designed with sedimentation, which can handle the changing coagulant doses without impacting treatment. As such, there is no reduction in treatment capacity and no more frequent backwashing associated with an enhanced coagulation process. However, the periods of time when a higher coagulant dose is required will experience higher chemical usage and greater sludge production. A direct filtration plant or a membrane filtration plant, however, does not have the option of meeting the DBP regulations by increasing the coagulant dose to provide greater TOC removal. So, although the regulations do not require enhanced coagulation for a direct filtration facility or a membrane filtration facility, significant TOC removal will be required to meet the DBP MCLs if free chlorine is used for final disinfection. Without sufficient TOC removal, chloramines will be required to meet DBP limits.

3.2.1.2 How do the coagulants tested compare in terms of their effectiveness for both TOC removal and turbidity removal?

Jar tests evaluating turbidity and TOC removal were performed on Tuolumne River water samples collected in November 2016 and January 2017. The November water was representative of what seems to be “dry weather” conditions: low streamflow, low turbidity (≤ 2 NTU), and low TOC (≤ 2 mg/L). The January water was collected shortly after a series of major storms affected the region, and was representative of “wet weather” high streamflow conditions with higher turbidity (5 – 10 NTU) and higher TOC (4.0 – 4.5 mg/L).

Settled water turbidity as a function of coagulant dose (mg/L) is shown on Figure 4. Alum and PACl consistently performed the same during both the November and January enhanced coagulation tests. Ferric chloride performed similar to the aluminum-based coagulants, but promoted particle settling at a slightly lower dose. All three coagulants were able to effectively destabilize and settle particulates.

Settled water TOC as a function of coagulant dose (mg/L) is shown on Figure 5. For both the November and January jar tests, alum and PACl performed the same while ferric provided better TOC removal at a lower dose. However, as discussed later in this TM, Mn^{2+} (a reduced form of manganese) is a common contaminant in ferric chloride coagulant, and could be a drawback of this coagulant in terms of finished water aesthetics.

ANSWER: Alum and PACl performed almost identically for both turbidity and TOC removal. Ferric chloride was able to provide comparable turbidity removal to alum and PACl; ferric provided greater TOC removal at comparable doses (mg/L). As discussed, though, the greater TOC removal provided by ferric does not justify the risk of adding Mn^{2+} to the water.

Figure 4. Comparison of Coagulants for Turbidity Removal in Coagulant Dose in Units of mg/L
(Nov. test on left; Jan. test on right)

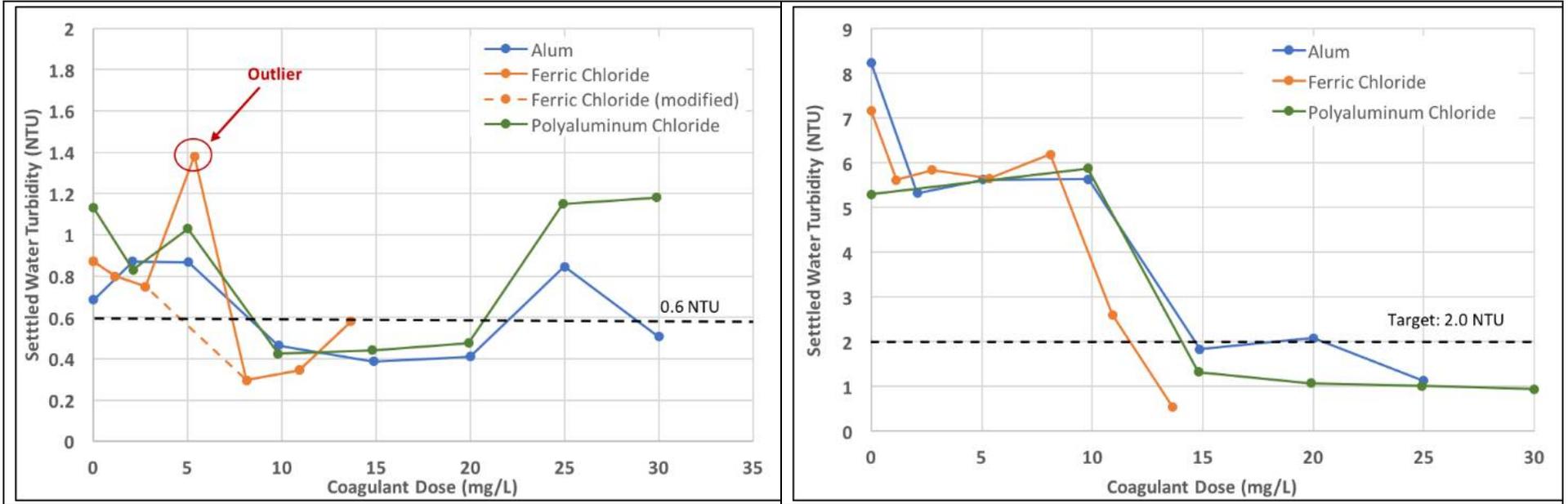
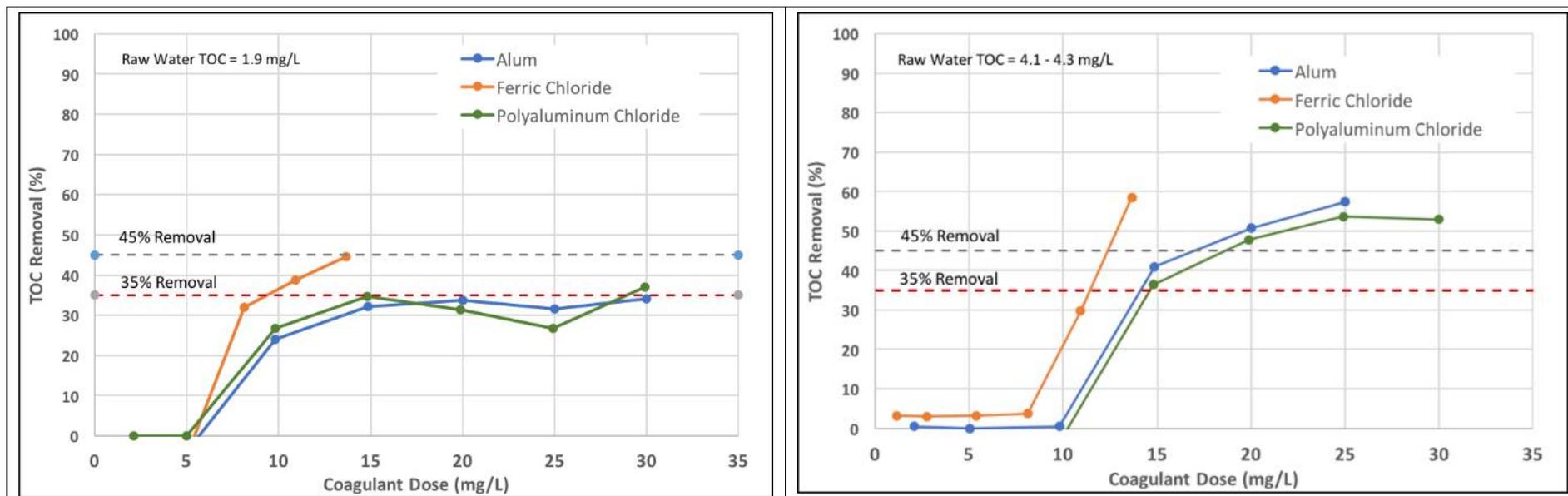


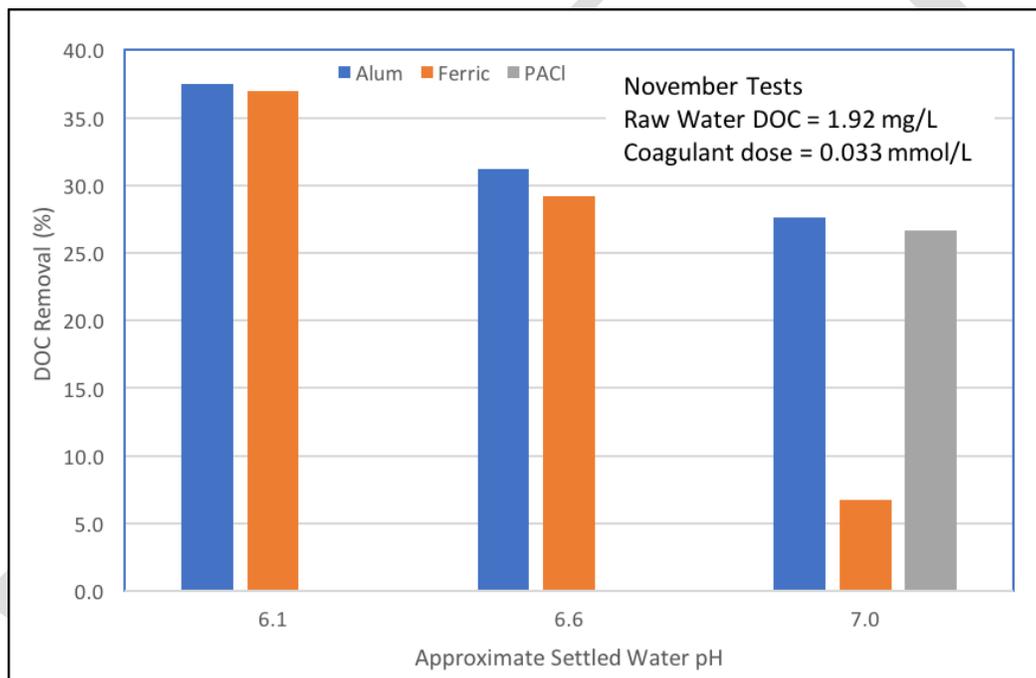
Figure 5. Comparison of Coagulants for TOC Removal with Coagulant Dose in Units of mg/L
(Nov. test on left; Jan. test on right)



3.2.1.3 Will pH reduction be required for effective TOC removal?

Figure 6 shows that greater TOC removals are achieved at lower pHs. This is consistent with the USEPA's Enhanced Coagulation Guidance Manual (USEPA, May 1999). However, for a water with a low alkalinity like SRWA's source water, if the pH is reduced for coagulation it will have to be raised at the end of the treatment train to produce a stable, non-corrosive water for the distribution system. The preceding section comparing coagulants for TOC removal showed that all three coagulants are able to achieve 35 percent TOC removal when the raw water TOC is between 2.0 and 4.0 mg/L, and 45 percent removal when the source water TOC is above 4.0 mg/L, as required by the regulations. Reasons to consider lowering the coagulation pH are (1) lower sludge production at lower coagulant doses, and (2) potential chemical cost savings depending on the unit cost of each bulk chemical and the chemicals chosen for post-treatment stabilization (e.g., lime versus caustic).

Figure 6. TOC Removal as a Function of Coagulation pH



ANSWER: pH reduction during coagulation does improve TOC removal, but it is not required for effective TOC removal (per the D/DBP Rule) from this source water.

3.2.1.4 Are the chlorination DBPs (i.e., TTHMS and HAA5) a concern for this source water?

SDSDBP tests have been conducted twice: once in November when the raw water was representative of “dry weather” conditions with a low turbidity (≤ 2 NTU) and low TOC concentration (≤ 2 mg/L); and once in February when the raw water was representative of “wet weather” conditions with a higher turbidity (5 – 10 NTU) and higher TOC (4.0 – 4.5 mg/L). The coagulant dose used to prepare coagulated/settled (CS) water for both the November and February

SDSDBP tests was selected to achieved a target 35 percent TOC removal consistent with the Enhanced Coagulation guidelines. Ferric was used in November at a dose of 7.9 mg/L and achieved an average 40 percent TOC removal. Alum at a dose of 9.8 mg/L was used to prepare the CS water for the February SDSDBP tests, and the average DOC removal was 26.5 percent (DOC removal is reported because TOC numbers were considered erroneous due to poor floc settling). Also during the February tests, a low alum dose of only 5 mg/L, representative of a dose for direct filtration, was used to prepare water for the SDSDBP tests.

Final disinfection with both free chlorine and combined chlorine was tested. The sample holding times were 1-hour, 48-hours and 96-hours. The 1-hour holding time is representative of a chlorine contact basin. The 96-hour holding time is representative of the estimated time in the finished water pipeline and Turlock's largest distribution system water age. Finally, the 48-hour holding time was selected to provide an additional data point for the development of trends.

The November SDSDBP test results are shown on Figure 7. The February low coagulant dose SDSDBP results are on Figure 8, and the February conventional coagulant dose is shown on Figure 9. The tabulated results are provided in Table 3. SDSDBP Formation with Free Chlorine & Combined Chlorine. Key conclusions that can be drawn are the following:

- With conventional coagulation treatment, and when the raw water TOC is 2.0 mg/L or less, the resultant TTHMs and HAAs should be well below regulatory limits.
- With direct filtration, when the coagulant dose is < 5 mg/L and the raw water TOC is elevated (i.e., ≥ 2.5 to 3 mg/L), the treatment facility will likely exceed both TTHM and HAA MCLs. With little or no TOC removal, chloramines will definitely be required for secondary disinfection.
- HAA formation is a greater concern for this water than are the TTHMs.
- Even with conventional treatment, there is potential to exceed the HAA MCLs when the raw TOC is elevated, such that the clarified/settled water TOC is greater than roughly 2.6 mg/L (Figure 9). Presumably, a higher coagulant dose can be used if needed for higher TOC removal. Or ozone with BAC filtration can be used to provide even greater TOC removal. Note that regulatory compliance is based on locational running annual average DBP concentrations.
- Ozonation of the coagulated/settled water resulted in lower DBP formation—both for TTHMs and HAA5.

ANSWER: With direct filtration treatment, which provides little or no TOC removal, DBPs are likely to exceed their MCLs with free chlorine for final disinfection. TOC removal, as required by the Enhanced Coagulation portion of the D/DBP Rule, will be required if the Cities choose to use free chlorine for final disinfection. This may preclude using direct filtration or membrane filtration treatment with free chlorine for secondary disinfection, or may require using chloramines for final disinfection rather than free chlorine. Sufficient TOC removal should be attainable with a conventional treatment train. Ozonation of the coagulated/settled water seems to result in lower levels of DBPs.

Table 3. SDSDBP Formation with Free Chlorine and Combined Chlorine (i.e., Chloramines)

| Month/Sample | Raw Water TOC, mg/L | Disinfectant | Dose, mg/L as Cl ₂ | TTHM 1-hr, µg/L | HAA5 1-hr, µg/L | TTHM 48-hr, µg/L | HAA5 48-hr, µg/L | Disinfectant Residual, 48 hrs | TTHM 96 hr, µg/L | HAA5 96-hr, µg/L | Disinfectant Residual, 96 hrs |
|--|---------------------|---------------|-------------------------------|-----------------|-----------------|------------------|------------------|-------------------------------|------------------|------------------|-------------------------------|
| Nov/CS (7.9 mg/L ferric) | 1.21 | Free chlorine | 2.0 | 11 | 8.3 | 31 | 24 | 0.60 | Not tested | Not tested | Not tested |
| Nov/CS-O ₃ (7.9 mg/L ferric) | 1.21 | Free chlorine | 2.0 | 3.1 | ND | 27 | 15 | 0.54 | Not tested | Not tested | Not tested |
| Nov/CS (7.9 mg/L ferric) | 1.21 | Chloramines | 3.25 | 11 | 8.3 | 16 | 11 | 2.24 | Not tested | Not tested | Not tested |
| Nov/CS-O ₃ (7.9 mg/L ferric) | 1.21 | Chloramines | 3.25 | 3.1 | ND | 7.1 | 3.6 | 2.22 | Not tested | Not tested | Not tested |
| Feb/CS (5.1 mg/L alum) | 3.35 | Free chlorine | 2.75 | 28 | 38 | 90 | 114 | 0.42 | 79 | 90 | 0.14 |
| Feb/CS (5.1 mg/L alum) | 3.35 | Chloramines | 3.25 | 30 | 33 | 40 | 46 | 1.85 | 37 | 47 | 1.83 |
| Feb/CS (9.8 mg/L alum) | 2.67 | Free chlorine | 2.5 | 16 | 15 | 55 | 47 | 1.05 | 49 | 52 | 0.83 |
| Feb/CS-O ₃ (9.8 mg/L alum) | 2.67 | Free chlorine | 2.5 | 10 | 12 | 41 | 37 | 0.91 | 49 | 53 | 0.63 |
| Feb/CS (9.8 mg/L alum) | 2.67 | Chloramines | 3.0 | | | 22 | 18 | 2.12 | 20 | 20 | 1.94 |
| Feb/CS-O ₃ (9.8 mg/L alum) | 2.67 | Chloramines | 3.0 | | | 15 | 12 | 2.04 | 14 | 13 | 1.78 |

Notes:
 Target free chlorine residual was 0.4 mg/L after 48 hours. Target chloramine dose was 2.0 mg/L after 48 hours. A phosphate buffer was used to maintain a constant pH of 7.7 – 8.0 during SDSDBP tests.
 An O₃:TOC ratio of 1.0 was used to prepare the CS-O₃ water.

Figure 7. November SDSDBP Test Results Representing Enhanced Coagulation with Low TOC Raw Water Quality

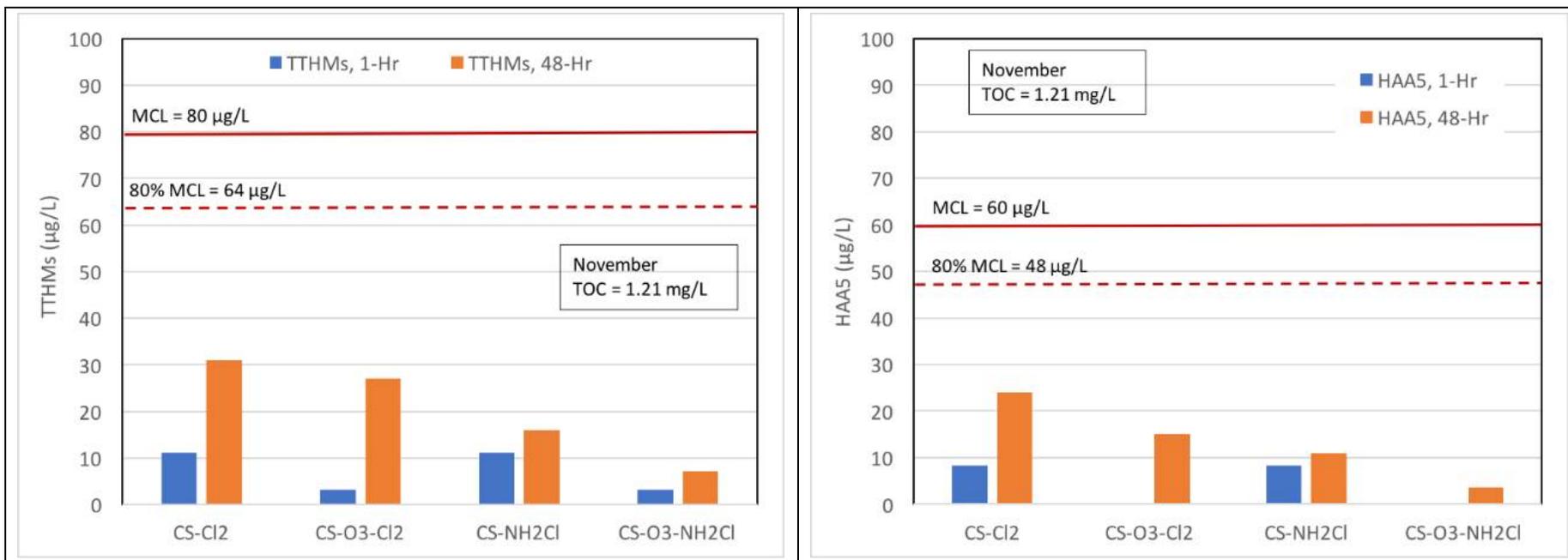


Figure 8. February SDSDBP Test Results Representing Direct Filtration Equivalent Low Coagulant Dose with High TOC Raw Water Quality

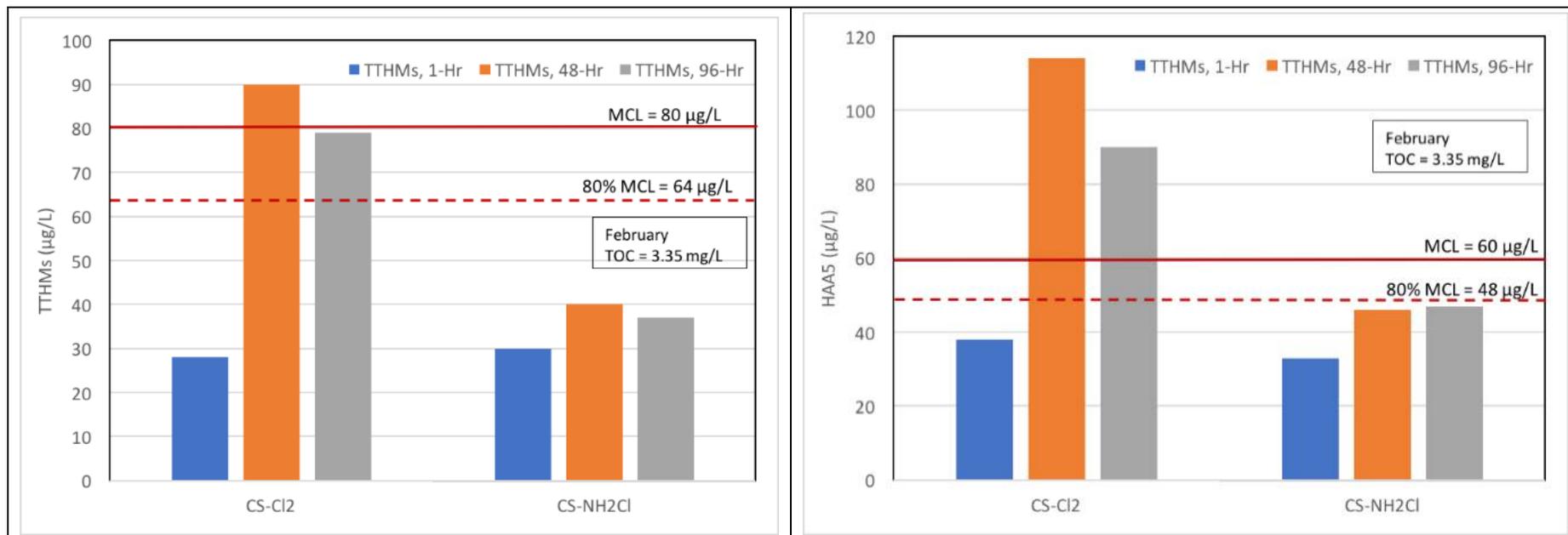
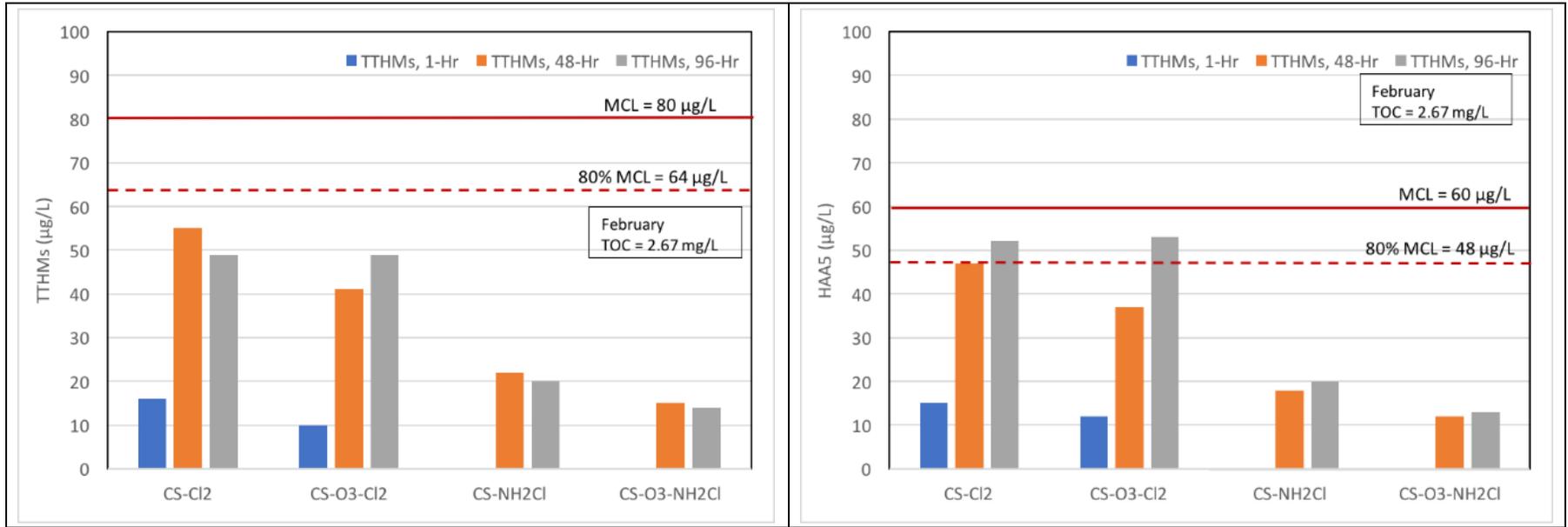


Figure 9. February SDSDBP Test Results Representing Enhanced Coagulation with High TOC Raw Water Quality



3.2.2 Ozone Demand and Bromate Formation

Bromate is an ozonation by-product that forms during ozonation when bromide is present at high enough concentrations. The bromate MCL is 10 µg/L. Bromate was analyzed in the raw water and in the CS water, for O₃:TOC ratios of 0.6 and 1.0, as part of the monthly ozone demand bench tests. As shown in Table 4, bromate concentrations were consistently below the detection limit. Therefore, bromate formation is not a concern for this water.

| Month | Bromate, µg/L | | | |
|---------------|---------------------------------|---------------------------------|--------------------------------|--------------------------------|
| | Raw, 0.6 O ₃ :TOC | Raw, 1.0 O ₃ :TOC | CS, 0.6 O ₃ :TOC | CS, 1.0 O ₃ :TOC |
| November 2016 | ND (1) | 1.0 | ND (1) | ND (1) |
| December 2016 | ND (1) | ND (1) | ND (1) | ND (1) |
| January 2017 | ND (1) | ND (1) | ND (1) | ND (1) |

There are multiple purposes for including ozone in the treatment train: primary disinfection for *Giardia* and viruses; treatment for pesticides and other SOCs; and taste and odor (T&O) control. A benefit of pre-ozonation experienced by Modesto Irrigation District (MID) at the Modesto Regional Water Treatment Plant was killing of Asian Clams (*Corbicula fluminea*) and preventing their shells from moving past the ozone contactor. As shown in the preceding section, ozonation resulted in lower TTHM and HAA formation; it is expected that ozone with BAC filtration would result in even lower DBP formation due to biodegradation of the DBP precursor material through the filters.

In a conventional treatment train, ozone can be located at the front of the treatment train prior to coagulant addition (pre-ozonation) or between clarification and filtration (intermediate ozonation). Pre-ozonation would require a higher ozone dose than intermediate ozonation because the ozone demand of the water would be greater prior to TOC removal (i.e., through clarification). Based on the preliminary ozone demand bench test results, an appropriate design ozone dose for pre-ozonation of the raw water is 2.5 mg/L (see Figure 10). For intermediate ozonation (see Figure 11), an appropriate design ozone dose is 1.5 mg/L.

In order to receive disinfection credit with ozone, the ozone demand of the water must be met and then an ozone residual must be provided in order to achieve the required CT for disinfection credit. The simplest way to achieve ozone disinfection credit is to meet the ozone demand of the water and then maintain an ozone residual out of the first chamber of the ozone contactor above 0.3 mg/L. When this condition is maintained, the SWTR regulations allow 0.5-log *Giardia* inactivation credit and 1-log virus inactivation credit. Additional CT credit is achieved by monitoring ozone residual throughout the remainder of the ozone contactor.

Figure 10. Ozone Demand as a Function of Ozone Dose in Raw Water

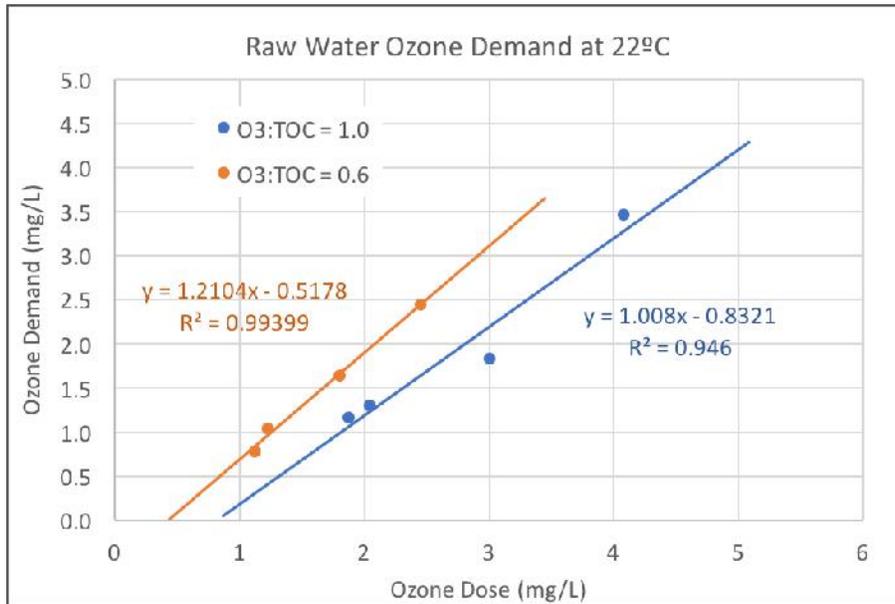
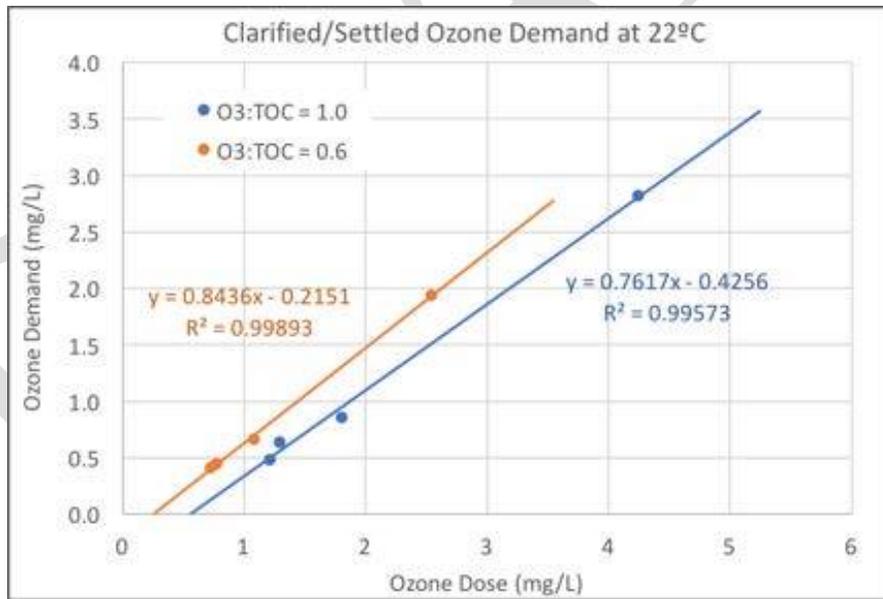


Figure 11. Ozone Demand as a Function of Ozone Dose in Clarified/Settled Water



3.2.3 Manganese Removal

If reduced Mn^{2+} is present in the water, ozonation must be carefully managed so that colloidal MnO_2 is not formed and allowed to pass through to the distribution system where it can present aesthetic issues. The Tuolumne River at the infiltration gallery location seems to have mostly particulate manganese that has already been oxidized (i.e., to MnO_2). It is unknown whether this infiltration gallery, which is embedded within a layer of coarse pea gravel and should allow fairly rapid flow, will promote reduction of particulate manganese or will draw more groundwater than anticipated, but planned construction of the raw water pump station wet well will allow SRWA to test this possibility. As discussed previously, though, experience indicates that reduce manganese can show up in the influent to the WTP even if it was not measured during the source water characterization program, and the WTP design should be flexible to accommodate manganese removal if needed (Trussell and Snoeyink, 2017).

A second round of manganese removal bench tests are currently underway. These tests are evaluating (1) the potential for ozonation to form colloidal MnO_2 which passes through treatment, (2) the effectiveness of potassium permanganate for oxidizing Mn^{2+} to MnO_2 and subsequent removal through clarification, (3) the importance of reaction time for permanganate oxidation, and (4) the preferred location for ozonation—pre- or intermediate—for particulate and colloidal MnO_2 removal. For the first round of manganese removal bench tests conducted in December, the raw water was spiked with 0.3 mg/L Mn^{2+} . Aside from one outlier in the historical data set, the maximum total manganese concentration measured at the infiltration gallery or nearby was 0.11 mg/L. For this second round of manganese tests, the raw water was spiked with a lower Mn^{2+} concentration of 0.1 mg/L. No results from this second round of testing are available at this time.

From the December tests, we learned the following that may impact treatment:

- The stock ferric chloride used in the tests contained dissolved Mn^{2+} at undesirable concentrations. Mn^{2+} is a common contaminant in ferric chloride, a result of the manufacturing processes. Different grades of ferric chloride can be purchased resulting in varying amounts of manganese contamination. The ferric chloride used for these jar tests was a sample provided by Kemira. The stock chemical was analyzed by Eurofins for both iron and manganese; lab results showed that every 5 mg/L of ferric chloride adds 0.02 mg/L Mn^{2+} ions to the raw water.
- Contact time is important for $KMnO_4$ oxidation of Mn^{2+} ; one minute and five minutes were tested. A 56-minute contact time, which represents travel time from the raw water pump station to the WTP influent, is being tested this round.
- Higher manganese removals were observed at higher ozone doses.

3.3 High River Flows and Raw Water Quality

This section provides a discussion of the significant Tuolumne River flows observed during the winter of 2017 and their impacts on the raw water quality for the SRWA Project.

3.3.1 Winter 2017 and Historical Stream Flows

January and February 2017 witnessed extended periods of significant precipitation in the watershed of the lower Tuolumne River, and have contributed to an extended period of unusually high flows in the Tuolumne River below Don Pedro Reservoir. For example, the highest daily average flow measured below LaGrange Dam during the month of February 2017 was 13,900 cfs, versus an average daily flow for February over the previous ten years (2007 to 2016) of 506 cfs⁵. Because the recent high flow periods have coincided with reductions in raw water quality for several key parameters, an effort has been made to place this period into proper historical context and help predict how frequently similar high flow periods might occur in the future. To this end, historical stream flows on the Tuolumne River below La Grange Dam and at Modesto since 1970 (when construction of Don Pedro Reservoir was completed) are shown on Figure 12; a zoomed in plot, from 1980 to present, is shown on Figure 13). As indicated, there have been numerous extended periods of high stream flows since 1970. Table 5 provides a summary of stream flow statistics of interest since 1970. Since January 1, 2005 there have been nine extended periods (defined as periods greater than seven days) when stream flows were consistently above 5,000 cfs. This flow represents the 95th percentile flow below LaGrange Dam since 1970, and represents a significant increase over the median value over the same period. The dates and duration of each of these extended high flow periods were:

- Mar 25, 2005 to Apr 7, 2005 14 days
- May 19, 2005 to May 31, 2005 13 days
- Jan 4, 2006 to Jan 14, 2006 11 days
- Mar 27, 2006 to May 30, 2006 65 days
- Jun 20, 2006 to Jun 26, 2006 7 days
- Dec 17, 2010 to Jan 7, 2011 22 days
- Mar 20, 2011 to Apr 28, 2011 40 days
- Jun 3, 2011 to Jun 19, 2011 17 days
- Jan 4, 2017 to Mar 13, 2017 ongoing (69+ days)

⁵ USGS Station ID 11289650 (Tuolumne River Below La Grange Dam Near La Grange, CA) and USGS Station ID 11290000 (Tuolumne River at Modesto, CA).

Figure 12. Historical Stream Flows on the Tuolumne River Upstream and Downstream of the Infiltration Gallery, 1970 to Present

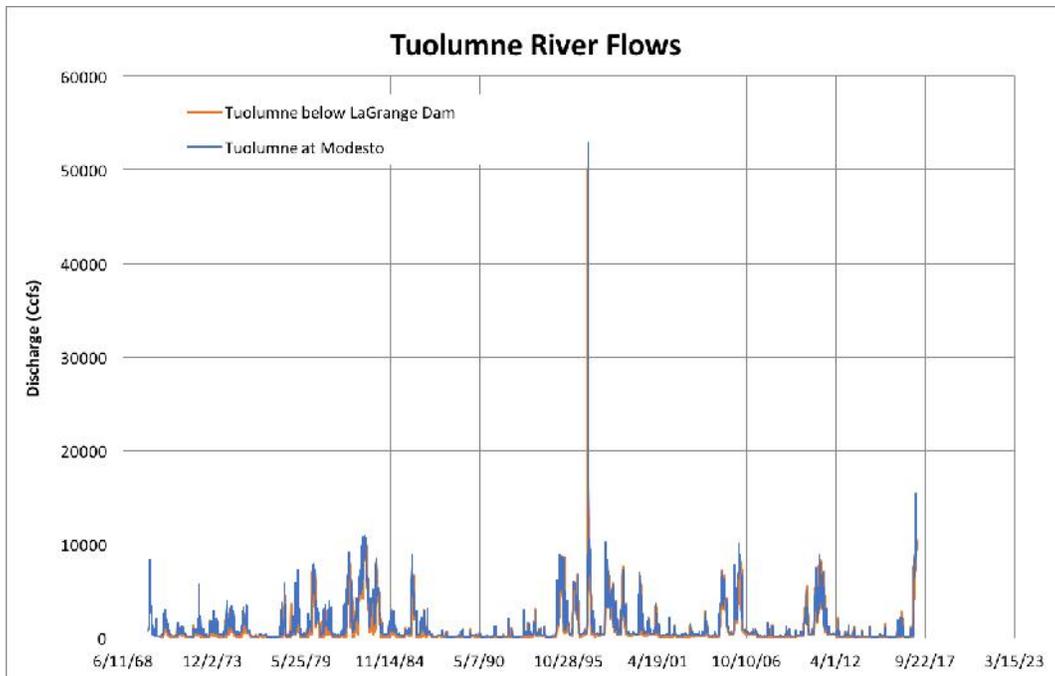
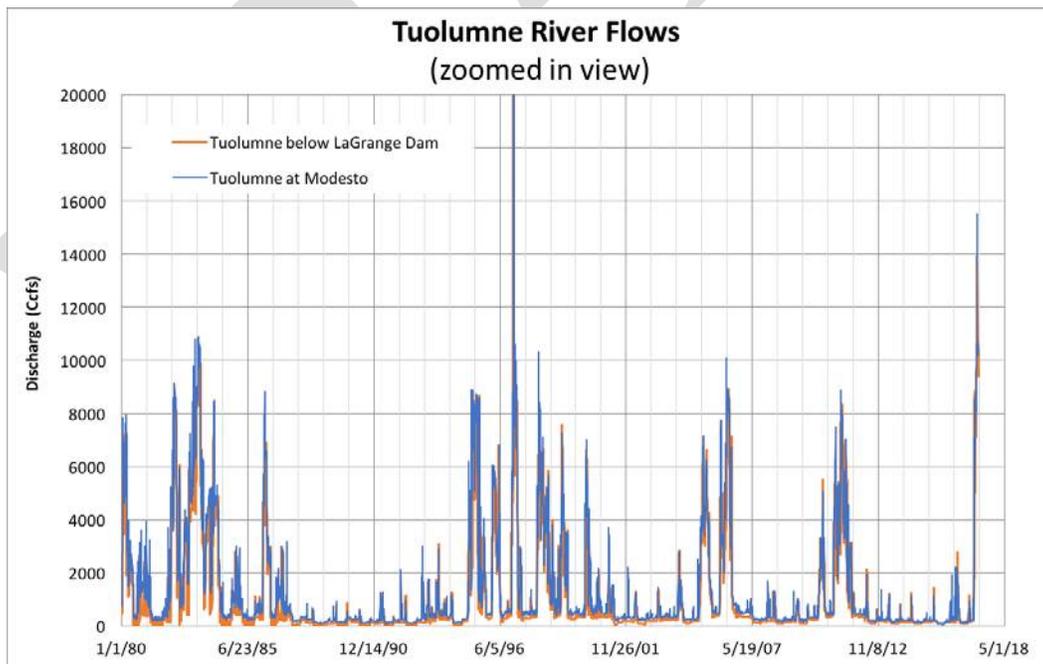


Figure 13. Historical Stream Flows on the Tuolumne River Upstream and Downstream of the Infiltration Gallery, 1980 to Present



3.3.2 Impacts of Recent High River Flows on TOC and Turbidity

The response of TOC and turbidity to recent storm events and high stream flows are shown on Figure 14 and Figure 15. If a treatment train were in place and shutdown or reduced production resulting from elevated raw water TOC or turbidity was required, SRWA would potentially not have finished water from this WTP for extended periods of time every 21 months, or at least once every other year. Additionally, with direct filtration or membrane filtration, and degraded raw water quality, little or no TOC removal would be achieved (due to the low coagulant dose), which would require that chloramines be used for secondary disinfection in order to comply with DBP regulatory limits. As discussed in Section 3.2.1.4 (and shown on Figure 8), when the raw water TOC is elevated, a low coagulant dose is used (e.g., representative of direct filtration or membrane filtration), and chloramines are used for secondary disinfection, little or no TOC removal is achieved and the SDS⁶ HAA5 concentrations approach 80 percent of the MCL concentration (or 48 µg/L). SDS THM concentrations with chloramines, on the other hand, are well below 80 percent of the MCL level (or 64 µg/L). These initial SDS tests indicate this water forms higher concentrations of HAAs than THMs. Even when chloramines are used for secondary disinfection, there should be a brief period (e.g., 60 minutes) of free chlorine contact to attain virus and *Giardia* inactivation (per the multi-barrier requirement of the regulations) and to eliminate the potential for elevated levels of Heterotrophic Plate Count (HPC) and ammonia oxidizing bacteria (AOBs) in the finished water—making a more biologically stable water for the distribution system. The detention time and size of this chlorine contact basin will be the same for either the free chlorine or the chloramine secondary disinfection scenarios; the only difference is that the chloramine scenario requires ammonia addition and mixing before the water is sent to the distribution system.

| Category | Value |
|---|---------------------|
| All Data | |
| Average Flow | 982 cfs |
| 99 th Percentile Flow | 8,470 cfs |
| 95 th Percentile Flow | 5,040 cfs |
| 90 th Percentile Flow | 3,210 cfs |
| 50 th Percentile (Median) Flow | 229 cfs |
| 10 th Percentile Flow | 19 cfs |
| High Flow Events^(b) | |
| No. Events | 27 |
| Max Event Duration | 105 days |
| Average recurrence interval | 21 months |
| Longest streak without events | 8 years (1987-1994) |
| Longest streak with events | 6 years (1995-2000) |
| No. events lasting ≥ 4 weeks | 12 |
| No. events lasting ≥ 8 weeks | 4 |
| ^(a) Raw data source: USGS Station ID 11289650 (Tuolumne River Below La Grange Dam Near La Grange, CA. Data through March 13, 2017. | |
| ^(b) Defined as periods with flow ≥ 5,000 cfs for ≥ 7 days. | |

⁶ SDS: Simulated distribution system

Figure 14⁷. Raw Water TOC in Relation to High Stream Flows on the Tuolumne River from Recent Winter Rain Events

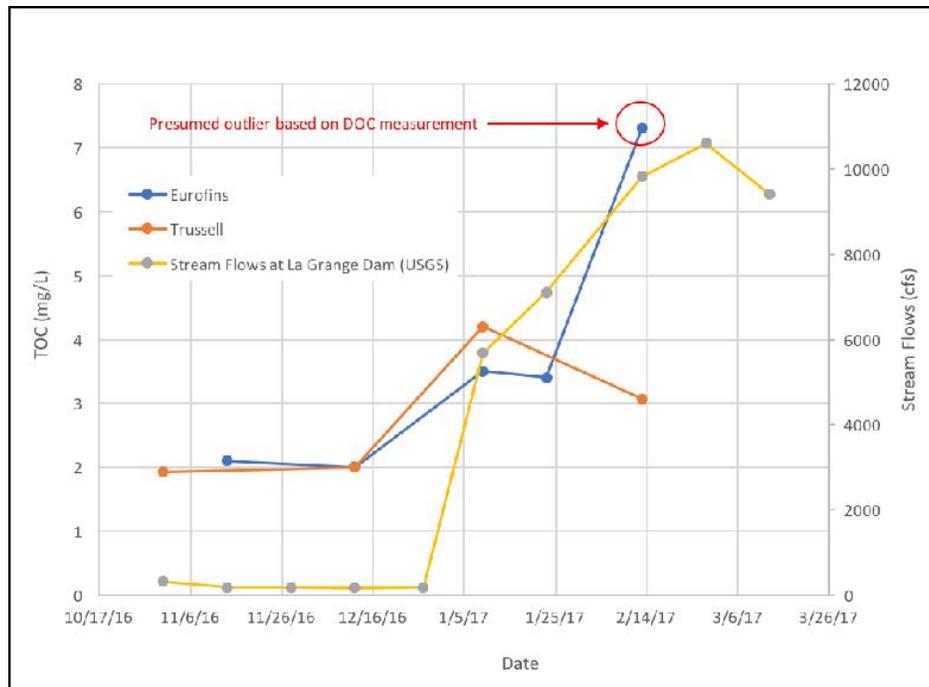
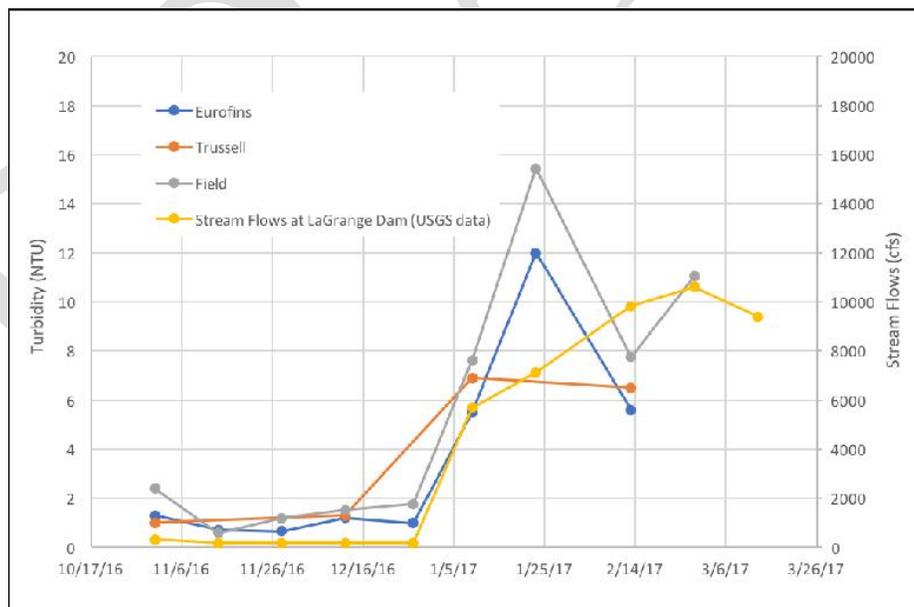


Figure 15. Raw Water Turbidity in Relation to High Stream Flows on the Tuolumne River from Recent Winter Rain Events



⁷ Duplicate of Figure 3. Repeated for ease of reference.

4.0 DEVELOPMENT OF REFINED TREATMENT TRAIN ALTERNATIVES

This section describes the process by which an updated and refined set of available treatment train alternatives was developed. This evaluation was made possible by the additional source water quality and bench testing results, and was conducted in accordance with the feedback provided by the TAC at a January 2017 workshop and in discussions at subsequent TAC correspondence.

4.1 Treatment Train Discussion at the January 12, 2017 TAC Workshop

At the TAC workshop on January 12, 2017, the PM Team led a discussion of available unit processes within the context of three treatment trains. These trains (defined below) were used as the basis for discussion based on available source water quality data at the time, and the performance goals previously developed and adopted by the TAC and Board. The three trains discussed during the January TAC meeting were comprised of the following unit processes:

- **Train A:** Direct Filtration – Ozone Treatment – Biologically Active Filters
- **Train B:** Conventional Pretreatment – Ozone Treatment – Biologically Active Filters
- **Train C:** Membrane Filtration – Ozone Treatment – Biologically Active Filters

The principle differences between these three trains were the methods of pretreatment (direct filtration versus conventional coagulation, flocculation and sedimentation) and the primary methods of filtration (membrane filtration versus media filtration). Each of these trains included ozone treatment and biologically active filters (BAF), followed by the use of free chlorine for secondary disinfection.

Discussion at the January 12, 2017 TAC workshop included the following important topics and related direction for further evaluation:

- **Need for comparative cost and benefit information.** In general, the TAC emphasized the need to better understand the costs and benefits associated with the various unit processes under consideration before selecting a treatment train.
- **Costs vs. benefits of ozone treatment.** Despite consensus among the TAC and PM Team that ozone treatment would provide a variety of benefits consistent with the adopted treatment performance goals, the TAC requested that the cost and benefit information alluded to above be evaluated before confirming whether ozone should be included in the treatment train.
- **Willingness to consider use of chloramines.** The TAC indicated they preferred not using chloramines for final disinfection, but they would leave it open as an option until they were able to review the cost/benefit analysis provided in this TM.
- **Amenability to periodic, short-term WTP shutdowns.** Prior to the January 12, 2017 workshop, all but one of the six source water samples analyzed to date had indicated that a treatment train that relied on enhanced coagulation (e.g., a direct filtration process) or the use of chloramines could be used without jeopardizing compliance with DBP limits. However, TOC data from the January 9, 2017 sampling event indicated that such a treatment train would be unlikely to meet DBP limits, and

would be subject to periodic shutdowns or capacity reductions when similar raw water conditions prevailed. Based on the assumption that such high river flow and corresponding high TOC level events would be rare (i.e., once every 10 to 20 years), relatively short in duration (i.e., a few weeks at a time), and coincident with low treated water demand periods (i.e., during the winter months), the TAC indicated a willingness to consider periodic, short-term shutdowns or reductions in treatment capacity to accommodate a potentially less expensive direct filtration or membrane filtration treatment train.

Considering the above feedback, as well as the additional source water quality and bench test results collected since October 2016, the treatment trains previously presented in TM No. 1 have been reorganized to include updated combinations of unit processes. Because the inclusion or omission of certain treatment processes (e.g., primary disinfection with ozone) impacts a train's ability to meet minimum regulatory requirements for the treatment of pathogens, pathogen treatment requirements have been used herein as a framework for re-assembling and comparing the updated list of feasible treatment trains. **A discussion of this procedure and the resulting updated treatment trains is provided below.** Qualitative descriptions and comparison of individual unit processes that comprise the trains resulting from this procedure are provided in Section 5 of this TM.

4.2 Pathogen Treatment Requirements and the Development of Updated Treatment Train Alternatives

There have been a series of four federally mandated Rules that have been promulgated with the intent of preventing waterborne diseases caused by pathogenic microorganisms, starting with the Surface Water Treatment Rule (SWTR). These Rules established treatment techniques to remove and/or inactivate microbial contaminants through effective filtration and disinfection. The following is a summary of the requirements of these Rules as applicable to SRWA process train selection. The unit processes making up each alternative treatment train is dictated in many ways by the need to meet pathogen treatment.

- The SWTR, promulgated in 1989, requires 4-log (99.99 percent) removal/inactivation of viruses and 3-log (99.9 percent) removal/inactivation of *Giardia lamblia*.
- The Interim Enhanced Surface Water Treatment Rule (IESWTR), promulgated in 1998, requires 2-log removal of *Cryptosporidium* by meeting the combined filter effluent turbidity standards to 0.3 NTU.

The Long Term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR), promulgated in 2006, requires additional *Cryptosporidium* treatment depending on the source water's "Bin" classification. Bin classification is summarized below in Table 6.

| Bin | Average Cryptosporidium Concentration, oocysts/L | Treatment Requirements for Conventional Filtration | Treatment Requirements for Direct Filtration |
|-----|--|--|--|
| 1 | <0.075 | No additional treatment | No additional treatment |
| 2 | 0.075 to <1.0 | 1-log | 1.5-log |
| 3 | 1.0 to <3.0 | 2-log | 2.5-log |
| 4 | ≥3.0 | 2.5-log | 2-log |

In addition to stipulating the overall requirements, these rules require a multi-barrier treatment approach (i.e., removal and disinfection) to ensure effective microbial treatment.

DDW has stated it plans to follow the DDW Surface Water Treatment Rule (SWTR) guidance document⁸ with regard to log treatment requirements for *Giardia* and viruses:

Total coliform (monthly median):

- If <1000 /100 mL, then 3-log or 4-log treatment requirements for *Giardia* and viruses, respectively.
- If >1000 /100 mL, then 4-log or 5-log treatment requirements for *Giardia* and viruses, respectively.

E. coli (monthly median):

- If <200 /100 mL, then 3-log or 4-log treatment requirements for *Giardia* and viruses, respectively.
- If >200 /100 mL, then 4-log or 5-log treatment requirements for *Giardia* and viruses, respectively.

Initial data from the source water monitoring program (Nov 2016 to Feb 2017 only) indicate the Tuolumne River at the infiltration gallery location will fall into Bin 1 for *Cryptosporidium*. As discussed in Section 3.1.5, the overall median total coliform concentration (thus far) for the SRWA monitoring program is 1,700 MPN/100 mL, which is above the threshold for requiring 1-log higher treatment for both *Giardia* and viruses. The *E. coli* median concentration for the SRWA monitoring program is 41 MPN/100 mL, which is below the threshold for requiring additional treatment, even though some individual samples exceeded the 200 MPN/100 mL threshold. Therefore, based on total coliform and *E. coli* data, DDW may opt to require 4-log *Giardia* treatment and 5-log virus treatment. Even though the SRWA monitoring results to date indicate Bin 1 for *Cryptosporidium*, DDW may decide to require 1-log additional treatment for *Cryptosporidium* to follow suit with the additional treatment for *Giardia* and viruses. A conservative estimate of the overall pathogen removal requirements for SRWA's new WTP is

⁸ "Appendix B, Guidelines for Determining when Surface Waters will Require More than the Minimum Levels of Treatment Defined in the Surface Water Treatment Regulations".

summarized in Table 7. Although potentially conservative, these treatment requirements are assumed for the discussion and cost estimates presented in this TM. DDW's interpretation of these data in relation to the required level of treatment should be discussed with DDW staff.

| Pathogen | DDW Standard Removal/Inactivation for Non-Impaired Source Water | Assumed DDW Removal/Inactivation Requirements based on SRWA Data |
|------------------------|---|--|
| <i>Cryptosporidium</i> | 2-log | 3-log |
| <i>Giardia</i> | 3-log | 4-log |
| Viruses | 4-log | 5-log |

Greater *Giardia* and *Cryptosporidium* removal credit is awarded for membrane filtration than for direct filtration with GMF, as summarized in Table 8 below. The additional required treatment credit, for multi-barrier treatment, is achieved through disinfection.

| Pathogen | Assumed DDW Treatment Requirements | Credit for Conventional Treatment with GMF | Credit for Direct Filtration | |
|------------------------|------------------------------------|--|------------------------------|---------|
| | | | With GMF | With MF |
| <i>Cryptosporidium</i> | 3-log | 2-log | 2-log | 4-log |
| <i>Giardia</i> | 4-log | 2.5-log | 2-log | 4-log |
| Viruses | 5-log | 2-log | 1-log | -- |

The different alternative treatment trains will achieve pathogen treatment requirements in different ways depending on the filtration process, whether ozone is included, and whether sufficient DBP precursor (i.e., TOC) is removed to allow primary disinfection with free chlorine. The following key points must be considered in deciding how each train can best achieve pathogen treatment.

- Little or no TOC removal is achieved with the coagulant doses used for direct filtration and membrane filtration. This means free chlorine contact time should be limited to an hour or less and chloramines should be used for secondary disinfection to control DBP formation for meeting regulatory DBP limits.
- The SWTR regulations require 2-log *Cryptosporidium* removal through filtration. If additional *Cryptosporidium* treatment is required, options include (1) achieving individual filter effluent (IFE) turbidity and combined filter effluent (CFE) turbidity ≤ 0.15 NTU 95 percent of the time with conventional or direct filtration treatment or (2) disinfection with ozone or UV. *Cryptosporidium* are resistant to chlorine disinfection so chlorine disinfection is not a good choice. A high ozone dose is required for 1-log Crypto inactivation compared to *Giardia* and virus inactivation. The most effective disinfectant for *Cryptosporidium* (and *Giardia*) is UV.

- Per the SWTR regulations, 0.5-log *Giardia* credit and 1-log virus credit is awarded for maintaining an ozone residual out of the first chamber of the ozone contactor.

Table 9 shows an updated list of feasible treatment trains and summarizes the probable approach for pathogen inactivation for each.

5.0 NON-COST COMPARISON OF UNIT PROCESSES

This section provides descriptions and non-costs comparisons of individual unit processes that comprise the updated treatment trains presented in Table 9. In general, the comparisons below are made between processes that provide similar core treatment functions (e.g., disinfection and filtration). Presentation and comparison of planning-level construction costs for the individual unit processes is included in Section 6 of this TM.

5.1 Ozone vs. Chlorine for Primary Disinfection

Disinfection in water treatment is typically provided in two treatment steps, often referred to as primary disinfection (for inactivation of microorganisms) and secondary disinfection (for maintenance of a disinfectant residual in the distribution system). Primary disinfection methods reflected in Table 8 include combinations of ozone, free chlorine and UV light. Secondary disinfection methods reflected in Table 9 are free chlorine and chloramines⁹. A brief overview of ozone and chlorine processes is provided below, followed by a summary of the relative advantages and disadvantages of each process.

5.1.1 Ozone Treatment

Ozone is a very powerful disinfectant and oxidant in water treatment. It can be applied in the treatment train ahead of clarification as pre-ozonation, or between clarification and filtration as intermediate ozonation. Because ozone breaks down large molecular weight natural organic matter (NOM) into smaller, more easily biodegraded organic pieces, it is preferable to include biologically active filtration (typically with a combination of Granular Activated Carbon (GAC) and sand media) at some point after ozonation to reduce the potential for biological regrowth and loss of disinfectant residual in the distribution system.

When disinfection is the objective, pre-ozonation generally requires a higher dose than intermediate ozonation because the NOM has not yet been reduced and exerts a greater ozone demand. To obtain disinfection credit, the dose must meet the demand of the water plus additional ozone for CT (i.e., residual concentration x contact time = CT) disinfection credit. Based on ozone demand testing completed to date, an ozone dose of 2.5 mg/L is estimated for pre-ozonation of this source water, and a dose of 1.5 mg/L is estimated for intermediate ozonation.

⁹ Even when chloramines are used for secondary disinfection, there is a relatively brief period of free chlorine contact (i.e., 30 to 60 minutes) for primary disinfection prior to ammonia addition to form chloramines.

Table 9. Approach to Pathogen Treatment for each Alternative Treatment Train

| Train No. | Treatment Train | Pathogen Treatment Per Unit Process (Log Removal) | | | | | | | Total Pathogen Treatment Achieved | Assumed Pathogen Treatment Requirements |
|-----------|---|---|-------------|------------------------------|-------------------|------------------|-----|---------------|-----------------------------------|---|
| | | Pre Ozonation | Coagulation | Flocculation / Sedimentation | Interim Ozonation | GAC/Sand Filters | UV | Free Chlorine | | |
| 1 | Conventional w/ Pre-O₃ | | | | | | | | | |
| | <i>Cryptosporidium</i> | | | | | 3 | | | 3 | 3 |
| | <i>Giardia</i> | 1 | | | | 2.5 | | 0.5 | 4 | 4 |
| | Viruses | 2 | | | | 2 | | 4 | 8 | 5 |
| 2 | Conventional w/ Intermediate-O₃ | | | | | | | | | |
| | <i>Cryptosporidium</i> | | | | | 3 | | | 3 | 3 |
| | <i>Giardia</i> | | | | 1 | 2.5 | | 0.5 | 4 | 4 |
| | Viruses | | | | 2 | 2 | | 4 | 8 | 5 |
| 3 | Conventional w/o O₃ | | | | | | | | | |
| | <i>Cryptosporidium</i> | | | | | 3 | 1 | | 4 | 3 |
| | <i>Giardia</i> | | | | | 2.5 | 1 | 0.5 | 4 | 4 |
| | Viruses | | | | | 2 | | 4 | 6 | 5 |
| 4 | Direct Filtration w/ O₃ | | | | | | | | | |
| | <i>Cryptosporidium</i> | | | | | 3 | 1 | | 4 | 3 |
| | <i>Giardia</i> | 0.5 | | | | 2 | 1 | 0.5 | 4 | 4 |
| | Viruses | 1 | | | | 1 | | 4 | 6 | 5 |
| 5 | Direct Filtration w/o O₃ | | | | | | | | | |
| | <i>Cryptosporidium</i> | | | | | 3 | 1.5 | | 4.5 | 3 |
| | <i>Giardia</i> | | | | | 2 | 1.5 | 0.5 | 4 | 4 |
| | Viruses | | | | | 1 | | 4 | 5 | 5 |
| 6 | Membrane Filtration w/ O₃ | | | | | | | | | |
| | <i>Cryptosporidium</i> | | | | | 4 | | | 4 | 3 |
| | <i>Giardia</i> | | | | 0.5 | 4 | | 0.5 | 5 | 4 |
| | Viruses | | | | 1 | | | 4 | 5 | 5 |
| 7 | Membrane Filtration w/o O₃ | | | | | | | | | |
| | <i>Cryptosporidium</i> | | | | | 4 | 4 | | 8 | 3 |
| | <i>Giardia</i> | | | | | 4 | | 0.5 | 8 | 4 |
| | Viruses | | | | | | 1 | 4 | 5 | 5 |

A conventional ozone contactor is an enclosed, baffled contactor with a hydraulic detention time of four to six minutes. Ozone gas is generated in an ozone generator, producing an ozone stream that is 10 to 12 percent ozone by weight. Liquid oxygen (LOX) is more commonly used than air as the feed gas for ozone generation. Ozone can be introduced into the water through side-stream injection or bubble diffusion with diffusers on the bottom of the first cell of the ozone contactor. Components of an ozone system include: ozone contactors, LOX storage, vaporizers (to convert LOX to gaseous oxygen), ozone generators, a nitrogen boost system, a cooling water system, ozone injection and associated pumps as needed, power supply, ozone destruct system, associated particle filters and desiccant dryers, oxygen monitors, ozone gas monitors, and ozone residual monitors.

5.1.2 Chlorine Disinfection

A relative comparison of the effectiveness of free chlorine, ozone and UV for primary disinfection is shown in Table 10.

| Microorganism | Free Chlorine | Ozone | UV |
|------------------------|---------------|-----------|-----------|
| Bacteria | Excellent | Excellent | Good |
| Viruses | Excellent | Excellent | Fair |
| <i>Giardia</i> | Fair | Good | Excellent |
| <i>Cryptosporidium</i> | Poor | Good | Excellent |

As a primary disinfectant, chlorine can be added at the beginning of the treatment train prior to coagulation and sedimentation, or after clarification, depending on the TOC concentration and DBP formation potential of the water. Chlorine generally is not added immediately prior to a GAC filter since the GAC removes chlorine, which therefore would not be providing any pathogen inactivation. Often, chlorine is added after clarification and filtration, in a chlorine contact basin (or pipeline) to achieve the required CT.

Chlorine disinfection typically requires an open, baffled chlorine contact basin, a chlorine feed solution (typically a 12.5 percent solution of sodium hypochlorite) and associated chemical storage tanks, chemical metering pumps and residual chlorine monitors. The hydraulic detention time (HDT) for the chlorine contact basin will depend on how much CT credit is needed and whether on-site storage is needed for other purposes. For discussion purposes, though, if free chlorine is used for both primary and secondary disinfection, the contact basin may have a HDT of one to two hours. If chloramines are used for secondary disinfection, 30 minutes to one hour of free chlorine contact may be provided prior to ammonia addition to achieve the required virus and *Giardia* inactivation. Based on chlorine decay curves developed during the SDSDBP bench tests in November 2016 and February 2017, a chlorine dose of 2 mg/L is appropriate for a free chlorine system, and a chlorine dose of 3 mg/L followed by ammonia addition at a 4:1 Cl₂:NH₃-N weight ratio is appropriate for a chloramination system. Chloramines are a less effective disinfectant compared to free chlorine, so a higher chloramine concentration is generally maintained in the distribution system compared to free chlorine.

5.1.3 Advantages and Disadvantages

Ozone is a very powerful oxidant and provides additional benefits beyond disinfection, including: treatment of taste and odor compounds; breakdown and removal of pesticides and other contaminants of emerging concern (CECs) when combined with biologically active carbon (BAC) filtration; enhanced clarification and filtration performance; and a more stable finished water, with respect to organics, for the distribution system. Advantages and disadvantages of chlorine versus ozone for primary disinfection is summarized in Table 11.

| Table 11. Advantages and Disadvantages of Ozone vs. Chlorine for Primary Disinfection | | |
|---|---|---|
| Treatment Process | Advantages | Disadvantages |
| Ozone | <ul style="list-style-type: none"> Provides treatment for pesticides, CECs, and algal toxins. Provides taste and odor treatment. SDSDBP bench tests showed lower DBP formation with ozone. Ozone with BAC filter can provide up to 40 percent DOC removal (Crittenden, et al., 2012). For SRWA's source water, the DOC is consistently 94 percent to 96 percent of the TOC. The ozonation by-product, bromate, is not an issue for this source water. Shorter contact time is required compared to free chlorine. | <ul style="list-style-type: none"> Ozone must be generated on-site. Can contribute to manganese passing through treatment train (depending on form of manganese). Refer to Section 3.2.3 for discussion. Safety concerns requires ozone gas phase monitoring and alarms. |
| Free Chlorine | <ul style="list-style-type: none"> Least expensive disinfection option. Effective disinfectant for viruses and Giardia. | <ul style="list-style-type: none"> Forms TTHMs and HAAs at high levels, depending on TOC concentration. MCLs may be exceeded in the distribution system. Chloramines may be preferred over free chlorine for secondary disinfection in the distribution system, depending on DBP concentrations formed. |

5.2 Direct Filtration Treatment vs. Conventional Filtration

Filtration in water treatment is generally preceded by a combination of several pretreatment processes. In a treatment train featuring conventional filtration, the filters are preceded by coagulation, flocculation and sedimentation. In a direct filtration treatment train, the sedimentation process is omitted. A schematic comparing a conventional filtration train with a direct filtration train is provided on Figure 16.

Of the seven treatment trains depicted in Table 8, three would be considered conventional filtration trains (Trains 1, 2 and 3) and two would be considered direct filtration trains (Trains 4 and 5). Membrane filtration (Trains 6 and 7) is generally not classified as a “direct filtration” process,

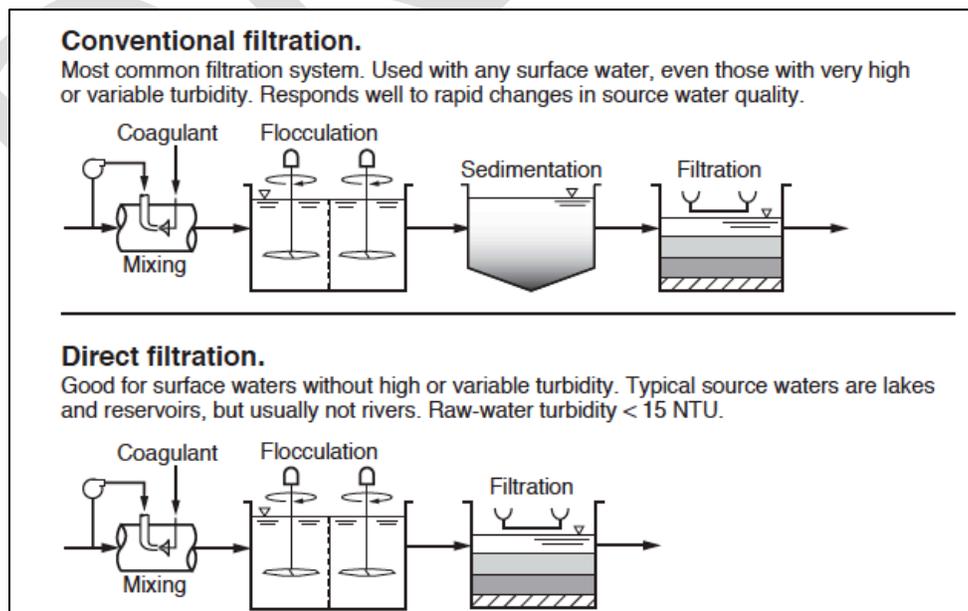
even though it can include coagulation and typically does not include sedimentation. Membrane filtration is discussed separately in the next section.

A brief overview of each process is provided below, followed by a summary of the relative advantages and disadvantages of each.

5.2.1 Direct Filtration

As shown on Figure 16, a direct filtration train includes coagulant addition, flocculation, and filtration. Three main differences between a direct filtration train and a conventional treatment train are (1) the sedimentation basin, which is not included with direct filtration, (2) chemical conditioning, and (3) the detention time of flocculation step. Direct filtration is an appropriate technology if the influent turbidity is consistently less than 10 NTU, with occasional brief turbidity spikes of no more than 20 NTU. Coagulant doses used in direct filtration are typically only 1-5 mg/L, significantly lower than those used in conventional treatment (often 15-30 mg/L). Cationic polymer (e.g., Polydiallyldimethylammonium chloride [polyDADMAC]) is also commonly used with direct filtration at doses ranging from 0.5 to 2.5 mg/L. Cationic polymers can also be used in conventional treatment to aid in floc formation, but the dose is typically lower, on the order of 0.5 to 1 mg/L. The objective of chemical conditioning in direct filtration is to destabilize the particles which allows them to be removed through the filter bed (i.e., depth filtration) rather than forming a sweep floc that will settle. A disadvantage of using cationic polymer such as polyDADMAC is that it contains precursor material that can form *N*-Nitrosodimethylamine (NDMA) when reacted with chloramines. NDMA is one of several nitrosamines considered potential carcinogens. It forms as a by-product of some water treatment practices. NDMA and other nitrosamines are on EPA's CCL4. In California, it is regulated with a Notification Level (NL) of 10 ng/L, and is considered a good candidate for future regulation with a MCL.

Figure 16. Comparison of a Conventional Treatment Train with a Direct Filtration Treatment Train (Crittenden, et al., 2012)



Unit processes and equipment associated with direct filtration treatment include: flash mixing facilities for rapid mixing of the coagulant with raw water; flocculation basin(s) and mechanical mixers; and dual or mono-media filters with a backwash and air-scour system. A flocculation time of 10 to 20 minutes is typical for direct filtration, while 30 to 45 minutes of flocculation time is typical for conventional treatment. As such, the flocculation basin is generally smaller with direct filtration. Design parameters for the filters themselves, including filter loading rates, bed depths, and backwash systems, are very similar for both direct filtration and conventional treatment approaches. However, because effective treatment is so dependent on chemical conditioning and particle removal through the filter bed, at least six months of pilot testing is recommended for proper selection of media size, design of the filter bed, selection of design filtration rate, selection of appropriate chemicals and doses, and to demonstrate performance to DDW.

One significant difference between direct filtration treatment and conventional treatment is the inherent difficulty in responding to changing water quality conditions associated with “flashy” water (i.e., a source water prone to turbidity spikes) and/or seasonal storm events. Direct filtration is limited by the coagulant dose (generally no greater than 5 mg/L) and the coagulated particles’ inability to settle. During the preparation of this TM, three large direct filtration treatment facilities were contacted about operational challenges they face, and detailed responses were received from two facilities. The facilities contacted were: (1) the Los Angeles Aqueduct Filtration Plant (LAAFP) in Los Angeles, CA (a 600-mgd direct filtration facility with pre-ozonation); (2) the Tolt Water Treatment Facility in Duvall, Washington; and (3) Metropolitan Water District of Southern California’s (MWDSC) Skinner treatment facility that has both a conventional train and a direct filtration train. The operational experiences from LAAFP and Tolt are discussed in Attachment A to this TM, and general feedback provided by MWDSC is discussed here. The common response from all three facilities was that when influent water quality degrades, such as during storm events, treatment becomes challenging and there are four available options: increase coagulant dose; reduce filter run length; reduce plant flows; or reject the source water (i.e., switch sources or shut down). One or more of these options could be used to respond to the degradation of influent water quality.

5.2.2 Conventional Filtration

As discussed above, a conventional treatment facility differs from a direct filtration treatment facility in the following ways: conventional treatment typically uses higher coagulant doses and lower polymer doses; conventional treatment typically utilizes a longer flocculation time; and conventional treatment requires a sedimentation basin. A conventional treatment facility is more robust and able to effectively respond to changing water quality brought on by storm events. Importantly, conventional treatment can accommodate a sufficiently high coagulant dose for enhanced coagulation and subsequent removal of DBP precursor material (i.e., TOC).

Per California Title 22 CCR, both conventional treatment and direct filtration treatment filters are generally operated at a filtration rate of no more than 6.0 gallons per minute per square foot (gpm/ft²), and should be designed to operate at this rate with one filter off-line for backwashing. After a period of operation, a utility may re-rate their filters to operate at higher filtration rate by submitting a demonstration report to DDW based on filter effluent turbidity performance at the higher rates. This approach presents an excellent opportunity to increase treatment capacity without incurring additional construction costs. Details of the re-rating process are discussed in Title 22 CCR.

5.2.3 Advantages and Disadvantages

Comparative advantages and disadvantages of direct filtration treatment and conventional filtration treatment are summarized in Table 12.

| Table 12. Advantages and Disadvantages of Direct Filtration and Conventional Filtration Processes | | |
|---|---|--|
| Treatment Process | Advantages | Disadvantages |
| Direct Filtration | <ul style="list-style-type: none"> • Lower coagulant dose (lowers chemical costs). • Smaller footprint due to: <ul style="list-style-type: none"> — Lack of sedimentation basin — Shorter HDT through flocculation | <ul style="list-style-type: none"> • Higher polymer dose (increases chemical costs) • If a polyDADMAC cationic polymer is used, NDMA (NL = 10 ng/L) can form during final disinfection with chloramines^(a) • Not a robust treatment for a “flashy” source water. For persistent turbidity spikes above 10-20 NTU, the WTP would likely have to shut down until the raw water turbidity subsided. • Six months of pilot testing required for proper design and chemical selection, and demonstration of performance to DDW. • Operations can be challenging when source water quality degrades. • May be difficult to find operators that understand how to operate a direct filtration facility. • DDW discourages the use of direct filtration. |
| Conventional Filtration | <ul style="list-style-type: none"> • Robust treatment for changing influent water quality • Amenable to enhanced coagulation for DBP control • Can accommodate use of powdered activated carbon if needed for T&O control. | <ul style="list-style-type: none"> • Larger footprint • Higher coagulant use |

^(a) Najm and Trussell, 2000; Wilczak, et al., 2003

5.3 Membrane Filtration vs. Media Filtration

Membrane filtration (MF), like media filtration, relies on particulate and pathogen removal for treatment. Just as for direct filtration (with media filters), membrane filtration is exempt from the enhanced coagulation requirements of the D/DBP Rule, but must still meet DBP MCLs.

Of the seven treatment trains depicted in Table 8, five rely strictly on media filtration (Trains 1 through 5), one places media filtration after membrane filtration (Train 6), and one relies strictly on membrane filtration (Train 7). A brief overview of each process is provided below, followed by a summary of the relative advantages and disadvantages of each process.

5.3.1 Membrane Filtration

In a membrane filtration treatment train, either microfiltration or ultrafiltration membranes can be used. Coagulation may or may not be needed for effective filtration, but is often included to aid in particulate removal. Flocculation, however, is not required for membrane filtration. When a coagulant is added, the dose is generally quite low (i.e., 1 to 5 mg/L); the coagulant is added to help reduce membrane fouling, increase the time between membrane cleanings, and possibly allow operation at a higher flux (i.e., the flow rate through the membrane). This low coagulant dose does not provide effective TOC removal. Polymers are typically not used in membrane filtration treatment. And just as for direct filtration (with media filters), membrane filtration treatment is most appropriate for raw waters with turbidities less than 10-15 NTU. Membrane filtration is more adept at handling infrequent and short-lived turbidity spikes than direct filtration, without compromising pathogen removal or filter effluent turbidity. Without sedimentation, a membrane treatment facility would have to either reduce production or shut-down for extended periods of turbidities exceeding 15 NTU. And just as for direct filtration, four to six months of pilot testing is recommended for membrane filtration to investigate the effect of coagulant on membrane performance, optimum coagulant type and dose, and demonstrate effective performance to DDW.

Operation of a membrane filtration system includes automatic reverse filtration/air scrubbing to remove accumulated particulate material from the membranes, a daily chemically enhanced backwash to disinfect the membranes and restore permeability, and less frequent, but periodic, clean-in-place (CIP) chemical cleaning sequences. CIP sequences typically use citric acid. Filter runs are typically 30 to 40 minutes between backwashes; the optimum backwash frequency would be determined through pilot testing.

Components of a membrane filtration system include feed water pumps, auto-backwashing strainers, membranes, compressed air for daily pressure decay testing of membrane integrity, potentially two CIP chemical storage tanks (i.e., one acid tank and one base tank), backwash pumps and an air scour system, and a filtrate tank. Membrane systems are typically housed within an enclosed, climate controlled building.

Membrane filtration is considered an “absolute barrier” to *Giardia* and *Cryptosporidium*. Generally, DDW will credit membrane filtration with 4-log *Giardia* and 4-log *Cryptosporidium* removal. The membrane manufacturer must conduct a “challenge test” using the specific membrane to be installed and DDW must approve the submitted challenge test report. This is a product-specific challenge test and not a water-specific test. Greater *Giardia* and *Cryptosporidium* removal credit is awarded for membrane filtration than for direct filtration with granular media filters. The additional required pathogen treatment credit (for multi-barrier treatment) is achieved through disinfection. Virus removal credit is awarded for direct filtration with media filters, but typically not for membrane filtration.

5.3.2 Media Filtration

Media filtration was discussed briefly in the preceding section. The components of a dual media filtration process include: open, reinforced concrete filter cells; filter media (either anthracite over sand or GAC over sand); backwash pumps and air scour equipment to assist cleaning the media during backwash; and underdrain and filtered water collection systems. For a dual-media filter, the filter bed would be approximately 5-6 feet of anthracite or GAC over 1-foot of sand. The head loss across each individual filter, individual filter effluent turbidities, and combined filter effluent turbidity would be monitored continuously. A granular media filter is not considered an “absolute barrier” to pathogens, and therefore receives less pathogen removal credit than a membrane filtration system. (This was discussed previously in Section 4.2.)

Title 22 CCR limits filtration rates at conventional filtration and direct filtration treatment facilities to a maximum of 6 gpm/ft², with one filter off-line for backwashing. Filter re-rating to a higher filtration rate is a viable option for future plant expansion. Filter re-rating requires a full-scale filtration performance study be performed. Re-rating to a filtration rate less than twice the original permitted rate can be based on filter effluent turbidity performance. Higher filtration rates require a study be conducted to demonstrate *Giardia* and virus removal.

5.3.3 Advantages and Disadvantages

Advantages and disadvantages of membrane filtration and media filtration are summarized in Table 13.

Table 13. Advantages and Disadvantages of Membrane Filtration and Media Filtration Processes

| Treatment Process | Advantages | Disadvantages |
|---------------------|--|--|
| Membrane Filtration | <ul style="list-style-type: none"> • Up to 4-log <i>Giardia</i> and <i>Cryptosporidium</i> treatment credit are offered for effective and compliant operation. • Modular system allows for relatively straightforward expansion, provided adequate space is available. • Can handle brief (e.g., hours) turbidity spikes while producing consistent filtrate water quality because of inherent straining and small pore size characteristics. | <ul style="list-style-type: none"> • Little or no TOC removal is achieved so chlorination DBPs will be an issue if free chlorine is used for final disinfection; SRWA would have to consider switching to chloramines for residual maintenance in the distribution systems. • Without ozone/BAC included in the process train, a membrane filtration facility cannot address T&O issues or CECs, pesticides and/or other SOCs. • At least 4-6 months of pilot testing would be required to satisfactorily demonstrate system performance and develop design criteria. • Membrane filtration treatment requires more chemical use and storage than a conventional or direct filtration treatment systems, because of the additional CIP chemicals. • Potential difficulties disposing of CIP waste chemicals. DDW has clearly stated that CIP chemicals cannot be returned to the head of the plant for blending with raw water. • Mixed reviews for membrane facilities in the region indicate a potential for unanticipated performance and/or reliability issues |
| Media Filtration | <ul style="list-style-type: none"> • Filter re-rating is a viable, cost-effective means of plant expansion after a period of full-scale performance data has been gathered at design filtration rates of 6 gpm/ft². • Proven technology | <ul style="list-style-type: none"> • Less pathogen treatment credit is awarded for media filtration than for MF |

6.0 CONSTRUCTION COST COMPARISON OF UNIT PROCESSES AND TREATMENT TRAINS

This section provides a summary of planning-level construction cost estimates for the variety of unit processes and treatment trains discussed in Sections 4 and 5 of this TM. The methodologies used to develop the cost information presented herein are described in a TM titled *Methodology for Developing Planning Level Construction Cost Information for SRWA Surface Water Treatment Unit Processes* (West Yost, March 2017), which is included as Attachment B to this TM.

A summary of the unit process cost estimates presented in Attachment B is included in Table 14. Costs shown in Table 15 reflect the combinations of unit processes associated with the treatment train alternatives in Table 9. In instances where cost data were available from more than one reference facility, the capacity-adjusted reference costs from the more recently constructed facility are used. Percentage adders are then applied for a variety of categories (sitework, yard piping, electrical & instrumentation and mobilization) to capture a more complete picture of potential WTP construction costs. Finally, an overall estimating contingency of 25 percent is applied.

Section 7 of this TM presents planning-level operation and maintenance (O&M) cost information for the treatment trains identified by the TAC and PM Team for further evaluation at the conclusion of the March 30, 2017 workshop.

Table 14. Summary of Planning-Level Unit Process Construction Costs^(a)

| Unit Process | Reference Facility Information | | | Adjusted Facility Information | | |
|--|-----------------------------------|------------------|---|--|----------------------|---|
| | Source of Reference Costs | Process Capacity | Reference Facility Midpoint of Construction | Inflated to Midpoint of SRWA WTP Construction (June 2020), dollars | SRWA Target Capacity | Adjusted to SRWA WTP Target Capacity, dollars |
| Flash Mixing | WDCWA Plant | 30 mgd | Jan 2015 | 602,000 | 15 mgd | 397,000 |
| Coagulation, Flocculation and Sedimentation | Vineyard Plant | 50 mgd | Aug 2009 | 17,297,000 | 15 mgd | 8,399,000 |
| | WDCWA Plant | 30 mgd | Jan 2015 | 6,731,000 | 15 mgd | 4,441,000 |
| Coagulation and Flocculation Only (No Sedimentation) | Vineyard Plant | 50 mgd | Aug 2009 | 7,310,000 | 15 mgd | 3,550,000 |
| Granular Media Filtration | WDCWA Plant | 30 mgd | Jan 2015 | 14,929,000 | 15 mgd | 9,849,000 |
| Membrane Filters | MID Plant | 30 mgd | Jun 2008 | 30,438,000 | 15 mgd | 20,082,000 |
| | Lodi Plant | 8 mgd | May 2012 | 7,268,000 | 15 mgd | 10,598,000 |
| Ozone Treatment | MID Plant | 30 mgd | Jun 2008 | 12,599,000 | 15 mgd | 8,312,000 |
| | WDCWA Plant | 30 mgd | Jan 2015 | 6,577,000 | 15 mgd | 4,339,000 |
| Chlorine Contact Basin (Free Chlor. and Chloramines) | WDCWA Benchmark WTP | 212,000 gal | Jul 2011 | 684,000 | 625,000 gal | 1,309,000 |
| UV Disinfection | Vendor Proposal/Conceptual Layout | 15 mgd | Mar 2017 | 748,000 | 15 mgd | 748,000 |
| Chemical Building | WDCWA Plant | 30 mgd | Jan 2015 | 5,546,000 | 15 mgd | 5,546,000 |
| Operations & Administration Building | WDCWA Plant | 30 mgd | Jan 2015 | 4,075,000 | 15 mgd | 4,075,000 |
| Maintenance Building | WDCWA Plant | 30 mgd | Jan 2015 | 1,588,000 | 15 mgd | 1,588,000 |
| In-Plant Pump Station | WDCWA Plant | 30 mgd | Jan 2015 | 1,935,000 | 15 mgd | 1,277,000 |
| Finished Water Clearwell | WDCWA Plant | 5.75 MG | Jan 2015 | 7,487,000 | 2.375 MG | 4,432,000 |
| Backwash Supply / Finished Water Pump Station | WDCWA Plant | 30 mgd | Jan 2015 | 6,541,000 | 15 mgd | 4,315,000 |
| Backwash Equalization Basin | WDCWA Plant | 30 mgd | Jan 2015 | 2,838,000 | 15 mgd | 1,872,000 |
| Gravity Thickeners | WDCWA Plant | 30 mgd | Jan 2015 | 2,533,000 | 15 mgd | 1,671,000 |
| Drying Beds | WDCWA Plant | 30 mgd | Jan 2015 | 2,691,000 | 15 mgd | 1,775,000 |

^(a) Does not include electrical and instrumentation costs. These costs are more appropriately captured as a percentage of the overall treatment process.

Table 15. Summary of Planning-Level Construction Costs for Available Treatment Trains for 15-mgd Surface Water Treatment Plant

| Process/Facility | Treatment Train No. | | | | | | |
|---|---|---|--|--|---|--|---|
| | 1 Conventional with Pre-O ₃ , dollars | 2 Conventional with Interim O ₃ , dollars | 3 Conventional without O ₃ , dollars | 4 Direct Filtration with O ₃ , dollars | 5 Direct Filtration without O ₃ , dollars | 6 Membrane Filtration with O ₃ , dollars | 7 Membrane Filtration without O ₃ , dollars |
| Unit Processes Associated with Specific Treatment Trains | | | | | | | |
| Pre-Ozonation | 4,339,000 | | | 4,339,000 | | | |
| Coagulation and Flocculation | | | | 3,947,000 | 3,947,000 | 3,947,000 | 3,947,000 |
| Coagulation, Flocculation and Sedimentation | 4,838,000 | 4,838,000 | 4,838,000 | | | | |
| Intermediate Ozonation | | 4,339,000 | | | | 4,339,000 | |
| Granular Media Filters | 9,849,000 | 9,849,000 | 9,849,000 | 9,849,000 | 9,849,000 | | |
| Membrane Filters | | | | | | 10,598,000 | 10,598,000 |
| Backwash Equalization Basin | 1,872,000 | 1,872,000 | 1,872,000 | 1,872,000 | 1,872,000 | | |
| UV Disinfection | | | 700,000 | 748,000 | 748,000 | | 748,000 |
| Chlorine Contact Basin - Free Chlorine and Chloramines ^(a) | 1,309,000 | 1,309,000 | 1,309,000 | | | | |
| Subtotal | 22,207,000 | 22,207,000 | 18,568,000 | 22,016,000 | 17,677,000 | 20,193,000 | 16,554,000 |
| Unit Processes and Facilities Common to all Treatment Trains | | | | | | | |
| Flash Mixing | 397,000 | 397,000 | 397,000 | 397,000 | 397,000 | 397,000 | 397,000 |
| In-Plant Pump Station | 1,277,000 | 1,277,000 | 1,277,000 | 1,277,000 | 1,277,000 | 1,277,000 | 1,277,000 |
| Clearwell | 4,432,000 | 4,432,000 | 4,432,000 | 4,432,000 | 4,432,000 | 4,432,000 | 4,432,000 |
| Backwash Supply / Finished Water Pump Station | 4,315,000 | 4,315,000 | 4,315,000 | 4,315,000 | 4,315,000 | 4,315,000 | 4,315,000 |
| Gravity Thickeners | 1,671,000 | 1,671,000 | 1,671,000 | 1,671,000 | 1,671,000 | 1,671,000 | 1,671,000 |
| Drying Beds | 1,775,000 | 1,775,000 | 1,775,000 | 1,775,000 | 1,775,000 | 1,775,000 | 1,775,000 |
| Chemical Building | 5,546,000 | 5,546,000 | 5,546,000 | 5,546,000 | 5,546,000 | 5,546,000 | 5,546,000 |
| Administration & Operations Building | 4,075,000 | 4,075,000 | 4,075,000 | 4,075,000 | 4,075,000 | 4,075,000 | 4,075,000 |
| Maintenance Building | 1,588,000 | 1,588,000 | 1,588,000 | 1,588,000 | 1,588,000 | 1,588,000 | 1,588,000 |
| Subtotal | 47,283,000 | 47,283,000 | 43,644,000 | 47,092,000 | 42,753,000 | 45,269,000 | 41,630,000 |
| Sitework ^(b) 15% | 7,092,000 | 7,092,000 | 6,547,000 | 7,064,000 | 6,413,000 | 6,790,000 | 6,245,000 |
| Yard Piping ^(b) 13% | 6,147,000 | 6,147,000 | 5,674,000 | 6,122,000 | 5,558,000 | 5,885,000 | 5,412,000 |
| Electrical and Instrumentation ^(b) 21% | 9,929,000 | 9,929,000 | 9,165,000 | 9,889,000 | 8,978,000 | 9,506,000 | 8,742,000 |
| Subtotal | 70,451,000 | 70,451,000 | 65,030,000 | 70,167,000 | 63,702,000 | 67,450,000 | 62,029,000 |
| Mobilization / Demobilization ^(b) 3% | 2,114,000 | 2,114,000 | 1,951,000 | 2,105,000 | 1,911,000 | 2,024,000 | 1,861,000 |
| Subtotal | 72,565,000 | 72,565,000 | 66,981,000 | 72,272,000 | 65,613,000 | 69,474,000 | 63,890,000 |
| Estimating Contingency 25% | 18,141,000 | 18,141,000 | 16,745,000 | 18,068,000 | 16,403,000 | 17,369,000 | 15,973,000 |
| TOTAL ESTIMATED CONSTRUCTION COST | \$90,706,000 | \$90,706,000 | \$83,726,000 | \$90,340,000 | \$82,016,000 | \$86,843,000 | \$79,863,000 |

^(a) Does not include any costs for incorporation of chloramines at City groundwater wells.
^(b) Percentage adders are based on the averages of such costs for the WDCWA and SCWA reference projects.

7.0 RISK ASSESSMENT, RECOMMENDATIONS AND SUPPLEMENTAL EVALUATION INFORMATION

This section summarizes potential risks and provides recommendations regarding the treatment train alternatives discussed above. The PM Team recommendations in Section 7.2 were intended to guide discussion at the TAC workshop on March 30, 2017; recommendations presented in Section 7.3 reflects discussion at the end of that workshop. Supplemental analyses requested by the TAC during the March 30th workshop are presented in Section 7.4. Finally, updated TAC recommendations are presented in Section 7.5, based on additional discussion at a subsequent workshop on May 17, 2017.

7.1 Risks Associated with Treatment Train Alternatives

Table 16 lists several categories of finished water quality risks that may face SRWA's new WTP, and provides the PM Team's assessment of the relative likelihood that each risk might be realized for each treatment train alternatives considered. To place the risk assessments into economic perspective, the table also includes the relative differences in construction cost between Train No. 1 (the most expensive alternative) and the other alternatives. In general, the alternatives with lower risk assessments are more expensive, while riskier alternatives offer greater potential cost savings.

7.2 PM Team Recommendations (Developed prior to March 30, 2017 Workshop)

- **Do not select a treatment train that will require shut-down or reduced finished water production.** The average historical recurrence interval of the extended periods of high stream flows (which are assumed to coincide with elevated TOC levels) is too short, and the averaged historical durations of the same periods too long, to consider shut-down as an option.
- **Include ozone in the treatment train.** In addition to disinfection, ozone will provide taste and odor removal, pesticide and CEC removal, reduced chlorinated DBP formation, and increase flexibility for water quality changes in the Tuolumne River.
- **Include BAC dual-media filtration after ozonation.** BAC following ozone will provide up to 40 percent more TOC removal, which will limit DBP formation. BAC filtration ensures effective removal of the CECs and pesticides that are broken apart by the ozone.
- **Do not allow ferric chloride for clarification.** Avoiding the use of ferric chloride will reduce the potential for manganese control issues, as Mn^{2+} is a typical contaminant found in bulk ferric chloride.

7.3 Preliminary TAC Recommendations (Developed during March 30, 2017 Workshop)

- **Include ozone in the treatment train.** Adopting this recommendation results in the elimination of Trains 3, 5 and 7. In the case of Trains 1 and 2, Train 1 is preferred by the TAC, due to the reduced likelihood of manganese control issues associated with pre-ozonation. However, Train 2 may still be a viable alternative depending on the outcome of additional manganese removal bench testing and future raw water quality sampling after construction of the raw water pump station wet well.

- **Do not utilize direct filtration.** Adopting this recommendation results in the elimination of Trains 4 and 5.
- **Use free chlorine for secondary disinfection.** In accordance with the descriptions of available treatment trains in Table 9, excluding chloramines from further consideration would result in the elimination of Trains 4, 5, 6 and 7. Among these trains, all but Train 6 are simultaneously eliminated from consideration on the basis of the above TAC recommendations (i.e., include ozone and exclude direct filtration). With respect to Train 6, the TAC acknowledged that while the risk of exceeding regulatory limits for DBPs for Train 6 was higher with free chlorine than with chloramines, the potential capital cost savings associated with Train 6 warranted its further consideration.
- **Preliminary preferred trains**, after adoption of the above TAC recommendations, are as follows:
 - **Train 1:** Conventional Filtration with Pre-Ozonation, Biologically Active Filters and Secondary Disinfection with Free Chlorine
 - **Train 6:** Membrane Filtration with Intermediate Ozonation, Biologically Active Filters and Secondary Disinfection with Free Chlorine

7.4 Supplemental Evaluation Information for Preferred Treatment Trains

Following the March 30, 2017 workshop, the TAC and PM Team identified the following topics for further evaluation of the two preferred trains:

- Additional desktop evaluation of DBP compliance risks
- Planning-level O&M costs
- Treatment facility expandability
- Disposal options for membrane chemical cleaning wastes

These items are presented below.

7.4.1 Additional Desktop Evaluation of DBP Compliance Risks

As discussed previously, a conventional treatment train (e.g., Train 1) relies primarily on enhanced coagulation for removal of DBP precursor material (i.e., TOC), augmented by removal through ozone and biofiltration. To assess the likely performance of Train 1, Trussell conducted bench-scale jar tests to measure DBP precursor removal through enhanced coagulation. Additionally, bench-scale simulated distribution system DBP tests (or SDSDBP tests) were conducted in November 2016 and February 2017 to assess the potential formation of regulated DBPs in the distribution system after exposure to free chlorine as a secondary disinfectant. The results of these tests (shown in Figure 7 and Figure 9) neglect the additional DBP-removal benefit of ozone and biofiltration in combination since biofiltration cannot be easily evaluated at the bench-scale, and so provide a somewhat conservative estimate of the likely performance of Train 1.

In contrast to Train 1, a membrane filtration treatment train (e.g., Train 6) is not amenable to enhanced coagulation, and thus must rely solely on ozone and biofiltration for DBP precursor removal. Ozonation serves to break larger organic molecules into smaller, more easily biodegradable material, and biodegradation occurs as the ozonated water passes among the microbial communities which develop over time on the filter media. Often, DBP precursor concentration correlates with the TOC concentration of a water, and TOC is an easily measurable parameter. The amount of TOC removal that occurs through ozonation and biofiltration is typically specific to the water source, and cannot be reliably tested at the bench scale. Even larger scale pilot testing of TOC removal with ozone and biofiltration and is challenging, as the adsorption capacity of virgin GAC must first be exhausted and biological activity must be established prior to observing performance indicative of long-term operations. As such, bench-scale test data are not available to estimate potential concentrations of DBPs after treatment using Train 6 that reflect the impact of ozone and biofiltration (Figure 8 showed SDSDBP test results reflective of a low coagulant dose that would be appropriate for Train 6, plus primary disinfection with free chlorine). To generate estimates for Train 6 that consider ozone and biofiltration, Trussell instead conducted a desktop evaluation relying on data from a combination of literature reported studies, SRWA's ongoing source sampling program and historical source water data from TID's 2006-2007 sampling program. The methodology and results of this desktop evaluation are described in the following paragraphs.

To estimate TOC removal through ozone and biofiltration, literature reported studies must be relied upon. A 2005 American Water Works Association's Research Foundation (AWWARF) study of nine full-scale water treatment plants employing ozone and biofiltration¹⁰ provides an indication of TOC removal through these processes for a variety of surface water supplies around the country (Westerhoff, et al., 2005). A summary of TOC removals reported by Westerhoff, et al., is shown in Figure 17. In the study, full-scale TOC removal through ozone and biofiltration ranged from 13 percent to 64 percent, with an average removal of 27 percent and median removal of 19 percent. To estimate TOC removal through ozone and biofiltration for SRWA, a conservative TOC removal rate of 18 percent was assumed. It is also assumed that DBP precursor levels are reduced by the same percentage, which allows estimation of DBP concentrations in the distribution system based on the reduced TOC concentrations.

¹⁰ Two of the utilities (#5 and #7) utilize anthracite/sand biofilters rather than GAC/sand biofilters used by the other utilities.

Figure 17. TOC Removal Measured in a Nationwide Survey of Full-Scale Water Treatment Facilities Employing Ozone and Biofiltration (Westerhoff, et al., 2005)

| TOC removals in utilities | | | | | | |
|---------------------------|------------------|--------------------|-------|--------------------|---------------|-------|
| Utilities ID # | 2002 TOC Removal | | | 2003 TOC Removal | | |
| | ozonation | biofiltration | Total | ozonation | biofiltration | Total |
| 1 | 1 % | 15 % | 18 % | 26 % | 15 % | 38 % |
| 2 | 3 % | 24 % | 30 % | <i>No sampling</i> | | |
| 3 | | | | - | 1 % | 19 % |
| 4 | | <i>No sampling</i> | | 1 % | 31 % | 31 % |
| 5 | -1 % | 18 % | 29 % | -29 % | 16 % | 13 % |
| 6 | -13 % | 26 % | 18 % | -14 % | 16 % | 14 % |
| 7 | -3 % | 1 % | 19 % | -23 % | 17 % | 19 % |
| 8 | | <i>No sampling</i> | | <i>No TOC data</i> | | |
| 9A | -4 % | 21 % | 18 % | 12% | 23% | 52% |
| 9B | | <i>No sampling</i> | | 4% | 23% | 64% |

By applying the assumed additional 18 percent TOC removal to the SDSDBP tests from November 2016 and February 2017 (i.e., those depicted previously in Figure 7 and Figure 9), a more representative assessment of DBPs in the distribution system can be estimated, as shown in Figure 18. Similarly, Figure 19 shows the estimated impact of ozone and biofiltration on distribution system DBPs for Train 6, based on SDSDBP results from February 2017¹¹ (i.e., those depicted previously in Figure 8).

Figure 18. Estimated DBP Concentrations with Conventional Treatment Plus Ozone and Biofiltration (Train #1) Relative to MCLs and Treatment Goals

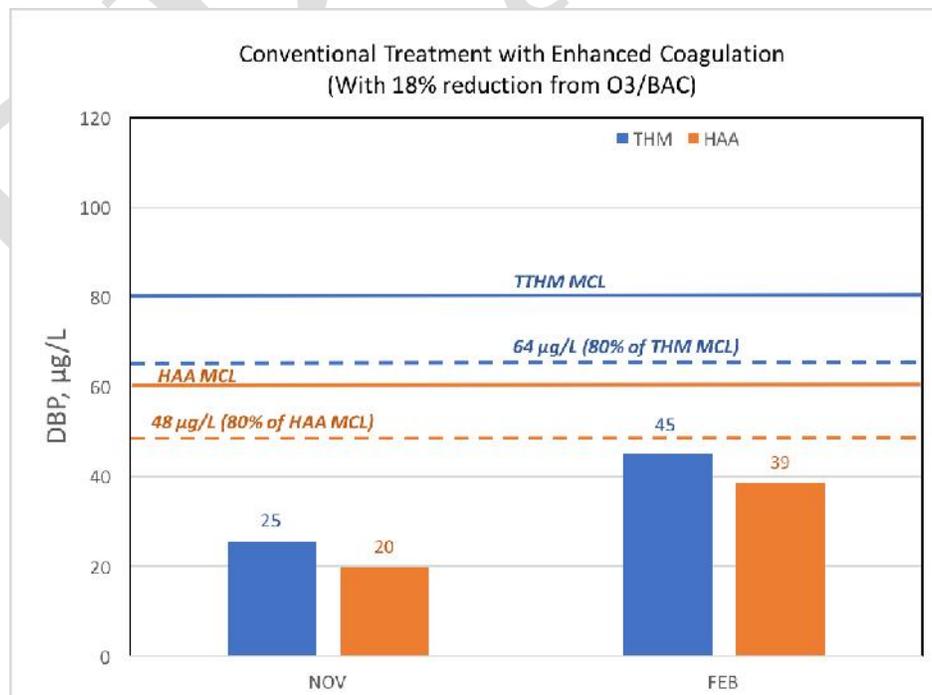
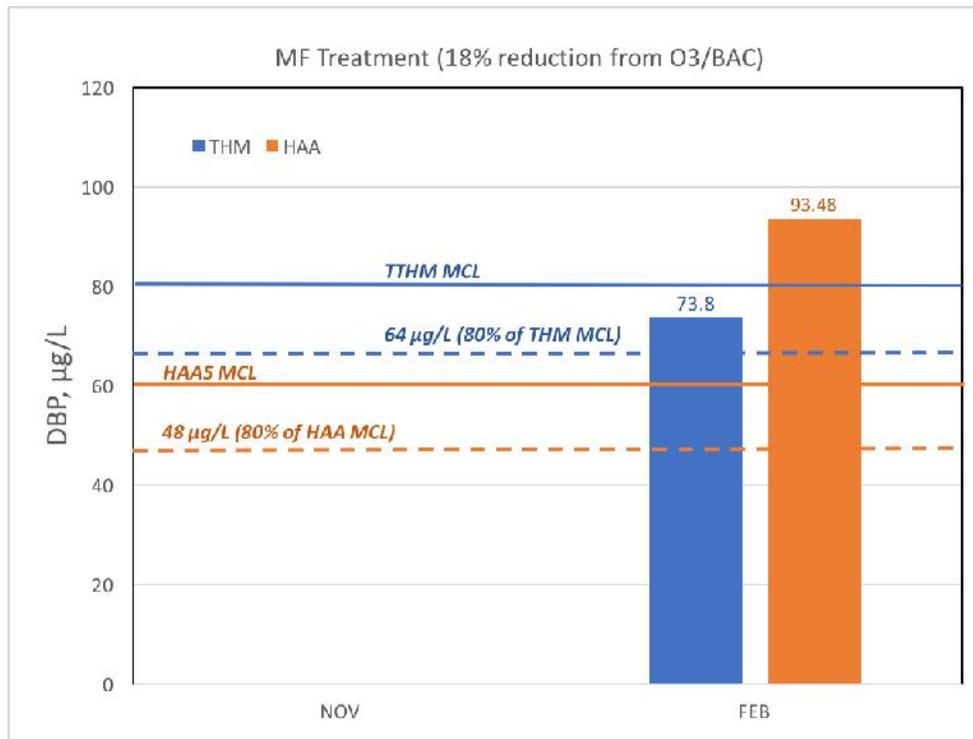


Figure 19. Estimated DBP Concentrations with Membrane Filtration Treatment Plus Ozone and Biofiltration (Train #6) Relative to MCLs and Treatment Goals



Conventional treatment with ozone and biofiltration (Figure 18) results in TTHM and HAA5 levels below both the MCLs and treatment goals (i.e., 80 percent of the MCL), under both dry- and wet-weather stream flow conditions. For membrane filtration treatment with ozone and biofiltration (Figure 19), the TTHMs were just slightly below the MCL but above the treatment goal, while the HAA5s were well above the MCL.

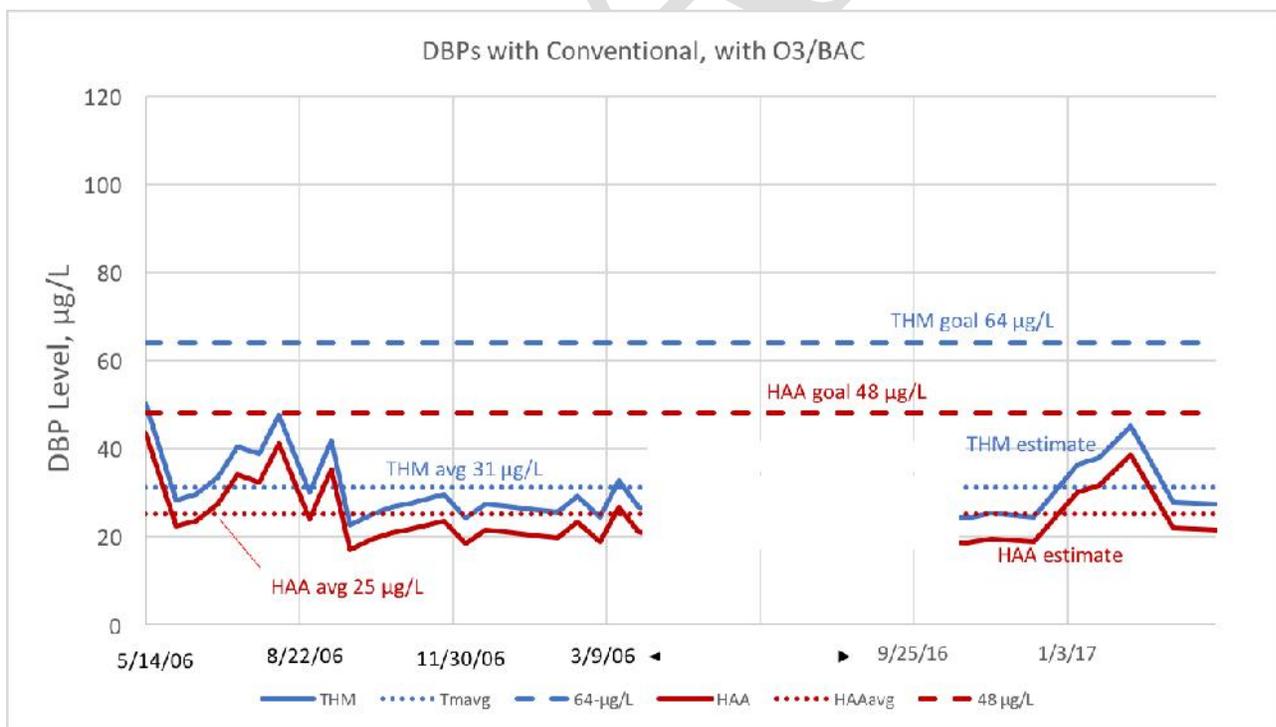
While the results shown on Figures 18 and 19 are instructive, they provide limited information about potential long-term trends for SRWA’s source water, or of the locational running annual average (LRAA) DBP values which will be the basis for demonstrating DBP compliance in each City under the Stage 2 D/DBP Rule¹². To estimate distribution system average DBP values for Trains 1 and 6, it was necessary to examine the potential TOC and DBP removal impacts of ozone and biofiltration on a larger set of raw water quality data, as described below.

¹² State and federal drinking water regulations for the Stage 2 D/DBP Rule require an Initial Distribution System Evaluation (IDSE) be conducted to identify locations in the distribution system where the highest DBP concentrations are likely to occur. These locations are then used for compliance monitoring. The Stage 2 D/DBP Rule requires that compliance with the TTHM and HAA5 MCLs be met at each compliance monitoring location based on calculated locational running annual average (LRAA), rather than a system-wide running annual average (RAA) as defined under the earlier Stage 1 D/DBP Rule. Compliance using LRAAs is more challenging and requires more conservatism than meeting the system-wide RAAs.

By comparing measured DBP concentrations from the November 2016 and February 2017 SDSDBP tests with measured raw water TOC concentrations from the same sampling events, correlations between raw water TOC and distribution system DBP concentrations were established. These correlations were then applied to historical TOC data collected at the Infiltration Gallery location during the TID pilot study (2006-2008) and the entirety of the recent TOC dataset collected as part of the SRWA sampling program to establish baseline estimated DBP concentrations for Train 1 and Train 6. By applying an additional 18 percent reduction in TOC concentrations, and thus DBP concentrations, via ozone and biofiltration treatment, DBP concentrations which more accurately reflect the performance of Trains 1 and 6 were estimated for all available raw water TOC measurements.

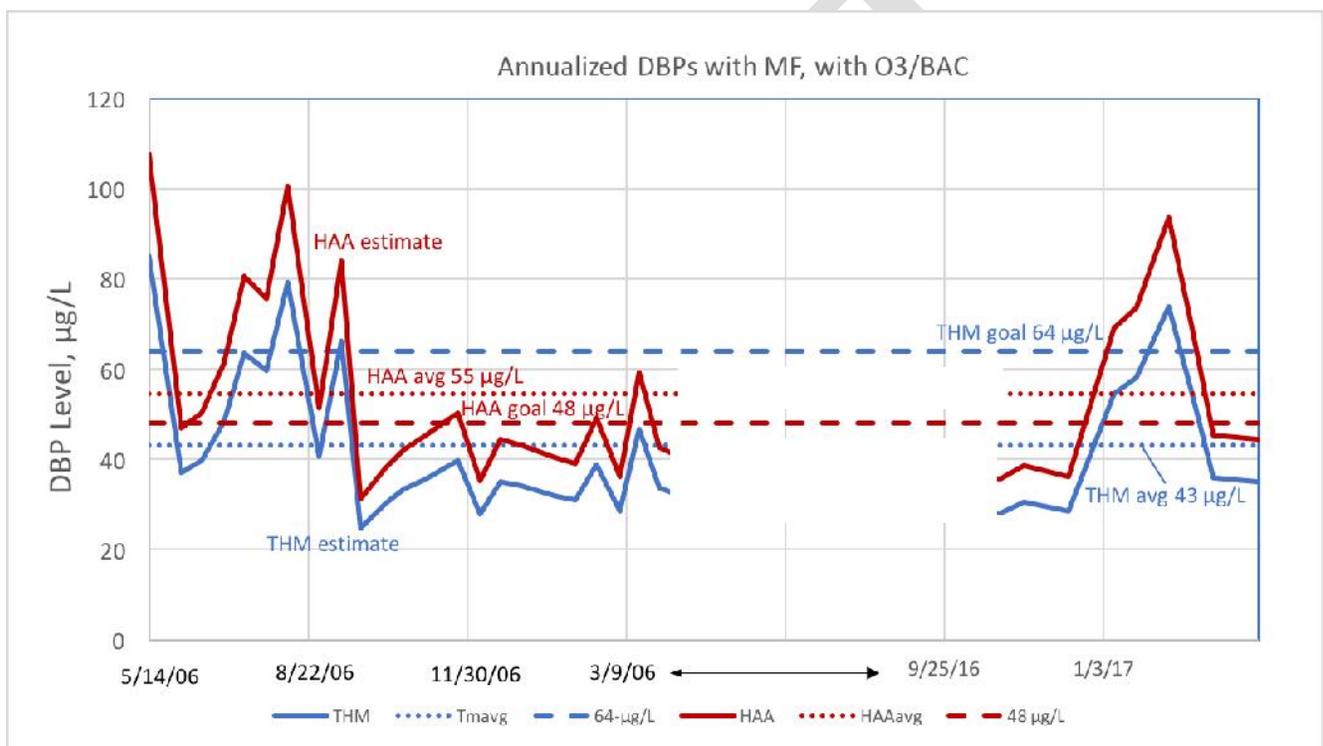
The resulting estimated DBP concentrations for conventional treatment with ozone and biofiltration (Train 1) and for membrane filtration treatment with ozone and biofiltration (Train 6) are shown in Figure 20 and Figure 21, respectively. For Train 1, estimated monthly TTHM and HAA concentrations are each consistently below their respective MCLs and treatment goals. The average TTHM concentration was estimated to be 31 µg/L and the average HAA5 concentration was estimated to be 25 µg/L. Thus, a conventional treatment train practicing enhanced coagulation that includes ozone and biofiltration plus free chlorine final disinfection (Train 1), is expected to result in TTHMs and HAA5s levels that meet DBP treatment goals and regulatory standards year-round.

Figure 20. Estimated Monthly and Average DBP Levels for Conventional Treatment Plus Ozone/BAC (Train #1) Relative to MCLs and Treatment Goals



For Train 6, monthly HAAs are estimated to exceed the MCL (60 µg/L) several times per year, and the estimated annual average concentration of 55 µg/L is above the treatment goal of 48 µg/L and only slightly below the MCL. Estimated monthly TTHM concentrations were predicted to occasionally exceed the MCL (80 µg/L) as well as the treatment goal of 64 µg/L. The estimated annual average TTHM concentration was 43 µg/L, which is below both the treatment goal and the MCL. Thus, even with ozone and biofiltration included in the treatment train, membrane filtration with free chlorine final disinfection (Train 6) is expected to result in DBP levels that exceed regulatory standards.

Figure 21. Estimated Monthly and Average DBP Levels for Membrane Filtration Treatment with Ozone/BAC (Train #6) Relative to MCLs and Treatment Goals



7.4.2 Planning-level O&M Costs

Planning-level O&M costs were developed for WTPs comprised of Trains 1 and 6. Because detailed design criteria have not yet been developed for either treatment train, the costs presented in this section rely heavily on industry expertise and recent cost information from similar facilities. In each case, O&M costs were estimated for the following categories:

- **Electrical power:** This category includes the raw water pump station, all WTP processes and the finished water pump stations. Raw water pump stations were included in either case because the treatment train is likely to influence the design hydraulic grade to which the raw water pump station must lift water to.

- **Chemicals:** This category includes all process chemicals, including coagulants, flocculants, disinfectants, membrane cleaning agents (specific to Train 6), pH adjustment, corrosion inhibitors, and so on.
- **Chemical disposal:** This category is unique to Train 6, and includes estimated costs for the offsite disposal of certain chemicals associated with the periodic cleaning of membrane filters.
- **Major equipment repair & replacement:** This category is intended to reflect annual SRWA contributions to an escrow account from which periodic major equipment repair, overhaul and replacement expenditures will be withdrawn. The estimated annual contributions are a function of the types, numbers, costs and estimated useful lives of the various major equipment items associated with each treatment train.
- **All other O&M costs:** This category includes all other typical O&M expenses not captured in the above categories (e.g., labor, routine maintenance activities, solids management, minor onsite utilities and contract services, and so on). Of these categories, labor comprises the largest portion of the estimated costs.

7.4.2.1 Train 1 O&M Cost Assumptions

Major assumptions used in the development of Train 1 O&M costs are summarized below. In each case, the basis for the Train 1 costs was recent cost information for a surface water treatment plant operated by the Woodland-Davis Clean Water Agency (which uses a treatment train that is essentially identical to Train 1), with as-needed adjustments to reflect characteristics specific to SRWA's project.

- **Power:** Power costs for Train 1 assume that the raw water pump station provides the necessary head to drive liquid stream flows through flash mixing, coagulation, flocculation, sedimentation, ozonation and media filtration. After the filters, it is assumed that an in-plant pump station lifts the filtered water to the clearwells. The finished water pump stations pump from the clearwells to either city.
- **Chemicals:** Chemical costs for Train 1 assume an average coagulant dose of 15 mg/L, reflective of bench-scale jar testing to simulate enhanced coagulation.
- **Chemical Disposal:** No chemical disposal costs are assumed for Train 1, as any overdosed or spent chemicals will remain in the liquid stream or be returned to the head of the plant for treatment.
- **Major Equipment Repair & Replacement:** Repair and replacement costs for Train 1 generally reflect equipment rebuilds 5 to 10 years after installation, and equipment replacement 15 to 20 years after installation. Equipment requiring annual contributions to the repair and replacement escrow account of over \$100,000 include: sedimentation basin scraper and internal components, ozone contactor diffusers, ozone generators, liquid oxygen storage tanks, filter underdrains, and granular filter media.

- **All Other O&M Costs:** Labor and other O&M costs not included above were assumed to be equivalent to such costs for the recently completed Woodland Davis Clean Water Agency surface water treatment plant.

7.4.2.2 Train 6 O&M Cost Assumptions

Major assumptions used in the development of Train 6 O&M costs are summarized below.

- **Power:** Power costs for Train 6 assume that the raw water pump station provides the necessary head to drive liquid stream flows through flash mixing, coagulation and flocculation, sedimentation, ozonation and media filtration. After the coagulation and flocculation facility, it is assumed that an in-plant membrane feed pump station provides sufficient head to drive the water across a pressurized membrane facility and then through ozonation, biological filters, and on to the clearwells. Similar to Train 1, the finished water pump stations pump from the clearwells to either city.
- **Chemicals:** Chemical costs for Train 6 assume an average coagulant dose of 5 mg/L, reflective of the typical maximum coagulant dose ahead of membrane filters. Additional costs are included for the chemicals necessary to conduct periodic membrane filter cleaning cycles.
- **Chemical Disposal:** For Train 6, it is assumed that spent citric acid solutions used during bi-monthly (i.e., six times per year) membrane clean-in-place (CIP) procedures are disposed of offsite at East Bay Municipal Utility District (EBMUD) facilities in Oakland, CA. This assumption is consistent with DDW feedback received by SRWA in June 2016 during a discussion of treatment processes which might be considered by SRWA; in that meeting, DDW staff indicated that return of spent CIP chemicals to the head of the plant, particularly citric acid, would not be allowed. The cost for disposal of chemicals from each CIP event are based on costs for similar disposal activities developed by MID. While the actual frequency for CIP events would not be known until after pilot testing, bi-monthly cleanings results in a conservative estimate. Other disposal options for membrane CIP waste are discussed in Section 7.4.3.
- **Major Equipment Repair & Replacement:** Repair and replacement costs for Train 6 are assumed to be similar to those of Train 1, except for the addition of annual contributions of \$390,000 to reflect the replacement of all membrane modules after a seven-year period.
- **All Other O&M Costs:** Labor costs estimates for Train 6 reflect input from several facilities with membrane treatment systems, including MID's Modesto Regional Water Treatment Plant and San Diego County Water Agency's Twin Oaks Valley Water Treatment Plant. Coincidentally, the resulting estimate of labor costs was nearly identical to the labor estimate used for Train 1. As such, the total Train 6 costs for labor and other O&M activities not captured elsewhere was assumed to be equal to that of Train 1.

7.4.3 Treatment Facility Expandability

The following discussion on treatment facility expandability assumes an initial design capacity of 15 mgd, with a planned expansion to roughly double capacity. Expandability considerations are presented for each of the preferred treatment trains, Trains 1 and 6.

Train 1 – Conventional Treatment with Pre-Ozone and Biofiltration



Ozonation. The major components of the ozonation system include: ozone generators and power supply units, cooling water system, ozone contactors, liquid oxygen (LOX) storage tanks and vaporizers, and ozone destruct system. For the initial design phase for a 15 mgd treatment facility, the following design conditions might be considered. The exact design could be different depending on factors such as required turn down, variability in water quality, and desired degree of oversizing.

- Ozone Generators and Power Supply Units:
 - Initially sized for one duty, one standby (i.e., 1 + 1) redundancy. Each generator and power supply unit should be able to treat the full plant flow at the design ozone dose. Both generators should be run during operation to maintain dry conditions with a dry gas flow through the dielectrics (i.e., at 50 percent power).
 - Expand to 2 + 1 redundancy. When expanding the facility, add one additional ozone generator and power supply unit that has the same production capacity as the first two generators and power supply units, making it capable of treating the full additional flow. The initial redundant generator now serves as a redundant generator for both the initial facility flow and the expansion flow; the level of redundancy after expansion, though, is only 50 percent, whereas redundancy was 100 percent after initial construction. A second ozone generator and power supply unit could be added at expansion, rather than just one, if greater redundancy is desired.
- Cooling Water System
 - There will be one cooling water system for the two generators. The open loop and the closed loop will both have 1 duty + 1 standby pumps. Heat will be transferred between the open and closed loops by 1 duty + 1 standby heat exchangers.
 - For the expansion, the open loop cooling water pumps, closed loop cooling water pumps, and heat exchangers will each have 2 duty + 1 standby units.
- Ozone Contactors:
 - Assume traditional over/under water flow pattern through the contactor, with diffusers on the floor of the first contact chamber and countercurrent gas:water flow.

- Assume 2 + 0 redundancy for the contactors, with each contactor sized to handle half the flow at a hydraulic detention time (HDT) of roughly 5 minutes. Redundancy is not needed since contactors rarely need to be taken out of service for maintenance or cleaning. If diffuser repair is required, scheduled down time can likely be planned.
- Although each contactor would be designed to have a higher hydraulic capacity than the design flow rate (i.e., 150 percent of the design flow), to double the plant's capacity two additional equal sized ozone contactors should be constructed. Increasing the flow rate through each contactor is not a recommended expansion approach.
- LOX Storage Tank:
 - The initial design would require only one LOX tank, with one duty and one standby vaporizers (1+1). The vaporizers would cycle between each other, such that while one is in operation, the other is thawing.
 - The LOX storage tank is sized based on a typical 15 days of storage at the maximum ozone production rate. Typical oxygen boil off is 0.3 percent to 0.5 percent of the tank's capacity per day (Rakness, 2005).
 - For facility expansion, a second LOX tank should be added with the same capacity as the first one. An additional vaporizer will be added so there are 2 duty + 1 standby vaporizers.
- Ozone Destruct System:
 - The destruct system should be installed with the same redundancy as the generators. The initial design should have 1 duty + 1 standby destruct system, with each sized to accommodate the total gas flow.
 - For facility expansion, one additional destruct system should be added resulting in 2 duty + 1 standby destruct units.

Coagulation/Flocculation/Sedimentation. Major components of the Coagulation/Flocculation/Sedimentation system are the flash mix system for coagulant addition, flocculation basins with mixers, and sedimentation basin with sludge removal system. The flocculation/sedimentation facility could be any of a variety of designs, including conventional tapered flocculation with a traditional large sedimentation basin, conventional tapered flocculation with tube or plate settlers, or sand ballasted flocculation/sedimentation. Some thoughts on expandability of these components are as follows:

- Coagulant Addition:
 - Coagulant addition should be achieved through in-line pump flash mix system. Influent piping would likely be sized for the expanded plant capacity, with the flash mix system located in the influent piping.
 - The system should be designed with 1 duty + 1 standby flash mix systems.
 - Expansion of the treatment facility would not require any changes to the flash mix system except possibly increasing the capacity of the chemical metering pumps.

- Flocculation/Sedimentation:
 - The initial treatment facility should be designed with N+0 redundancy for the flocculation/sedimentation (floc/sed) system. Depending on how much plant capacity can be off-line for occasional maintenance, the facility can be designed with two or three parallel floc/sed trains.
 - Each floc/sed train is designed for a “standard” surface loading rate (SLR), although the SLR of each type floc/sed system is different. Expansion will require duplication of the initial facility’s floc/sed train(s) unless the units are intentionally under-designed (i.e., at a lower than “standard” SLR) when the initial plant is constructed. It is possible that the source water quality and full-scale operations experience will allow the system to be operated at a higher SLR than initially designed, which ultimately could affect sizing of the expansion floc/sed units but this is not something that can be planned for now.

GAC/Sand Filters (Biofilters). The major components of a dual media filtration process include: open, reinforced concrete filter cells; filter media (i.e., GAC over sand); backwash pumps and air scour equipment to assist cleaning the media during backwash; and underdrain and filtered water collection systems. The individual components do not need to be discussed separately with regards to expansion, since additional filter cells complete with media and a backwash system would be added during facilities expansion. However, unlike the other systems discussed for Train #1, some additional treatment capacity can be gained by re-rating the initial filters to operate at a higher filtration rate. When new filters are added during facility expansion, they should be designed at the higher filtration rate, assuming DDW approved the filter re-rating study. (Filter re-rating was discussed in Section 5.3.2 of this TM.)

Some additional thoughts on initial filter design and future expandability are the following:

- The initial design should include N+2 redundancy to accommodate having one filter off-line for maintenance and one filter off-line for backwashing. Title 22 CCR limits filtration rates for conventional filtration facilities to a maximum of 6 gpm/ft², with one filter off-line for backwashing.
- Prior to facility expansion, consider re-rating existing filters to a higher filtration rate such as 8 gpm/ft². This would increase capacity by 33 percent more capacity without physical construction.
- Once the higher filtration rate has been approved by DDW, future filters that are added during facility expansion can be designed at the higher filtration rate. The new bank of filters should include N+0 redundancy, so the whole filtration system will retain the N+2 redundancy allowing the filters to operate at the approved filtration rate with one off-line for maintenance and one off-line for backwash.

Chlorine Contact Basin. The size of the chlorine contact basin will depend on the HDT needed for disinfection CT credit under worst-case temperature conditions and the on-site finished water storage capacity needed by SRWA. The basin should be baffled to provide a baffle factor (i.e., T10/T) of 0.6 or higher, improve disinfection efficiency and minimize short circuiting through the basin. A factor or redundancy is not required for the chlorine contact basin since there should be

very little down-time for maintenance. But on the other hand, if the facility had two side-by-side chlorine contact basins, one basin could be taken off-line without having to shut-down the entire treatment facility.

For facility expansion, additional chlorine contact time would be required to meet regulatory disinfection requirements. The preferred expansion approach would likely be to add a second contact basin; otherwise, the whole treatment facility would need to be off-line while the existing basin was modified since disinfection is a critical component of treatment. Facility expansion would also be a good time for SRWA to reassess on-site finished water storage needs. Additional chemical storage for the chlorine (and other additional stabilization chemicals), as well as additional chemical metering pumps, would be needed when the chlorine contact basin is expanded.

7.4.3.1 Train 6 – Membrane Filtration with Ozone and BAC Filtration



The key difference in unit processes between Train 6 compared to Train 1 is the addition of membrane filtration and the elimination of the flocculation/sedimentation basins. Expandability considerations for the common unit processes are the same whether considering the conventional treatment train or the membrane filtration train. Therefore, the discussion of expandability for those processes included in Train 1 is not repeated here.

The main components of the MF system are the membrane rack, the backwash (with air scour) system, and the enhanced flux maintenance (EFM) and CIP systems which include chemical mixing tanks, pumps and chemical storage. Considerations for expansion of the MF system are the following:

- The initial design should have an N+2 redundancy on the number of membrane skids to accommodate one skid being backwashed and another being cleaned (i.e., CIP) or maintained (i.e., EFM) while not sacrificing production capacity.
- For expansion, consider modular expansion and universal racks to increase production. Depending on the number of MF racks or basins, redundancy should be increased to N+3 to accommodate more flexibility in backwash and EFM/CIP cleaning.
- The initial MF system design should leave space for the future equipment needed for expansion.
- Re-rating, or increasing the operating flux is generally not a viable approach for increased production.

7.4.4 Disposal Options for Membrane CIP and other WTP Wastes

As discussed in Section 7.4.3, the planning-level O&M costs for Train 6 assume that membrane CIP waste chemicals would be hauled from the WTP to a suitable disposal facility. In lieu of this approach, it may be possible to construct a sanitary sewer connection between the WTP and a nearby wastewater treatment plant (WWTP) such as the City of Hughson's WWTP. Regardless of the treatment train ultimately selected and constructed, the ability to send WTP waste streams (e.g., CIP wastes, treatment residuals, sanitary waste, and so on) to a WWTP instead of one or more on-site treatment systems may offer advantages to SRWA. The ability of one or more local WWTPs to accept such wastes, and the potential capital and operating costs associated with conveying such wastes by pipeline, will be evaluated by the PM Team in greater detail during the next phase of the Project.

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Table 16. Treatment Train Risk Assessment

| Risk/Issue | Train #1 | Train #2 | Train #3 | Train #4 | Train #5 | Train #6 | Train #7 |
|---|----------------------------------|---|--|--|---|--|---|
| | Conventional w/ Pre-Ozonation | Conventional w/ Intermediate Ozonation | Conventional w/o Ozone | Direct Filtration w/ Ozone | Direct Filtration w/o Ozone | Membrane Filtration w/ Ozone | Membrane Filtration w/o Ozone |
| Exceedance of DBP MCLs | Low | Low | Low-CC ^(b) Med-FC ^(c) | Low-CC ^(b) Med-FC ^(c) | Low-CC ^(b) High-FC ^(c) | Low-CC ^(b) Med-FC ^(c) | Low-CC ^(c) High-FC ^(b) |
| Taste & Odor ^(a) Complaints and/or Inadequate Treatment of Algal Toxins ^(a) | Low | Low | High | Low | High | Low | High |
| Inadequate Treatment of Pesticides ^(a) | Low | Low | Med | Low | Med | Low | High |
| Inadequate Control of Manganese ^(a) | Low | Med | Low | Low | Med | Med | Med |
| Cost Difference Relative to Train No. 1, Rounded to Nearest \$M | -- 0% | -- 0% | (\$7M) -8% | -- 0% | (\$9M) -10% | (\$4M) -4% | (\$11M) -12% |
| ^(a) If present ^(b) CC = combined chlorine (i.e., chloramines) ^(c) FC = free chlorine | | | | | | | |

Table 17 summarizes the planning-level O&M cost estimates for Trains 1 and 6. A summary of the assumptions used in the development of the costs for each train, particularly those that result in significant differences among the costs for the two trains, is included below.

| Table 17. Planning-level WTP O&M Costs for Trains 1 and 6 | | |
|---|-------------------------|-------------------------|
| O&M Cost Element | Train 1, dollars | Train 6, dollars |
| Power (1) | 700,000 | 750,000 |
| Chemicals (2) | 550,000 | 470,000 |
| Chemical Disposal (3) | N/A | 600,000 |
| Major Equipment Repair & Replacement (4) | 410,000 | 800,000 |
| All Other O&M Costs (5) | 2,860,000 | 2,860,000 |
| Total | \$4,520,000 | \$5,480,000 |
| Notes: | | |
| 1) Includes raw and finished water pump station and all WTP loads. For Train 6, assumes pressurized membrane system. | | |
| 2) Includes all process chemicals. Assumes coagulant doses. 5 mg/L for Train 1, and 5 mg/L dose for Train 6. Does not account for potentially-higher dose for "hybrid" Train 6. | | |
| 3) Assumes offsite disposal of citric acid waste from MF system for six cleanings per year. Assumes disposal to EBMUD facilities. | | |
| 4) Annual contributions to major equipment R&R escrow account. For MF system, assumes module replacement after 7 years. | | |
| 5) Includes labor, maintenance, routine R&R, solids management, and onsite utilities. | | |

7.5 Updated TAC Recommendations

The information presented in Section 7.4 was summarized and presented to the TAC on May 16, 2017. At the conclusion of the presentation, the TAC and PM Team agreed that Train 6 should be eliminated from further consideration by SRWA due that train's increased risks associated with DBP formation and regulatory compliance, as well as the likelihood that O&M costs for Train 6 may exceed those for Train 1. To foster innovation and cost competition among design-build proposers, it was agreed that opportunities for allowing flexibility in the manner in which design-build proposers are able to satisfy performance requirements will be explored.

8.0 NEXT STEPS

During the next phase of the Project, which is set to begin in approximately July 2017, the TAC and PM Team will advance the definition of treatment process requirements in advance of issuing a request for design-build proposals in late 2019. The following activities critical to the evaluation, definition, design, construction and eventual operation of the treatment plant will be conducted during this upcoming phase:

- Continued collection and analysis of source water samples, with a potentially abbreviated sampling program following the first year of sample collection
- Completion of remaining bench testing activities (ozone demand and manganese removal)

- Preparation of preliminary design information for the preferred treatment train, including:
 - Development of preliminary design criteria
 - Development of preliminary site plan(s)
 - Development of a preliminary instrumentation and control systems design
 - Development of refined construction and O&M cost estimates
- Development of treatment process performance and design-build acceptance test requirements

DRAFT

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ATTACHMENT A

Direct Filtration Operational TM

DRAFT



TECHNICAL MEMORANDUM

prepared for Stanislaus Regional Water Authority

Date: March 23, 2017

Authors: Fred W. Gerringer, D. Env., P.E., BCEE

Reviewers: R. Rhodes Trussell, Ph.D., P.E., BCEE
Elaine W. Howe, P.E.

Job Number: 69.014

Subject: Operational Experience of Large Direct Filtration Water Treatment Plants

Trussell Technologies contacted three direct filtration (DF) water treatment plants to gather information about their operating experiences, such as some of the challenges they face and how they respond to changing source water quality. The information received from two of the DF plants; the Los Angeles Aqueduct Filtration Plant (LAAFP) in Los Angeles, California and the Tolt Water Treatment Facility (TWTF) in Seattle, Washington; are discussed in this technical memorandum.

Los Angeles Aqueduct Filtration Plant, Los Angeles, CA

The LAAFP in Los Angeles, California was originally designed to treat 600 million gallons per day (MGD) of imported water from the Los Angeles Aqueduct and was later approved to treat water from the State Water Project. The water from the Los Angeles Aqueduct was served to the city with only chlorination treatment from 1913 until 1986 when the LAAFP came on line¹. The quality of both source waters is typically stable and are blended together to produce average influent turbidity and TOC levels of 3.8 NTU and 1.6 mg/L, respectively. The treatment train includes fluoridation, ozonation, rapid mixing, flocculation, media filtration, disinfection with ultraviolet light, and chloramination (Figure 1). Ozone dose ranges from 1 to 1.5 mg/L, and coagulant dose ranges are 1 to 1.5 mg/L for ferric

¹ Coagulants were sometimes added to the aqueduct in the late 1970s and 1980s. The LA aqueduct passes through several reservoirs on its way to Los Angeles.

chloride and 1 to 5 mg/L for cationic polymer. The filters consist of 5 feet of 1.5 mm anthracite mono-media and are designed to operate with a loading rate of 13 gpm/ft², and filter run lengths vary from 8 to 24 hours, depending on the water quality conditions and the filtration rate. Approval for this high filtration rate required extensive (> 2 years) pilot and full-scale testing².

Operation of the facility has been more challenging in the winter of 2017 because runoff from heavy rainfall has carried fine glacial till, or “rock flour”, to LAAFP. Despite this challenge, the facility continues to satisfy regulatory requirements. When encountering difficult raw water quality, LAAFP has four primary options: reject the water source, increase the coagulant dose, reduce filter run lengths, or reduce flows. The decision of how to respond depends on factors such as the status of treated water storage, the duration of the poor water quality event, and water demands. One challenge associated with operating a DF plant is the availability of fewer tools for addressing challenging water quality compared to a conventional treatment plant. The effective operation of a DF plant like LAAFP requires staff to diligently perform routine maintenance and to ensure sufficient chemical is stored to respond to water quality that is difficult to treat. Because LAAFP does not use free chlorine for primary disinfection and uses chloramines for secondary disinfection, chlorinated DBPs are well below regulatory limits. However, the ozone dose needs to be managed to control bromate formation, as bromide is present in water from the State Project.

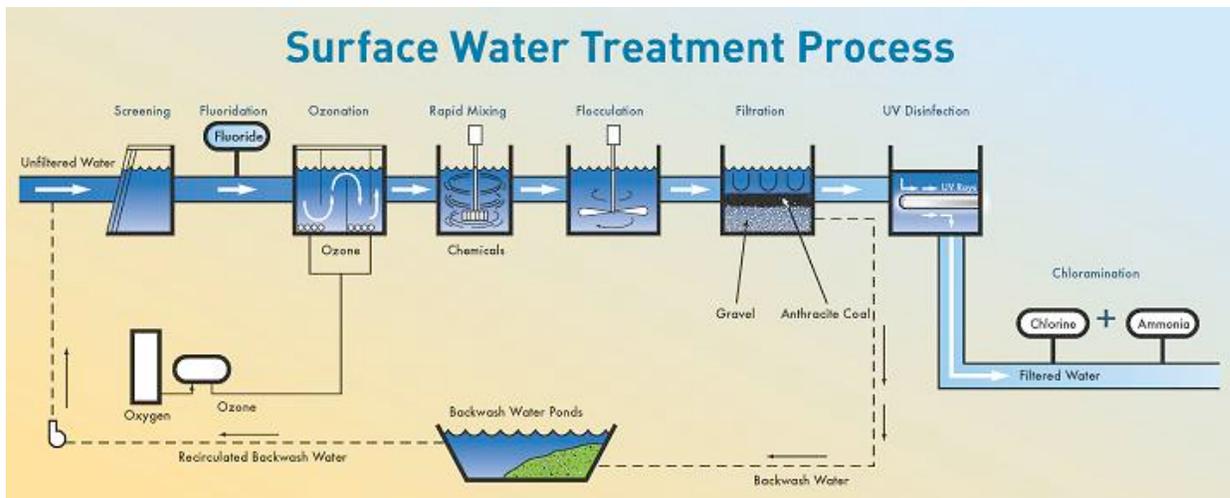


Figure 1. Los Angeles Aqueduct Filtration Plant Process Flow Diagram
https://www.ladwp.com/ladwp/faces/wcnav_externalId/a-w-wqreport-wtrtmntprocess

² Filter re-rating must be done after the full-scale facility has been constructed and operated. The re-rating study required by DDW is based on full-scale demonstration testing. This high of a filtration rate may not get DDW approval today based on the current regulatory climate.

Tolt Water Treatment Facility, Duvall, WA

The TWTF in Seattle, Washington has a capacity of 120 MGD and treats water from the Tolt Reservoir, which was created by a dam on the South Fork Tolt River. Seattle originally served this water with only chlorination and, eventually, pH adjustment until the promulgation of the Surface Water Treatment Rule required that it be filtered. Water quality is usually stable because the reservoir minimizes water quality fluctuations. Turbidity typically ranges from 0.2 to 0.5 NTU and generally does not exceed 5 NTU. The normal range for TOC is 1.1 to 1.5 mg/L, although it has occasionally reached 2.0 mg/L. The treatment train includes ozonation, coagulation/flocculation, lime addition, media filtration, carbon dioxide, chlorination, and fluoridation (Figure 2). The normal range of the coagulant doses are 0.4 to 0.7 mg/L for both ferric chloride and cationic polymer, although polymer is only used for about 6 months every year. The media filters contain 6 ft of anthracite coal and have a design loading rate of 12 gpm/ft². Just as for the LAAFP, extensive pilot and full-scale demonstration testing was required to get the approval of state regulators for this high filtration rate. Filter run lengths usually range from 24 to more than 48 hours, but have dropped below 24 hours in rare circumstances.

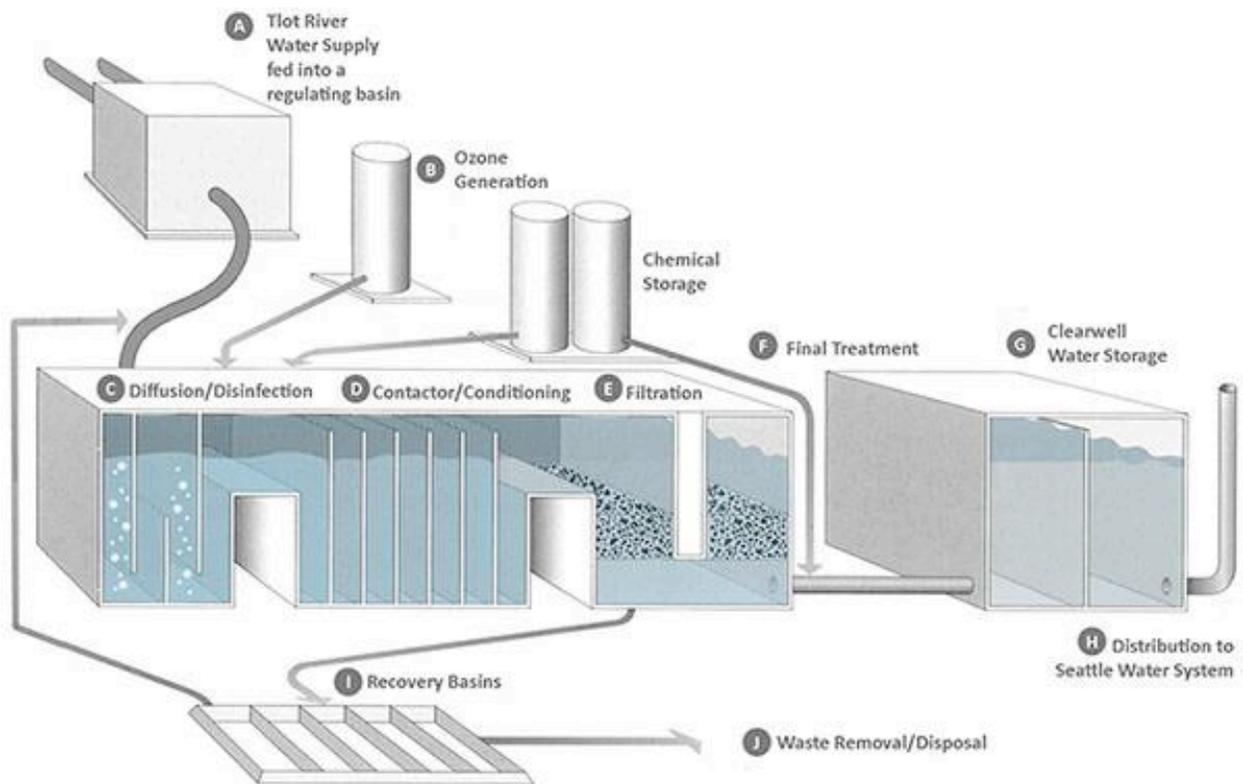


Figure 2. Tolt Water Filtration Plant process flow diagram
<http://www.seattle.gov/util/MyServices/Water/AbouttheWaterSystem/WaterSystemOverview/ToltTreatmentFacility/index.htm>

One of the challenges with operating this plant comes from the short detention time from the plant influent to the filter effluent (approximately 30 minutes), which limits the amount of time available to respond to rapid changes in water quality or equipment failure. Another challenge is when high turbidity occurs with cold water temperatures, which makes it difficult to manage filter effluent turbidity³. Removing one of the two treatment trains for maintenance when the water is cold makes operation more difficult because the coagulation/flocculation time is reduced by 50%.

³ Temperature affects reaction kinetics of the coagulation process—colder temperatures slow reaction kinetics. Headloss is also greater through a filter in cold temperatures because the viscosity of the water increases.

ATTACHMENT B

*Methodology for Developing Planning Level Construction Cost Information
for SRWA Surface Water Treatment Unit Processes (West Yost,
March 2017)*

DRAFT

TECHNICAL MEMORANDUM

DATE: March 28, 2017 Project No.: 693-20-16-01
SENT VIA: EMAIL

TO: SRWA Technical Advisory Committee

FROM: Andy Smith, RCE #C74673

REVIEWED BY: Gerry Nakano, RCE #C29524
Lindsay Smith, RCE #C72996
Rhodes Trussell, Trussell Technologies, RCE #C25107
Fred Gerring, Trussell Technologies, RCE #C67467

SUBJECT: Methodology for Developing Planning-Level Construction Cost Information
for SRWA Surface Water Treatment Plant Unit Processes

INTRODUCTION

The Stanislaus Regional Water Authority (SRWA) is planning to construct a new surface water treatment plant (WTP) to provide a new, supplemental drinking water supply to the cities of Ceres and Turlock. As part of the SRWA Technical Advisory Committee's (TAC) evaluation of alternative treatment processes for the new WTP, planning-level construction cost information has been developed for the unit treatment processes that comprise the available treatment train alternatives.

The purpose of this Technical Memorandum (TM) is to describe the methodology used for developing these planning-level construction cost estimates. This TM is organized as follows:

- Introduction
- Background
- Classification and Intended Use of Cost Estimates
- Construction Cost Estimating Approaches
- Sources of Reference Costs
- Summary of Estimated Construction Costs

BACKGROUND

The first cost information related to the WTP provided to the TAC was developed in September 2016 as part of a request by the TAC to provide preliminary cost information to support a preliminary evaluation of the potential monthly cost impact to existing water customer bills. At that time, there was limited definition of the treatment processes to be included in the future WTP. As such, the costs presented in September 2016 were developed by making coarse cost adjustments to a surface WTP recently constructed for the Woodland-Davis Clean Water Agency (WDWCA) in Woodland, California. The adjustments made included the following:

- Elimination of costs for facilities or processes anticipated to be absent for the SRWA project,
- Coarse scaling of costs for facilities or processes anticipated to be smaller or larger and/or more or less robust than the WDCWA project, and
- Inflation adjustments.

The resulting estimate was intended as a placeholder amount until more detailed source water quality information was available, and a more thorough and comparative evaluation of treatment trains could be made.

CLASSIFICATION AND INTENDED USE OF COST ESTIMATES

The updated cost information presented herein is considered by West Yost Associates (West Yost) to be compatible with Class 5 estimates, per the Association for the Advancement of Cost Engineering (AACE). AACE's cost estimate classification matrix is shown in Table 1. The intended use of these estimates is to help facilitate the TAC's selection of one or more preferred treatment trains for further analyses and refinement. It is assumed that refined cost estimates for the TAC's preferred treatment train will be developed in conjunction with ongoing pre-design efforts, including the development of preliminary design criteria, site layout and a hydraulic profile for the selected treatment train. A cost estimating contingency of 25 percent has been applied to all cost estimates, in accordance with the "low" end of the expected accuracy range for Class 5 estimates.

| Table 1. AACE Cost Estimate Classification Matrix^(a) | | | | |
|--|---|---------------------------------|--|--|
| Estimate Class | Primary Characteristics | Secondary Characteristic | | |
| | Maturity Level of Project Definition Deliverables | End Usage | Methodology | Expected Accuracy Range |
| Class 5 | 0% to 2% | Concept screening | Capacity factored, parametric models, judgement or analogy | Low: -20% to -50% High: +30% to +100% |
| Class 4 | 1% to 15% | Study or feasibility | Equipment factored or parametric models | Low: -15% to -30% High: +20% to +50% |
| Class 3 | 10% to 40% | Budget authorization or control | Semi-detailed unit costs with assembly level line items | Low: -10% to -20% High: +10% to +30% |
| Class 2 | 30% to 75% | Control or bid/tender | Detailed unit costs with forced detailed take-off | Low: -5% to -15% High: +5% to +20% |
| Class 1 | 65% to 100% | Check estimate or bid/tender | Detailed unit costs with forced detailed take-off | Low: -3% to -10% High: +3% to +15% |

^{a)} Source: AACE International Recommended Practice No. 18R-97, revised March 1, 2016

CONSTRUCTION COST ESTIMATING APPROACHES

Currently, because specific treatment train processes have not yet been decided upon by the TAC and Board, preliminary design details for the specific capacities and processes under consideration cannot be developed. However, several simplified approaches have been utilized for developing unit process construction cost estimates, as described below.

Unit process cost estimates have been developed primarily by adapting known construction costs from similar facilities to conform to the size and characteristics currently known for the SRWA project. Under this approach, the most detailed cost information available for the processes in question were obtained from one or more reference facilities. The available cost information was then adjusted as follows:

- Costs were screened to remove or adjust sub-elements that are not directly applicable to the SRWA project and/or treatment process.
- Costs were further screened to remove electrical and instrumentation costs, which are more appropriately captured at the planning level as a percentage of the overall treatment process construction costs.

- Costs were adjusted (i.e., inflated) to bring the reference costs to the midpoint of construction anticipated for the SRWA project, which is projected to be around June 2020.
- Costs were further adjusted to reflect differences in capacity between the reference facility and the anticipated capacity for the first phase of the SRWA project, which is currently assumed to be 15 million gallons per day (mgd). Additional discussion of this capacity-based adjustment is provided below.

Capacity-based Cost Adjustments

Capacity-based construction cost adjustments were made using the power law, a simple approach used to estimate costs of facilities based on a known cost and capacity of a similar (i.e., reference) facility. A simplified form of the power law for comparing similar facilities is the “six tenths rule”. Because the facilities compared herein are assumed to be identical except for capacity, the six tenths rule is appropriate for these planning-level cost estimates (AWWA and ASCE, Water Treatment Plant Design 26.6). The equation used to determine the estimated cost is as follows:

$$C_B = C_A \left(\frac{S_B}{S_A} \right)^x$$

Where: C_B = Estimated cost of facility having capacity S_B

C_A = Known cost of facility having capacity S_A

$\frac{S_B}{S_A}$ = Ratio of capacities

x = Correlating exponent, $0 < x < 1$ ($x = 0.6$ in the six tenths rule)

For the costs presented herein, the known costs are those associated with the reference facilities described below.

Other Cost Estimating Methodologies

For the ultraviolet (UV) disinfection facilities envisioned for several of the treatment train alternatives under consideration, applicable reference facility costs could not be obtained by West Yost. The methodology for developing costs for these facilities is described below.

- Solicitation of budgetary equipment cost information based on required equipment capacity, quantity and UV dose. The assumed equipment type is closed vessel reactors.

- Development of a conceptual facility layout to facilitate preparation of quantity take-offs for estimating concrete foundations, exposed piping, canopies and other ancillary items.
- Preparation of construction cost estimates using unit costs from recent treatment plant construction projects and the quantity take-offs described above.

SOURCES OF REFERENCE COSTS

This section provides a brief overview of the projects from which reference cost information was obtained and adapted. In some instances, cost information from more than one process at a given reference facility was utilized for this exercise. In instances where cost information for a given process was available from more than one reference facility, the more costs from the more recently constructed facility were used in the evaluation of available SRWA treatment trains.

Modesto Irrigation District Modesto Regional Water Treatment Plant

The Modesto Irrigation District (MID) Regional Water Treatment Plant (MID Plant) is a 60-mgd facility owned and operated by MID. The facility treats surface water from the Modesto Reservoir, and features two independent 30-mgd treatment trains, one using a conventional treatment process, and one using membranes. The conventional treatment train was constructed in 1994. Construction of the membrane process was completed in 2016¹. Reference costs for the SRWA Project were obtained for the following processes, each of which is part of the newer membrane treatment train:

- Ozone treatment
- Membrane filters

City of Lodi Surface Water Treatment Facility

The Lodi Surface Water Treatment Plant (Lodi Plant) is an 8-mgd facility owned and operated by the City of Lodi. The facility treats surface water from the Mokelumne River (via Lodi Lake). Construction of the facility was completed in 2013. Reference costs for the SRWA Project were obtained for the following processes:

- Membrane filters

WDCWA Regional Water Treatment Facility

The WDCWA Regional Water Treatment Facility (WDCWA Plant) is a 30-mgd facility owned and operated by WDCWA. The facility treats surface water from the Sacramento River, upstream of the confluence with the American River. Construction of the facility was completed in 2016. Reference costs for the SRWA Project were obtained for the following processes:

¹ The original construction of the membrane process was completed in 2009. Due to operational issues, however, additional construction efforts were undertaken and eventually completed in 2016. The cost information obtained for this analysis is from the work that was completed in 2009.

- Flash mixing
- Coagulation, flocculation and sedimentation basins²
- Ozone treatment
- Granular media filters
- Chlorine contactor³
- In-plant pump station
- Finished water clearwell
- Backwash supply & finished water pump station
- Backwash equalization basin
- Gravity thickeners
- Solids drying beds

In addition, reference costs for several typical ancillary buildings were obtained from available WDCWA cost data:

- Chemical building
- Operations & administration building
- Maintenance building

Sacramento County Water Agency Vineyard Surface Water Treatment Plant

The Sacramento County Water Agency (SCWA) Vineyard Surface Water Treatment Plant (Vineyard Plant) is a 50-mgd facility owned and operated by SCWA. The facility treats surface water from the Sacramento River, downstream of the confluence with the American River. Construction of the facility was completed in 2010. Reference costs for the SRWA Project were obtained for the following processes:

- Coagulation, flocculation and sedimentation basins

SUMMARY OF ESTIMATED CONSTRUCTION COSTS

Table 2 summarizes the results of the cost estimating procedures described above. Additional details for each listed process and reference facility can be found in Attachment 1.

² The WDCWA Plant uses a system referred to as “Sand Ballasted Clarification”, better known by its trade name Actiflo®.

³ The completed WDCWA Plant does not include a true chlorine contactor, as free chlorine is injected at a pump station ahead of the finished water clearwells. In this case, the reference facility cost information comes from a detailed estimate developed for the “benchmark” WTP, which was defined by WDCWA prior to final design of their WTP. The benchmark WTP for WDCWA included a standalone chlorine contactor.

Table 1. Summary of Planning-Level Unit Process Construction Costs^(a)

| Unit Process | Reference Facility Information | | | Adjusted Facility Information | | |
|--|------------------------------------|------------------|---|--|----------------------|---|
| | Source of Reference Costs | Process Capacity | Reference Facility Midpoint of Construction | Inflated to Midpoint of SRWA WTP Construction (June 2020), dollars | SRWA Target Capacity | Adjusted to SRWA WTP Target Capacity, dollars |
| Flash Mixing | WDCWA Plant | 30 mgd | Jan 2015 | 602,000 | 15 mgd | 397,000 |
| Coagulation, Flocculation and Sedimentation | Vineyard Plant | 50 mgd | Aug 2009 | 17,297,000 | 15 mgd | 8,399,000 |
| | WDCWA Plant | 30 mgd | Jan 2015 | 6,731,000 | 15 mgd | 4,441,000 |
| Coagulation and Flocculation Only (No Sedimentation) | Vineyard Plant | 50 mgd | Aug 2009 | 7,310,000 | 15 mgd | 3,550,000 |
| Granular Media Filtration | WDCWA Plant | 30 mgd | Jan 2015 | 14,929,000 | 15 mgd | 9,849,000 |
| Membrane Filters | MID Plant | 30 mgd | Jun 2008 | 30,438,000 | 15 mgd | 20,082,000 |
| | Lodi Plant | 8 mgd | May 2012 | 7,268,000 | 15 mgd | 10,598,000 |
| Ozone Treatment | MID Plant | 30 mgd | Jun 2008 | 12,599,000 | 15 mgd | 8,312,000 |
| | WDCWA Plant | 30 mgd | Jan 2015 | 6,577,000 | 15 mgd | 4,339,000 |
| Chlorine Contact Basin (Free Chlorine and Chloramines) | WDCWA Benchmark WTP | 212,000 gal | Jul 2011 | 684,000 | 625,000 gal | 1,309,000 |
| UV Disinfection | Vendor Proposal/ Conceptual Layout | 15 mgd | Mar 2017 | 748,000 | 15 mgd | 748,000 |
| Chemical Building | WDCWA Plant | 30 mgd | Jan 2015 | 5,546,000 | 15 mgd | 5,546,000 |
| Operations & Administration Building | WDCWA Plant | 30 mgd | Jan 2015 | 4,075,000 | 15 mgd | 4,075,000 |
| Maintenance Building | WDCWA Plant | 30 mgd | Jan 2015 | 1,588,000 | 15 mgd | 1,588,000 |
| In-Plant Pump Station | WDCWA Plant | 30 mgd | Jan 2015 | 1,935,000 | 15 mgd | 1,277,000 |
| Finished Water Clearwell | WDCWA Plant | 5.75 MG | Jan 2015 | 7,487,000 | 2.375 MG | 4,432,000 |
| Backwash Supply/Finished Water Pump Station | WDCWA Plant | 30 mgd | Jan 2015 | 6,541,000 | 15 mgd | 4,315,000 |
| Backwash Equalization Basin | WDCWA Plant | 30 mgd | Jan 2015 | 2,838,000 | 15 mgd | 1,872,000 |
| Gravity Thickeners | WDCWA Plant | 30 mgd | Jan 2015 | 2,533,000 | 15 mgd | 1,671,000 |
| Drying Beds | WDCWA Plant | 30 mgd | Jan 2015 | 2,691,000 | 15 mgd | 1,775,000 |

^{a)} Does not include electrical and instrumentation costs. These costs are more appropriately captured as a percentage of the overall treatment process.

ATTACHMENT 1

Project Cost Breakdown for Ozone Facility at the WDCWA Regional Water Treatment Facility

DRAFT



Project: SRWA Surface Water Supply Project
 Job No.: 693-20-16-01 Date: 3/28/2017
 Calc. By: W. Sandelin Chkd. By: A. Smith
 Subject: Ozonation Cost Derivation

COST ANALYSIS

Develop base cost for ozone from actual costs obtained for similar work at the WDCWA Regional Water Treatment Facility.

Project Cost Breakdown for Ozone Facility at the WDCWA Regional Water Treatment Facility

| Work Element | SOV | Use | Notes |
|--|------------------|------------------|-------|
| Over-Excavate/Backfill to Bottom of Foundation Slab | 30,000 | 30,000 | |
| Over-Excavate/Backfill to Bottom of Foundation Slab Ozone Generation an | 56,269 | 56,269 | |
| Final Backfill Ozone | 28,756 | 28,756 | |
| Form/Rebar/Pour - Foundation Slab for Ozone Contactor | 155,024 | 155,024 | |
| Form/Rebar/Pour - Wall Pour 1 - Ozone Contactor | 194,226 | 194,226 | |
| Form/Rebar/Pour - Wall Pour 2 - Ozone Contactor | 194,227 | 194,227 | |
| Form/Rebar/Pour - Wall Pour 3 - Ozone Contactor | 194,227 | 194,227 | |
| Shoring - Deck for Ozone Disp Contract | 20,000 | 20,000 | |
| Form/Rebar/Pour - Deck for Ozone Contactor | 135,402 | 135,402 | |
| Remove Shoring - Deck for Ozone Contactor | 10,000 | 10,000 | |
| Water Leak Test - Ozone Contactor | 7,189 | 7,189 | |
| Form/Rebar/Pour - Foundation Slab for Ozone Generator | 279,079 | 279,079 | |
| Form/Rebar/Pour - Foundation Slab for LOX System Slab | 28,756 | 28,756 | |
| Form/Rebar/Pour - Equipment Pedestals at Ozone Generator | 9,189 | 9,189 | |
| Form/Rebar/Pour - Foundation Slab for HVAC Unit | 2,000 | 2,000 | |
| Erect Rigid-Frame Steel, Girts and Purlins - Ozone Generation Building | 110,000 | 110,000 | |
| Erect Insulated Metal Panels - Roof/Siding - Ozone Generation Building | 111,292 | 111,292 | |
| Install Interior Framed Walls and Panels - Ozone Generation Building | 78,756 | 78,756 | |
| Install Walk Doors and Overhead Doors - Ozone Generation Building | 20,024 | 20,024 | |
| Install Underslab Piping - Ozone Generation Building | 45,000 | 45,000 | |
| Install Underslab Piping - Ozone Generation Slab | 12,512 | 12,512 | |
| Install Above Ground Piping - Ozone Contactor | 192,698 | 192,698 | |
| Install Ozone Dispersion Systems - Ozone Contactor | 192,697 | 192,697 | |
| Install Ozone Destructor Skids - Ozone Generation | 50,000 | 50,000 | |
| Install Ozone Cooling Water Skids - Ozone Generation | 50,000 | 50,000 | |
| Install Nitrogen Booster Skid - Ozone Generation | 50,000 | 50,000 | |
| Install Ozone Generator Skids | 50,000 | 50,000 | |
| Install LOX Tank | 17,560 | 17,560 | |
| Install Vaporizers | 20,000 | 20,000 | |
| Install A/G Pipe - Ozone Generation and LOX Area | 530,742 | 530,742 | |
| Test/Flush Piping - Ozone Generation and LOX Area | 50,000 | 50,000 | |
| Set HVAC Unit and Bring Duct Work to Inside Building | 100,725 | 100,725 | |
| Install Interior HVAC Ductwork - Ozone Generation Building | 79,000 | 79,000 | |
| Install Underslab Electrical - Ozone Contact Slab | 5,000 | - | [1] |
| Install Underslab Electrical - Ozone Generation Slab | 38,804 | - | [1] |
| Install In-Slab Electrical - Ozone Generation Slab | 18,804 | - | [1] |
| Rough-in Above Ground Electrical - Ozone Generation Slab | 129,069 | - | [1] |
| Install Electrical and I&C Equipment - Ozone Generation Building | 142,825 | - | [1] |
| Pull/Terminate from Electrical Room to XFMR - Ozone Generation Building | 20,078 | - | [1] |
| Install and Fitup Light Fixtures | 53,804 | 53,804 | |
| Rough-in/Fitup - Ozone Equipment Skids and LOX Area | 96,000 | 96,000 | |
| Rough-in/Fitup - Instrumentation - Ozone Facility | 90,021 | - | [1] |
| Pull/Terminate/Test - Electrical and Instrument Circuits - Ozone Facility (Inc | 124,940 | - | [1] |
| Energize Electrical and Test - Ozone Facility | 16,174 | - | [1] |
| Paint A/G Pipe and Equipment - Ozone Facility | 40,000 | 40,000 | |
| Touch Up Walls and Doors - Ozone Generation Building | 25,000 | 25,000 | |
| LOX Equipment | 182,401 | 182,401 | |
| Ozone Supply System Equipment | 2,034,784 | 2,034,784 | |
| HEAT XCHR CARRIER WATER PUMPS | 30,000 | 30,000 | |
| WATER CONTROL GATES | 63,560 | 31,780 | [2] |
| Totals | 6,216,614 | 5,599,119 | |
| Cost per System | 6,216,614 | 5,599,119 | |

NOTES

1. Do not include in component base. Use overall multiplier for electrical costs.
2. Factored by 0.5 to reflect that 4 of 8 control gates for the project are associated with this facility.



Project: SRWA Surface Water Supply Project
 Job No.: 693-20-16-01 Date: 3/28/2017
 Calc. By: W. Sandelin Chkd. By: A. Smith
 Subject: Ozonation Cost Derivation

Adjustments

| | | | |
|--|-------|------------------------|-----------|
| a. Inflation to Current Dollars | | | |
| ENR at Construction Midpoint | 9972 | (Jan 2015) | |
| Most Recent Available ENR | 10530 | (Dec 2016) | |
| ENR Ratio = | 1.056 | | 5,912,000 |
| b. Inflation to Future Dollars | | | |
| Months to SRWA Construction Midpoint | 42 | (Jun 2020) | |
| Years to SRWA Construction Midpoint | 3.5 | | |
| Most Recent Year/Year Inflation | 3.1% | (Dec 2015 to Dec 2016) | |
| Inflation to SRWA Construction Mid-point | 1.11 | | 6,577,000 |

c. Capacity Adjustment

Costs for different sized systems can be estimated by multiplying the base cost by the ratio of their respective treatment capacities raised to a power factor. Power factor derived from AWWA and ASCE, Water Treatment Plant Design 26.6

Power factor = 0.60
 Installed capacity = 30 (mgd)

| Capacity Increments | Unit Component Cost, \$ |
|---------------------|-------------------------|
| 5 | 2,245,000 |
| 10 | 3,402,000 |
| 15 | 4,339,000 |
| 20 | 5,157,000 |
| 25 | 5,895,000 |
| 30 | 6,577,000 |
| 34 | 7,090,000 |
| 40 | 7,816,000 |
| 45 | 8,388,000 |



Project: SRWA Surface Water Supply Project
 Job No.: 693-20-16-01 Date: 3/28/2017
 Calc. By: W. Sandelin Chkd. By: A. Smith
 Subject: Ozonation Cost Derivation

COST ANALYSIS

Develop base cost for ozone from actual costs obtained for similar work at the MID Regional Water Treatment Plant.

Project Cost Breakdown for Ozone Facility at the MID Regional Water Treatment Plant

| Work Element | SOV | Use | Notes |
|--|---------|---------|-------|
| Ozone Contactor | | | |
| <u>Structural</u> | | | |
| Earthwork - Shoring at Ozone Structure | 427,037 | 427,037 | |
| Earthwork - Excavation | 720,674 | 720,674 | |
| Earthwork - Aggregate Base | 16,144 | 16,144 | |
| Earthwork - Backfill | 288,872 | 288,872 | |
| Concrete - Ozone Slabs | 426,403 | 426,403 | |
| Concrete - Injection & Destruct Slabs | 16,943 | 16,943 | |
| Concrete - Walls | 560,163 | 560,163 | |
| Concrete - Decks | 343,964 | 343,964 | |
| Concrete - Baffles | 3,056 | 3,056 | |
| Metals - Stairs, Handrail, & Grating | 41,882 | 41,882 | |
| Damproofing - Walls Below Grade | 7,617 | 7,617 | |
| Test - Leak Test Structure | 8,910 | 8,910 | |
| <u>Mechanical</u> | | | |
| Protective Coatings | 78,947 | 78,947 | |
| Equipment - Ozone Destruct Units ODU-04-01, 02 | 6,873 | 6,873 | |
| Equipment - Ozone Inject Skid SSP-04-01, 02, 03 | 36,364 | 36,364 | |
| Equipment - Sump Pumps 201, 202 & Piping | 23,664 | 23,664 | |
| Piping - 60" TW (Interior) | 31,288 | 31,288 | |
| Piping - 8" Water Piping to Injection Skid | 10,123 | 10,123 | |
| Piping - 6" Ozone Off-Gas (Buried) | 3,942 | 3,942 | |
| Piping - 6" Ozone Off-Gas (Exposed) | 14,078 | 14,078 | |
| Piping - 6" OZW Piping (Buried) | 8,460 | 8,460 | |
| Piping - 6" & 3" Injection Piping (Exposed) | 4,303 | 4,303 | |
| Piping - 6" Perforated Drain | 17,448 | 17,448 | |
| Piping - Sample Piping Within Contactor | 19,736 | 19,736 | |
| Piping - Sample Piping & Sample Pumps at Ozone Gallery | 81,771 | 81,771 | |
| Piping - CATS & NOCL Chemical Systems | 8,342 | 8,342 | |
| Test - Piping | 9,819 | 9,819 | |
| Test - Ozone Equipment | 4,627 | 4,627 | |
| <u>Plumbing</u> | | | |
| Plumbing - Floor Drain System | 50,353 | 50,353 | |
| Plumbing - NPW/CW System | 52,087 | 52,087 | |
| <u>HVAC</u> | | | |
| HVAC - Equipment, Ductwork, Controls | 59,902 | 59,902 | |
| <u>Electrical</u> | | | |
| Electrical - Rough Branch Power | 109,800 | - | [1] |
| Electrical - Rough Devices | 68,600 | - | [1] |
| Electrical - Rough Fixtures | 34,300 | - | [1] |
| Electrical - Rough Equipment | 61,800 | - | [1] |
| Electrical - Wire Branch Power | 82,500 | - | [1] |
| Electrical - Wire Lighting | 13,700 | - | [1] |
| Electrical - Wire Equipment | 68,699 | - | [1] |
| Electrical - Wire Instrumentation | 151,000 | - | [1] |
| Electrical - Install Gear & Terminate | 27,500 | - | [1] |
| Electrical - Data & Security | 47,429 | - | [1] |
| Electrical - Light Fixtures | 28,500 | - | [1] |
| Electrical - Grounding | 31,251 | - | [1] |



Project: SRWA Surface Water Supply Project
 Job No.: 693-20-16-01 Date: 3/28/2017
 Calc. By: W. Sandelin Chkd. By: A. Smith
 Subject: Ozonation Cost Derivation

LOX Equipment

Structural

| | | |
|---------------------------------------|---------|---------|
| Earthwork - Excavation | 3,423 | 3,423 |
| Earthwork - Aggregate Base Below Pads | 2,030 | 2,030 |
| Earthwork - 3/4" Washed Rock | 11,127 | 11,127 |
| Earthwork - Backfill | 2,476 | 2,476 |
| Concrete - Perimeter Curb | 12,234 | 12,234 |
| Concrete - Equipment & Misc. Pads | 103,588 | 103,588 |
| Metals - Guard Post | 1,539 | 1,539 |

Mechanical

| | | |
|---|--------|--------|
| Paint Piping | 19,171 | 19,171 |
| Specialties - Signage | 3,290 | 3,290 |
| Equipment - LOX Tank LST-Z-01 | 10,519 | 10,519 |
| Equipment - Vaporizers VAP-Z-01, 02, 03 | 12,097 | 12,097 |
| Piping - LOX System Piping | 54,616 | 54,616 |
| Insulation - Lox Piping | 24,353 | 24,353 |
| Test - Piping | 4,685 | 4,685 |
| Test - Ozone Equipment | 7,545 | 7,545 |

Electrical

| | | |
|-----------------------------------|--------|--------|
| Electrical - Rough Branch Power | 56,000 | 56,000 |
| Electrical - Rough Devices | 40,000 | 40,000 |
| Electrical - Rough Fixtures | 25,765 | 25,765 |
| Electrical - Light Fixtures | 22,000 | 22,000 |
| Electrical - Wire Branch Power | 25,500 | 25,500 |
| Electrical - Wire Lighting | 12,000 | 12,000 |
| Electrical - Wire Equipment | 28,000 | 28,000 |
| Electrical - Wire Instrumentation | 40,840 | 40,840 |
| Electrical - Grounding | 22,728 | 22,728 |

Ozone Generation

Structural

| | | |
|----------------------------------|--------|--------|
| Concrete - Fill | 14,525 | 14,525 |
| Masonry | 24,967 | 24,967 |
| Doors - Steel Doors and Hardware | 2,087 | 2,087 |
| Finishes - Acoustical Treatment | 28,249 | 28,249 |
| Concrete - Equipment Pads | 18,227 | 18,227 |

Mechanical

| | | |
|--|-----------|-----------|
| Protective Coatings | 61,717 | 61,717 |
| Equipment - Ozone Generators | 354,521 | 354,521 |
| Equipment - Blowers | 26,128 | 26,128 |
| Equipment - Supplemental Air Equipment | 3,952 | 3,952 |
| Piping - 6" COWL | 28,186 | 28,186 |
| Piping - 4" COWL | 22,582 | 22,582 |
| Piping - 3" GOX | 86,224 | 86,224 |
| Piping - 2" GOX | 18,811 | 18,811 |
| Piping - 3" OZN | 86,225 | 86,225 |
| Piping - 2" OZN | 16,436 | 16,436 |
| Piping - 3" Air In Blower Room | 53,863 | 53,863 |
| Piping - 1" SA | 17,934 | 17,934 |
| Piping - 3/4" Sample | 5,968 | 5,968 |
| Piping - Oxygen Cleaning | 228,928 | 228,928 |
| Test - Piping | 32,143 | 32,143 |
| Test - Equipment | 16,320 | 16,320 |
| Test - Ozone Equipment | 170,000 | 170,000 |
| Deliver Ozone Equipment | 3,530,000 | 3,530,000 |

HVAC

| | | |
|--|--------|--------|
| HVAC - Equipment, Ductwork, Controls | 17,349 | 17,349 |
| HVAC - Gas Unit Heater @ File Storage Room | 8,195 | 8,195 |

Electrical

| | | | |
|---------------------------------|--------|---|-----|
| Electrical - Rough Branch Power | 74,000 | - | [1] |
| Electrical - Rough Devices | 33,000 | - | [1] |
| Electrical - Rough Fixtures | 15,000 | - | [1] |
| Electrical - Rough Equipment | 22,000 | - | [1] |
| Electrical - Install Fixtures | 11,000 | - | [1] |
| Electrical - Wire Branch Power | 63,000 | - | [1] |



Project: SRWA Surface Water Supply Project
 Job No.: 693-20-16-01 Date: 3/28/2017
 Calc. By: W. Sandelin Chkd. By: A. Smith
 Subject: Ozonation Cost Derivation

| | | | |
|---------------------------------------|------------------|------------------|-----|
| Electrical - Wire Lighting | 4,116 | - | [1] |
| Electrical - Wire Equipment | 26,000 | - | [1] |
| Electrical - Wire Instrumentation | 74,000 | - | [1] |
| Electrical - Install Gear & Terminate | 48,000 | - | [1] |
| Electrical - Ground | 21,104 | - | [1] |
| Electrical - Demolition | 53,752 | - | [1] |
| Totals | 9,972,906 | 8,802,855 | |
| Cost per System | 9,972,906 | 8,802,855 | |

NOTES

- Do not include in component base. Use overall multiplier for electrical costs.
- Not used.

Adjustments

| | | | |
|--|--------------|------------------------|------------|
| a. Inflation to Current Dollars | | | |
| ENR at Construction Midpoint | 8185 | (Jun 2008) | |
| Most Recent Available ENR | 10530 | (Dec 2016) | |
| ENR Ratio = | 1.286 | | 11,325,000 |
| b. Inflation to Future Dollars | | | |
| Months to SRWA Construction Midpoint | 42 | (Jun 2020) | |
| Years to SRWA Construction Midpoint | 3.5 | | |
| Most Recent Year/Year Inflation | 3.1% | (Dec 2015 to Dec 2016) | |
| Inflation to SRWA Construction Mid-point | 1.11 | | 12,599,000 |

c. Capacity Adjustment

Costs for different sized systems can be estimated by multiplying the base cost by the ratio of their respective treatment capacities raised to a power factor. Power factor derived from AWWA and ASCE, Water Treatment Plant Design 26.6

Power factor = 0.60
 Installed capacity = 30 (mgd)

| Capacity Increments | Unit Component Cost, \$ |
|---------------------|-------------------------|
| 5 | 4,300,000 |
| 10 | 6,517,000 |
| 15 | 8,312,000 |
| 20 | 9,878,000 |
| 25 | 11,293,000 |
| 30 | 12,599,000 |
| 34 | 13,582,000 |
| 40 | 14,973,000 |
| 45 | 16,069,000 |



Project: SRWA Surface Water Supply Project
 Job No.: 693-20-16-01 Date: 3/28/2017
 Calc. By: W. Sandelin Chkd. By: A. Smith
 Subject: Flash Mix Cost Derivation

COST ANALYSIS

Develop base cost for flash mix from actual costs obtained for similar work at the WDCWA Regional Water Treatment Facility.

Project Cost Breakdown for Flash Mix Facility at the WDCWA Regional Water Treatment Facility

| Work Element | SOV | Use | Notes |
|---|----------------|----------------|-------|
| Excavate and Prep for Flash Mix Facility Slab | 21,567 | 21,567 | |
| Final Backfill around Perimeter of Facility | 7,189 | 7,189 | |
| Form / Rebar / Pour - Flash Mix Facility Slab | 43,134 | 43,134 | |
| Form / Rebar / Pour - Equipment Pedestals | 7,189 | 7,189 | |
| Install Underslab Pipe - Flash Mix Facility | 21,567 | 21,567 | |
| Install Above Ground Piping - Rough-in - Flash Mix Facility | 275,000 | 275,000 | |
| Install Jet Mix Pumps | 20,756 | 20,756 | |
| Piping Hook-up - Jet Mix Pumps | 58,231 | 58,231 | |
| Install Sample Piping and Hookup | 8,000 | 8,000 | |
| Test/Flush Piping | 29,115 | 29,115 | |
| Install Underslab Electrical | 3,000 | - | [1] |
| Rough-in Aboveground Electrical and I&C | 5,000 | - | [1] |
| Install Stands & Fitup Electrical Equipment and I&C | 3,000 | - | [1] |
| Pull / Terminate / Test Electrical and I&C | 2,500 | - | [1] |
| Pating / Coatings - Pipe and Equipment | 20,000 | 20,000 | |
| Totals | 525,000 | 512,000 | |
| Cost per System | 525,000 | 512,000 | |

NOTES

- Do not include in component base. Use overall multiplier for electrical costs.
- Not used.

Adjustments

| | | | |
|--|-------|------------------------|---------|
| a. Inflation to Current Dollars | | | |
| ENR at Construction Midpoint | 9972 | (Jan 2015) | |
| Most Recent Available ENR | 10530 | (Dec 2016) | |
| ENR Ratio = | 1.056 | | 541,000 |
| b. Inflation to Future Dollars | | | |
| Months to SRWA Construction Midpoint | 42 | (Jun 2020) | |
| Years to SRWA Construction Midpoint | 3.5 | | |
| Most Recent Year/Year Inflation | 3.1% | (Dec 2015 to Dec 2016) | |
| Inflation to SRWA Construction Mid-point | 1.11 | | 602,000 |

c. Capacity Adjustment

Costs for different sized systems can be estimated by multiplying the base cost by the ratio of their respective treatment capacities raised to a power factor. Power factor derived from AWWA and ASCE, Water Treatment Plant Design 26.6

Power factor = 0.60
 Installed capacity = 30 (mgd)

| Capacity Increments | Unit Component Cost, \$ |
|---------------------|-------------------------|
| 5 | 205,000 |
| 10 | 311,000 |
| 15 | 397,000 |
| 20 | 472,000 |
| 25 | 540,000 |
| 30 | 602,000 |
| 35 | 660,000 |
| 40 | 715,000 |
| 45 | 768,000 |



Project: SRWA Surface Water Supply Project
 Job No.: 693-20-16-01 Date: 3/28/2017
 Calc. By: W. Sandelin Chkd. By: A. Smith
 Subject: Flocculation/Sedimentation Facilities Cost Derivation

COST ANALYSIS

Develop base cost for Actiflo ballasted flocculation and sedimentation facilities from actual costs obtained for similar work at the WDCWA Regional Water Treatment Facility.

Project Cost Breakdown for Actiflo Facility at the WDCWA Regional Water Treatment Facility

| Work Element | SOV | Use | Notes |
|--|-----------|-----------|-------|
| SAND BALLASTED CLARIFICATION EQUIPMENT | 2,800,508 | 2,800,508 | |
| 17 - Over-Excavate/Fill for U/S Pipe and Foundation Slab - SBC - South E | 45,400 | 45,400 | |
| 17 - Backfill / Prep to bottom of Foundation Slab - SBC Middle North End | 26,490 | 26,490 | |
| 17 - Final Backfill around facility | 14,378 | 14,378 | |
| 17 - Form/Rebar/Pour - Foundation Slab - SBC South End | 170,347 | 170,347 | |
| 17 - Form/Rebar/Pour - Foundation Slab - SBC Middle North End | 130,000 | 130,000 | |
| 17 - Form/Rebar/Pour - Foundation Slab - SBC Very North End | 72,918 | 72,918 | |
| 17 - Form/Rebar/Pour - Wall Pour #1 - SBC | 151,867 | 151,867 | |
| 17 - Form/Rebar/Pour - Wall Pour #2 - SBC | 99,499 | 99,499 | |
| 17 - Form/Rebar/Pour - Wall Pour #3 - SBC | 68,078 | 68,078 | |
| 17 - Form/Rebar/Pour - Wall Pour #4 - SBC | 94,262 | 94,262 | |
| 17 - Form/Rebar/Pour - Wall Pour #5 - SBC | 109,974 | 109,974 | |
| 17 - Form Rebar Pour Equipment Pedestals for Sand Recirculation Pumps | 4,189 | 4,189 | |
| 17 - Shoring for Basin Decking - SBC Basins | 75,000 | 75,000 | |
| 17 - Shoring for Effl Channel - SBC Channel | 25,000 | 25,000 | |
| 17 - Form/Rebar/Pour Basin Decking and Effl Channel - SBC Basins | 201,604 | 201,604 | |
| 17 - Remove Shoring for Basin Decking - SBC Basins | 22,500 | 22,500 | |
| 17 - Remove Shoring for Basin Decking - SBC Basins | 3,000 | 3,000 | |
| 17 - Form/Rebar/Pour - Walls for Effl Channel | 108,917 | 108,917 | |
| 17 - Remove Shoring for Effluent Channel | 20,000 | 20,000 | |
| 17 - Water Leak Test - Basins | 2,156 | 2,156 | |
| 17 - Form/Rebar/Pour - In-fill for Settling Tank Floors | 116,591 | 116,591 | |
| 17 - Install Handrail on Perimeter of Decking - SBC | 273,182 | 273,182 | |
| 17 - Install Stairway and Grating- SBC | 71,891 | 71,891 | |
| 17 - Install Underslab Pipe - SBC South End | 4,378 | 4,378 | |
| 17 - Install Underslab Pipe - SBC North End | 250,000 | 250,000 | |
| 17 - Install In-slab pipe - SRC - Settling Tank In-Fill | 10,000 | 10,000 | |
| 17 - Install SBC Sand Recirculation Pumps at Pump Gallery | 19,657 | 19,657 | |
| 17 - Install Sand/Solids Scrappers at Settling Tanks | 66,860 | 66,860 | |
| 17 - Install Draft Tubes & Baffles - Maturation Tanks w/Support Steel | 35,379 | 35,379 | |
| 17 - Install Vertical Mixers for Maturation & Coagulation Tanks | 23,589 | 23,589 | |
| 17 - Install Hydro-Cyclones - on Deck of SBC Basins | 23,589 | 23,589 | |
| 17 - Install Settling Tubes - in Settling Tanks | 35,379 | 35,379 | |
| 17 - Install Collection Troughs - in Settling Tanks | 35,379 | 35,379 | |
| 17 - Install Sample Piping | 11,789 | 11,789 | |
| 17 - Install A/G Piping - 6"-USL Sys and SB PO, SAM, W2 Sys's | 378,037 | 378,037 | |
| 17 - Test/Flush Piping Systems - SBC | 75,485 | 75,485 | |
| 17-Install Underslab Electrical - SBC North End | 36,522 | - | [1] |
| 17 - Install In-Slab Electrical on Deck - SBC Basin | 52,173 | - | [1] |
| 17 - Install / Fit-up Equipment Electrical Stands - SBC | 138,319 | - | [1] |
| 17 - Install / Fit-up Instrument Stands - SBC | 138,319 | - | [1] |
| 17 - Pull/Term/Test - Equipment & Instrument Circuits (Including Interconn | 80,217 | - | [1] |
| 17 - Paint A/G Pipe and Equipment - SBC | 51,323 | 51,323 | |
| | | - | |
| Totals | 6,174,000 | 5,729,000 | |
| Cost per System | 6,174,000 | 5,729,000 | |

NOTES

- Do not include in component base. Use overall multiplier for electrical costs.
- Not used.



Project: SRWA Surface Water Supply Project
 Job No.: 693-20-16-01 Date: 3/28/2017
 Calc. By: W. Sandelin Chkd. By: A. Smith
 Subject: Flocculation/Sedimentation Facilities Cost Derivation

Adjustments

| | | | |
|--|-------|------------------------|-----------|
| a. Inflation to Current Dollars | | | |
| ENR at Construction Midpoint | 9972 | (Jan 2015) | |
| Most Recent Available ENR | 10530 | (Dec 2016) | |
| ENR Ratio = | 1.056 | | 6,050,000 |
| b. Inflation to Future Dollars | | | |
| Months to SRWA Construction Midpoint | 42 | (Jun 2020) | |
| Years to SRWA Construction Midpoint | 3.5 | | |
| Most Recent Year/Year Inflation | 3.1% | (Dec 2015 to Dec 2016) | |
| Inflation to SRWA Construction Mid-point | 1.11 | | 6,731,000 |

c. Capacity Adjustment

Costs for different sized systems can be estimated by multiplying the base cost by the ratio of their respective treatment capacities raised to a power factor. Power factor derived from AWWA and ASCE, Water Treatment Plant Design 26.6

Power factor = 0.60
 Installed capacity = 30 (MGD)

| Capacity Increments | Unit Component Cost, \$ |
|---------------------|-------------------------|
| 5 | 2,297,000 |
| 10 | 3,482,000 |
| 15 | 4,441,000 |
| 20 | 5,277,000 |
| 25 | 6,034,000 |
| 30 | 6,731,000 |
| 35 | 7,383,000 |
| 40 | 7,999,000 |
| 45 | 8,585,000 |



Project: SRWA Surface Water Supply Project
 Job No.: 693-20-16-01 Date: 3/28/2017
 Calc. By: W. Sandelin Chkd. By: A. Smith
 Subject: Flocculation/Sedimentation Facilities Cost Derivation

COST ANALYSIS

Develop base cost for flocculation/sedimentation from actual costs obtained for similar work at the SCWA Vineyard WTP.

Project Cost Breakdown for Flocculation/Sedimentation Facility at the SCWA Vineyard WTP

| Work Element | SOV | Use | Notes |
|--|------------|------------|-------|
| <u>Structural</u> | | | |
| Excavation | 100,000 | 100,000 | |
| Subgrade Preparation | 202,000 | 202,000 | |
| Form Slabs On Grade | 868,000 | 868,000 | |
| Rebar Slabs On Grade | 1,550,000 | 1,550,000 | |
| Place Slabs On Grade | 550,000 | 550,000 | |
| Form Walls/Columns | 2,800,000 | 2,800,000 | |
| Rebar Walls/Columns | 800,000 | 800,000 | |
| Place Walls/Columns | 1,090,000 | 1,090,000 | |
| Form Suspended Slabs | 1,200,000 | 1,200,000 | |
| Rebar Suspended Slabs | 250,000 | 250,000 | |
| Place Suspended Slabs | 199,500 | 199,500 | |
| Stairs | 96,000 | 96,000 | |
| Hydrostatic Structure Testing | 30,000 | 30,000 | |
| Backfill | 150,000 | 150,000 | |
| Metals | 319,500 | 319,500 | |
| Carpentry | 263,000 | 263,000 | |
| Moisture Protection | 112,000 | 112,000 | |
| Insulation | 10,000 | 10,000 | |
| Doors | 10,000 | 10,000 | |
| Louvers | 2,000 | 2,000 | |
| Specialties | 1,000 | 1,000 | |
| <u>Mechanical - Furnish</u> | | | |
| Vertical Shaft Flocculators | 500,000 | 500,000 | |
| Chain and Flight Collectors | 900,000 | 900,000 | |
| FURNISH SMALL ABOVE GROUND PIPING | 15,000 | 15,000 | |
| FURNISH LARGE ABOVE GROUND PIPE, DIV 02 | 4,500 | 4,500 | |
| MECH PIPING 2 TO 10 IN | 12,800 | 12,800 | |
| <u>Mechanical - Install</u> | | | |
| VERTICAL SHAFT FLOCCULATORS | 145,000 | 145,000 | |
| CHAIN AND FLIGHT COLLECTORS | 160,000 | 160,000 | |
| SET PIPE SPOOLS AND SLEEVES | 8,000 | 8,000 | |
| PIPE SUPPORTS | 15,000 | 15,000 | |
| LAY SMALL ABOVE GROUND PIPING | 10,000 | 10,000 | |
| LAY LARGE ABOVE GROUND PIPE, DIV 02 | 3,375 | 3,375 | |
| MECH PIPING 2 TO 10 IN | 6,400 | 6,400 | |
| Plumbing | 90,000 | 90,000 | |
| <u>HVAC</u> | | | |
| Layout Drawings | 3,830 | 3,830 | |
| Deliver HVAC Equipment (EF, EH, AC) | 20,000 | 20,000 | |
| Deliver Duct | 16,080 | 16,080 | |
| Install Rooftop Unit, Unit Heater, Louver | 13,040 | 13,040 | |
| Rough-In SS Duct | 10,060 | 10,060 | |
| Rough-In Duct | 2,650 | 2,650 | |
| Test Duct | 620 | 620 | |
| Install Air Outlet | 1,230 | 1,230 | |
| Install Controls | 2,195 | 2,195 | |
| Start Up HVAC | 1,000 | 1,000 | |
| Test and Balance HVAC | 1,000 | 1,000 | |
| <u>O&M Manuals</u> | | | |
| Vertical-Shaft Flocculator Units (11210-1.2-C) | 50,000 | 50,000 | |
| Chain and Flight Sludge Collectors (11234) | 50,000 | 50,000 | |
| Totals | 12,645,000 | 12,645,000 | |
| No. Units (Trains) | 1 | | |
| Cost per Unit (Train) | 12,645,000 | 12,645,000 | |

NOTES

- Not used
- Costs for electrical, instrumentation and chemical feed systems not included in component base costs. Use overall multiplier for electrical costs, and treat chemical feed as separate system.



Project: SRWA Surface Water Supply Project
 Job No.: 693-20-16-01 Date: 3/28/2017
 Calc. By: W. Sandelin Chkd. By: A. Smith
 Subject: Flocculation/Sedimentation Facilities Cost Derivation

Adjustments

| | | | |
|--|-------|------------------------|------------|
| a. Inflation to Current Dollars | | | |
| ENR at Construction Midpoint | 8564 | (Aug 2009) | |
| Most Recent Available ENR | 10530 | (Dec 2016) | |
| ENR Ratio = | 1.230 | | 15,548,000 |
| b. Inflation to Future Dollars | | | |
| Months to SRWA Construction Midpoint | 42 | (Jun 2020) | |
| Years to SRWA Construction Midpoint | 3.5 | | |
| Most Recent Year/Year Inflation | 3.1% | (Dec 2015 to Dec 2016) | |
| Inflation to SRWA Construction Mid-point | 1.11 | | 17,297,000 |

c. Capacity Adjustment

Costs for different sized systems can be estimated by multiplying the base cost by the ratio of their respective treatment capacities raised to a power factor. Power factor derived from AWWA and ASCE, Water Treatment Plant Design 26.6

Power factor = 0.60
 Installed capacity = 50 (mgd)

| Capacity Increments (Per Train) | Unit Component Cost, \$ |
|------------------------------------|-------------------------|
| 1 | 1,654,000 |
| 2 | 2,507,000 |
| 3 | 3,198,000 |
| 4 | 3,800,000 |
| 5 | 4,345,000 |
| 7.5 | 5,541,000 |
| 10 | 6,586,000 |
| 15 | 8,399,000 |
| 20 | 9,982,000 |
| 25 | 11,412,000 |
| 30 | 12,731,000 |



Project: SRWA Surface Water Supply Project
 Job No.: 693-20-16-01 Date: 3/28/2017
 Calc. By: W. Sandelin Chkd. By: A. Smith
 Subject: Flocculation/Sedimentation Facilities Cost Derivation

COST ANALYSIS

Develop base cost for flocculation/sedimentation from actual costs obtained for similar work at the SCWA Vineyard WTP.

Project Cost Breakdown for Flocculation/Sedimentation Facility at the SCWA Vineyard WTP

| Work Element | SOV | Use | Notes |
|--|------------|-----------|-------|
| <u>Structural</u> | | | |
| Excavation | 100,000 | 41,000 | [3] |
| Subgrade Preparation | 202,000 | 82,820 | [3] |
| Form Slabs On Grade | 868,000 | 355,880 | [3] |
| Rebar Slabs On Grade | 1,550,000 | 635,500 | [3] |
| Place Slabs On Grade | 550,000 | 225,500 | [3] |
| Form Walls/Columns | 2,800,000 | 1,148,000 | [3] |
| Rebar Walls/Columns | 800,000 | 328,000 | [3] |
| Place Walls/Columns | 1,090,000 | 446,900 | [3] |
| Form Suspended Slabs | 1,200,000 | 492,000 | [3] |
| Rebar Suspended Slabs | 250,000 | 102,500 | [3] |
| Place Suspended Slabs | 199,500 | 81,795 | [3] |
| Stairs | 96,000 | 39,360 | [3] |
| Hydrostatic Structure Testing | 30,000 | 12,300 | [3] |
| Backfill | 150,000 | 61,500 | [3] |
| Metals | 319,500 | 130,995 | [3] |
| Carpentry | 263,000 | 107,830 | [3] |
| Moisture Protection | 112,000 | 45,920 | [3] |
| Insulation | 10,000 | 4,100 | [3] |
| Doors | 10,000 | 10,000 | |
| Louvers | 2,000 | 2,000 | |
| Specialties | 1,000 | 410 | [3] |
| <u>Mechanical - Furnish</u> | | | |
| Vertical Shaft Flocculators | 500,000 | 500,000 | |
| Chain and Flight Collectors | 900,000 | - | [1] |
| FURNISH SMALL ABOVE GROUND PIPING | 15,000 | 15,000 | |
| FURNISH LARGE ABOVE GROUND PIPE, DIV 02 | 145,000 | 145,000 | |
| MECH PIPING 2 TO 10 IN | 12,800 | 5,248 | [3] |
| <u>Mechanical - Install</u> | | | |
| VERTICAL SHAFT FLOCCULATORS | 145,000 | 145,000 | |
| CHAIN AND FLIGHT COLLECTORS | 160,000 | - | [1] |
| SET PIPE SPOOLS AND SLEEVES | 3,830 | 3,830 | |
| PIPE SUPPORTS | 15,000 | 6,150 | [3] |
| LAY SMALL ABOVE GROUND PIPING | 10,000 | 4,100 | [3] |
| LAY LARGE ABOVE GROUND PIPE, DIV 02 | 3,830 | 3,830 | |
| MECH PIPING 2 TO 10 IN | 6,400 | 2,624 | [3] |
| <u>Plumbing</u> | 90,000 | 36,900 | [3] |
| <u>HVAC</u> | | | |
| Layout Drawings | 3,830 | 3,830 | |
| Deliver HVAC Equipment (EF, EH, AC) | 20,000 | 20,000 | |
| Deliver Duct | 16,080 | 16,080 | |
| Install Rooftop Unit, Unit Heater, Louver | 13,040 | 13,040 | |
| Rough-In SS Duct | 10,060 | 10,060 | |
| Rough-In Duct | 2,650 | 2,650 | |
| Test Duct | 620 | 620 | |
| Install Air Outlet | 1,230 | 1,230 | |
| Install Controls | 2,195 | 2,195 | |
| Start Up HVAC | 1,000 | 1,000 | |
| Test and Balance HVAC | 1,000 | 1,000 | |
| <u>O&M Manuals</u> | | | |
| Vertical-Shaft Flocculator Units (11210-1.2-C) | 50,000 | 50,000 | |
| Chain and Flight Sludge Collectors (11234) | 50,000 | - | [1] |
| Totals | 12,782,000 | 5,344,000 | |
| No. Units (Trains) | 1 | | |
| Cost per Unit (Train) | 12,782,000 | 5,344,000 | |

NOTES

- Removed to reflect coagulation and flocculation only.
- Costs for electrical, instrumentation and chemical feed systems not included in component base costs. Use overall multiplier for electrical costs, and treat chemical feed as separate system.
- Factored by 0.41 to reflect relative quantities of concrete for [coagulation/flocculation/settled water collection] and total facility



Project: SRWA Surface Water Supply Project
 Job No.: 693-20-16-01 Date: 3/28/2017
 Calc. By: W. Sandelin Chkd. By: A. Smith
 Subject: Flocculation/Sedimentation Facilities Cost Derivation

Adjustments

a. Inflation to Current Dollars
 ENR at Construction Midpoint 8564 (Aug 2009)
 Most Recent Available ENR 10530 (Dec 2016)
 ENR Ratio = 1.230 6,571,000

b. Inflation to Future Dollars
 Months to SRWA Construction Midpoint 42 (Jun 2020)
 Years to SRWA Construction Midpoint 3.5
 Most Recent Year/Year Inflation 3.1% (Dec 2015 to Dec 2016)
 Inflation to SRWA Construction Mid-point 1.11 7,310,000

c. Capacity Adjustment
 Costs for different sized systems can be estimated by multiplying the base cost by the ratio of their respective treatment capacities raised to a power factor. Power factor derived from AWWA and ASCE, Water Treatment Plant Design 26.6

Power factor = 0.60
 Installed capacity = 50 (mgd)

| Capacity Increments (Per Train) | Unit Component Cost, \$ |
|------------------------------------|-------------------------|
| 1 | 699,000 |
| 2 | 1,060,000 |
| 3 | 1,351,000 |
| 4 | 1,606,000 |
| 5 | 1,836,000 |
| 7.5 | 2,342,000 |
| 10 | 2,783,000 |
| 15 | 3,550,000 |
| 20 | 4,218,000 |
| 25 | 4,823,000 |
| 30 | 5,380,000 |



Project: SRWA Surface Water Supply Project
 Job No.: 693-20-16-01 Date: 3/28/2017
 Calc. By: W. Sandelin Chkd. By: A. Smith
 Subject: Granular Media Filters Cost Derivation

COST ANALYSIS

Develop base cost for granular media filtration from actual costs obtained for similar work at the WDCWA Regional Water Treatment Facility.

Project Cost Breakdown for Granular Media Filtration Facility at the WDCWA Regional Water Treatment Facility

| Work Element | SOV | Use | Notes |
|--|------------|------------|-------|
| Excavate for Underslab Piping | 70,093 | 70,093 | |
| Excavate and Prep for Floor Slabs | 70,093 | 70,093 | |
| Final Backfill | 46,728 | 46,728 | |
| Form/Rebar/Pour - Slab Pour 1 (Includes Form/Rebar on Slab Pour 2) | 192,092 | 192,092 | |
| Complete Form/Rebar/Pour - Slab Pour 2 | 192,092 | 192,092 | |
| Form/Rebar/Pour - Short Wall Pour 1 (Includes Form/Rebar on Short Wall | 48,023 | 48,023 | |
| Complete Form/Rebar/Pour - Short Wall 2 | 48,023 | 48,023 | |
| Form/Rebar/Pour - Slab Pour 3 (Includes Form/Rebar on Slab Pour 4A) | 348,167 | 348,167 | |
| Complete Form/Rebar/Pour - Slab Pour 4A | 186,090 | 186,090 | |
| Form/Rebar/Pour - Slab Pour 4B | 186,090 | 186,090 | |
| Form/Rebar/Pour - Wall Pour 1A | 139,367 | 139,367 | |
| Form/Rebar/Pour - Wall Pour 2 | 114,028 | 114,028 | |
| Form/Rebar/Pour - Wall Pour 3 | 63,349 | 63,349 | |
| Form/Rebar/Pour - Wall Pour 4 | 126,698 | 126,698 | |
| Form/Rebar/Pour - Wall Pour 5 | 152,037 | 152,037 | |
| Form/Rebar/Pour - Wall Pour 6 | 126,698 | 126,698 | |
| Form/Rebar/Pour - Wall Pour 7 | 152,037 | 152,037 | |
| Form/Rebar/Pour - Wall Pour 8 | 152,037 | 152,037 | |
| Form/Rebar/Pour - Wall Pour 9 | 63,349 | 63,349 | |
| Form/Rebar/Pour - Wall Pour 10 | 88,688 | 88,688 | |
| Form/Rebar/Pour - Wall Pour 11 | 88,688 | 88,688 | |
| Shore/Rebar/Pour - Elev Floor Dividing Influent and Effluent Channels | 136,457 | 136,457 | |
| Shore/Rebar/Pour - Perimeter Deck | 326,292 | 326,292 | |
| Remove Shoring Perimeter Deck | 10,000 | 10,000 | |
| Water Leak Test | 21,567 | 21,567 | |
| Install Misc Steel - Filter Facility | 893,625 | 893,625 | |
| Install Rigid Frame and Purlins - at Blower Canopy | 50,890 | 50,890 | |
| Install Metal Roof, Flashing, Gutters, Downspouts - at Blower Canopy | 21,000 | 21,000 | |
| Install U/S Pipe - under Filter Facility Pipe Gallery | 1,288,550 | 1,288,550 | |
| Install Air Scour Blowers - Filter Blower Area | 50,000 | 50,000 | |
| Install Under Drain Equipment- Filter Basins | 441,935 | 441,935 | |
| Install Backwash Waste Troughs - Filter Basins | 80,000 | 80,000 | |
| Receive and Install Large Bore A/G Pipe Headers - Filter Pipe Gallery | 2,249,915 | 2,249,915 | |
| Sample Pump and Sumps - Install and Hookup - Filter Influent | 4,800 | 4,800 | |
| Receive and Install Large Bore A/G Pipe Branch Piping - Filter Facility Ove | 1,453,714 | 1,453,714 | |
| Test/Flush Piping Systems - Filter Facility Piping Systems | 100,000 | 100,000 | |
| Install Under-Slab Electrical - Filter Facility | 63,630 | 63,630 | |
| Rough-in Electrical - In-Slab - Filter Facility | 190,498 | 190,498 | |
| Rough-in Electrical - In Wall - Filter Facility | 54,000 | 54,000 | |
| Install/Fit-up Equipment Electrical Stands - Filter Facility | 199,218 | 199,218 | |
| Install/Fit-up Instrument Stands - Filter Facility | 129,043 | 129,043 | |
| Pull/Terminate/Test - Electrical and Instrument Circuits - Filter Facility (incl | 99,130 | 99,130 | |
| Paint A/G Pipe and Equipment - Filter Facility | 105,000 | 105,000 | |
| Granular Activated Carbon Media | 903,407 | 903,407 | |
| Granular Activated Carbon Underdrain System and Media | 882,896 | 882,896 | |
| SUBMITTAL Backwash Troughs | 9,810 | 9,810 | |
| REC ON SITE BACKWASH TROUGHS | 88,290 | 88,290 | |
| Submittal - Air Scour Blowers | 19,974 | 19,974 | |
| Rec. On Site - Air Scour Blowers | 179,769 | 179,769 | |
| Totals | 12,708,000 | 12,708,000 | |
| No. Units (Trains) | 5 | | |
| Cost per System | 2,542,000 | 2,542,000 | |

NOTES

1. Do not include in component base. Use overall multiplier for electrical costs.
2. Not used.



Project: SRWA Surface Water Supply Project
 Job No.: 693-20-16-01 Date: 3/28/2017
 Calc. By: W. Sandelin Chkd. By: A. Smith
 Subject: Granular Media Filters Cost Derivation

Adjustments

| | | | |
|--|-------|------------------------|------------|
| a. Inflation to Current Dollars | | | |
| ENR at Construction Midpoint | 9972 | (Jan 2015) | |
| Most Recent Available ENR | 10530 | (Dec 2016) | |
| ENR Ratio = | 1.056 | | 13,419,000 |
| b. Inflation to Future Dollars | | | |
| Months to SRWA Construction Midpoint | 42 | (Jun 2020) | |
| Years to SRWA Construction Midpoint | 3.5 | | |
| Most Recent Year/Year Inflation | 3.1% | (Dec 2015 to Dec 2016) | |
| Inflation to SRWA Construction Mid-point | 1.11 | | 14,929,000 |

c. Capacity Adjustment

Costs for different sized systems can be estimated by multiplying the base cost by the ratio of their respective treatment capacities raised to a power factor. Power factor derived from AWWA and ASCE, Water Treatment Plant Design 26.6

Power factor = 0.60
 Installed capacity = 30 (MGD)

| Capacity Increments | Unit Component Cost, \$ |
|---------------------|-------------------------|
| 5 | 5,095,000 |
| 10 | 7,723,000 |
| 15 | 9,849,000 |
| 20 | 11,705,000 |
| 25 | 13,382,000 |
| 30 | 14,929,000 |
| 35 | 16,376,000 |
| 40 | 17,742,000 |
| 45 | 19,041,000 |



Project: SRWA Surface Water Supply Project
 Job No.: 693-20-16-01 Date: 3/28/2017
 Calc. By: W. Sandelin Chkd. By: A. Smith
 Subject: Membrane Filtration Cost Derivation

COST ANALYSIS

Develop base cost for membrane filtration from actual costs obtained for similar work at the Lodi Surface Water Treatment Plant.

Project Cost Breakdown for Membrane Filtration Facility at the Lodi Surface Water Treatment Plant

| Work Element | SOV | Use | Notes |
|--|-----------|-----------|-------|
| REBAR OPS BLDG | 155,000 | 80,600 | [1] |
| STR STEEL OPS BLDG SHOP DWGS | 10,000 | 5,200 | [1] |
| STR STEEL OPS BLDG FOB ITEMS | 56,575 | 29,419 | [1] |
| STR STEEL OPS BLDG ROOF STRUCTURE | 91,900 | 47,788 | [1] |
| STR STEEL OPS BLDG JOIST | 126,150 | 65,598 | [1] |
| STR STEEL OPS BLDG MASONRY EMBEDS | 46,525 | 24,193 | [1] |
| STR STEEL OPS BLDG DECKING | 76,625 | 39,845 | [1] |
| MISC STEEL OPS BLDG | 55,000 | 55,000 | |
| SHEETMETAL ROOFING OPS BLDG | 118,500 | 61,620 | [1] |
| COATINGS OPS BLDG | 159,500 | 159,500 | |
| PLUMBING OPS BLDG UNDER SLAB | 33,660 | 17,503 | [1] |
| PLUMBING OPS BLDG A/G | 34,328 | 17,851 | [1] |
| PLUMBING OPS BLDG FINISH | 15,330 | 7,972 | [1] |
| HVAC OPS BLDG | 192,000 | 99,840 | [1] |
| REV FILT WASTE TANK | 35,000 | 35,000 | |
| RECIRCULATION PS | 20,000 | 20,000 | |
| FTW PS COMPLETE | 15,000 | 15,000 | |
| PIT SOG | 45,000 | 45,000 | |
| PIT WALLS | 90,000 | 90,000 | |
| FOOTINGS | 60,000 | 31,200 | [1] |
| SOG | 226,320 | 117,686 | [1] |
| PERIMTER WALLS 1 | 15,000 | 7,800 | [1] |
| PERIMTER WALLS 2 | 15,000 | 7,800 | [1] |
| WOOD BLOCKING AT ROOF | 48,000 | 24,960 | [1] |
| PLYWOOD SOFFITS | 25,000 | 13,000 | [1] |
| Membranes | 60,000 | 60,000 | |
| Aut Str/Membrane Feed | 65,000 | 65,000 | |
| Membrane Filter Underslab | 30,000 | 30,000 | |
| Membrane FIL | 45,000 | 45,000 | |
| Membrane RFS | 30,000 | 30,000 | |
| Membrane RFS/PW Copper | 25,000 | 25,000 | |
| Membrane RFW Underslab | 18,000 | 18,000 | |
| Membrane RFW | 15,000 | 15,000 | |
| Membrane MF Underslab | 12,000 | 12,000 | |
| Membrane MF | 28,000 | 28,000 | |
| Membrane CIPR | 38,000 | 38,000 | |
| Membrane CIPS | 15,000 | 15,000 | |
| Membrane CIP/REC/EFM | 35,000 | 35,000 | |
| Membrane SB Chemical Piping | 28,000 | 28,000 | |
| Membrane Air | 15,000 | 15,000 | |
| Pall Corp Coordination | 47,766 | 47,766 | |
| Pall System Modifications | 8,962 | 8,962 | |
| Pall Membrane System | 3,926,081 | 3,926,081 | |
| RFR TANK | 14,000 | 14,000 | |
| FW TANK / DRAINAGE PS | 18,000 | 18,000 | |
| CHEMICAL SYSTEMS | 85,000 | 85,000 | |
| CO 9 CREDIT CATHODIC PROTECTION AT RFWT | (4,675) | (4,675) | |
| CO 11 RFI 150 155 OPS/CHEM TOP OF WALL EMBED COATING | 15,515 | 5,275 | [2] |
| CO 11 RFI 171 OPS AND CHEM RAFTER TAIL | 33,639 | 11,437 | [2] |
| CO 12 AIR DRYER AND FILTER | 9,319 | 9,319 | |
| CO 12 OPS PIT SUMP PUMP | 2,899 | 2,899 | |
| CO 13 RFI 98 8" RFS OVERFLOW AT RFT TNK | 4,163 | 4,163 | |
| CO 13 RIF 279 CIP TANK HEATERS/NEUT TANK BKR | 2,420 | 2,420 | |
| CO 13 COAT CHEM METERING PUMP SUPPORTS | 4,833 | 4,833 | |
| CO 13 RFI 2043 ADDED CIP DRAIN AT PALL SYSTEM | 1,779 | 1,779 | |
| CO 13 RFI 3001B PALL COORD EYEWASH, DRAIN, TOTES | 30,057 | 30,057 | |
| CO 13 BOOSTER PUMP FOR CHEM SYSTEM | 17,992 | 17,992 | |
| Totals | 6,442,000 | 5,764,000 | |
| Cost per System | 6,442,000 | 5,764,000 | |

NOTES

1. Factored by 0.52 to reflect relative footprint for [membranes/mechanical room/CIP chemicals] and total Ops bldg



Project: SRWA Surface Water Supply Project
Job No.: 693-20-16-01 Date: 3/28/2017
Calc. By: W. Sandelin Chkd. By: A. Smith
Subject: Membrane Filtration Cost Derivation

Factored by 0.34 to reflect relative footprint for [membranes/mechanical room/CIP chemicals] and total of Ops and
2. Chem bldgs



Project: SRWA Surface Water Supply Project
 Job No.: 693-20-16-01 Date: 3/28/2017
 Calc. By: W. Sandelin Chkd. By: A. Smith
 Subject: Membrane Filtration Cost Derivation

Adjustments

| | | | |
|--|-------|------------------------|-----------|
| a. Inflation to Current Dollars | | | |
| ENR at Construction Midpoint | 9290 | (May 2012) | |
| Most Recent Available ENR | 10530 | (Dec 2016) | |
| ENR Ratio = | 1.133 | | 6,533,000 |
| b. Inflation to Future Dollars | | | |
| Months to SRWA Construction Midpoint | 42 | (Jun 2020) | |
| Years to SRWA Construction Midpoint | 3.5 | | |
| Most Recent Year/Year Inflation | 3.1% | (Dec 2015 to Dec 2016) | |
| Inflation to SRWA Construction Mid-point | 1.11 | | 7,268,000 |

c. Capacity Adjustment

Costs for different sized systems can be estimated by multiplying the base cost by the ratio of their respective treatment capacities raised to a power factor. Power factor derived from AWWA and ASCE, Water Treatment Plant Design 26.6

Power factor = 0.60
 Installed capacity = 8 (mgd)

| Capacity Increments | Unit Component Cost, \$ |
|---------------------|-------------------------|
| 5 | 5,482,000 |
| 10 | 8,309,000 |
| 15 | 10,598,000 |
| 20 | 12,594,000 |
| 25 | 14,399,000 |
| 30 | 16,063,000 |
| 34 | 17,316,000 |
| 40 | 19,090,000 |
| 45 | 20,487,000 |



Project: SRWA Surface Water Supply Project
 Job No.: 693-20-16-01 Date: 3/28/2017
 Calc. By: W. Sandelin Chkd. By: A. Smith
 Subject: Membrane Filtration Cost Derivation

COST ANALYSIS

Develop base cost for membrane filtration from actual costs obtained for similar work at the MID Regional Water Treatment Plant.

Project Cost Breakdown for Membrane Filtration Facility at the MID Regional Water Treatment Plant

| Work Element | SOV | Use | Notes |
|---|-----------|-----------|-------|
| <u>Structural</u> | | - | |
| Earthwork - Shoring at Membrane Building | 140,707 | 140,707 | |
| Earthwork - Aggregate Base | 42,697 | 42,697 | |
| Earthwork - Backfill | 261,788 | 261,788 | |
| Earthwork - Excavation | 500,092 | 500,092 | |
| Concrete - Encase 20" BWV Piping | 18,070 | 18,070 | |
| Concrete - Encase 60" FLT Piping | 207,820 | 207,820 | |
| Concrete - Footings at Exterior CMU Columns | 33,122 | 33,122 | |
| Concrete - Slabs at Elev. 174.50' | 843,517 | 843,517 | |
| Concrete - Slabs at Elev. 192.50' | 315,889 | 315,889 | |
| Concrete - Walls | 1,128,663 | 1,128,663 | |
| Concrete - Beams | 21,740 | 21,740 | |
| Concrete - Columns | 12,496 | 12,496 | |
| Concrete - Decks | 163,398 | 163,398 | |
| Concrete - Equipment Pads & Curbs | 28,542 | 28,542 | |
| Masonry | 630,891 | 630,891 | |
| Metals - Roof Joist & Deck at EL. 206.50 | 290,400 | 290,400 | |
| Metals - Roof Joist & Decking at El 214.50 | 824,400 | 824,400 | |
| Metals - Steel Corner Roof Support | 49,179 | 49,179 | |
| Metals - Metal Deck (1") at Mansard | 42,468 | 42,468 | |
| Metals - Mansard Framing | 264,217 | 264,217 | |
| Metals - Light Gauge Framing Room 103 & 104 | 46,984 | 46,984 | |
| Metals - Handrail | 44,492 | 44,492 | |
| Metals - Grating & Supports at El. 197.83 | 30,765 | 30,765 | |
| Metals - Stairs | 32,370 | 32,370 | |
| Rough Carpentry - Roof & Accent Blocking Detail AM301 | 171,944 | 171,944 | |
| Damproofing - Walls Below Grade | 79,980 | 79,980 | |
| Roofing - Standing Seam Metal Panel System | 190,413 | 190,413 | |
| Roofing - Membrane | 119,805 | 119,805 | |
| Roofing Specialties - Skylights | 115,699 | 115,699 | |
| Roofing Specialties - Mansard & Skylight Curbs & Blocking | 128,317 | 128,317 | |
| Doors - Steel Doors and Hardware | 37,537 | 37,537 | |
| Doors - Rolling Steel Doors | 17,137 | 17,137 | |
| Finishes - Stucco | 166,777 | 166,777 | |
| Finishes - Gypsum Board @ Rooms 103 & 104 | 32,379 | 32,379 | |
| Finishes - Acoustical Treatment at Blower Room | 50,752 | 50,752 | |
| Specialties - Louvers | 13,750 | 13,750 | |
| | | - | |
| <u>Mechanical - Furnish</u> | | - | |
| Protective Coatings | 342,444 | 342,444 | |
| Equipment - TR Pumps | 49,171 | 49,171 | |
| Equipment - CIP Pumps | 10,591 | 10,591 | |
| Equipment - Backwash Pumps | 12,993 | 12,993 | |
| Equipment - Blowers | 17,352 | 17,352 | |
| Equipment - Filtrate Pumps | 52,058 | 52,058 | |
| Equipment - Membrane Cell Internals | 201,502 | 201,502 | |
| Equipment - Membrane Modules | 119,395 | 119,395 | |
| Equipment - Membrane Crane | 15,684 | 15,684 | |
| Equipment - Memsap Rails | 26,689 | 26,689 | |
| Equipment - Jib Crane | 63,856 | 63,856 | |
| Equipment - Sump Pumps | 23,664 | 23,664 | |
| Equipment - Pilot Plant Equipment | 293,635 | 293,635 | |
| Equipment - Chemical Pumps & Equipment @ CIP Area | 16,675 | 16,675 | |
| Equipment - Adjustable Frequency Drives in Room 103 | 1,495 | 1,495 | |



Project: SRWA Surface Water Supply Project
 Job No.: 693-20-16-01 Date: 3/28/2017
 Calc. By: W. Sandelin Chkd. By: A. Smith
 Subject: Membrane Filtration Cost Derivation

| | | | |
|---|------------|------------|-----|
| Piping - Fire Sprinkler System | 96,678 | 96,678 | |
| Piping - 60" FLT (Below Slab) | 2,507,725 | 2,507,725 | |
| Piping - 20" BWW (Below Slab) | 84,000 | 84,000 | |
| Piping - 60" MI Piping | 205,338 | 205,338 | |
| Piping - 24" MI | 679,000 | 679,000 | |
| Piping - 24" & 20" FLT | 802,000 | 802,000 | |
| Piping - 18" BWS | 132,000 | 132,000 | |
| Piping - 14" ARW | 300,000 | 300,000 | |
| Piping - 20" & 12" BWW (Exposed) | 68,213 | 68,213 | |
| Piping - 10" CIP | 94,914 | 94,914 | |
| Piping - 8" TR | 21,726 | 21,726 | |
| Piping - 6" HW | 22,477 | 22,477 | |
| Piping - Instrument Air at Blower Room | 129,413 | 129,413 | |
| Piping - Instrument Air at Membrane Area (Header to Valves) | 165,496 | 165,496 | |
| Piping - Instrument Air (2" Header & Underslab) | 189,270 | 189,270 | |
| Piping - Pilot Plant System | 319,473 | 319,473 | |
| Piping - Small Diameter CIP System in Membrane Area | 31,316 | 31,316 | |
| Piping - CIP System in CIP Room | 108,326 | 108,326 | |
| Piping - Sample Within 60" FLT | 21,790 | 21,790 | |
| Piping - Sample at Membrane Area | 74,485 | 74,485 | |
| Insulation - Air Piping | 94,372 | 94,372 | |
| Test - Leak Test Filters & Tanks | 5,897 | 5,897 | |
| Test - Piping | 72,036 | 72,036 | |
| Test - TR Pumps | 695 | 695 | |
| Test & Start Membrane Filtration Equipment | 165,357 | 165,357 | |
| Deliver Membrane Filtration Equipment | 5,118,079 | 5,118,079 | |
| | - | - | |
| <u>Plumbing</u> | | | |
| Insulation - Plumbing Piping | 57,601 | 57,601 | |
| Plumbing - Roof Drain System | 393,325 | 393,325 | |
| Plumbing - Floor Drain System (Lower Level) | 248,646 | 248,646 | |
| Plumbing - Floor Drain System (Upper Level) | 106,563 | 106,563 | |
| Plumbing - CW Plumbing System | 64,292 | 64,292 | |
| Plumbing - TW Plumbing System | 33,320 | 33,320 | |
| Plumbing - HW Plumbing System | 33,320 | 33,320 | |
| Plumbing - Propane Gas | 59,513 | 59,513 | |
| | - | - | |
| <u>HVAC</u> | | | |
| HVAC - Equipment & Ductwork | 301,823 | 301,823 | |
| HVAC - Controls | 112,505 | 112,505 | |
| | - | - | |
| <u>Electrical</u> | | | |
| Electrical - Rough Branch Power | 127,000 | - | [1] |
| Electrical - Rough Devices | 44,000 | - | [1] |
| Electrical - Rough Fixtures | 34,000 | - | [1] |
| Electrical - Rough Equipment | 44,000 | - | [1] |
| Electrical - Wire Branch Power | 73,000 | - | [1] |
| Electrical - Wire Lighting | 20,000 | - | [1] |
| Electrical - Wire Equipment | 48,000 | - | [1] |
| Electrical - Wire Instrumentation | 44,000 | - | [1] |
| Electrical - Install Gear & Terminate | 20,000 | - | [1] |
| Electrical - Data & Security | 32,880 | - | [1] |
| Electrical - Light Fixtures | 110,500 | - | [1] |
| Electrical - PLC4 | 197,400 | - | [1] |
| Electrical - Light Fixtures | 110,500 | - | [1] |
| Electrical - Lightning Protection System | 31,251 | - | [1] |
| Electrical - Grounding | 30,001 | - | [1] |
| Electrical - MCC 2A | 156,000 | - | [1] |
| Totals | 22,389,917 | 21,267,385 | |
| Cost per System | 22,389,917 | 21,267,385 | |

NOTES

1. Do not include in component base. Use overall multiplier for electrical costs.
2. Not used.



Project: SRWA Surface Water Supply Project
 Job No.: 693-20-16-01 Date: 3/28/2017
 Calc. By: W. Sandelin Chkd. By: A. Smith
 Subject: Membrane Filtration Cost Derivation

Adjustments

| | | | |
|--|-------|------------------------|------------|
| a. Inflation to Current Dollars | | | |
| ENR at Construction Midpoint | 8185 | (Jun 2008) | |
| Most Recent Available ENR | 10530 | (Dec 2016) | |
| ENR Ratio = | 1.286 | | 27,360,000 |
| b. Inflation to Future Dollars | | | |
| Months to SRWA Construction Midpoint | 42 | (Jun 2020) | |
| Years to SRWA Construction Midpoint | 3.5 | | |
| Most Recent Year/Year Inflation | 3.1% | (Dec 2015 to Dec 2016) | |
| Inflation to SRWA Construction Mid-point | 1.11 | | 30,438,000 |

c. Capacity Adjustment

Costs for different sized systems can be estimated by multiplying the base cost by the ratio of their respective treatment capacities raised to a power factor. Power factor derived from AWWA and ASCE, Water Treatment Plant Design 26.6

Power factor = 0.60
 Installed capacity = 30 (mgd)

| Capacity Increments | Unit Component Cost, \$ |
|---------------------|-------------------------|
| 5 | 10,388,000 |
| 10 | 15,745,000 |
| 15 | 20,082,000 |
| 20 | 23,865,000 |
| 25 | 27,284,000 |
| 30 | 30,438,000 |
| 34 | 32,812,000 |
| 40 | 36,173,000 |
| 45 | 38,821,000 |



Project: **SRWA Surface Water Supply Project**
 Job No.: **693-20-16-01** Date: **3/28/2017**
 Calc. By: **A. Smith W. Sandeli** Chkd. By: _____
 Subject: **UV Disinfection Facility Cost Derivation**

COST ANALYSIS

Develop base cost for a UV disinfection facility from preliminary design criteria for the SRWA WTP

Project Cost Breakdown for UV Disinfection Facility at the SRWA WTP

| Item Description | Quantity | Units | Unit Price | Total |
|---|-------------------|-------|------------|-----------|
| Division 2-Site Work | \$ 15,000 | | | |
| Underslab Pipe Encasement | 1 | LS | \$10,000 | \$10,000 |
| Install Underslab AB | 22 | CY | \$200 | \$4,467 |
| Division 3-Concrete | \$ 16,000 | | | |
| Slabs/Foundations | 22 | CY | \$600 | \$13,400 |
| Misc Concrete | 5 | CY | \$600 | \$3,000 |
| Division 5-Metals | \$ 10,000 | | | |
| Miscellaneous Metals (Supports) | 1 | LS | \$10,000 | \$10,000 |
| Division 9-Coating Systems | \$ 11,000 | | | |
| Piping Systems | 2% | % | | \$11,000 |
| Division 11-Equipment | \$ 462,000 | | | |
| UV Equipment | 1 | LS | \$440,000 | \$440,000 |
| Installation | 5% | % | \$22,000 | \$22,000 |
| Division 13-Special Construction | \$ 10,000 | | | |
| Canopy Structure | 1 | LS | \$10,000 | \$10,000 |
| Division 15-Mechanical | \$ 110,000 | | | |
| 24 inch inlet piping (exposed) | 30 | LF | \$240 | \$7,200 |
| 24 inch outlet piping (exposed) | 30 | LF | \$240 | \$7,200 |
| 2 inch cooling water/drain piping (exposed) | 20 | LF | \$20 | \$400 |
| 24" BFV Valves | 4 | EA | \$20,000 | \$80,000 |
| Misc Valves | 1 | LS | \$15,000 | \$15,000 |
| | | | | \$0 |

Estimated Component Cost \$634,000

Current Date (Mar 2017)

Inflation to Future Dollars

Months to SRWA Construction Midpoint 39 (Jun 2020)

Years to SRWA Construction Midpoint 3.2

Most Recent Year/Year Inflation 3% (Dec 2015 to Dec 2016)

Inflation to SRWA Construction Mid-point 1.10 \$ 700,000



Project: SRWA Surface Water Supply Project
 Job No.: 693-20-16-01 Date: 3/28/2017
 Calc. By: W. Sandelin Chkd. By: A. Smith
 Subject: In-Plant Pump Station Cost Derivation

COST ANALYSIS

Develop base cost for an in-plant pump station from actual costs obtained for similar work at the WDCWA Regional Water Treatment Facility.

Project Cost Breakdown for In Plant Pump Station at the WDCWA Regional Water Treatment Facility

| Work Element | SOV | Use | Notes |
|---|-----------|-----------|-------|
| Over-excavation / Backfill to Bottom of Foundation Slab | 73,235 | 73,235 | |
| Backfill PS Wet Well | 24,412 | 24,412 | |
| Backfill Facility to Subgrade | 3,000 | 3,000 | |
| Form / Rebar - Foundation Slab | 46,890 | 46,890 | |
| Pour - Foundation Slab | 25,000 | 25,000 | |
| Form / Rebar / Pour - North Walls | 136,591 | 136,591 | |
| Form / Rebar / Pour - South Walls | 91,591 | 91,591 | |
| Shore - Upper Deck | 44,701 | 44,701 | |
| Form / Rebar / Pour - Upper Deck | 39,000 | 39,000 | |
| Remove Shoaring from Deck | 15,000 | 15,000 | |
| Water Leak Test | 7,189 | 7,189 | |
| Form / Rebar / Pour - PS Electrical Bldg and FW Pipe Support Slab | 35,756 | 17,878 | [2] |
| Form / Rebar / Pour - Pipe Pedestals | 11,189 | 11,189 | |
| Install Access Hatch and Ladder | 86,268 | 86,268 | |
| Erect Bldg Structural Steel, Girts and Purlins - PS Electrical Bldg | 54,000 | - | [1] |
| Erect Insulated Metal Panels, Roof/Siding - PS Electrical Bldg | 50,835 | - | [1] |
| Install GW Piping - Under Foundation Slab | 21,567 | 21,567 | |
| Install Vertical In-Plant Pumps | 107,835 | 107,835 | |
| Install Aboveground FW Piping | 440,908 | 440,908 | |
| Test/Flush Piping | 25,000 | 25,000 | |
| Install HVAC System - PS Electrical Bldg | 28,756 | - | [1] |
| In-Slab Electrical - Deck for PS | 10,000 | - | [1] |
| Under-Slab Electrical - PS Elect Bldg | 157,978 | - | [1] |
| Backfill & Underslab Electrical | 13,915 | - | [1] |
| Install / Fit-up Equipment Electrical Stands | 25,000 | - | [1] |
| Install / Fit-up Instrument Stands | 20,000 | - | [1] |
| Install Electrical and I&C Equipment | 350,000 | - | [1] |
| Pull / Terminate / Test - Equipment and Instrument Circuits | 84,039 | - | [1] |
| Pull / Terminate from Elect Bldg to XFMR | 20,000 | - | [1] |
| Energize and Test | 16,174 | - | [1] |
| Paint Aboveground Pipe and Equipment | 51,700 | 51,700 | |
| Install Doors - PS Electrical Bldg | 3,000 | - | [1] |
| SUBMITTAL VERTICAL TURBINE PUMPS | 152,804 | 44,313 | [3] |
| REC ON SITE VERTICAL TURBINE PUMPS | 1,150,234 | 333,568 | [3] |
| Totals | 3,424,000 | 1,647,000 | |
| Cost per System | 3,424,000 | 1,647,000 | |

NOTES

1. Do not include in component base. Use overall multiplier for electrical costs.
2. Assume half of this cost is associated with finished water (FW) piping slab.
3. Factored by (4/14 = .29) to reflect four (4) VT pumps for IPPS out of 14 total VT pumps for WTP



Project: SRWA Surface Water Supply Project
 Job No.: 693-20-16-01 Date: 3/28/2017
 Calc. By: W. Sandelin Chkd. By: A. Smith
 Subject: In-Plant Pump Station Cost Derivation

Adjustments

- a. Inflation to Current Dollars
 ENR at Construction Midpoint 9972 (Jan 2015)
 Most Recent Available ENR 10530 (Dec 2016)
 ENR Ratio = 1.056 1,739,000
- b. Inflation to Future Dollars
 Months to SRWA Construction Midpoint 42 (Jun 2020)
 Years to SRWA Construction Midpoint 3.5
 Most Recent Year/Year Inflation 3.1% (Dec 2015 to Dec 2016)
 Inflation to SRWA Construction Mid-point 1.11 1,935,000
- c. Capacity Adjustment
 Costs for different sized systems can be estimated by multiplying the base cost by the ratio of their respective treatment capacities raised to a power factor. Power factor derived from AWWA and ASCE, Water Treatment Plant Design 26.6

Power factor = 0.60
 Installed capacity = 30 (mgd)

| Capacity Increments | Unit Component Cost, \$ |
|---|--|
| 5 | 660,000 |
| 10 | 1,001,000 |
| 15 | 1,277,000 |
| 20 | 1,517,000 |
| 25 | 1,734,000 |
| 30 | 1,935,000 |
| 35 | 2,123,000 |
| 40 | 2,300,000 |
| 45 | 2,468,000 |



Project: SRWA Surface Water Supply Project
 Job No.: 693-20-16-01 Date: 3/28/2017
 Calc. By: W. Sandelin Chkd. By: A. Smith
 Subject: Chlorine Contact Tank Cost Derivation

COST ANALYSIS

Develop base cost for chlorine contact tank from detailed cost estimate prepared for the DWWSP Benchmark WTP.

Project Cost Breakdown for Chlorine Contact Tank at the DWWSP Benchmark WTP

| Work Element | SOV | Use | Notes |
|--|---------|---------|-------|
| <u>Sitework</u> | | | |
| Survey and layout | 305 | 305 | |
| Structure excavation | 19,613 | 19,613 | |
| Structure backfill | 16,284 | 16,284 | |
| Install underslab gravel - AB | 5,234 | 5,234 | |
| Transport to Stockpile | 4,370 | 4,370 | |
| Transport to Backfill | 3,651 | 3,651 | |
| Assist pile driver | 2,502 | - | [1] |
| Furnish and install concrete piles | 87,328 | - | [1] |
| Clean up after piles | 1,544 | - | [1] |
| Prepare dowels in top of concrete piles | 4,296 | - | [1] |
| <u>Concrete</u> | | | |
| Fine Grade | 582 | 582 | |
| Form Footing | 3,513 | 3,513 | |
| Form Construction Joint | 6,561 | 6,561 | |
| Form Wall | 94,221 | 94,221 | |
| Pour Concrete | 71,488 | 71,488 | |
| Sandblast Joints | 473 | 473 | |
| Install Waterstop | 3,194 | 3,194 | |
| Strip & Patch | 57,951 | 57,951 | |
| Exposed Finish - Sacking | 1,238 | 1,238 | |
| JFM/CFM | 46,640 | 46,640 | |
| Rebar | 58,609 | 58,609 | |
| Rebar Couplers - Form Savers | 11,671 | 11,671 | |
| Install Caulking | 1,100 | 1,100 | |
| Install Sleeves - Baffle Walls | 1,455 | 1,455 | |
| Watertest Structure | 5,842 | 5,842 | |
| Grout Basin Floor - (furnish conc. Included above) | 9,857 | 9,857 | |
| <u>Metals</u> | | | |
| Receive/Inventory/Store Metals | 157 | 157 | |
| F&I Beam Support Brackets | 2,864 | 2,864 | |
| F&I Aluminum Beam Supports for FRP Grating | 6,653 | 6,653 | |
| <u>Specialties</u> | | | |
| F&I Gasketed FRP Covers | 85,252 | 85,252 | |
| <u>Mechanical</u> | | | |
| Receive/Inventory Pipe | 88 | 88 | |
| Cores and Spools | - | - | |
| Install Very Large Wall Spools- >48" | 2,893 | 2,893 | |
| Furnish Prefabricated Steel Pipe | 8,000 | 8,000 | |
| Totals | 625,000 | 530,000 | |
| Cost per Unit (Train) | 625,000 | 530,000 | |

NOTES

1. No piles assumed for this project.
2. Costs for electrical, instrumentation and chemical feed systems not included in component base costs. Use overall multiplier for electrical costs, and treat chemical feed as separate system.



Project: SRWA Surface Water Supply Project
 Job No.: 693-20-16-01 Date: 3/28/2017
 Calc. By: W. Sandelin Chkd. By: A. Smith
 Subject: Chlorine Contact Tank Cost Derivation

Adjustments

| | | | |
|--|-------|------------------------|---------|
| a. Inflation to Current Dollars | | | |
| ENR at Construction Midpoint | 9080 | (Jul 2011) | |
| Most Recent Available ENR | 10530 | (Dec 2016) | |
| ENR Ratio = | 1.160 | | 615,000 |
| b. Inflation to Future Dollars | | | |
| Months to SRWA Construction Midpoint | 42 | (Jun 2020) | |
| Years to SRWA Construction Midpoint | 3.5 | | |
| Most Recent Year/Year Inflation | 3.1% | (Dec 2015 to Dec 2016) | |
| Inflation to SRWA Construction Mid-point | 1.11 | | 684,000 |

c. Capacity Adjustment

Costs for different sized systems can be estimated by multiplying the base cost by the ratio of their respective treatment capacities raised to a power factor. Power factor derived from AWWA and ASCE, Water Treatment Plant Design 26.6

Power factor = 0.60
 Installed capacity = 212,000 gal

| Capacity Increments (Per Train) | Unit Component Cost, \$ |
|------------------------------------|-------------------------|
| 600,000 | 1,277,000 |
| 605,000 | 1,283,000 |
| 610,000 | 1,290,000 |
| 615,000 | 1,296,000 |
| 620,000 | 1,302,000 |
| 625,000 | 1,309,000 |
| 630,000 | 1,315,000 |
| 635,000 | 1,321,000 |
| 640,000 | 1,327,000 |



Project: SRWA Surface Water Supply Project
 Job No.: 693-20-16-01 Date: 3/28/2017
 Calc. By: W. Sandelin Chkd. By: A. Smith
 Subject: Clearwell Cost Derivation

COST ANALYSIS

Develop base cost for clearwell from actual costs obtained for similar work at the WDCWA Regional Water Treatment Facility.

Project Cost Breakdown for Clearwell Facility at the WDCWA Regional Water Treatment Facility

| Work Element | SOV | Use | Notes |
|--|-----------|-----------|-------|
| Excavate for Tank Floor Slab - CW Tank - Both Tanks | 158,518 | 158,518 | |
| Backfill with Aggregate, In Conjunction with Drain Pipe - CW Tank - Both Tanks | 237,776 | 237,776 | |
| Backfill Tanks to Sub-Grade - CW Tank - Both Tanks | 132,098 | 132,098 | |
| Form/Rebar/Pour Floor and Wall Footing & Wall Bearing Pads - CW Tank (| 419,111 | 419,111 | |
| Place Wall Bearing Pads - CW Tank (west) | 2,500 | 2,500 | |
| Assemble Wall Forms - CW Tanks | 132,222 | 132,222 | |
| Form/Rebar/Pour Core Walls 1 thru 8 - CW Tank (west) | 432,171 | 432,171 | |
| Shoring for Dome Roof - CW Tank (west) | 50,707 | 50,707 | |
| Form/Rebar/Pour Core Wall 9 - CW Tank (west) | 69,148 | 69,148 | |
| Concrete Dome Roof - CW Tank (west) | 390,094 | 390,094 | |
| Stress Vertical Tendons and Epoxy - CW Tank (west) | 42,500 | 42,500 | |
| Set-up Pre-Stressing Equipment - CW Tank (west) | 12,500 | 12,500 | |
| Abrasive Blast, Wrapping and Shotcrete (includes Cure Time - CW Tank (w | 787,500 | 787,500 | |
| Dismantle Dome Shoring & Tear Down Pre-Stress Equipment- CW Tank (t | 63,207 | 63,207 | |
| Install Ladders, Pipe Supports, Paint Interior Pipe and Seal Tank - CW Tan | 40,500 | 40,500 | |
| Water Leak Test - CW Tank - CW Tank (west) | 12,000 | 12,000 | |
| Form/Rebar/Pour Floor and Wall Footing & Wall Bearing Pads - CW Tank (| 418,111 | 418,111 | |
| Place Wall Bearing Pads - CW Tank (east) | 2,500 | 2,500 | |
| Form/Rebar/Pour Core Walls 1 thru 8 - CW Tank (east) | 432,171 | 432,171 | |
| Shoring for Dome Roof - CW Tank (east) | 50,707 | 50,707 | |
| Form/Rebar/Pour Core Wall 9 - CW Tank (east) | 69,148 | 69,148 | |
| Concrete Dome Roof - CW Tank (east) | 390,094 | 390,094 | |
| Stress Vertical Tendons and Epoxy - CW Tank (east) | 42,500 | 42,500 | |
| Set-up Pre-Stressing Equipment - CW Tank (east) | 12,500 | 12,500 | |
| Abrasive Blast, Wrapping and Shotcrete (includes Cure Time - CW Tank (e | 787,500 | 787,500 | |
| Dismantle Dome Shoring & Tear Down Pre-Stress Equipment- CW Tank (t | 63,207 | 63,207 | |
| Install Ladders, Pipe Supports, Paint Interior Pipe & Seal Tank - CW Tank (| 40,500 | 40,500 | |
| Water Leak Test - CW Tank - CW Tank (east) | 12,000 | 12,000 | |
| Install Underslab Piping - FW & OF Piping - CW Tanks (both) | 503,230 | 503,230 | |
| Install Underslab Piping - GW Piping - CW Tanks (both) | 503,230 | 503,230 | |
| Install A/G Pipe - FW and OF Piping - Both Tanks | 3,500 | 3,500 | |
| Install Sample Pump - CW Tank | 3,500 | 3,500 | |
| Rough-in for Electrical & I&C | 19,565 | - | [1] |
| Set/Fitup - Sample Pump & Level Instrument Stands - CW Tank | 5,000 | - | [1] |
| Pull/Terminate/Test - Electrical and I&C Circuits - CW Tank (including interi | 9,261 | - | [1] |
| Paint A/G Pipe - CW Tank | 1,000 | 1,000 | |
| Install Exterior Ladder and Handrail on Tanks | 10,000 | 10,000 | |
| Paint Exterior of Tanks | 45,000 | 45,000 | |
| Totals | 6,407,000 | 6,373,000 | |
| Cost per System | 6,407,000 | 6,373,000 | |

NOTES

1. Do not include in component base. Use overall multiplier for electrical costs.
2. Not used.



Project: SRWA Surface Water Supply Project
 Job No.: 693-20-16-01 Date: 3/28/2017
 Calc. By: W. Sandelin Chkd. By: A. Smith
 Subject: Clearwell Cost Derivation

Adjustments

| | | | |
|--|-------|------------------------|-----------|
| a. Inflation to Current Dollars | | | |
| ENR at Construction Midpoint | 9972 | (Jan 2015) | |
| Most Recent Available ENR | 10530 | (Dec 2016) | |
| ENR Ratio = | 1.056 | | 6,730,000 |
| b. Inflation to Future Dollars | | | |
| Months to SRWA Construction Midpoint | 42 | (Jun 2020) | |
| Years to SRWA Construction Midpoint | 3.5 | | |
| Most Recent Year/Year Inflation | 3.1% | (Dec 2015 to Dec 2016) | |
| Inflation to SRWA Construction Mid-point | 1.11 | | 7,487,000 |

c. Capacity Adjustment

Costs for different sized systems can be estimated by multiplying the base cost by the ratio of their respective treatment capacities raised to a power factor. Power factor derived from AWWA and ASCE, Water Treatment Plant Design 26.6

Power factor = 0.60
 Installed capacity = 5.75 (MG)

| Capacity Increments | Unit Component Cost, \$ |
|---------------------|-------------------------|
| 2.1 | 4,091,000 |
| 2.2 | 4,207,000 |
| 2.3 | 4,321,000 |
| 2.4 | 4,432,000 |
| 2.5 | 4,542,000 |
| 2.6 | 4,650,000 |
| 2.7 | 4,757,000 |
| 2.8 | 4,862,000 |
| 2.9 | 4,965,000 |



Project: SRWA Surface Water Supply Project
 Job No.: 693-20-16-01 Date: 3/28/2017
 Calc. By: W. Sandelin Chkd. By: A. Smith
 Subject: Backwash Supply & FWPS Cost Derivation

COST ANALYSIS

Develop base cost for backwash supply and finished water pump station from actual costs obtained for similar work at the WDCWA Regional Water Treatment Facility.

Project Cost Breakdown for Backwash Supply and Finished Water Pump Station Facility at the WDCWA Regi

| Work Element | SOV | Use | Notes |
|---|-----------|-----------|-------|
| Mass Excavate/Waste Slab for Pump Cans - FW PS | 75,000 | 75,000 | |
| Backfill up to FW Inlet at Pump Cans - FW PS | 10,000 | 10,000 | |
| Backfill up to Bottom of Foundation Slab - FW PS | 10,000 | 10,000 | |
| Excavate for Surge Tank Foundations - FW PS Exterior | 7,500 | 7,500 | |
| Final Backfill at Facility | 16,119 | 16,119 | |
| Form/Rebar/Pour - Lower Encasement of Pump Cans - FW PS | 41,120 | 41,120 | |
| Form/Rebar/Pour - Encasement of FW Inlet Pipe - FW PS | 42,200 | 42,200 | |
| Form/Rebar/Pour - Upper Encasement of Pump Cans | 50,000 | 50,000 | |
| Form/Rebar/Pour - Foundation Slab - FW PS | 312,088 | 312,088 | |
| Form/Rebar/Pour - Surge Tank Foundations - FW PS Exterior | 25,945 | 25,945 | |
| Form/Rebar/Pour - Pump Pedestals - FW PS | 15,378 | 15,378 | |
| Form/Rebar/Pour - Pipe Supports FW PS | 15,378 | 15,378 | |
| Form/Rebar/Pour - HVAC Unit(s) Foundation - FW PS | 13,000 | 13,000 | |
| Erect Rigid Frame, Girts, Purlins, Hatch Framing - FW PS | 180,846 | 180,846 | |
| Install Insulated Metal Panels - Roof/Siding - FW PS | 150,316 | 150,316 | |
| Install Interior Divider Wall, Doors, Rollup Doors, Windows & Skylights - F | 130,186 | 130,186 | |
| Set Pump Cans - FW PS | 208,617 | 208,617 | |
| Install Remaining Underslab Pipe - FW PS | 195,510 | 195,510 | |
| Set Surge Tanks - FW PS Exterior | 40,000 | 40,000 | |
| Install FW and Backwash Pumps - FW PS | 304,633 | 304,633 | |
| Install A/G Piping - FW PS | 1,778,180 | 1,778,180 | |
| Test/Flush Piping Systems in Facility - FW PS | 50,000 | 50,000 | |
| Set HVAC Units - Outside | 140,000 | 140,000 | |
| Rough-in Interior HVAC Ductwork - FW PS | 152,772 | 152,772 | |
| Finsh HVAC and HVAC Controls - FW PS | 17,560 | 17,560 | |
| Install Underslab Electrical - FW PS | 254,226 | - | [1] |
| Install In-Slab Electrical Rough-in - FW PS | 152,121 | - | [1] |
| Install U/S Electr/I&C Under Surge Tank Slabs - FW PS Exterior | 7,000 | - | [1] |
| Rough-In Overhead Lighting and Security - FW PS | 91,304 | - | [1] |
| Install Electrical & I&C Equipment - FW PS | 300,000 | - | [1] |
| Pull/Term from Electrical Room to XFRR - FW PS | 20,000 | - | [1] |
| Install Equip Elec Stands and Fit-up Equipment - FW PS | 183,738 | - | [1] |
| Install Instr Stands and Fit-up - Field Instruments - FW PS | 100,000 | - | [1] |
| Pull/Term/Test Electrical and I&C Circuits - FW PS (Including Interconnec | 150,606 | - | [1] |
| Energize Electrical Room - FW PS | 16,174 | - | [1] |
| Paint Interior Divider Wall - FW PS | 10,000 | 10,000 | |
| Paint Pipe, Equipment, Doors and Door Frames - FW PS | 191,821 | 191,821 | |
| SUBMITTAL VERTICAL TURBINE PUMPS | 152,804 | 108,491 | [3] |
| SUBMITTAL PUMP CANS | 22,500 | 15,975 | [3] |
| REC ON SITE VERTICAL TURBINE PUMPS | 1,150,234 | 816,666 | [3] |
| REC ON SITE PUMP CANS | 202,500 | 143,775 | [3] |
| SURGE TANKS | 421,075 | 298,963 | |
| Totals | 7,408,000 | 5,568,000 | |
| Cost per System | 7,408,000 | 5,568,000 | |

NOTES

1. Do not include in component base. Use overall multiplier for electrical costs.
2. Not used.
3. Factored by (10/14 = .71) to reflect ten (10) VT pumps for BWS/FWPS out of 14 total VT pumps for WTP



Project: SRWA Surface Water Supply Project
 Job No.: 693-20-16-01 Date: 3/28/2017
 Calc. By: W. Sandelin Chkd. By: A. Smith
 Subject: Backwash Supply & FWPS Cost Derivation

Adjustments

| | | | |
|--|-------|------------------------|-----------|
| a. Inflation to Current Dollars | | | |
| ENR at Construction Midpoint | 9972 | (Jan 2015) | |
| Most Recent Available ENR | 10530 | (Dec 2016) | |
| ENR Ratio = | 1.056 | | 5,880,000 |
| b. Inflation to Future Dollars | | | |
| Months to SRWA Construction Midpoint | 42 | (Jun 2020) | |
| Years to SRWA Construction Midpoint | 3.5 | | |
| Most Recent Year/Year Inflation | 3.1% | (Dec 2015 to Dec 2016) | |
| Inflation to SRWA Construction Mid-point | 1.11 | | 6,541,000 |

c. Capacity Adjustment
 Costs for different sized systems can be estimated by multiplying the base cost by the ratio of their respective treatment capacities raised to a power factor. Power factor derived from AWWA and ASCE, Water Treatment Plant Design 26.6

Power factor = 0.60
 Installed capacity = 30 (mgd)

| Capacity Increments | Unit Component Cost, \$ |
|---------------------|-------------------------|
| 5 | 2,232,000 |
| 10 | 3,384,000 |
| 15 | 4,315,000 |
| 20 | 5,128,000 |
| 25 | 5,863,000 |
| 30 | 6,541,000 |
| 35 | 7,175,000 |
| 40 | 7,773,000 |
| 45 | 8,343,000 |



Project: SRWA Surface Water Supply Project
 Job No.: 693-20-16-01 Date: 3/28/2017
 Calc. By: W. Sandelin Chkd. By: A. Smith
 Subject: Backwash EQ Basin Cost Derivation

COST ANALYSIS

Develop base cost for backwas EQ basin from actual costs obtained for similar work at the WDCWA Regional Water Treatment Facility.

Project Cost Breakdown for Backwash EQ Facility at the WDCWA Regional Water Treatment Facility

| Work Element | SOV | Use | Notes |
|--|-----------|-----------|-------|
| Over-Ex/Backfill to Bottom of Foundation Slab | 172,536 | 172,536 | |
| Partial Backfill BWR EQ Basin | 47,512 | 47,512 | |
| Complete Backfill BWR EQ Basin at BWV/OF Wet Well | 10,000 | 10,000 | |
| Form/Rebar/Pour - Foundation Slab - Lower Slab - Slab Pour 1 | 224,357 | 224,357 | |
| Form/Rebar/Pour - 1st Foundation/Slab and Stem Wall Upper - Slab Pour | 246,491 | 246,491 | |
| Form/Rebar/Pour - 2nd Foundatiion/Slab and Stem Wall Upper - Slab Pou | 246,491 | 246,491 | |
| Form/Rebar/Pour - Walls - Pour #1 | 129,870 | 129,870 | |
| Form/Rebar/Pour - Walls - Pour #2 | 103,328 | 103,328 | |
| Form/Rebar/Pour - Walls - Pour #3 | 98,588 | 98,588 | |
| Form/Rebar/Pour - Walls - Pour #4 | 60,669 | 60,669 | |
| Form/Rebar/Pour - Walls - Pour #5 | 66,357 | 66,357 | |
| Form/Rebar/Pour - Walls - Pour #6 | 66,357 | 66,357 | |
| Shore/ Form/Rebar - Deck at East End - Lower Level | 5,000 | 5,000 | |
| Pour - Deck at East End - Lower Level | 10,945 | 10,945 | |
| Remove Shoring - Deck at East End - Lower Level | 2,000 | 2,000 | |
| Water Leak Test - BW EQ Basin | 3,595 | 3,595 | |
| Form/Rebar/Pour - Valve Station Slab - SOG East end Facility | 10,567 | 10,567 | |
| Form/Rebar/Pour - Fdn Slab - BWV/OF Wet Well | 22,378 | 22,378 | |
| Form/Rebar/Pour - Walls - BWV/OF Wet Well | 14,000 | 14,000 | |
| Water Leak Test BWV/OF Wet Well | 1,000 | 1,000 | |
| Erect Stairs and Handrail - BW EQ Basin | 158,158 | 158,158 | |
| Install GW Piping - Under Foundation Slab - BWEQ | 143,782 | 143,782 | |
| Set - Sub. Backwash Return Pumps (including rails) | 35,000 | 35,000 | |
| Set - Sub. Unthickened Sludge Pumps (including rails) | 35,000 | 35,000 | |
| Set - Hoseless Sludge Collection System | 150,000 | 150,000 | |
| Set - Water Control Gates (assuming surface mounted) | 47,560 | 47,560 | |
| Erect A/G Pipe and Instruments - BW EQ Basin | 176,292 | 176,292 | |
| Test/Flush Piping - BW EQ Basin | 10,000 | 10,000 | |
| In-Slab Electrical - Deck at East End | 23,478 | - | [1] |
| Rough-in A/G Electrical - BW EQ Basin | 24,783 | - | [1] |
| Set Stands and Fitup Equipment - BW EQ Basin | 21,000 | - | [1] |
| Set Stands and Fitup Instrumentation - BW EQ Basin | 13,043 | - | [1] |
| Pull / Term / Test Electrical & I&C Circuits - BW EQ Basin (including Interc | 10,735 | - | [1] |
| Paint Pipe and Equipment - BW EQ Basin | 15,000 | 15,000 | |
| SUBMITTAL SLUDGE COLLECTORS | 10,937 | | |
| REC ON SITE SLUDGE COLLECTORS | 98,430 | | |
| SUBMERSIBLE PUMPS | 190,899 | 102,792 | [2] |
| WATER CONTROL GATES | 63,560 | | |
| <hr/> | | | |
| Totals | 2,769,698 | 2,415,625 | |
| Cost per System | 2,769,698 | 2,415,625 | |

NOTES

1. Do not include in component base. Use overall multiplier for electrical costs.
2. Factored by 0.54 to reflect that 7 of 13 submersible pumps for the project are associated with this facility.



Project: SRWA Surface Water Supply Project
 Job No.: 693-20-16-01 Date: 3/28/2017
 Calc. By: W. Sandelin Chkd. By: A. Smith
 Subject: Backwash EQ Basin Cost Derivation

Adjustments

| | | | |
|--|-------|------------------------|-----------|
| a. Inflation to Current Dollars | | | |
| ENR at Construction Midpoint | 9972 | (Jan 2015) | |
| Most Recent Available ENR | 10530 | (Dec 2016) | |
| ENR Ratio = | 1.056 | | 2,551,000 |
| b. Inflation to Future Dollars | | | |
| Months to SRWA Construction Midpoint | 42 | (Jun 2020) | |
| Years to SRWA Construction Midpoint | 3.5 | | |
| Most Recent Year/Year Inflation | 3.1% | (Dec 2015 to Dec 2016) | |
| Inflation to SRWA Construction Mid-point | 1.11 | | 2,838,000 |

c. Capacity Adjustment

Costs for different sized systems can be estimated by multiplying the base cost by the ratio of their respective treatment capacities raised to a power factor. Power factor derived from AWWA and ASCE, Water Treatment Plant Design 26.6

Power factor = 0.60
 Installed capacity = 30 (mgd)

| Capacity Increments | Unit Component Cost, \$ |
|---------------------|-------------------------|
| 5 | 969,000 |
| 10 | 1,468,000 |
| 15 | 1,872,000 |
| 20 | 2,225,000 |
| 25 | 2,544,000 |
| 30 | 2,838,000 |
| 35 | 3,113,000 |
| 40 | 3,373,000 |
| 45 | 3,620,000 |



Project: SRWA Surface Water Supply Project
 Job No.: 693-20-16-01 Date: 3/28/2017
 Calc. By: W. Sandelin Chkd. By: A. Smith
 Subject: Gravity Thickeners Cost Derivation

COST ANALYSIS

Develop base cost for gravity thickeners from actual costs obtained for similar work at the WDCWA Regional Water Treatment Facility.

Project Cost Breakdown for Gravity Thickener Facility at the WDCWA Regional Water Treatment Facility

| Work Element | SOV | Use | Notes |
|---|-----------|-----------|-------|
| Over-Ex/Backfill to Bottom of Foundation Slabs | 99,209 | 99,209 | |
| Backfill to Sub-Grade - Gravity Thickeners | 33,069 | 33,069 | |
| Form/Rebar/Pour - Pedestal Sprt Base - Gravity Thickeners #1 | 28,756 | 28,756 | |
| Form/Rebar/Pour - Pedestal Sprt Base - Gravity Thickeners #2 | 28,756 | 28,756 | |
| Form/Rebar/Pour - Foundation Slab - Gravity Thickener #1 | 194,835 | 194,835 | |
| Form/Rebar/Pour - Foundation Slab - Gravity Thickener #2 | 194,835 | 194,835 | |
| Form/Rebar/Pour - Tank Walls - Gravity Thickener #1 | 200,560 | 200,560 | |
| Shore for Launder Construction - Gravity Thickener #1 | 25,100 | 25,100 | |
| Form/Rebar/Pour - Launder Floor - Gravity Thickener #1 | 35,000 | 35,000 | |
| Form/Rebar/Pour - Launder Walls - Gravity Thickener #1 | 26,268 | 26,268 | |
| Water Leak Test - Gravity Thickeners - Gravity Thickener #1 | 3,494 | 3,494 | |
| Form/Rear/Pour - Tank Walls - Gravity Thickener #2 | 200,560 | 200,560 | |
| Shore for Launder Construction - Gravity Thickener #2 | 25,100 | 25,100 | |
| Form/Rebar/Pour - Launder Floor - Gravity Thickener #2 | 35,000 | 35,000 | |
| Form/Rebar/Pour - Launder Walls - Gravity Thickener #2 | 26,268 | 26,268 | |
| Water Leak Test - Gravity Thickeners - Gravity Thickener #2 | 3,495 | 3,495 | |
| Form/Rebar/Pour - TS Pump & Misc Slabs and Equip Pedestals - Gravity | 21,567 | 21,567 | |
| Erect Center Walkways/Handrails- Gravity Thickeners | 90,323 | 90,323 | |
| Erect Stairs/Platforms/Handrails - Gravity Thickeners | 35,945 | 35,945 | |
| Install Underslab Piping - Gravity Thickeners | 43,134 | 43,134 | |
| Install Gravity Thickener Mechanisms | 90,000 | 90,000 | |
| Install A/G Piping & Instr on Tanks - Gravity Thickeners | 25,000 | 25,000 | |
| Install Mechanism Drives - Gravity Thickeners | 20,000 | 20,000 | |
| Install TS Pumps - Gravity Thickeners | 34,103 | 34,103 | |
| Install A/G Pipe, Pipe Supports & Instr at TS Pumps - Gravity Thickeners | 109,725 | 109,725 | |
| Test/Flush Piping Systems - Gravity Thickener Facility | 15,000 | 15,000 | |
| Install Underslab Elec - TS Pump Slab - Gravity Thickeners | 14,348 | - | [1] |
| Rough-in A/G Elec - Entire Facility - Gravity Thickeners | 18,261 | - | [1] |
| Fitup Stands - Entire facility - Gravity Thickeners | 11,087 | - | [1] |
| Pull/Term/Test - Electrical & I&C - Gravity Thickeners (including interconn | 17,857 | - | [1] |
| Vendor Inspection and Certification - Gravity Thickeners | 10,000 | 10,000 | |
| Paint Pipe and Equipment - Gravity Thickeners | 30,000 | 30,000 | |
| SUBMITTAL TS SCRAPER MECHANISMS | 42,622 | 42,622 | |
| REC ON SITE TS SCRAPER MECHANISMS | 383,596 | 383,596 | |
| ROTARY LOBE PUMPS | 45,091 | 45,091 | |
| Totals | 2,217,964 | 2,156,411 | |
| Cost per System | 2,217,964 | 2,156,411 | |

NOTES

1. Do not include in component base. Use overall multiplier for electrical costs.
2. Not used.



Project: SRWA Surface Water Supply Project
 Job No.: 693-20-16-01 Date: 3/28/2017
 Calc. By: W. Sandelin Chkd. By: A. Smith
 Subject: Gravity Thickeners Cost Derivation

Adjustments

| | | | |
|--|-------|------------------------|-----------|
| a. Inflation to Current Dollars | | | |
| ENR at Construction Midpoint | 9972 | (Jan 2015) | |
| Most Recent Available ENR | 10530 | (Dec 2016) | |
| ENR Ratio = | 1.056 | | 2,277,000 |
| b. Inflation to Future Dollars | | | |
| Months to SRWA Construction Midpoint | 42 | (Jun 2020) | |
| Years to SRWA Construction Midpoint | 3.5 | | |
| Most Recent Year/Year Inflation | 3.1% | (Dec 2015 to Dec 2016) | |
| Inflation to SRWA Construction Mid-point | 1.11 | | 2,533,000 |

c. Capacity Adjustment

Costs for different sized systems can be estimated by multiplying the base cost by the ratio of their respective treatment capacities raised to a power factor. Power factor derived from AWWA and ASCE, Water Treatment Plant Design 26.6

Power factor = 0.60
 Installed capacity = 30 (mgd)

| Capacity Increments | Unit Component Cost, \$ |
|---------------------|-------------------------|
| 5 | 864,000 |
| 10 | 1,310,000 |
| 15 | 1,671,000 |
| 20 | 1,986,000 |
| 25 | 2,271,000 |
| 30 | 2,533,000 |
| 35 | 2,778,000 |
| 40 | 3,010,000 |
| 45 | 3,231,000 |



Project: SRWA Surface Water Supply Project
 Job No.: 693-20-16-01 Date: 3/28/2017
 Calc. By: W. Sandelin Chkd. By: A. Smith
 Subject: Drying Beds Cost Derivation

COST ANALYSIS

Develop base cost for drying beds from actual costs obtained for similar work at the WDCWA Regional Water Treatment Facility.

Project Cost Breakdown for Drying Beds Facility at the WDCWA Regional Water Treatment Facility

| Work Element | SOV | Use | Notes |
|--|-----------|-----------|-------|
| Excavate one-third of Drying Bed 2 | 180,000 | 180,000 | |
| Excavate Remaining two-thirds of Bed 2 | 370,000 | 370,000 | |
| Excavate/Build up Berm at Drying Bed 1 and Build up Berm at Dry | 660,661 | 660,661 | |
| Excavate for Decant Structures in Beds 1 & 2 | 28,756 | 28,756 | |
| Excavate/Build up Berms at Existing Drying Beds - 3 & 4 | 403,552 | 403,552 | |
| Excavate for - Decant Structures in Beds 3,4 | 28,756 | 28,756 | |
| Finish Berms / Final Backfill to Subgrade at Facility | 64,701 | 64,701 | |
| Form/Rebar/Pour Fdn Slabs for Decant Struct's & Pump Stations - | 12,878 | 12,878 | |
| Form/Rebar/Pour Fdn Slabs for Decant Struct's & Pump Stations - | 12,878 | 12,878 | |
| Form/Rebar/Pour Walls for Decant Struct's & Pump Stations - Beds | 61,741 | 61,741 | |
| Form/Rebar/Pour Walls for Decant Struct's & Pump Stations - Beds | 61,740 | 61,740 | |
| Form/Rebar/Pour Fdn Slab for entry - Decant Struct's and Pump St | 11,000 | 11,000 | |
| Form/Rebar/Pour Fdn Slab for Entry - Decant Struct's and Pump S | 11,000 | 11,000 | |
| Form/Rebar/Pour Wing Walls for Decant Struct's and Pump Stations | 33,000 | 33,000 | |
| Form/Rebar/Pour Wing Walls for Decant Struct's and Pump Stations | 33,000 | 33,000 | |
| Water Leak Test - Decant Struct's - Beds 1,2 | 1,798 | 1,798 | |
| Water Leak Test - Decant Struct's - Beds 3,4 | 1,797 | 1,797 | |
| Erect Grating & Handrail - Decant Struct's - Beds 1,2 3,4 | 71,890 | 71,890 | |
| Install Slide Gates at Structures - Beds 1,2 | 12,500 | 12,500 | |
| Install Slide Gates at Structures - Beds 3,4 | 12,500 | 12,500 | |
| Install Sub. Pumps in Beds 1 Pump Structure | 12,662 | 12,662 | |
| Install Sub. Pumps in Beds 3 Pump Structure | 12,661 | 12,661 | |
| Install DSL and TSL Piping at Structures - Beds 1,2 | 45,323 | 45,323 | |
| Install DSL and TSL Piping at Structures - Beds 3,4 | 45,323 | 45,323 | |
| Test/Flush DSL and TSL Piping - Beds 1,2 | 5,000 | 5,000 | |
| Test/Flush DSL and TSL Piping - Beds 3,4 | 5,000 | 5,000 | |
| Install / Fitup Equip & I&C Stands - Structures - Beds 1,2 | 12,391 | - | [1] |
| Install / Fitup Equip & I&C Stands - Structures - Beds ,3,4 | 12,391 | - | [1] |
| Install Direct Bury from Structures back to Plant -Tie-in and PG | 165,652 | - | [1] |
| Pull / Term Elect & I&C circuits - Beds 1,2,3,4 | 104,243 | - | [1] |
| SUBMERSIBLE PUMPS | 190,899 | 58,738 | [2] |
| WATER CONTROL GATES | 63,560 | 31,780 | [3] |
| Totals | 2,749,253 | 2,290,635 | |
| Cost per System | 2,749,253 | 2,290,635 | |

NOTES

1. Do not include in component base. Use overall multiplier for electrical costs.
2. Factored by 0.31 to reflect that 4 of 13 submersible pumps for the project are associated with this facility.
3. Factored by 0.5 to reflect that 4 of 8 control gates for the project are associated with this facility.



Project: SRWA Surface Water Supply Project
 Job No.: 693-20-16-01 Date: 3/28/2017
 Calc. By: W. Sandelin Chkd. By: A. Smith
 Subject: Drying Beds Cost Derivation

Adjustments

a. Inflation to Current Dollars
 ENR at Construction Midpoint 9972 (Jan 2015)
 Most Recent Available ENR 10530 (Dec 2016)
 ENR Ratio = 1.056 2,419,000

b. Inflation to Future Dollars
 Months to SRWA Construction Midpoint 42 (Jun 2020)
 Years to SRWA Construction Midpoint 3.5
 Most Recent Year/Year Inflation 3.1% (Dec 2015 to Dec 2016)
 Inflation to SRWA Construction Mid-point 1.11 2,691,000

c. Capacity Adjustment
 Costs for different sized systems can be estimated by multiplying the base cost by the ratio of their respective treatment capacities raised to a power factor. Power factor derived from AWWA and ASCE, Water Treatment Plant Design 26.6

Power factor = 0.60
 Installed capacity = 30 (mgd)

| Capacity Increments | Unit Component Cost, \$ |
|---------------------|-------------------------|
| 5 | 918,000 |
| 10 | 1,392,000 |
| 15 | 1,775,000 |
| 20 | 2,110,000 |
| 25 | 2,412,000 |
| 30 | 2,691,000 |
| 35 | 2,952,000 |
| 40 | 3,198,000 |
| 45 | 3,432,000 |



Project: SRWA Surface Water Supply Project
 Job No.: 693-20-16-01 Date: 3/28/2017
 Calc. By: W. Sandelin Chkd. By: A. Smith
 Subject: Chemical Facility Cost Derivation

COST ANALYSIS

Develop base cost for chemical facility from actual costs obtained for similar work at the WDCWA Regional Water Treatment Facility.

Project Cost Breakdown for Chemical Facility at the WDCWA Regional Water Treatment Facility

| Work Element | SOV | Use | Notes |
|---|-----------|-----------|-------|
| Over-Ex/Backfill Bottom of Slab (lower and Upper slabs) | 70,204 | 70,204 | |
| Re-Grade and Prep for SOG Level - Chem Facility | 45,000 | 45,000 | |
| Backfill and Grading at Perimeter to sub- grade - Chem Facility | 14,378 | 14,378 | |
| Form / Rebar / Pour - Lower Slabs, w/ Fdns for Pre-Engr'd Metal Bldg - Ct | 183,435 | 183,435 | |
| Form / Rebar / Pour - Pedestal for Sodium Bisulfite Tank. | 15,512 | 15,512 | |
| Form / Rebar / Pour - Containment walls - Chem Facility | 82,560 | 82,560 | |
| Form / Rebar / Pour - SOG Slab w/Fdns for Pre-Engr'd Metal Bldg- Chem | 183,434 | 183,434 | |
| Form / Rebar / Pour - Remaining Tank Pedestals Inside Bldg- Chem Facil | 50,000 | 50,000 | |
| Form / Rebar / Pour - Tank Pedestals Outside Bldg - Chem Facility | 50,000 | 50,000 | |
| Form / Rebar / Pour - HVAC Unit Foundations | 10,000 | 10,000 | |
| Install Stairways and Handrails (FRP & Aluminum)) | 179,725 | 179,725 | |
| Erect Rigid-Frame Steel, Girts and Purlins - Chem Facility | 234,426 | 234,426 | |
| Erect Insulated Metal Panels - Roof/Siding - Chem Facility | 190,000 | 190,000 | |
| Erect Purlins and Insulated Roof Panels above SB Tank - Chem Facility | 20,000 | 20,000 | |
| Install Masonry Walls - Chem Facility | 64,701 | 64,701 | |
| Install All Doors - Chem Facility | 64,701 | 64,701 | |
| Install Underslab Pipe - Lower Slabs - Chem Facility | 50,000 | 50,000 | |
| Install In-slab Pipe - Lower Slabs - Chem Facility | 5,000 | 5,000 | |
| Install Underslab Pipe - SOG Level - Chem Facility | 33,457 | 33,457 | |
| Install In-slab Pipe - SOG Level - Chem Facility | 5,000 | 5,000 | |
| Install Chem Storage Tanks (Inside Bldg (SHC,SH,NIP) - Chem Facility | 85,000 | 85,000 | |
| Install Chem Storage Tank (Inside Bldg (SB) - Chem Facility | 15,000 | 15,000 | |
| Install Chem Storage Tanks (Outside Bldg (FE, Phos Acid) - Chem Facility | 100,000 | 100,000 | |
| Install High Elev - Process/Chem Pipe - Chem Facility | 500,290 | 500,290 | |
| Install Chemical Pump Skids - Chem Facility | 181,340 | 181,340 | |
| Install PBU Units - Chem Facility | 50,000 | 50,000 | |
| Install Hookup Piping - Chem Facility | 65,000 | 65,000 | |
| Test/Flush Piping - Chem Facility | 75,500 | 75,500 | |
| Install High Elev - Fire Protection Pipe - Chem Facility | 150,000 | 150,000 | |
| Install Fire Protection Riser and Hookup - Chem Facility | 115,000 | 115,000 | |
| Hydro-Test Fire Protection Piping - Chem Facility | 13,230 | 13,230 | |
| Install High Elev - HVAC Ductwork - Chem Facility | 60,000 | 60,000 | |
| Install HVAC Equipment - Chem Facility | 140,000 | 140,000 | |
| Install HVAC Ductwork - Equip to Duct - Chem Facility | 60,000 | 60,000 | |
| Install HVAC Controls | 20,371 | 20,371 | |
| Install Underslab Electrical - Lower Slabs - Chem Facility | 21,739 | - | [1] |
| Install In-Slab Electrical - Lower Slabs - Chem Facility | 24,247 | - | [1] |
| Install Underslab Electrical - SOG Level - Chem Facility | 81,000 | - | [1] |
| Install In-Slab and Above Ground Electrical - SOG Level - Chem Facility | 94,000 | - | [1] |
| Install High Elev - Electrical & I&C Rough-in - Chem Facility | 60,868 | - | [1] |
| Install Electrical & I&C Equipment - Electrical Room - Chem Facility | 254,564 | - | [1] |
| Pull / Term from Electrical Room to XFMR - Chem Facility | 20,000 | - | [1] |
| Install and Fitup Electrical & I&C Stands - Chem Facility | 200,000 | - | [1] |
| Pull / Term / Test - Electrical & I&C Circuits - Chem Facility (including inter | 121,652 | - | [1] |
| Energize Electric and Test - Chem Facility | 16,174 | - | [1] |
| Paint Masonry Walls - Chem Facility | 25,000 | 25,000 | |
| Paint Pipe and Equipment | 50,000 | 50,000 | |
| Install Special Coatings - Sodium Bisulfite Tank Room - Inside Chem Bldg | 25,000 | 25,000 | |
| Install Special Coatings - Containment Areas - Outside Chem Bldg | 75,000 | 75,000 | |
| FRP CHEMICAL STORAGE TANKS | 643,717 | 643,717 | |
| CHEMICAL METERING PUMPS | 587,761 | 587,761 | |
| PBUs | 132,727 | 132,727 | |
| Totals | 5,616,000 | 4,721,000 | |
| Cost per System | 5,616,000 | 4,721,000 | |

NOTES

1. Do not include in component base. Use overall multiplier for electrical costs.
2. Not used.



Project: SRWA Surface Water Supply Project
 Job No.: 693-20-16-01 Date: 3/28/2017
 Calc. By: W. Sandelin Chkd. By: A. Smith
 Subject: Chemical Facility Cost Derivation

Adjustments

| | | | |
|--|-------|------------------------|-----------|
| a. Inflation to Current Dollars | | | |
| ENR at Construction Midpoint | 9972 | (Jan 2015) | |
| Most Recent Available ENR | 10530 | (Dec 2016) | |
| ENR Ratio = | 1.056 | | 4,985,000 |
| b. Inflation to Future Dollars | | | |
| Months to SRWA Construction Midpoint | 42 | (Jun 2020) | |
| Years to SRWA Construction Midpoint | 3.5 | | |
| Most Recent Year/Year Inflation | 3.1% | (Dec 2015 to Dec 2016) | |
| Inflation to SRWA Construction Mid-point | 1.11 | | 5,546,000 |

c. Capacity Adjustment

Costs for different sized systems can be estimated by multiplying the base cost by the ratio of their respective treatment capacities raised to a power factor. Power factor derived from AWWA and ASCE, Water Treatment Plant Design 26.6

Power factor = 0.60
 Installed capacity = 30 (mgd)

| Capacity Increments | Unit Component Cost, \$ |
|---------------------|-------------------------|
| 5 | 1,893,000 |
| 10 | 2,869,000 |
| 15 | 3,659,000 |
| 20 | 4,348,000 |
| 25 | 4,971,000 |
| 30 | 5,546,000 |
| 35 | 6,083,000 |
| 40 | 6,591,000 |
| 45 | 7,074,000 |



Project: SRWA Surface Water Supply Project
 Job No.: 693-20-16-01 Date: 3/28/2017
 Calc. By: W. Sandelin Chkd. By: A. Smith
 Subject: Operations Bldg Cost Derivation

COST ANALYSIS

Develop base cost for operations building from actual costs obtained for similar work at the WDCWA Regional Water Treatment Facility.

Project Cost Breakdown for Operations Building at the WDCWA Regional Water Treatment Facility

| Work Element | SOV | Use | Notes |
|---|-----------|-----------|-------|
| Over-Ex/Backfill to Sub Grade and for Cut Wall | 35,947 | 35,947 | |
| Encase Plumbing and Backfill | 10,000 | 10,000 | |
| Backfill over Elec/Plmg In-Slab & Perimeter of Bldg | 76,268 | 76,268 | |
| Final Backfill to Subgrade around Building | 14,378 | 14,378 | |
| Install Cut-off Wall | 10,000 | 10,000 | |
| FRP 3 Column Foundations | 31,550 | 31,550 | |
| FRP Beams and Remaining Footings | 100,000 | 100,000 | |
| FRP Building Slab | 193,457 | 193,457 | |
| FRP HVAC Equipment Foundations | 7,189 | 7,189 | |
| Install Masonry Walls | 295,000 | 295,000 | |
| Install Structural Roof Steel and Decking | 85,000 | 85,000 | |
| Install Roof Insulation and Standing Seam Roof | 140,000 | 140,000 | |
| Install Exterior Windows and Doors | 116,268 | 116,268 | |
| Install Metal Canopies, Trellis, Flashing and other Misc Metals | 97,010 | 97,010 | |
| Install Under Foundation Plumbing - Operations Bldg | 5,000 | 5,000 | |
| Install Underslab Plumbing | 90,000 | 90,000 | |
| Install In-Slab Plumbing | 10,000 | 10,000 | |
| Install Plumbing Roof Penetrations | 5,000 | 5,000 | |
| Install Above Ceiling Plumbing and Fire Protection - Rough-in | 200,000 | 200,000 | |
| Install In-Wall Plumbing - Rough-in | 303,900 | 303,900 | |
| Install Plumbing Fixtures | 100,000 | 100,000 | |
| Install Utility Room Equipment and Hook-up | 25,000 | 25,000 | |
| Install Fire Protection Riser and Hookup | 24,701 | 24,701 | |
| Install Fire Sprinklers into Ceiling Grid System | 20,000 | 20,000 | |
| Install Above Ceiling HVAC Ductwork - Rough-in | 170,000 | 170,000 | |
| Hook-up Above Ceiling HVAC Equip - Elec and Plumbing | 5,000 | 5,000 | |
| Install HVAC Unit - Outside | 287,560 | 287,560 | |
| Install HVAC Ductwork for AHU Hookup | 30,000 | 30,000 | |
| Install HVAC Diffusers into Grid system | 25,000 | 25,000 | |
| Startup and Commission HVAC | 14,426 | 14,426 | |
| Install Under Foundation Electrical | 7,512 | - | [1] |
| Install Underslab Electrical and Grounding Ring | 30,048 | - | [1] |
| Install In-Slab Electrical | 25,048 | - | [1] |
| Install all Electrical Roof Penetrations | 9,358 | - | [1] |
| Rough-in Electrical Systems Conduit - Above Ceiling | 46,785 | - | [1] |
| ough-in Electrical Systems Conduit - In-Wall | 62,396 | - | [1] |
| Install Electrical Panels and Equipment | 97,826 | - | [1] |
| Install I & C Panels | 13,043 | - | [1] |
| Install Fire Alarm Panel and System | 45,652 | - | [1] |
| Install Security Panel and System | 117,391 | - | [1] |
| Pull / Term / Test Electrical Systems - within Building | 82,956 | - | [1] |
| Install Light Fixtures into Grid System - Hookup | 71,739 | - | [1] |
| Energize and Test Electrical Room. | 16,174 | - | [1] |
| Install Laboratory Cabinets, Shelves and Counters | 101,050 | 101,050 | |
| Install Laboratory Equipment | 18,707 | 18,707 | |
| Install Interior Wall/Ceiling Framing and Opening Frames | 215,670 | 215,670 | |
| Install Sheetrock and Water Board | 143,780 | 143,780 | |
| Install Quarry Tile - Bathrooms/Locker Rooms | 100,646 | 100,646 | |
| Install Cabinetry (not including LAB) | 35,945 | 35,945 | |
| Paint Interior Walls and Ceilings | 57,512 | 57,512 | |
| Install Restroom/Shower/Locker Room Accessories | 35,945 | 35,945 | |
| Install Ceiling Grid - Rough-in | 20,000 | 20,000 | |
| Install Ceiling Tiles | 15,945 | 15,945 | |
| Install Floor Finishes | 43,134 | 43,134 | |
| Interior Doors and Glazing | 57,512 | 57,512 | |
| Final Finishes and Touch-up | 21,567 | 21,567 | |
| Furnish and Install Office Furniture & Cubicles | 23,951 | 23,951 | |
| FURNITURE | 50,000 | 50,000 | |
| Totals | 4,094,946 | 3,469,018 | |
| Cost per System | 4,094,946 | 3,469,018 | |

NOTES



Project: SRWA Surface Water Supply Project
Job No.: 693-20-16-01 Date: 3/28/2017
Calc. By: W. Sandelin Chkd. By: A. Smith
Subject: Operations Bldg Cost Derivation

1. Do not include in component base. Use overall multiplier for electrical costs.
2. Not used.



Project: SRWA Surface Water Supply Project
 Job No.: 693-20-16-01 Date: 3/28/2017
 Calc. By: W. Sandelin Chkd. By: A. Smith
 Subject: Operations Bldg Cost Derivation

Adjustments

| | | | |
|--|-------|------------------------|-----------|
| a. Inflation to Current Dollars | | | |
| ENR at Construction Midpoint | 9972 | (Jan 2015) | |
| Most Recent Available ENR | 10530 | (Dec 2016) | |
| ENR Ratio = | 1.056 | | 3,663,000 |
| b. Inflation to Future Dollars | | | |
| Months to SRWA Construction Midpoint | 42 | (Jun 2020) | |
| Years to SRWA Construction Midpoint | 3.5 | | |
| Most Recent Year/Year Inflation | 3.1% | (Dec 2015 to Dec 2016) | |
| Inflation to SRWA Construction Mid-point | 1.11 | | 4,075,000 |

c. Capacity Adjustment

Costs for different sized systems can be estimated by multiplying the base cost by the ratio of their respective treatment capacities raised to a power factor. Power factor derived from AWWA and ASCE, Water Treatment Plant Design 26.6

Power factor = 0.60
 Installed capacity = 30 (mgd)

| Capacity Increments | Unit Component Cost, \$ |
|---------------------|-------------------------|
| 5 | 1,391,000 |
| 10 | 2,108,000 |
| 15 | 2,688,000 |
| 20 | 3,195,000 |
| 25 | 3,653,000 |
| 30 | 4,075,000 |
| 35 | 4,470,000 |
| 40 | 4,843,000 |
| 45 | 5,197,000 |



Project: SRWA Surface Water Supply Project
 Job No.: 693-20-16-01 Date: 3/28/2017
 Calc. By: W. Sandelin Chkd. By: A. Smith
 Subject: Maintenance Bldg Cost Derivation

COST ANALYSIS

Develop base cost for maintenance building from actual costs obtained for similar work at the WDCWA Regional Water Treatment Facility.

Project Cost Breakdown for Maintenance Building at the WDCWA Regional Water Treatment Facility

| Work Element | SOV | Use | Notes |
|--|-----------|-----------|-------|
| Over-Exc/Backfill up to bottom of Slab | 30,323 | 30,323 | |
| Backfill Underslab Electrical and Plumbing | 20,000 | 20,000 | |
| Final Backfill around perimeter of Bldg | 2,876 | 2,876 | |
| FRP Building Slab with Thickened Edge (2 Pours) | 115,024 | 115,024 | |
| FRP Slabs for HVAC Equipment | 7,189 | 7,189 | |
| Erect Rigid Steel Frame, Girts and Purlins | 101,670 | 101,670 | |
| Erect Insulated Metal Panels - Roof/Siding | 104,000 | 104,000 | |
| Install Exterior Doors and Glazing | 10,000 | 10,000 | |
| Install Underslab Plumbing - Maint Bldg | 16,567 | 16,567 | |
| Install In-Slab Plumbing | 5,000 | 5,000 | |
| Rough-in Plumbing Above Ceiling Height | 143,780 | 143,780 | |
| Rough-in Plumbing in Walls | 147,560 | 147,560 | |
| Install Plumbing Fixtures | 140,000 | 140,000 | |
| Install HVAC Equipment | 107,835 | 107,835 | |
| Install Ductwork Above typical Suspended Ceiling H | 61,890 | 61,890 | |
| Install Remaining Ductwork | 10,000 | 10,000 | |
| Install Diffusers and Balance | 10,784 | 10,784 | |
| Install Underslab Electrical and Grounding Ring | 26,500 | - | [1] |
| Install In-slab Electrical | 10,022 | - | [1] |
| Install Electrical Above typical Suspended Ceiling | 48,260 | - | [1] |
| Install Electrical at Interior Walls | 48,260 | - | [1] |
| Install Electrical Panels. | 16,200 | - | [1] |
| Pull / Term / Test Electrical - within Bldg | 56,870 | - | [1] |
| Install Building Lights and Hook-up | 19,565 | - | [1] |
| Energize Electrical and Test - Maintenance Bldg | 16,174 | - | [1] |
| Frame Interior Divider Walls | 79,079 | 79,079 | |
| Install Sheetrock and Waterboard | 50,323 | 50,323 | |
| Paint Interior Walls | 28,756 | 28,756 | |
| Install Quarry Tile in Bathroom / Shower | 43,134 | 43,134 | |
| Install Floor Sealer | 35,945 | 35,945 | |
| Install Ceiling Grid | 21,567 | 21,567 | |
| Install Restroom / Shower Room Accessories | 14,378 | 14,378 | |
| Interior Doors and Glazing | 43,134 | 43,134 | |
| Totals | 1,592,665 | 1,350,814 | |
| Cost per System | 1,592,665 | 1,350,814 | |

NOTES

1. Do not include in component base. Use overall multiplier for electrical costs.
2. Not used.



Project: SRWA Surface Water Supply Project
 Job No.: 693-20-16-01 Date: 3/28/2017
 Calc. By: W. Sandelin Chkd. By: A. Smith
 Subject: Maintenance Bldg Cost Derivation

Adjustments

| | | | |
|--|-------|------------------------|-----------|
| a. Inflation to Current Dollars | | | |
| ENR at Construction Midpoint | 9972 | (Jan 2015) | |
| Most Recent Available ENR | 10530 | (Dec 2016) | |
| ENR Ratio = | 1.056 | | 1,427,000 |
| b. Inflation to Future Dollars | | | |
| Months to SRWA Construction Midpoint | 42 | (Jun 2020) | |
| Years to SRWA Construction Midpoint | 3.5 | | |
| Most Recent Year/Year Inflation | 3.1% | (Dec 2015 to Dec 2016) | |
| Inflation to SRWA Construction Mid-point | 1.11 | | 1,588,000 |

c. Capacity Adjustment

Costs for different sized systems can be estimated by multiplying the base cost by the ratio of their respective treatment capacities raised to a power factor. Power factor derived from AWWA and ASCE, Water Treatment Plant Design 26.6

Power factor = 0.60
 Installed capacity = 30 (mgd)

| Capacity Increments | Unit Component Cost, \$ |
|---------------------|-------------------------|
| 5 | 542,000 |
| 10 | 821,000 |
| 15 | 1,048,000 |
| 20 | 1,245,000 |
| 25 | 1,423,000 |
| 30 | 1,588,000 |
| 35 | 1,742,000 |
| 40 | 1,887,000 |
| 45 | 2,025,000 |



From: Michael Cooke, TAC Member

Prepared by: Monique Day, Program Management Team

1. ACTION RECOMMENDED:

Resolution: Declaring intention to seek reimbursement for expenditures paid prior to the issuance of the obligations or the approval by the State Water Board (Drinking Water State Revolving Fund (SRF) Program) for the SRWA Surface Water Supply Project (Project) funds in the maximum principal amount of \$275,654,000.

2. DISCUSSION OF ISSUE:

To reduce the cost burden on the Project partners' ratepayers, a funding strategy was adopted by the SRWA Board on August 11, 2016 to aggressively pursue all forms of potential outside funding for the Project. Consistent with this funding strategy, SRWA submitted a General Application for Drinking Water SRF funding in December 2016 expressing its intentions to finance the costs of designing and constructing the Project with a Drinking Water SRF low-interest loan. The General Application was the first of four application packages required to be considered for an SRF loan. The other three packages include the Financial, Environmental, and Technical application packages.

One of the requirements of the Financial application package is the Tax Questionnaire, which is used by SRF to determine whether SRWA is eligible to receive funds from tax-exempt revenue bond sales. Approval of the Tax Questionnaire, and subsequent confirmation that SRWA will be eligible to receive SRF financing, is critical to the ongoing efforts with SRF. SRF staff has reviewed a draft Tax Questionnaire prepared by SRWA and determined that a necessary next step prior to submitting the Tax Questionnaire is the adoption of this resolution.

While issues with SRWA's eligibility are not expected, early submittal of the Tax Questionnaire will provide sufficient time to pursue other funding sources if SRWA is found ineligible for SRF funding or, if possible, address the issues that are making SRWA ineligible so that it becomes eligible, without impacting the overall Project schedule. To submit the Tax Questionnaire for SRF staff review, SRWA must have an adopted resolution that states that the SRWA intends, and reasonably expects, to "reimburse expenditures paid prior to the issuance of the Obligations or the approval by the State Water Board of the Project Funds."

Pending the approval of this resolution, staff is prepared to submit the Tax Questionnaire to confirm SRWA's eligibility for SRF funding. Following confirmation of eligibility, the remaining portions of the Financial application package are planned to be submitted to the state later this year.

3. FISCAL IMPACT / BUDGET AMENDMENT:

There will be some costs associated with preparing the SRF loan application packages (the cost for the application preparation will be brought to the Board for consideration at a future meeting as part of West Yost's Phase 2 contract); however, these costs will be offset by the large savings expected over time with the low-interest rate SRF loan. Compared to a municipal bond (assumed at 4%¹), the low-interest rate SRF loan (assumed at 1.7%²) is expected to save SRWA about \$51 million in interest costs over the 20-year loan period.

4. INTERIM GENERAL MANAGER'S COMMENTS:

Recommend approval.

5. ENVIRONMENTAL DETERMINATION: N/A

6. ALTERNATIVES:

If the Board wants to pursue an SRF loan for this project the adoption of this resolution is required. The alternative is to not adopt this resolution and, therefore, not apply for an SRF loan.

¹ 4% is an example of a typical municipal bond interest rate and is used for illustration purposes only.

² The SRF loan interest rate is half of the State's average general obligation bond rate for the previous calendar year. The Drinking Water SRF interest rate in 2017 is 1.7%. This rate is shown for illustration purposes only. SRWA's interest rate for an SRF loan will not be known until the calendar year in which SRWA signs an SRF loan agreement.



BEFORE THE BOARD OF THE STANISLAUS REGIONAL WATER AUTHORITY

**IN THE MATTER OF DECLARING INTENTION
OF THE STANISLAUS REGIONAL WATER
AUTHORITY TO SEEK REIMBURSEMENT OF
WATER SUPPLY PROJECT EXPENDITURES
FROM THE DRINKING WATER STATE REVOLVING
FUND PROGRAM**

}
}
}
}
}
}

RESOLUTION NO. 2017-xxx

WHEREAS, the Stanislaus Regional Water Authority (the “Agency”) desires to finance the costs of constructing and/or reconstructing certain public facilities and improvements relating to its water system, including certain treatment facilities, pipelines and other infrastructure (the “Project”); and

WHEREAS, the Agency intends to finance the construction and/or reconstruction of the Project or portions of the Project with moneys (“Project Funds”) provided by the State of California, acting by and through the State Water Resources Control Board (“State Water Board”); and

WHEREAS, the State Water Board may fund the Project Funds with proceeds from the sale of obligations the interest upon which is excluded from gross income for federal income tax purposes (the “Obligations”); and

WHEREAS, prior to either the issuance of the Obligations or the approval by the State Water Board of the Project Funds the Agency desires to incur certain capital expenditures (the “Expenditures”) with respect to the Project from available monies of the Agency; and

WHEREAS, the Agency has determined that those moneys to be advanced on and after the date hereof to pay the Expenditures are available only for a temporary period and it is necessary to reimburse the Agency for the Expenditures from the proceeds of the Obligations.

NOW, THEREFORE, THE AGENCY DOES HEREBY RESOLVE, ORDER AND DETERMINE AS FOLLOWS:

SECTION 1. The Agency hereby states its intention and reasonably expects to reimburse Expenditures paid prior to the issuance of the Obligations or the approval by the State Water Board of the Project Funds.

SECTION 2. The reasonably expected maximum principal amount of the Project Funds is \$275,654,000.00.

SECTION 3. This resolution is being adopted no later than sixty (60) days after the date on which the Agency will expend moneys for the construction portion of the Project costs to be reimbursed with Project Funds.

SECTION 4. Each Agency expenditure will be of a type properly chargeable to a capital account under general federal income tax principles.

SECTION 5. To the best of our knowledge, this Agency is not aware of the previous adoption of official intents by the Agency that have been made as a matter of course for the purpose of reimbursing expenditures and for which tax-exempt obligations have not been issued.

SECTION 6. This resolution is adopted as official intent of the Agency in order to comply with Treasury Regulation §1.150-2 and any other regulations of the Internal Revenue Service relating to the qualification for reimbursement of Project costs.

SECTION 7. All the recitals in this Resolution are true and correct and this Agency so finds, determines and represents.

PASSED AND ADOPTED at a regular meeting of the Board of the Stanislaus Regional Water Authority this ___ day of _____, 2017, by the following vote:

AYES:
NOES:
NOT PARTICIPATING:
ABSENT:

ATTEST:

Tish Foley, Board Secretary

CERTIFICATION

I do hereby certify that the foregoing is a full, true, and correct copy of a resolution duly and regularly adopted at a meeting of the STANISLAUS REGIONAL WATER AUTHORITY held on (DATE).

Tish Foley
Board Secretary



From: Marie Lorenzi, Senior Accountant

Prepared by: Marie Lorenzi, Senior Accountant

1. ACTION RECOMMENDED:

Resolution: Adopting the Annual Budget for the Stanislaus Regional Water Authority for the 2017-18 Fiscal Year and Adopting a minimum cash reserve target for 2017-18

2. DISCUSSION OF ISSUE:

In accordance with Article VII (F) of the Joint Powers Agreement, the Governing Board of the Stanislaus Regional Water Authority (SRWA) is hereby presented with the proposed 2017-18 annual budget for the JPA. The proposed budget is prepared based on the estimated unexpended balance of the JPA's existing contracts plus the estimated administrative costs for 2017-18 based on how those functions are currently being executed.

The proposed budget does not contain appropriations for projects that the Board may be asked to consider during the 2017-18 fiscal year - specifically Phase II of the surface water project design and planning process. As the planning process proceeds and the Board executes new contracts or amendments to existing contracts for the next phase of the project, budget amendments will be brought before the Board for consideration.

Article XV(F) of the Joint Powers Agreement states that the following with regard to the JPA's cash reserves:

The Governing Board shall determine on an annual basis, prior to the beginning of each fiscal year, a level of reasonable cash reserves to be accumulated by the Authority. This reserve shall be accumulated from revenues collected in excess of all actual costs of the Authority. Once the targeted reserve level is reached, all additional revenues collected in excess of the actual costs of the Authority shall be considered excess revenue and, subject to any limitation in any bond or other financing agreement, carried forward as revenue for the next fiscal year and serve to reduce each Participant's respective assessment for such subsequent fiscal year.

As part of the 2016-17 budget, Staff recommended that the then current process of requiring the JPA participants to pay periodic deposits when requested continue into 2016-17. During the May 25, 2017 Board meeting, Staff revisited this topic due to the increasing expenditure level as the project's planning and design proceeded. During that meeting, Staff discussed with the Board an appropriate reserve level and recommended a minimum reserve sufficient to fund 3 months of projected expenditures. Staff indicated that this item would be brought back to the Board for consideration in conjunction with the adoption of the 2017-18 budget.

3. FISCAL IMPACT / BUDGET AMENDMENT:

The proposed 2017-18 annual budget for the SRWA totals \$1,319,040 consisting of \$1,045,440 in appropriations related to the contracts for program management (West Yost Associates), environmental services (Horizon Water and Environment), wet well design and construction (West Yost Associates), and special legal services (Bartkewicz, Kronick & Shanahan); \$86,000 in appropriations related to permitting and property acquisition; and \$187,600 in appropriations for administrative support including the services of the interim General Manager.

In accordance with the current Joint Powers Agreement, the participants (City of Ceres and City of Turlock) will share equally in funding most of these expenditures. The Turlock Irrigation District will share in the funding of the district delivery facilities. The estimated contribution from TID based on the status of the current contracts related to the district delivery facilities is \$48,630. The estimated contributions for the Cities of Turlock and Ceres for 2017-18 based on the proposed budget are \$526,670 and 530,575, respectively.

Attached to the Resolution is the detail for the proposed 2017-18 budget along with a second schedule summarizing the project's total revenues and expenses since December 2015.

Included in the attached Resolution approving the 2017-18 budget is authorization to the Finance Director to adjust the 2017-18 appropriations related to the contracts for West Yost Associates (both project management and wet well contracts), Horizon Water and Environment, and Bartkewicz, Kronick & Shanhan to the previously approved, unexpended portions of their contracts at June 30, 2017 without bringing formal action back before the Board. If any of these contracts are amended beyond the approved contract amount at June 30, 2017, this amendment would also require a budget adjustment.

4. INTERIM GENERAL MANAGER'S COMMENTS:

Recommend approval.

5. ENVIRONMENTAL DETERMINATION: N/A

6. ALTERNATIVES:

The Board may approve amendments as desired to the proposed 2017-18 annual budget for the SRWA.

Stanislaus Regional Water Authority

Proposed Budget for 2017-18

ATTACHMENT A.1

| | 2015-16 Final | 2016-17 Amended Budget | 2016-17 YTD as of 6-26-2017 | 2016-17 Projected for Full Year | 2017-18 Proposed Budget |
|--|---------------------|------------------------------|-----------------------------------|---------------------------------------|-------------------------------|
| REVENUES | | | | | |
| 950-53-552 33000 Interest Income | (609.16) | 0.00 | 209.09 | (1,000.00) | (750.00) |
| 950-53-552 34900 001 Member Agency Contributions Turlock, City of | (347,487.50) | (1,733,248.00) | (1,175,000.00) | (1,175,000.00) | (526,670.00) |
| 950-53-552 34900 002 Member Agency Contributions Ceres, City of | (379,561.50) | (1,733,248.00) | (1,138,659.60) | (1,138,659.60) | (530,575.00) |
| 950-53-552 34900 003 Member Agency Contributions Modesto, City of | | | | | |
| TID Contribution | | | | (107,000.00) | (48,630.00) |
| Total Revenues | (727,658.16) | (3,466,496.00) | (2,313,450.51) | (2,421,659.60) | (1,106,625.00) |
| EXPENDITURES | | | | | |
| 950-53-552 43011 Gov't Relations / Public Affairs | | 80,000.00 | 54,199.05 | 60,148.00 | 19,850.00 |
| 950-53-552 43055 002 Consultant Audit | | 5,400.00 | 5,400.00 | 5,400.00 | 5,750.00 |
| 950-53-552 43060 012 Contract Services Program Management Services | 410,015.90 | 2,134,891.00 | 1,650,248.30 | 1,440,191.00 | 694,700.00 |
| 950-53-552 43105 003 Interdepartmental Admin Support Clerical | 23,165.12 | 57,200.00 | 34,786.63 | 10,146.00 | 15,000.00 |
| Accounting | | | | 8,295.00 | 12,500.00 |
| Interim JPA Attorney | | | | 22,200.00 | 22,000.00 |
| 950-53-552 43106 001 Administrative Support Ceres Interim General Manager | 32,074.00 | 123,000.00 | 105,733.60 | 106,088.00 | 125,000.00 |
| 950-53-552 43195 Special Legal Counsel | 12,547.49 | 87,450.00 | 27,577.76 | 33,560.00 | 53,890.00 |
| 950-53-552 43329 Environmental Services | 13,545.45 | 586,745.00 | 219,077.53 | 374,745.00 | 212,000.00 |
| 950-53-552 43332 Permitting | | 50,000.00 | 0.00 | 0.00 | 56,000.00 |
| 950-53-552 44001 000 Supplies General | 115.51 | 500.00 | 29.98 | 315.00 | 500.00 |
| 950-53-552 44035 Photo Copies | 45.51 | 150.00 | 67.75 | 150.00 | 250.00 |
| 950-53-552 44040 000 Postage General | 8.58 | 2,550.00 | 486.23 | 2,550.00 | 5,000.00 |
| 950-53-552 47010 Bank Charges | 14.91 | 50.00 | 0.00 | 50.00 | 100.00 |
| 950-53-552 47040 000 Dues Miscellaneous | | 375.00 | 375.00 | 375.00 | 500.00 |
| 950-53-552 47095 000 Training General | 0.00 | 1,000.00 | 0.00 | 0.00 | 1,000.00 |
| 950-53-552 51001 Property Acquisition | | 30,000.00 | 0.00 | 0.00 | 30,000.00 |
| 950-53-552 51800 001 SRWA Capital Projects Wet Well Design/Constructn Mgmt | | 390,160.00 | 264,169.34 | 325,160.00 | 65,000.00 |
| Total Expenditures | 491,532.47 | 3,549,471.00 | 2,362,151.17 | 2,389,373.00 | 1,319,040.00 |
| Revenues over (under) Expenditures | (236,125.69) | 82,975.00 | 48,700.66 | (32,286.60) | 212,415.00 |
| (Unexpended) Member Contributions | (236,125.69) | | | (268,412.29) | (55,997.29) |

Stanislaus Regional Water Authority
Projected through 2017-18 Budget

ATTACHMENT A.2

| | Ceres | Turlock | TID | Total |
|--|---------------------|---------------------|-------------------|---------------------|
| Expenses | | | | |
| Actual Expenses for 2015-16 | 245,766.24 | 245,766.23 | | 491,532.47 |
| Projected Expenses to date for 2016-17 | 1,141,186.50 | 1,141,186.50 | 107,000.00 | 2,389,373.00 |
| Proposed Expenses for 2017-18 | 635,205.00 | 635,205.00 | 48,630.00 | 1,319,040.00 |
| Total project to date expenses (since Dec 2015) | 2,022,157.74 | 2,022,157.73 | 155,630.00 | 4,199,945.47 |
| Contributions | | | | |
| Contribution #1 | 347,487.50 | 347,487.50 | | 694,975.00 |
| Credit for Interim General Manager For 2015-16 | 32,074.00 | | | 32,074.00 |
| Contribution #2 | 467,926.00 | 500,000.00 | | 967,926.00 |
| Contribution #3 | 200,000.00 | 200,000.00 | | 400,000.00 |
| Contribution #4 | 365,000.00 | 475,000.00 | | 840,000.00 |
| Credit for Interim General Manager For July - Dec 2016 | 53,088.00 | | | 53,088.00 |
| For Jan - June 2017 | 52,645.60 | | | 52,645.60 |
| Amount to be billed to TID | | | 107,000.00 | 107,000.00 |
| Total Contributions through 6-30-2017 | 1,518,221.10 | 1,522,487.50 | 107,000.00 | 3,147,708.60 |
| Projected for 2017-18 | 500,575.00 | 496,670.00 | 48,630.00 | 1,045,875.00 |
| Additional Contribution for Reserves | 30,000.00 | 30,000.00 | | 60,000.00 |
| Total Projected Contributions | 2,048,796.10 | 2,049,157.50 | 155,630.00 | 4,253,583.60 |
| Revenues In Excess of Actual & Projected Expenditures | 26,638.36 | 26,999.77 | 0.00 | 53,638.13 |



BEFORE THE BOARD OF THE STANISLAUS REGIONAL WATER AUTHORITY

**IN THE MATTER OF ADOPTING THE ANNUAL
BUDGET FOR THE STANISLAUS REGIONAL
WATER AUTHORITY FOR THE 2017-18 FISCAL
YEAR AND ADOPTING A MINIMUM CASH
RESERVE TARGET FOR 2017-18**

RESOLUTION NO. 2017-xxx

WHEREAS, the Finance Director presented the proposed 2017-18 fiscal year budget to the Stanislaus Regional Water Authority (SRWA) Board for their consideration; and

WHEREAS, the SRWA Board reviewed the submitted budget and desires to adopt the 2017-18 fiscal year budget as detailed in Exhibit A to this resolution; and

WHEREAS, contained in the proposed budget are appropriations for various contracts (West Yost Associates for program management and wet well design/construction, Horizon Water & Environment for environmental services, and Bartkiewicz Kronick & Shanahan for outside legal services) entered into during fiscal year 2015-16 or 2016-17 for which the scope of work is anticipated to span more than one fiscal year; and

WHEREAS, Staff provided their best estimate as to the amount of the previously approved appropriation related to these contracts that should be carried from the 2016-17 fiscal year to the 2017-18 fiscal year; and

WHEREAS, the SRWA Board considered the recommendation by the Finance Director to authorize the automatic adjustment (without additional formal Board action) in fiscal year 2017-18 to the proposed appropriations for these contracts to the actual unexpended amount as of June 30, 2017. Said amount to be determined upon the completion of the accounting for the 2016-17 fiscal year;

WHEREAS, in accordance with Article XV(F) of the Joint Powers Agreement, Staff recommends a targeted cash reserve level of three (3) months of expenditures as projected by the Finance Director in consultation with the Project Manager and General Manager.

NOW, THEREFORE, BE IT RESOLVED that the Board of the Stanislaus Regional Water Authority does hereby:

1. Adopt the annual budget for the SRWA for the 2017-18 fiscal year in the amount of \$1,319,040 as detailed in Exhibit A. As stated in Exhibit A to the

SRWA Joint Powers Authority Agreement, the Cities of Turlock and Ceres will share equally in the funding of the SRWA's expenditures for 2017-18 fiscal year with the exception of the district delivery facilities whose related expenses will be partially funded by the Turlock Irrigation District in accordance with the Water Sales Agreement; and

2. Authorize the Finance Director to review the unexpended portions of the previously approved contracts with West Yost Associates for program management and wet well design/construction, Horizon Water & Environment for environmental services, and Bartkiewicz Kronick & Shanahan for outside legal services once the accounting for the 2016-17 fiscal year is complete and to adjust the fiscal year 2017-18 appropriation related to each of these contracts to the previously approved, unexpended balance;
3. Approve a target cash reserve balance equal to three (3) months of expenditures as projected by the Finance Director in consultation with the Project Manager and General Manager and authorize the Finance Director to send invoices to the Cities of Ceres and Turlock and the Turlock Irrigation District for their proportionate share of projected expenditures.

PASSED AND ADOPTED at a special meeting of the Board of the Stanislaus Regional Water Authority this 7th day of July, 2017, by the following vote:

AYES:
NOES:
NOT PARTICIPATING:
ABSENT:

ATTEST:

Tish Foley, Board Secretary