Chapter 6
Operational Analysis

2020 City of Billings Water Master Plan
(Final Draft)

City of Billings, MT

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Introduction

The City of Billings is planning a new West End Water Treatment Plant (WEWTP) to work in conjunction with the existing WTP for delivery of treated water to the distribution system. The distribution operations will then need to account for the new WEWTP operating on its own, as well as the two plants operating simultaneously.

Key operational elements of the WEWTP in comparison to the existing WTP are:

- The WEWTP will be higher in elevation,
- The WEWTP will be constructed to deliver approximately 18 mgd and will likely have more efficient operations primarily related to screening and residuals handling, and
- The WEWTP is planned to be located in Zone 3 and can also be connected to Zone 2 with about a half-mile of new waterline. Whereas the existing WTP is connected to Zone 1, Zone 2 and Zone 2E with Zone 2 and 2E being interconnected inside the existing High Service Pump Station (HSPS) which serves as the common discharge header of the Zone 2 HSPS pumps.

In consideration of these new operational elements, the water model was further developed and used to evaluate potential options for the two-plant operation. Additionally, other potential operational changes of the water distribution system were analyzed.

Two-Water Treatment Plant Operations Analysis

Assumptions

One of the primary goals of the WEWTP is to improve the overall resiliency of the City's water system through its ability to supply the entire water distribution system in the event the existing WTP is off-line. The WEWTP is planned to be located just west of the Shiloh Road and Hesper Road intersection on the south side of the road. Since this site is located in Zone 3, at a minimum, the WEWTP high service pumps would be used to supply this zone. If the discharge of the WEWTP was designed to only supply Zone 3, then water would need to transfer from Zone 3 to Zone 2 and then transfer from Zone 2 to Zone 1 to supply the entire distribution system. Under this operational approach, each transfer from a higher to a lower pressure zone would be accompanied by a drop in pressure for that zone.

As an operational alternative, the City could also directly connect the WEWTP to the Zone 2 waterline (24-inch) at Gabel Road and Hesper Road, which is approximately a half-mile from the WEWTP. This additional direct connection to Zone 2, would significantly reduce the energy usage (when only the WEWTP is operating) as Zone 1, Zone 2 and Zone 2E represent about 65% of the overall system demand.

A similar operational assessment of a direct connection to Zone 1 was also performed to evaluate its cost effectiveness. Given that a new direct connection to Zone 1 would require over 6 miles of pipe, this capital investment was not deemed to be cost effective for the short amount of time that the WEWTP would be the only plant operating. Based on these findings and discussions with City staff, the modeling analysis performed herein was focused as follows:

- One modeling scenario was performed to evaluate a Zone 3 only connection from the WEWTP.
- The rest of the modeling scenarios were performed using a Zone 3 and a Zone 2 connection.
- For each modeling scenario, the Zone 3 connection was assumed to be at King Avenue and 44th St. West with the Zone 2 connection at Hesper Road and Gabel Road.

The WEWTP connection to Zone 3 would allow water to also be distributed to Zone 4, 5, 5W and 6. The connection to Zone 2 would provide water to Zone 3S and Zone 4S. A bypass of the Zone 2 check valve at the existing WTP High Service Pump Station (HSPS) would allow water to move from Zone 2 to Zone 2E. A connection from Zone 2 to Zone 1 at the HSPS (that includes a sleeve valve to safely drop the pressure of water moving from Zone 2 to Zone 1) would supply water to Zone 1. The Zone 2 to 2E connection would then provide water to Zone 3E, Zone 4E and Zone 4N similar to the typical current operation. Proceeding in this manner, the WEWTP would be configured to supply the City's entire water distribution system, with the final assessment of system pressures derived from the modeling analysis scenarios. A schematic of the water system that includes the WEWTP is provided in Figure 6-1 at the end of the chapter. Black arrows on the schematic indicate the water flow path for the WEWTP to meet the demands of the entire system.

As presented in Chapter 3, the current average day demand is 20.0 mgd. Minimum demands are as low as 10-11 mgd. Under theses demand conditions, a goal of the WEWTP is to meet the entire system winter demands (when the existing WTP is off-line) and a rationed water demand during other times of the year. Another goal of the WEWTP would be to supplement the existing WTP delivered capacity (60 mgd) so that together, both plants could meet the projected 2040 peak day of 68.7 mgd. The assumed WEWTP delivered capacity of 18 mgd would be able to meet both these goals.

An analysis of various modes of operations and demands for the two-water treatment plant system is provided in the following sections.

Only WEWTP Operating/Connected to Only Zone 3

Description

The existing WTP is off-line and the WEWTP provides up to 18 mgd of treated water to Zone 3. A pressure zone transfer station at Voelker Pump Station allows water to go from Zone 3 to Zone 2. The rest of the distribution system is supplied as described above.

Benefit

This option would save money by avoiding the cost of the half-mile pipeline that is required to also connect directly to Zone 2 that includes going through the Shiloh Road/Hesper Road intersection and under the BBWA Canal.

Results

High pressures and high velocities are expected in the piping in King Ave. and near the Voelker Pump Station. To improve the performance of this option, pipe sizes would need to be increased or pipes paralleled which would begin to reduce the benefit of avoiding the Zone 2 connection.

Concerns

- High pressures and velocities on King Ave. and near Voelker.
- Energy wasted by not going directly to Zone 2 from the WEWTP (about $400 per day).
- The water system would have less resiliency with only one connection to the distribution system while the existing WTP is off-line.
- Stagnant water at the existing WTP when not operating. Water would be flowing into and out of HSPS so those waterlines would have water movement, but the pipelines and facilities within the plant would not.

Recommendations

Only connecting to Zone 3 from the WEWTP is not recommended.

Only WEWTP Operating/Connected to Both Zones 2 and 3

Description

The existing WTP is off-line and the WEWTP delivers 18 mgd of treated water to Zones 2 and 3. As modeled and based on demands, approximately 13 mgd would be delivered directly to Zone 2 and 5 mgd would be delivered to Zone 3.

Benefits

Two connections from the WEWTP to the distribution system would provide more resiliency when the existing WTP is off-line, eliminate the pressure/velocity issues that are experienced under the only a Zone 3 connection scenario, and would be a more sustainable solution that immediately begins to reduce the water utility’s energy usage.

Results

The hydraulic modeling simulation of this configuration indicates that the system performs very well initially, but over an extended period simulation the Heights Water District (HWD) Hilltop and Lanier reservoir levels cannot be maintained. To further assess this finding, a subsequent modeling simulation was performed whereby the Zone 3 to Zone 2 pressure reducing valve (PRV) at Staples Pump Station was allowed to open. This option increased the pressure in Zone 2, which increased the flow to the HWD so that the HWD reservoir levels were maintained. In this scenario, the average flow moving from Zone 3 to 2 through the PRV was 1 mgd and the Staples reservoirs needed to be maintained within a few feet of the overflow. Other options evaluated to resolve this HWD reservoir filling issue included increasing the pressure of the Zone 2 pumps at the WEWTP and enlarging the size of the Zone 2 piping from Hesper Road to King Ave./Overland Ave. These two options were less effective than the PRV adjustment scenario.

Other options aside from the Staples PRV that could be used to help meet HWD demands or maintain levels in the HWD reservoirs:

- Transfer more water from Zone 2 to Zone 1 at the HSPS so that Walter Pump Station can pump from Zone 1 to supply the HWD as well as Zone 3E and 4N.
- Add another sleeve valve at HSPS to allow water to go to from Zone 2 to the clearwells so that the water can be pumped to Zone 2E from HSPS. Water could also then be pumped to Zone 1 if needed for any reason.

Concerns

- Confidence in the reliability of the PRV at Staples Pump Station to operate as a control facility that would automatically operate or be remotely operated when needed.
- Operating Staples reservoirs nearly full. Use of automation with the reservoir levels and the PRV would reduce some concern.
- Switching Walter Pump Station to pump from Zone 1 to Zone 2E and Zone 3E takes about a day for valve/piping reconfiguration and flushing of the Zone 1 waterline that supplies Walter.
- Stagnant waterlines when operating in this mode. Voelker Pump Station would not be operating and so the piping into and out of the pump station would not have water movement.
- Stagnant water at the existing WTP when not operating. Water would be flowing into and out of HSPS so those waterlines would have water movement, but the pipelines and facilities within the plant would not.

Recommendations

Hydraulic modeling simulations of the City's water system confirmed that this is a viable operating mode when the existing WTP is off-line. Once the WEWTP is operational it is recommended to test the plant for delivering to the HWD without implementing any of the discussed options. The testing should be done with the WEWTP at full capacity and the demands matching the capacity. If the HWD reservoir levels cannot be maintained then it is recommended to experiment with the existing Staples Zone 3 to Zone 2 PRV do determine ability and operation requirements to maintain Staples Zone 2 reservoirs at a near full level (this could be done at any time including currently). If this system works well then upgrading the pressure reducing valve at Staples would be recommended to have more confidence in the operation. A sleeve valve could be installed to replace the PRV and operated remotely by a plant operator. A flow meter should also be installed so the operator knows how much flow is moving between zones at this location.

If using the pressure reducing station at Staples to keep the Staples Zone 2 reservoirs near full proves to have operational difficulty or too much risk, then dropping more water into Zone 1 at HSPS for pumping at Walter is recommended. This option does not require any additional capital improvements but is not the highest recommendation because it uses more energy for pumping water backup to Zone 2E pressure.

Also recommended is providing a second sleeve valve at HSPS to safely allow water to go from Zone 2 to the clearwells. This provides system resiliency by allowing additional means to get water from Zone 2 to Zone 1 and then Zone 2E, Zone 3E and Zone 4N.

Operational items to note:

- This operating scenario and other operating scenarios result in stagnant water at Voelker and other locations, suggesting the need for a Standard Operating Procedure (SOP) under these conditions. Operations staff may consider starting Voelker and other pertinent pump stations on a frequent basis for short durations to reduce stagnant water or just leave the stagnant water and flush appropriate waterlines when associated pump stations are turned back on for regular use.
- The WEWTP could just supply Zone 2, up to demands of 13 mgd, and use Voelker to supply Zone 3. There would be stagnant water in Zone 3 out of the WEWTP but it would be less of an issue than with Voelker not operating. Another option would be to have both Voelker and the WEWTP pumping into Zone 3.

CIP Items and Triggers

- Zone 2 to Zone 2E connection at the High Service Pump Station and sleeve valve to drop water from Zone 2 to the Clearwells. Trigger - complete by the time the WEWTP is on-line. Estimated cost - $715,000.
- Upgrade the Staples Zone 3 to 2 zone transfer station. Trigger - complete if necessary, after the WEWTP is on-line. Estimated cost - $176,000.

Existing WTP Supplies Zone 1/WEWTP Supplies Rest of Distribution

Description

The existing WTP would operate at 5 mgd to supply Zone 1 only (currently the existing plant can only operate in its normal configuration down to a delivered rate of 10 mgd without cycling pumps on/off or throttling the discharge of pumps). The L-Structure, Sedimentation Basin 1 and one of the small pumps in Low Service Pump Station (LSPS) 1 would be operated to supply water to the Filter Building. Sedimentation Basin 2 and LSPS 2 would be off-line. Alternatively, at LSPS 2 a smaller could replace one of the larger pumps or a smaller pump installed adjacent to LSPS 2. This would allow LSPS 2 and Sedimentation Basin 2 to be used and thus the normal pretreatment flow configuration. Two filters would be regularly operated at low loading rates. The 12 filters would be cycled on and off-line to maintain their operability. An additional smaller transfer pump in the HSPS would be needed to meet the lower flow rates and provide a continuous flow to one UV reactor. Alternatively, an existing pump could be replaced with a smaller pump. Pump H1-2 would serve as the low speed pump to supply Zone 1. During low demands, without additional Zone 1 storage, Pump H1-2 may need to be cycled on and off. The WEWTP would be operated to meet the rest of the system demands up to 18 mgd. As Zone 1 demands increase, the existing WTP production would also increase proportionally to meet this Zone 1 demand.

Benefits

There are several benefits to this mode of operation:

- Energy wouldn’t be wasted moving water from Zone 2 down to Zone 1.
- The existing WTP being on-line would reduce stagnant water at the plant.

- If there was an issue meeting demands for the Zone 2E, 3E, 4E and 4N (Heights) from the WEWTP, a Zone 2 pump in HSPS could be turned to pump water out of the clearwells to meet the Heights demands. The existing WTP would be ramped up correspondingly.
- The costs, operational concerns and inefficiencies associated with moving water from Zone 3 to Zone 2 at Staples would be avoided.

Results

This mode of operation worked very well in the hydraulic model simulation. With the existing WTP operating to serve Zone 1, the system demand on Zone 2 (i.e. didn't need to supply Zone 1 from the WEWTP) was reduced, which increased the pressure enough that the HWD reservoirs maintained their operating levels without water being supplied from Zone 3 to Zone 2 at Staples. During this scenario, Voelker and Willett are not operating. This mode of operation works well from a system demand of 10-26 mgd. Above 26 mgd, the WEWTP begins having trouble providing adequate water for Zone 2 and the Heights due to pressure limitations, similar to the previous scenario.

Operational item to note:

- The WEWTP can either deliver to Zone 2 and 3 or just to Zone 2 and use Voelker to pump from Zone 2 to Zone 3 to meet an overall demand of approximately 19 mgd.
- When Zone 1 demands are less than 5 mgd, instead of cycling pump H1-2 off and reducing the existing plant production, the 5 mgd flow could be delivered to Zone 1 and Willett Pump Station used to move excess demands to Zone 2 which would then decrease the WEWTP supply to Zone 2. Walter Pump Station could do something similar pumping to Zone 3E if the Zone 1 waterline to Walter has been utilized and is not stagnant.

Concerns

- There is concern that Intake 1/L-Structure and Sedimentation Basin 1 could freeze solid with shallow water, low flow and cold temperatures in the winter. This concern led to evaluating taking Intake 1/L-Structure and Sedimentation Basin 1 off-line in the winter. In the current setup this would require chemical addition at the Mixer Building except there are concerns with the Amiad Strainer (which supplies the jet pump used to mix chemicals) in the Mixer Building plugging. Two primary options were developed to facilitate system operations with Intake 1/L-Structure and Sedimentation Basin 1 off-line: 1) Add fine screening at Intake 2 (this would allow bypassing the Amiad Strainer) and a lower capacity submersible pump in one side of LSPS 2 wetwell with walls vertically extended to the LSPS 2 floor level; 2) extend PACL feed lines from the Mixer Building to one side of the LSPS 2 wetwell, use the existing coarse bubble mixing system to mix in the PACL and replace one of the larger LSPS 2 pumps with a smaller pump. A benefit of the first option is that it would provide automatic, mechanical cleaned, fine screening to potential capacities of 30 mgd and would not reduce the pumping capacity of LSPS 2. The benefit of the second option is lower cost.

- Stagnant waterlines when operating in this mode. Voelker Pump Station would not be operating, so the piping into and out of the pump station would not have water movement.
- Inefficiency of operation and personnel in operating two plants to meet low demands.

Recommendations

If the existing WTP is available, this is a good mode of operation. This operational mode avoids the energy loss associated with for supplying Zone 1 from the WEWTP, maximizes the efficiency of the WEWTP and maintaining the existing WTP in a running mode enables it to be ramped up to meet additional demands or if the WEWTP needs to be taken off-line for whatever reason.

CIP Items and Triggers

While an evaluation of the existing WTP is not a part of this master plan, a preliminary review of capital needs for running at a low flow 5 mgd level includes the following:

- Screening improvements and adding a smaller pump at LSPS 2. Cost Estimate - $1,422,000. Or second option of extending PACL lines to LSPS 2 and replacing one LSPS 2 pump. Cost Estimate - $320,000. Trigger – complete by the time the WEWTP is on-line.
- A smaller transfer pump in HSPS. An 8-9 mgd pump could meet the lowest flows and bridge the gap to the next larger pump (15 mgd on a VFD). Trigger - complete by the time the WEWTP is on-line. Cost estimate - $403,000 (the City is planning to do this as a Special Building Request (SBR) and so would not be to be included in the CIP.

Both WTPs Operating to Meet Demands up to Current Maximum Day

Description

This analysis includes the new WEWTP operating at maximum capacity (18 mgd) and the existing WTP delivering up to 30.6 mgd to meet the current maximum day demand (MDD) of 48.6 mgd. The existing plant would continue supplying only Zone 1 until the WEWTP reaches maximum capacity or cannot maintain reservoir levels in the HWD. At that point the existing plant would begin supplying Zone 2 and/or 2E directly at HSPS or with Willett or Walter pump stations via Zone 1.

Benefits

This mode of operation maximizes the use of the WEWTP which should be more efficient for operations and energy depending on the treatment method selected.

Results

The hydraulic modeling simulation of the system using the current MDD showed good results as it met the prescribed operational needs and system design criteria. At the current MDD, the WEWTP was supplying all of Zone 3 and higher (13 mgd). Therefore, Voelker was not operating. The WEWTP was also supplying 5 mgd into Zone 2. The existing WTP was meeting the remaining Zone 2 demand, the Zone 1 demand, and the Heights demand. Willett Pump Station was not operating.

Concerns

- At demands around 26-28 mgd, and the WEWTP meeting all demands except Zone 1, the levels in the HWD reservoirs cannot be continuously maintained similar to the operating scenario where only the WEWTP is operating.
- Minimum pumping capability of Pump H2-3 in HSPS when the existing WTP only needs to supplement small flows to Zone 2 and the Heights.
- Balancing the delivery of water into Zone 2 and the Heights, when both plants are pumping into Zone 2/2E and the throttling valves in HSPS needs to adjust to deliver adequate water to the Heights.
- Stagnant water at lower demands and at Voelker.

Recommendation

This mode of operating with the two WTPs to meet up to the current 48 mgd peak day demand is recommended. However, there are transition demands that can cause some issues for operation as well as balancing of flows between Zone 2 and 2E discharges in HSPS. Below are recommendations to resolve these issues as well as other operation considerations.

DEMANDS AT 26-28 MGD

When the demand approaches 26 mgd, the WEWTP starts to have difficulty maintaining reservoir levels in the HWD without moving water from Zone 3 down to Zone 2 at Staples Pump Station. An option to the water dropping from Zone 3 to Zone 2 at Staples is to supply water to Zone 2 or 2E from Zone 1. Willett Pump Station could be used to supply Zone 2 and/or Walter Pump Station could be used to supply Zone 2E and Zone 3E. In these cases, for a given demand, the WEWTP production would decrease and the existing WTP production would increase to delivery more water to Zone 1. As demands increase beyond 28 mgd, the water supplied to Zone 2 from the WEWTP decreases (as more water is supplied to Zone 3) and so this issue begins to go away.

EXISTING WTP MINIMUM ZONE 2 PUMPING LIMITATION

Once the WEWTP can't meet the demands of Zone 2 and the Heights, the existing WTP needs to supplement meeting these demands. The smallest HSPS Zone 2 pump (H2-3) can potentially turndown to 7 mgd. As a result, this pump could be cycled on and off or Willett and Walter can be used via Zone 1 to meet the Zone 2 or Heights demands. These pump stations have smaller pumps that could be operated continuously. As demands increase, the WEWTP is providing more water to Zone 3 and less water to Zone 2 and for the latter option the existing WTP would continue to only supply Zone 1 with Willett and/or Walter meeting the Zone 2 and Heights demand with no HSPS Zone 2 pump operating. This mode of operation could continue up to about 38 mgd at which point 7 mgd of water would needed to be supplied to Zone 2 and the Heights by the existing WTP and so H2-3 pump at HSPS could be turned on and used continuously at a turned down condition.

Alternatively, the WEWTP production could be reduced so that H2-3 could be turned on and ran at low speeds continuously.

BALANCING FLOW IN HSPS BETWEEN ZONE 2 AND 2E

As the WEWTP starts to be unable to meet the demands of Zone 2 and the Heights, water will need to be balanced between Zone 2 and 2E in HSPS.

The previous two sections discussed using Walter Pump Station to pump water from Zone 1 to the Heights. For this option, the throttling valve on Zone 2E in HSPS would be used to push more water in Zone 2. If H2-3 is cycled on and off, throttling this valve would need to coincide with the pump turning on and off which wouldn't work as easily. Also, Walter Pump Station pumps would then need to be cycled to match H2-3 as water can't be pulled out of the HWD to supply Zone 3E.

When overall demands get to about 35 mgd the Heights demand would be at 7 mgd. At this point Zone 2 and 2E could be separated by closing a motorized throttling valve to Zone 2 in HSPS. H2-3 would supply the Zone 2E discharge and the WEWTP would supply water to Zone 2, 3S and 4S. The WEWTP would drop off to a little less than 17 mgd. The existing WTP would be supplying Zone 1 and the Heights and the WEWTP the rest.

As demands increase to 38 mgd, H2-3 speed would increase to match the Heights demands and the WEWTP production would increase to meet Zone 2, 3S and 4S. For demands starting at 38 mgd however, the WEWTP begins to not be able to meet the Zone 2, 3S and 4S demands. At this point the throttling valve to Zone 2 could be cracked open to meet the additional Zone 2, 3S and 4S demands or left closed and use Willett to meet the additional demands via Zone 1.

STAGNANT WATER

Aside from Voelker not being used up to peak day maximum demands, if Zone 2 is isolated from Zone 2E there would be no water movement in Zone 2 between HSPS and South Billings Boulevard. Similar to what was described earlier, water can be moved in the Zone 2 pipe on a frequent basis to keep it fresh or flushed out when it becomes needed.

CIP Items and Triggers

- Items noted in the previous section for operating the plant at minimum flows.

Both WTPs Operating to Meet Demands from Current MDD to 2030 MDD

Description

This analysis includes the existing WEWTP operating at maximum capacity (18 mgd) and the existing WTP delivering up to 41.1 mgd to meet the 2030 MDD of 59.1 mgd. From the current MDD to the 2030 MDD, the WEWTP would be at maximum capacity and deliver 13 mgd of water to Zone 3 and 5 mgd to Zone 2. The existing plant would supply all of Zone 1 and the Heights plus the rest of the demands for Zone 2 and Zone 3 and higher (via Voelker).

Benefits

This mode of operation maximizes the use of the WEWTP which should be more efficient for operations and energy depending on the treatment method selected.

Results

The model was run up to the 2030 MDD and showed good results. At the 2030 MDD, the WEWTP was supplying 13 mgd of the 19.3 Zone 3 and higher demands with Voelker meeting the remaining 6.3 mgd. Staples Zone 3 was not operating. The WEWTP was also supplying 5 mgd into Zone 2. The existing WTP was meeting the rest of the Zone 2 (12.1 mgd) demand, the Zone 1 (15.8 mgd) demand and the Heights (12.6 mgd) demand. Willett Pump Station was not operating.

Concerns

- None

Recommendation

This mode of operating with the two WTPs to meet up to 2030 MDD is recommended. As an option to the existing WTP meeting all the Zone 2 demands not met by the WEWTP and Heights demands, Willett could be used so that only one large Zone 2 pump in HSPS would need to operate. Another option would be to split the four HSPS Zone 2 pump discharges so that two pumps could be dedicated to Zone 2 East and two pumps dedicated to Zone 2 while maintaining the ability for all pumps to still pump into the common Zone 2 header. This split between Zone 2 and Zone 2 East would avoid the need for using the throttling valves and save energy.

CIP Items and Triggers

The primary potential CIP item identified in this scenario would be HSPS Zone 2 pump discharge modifications to allow two pumps to be dedicated to Zone 2 and two pumps dedicated to Zone 2E. The trigger would be if a throttling valve on the Zone 2 pump discharge header is required to be significantly closed to balance flow resulting in a substantial loss of energy.

Both WTPs Operating to Meet Demands from 2030 MDD to 2040 MDD

Description

This analysis includes the existing WEWTP operating at maximum capacity (18 mgd) and the existing plant delivering up to 50.7 mgd to meet the 2040 MDD of 68.7 mgd. From the 2030 MDD to the 2040 MDD, the WEWTP would continue to run at its maximum capacity and deliver 13 mgd of water to Zone 3 and 5 mgd to Zone 2. The existing plant would supply all of Zone 1 and the Heights plus the rest of the demands for Zone 2 and Zone 3 and higher (via Voelker).

This scenario of operation results and recommendation are the same as the previous one. The existing WTP is just meeting the additional demands up to the 2040 MDD and is still within its delivered capacity.

Two Plants Continuously Operating Summary

Appendix 6A includes a table summarizing detailed demands and options for how the WTPs and pumps would supply the distribution system for demands up to 70 mgd with both plants normally operating. Table 6-1 provides a summary for key ranges of demands. Demands and delivery flow numbers are based on projections from Table 3-6 and interpolation between the projected demands. Below are some key points:

- Existing WTP estimated minimum production is more than Zone 1 minimum demands. Willet Pump Station or Walter Pump Station can be used to pump the excess water supplied to Zone 1.
- Delivery to Zone 2 from the WEWTP is limited to approximately 13 mgd without significant pressure increase or waterline improvements.
- Delivery to Zone 3 from the WEWTP is limited to 13 mgd without additional Zone 3 piping provisions.
- LSPS 2 and Sedimentation Basin 2 wouldn't be available until demands of 30 mgd are reached without additional capital improvements or an operating decision to burn head in LSPS 2.
- Zone 2 pumping at the existing HSPS doesn't start until demands of 35 mgd.
- Voelker Pump Station is not required until demands get to 45 mgd.
- Willett Pump Station can be used to help with flow balancing in the Zone 2 discharge header in the existing HSPS and to meet Zone 2 demands.

Table 6-1. Summary of Demands for Two Plant Operation

Overall Demand Range/Facility	Delivered Demand (mgd)	Delivered Demand Option (mgd)
10.0 – 19.0 mgd		
Existing WTP		
Total delivery	**5.0-6.0**	
Zone 1[a]	5.0-6.0	
Zone 2	Off	
WEWTP		
Total delivery	**5.0-13.0**	
Zone 2	5.0-13.0	2.1-7.4
Zone 3	Off	2.9-5.6
Pump Stations		
Willett	1.8-0.2[a]	Off
Walter	From Zone 2E Only	1.8-0.2[a]
Voelker	2.9-5.6	

Table 6-1. Summary of Demands for Two Plant Operation

Overall Demand Range/Facility	Delivered Demand (mgd)	Delivered Demand Option (mgd)
20.0 – 25.0 mgd		
Existing WTP		
Total delivery	**6.3-7.9**	
Zone 1	6.3-7.9	
Zone 2	Off	
WEWTP		
Total delivery	**13.6-17.1**	
Zone 2	7.8-9.8	
Zone 3	5.8-7.3	
Pump Stations		
Willett	Off	
Walter	From Zone 2E Only	
Voelker	Off	
26.0 – 27.0 mgd		
Existing WTP		
Total delivery	**8.4-9.1**	
Zone 1[b]	8.4-9.1	
Zone 2	Off	
WEWTP		
Total delivery	**17.6-17.9**	
Zone 2[b]	10.0	
Zone 3	7.6-7.9	
Pump Stations		
Willett	0.2-0.6[b]	Off
Walter	From Zone 2E Only	0.2-0.6[b]
Voelker	Off	Off
28.0 – 34.0 mgd		
Existing WTP[c]		
Total delivery	**10.1-16.1**	
Zone 1[b]	10.1-16.1	
Zone 2	Off	
WEWTP		
Total delivery	**18.0**	
Zone 2[b]	9.8-8.0	
Zone 3	8.2-10.0	
Pump Stations		
Willett	1.2-5.3	Off
Walter	From Zone 2E Only	1.2-5.3
Voelker	Off	Off
35.0 – 37.0 mgd		
Existing WTP		
Total delivery	**18.2-19.2**	
Zone 1	11.1-11.7	
Zone 2[d]	7.1-7.5	
WEWTP		
Total delivery	**16.8-17.8**	
Zone 2	6.6-7.0	
Zone 3	10.2-10.8	
Pump Stations		
Willett	Off	
Walter	From Zone 2E Only	
Voelker	Off	

Table 6-1. Summary of Demands for Two Plant Operation

Overall Demand Range/Facility	Delivered Demand (mgd)	Delivered Demand Option (mgd)
38.0 – 54.0 mgd		
Existing WTP		
Total delivery	**20.0-36.0**	
Zone 1	12.0-15.6	12.3-24.7[e]
Zone 2	8.0-20.4	7.4-11.3[e]
WEWTP		
Total delivery	**18.0**	
Zone 2	6.9-5.0	
Zone 3	11.1-13.0	
Pump Stations		
Willett	Off	0.3-9.1[e]
Walter	From Zone 2E Only	
Voelker	0.2-3.8	
56.0 – 70.0 mgd		
Existing WTP		
Total delivery	**38.0-52.0**	
Zone 1	15.7-16.3	
Zone 2	22.3-35.8	12.3-25.8[f]
WEWTP		
Total delivery	**18.0**	
Zone 2	5.0	
Zone 3	13.0	
Pump Stations		
Willett	Off	10.0[f]
Walter	From Zone 2E Only	From Zone 2E Only
Voelker	4.8-11.3	4.8-11.3

[a] Minimum existing WTP can produce is estimated at 5.0 mgd. When Zone 1 demands are less than this Willett or Walter Pump Stations can pump out of Zone 1 to Zone 2 or the Heights.

[b] Delivery to Zone 2 is limited to 10 mgd. Existing WTP/Zone 1 delivers more to make up for limitation. Willett or Walter pumps excess out of Zone 1.

[c] At 30 mgd demand Sedimentation Basin 2 can start to be used based on turndown of one LSPS 2 pump.

[d] Smallest Zone 2 Pump can now be turned on so existing WTP Zone 2 discharge is started.

[e] Option to delivering a small amount of water to Zone 2 from existing HSPS would be to deliver more to Zone 1 and use Willett to pump to Zone 2.

[f] Can use Willett to reduce the amount of Zone 2 pumping.

Operating Summary for Existing WTP Off-Line During Low Demands

This section builds on results from the hydraulic model analysis and evaluations in the previous sections to summarize operating scenarios throughout the year if the existing WTP is taken off-line during low demands in the winter.

Existing WTP with Low Demand Improvements

The operating scenario is this section is based on improvements at the existing WTP to allow a continuous delivered capacity of 5 mgd (described earlier). The summary below begins in the winter when only the WEWTP is operating.

- The WEWTP operating to meet system wide demands and the existing WTP is off-line. As demands increase to 15 mgd in late winter/early the existing WTP would be started up.
- The existing WTP would operate to meet its minimum delivered capacity of 5 mgd to Zone 1. If Zone 1 demand is less than 5 mgd excess water is pumped to Zone 2 by Willett Pump Station. The WEWTP meets the rest of the system demand operating to maintain levels in Staples 3 MG and 6 MG reservoirs for Zone 2 and Chapple for Zone 3. Zone 2E is fed from Zone 2 at HSPS and flow is controlled to the Heights by the throttling valve on the Zone 2E waterline in HSPS. Operation in this mode continues until the WEWTP gets to it maximum capacity.
- Once WEWTP gets to capacity it would operate at a constant rate and the existing WTP would begin increasing production to meet demand. The WEWTP would deliver more water to Zone 3, as demands increase, up to 13 mgd while decreasing supply to Zone 2, down to 5 mgd. The existing plant would increase delivery of water to Zone 1 and eventually begin supply Zone 2E and then Zone 2 as described in previous sections. This would continue until demands have peaked and then reduce back down to around 20 mgd.
- When demands are around 20 mgd, the existing plant delivered capacity would be down to 5 mgd and the WEWTP would be at 15 mgd and changing its production to meet the fluctuating system demand.
- Once demands decreased to 15 mgd, the existing WTP would be shutdown for the winter and the WEWTP would be meeting demands on its own. Then in late winter/early spring the cycle repeats.

Existing WTP at Current Low Demand Delivered Capacity

The second scenario is based on the currently existing WTP lowest continuous delivered capacity of 10 mgd.

- In late winter/early spring the existing WTP would need to be started up at the same time as the first scenario, about 15 mgd demand.
- The existing plant would deliver about 10 mgd. Zone 1 demand would be at 5 mgd or less. The Heights demand would be less than 4 mgd so there would be some operational challenges to use a HSPS Zone 2 pump to pump that low of flow continuously. A simpler operation could be to deliver all the 10 mgd flow to Zone 1 and use Walter to pump to Zone 2E and Zone 3E. Any excess water would be pumped to Zone 2 by Willett. As the Heights demand increases, Willett would pump less until there was no excess water in Zone 1 and then the existing WTP would produce more water to meet the increased demand in the Heights up to about 7 mgd. At this point H2-3 at HSPS would be started and begin delivery water to Zone 2E only and pumping to Zone 1 would be reduced to match Zone 1 demand only. The WEWTP would initially be delivering about 5 mgd meeting all the demand in Zone 3 and higher as well as the remaining demand in Zone 2, Zone 3S and Zone 4S and then increase production as needed up to 18 mgd.
- Once the WEWTP gets to maximum delivered capacity, the existing WTP would increase production to match increased demands. As the existing WTP begins to

need to supply water to Zone 2, the throttling valve on Zone 2 at HSPS could be opened or more water could be delivered to Zone 1 and Willett used to supply Zone 2 until the Zone 2 demand is high enough that the throttling valve would be more open so that only a small amount of energy would be wasted. This mode of operation works up to and including the peak demands.

- When demands begin to drop off the existing WTP would reduce production while the WEWTP production is constant. The pumping scenarios described in the previous paragraphs would occur in reverse order. At about 28 mgd, the existing WTP would maintain delivered production of 10 mgd and the WEWTP production would drop until demands are about 15 mgd and then existing WEWTP would be shut down for the winter and the WEWTP would delivery water to the entire system.

Relevant Pump Station Analysis

Walter Pump Station

Near-Term

Normally water is supplied to Walter Pump Station and HWD directly from HSPS via the Zone 2E waterline. Recently repairs have been completed to this pipeline. The second means to supply Walter is Zone 1. Zone 1 is only used in emergencies and needs to be flushed out prior to being used and numerous valves manually operated. An option could be to always pump out of Zone 1 to Zone 3E to keep the line fresh in case of an emergency and add electric actuators to the manual valves when possible. This approach would be even more acceptable if additional Zone 1 storage is added.

Long-Term

The mode of operation in the previous paragraph could provide another benefit in twenty years or so when the Zone 2E waterline would start to see high velocities if it is supplying all the Heights demands. Using Zone 1 would reduce the demand on the waterline and delay the time before another waterline or means is needed to get more water to the Heights.

Leavens Pump Station

Leavens is used for short periods of time during high demands in the summer. Leavens pumps are 3, 5 and 7.2 mgd. The two larger pumps are rarely used. The discharge of Leavens goes nearly to Staples before getting to the Zone 3 distribution. This results in a large volume of dead water when there is no pumping from Leavens.

If a variable frequency drive (VFD) is installed on the smallest pump, Leavens could be operated more often and keep the discharge line fresh. The pump would still need to cycle on and off based on Staples Standpipe level. However, if the Standpipe is taken off-line the pump could operate continuously more of the time.

Operation of the Leavens pump would result in less flow from the Staples Zone 3 pumping. This mode of operation is more practical if there is more Zone 1 storage added. Once the WEWTP is operational this option will be most applicable at very low demands when excess water is being supplied to Zone 1 as well as higher demands with Zone 3 pumping at the WEWTP reaches 13 mgd.

Willett Pump Station

Willett Pump Station can play a key role in operations with the WEWTP. During normal two plant operation, using the existing WTP to meet Zone 1 demands would be an efficient operation mode. At low demands the WTP would likely be producing more water than Zone 1 demands. Willett can be used to pump the extra flow. This can be easily done with the existing pumps.

At demands in the range of 26-34 mgd, Willett would be needed to help meet Zone 2 demands. In this flow range the WEWTP is limited in supply to Zone 2 but the remaining demand in Zone 2 and the Heights is less than what the smallest HSPS Zone 2 pump can turn down to without burning head. To compensate for this more water can be delivered to Zone 1 and Willett used to pump to Zone 2. In this range of demands, one pump at Willett can meet the requirements.

Above 38 mgd demands and the new WEWTP operating at full capacity, only a small amount of water is needed to be supplied to Zone 2 from HSPS. The throttling valve in HSPS on Zone 2 would need to burn a lot of head to deliver small flows. An option to this would be to have Zone 2 completely shut off at HSPS and meet this demand with Willett. Above 48 mgd two Willett pumps would be needed.

Willett operation with the WEWTP can provide more versatility for the water system and will likely be relied on. Based on this the third Willett pump should be installed by the time the new WEWTP comes on-line.

Water System Operation and Control Summary

In general, there are two primary modes to operate the water system with the two WTPs: 1) Two plants normally operating year-round and 2) the existing WTP shut down during winter months. This chapter has described how each of these modes would work based on hydraulic modeling results and two scenarios of minimum production rates at the existing WTP.

The primary advantages of the two-plant year-round operation mode are:

- The least amount of pumping energy is used to deliver flow to the water system.
- Large fluctuations in demand can be more easily met including avoiding the situation where the existing WTP would need to be suddenly started up if the WEWTP can’t meet all the demand.
- Stagnant water at the existing WTP can be avoided by the plant always operating.
- Concerns with water freezing and potential equipment and structure ice damage in various locations at the existing WTP can be avoided. Ice could also be an issue if the existing WTP needed to be started up during the winter.
- In an emergency at either plant, the other plant would already be operating, and production rate would just need to be increased to meet overall system demands.

Advantages of shutting down the existing WTP in the winter include:

- The WEWTP should be the most efficient to operate, especially screenings and residuals handling, and this operating mode would maximize the WEWTP use.
- Personnel requirements for operating and maintenance would be reduced when the existing WTP is off-line.
- Routine maintenance and small projects could be completed annually at the existing WTP when not operating.

There is no obvious mode of operation that is clearly better than the other. As the WEWTP nears completion the City can decide what mode works best for the current needs and provides the most benefit. It is recommended though that the first fall that the WEWTP is in operation that the City experiment with the WEWTP supplying the entire distribution system so it can be determined how the system reacts and if any adjustments in operation or facilities are needed for the system to operate efficiently as well as provide initial information as to which mode to operate in.

As described herein, with the addition of the new WEWTP, the City has significantly improved the resiliency of its water system. As shown from the results of the hydraulic modeling of the various operational scenarios, this increased resiliency is accompanied by a wide range of operational alternatives that may be appropriate to meet the system needs at that time. It is recommended the City establish a Business Operations Plan that aligns the applicable mode of operation with the various supply/demand conditions affecting the water system, and develop the necessary Standard Operating Procedures (SOPs) to improve performance and support long-term staff training and knowledge retention goals and objectives. Combining these SOPs into a robust Business Operations Plan will also provide an effective bridge with the water utility's Emergency Response Plan for future emergency conditions.

Water Quality

Water quality can have a significant impact on the operational needs and approach to deliver treated water to its customers. With the addition of the new WEWTP, the City will need to address a variety of seasonal water quality-related conditions that will affect both performance, reliability, and cost effectiveness of the water system. A few of the key treated water quality items that will need additional operational protocols developed are highlighted below.

Stagnant Water

The focus of this chapter has been on the water distribution system facilities operation to meet MDD through 2040. References have been made to stagnant water due to facilities not operating. Stagnant water can also occur where water supplied from one plant meets the water supplied by the other plant in the distribution system piping. Although the water distribution system demand and supply are dynamic, they may not routinely change enough to avoid the potential of a stagnant water condition. As part of the Business Operations Plan noted above, SOPs could be developed to address the potential of a variety of stagnant water conditions.

Water Age

Water age is another potential water quality issue. Adding a second plant on the West End and supplying water from it all the way to the northwest part of the Heights will be an increase in water age for that far reach compared to the existing WTP supplying water to that area. However, other areas on the West End will have reduced water age from this nearby supply. When developing the Business Operations Plan and deciding on the appropriate seasonal modes of operation, water age should also be considered.

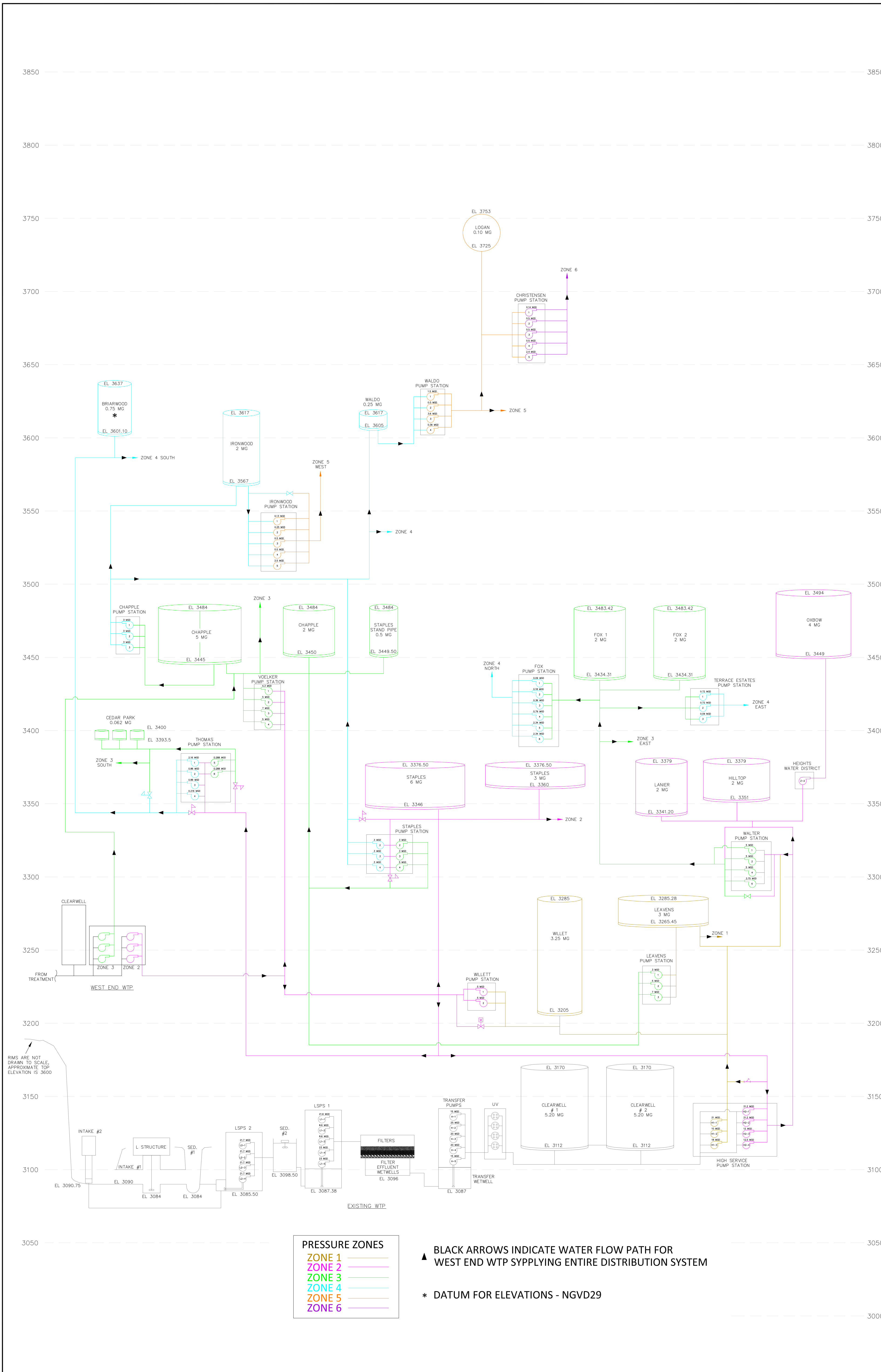
Two Sources of Treated Water

The two WTPs will have the same source of water, which is the Yellowstone River. However, the new WEWTP is planned to normally withdraw water that has been stored in a reservoir. Additionally, the WEWTP process could be different from the existing WTP. Verifying compatibility of water chemistry is essential for a water distribution system with two operating WTPs and should be incorporated in the Business Operations Plan.

CIP Summary

Below summarizes the recommended capital projects. Chapter 11 provides additional information on these and other recommendations.

- Complete bypass of Zone 2 check valve in existing HSPS and sleeve valve addition for moving water from Zone 2 to the clearwells. Trigger – complete by the time the WEWTP is on-line. Cost estimate - $715,000.
- Upgrade zone transfer station from Zone 3 to Zone 2 at Staples. Trigger – determine if necessary, from initial experiment for WEWTP supplying entire distribution system. Cost Estimate - $176,000.
- Install a smaller transfer pump in existing HSPS. Trigger – complete by the time the WEWTP is on-line if the City decides to operate the existing WTP at a delivered capacity of 5 mgd. Cost Estimate - $403,000. This is a City SBR and would not be in CIP.
- Intake 2 screening improvements and adding a smaller pump at LSPS 2. Cost Estimate - $1,422,000. Or second option of extending PACL lines to LSPS 2 and replacing one LSPS 2 pump. Cost Estimate - $320,000. Trigger – complete by the time the WEWTP is on-line.
- Add a third pump at Willett Pump Station. Trigger – complete by the time the WEWTP is on-line. Cost Estimate - $350,000.



WATER SYSTEM INCLUDING WEST END WTP
FIGURE 6-1

Appendix 6A

The spreadsheet below shows a breakdown of key demands and how those demands would be met by the existing WTP and the WEWTP. Also excluded where applicable are additional options for each plant to meet the demands and how key pump stations might be used. All values are in mgd.

Overall	Zone 1	Heights=Z2E,Z3E,Z4N,Z4E	Z2,Z3S,Z4S,Heights	Z3 & Higher	Existing WTP						WEWTP							Willett or	
Demand	Demand	Demand	Demand	Demand	Zone 1[1]	Z1 Opt	Zone 2	Zone 2E	Z2 Pmpng	Total	Z2 Max Pot	Z3 Max Pot	Z2 Opt 1	Z3 Opt 1	Z2 Opt 2	Z3 Opt 2	Total	Walter	Voelker
10.0	3.2	2.0	3.9	2.9	5.0		0.0	0.0	0.0	**5.0**	3.9	2.9	6.8	0.0			**6.8**	1.8	2.9
11.0	3.5	2.2	4.3	3.2	5.0		0.0	0.0	0.0	**5.0**	4.3	3.2	7.5	0.0			**7.5**	1.5	3.2
12.0	3.8	2.4	4.7	3.5	5.0		0.0	0.0	0.0	**5.0**	4.7	3.5	8.2	0.0			**8.2**	1.2	3.5
13.0	4.1	2.6	5.1	3.8	5.0		0.0	0.0	0.0	**5.0**	5.1	3.8	8.9	0.0			**8.9**	0.9	3.8
14.0	4.4	2.8	5.5	4.1	5.0		0.0	0.0	0.0	**5.0**	5.5	4.1	9.6	0.0			**9.6**	0.6	4.1
15.0	4.8	3.0	5.9	4.4	5.0		0.0	0.0	0.0	**5.0**	5.9	4.4	10.3	0.0			**10.3**	0.2	4.4
16.0	5.1	3.2	6.3	4.7	5.1		0.0	0.0	0.0	**5.1**	6.3	4.7	11.0	0.0			**11.0**		4.7
17.0	5.4	3.4	6.6	5.0	5.4		0.0	0.0	0.0	**5.4**	6.6	5.0	11.6	0.0			**11.6**		5.0
18.0	5.7	3.6	7.0	5.3	5.7		0.0	0.0	0.0	**5.7**	7.0	5.3	12.3	0.0			**12.3**		5.3
19.0	6.0	3.8	7.4	5.6	6.0		0.0	0.0	0.0	**6.0**	7.4	5.6	13.0	0.0			**13.0**		5.6
20.0	6.3	4.0	7.8	5.8	6.3		0.0	0.0	0.0	**6.3**	7.8	5.8					**13.6**		
21.0	6.6	4.2	8.2	6.1	6.6		0.0	0.0	0.0	**6.6**	8.2	6.1					**14.3**		
22.0	7.0	4.4	8.6	6.4	7.0		0.0	0.0	0.0	**7.0**	8.6	6.4					**15.0**		
23.0	7.3	4.6	9.0	6.7	7.3		0.0	0.0	0.0	**7.3**	9.0	6.7					**15.7**		
24.0	7.6	4.8	9.4	7.0	7.6		0.0	0.0	0.0	**7.6**	9.4	7.0					**16.4**		
25.0	7.9	5.0	9.8	7.3	7.9		0.0	0.0	0.0	**7.9**	9.8	7.3					**17.1**		
26.0	8.2	5.2	10.2	7.6	8.2	8.4	0.0	0.0	0.0	**8.4**	10.2	7.6	10.0				**17.6**	0.2	
27.0	8.5	5.4	10.6	7.9	8.5	9.1	0.0	0.0	0.0	**9.1**	10.6	7.9	10.0				**17.9**	0.6	
28.0	8.9	5.6	11.0	8.2	8.9	10.1	0.0	0.0	0.0	**10.1**	11.0	8.2	9.8				**18.0**	1.2	
29.0	9.2	5.8	11.3	8.5	9.2	11.0	0.0	0.0	0.0	**11.0**	11.3	8.5	9.5				**18.0**	1.8	
30.0	9.5	6.0	11.7	8.8	9.5	12.0	0.0	0.0	0.0	**12.0**	11.7	8.8	9.2				**18.0**	2.5	
31.0	9.8	6.3	12.1	9.1	9.8	13.0	0.0	0.0	0.0	**13.0**	12.1	9.1	8.9				**18.0**	3.2	
32.0	10.1	6.5	12.5	9.4	10.1	14.0	0.0	0.0	0.0	**14.0**	12.5	9.4	8.6				**18.0**	3.9	
33.0	10.4	6.7	12.9	9.6	10.4	14.9	0.0	0.0	0.0	**14.9**	12.9	9.6	8.4				**18.0**	4.5	
34.0	10.8	6.9	13.3	10.0	10.8	16.1	0.0	0.0	0.0	**16.1**	13.3	10.0	8.0				**18.0**	5.3	
35.0	11.1	7.1	13.7	10.2	11.1		0.0	7.1	7.1	**18.2**	13.7	10.2	6.6				**16.8**		
36.0	11.4	7.3	14.1	10.5	11.4		0.0	7.3	7.3	**18.7**	14.1	10.5	6.8				**17.3**		
37.0	11.7	7.5	14.5	10.8	11.7		0.0	7.5	7.5	**19.2**	14.5	10.8	7.0				**17.8**		
38.0	12.0	7.7	14.9	11.1	12.0	12.3	0.3	7.7	8.0	**20.0**	14.9	11.1	6.9				**18.0**	0.3	
39.0	12.3	7.9	15.2	11.4	12.3	13.0	0.7	7.9	8.6	**20.9**	15.2	11.4	6.6				**18.0**	0.7	
40.0	12.7	8.1	15.6	11.7	12.7	13.9	1.2	8.1	9.3	**22.0**	15.6	11.7	6.3				**18.0**	1.2	
41.0	13.0	8.3	16.0	12.0	13.0	14.7	1.7	8.3	10.0	**23.0**	16.0	12.0	6.0				**18.0**	1.7	
42.0	13.3	8.5	16.4	12.3	13.3	15.5	2.2	8.5	10.7	**24.0**	16.4	12.3	5.7				**18.0**	2.2	
43.0	13.7	8.7	16.8	12.6	13.7	16.4	2.7	8.7	11.4	**25.1**	16.8	12.6	5.4				**18.0**	2.7	
44.0	14.0	8.9	17.2	12.9	14.0	17.2	3.2	8.9	12.1	**26.1**	17.2	12.9	5.1				**18.0**	3.2	
45.0	14.2	9.1	17.6	13.2	14.2	17.9	3.7	9.1	12.8	**27.0**	17.6	13.2	5.0	13.0			**18.0**	3.7	0.2
46.0	14.6	9.3	18.0	13.4	14.6	18.7	4.1	9.3	13.4	**28.0**	18.0	13.4	5.0	13.0			**18.0**	4.1	0.4
47.0	15.3	9.4	18.3	13.4	15.3	19.6	4.3	9.4	13.7	**29.0**	18.3	13.4	5.0	13.0			**18.0**	4.3	0.4
48.0	15.4	9.6	18.7	13.9	15.4	20.4	5.0	9.6	14.6	**30.0**	18.7	13.9	5.0	13.0			**18.0**	5.0	0.9
49.0	15.4	9.9	19.2	14.4	15.4	21.1	5.7	9.9	15.6	**31.0**	19.2	14.4	5.0	13.0			**18.0**	5.7	1.4
50.0	15.4	10.2	19.7	14.9	15.4	21.8	6.4	10.2	16.6	**32.0**	19.7	14.9	5.0	13.0			**18.0**	6.4	1.9
52.0	15.5	10.7	20.6	15.9	15.5	23.3	7.8	10.7	18.5	**34.0**	20.6	15.9	5.0	13.0			**18.0**	7.8	2.9
54.0	15.6	11.3	21.6	16.8	15.6	24.7	9.1	11.3	20.4	**36.0**	21.6	16.8	5.0	13.0			**18.0**	9.1	3.8
56.0	15.7	11.8	22.5	17.8	15.7		10.5	11.8	22.3	**38.0**	22.5	17.8	5.0	13.0			**18.0**	10.5	4.8
58.0	15.8	12.4	23.5	18.8	15.8		11.9	12.4	24.3	**40.1**	23.5	18.8	5.0	13.0			**18.0**		5.8
60.0	15.9	12.9	24.4	19.7	15.9		13.2	12.9	26.1	**42.0**	24.4	19.7	5.0	13.0			**18.0**		6.7
62.0	15.9	13.5	25.4	20.6	15.9		14.5	13.5	28.0	**43.9**	25.4	20.6	5.0	13.0			**18.0**		7.6
64.0	16.0	14.2	26.4	21.5	16.0		15.7	14.2	29.9	**45.9**	26.4	21.5	5.0	13.0			**18.0**		8.5
66.0	16.1	14.8	27.5	22.4	16.1		17.1	14.8	31.9	**48.0**	27.5	22.4	5.0	13.0			**18.0**		9.4
68.0	16.2	15.4	28.5	23.4	16.2		18.5	15.4	33.9	**50.1**	28.5	23.4	5.0	13.0			**18.0**		10.4
70.0	16.3	16.0	29.5	24.3	16.3		19.8	16.0	35.8	**52.1**	29.5	24.3	5.0	13.0			**18.0**		11.3

[1]Assume minimum Existing WTP Capacity of 5 mgd

- With the existing WTP at a minimum 5 mgd delivery, Walter or Willett could be used to pump excess water out of Zone 1
- Could reduce the amount of Zone 2 pumping by sending more to Zone 1 and using Willett
- Assuming that H2-3 can be turned down to 7 mgd, begin using Z2 pumping in HSPS to deliver all the water to the Heights. Begin using WEWTP to only deliver water to Z2 and Z3. Z2 and 2E are isolated in HSPS
- Need to verify if delivery of water to Z2 etc is limited at 10 mgd. If so have existing WTP deliver additonal water to Z1 and use Walter Pump Station to pump from Zone 1
- Assume the WEWTP max Z3 delivery is 13 mgd due to limitation in piping in King and Shiloh. So overall demands higher than this for the WEWTP 5 mgd will go to Z2 and 13 mgd to Z3. Begin using Voelker to meet Z3 demands.
- Don't have to supply Z3 from WEWTP. WEWTP could just supply Z2 and use Voelker to supply Z3
- Assume maximum deliver from Z2 at WEWTP is 13 mgd. Above this start using Z3 pumps at WEWTP and stop using Voelker
- At this point the WEWTP can't meet all the demand in Z2, Z3S, Z4S so additional water is needed from the existing WTP. Throttling valve in HSPS can be used to deliver the additonal water. Or leave Z2 isolated from Z2E and meet the additonal demands with Willett
- Willett existing capacity 10 mgd
- Overall demand is 30 mgd. Existing plant is at 12 mgd. At this point could start using Sed Basin 2 with one LSPS 2 pump operating at minium speed. Maybe the pump could pump lower and Sed Basin 2 could be started sooner