Council Study Session

January 3rd, 2022

Agenda Item	Water Treatment Plant Update	
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Item Type	Requested by Council ☒ Update ☒ Request for Direction ☒ Presentation ☒	

SUMMARY

Before the Council is an update on the water treatment plant project and staff is providing additional information on the City's conservation program. Staff previously updated the Council at the April 19, 2021 Study Session (Staff Report). At the study session Council asked additional questions regarding the project that needed further time to analyze and bring back appropriate answers. In addition, due to time constraints, the discussion questions asked by staff of Council were not answered. Since the April update staff has not moved the project forward to the 90% design iteration as both the Council questions and previously established discussion questions require answers.

POLICIES, PLANS & GOALS SUPPORTED

City Council Goals:

- Essential Service-Drinking Water System
- Emergency Preparedness
- Address Climate Change

CEAP Goals:

Natural Systems: Air, water, and ecosystem health, including opportunities to reduce emissions and prepare for climate change through improved resource conservation and ecosystem management.

- Strategy NS-2: Manage and conserve community water resources

- Strategy NS-3: Conserve water use within City operations

Department Goals:

- Maintain existing infrastructure to meet regulatory requirements and minimize life-cycle costs
- Deliver timely life cycle capital improvement projects
- Maintain and improve infrastructure that enhances the economic vitality of the community
- Evaluate all city infrastructure regarding planning management and financial resources

BACKGROUND AND ADDITIONAL INFORMATION

The City has long been heavily focused on strategic planning and improvements associated with its critical water resource systems. This planning and improvement to the community's water system has provided a robust, resilient and redundant water system for all users.

Discussions regarding a new water treatment plant have long since been had by the City Council, dating back to the original Water Advisory Group (WAG) in the 1990's and the Ashland Water Advisory Committee (AWAC) in the 2000's. These two Committees led the charge in conjunction with Public Works staff to develop water system planning documents and bring forward appropriate recommendations to Council for adoption.

2012 Water Master Plan (Link)
2013 Water Management and Conservation Plan (Link)
2020 Water Master Plan (Link)

From a historical perspective and to gain better understanding of origins of water needs and planning for the City of Ashland, staff recommends reading "Where Living Waters Flow" (1998) by Kay Atwood.

New Water Treatment Plant Project:

Staff provided Council with a status update of the new water treatment plant project at the April 19, 2021 Study Session (Staff Report). During the meeting several questions were raised by the Council that needed further analysis and resolution. In addition, due to time constrains the discussion questions posed by staff were unable to be answered by the Council.

After conclusion of the April 19, 2021 Study Session, staff has worked with HDR to develop answers to questions that were posed during the meeting. These questions are itemized below and full responses are identified in attachment #1.

Council Questions from April 6, 2021 Study Session:

1. Algae and algal toxins – what are the treatment options, the ability to be installed at the existing water treatment plant (WTP), and their costs?
2. What is the impact of inflation and the current costs to modify the existing WTP?
3. What is the expected life of various water treatment components and systems?
4. What is the cost of operating the existing WTP compared to the new one?
5. What is the electricity generation with the new photovoltaic system? and
6. What is the impact of the new WTP to the City's trail system?

Staff is also looking for direction with respect to questions raised in the April 19, 2021 Study Session. Responses to the questions will affect the final design and associated cost estimates.

Discussion Question #1:

Does the Council agree with the new optimized sizing plan for the Water Treatment Plant?

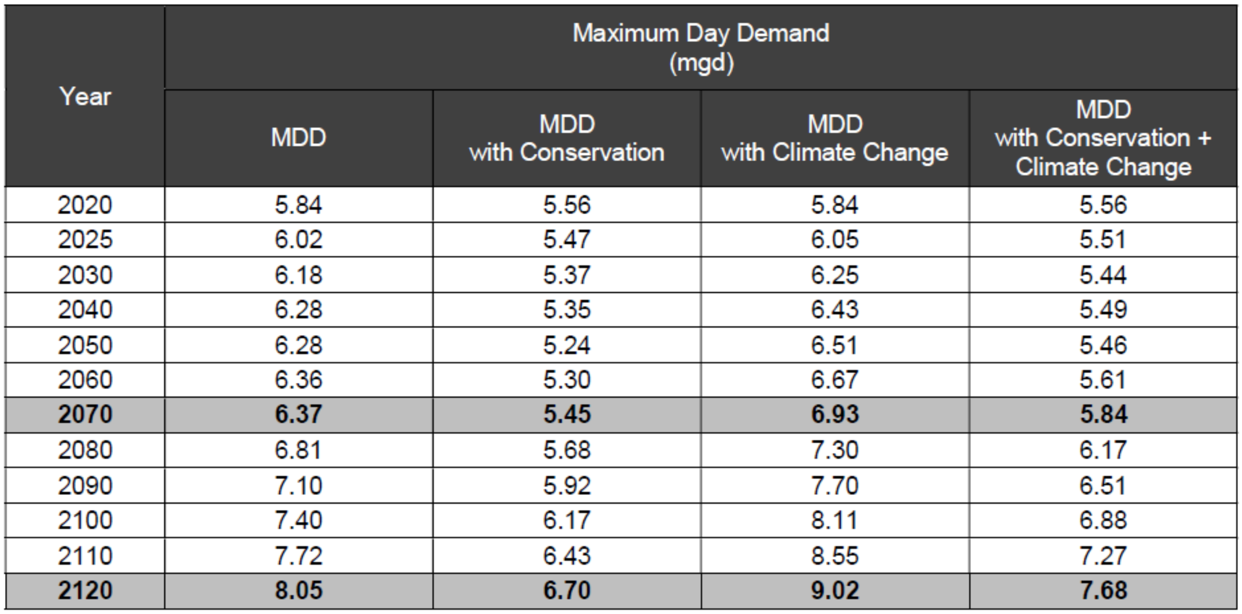
There has been concern expressed that the initial facility sizing is too large based on updated supply/demand forecasts generated in the 2020 Water Master Plan Update. The 2020 plan forecasts demand without additional conservation or impacts from climate change, based on the current per-capita usage. The demand is projected to be 6.6 MGD by 2040. With respect to the plant sizing question, HDR and City staff reviewed multiple years of demand and production data for the water treatment plant to formally address these concerns moving forward.

Staff worked with HDR to analyze plant sizing and a memo detailing the analysis was provided to Council at the April 19, 2021 Study Session. The recommendation is to size the plant initially for 7 MGD and provide expansion capacity to 9 MGD in the future. The updated analysis looked at straight line demand, demand with conservation, demand with climate change impacts and the combined demand of conservation with climate change. Reference table 1 for demand analysis breakdown.

These Water demands and facility sizing were initially analyzed in August of 2020 prior to the Almeda Fire. These pre-Almeda Fire demands also included potential climate impacts on water supply as part of the maximum day demand forecasting. The August projection and recommendation by HDR was to develop an initial facility size of 6.5 MGD (50-year life) expandable to 8.5 MGD (100-year life).

After the Almeda Fire HDR revised the demand projections and provided an updated recommendation for an initial facility size of 7.0 MGD expandable to 9.0 MGD in part due to actual production during the fire period (September 9th maximum day demand was 5.84 MGD).

Table 1: Maximum Day Demand – Forecast Period



Year	Maximum Day Demand (mgd)			
	MDD	MDD with Conservation	MDD with Climate Change	MDD with Conservation + Climate Change
2020	5.84	5.56	5.84	5.56
2025	6.02	5.47	6.05	5.51
2030	6.18	5.37	6.25	5.44
2040	6.28	5.35	6.43	5.49
2050	6.28	5.24	6.51	5.46
2060	6.36	5.30	6.67	5.61
2070	**6.37**	**5.45**	**6.93**	**5.84**
2080	6.81	5.68	7.30	6.17
2090	7.10	5.92	7.70	6.51
2100	7.40	6.17	8.11	6.88
2110	7.72	6.43	8.55	7.27
2120	**8.05**	**6.70**	**9.02**	**7.68**

Discussion Question #2:
Does the Council have any recommendations on Envision program implementation parameter for the final design?

Envision Recommendations:
Based on the current design status for the plant, the project currently rates at Silver status with 369 points. 382 points are required to reach Gold status and Platinum required 477 points. The original request by Council was to focus on energy with respect to the Envision program, but there are also additional lower cost items that add points moving towards Platinum status and some are inherent to engineering phase.

Staff has the following recommendations for the Envision program to reach Gold level and include in the final design:

1. 199 kW rooftop solar on buildings
2. Increase storm drain retention and treatment
3. Develop a sustainability management plan
4. Prepare End of Life Analysis
5. Restart AWAC as a formal City Commission that meets as needed (twice per year/minimum)*

***Note**: Restarting AWAC can also provide additional benefits, including working with staff to make recommendations to Council on priority Capital Improvement Projects (CIP) that focus on minimizing risk and increasing resiliency as was previously discussed by Council during the CIP adoption process.

These recommendations increase the proposed score from 369 to 440 and meet the Gold level status while minimizing overall cost.

Table 1: Envision Estimated Costs

Envision Additions	Cost	Points
199 kW rooftop solar on buildings	$2,000,000	10
Increase storm drain retention and treatment	$ 150,000	15
Develop sustainability management plan	$ 50,000	16
Prepare End of Life Analysis	$ 100,000	15
Restart AWAC as a formal City Commission	$ -	15
Totals	$2,300,000	71
Current Silver Status (60% design)		**369**
Projected Gold Total		**440**

City Charter:

At the April 19, 2021 study session, questions were asked if the City Charter allowed the City to contract out the operation of the water treatment plant. After reviewing Article 16, Section 1 of the Charter it is staff's initial opinion the Charter does not allow us to contract out the operation of the water treatment plant:

> ARTICLE 16 Miscellaneous Provisions Section 1.
> Public Utilities - Water Works The City of Ashland, a municipal corporation, shall have the power to provide the residents of said City with such services as water, sewer, electric power, public transportation and such other public utilities as the people desire by majority vote; and to exact and collect compensation from the users of such public utility; provided, however, that any and all water and water works and water rights now owned or which may hereafter be acquired by said City, for the purpose of supplying the inhabitants thereof with water shall never be rented, sold or otherwise disposed of; nor shall the City ever grant any franchise to any person or corporation for the purpose of supplying the inhabitants of said City with water.

Conservation programs, Capture, Reuse and Rebates:

The City of Ashland has long had a robust water conservation and efficiency program and implemented many different measures over the years. During the 2020 Water Master Plan Update conservation programs were analyzed through a cost benefit lens and programmatic elements were vetted and recommended by AWAC as part of the process.

The City has rebates in place for replacing water consuming household systems with high efficiency systems. In addition, the City has created a lawn replacement rebate program and is currently promoting smart irrigation controller system rebates. The conservation program also provides giveaways for community members including low flow showerheads and moisture meters.

As well as rebate programs there are options for rainwater capture and graywater reuse. Links to detailed information are below. Rainwater capture and graywater reuse require permits through the building department and the Department of Environmental Quality. Capture and reuse programs are not current supported via a rebate system structure through the conservation program as they were shown to not provide a significant cost benefit. Instead of rebates Conservation staff have hosted capture and reuse workshops for local community members and contractors to demonstrate how the systems are installed and utilized.

Rainwater Capture:
https://www.ashland.or.us/Files/Rainwater%20resources%20Oregon%20Smart%20Guide.pdf
http://www.ashland.or.us/Files/Rainbarrel_guide_May2012.pdf

Graywater Reuse:
http://www.ashland.or.us/Files/DEQ_Graywater_QA.pdf
http://www.ashland.or.us/Files/OutdoorGraywater_fullhandout.pdf
http://www.ashland.or.us/Files/Indoor_graywater_fullhandout.pdf
http://www.ashland.or.us/Files/OutdoorGraywater_fullhandout.pdf

Rebate Programs:

WaterSense Toilet Rebates
Rebates are given to customers who replace existing toilets greater than 3.0 gallons per flush (gpf) with WaterSense labeled toilets.

Washing Machine Rebates
Rebates are given to customers who purchase resource efficient clothes washers. These machines use up to 40% less water and up to 50% less energy. Qualifying appliance lists can be found at www.energystar.gov.

Irrigation Smart Controller Rebate
A rebate is being offered for the installation of a WaterSense Labeled Smart Irrigation Controller.

Lawn Replacement Rebate
A rebate is being offered by the City of Ashland for the removal of live, maintained and irrigated lawn that is replaced with climate appropriate, low water use landscapes and efficient irrigation systems.

FISCAL IMPACTS

Public Works staff is working with the State of Oregon’s Infrastructure Financing Authority (IFA) on potential funding mechanisms for funding the complete water treatment plant project. One of the funding streams is the federal Water Infrastructure Finance and Innovation Act (WIFIA). WIFIA has a small cities funding program which can fund up to 80% of the total project with a maximum 35-year term and associated low interest rate. The additional 20% funding requirement can come from a secondary loan through the Infrastructure Financing Authority, revenue bond, special public works fund and/or combination of available cash.

Staff submitted a letter of interest through the WIFIA program to fund a portion of the project. On October 27th the City was notified the water treatment plant project has been selected to apply for formal funding through the WIFIA program. On December 7th Public Works and Finance staff attended a webinar detailing the WIFIA funding program.

The City previously had a loan with the IFA for $14.8 million with a 30-year term at 1.79% to partially fund the new water treatment plant. Since a significant amount of time has transpired since when the City originally obtained the loan (2016 award) and the project has advanced in scope, the IFA has requested the City convert the existing loan into a "planning" loan to fund the remainder of the final design for the project and obtain WIFIA or other funding for the construction phases of the project. The IFA is ready and willing to support the City anyway they can obtain full funding for the project.

WIFIA Background:
The WIFIA program offers federal loans with low, fixed interest rates and flexible financial terms. Borrowers and their customers benefit from significant cost saving. A single fixed interest rate is established at closing. A borrower may receive multiple disbursements over several years at the same fixed interest rate. Interest rate is equal to the US Treasury rate of a similar maturity **(current 30-year treasury rate is 1.77% for December 2021)**. The WIFIA program sets its interest rate based on the U.S. Treasury rate on the date of loan closing. The rate is calculated using the weighted average (WAL) life of the loan rather than the loan maturity date. The WAL is generally shorter than the loan's actual length resulting in a lower interest rate. Interest rate is not impacted by the borrower's credit or loan structure. All borrowers benefit from the AAA Treasury rate, regardless of whether they are rated AA or BBB. The WIFIA program does not charge a higher rate for flexible financial terms.

Customized repayment schedules. Borrowers can customize their repayments to match their anticipated revenues and expenses for the life of the loan. This flexibility provides borrowers with the time they may need to phase in rate increases to generate revenue to repay the loan.
Long repayment period. WIFIA loans may have a length of up to 35 years after substantial completion, allowing payment amounts to be smaller throughout the life of the loan.
Deferred payment. Payments may be deferred up to 5 years after the project's substantial completion.
Subordination. Under certain circumstances, WIFIA may take a subordinate position in payment priority, increasing coverage ratios for senior bond holders. WIFIA loans can be combined with various funding sources. WIFIA loans can be combined with private equity, revenue bonds, corporate debt, grants, and State Revolving Fund (SRF) loans.

Water Treatment Plant Cost Estimates:
Since 2017 to date the City has expended $3.75 million towards the project, including a siting study, alternatives analysis, preliminary engineering, and final engineering.

Staff has worked closely with HDR Engineering and Mortenson Construction to refine the WTP design and capture cost savings without sacrificing treatment or water quality capacities. The **September 2020** construction cost estimate is $32.8 million at the recommended plant sizing. This estimate does not include the estimated $2.3 million for the envision components ($35.1 million including envision components). Since the last formal cost estimate developed was in fall of 2020, staff and HDR expect the costs to change moving forward towards the 90% design/cost iteration due to inflationary factors and labor issues affecting the economy currently.

Cost Estimating Timeline for the WTP in Ashland		
Timeline	Design Stage	Cost Estimate (in millions)
Jan-19	Initial concept analysis	$ 42.1
May-19	Revised concept analysis	$ 45.3
Jun-19	Draft 30% design submittal	$ 43.3
Jul-19	Value engineering session	$ 36.0
Sep-19	Final 30% design submittal	$ 35.9
Apr-20	Initial 60% cost estimate	$ 43.9
May-20	Inclusion of Ashland Creek Culvert	$ 44.6
May-20	Value engineering session and equipment bids	$ 35.3
Sep-20	Facility resizing to 7.0 MGD	$ 32.8

Note: Cost estimates currently do not include any Envision additions as referenced above.

Staff is coordinating an update to the previous rate analysis done by Hansford Economic tied to the Water Master Plan update in order to better understand the financial/rate implications for the current capital plan, future materials and services requirements and inclusion of maintenance and improvement projects for the TAP system. This analysis will also tie directly into how the City can best maximize the WIFIA program for project funding with its flexibility in developing final loan documents.

All of this information will be compiled and reviewed with Administration and Finance to determine a recommended course of action that provides complete funding for the project while minimizing rate impacts to the Community. This information will be presented before Council at a date TBD.

DISCUSSION QUESTIONS

Does the Council agree with the new optimized sizing plan for the Water Treatment Plant?

Does the Council have any recommendations on Envision program implementation parameter for the final design?

Does the Council have any request for additional information to be provided as part of the design process?

Does the Council have any general direction or comments to provide staff?

SUGGESTED NEXT STEPS

Next steps include moving forward with finalizing the value engineering associated with the 60% design phase along with the final recommended Envision program inclusions and completing the 90% and 100% design phases. Additional actions include finalizing the rate model forecast and developing a recommended course of action for complete project funding.

REFERENCES & ATTACHMENTS

Attachment #1: HDR Technical Memorandum – Response to Council Questions
Attachment #2: Water Treatment Plant Decision History Memo

Attachment #3: Alliance for Water Efficiency – Water Savings and Financial Benefits of Single-Family Package Graywater Systems
Attachment #4: Graywater process outline

Memo

Date:	Tuesday, October 26, 2021
Project:	Ashland WTP Final Design
To:	Scott Fleury (City of Ashland), Kevin Caldwell (City of Ashland)
From:	Pierre Kwan, Verena Winter (HDR)
Subject:	**Response to City Council Comments**

This memorandum has been prepared in response to the following City Council questions received at the April 19, 2020 study session:

1. Algae and algal toxins – what are the treatment options, the ability to be installed at the existing water treatment plant (WTP), and their costs?
2. What is the effect of inflation and the current costs to modify the existing WTP?
3. What is the expected life of various water treatment components and systems?
4. What is the cost of operating the existing WTP compared to the new one?
5. What is the electricity generation with the new photovoltaic system?
6. How will the new WTP affect the City's trail system?

Q1 – Algae and Algae Toxins

Blue-green algae, formally known as cyanobacteria, are naturally occurring in Oregon surface waters. When conditions are favorable, the algae rapidly multiply and cause harmful algal blooms (HABs). HABs are designated as harmful because the high presence of blue-green algae produce cyanotoxins. The federal Environmental Protection Agency (EPA) is concerned about four specific cyanotoxins due to their acute and chronic human health impacts and actively considering nationwide drinking water regulations for: anatoxin-a, microcystin, cylindrospermopsin, and saxitoxin.

Of these four, the Oregon Health Authority (OHA), ahead of federal EPA regulatory action, implemented statewide regulations for microcystins and cylindrospermopsin (https://www.oregon.gov/oha/ph/healthyenvironments/drinkingwater/rules/documents/61-0510.pdf) on January 28, 2019. Microcystins have also been historically found in Reeder Reservoir. It was this historical presence that caused OHA to designate the City as being susceptible to HABs. On August 20, 2020, microcystins in the City's Talent Irrigation District (TID) supplemental water supply caused the City to shut down part of its water supply and immediately implement water conservation measures. OHA and the Department of Environmental Quality (DEQ) indicated in their April 2021 statewide reporting and monitoring update that the City of Ashland has reported the highest concentrations of algal toxins in the entire state in 2020 (OHA/DEQ, 2021 – Page 20, 21, and 22 of the presentation) (https://www.oregon.gov/oha/ph/healthyenvironments/drinkingwater/operations/treatment/documents/algae/oha-deq-cyanotoxin-monitoring-webinar-april-2021.pdf). In comparison, the concentrations in Salem's water supply, the cause of the Legislature's 2019 emergency algal toxin rulemaking, were only 12 percent that of Ashland's.

There are no records that a cylindrospermospin analysis has been conducted in Reeder Reservoir, and the City does not analyze for anatoxin or saxotoxin in any of its water supplies.

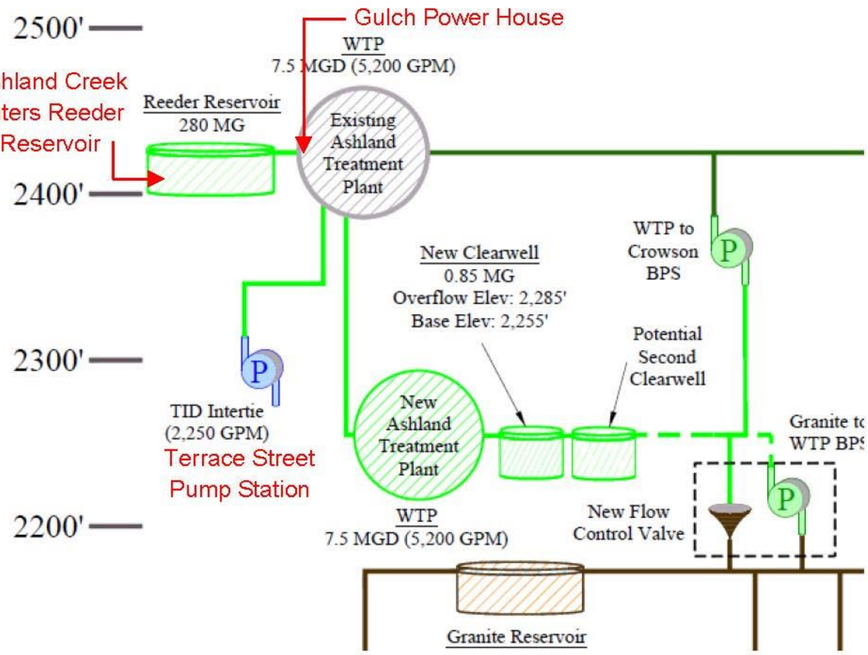
Algae Treatment Methods

There are three main methods for algae treatment:

1. Preventing blue-green algae from growing into HABs.
2. Preventing any formed algae from entering the WTP and releasing algal toxins.
3. Removing any formed algal toxins.

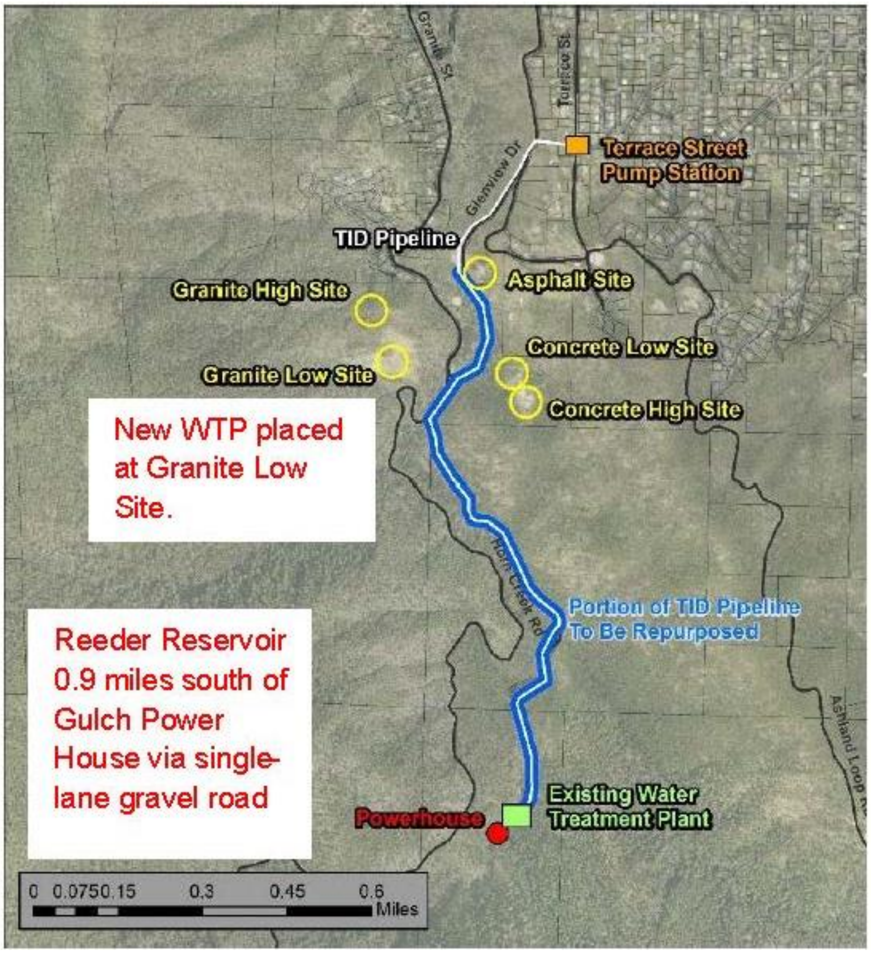
Figures 1 and 2 are a schematic and map of the City's water supplies to provide context. Table 1 summarizes the available methods to treat the algae and algal toxins discussed in this section.

Figure 1. Schematic of City Water Supplies



Source: 2019 Water Master Plan

Figure 2. Aerial Showing Location of Key Facilities



Source: 2018 TID Pipeline Report

Table 1. Summary of Algae and Algal Treatment Options

Method	Option	Implementation at:		
		Ashland Creek/ Reeder Reservoir	TID Supply	Existing WTP
Preventing blue-green algae from growing	Preventing nutrients or sunlight from entering water	Watershed already protected against nutrients. Install a floating cover over water surface to block sunlight.	Pipe canal	Nutrient control not required and there is little direct sunlight at the existing WTP.
	Cooling water	Impractical given size of reservoir	Pipe canal	Impractical given WTP size
	Eliminating stagnant pools of water	Install new powerlines and pumps in reservoir	Not required as canal is already flowing	Not applicable
	Adding algaecide chemicals	Already in use	Prior testing found no benefit – canal has too much algae	Too late to be effective
Preventing blue-green algae from entering the WTP and releasing algal toxins (does not address toxins already released prior to WTP)	Selective withdraw of water to avoid algae	Already in use	Infeasible - Canal is too shallow to accomplish this	Not applicable
	Adding screens or dissolved air flotation	Already in use	Already in use	Not required as screening already occurs at Reeder Reservoir and Terrace Street Pump Station
Removing any formed algal toxins	Activated carbon absorption	Less effective than at WTP	Less effective than at WTP	Already in use
	Ozone addition	Not recommended to store the required equipment and chemicals in the watershed.	Requires City acquiring more property as Terrace Street Pump Station lacks space to install such equipment. Station increases 10x in size.	The concept of retrofitting ozone at the existing WTP is discussed later in this document.
	Other oxidant addition (chlorine, permanganate)	Not recommended to store the required equipment and chemicals in the watershed.	Already in use	Already in use

Steps to prevent algae growth consist of preventing nutrients or sunlight from entering the water, cooling the water, eliminating calm or stagnant pools of water, or adding algaecides. Reeder Reservoir and Ashland Creek are already in a protected watershed so algal blooms are forming despite watershed control measures to prevent nutrient additions. Eliminating sunlight into the creek and reservoir would take a large expanse of fabric to cover the water and quickly cause severe ecological damage to animals and plants in the water (killing the algae also eliminates the plants that provide oxygen to fish and amphibians). Cooling a waterbody the size of Reeder Reservoir is not economically feasible to install or operate. Eliminating the stagnant areas of the Reservoir may be viable but would require installation and operation of pumps in the remote watershed. Installation and operational costs likely would be high as new powerlines and equipment would need to be placed throughout the protected watershed and the permanent impacts to aquatic life by mechanically pumping water around the reservoir is unknown. City staff have already been adding algaecide chemicals to Reeder Reservoir for many seasons to minimize HABs. Their current work prevents algae growth in early to mid-summer but has proven ineffective in stopping or even slowing growth in late summer when the water temperatures are hottest and the amount of Ashland Creek water entering Reeder Reservoir is reduced to a trickle.

Sunlight and nutrient elimination may be feasible with the TID supply by piping the canal. Such construction prevents sunlight and nutrients from entering the water. Extensive coordination would be required with the TID to conduct this activity and further study would be required to determine how much of the canal would need to be piped – at a minimum, the portions of the TID canal through the urbanized areas within the City should be considered. In addition, piping the canal would also cool the water further and make less hospitable for algae growth. Algaecide addition into the TID canal has been tried by the City in the past but its use was ineffective. Sunlight control at the existing WTP is not a problem as the WTP is situated in a narrow canyon where there are only a few days a year when direct sunlight can reach exposed water. Sunlight control is provided at the new WTP with the proposed roof structure over the filters. This roof structure would also support the new photovoltaic system.

Preventing HABs from entering the WTP and releasing algal toxins can be accommodated by selective withdrawal of water from Reeder Reservoir to avoid the shallow water depths with the most algae and by physically stopping algae from entering the water intake. Selective withdrawal is already conducted by City staff, which helps delay the annual onset of taste-and-odor issues (an early indicator of algae) in the raw water. Physically stopping algae at the WTP would require installing screens or using a process like dissolved air flotation to separate algal cells from the water. Screening is already used at both the Reeder Reservoir intake and Terrace Street Pump Station. Note that this treatment method is aimed at preventing algae from releasing algal toxins once it enters the City's system and does not address any toxins already present in Ashland Creek, Reeder Reservoir, or the TID canal. Screening is effective for removing algae; all prior issues, including the August 20, 2020 mandatory shutdown of the TID supply, have been with algal toxins already in the water.

The final method is to remove algal toxins formed in the raw water supply or released from HABs entering the WTP. Removal is typically conducted by absorbing toxins onto activated carbon. Activated carbon is manufactured by heating wood or coal to high temperatures in natural gas-fired furnaces to partially release some of the carbon dioxide to form pores that readily absorb compounds like algal toxins. The required wood or coal is specific to the eastern United States so additional greenhouse gas emissions are generated by the transport of this material. This is a process that the City already uses every summer and fall in conjunction with adding algaecide chemicals to the watershed and selective withdrawal from the reservoir to minimize algae impacts to the drinking water. The alternative process is to use a powerful oxidant, such as ozone, to destroy all types of algal toxins. This is the process that has been selected for the new WTP, already in use by Medford and Salem, and will soon be installed at Grants Pass, Eugene, and Portland. Chlorine is an oxidant that is already in use at the WTP but it is not effective against all algal toxins or is only effective at dosages that inadvertently generate disinfection byproducts (DBPs), a group of strictly regulated cancer-causing compounds. High chlorine dosages had been previously used at the WTP to help address algae issues but was stopped in 2013 because of DBP compliance issues. The Terrace Street Pump Station adds permanganate, another powerful oxidant, to address some of the algae and algal toxin issues – its use is carefully controlled as staff experience has found this chemical can easily turn the water bright pink or dark black in color.

To summarize, the existing WTP processes and systems already in use to minimize algal toxin exposure to customers include:

1. Ashland Creek/Reeder Reservoir – algaecide application to slow down algae growth, selectively withdrawing water to avoid algae, and screening to minimize algae entering the WTP.
2. TID canal/Terrace Street Pump Station – screening and permanganate addition.
3. Existing WTP – activated carbon addition, chlorine addition, and naturally occurring sunlight control.

Additional Algal Toxin Control at the Existing WTP

A major process or system not already in use at the existing WTP to control algae and algal toxins is ozone addition. Ozone is highly effective at destroying algal toxins and is increasingly commonly used for drinking water treatment (https://www.epa.gov/sites/default/files/2014-08/documents/cyanobacteria_factsheet.pdf). Attachment A shows a potential option for installing the ozone equipment, which was developed to:

1. Provide equivalent performance to the new WTP for addressing algae and algal toxins
2. Avoid disrupting the Gulch Power House and its hydroelectric power generation
3. Prevent temporary construction or permanent impacts to Ashland Creek
4. Provide unloading area for the required chemical delivery trucks

The existing WTP is in the narrow confines of a canyon so this option requires blasting and excavating a 15,000-square-foot area in the adjacent 65-foot-tall granite hillside (Figure 3). This area would be used to house the liquid oxygen storage equipment, ozone generation system, and a buried pipeline contactor. For this effort, the building and pipeline sizes are equivalent to those in the proposed new WTP. This equipment must be placed in new buildings as the existing structure cannot be made compatible with the City's fire code for storing and using liquid oxygen in these quantities.

Figure 3. Ashland Water Treatment Plant

Q2 – Cost Inflation and Current Costs to Modify Existing WTP

Cost inflation is an important factor for construction projects, especially ones like the City's WTP. Multiple years of planning and design can transform a few percentage points of annual inflation into a substantive fraction of project costs. These costs can add millions of dollars to large capital projects like the WTP. This section describes Figure 4 historical inflation, HDR and Mortenson's estimates for near-term future inflation, and their respective impact to modifying the existing WTP.

Historical Construction Inflation

Figure 4 compares the U.S. Bureau of Labor Statistics' national Consumer Price Index (CPI) against Engineering News-Record's Construction Cost Index (CCI). The CPI is a representation of cost inflation to a typical U.S. consumer whereas the CCI is a specific measure of inflation as it relates to public works capital projects, such as the WTP. The chart shows that cost inflation has been continually occurring the past ten years, with historical CCI increases always higher than CPI increases, by an overall average of one percent higher per year. Compounding this annually higher inflation results in total higher costs solely because of time. Figure 5 shows that annual inflation compounding from May 2011 to May 2021 has resulted in a 19 percent increase in consumer goods and a 33 percent in construction costs. Put another way, personal goods like groceries costing $100 in May 2011 would now cost $119, whereas $100 of construction costs in May 2011 would now cost $133.

Figure 4. Annual Year-Over-Year Change in Consumer Price Index and Construction Cost Index National Values for the Month of May

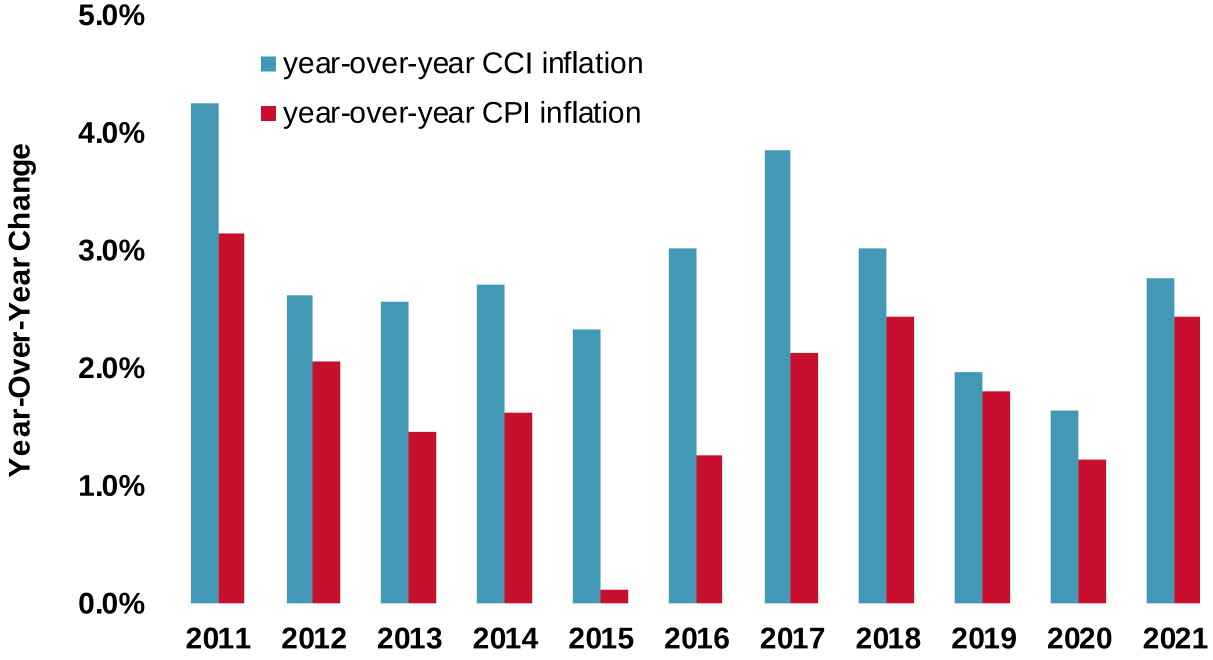
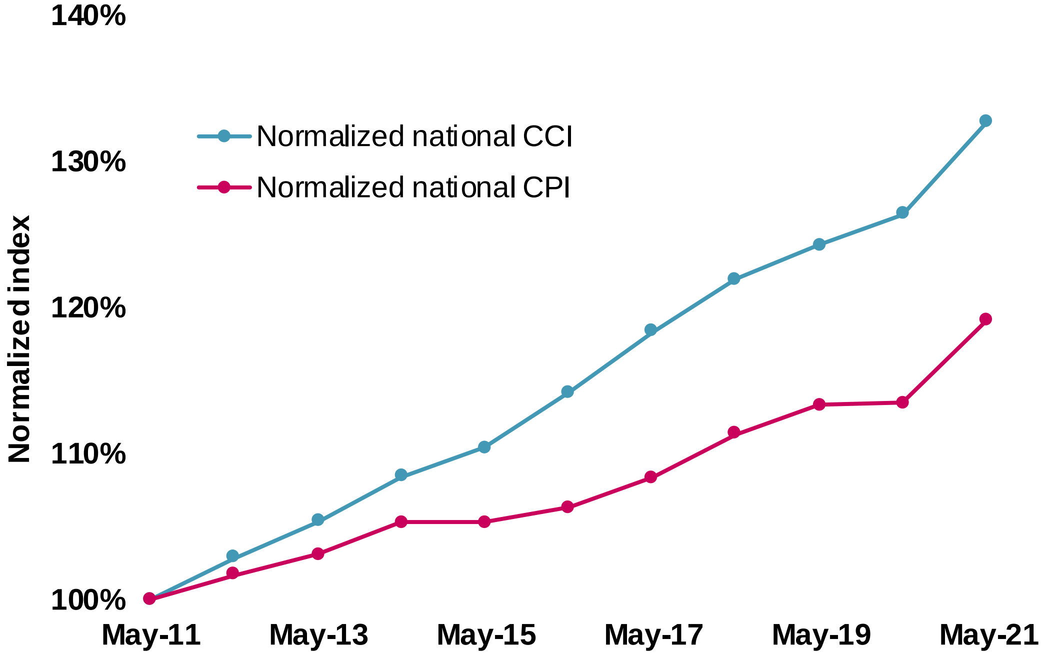


Figure 5. Compounded Inflation Over Time (May 2011 = 100)



Cost Inflation for 2021 and 2022

HDR and Mortenson project that inflation for the next 12 months will remain high. Inflation is caused by shortages in many of the common materials used for construction: diesel fuel, raw metals (steel, copper, aluminum), wood products (lumber and plywood), and plastics (PVC piping). The shortages and associated inflation are caused by many North American factories that were idled or operating at reduced capacities. As the nation's economy strengthens and construction activities increase, there is a shortage in raw materials as construction firms have been purchasing and using materials faster than factories can produce them.

HDR and Mortenson currently estimate construction cost inflation for the next 12 months to be 4.0 to 6.0 percent, a rate that has not occurred since 2011, as both companies estimate it will take that long for North American materials supply to finally catch up with demand. Beyond that, there is no indication that construction cost inflation will ever decrease to be equal to, let alone below, consumer inflation.

Algae Treatment Costs and Total Construction Cost

The cost of implementing algae/algal toxin treatment at the existing WTP is listed in Table 2. The table also shows the 2021-inflated costs of renovating the existing WTP to extend its useful life and the estimated costs for flood protection and seismic resiliency based on the estimates from the 2018 Black & Veatch existing WTP evaluation report (http://www.ashland.or.us/files/COA_WTP_Evaluation_FINAL_w_RH2_cover_letter.pdf).

Table 2. Existing WTP Retrofit Cost Breakdown

Upgrade Component	Cost
Algae/Algal toxin treatment upgrade	$14.3M
Existing plant mechanical renewal, new flood wall, and seismic retrofit	$8.0M
Cost escalation, insurance, bonds, and taxes	$4.9M
Total construction cost	**$27.3M**

Cost/Benefit Comparison

Table 3 compares the costs of retrofitting the existing WTP or constructing the new WTP with the benefits that can be obtained.

Table 3. Cost/Benefit Comparison of Retrofitting Existing WTP and Constructing New WTP

Parameter	Retrofitting Existing WTP	Constructing New WTP
Construction Cost	$27.3M	$32.8M
WTP lifespan after construction	Up to 25 years	Approx. 75 years
Treatment for algae/algal toxins	Yes – added ozone	Yes – added ozone
Seismic resiliency	Yes – retrofitted to current code requirements	Yes – designed to current code requirements
Protection against Ashland Creek flooding	Yes, but for less than 100-year storm	Yes, site is well above 100-year storm
Ability to treat highly turbid and silt-laden water	No – this feature was removed during the 1993 upgrades.	Yes, designed with this feature
Protection against emergency water release from Hosler Dam	No – WTP facility will be submerged underneath 30 feet of water; no City staff life safety protection.	Yes, site is well above inundation zone.
Protection against wildfires	No – existing WTP and access road is surrounded by trees. Facility has no perimeter firefighting system.	Yes – new site is a naturally barren site with little tree coverage and much closer to town. In addition, new site will have perimeter firefighting system installed.
Improved fish habitat in Ashland Creek	No – construction of flood wall will cause extensive damage to Ashland Creek	Yes – fish friendly culvert at Horn Creek Road
Improved flood protection along Horn Creek Road and Granite Street	No – existing undersized culvert remains.	Yes – new, larger culvert replaces existing one that has collapsed twice in 50 years.

Q3 – Lifespan of Water Treatment System and Components

Table 4 provides the estimated lifespan of various systems and components for a WTP similar to the City's existing one and the planned new one. This information is derived from guidance provided by the American Water Works Association, the Water Environment Federation, the U.S. Bureau of Reclamation, and HDR's professional experience.

Table 4. Estimated Useful Life of Various Water Treatment Plant Systems and Components

Asset Class	Useful Life (years)	Description
Site Work and Structures		
Civil/Sitework	50	With pavement inspection and repair every 15 – 20 years.
Structural/Architectural	50	Can be extended in 20- to 25-year increments with major renovations for a max. 75 to 100 yrs, if no seismic damage.
Water Tank – Concrete	50 – 75	Requires patch and crack sealing every 25 years if no seismic damage.
Water Tank – Steel	50 – 60	Requires recoating every 25 years if no seismic damage.
Piping and Valving		
Actuated Valves – Water	20 – 25	For open/close valves. Throttling valves can see useful life reduced by up to half.
Manual Valves – Water	25 – 35	For open/close valves. Throttling valves can see useful life reduced by up to half.
Piping - Above Ground/Exposed	30 – 50	Assumes no seismic damage or exposure to chemicals.
Piping – Buried	30 – 75	Assumes no seismic damage.
Valves – Chemicals	12 – 15	For chemicals at existing and new WTP.
Mechanical/Chemical Systems		
Blower	20 – 25	--
Feeder – Dry Chemical	15	--
Heating, Ventilation, Air Conditioning Systems	12 – 20	Shorter life for systems in chemical and filter rooms, longer life in office spaces
Pump – Chemical	12 – 15	For chemicals at existing and new WTP.
Pump – Water	20 – 30	
Tank - Chemical	15 – 25	For chemicals at existing and new WTP.
Electrical and Instrument Systems		
Electrical Motors	20 – 25	--
Field Analyzers and Digital Transmitters	10 – 15	Dependent on weather and chemical exposure, and vendor production cycles.
Power Distribution Panels and Wiring	25 – 30	--
Programmable Controller Hardware and Panels	10 – 15	Shorter lifespan in chemical, outdoor, and wet areas, longer life in dry/indoor areas.
Remote Telemetry Units	10	--
SCADA Hardware and Software	12	--
Standby Generator	20	--
Switchgear	30	--
Transformers	20 – 25	--
Uninterruptable Power Supply	12	--
Variable Frequency Drives	12	--

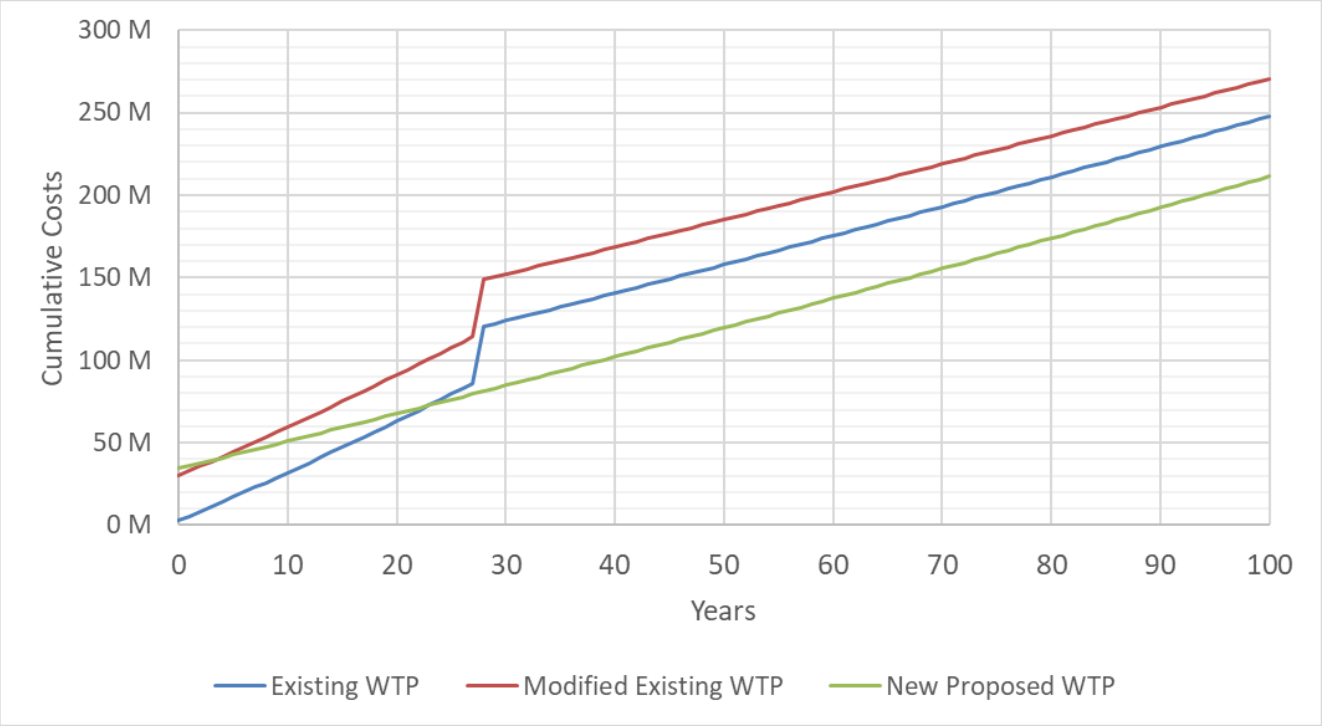
Q4 – Comparison of Existing and New Plant Operating Costs

Nearly 50 percent of operations and maintenance costs over the past few years has gone towards rehabilitation and improvement projects necessary to keep the existing WTP operating effectively. Significant annual investment in aging infrastructure is common for facilities that are reaching the end of their useful life. The new WTP is expected to have higher electricity costs, mainly due to the additional treatment and pumping requirements, but maintain lower overall annual operations and maintenance costs due to not needing to replace or rehab so much aging equipment and infrastructure regularly.

Figure 6 compares the cumulative lifecycle costs of building a new WTP now to the alternative of retrofitting the existing WTP now and building a new WTP in 25 years when the existing plant would be expected to reach the end of its maximum useful lifespan with renovation. This analysis shows:

- Deferring any attempts to meet seismic resiliency, reduce fire risks, address water quality issues, and provide any level of flood protection is the lowest cost option for the next 25 years. However, it still has a high annual cost due to the increasing need to maintain old equipment during this period. Upon WTP replacement in 25 years, this option would cost the City an estimated additional $40 million.
- Upgrading the existing WTP to provide some improvements for water quality (but deferring improvements to seismic resiliency, fire risks, and flood protection), is less expensive than construction of the new WTP but the combined cost of operating a new WTP while continuing to maintain and operate the rest of the 74-year facility results in this option become more expensive to the City after five years when compared to construction of a new WTP with an estimated $60 million more for the City after only 25 years.
- Construction of a new WTP has the highest initial City cost (and greatest City benefits) but will be less expensive than renovating the existing WTP in five years, less than the City providing zero upgrades to the WTP by Year 25, and will be the overall lowest cumulative cost from Years 26 to 100.

Figure 6. Lifecycle Costs



Q5 – Energy Generation with the New Photovoltaic System

The proposed new WTP's 199 kilowatts (kW) photovoltaic system is expected to produce approximately 296 megawatts per hour (MWh) per year, equivalent to the annual electricity use of 28 homes. This generation is estimated to defer the annual release of 89 metric tons of carbon dioxide equivalent (296 MWh x 0.30 MT CO_2e Northwest Power Pool power grid average). Production of 296 MWh/year at $0.08/kWh would result in $23,680 per year of earnings that would be used to offset other annual WTP costs. Table 5 compares WTP solar electricity production to power demand for low, average and maximum capacity water production.

Table 5. WTP Solar Electricity Production vs Demand

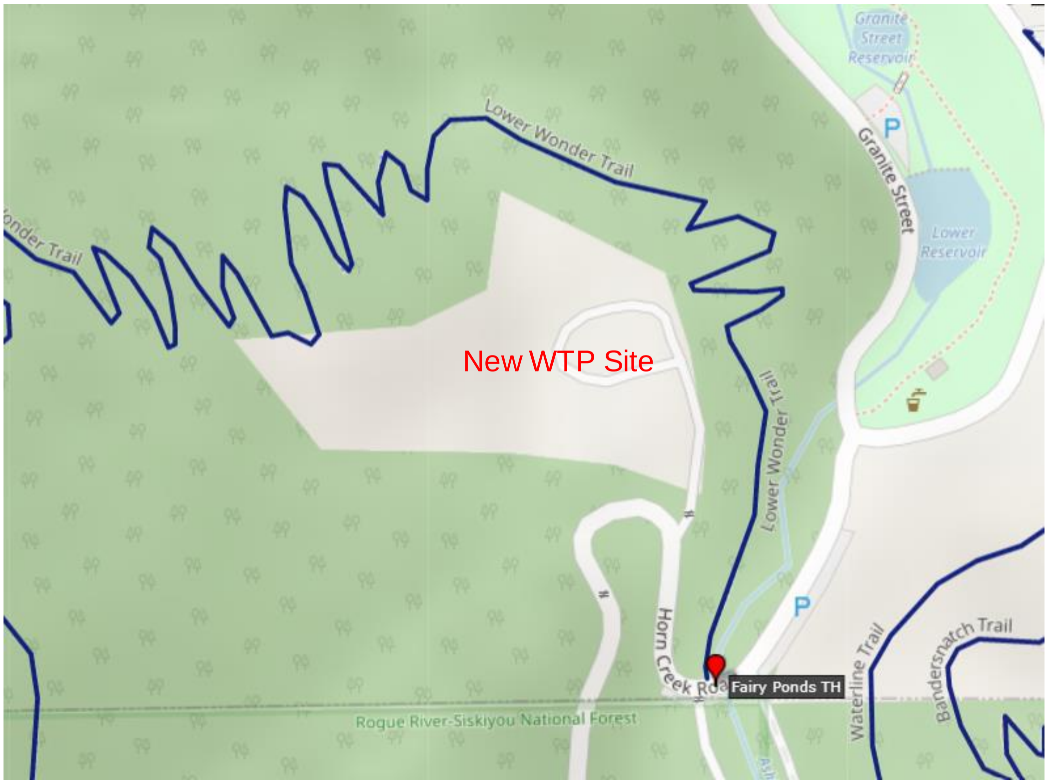
Water Production	Power Demand (kW)	Daytime Result with 199 kW System
Winter (1.5 MGD)	167	Sell 32 kW to grid
Average day (3.0 MGD)	250	Buy 51 kW from grid
Max capacity (6.5 MGD)	516	Buy 317 kW from grid

Note – 199 kW system would have provided 178 days of net daytime generation in 2019
MGD = million gallons per day

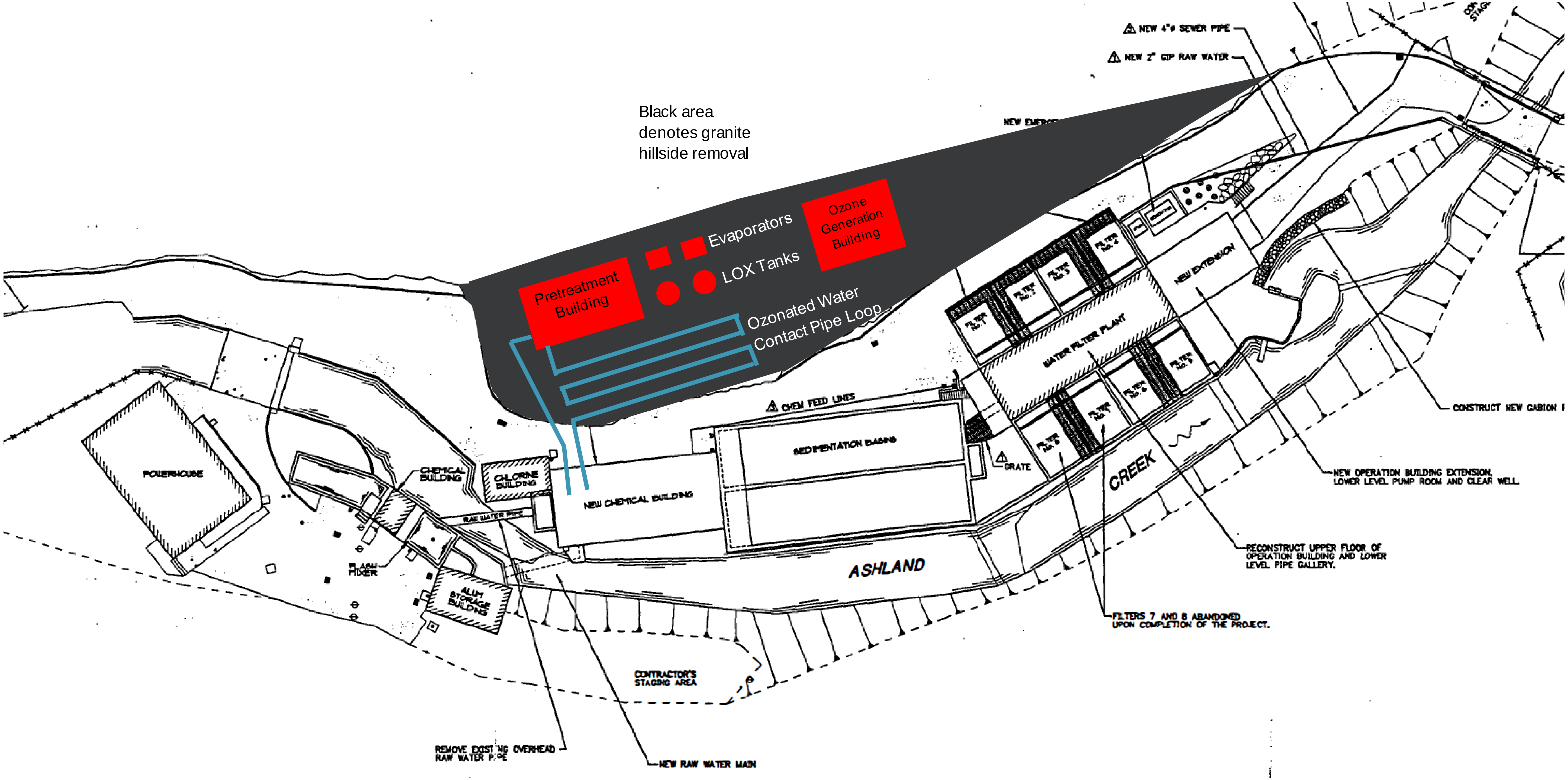
Q6 – Impacts to City Trails

The design of the new WTP has been coordinated with the Ashland Woodland and Trails Association (AWTA). Below is a map from the AWTA online mapping system showing the trails around the new WTP site. The new Lower Wonder Trail has been routed around the new WTP so the site can accommodate both construction and future operation of the new WTP and trail use with little to no reductions in usage by either water treatment operations or recreational hikers.

Figure 7. Trails Around New WTP Site



Attachment A. Potential Layout of New Ozone Equipment at Existing WTP



Black area denotes granite hillside removal

Memo

CITY OF ASHLAND

Date: December 30, 2021
From: Scott Fleury PE, Public Works Director
To: Gary Milliman, City Manager Pro Tem
RE: Water Treatment Plant Decision Points

Below is a list of items with specific decisions as actions through the City Council.

April 17, 2012-2012 Comprehensive Water Master Plan
Council adopted the master plan at the April 17, 2012 Business Meeting. The plan included development of a 2.5 MGD water treatment plant and 2.6 MG storage reservoir.
2.5 MGD Plant estimated at $12 million plus one additional employee requirement.
2.6 MG storage reservoir estimated at $6.7 million.
April 17, 2012 Minutes

April 7, 2015-2015-2017 Capital Improvement Program
Council approved the 2015-2017 Capital Improvement Program at the April 7, 2015 Business Meeting. The CIP included the 2.5 MGD water treatment plant and 2.6 MD water storage reservoir.
2.5 MGD Plant estimated at $14.5 million plus one additional employee requirement.*
2.6 MG storage reservoir estimated at $8.13 million.*
***Numbers inflated annually from the 2011 master plan project estimate.**
April 7, 2015 Minutes

June 16, 2015-2015-2017 Biennium Budget
Council approved the 2015-2017 Budget at the June 16, 2015 Business Meeting that included appropriations for the 2.5 MGD water treatment plant and 2.6 MD water storage reservoir.
2.5 MGD Plant estimated at $14.5 million plus one additional employee requirement.
2.6 MG storage reservoir estimated at $8.13 million.
June 16, 2015 Minutes

June 7, 2016-Infrastructure Finance Authority Funding Resolution
Council approved a resolution at the June 7, 2016 Business meeting authorizing an Infrastructure Financing Authority loan for engineering and construction of a new 2.5 MGD water treatment plant. The terms of the loan include $14,811,865 in principal, $1,030,000 in loan forgiveness and an interest rate of 1.79% for thirty years
June 7, 2016 Minutes

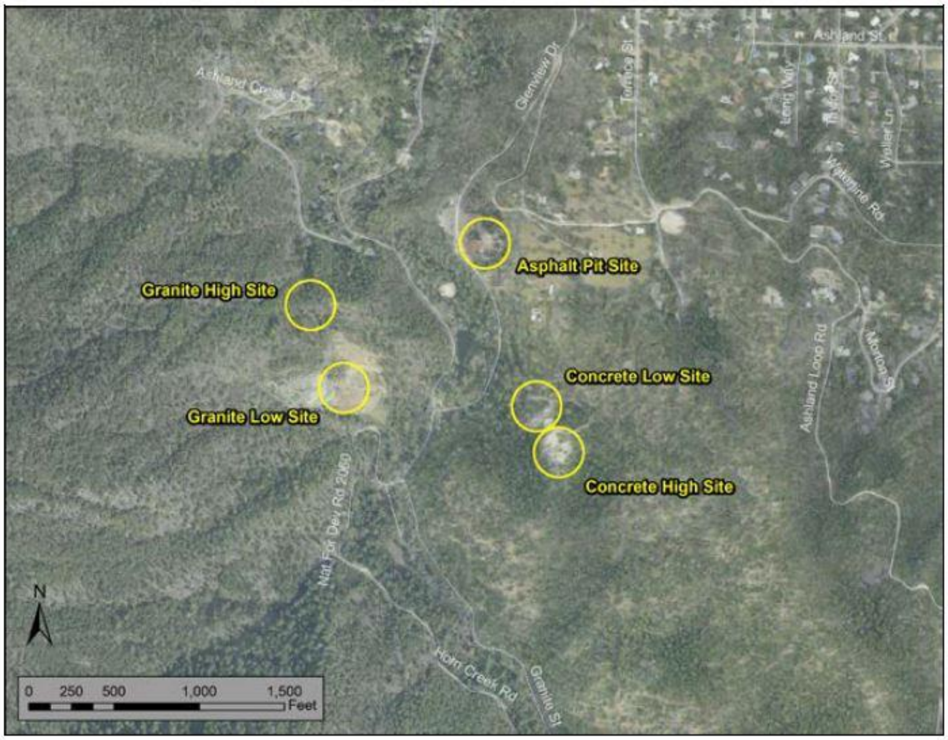
December 6, 2016-2.6 MG Storage Reservoir Reimbursement Resolution
Council approved a reimbursement resolution at the December 6, 2016 Business Meeting associated with the 2.6 MG water storage reservoir recommended in the 2012 master plan. The reimbursement resolution allows the City to reimburse itself via loan proceeds for all engineering work completed prior to construction.

December 6, 2016 Minutes

March 21, 2017-2.5 MGD Water Treatment Plant Preliminary Engineering
Council approved a professional services contract with Keller Associates at the March 21, 2017 Business Meeting for the design development of a 2.5 MGD water treatment plant and 2.6 MG water storage reservoir. The preliminary engineering included a siting study and treatment process analysis.
Initial site costs:*

1. Concrete Pit (high) $11.6 million
2. Concrete (low) $13.5 million
3. Granite (high) $14.7 million
4. Granite (low) $11.6 million
5. Asphalt Pit $15.4 million

*The initial site costs developed by Keller Associates in the preliminary phase only account for site work (grading/excavation), piping, pumping and electrical. Total cost was evaluated after the Granite low site was selected. All sites evaluated are on city owned property.



Total estimated cost of construction for the Granite low site:

1. Granite Low Membrane Filtration $26.2 million
2. Granite Low Membrane Filtration + UV $24.4 million
3. Granite Low Membrane Filtration + Ozone $29.4 million
4. Granite Low Conventional Filtration $30.7 million

March 21, 2017 Minutes

November 6, 2017-2.5 MGD Water Treatment Plant Project Review
Council received a presentation at the November 6, 2017 Study Session from the Director of Public Works who recommended a fresh look at the proposed 2.5 MGD water treatment plant. Options provided to Council where to analyze and compare costs and risks associated with rehabilitation of the existing plant to provide a 20-year useful life vs. construction of a brand new 7.5 MGD water treatment plant. The proposal was to compare the City's current water treatment

plant with a new one that would treat water in exactly the same way. At this time the City wasn't looking at other water treatment alternatives. In addition, prior to this meeting the Director discussed these options with the Ashland Water Advisory Ad-Hoc Committee (AWAC) at their regular meeting on September 26, 2017. The Committee unanimously supported the Director moving forward with the analysis.
November 6, 2017 Minutes

April 2, 2018-Water Treatment Plant Next Steps
Council received a follow up presentation at the April 2, 2018 Study Session from the Director of Public Works regarding an analysis done by Black and Veatch and RH2 regarding improvements to the existing plant and risk mitigation compared to building a new 7.5 MGD facility at an alternate site.
Existing plant rehabilitation (20 year life) $5.57 million.
No feasible cost developed for risk mitigation (fire, flood, landslide, seismic).
7.5 MGD Plant (new) $22.59 million (direct filtration-same as existing plant).
April 2, 2018 Minutes

October 2, 20189-Preliminary Engineering 7.5 MGD Water Treatment Plant
Council at the October 2, 2018 Business Meeting approved a professional services contract with HDR Engineering for the preliminary engineering phase for the new 7.5 MGD water treatment plant.
October 2, 2018 Minutes

April 2, 2019-2019-2039 Capital Improvement Program
Council approved the 20-year CIP at the April 2, 2019 Business Meeting. The 20-year CIP contained the proposed 7.5 MGD water treatment plant project in the water fund.
7.5 MGD water treatment plant 5% design opinion of cost $32 million.
April 2, 2019 Minutes

June 4, 2019-2019-2021 Biennium Budget
Council approved the 2019-2020 biennial budget at the June 4, 2019 Business meeting, which included appropriations for the 7.5 MGD Water Treatment Plant.
7.5 MGD water treatment plant 5% opinion of cost $32 million.
June 4, 2019 Minutes

June 4, 2019-FY 2020 Water Rates
Council approved a 4% water rate increase at the June 4, 2019 Business meeting. Water rates/revenues support the water fund and in turn all water capital improvement projects including the 7.5 MGD water treatment plant.
June 4, 2019 Minutes

August 5, 2019-7.5 MGD Water Treatment Plant Progress Update
Council received a presentational update on the preliminary engineering phase for the new plant at the August 5, 2019 Study Session.
7.5 MGD water treatment plant 30% design cost estimate $36 million.
No proposed staffing increases.
August 5, 2019 Staff Report
August 5, 2019 Minutes

In addition to Council actions staff has continuously updated AWAC during their regularly scheduled public meetings on project status during 2019. This included a presentation by HDR similar to the one given before Council on August 5, 2019.

October 1, 2019- Award of a Professional Services Contract; Phase 2, Final Engineering for a New 7.5 Million Gallon per Day Water Treatment Plant

Council authorized a professional services contract with HDR Engineering for Final Engineering. The Final Engineering contract allows HDR to proceed forward with the 60%, 90% and 100% iterations of design and cost estimating.

October 1, 2019 Staff Report
October 1, 209 Minutes

November 19, 2019-Envision Water Treatment Plant Solar

Council clarified their position regarding expectation for solar power and the Envision program associated with the design for the new plant.

November 19, 2019 Minutes

April 19, 2021 – Water Treatment Plant Design Envision Update

Provided and comprehensive project update including potential Envision component enhancements for energy efficiency.

Staff Report

Alliance
for Water
Efficiency

Water Savings & Financial Benefits of Single-Family Package Graywater Systems

JANUARY 2017

Water Savings and Financial Benefits Associated with Single-Family Package Graywater Systems

January 2017

A Project of the Alliance for Water Efficiency
Water Efficiency Research Committee

Author

Bill Gauley, P.Eng., Principal, Gauley Associates Ltd.

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Thank You

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- Richard Harris, Manager of Water Conservation, East Bay Municipal Utility District
- Judi Ranton, Water Efficiency Program Manager, Portland Water Bureau
- Dave Bracciano, Demand Management Coordinator, Tampa Bay Water
- Chelsea Hawkins, Program Planner, Alliance for Water Efficiency

The Alliance for Water Efficiency would also like to thank its intern Farah Fidai who conducted research related to this project.

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Executive Summary

Potable water is typically used by homeowners to meet all indoor and outdoor water demands; however, some demands do not require potable water quality, e.g., toilet flushing and landscape irrigation. Graywater systems use non-potable water generated from showering and clothes washing as an alternative water supply to meet demands that do not require potable water[1]. This report provides some general water savings and cost information for use by water utilities and their customers when considering the merits associated with residential graywater systems. Although financial and water savings benefits may not be the only reasons for installing a graywater system, this report attempts to highlight key life-cycle cost considerations associated with owning and operating a graywater system.

While there is no cost associated with graywater generation in the home, the costs associated with buying, installing, and maintaining systems that reuse graywater must be considered when completing a benefit/cost analysis.

There are two main types of single-family packaged graywater systems[2]:

1. Graywater used for toilet flushing
2. Graywater used for landscape irrigation

There are three main types of landscape-based graywater systems:

1. Laundry to Landscape - Water from clothes washers is discharged directly to landscape.
2. Branched Drain - Showers and/or lavatory sinks drain via gravity directly to landscape.
3. Pumped Systems - Water from showers and/or clothes washer and/or lavatory sinks is directly pumped or temporarily stored in a holding tank before being pumped to the landscape.[3]

Note: The volume of water savings achieved via the use of a graywater system is not equal to the volume of graywater generated or collected. It is equal to the volume of potable water savings (offset) achieved by the user.

The water demands associated with showering and toilet flushing tend to be relatively consistent on a daily basis; therefore, the potential water savings associated with single-family shower-to-toilet graywater systems can be estimated with some accuracy. However, because there are significant variables and uncertainties associated with landscape irrigation demands, it is much more difficult to estimate the potential for water savings associated with landscape-based graywater systems.

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[1] Water from kitchen faucets and dishwashers is generally not considered as a source of graywater because it may contain food particles or grease. The volume of graywater provided by lavatory faucets is minimal and is not considered in the savings estimates included in this report.

[2] A packaged system is an "off the shelf" system vs. a system that is designed and engineered for a specific site.

[3] Note that regulations and code requirements regarding the design, installation, and use of graywater storage tanks vary from state to state.

Graywater financial benefits are derived from reducing potable water demands. These systems provide a financial benefit to the homeowner if the total life-cycle value of the potable water savings is greater than the total life-cycle cost of the system.[4]

Shower-to-Toilet Graywater Systems

The *Residential End Uses of Water, Version 2* (REUS 2016) determined an average home produces almost twice as much shower-based graywater than would be required for toilet flushing (assuming the use of WaterSense®-labeled toilets). As such, the potential for potable water savings is related to the volume of water used for toilet flushing and not to the volume of graywater generated by showering.

The REUS 2016 also verified that, on average, each person flushes a toilet in the home about five times per day. Therefore, theoretical potable water savings associated with shower-to-toilet graywater systems is equal to about 2,336 gallons per capita per year.[5]

The annual net cost savings of a graywater system equals the annual volume of potable water savings multiplied by the marginal volumetric rate for water (or water & wastewater) minus any operations and maintenance (O&M) costs for chemicals, electricity, replacement parts, etc.

The simple payback period of a graywater system equals the total installed cost of the system divided by the average annual net cost savings. If the payback period exceeds the expected life span of the graywater system, the system will have a net cost to the customer.

A water/cost savings analysis was completed using demand values from the REUS 2016. This analysis indicates that shower-to-toilet graywater systems may not be cost-effective to the homeowner unless household occupancy is very high, and/or water rates are very high, and/or system costs are relatively low.

Landscape Irrigation Graywater Systems

The REUS 2016 determined an average home with an occupancy rate 2.64 persons produces about 28 gallons of graywater per day from showers and 23 gallons from clothes washers, equating to about 10.6 gallons per capita per day (gcd) from showers and 8.7 gcd from the clothes washer. While a total graywater production of 19.3 gcd equates to about 7,045 gallons per person per year there are three variables making it extremely unlikely 100 percent of the graywater produced would offset potable water demand:

1. <u>Climate</u>: Savings will be lower in areas where the irrigation season or plant water use requirements occur less than 12 months per year.
2. <u>Weather</u>: Even during the irrigation season there are likely to be days when precipitation provides all or part of required irrigation.

---

[4] Formulas used to calculate the water and cost savings associated with the different types of graywater systems are provided in the main body of the report.

[5] 1.28 gallons/flush x 5 flushes/person/day x 365 days/year = 2,336 gallons/year/person.

3. Accuracy/Timing Limitations: It is unlikely a homeowner would accurately calculate and balance irrigation demands and graywater availability on a daily basis.

Naturally, the potential for potable water savings for irrigation-based graywater systems is greater if they are installed in climates with longer irrigation seasons. While the impact of weather and accuracy/timing has not been verified by known independent third-party studies, this report assumes potable water irrigation savings equivalent to 75% of the volume of graywater produced. The theoretical annual household potable water savings are therefore:

- laundry-to-landscape systems =

  8.7 gcd x 75% x number of persons/household (pph) x irrigation season (days/year)

- branched drain systems =

  10.6 gcd x 75% x pph x irrigation season (days/year)

- pumped systems =

  19.3 gcd x 75% x pph x irrigation season (days/year)

The annual net cost savings of a graywater system equals the annual volume of potable water savings multiplied by the marginal volumetric rate for water (or water & wastewater) minus any O&M costs for chemicals, electricity, replacement parts, etc.[6]

The simple payback period of the graywater system equals the total installed cost of the system divided by the annual net cost savings. Installed costs are estimated to range from as little as a couple hundred dollars for a do-it-yourself laundry-to-landscape system to more than $5,000 for a professionally installed pumped system. If the payback period exceeds the expected life span of the graywater system, the system will have a net cost to the customer.

Landscape-based graywater systems are more likely to be cost-effective to the homeowner if:

- Home has a high marginal volumetric water (or water/sewer) rate
- Home is located in area with long irrigation season (e.g. >7 months for landscape-based graywater systems)
- Home has a high occupancy rate
- A low cost graywater system is installed
- The graywater system has low operations and maintenance costs
- A Do-It-Yourself graywater system is installed during home construction vs. retrofit

---

[6] O&M costs associated with laundry-to-landscape and branched drain systems are minimal.

Graywater Financial Benefits to the Utility

Reducing customer water demands can financially benefit a water utility, especially if the utility is operating at or near its system's peak production rate or if it is faced with a shortage of water supply.[7] Utilities can compare their unit cost (e.g., $ per gallon/day) of achieving water savings through a graywater reuse program (demand-side management) to the unit cost of expanding the system's water supply. If the unit cost of the demand-side option is lower, the program is cost-effective and provides a financial benefit to the utility.

Conclusion

Due to their cost and, often, complexity, graywater reuse programs are better suited as long-term, ongoing programs rather than as short-term solutions to drought. The water savings achieved by a graywater system is equal to the **long-term reduction in potable water demands** achieved by the homeowner. While financial benefits may not be the only reason for a homeowner to install a graywater system, if the total life-cycle costs of the system exceed the total life-cycle savings from reduced potable water purchases, the system will have a net cost to the homeowner.

Water utilities are strongly encouraged to use their own values, e.g., volumetric water rates, persons per household, length of irrigation season, graywater system cost, unit cost of adding additional water supply, etc., to assess the cost-effectiveness associated with implementing a single-family graywater reuse program in their own community. As data from more independent third-party field studies becomes available (especially regarding landscape-based graywater systems) it is hoped that the values identified in this report can be further refined.

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[7] Lower water demands can also reduce a utility's variable costs (e.g., energy and chemical costs).

1.0 Introduction

The Alliance for Water Efficiency (AWE) website describes graywater as, “untreated wastewater resulting from lavatory wash basins, laundry and bathing.” Graywater does not include wastewater from toilets, urinals, or any industrial process. Wastewater from kitchen sinks and dishwashers is also typically excluded due to the potential presence of food particles and/or grease.

Graywater systems provide users with non-potable water generated onsite as an alternative water supply to meet demands that do not require potable water, e.g., toilet flushing and landscape irrigation. While graywater is produced onsite and available to the user at no cost, there are costs associated with buying, installing, and maintaining residential graywater systems and these costs must be considered when evaluating the financial benefits associated with the use of these systems.

Water utilities often come under well-intended pressure from the public, decision makers, non-government organizations (NGOs), and other stakeholders to promote and incentivize water demand management measures, especially during times of drought and water scarcity. It is difficult, however, for water providers to make informed water conservation and efficiency planning decisions in cases where there is insufficient or conflicting information regarding expected water savings and/or program cost-effectiveness. The AWE Water Efficiency Research Committee identified a need to develop this reference document to outline the range of expected costs and savings associated with installing and operating single-family package graywater systems.

Note: While individual homes may save more or less potable water/money than the values presented herein, it is the intent of this document to present realistic savings and costs values that average homeowners installing residential graywater systems might be expected to achieve. The information presented herein is also intended to assist water utilities considering the merits of a graywater conservation incentive program.

1.1 *Types of Graywater Systems*

There are two main types of single-family packaged graywater systems:

1. Graywater used for toilet flushing
2. Graywater used for landscape irrigation

There are three main types of landscape-based graywater systems:

1. Laundry to Landscape - Water from clothes washers is discharged directly to landscape.
2. Branched Drain - Showers and/or lavatory sinks drain via gravity directly to landscape.
3. Pumped Systems - Water from showers and/or clothes washer and/or lavatory sinks is pumped or temporarily stored in a holding tank before being pumped to the landscape.[8]

---

[8] Note that regulations and code requirements regarding the design, installation, and use of graywater storage tanks vary from State to State.

1.2 *Calculating Water Savings*

It is important to note that the volume of water savings achieved via the use of a graywater system is not equal to the volume of graywater generated or collected but rather to the resulting volume of potable water savings achieved by the user.

The volume of water savings is not equal to the volume of graywater collected.

The volume of water savings is equal to the reduction in potable water demands.

Because the volume of water generated from showering and the volume of water used for toilet flushing in single-family homes tend to be fairly consistent on a daily basis, the potential water savings associated with single-family shower-to-toilet graywater systems can be estimated with some accuracy.

There are significant variables and uncertainties associated with determining the potential potable water savings derived from landscape-based graywater systems. Irrigation demands are weather-dependent, meaning that they can vary from day to day, season to season, and from geographic location to geographic location. Irrigation demands can also vary significantly from homeowner to homeowner depending on landscape properties and customer behavior. Unfortunately, there are no known independent third-party field studies that accurately identify potable water savings values. As such, while verified and referenced values have been used in this report where possible, values have been assumed when necessary.

1.3 *Use of Volumetric Rates when Calculating Financial Benefit*

The financial benefit to a customer using a graywater system is equal to the volume of potable water savings multiplied by the marginal volumetric water rate (or combined water and sewer rate), minus any operations and maintenance (O&M) costs. Note that there will be no reduction in homeowner wastewater (sewer) service charges for landscape-based graywater systems in areas where these charges are billed on a flat rate basis or where these charges are based on non-seasonal (winter) water demands. It is also important that any fixed fees on the water bill, e.g., meter charges or debt reduction charges, etc., are not included when calculating the marginal volumetric rate.

When calculating financial savings associated with graywater systems, use only the volumetric cost of water and/or sewer.

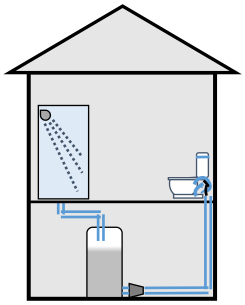
2.0 Shower-to-Toilet Graywater Systems

2.1 *Theoretical Annual Household Water Savings*

The *Residential End Uses of Water, Version 2* (REUS 2016) identifies an average occupancy rate of 2.64 persons per household (pph) with an average per capita toilet flushing rate of 5.0 times per day.[9] These values are used in many of the calculations provided in this report to estimate theoretical savings.

The REUS 2016 also found that an average home produces about 10.6 gallons of shower-based graywater per person per day[10]. Since a home fitted with WaterSense®-labeled toilets using 1.28 gallons per flush would only require about 6.4 gallons per person day for toilet flushing[11], the volume of shower-based graywater produced each day is much greater than the volume required for toilet flushing. The potential for potable water savings, therefore, is related to the volume of water used for toilet flushing and not to the volume of graywater generated by showering.

Figure 1. *Shower to Toilet Graywater System Schematics*



In most cases, the volume of graywater derived from showers far exceeds the volume of potable water used for toilet flushing. This is a useful example for explaining that the potential for water savings relates to the

The theoretical water savings for a shower-to-toilet graywater system in a home with 2.64 persons (as per REUS 2016) would be 6,167 gallons per year[12], or somewhat higher than the 4,226[13] and 2,185[14] gallons per year observed in two field studies.

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[9] Water Research Foundation, Residential End Uses of Water, Version 2, (2016)

[10] REUS 2016, 28.1 gallons per home per day ÷ 2.64 persons per home = 10.6 gallons per capita per day

[11] 1.28 gallons/flush x 5.0 flushes/capita/day

[12] 2.64 persons x 6.4 gallons/capita/day x 365 days/year

[13] City of Guelph Residential Greywater Field Test, 2012, homes fitted with efficient toilet fixtures, prorated to 2.64 persons per home.

[14] Craig, Madeline J., Developing a Standard Methodology for Testing Field Performance of Residential Greywater Reuse Systems, 2015, Section 5.1.6, prorated to 2.64 persons per home.

Water utilities can estimate theoretical household potable water savings associated with shower-to-toilet graywater systems by using Equation 1 or the values provided in Table 1. Note that actual savings may be somewhat less than theoretical values.

Equation 1: Shower-to-Toilet Graywater System Theoretical Annual Household Water Savings

1.28 gallons/flush x 5.0 flushes/capita/day x pph x 365 days/year

Table 1. Shower-to-Toilet Graywater System Theoretical Annual Household Water Savings

Persons per Household (pph)	***Annual Water Saving (gallons)***
1	2,336
2	4,672
3	7,008
4	9,344
5	11,680
6	14,016

Example Calculation: 3 pph x 1.28 gal/flush x 5 flushes/person/day x 365 days/year = 7,008 gal/year

2.2 Estimated Gross Annual Cost Savings to Customer

The gross annual cost savings for a homeowner is calculated as the annual volume of potable water savings multiplied by the marginal volumetric rate for water (or water & wastewater) – see Equation 2.

Equation 2: Shower-to-Toilet Graywater System Gross Annual Cost Savings

Annual Household Savings x Marginal Cost of Water

Table 2 illustrates gross annual cost savings for different persons per household (pph) values based on a range of volumetric water/wastewater rates.[15] Fixed fees on the water bill, e.g., meter charges or debt reduction charges, etc., should not be included when calculating the volumetric rate.

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[15] Both water and wastewater rates must be considered when evaluating the savings related to shower-to-toilet graywater systems.

Table 2. Shower-to-Toilet Graywater System Gross Annual Household Cost Savings

Persons per household	***Annual Water Savings (gallons)***	***Volumetric Rate per 1,000 gallons***						
		$2	***$5***	***$8***	***$11***	***$14***	***$17***	***$20***
1	2,336	$5	$12	$19	$26	$33	$40	$47
2	4,672	$9	$23	$37	$51	$65	$79	$93
3	7,008	$14	$35	$56	$77	$98	$119	$140
4	9,344	$19	$47	$75	$103	$131	$159	$187
5	11,680	$23	$58	$93	$128	$164	$199	$234
6	14,016	$28	$70	$112	$154	$196	$238	$280

Example Calculation: 3 pph, 7,008 gallons/year savings, volumetric water rate of $5.00/1,000 gallons and volumetric wastewater rate of $9.00/1,000 gallons.

7.008 x 1,000 gal/year x ($5.00 + $9.00)/1,000 gal = $98 per year savings

2.3 Net Annual Cost Savings to Homeowner

The net annual cost savings to single-family homeowners equals the gross annual cost savings minus any operations and maintenance (O&M) costs, such as the cost of electricity, filters, chemicals, or replacement of parts – see Equation 3.

Equation 3: Shower-to-Toilet Graywater System Net Annual Cost Savings

Gross Annual Cost Savings – Annual O&M Costs

The National Academy of Sciences report, *Using Graywater and Stormwater to Enhance Local Water Supplies: An Assessment of Risks, Costs, and Benefits* (Table 7.1) estimates operational costs (i.e., chemical and energy costs) for residential graywater systems as approximately $1 per thousand gallons.

Some jurisdictions require backflow prevention devices to be installed on graywater systems if they are connected to a potable water system. In such cases it is not uncommon for the jurisdiction to require the homeowner to pay the purchase and installation costs of the backflow device as well as the annual or periodic testing or inspection of these devices to ensure they continue to function properly to avoid potential contamination of the potable water supply. Some jurisdictions may also require the homeowner to purchase a permit before installing a graywater system. Where these requirements exist, any associated costs must be included as an operational cost to the homeowner.

Maintenance costs are expected to be minimal for the first few years when the graywater system is relatively new; however, many system parts – and ultimately the entire system – will eventually need replacing. Each graywater system design will have its own maintenance requirements and costs for cleaning or replacing filters, for adding chemicals, for cleaning storage tanks, etc. While the average annual cost of maintenance will vary depending on system design, in lieu of system-specific maintenance costs identified through the implementation of independent third-party field studies, a minimum cost of $36 per year has been assumed for calculations included in this report.[16] Actual average annual maintenance costs should be used by water utilities in calculations where possible.

In Table 3, the estimated annual O&M costs (i.e., operations costs of $1 per thousand gallons and an average annual maintenance costs of $36 for replacement parts) are deducted from the annual gross cost savings values identified in Table 2. Table 3 identifies the annual net cost savings associated with shower-to-toilet graywater systems for various household occupancy rates and volumetric water/wastewater rates. The negative annual net savings values in Table 3 illustrate examples where the costs associated with using a graywater system may exceed the annual savings from reduced water purchases.

Table 3. Shower to Toilet System Annual Net Cost Savings

Persons per household	***Annual Water Savings (gallons)***	***Volumetric Rate per 1,000 gallons***						
		$2	***$5***	***$8***	***$11***	***$14***	***$17***	***$20***
1	2,336	-$34	-$27	-$20	-$13	-$6	$1	$8
2	4,672	-$31	-$17	-$3	$11	$25	$39	$53
3	7,008	-$29	-$8	$13	$34	$55	$76	$97
4	9,344	-$27	$1	$29	$57	$85	$114	$142
5	11,680	-$24	$11	$46	$81	$116	$151	$186
6	14,016	-$22	$20	$62	$104	$146	$188	$230

Example Calculation: 3 pph, 7,008 gallons/year savings, volumetric water/wastewater rate of $14/1,000 gallons, $1/1,000 gallons operational costs (energy and chemicals), $36/year average maintenance cost

7.008 x 1,000 gal x $14/1,000 gal – (7.008 x $1) – ($36) = $55 / year

2.4 Estimated Simple Cost Payback to Homeowner

The simple payback for installing a graywater system is calculated as the total installed cost of the system divided by the average annual net cost savings – see Equation 4. If the payback period exceeds the expected life span of the graywater system, the system will have a net cost to the homeowner. For example, a $3,000 graywater system[17] with a 15-year life-cycle[18] would need to achieve an annual net

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[16] A 2014 article by Donna Ferguson posted on www.theguardian.com (*Greywater Systems: Can They Really Reduce Your Bills?)* estimates maintenance costs of $36 per year (converted from £30 per year). Several reports identify higher costs, e.g., *Economic Assessment Tool for Greywater Recycling Systems* estimates costs of about $73 per year (converted from £60 per year for inspection and maintenance), F.A. Memon, PhD, et al.

[17] *A Guide to Greywater Systems*, https://www.choice.com.au/home-improvement/water/saving-water/articles/guide-to-greywater-systems, identifies a system cost of $4,000 Australian or about $3,000 USD.

[18] *Cost-Benefit Analysis of Onsite Residential Graywater Recycling – A Case Study: the City of Los Angeles*, Zita L.T.Yu, et al., estimates an average

savings of at least $200 per year to be cost-effective, i.e., to have a payback period less than the system's expected life span[19].

<u>Equation 4: Shower-to-Toilet Graywater System Payback Period (years)</u>

Total Installed Cost ÷ Net Annual Cost Savings

As an example, Table 4 illustrates payback periods in years for a $3,000 shower-to-toilet graywater system using different household occupancy rates and volumetric water/wastewater rates. Shaded cells indicate conditions where the anticipated payback period would be less than 15 years, i.e., where installing a $3,000 system with a 15-year life span would be cost-effective to the homeowner. Cells containing no values indicate conditions where annual costs exceed annual savings and, therefore, the system will never pay for itself.

Table 4. Shower-to-Toilet System Payback Period for a $3,000 Graywater System (Years)

Persons per household	***Annual Water Savings (gallons)***	***Volumetric Rate per 1,000 gallons***						
		$2	***$5***	***$8***	***$11***	***$14***	***$17***	***$20***
1	2,336	-	-	-	-	-	2,180	358
2	4,672	-	-	-	280	121	77	57
3	7,008	-	-	230	88	55	39	31
4	9,344	-	2,180	102	52	35	26	21
5	11,680	-	280	66	37	26	20	16
6	14,016	-	150	48	29	21	16	13

<u>Example Calculation</u>: 3 pph, volumetric water/wastewater rate of $14/1,000 gallons, net annual savings of $55 (Table 3), total installed graywater system cost of $3,000

$3,000 installed cost ÷ $55 net annual cost savings = 55 years

As illustrated in Table 4, shower-to-toilet graywater systems are unlikely to be cost-effective to homeowners except in cases where household occupancy is very high, and/or water rates are very high, and/or system costs are much lower than the $3,000 cost assumed in Table 4.

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service lifetime of 15 years.

[19] $3000 ÷ 15 years = $200 per year

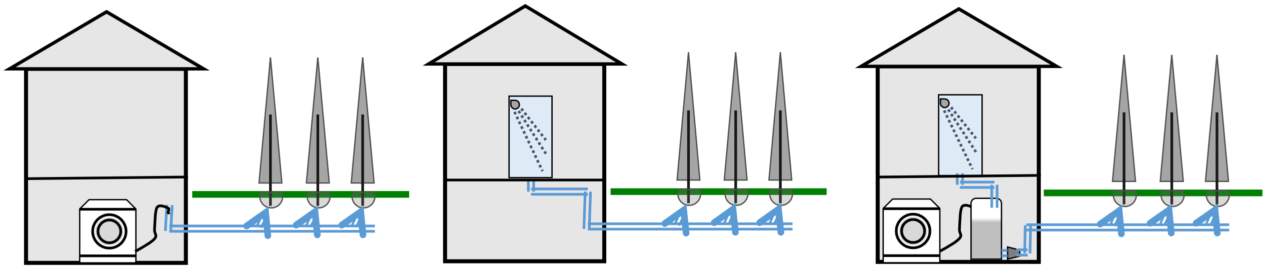
3.0 Landscape Irrigation Graywater Systems

3.1 *Potential Potable Water Savings*

While the volume of graywater production in a single-family home is equal to the total volume of water used for showering and clothes washing (the volume of water contributed by lavatory sinks is minimal), the financial benefit associated with the use of graywater systems is directly related to the volume of potable water saved by the homeowner. Because of the large number of variables associated with landscape irrigation (e.g., climate, weather, system efficiency, etc.) it is difficult to accurately estimate the potential for potable water savings.

The REUS 2016 (Figure 6.12) determined an average home with an occupancy rate 2.64 persons produces about 51 gallons of graywater per day split between 28 gallons from showers and 23 gallons from clothes washers. These demands equate to about 10.6 gallons per capita per day (gcd) from showers and 8.7 gcd from the clothes washer, for a total graywater production of 19.3 gcd.

Figure 2. *Landscape Irrigation Graywater System Schematics*



Graywater irrigation systems can be configured in a few ways. Combining graywater from showers and clothes washers is estimated to yield 51 gallons of graywater per day for an average household. Though significant, it's unlikely that there would be a complete offset of potable water demand for irrigation purposes.

While 19.3 gcd equates to about 7,045 gallons of graywater production per person per year, there are three variables that make it extremely unlikely that 100 percent of the graywater produced would offset potable water demand:

1. Climate: Savings will be lower if a landscape-based graywater system is installed in a location where irrigation is required for fewer than 12 months per year.
2. Weather: Even during the irrigation season there are likely to be days when precipitation provides all or part of required irrigation.
3. Accuracy and Timing Limitations: It is unlikely a homeowner would accurately calculate and balance irrigation demands and graywater availability on a daily basis.

There are currently no known independent third-party field studies that accurately quantify the potable water savings achieved by landscape-based graywater systems. The results that are available show a wide range in savings, with some homes actually using more potable water after their graywater systems were installed[20]. The National Academy of Sciences report *Using Graywater and Stormwater to Enhance Local Water Supplies: An Assessment of Risks, Costs, and Benefits* (page 57) states "the maximum possible potential for demand reduction that can be achieved through graywater reuse…does not reflect what can be realistically achieved in the near future" and the conclusion of the report (page 87) states "water savings associated with graywater irrigation at the household scale have not been demonstrated with confidence".

While it appears likely that less than one gallon of potable water will be offset for each gallon of graywater produced in a home, there are currently no known studies that accurately identify the relationship between graywater production and potable water savings. As such, Equations 5a, 5b, and 5c assume the combined impact of weather and accuracy and timing limitations (weather/accuracy) will conservatively reduce potable water savings to 75% of the theoretical value, thus reducing the potential savings from laundry-to-landscape systems to 6.5 gcd (75% x 8.7 gcd), the potential savings from shower-based (branched drain) systems to 8.0 gcd (75% x 10.6 gcd), and the potential savings from pumped systems to 14.5 gcd (75% x 19.3 gdc).[21]

As stated earlier, the potential for potable water savings is greater for irrigation-based graywater systems installed in climates with longer irrigation seasons. Water utilities should use the length of their own irrigation season when using Equations 5a through 5c. For illustration purposes, Table 5 provides examples of annual household savings values for the three types of systems using Equations 5a, 5b, and 5c and assuming an irrigation season of 274 days (9 months).

Equation 5a: Laundry-to-Landscape System Annual Household Savings, gallons

6.5 gcd x pph x irrigation season (days/year)

Equation 5b: Branched Drain System Annual Household Savings, gallons

8.0 gcd x pph x irrigation season (days/year)

Equation 5c: Pumped System Annual Household Savings, gallons

14.5 gcd x pph x irrigation season (days/year)

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[20] *Residential Greywater Irrigation Systems in California*, 2013, Laura Allen, et al., quote found on page 16: "some households actually used more water after installing graywater, (up to 32 gallons/day)…".

[21] An actual-to-theoretical savings factor has been assumed until sufficient independent third-party field study data becomes available to more accurately quantify the combined impact of weather and precision limitations.

Table 5. Landscape Irrigation Graywater Systems, Estimated Annual Household Water Savings (gallons) for 274-day Irrigation Season

Persons per Household	***Laundry-to Landscape (6.5 gcd x 274 days/yr)***	***Branched Drain (8.0 gcd x 274 days/yr)***	***Pumped (14.5 gcd x 274 days/yr)***
1	1,781	2,192	3,973
2	3,562	4,384	7,946
3	5,343	6,576	11,919
4	7,124	8,768	15,892
5	8,905	10,960	19,865
6	10,686	13,152	23,838

3.2 *Gross Cost Savings to Homeowner*

The gross annual cost savings to a homeowner installing a graywater system is calculated as the annual volume of potable water savings multiplied by the marginal volumetric rate for water (or water & wastewater) – see Equations 6a, 6b, and 6c.

Equation 6a: Laundry-to-Landscape System Gross Annual Cost Savings

6.5 gcd x pph x irrigation season (days/year) x Volumetric Cost of Water

Equation 6b: Branched Drain Systems Gross Annual Cost Savings

8.0 gcd x pph x irrigation season (days/year) x Volumetric Cost of Water

Equation 6c: Pumped Systems Gross Annual Cost Savings

14.5 gcd x pph x irrigation season (days/year) x Volumetric Cost of Water

Tables 6a, 6b, and 6c provide examples of gross annual cost savings values for different persons per household values and different volumetric water/wastewater rates assuming a 274-day (9-month) irrigation season. Water utilities with shorter or longer irrigation seasons should expect to achieve different annual savings values than those illustrated in Tables 6a, 6b,and 6c.

Table 6a. Laundry-to-Landscape Graywater System Gross Annual Household Cost Savings

Persons per Household	***Annual Water Savings (gallons)***	***Volumetric Rate per 1,000 gallons***						
		$2	***$5***	***$8***	***$11***	***$14***	***$17***	***$20***
1	1,781	$4	$9	$14	$20	$25	$30	$36
2	3,562	$7	$18	$28	$39	$50	$60	$71
3	5,343	$11	$27	$43	$59	$75	$91	$107
4	7,124	$14	$36	$57	$78	$100	$121	$142
5	8,905	$18	$44	$71	$98	$125	$151	$178
6	10,686	$21	$53	$85	$117	$149	$181	$214

<u>Example Calculation</u>: 3 pph, 274-day irrigation season, volumetric rate of $14/1,000 gallons.

5,343 gal/year x $14/1,000 gal = $75/year gross savings

Table 6b. Branched Drain Graywater System Gross Annual Household Cost Savings

Persons per Household	***Annual Water Savings (gallons)***	***Volumetric Rate per 1,000 gallons***						
		$2	***$5***	***$8***	***$11***	***$14***	***$17***	***$20***
1	2,192	$4	$11	$18	$24	$31	$37	$44
2	4,384	$9	$22	$35	$48	$61	$74	$88
3	6,576	$13	$33	$53	$72	$92	$112	$131
4	8,768	$18	$44	$70	$96	$123	$149	$175
5	10,960	$22	$55	$88	$120	$153	$186	$219
6	13,152	$26	$66	$105	$145	$184	$223	$263

<u>Example Calculation</u>: 3 pph, 274-day irrigation season, volumetric rate of $14/1,000 gallons.

6,576 gal/year x $14/1,000 gal = $92/year gross savings

Table 6c. Pumped Graywater System Gross Annual Household Cost Savings

Persons per Household	***Annual Water Savings (gallons)***	***Volumetric Rate per 1,000 gallons***						
		$2	***$5***	***$8***	***$11***	***$14***	***$17***	***$20***
1	3,973	$8	$20	$32	$44	$56	$67	$79
2	7,946	$16	$40	$64	$87	$111	$135	$159
3	11,919	$24	$60	$95	$131	$167	$202	$238
4	15,892	$32	$79	$127	$175	$222	$270	$318
5	19,865	$40	$99	$159	$218	$278	$337	$397
6	23,838	$48	$119	$191	$262	$333	$405	$477

Example Calculation: 3 pph, 274-day irrigation season, volumetric rate of $14/1,000 gallons.

11,919 gal/year x $14/1,000 gal = $167/year gross savings

3.3 Net Cost Savings to Homeowner

The annual net cost savings to a homeowner is calculated as the gross annual cost savings minus any operations and maintenance (O&M) costs, such as the cost of electricity, filters, chemicals, or replacement of parts – see Equation 7.

Equation 7: Landscape Irrigation Graywater Systems Net Annual Cost Savings

Gross Annual Cost Savings – Annual O&M Costs

There are few O&M costs associated with laundry-to-landscape and branched drain systems. In laundry to landscape systems the clothes washer pumps graywater directly to the landscape[22] and in branched drain systems the graywater flows directly to the landscape by gravity. As such, the net annual cost savings to customers for these two types of systems is essentially equal to the gross annual cost savings – see Table 7a and 7b.

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[22] The clothes washer will either pump graywater to the sewer or to the landscape. There are no 'additional' energy costs associated with pumping graywater to the landscape.

Table 7a. Laundry-to-Landscape Graywater System Net Annual Household Cost Savings

Persons per Household	***Annual Water Savings (gallons)***	***Volumetric Rate per 1,000 gallons***						
		$2	***$5***	***$8***	***$11***	***$14***	***$17***	***$20***
1	1,781	$4	$9	$14	$20	$25	$30	$36
2	3,562	$7	$18	$28	$39	$50	$60	$71
3	5,343	$11	$27	$43	$59	$75	$91	$107
4	7,124	$14	$36	$57	$78	$100	$121	$142
5	8,905	$18	$44	$71	$98	$125	$151	$178
6	10,686	$21	$53	$85	$117	$149	$181	$214

<u>Example Calculation</u>: 3 pph, 274-day irrigation season, volumetric rate of $14/1,000 gallons, $0 per year O&M costs

5,343 gal/year x $14/1,000 gal - $0/year O&M = $75/year net savings

Table 7b. Branched Drain Graywater System Net Annual Household Cost Savings

Persons per Household	***Annual Water Savings (gallons)***	***Volumetric Rate per 1,000 gallons***						
		$2	***$5***	***$8***	***$11***	***$14***	***$17***	***$20***
1	2,192	$4	$11	$18	$24	$31	$37	$44
2	4,384	$9	$22	$35	$48	$61	$74	$88
3	6,576	$13	$33	$53	$72	$92	$112	$131
4	8,768	$18	$44	$70	$96	$123	$149	$175
5	10,960	$22	$55	$88	$120	$153	$186	$219
6	13,152	$26	$66	$105	$145	$184	$223	263

<u>Example Calculation</u>: 3 pph, 274-day irrigation season, volumetric rate of $14/1,000 gallons, $0 per year O&M costs.

6,576 gal/year x $14/1,000 gal - $0/year O&M = $92/year net savings

For pumped systems, however, the National Academy of Sciences report *Using Graywater and Stormwater to Enhance Local Water Supplies: An Assessment of Risks, Costs, and Benefits* (Table 7.1) estimates operations costs (i.e., chemical and energy costs) to be about $1 per thousand gallons.

Maintenance costs associated with pumped systems are expected to be minimal for the first few years when the system is relatively new; however, many system parts – and ultimately the entire system – will eventually need replacing. Each pumped graywater system design will have its owns maintenance requirements and costs for cleaning or replacing filters, for adding chemicals, for cleaning storage tanks, etc. While the average annual cost of maintenance will vary depending on system design, in lieu of system-specific maintenance cost field data, a cost of $36 per year has been assumed for calculations in this report.[23]

Table 7c presents the annual net cost savings for pumped systems using an operational cost of $1 per thousand gallons and an annual maintenance cost of $36. The negative annual net savings values in Table 7c illustrate examples where the costs associated with using a graywater system may exceed the annual savings from reduced water purchases.

Table 7c. Pumped Graywater System Net Annual Household Cost Savings

Persons per Household	***Annual Water Savings (gallons)***	***Volumetric Rate per 1,000 gallons***						
		$2	***$5***	***$8***	***$11***	***$14***	***$17***	***$20***
1	3,973	-$32	-$20	-$8	$4	$16	$28	$39
2	7,946	-$28	-$4	$20	$43	$67	$91	$115
3	11,919	-$24	$12	$47	$83	$119	$155	$190
4	15,892	-$20	$28	$75	$123	$171	$218	$266
5	19,865	-$16	$43	$103	$163	$222	$282	$341
6	23,838	-$12	$59	$131	$202	$274	$345	$417

Example Calculation: 3 pph, 274-day irrigation season, volumetric rate of $14/1,000 gallons, $12/year operations costs (i.e., $1 per 1,000 gallons x 11.919 thousand gallons), $36/year maintenance cost.

11,919 gal/year x $14/1,000 gal - $12 /year operations - $36/year maintenance = $119/year net savings

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[23] A 2014 article by Donna Ferguson posted on www.theguardian.com (*Greywater Systems: Can They Really Reduce Your Bills?)* estimates maintenance costs of $36 per year (converted from £30 per year). Several reports identify higher costs, e.g., *Economic Assessment Tool for Greywater Recycling Systems* estimates costs of about $73 per year (converted from £60 per year for inspection and maintenance), F.A. Memon, PhD, et al.

3.4 *Estimated Simple Cost Payback to Homeowner*

The simple payback to a homeowner installing a graywater system is calculated as the total installed cost of the system divided by the annual net cost savings – see Equation 8.

Equation 8: Landscape Irrigation Graywater Systems Payback Period

Total Installed Cost ÷ Net Annual Cost Savings

Two reports – the National Academies of Sciences, *Using Graywater and Stormwater to Enhance Local Water Supplies: An Assessment of Risks, Costs, and Benefits* and the Greywater Action report *Residential Graywater Irrigation Systems in California: An Evaluation of Soil and Water Quality, User Satisfaction, and Installation Costs* estimate the costs for landscape-based graywater systems provided in Table 8.

Table 8. Purchase/Installation Cost of Landscape Irrigation Graywater Systems

Reference	***Laundry-to Landscape DIY***	***Laundry-to Landscape Professional Installation***	***Branched Drain DIY***	***Branched Drain Professional Installation***	***Pumped System DIY***	***Pumped System Professional Installation***
National Academies of Sciences	$120	$1,250	NA	NA	$2,300	$10,000*
Greywater Action	$250	$750	$700	$1,750	$1,800	$3,800
Average	**$185**	**$1,000**	**$700**	**$1,750**	**$2,050**	**$6,900**

**Report identifies a range in costs from $5,000 to $15,000. An average cost of $10,000 has been assumed.*

In Tables 9 through 11 shading indicates conditions that result in a payback period of 15 years or less based on the assumption that the average life span of a graywater system is about 15 years, i.e., shaded cells show conditions where the system should provide a net cost savings to the customer.[24]

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[24] The report *Life Cycle Impact Assessment of Greywater Recycling Technology for New Developments*, F.A. Memon et al. (revised 2007) estimates an average design life of 15 years.

Table 9a. Do-it-Yourself Laundry-to-Landscape Payback Period in Years (@$185)

Persons per Household	***Annual Water Savings (gallons)***	***Volumetric Rate per 1,000 gallons***						
		$2	***$5***	***$8***	***$11***	***$14***	***$17***	***$20***
1	1,781	52	21	13	9	7	6	5
2	3,562	26	10	6	5	4	3	3
3	5,343	17	7	4	3	2	2	2
4	7,124	13	5	3	2	2	2	1
5	8,905	10	4	3	2	1	1	1
6	10,686	9	3	2	2	1	1	1

<u>Example Calculation</u>: 3 pph, 274-day irrigation season, volumetric rate of $14/1,000 gallons.

$185 installed cost ÷ $75 /year net savings (Table 7a) *= 2 years*

Table 9b. Professional Installation Laundry to Landscape Payback Period in Years (@$1,000)

Persons per Household	***Annual Water Savings (gallons)***	***Volumetric Rate per 1,000 gallons***						
		$2	***$5***	***$8***	***$11***	***$14***	***$17***	***$20***
1	1,781	281	112	70	51	40	33	28
2	3,562	140	56	35	26	20	17	14
3	5,343	94	37	23	17	13	11	9
4	7,124	70	28	18	13	10	8	7
5	8,905	56	22	14	10	8	7	6
6	10,686	47	19	12	9	7	6	5

<u>Example Calculation</u>: 3 pph, 274-day irrigation season, volumetric rate of $14/1,000 gallons.

$1,000 installed cost ÷ $75 /year net savings (Table 7a) *= 13 years*

Table 10a. Do-it-Yourself Branched Drain Payback Period in Years (@$700)

Persons per Household	***Annual Water Savings (gallons)***	***Volumetric Rate per 1,000 gallons***						
		$2	***$5***	***$8***	***$11***	***$14***	***$17***	***$20***
1	2,192	160	64	40	29	23	19	16
2	4,384	80	32	20	15	11	9	8
3	6,576	53	21	13	19	8	6	5
4	8,768	40	16	10	7	6	5	4
5	10,960	32	13	8	6	5	4	3
6	13,152	27	11	7	5	4	3	3

Example Calculation: 3 pph, 274-day irrigation season, volumetric rate of $14/1,000 gallons

$700 installed cost ÷ $92 /year net savings (Table 7b) *= 8 years*

Table 10b. Professional Installation Branched Drain Payback Period in Years (@$1,700)

Persons per Household	***Annual Water Savings (gallons)***	***Volumetric Rate per 1,000 gallons***						
		$2	***$5***	***$8***	***$11***	***$14***	***$17***	***$20***
1	2,192	388	155	97	71	55	46	39
2	4,384	194	78	49	35	28	23	19
3	6,576	129	52	32	24	18	15	13
4	8,768	97	39	24	18	14	11	10
5	10,960	78	31	19	14	11	9	8
6	13,152	65	26	16	12	9	8	6

Example Calculation: 3 pph, 274-day irrigation season, volumetric rate of $14/1,000 gallons.

$1,700 installed cost ÷ $92 /year net savings (Table 7b) *= 18 years*

Table 11a. Do-it-Yourself Pumped Systems Payback Period in Years (@$2,050)

Persons per Household	***Annual Water Savings (gallons)***	***Volumetric Rate per 1,000 gallons***						
		$2	***$5***	***$8***	***$11***	***$14***	***$17***	***$20***
1	3,973	-	-	-	550	131	74	52
2	7,946	-	-	104	47	30	22	18
3	11,919	-	176	43	25	17	13	11
4	15,892	-	74	27	17	12	9	8
5	19,865	-	47	20	13	9	7	6
6	23,838	-	35	16	10	7	6	5

<u>Example Calculation</u>: 3 pph, 274-day irrigation season, volumetric rate of $14/1,000 gallons.

$2,050 installed cost ÷ $119 /year net savings (Table 7c) *= 17 years*

Table 11b. Professional Installation Pumped Systems Payback Period in Years (@$6,900)

Persons per Household	***Annual Water Savings (gallons)***	***Volumetric Rate per 1,000 gallons***						
		$2	***$5***	***$8***	***$11***	***$14***	***$17***	***$20***
1	3,973	-	-	-	1,850	441	250	175
2	7,946	-	-	352	159	103	76	60
3	11,919	-	591	145	83	58	45	36
4	15,892	-	250	92	56	40	32	26
5	19,865	-	159	67	42	31	24	20
6	23,838	-	116	53	34	25	20	17

<u>Example Calculation</u>: 3 pph, 274-day irrigation season, volumetric rate of $14/1,000 gallons.

$6,900 installed cost ÷ $119 /year net savings (Table 7c) *= 58 years*

4.0 Financial Benefit to the Utility

Utilities can benefit financially from reducing customer water demands, but the magnitude of these benefits vary from utility to utility depending on their own unique conditions. For example, benefits can be significant if the utility is operating at or near its system's peak production rate or if it is faced with a shortage of water supply, whereas the benefit to a utility with a plentiful water supply and an adequately sized water treatment and distribution infrastructure will not be as great.[25]

One way to evaluate the financial benefit of lowering water demands to a utility is to compare the unit cost of achieving water savings through the implementation of water efficiency programs (demand-side management) to the unit cost of expanding the system's water supply.[26] If the unit cost of the demand-side option is lower, the water efficiency program is cost-effective and provides a financial benefit to the utility.

Many water utilities provide financial incentives in the form of rebates to customers installing water-efficient products. Ideally the level of the rebate is set such that it is high enough to entice customers to participate in the program[27] but low enough to be cost-effective to the water utility. Stated another way, the unit cost of implementing the demand-side option must be lower (or at least no higher) than the unit cost of implementing the supply option if the program is to be cost-effective to the utility.

Water utilities can calculate their maximum rebate level for any water efficiency measure by multiplying their unit cost of providing additional supply ($/gallon/day) by the expected average daily water savings per participating customer (e.g., gallons/day)[28] – see Equation 9.

<u>Equation 9: Maximum Per Customer Rebate Level Based on Equivalent Unit Cost of Supply</u>

$$\text{gcd} \times \text{pph} \times \text{Irrigation Season (days)} \div 365 \text{ days} \times \text{Utility Unit cost of Supply (\$/gallon/day)}$$

<u>Example Calculation</u>: Maximum cost-effective rebate, landscape-based graywater system saving 14.5 gcd, 3 pph, 274-day irrigation season, and a Unit Cost of Supply of $8 per gallon/day.

$$14.5 \text{ gcd} \times 3 \text{ pph} \times 274/365 \text{ days/year} \times \$8 \text{ per gal/day} = \$261$$

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[25] Lower water demands will also reduce a utility's variable costs (e.g., energy and chemical costs).

[26] The capacity of a water treatment plants is expressed as its maximum daily production rate, e.g., gallons/day. As such, the unit cost of supply would be expressed as dollars per gallons/day or $/gallon/day. For example, if the cost of building a 1.0 MGD plant expansion is $10 million, the unit cost of this expansion is $10 per gallon/day of capacity.

[27] If a rebate level is relatively low compared to the total customer cost to participate in a program (e.g., to buy and install a graywater system) the rebate may not be sufficient to entice customers that would not participate in the program without a rebate. Thus many of the program participants might be considered "free riders".

[28] While it is acknowledged that there may be other benefits associated with reducing water demands, e.g., environmental benefits, the focus of this document is specifically on the financial benefits.

5.0 Conclusion

While most homes produce significant volumes of graywater each day, this water is typically discharged to the sewer or septic tank as wastewater. While graywater could be seen as a “free” alternative source of water for such uses as toilet flushing or landscape irrigation, there are generally costs associated with purchasing, installing, operating, and maintaining graywater systems. Although financial benefits are not the only reason homeowners may choose to install a graywater system, if the total life-cycle cost of owning/operating a graywater system is greater than the total cost savings achieved through lower potable water purchases, the graywater system would not be considered cost-effective to the homeowner. Features that may result in a greater potential customer cost savings include:

- High marginal volumetric water (or water/sewer) rates
- Home is located in area with long irrigation season (e.g. >7 months for landscape-based graywater systems)
- Home has a high occupancy rate
- Lower installed costs for graywater systems
- Lower operations and maintenance costs
- Do-it-Yourself Graywater system is installed during home construction vs. retrofit

While reducing customer demands during times of drought can be beneficial to water utilities, graywater reuse programs are better suited as long-term, ongoing programs rather than as short-term solutions to drought. Sustained reductions in customer demands are especially beneficial to water utilities with limited water supplies or that need to expand their water supply/treatment infrastructure. Utilities faced with growing water demands must either increase the supply or reduce the demand (or a combination of both). Utilities must consider the net “yield” and unit costs associated with both supply-side and demand-side options – the solution with the lowest overall unit cost of implementation (e.g., $/gallon/day) that delivers the required incremental or total supply or demand offset will be the most cost-effective solution for the utility.

One of the key messages in this report is that the water savings achieved by a home installing a graywater system is not equal to the volume of graywater produced or captured but rather to **the long-term reduction in potable water demands** achieved by the homeowner. While it is relatively easy to estimate the potential potable water savings associated with the use of shower-to-toilet graywater systems, it is difficult to estimate the potential potable water savings associated with the use of landscaped-based graywater systems because of the large number of variables involved. The completion of more independent field studies may help to quantify these savings.

The savings values provided in this report are based on clearly identified references and assumptions and are meant to provide insight regarding the key parameters that affect savings. Water utilities are strongly encouraged to apply their own values to the equations provided in this report, e.g., volumetric water rates, persons per household, length of irrigation season, graywater system cost, unit cost of adding additional water supply, etc., to assess the cost-effectiveness associated with implementing a single-family graywater reuse program in their own community. As data from more independent third-party filed studies becomes available (especially regarding landscape-based graywater systems) it is hoped that the values identified in this report can be further refined.

Additional information on graywater systems is available on the Alliance for Water Efficiency website: http://www.allianceforwaterefficiency.org.

Graywater – Laundry to Landscape System

Laundry to Landscape (washing machine water used to irrigate small landscape areas)

Cost: Between $200 - $300 per site, possibly less

Initial Permitting / Inspections:

1.) Fill out an application for each unit and submit to the Department of Environmental Quality (DEQ) with permit fees included. https://www.oregon.gov/deq/wq/programs/Pages/Water-Reuse-Graywater.aspx

2.) Submit to DEQ:

- **Permit Application** (Permit application is attached or follow the link above)
- Permit fees $93 ($52 new-permit application fee and $41 annual fee)
- Agree to follow the **Permit Conditions** (see attachment or website above)
- Include a system design plan
- Include an operation and maintenance manual
  (Description and example on Page 10 and 11 of the **Homeowners Guide to Graywater**, see attachment or website above) (Also in Graywater Manual by Laura Allen pg. 64)

If the permit application and fees are complete, DEQ will notify the permit applicant by email or postal mail that coverage under the permit has been granted.

3.) Allow City staff to inspect during the installation process to assess:

- Laundry to Landscape graywater system installation
- RPZ Backflow installation at common irrigation meter
- Additional cross connection concerns

4.) Refer to the **Indoor Water Use Guide** to determine how much water could potentially be produced from washing machines of different efficiency rates.

Homeowner:

1.) Submit Annual Renewal: DEQ will send a letter each year letting the homeowner know that they need to renew by either paying a $41.00 annual fee or by submitting an annual report.

- Submit $41.00 fee or
- Fill out and submit an **Annual Report** form and the annual fee will be waived (See attachment or website)

2.) Notify the City if you plan to install a below ground irrigation system in addition to the Laundry to Landscape System on any individual unit/meter.

3.) City may inspect system to ensure conditions are being met for water quality/cross connection requirements.

4.) Refer to the **Indoor Water Use Guide** to determine how much water could potentially be produced from washing machines of different efficiency rates.