LOTT Clean Water Alliance

Reclaimed Water Infiltration Study
Phase 1 (Technical Data Review)

Technical Memorandum – Case Study Summary

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HDR

606 Columbia Street NW
Suite 200
Olympia, WA 98501
(360) 570-4400

Table of Contents

1.0 Introduction

Background

The LOTT Clean Water Alliance (LOTT) is a public, non-profit entity formed by its four government partners – the Cities of Lacey, Olympia, and Tumwater, and Thurston County. LOTT is responsible for providing wastewater treatment and management for the urban areas in northern Thurston County. Wastewater treatment currently occurs primarily at the Budd Inlet Treatment Plant, with treated effluent discharged to the marine waters of Budd Inlet. LOTT also treats a portion of the wastewater to Class A Reclaimed Water standards. Reclaimed water can be used for a variety of non-drinking purposes such as fountains, toilet flushing, or irrigation. Reclaimed water not used for such purposes can be infiltrated to recharge groundwater, consistent with standards developed by the Washington State Departments of Ecology and Health. LOTT's long-range plan relies on the production and beneficial use of reclaimed water to meet northern Thurston County's growing demand for wastewater management. LOTT currently operates two reclaimed water plants and one groundwater recharge site, and has purchased properties to eventually expand the reclaimed water program.

Recently, questions and concerns about infiltration of reclaimed water have been raised. In particular, questions have focused on compounds of potential concern (CPCs), such as those from pharmaceuticals and personal care products. To address these questions, LOTT is undertaking a multi-year study to improve the scientific understanding of how infiltrated reclaimed water interacts with local groundwater, where these compounds exist in the environment, and what happens to them over time. Results of the Reclaimed Water Infiltration Study, combined with community conversations about these issues, will help with decision-making about future uses and levels of treatment for reclaimed water.

Purpose of Technical Memorandum

The Reclaimed Water Infiltration Study is being implemented in phases. Phase 1 involved a variety of background activities to inform the development of a detailed study scope of work, to be prepared in Phase 2. One of the Phase 1 activities was completion of a case study review to examine reclaimed water groundwater recharge projects that have been developed and implemented elsewhere. The primary purpose is to understand how groundwater studies and monitoring have been conducted to evaluate fate and transport of reclaimed water for recharge projects.

The case studies selected for review were:

1. Montebello Forebay Aquifer Recharge Project (Central Basin, Los Angeles, CA)
2. Inland Empire Utilities Agency, Recycled Water Recharge Project (Chino, CA)
3. City of Tucson, Sweetwater Recharge and Recovery (Tucson, AZ)
4. Reedy Creek Improvement District, Shallow Aquifer Recharge Project (Orlando, FL)
5. City of Aurora, Prairie Waters Project, South Platte River (Aurora, CO)
6. LOTT Clean Water Alliance, Hawks Prairie Reclaimed Water Ponds and Recharge Basins (Lacey, WA)

This technical memorandum presents a brief summary of each case study. More comprehensive and detailed descriptions of each project are contained within separate technical memoranda for each case study.

2.0 Montebello Forebay Aquifer Recharge Project (CA)

Project Background

Groundwater is used extensively to meet water supply demands in the Los Angeles (LA) metropolitan area. Groundwater pumping started in the early 1900s and expanded greatly through the 1940s in the LA area with hundreds of water supply wells. By the 1940s and 1950s groundwater levels were in decline. The natural recharge to groundwater was not enough to offset the depletions by pumping and a managed aquifer recharge program was developed to sustain the aquifers. The aquifer recharge program includes two methods: injection wells near the coastal areas of the LA basin to offset sea-water intrusion, and aquifer recharge basins (i.e., spreading basins) in the Montebello Forebay.

The Montebello Forebay is one of the oldest and largest aquifer recharge facilities in the U.S. and includes the Rio Hondo Spreading Grounds and the San Gabriel Spreading Grounds. These recharge basins have been in operation since the 1930s when they were constructed primarily for flood control to infiltrate stormwater.

The sources of water used for recharge at the Montebello Forebay include imported surface water from the Colorado River and the California State Water Project, stormwater from the San Gabriel and Rio Hondo Rivers, and reclaimed water (treated municipal wastewater). The on-going water shortages, the projected decline of surface water supplies, and the high cost of imported water in Southern California have been major drivers for the expansion of the reclaimed water aquifer recharge program at the Montebello Forebay in the last 50 years.

The operation of this complex and large system is co-managed mainly by three agencies. The Los Angeles County Sanitation District operates three water reclamation facilities that provide reclaimed water for recharge. The Los Angeles County Department of Public Works operates the Montebello Forebay spreading grounds. The Water Replenishment District of Southern California is the primary agency responsible for monitoring the quality and quantity of groundwater.

Because there are over 50 years of operational and monitoring data regarding reclaimed water being used for groundwater recharge, the Montebello Forebay is regarded as a key case study in the reclaimed water arena.

Reclaimed Water Treatment

Three large water reclamation facilities (the San Jose, Whittier Narrows, and Pomona plants) were developed in the 1960s and 1970s to produce reclaimed water. The treatment approach is similar to that used by LOTT. Key treatment processes include: primary sedimentation, activated sludge biological treatment (including advanced removal of nitrogen), dual media filtration, and chlorination. No higher levels of treatment, such as reverse osmosis or advanced oxidation, are employed.

Typical concentrations of key reclaimed water quality parameters are as follows:

- Biochemical Oxygen Demand (BOD) – Less than 5 milligrams per liter (mg/L).
- Total Organic Carbon (TOC) – Less than 7 mg/L.
- Total Nitrogen – Range of 3-6 mg/L (mostly nitrate).

Recharge Facility Description

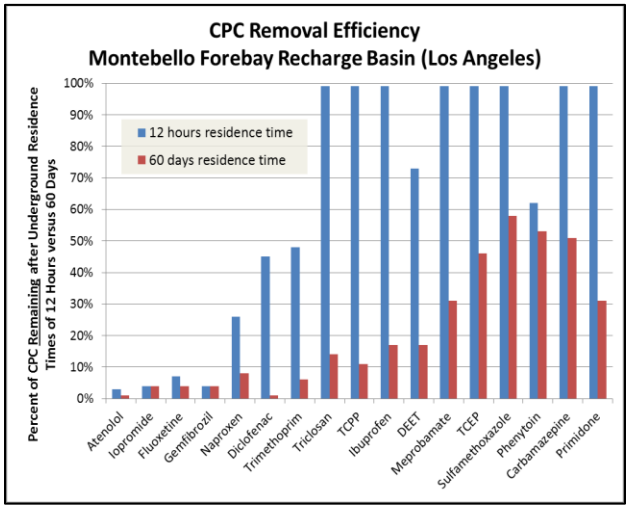
The recharge basins cover about 800 acres and are located in a densely-urban residential area. Since the 1960s, the quantity of reclaimed water used for aquifer recharge has ranged from 10 to 55 million gallons per day (mgd). The maximum recharge capacity of the facility is over 650 mgd.

Normal depth to groundwater ranges from 50 to 80 feet over the site. During recharge operations the groundwater levels near the basins increase to within 10 feet of the ground surface.

Numerous water supply production wells are located close to the basins. Twenty-three wells are located within six months travel time (meaning it takes reclaimed water less than six months to migrate from the point of recharge to the location of the wells), and 18 wells are located within two to 16 years from the recharge basins. (Note: The Montebello Forebay project was developed and constructed prior to the current California State reclaimed water regulatory standards for aquifer recharge which require a minimum residence time for reclaimed water prior to reuse at a public supply well of two to six months, depending upon project-specific conditions.)

Water Quality Monitoring

Several studies have focused on the attenuation of compounds of potential concern (CPCs) during infiltration and soil aquifer treatment (SAT) at the Montebello Forebay spreading grounds. The chart to the left summarizes data presented in a 2011 study evaluating a variety of pharmaceuticals and personal care products. The study found that attenuation for most CPCs took place in the vadose (unsaturated) zone, where concentrations dropped within the first seven feet below the basins (travel time of 12 hours) and remained relatively constant up to 23 feet below the basin (travel time of 70 hours). With an increased travel time (60 days), the concentration of all trace organic contaminants detected in the basin decreased further. The study reflects the range in SAT removal efficiencies associated with CPCs. Some are removed by more than 95%, while others are more persistent with removals of approximately 50%.



3.0 Inland Empire Utilities Agency, Recycled Water Recharge Project (CA)

Project Background

The Inland Empire Utilities Agency (IEUA) is a consortium of seven member agencies that provide water and wastewater services primarily for municipalities (including Chino, Chino Hills, Fontana, Montclair, Ontario, and Upland) and industrial uses in San Bernardino County. IEUA has a 242 square-mile service area serving approximately 850,000 residents.

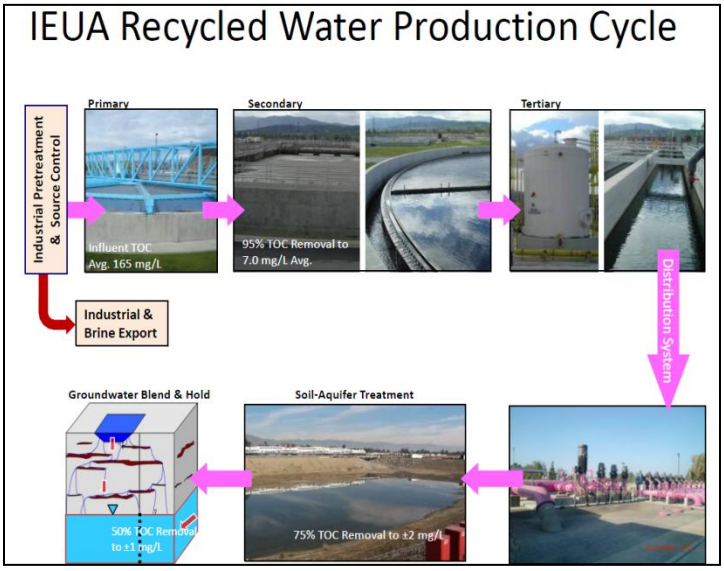
The agency collects and treats wastewater and produces reclaimed water. Reclaimed water is purveyed directly to customers for various uses (primarily industrial) and is also used for groundwater recharge. Reclaimed water is blended with other source waters (untreated surface water and stormwater runoff diverted from creeks and rivers) prior to being recharged.

Groundwater pumping supplies a large percentage of the potable water used in the Chino Basin. During the last decade the amount of groundwater withdrawals has exceeded the amount of natural recharge received by the local aquifers. IEUA's groundwater recharge program offsets the extent of pumping that exceeds natural recharge.

Reclaimed Water Treatment

IEUA owns and operates five water reclamation treatment facilities. Key treatment processes prior to groundwater recharge and soil aquifer treatment include primary, secondary, tertiary (for advanced nutrient removal), and disinfection. No higher levels of treatment, such as reverse osmosis or advanced oxidation, are employed.

IEUA reclaimed water facilities currently produce on average 53 mgd of reclaimed water. A portion of this recycled water goes directly to irrigation or industrial users, with the remainder going into the groundwater recharge basins.



Typical concentrations of key water quality parameters are as follows:

- Biochemical Oxygen Demand (BOD) – Less than 2 mg/L.
- Total Organic Carbon (TOC) – Ranges from 5-10 mg/L.
- Total Nitrogen – Ranges from 5-10 mg/L (with nitrate less than 0.5 mg/L).

Recharge Facility Description

Nine of IEUA's 17 groundwater recharge basins receive reclaimed water. The others receive only surface water and stormwater. Most of the basins are converted stormwater infiltration ponds, ranging in size from 6 to 40 acres of wetted infiltration area. The quantity of reclaimed

water used for recharge is currently approximately 7 mgd, which is about 13% of the total amount of water recharged at the basins. Ultimately, IEUA plans to recharge up to 20 mgd of reclaimed water throughout all its basins.

The depth to groundwater at the basins ranges from 200 to 400 feet, and the travel time through the vadose zone ranges from 17 to 110 days.

Drinking water supply wells are prohibited within the "soil aquifer treatment zone" which is defined as either a minimum of 500 feet away from a basin or a minimum underground retention time of six months from the point of recharge. Many potable water supply wells are located close to the basins, with some within a fiver year time of travel. In a few cases, wells are located just outside the six month time of travel from the edge of a basin.

Water Quality Monitoring

Groundwater quality is measured directly under the basins and at monitoring wells installed downgradient of the recharge basins. A groundwater monitoring well is installed within the one to three month travel time from the recharge basins or immediately downgradient of the wells. A second groundwater monitoring well is generally located between the recharge basins and the downgradient water supply production wells.

IEUA uses Total Organic Carbon (TOC) as the general measure of soil aquifer treatment effectiveness. TOC is monitored in the unsaturated zone beneath the basins, using samples from the top 35 feet of soil. The TOC in the reclaimed water conveyed to the basins is typically between 5 to 10 mg/L. Removal efficiency in the upper 35 feet of soil underneath the basis has been determined to be 75 to 80 percent, resulting in TOC in the unsaturated zone under the basins at around 1 mg/L. Total nitrogen is reduced from above 5 mg/L in the reclaimed water to less than 2 mg/L underneath the basins.

4.0 City of Tucson, Sweetwater Underground Storage and Recovery Facility (AZ)

Project Background

Since the mid-1980s, the City of Tucson has operated the Sweetwater Underground Storage and Recovery Facility (SUSRF), a non-potable reclaimed water production, storage, and delivery system that is separate from its potable water system. This system provides reclaimed water to golf courses, parks, schools and other large turf irrigation areas served by Tucson. The purpose is to reduce the City's reliance on potable water supplies for these non-potable uses. The system utilizes groundwater recharge and soil aquifer treatment (SAT) as part of the overall water resource management and treatment process; however, the purpose of the project is not expressly for groundwater augmentation.

Because the SUSRF was one of Arizona's first underground storage and recovery facilities, the project was built in phases over 13 years to demonstrate effectiveness and to plan for full-scale implementation.

Reclaimed Water Treatment

Tucson is permitted to supply the SUSRF infiltration basins with both secondary wastewater effluent (from the Roger Road Wastewater Treatment Plant) and reclaimed water (from the Tucson Water Reclamation Plant). A portion of the secondary effluent is conveyed through wetlands prior to infiltration. In recent years, the majority (90%) of recharged water has been secondary effluent and water from the wetlands. Thus, only a small amount of recharged water has actually been of higher quality reclaimed water.

The Roger Road treatment process utilizes primary sedimentation, biofilters, activated sludge, and chlorination. No advanced nutrient removal is currently conducted at this facility. The Reclamation Plant further treats the Roger Road effluent by means of dual-media (sand and coal) filtration in order to reduce turbidity. No higher levels of treatment, such as reverse osmosis or advanced oxidation, are employed.

Typical concentrations of key water quality parameters are as follows:

- Biochemical Oxygen Demand (BOD) – 30 mg/L.
- Total Organic Carbon (TOC) – Ranges from 12-20 mg/L.
- Total Nitrogen – Average of 20-25 mg/L (but can be up to 45 mg/L).

Recharge Facility Description

The SUSRF includes eight recharge basins covering approximately 30 acres on the banks of the Santa Cruz River, and two wetlands. The total recharge capacity is 5.8 million gallons per day (mgd).

Normal depth to groundwater is approximately 120 feet over the site. During recharge operations the groundwater levels near the basins rise between 15-50 feet, depending on the extent of recharge

and the amount of water being simultaneously extracted through the nearby recovery wells.

The closest potable water supply wells are located about one mile downgradient of the project site. No extensive travel time analyses have been conducted, but estimates suggest that recharged water would reach these wells after several years of subsurface travel.

Water Quality Monitoring

Nitrogen is of particular interest in the groundwater underlying the SUSRF. Historically, this area was used as a surface spreading site for sewage and agricultural waste, resulting in high groundwater nitrogen concentrations. Since the recharge basins have operated, monitoring data show that nitrogen in the soil and in the groundwater has been significantly reduced, from about 15 mg/L in the late 1980s to approximately 5 mg/L in the mid-1990s. This is occurring although the level of nitrogen in the applied secondary effluent and reclaimed water is high (20-25 mg/L), primarily due to the wetting/drying cycles of the recharge operation that create alternating aerobic/anoxic conditions that ultimately support conversion of nitrogen to its gaseous form.

TOC is closely monitored at this facility, since the levels in the applied water are fairly high (up to 20 mg/L) compared with higher quality reclaimed water used in other recharge projects throughout the country. TOC is also often used as an indicator of the presence of trace organic compounds (i.e., CPCs). At the SUSRF, TOC concentrations have been consistently reduced from 20 mg/L to less than 1 mg/L upon recovery in the extraction wells located in close proximity to the basins.

Because the SUSRF is one of the first groundwater recharge and recovery systems developed in Arizona that treats secondary effluent (as opposed to reclaimed water), the SUSRF has been the focus of extensive academic research regarding the fate and transport of CPCs during SAT. Studies of select pharmaceuticals at the SUSRF site indicate that SAT removes these compounds to levels so low they can no longer be detected. The long retention times in the biologically active vadose zone appear to be sufficient to remove many classes of pharmaceutical compounds. By contrast, studies of some antiepileptic pharmaceuticals at the SUSRF site indicate that these compounds remain even after long-term subsurface transport.

5.0 Reedy Creek Improvement District, Shallow Aquifer Recharge Project (FL)

Project Background

The Reedy Creek Improvement District (RCID) is a special district formed in 1967 to serve primarily the large tourist attractions owned by the Walt Disney World Company and located immediately southwest of the metropolitan area of Orlando, Florida. The 39 square mile area served by RCID is within Orange and Osceola counties.

The RCID collects and treats wastewater and produces reclaimed water. The service area contains over 40,000 hotel rooms, employee lodging, and residences within the cities of Bay Lake and Lake Buena Vista. It is equivalent to a municipality with a population of 150,000 to 200,000.

RCID began implementation of its reclaimed water program in the early 1990s as part of a plan to stop discharging wastewater effluent into the ecologically sensitive wetland and swamp environment of Central Florida, and in response to declining levels in the Upper Floridan aquifer, the primary source of potable water in the region.

In the 23 years that reuse has been practiced by this utility, RCID's water demands have more than doubled; however, RCID's net withdrawal of groundwater from the Upper Floridan aquifer has only increased by about 23 percent.

Reclaimed Water Treatment

The RCID operates a single wastewater/reclaimed water treatment facility. The treatment approach is similar to that used by LOTT. Key treatment processes include: screening and grit removal, biological nutrient removal (including advanced removal of nitrogen and phosphorus), final clarification, single media filtration, and chlorination.

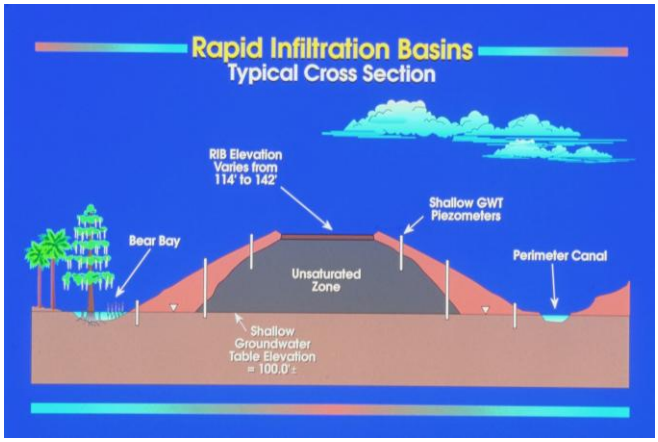
The treated effluent is pumped to two separate distribution systems: one system for landscape/turf irrigation, some toilet flushing, and street cleaning; and the other system for conveyance to the Rapid Infiltration Basins (RIBs). The RIBs are normally used in wet weather when reclaimed water demands for irrigation are low. When irrigation water demands are the highest, more reclaimed water is sent to the irrigation distribution system, and less water is put into the RIBs.

Typical concentrations of key water quality parameters are as follows:

- Biochemical Oxygen Demand (BOD) – Less than 2 mg/L.
- Total Nitrogen – Less than 2 mg/L (nitrate less than 1 mg/L).
- Phosphorus – Less than 0.2 mg/L.

Recharge Facility Description

The RIB system is located within a 1,000 acre site on a sandy ridge about two miles northwest of the RCID wastewater/reclaimed water treatment facility. The site has a total of 85 one-acre RIBs, located in an area that is primarily wooded with very little development. The RIBs are constructed along a naturally occurring sandy ridge of higher ground. The average depth to groundwater under the RIBs ranges from 15 to 40 feet.



There are no water supply wells near the RIBs. The nearest potable water supply well (serving the Walt Disney Resort) is approximately two miles to the east of the recharge area. Travel times in the Upper Floridan aquifer are very long, due primarily to the flat topography of the region. It is estimated that recharged water from the RIBs would take more than 20 years to reach the nearest well.

Water Quality Monitoring

RCID monitors the quality of water entering its wastewater/reclaimed water treatment facility, treated effluent leaving the facility and conveyed to the recharge site, and groundwater in 10 monitoring wells.

The most significant parameter with respect to potential impact upon the Upper Floridan aquifer is nitrogen. RCID's permit limit for Total Nitrogen in reclaimed water is 6.0 mg/L. While there is a slight seasonal variation in the level of Total Nitrogen in RCID's reclaimed water, the average is just under 1.0 mg/L.

Data from 2003 to 2008 show that chloride levels in the groundwater are elevated compared to background levels, an expected result of recharging reclaimed water into an unconfined aquifer that has no other wastewater-related inputs. Nitrate levels in the groundwater monitoring wells are very low, with most samples having concentrations less than can be detected and the maximum observed concentration being 0.076 mg/L).

No monitoring of CPCs or their surrogates is conducted in groundwater or in the reclaimed water prior to recharge.

6.0 City of Aurora, Prairie Waters Project, South Platte River (CO)

Project Background

The City of Aurora, Colorado, which serves a population of approximately 325,000, faced a critical water shortage in the early 2000s that prompted the City to rapidly expand water supplies. Water rights were not available for a new supply. However, the City was able to develop the Prairie Waters Project, which involved recapturing a portion of their wastewater treatment plant discharges to the South Platte River, and treating this to a level appropriate for reuse in its potable water distribution system.

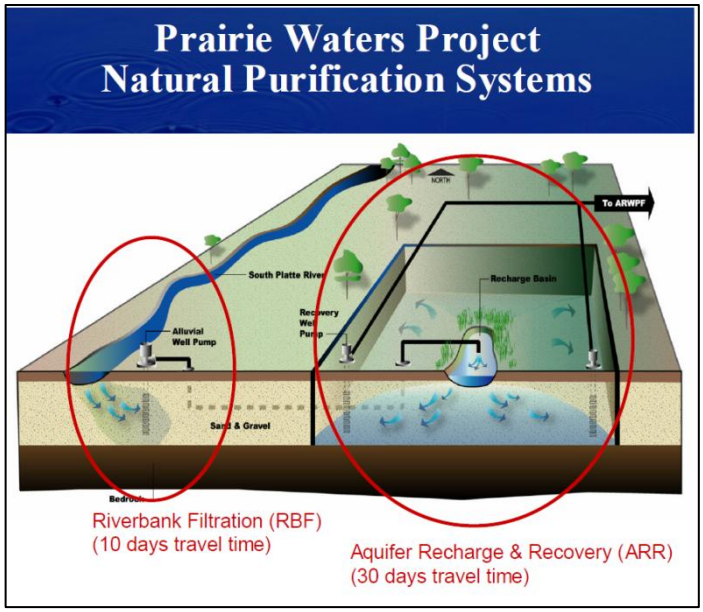
Up to 80 percent of the flow in the South Platte River is composed of treated wastewater from other upstream municipalities. Because of the concern for contamination from these upstream municipal wastewater discharges, the Prairie Water Project was developed to provide a very high degree of treatment. Water is first extracted from a series of wells located about 300 feet from the river. This is referred to as the riverbank filtration (RBF) component of the project. The water is then introduced into aquifer recharge basins and is treated by Soil Aquifer Treatment (SAT) prior to being extracted again and sent by pipeline to an advanced treatment facility.

This case study is different than the others, in that the Prairie Waters Project does not involve the recharging of groundwater with reclaimed water. However, this project was included in the case study review because of its use of SAT as a treatment process and the associated study of SAT's effectiveness on the removal of contaminants including CPCs.

Treatment Processes

The Prairie Waters Project is composed of three treatment stages:

1) RBF. South Platte River water is extracted through shallow wells located adjacent to the river. Riverbank filtration occurs as the river water travels from the river to the wells through the naturally occurring alluvial sediment that lines the river.
2) SAT. Water withdrawn from the RBF wells is then piped to a groundwater recharge (or aquifer recharge and recovery) basin, where it is further treated via SAT for longer periods of time than occurs during RBF.
3) Advanced Treatment. The water recovered from the ARR basin is pumped south through a 34 mile pipeline to the Binney Purification Facility which provides advanced treatment including softening to remove excess calcium and magnesium, advanced ultraviolet light



oxidation, granular media filtration, and activated carbon absorption prior to being sent to the City's potable water distribution system.

Typical concentrations of key water quality parameters for South Platte River water (i.e., before RBF) are as follows:

- Biochemical Oxygen Demand (BOD) – Ranges from 6-16 mg/L.
- Total Nitrogen – Ranges from 5-10 mg/L (nitrate ranges from 2-7 mg/L).
- Total Organic Carbon (TOC) – Ranges from 5-10 mg/L.
- Oxygen – Ranges from 8-11 mg/L.

Recharge Facility Description

The groundwater recharge facility includes three recharge basins in a 200-acre area that is surrounded on all sides by slurry walls that extend to bedrock. The slurry walls and bedrock hydrologically isolate the basins from the rest of the riverbank aquifers and create a closed groundwater system to maximize SAT and minimize the influence of native groundwater and river water that has high nitrate concentrations. Because of the isolation of the basins, there is no concern for recharged water reaching potable supply wells. All water that is infiltrated is eventually withdrawn from extraction wells and then sent to the advanced treatment facility.

Currently, the Prairie Waters Project produces approximately 9 mgd (20% of the City's total potable water needs). Future expansion is expected to increase production to approximately 40 mgd.

Water Quality Monitoring

The City monitors for select water quality parameters in the South Platte River, in the RBF extraction wells, and after the water is extracted from the groundwater recharge facility. Groundwater quality data for show that the combined RBF/SAT system reduces nitrate from an average of 5 mg/L in river water to 3 mg/L in the extracted groundwater. Phosphorus is reduced to 0.08 mg/L and TOC is reduced from an average of 8 mg/L in river water to 2 mg/L.

In addition to the City's routine monitoring of conventional parameters, the Prairie Waters Project has been the subject of academic research on the effectiveness of SAT in removing CPCs. Because of a climate that differs from most other groundwater recharge sites (such as those located in the southwestern US), an interesting element of the studies conducted to-date is evaluation of seasonal variability in CPC removals during SAT. In the winter, surface water and groundwater temperatures range from about 40 to 50 degrees F, while in the summer, water temperatures range from 60 to 70 degrees F. In general, removals of most CPCs in the winter are similar to removals in the summer. Some of the more persistent compounds (i.e., those that take longer to degrade) were observed to have lower removal rates at the lower winter temperatures.

7.0 LOTT Clean Water Alliance, Hawks Prairie Reclaimed Water Ponds and Recharge Basins (WA)

Project Background

Northern Thurston County experienced significant population growth from the 1980s to the 2000s. In response to this growth, and in recognition of water quality concerns regarding Puget Sound, a major regional wastewater planning effort was conducted in the 1990s. This culminated in the formation of the LOTT Clean Water Alliance (LOTT) and the development of the Wastewater Resource Management Plan (commonly referred to as the Highly Managed Plan). LOTT is a public, non-profit entity currently responsible for providing wastewater treatment and management for the Cities of Lacey, Olympia, and Tumwater in northern Thurston County.

The wastewater management approach selected for implementation in the Highly Managed Plan included upgrades to the Budd Inlet Treatment Plant and development of satellite treatment plants that would produce reclaimed water that could be used for a variety of purposes, including groundwater recharge.

As part of the Highly Managed Plan, LOTT plans to expand its reclaimed water program, including increasing groundwater recharge at the current Hawks Prairie site and creating recharge basins at several additional locations. Groundwater recharge is being implemented primarily to meet wastewater management objectives; however, it provides a secondary benefit as part of water right mitigation plans developed by the Cities in association with their continued use of groundwater for municipal water supplies.

Reclaimed Water Treatment

Presently, LOTT operates two reclaimed water production facilities. The Budd Inlet Reclaimed Water Plant has produced reclaimed water since 2004. It treats a portion of the secondary effluent generated by the Budd Inlet Wastewater Treatment Plant to Class A reclaimed water standards. This water is used for a variety of purposes including irrigation of parks and landscaped areas in downtown Olympia.

LOTT's other treatment facility is the Martin Way Reclaimed Water Plant, a satellite treatment plant that produces Class A reclaimed water through a biological nutrient removal system using membrane bioreactors. After biological treatment, the wastewater is filtered through separate membrane filters and then disinfected with chlorine. Presently, all reclaimed water generated at this facility is conveyed through three miles of pipeline to the Hawks Prairie Reclaimed Water Ponds and Recharge Basins.

Typical (2011 averages) concentrations of key water quality parameters in the water produced at the Martin Way Reclaimed Water Plant are as follows:

- Biochemical Oxygen Demand (BOD) – 2.7 mg/L.
- Total Nitrogen – 5.8 mg/L (nitrate 4.1 mg/L).
- Oxygen – 7.4 mg/L.

Recharge Facility Description

The Hawks Prairie site covers 41 acres, and includes five constructed wetland ponds and eight groundwater recharge basins. The recharge basins are each one acre in size. The basins are excavated into the subsurface, and contain about one foot of imported sand for filtration of fine particulates and for ease of maintenance when tilling the soil.

The wetland ponds are used for aesthetic/recreational/educational purposes and water quality polishing, while the groundwater recharge basins infiltrate reclaimed water to the aquifer. Normal depth to groundwater at this location ranges from 80 to 120 feet. During recharge, groundwater levels rise by about 10 feet.

Groundwater modeling has been conducted to evaluate the time of travel for recharged water to reach nearby potable water supply wells and area creeks. At a recharge rate of 1 mgd, the travel time to five wells located between the recharge basins and Woodland Creek was modeled to be 2 to 5.5 years. The travel time to Woodland Creek was estimated to be 10 years.

The recharge basins are designed for 5 mgd of continuous operation. The range of typical use since 2006 has been 0.36 to 0.65 mgd of recharge.

Water Quality Monitoring

LOTT monitors groundwater quality underneath and immediately downgradient of the recharge basins, per its permit issued jointly by the State Departments of Ecology and Health. Groundwater quality at the site meets the State permit conditions for the facility and Federal drinking water standards. Groundwater quality data show that chloride levels increased from less than 5 mg/L in 2005 (prior to recharge operations) to up to 30-60 mg/L in 2010, indicating that a higher percentage of groundwater on the site is originating from reclaimed water. Nitrate in monitored groundwater is typically below 1 to 3 mg/L.

Ecology completed a study published in 2012 that evaluated CPCs at three Washington reclaimed water groundwater recharge facilities, one of which was LOTT's Martin Way/Hawks Prairie Facility. Groundwater samples were collected and analyzed during the spring and fall of 2011 for select CPC compounds, and compared against concentrations observed in reclaimed water (prior to recharge). Carbamazepine, meprobamate and sulfamethoxazole were compounds that showed minimal degradation through the recharge basins (i.e., concentrations were not significantly different between reclaimed water and groundwater). Several compounds (sulfadimethoxine and B-sitosterol) were present in groundwater but not present in reclaimed water. All other compounds evaluated were not detected in groundwater or were presumably removed from the reclaimed water by soil aquifer treatment. The study report concludes that "*Carbamazepine (anti-epileptic), meprobamate (tranquilizer), and sulfamethoxazole (antibiotic) were consistently detected in both reclaimed water and down-gradient wells at all facilities. The*

majority of compounds (80%) identified in reclaimed water do not appear to persist in groundwater at readily detectable levels."