Ina Road Wastewater Reclamation Facility Capacity and Effluent Quality Upgrade

Disinfection

PREPARED FOR: Pima County Regional Wastewater Reclamation Department

PREPARED BY: Barb Engleson/CH2M HILL
Mo Mukiibi/CH2M HILL

REVIEWED BY: Dana Rippon/CH2M HILL
Julian Sandino/CH2M HILL

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Introduction

This design memorandum provides a preliminary description of the proposed disinfection system for the Ina Road Wastewater Reclamation Facility (WRF) Capacity and Effluent Quality Upgrade Project (Upgrade Project), including existing facilities and proposed modifications. In addition, this memorandum summarizes the following:

- Anticipated effluent disinfection design criteria.
- Background information from the enhanced chlorination testing done as part of the work for the Pima County Regional Wastewater Reclamation Department's November 2007 *Regional Optimization Master Plan Final Report* (ROMP), developed by Greeley and Hansen
- The proposed disinfection facility sizing and configuration based on preliminary recommendations in the ROMP and discussions with the Pima County Regional Wastewater Reclamation Department (PCRWRD).

The existing WRF uses sodium hypochlorite for disinfection and sodium bisulfite for effluent dechlorination. Chlorine is added separately at the east and west chlorine contact basins, with dechlorination provided for the combined flow downstream of the basins at the existing dechlorination box.

In the ROMP, three alternatives were discussed for meeting effluent disinfection criteria:

- Enhanced chlorination
- Enhanced chlorination following effluent filtration
- UV disinfection following filtration

Based on an evaluation of the alternatives, enhanced chlorination was selected as the preferred alternative and a number of field studies were conducted by Greeley and Hansen

at the WRF to determine the feasibility of using enhanced chlorination to meet the effluent disinfection criteria. These studies are summarized in Appendix G of the ROMP.

Functional Description

The function of the effluent disinfection system is to destroy human pathogenic organisms including bacteria, viruses, and protozoa in order to protect public health. The WRF effluent is required to meet Arizona Administrative Code disinfection requirements for wastewater treatment facilities and Best Available Demonstrated Control Technology pathogen standards for wastewater treatment plants.

Effluent Quality Requirements

Regulatory objectives for effluent quality currently are established by each facility's Aquifer Protection Permit (APP) and/or Arizona Pollutant Discharge Elimination System (AZPDES) permits. Limits in the AZPDES permits are driven by State Surface Water Quality Standards. Limits in the APP permits are driven by numeric State Aquifer Water Quality Standards and Best Available Demonstrated Control Technology (BADCT) requirements. Table 8-1 summarizes the effluent disinfection requirements. In addition to the disinfection criteria, a limit for trihalomethanes (THMs) is also listed.

The PCRWRD is planning to perform testing at the Ina Road WRF for THMs using the biological nitrogen removal activated sludge (BNRAS) secondary effluent. Other plants have found THM formation to occur due to the reaction of free chlorine with organics in the wastewater. Depending on the results from the THM testing, it may be necessary for PCRWRD to consider practicing chloramination. Chloramination is the process of adding a small amount of ammonia back into the effluent in the presence of chlorine in order to form chloramines. It has been shown and demonstrated that chloramines have been successful in limiting the quantity of THM formation. Depending on the results from the THM testing by PCRWRD, chloramination may be recommended for the Ina Road WRF to limit THM formation. If it is determined that chloramination is required to control THM formation, PCRWRD should perform additional testing for other disinfection byproducts of chloramination, such as NDMA. NDMA is a regulated compound in California for effluent recharged into the groundwater. Although currently not regulated in Arizona, it is possible that NDMA could become regulated prior to or soon after the completion of the Ina Road WRF in 2014.

In addition to meeting the effluent criteria listed above, the plant effluent is required to meet whole effluent toxicity (WET) requirements. WET testing results may identify issues that will need to be addressed in the WRF Upgrade Project effluent disinfection system.

TABLE 8-1
Effluent Disinfection Requirements
Ina Road WRF Capacity and Effluent Quality Upgrade

		Regulatory Requirement			
		Aquifer Protection Permit Program		Arizona Pollutant Discharge Elimination System	Reclaimed Water Quality Standards
Parameter	Unit	AWQS	BADCT	SWQS	Class B+
Total trihalomethanes (TTHMs)	mg/L	<0.1 (Will be modified to 0.08)		NNS	
Fecal coliforms					
4 out of 7 samples	cfu/100 mlLcfu/100 mL		ND		200
Single-sample maximum			<23		800
E. Coli					
4 out of 7 samples	cfu/100 mL		ND	<126[a]	
Single-sample maximum	cfu/100 mL		<15	<575[a]	
Total coliform	cfu/100 mL	ND			
Total chlorine residual					
Monthly average	µg/L			<4	
Daily maximum	µg/L			<8	

[a]Partial body contact - geometric mean (four-sample minimum)

µg/L = micrograms per liter
BADCT = Best Available Demonstrated Control Technology
ml = milliliter
SWQS = Surface Water Quality Standards
AWQS = Aquifer Water Quality Standards
cfu = colony forming unit
ND = nondetect
NNS = no numeric standard

ROMP Recommendations

The ROMP includes a number of recommendations for enhanced chlorination implementation. Conclusions from the field testing included the following:

- For a high-quality secondary effluent such as that from BNRAS portion of the plant, the plant is likely to meet the requirement of four samples out of seven being at nondetect for fecal coliform or E. coli.
- Based on the secondary effluent quality at the time of testing, a minimum CT of 100 milligrams per liter (mg/L)*minute was recommended as the target at peak day flow for sizing the contact basins. The CT is a product of the chlorine residual and the modal contact time measured at the same time when the chlorine residual sample is taken, typically at the end of the contact time.
- The enhanced chlorination system potentially may not meet the single-sample criterion for E. coli of 15 cfu/100mL. The ROMP testing indicated this maximum value may be exceeded a number of times each year.

- Additional testing was recommended as a means of verifying the CT recommendation for the Upgrade Project disinfection system and testing effluent WET with increased dechlorination resulting from higher chlorine residuals.

As described in the ROMP recommendations, operation of the secondary treatment system to consistently provide a high-quality effluent will be necessary to meet the disinfection criteria. Based on experience at other treatment facilities with similar criteria and the ROMP recommendations, recommendations for the enhanced chlorination system are presented in the following sections.

CT and Dose Recommendations

The ROMP enhanced chlorination study recommended providing a CT of 100 mg/L*minute at peak flow. It is expected that the chlorine residual concentrations typically will be 1 to 3 mg/L upstream of dechlorination. The T or contact time represented in the CT typically is required to be verified by a tracer study of the actual contact basins. Therefore, the T is modal contact time rather than a theoretical contact time based on basin volume and flow. A peak day flow will be used to determine contact volume requirements associated with a CT of 100 mg/L*minute. Based on an evaluation of plant data from 2004 through 2008, peak day is estimated to be approximately 1.4 times the average annual flow. Therefore, at annual average flow, the CT will be 140 mg/L*minute.

The east existing contact basins provide a theoretical contact time of 14.5 .7 minutes at the peak day flow condition. These basins have a 20:1 length-to-width ratio. Tracer studies conducted for these basins as part of ROMP enhanced chlorination studies indicated actual contact time was approximately 60 percent of the theoretical or calculated contact time. Although these existing basins provide a limited amount of contact time relative to future flows and overall chlorine contact requirements, these basins are proposed to remain in service because the existing service water and heat exchanger water pumps draw from these basins. Typically, chlorine contact basins should be designed with a length-to-width ratio of 40:1 or greater to minimize short-circuiting. Studies done on basins with a 40:1 length-to-width ratio indicate that actual contact time is approximately 70 percent of the calculated time, because of hydraulic inefficiencies. Therefore, for a modal contact time of 100 minutes, a contact basin volume with a calculated contact time of 143 minutes should be provided. Keeping the existing basins in service also minimizes the volume required for a new basin.

During ROMP enhanced chlorination testing, the chlorine residual ranged from 1.6 to 3.5 mg/L. Although a design residual of 1.5 mg/L was proposed in the Preliminary Report, a design residual of 3.0 mg/L is proposed for the upgrade. For the same CT value , higher chlorine residuals increase chlorination and dechlorination chemical usage, but result in a lower contact time and a lower overall chlorine contact basin volume and size. Therefore, the design criteria listed later in this design memorandum are based on an assumed average chlorine residual of 3.0 mg/L. This recommendation is preliminary, and additional kinetic testing as recommended in the ROMP would provide further verification of ability to meet effluent disinfection, disinfection byproduct and whole effluent toxicity (WET) requirements, using this basis of design.

Contact Basin Configuration- Alternative Evaluation

The Upgrade Project will increase the total chlorine contact basin volume to meet regulatory disinfection criteria. This can be achieved by adding volume to the existing chlorine contact basins (CCB) or by providing a new basin. The following three alternatives for increasing the total chlorine contact basin volume to meet the design 100 mg/L*minute were evaluated.

1. Expansion of existing CCBs.
2. Utilization of the existing CCBs and construction of a new CCBsto meet the CT requirements.
3. Construction of a new CCB to meet the CT requirements without consideration of the existing CCB volume.

With input from PCRWRD, the second alternative, which is utilization of the existing CCBs and construction of a new CCB was selected because its configuration had least cost implications on both the Upgrade Project and future filter construction.

Chlorination and Dechlorination Systems

Sodium hypochlorite will be injected into the secondary effluent flows at the mixing chambers located on the north end of the existing CCBs. Each of these chambers are equipped with induction mixers to blend the secondary effluent with sodium hypochlorite. Each existing CCB has two trains which use sluice gates for isolation from the mixing chambers. The existing west CCB trains cannot be fully isolated due to unidentified leaks between trains. The chlorinated effluent from the existing CCBs is combined in the existing dechlorination box, which will no longer be used for dechlorination. The chlorinated effluent uses the existing outfall pipe and will be diverted via a new 84-inch pipe to the new CCB.

To provide space for future filtration and reuse facilities, it is proposed that the new CCB be located southwest of the Centrifuge Building and downstream of both the existing CCBs. The CCB has been designed with a serpentine flow pattern using two trains in parallel to achieve a 40:1 length to width ratio. The side-water depth of the new CCB will be maintained at 14 feet. Each train will consist of three paths, each 14-feet wide. Each train will also have one 8-foot adjustable motor operated weir gate, which will enable the operators to isolate trains and balance the flow.

The chlorinated effluent flows over broad-crest weirs, through launders, and into a 10-foot-wide effluent channel. Future reuse pump stations will draw chlorinated effluent from this channel. Sodium bisulfite will be used to dechlorinate the remaining final effluent before it flows into the outfall. The sodium bisulfite will be injected at the downstream end of the effluent channel. Final effluent will be returned to the existing outfall pipe through a new 84-inch pipe. The chlorination and dechlorination chemical systems are described further in Design Memorandum 14, Chemical Storage and Feed Systems, including proposed chemical doses based on experience at other treatment plants that are required to meet similar criteria.

Final Effluent Sampling

A final effluent sample will be collected from the outfall junction box located downstream of the new CCB. A peristaltic sample pump will pump flow to a final effluent composite sampler and effluent analyzers housed in a prefabricated building located adjacent to the outfall junction box. Parameters to monitored include; pH and residual bisulfite. A second effluent composite sampler will be provided for redundancy.

Provisions for Other Future Facilities

Filters

In the future, tertiary filtration by conventional deep bed filters, membranes, or other types of filters may be added to Ina Road WRF. The Upgrade Project has provide space onsite for filtration of 100 mgd peak flow using a filter facility located west of the west CCB and upstream of the new CCB.

Reuse Water

Reuse water can be drawn from the new CCB effluent channel upstream of dechlorination.

Design Criteria

Table 8-2 lists the design criteria for disinfection for the current facilities and the Upgrade Project.

TABLE 8-2
Effluent Disinfection System Criteria
Ina Road WRF Capacity and Effluent Quality Upgrade

Design Criteria	Unit	Criterion
Annual average flow (AAF)	mgd	50
Peak daily flow (PDF)	mgd	70
Modal contact time at AAF (based on 3.0 mg/L chlorine residual and CT=140 mg/L*min)[a]	minutes	47
Modal contact time at PDF (based on 3.0 mg/L chlorine residual and CT=100 mg/L*min)[a]	minutes	34
Existing Contact Basins		
Number of units		4 (2 east, 2 west)
Volume	gallons	857,000
Modal contact time provided at peak daily flow[b]	minutes	8.7
Theoretical contact time at peak daily flow	minutes	14.5

TABLE 8-2
Effluent Disinfection System Criteria
Ina Road WRF Capacity and Effluent Quality Upgrade

Design Criteria	Unit	Criterion
New Contact Basins		
Number of units		2
Total volume	gallons	1,710,000
Modal contact time provided at peak daily flow (0.7*Theoretical)	minutes	24.6
Theoretical contact time at peak daily flow	minutes	35.2

[a]The CT is a product of the chlorine residual and the modal contact time measured at the same time when the chlorine residual sample is taken, typically at the end of the contact time.

[b]Existing basins have a 0.6 modal efficiency, based on testing done as part of the Enhanced Chlorination Study

Reliability and Redundancy

Two new contact basins are proposed for enhanced chlorination disinfection. Because the need for taking a contact basin out of service for cleaning is infrequent, the plant staff can determine the timing for basin cleaning and plan for this to occur at low flow conditions.

Redundancy will be provided for mixing systems by providing installed backup diffusion and mixing systems. The reliability of the enhanced chlorination system is dependent on the plant operating to consistently provide a high-quality, low suspended solids effluent like that produced by the BNRAS system during the ROMP enhanced chlorination study. This is the key to reducing (not eliminating) the risk associated with exceeding the single sample maximum for pathogens.

Instrumentation and Control Strategy

For control strategies, refer to Appendix A, Process Control Descriptions.