TECHNICAL MEMORANDUM

PROJECT: State of Washington - Water Reclamation and Reuse Standards
Facilities Performance Assessment

DATE: January 5, 2003

TO: State of Washington, Water Reuse Advisory Committee
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RE: Summary Report

Authorization

This Technical Memorandum has been prepared in accordance with the December 3, 2002 correspondence between Mr. Ronald Linsky, Executive Director of the National Water Research Institute (NWRI), and Dr. Frank Loge, P.E., Washington State University Department of Civil and Environmental Engineering.

Background

In 1992, the State of Washington implemented its Reclaimed Water Act, which was designed to provide more sustainable water resources, and to recognize that reclaimed water from municipal wastewater treatment plants was an asset that could be utilized for a wide variety of purposes. The specifics of this Act are provided under the Revised Code of Washington (RCW), Chapter 90.46. From authorization under this Act, Water Reclamation and Reuse Standards were completed by the State Departments of Ecology and Health (DOE and DOH, respectively) in 1997. These Standards specify the requirements that must be achieved for a wide variety of end uses for reclaimed water, and furthermore prescribe minimum treatment and effluent quality standards for four classes of reclaimed water (identified as Class A, B, C, and D). Class A effluent is considered the highest quality, and thus such reclaimed water can be utilized most flexibly. Example uses of Class A reclaimed water include irrigation of food crops, landscape irrigation of public access facilities, discharge into public access

recreational impoundments, street washing, toilet flushing water, and industrial process and cooling water. Class D effluent does not require as rigorous of treatment, and thus its use is more limited.

Also in 1997, building from the original Act, the State Legislature dedicated funds to assist in the development of five demonstration water reuse projects in the State. These projects, which included a feasibility study in Lincoln County and Class A water reclamation facilities in the cities of Ephrata, Royal City, Sequim, and Yelm, have since been completed and are currently in service. Performance reports prepared by the State are attached as supplements to this memorandum.

While the State and the Water Reuse Advisory Committee recognize the value of reclaimed water at all levels, Class A facilities are of principle interest due to the wide range of potential effluent uses and the associated public interest and perceptions that such facilities will likely generate. Furthermore, recognizing the involvement of the State legislature and the associated high profile nature of the undertaking, the four demonstration facilities are of primary interest. While these recently constructed water reclamation facilities have generally been operating within the permitted conditions for Class A quality effluent, they have not all been consistently complying specifically with the total coliform standard. The Water Reuse Advisory Committee, recognizing the importance of these four projects, has determined that a Facilities Performance Assessment is the necessary first step toward addressing these compliance issues in order to further advance the field of water reuse within the State of Washington.

Purpose

The purpose of this facilities performance assessment is to review recent operational data on the four constructed demonstration projects, and a select few additional projects, and present both a narrative and graphical summary of the effluent quality relative to the State's standards. Data will also be analyzed to identify any potential causes or indicators of the permit violations. This assessment will further present a facilities comparison. Conclusions and recommendations will be developed and presented based on available information.

Facilities Description

A brief description of the water reclamation facilities evaluated in this report is presented below. Table 1 also provides a side-by-side comparison.

City of Ephrata

Ephrata owns and operates an activated sludge wastewater treatment facility coupled with a chemical coagulation and an upflow continuous backwash sand filtration system. The City operates a conventional gravity sanitary sewer collection system. Effluent is disinfected with a low pressure, low intensity ultraviolet (UV) light system. A telemetry system is employed

to continuously monitor operating conditions, alarm City staff in the event of a system failure, and automatically divert inadequately treated water to a storage basin for re-treatment later. The Class A rated facility supplies reclaimed water to a groundwater recharge system year round. Reclaimed water is also used for facility operations and on site irrigation, and for use as construction water. The facility, which has a design capacity of 1.12 mgd, was placed into operation in September 2000.

City of Royal City

Royal City owns and operates a proprietary "packaged" activated sludge wastewater treatment facility coupled with a chemical coagulation and disk cloth membrane filtration system. The City operates a conventional gravity sanitary sewer collection system. Effluent is disinfected with a low pressure, low intensity UV light system. A telemetry system is employed to continuously monitor operating conditions, alarm City staff in the event of a system failure, and automatically divert inadequately treated water to a storage basin for re-treatment later. The Class A rated facility supplies reclaimed water to a groundwater recharge system year round. Reclaimed water is also used for facility operations and on site irrigation, and the pre-existing 11.5 acre irrigation site can still be utilized. The facility, which has a design capacity of 0.25 mgd, was placed into operation in January 2000.

City of Sequim

Sequim owns and operates an activated sludge wastewater treatment facility, with flow equalization, coupled with chemical coagulation, a flocculation chamber, and a dual media sand/anthracite filter. The City operates a conventional gravity sanitary sewer collection system. Effluent is disinfected with a low pressure, low intensity UV light system. A telemetry system is employed to continuously monitor operating conditions, alarm City staff in the event of a system failure, and automatically divert inadequately treated water to a storage basin for re-treatment later. The Class A rated facility supplies reclaimed water year round to an irrigation demonstration site, the Carrie Blake Park for toilet flushing, and a lined constructed wetlands. Reclaimed water is also used for facility operations and on site irrigation, and can be diverted to augment stream flow in Bell Creek. The facility upgrade, which has a design capacity of 0.67 mgd, was placed into operation in 1998.

City of Yelm

Yelm owns and operates an activated sludge wastewater treatment facility, with flow equalization, coupled with chemical coagulation and upflow continuous backwash sand filtration. The City operates a Septic Tank Effluent Pumping collection system. Effluent is disinfected with chlorine. A telemetry system is employed to continuously monitor operating conditions, alarm City staff in the event of a system failure, and automatically shut down the filtration system to prevent the discharge of inadequately treated water. The Class A rated facility supplies reclaimed water during the summer months to a City wetlands park and catch-and-release fishing pond. Reclaimed water is also distributed via a dedicated

transmission line to some local churches, City parks, and private residences for landscape irrigation. Reclaimed water not used for upland requirements is supplied to the Centralia power canal upstream of the power generator. The facility also uses water for facility operations and on site irrigation. The facility, which has a design capacity of 1.0 mgd, was placed into operation in August 1999.

City of Walla Walla

Walla Walla owns and operates a combination trickling filter-activated sludge wastewater treatment facility, coupled with chemical coagulation and a traveling bridge mixed media filter. The City operates a conventional gravity sanitary sewer collection system. Effluent is disinfected with liquid chlorine. The Class A rated facility supplies reclaimed water during the summer months for irrigation of food crops. The facility has a design capacity of 9.6 mgd.

Holmes Harbor Sewer District

Holmes Harbor SD owns and operates an activated sludge wastewater treatment facility, coupled with chemical coagulation and a traveling bridge sand filter. The City operates a Septic Tank Effluent Pumping collection system. Effluent is disinfected with chlorine. The Class A rated facility supplies reclaimed water during the summer months to a golf course, and stores reclaimed water during the winter for summer use. The facility has a design capacity of 0.1 mgd.

Facilities Comparison

While these six water reclamation facilities are generally similar, some key differences exist that could be relevant to this assessment. Relevant differences include the following:

- Yelm and Holmes Harbor SD utilized STEP collection systems, while the others receive wastewater from conventional gravity sanitary sewer collection systems. Since solids are mostly removed in the septic tanks for each sewer connection, STEP systems would experience significantly reduced influent total suspended solids.
- Sequim is the only facility analyzed that employs a flocculation basin following chemical coagulation and prior to filtration.
- A wide variety of filter units are utilized, which could provide some insight on different filter media efficiencies relative to the required effluent standards.
- Ephrata, Royal City, and Sequim all utilize UV light as a disinfecting agent, while the others utilize chlorine.

It should also be noted that, with the exception of Walla Walla, these facilities are generally small. While no specific information is available, it is noted that treatment plant staffing is often somewhat limited in small communities. This condition could ultimately impact facility performance, particularly for facilities that may require a higher level of attention to

operate successfully. For example, activated sludge wastewater treatment plants can require a relatively high degree of knowledge to operate most effectively, and for staff-limited facilities this could create a condition where higher effluent concentrations (specifically TSS, as related to filter operations) occur from the secondary clarifiers. However, such facilities that have higher levels of unit process "factors of safety" (e.g. - redundant units, additional pretreatment units, lower unit loading) would be expected to perform better.

Performance Assessment

Facility operations were first generally reviewed to determine compliance with the total suspended solids, total coliform, and turbidity standards. Discharge Monitoring Reports (DMRs) for the period of November 2001 through October 2002 were provided for the six facilities by the State. Table 2 presents a summary performance comparison of the six facilities for effluent total suspended solids, turbidity, and total coliform. Figure 1 presents a summary of each facility's compliance with the turbidity and coliform standards, on a percentage basis, with the raw data provided in Table 3. Key conclusions from this data include:

- All facilities easily achieved their respective permit limits for average monthly effluent total suspended solids.
- Only Royal City experienced turbidity permit violations.
- Ephrata and Royal City experienced a relatively significant number of total coliform permit exceedances. Ephrata, in particular, experienced consistently high average daily total coliform counts for the entire period analyzed. Royal City's permit exceedances occurred more during the period of April through September (note - the City was without a full-time experienced operator in charge during this period, primarily due to City budget constraints).
- A review of average monthly effluent flow data for all facilities shows that flow from the filter units was relatively constant over the year, and thus does not appear to be a factor in adverse facility performance. Royal City did experience a few spikes in effluent flow corresponding to the maximum recorded total coliform, but the pattern was not consistent.
- While few facilities happened to measure effluent TSS when the maximum total coliform occurred, Holmes Harbor SD and Walla Walla did record such data. For Holmes Harbor, over 50% of the days on which the total coliform count occurred also yielded the maximum effluent TSS concentration. Walla Walla did not show such consistency, however, there were a few occasions where this condition occurred.

Utilizing this data and these general findings, a more detailed review of operational results was conducted to attempt to isolate possible causes or indicators of the permit violations. Figures 2 through 4 present plots of total coliform versus effluent TSS versus turbidity, respectively, for Ephrata, Royal City, and Sequim. All data represents average daily conditions. These facilities were selected for comparison because the former two

experienced the most permit exceedances, while the latter facility is relatively similar in unit process configuration. Key conclusions from this analysis are as follows:

- For Ephrata, there does not appear to be a responsive relationship between effluent total coliform counts and effluent turbidity levels, other than it appears that total coliform counts respond in a one month lag manner. This observation, however, is likely more coincidental.
- Turbidity and TSS, for Ephrata, also do not appear to be related.
- For Royal City, there does appear to be some direct relationship between effluent total coliform and effluent turbidity. Also, the effluent TSS-turbidity relationship is more apparent at this facility.
- At Sequim, there appears to be a direct, responsive relationship between all three parameters.

Summary and Conclusions

Based on these evaluations, the following general conclusions are offered as potential explanations of the various facility performances relative to the State standards:

- Current Facility Operating Capacity
  - Yelm is operating significantly under its design capacity, thus, it should be expected that the facility would consistently be in compliance. While it is understood that the plant is not operating all units concurrently, details were not available regarding the design rated capacity and unit redundancy.
  - Holmes Harbor SD is also operating significantly under design capacity, and the effluent quality reflects this condition.
  - The remaining facilities are operating at or above 50% of design rated capacity. In general, it would be expected that they would all be in compliance consistently. Walla Walla and Sequim meet this condition, while Ephrata and Royal City do not. Note that Sequim is operating nearest its design capacity.
  - It should be noted that the capacity analysis was based on the average flow for the analyzed period relative to the average rated capacity. Regarding this average rated capacity and actual operations, it is not known how each individual facility manages redundant treatment units, nor how the average rated capacity was determined relative to redundant units.
- Disinfection Technique and Effluent Solids Concentration
  - Yelm, Walla Walla, and Holmes Harbor all utilize chlorine as a disinfecting agent, and all three consistently meet the coliform standard. Yelm maintains a relatively high residual (4-5 mg/L), and also has a chlorine contact time of 60 to 180 minutes. Holmes Harbor SD maintains approximately a 3 mg/L chlorine residual, with 60 minutes of contact time.
  - Ephrata, Royal City, and Sequim all utilize low pressure, low intensity UV light as a disinfecting agent, and the former two consistently exceed the total coliform standard.

    - Holmes Harbor SD experiences similar effluent TSS and turbidity concentrations to those from Ephrata and Royal City, facilities that are routinely out of compliance.
- Pretreatment
    - All facilities, with the exception of Sequim, utilize only chemical injection and rapid mixing for pretreatment prior to filtration. Sequim also incorporates a flocculation basin in the pretreatment scheme. Relative to Ephrata and Royal City, which utilize the same disinfection technique as Sequim, the additional unit process would appear to improve overall turbidity, and thus total coliform, removal.

Based on these evaluations, it would appear that the following combinations of unit processes or process modifications would yield more successful operations:

- For UV disinfection, adding a flocculation basin and possibly a sedimentation basin prior to filtration would reduce solids loading to the filters, which should reduce effluent turbidity and TSS levels. This, in turn, should improve overall facility performance relative to total coliform reduction.
- The use of chlorine as a disinfecting agent would appear to be more effective at total coliform reduction. For Ephrata and Royal City, perhaps the addition of chlorine prior to filtration would improve facility operations.

Perhaps the State could set up a work program with Ephrata and Royal City to evaluate certain process modifications and the impact on facility performance. This would appear to be most critical for those facilities utilizing UV for disinfection, since this technology is finding more favor in the industry.

Suggested additional work that may help further elucidate the causes of the permit violations are as follows:

- Determine and compare actual unit hydraulic and solids loading rates for each facility's filter system. Also understand if facilities are potentially "batching" to the filter units, which could potentially cause hydraulic/solids overloading that would not be reflected on the DMRs. Under this task, each facility would be evaluated to understand how redundant treatment units are operated, if at all, under lower influent flow conditions.
- Interview facility operators to gain a better understanding of the facility's operations and maintenance procedures relative to filter system operations.
- Determine and compare/contrast each facility's type and methods for utilizing chemical coagulation, including the form of rapid mixing. Also determine the lab testing frequency to verify required chemical dosage.
- Request that those facilities that are not currently collecting effluent TSS every day begin collecting this data.

Table 1
Facility Description Summary

Facility	Design Average Capacity (mgd)	Influent System	Secondary Process	Tertiary Process		Disinfectant
				Pretreatment	Filtration	
Ephrata	1.12	Conventional Sanitary Sewer	Activated Sludge (Oxidation Ditch)	Coagulation (rapid mix)	Upflow Sand Filter	Low Pressure, Low Intensity UV
Royal City	0.25	Conventional Sanitary Sewer	Activated Sludge ("Packaged" Extended Air)	Coagulation (rapid mix)	Cloth Disk Filter	Low Pressure, Low Intensity UV
Sequim	0.67	Conventional Sanitary Sewer	Activated Sludge (Oxidation Ditch)	Coagulation (rapid mix) and Flocculation	Downflow Dual Media Sand/Anthracite Filter	Low Pressure, Low Intensity UV
Yelm	1.0	STEP System	Activated Sludge (Sequencing Batch Reactor)	Coagulation (rapid mix)	Upflow Sand Filter	Chlorine
Walla Walla	9.6	Conventional Sanitary Sewer	Trickling Filter-Activated Sludge (Oxidation Ditch)	Coagulation (rapid mix)	Traveling Bridge Mixed Media Filter	Chlorine (on site generation)
Holmes Harbor Sewer District	0.1	STEP System	Activated Sludge (Sequencing Batch Reactor)	Coagulation (rapid mix)	Traveling Bridge Sand Filter	Chlorine

Table 2
Effluent Quality Summary
November 2001 - October 2002

Facility	Total Suspended Solids (mg/L)		Total Coliform (organisms/100 mL)		Turbidity (NTU)	
	Average Monthly (Permit Limit)	Maximum Month	Average Daily	Maximum (Permit=23)	24-hr Average (Permit=2)	Maximum (Permit=5)
Ephrata	2.0 (15)	13.0	16.1	201	0.6	1.7
Royal City	2.5 (15)	7.2	3.7	200	0.89	6.8
Sequim	2.25 (30)	9.0	0.12	4.5	0.55	2.3
Yelm	0.9 (30)	3.3	0.66	200	0.51	3.4
Walla Walla	0.8 (10)	4.5	1.1	6.6	0.97	2.3
Holmes Harbor Sewer District	2.0 (7)	9.3	0.1	15	0.9	2.4

Table 3
Class A Standards Exceedances Summary
Number of Permit Exceedances
November 2001 - October 2002

Facility	Average:Design Hydraulic Capacity	Total Coliform		Turbidity	
		7-day Median	Maximum	24-hr Average	Maximum
Ephrata	59%	77	93	0	0
Royal City	64%	72	35	1	2
Sequim	81%	0	0	0	0
Yelm	22%	0	1	0	0
Walla Walla	50%	7	0	0	0
Holmes Harbor Sewer District	30%	0	0	0	0

Figure 1
Water Reclamation Facility Performance Assessment
Permit Compliance Summary: Nov 2001-Oct 2002

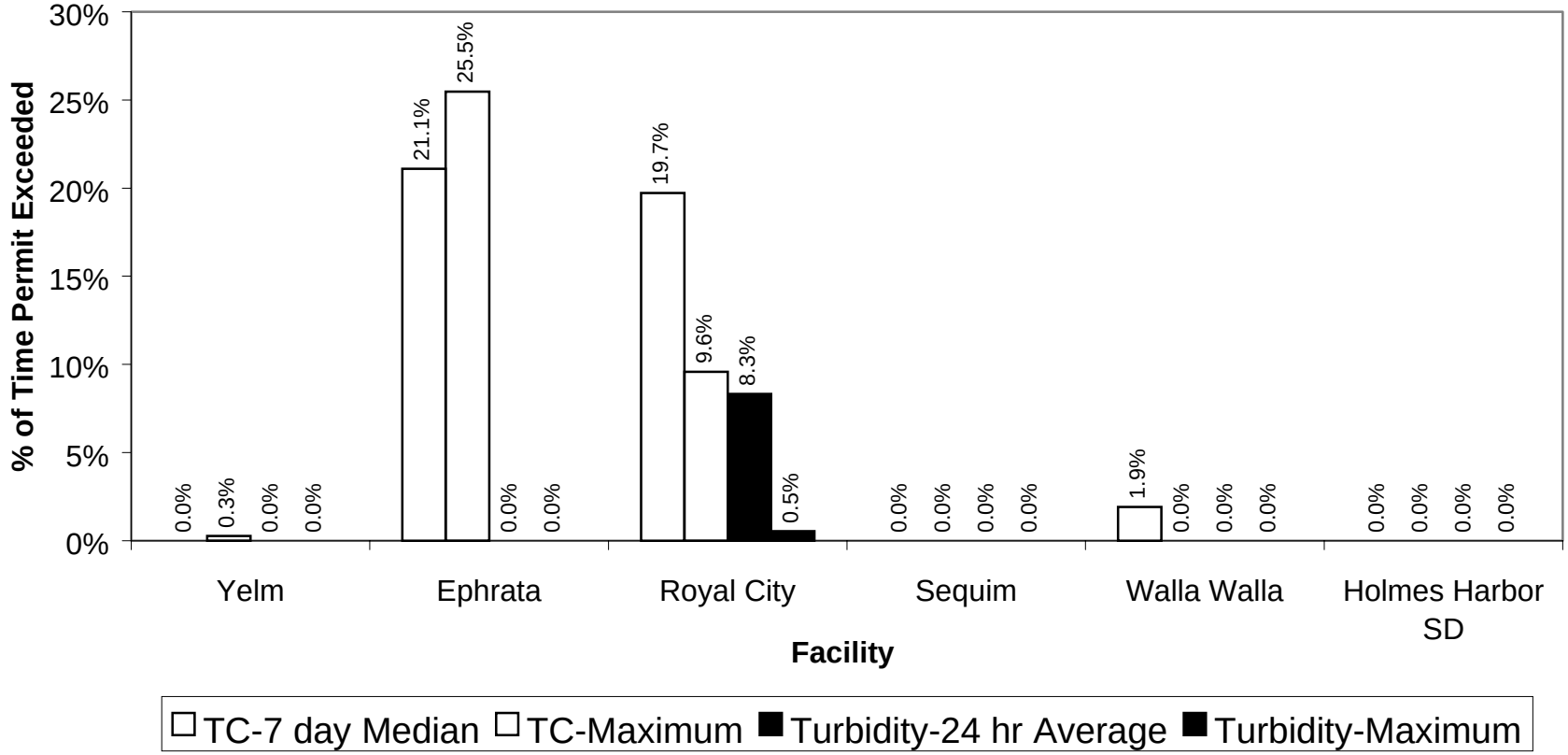


Figure 2
Ephrata WRF
Effluent Turbidity vs Total Coliform vs TSS

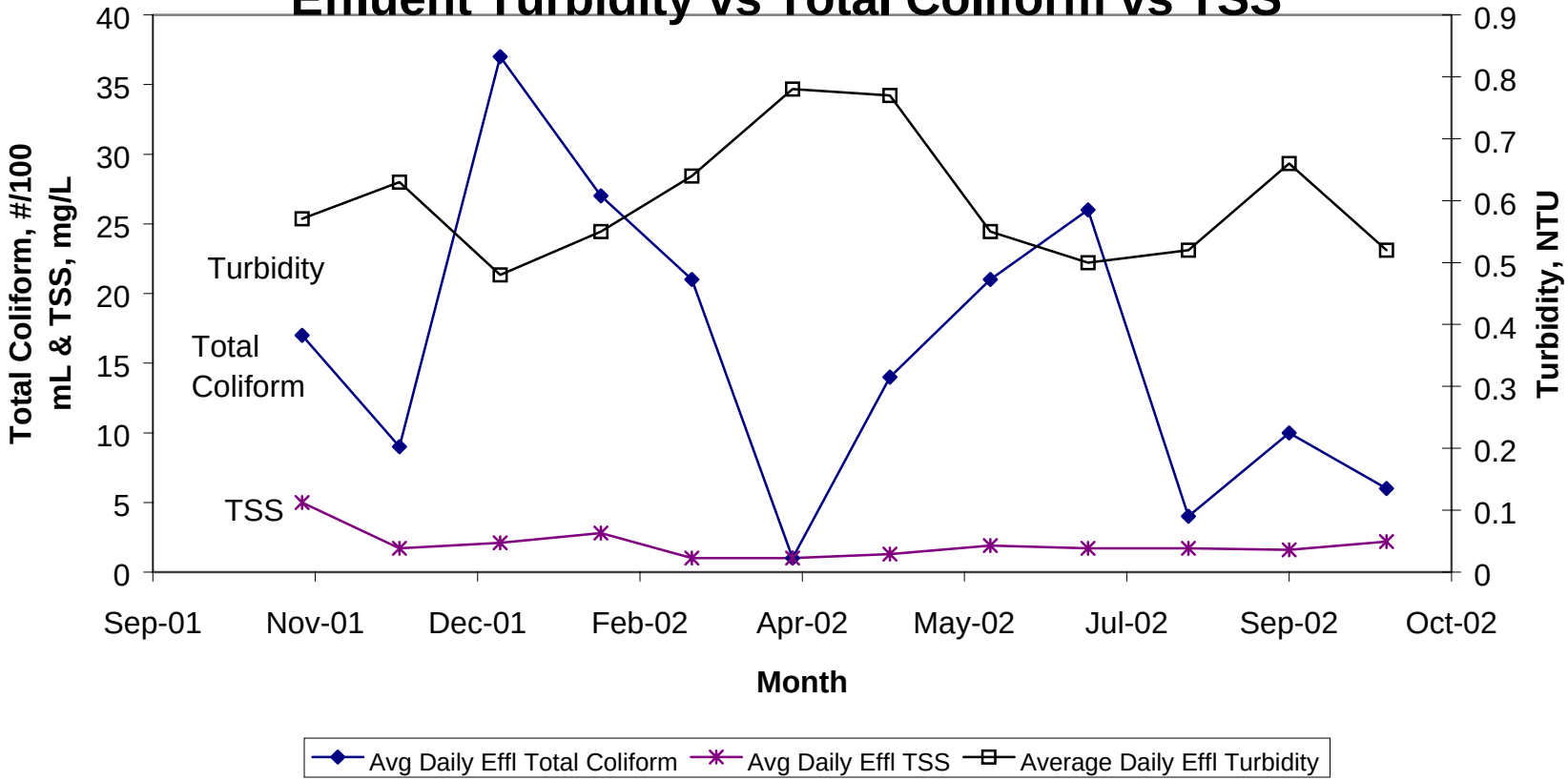


Figure 3
Royal City WRF
Effluent Turbidity vs Total Coliform vs TSS

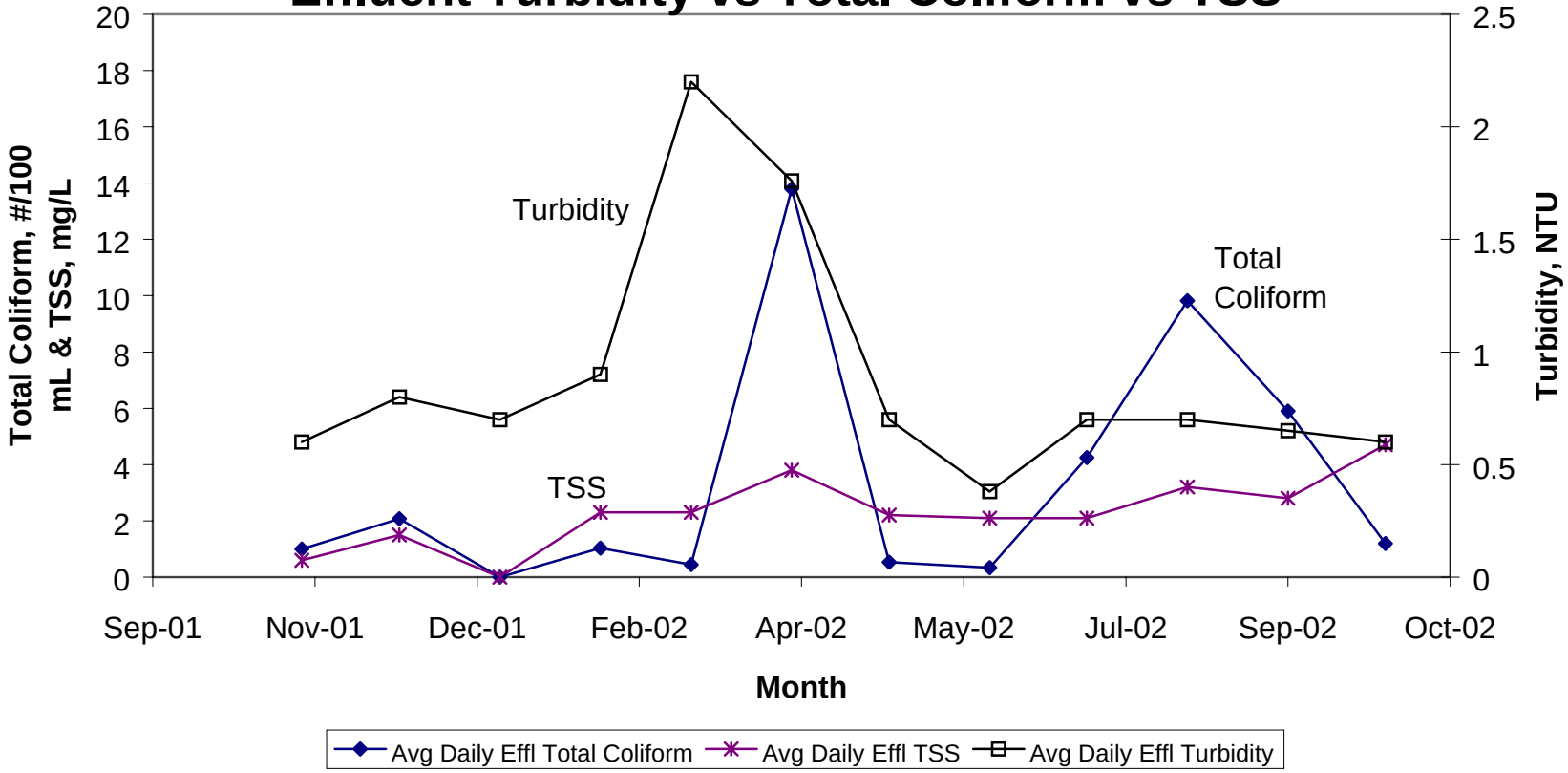
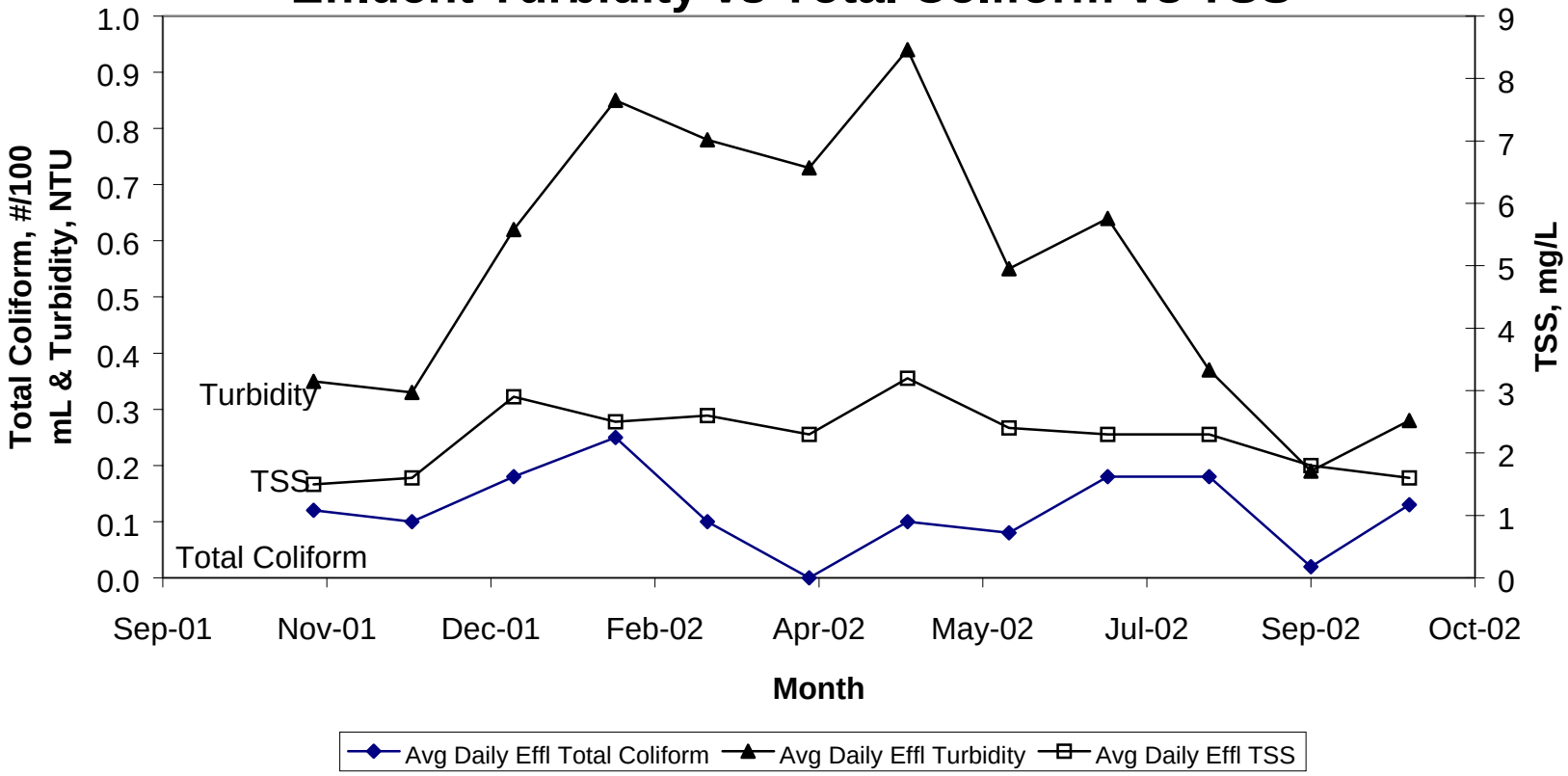


Figure 4
Sequim WRF
Effluent Turbidity vs Total Coliform vs TSS



APPENDIX A
RAW DATA

CITY OF YELM

Filter Surface Area = SF

The following data presents a summary of monthly facility operations

Date	Effluent Total Coliform			Effluent Turbidity		Flow				Raw TSS			Effluent TSS			
	Avg Daily	7 day Max	Maximum	Avg	Maximum	Avg (mgd)	Unit (gpd/SF)	Max (TC-mgd)	Max (Turb-mgd)	Avg (mg/L)	Maximum (mg/L)	Maximum (TC-mg/L)	Avg (mg/L)	Max (mg/L)	Max (TC-mg/L)	Max (Turb-mg/L)
Nov-01	0.00	0.00	0.00	0.44	1.35	0.23		na	0.046	51.7	61	na	0.52	1.3	na	na
Dec-01	6.60	0.00	200.50	0.58	3.16	0.22		0.235	0.222	47.6	57	49	1	1.4	0.5	na
Jan-02	1.10	0.00	13.70	0.55	3.41	0.204		0.188	0.151	55.5	123	54	0.9	1.3	0.6	na
Feb-02	0.21	0.00	2.00	0.72	2.95	0.194		0.21	0.2	45.5	76	na	1.4	2.6	na	na
Mar-02	0.00	0.00	0.00	0.45	2.18	0.211		na	0.189	45.1	55	na	1.6	2.5	na	na
Apr-02	0.00	0.00	0.00	0.52	1.95	0.204		na	0.212	51.8	63	na	1.1	2.7	na	na
May-02	0.00	0.00	0.00	0.57	1.9	0.22		na	0.214	56.1	69	na	0.6	1.3	na	na
Jun-02	0.00	0.00	0.00	0.48	2.38	0.21		na	0.233	55.8	67	na	0.4	0.6	na	na
Jul-02	0.00	0.00	0.00	0.58	3.05	0.239		na	0.239	61.6	86	na	1.3	3.3	na	na
Aug-02	0.00	1.00	0.00	0.49	2.96	0.241		0.225	0.222	67.1	128	na	0.7	1.8	na	na
Sep-02	0.00	0.00	0.00	0.35	2.22	0.232		na	0.242	60.7	80	na	0.6	2.1	na	na
Oct-02	0.00	0.00	0.00	0.34	2.28	0.207		na	0.183	54.3	86	na	0.3	0.6	na	na

CITY OF EPHRATA

Filter Surface Area = SF

The following data presents a summary of monthly facility operations

Date	Effluent Total Coliform			Effluent Turbidity		Flow				Raw TSS			Effluent TSS			
	Avg Daily	Max 7-day	Maximum	Avg	Maximum	Avg (mgd)	Unit (gpd/SF)	Max (TC-mgd)	Max (Turb-mgd)	Avg (mg/L)	Maximum (mg/L)	Maximum (TC-mg/L)	Avg (mg/L)	Max (mg/L)	Max (TC-mg/L)	Max (Turb-mg/L)
Nov-01	17.00	8.00	200.00	0.571	1.05	0.67		0.718	0.737	214	251	na	5	13	na	na
Dec-01	9.00	8.00	201.00	0.63	1.365	0.65		na	0.59	250	322	na	1.7	5	na	na
Jan-02	37.00	38.00	200.00	0.48	0.82	0.68		0.783	0.761	165	213	na	2.1	5	na	na
Feb-02	27.00	34.00	200.00	0.55	0.68	0.66		0.722	0.687	134	186	na	2.8	10	na	na
Mar-02	21.00	2.00	200.00	0.64	1.16	0.67		0.753	0.668	184	217	na	1	3	na	na
Apr-02	1.00	0.00	11.00	0.78	1.46	0.65		0.646	0.635	203	280	na	1	4	na	na
May-02	14.00	6.00	200.00	0.77	1.7	0.65		0.614	0.66	200	237	na	1.3	4	na	na
Jun-02	21.00	0.00	200.00	0.55	1.01	0.65		0.621	0.868	191	234	na	1.9	6	na	na
Jul-02	26.00	0.00	200.00	0.5	0.67	0.66		0.657	0.667	180	253	na	1.7	6	na	na
Aug-02	4.00	0.00	70.00	0.52	0.79	0.67		0.624	0.663	231	347	na	1.7	6	na	na
Sep-02	10.00	0.00	200.00	0.66	1.54	0.67		0.743	0.685	208	245	na	1.6	3	na	na
Oct-02	6.00	2.00	88.00	0.52	1.67	0.64		0.638	0.569	210	289	na	2.2	7	na	na

CITY OF ROYAL CITY

Filter Surface Area = SF

The following data presents a summary of monthly facility operations

Date	Effluent Total Coliform			Effluent Turbidity			Flow				Raw TSS			Effluent TSS			
	Avg Daily	Max 7-day	Maximum	Avg	Maximum	Max @ max TC	Avg (mgd)	Unit (gpd/SF)	Max (TC-mgd)	Max (Turb-mgd)	Avg (mg/L)	Maximum (mg/L)	Maximum (TC-mg/L)	Avg (mg/L)	Max (mg/L)	Max (TC-mg/L)	Max (Turb-mg/L)
Nov-01	1.00	1.00	3.20	0.6	0.8	0.3	0.15		0.15	0.16	203	298		0.6	1.1	na	na
Dec-01	2.08	1.00	200.50	0.8	2.4	2.4	0.14		0.168	0.168	234	356		1.5	3.4	na	na
Jan-02	na	na	na	0.7	2	na	0.143		na	0.153	243	367		na	na	na	na
Feb-02	1.03	1.00	2.00	0.9	4.6	1.3	0.147		0.164	0.148	294	371		2.3	4	na	na
Mar-02	0.45	1.00	2.00	2.2	3.2	2.8	0.144		0.32	0.153	276	312		2.3	3.2	na	na
Apr-02	13.80	1.50	200.50	1.76	6.8	5.4	0.158		0.145	0.137	235	251		3.8	6.6	na	na
May-02	0.53	1.00	3.10	0.7	2.3	0.6	0.146		0.158	0.147	284	341		2.2	3.2	na	na
Jun-02	0.34	2.00	13.70	0.38	0.6	0.5	0.142		0.138	0.198	266	337		2.1	3.4	na	na
Jul-02	4.25	13.70	165.20	0.7	0.9	0.7	0.201		0.327	0.147	193	205		2.1	3	na	na
Aug-02	9.82	94.50	200.50	0.7	3.7	0.7	0.261		0.361	0.404	384	1203		3.2	4.1	na	na
Sep-02	5.90	73.80	200.50	0.65	2.9	2.2	0.16		0.14	0.062	228	396		2.8	4.6	na	na
Oct-02	1.19	6.40	78.20	0.6	1.2	0.4	0.186		0.161	0.161	267	422		4.7	7.2	na	na

CITY OF WALLA WALLA

Filter Surface Area = SF

The following data presents a summary of monthly facility operations

Date	Effluent Total/Fecal Coliform			Effluent Turbidity			Flow				Raw TSS			Effluent TSS			
	Avg Daily	Max 7-day	Maximum	Avg	Max	Max @ max TC	Avg (mgd)	Unit (gpd/SF)	Max (TC-mgd)	Max (Turb-mgd)	Avg (mg/L)	Maximum (mg/L)	Maximum (TC-mg/L)	Avg (mg/L)	Max (mg/L)	Max (TC-mg/L)	Max (Turb-mg/L)
Nov-01	1.30	3.00	5.00	0.95	1.58	1.44	4.9		5.43	5.41	113	155	96	0.4	1	0.3	0.6
Dec-01	1.00	1.00	2.00	0.99	1.38	1.28	5.44		5.55	5.41	101	200	97	0.7	1.5	1.1	1.2
Jan-02	1.00	1.00	1.00	0.78	0.96	0.96	5.31		5.76	5.34	105	162	162	0.7	1.3	1.3	0.9
Feb-02	1.50	3.00	6.60	1.59	2.32	1.89	5.37		5.33	5.15	109	180	119	1.5	4.5	4.5	na
Mar-02	1.00	1.00	1.00	1.07	1.53	1.53	5.51		6.25	6.25	134	258	258	1	1.8	1.8	1.7
Apr-02	1.00	1.00	1.00	0.95	1.27	1.27	5.44		5.65	5.48	126	174	174	1.2	2	2	1
May-02	1.07	1.00	1.60	1.2	1.94	1.75	4.7		4.8	5.12	196	352	229	0.6	1	1	0.5
Jun-02	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
Jul-02	1.05	1.10	1.40	0.84	1.45	1.03	4.25		4.19	4.29	233	546	186	0.6	1.2	0.4	1.2
Aug-02	1.08	1.10	1.60	0.71	1.25	1.25	4.01		4.18	4.18	172	286	150	0.7	1.7	0.2	0.2
Sep-02	1.10	1.10	1.60	0.92	1.81	0.85	4.07		3.95	4.07	163	220	164	0.7	1.2	0.4	0.8
Oct-02	1.10	1.20	1.60	0.63	0.9	0.74	4.22		4.13	4.24	186	395	182	0.6	0.9	0.8	na

HOLMES HARBOR SEWER DISTRICT

Filter Surface Area = SF

The following data presents a summary of monthly facility operations

Date	Effluent Total Coliform			Effluent Turbidity			Flow				Raw TSS			Effluent TSS			
	Avg Daily	Max 7-day	Maximum	Avg	Maximum	Max @ max TC	Avg (mgd)	Unit (gpd/SF)	Max (TC-mgd)	Max (Turb-mgd)	Avg (mg/L)	Maximum (mg/L)	Maximum (TC-mg/L)	Avg (mg/L)	Max (mg/L)	Max (TC-mg/L)	Max (Turb-mg/L)
Oct-01	0.10	0.10	0.70	0.8	1.8	0.60	0.043		0.038	0.051	44	69	35	1.8	5.5	5.5	2.4
Nov-01	0.10	0.10	0.10	0.6	0.8	0.80	0.037		0.064	0.057	44	70	70	1.3	2.3	2.3	na
Dec-01	0.10	0.10	0.10	1.1	2.4	2.40	0.03		0.04	0.032	43	85	85	3.4	9.3	9.3	na
Jan-02	0.10	0.10	0.10	0.6	1.2	1.20	0.034		0.057	0.03	41	59	59	1.4	2.6	2.6	2.6
Feb-02	0.10	0.10	0.70	0.9	1.7	1.00	0.035		0.026	0.023	40	76	76	1.8	5	na	na
Mar-02	0.10	0.10	0.10	0.9	1.9	1.90	0.029		0.037	0.025	65	160	160	2.2	6.2	6.2	na
Apr-02	0.10	0.10	15.00	1	1.7	0.80	0.026		0.027	0.025	63	111	na	2.2	2.8	na	na
May-02	0.10	0.10	0.10	1.1	1.7	1.70	0.027		0.04	0.026	53	83	62	2.7	4.9	4.9	4.9
Jun-02	0.10	0.10	1.30	0.9	1.3	0.90	0.028		0.025	0.029	60	147	73	1.5	5	0.9	na
Jul-02	0.10	0.10	9.30	1.1	1.6	1.6	0.027		0.027	0.027	80	247	na	2.5	3.6	na	na
Aug-02	0.10	0.10	0.10	1	1.6	1.6	0.034		0.058	0.058	65	83	83	2.8	6	6	na
Sep-02	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
Oct-02	0.1	0.7	4	0.6	0.9	0.6	0.036		0.022	0.028	49	92	na	0.6	0.7	na	na

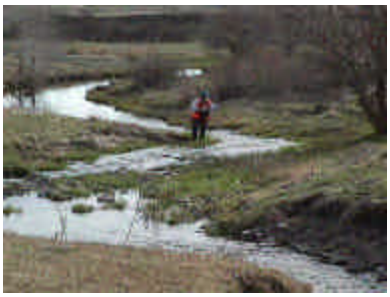
CITY OF SEQUIM

Filter Surface Area = SF

The following data presents a summary of monthly facility operations

Date	Effluent Total Coliform			Effluent Turbidity			Flow				Raw TSS			Effluent TSS			
	Avg Daily	Max 7-day	Maximum	Avg	Maximum	Max @ max TC	Avg (mgd)	Unit (gpd/SF)	Max (TC-mgd)	Max (Turb-mgd)	Avg (mg/L)	Maximum (mg/L)	Maximum (TC-mg/L)	Avg (mg/L)	Max (mg/L)	Max (TC-mg/L)	Max (Turb-mg/L)
Nov-01	0.12	0.00	1.50	0.35	0.56		0.52		0.6	0.515	183	234	188	1.5	2	2	na
Dec-01	0.10	0.00	2.00	0.33	1.3		0.57		0.665	0.998	198	294	na	1.6	2.5	na	na
Jan-02	0.18	0.00	3.50	0.62	1.4		0.60		0.679	0.614	174	276	na	2.9	9	na	na
Feb-02	0.25	0.00	4.50	0.85	1.9		0.64		0.606	0.585	145	205	128	2.5	4.5	4	4
Mar-02	0.10	0.00	1.50	0.78	1.6		0.60		0.562	0.707	170	248	152	2.6	3.5	2	2
Apr-02	0.00	0.00	0.50	0.73	2		0.52		0.574	0.488	189	306	na	2.3	5	na	3
May-02	0.10	0.00	1.00	0.94	1.7		0.52		0.515	0.507	215	344	na	3.2	5.5	na	na
Jun-02	0.08	0.00	1.50	0.55	1.5		0.49		0.496	0.556	197	264	na	2.4	3.8	na	na
Jul-02	0.18	0.00	2.50	0.64	2.3		0.497		0.532	0.507	198	298	na	2.3	3.5	na	na
Aug-02	0.18	0.00	2.50	0.37	1.45		0.501		0.506	0.476	175	385	na	2.3	3.5	na	na
Sep-02	0.02	0.00	0.50	0.19	0.69		0.488		0.468	0.522	164	280	138	1.8	5.5	na	na
Oct-02	0.13	0.00	3	0.28	1.2		0.492		0.549	0.549	271	312	na	1.6	2.5	na	na

APPENDIX B
DEMONSTRATION PROJECTS
DOE PERFORMANCE REPORTS



Water Reclamation and Reuse
Lake Creek (Lincoln County) Feasibility Study

Project Description

The Lincoln County Conservation District conducted a study for Lincoln County regarding the feasibility of using up to 44 million gallons per day of reclaimed water from the Spokane area to rehydrate and restore depleted streambeds within the Lake Creek watershed. The watershed occupies approximately 91,385 acres. There has been a steady drop in the groundwater level resulting in drying up Lake Creek and several of the fourteen lakes within the watershed during low rainfall years. Lake Creek has been dry for nearly a decade. In addition, there are water quality concerns related to impacts from agricultural and rangeland activities in the upper watershed including runoff, erosion and sedimentation. The project was funded through a $169,688 Centennial Clean Water Fund grant via legislative appropriation.

The project included collection of existing data within the watershed as well as twelve months field monitoring of water quality and stream velocity at 14 sites to generate baseline information, to identify specific water quality concerns and to assess the environmental and hydrological impacts downstream from the addition of reclaimed water. Parameters monitored include temperature, dissolved oxygen, pH, conductivity, turbidity, total suspended solids, nitrogen, phosphorus, fecal coliform, chlorophyll A, phytoplankton, zooplankton, alkalinity, and chlorides.

A newsletter provided information to local landowners and agencies that might be interested in the study. Additional outreach was provided via the Lincoln County Fair, Lake Creek Appreciation Day, and public meetings.

Project Benefits

Possible benefits from using the reclaimed water include re-hydration of numerous streams, lakes and ponds in Lincoln and Grant counties. Also, the project provides a source of water for commercial electric power at Creston, reestablishment of riparian wildlife habitat, wetlands restoration, and fisheries enhancement – as well as increased tourism and recreation and economic development.

Project Results

The study provides useful baseline information on the existing status of the Lake Creek watershed. It is also clear that the addition of reclaimed water would change the characteristics of the watershed both in terms of water quantity and quality.

There are over 70 recorded wells within the watershed boundaries used for irrigation, watering livestock and domestic use. If the permitted withdrawals were taken, it could adversely impact the levels of Lake Creek and the area lakes.



The channel below Seven Springs was identified as the critical section of the Lake Creek drainage. The addition of 33 cfs (cubic feet per second) to the watershed would result in potential flooding at this area. The increase in water would require enlarging the channel capacity or would flood considerable acreage and cause soil erosion until the channel restabilized. Culverts and bridges affected by Lake Creek would also require improvements.

To provide a stable flow volume there would have to be some means of storage and metering of the reclaimed water. Placement of storage ponds over aquifer recharge zones could result in rapid discharge to a series of multiple, interconnected, unconfined and semi-confined aquifers that supply drinking water throughout a wide area.

Next Steps

The study recommends that Lincoln County take the following steps:

- Additional public education and input is needed for prioritization of benefits such as re-establishment of lost wetlands, wildlife enhancement, types of recreational fisheries, economic growth and groundwater quality.

- More investigation on the effects of rehydration on groundwater quality, wetlands, channel stabilization, and flooding potential. Hydrological studies of by-pass channel options for Crab Creek, Sinking Creek, Hawk Creek, Goose Creek and other drainages are recommended.

- Further investigation is needed to determine the impact of water quality parameters that might be present in reclaimed water such as nutrients, heavy metals and synthetic organics.

- Regional planning efforts are needed to implement land use priorities as well as to determine the most appropriate sites and methods of transporting, diverting and storing reclaimed water.

For more information

Bill Graedel, Lincoln County, (509) 725-3031
David Lundgren, Lincoln County Conservation District, (509)-725-4181
Kathy Cupps, Department of Ecology, (360) 407-6452, kcup461@ecy.wa.gov

Water Reclamation and Reuse
City of Ephrata (Grant County) Demonstration Project

Project Description

The city of Ephrata demonstration project's objective was to reclaim and beneficially use their wastewater to recharge the groundwater aquifer and reduce the nitrate concentrations that currently exceed drinking water standards. A reclaimed water permit was issued for the facility on August 12, 1999. The project was competed in June 2000 and grand opening ceremonies were held in September 2000.

Reclamation Plant

The Class A water reclamation plant has a design capacity of 1.12 million gallons per day. The major facility components include: a grit removal channel and a self-cleaning fine screen to remove incoming debris from the treatment processes; an oxidation ditch using extended aeration activated sludge technology for biological treatment and nitrogen removal; two circular secondary clarifiers to settle solids from the wastewater; an automated chemical feed system and in-line static mixer to coagulate solids for more effective filtration; a Waterlink continuous backwash, upflow sand media filtration system; and a Trojan technology low-pressure, low-intensity ultraviolet (UV) disinfection system. The facility also includes an on-line computerized monitoring system providing continuous monitoring of flows, turbidity and other important process parameters. Alarms immediately notify the facility operators and divert inadequately treated water to a lined storage basin to be retreated at the plant at a later time. Only reclaimed water meeting the Class A standard is ever sent to use areas.

Project Funding

The city of Ephrata funded project construction through a $ 1.97 million Centennial Clean Water Fund Grant legislative appropriation and a $5.35 million Clean Water State Revolving Fund Loan. The project's estimated capital construction cost was $6,950,700. The actual capital construction costs were slightly lower at $6,843,000.

To repay their debt, residential sewer rates are set at $29 per month. There is also a one-time residential connection charge of $750 for new connections to the sewer system. In the future, additional cost recovery is anticipated from the sale of reclaimed water. However, without the

legislative grant, the city would have needed to obtain additional funding through loan programs or through conventional municipal bonds. This would have increased monthly residential sewer rates to approximately $40 per month.

Beneficial Uses

Ephrata is using reclaimed water for many uses including treatment plant equipment washdown, process water, and site irrigation. A groundwater recharge system was constructed entirely from the city's previous four-cell lagoon system using a computer model. This method identified an optimum recharge strategy which allows 100 % beneficial reuse on a year round basis without constructing additional infiltration basins.

A key and touch-pad access system was designed to allow the city to dispense reclaimed water to tank trucks for use as construction water without requiring the plant operator to be present. This system will help the city offset the plant operating expenses by selling the reclaimed water to commercial construction contractors and Washington State Department of Transportation (WSDOT) road crews. At the dedication ceremony, officials from the Port District were asking for information on how to become a customer.

Other Notable Features

The city of Ephrata installed an on-line, particle-size analyzer to test the use of particle analysis as a surrogate for total coliform testing. If successful, this could be a method used to measure the effectiveness of UV disinfection on weekends and holidays. This would reduce the staff hours and overtime expenditures required for monitoring the disinfection system.

Ephrata is using an innovative energy efficient design for the nitrogen removal process. An oxidation-reduction potential (ORP) based control system provides the sequential cycles necessary for nitrogen removal within a single oxidation ditch.

A shallow groundwater monitoring system that was originally used to obtain baseline water quality characterization will continue to be used to verify groundwater quality improvements as well as monitor for mounding under the infiltration basins.

For More Information

Jim Cherf, City Manager, city of Ephrata, (509) 754-4601
Kathy Cupps, Department of Ecology, (360) 407-6452, kcup461@ecy.wa.gov

Water Reclamation and Reuse
City of Royal City (Grant County) Demonstration Project

Project Description

The city of Royal City demonstration project's objective was to replace an existing facultative lagoon treatment system and wastewater disposal sprayfield with a water reclamation facility. The original goal was to reclaim and beneficially use 100 % of its discharge to enhance local wetlands and lakes in the winter and potentially to irrigate a golf course. The constructed project was modified to use 100 % of the reclaimed water for aquifer recharge. A reclaimed water permit was issued for the facility on August 25, 1999. Royal City officially started operation on January 1, 2000.

Reclamation Plant

The Class A water reclamation facility has a design capacity of 0.25 million gallons per day. Major facility components include an influent screen, an AeroMod package plant extended aeration biological treatment system with nitrogen removal, an automated chemical feed system and in-line static mixer to coagulate solids for more effective filtration, an Aqua Aerobics disk cloth membrane filter; and a Trojan technology low-pressure, low intensity ultraviolet disinfection system. The facility also includes an on-line computerized monitoring system providing continuous monitoring of flows, turbidity and other important process parameters. Solids treatment includes an aerobic holding tank and two asphalt-lined sludge drying beds. Alarms immediately divert inadequately treated water to a lined bypass lagoon with a return to re-treat rejected water and notify the facility operators. Only reclaimed water meeting the Class A standard is sent to use areas.

Project Funding

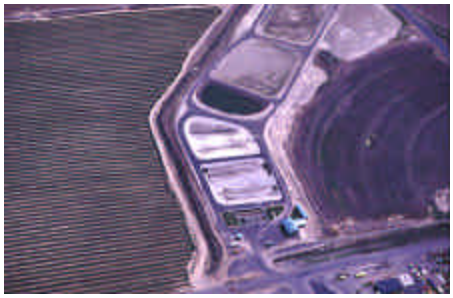
The city funded the project through a $1.8 million USDA-Rural Development grant, a $985,000 Centennial Clean Water Fund (legislative appropriation) grant, a $750,000 Community Development Block Grant, a $640,000 USDA-Rural Development loan, a $245,525 Clean Water State Revolving Fund loan, and $79,585 in city funds.

The project's estimated construction capital cost was $4,059,956.40. The actual capital construction costs were lower at $3,661,668.34.

To repay their debt, residential sewer rates are set at $39.25 per month. There is a residential system development charge of $2,120 plus a connection charge of $550. Without the grant funding, the city would have faced constructing a wastewater treatment system that would have produced a lower water quality at a higher cost than customers could afford.

Beneficial Uses

Royal City is using the reclaimed water for treatment plant equipment washdown, process water and site irrigation. Groundwater recharge is accomplished in three infiltration basins. The existing 11.5-acre sprayfield is still available for use.



Other Notable Features

The Royal City facility provides the opportunity to evaluate the effectiveness of several features that were implemented to reduce costs. Longer-term evaluation is necessary to determine how effective these methods will be in consistently meeting the reclaimed water Class A standards. Three of these are briefly discussed below.

Royal City is the only reclaimed water facility that has used a proprietary "packaged" extended aeration activated sludge secondary treatment process. The AeroMod system was selected to save approximately $250,000 in construction costs. The treatment system took several months of operation before it began to achieve the required effluent quality.

Royal City selected the Aqua Disk filter system, a unique design using a washable cloth-membrane as the filter media. The unit operates on gravity, requires far less area than conventional filtration units and eliminates the use of both sand media and underdrains. The majority of components were assembled prior to shipment, which also reduced installation labor and cost. The effectiveness of this unit following coagulation via an in-line static mixer is being monitored.

Compliance monitoring for total coliform, the indicator for effective disinfection, uses an alternative cost-effective colorimetric method, Autoanalysis Coliert System Quanti-Tray™. The method is EPA approved and is becoming popular at other facilities.

For More Information

John Lasen, city of Royal City, (509) 346-2263
Kathy Cupps, Department of Ecology, (360) 407-6452, kcup461@ecy.wa.gov

Water Reclamation and Reuse
City of Sequim (Clallam County) Demonstration Project

Project Description

The city of Sequim demonstration project's objective was to implement a tertiary treatment system and reuse 100 % of the city's wastewater. As a result, the city wanted to reopen an existing shellfish closure area to benefit state and tribal resources, improve streamflows in the Dungeness River, and provide a sustainable water supply for irrigation purposes. The city established a water reuse task force in November 1995. The treatment plant was upgraded to a Class A reclamation facility and was permitted on March 4, 1998. At that time, the city began planning, design and construction for a comprehensive upland reuse program to use 100 % of the reclaimed water.

Reclamation Plant

The Class A water reclamation facility has a design capacity of 0.67 million gallons per day. It was financed with the aid of a $5.3 million Clean Water State Revolving Fund Loan. The facility uses an existing oxidation ditch biological secondary treatment system and added flow equalization, coagulation/ filtration and disinfection facilities to meet reclaimed water standards. Sequim also extended the marine outfall by 1,320 feet to allow opening of impacted shellfish beds. The coagulation/ filtration components include a lift station, coagulant feeds, metering pump, flocculation chamber, gravity feed anthracite media filter by general filter. The disinfection system is a Trojan low-pressure, low-intensity ultraviolet system. On-line process monitors provide continuous monitoring of flow, turbidity and other important parameters. The reclamation facility also includes alarms to automatically divert substandard flows and notify operators. A holding pond with a recycle pump returns substandard flows for treatment. Only reclaimed water meeting Class A standards is discharged from the facility.

Project Funding

A $3.4 million legislative appropriation from the Centennial Clean Water Fund funded the planning, design and construction of Sequim's upland reuse program. This includes transmission and distribution lines, land purchase and construction of a reclaimed water demonstration site and educational building with restrooms using reclaimed water for toilet flushing at Carrie Blake Park. Residential sewer rates at Sequim are currently $37 per month. The residential connection, general facility charge is $3,000.

Beneficial Uses

Reclaimed water is available for treatment plant equipment washdown and process water, landscape irrigation, constructed wetlands, toilet flushing, municipal non-potable water, and streamflow augmentation.

Other Notable Features

A number of aspects of the project are precedent setting including:

- Purchase of a large land area for use as an irrigation demonstration site, accessible to the general public without physical buffers or night watering schedules.
- Installation of subsurface monitoring systems composed of soil moisture probes to verify organic application rates to maximize conservation of the reclaimed water and minimize leaching below the root zone.
- Augmenting streamflow in a small creek, Bell Creek, that supports salmonid habitat and livestock watering downstream.

The project also incorporates several innovative features including:

- Use of a long underground pipe to passively cool the water and reduce the temperature prior to discharge into Bell Creek.
- Use of a cascade aeration structure to elevate water dissolved oxygen levels prior to discharge into Bell Creek.
- Use of a lined constructed wetland to polish the reclaimed water as well as provide aesthetic enhancement.

Sequim uses ultraviolet disinfection and requested a waiver from the requirement to continuously maintain a 0.5 mg/L chlorine residual in the distribution system. However the city also provided a sodium hypochlorite feed system to chlorinate irrigation water immediately prior to application and maintain a residual if needed for irrigation line maintenance or public health protection.

Sequim also installed shallow groundwater monitoring wells to establish baseline conditions before the project begins and monitor for any effects on groundwater from the reclaimed water.

For more information

James Bay, city of Sequim Public Works Director, (360) 683-4908
Kathy Cupps, Department of Ecology, (360) 407-6452, kcup461@ecy.wa.gov

Water Reclamation and Reuse
City of Yelm (Thurston County) Demonstration Project

Project Description

The city of Yelm demonstration project's objective was to reclaim and beneficially use 100 % of its wastewater to provide an alternative water supply for irrigation, industrial and commercial uses, to offset the increasing demand for water, to protect the Nisqually River chum salmon runs, and to develop wetlands. The reclamation plant went on-line in August of 1999. A reclaimed water permit was issued on October 5, 1999. From the outset, 100 % of the reclaimed water leaving the treatment plant has been used for irrigation and groundwater recharge during the summer months. When there is not sufficient irrigation demand, the reclaimed water is discharged to the Centralia power canal upstream of the electric generator.

Reclamation Plant

The Class A reclamation plant has a design capacity to reclaim 1.0 million gallons per day. Major facility components include: activated sludge biological treatment with nitrogen and phosphorus removal using Sequencing Batch Reactor (SBR) technology; flow equalization; an automated chemical feed system and in-line static mixers to coagulate remaining solids prior to filtration; a Dynansand continuous backwash, upflow sand media filtration system; and chlorine disinfection. A small, reverse osmosis pilot unit was also installed at the plant to demonstrate the potential and higher level of treatment required for direct groundwater recharge. The facility also includes an on-line computer monitoring system. Process monitors provide continuous monitoring of flow and other important parameters. Alarms immediately shut down discharge and notify operators so that only reclaimed water meeting Class A standards is sent to use areas.

Project Funding

The project's actual capital construction cost was $8,177,741. The total project cost including administrative expenses was $9.6 million dollars. The city of Yelm funded the project through a combination of grants and loans including $3,398,500 Centennial Clean Water Fund Grant legislative appropriation, $3,857,000 USDA Rural Development loan, $344,449 USDA Rural Development grant, $2,000,000 Utility Local Improvement District (ULID) and $30,901 in city

funds. Without the legislative appropriation grant, the city could not have afforded the project. To repay the debt, residential sewer rates are set at $35 per month. The charge for a new residential connection is $4,850. Use area agreements also allow the city to collect revenue from users at approximately 80 % of the potable water rate.

Beneficial Uses

Reclaimed water is available for many uses including treatment plant equipment washdown and process water, fire fighting, street cleaning and dust control. The city also provides reclaimed water for landscape irrigation at local churches, city parks and even a private residence along the route.

The showcase of the Yelm project is Cochrane Memorial Park, an aesthetically pleasing constructed wetland park designed to polish the reclaimed water and recharge groundwater. In the center of the park, a fishpond uses reclaimed water to raise and maintain stocked rainbow trout for catch and release.

Other Notable Features

The city of Yelm implemented a highly effective public education and outreach program. Communication through the schools was a very successful tool in gaining public acceptance. Cochrane Memorial Park, a highly visible reuse component that the public wanted and can identify with, has also been a strong positive factor. The city adopted a local reclaimed water ordinance establishing conditions of use. The ordinance has a "mandatory use" clause through which the city may require construction of reclaimed water distribution facilities as a condition of development approval.

Groundwater monitoring has not detected any measurable changes in the groundwater when compared to baseline testing conducted by Ecology prior to the project. Yelm recently received an Ecology grant to provide a more extensive groundwater monitoring study to monitor for any groundwater impacts from the reclaimed water. Yelm's plans for future uses of reclaimed water include an educational wetland at Yelm High School as well as additional industrial and commercial uses.

For More Information

Shelly Badger, Yelm City Administrator, (360) 458-8405, shelly@yelmtel.com
Kathy Cupps, Department of Ecology, (360) 407-6452, kcup461@ecy.wa.gov