Appendix C

Wastewater Reclamation Study

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SUMMARY

Background

The City of Lincoln is currently constructing a wastewater treatment and reclamation facility (WWTRF) for the purpose of treating and disposing of effluent generated within the City of Lincoln General Plan. Upon start-up (2003), the WWTRF is expected to produce an average dry weather flow (ADWF) of approximately 2.4 million gallons per day (MGD). The initial treatment capacity of the WWTRF will be 3.3 MGD. Over the subsequent 5 to 10 years, the City of Lincoln is projecting an average dry weather flow production of up to 4.2 MGD. At build-out of the City General Plan, the City is expected to generate an average dry weather wastewater flow of 10 to 12 MGD. The Placer Nevada Wastewater Authority, comprised of western Placer and Nevada County jurisdictions, is considering expansion of the City of Lincoln WWTRF for regional wastewater treatment and disposal. If implemented, the total average wastewater flow at an expanded WWTRF could be as much as 25 MGD.

The effluent from the City of Lincoln WWTRF will be of sufficient quality to allow unrestricted reuse, including the farming of salinity sensitive crops. The State of California has stated a preference for recycling effluent to the extent possible rather than discharging effluent to surface waters or disposing of effluent on land (The Sacramento River and San Joaquin River Basin Plan, 1998, p. IV-14.00).

Approach

The Reclamation Study is divided into three phases:

Phase I: Short Term Strategy focuses on identifying and prioritizing potential reclamation projects required for operation of the City of Lincoln Wastewater Treatment and Reclamation Facility (WWTRF) at wastewater flows up to 4.2 MGD. This phase is designed to provide groundwork for further expansion of the reclamation projects to accommodate regional wastewater flow up to 25 MGD. In addition, this phase included applying for grant funding from State and Federal agencies for construction of the reclamation projects, obtaining Regional Water Quality Control Board permit for Auburn Ravine discharge and reclamation permit, and working with DHS to permit use of reclaimed water for rice irrigation.

Phase II: Mid Term / Long Term Strategy will build on the work completed in Phase I and will develop and prioritize projects for the reuse of 25 MGD of wastewater. In addition, Phase II will develop region-wide policies and procedures for implementation of the reclamation projects. It is anticipated that completion of Phase II will involve numerous stakeholders as well as formation of a technical advisory committee.

Phase III: Implementation Strategy will develop funding mechanisms for implementation of the reclamation projects identified in Phase II.

This report presents the methodology and findings of Phase I. It is anticipated that Phase II and Phase III findings will be presented a separate report.

Objectives

This study was undertaken to define Short Term Strategy (Phase I) and to determine the potential of reclaiming treated effluent from the City of Lincoln WWTRF for agricultural irrigation or non-potable urban uses. The objectives of this study were:

1. To identify potential reclamation areas near the WWTRF,
2. To review water supplies currently available in the use area,
3. To analyze applicable wastewater recycling regulations and summarize their impact on required wastewater treatment facilities,
4. To evaluate the water market for wastewater reclaiming opportunities, and
5. To identify and prioritize the most likely projects for wastewater reclamation.

Methodology

The study area is located in the vicinity of the WWTRF and is bounded by Nicolaus Road on the north, Fiddyment Road on the east, West Sunset Boulevard on the south, and Brewer Road on the west. The area is comprised of approximately 16,700 acres, with most irrigated land used for rice farming. Rice irrigation is the largest potential use of recycled water in the study area.

Two types of delivery systems were considered for delivering recycled water to the end users: (1) construction of delivery pipelines, storage reservoirs, and pumps, and (2) making use of natural or existing waterways such as Auburn Ravine creek and the canal distribution system used by Placer County Water Agency (PCWA) and South Sutter Water District (SSWD). Making use of Auburn Ravine greatly reduces the need (and thus cost) of infrastructure for water delivery, but also requires that the recycled water comply with discharge permit requirements. These requirements include temperature restrictions that would probably require construction of cooling facilities (e.g., cooling towers or mechanical chillers). However, discharge to natural watercourses has the benefit of removing many of the regulatory restrictions associated with reuse.

A prioritized list of the proposed reclamation projects has been developed. The proposed projects rely on delivery of reclaimed water to agricultural and industrial users. Priority was assigned to the projects based on a property owner's willingness to use the reclaimed water, cost of the project per acre of land (not including land purchase), availability of State or Federal grants for project construction, and the potential for grouping projects near a logical pipeline alignment. The identified projects can be implemented to accommodate City of Lincoln growth, i.e. wastewater ADWF rate up to 12 MGD, and for regional expansion in excess of 25 MGD of ADWF.

Conclusions

Three conclusions derived from this study will influence decision to pursue water reclamation projects:

1. There is adequate land availabile within the study area to recycle up to 25 MGD of average dry weather flow. To recycle 3.3 MGD (ADWF) of wastewater, approximately 320 irrigable acres of rice or 410 irrigable acres of pasture are required. Correspondingly, 12 MGD would require 1,150 acres of rice or 1,500 irrigable acres of pasture, and 25 MGD would require 2,460 acres of rice or 3,130 irrigable acres of pasture.

2. Surface water is readily available within the Study Area during average rainfall years through Placer County Water Agency (PCWA) and South Sutter Water District (SSWD) to the customers located along the existing water conveyance facilities. Groundwater is used to supplement surface water during drought years. The price of surface water in the study area is relatively low, typically between $5 to $25 per acre-foot.

3. Year-round availability and reliability of reclaimed water deliveries make it an attractive alternative for industrial and agricultural users. However, regulatory restrictions (e.g., tail water and stormwater containment, groundwater monitoring, set back requirements) have to be properly addressed by the reclaimed water provider and by the end users in order to implement reclamation projects.

Several projects have been identified and prioritized. They provide significant wastewater reuse opportunities. The following conclusions and recommendations discuss the implementation of those projects:

1. Although construction and operation of cooling towers and delivery via Auburn Ravine appears to be the most cost effective approach to the reclamation and delivery of recycled wastewater, limited experience is available in making use of cooling towers for wastewater applications. Additionally, significant power requirements associated with wastewater cooling and the uncertainty associated with long-term power availability and cost might reduce the economic advantages of this alternative. Because of this significant uncertainty, at this time it is recommended that the land purchase/lease and construction of delivery pipelines option be pursued.

2. Irrigation of rice is water intensive, will reduce disposal land area requirements, and will allow significant cost savings associated with the construction of the reclaimed water distribution system and farming areas preparation and grading.

3. Industrial projects provide for year-round reclamation potential, which maximizes total volume of reclaimed water used for beneficial purposes.

4. Current design of the WWTRF includes storage basins sized for emergency conditions, such as treatment process failures. If the City desires to maximize reclamation by storing treated water during the winter for agricultural re-use during the irrigation season, additional storage basins have to be constructed.

5. Periodic re-evaluation of cooling tower construction feasibility is recommended as WWTRF expansions are considered.

6. A partnership of interested stakeholders is needed to develop and implement Phase II and Phase III of the Reclamation Study. Potential stakeholders include the City of Lincoln, PCWA, SSWD, Placer County, Sutter County, State Water Resources Control Board, Regional Water Quality Control Board, Department of Health Services, local mosquito abatement district, land developers and agricultural and industrial reclaimed water users.

1. STUDY AREA CHARACTERISTICS

Study Area Boundaries

The project Study Area boundaries were developed based on the following guidelines for inclusion:

- Areas adjacent to the proposed City of Lincoln Regional WWTRF.
- Areas adjacent to Auburn Ravine.
- Irrigated agricultural areas and other areas of high water use.

The selected study area is bounded by Nicolaus Road on the north, Fiddyment Road and HW 65 on the east, West Sunset Boulevard on the south, and Brewer Road on the west. The encompassed area is approximately 21,300 acres.

Hydrologic Features

Average annual rainfall in Lincoln is reported as approximately 24 inches, most of which occurs between November and April. Major surface water drainage courses in the area are Markham and Auburn Ravines, Ingram Slough, and Orchard Creek. Markham and Auburn Ravines have well defined drainage ways and originate east of Lincoln in the foothills. Localized flooding of roadways and the flat farm land frequently occurs along Auburn Ravine, Ingram Slough, and Orchard Creek due to the level ground surfaces, flow channel barriers, and naturally high groundwater levels. A number of manmade canals and ditches have been excavated through the area to convey water for agricultural irrigation.

Geology and Soils

The study area is sited in the geologic zone of transition between the Sierra Nevada Mountains and the Central Valley. Rock deposits in the area are granitic, volcanic, and sedimentary type units. Regional geologic horizons beneath the project are Riverbank, Laguna, Mehrten, and Ione Formations. Topography is relatively flat with elevations approximately 100 to 125 feet above mean sea level. Figure 1-1 presents the USGS topographic map of the area.

Soils within the study area are reported to consist of 1 to 5 percent Cometa-Fiddyment complex. The Cometa is of granitic origin and is a deep well drained alluvium deposit, while the Fiddyment soils are old valley fill siltsone, which are also well drained. The soils in this complex are typically characterized with high shrink-swell potential and with poor load bearing capabilities. Observed hydraulic drainage is relatively slow. These soils can be moderate to highly corrosive to uncoated steel and concrete structures. Seismic movement in the area has not been evidenced during the past 11,000 years and therefore the California Division of Mines and Geology concludes that insufficient evidence exists to categorize the area as active.

Groundwater

There are two main water-bearing litho-structures beneath the Lincoln area. Volcanic deposits of the Mehrten Formation and non-volcanic sediments of the Ione Formation characterize the deeper aquifer system. The shallow aquifer system includes the non-volcanic sediments of the Laguna and Victor Formations. The near surface fluvial and alluvial deposits for the project appear to provide limited areas where perched water may reside above the main aquifers previously described.

Land Use

Current land uses include cultivated and idle farmland, pasture, riparian vegetation along Auburn Ravine, and native vegetation. The study area is designated as Agricultural by the Placer County General Plan (see Figure 1-2). The northern portion of the Study Area has been subdivided into ten-acre rural residential lots that are no longer used for commercial agriculture.

2. SURFACE AND GROUNDWATER WATER SUPPLY CHARACTERISTICS AND FACILITIES

Wholesale and Retail Entities

Placer County Water Agency (PCWA) Zone 5 and South Sutter Water District (SSWD) provide surface water for commercial agriculture in the study area. The water delivered by PCWA and SSWD is untreated surface water and is unsuitable for human consumption. It is available during typical rice irrigation season from April 15th through October 15th. The water is delivered through the system of natural creeks, open ditches, canals, conduits, and flumes. The PCWA Zone 5 and SSWD boundaries within the Study Area and the locations of the irrigation canals are presented in Figure 2-1.

Groundwater

In addition to surface water, farmers use groundwater for crop irrigation. The percentage of annual groundwater use depends on the surface water allocations by the PCWA and SSWD. Figure 2-2 presents agricultural water use for the area. Most of the farmers in the area use a combination of surface and groundwater, especially during drought years when surface water allocations do not satisfy water demands.

Water Availability

Surface water allocations are determined each year based on the water availability. Farmers who received water the previous year are given the first priority for services by PCWA or SSWD in the present year for the same or lesser amount of water than that received during the preceding year.

PCWA delivers raw water for commercial agriculture down the Auburn Ravine Creek. During recent years, PCWA provided approximately 16,500 acre-feet of raw to a small group of farmers who have land adjacent to Auburn Ravine. During the 2001 irrigation season, PCWA was only able to deliver 12,000 acre-feet of water. Land irrigated with the PCWA water is shown in Figure 2-2.

The overall demand for Zone 5 is estimated at 70,000 acre-feet (PCWA Surface Water Supply Update, March 2001). Currently the source of this water is predominantly groundwater that is pumped by individual landowner wells. At this time, PCWA is not capable of meeting this demand while still meeting the demand for treated wastewater deliveries based on anticipated the growth and development of the Placer County.

Water supplied by SSWD is supplemental for the farmers. During average precipitation years SSWD delivers two acre-feet of water to the farmers per each acre of farmland. In drought years, cutbacks in water deliveries are experienced. During the 2001 irrigation season, SSWD was only able to deliver 1.25 acre-feet of water per acre of land.

Quality of Water Supplies

Most farmers in the study area irrigate with a combination of surface and groundwater. A summary of typical water quality available for irrigation is presented in Table 2-1. Descriptive data for SSWD water is not currently available.

The surface water provided by PCWA has a low sodium adsorption ratio (SAR) and very low electrical conductivity (EC). The low SAR indicates that the use of the surface water is not likely to result in soil salinity problems. However, water with low EC values, especially below 200 umho/cm, tends to leach soluble minerals and salts from the soil. Without salts, particularly calcium, "the soil disperses and the dispersed finer soil particles fill many of the smaller pore spaces, sealing the surface and greatly reducing rate at which water infiltrates the soil surface" (Ayers and Westcost, 1985). The resulting low infiltration rate of water into the root zone results in ponding, and may cause crop water stress between irrigation events. This issue is important for pasture and field crop growers, but does not affect rice farming.

Water quality data for groundwater was obtained through the DWR records and Western Regional Landfill monitoring records. Groundwater has a higher SAR and EC than the surface water supplies. However, both parameters are within the acceptable range for agricultural irrigation. Groundwater depth varies slightly through the study area. On average, groundwater levels during drought years were observed 55 feet below the ground surface (DWR, 1992 data). In the year 2000, average groundwater levels were measured 50 feet below surface.

Table 2-1.
TYPICAL WATER QUALITY DATA

Test Description		Units	Surface Water [1]	Groundwater [2]
Cations				
	Calcium	mg/L	3.6	33
	Magnesium	mg/L	0.77	24
	Hardness as $CaCO_3$	mg/L	12	181
	Potassium	mg/L	<5.0	1
	Sodium	mg/L	1.3	112
Anions				
	Carbonate	mg/L	<1.0	NA*
	Bicarbonate	mg/L	24	NA*
	Sulfate	mg/L	3.2	4-112
	Chloride	mg/L	0.84	33-127
	Nitrate as Nitrogen	mg/L	<2.0	3-20
	Fluoride	mg/L	<0.1	NA
Minor Elements				
	Boron	mg/L	NA*	2
	Copper	mg/L	<0.05	NA*
	Iron	mg/L	<0.1	NA*
	Manganese	mg/L	<0.03	NA*
	Zinc	mg/L	<0.05	NA*
Other				
	PH		7.5	7.6
	E.C.	umho/cm	35	290-595
	SAR		0.16	3.6

1. PCWA Water Quality Report for Foothill WTP - raw water grab sample. Report is dated October 20, 2000.
2. DWR and Western Regional Landfill groundwater water quality data (limited data sets).
* NA – Not analyzed.

Water Prices

The SSWD sells surface water delivered through the open channel/ditch systems at a rate of $5.00 per acre-foot if the farmer has to pump the water from the irrigation ditch into the field. If gravity is used to deliver the water from the SSWD ditch to the field, the SSWD charges $6.00 per acre-foot of water. The lower price for pumped water is intended to offset expenses associated with pumping. A small portion of the SSWD water is delivered through a pipeline system located next to the Bear River (i.e., outside of the study area). Water delivered through the pipeline system is used for orchard irrigation and is sold at a rate of $10 per acre-foot. In addition to water use charges, SSWD charges all the customers an annual fee of $1.20 per acre of irrigated land.

The PCWA charges its customers in accordance with the following 2002 rate schedule:

Seasonal Irrigation	Monthly Rate For 1st Inch	Monthly Rate For Each Additional Inch	Rate per Acre-Foot
For 1st Miners' Inch(a)	$42.53	---	$28.59
2nd Miners' Inch	$42.53	$36.47	$26.55
3rd Miners' Inch	$42.53	$33.32	$24.46
4th Miners' Inch	$42.53	$29.76	$22.15
5th to 10th Miners' Inch	$42.53	$27.36	
11th to 60th Miners' Inch	$42.53	$24.99	
61st or more Miners' Inch	$42.53	$20.62	

(a) Miners' Inch is defined as a rate of flow equal to one-fortieth cubic foot per second. One miners inch flowing for six month is equivalent to nine-acre feet.

Groundwater delivery costs increased significantly in year 2001, as power costs increased to $0.22 per kW-hr during peak hours (12:00 P.M. to 6:00 P.M.) and $0.09 per kW-hr during off peak hours. To minimize costs, most farmers do not operate groundwater pumps during the peak hours.

The University of California Cooperative Extension prepared a report titled "Sample Costs to Produce Rice" (March, 2001). According to the report, a farmer uses on average five acre-feet of water per acre for rice irrigation during a growing season, with water purchased from an irrigation district and supplemented with well water. The estimated cost per acre of rice per season was reported at $54.13. Although this cost was based on a survey conducted in the Sacramento valley, unit power costs were not disclosed so the cost for irrigation in the study area might vary slightly from that reported.

3. WASTEWATER CHARACTERISTICS AND FACILITIES

Wastewater Treatment Facilities

The City of Lincoln operates a Wastewater Treatment Plant (WWTP) that will be upgraded to treat average dry weather flow (ADWF) of 2.4 million gallons per day (MGD) by 2002. Additionally, a new Wastewater Treatment and Reclamation Facility (WWTRF) is under construction and is expected to be operational by 2004. Upon start-up, the new facility is expected to treat an ADWF of 2.4 MGD, but will have an ADWF treatment capacity of 3.3 MGD. Over the following 5 to 10 years the City of Lincoln is projecting an increase in ADWF to 4.2 MGD from various existing and proposed residential and commercial developments. Based on the current City of Lincoln General Plan, the City is expecting to generate an ultimate ADWF of 10 to 12 MGD. Western Placer and Nevada County jurisdictions are considering implementation of regional wastewater treatment involving expansion of the Lincoln WWTRF. Full participation of the Placer-Nevada Wastewater Authority agencies and adjacent tributary areas could result in an ADWF approaching 25 MGD. The new WWTRF will be expanded as required to treat the larger flows. The existing WWTP will be decommissioned after the WWTRF is operational.

Water Quality Requirements

The adopted Water Quality Control Plan for the Sacramento/San Joaquin Basin established by the State Water Resources Control Board sets forth guidelines for establishing the acceptability of and specific standards for discharges of treated wastewater effluent. The standards are a function of the disposal method. The WWTRF received waste discharge permit limitations associated with a discharge to Auburn Ravine Creek. The permit contains both effluent limitations (e.g., BOD, TSS) and receiving water limitations (e.g., temperature, turbidity, pH, dissolved oxygen concentration). These discharge standards establish the nature and extent of treatment facilities required. If effluent from the WWTRF will be used for landscape irrigation, a reclamation permit will control effluent requirements. The City of Lincoln is in a process of obtaining a reclamation permit.

Treatment process requirements for a discharge to Auburn Ravine Creek or for unrestricted irrigation reuse are provided in Table 3-1. Treatment requirements for each disposal method are essentially identical. However, unrestricted reuse of effluent has monitoring and alarms, redundancy, and disinfection requirements that are not applicable to a direct discharge to Auburn Ravine Creek, whereas a discharge of effluent to Auburn Ravine Creek has toxicity requirements that are not applicable to reuse applications. Fodder, fiber, and seed crops can be irrigated with water meeting less stringent regulatory requirements than those associated with unrestricted reuse.

Table 3-1

PROCESS REQUIREMENTS FOR PROPOSED DISPOSAL METHODS

Process Requirements	Disposal Method: Unrestricted Irrigation	Disposal Method: Direct Discharge to Auburn Ravine
Minimum Process Level	Oxidized, coagulated, filtered, and disinfected	Oxidized, coagulated, filtered, and disinfected
Monitoring and Alarms	Per Title 22[(a)]	None required
Redundancy	Per Title 22[(a)]	None required
Disinfection Requirement	5-log virus inactivation, coliform < 2.2/100 mL	Virus inactivation not specified[(b)] coliform < 2.2/100 mL

(a) Title 22 of California Code of Regulations.

Effluent and receiving water limitations for discharge to either Auburn Ravine Creek or recycled for unrestricted irrigation are presented in Tables 3-2 and 3-3. The limits associated with reclamation are projected at this time, and subject to change once the Master Reclamation Permit has been obtained.

Table 3-2

EFFLUENT LIMITATIONS

Effluent Limitation	Disposal Method: Unrestricted Irrigation	Disposal Method: Direct Discharge to Auburn Ravine[(a)]
BOD_5 (mg/L) [(a)]		
Monthly average	10	10
Weekly average	15	15
Daily maximum	30	20
Suspended solids (mg/L) [(a)]		
Monthly average	10	10
Weekly average	15	15
Daily maximum	30	30
Settleable solids[(a)]		
Monthly average	0.1	0.1
Daily maximum	No standard	0.2
Ammonia (mg/L)		
1 hour average	No groundwater degradation	24[(b)]
30-day average	No groundwater degradation	3[(c)]
Nitrate (mg/L)		
Monthly average	No groundwater degradation	10
Turbidity (NTU)		
Daily average	2	2
Daily maximum	>5 NTU ≤ 5% of time	5
Chlorine residual (mg/L)		
Weekly average	No standard	<0.01
Hourly average	No standard	<0.02
Total coliform (MPN/100 Ml)		
7-Day median	2.2	2.2
Daily maximum	23	240[(d)]
Oil and grease (mg/L)		
Monthly average	No standard	10
Daily average	No standard	15
pH	No standard	6.5 to 8.5
Acute toxicity		
Minimum	No standard	≥70%
Median of 3 or more	No standard	≥90%

(a) Values listed are for effluent entering filter clearwell. Different limits apply for discharge from storage (See Appendix B, NPDES permit).
(b) pH dependent. Value listed corresponds to a pH of 7.0.
(c) Temperature and pH dependent. Value listed corresponds to a pH of 7.0 and a temperature of 25 °C.
(d) The total number of total coliform bacteria shall not exceed a MPN of 23 per 100 ml in more than one sample in any 30-day period. No single sample shall exceed an MPN of 240 total coliform bacteria per 100 ml.

Table 3-3

RECEIVING WATER LIMITATIONS

Water Quality Parameter	Regulatory Limit for Disposal Method: Unrestricted Irrigation	Direct Discharge to Auburn Ravine
Toxicity	None required	The effluent discharge shall not cause non-compliance with the National Ammonia Criteria or the National or California Toxics Rule.
pH	None required	The ambient pH shall not fall below 6.5, exceed 8.5 or on an annual average basis change by more than 0.5 units as result of the discharge.
Dissolved oxygen	None required	Not to fall below 7 mg/l. The monthly median shall not fall below 85% of saturation in the main water mass, and 95 percentile concentration shall not fall below 75 % saturation.
Turbidity	None required	Monthly increase less than: (a) 1 NTU where natural turbidity is between 0 and 5 NTU (b) 20% where natural turbidity is between 5 and 50 NTU (c) 10 NTU where natural turbidity is between 50 and 100 NTU (d) 10% where natural turbidity is greater than 100 NTU
Temperature	None required	The discharge shall not cause the annual average ambient temperature to increase by more than 5° F and shall not rise the ambient temperature above: (a) 58° F on monthly average and weekly median from 10/1 to 5/31; (b) 64° F from 10/1 through 5/31; (c) 5° F over the ambient background as daily average from 6/1 through 9/30.

Design Criteria

Table 3-4 presents expected average dry weather flow and peak month, day, and hour flows for the WWTRF. The peaking factors for the 2.3 MGD facility are conventional with respect to flow rate and population base. As the population served by the WWTRF increases, the ratio of peak flows to average flows decrease due primary to a greater variance in flow residence times from the various points of discharge in the expanded collection system to the treatment facilities. Additionally, in the Lincoln case, with much of the ultimate collection system as yet not constructed, the influence on the peak wet weather flows of extraneous infiltration and inflow into existing older sewers is reduced in the future.

Table 3-4

WWTRF DESIGN FLOW CRITERIA

Parameter	Average Dry Weather Flow, MGD	
	3.3[(a)]	12[(a)]
Peak Flows Ratio to ADWF		
Peak month	1.7	1.5
Peak day	2.9	2.4
Peak hour	3.7	3.0
Peak Flows		
Peak month, MGD	5.6	18.0
Peak day, MGD	9.6	28.2
Peak hour, MGD	12.21	36.0

(a) Includes incorporation of existing City WWTP wastewater.

Table 3-5 presents anticipated reclaimed wastewater production rates for Lincoln WWTRF. The production rates are based on the ADWF and an estimate of inflow and infiltration rates. The losses and gains due to evaporation, percolation and direct precipitation into the maturation ponds and storage reservoirs are not included into the reclaimed wastewater production rate estimates. Note that 1,560 AC-FT (500 million gallons) of storage has been constructed at the WWTRF. However, the storage has not been designed for seasonal storage of effluent for the purposes of maximizing reclamation. Storage reservoirs are sized for treatment failures / emergency conditions at the WWTRF that will prevent discharge to the creek and / or reclamation. Additional storage facilities will have to be constructed if the City wishes to maximize reclamation in the future.

Table 3-5

WWTRF RECLAIMED WASTEWATER PRODUCTION

Plant Capacity, MGD		3.3	12	30
Month	# Days / Month	Reclaimed Wastewater AC-FT	Reclaimed Wastewater AC-FT	Reclaimed Wastewater AC-FT
May	31	321	1,159	2,894
June	30	306	1,110	2,773
July	31	314	1,143	2,857
August	31	315	1,144	2,860
September	30	308	1,114	2,783
Irrigation Season Total, AC-FT		1,570	5,670	14,170
October	31	332	1,188	2,958
November	30	373	1,278	3,152
December	31	379	1,305	3,220
January	31	423	1,417	3,473
February	28	355	1,210	2,981
March	31	367	1,207	2,947
April	30	330	1,171	2,911
Non-irrigation Season Total, AC-FT		2,560	8,780	21,650
Total, AC-FT		**4,130**	**14,450**	**35,820**

Process Design and Facilities Required for Wastewater Discharge and Reclamation

A description of the detail process design methodology for the Lincoln WWTRF is presented in the Final Draft Stage 1 Pre-design Report that was completed in July 200 and bound under separate cover. This section summarizes the results of the pre-design process.

The following process components for the Lincoln WWTRF are currently planned for construction, and allow for unrestricted reuse per Title 22:

- Influent Pumping
- Fine Screening
- Flow Measurement
- Nitrification/Denitrification Activated Sludge (Oxidation Ditch)
- Secondary Clarification
- Return and Waste Sludge Pumping
- Priority Pollutant Maturation Ponds
- Dissolved Air Flotation
- Tertiary Filtration
- UV Disinfection
- Effluent Aeration
- Effluent Storage
- Effluent Pumping and Conveyance
- Emergency Effluent Storage
- Creek Outfall
- Reclaimed Water Distribution Pipelines
- Waste Sludge Holding
- Waste Sludge Dewatering

The maturation ponds are included to address priority pollutant concentrations for the discharge to Auburn Ravine Creek. A treatment plant flow diagram and site layout are presented in Figures 3-1 and 3-2, respectively.

It is expected that during certain times of the year effluent from WWTRF will not be able to meet receiving water limitations for creek discharge, particularly with respect to temperature. The temperature limitation effectively governs as the most likely regulatory constraints affecting WWTRF facility components. Receiving Water Limitation in the adopted NPDES permit requires:

> *"The discharge shall not cause ... the annual temperature to increase more than 5 °F compared to the ambient stream temperature and shall not cause the receiving stream temperature to rise above:*
>
> - *58 °F on a monthly average and weekly median basis from October 1 through May 31.*

- *64 °F at any time from October 1 through May 31.*

- *5 °F over the ambient background temperature as a daily average for the period from 1 June through 30 September."*

A review of the temperature and flow data for Auburn Ravine leads to the observation that compliance with the 58 °F average month and median week temperature limitation will be problematic every year during the months May and October. During these months Auburn Ravine Creek typically already exceeds the 58 °F limitation, and therefore the discharge cannot result in any further temperature increase. The effluent, projected at an average temperature approximately 12 °F warmer than ambient receiving water conditions in both May and October, would necessarily result in an increase in temperature.

Seasonal variations in ambient Auburn Ravine flow and air temperatures can also cause compliance problems. The duration of such problems can range from as little as several weeks when agricultural flows in Auburn Ravine cease prior to the onset of seasonal rains to as long as nine months as occurred during prolonged droughts (e.g., calendar year 1988).

To deal with the temperature limitations associated with the surface discharge, wastewater reclamation can be implemented. Alternatively, the effluent can be further processed via cooling towers or mechanical chillers to decrease the temperature of the effluent prior to discharge to Auburn Ravine. Section 7 of this report presents a detailed evaluation of these discharge options.

Existing Reclaimed Water Users

Effluent from the existing Lincoln WWTP is used to irrigate approximately 382 acres of vegetation at the Lincoln airport, existing WWTP, and the site of the proposed WWTRF. Based on the design 100-year water balance and restriction to agronomic application rates, these acreages are capable of a reliable disposal of 1.8 MGD from the existing Lincoln service area.

Existing WWTP and proposed WWTRF use different operational strategies and thus have different irrigable land requirements. The strategy currently employed at the WWTP relies on storing effluent during non-irrigation season and eventual disposal during the irrigation season. This practice will be abandon once the WWTRF becomes operational and land will be used on as-produced basis, i.e., storage is not used to purposefully store effluent during the non-irrigation season for eventual use during the irrigation season.

Water Rights Issues

To deliver the reclaimed water to the farmers for crop irrigation, the City can either construct a special pipe system directed to points of use or discharge effluent to a natural waterway from which irrigation supplies are withdrawn downstream.

1. Generally, Water Code section 1210 provides that the owner of the treatment plant has an "exclusive right" to the use of treated wastewater as against the supplier of the fresh water to the treatment plant owner.

2. If the treated wastewater is applied to land (for disposal by irrigation or evaporation), it must meet the permit requirements discussed above, i.e., it will be subject to the waste discharge requirements pursuant to Water Code section 13263, or the disposal to land may be subject to reclamation permit pursuant to Water Code 13523 et seq. Either permit would be issued by the Regional Water Quality Control Board. If the water is delivered by discharge into a natural waterway, it is a discharge of treated wastewater into waters of the State and is also subject to the provisions of the Federal Clean Water Act and requires a NPDES permit, also issued by the Regional Board in conjunction with waste discharge requirements pursuant to State law.

3. If treated wastewater is discharged into a watercourse, it becomes subject to downstream appropriation as abandoned water unless it is being discharged for delivery to a purchaser of such water, or unless the producer of the wastewater has introduced the water into the watercourse with the prior stated intention of maintaining or enhancing, fishery, wildlife, recreational or other instream beneficial use (under Water Code Section 1212). Section 7075 of the Water Code provides that water which has been appropriated may be turned into the channel of another stream, mingled with its water, and then reclaimed; but in reclaiming it the water already appropriated by another shall not be diminished. Although it is not certain, that Section would presumably also authorize the use of a watercourse for the conveyance of treated wastewater to a downstream user. It would be prudent for the City of Lincoln to file an application with the SWRCB and obtain a permit to appropriate the treated wastewater under Water Code Section 1200, to document that there has been no abandonment, and that the producer is merely conveying the water from one location to another.

4. Whether the water is delivered via pipeline or via a watercourse, Section 1211 provides that the owner of a treatment plant is required to obtain the approval of the State Water Resources Control Board prior to making any change in the point of discharge, or the place or purpose of use of treated wastewater. The procedure for obtaining permission of the Board to add to or change the City's existing place of use or to change the purpose of use of the effluent would be to file a change petition, in the manner provided in Water Code Section 1700 et seq. Generally the procedural and substantive rules of a change petition for any appropriative water rights will apply.

4. TREATMENT REQUIREMENTS FOR DISCHARGE AND REUSE

Water Quality Requirements for Potential Agricultural Users

The guidelines for use of reclaimed water for irrigation have been developed based on the long-term influence of water quality on crop production and soil conditions. The guidelines developed by Food and Agriculture Organization (FAO) of the United Nations are presented in Table 4-1. Appendix "A" presents the assumptions used by FAO during development of the guidelines. The guidelines are used for evaluation of surface freshwater, groundwater and reclaimed water for irrigation.

Table 4-1

FAO GUIDELINES FOR INTERPRETATION OF WATER QUALITY FOR IRRIGATION[1]

Potential Irrigation Problem	Units	Degree of Restriction on Use		
		None	Slight to Moderate	Severe
Salinity *(affects crop water availability)*[2]				
EC_w	dS/m	< 0.7	0.7 – 3.0	> 3.0
(or)				
TDS	mg/l	< 450	450 – 2000	> 2000
Infiltration *(affects infiltration rate of water into the soil. Evaluate using EC_w and SAR together)*[3]				
SAR = 0 – 3 and EC_w =		> 0.7	0.7 – 0.2	< 0.2
= 3 – 6 =		> 1.2	1.2 – 0.3	< 0.3
= 6 – 12 =		> 1.9	1.9 – 0.5	< 0.5
= 12 – 20 =		> 2.9	2.9 – 1.3	< 1.3
= 20 – 40 =		> 5.0	5.0 – 2.9	< 2.9
Specific Ion Toxicity *(affects sensitive crops)*				
Sodium (Na)[4]				
surface irrigation	me/l	< 3	3 – 9	> 9
sprinkler irrigation	me/l	< 3	> 3	
Chloride (Cl)[4]				
surface irrigation	me/l	< 4	4 – 10	> 10
sprinkler irrigation	me/l	< 3	> 3	
Boron (B)	mg/l	< 0.7	0.7 – 3.0	> 3.0
Miscellaneous Effects *(affects susceptible crops)*				
Nitrogen (NO_3 – N)[5]	mg/l	< 5	5 – 30	> 30
Bicarbonate (HCO3) *(overhead sprinkling only)*	me/l	> 1.5	1.5 – 8.5	> 8.5
pH			Normal range 6.5 – 8.4	

[1] Adapted from University of California Committee of Consultants 1974.
[2] EC_w means electrical conductivity, a measure of the water salinity, reported in deciSiemens per metre at 25°C (dS/m) or in units millimhos per centimeter (mmho/cm). Both are equivalent. TDS means total dissolved solids, reported in milligrams per litre (mg/l).
[3] SAR mean sodium adsorption ratio. SAR is sometimes reported by the symbol RNa. At a given SAR, infiltration rate increases as water salinity increases. Evaluate the potential infiltration problem by SAR as modified by EC_w. Adapted from Rhodes 1977, and Oster and Schroer 1979.
[4] For surface irrigation, most tree crops and woody plants are sensitive to sodium and chloride; use the values shown. Most annual crops are not sensitive. With overhead sprinkler irrigation and low humidity (< 30 percent), sodium and chloride may be absorbed through the leaves of sensitive crops.
[5] NO3 –N means nitrate nitrogen reported in terms of elemental nitrogen (NH_4 –N and Organic-N should be included when wastewater is being tested).

Health Related Water Quality Requirements

Health related water quality requirements for reclaimed water are defined by DHS regulations known as Title 22 that were revised in 1999. Title 22 defines the allowable uses of reclaimed water based on the level of treatment provided by the wastewater treatment processing. The effluent produced by the Lincoln WWTRF will be oxidized, coagulated, clarified, filtered, and disinfected to 2.2 MPN/100 ml conforming to Title 22 unrestricted reuse criteria. According to Title 22, such effluent can be used for the following purposes:

- Irrigation of food crops, including all edible root crops, where the reclaimed water comes into contact with edible portion of the crop.
- Irrigation of parks and playgrounds.
- Irrigation of school yards.
- Irrigation of residential landscaping and unrestricted access golf courses.
- As a source of water supply for non-restricted recreational impoundments.

Reclaimed water of lesser quality can be used for the following:

- Irrigation of food crops, including crops with edible portion produced above groundwater and not contacted by the reclaimed water (disinfected secondary-2.2 reclaimed water minimum).
- Irrigation of cemeteries, freeway landscaping, restricted access golf courses, ornamental nursery stock and sod farms, pastures for animals producing milk for human consumption, and non-edible vegetation with controlled access (disinfected secondary-23 reclaimed water minimum).
- Irrigation of orchards, vineyards, non food-bearing trees, fodder and fiber crops for non-milk producing animals, seed crops not eaten by humans, food crops that undergo commercial pathogen-destroying processing, ornamental nursery stock, and farms with limited public access (undisinfected secondary reclaimed water minimum).
- As a source of water supply for restricted recreational impoundments and publicly accessible impoundments at fish hatcheries (disinfected secondary-2.2 reclaimed water minimum).
- As a source of water supply for landscape impoundments without decorative fountains (disinfected secondary-23 reclaimed water minimum).
- Cooling and other purposes (See Sections 60306 and 60307 for allowed uses and restrictions).

However, Title 22 places a number of restrictions on use of the tertiary oxidized 2.2 mpn/100 ml wastewater including the following:

- No irrigation with reclaimed water shall take place within **50 feet** of any domestic water supply, unless conditions specified in Section 60310 of Title 22 are met.
- No impoundment of tertiary reclaimed water shall occur within **100 feet** of any domestic water supply.

- All areas where reclaimed water is used shall be properly signed to alert the public regarding the use of reclaimed water.
- Any irrigation reclaimed water runoff shall be confined to the reclaimed water use area, unless the runoff does not pose a public health threat and is authorized by the regulatory agency.
- No connections shall be made between reclaimed water system and potable water system, except as defiled in Title 17, Section 7604.
- No use of hose bibs us allowed in the portions of the reclaimed water piping system that is accessible by the general public.
- Producer of the reclaimed water shall prepare an Engineering Report to cover production, distribution and reuse of reclaimed water. The Engineering Report shall identify the means of compliance with Title 22 regulation and "any other features specified by the regulatory agency", e.g., Regional Water Quality Board permit requirements. The Engineering Report is also required to provide " a contingency plan which will assure that no untreated or inadequately treated wastewater will be delivered to the use area".
- The treatment plant shall comply with Title 22 requirements for design and reliability.

In addition, to Title 22 regulations, DHS developed guidelines for use of the reclaimed water. The guidelines have not been updated since 1972 and some discrepancies exist between the Title 22 regulations and the guidelines. The following guidelines are applicable to the reclaimed water to be produced by the Lincoln WWTRF:

- The reclaimed water can be used for surface or spray irrigation of all crops except for rice. "No effluent allowed in irrigation water [used for rice irrigation] because of mosquito propagation problem"(DHS, 1972). Section 5 of this report ("Rice Irrigation") describes an agreement between the DHS and the City of Lincoln that modified the 1972 guidelines and allowed irrigation of rice with tertiary disinfected effluent in the Study Area.
- Recycled wastewater shall not be used for irrigation or impoundment within **500 feet** of any well used for domestic water supply or **100 feet** of any irrigation well unless it can be demonstrated that special circumstances justify lesser distances to be acceptable.
- Impoundments should have perimeter signs.
- Runoff should be prevented from entering the impoundment unless the impoundment is sized to accept the runoff without discharge or an NPDES permit has been issued for the discharge.
- There should be no discharge of reclaimed water to any impoundment with less than one foot of freeboard unless discharge from the impoundment is allowed by NPDES permit.
- At areas irrigated with the reclaimed water, warning signs indicating that the reclaimed water is unsafe for drinking should be posted every 500 feet with a minimum of one sign at each corner and one at each access road.

Regional Water Quality Control Board Reclamation Requirements

The DHS requirements including Title 22 regulations as well as the guidelines will be included into the Waste Discharge Permit and Reclamation Permit that will be issued by the California Central Valley Regional Water Quality Control Board (RWQCB). The Waste Discharge Permit will also contain effluent limitations (e.g., BOD, TSS, priority pollutants) and receiving water limitations (e.g., temperature, turbidity, pH, dissolved oxygen concentration) as discussed in Section 3.0 above. The Reclamation Permit will contain the reclaimed water prohibitions and reclaimed water limitations designed to protect surface and/or groundwater from potential problems resulting from reclaimed water use.

Requirements similar to the Master Water Reclamation Permit for the City of Roseville (Order No. 97-147) are expected to apply to the proposed City of Lincoln WWTRF. Pertinent requirements in the Roseville Master Reclamation Permit are as following:

- Direct discharge of reclaimed water to surface water is prohibited.
- Excessive irrigation with reclaimed water which results in excessive runoff of reclaimed water, or continued irrigation of reclaimed water during periods of rain is prohibited. Overspray or runoff associated with normal sprinkler use is acceptable.
- Application or impoundment of reclaimed water within 50 feet of any well used for domestic water supply is prohibited, unless approved by the DHS Drinking Water Branch.
- The directed discharge of reclaimed water to irrigation channels that are hydraulically connected to waters of the State is prohibited.
- Reclaimed water shall not be allowed to escape from the authorized use areas by airborne spray or by surface flow except in minor amounts such as that associated with good irrigation practices.

In addition, the Roseville Master Reclamation Permit requires that:

- The Producer of the reclaimed water shall establish and enforce rules and/or regulations for the Users of the reclaimed water. The Producer shall establish the procedures for permit-based system regulating the Users. Upon Executive Officer approval of the Producer's program, the Producer may authorize specific reclamation projects on a case-by-case basis.

- The Producer shall submit a notice to the Regional Board in anticipation of reclaimed water application at a new location. The notice shall include, among other documentation, a User Reclamation Plan that reflects consultation with state and local health departments, and explains how the compliance with Title 22 and Master Reclamation Permit requirements will be achieved. "If, in the opinion of the Executive Officer, reclamation at the proposed new location cannot be adequately regulated under the Master Reclamation Permit, a Report of Waste Discharge may be requested and individual Water Reclamation Requirements may be formulated".

- Runoff containing wastewater shall not be allowed. The Producer of the wastewater will have to certified that the fields owned by the City are completely dry, i.e. no ponded water or puddles, prior to the beginning of the rainy season. If the fields are not completely dry, the storm water commingled with the wastewater will either have to be contained on the fields or collected and stored in the storage basins. The collected commingled water can be used for irrigation and/or land disposal; discharge of the commingled water to the creek will not be allowed without a NPDES permit from the Regional Board.

5. RECLAIMED WATER MARKET

Market Assessment Procedures

Statewide, recycled water is most often used for the irrigation of parks, golf courses, street landscapes, and for agricultural uses. The study area has been evaluated for water reclamation opportunities. The following criteria were considered:

- Existing land use,
- Proposed land use based on the City of Lincoln General Plan,
- Proximity to the WWTRF,
- Water quality requirements,
- Technical feasibility of water delivery.

The following sources were contacted or used to aid in the identification and evaluation of potential reclaimed water uses:

- City of Lincoln and Placer County staffs.
- Agricultural parcel owners and farmers.
- Prospective commercial users (e.g., lumber mill, power plant, landfill representatives).
- Golf course developer.
- Planning documents, crop production maps, water use maps, and aerial photographs.

Although a defined study area was the focus of this study (Chapter 1), the Placer County landfill, Sierra Pacific Lumber Mill, and Rio Bravo Power Plant were also considered during the evaluation because of potentially high water needs.

Potential Reclaimed Water Users

Potential recycled water use categories have been identified and are described below. In some instances, subcategories have also been developed and will be described in their respective sections. The six primary categories include:

1. Agriculture
2. Proposed Golf Course
3. Western Regional Landfill Authority
4. Industrial Users
5. Other Users
6. Users Outside Study Area

Agricultural Users

Agricultural water users can be further subdivided into the sub-categories based on the crop grown by the farmers. The following sub-categories of farm users were identified in this study:

a) Rice growers,
b) Pasture crop growers,
c) Grain and Hay growers,
d) Field Crop (including corn and sudan) growers.

Table 5-1 presents agricultural land uses in the study area, including identification of acreages utilized for different crops, water use requirements during peak irrigation demand and total annual water demand.

Table 5-1

CROP PRODUCTION AND AGRICULTURAL WATER DEMANDS

Crop	Acreage in the Study Area	Peak Water Demand (gallons/acre•day) [a]	Annual Water Demand (million gallons per acre) [a]
Rice	5,400	9,150	1.3
Pasture	840	7,150	1.3
Grain and Hay	640	2,900-4,200	0.3-0.4
Field Crops	970	8,580	0.7

[a] Water demand has not been reduced by available rainfall amount.

The peak water demand for rice, pasture, and field crops is in the summer, particularly during the month of July. During the winter months rice and field crops do not require irrigation as these crops are planted in April/May and harvested in September/October. Pasture requires water year-round. However, rainfall usually satisfies the water demand of pasture during the winter months and therefore the potential for irrigation with the reclaimed water would only be during the summer. Additionally, recycled water management is problematic during the winter season as stormwater released from the use areas is not allowed to commingle with recycled water. Grain crops such as wheat are planted in the fall or winter and harvested at the end of May. During the winter growing season, rainfall is likely to satisfy the grain water demand. Supplemental irrigation of grain crops with recycled water would only be required in April and May. Table 5-2 presents monthly water demand for different crops and rainfall data for average year and 100-year rainfall. The table is based on SWRCB data for Sacramento Area. Table 5-3 presents actual PCWA monthly water deliveries for irrigation of rice in the study area.

Table 5-2

MONTHLY CROP WATER DEMANDS AND RAINFALL DATA

	Rice Demand, inches [(a)]	Pasture Demand, inches [(a)]	Field Crops Demand, inches [(a)]	Winter Grain Demand, inches [(a)]	Fall Grain Demand, inches [(a)]	Average Rainfall, inches[(b)]	100-yr Rainfall, inches[(c)]
January	0.0	1.1	0.0	0.46	1.03	4.5	8.1
February	0.0	1.8	0.0	1.64	2.30	3.7	6.8
March	0.0	3	0.0	3.75	3.24	4	7.1
April	6.2	4.4	0.0	4.66	2.86	1.9	3.5
May	6.7	5.8	0.9	3.71	1.51	0.7	1.3
June	9.3	7.3	4.5	1.90	0	0.3	0.5
July	10.1	7.9	9.5	0	0	0.1	0.1
August	8.6	6.7	7.2	0	0	0.1	0.2
September	6.1	5.2	3.4	0	0	0.5	0.9
October	0.1	3.4	0.0	0	0	1.5	2.7
November	0.0	1.6	0.0	0	0.22	3.5	6.3
December	0.0	1	0.0	0	0.43	3.3	6

(a) Based on California SWRCB Report Number 84-1, Tables 5-1 and 5-12.
(b) Based on Department of Water Resources station #A00 4947 00.
(c) Based on 100-year Rainfall to Average Rainfall ratio of 1.81.

Table 5-3

PCWA MONTHLY WATER DELIVERIES FOR RICE IRRIGATION FOR THE STUDY AREA, IN ACRE-FEET

	1997	1998	1999	2000	2001	2002	Average
May	3,197	865	2,911	3,061	2,166	2,024	2,371
June	2,695	1,194	2,697	3,378	2,926	1,864	2,459
July	3,774	2,356	4,073	4,335	3,554	3,030	3,520
August	3,396	2,384	3,885	3,952	2,769	2,749	3,189
September	1,187	1,245	1,725	1,425	899	1,177	1,276
October	24	20	371	279	36	137	145

Required Irrigation System Conversions

When using recycled water for agricultural needs, allowance must be provided for switching among various water sources (e.g., from groundwater to recycled water, from surface water to recycled water). The following structural or operational modifications to agricultural use areas would typically be required to accommodate the need for switching among sources:

1) Construction of a new recycled water conveyance system to deliver the water from the WWTRF to the users,
2) Construction of on- or off-site storage/stormwater reservoirs,
3) Construction of irrigation return ditches and pumps (as needed),
4) Construction of containment systems (e.g., berms) to prevent recycled water from inadvertently entering waters of the state,
5) Use area set backs from domestic and irrigation wells (in accordance with Title 22),
6) Use area set backs from property lines, roads, residences, etc. (a function of water quality),
7) Employee training regarding proper handling of the recycled water,
8) Monitoring of irrigation practices,
9) Groundwater monitoring,
10) Overall compliance with the requirements of Title 22 and the Engineering Report prepared by the reclaimed water producer.

Rice Irrigation

Effluent from the Lincoln WWTRF will meet the Title 22 standards required for irrigation of food crops, including all edible root crops [i.e., where the recycled water comes into contact with edible portion of the crop (see Section 3)]. Thus, from a pathogen standpoint, recycled water can be used by agriculture in the study area, without exception. The irrigation of rice with recycled water had, until recently, been prohibited via State of California Department of Health Services (DHS) guidance based on concerns that recycled water might encourage mosquito propagation. The City of Lincoln reached agreement with the DHS and the California Regional Water Quality Control Board (Regional Board) allowing for the irrigation of rice with recycled water. The agreement states specific restrictions that aid in preventing the occurrence of problematic numbers of mosquitoes. For example, there are nutrient limitations, filtration requirements, mosquito surveillance and control by the Placer Mosquito Abatement District (PMAD), and design of irrigated rice acreage to ensure accessibility to PMAD personnel and equipment. As the program matures, it is expected that the City of Lincoln will discover other management techniques that can also aid in the reduction of the numbers of mosquitoes on irrigated land.

Rice production utilizes the largest acreage within the study area and has the highest peak water demand (refer to Table 5-1 and Figure 5-1); therefore, rice growers are the largest potential reclaimed water users in the study area. Additionally, some of the rice fields are located immediately adjacent to the WWTRF, which would require minimum infrastructure investment for the recycled water conveyance system. Total land requirements that would be needed for various crop irrigation options for the City of Lincoln WWTRF effluent disposal at current and future flow capacities are presented in Table 5-3. As flow through the WWTRF increases to accommodate the City of Lincoln growth (as well as to allow potential regional flows), there is insufficient non-rice agricultural land to use available recycled water. Table 5-4 presents land requirements per crop during peak month water demand time, assuming only one type of crop will be irrigated using reclaimed water. Note that during non-peak water demand months, larger land areas can be irrigated with the recycled water or a portion of the effluent will have to be discharged to Auburn Ravine.

Table 5-4

LAND REQUIREMENTS DURING PEAK MONTH WATER DEMAND[(a)]

Crop	Land Requirements at WWTRF flow of 3.3 MGD	Land Requirements at WWTRF flow of 4.2 MGD	Land Requirements at WWTRF flow of 12 MGD	Land Requirements at WWTRF flow of 25 MGD
Rice	320	410	1,150	2,460
Pasture	410	530	1,500	3,130
Grain and Hay	1,150	1,500	4,300	9,000
Field Crops	340	440	1,250	2,630

(a) Land requirements were calculated assuming that all flow will be used for irrigation of a single crop.
90% irrigation efficiency was assumed.
100-year rainfall was assumed.

To irrigate all 840 acres of pasture and all 970 acres of field crops in the study area (see Table 5-1) during the peak month water demand period, an approximate average dry weather recycled water flow of 14.3 MGD would be required. Because grain is irrigated in the spring, this crop will not contribute to the peak flow requirement. To reclaim the wastewater generated by the entire region (approximately 25 MGD), either rice irrigation, irrigation of currently fallow land, non-agricultural use for the reclaimed water or expansion of the use area will be required. Irrigation of all the pasture and field crop acreage within the study area is probably not feasible due to technical and financial constraints associated with the use and distribution of the recycled water.

Existing City Controlled Agriculture

Some of the existing agricultural land under City control will continue to use effluent for crop irrigation. The City of Lincoln WWTP currently makes use of four land disposal and reclamation sites, encompassing 382 net irrigable acres:

- 122 acres near the airport (spray irrigated),
- 38 acres on the WWTP site (spray irrigated with flood irrigation near the north perimeter homes),
- 105 acres at the Antonio Mountain Ranch (flood irrigated), and
- 117 acres under construction at Warm Springs site (flood irrigated).

All four sites are designed to produce fodder crops. During the peak water demand, the City owned land can dispose of 1.8 MGD with no discharge to Auburn Ravine. Upon completion of the WWTRF (i.e., constructed and operational), the WWTP and irrigation fields next to the

Airport and on the WWTP site will be decommissioned. However, the Antonio Mountain Ranch and Warm Springs sites (total of 222 net irrigable acres) can continue to accept effluent for reclamation until that land is needed for other uses (e.g., construction of additional maturation ponds on the Warm Springs site, or construction of additional storage reservoirs or process components on the Antonio Mountain Ranch site.

Golf Course Irrigation

Another potential reclaimed water user in the study area is a proposed golf course. Presently, there are no golf courses in the vicinity of the Lincoln WWTRF. However, a developer has approached the City with a proposal to convert 140 acres of the Antonio Mountain Ranch and Warm Spring reclamation sites into a golf course complex. A golf course will require almost year round irrigation. Required irrigation flow varies significantly through the year with minimum of 0.02 MGD in the winter to maximum of 0.9 – 1.2 MGD in August. A typical golf course would use 435 acre-feet of water per year.

Landfill and Material Recovery Facility Irrigation

Additional potential users of recycled water are the Placer County Western Regional Landfill and the Material Recovery Facility (MRF), located at the corner of Fiddyment Road and Athens Road. Presently, groundwater pumped from an on-site well is used by the landfill for dust control. Water demand during the summer months is estimated at 50,000 to 60,000 gallons per day (0.05 to 0.06 MGD). The MRF uses potable PCWA water for landscape irrigation, vehicle washing, and other minor uses. The water demand for landscape irrigation and vehicle washing that can be replaced with the WWTRF reclaimed water, is estimated at 50,000 gallons per day (0.05 MGD). The landfill and MRF are located adjacent to potential agricultural users of the reclaimed water. If a delivery pipeline is constructed to service these agricultural users, the same line would be able to serve the landfill. Construction of a 1.3 miles pipeline solely for the landfill and MRF may not be economically feasible due to the low water demand at this site.

Industrial Users

Industrial users, unlike agricultural users, are able to use reclaimed water on a year-round basis. Year-round use maximizes the volume of wastewater reclaimed each year for beneficial uses. Described below are four potential industrial users of reclaimed water that were identified in the Study Area. Letters of interest to utilize City of Lincoln Reclaimed water from these potential industrial users are presented in Appendix D.

<u>Lumber Mill</u>

The Sierra Pacific lumber mill is located on Nicolaus Road north of the existing Lincoln commercial center. The mill uses water to spray over the timber to prevent it from drying and for an on-site power generating facility. The average water use by the mill is approximately 300 gallons per minute (0.4 MGD). A pipeline along Moore Road, Joiner Parkway and Nicolaus Road would need to be constructed to deliver the water from the WWTRF to the mill. Alternatively, the existing 18-inch force main along Moore Road and 12-inch force main along Joiner Parkway can be utilized to deliver the water. The existing 12-inch pipeline will be available after the City completes construction of the 36-inch sewer interceptor along Westlake Boulevard in 2004. The 18-inch force main will be available in approximately 2005 after the

City constructs the 36-inch sewer interceptor along Moore Road. The existing pipes will have to be connected and extended to the Sierra Pacific site. Approximately 6,000 feet of new pipelines will have to be constructed.

<u>Power Plant</u>
The Rio Bravo Power Plant is located in the Sunset Industrial Park near the intersection of Industrial Boulevard and Athens Road. Average water use by the plant is approximately 300 gallons per minute (0.4 MGD). A pipeline along Fiddyment Road and Athens Road would have to be constructed to deliver the water from the WWTRF to the power plant. This pipeline can also be used to deliver the water for the landfill property, including the portion of the landfill property (approximately 200 acres) that is currently used for agriculture.

<u>Formica Company</u>
The Formica Company, located on Cincinnati Drive, has expressed interest to utilize recycled water at their plant. The company anticipates that approximately 0.5 MGD will be required for Formica production. The pipeline to the Rio Bravo plant will have to be extended in order to deliver the reclaimed water to the Formica Company.

<u>Livingston Concrete</u>
Livingston Concrete Company also expressed interest in using recycle water for concrete production. The company is anticipating that approximately 0.05 MGD will be required. Livingston Concrete is located on Atherton Road and pipeline to the power plant can be used to deliver water to this industrial user.

City Parks and Recreational Areas

The City of Lincoln is proposing to construct a school and a park at the corner of the Nicolaus Road and Joiner Parkway. The park will have several soccer fields and baseball fields. The City is planning to use the reclaimed water for irrigation of the park. It is anticipated that during summer months approximately 0.3 MGD of water will be required for irrigation. The park is located adjacent to the Sierra Pacific lumber mill. If a delivery pipeline is constructed to service the mill, the same line would be able to serve the park.

Environmental Users
Two wetland mitigation banks managed by Wildland Inc. are located within the Study Area. Further discussion with the Wildland Inc. and RWQCB is warranted to determine feasibility of the reclaimed water use for maintenance and management of the wetlands.

Other Potential Recycled Water Users
Other potential recycled water uses, such as park irrigation and street and highway median irrigation, have been considered within the Study Area.

At this time no residential developments are proposed for the Study Area. The streets in the study area have no medians or irrigated roadside vegetation. The existing Highway 65 right of way has no vegetated median as it passes through the City of Lincoln. However, the California Department of Transportation is in the process of designing a Highway 65 Bypass that passes through the study area. The final alignment of the bypass has not been determined at this time.

Alternatives being considered would place the Bypass 6,500 to 8,000 feet from the northeast corner of the WWTRF property. The new right of way will have a vegetated median and roadside landscaping that Caltrans is planning to irrigate. Depending on the cost of the construction, irrigation may not be included in the initial Bypass design, but could be added after the facility has been constructed and when additional funding becomes available. Construction of the recycled water delivery system from the WWTRF to the Bypass is likely to be financially feasible only if other uses of reclaimed water will be utilizing the same pipeline delivery system. After the final alignment of the Bypass is selected, the City and Caltrans may re-evaluate the feasibility of using reclaimed water for the landscape irrigation.

Users Outside Study Area
The study area analyzed in this report was selected for its proximity to the WWTRF. However, users located outside the study area can provide opportunities for use of the reclaimed water. To transport the water to the out-of-area users natural or existing waterways such as Auburn Ravine Creek and/or the diversion canal distribution system will have to be used. Potentially the reclaimed water can be transported to the Sacramento River and the Delta. The investigation of the pros and cons of this option is outside the scope of this Reclamation Study. However, as the production rate of reclaimed wastewater increases due to the City build-out (see Table 3-5) it is recommended that the out-of-area reuse option be re-evaluated.

Reclaimed Water Demand

Table 5-5 presents the potential reclaimed water uses identified in this investigation. As can be seen, agricultural uses have the largest potential reclaimed water demand in the study area.

Table 5-5
WWTRF POTENTIAL RECLAIMED WATER DEMAND

Reclaimed Water Use	Peak Demand in MGD	Annual Demand in acre-feet [a]
Existing		
Agricultural (Non-Rice)	1.80	2,000
Potential		
Agricultural (Non-Rice)	14.30	3,200
Agricultural (Rice)	49.40	18,200
Golf Course	1.20	350
Landfill/MRF	0.11	85
Parks	0.3	90
Industrial Users	1.35	1,500
Other	Not significant at this time	Not significant at this time
Total	**68.5**	**25,400**

[a] Annual demand is calculated based on 100-year rainfall.

6. PROJECT ALTERNATIVES ANALYSIS

Two types of delivery systems can be considered to convey recycled water to end users: (1) constructed infrastructure, and (2) waters of the State. Constructed infrastructure consists of delivery pipelines, storage reservoirs, and pumps. Making use of waters of the state consists of discharging the recycled water to natural existing waterways such as Auburn Ravine Creek for subsequent removal and use later downstream. The primary benefit associated with using waters of the State for conveying recycled water is the cost savings associated with infrastructure construction. Additionally, there are secondary benefits like the removal of some regulatory restrictions and increased marketability because farmers can then use conventional farming practices. However, making use of waters of the state for recycled water conveyance requires that the recycled water comply with all NPDES permit requirements, including temperature limitations.

This chapter evaluates alternatives for reclaimed water use and delivery. Three alternatives were considered:

(1) land purchase and construction of a pipeline delivery system,
(2) construction of cooling towers and delivery via Auburn Ravine Creek, and
(3) construction of mechanical chillers and delivery via Auburn Ravine Creek.

Advantages, disadvantages, and comparative costs of each alternative are presented in the remainder of this section.

Land Purchase and Construction of a Pipeline Delivery System

The land purchase alternative has been presented in the Pre-design Report and to date serves as the default approach to mitigating temperature concerns. Key components of the land purchase alternative include:

- Roughly 190 and 500 MG of effluent storage reservoir volume at average dry weather flow (ADWF) treatment capacities of 3.3 and 12 MGD, respectively.

- Roughly 410 and 1,500 net acres of effluent disposal area for ADWF treatment capacities of 3.3 and 12 MGD, respectively. Due to wetland mitigation requirements, recent experience has found that approximately 25 to 50% of any parcel is unusable for wastewater disposal due to setback requirements from property lines, wetlands areas, and other physical constraints.

- Construction of delivery reclaimed water pipelines.

Table 6-1 presents costs associated with reliance on the land disposal and storage alternative. Estimated separable project costs for the 3.3 MGD and 12 MGD facility design capacities would be $10,700,000 and $37,200,000, respectively. For the purpose of this analysis, it is estimated that of the parcels obtained, 25 percent of any acquired land is unusable. Land costs are assumed to be $4,000 per acre, with an additional $2,000 per acre allotted for the cost of condemnation, appraisal, wetland delineation, and wetlands mitigation. The costs presented in Table 6-1 for this alternative can be considered the minimum since recent land acquisition and disposal development experience in the area indicate an unusable portion greater than 25 percent.

Table 6-1

LAND AND STORAGE ALTERNATIVE COST ESTIMATE [(a)]

Facility Component	Facility Treatment Capacity 3.3 MGD	12 MGD
WWTRF Storage Reservoirs[(b)]	1,400,000	3,600,000
Disposal Area		
Clearing, Grading[(c)]	410,000	1,500,000
Irrigation System[(d)]	2,050,000	7,500,000
Runoff Recovery System with pump stations[(e)]	820,000	3,000,000
Service Roads[(f)]	410,000	1,500,000
Storage/Disposal Fencing[(g)]	200,000	750,000
Subtotal	5,290,000	17,850,000
Engineering/Administration @ 20%	1,060,000	3,600,000
Appraisals, Condemnation, Environmental Assessment[(h)]	820,000	3,000,000
Soft Cost Subtotal	1,880,000	6,600,000
Irrigation Area Transport Pipelines[(i)]	1,430,000	5,250,000
Land Acquisition for Disposal Area[(j)]	2,100,000	7,500,000
Land Disposal Facility Subtotal	3,530,000	12,750,000
Total Project Costs	10,700,000	37,200,000

(a) Cost based on ENR 20-Cities Construction Cost Index of 6410.
(b) Price based on cost of constructing the 190 MG of storage on the Antonio Mountain Ranch Site. Linear interpolation from the cost to construct 190 MG to the cost to construct 500 MG. Although there will be economies of scale associated with the construction of additional storage reservoirs (e.g., levees used for dual reservoirs), it is assumed that there will be offsetting costs related to staging the construction of storage facilities (e.g., crew mobilization). Storage reservoir costs do not include lining or erosion protection.
(c) Price based on $1,000 per net acre.
(d) Price based on $5,000 per net acre
(e) Price based on $2,000 per net acre.
(f) Price based on $1,000 per net acre.
(g) Price based on $500 per net acre.
(h) Price based on $2,000 per net acre.
(i) Price based on $3,500 per net acre.
(j) Price based on $4,000 per gross acre, assuming 25% unusable land.

The principal advantages of this alternative are that reclamation of effluent is maximized (in concert with the Basin Plan), and a discharge to Auburn Ravine Creek during periods of critical low temperature is minimized. In addition, the acquired land can be potentially leased to area farmers, thus preserving open space.

The major drawbacks of this alternative, and thus the basis for investigating other alternatives, are the socio-economic and political impacts of the City acquiring this much land for wastewater treatment and disposal. To ensure the reliability of this disposal alternative, it is assumed herein that the City must own all of the land utilized for disposal because the City cannot have its means of wastewater disposal undermined by development pressure and/or refusal by property owners to accept wastewater in the future. It has been the experience to date that long-term reclamation contracts have not been a viable option due to the significant and onerous regulatory constraints associated with using reclaimed water for agricultural uses (e.g., risk of groundwater contamination, need for monitoring wells, full tailwater containment, etc).

Cooling Towers

Cooling towers use evaporation to reduce the wastewater temperature, which would allow compliance with the NPDES permit temperature limitations described in Section 3 of this report. The minimum attainable temperature is dictated by the local wet-bulb temperature; cooling towers can only cool the water to within 3 to 5°F above the wet-bulb temperature. In the Lincoln area, the design (24-hour) wet bulb temperature is approximately 72°F. Two manufacturers of cooling towers have been contacted, and both have stated inability to obtain temperature below 75-77°F during the summer, based on an assumed 24-hour per day discharge. This temperature range is at or above the expected ambient effluent temperature in May through October and, therefore, provides no additional benefit.

Review of hourly, rather than daily average wet bulb temperature data (Beale Air Force Base) indicates that the wet bulb temperature is significantly lower during the hours from 12 A.M. through 8 A.M. in the months of June through August. Specifically, the wet bulb temperature remains below 62°F during that specific 8-hour period 90 percent of the time. Thus, it is theoretically possible to construct cooling towers and operate them only 8 out of 24 hours per day. In this case, the cooling towers, pumps and discharge facilities would have to be sized for at least three times the ADWF (i.e., 36 MGD for 12 MGD ADWF conditions) to allow discharge of all the wastewater generated over the course of a day.

In the specific months of May and October, the wet bulb temperature in the morning hours from 12 A.M. through 8 A.M. is 55°F at least 90 percent of the time. Thus, the cooling towers can be used to cool the effluent to 60°F. Since daily average creek temperatures are 60-61°F in May and October, cooling towers should sufficiently reduce effluent temperature for discharge to the creek based on an 8 out of 24 hour discharge schedule.

The frequency and duration of cooling tower operation would establish the amount of required supplemental storage. It is estimates that the cooling towers would have to be operated at least two months of the year assuming average flow conditions in Auburn Ravine. Under low flow conditions, the typical duration of operation would have to be increased to three or four months per year. Under the extreme drought conditions (e.g. 1988), nine months of operation will be required.

Table 6-2 presents project costs associated with use of cooling towers. Estimated project costs specific to recycled water cooling for the 3.3 MGD and 12 MGD facility design capacities would be $6,100,000 and $16,800,000, respectively.

Table 6-2

COOLING TOWERS ALTERNATIVE COST ESTIMATE [a]

Facility Component	Facility Treatment Capacity 3.3 MGD	12 MGD
Storage Reservoirs[b]	750,000	2,750,000
Cooling Tower Capital Costs		
Cooling Tower	510,000	1,850,000
Pump Stations	550,000	1,350,000
Installation and Piping	425,000	1,300,000
Electrical	360,000	950,000
Increase Outfall Pipe from 42" to 48" [c]	300,000	300,000
Subtotal	3,405,000	8,500,000
Engineering/Administration @ 20%	680,000	1,700,000
Present Worth O&M[d]	1,015,000	3,800,000
Contingency (20%)	1,000,000	2,800,000
Total Project Costs	6,100,000	16,800,000

(a) Cost based on ENR 20-Cities Construction Cost Index of 6410.
(b) Price based on cost of constructing the 190 MG of storage on the Antonio Mountain Ranch Site. Linear interpolation from the cost to construct 190 MG to the cost to construct 102 MG and 372 MG. Although there will be economies of scale associated with the construction of additional storage reservoirs (e.g., levees used for dual reservoirs), it is assumed that there will be offsetting costs related to staging the construction of storage facilities (e.g., crew mobilization).
Storage reservoir costs do not include lining or erosion protection.
(c) Cost includes only over-sizing to account for increase in flow during cooling tower operation.
(d) O&M cost include power costs only and are based on a 20-year life of the equipment and 5% interest rate. Power costs were calculated for 12 MGD ADWF assuming that cooling towers would be operated for 2 months out of the year each year, for 4 months every other year, and for 9 months once every 10 years. Power costs were pro-rated for the 3.3 MGD flow.

The 12 MGD ADWF cooling tower will use approximately 900 HP (672 kW) to operate the air fans. The operating power costs are estimated at $82,200 per month not including pumping power costs.

A separate pump station would have to be constructed to feed effluent to the cooling towers. The current effluent pump station design would not be able to serve the cooling towers as well as deliver effluent to either storage basins or the irrigation fields. Cooled effluent will be discharged to the creek by gravity via a 48-inch discharge pipeline.

Mechanical Chillers

Mechanical chillers can also be used to cool wastewater. Mechanical chillers use a refrigerant and either water or air to transfer the heat from the wastewater. Water-cooled chillers use a separate water stream to transfer heat from the refrigerant. The cooling water is circulated between the chiller and a cooling tower. Air-cooled chillers use atmospheric air to transfer the heat from the refrigerant (similar to home air conditioning units). Capital costs of water cooled chillers are higher than air cooled chillers, while power costs are about 20% lower. However, power cost savings associated with water cooled chillers are likely offset by significantly higher maintenance required for water cooled chillers and the need to also construct and operate cooling towers. For the Lincoln area, air cooled chillers are believed to be best suited and were therefore evaluated herein.

It is not recommended that wastewater effluent, even though it has been treated to meet Title 22 requirements, be cooled directly by chillers. Treated wastewater contains up to 10 mg/L of suspended solids that could significantly increase maintenance requirements for the chillers. Therefore use of heat exchangers is recommended. Clean water would be circulated between the heat exchanger and the chiller. Wastewater that enters and exits the heat exchanger does not commingle with the clean water.

Chiller and heat exchanger sizing is based on the following assumptions:

Hot Water (Wastewater):		**Cold Water** (Clean Water):	
Temperature In	75°F	Temperature In	48°F
Temperature Out	62°F	Temperature Out	62°F
Flow Rate	12.0 MGD	Flow Rate	12.0 MGD

The flow rate of clean water is equal to the flow rate of the wastewater. The selected temperature range was based on ten years of flow data and two years of temperature data available for Auburn Ravine. The selected temperature range is expected to allow discharge during problematic periods that are projected to occur annually during the months October and May, as well as during low flow and drought conditions (See Section 3 of this report for the specific temperature limitations imposed by the NPDES permit).

The frequency and duration of chiller operation would establish the amount of required supplemental effluent storage. To maintain the storage volume below 102 MG or 372 MG (one month of storage for 3.3 MGD and 12 MGD flows, respectively), the chillers would have to be operated at least two months of the year assuming average flow conditions in Auburn Ravine. Under low flow conditions, the typical duration of operation would have to be increased to three or four months per year. Under extreme drought conditions, nine months of operation would be required. These storage volumes are equivalent to those described for the cooling tower option.

Pumping facilities would have to be constructed to pump wastewater and clean water through the cooling facilities. The effluent pump station design could be modified to re-route wastewater through the heat exchangers prior to discharge. However, the clean water will require a pump station with the same capacity as the ADWF capacity of the wastewater pump station.

Table 6-3 presents a preliminary cost estimate for construction of the mechanical chiller facility.

Table 6-3

MECHANICAL CHILLERS ALTERNATIVE COST ESTIMATE [(a)]

Facility Component	Facility Treatment Capacity 3.3 MGD	12 MGD
Storage Reservoirs[(b)]	750,000	2,750,000
Chiller Capital Costs		
Heat Exchanger	105,000	315,000
Chillers	625,000	2,300,000
Pump Stations [(c)]	500,000	900,000
Installation and Piping	320,000	1,000,000
Electrical	500,000	1,000,000
Subtotal	2,800,000	8,265,000
Engineering/Administration @ 20%	560,000	1,655,000
Present Worth O&M[(d)]	8,100,000	29,400,000
Contingency (20%)	2,290,000	7,860,000
Total Project Costs	13,750,000	47,200,000

(a) Cost based on ENR 20-Cities Construction Cost Index of 6410.

(b) Price based on cost of constructing the 190 MG of storage on the Antonio Mountain Ranch Site. Linear interpolation from the cost to construct 190 MG to the cost to construct 102 MG and 372 MG. Although there will be economies of scale associated with the construction of additional storage reservoirs (e.g., levees used for dual reservoirs), it is assumed that there will be offsetting costs related to staging the construction of storage facilities (e.g., crew mobilization).
Storage reservoir costs do not include lining or erosion protection.

(c) Cost estimate includes two pump stations: one for the wastewater and the second one to circulate clean water between chillers and heat exchangers.

(d) O&M cost include power costs only and are based on a 20-year life of the equipment and 5% interest rate. Power costs were calculated assuming that chillers would be operated for 2 months out of the year each year, for 4 months every other year, and for 9 months once every 10.

It is estimated that four chillers (3.3 MGD flow) will require 1,500 kW of power. Based on a unit cost of $0.17 per kW-hr, the power cost for the operation of the chillers is $184,000 per month. Monthly power cost for chillers required for 12 MGD flow is estimated at $700,000 per month.

Selection of Preferred Reclamation Plan

Based on the analysis presented above, construction and operation of the cooling towers and direct discharge to the Auburn Ravine appears to be the least cost approach for reclamation of the treated effluent. However, limited experience is available in use of cooling towers for wastewater applications. In addition, significant power requirements for the cooling towers and uncertainty associated with long term power availability and cost may reduce the economic advantages of this alternative.

At this time, it is recommended that the storage and land irrigation alternative (construction of delivery pipelines) be pursued on the near term basis. As land for purchase or lease by the City of Lincoln becomes less readily available or more costly, the cooling tower alternative can be reconsidered.

7. DESCRIPTION OF PROPOSED PLAN

This section presents the proposed plan for development of the reclaimed water delivery system within the Study Area. The plan involves implementation of specific projects designed to deliver reclaimed water to industrial and agricultural users.

Reclaimed Water System

The following assumptions were used to estimate the cost of a recycled water conveyance system:

- 75% of each parcel is usable for reclamation.
- Modifying existing rice fields for reclaimed water irrigation was assumed to cost $2,000 per acre.
- On-site runoff containment improvements, including berm construction, tail water ditches and pumping, was assumed to cost $2,000 per acre for fields that are currently flood irrigated.
- Transmission pipeline construction was assumed to cost $8 per inch diameter of pipe per foot if pipe is placed in a paved road, or $6 per inch diameter of pipe per foot if pipe is placed in unpaved area.
- Stormwater / tail water containment reservoirs were assumed to be constructed at a cost of $90,000 per reservoir. It was assumed that one reservoir of approximate volume of 8,000 cubic yards would be required per every 200 to 250 acres of irrigable land.
- Engineering and administration cost were estimated at 20% of the construction cost.
- A contingency factor of 10% of construction cost is included.
- Environmental review costs (e.g., CEQA) are not included into the cost estimate.
- Land acquisition costs are not included in the cost estimate.
- Groundwater monitoring well installation cost is not included into the cost estimate.
- Operation, maintenance and monitoring costs including groundwater sampling and analysis are not included into the cost estimate.

Reclamation Plan

Table 7-1 presents a prioritized list of the proposed reclamation projects. The locations of the projects are shown in Figure 7-1. The proposed projects rely on delivery of reclaimed water to agricultural and industrial users. Priority was assigned to the projects based on a property owner's willingness to use the reclaimed water, cost of the project per acre of land (not including land purchase), availability of State or Federal grants for project construction, and the potential for grouping projects near a logical pipeline alignment. Cost of land was not included in the analysis, as some agricultural property owners might be willing to sign long term agreements with the City for reclaimed water use.

Eight projects have been identified: one industrial project and seven agricultural projects. Project 2 serves the industrial users located in the Sunset Industrial Area. It is anticipated that additional industrial users will benefit from the construction of Project 2 as the Sunset Industrial Area develops. Projects 3 through 7 provide irrigation water for the existing rice fields and pastures. Implementation of best management practices (BMPs) designed to minimize mosquito production on rice fields will be required for these projects in addition to the proper reclaimed water management practices (See Appendix C, DHS letter to the City of Lincoln). Project 1 and 8 utilizes reclaimed water for irrigation of pasture and field crops. Each of the agricultural projects includes construction of the transmission pipeline and onsite improvements including grading, irrigation system, storage reservoir(s), and tail water collection system.

The cost of the agricultural recycled water projects varies from $3,100 to $16,800 per acre of land used. Projects 1 through 5 would accommodate City of Lincoln growth, i.e. wastewater ADWF rate up to 12 MGD. Projects 6 through 8 might then be used for regional expansion up to approximately 25 MGD of ADWF.

In the unlikely event that DHS reverses its position on use of the tertiary effluent for rice irrigation or implementation of the mosquito control BMPs proves to be cost prohibitive, the projects described in Table 7-1 should be completed in the following order:

1. Project 1
2. Project 2
3. Project 8
4. Project 3
5. Project 5
6. Project 6
7. Project 7
8. Project 4

In addition, all existing rice fields identified in Table 7-1 will have to be re-graded and converted to pastures. Analysis shows that re-grading of the existing rice fields and construction of the on-site flood irrigation can be very expensive. The re-grading and on-site flood irrigation construction for the Warm Springs property acquired in 2002 cost approximately $9,500 per acre. The re-grading cost will raise the cost of agricultural projects to $7,500 - $16,800 per acre. In addition, re-grading of the fields would most likely require that the City purchase the land. Current landowners will have limited economic incentive to convert existing rice fields to pasture or other non-rice crop. This disposition has been borne out by discussions with several property owners and irrigators in the vicinity of the WWTRF.

Table 7-1

PROPOSED PROJECTS AND COST ESTIMATE FOR RECLAMATION PROJECTS

Project Priority	Proposed Property / APN (usable acres)	Transmission Pipeline Alignment/Cost	Required On-Site Improvements	Estimated Project Cost[(a)(b)]	Estimated Peak Water Use
1	017-061-065 017-061-066 017-061-067 (190 Acres)	Construct 5,200 ft 24" pipe along Fiddement Rd. to E. Catlett Rd., construct 12" pipe to the property ($2.2 mil)	Improve existing fields for reclaimed water use. Construct on-site distribution pipes, booster pumps, storage reservoir (1), and tail water collection and pumping system.	$3,200,000[(c)]	1.53 MGD
2	Rio Bravo Power Plant MRF and Landfill Livingston Concrete	Construct 13,000 ft of 12" pipe along Athens Road, east of Fiddement Rd. ($2.4 mil)	Improvements will be completed by the industrial property owners if necessary.	$2,400,000	0.56 MGD
3	021-280-053 021-140-004 (230 Acres)	Use WWTRF Outlet Pipe – 30" pipe (N/A)	Improve existing rice fields for reclaimed water use. Construct on-site tail water collection and pumping system. Use WWTRF storage reservoir.	$700,000	2.37 MGD
4	021-082-013 021-500-001 021-261-002 021-082-008 021-082-010 (700 Acres)	Construct 8,100 ft of 24" pipeline north of Moore Rd. Easement required ($1.55 mil)	Improve existing rice fields for reclaimed water use. Construct on-site storage reservoir (3) and tail water collection and pumping system.	$3,700,000	7.22 MGD
5	021-082-015 (180 Acres)	Extend Outlet Pipe by 3,500 ft along Moore Road (West) – 30" pipe ($1.1 mil)	Improve existing rice fields for reclaimed water use. Construct on-site storage reservoir (1) and tail water collection and pumping system.	$1,700,000	1.86 MGD
6	021-140-013 021-140-017 (700 Acres)	Extend Outlet Pipe by another 7,500 along Moore Road (West) - 30" pipe ($2.34 mil)	Improve existing rice and pasture fields for reclaimed water use. Construct on-site storage reservoir (4) and tail water collection and pumping system.	$4,600,000	6.99 MGD
7	021-081-016 021-090-047 021-030-019 (270 Acres)	Extend Outlet Pipe by another 4,500 along Moore Road (West) – 20" pipe ($950,000)	Improve existing rice and sudan grass fields for reclaimed water use. Construct on-site storage reservoir (1) and tail water collection and pumping system.	$1,800,000	2.37 MGD
8	021-140-018 021-140-021 021-140-020 021-140-006 021-140-007 021-140-008 (760 Acres)	Construct 15,000 ft of 24" pipe along E. Catlett Road, west of Fiddement Rd. ($3.74 mil)	Improve existing pastures for reclaimed water use. Construct on-site storage reservoirs (4) and tail water collection and pumping system.	$6,200,000	6.11 MGD

[(a)] Cost based on ENR 20-Cities Construction Cost Index of 6410.
[(b)] Land purchase cost is not included.
[(c)] Long-term lease contract w/ Placer County option might be available for these parcels.

Conclusions

Three conclusions derived from this study will influence decision to pursue water reclamation projects:

1. There is adequate land availabile within the study area to recycle up to 25 MGD of average dry weather flow. To recycle 3.3 MGD (ADWF) of wastewater, approximately 320 irrigable acres of rice or 410 irrigable acres of pasture are required. Correspondingly, 12 MGD would require 1,150 acres of rice or 1,500 irrigable acres of pasture, and 25 MGD would require 2,460 acres of rice or 3,130 irrigable acres of pasture.

2. Surface water is readily available within the Study Area during average rainfall years through Placer County Water Agency (PCWA) and South Sutter Water District (SSWD) to the customers located along the existing water conveyance facilities. Groundwater is used to supplement surface water during drought years. The price of surface water in the study area is relatively low, typically between $5 to $25 per acre-foot.

3. Year-round availability and reliability of reclaimed water deliveries make it an attractive alternative for industrial and agricultural users. However, regulatory restrictions (e.g., tail water and stormwater containment, groundwater monitoring, set back requirements) have to be properly addressed by the reclaimed water provider and by the end users in order to implement reclamation projects.

Several projects have been identified and prioritized. They provide significant wastewater reuse opportunities. The following conclusions and recommendations discuss the implementation of those projects:

1. Although construction and operation of cooling towers and delivery via Auburn Ravine appears to be the most cost effective approach to the reclamation and delivery of recycled wastewater, limited experience is available in making use of cooling towers for wastewater applications. Additionally, significant power requirements associated with wastewater cooling and the uncertainty associated with long-term power availability and cost might reduce the economic advantages of this alternative. Because of this significant uncertainty, at this time it is recommended that the land purchase/lease and construction of delivery pipelines option be pursued.

2. Irrigation of rice is water intensive, will reduce disposal land area requirements, and will allow significant cost savings associated with the construction of the reclaimed water distribution system and farming areas preparation and grading.

3. Industrial projects provide for year-round reclamation potential, which maximizes total volume of reclaimed water used for beneficial purposes.

4. Current design of the WWTRF includes storage basins sized for emergency conditions, such as treatment process failures. If the City desires to maximize reclamation by storing treated water during the winter for agricultural re-use during the irrigation season, additional storage basins have to be constructed.

5. Periodic re-evaluation of cooling tower construction feasibility is recommended as WWTRF expansions are considered.

6. A partnership of interested stakeholders is needed to develop and implement Phase II and Phase III of the Reclamation Study. Potential stakeholders include the City of Lincoln, PCWA, SSWD, Placer County, Sutter County, State Water Resources Control Board, Regional Water Quality Control Board, Department of Health Services, local mosquito abatement district, land developers and agricultural and industrial reclaimed water users.

APPENDIX A

Assumptions in the FAO Guidelines

Assumptions in the FAO Guidelines

The water quality guidelines in Table 4-1 are intended to cover the wide range of conditions encountered in irrigated agriculture. Several basic assumptions have been used to define their range of usability. If the water is used under greatly different conditions, the guidelines may need to be adjusted. Wide deviations from the assumptions might result in wrong judgments on the usability of a particular water supply, especially if it is a borderline case. Where sufficient experience, field trials, research or observations are available, the guidelines may be modified to fit local conditions more closely.

The basic assumptions in the guidelines are:

Yield potential: Full production capability of all crops, without the use of special practices, is assumed when the guidelines indicate no restrictions on use. A "restriction on use" indicates that there may be a limitation in choice of crop, or special management may be needed to maintain full production capability. A "restriction on use" does not indicate that the water is unsuitable for use.

Site Conditions: Soil texture ranges from sandy-loam to clay-loam with good internal drainage. The climate is semi-arid to arid and rainfall is low. Rainfall does not play a significant role in meeting crop water demand or leaching requirement. (In a monsoon climate or areas where precipitation is too high for part or all of the year, the guideline restrictions are too severe. Under the higher rainfall situations, infiltrated water from rainfall is effective in meeting all or part of the leaching requirement.) Drainage is assumed to be good, with no uncontrolled shallow water table present within 2 metres of the surface.

Methods and Timing of Irrigation: Normal surface or sprinkler irrigation methods are used. Water is applied infrequently, as needed, and the crop utilizes a considerable portion of the available stored soil-water (50 percent or more) before the next irrigation. At least 15 percent of the applied water percolates below the root zone (leaching fraction [LF]$\geq$15 percent). The guidelines are too restrictive for specialized irrigation methods, such was localized drip irrigation, which results in near daily or frequent irrigations, but are applicable for subsurface irrigation if surface applied leaching satisfies the leaching requirements.

Water Uptake by Crops: Different crops have different water uptake patterns, but all take water from wherever it is most readily available within the rooting depth. On average about 40 percent is assumed to be taken from the upper quarter of the rooting depth, 30 percent from the second quarter, 20 percent from the third quarter, and 10 percent from the lowest quarter. Each irrigation leaches the upper root zone and maintains it at a relatively low salinity. Salinity increases with depth and it's greatest in the lower part of the root zone. The average salinity of the soil-water is three times that of that applied water and is representative of the average root zone salinity to which the crop responds. These conditions result from a leaching fraction of 15-20 percent and irrigation that are timed to keep the crop adequately watered at all times.

Salts leached from the upper root zone accumulate to some extent in the lower part but a salt balance is achieved as salts are moved below the root zone by sufficient leaching. The higher salinity in the lower root zone becomes less important if adequate moisture is maintained in the upper, "more active" part of the root zone and long-term leaching is accomplished.

Restriction on Use: The "Restriction on Use" shown in table 1 is divided into three degrees of severity: none, slight to moderate, and severe. The divisions are somewhat arbitrary since change occurs gradually and there is no clearcut breaking point. A change of 10 to 20 percent above or below a guideline value has little significance if considered in proper perspective with other factors affecting yield. Field studies, research trials and observations have led to these divisions, but management skill of the water user can alter them. Values shown are applicable under normal field conditions prevailing in most irrigated areas in the arid and semi-arid regions of the world.