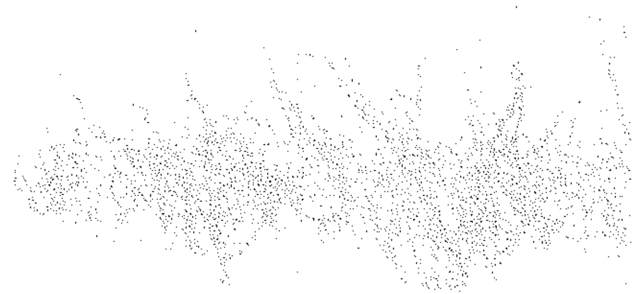
APPENDICES

APPENDIX A

SKF RECYCLED WATER FEASIBILITY STUDY - 2003

Recycled Water Feasibility Study

October 2003



Prepared for:

SELMA-KINGSBURG-FOWLER
COUNTY SANITATION DISTRICT

Prepared by:

WHITLEY, BURCHETT *& Associates* ◦ *Walnut Creek, California*

WHITLEY BURCHETT & *Associates*

October 8, 2003

David Michel, General Manager
Selma-Kingsburg-Fowler County Sanitation District
11301 East Conejo Avenue
Kingsburg, CA 93631

Subject: SKF Recycled Water Feasibility Study

Dear David,

Whitley Burchett & Associates is pleased to submit 25 copies of the SKF Recycled Water Feasibility Study. This report has been prepared on behalf of the District to fulfill Provision F.18 of the District's California Regional Water Quality Control Board Waste Discharge Requirements Order No. 5-01-255.

Provision F.18 states:

"By October 15 2003, the Discharger shall submit a feasibility study that describes opportunities to recycle effluent on agricultural lands where fresh water is currently used. The study shall also include implementation schedules for each identified opportunity."

Information contained within this report is the product of the study team selected by the District. The team studied and assessed the quantity and quality of recycled water which could be available, the level of treatment which could be required, potential water rights issues for users outside of the District's service area, the support of the local water agencies, and the potential recycled water users. The study of potential recycled water users included a market assessment which entailed of separate meetings with three local major food processing companies who would be impacted by the project. Key representatives from each industry indicated that they believe that there is a negative perception of recycled water in the domestic and international marketplaces. Consequently, the local food packing industries would suffer if the recycled water project was implemented. Because the food processors will not accept crops grown with recycled water, it is not feasible to use recycled water for irrigation of agricultural areas in the vicinity of the SKF treatment plant.

The collaboration and efforts of the study team have been invaluable in the development of this study. We have enjoyed the process by which this report has come together and look forward to future work with the District.

Sincerely,
WHITLEY BURCHETT & *Associates*

Robert D. Whitley, P.E.
District Engineer

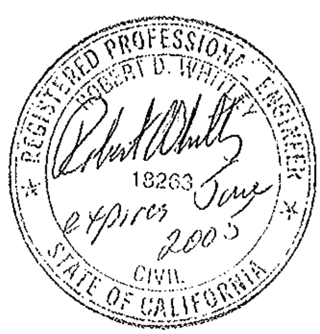
Anita C. Jain
Associate Engineer

Civil/Environmental Engineers
36 Quail Court Walnut Creek California 94596
tel: 925•945•6850 fax: 925•945•7415

Recycled Water Feasibility Study

Prepared for:
Selma-Kingsburg-Fowler
County Sanitation District

Prepared by:
Whitley Burchett & Associates



October 2003

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1.1 INTRODUCTION

The Selma-Kingsburg-Fowler County Sanitation District (SKF or District) is submitting this report in accordance with Provision F.18 of the California Regional Water Quality Control Board Central Valley Region (RWQCB or Regional Board) Waste Discharge Requirements Order No. 5-01-255. This report has been prepared to determine the feasibility of a recycled water project for agricultural irrigation.

Provision F.18 states:

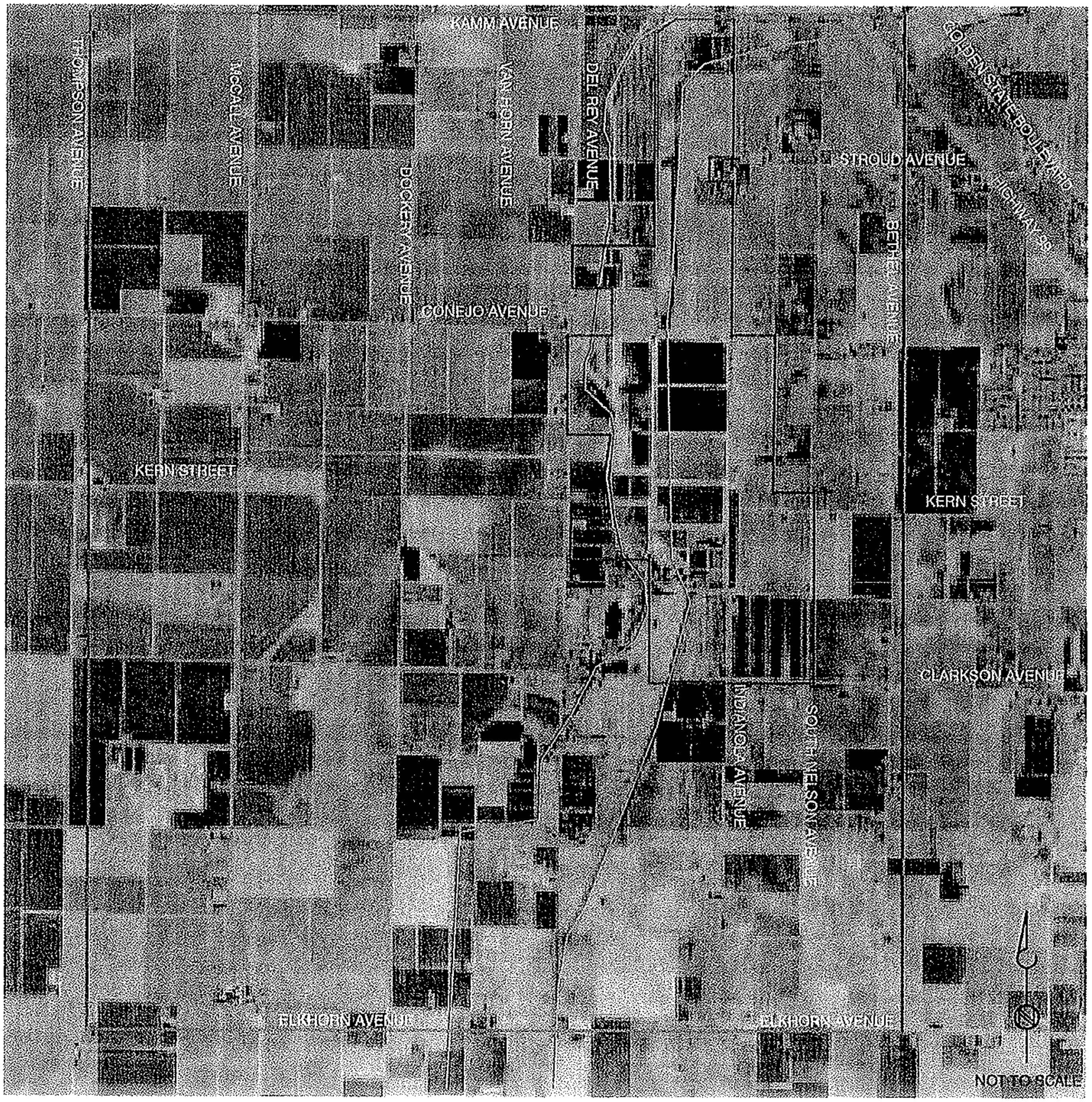
"By October 15 2003, the Discharger shall submit a feasibility study that describes opportunities to recycle effluent on agricultural lands where fresh water is currently used. The study shall also include implementation schedules for each identified opportunity."

The SKF Wastewater Treatment Plant (WWTP or plant) treats wastewater to meet requirements for undisinfected secondary treated effluent. Treated effluent is currently disposed of on-site at the percolation evaporation disposal ponds. The SKF WWTP is surrounded by acres of agricultural lands currently irrigated with fresh water. As a beneficial reuse option, SKF is studying the opportunities to reuse effluent on agricultural lands surrounding the WWTF. For this report, the study area is limited to agricultural lands located near the SKF plant. The boundaries of the study area are indicated in Figure 1.1.

1.2 STUDY TEAM AND ACKNOWLEDGEMENTS

In preparation of this report, a recycled water feasibility study team was formed to bring together the knowledge and experience of individuals familiar with the treatment plant, as well as the land and people which surround it. The study team was comprised of the following individuals:

- Mr. David Michel, Mr. Walt Schmidt, Mr. Ben Munoz, Mr. Bob Currie, and Mr. Gabe Jimenez of Selma-Kingsburg-Fowler County Sanitation District;
- Mr. Nat Dellavalle of Dellavalle Laboratory, Inc.;
- Mr. Randy McFarland of J. Randall McFarland Communications;
- Mr. Richard Hargrove; and
- Mr. Bob Whitley, Ms. Anita Jain, Mr. Mike Barnes, and Ms. Teresa Herrera of Whitley Burchett & Associates.



LEGEND

- SKF BOUNDARY
- SELMA COLONY CANAL
- WARD DRAIN
- STUDY AREA BOUNDARY

WHITLEY BURCHETT & ASSOCIATES, Inc. Walnut Creek, California (925) 945-6850	SELMA-KINGSBURG-FOWLER COUNTY SANITATION DISTRICT RECYCLED WATER FEASIBILITY STUDY STUDY AREA BOUNDARY	FIGURE 1.1

2 BACKGROUND

2.1 WASTEWATER TREATMENT PLANT

The SKF WWTP collects and treats municipal and industrial sewage from the cities of Selma, Kingsburg, Fowler, and unincorporated areas of Fresno County. Discharge from the wastewater treatment plant is permitted under RWQCB Waste Discharge Order No. 5-01-255. The plant currently treats an average of approximately 3-mgd of influent wastewater.

2.1.1 Treatment Plant Location

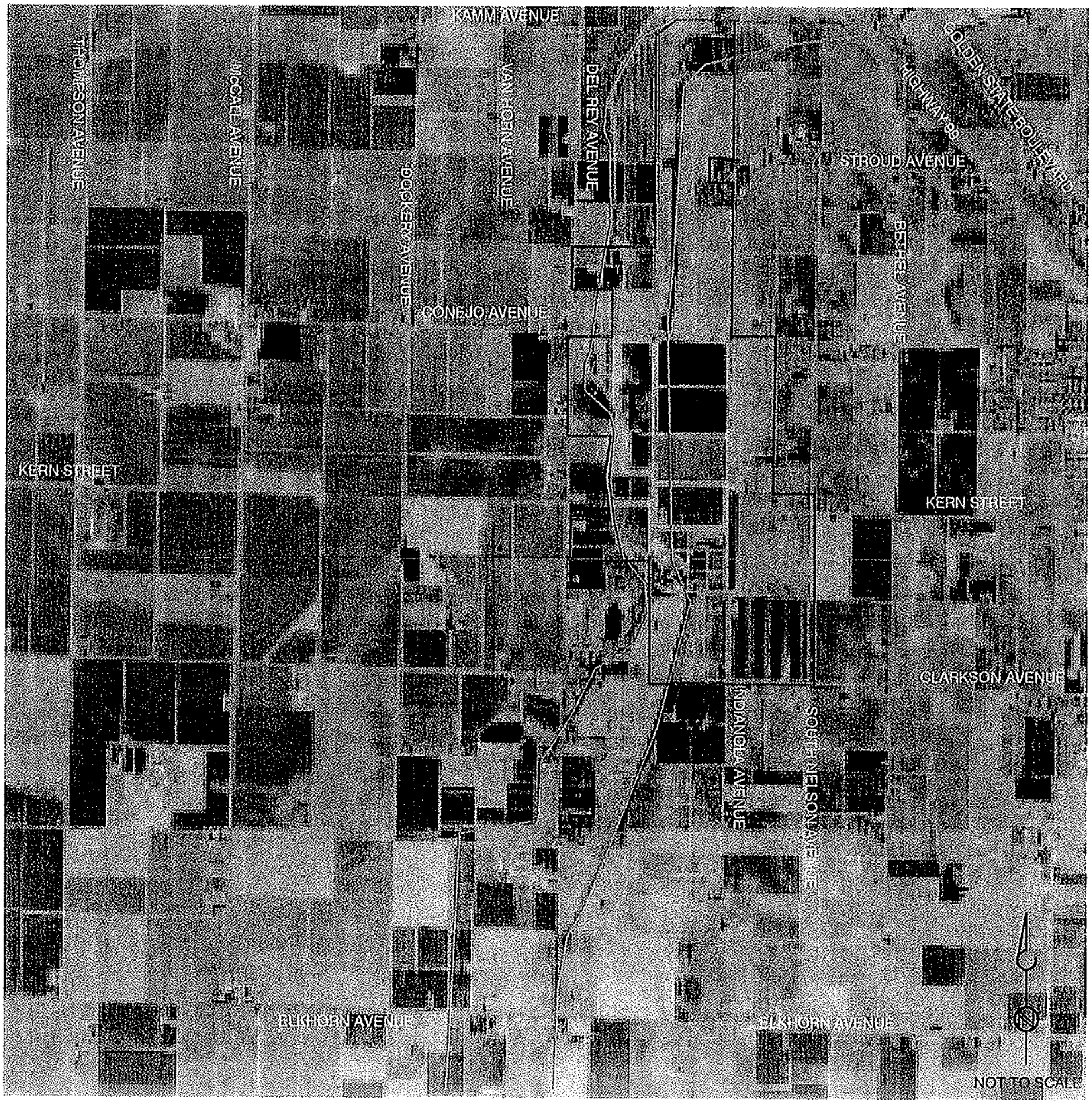
The SKF WWTP is located two miles west of Kingsburg in Fresno County. The plant is comprised of approximately 535 acres of land and is surrounded by agricultural fields used for the commercial production of primarily raisin grapes, peaches, plums, and walnuts. Bordering the plant on its west, is the Selma Colony Canal. Crossing directly beneath the plant through a closed pipeline, is the Ward Drain. The canals are further described in a later section of this report. The SKF boundaries and the relation of the neighboring canals are depicted in Figure 2.1.

2.1.2 Treatment Plant Facilities

The treatment process at the plant is an extended aeration activated sludge system, consisting of three equalization basins, headworks, two aerated grit chambers, scum removal area, three aeration basins (one of which is used as an aerobic digester), four clarifiers, two dual media filters, one facultative pond used as an aerobic digester, one dissolved air floatation thickener, one gravity thickener, two fine bubble aerobic digesters, six disposal ponds (the sixth pond primarily reserved as a temporary pond), and 39 paved sludge drying beds. The plant layout is illustrated in Figure 2.2.

2.1.3 Secondary Treatment Process

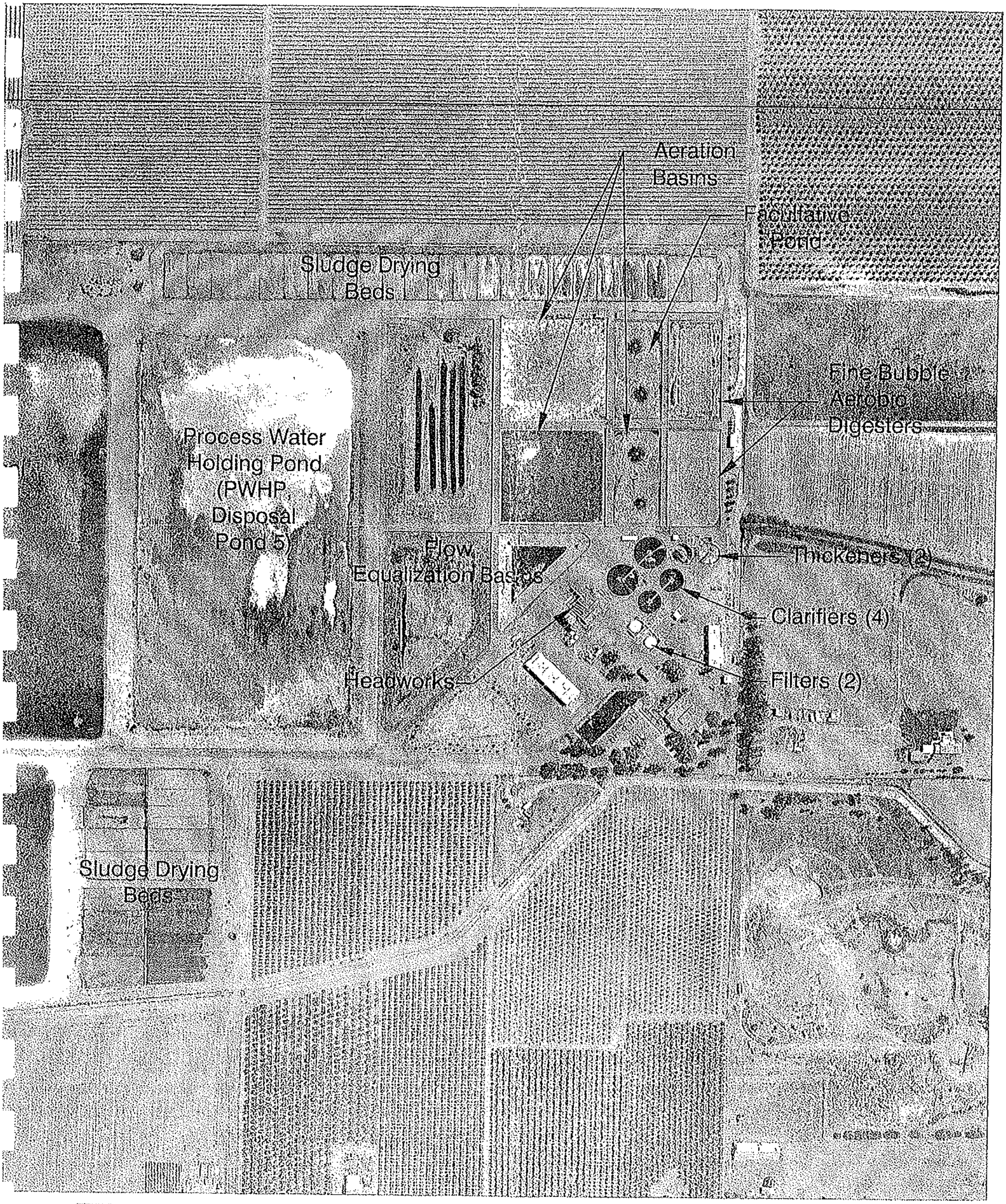
Wastewater flow through the treatment facilities is as follows: headworks, grit chambers, scum collection, aeration, clarifier, discharge to disposal pond. Secondary effluent is discharged to the disposal ponds where it is removed by evaporation and percolation. Characteristics of the disposal ponds are listed in Table 2.1.



LEGEND

- SKF BOUNDARY
- SELMA COLONY CANAL
- WARD DRAIN

WHITLEY BURCHETT & ASSOCIATES, Inc. Walnut Creek, California (925) 945-6850	SELMA-KINGSBURG-FOWLER COUNTY SANITATION DISTRICT RECYCLED WATER FEASIBILITY STUDY WASTEWATER TREATMENT PLANT LOCATION	FIGURE 2.1



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(925) 945-6850

SELMA-KINGSBURG-FOWLER COUNTY SANITATION DISTRICT
RECYCLED WATER FEASIBILITY STUDY

FIGURE 2.2

Table 2.1 Disposal Pond Characteristics

Pond Number	Pond Area[a] (acre)	Maximum Operating Depth[b] (ft)	Maximum Available Capacity (acre-ft)
1	18.27	12.89	235.50
2	17.79	12.89	229.32
3	16.92	13.33	225.58
4	26.62	7.19	191.38
5 (PWHP)	14.42	13.58	195.87
Total Ponds 1-4			881.79
Total Ponds 1-5			1,077.65

Notes:
[a] "Disposal Pond Capacity Analysis and Nutrient Balance Technical Report – As Approved", Whitley Burchett & Associates, April 2002.
[b] Source: SKF November 2002 monthly monitoring report to the RWQCB. As noted in the monthly monitoring report, surveying of the disposal ponds was performed on January 20 and 30, 2002.

2.1.4 Industrial Users and Pre-Treatment Program

Industrial flow to the treatment plant makes up approximately 20% of the total plant flow (the remaining 80% comprised of mainly residential flow). The highest influent flow typically occurs during the month of August, the month that local canneries are in operation. SKF receives wastewater from twelve significant industrial dischargers and has in effect an approved pre-treatment program.

2.2 WATER SUPPLIES AND DISTRICTS

Farmers in the areas surrounding the treatment plant receive irrigation water from the Consolidated Irrigation District. These farmers rely on both surface water and ground water supplies for irrigation water. At times when surface water is unavailable, farmers rely on ground water. For farmers without surface water supply, ground water pumped from individual wells is the sole source of irrigation water. Surface water is conveyed to users via a system of irrigation canals which run through the study area. Surface water originates from the Kings River, whose flow is regulated under rights defined in a series of Kings River agreements.

Other local water agencies which may be impacted by the recycled water project are the Kings River Water Association and the Kings River Conservation District. Because of the influence that a recycled water project would have on all three agencies, it was important to inform the agencies of the study and gain their feedback. The following paragraphs describe each agency and its relation to the study area. Each agency's view on the concept of the study is included in subsequent sections of this report.

2.2.1 Kings River Water Association (KRWA)

The Kings River Water Association (KRWA), in conjunction with the Kings River Watermaster, administer the water rights defined in the Kings River agreements. The agreements establish the scheduled water entitlements of the Consolidated Irrigation District, and other KRWA member districts and canal companies, based on the river's mean daily calculated natural flow.

2.2.2 Consolidated Irrigation District (CID)

The Consolidated Irrigation District (CID) is a public agency that delivers surface water, diverted from the Kings River, as an agricultural water supply to those within its service area. At times when Kings River floodwater is available, CID provides this water for ground water recharge. The CID service area encompasses portions of Fresno, Kings and Tulare counties, and includes rural areas around Kingsburg, Selma, Fowler, Parlier, Sanger, Del Rey, Monmouth and Caruthers[1]. The Kings River provides CID with its surface water supply. During an average year, CID is able to supply Kings River water to its customers for approximately 3 to 4 months. During low flow years, they may only be able to deliver Kings River water for 3 to 4 weeks.

While there are many CID properties with access and rights to surface water deliveries, there is also a large number that do not have access nor rights. Parcels without rights to surface water are indicated on Figure 2.3. Agricultural users on the indicated parcels rely solely on ground water supplies for irrigation.

2.2.3 Kings River Conservation District (KRCD)

The Kings River Conservation District (KRCD) is a public agency that has no surface water rights or surface water delivery system. Irrigation users in this area rely on ground water, and heavy pumping over the years has resulted in overdraft conditions. The KRCD is actively addressing ground water overdraft problems. In addition, as part of its responsibilities the KRCD is assisting with water conservation throughout the study area, including areas that receive surface water.

An area within the KRCD service area, referred to as the Elkhorn Area for this study, is considered as a potential recycled water customer for this study. Providing recycled water as a water supply to this area would help to reduce overdraft within the KRCD boundaries. The Elkhorn Area is within a Ground Water Management Area administered by KRCD.

[1] Source: "Downstream on the Selma Colony", a memo prepared by Randy McFarland, February 27, 2003 for this study.

LEGEND

SKF BOUNDARY

SELMA COLONY CANAL

WARD DRAIN

SITES WITHOUT SURFACE WATER RIGHTS

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SELMA-KINGSBURG-FOWLER
COUNTY SANITATION DISTRICT
RECYCLED WATER FEASIBILITY STUDY
SITES WITHOUT SURFACE WATER RIGHTS

FIGURE 2.3

2.3 CANAL NETWORK

The agricultural distribution network in the surrounding areas of the plant is comprised of a system of canals, with some sections of the canals piped, but most sections uncovered. The two main canals which lie in the study area are the Ward Drainage Canal and the Selma Colony Canal. Both canals belong to the CID. In many instances, the canals pass through residential areas and are susceptible to human contact.

2.3.1 Ward Drainage Canal

The Ward Drainage Canal (Ward Drain) runs approximately eight miles beginning east of Selma and ending at the Cole Slough, southwest of Kingsburg. A portion of the Ward Drain is located directly under the SKF WWTP and is enclosed in a pipeline beneath the plant. Ward Drain was constructed to provide drainage to about 9,000 acres of land. The Ward Drain is still used by the CID for operational spills and during times of high ground water.

Approximately four miles southwest of the SKF WWTP, the Ward Drain empties into the Cole Slough. In that particular reach, Cole Slough functions as the primary branch of the lower Kings River. Thus, this portion of Cole Slough is the principal river channel used to deliver Kings River irrigation water for diversion by 22 of KRWA's 28 member units, as well as the transport of flood releases when required by the U.S. Army Corps of Engineers, from Pine Flat Dam.

The Ward Drain is a tributary network comprised of open channels and closed pipe. Much of the Ward Drain, including open channel portions of the canal, runs through residential areas.

2.3.2 Selma Colony Canal

The Selma Colony Canal begins at the Kingsburg Branch Canal, east of Huntsman and Bethel Avenues and flows along the western boundary of the SKF WWTP. The Selma Colony Canal generally flows south for about 1 ½ miles until terminating at Ward Drain, just south of Elkhorn Avenue and east of Del Rey Avenue. The primary function of the Selma Colony Canal is to deliver irrigation water to farms with surface water irrigation rights. In the event of an operational spill, the water conveyed through the Selma Colony Canal may discharge into the Ward Drain, and thus ultimately into the Kings River.

The Selma Canal is a distribution network comprised of open channels and closed pipe. Much of the Selma Canal, including open channel portions of the canal, runs through residential areas.

2.4 TULARE LAKE BASIN

The purpose of the RWQCB Central Valley Region Water Quality Control Plan for the Tulare Lake Basin is to preserve the integrity of the Tulare Lake Basin (Tulare Basin). The Tulare Basin is approximately 10.5 million acres and receives the bulk of its surface water supply from the Kings River, as well as the Kaweah, Tule, and Kern Rivers. It is one of the most important agricultural centers in the world, with industries such as food processing and packaging (including canning, drying, and wine making) prominent throughout the area[2]. Water demand for these uses are high and in many years exceed the available surface water supplies tributary to or imported for use within the Tulare Basin. To augment the water supply for irrigation, ground water is pumped and utilized for agricultural and industrial uses.

Extensive ground water pumping has resulted in overdraft conditions. Overdraft depletes good quality water supplies and introduces salts from poorer quality aquifers. Additionally, salt accumulation in irrigated soils results from evaporation and crop transpiration removing water from soils, leaving behind an accumulation of salts in the root zone. Salts in the root zone restrict plant growth. Additional amounts of water are added to the soil to force the salts to leach below the root zone, consequently pushing the salts into the ground water. Salinity increases in ground water could ultimately eliminate the beneficial uses of the Tulare Basin.

The most feasible and practical short-term alternative to minimize degradation of the Tulare Basin is to manage the rate of degradation by minimizing salt loads to the ground water body. Use of recycled water would decrease ground water overdraft, consequently reducing salt loading to the ground water. The Tulare Lake Basin Plan encourages reclamation on irrigated crops wherever feasible and that recycled water be used in places where opportunities exist to replace the use of fresh water.

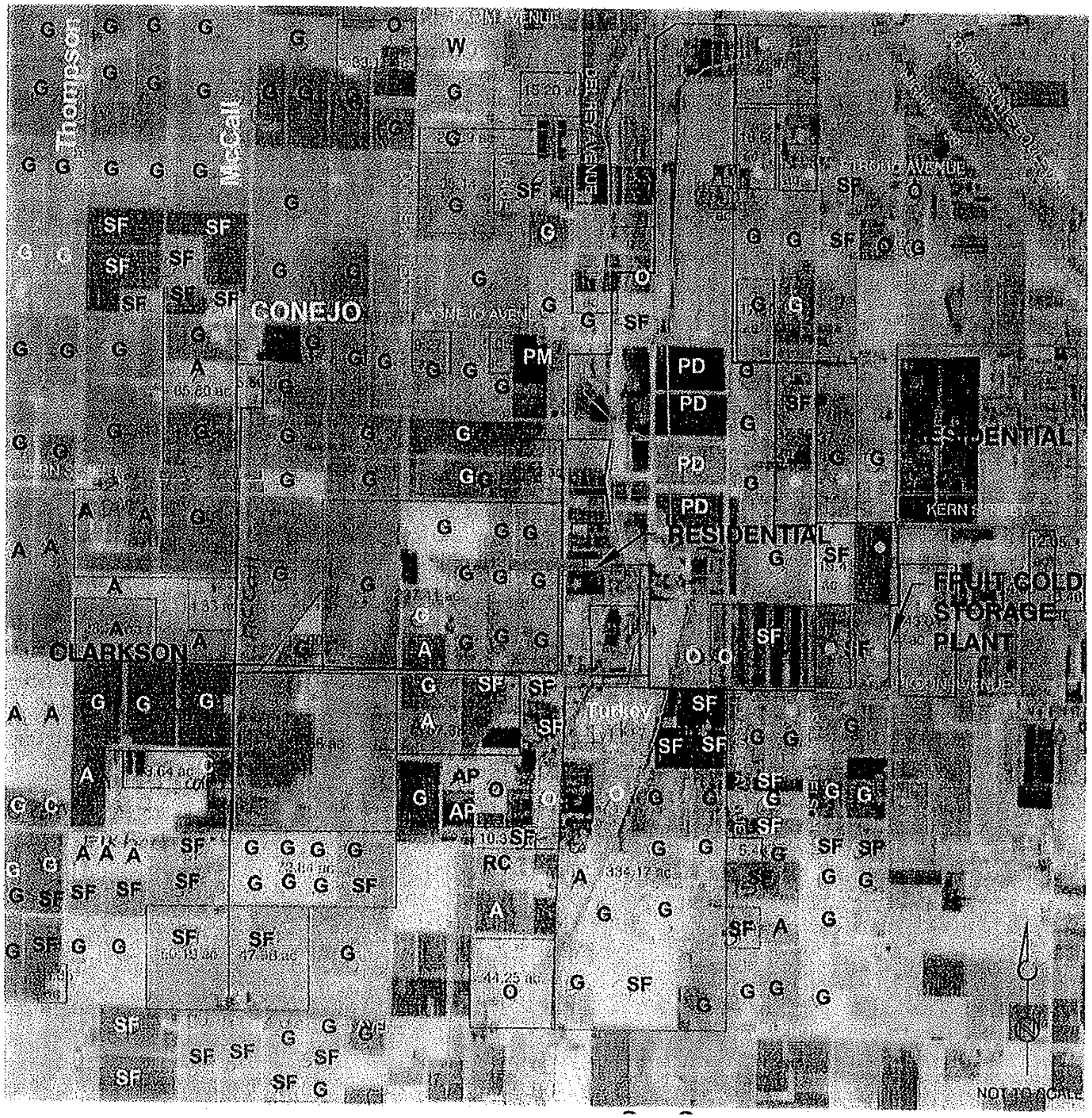
2.5 AGRICULTURAL CROPS

A crop survey[3] of the plant vicinity identified grapes, stone fruit[4], apples, almonds, and walnuts surrounding the SKF plant. The survey covered the area bounded by Kamm Avenue, Elkhorn Avenue, Thompson Avenue, and Bethel Avenue. An aerial photograph with local crops identified is included as Figure 2.4.

2.5.1 Agricultural Irrigation Practice

The majority of irrigation occurs typically for half of the year, during the months of April through September. The most common methods of irrigation in the area are drip and micro irrigation systems. These systems usually include a filtration system to remove

[2] "Water Quality Control Plan for the Tulare Lake Basin Second Edition – 1995", California Regional Water Quality Control Board Central Valley Region
[3] Performed by Dellavalle Laboratory, Inc.
[4] Stone fruit includes peaches, plums, nectarines, and apricots.



LEGEND

A = ALMOND
AP = APPLE
G = GRAPE
C = CORN
O = OPEN
PD = POND
SF = STONE FRUIT
W = WALNUT

SOURCE: DELLAVALLE LABORATORY, INC.
DATE OF CROP SURVEY: AUGUST 14, 2003

WHITLEY BURCHETT & ASSOCIATES, Inc. Walnut Creek, California (925) 945-6850	SELMA-KINGSBURG-FOWLER COUNTY SANITATION DISTRICT RECYCLED WATER FEASIBILITY STUDY SURVEY OF CROPS AROUND SKF PLANT	FIGURE 2.4

particles such as seeds, weeds, sand, and algae, that have made their way into the open channels during surface water transport. Drip and micro irrigation systems allow for irrigation at agronomic rates, and are more efficient methods than flood irrigation. Furrow irrigation is also used in the area.

3 WATER QUALITY

3.1 RECYCLED WATER REGULATORY REQUIREMENTS

Recycled water projects are required to comply with Water Recycling Criteria established in Title 22 of the California Code of Regulations, Division 4, Chapter 3, hereafter referred to as Title 22. Title 22 defines the level of wastewater treatment required for the various types of allowable uses.

Under Title 22, undisinfected secondary treated water is permitted for irrigation of orchards, vineyards, and various other approved uses. However, a recent letter by the Food and Drug Branch (FDB) of the Department of Health Services (DHS) recommends a treatment level higher than undisinfected secondary effluent for irrigation of orchards and vineyards. In its letter dated January 8, 2003, the FDB recommends that orchards and vineyards be irrigated with a wastewater treated to meet the requirements of a disinfected secondary-2.2 effluent. A copy of the letter is included in Appendix A.

Historically, the FDB has provided guidance specifying a lag time between the time that an orchard or vineyard is irrigated with recycled water, and the time that crops are harvested. The amount of time recommended has varied between 7 and 45 days, the longer timeframes associated with the application of undisinfected secondary treated effluent on soils used for growth of orchards and vineyards. The recommended lag time also depends on the local soil and environmental conditions. If a recycled water program is implemented, it is recommended that sufficient time be allowed between crop irrigation and crop harvesting so that at the time that crops are harvested, soils are not completely saturated.

Although not mandatory, as a result of the recent guidance, as well as the study team's anticipation of public acceptance of recycled water use for agricultural irrigation, the team decided to study disinfected secondary effluent which meets Title 22 criteria for disinfected secondary-2.2 recycled water. The FDB may enforce a specified lag time between time of irrigation with recycled water and the harvesting of crops.

3.1.1 Title 22

Per Title 22, disinfected secondary-2.2 recycled water means:

"...recycled water that has been oxidized and disinfected so that the median concentration of total coliform bacteria in the disinfected effluent does not exceed a most probable number (MPN) of 2.2 per 100 milliliters utilizing the bacteriological results of the last seven days for which analyses have been completed, and the number of total coliform bacteria does not exceed an MPN of 23 per 100 milliliters in more than one sample in any 30 day period."

Besides irrigation of orchards and vineyards, disinfected secondary-2.2 recycled water is also acceptable for *"the surface irrigation of food crops where the edible portion is produced above ground and not contacted by the recycled water"*. Additional acceptable uses are included in Title 22.

3.2 EXISTING GROUND WATER WELLS

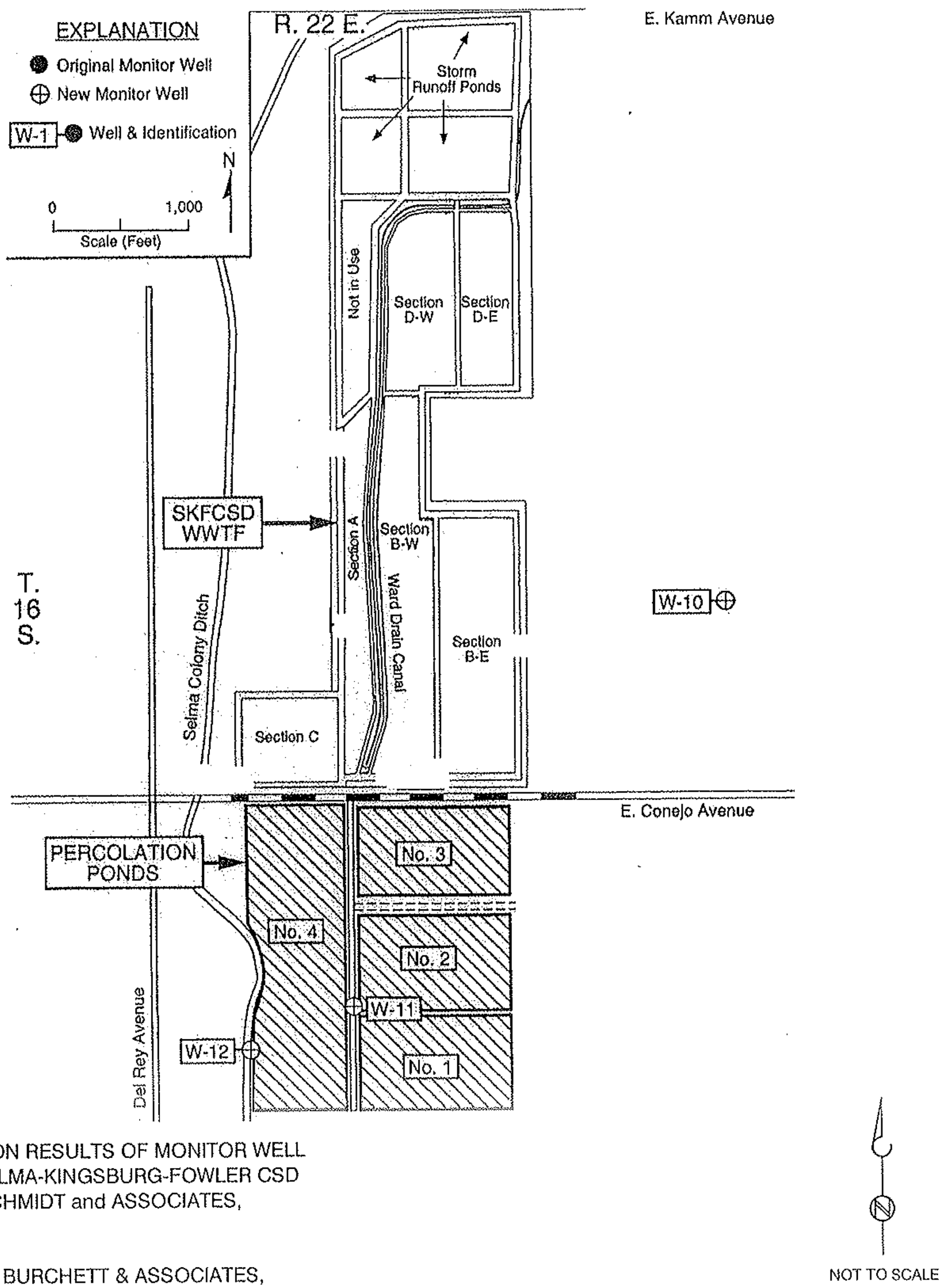
There are three monitoring wells located at the plant, ranging in depth from 60 to 190 feet. The location of each is shown in Figure 3.1. Monitoring well 10 (W-10) is located upgradient of the plant. W-11 is located at the mound of the disposal ponds, and W-12 is located on the western edge of disposal pond 4. Ground water generally flows in the southwest direction.

3.3 SECONDARY EFFLUENT WATER QUALITY

Water quality parameters of concern for irrigation of agricultural products are primarily specific to a particular crop. Overall, the primary parameters of concern are sodium absorption ratio (SAR) values, nitrogen, and boron.

Evaluation of SKF secondary effluent and ground water quality was performed by Dellavalle Laboratory, Inc. The evaluation is described in the report "Water Quality and Quantity for Selma-Kingsburg-Fowler County Sanitation District" (Water Quality and Quantity Report) and is attached as Appendix B.

Secondary effluent (sampled before discharge to the disposal ponds) data collected between 2002-2003 and ground water samples collected at three monitoring wells at and around the plant were evaluated. Table 3.1 lists typical parameters critical to irrigation with recycled water, historic SKF effluent values, and an assessment of quality of the SKF effluent for each parameter. Overall, the quality of the SKF effluent is similar to the quality of the ground water.



SOURCE: "REPORT ON RESULTS OF MONITOR WELL INSTALLATION AT SELMA-KINGSBURG-FOWLER CSD WWTF", KENNETH SCHMIDT and ASSOCIATES, FEBRUARY 2002.

MODIFIED: WHITLEY BURCHETT & ASSOCIATES, SEPTEMBER 24, 2003. MODIFIED TO DELETE OLD MONITORING WELLS FROM FIGURE.

WHITLEY BURCHETT & ASSOCIATES, Inc. Walnut Creek, California (925) 945-6850	SELMA-KINGSBURG-FOWLER COUNTY SANITATION DISTRICT RECYCLED WATER FEASIBILITY STUDY MONITORING WELL LOCATIONS	FIGURE 3.1

Table 3.1 SKF Effluent and Ground Water Quality Analysis[a]

		Effluent[b]		Ground Water[c]	
	Units	Values	interpretation	Values	interpretation
EC	dS/m	0.6	OK	0.4 to 0.7	OK
SAR		3.8 to 5.6	Moderate-high	3 to 18	Moderate-excessive
Na	meq/L	3.1 to 3.7	OK - moderate	1.0 to 4.0	OK - moderate
Cl	meq/L	1.6 to 1.9	OK	0.4 to 1.9	OK
CO_3+HCO_3	meq/L	2.4 to 3.2	Moderate	2.8 to 6.0	Moderate
B	mg/L	0.1 to 0.2[d]	OK	0.1 to 0.3	OK
N	mg/L	4.9 to 16	Moderate	0.1 to 18	OK - moderate
	lbs/ac-ft	13 to 44		0.3 to 49	

Notes

[a] Source: "Recycled Water Feasibility Study Water Quality and Quantity ", Dellavalle Laboratory, Inc., August 19, 2003.

[b] Effluent samples collected before discharge to the disposal ponds. Values shown are the ranges for samples collected from January 2002 through April 2003.

[c] Ground Water samples collected from Monitoring Wells 10, 11 and 12. Values shown are the ranges for the three wells for sampling performed from April 2002 through April 2003.

[d] In July 2002, the effluent boron concentration reported was 3.7 mg/L. This detection was believed to have been an anomaly. Sampling for boron was increased for the period of May through August. Sampling was conducted once in May and twice during the months of June, July, and August. The results were in the range of 0.1 to 0.2 as shown in the table above, and confirmed that the 3.7 mg/L detection must have been an anomaly.

3.3.1 Sodium Absorption Ratio (SAR)

The SAR indicates the probable influence that the sodium ion has on soil properties. The SAR is a calculated value determined by sodium, calcium, and magnesium concentrations. The SAR values may also be adjusted to include a more correct estimate of calcium remaining in the soil following irrigation.

At values greater than 3, the SAR value is considered high and may reduce infiltration rates. High SAR values may be offset by the addition of gypsum. The addition of gypsum can beneficially increase salinity and reduce the SAR. The amount of gypsum required depends upon the physical properties of the soil as well as the soil chemistry.

3.3.2 Nitrogen

Nitrogen levels in the SKF plant effluent may be too high for irrigation of grape vineyards. To reduce nitrogen loading to the soils, nitrogen fertilization could be reduced such that the nitrogen content of the recycled water would equal the loading expected from fertilization. Nitrogen loading is further discussed in the appended Water Quality and Quantity Report.

4 SUPPLY AND DISTRIBUTION SYSTEMS

4.1 RECYCLED WATER TREATMENT SYSTEM

As a result of regulatory guidance, and in anticipation of public concern, the study team decided to include disinfection in the evaluation process. This study assumes that filtration and disinfection shall be provided such that the resulting water quality meets the standards prescribed in Title 22, standards for disinfected secondary-2.2 recycled water. Disinfection would occur prior to discharge to the disposal ponds.

Disinfection by either chlorination or ultra-violet light (UV) are considered for this feasibility study. The types of filters considered in this study are dual media filtration (DMF) and the continuous backwash filter. Cost estimates for the treatment facilities are included in section 5 of this report.

4.2 PROJECT CONSTRAINTS

Project constraints were also established during the team meetings. The following project constraints were developed:

- Recycled water would be distributed to users within Fresno County only; and
- Avoid distribution options that would require a National Pollutant Discharge Elimination System permit from the RWQCB.

4.3 AVAILABLE RECYCLED WATER QUANTITY

The SKF treatment plant has five percolation ponds on-site, with a total volume of 1,100 acre-feet (AF)[5]. Undisinfected secondary effluent is discharged to the percolation ponds for disposal via methods of evaporation or percolation. For this study, it is assumed that all treated wastewater discharged to the disposal ponds is available as recycled water.

Recycled water can be pumped directly from the disposal pond, or extracted from the aquifer underlying the ponds. Storage would be provided by the aquifer. The annual volume to be extracted from the aquifer would not exceed the annual volume of water that percolates to the aquifer.

Implementation of a recycled water project should be completed in multiple phases. The initial treatment system capacity should be adequate to accommodate recycled water flows projected to occur ten years from the date of this report (2013). The 10-year

[5] Areas and depths of pond were taken from November 2002 annual percolation pond report to the RWQCB, included in the November monthly monitoring report.

projected average annual flow is 3.1 mgd[6]. The treatment facilities will be sized to meet this projected supply. However, due to evaporation during the warmer months, the annual available quantity for distribution would be about 3,100 AF or approximately 2.8 mgd. This assumes that there would be storage available.

The following assumptions were used to make the supply estimate:

- Projected influent plant flow is based on a total growth rate (residential plus industrial) of slightly greater than 1%; and
- The average rainfall and evaporation rates used will not change significantly.

4.4 DEMAND

For initial implementation, it is assumed that recycled water would be used for irrigation of agricultural lands in the vicinity of the treatment plant only. During a year with an average annual demand of 3 AF per acre, assuming that irrigation occurs for 24 hours per day, consumptive use may be as high as 7.5 inches per acre[7] during the average peak month, or 4.7 gallons per minute (gpm) per acre. Assuming that the average peak month demand occurs once in a one-year period and that storage would be available, enough recycled water would be available to supply 800 acres of land with irrigation water without causing a temporary drawdown of the ground water table.

For design of the distribution system, irrigation is assumed to occur for 12 hours per day. The remaining 12 hours per day would be available to apply extra volume required during periods of unusually hot weather as well as providing downtime for system maintenance. With an irrigation period of 12 hours per day, the average peak demand doubles to about 9.4 gpm. Adding on a leaching factor of 10%, the average peak month demand is about 10 gpm per acre. This is consistent with the minimum 10 gpm per acre rule of thumb used by agricultural engineers. The distribution pumps and pipes should be designed for a minimum capacity of 10 gpm per acre.

Initially limiting the use area to sites near the treatment plant would require less piping infrastructure to be constructed during the early phases of the project. Additionally, enough acreage which could be irrigated with recycled water was identified within this boundary. Beyond it, demand would exceed the supply.

The projected average demand for recycled water is based on the following assumptions:

[6] The projected supply is based on the projected growth rate and ten-year average evaporation and rainfall rates. The assumed rates are included in Appendix C.
[7] Average peak monthly demands were provided by Dellavalle Laboratory. Tables are included in the "Water Quantity and Quality Report" attached as Appendix B.

- Land use of the identified potential irrigation sites will not change (i.e. the sites will remain agricultural sites producing the same crops that are currently being grown);

- The average reference evapotranspiration (ET_O) values and crop factors used to calculate crop water usage will not change significantly; and

- Average rainfall and evaporation rates used will not change significantly.

4.4.1 Water Usage

The estimated water usage for crops in the area around the plant (including the properties within SKF boundaries) and for the Elkhorn area are included in the appended Water Quality and Quantity Report. On average, the area around the plant has an average irrigation demand of 3AF/acre/year, and an average peak month demand occurring in July of 7.5 inches per acre.

The Elkhorn area, an identified alternative recycled water user area, also has an average irrigation demand of approximately 3 AF/acre/year.

4.5 POTENTIAL USERS

For this study, the following potential agricultural users were considered:

- Users at SKF owned properties;

- Users within the CID service area; and

- Users in Elkhorn area, an area outside of the CID service area.

Analysis of the customer options, as well as a meeting with the local water agencies, concluded that initially any recycled water should be utilized within the CID service area, including the SKF-owned properties. Beyond this area, demand will exceed the supply. If more recycled water is available than the user demand within the CID service area, then the delivery of recycled water to users in the Elkhorn area should be considered[8].

In accordance with the RWQCB requirements for this report, this study focuses on investigating "opportunities to recycle effluent on agricultural lands where fresh water is currently used". However, it should be noted that other potential uses for recycled water within the study area include the irrigation of highways and parks, and industrial uses.

[8] SKF attorney Richard Hargrove attended a study team meeting on May 15, 2003 to discuss water rights issues in consideration of delivery to the Elkhorn area. A summary of the meeting is included as Appendix D.

These potential use sites were briefly discussed during the course of this study and are presented again later in this section of the report.

Two of the most significant challenges in implementation of a recycled water project in the SKF area were anticipated to be the acceptance of the water agencies, and more importantly, public perception. Accordingly, a meeting was held between representatives of the study team and key water agency members, and separate meetings were held between representative study team members and key representatives of three major food packers in the study area to discuss the potential use of recycled water. The meetings with the local food packers is discussed under "Market Assessment", Section 6 of this report.

4.5.1 Interview With Water Agencies

To better assess the view of the water agencies' on a recycled water project, Mr. Bob Whitley and Mr. Randy McFarland of the study team met with members of the three relevant water agencies on June 3, 2003. The water agency representatives were:

- CID General Manager – Mr. Gene Branch;
- CID Director (Kingsburg-Selma area) – Mr. Bob Petersen;
- KRCD General Manager – Mr. David Orth; and
- KRWA Assistant Watermaster – Mr. Steve Haugen.

The meeting provided an overview of the study and gave agency representatives an opportunity to provide feedback on the potential recycled water project. Although KRWA would not be directly impacted by the project, Mr. Haugen made no objections to the concept, nor indicated potential water rights issues. He indicated that the concept is a good one, and noted concern over the issues of nitrates, especially on their impact on grapes used for raisin making. CID and KRCD generally accept the use of recycled water, as noted in the subsequent paragraphs.

4.5.2 Users at SKF Owned Property Sites

SKF owns a total of about 535 acres, approximately 158 acres[9] of which can potentially be irrigated with recycled wastewater. The SKF owned agricultural areas surrounding the treatment facilities are leased to farmers and are predominantly vineyards and stone fruit orchards. Currently, ground water is being pumped by the farmers via extraction wells located at various agricultural sites. The average peak month demand for the 158 acres is approximately 1,580 gpm or 2.3 million gallons per day (mgd). The average

[9] Estimated from aerial photograph.

daily flow for the 158 acres during a 6-month irrigation season is approximately 0.86 mgd. SKF may consider purchasing additional properties in the near future.

4.5.3 Users Within CID Service Area

Properties within the CID service area located within two miles of the treatment plant without access to surface water[10] are identified on Figure 4.1. These properties rely solely on ground water. During the June meeting, CID indicated that they would like to offer recycled water to irrigation customers without surface water rights within the CID service area. If recycled water is distributed to 158 acres of SKF land, then enough water would be available to irrigate 642 acres of land within the CID service area. The average peak month demand for the 642 acres is approximately 6,420 gpm or 9.2 mgd. The average daily flow for the 642 acres during a 6-month irrigation season is approximately 3.5 mgd.

Figure 4.1 identifies more than 642 acres of land within the CID service area without surface water rights. It is anticipated that not all farmers would want recycled water. As such, accepting users could be added to the distribution system based on their proximity to the plant. Although there are more than 642 acres of land which could use recycled water, there would not be adequate supply to meet a greater demand.

4.5.4 The Elkhorn Alternative

The Elkhorn Alternative considers providing recycled wastewater to irrigation areas located outside of the CID service area. The area considered for this alternative is located southwest of the intersection of Elkhorn and Del Rey avenues, approximately 1.5 miles southwest of the plant. There are nearly 2,600 acres for potential irrigation in the Elkhorn area. This area is within the KRCD boundaries, but outside of the Kings River service area and has no surface water supply. The Elkhorn area and its relation to the treatment plant is illustrated in Figure 4.2.

The Elkhorn Area relies exclusively on pumped ground water for irrigation. Crops in the Elkhorn area include almonds, grapes, row crops, stone fruit, and walnuts. Results of a crop survey done for the Elkhorn area are depicted in Figure 4.3. Because farmers in this area rely on ground water for irrigation, heavy pumping to meet high water demand in the area is contributing to ground water overdraft along the southern and western portion of CID and the western end of the Fresno Irrigation District. Implementation of the Elkhorn Alternative would indirectly provide ground water recharge to the area's depleting aquifer.

Also, the pumping cost for retrieving ground water can be rather costly. Energy costs have increased significantly over the last few years. In addition, possible regulatory

[10] Source: Parcel map provided by CID.

LEGEND

SKF BOUNDARY

SELMA COLONY CANAL

WARD DRAIN

POTENTIAL IRRIGATION SITES - PHASE 1

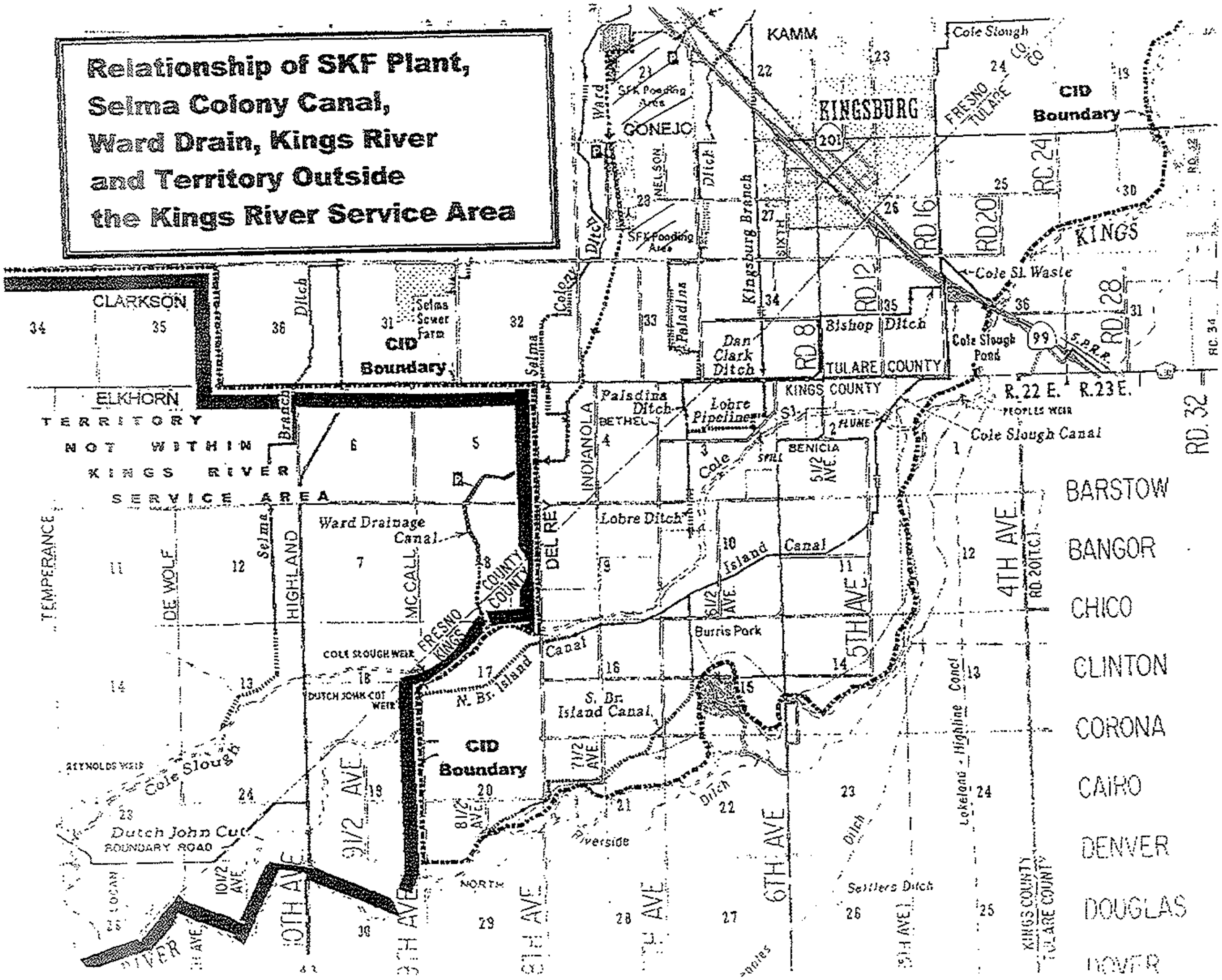
POTENTIAL ALTERNATIVE IRRIGATION SITES - PHASE 2

PROPOSED NEW RECYCLED WATER IRRIGATION WELL

WHITLEY BURCHETT & ASSOCIATES, Inc.
Walnut Creek, California
(925) 945-6850

SELMA-KINGSBURG-FOWLER COUNTY SANITATION DISTRICT
RECYCLED WATER FEASIBILITY STUDY
POTENTIAL IRRIGATION SITES

FIGURE 4.1

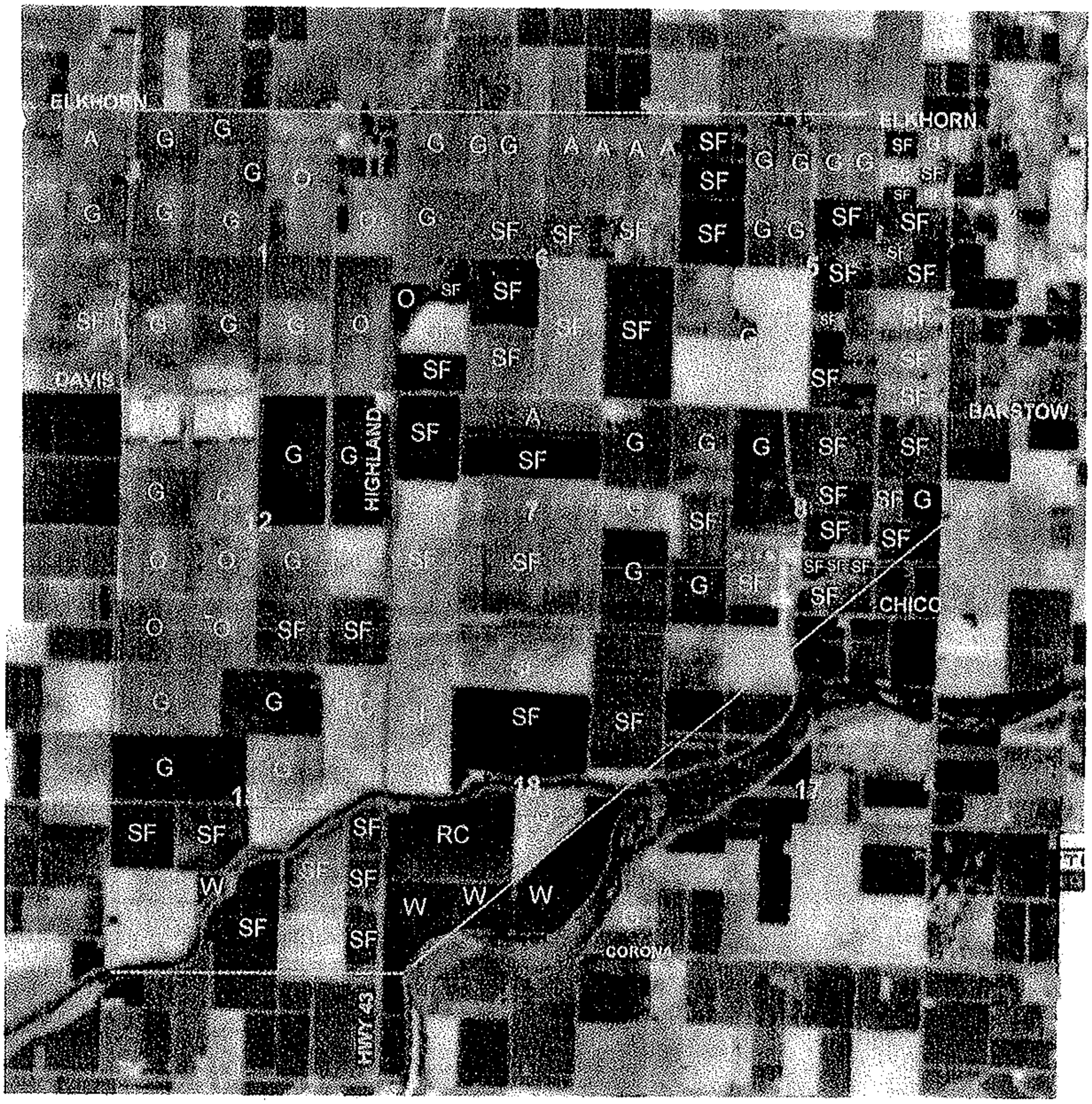


SOURCE: RANDY McFARLAND

WHITLEY BURCHETT
& ASSOCIATES, Inc.
Walnut Creek, California
(925) 945-6850

SELMA-KINGSBURG-FOWLER
COUNTY SANITATION DISTRICT
RECYCLED WATER FEASIBILITY STUDY
ELKHORN AREA

FIGURE
4.2



LEGEND

A = ALMOND
G = GRAPE
O = OPEN
RC = ROW CROPS
SF = STONE FRUIT
W = WALNUT

SOURCE: DELLAVALLE LABORATORY, INC.
DATE OF CROP SURVEY: MARCH 14, 2003

NOT TO SCALE

WHITLEY BURCHETT & ASSOCIATES, Inc.
Walnut Creek, California
(925) 945-6850

SELMA-KINGSBURG-FOWLER COUNTY SANITATION DISTRICT
RECYCLED WATER FEASIBILITY STUDY
SURVEY OF CROPS IN ELKHORN AREA

FIGURE 4.3

implementation of stricter and more costly air quality regulations for diesel-powered engines would greatly impact farmers with diesel powered pumps.

Discussion of the Elkhorn Alternative with the water agencies at the June 3 meeting resulted in support of this option. CID agreed that if there were not enough users within the CID area, that the recycled water should be distributed to the Elkhorn area. KRCD was receptive to the concept since it would aid in KRCD's ground water management activities.

4.5.5 Non-agricultural Users

Other potential uses briefly discussed during the study were the irrigation of parks, golf courses, and freeway median landscaping. However, spray irrigation is required for these types of landscape uses, which may require restricted access to the sites, as well as a more costly pressurized pipe distribution system. These requirements and other water quality restrictions for spray irrigation should be considered if this option is pursued. The purpose of this study is to investigate reuse options for agricultural irrigation, therefore, these options were not considered in detail.

4.6 RECYCLED WATER SUPPLY (PUMPING)

For the study, it is assumed that the disposal ponds shall be nearly empty at the end of October, and that the quantity of disinfected wastewater that is discharged to the disposal ponds is the supply that will be available for recycled water. The supply can be either pumped directly from the disposal ponds or extracted via extraction wells from the underlying aquifer for distribution.

Recycling wastewater that would normally mix with the ground water and flow downstream of the plant could impact users downgradient of the treatment plant who rely on ground water for agricultural irrigation. This should be further studied before a recycled water project is implemented.

The following supply options were considered for this study:

- Individual extraction wells drawing recycled water from the aquifer;
- Central pond pump station pumping water from the disposal ponds;
- Central aquifer well and pump station pumping water from the aquifer; and
- A combination of the three.

Analysis of the alternatives concluded that a combination of individual wells, a pump station pumping directly from the disposal ponds, and a central well with a pump station pumping from the aquifer would meet the average peak month demand. Individual wells could be installed at the irrigation sites owned by SKF. A central well and pump station could be installed at the corner of Clarkson and McCall to serve as the distribution network center for delivery to potential customers outside of the SKF boundaries. This combination would reduce the initial cost of distribution facilities.

Enough information on the existing agricultural wells at parcels within the SKF environmental buffer zone was not available for this study. It is uncertain if the existing wells could be used for a recycled water program. The installation of new wells at these sites would be recommended. The SKF-owned properties and assumed well locations are shown on Figure 4.1.

The individual wells should be sized for the average peak month demand, a total capacity of 2.3 mgd. Assuming that eight new individual wells would be installed to service the SKF owned properties, each well would have an approximate capacity of 0.29 mgd.

The installation of individual wells at sites not owned by SKF is not recommended because it would require individual easements with landowners. Instead, a new central well and pump station can be installed to pump water directly from the storage aquifer. This would provide recycled water supply to CID users and could be located at the intersection of Clarkson and McCall. The central well would extract water from a depth of 40' below ground surface, and the pump station would distribute the water to irrigation users via a new recycled water pipeline network.

The central well and pump station serving the 642 acres without individual wells should also be sized to meet the average peak day demand of about 10 mgd.

Additionally, a 10 mgd pump could be installed to pump water directly from the disposal ponds. Pumping from both the storage aquifer and directly from the disposal ponds is necessary because if recycled water is continuously extracted from the storage aquifer only, then there may be a period when storage is depleted and enough effluent has not percolated back into the aquifer to meet the demand. Also, pumping directly from the disposal ponds will buffer out the variability in the quantity of recycled water effluent which will percolate to the aquifer storage. Since the percolation rate is a function of the depth of water in the pond, there may be times that percolation does not occur at a high enough rate to meet the irrigation demand. Piping within the disposal ponds can be configured such that all ponds drain to one pond from which the recycled water can be pumped. This will also insure turnover of the water in the ponds.

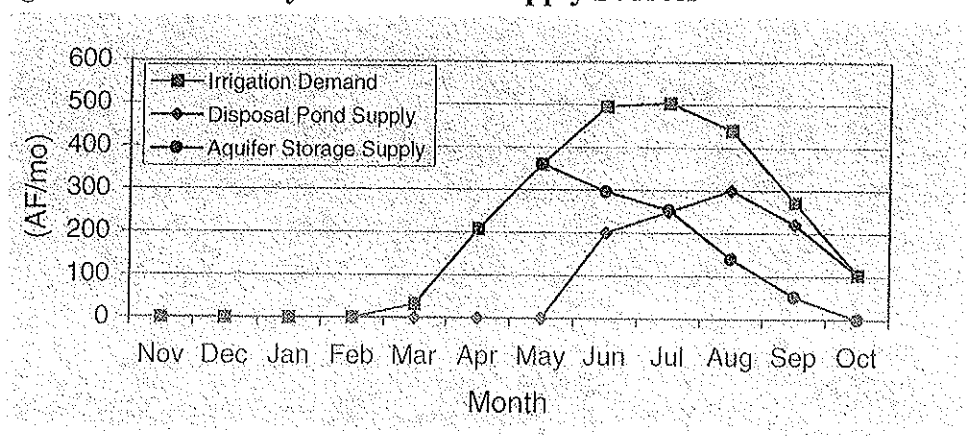
Table 4.1 summarizes the number of wells and pumps that would be required based on assumptions made in this report. The capacity of the wells and pumps that would be required are also included on the table.

Table 4.1 Wells and Pumps

Pump/Well	Capacity	Number Required	Total Capacity
Individual Wells (serving multiple properties)	Average 0.29 mgd	8	2.3 mgd
Central Aquifer Pump Station	10 mgd	2 (1 in use, 1 stand-by)	10
Central Pond Pump Station	10 mgd	2 (1 in use, 1 stand-by)	10

During the months of November through May, demand can be met by pumping from the storage aquifer. From June through October, demand[11] can be met by pumping from the central aquifer pump station as well as the central pond pump station. The monthly use of disposal pond supply and aquifer storage supply is depicted graphically in Figure 4.4. For instance, from the graphic, during the month of April, the approximate 200 AF irrigation demand is met by supplying recycled water from pumping directly from the aquifer storage only. In contrast, during the month of August, the approximate 450 AF demand is met by supplying about 300 AF from the disposal pond supply and about 150 AF from the aquifer storage supply.

Figure 4.4 Monthly Demand and Supply Sources



[11] These demand estimates are based on the average peak month use rates. During periods of hotter than normal months, ground water may need to be pumped to supplement the recycled water source in order to meet demand.

4.7 DISTRIBUTION OPTIONS

The following distribution options were considered for this study:

- Use of the Selma Colony Canal and the Ward Drain;
- Installation of a new recycled water distribution main within the Selma Colony Canal right-of-way;
- Pipe the Selma Colony Canal and/or Ward Drain and mix recycled water with CID water; and
- Installation of a new recycled water distribution system within public easements.

The first two alternatives were eliminated early in the study. Many portions of the canals are open and the potential for human contact is high. Also, discharging recycled water into the Selma Colony Canal and the Ward Drain would require a National Pollutant Discharge Elimination System (NPDES) permit from the RWQCB. An NPDES permit would be required since the canals ultimately discharge to the Kings River.

Installation of a closed pipe distribution system within Selma Colony Canal right-of-way is unfavorable because in the event that the coliform count is high for canal water, it would be laborious to determine whether the coliform source is from a leak in the recycled water pipeline, or from the canal water. Also, this would require a failsafe method of preventing recycled water from eventually discharging to the Kings River. The option of piping the Selma Colony Canal and/or the Ward Drain would also require such a failsafe method.

The most feasible is construction of a new separate pipeline distribution system. This alternative eliminates the potential of human contact with recycled water, as well as prevents the discharge of recycled water to the Kings River. The transmission mains could be installed within public easements.

4.8 PHASED IMPLEMENTATION

It is recommended that if a recycled water program is implemented, that it be done so in phases. The first phase could deliver water to agricultural lands lying within the SKF environmental buffer zone. The acreage within this boundary totals approximately 158 acres. This first phase could be a demonstration project, to confirm that irrigated crops respond positively to the recycled water, and to gain the confidence of the local growers and residents.

The second phase could be the identified CID customers who do not have surface water rights. A new closed pipe distribution network and central well and pump station would be constructed to service these 642 acres. Distribution to these 642 acres could be phased as well to reduce initial piping costs. Since phasing of the distribution system will depend on the location of the accepting irrigation customers, a distribution system phasing approach is not specified in this study. If possible, sites located nearest to the proposed central pump station should be the first users connected to the system.

4.9 DISTRIBUTION SYSTEM

Since out of the 800 acres to receive water, 158 acres will be receiving water via individual extraction wells, only 642 acres of land will receive recycled water via closed pipe distribution. A combination of pipes ranging from 10 to 24 inches in diameter could be used to deliver the peak day demand. Development of the distribution system and central well and pump station would be the second phase of the project.

5 RECYCLED WATER TREATMENT SYSTEM ALTERNATIVES AND COST ESTIMATES

5.1 RECYCLED WATER TREATMENT SYSTEM DESIGN

Recycled water treatment facilities should be sized to meet the 10-year projected average flow of 3.1 mgd. Treatment facilities consist of filtration followed by disinfection.

5.2 FILTRATION

Filtration ahead of disinfection removes suspended solids from the effluent which might otherwise inhibit effective disinfection. To determine the order of magnitude cost for the filtration process, the cost for continuous backwash filters is used. Other methods of filtration which may be applicable are: dual media filtration, fuzzy filter filtration, membrane filtration, and cloth filtration.

5.2.1 Continuous Backwash Filters

Continuous backwash filters do not require periodic backwashing as do conventional filters. Continuous backwash filters continuously circulate to clean the filter medium. The DynaSand continuous backwash filter is considered for the cost estimating purpose of this study. Similar types of continuous backwash filters by various manufacturers have been approved by DHS for Title 22 recycled water treatment and should be considered if a project is implemented.

New filters and controls, and a new structure to house the filters are assumed for this study. Two filters, housed in a concrete structure, were constructed at the SKF plant during the original construction. The existing structure is not considered for this study since the size and configuration may not be adequate to house continuous backwash filters.

5.3 DISINFECTION

Two common methods of disinfection are chlorination and UV disinfection. Chlorination is the more conventional method of disinfection. However, handling and safety issues associated with chlorine, especially gaseous chlorine, have caused agencies to consider UV. UV disinfection systems are becoming more widely used throughout the wastewater industry, and DHS has approved a number of systems for recycled water use. It is assumed that space requirements for a new disinfection system at the SKF plant will not be an issue.

5.3.1 Hypochlorite

Due to the handling and safety issues of chlorine gas, hypochlorite is now more typically used for wastewater disinfection. Hypochlorite is assumed for this study. One disadvantage of the addition of hypochlorite for recycled water production is the resulting increase in the salt concentration of the recycled water. The impact of this increase to the local crops would require further study.

5.3.2 UV Disinfection

UV disinfection is becoming more widely used for wastewater disinfection. Two advantages of UV over chlorination are that UV disinfection produces no known by-products, and UV does not have the safety concerns of chlorine gas. Also, there would be not additional salts added to the treated water.

There are three main types of UV disinfection systems currently available. The three systems are: low-pressure, low-intensity; medium-pressure, high-intensity; and low-pressure, high intensity. The pressure refers to the mercury vapor in the lamps. The intensity refers to the power output of each lamp. Based on a phone conversation with a UV system supplier, a low pressure high output system is recommended for the project as described in this study. Additional studies should be performed to confirm use of this system if a project using UV disinfection is implemented.

5.4 DISTRIBUTION SYSTEM SIZING

5.4.1 Individual Wells

The typical acreage of parcels within the SKF boundaries ranges between approximately 20 to 40 acres. The outlined SKF-owned acreages on Figure 4.1 are conceptual and are not necessarily indicative of the number of individual parcels. The figure assumes that 8 individual wells would be used. Eight equally sized individual wells with a total capacity of 2.3 mgd are assumed for cost estimating in this study.

The following criteria was to size the individual wells:

Design Irrigation Rate	10	gpm per acre
Required Flow Rate (mgd)	0.29	mgd (to irrigate 20 acres)
Aquifer Depth (ft)	40	ft
Pump Efficiency	70	%

The minimum required pump size for each individual well is approximately 5 hp.

5.4.2 Central Well and Pump Station

A central well and pump station is proposed to be installed at the intersection of McCall Ave. and Clarkson Ave. By locating the well and pump station at this central location for the first phase of potential irrigation sites, the transmission pipe diameter can be minimized. As described in Section 4.6, the central well and pump station should have at a minimum a 10 mgd capacity.

5.4.3. Pipe Sizing

Construction of piping infrastructure and the central well and pump station would be phase 2 of the project. Piping from the central well could range from 10 to 24 inches in diameter depending on the location of the irrigation user.

5.5 TREATMENT FACILITY AND PUMPING COST ESTIMATES

For this study, cost estimates are included for phase 1 components only. Phase 1 consists of treatment facilities and the construction of new agricultural irrigation wells on property owned by SKF.

5.5.1 Treatment Facility Costs

The following table lists the order of magnitude capital costs for filtration and disinfection.

Table 5.1 Capital Cost Estimates[12]

Treatment Facility	Cost With Hypochlorite Disinfection	Cost With UV Disinfection
Continuous Backflow Filtration	$ 2,600,000	$ 2,600,000
Disinfection		
Hypochlorite	$ 1,600,000	---
UV Disinfection	---	$ 2,800,000
TOTAL COST	$ 4,200,000	$ 5,400,000

5.5.2 Individual Wells

From the assumptions made in this study, eight individual wells are used to supply the 158 acres of SKF owned land. The average acreage of land to be served by one individual well is 20 acres.

The current energy cost per kilowatt-hour (kWh) is $0.13 per kWh. At this rate, the average daily cost to irrigate 20 acres is about $4.70 per day[13].

[12] Capital cost estimates include professional services, change orders, and contingencies. The total cost estimates on this table do not include distribution piping or the eight supply wells.
[13] This cost assumes the average irrigation demand of 3 AF/acre/year. The rate could be nearly twice this amount during a peak day irrigation period.

6 MARKET ASSESSMENT

6.1 INTERVIEW WITH LOCAL FOOD PROCESSORS

Along with the importance of water quality, is the importance of the marketability of products irrigated with recycled water. Since the intent of the study is to investigate the opportunities for recycled water use on agricultural lands, it is critical to this project to consider the acceptability of produce irrigated with recycled water in the marketplace. Rejection of produce irrigated with recycled water in the marketplace would mean that a farmer would not be able to use recycled water.

To assess the acceptance of recycled water use in the marketplace, separate meetings were set up between representatives from the study team and key members of three major local food processing companies. Generally, the response of all three companies was the same.

Fresh Fruit Packer – During this meeting, the importance of strict quality control standards faced by food growers and processors was emphasized. Growers and food processors are required to have third party audits that inspect and certify their practices and facilities for compliance with "good agricultural practices". Major food distributors also hire their own independent third party auditor to inspect and certify individual growers and food processors according to their own quality standards. In addition to the domestic market, international customers must also be considered. The thought was that the domestic and international marketplaces would not be receptive to the use of recycled water on their food products.

Food Processor – Representatives from a major food processing corporation indicated that they would accept crops irrigated by recycled water only as a last resort, if at all. They explained that questions of water quality from purchasers of major food products have increased over recent years, and quality standards have become increasingly stringent, particularly in the international market. The representatives stated that the international market would not accept recycled water, and that the issue is one of perspective for the customer.

Food Canning – Representatives from a major food canning company reiterated the comments of the other agencies, that perception is critical. Domestically, much of the concern over food safety is linked to Homeland Security. The company spends a significant amount of time complying with food safety-related regulations, and takes great care in what is applied to their land. The company may consider use of recycled water on crops on a case-by-case basis. Before review is initiated, the request must go through a company approval process.

7 MONITORING AND REPORTING

7.1 REGULATORY APPROVAL

Implementation of a recycled water project is subject to the approval of the RWQCB and the DHS. Article 7, Section 60323, of Title 22 requires submittal of an Engineer's Report to the DHS prior to production or distribution of recycled water. Under the Division of Drinking Water and Environmental Management (DDWEM), the DHS has established "Guidelines for the Production, Distribution and Use or Recycled Water" which describe information that must be contained within the Engineer's Report. Based on its review of the report, the DHS will make recommendations to the RWQCB for project acceptance or denial.

In addition to DHS review of the project, other regulatory agencies who may have jurisdiction over the project area should also be included in the review process. Such agencies may enforce regulations which take precedence over Title 22 requirements.

Examples of additional regulatory agencies that may need to be included in review and approval of a future SKF recycled water project include but are not limited to:

- Food and Drug Branch of the DHS;
- US Department of Agriculture; and
- State Food and Drug Branch.

7.2 MONITORING REQUIREMENTS

Upon approval of a project, the RWQCB would issue a permit describing the water quality and distribution monitoring requirements. Quarterly, or possibly monthly reports describing recycled water quality, the distribution system, and the recycled water use area would be required for submission to the RWQCB as part of a recycled water use permit. Additionally, an annual report to the RWQCB may be required.

Title 22 monitoring and reporting requirements for recycled water have been summarized by DHS DDWEM. These requirements are incorporated by the RWQCB into a recycled water use permit.

The following are water quality monitoring parameters for secondary 2.2 disinfected effluent described in the summary[14]:

- The effluent shall be monitored at least daily for total coliform bacteria; and
- Chlorine residual shall be monitored continuously at a point following disinfection.

At a minimum, results of daily coliform monitoring, running 7-day median calculation, maximum daily coliform reading for previous month(s), and minimum daily chlorine residual would have to be reported to the Regional Board on a quarterly basis. Nitrogen loading rates will also be required for reporting.

Per the reporting criteria, the following events would trigger reporting to the Regional Board within 24 hours:

- Failure of chlorination equipment;
- Loss of detectable chlorine residual; or
- Effluent total coliform bacteria MPN greater than 240/100 mL in any one sample.

Special reporting requirements for a UV disinfection system would be established by the RWQCB on a project by project basis.

The Regional Board permit may include additional water quality parameters which would need to be monitored, and will define any required monitoring and reporting parameters for the distribution system and land use area of a recycled water project.

[14] "Recycled Water Monitoring and Reporting", California Department of Health Services, Division of Drinking Water and Environmental Management, August 2000.

8 CONCLUSION

This study evaluated key components in determining the feasibility of a recycled water project for the agricultural area surrounding the SKF treatment plant. The key components evaluated were:

- Technical feasibility of producing recycled water at the SKF WWTP;
- Estimate of capital costs for recycled water treatment and distribution facilities;
- Identification of potential agricultural irrigation users; and
- Assessment of marketability of food crops irrigated with recycled water.

From the study, it was determined that a recycled water project is technically feasible. With filtration and disinfection, SKF's secondary effluent can be treated to meet Title 22 requirements for disinfected secondary-2.2 recycled water.

To reduce the initial capital costs, a recycled water project could be implemented in two phases. To utilize the projected 10-year wastewater effluent supply, a total of 800 acres can be supplied with recycled water through a combination of individual and central wells. The first phase could provide recycled water to properties owned by SKF as a demonstration project. The second phase could be the expansion of recycled water delivery to CID users located near the plant.

A meeting with the three local water agencies indicated support of a recycled water project. CID would prefer that the water be utilized by accepting growers within the CID service area. In the event that more recycled water is available than can be used within the CID service area, both CID and KRCD agree that the water can be used in the Elkhorn area.

However, ultimately the feasibility of implementing a recycled water project for irrigation of agricultural areas is acceptance in the marketplace. Meetings with three local major food processing companies indicated that currently there is not such a marketplace.

Recycled water use would require consent by individual customers to irrigate their orchards and vineyards. Even though the water would satisfy governmental water quality standards, the food processors which are the marketplace for farm-grown crops have indicated that their own food quality requirements question the marketability of those crops irrigated by recycled water. Many crops grown in the area are processed for both the domestic and international markets. The food processors believe that buyers in both markets would not accept crops irrigated with recycled water. As long as the food processors remain skeptical about the use of recycled water, the growers will likely continue with their existing irrigation practices.

Because the food processors will not accept crops grown with recycled water, the project is not feasible. Without the support of the food processors and then the individual customers, there will not be a "marketplace" for recycled water and therefore a capital intensive project of this type will not be feasible.

If growers begin to experience shortages with their current water supply, or if the quality of their water supply deteriorates, then they may be more willing to consider using recycled water. If there is future consideration of a recycled water project, extensive public education and outreach would be required. A good reference project would be the Monterey County Water Recycling Projects (MCWRP). Since 1998, recycled water has been used to irrigate food crops such as artichokes, lettuce, cauliflower, celery, and strawberries for national and international distribution. Success of the project is the result of nearly 20 years of planning, with emphasis not only on the safety of human consumption of produce irrigated with recycled water, but also an extensive marketability study and an aggressive community education program.

If SKF elects to further pursue exploration of recycled water feasibility for agricultural reuse, then the studies and outreach programs developed by the Monterey Regional Water Pollution Control Agency for the MCWRP could provide a basis for marketing research and public outreach. Additionally, a recycled water demonstration project would allow SKF to address grower concerns by demonstrating that local crops can respond positively to recycled water. A demonstration project would also provide more opportunity for the public to engage in development of the project before a more expansive program is implemented.

APPENDIX A
DHS RECYCLED WATER IRRIGATION GUIDANCE LETTER

California Department of Health Services

State of California—Health and Human Services Agency
Department of Health Services

NA M. BONTÁ, R.N., Dr. P.H.
Director

GRAY DAVIS
Governor

January 8, 2003

TO: State of California
Regional Water Quality Control Boards

SUBJECT: Orchard and Vineyard Irrigation Using Recycled Water

This memo is being sent to provide you with clarification concerning the application of recycled water on orchard and vineyard crops based on the current position of the California Department of Health Services Food and Drug Branch (FDB). General guidance is also presented for developing permit conditions for existing and proposed projects involving orchard and vineyard crops identified under Section 60340 (d) of the Water Recycling Criteria.

Section 60304(d) of the Criteria allows for the use of undisinfected secondary recycled water for prescribed applications involving limited food and seed crops, subject to certain restrictions. Such applications are limited to 1) Orchards and Vineyards where the recycled water does not come into contact with the edible portion of the food crop, 2) seed crops not eaten by humans, and 3) food crops that must undergo commercial pathogen destroying processing before being consumed by humans. The FDB, with the concurrence of the Division of Drinking Water and Environmental Management (DDWEM) believes that undisinfected secondary effluent represents a potential public health threat when direct or indirect modes of public contact with the recycled water, or a food product having been directly exposed to the recycled water, is allowed to occur.

It is the position of the FDB that orchard and vineyard crops will quite likely come into contact with recycled water or soil irrigated with recycled water through typical harvesting practices (e.g. sweeping of nuts shaken from trees) and/or improper use-site control measures (e.g. harvesting of grounders). Furthermore, FDB has reported that recent studies have indicated there may be a potential for pathogens to gain access to the interior of fruits or seeds through uptake by the root system, breaks in the surface of the food product and stem scars. As a result, the FDB recommends that orchard and vineyard crops are irrigated with water, which (at a minimum) meets the requirements of a disinfected secondary-2.2 recycled water as defined in Section 60301.220. Furthermore, it is the position of FDB that the coliform standard be achieved using chlorine as the disinfectant due to limited data available on the effectiveness of other

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APPENDIX B

RECYCLED WATER FEASIBILITY STUDY
WATER QUALITY AND QUANTITY STUDY FOR SKF CSD

INTRODUCTION

The Selma-Kingsburg-Fowler County Sanitation District (SKF) is in the process of studying feasibility of agricultural use of recycled water from its Wastewater Treatment Plant (WWTP). Both water quality and quantity are of primary importance to success of irrigated agriculture.

Quality is the more important of the two. Without water of adequate quality, no irrigated agriculture can occur. Water characteristics will over time influence soil quality more than any other factor. Constituents also directly impact plant health. Salt components can be phytotoxic. Nutrient content of irrigation water is of economic value but can occur in excessive amounts for some crops, grape for example. The report examines agricultural suitability of SKF recycled water with special emphasis on impact of nitrogen on growth of grape and other crops.

Crops require specific amounts of water based on their individual characteristics, climatic conditions and other factors. In order to utilize recycled water available from the SKF WWTP a system for delivery to sufficient acreage will be required. The report examines two areas with respect to water quality and quantity.

The objective of the report is to evaluate agricultural quality of SKF recycled water and the size of two areas that could be used for agricultural reuse for the purpose of supporting the Recycled Water Feasibility Study.

IRRIGATION WATER QUALITY

SKF WWTP effluent quality data for years 2002 and 2003 were compiled and summarized in **Exhibit 1**. It is assumed that effluent quality would be similar to these historic values. Characteristics of ground water near the effluent disposal ponds based on samples from monitoring wells for the same time period are also summarized in **Exhibit 2**.

Effluent from the WWTP and well water are available at the project site. Quality characteristics of the effluent, using agronomic criteria presented in **Table 1** are based on the water compositions reported in **Exhibits 1 & 2**. Agricultural characteristics of groundwater, based on ground water monitoring, are expressed in **Table 2,** see **Figure 1** for monitoring well locations.

Table 1. Effluent Characteristics

Quarter	EC dS/m	Ca (meq/l)	Mg (meq/l)	Na (meq/l)	SAR	Cl (meq/l)	CO_3+ HCO_3 (meq/l)	SO_4 (meq/l)	B (mg/l)	TN (mg/l)	NO_3-N (mg/l)	NH_4-N (mg/l)
Jan 02	0.6	0.9	0.3	3.2	4.2	1.4		0.7	0.2		9.8	
Apr 02	0.6	1.1	0.3	3.7	4.5	1.7	2.8	0.5	0.2		11.9	
Jul 02	0.6	0.9	0.2	3.1	4.1	1.7	3.0	0.5	3.7[1]		15.7	
Oct 02	0.6	1.0	0.3	3.4	4.2	1.9	3.2	0.4	0.2		4.9	
Jan 03	0.6	1.0	0.3	3.4	5.6	1.6	2.4	0.5	0.2		8.1	
Apr 03	0.6	1.0	0.3	3.2	3.8	1.6	2.6	0.6	0.1			

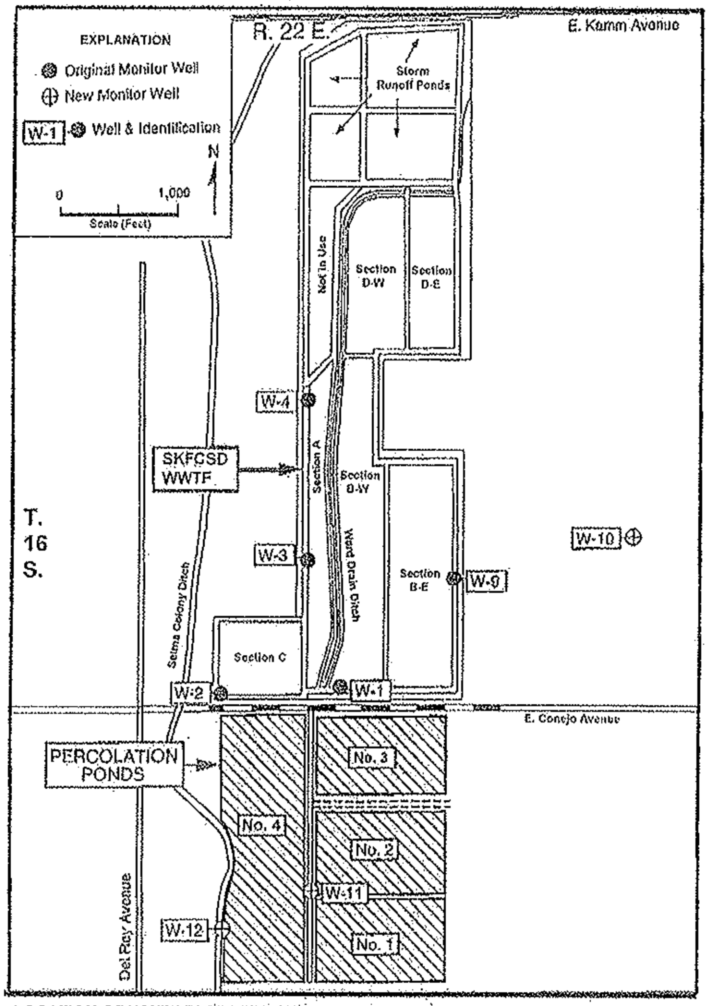
[1] This high boron concentration is believed anomalous. See "D. SPECIBIC ION TONICITY" for more detail.

Table 2. Groundwater Characteristics

Description		EC dS/m	Ca + Mg (meq/l)	Na (meq/l)	SAR	Cl (meq/l)	CO3+HCO3 (meq/l)	SO4 (meq/l)	B[1)] (mg/l)	T-N (mg/l)	NO_3-N (mg/l)	NH_4-N (mg/l)	TDS
Well 10	4-02	04	2.9	1.0	4	0.3	2.8		0.1		3.4		240
	7-02	.4	3.1	1.3	5	0.3	3.4		0.1		4.6		320
	10-02	.5	3.4	1.2	4	0.3	3.2		0.1		5.2		310
	1-03	.4	3.3	1.0	3	0.4	3.0		0.1		17.6		280
	4-03	.5	3.5	1.1	4	0.4	3.4		0.1		4.7		300
Well 11	4-02	.6	2.3	4.1	17	1.8	3.6		0.2		3.4		380
	7-02	.6	2.1	3.9	17	1.8	3.4		0.2		1.5		380
	10-02	.6	2.0	3.8	17	1.9	3.2		0.2		1.5		340
	1-03	.6	1.9	4.0	18	1.7	2.6		0.2		5.6		330
	4-03	.6	2.3	3.4	14	1.7	2.8		0.2		3.8		340
Well 12	4-02	0.7	2.4	4.1	17	1.9	4.6		0.3		0.1		400
	7-02	0.3	1.0	1.8	11	0.4	2.2		0.1		0.8		190
	10-02	0.8	3.4	4.3	15	1.7	6.0		0.3		0.1		460
	1-03	0.6	2.6	3.5	14	1.7	3.2		0.2		4.0		380
	4-03	0.6	2.5	3.4	14	1.7	3.0		0.2		5.4		360

An "**Agricultural Water Interpretation Guide**" is included in **Exhibit 3**. This guide is also pertinent to the ground and recycled water quality. Paragraphs below provide a brief discussion of pertinent characteristics. For additional background, see "Water Quality for Agriculture" by Ayers and Westcott, 1985. http://www.fao.org/DOCREP/003/T0234E/T0234E00.HTM.

Figure 1.



LOCATION OF WWTF FACILITIES AND MONITOR WELLS

A. DISCUSSION

Quality of water for use in agriculture can be divided into five issues:

- Salinity.
- Water infiltration rate.
- Specific ion toxicity.
- Nutrients, and
- Miscellaneous items including cosmetic deposits, corrosion of equipment and others.

Quality of water available at the site is summarized in **Table 3.**

Table 3. Water Characteristics

	Units	Effluent values	Effluent interpretation	Ground Water values	Ground Water interpretation
EC	dS/m	0.6	OK	0.4 to 0.7	OK
SAR		3.8 to 5.6	Moderate-high	3 to 18	Moderate- excessive
Na	meq/L	3.1 to 3.7	OK - moderate	1.0 to 4.0	OK - moderate
Cl	meq/L	1.6 to 1.9	OK	0.4 to 1.9	OK
CO_3+HCO_3	meq/L	2.4 to 3.2	Moderate	2.8 to 6.0	Moderate
B	mg/L	0.1 to 0.2	OK	0.1 to 0.3	OK
N	mg/L	4.9 to 16	Moderate	0.1 to 18	OK - moderate
	lbs/ac-ft	13 to 44		0.3 to 49	
P	mg/L				
	lbs/ac-ft				

B. SALINITY

Salts of all types within the root zone impact plant growth. The ability of plants to extract water from the soil decreases as root zone salinity increases. Above threshold salinity, growth reduction occurs. Plant growth and crop yield decreases as salinity increases above this threshold concentration. Both the threshold salinity and the rates at which yields decrease above the thresholds are known as the salt tolerance coefficients (**Table 4**). These coefficients vary among plant species being considered for the project.

For a given species, salinity impacts can vary with stage of growth. Although excess salinity can delay seed germination, this stage of crop growth is usually the most salt tolerant, whereas the seedling growth stage is often the most salt sensitive.

Table 4. Salt Tolerance & Yield Potential of Selected Crops[1/]

CROP	Yield Potential 100% EC_e[2/]	100% EC_w[7/]	90% EC_e	90% EC_w	75% EC_e	75% EC_w	50% EC_e	50% EC_w	0% EC_e[3/]
Barley grain[4,5]	8.0	5.3	10.0	6.7	13.0	8.7	18.0	12.0	28.0
Barley forage[4,5]	6.0	4.0	7.4	4.9	9.5	6.3	13	8.7	20
Wheat[4,5]	6.0	4.0	7.4	4.9	9.5	6.4	13	8.7	20
Wheat grass, tall	7.5	5.0	9.9	6.6	13	9.0	19	13.0	31
Cotton	7.5	5.1	9.6	6.4	13	8.4	17	12.0	27
Tomato	2.5	1.7	3.5	2.3	5.0	3.4	7.6	5.0	13
Cantaloupe	2.2	1.5	3.6	2.4	5.7	3.8	9.1	6.1	16
Alfalfa, not tolerant	2.0	1.3	3.4	2.2	5.4	3.6	8.8	5.9	16
Corn Forage	1.7	1.1	2.5	1.7	3.8	2.5	5.9	3.9	10
Peach	1.7	1.1	2.2	1.5	2.9	1.9	4.1	2.7	8
Grape	1.5	1.0	2.5	1.7	4.1	2.7	6.7	4.5	12
Almond	1.5	1.0	2.0	1.4	2.8	1.9	4.1	2.7	7
Lettuce	1.3	0.9	2.1	1.4	3.2	2.1	5.2	3.4	9
Strawberry	1.0	0.7	1.3	0.9	1.8	1.2	2.5	1.7	4

1. *Taken from Ayers and Westcot (1985), as are notes 1 through 7. Data is for relative tolerances. Absolute tolerances vary depending upon environmental conditions and cultural practices. These data serve as a guide to relative tolerances among crops. Absolute tolerance varies depending upon climate, soil conditions and cultural practices.*
2. *EC_e means average salinity of the root zone.*
3. *The zero yield potential or maximum EC_e indicates the theoretical soil salinity (EC_e) at which crop growth ceases.*
4. *Barley and wheat are less tolerant during germination and seeding stage. EC_e should not exceed 4-5 dS/m in the upper (3 to 6 inches) soil during this period.*
5. *Grains grown for forage are normally less tolerant than when grown for grain.*
6. *Ranking estimates based upon tests in progress. Grattan, 2001*
7. *EC_w means the electrical conductivity of the irrigation water in dS/m.*

1/ Taken from Ayers and Westcot. Data is for relative tolerances. Absolute tolerances vary depending upon environmental conditions and cultural practices. See Ayers and Westcot for additional notes.
2/ EC_e means average salinity of the root zone. EC_w means salinity of irrigation water. Both are expressed as ds/m.
3/Pistachio reference: Growth of pistachio as influenced by rootstock and mixed salinity with moderate boron.

The level of soil salinity achieved during irrigation depends on the salinity and amount of infiltrated water. The relative amount of infiltrated water used by the plant decreases as the amount of applied water increases. The fraction of the applied water that is not used by the crop passes through the root zone. This fraction of unused water is known as the leaching fraction. The greater the leaching fraction, the lower the soil salinity can be achieved for a given irrigation water.

Salinity becomes more concentrated in the soil solution as evapotranspiration occurs. Subsequent irrigations will leach accumulated salinity toward underlying groundwater. In time salinity of groundwater will be impacted. Management of irrigation timing and quantity will determine soil salinity and salinity of percolate.

C. INFILTRATION

Two water characteristics impact infiltration and crusting properties of soils: salinity and sodicity. Salinity below 0.5 dS/m tends to deffloculate soil colloids resulting in reduced infiltration rates. At this salinity, the propensity for reduction of infiltration rates increases as the sodium adsorption ratio (SAR) increase above three. These two properties operate at the same time creating a complex interaction. General guidelines are presented in **Exhibit 3 "Agricultural Water Interpretation Guide"** and are presented graphically along with the water quality data in **Figures 2** through **4**. Low salinity – high sodium waters tend to penetrate very poorly. As salinity approaches zero, penetration will be reduced at any SAR value, including zero. When the SAR is zero, water contains no sodium. Slow water penetration is common with snow melt waters delivered from the Kings or San Joaquin Rivers typically is nearly pure.

Recycled water has satisfactory salinity values with respect to infiltration but higher then desirable SAR values. As water evaporates at the soil surface or is removed by plants from within the soil, salt becomes more concentrated in the remaining soil solution. Consequently both salinity and sodicity (SAR) increase. At some point along this concentrating process calcium carbonate precipitation occurs which accelerates the rate SAR increase. Unfavorable combinations of salinity and sodicity can result.

Addition of gypsum to water has the dual effect of increasing salinity and reducing SAR resulting in a more favorable combination of salinity and sodicity. Consequences of such a shift can reduce the tendency for crust formation and improvement in infiltration rates. The effect of adding gypsum to effluent on relative infiltration rates is illustrated in **Figure 4**.

Well water has satisfactory salinity but SAR equal to and much higher than recycled water. Infiltration is likely to be reduced and addition of gypsum may be required with both waters. The amount of gypsum required is dependent upon the leaching fraction soil chemistry and physical properties of the soil. Determination of the amount of gypsum required to off set water characteristics is best determined over time by monitoring soil conditions and adding gypsum as needed to maintain permeability.

Adding sufficient gypsum to displace the sodium being added sodium applied in recycled or ground water. Sodium concentrations in recycled and ground waters range from one to four milliequivelents per liter. Replacing those amounts of sodium will require from 237 to 950 pounds of pure gypsum per acre-foot of water. Not more than that amount would be required.

Figure 2. Relative Infiltration Rates

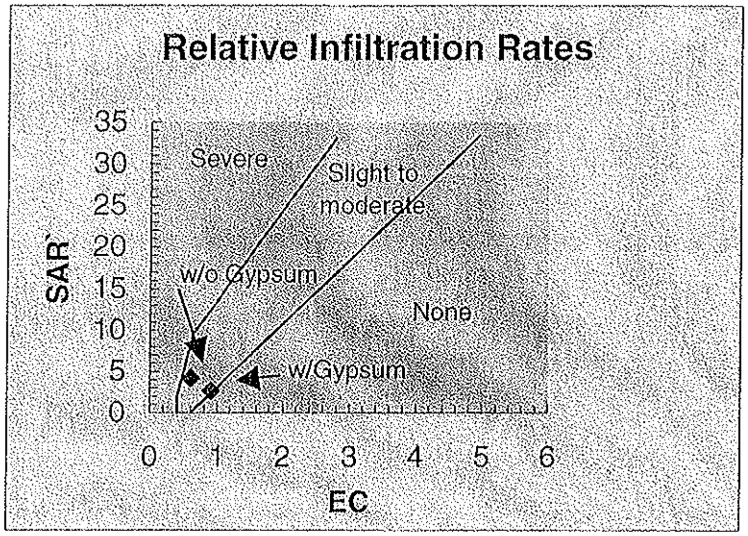


Figure 3. Monitoring Wells

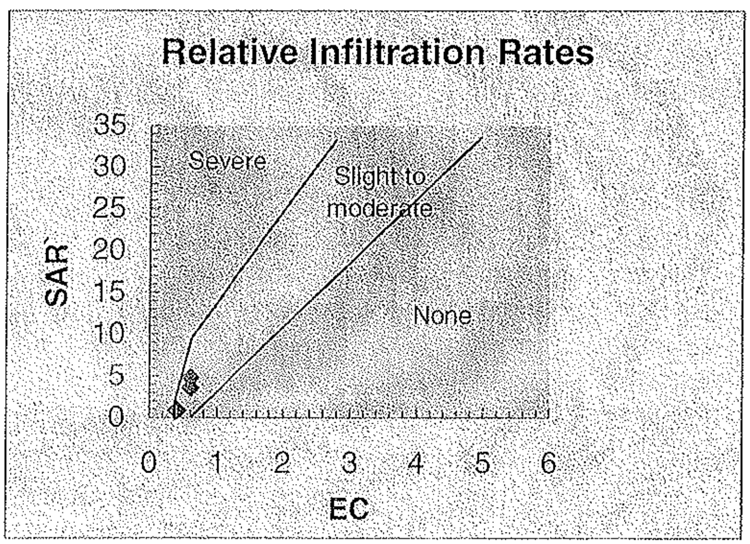
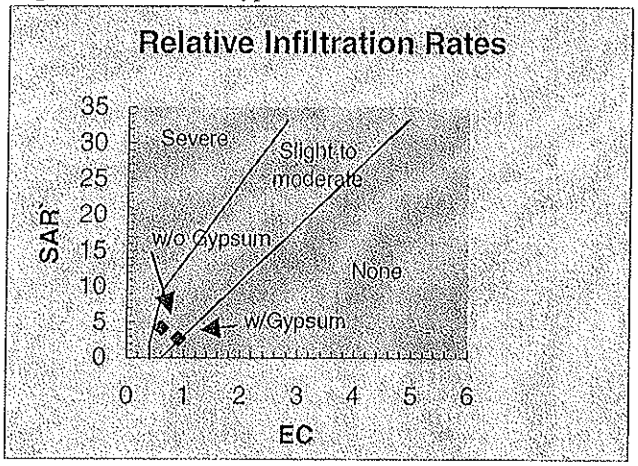


Figure 4. Effect of Gypsum on Effluent



Gypsum can be applied directly to soil or injected in to water. Cost is related to purity and source. Transportation cost is significant. Material containing 50% gypsum is available for about $20.00 per ton would be applied to soil. Material suitable for addition to water, which must be nearly pure, is available for $90.00 per ton.

Soil application of two tons per acre plus $5.00 per acre would cost $45.00 per acre per year. Solubility of soil applied material would be controlled by the amount of water applied so that annual applications may be in order.

Water applied gypsum must be nearly pure. The amount dissolved would be determined by the amount added to the irrigation water so that the amount applied can be limited to about 775 pounds per acre per year. Agitation required would be supplied by equipment costing three to four thousand dollars. Bulk material would cost about 30.00 per ton less but a $12,000 silo is needed. Condensation and humid conditions complicate management of gypsum in a silo. Cost for water injection would be about the same as soil applied lower quality material and much less salinity would be added.

D. SPECIFIC ION TOXICITY

Economic toxicity problems occur when a constituent is present in concentrations sufficient to reduce crop value. Boron, sodium and chloride when present in high concentrations cause leaf burn, reduced growth or plant death. Toxicity occurs from plant uptake from the soil solution or from direct absorption of the constituent on leaf surfaces.

Boron concentration in irrigation water is above 0.7 mg/L is may pose a risk to crop production. Because the 3.7 mg/L value reported for the sample collected July 2002 is well above 0.7 mg/L and that NO other result was above 0.2 mg/L the result was suspected to be anomalous. Between May 15 and August 20, 2003 seven samples were analyzed for boron content. The result for May 15 was 0.10 mg/L and all others were 0.20 mg/L. Therefore, the July 2002 result is considered anomalous.

The symptoms are leaf burn or other foliar symptoms. If leaf burn occurs at the seedling stage, the impacts can be severe. If, on the other hand, leaf burn develops slowly there may be no impact on plant growth because the leaf has been fully functional during most or all of the time it contributes to plant growth. Cosmetic leaf burn in and of itself reduces value of some crops. For example, any tip burn of leafy vegetables or ornamental plants reduces value. Leaf burn of forage crops may reduce biomass, less for alfalfa because of the 30 day crop cycle and more for Sudan grass, and therefore, yields. Leaf burn of the same crops grown for grain may have little economic impact. For surface irrigation with these waters, specific ion toxicity problems are not a concern, because of the low concentrations of boron, sodium and chloride in the recycled water and well waters available for irrigation at the project site.

Overhead sprinkler irrigation is another matter. Sodium and chloride toxicity can occur under sprinkler irrigation where windy hot conditions favor concentration of water on the leaf surface due to evaporation. Evaporation occurs in intervals between intermittent wettings. This effect is due primarily to osmotic potential as apposed to the specific ions. Other ions in irrigation waters precipitate during the concentration phase preventing high osmotic potentials. Techniques to prevent absorption through leaves include: irrigation in the evening or at night, minimizing the frequency of irrigation particularly during the late morning through afternoon, moving sprinkler equipment downwind so that leaves wetted by mist are rinsed, and good maintenance with a particular focus on the rate of sprinkler rotation to assure frequent uniform application of water on the crop canopy.

E. NUTRIENTS

Accumulation of excessive quantities of nitrogen is of concern. Excessive nitrogen can cause lodging of grain or forage crops, reduced fruit set or excessive growth of some crops including cotton and grape or other undesirable responses. A primary concern is that unused nitrogen will leach from the soil and contaminate groundwater.

F. NITROGEN

Nitrogen is required by all life forms. It is an essential part of amino acids, proteins, nucleic acids and other compounds that are building blocks for enzymes, DNA and RNA. With out nitrogen there would be no live. With out sufficient nitrogen growth rates are reduced. Nitrogen fertilizers are one of the primary factors in abundant modern low cost food supply.

Nitrogen reuse is a primary component of groundwater protection. Consideration should be given to nitrogen content of irrigation waters from all sources when fertilizer rates are being established. Nitrogen utilization of several crops is presented in **Table 5.**

Table 5. Plant Nutrient Utilization[1]

Crop	Yield (tons or lbs/acre)	N (lbs/acre)	P_2O_5 (lbs/acre)	K_2O (lbs/acre)
Barley[2]	2-1/2 tons	160	60	160
Oats[2]	3,200 lbs	115	40	145
Wheat[2]	3 tons	175	70	200
Alfalfa[2]	8 tons	480	95	480
Sudan[2]	8 tons	325	125	475
Almonds	2 tons in shell	260	100	340
Grape	10 tons	83	60	130
Peaches	15 tons	95	40	120
Pistachios[3]	5,000 lbs	117	--	220

[1] *Total uptake in harvested portion of crop. Values are estimates as they vary by 30 % or more.*
[2] *Source the Western Fertilizer Handbook.*
[3] *Weinbaum, S.A., R.C. Rosecrance & Craig.*

Where nitrogen is deficient a few dollars spent for nitrogen can return tens, hundreds or thousands of dollars of increased yield. It is this wide cost benefit ratio that contributes to the inexpensive food supply we enjoy.

Where there is sufficient nitrogen for optimum yields addition of additional fertilizer may add cost with out increasing revenue. Some crops simply do not respond to nitrogen to more than optimum yet nitrogen in excess of the optimum amount may be considered insurance against losses of reduced yields due to deficiency. Such applications have potential for leaching losses and in some situations are threats to ground water quality. Some crops respond to more than optimum nitrogen in ways that reduce yield or crop value. For example sugar beets produce more tons of roots but less sugar per acre. Maturity of many tree fruit varieties is delayed and fruit may be too soft to survive packing, transportation, and storage. Grape will respond by producing more vegetative growth at the expense of reproductive growth. Lush, green unfruitful vines result.

G. EFFECT OF NITROGEN CONCENTRATION OF POTENTIAL WATER DELIVERY.

Adjustments for nitrogen concentration could decrease the amount of recycled water applied. Grapes for example can be adversely impacted by excessive amounts of nitrogen. Total nitrogen in effluent will be oxidized in soil profiles to nitrate nitrogen (NO_3 –N) and will then be available for crop use or leaching below the root zone. Nitrogen in recycled water reported in **Table 1** ranges from 8 to 15 mg/ and nitrate nitrogen ground water reported in **Table 2** ranges from zero to17 mg/L. Only one ground water sample had more than 6 mg/L. While the amount of nitrogen in both substrates is variable, 15 mg/L is considered for this discussion.

The annual consumptive use of grape estimated in **Table 6** is 27.8 inches. When adjusted for 5.3 inches of useful rainfall and 80 percent DU average applied water is 28.1 inches. Application of 28.1 inches of water containing 15mg/L of nitrogen also applies 95.5 pounds of nitrogen. Grapes remove about 80 pounds of nitrogen per acre. Application of 95 pounds per acre could cause excessively vegetative growth if excess water was also applied.

Grape responds to excess water as well as nitrogen by producing excessive vegetative growth at the expense of reproductive (fruitful) growth. Recycled water may or may not contain more nitrogen that ground waters available at the various fields. Clearly nitrogen content of recycled and ground water would have to be considered. Of particular importance would be vineyards with excessive vigorous growth. Less recycled water would be required if it is determined that excess vigor is related to nitrogen application.

Nitrogen application for other crops could be reduced by the amount of nitrogen applied in recycled or ground water. Except for sugar beets late during the session nitrogen is a positive recycled and ground water characteristic.

H. MISCELLANEOUS

Miscellaneous items include cosmetic deposits, corrosion of equipment. Evaporation of water from plant surfaces can result in unsightly deposit of lime on leaf surfaces but should not be a limitation in production of crops grown in the area. Plugging of low-pressure irrigation system can be significant, as can be corrosion of aluminum or brass fixtures. A significant risk addressed by elimination of numerous crops from consideration is that of disease transmission to humans. Properties relating to low water infiltration rates can impact insect vectors and other nuisances.

I. RECOMMENDATIONS:

- To the extent possible match nitrogen loading and application with crop requirement and provide uniform application of irrigation water to protect against groundwater contamination with nitrate.
- Consider nitrogen content of recycled and ground water when determining amounts of fertilizer nitrogen to apply.
- Consider nitrogen content of recycled and ground water and the crop nitrogen requirement when selecting crops to plant.
- Irrigation methods to reduce the concentration of these salts drying on the plants after irrigation should be used for effluent with high sodium and chloride.
- To protect against salt (TDS or EC) accumulation in the root zone, maintain an adequate leaching fraction.

IRRIGATION WATER QUANTITY

Crops require specific amounts of water based on their individual characteristics, climatic conditions and other factors. In order to utilize all or most of recycled water available from the SKF WWTP A system for delivery to sufficient acreage will be required. This section examines two areas with respect to water crop water use for the purpose of conceptual design of distribution system alternatives as part of the reclaimed water feasibility study. Neither area is served with surface water.

The Plant area adjacent to the SKF WWTP is bounded by Kamm, McCall, Elkhorn, and Bethel avenues. The approximately 3020 acre area is in Consolidated Irrigation District (CID) and the Kings River Conservation District (KRCD) service area. Crops are almond, deciduous fruit, grape, walnut, and open ground. While the open ground may be returned to perennial crops or used for a range of row crops, double cropped sorghum and winter grains are considered for this report The plant area crop mix is depicted in **Figure 5**.

The Elkhorn area south west of the SKF WWTP is bounded by Elkhorn, Del Rey, Harlan, and De Wolf avenues and the Fresno-Kings county line. The area approximately 4435 acre area is not in any irrigation district or the KRCD service area. Crops are almond, deciduous fruit, grape, walnut, and open ground. While the open ground may be returned to perennial crops, double cropped sorghum and winter grains are considered for this report. The Elkhorn area and crop mix is depicted in **Figure 6**.

A. CROP WATER USAGE

The amount of water that can be utilized in an area is a function of crop water requirement, crop acreage, crop mix, water quality, and management factors. The current crop mix in the two areas is considered to provide information for the recycled water feasibility study.

Weather conditions are a primary crop water use factor. The California Irrigation Management Information System (CIMIS), a service of the California Department of Water Resources (DWR), is a source of reference evapotransporation information. Reference evapotransporation (ETo) is based on solar radiation, humidity, wind and other factors. A crop factor (Kc) is used to adjust ETo to crop evapotransporation (ETc). Crop factors are based on variety, stage of growth, planting date and harvest date. ETo multiplied by Kc results in ETc. Average ETo data from the Parlier CIMIS station located at the University of California Kearney Horticultural Field Station, the nearest to the project site is presented in **Table 6**. Kc factors for almond deciduous trees grape walnut and small grains and sorghum and resulting ETc are also presented in **Table 6** in fourteen day increments.

The crop use for an area was determined by multiplying ETc for that each by the number of that crop in the area. Crop water usage for the Plant Area and Elkhorn is presented **Tables 7 and 8** respectively.

Useful rain fall reduces the amount of water that must be applied. Useful rainfall is that portion of precipitation that is likely to be available for crop use. Calculations are from DWR. 1989. *Effective Precipitation, a Field Study that Assess Consumptive use of Winter Rains by Spring and Summer Crops.* California Department of Water Resources.

Additional water must be applied to compensate for system uniformity. No irrigation system applies water uniformly to an area. When sufficient water is applied to the areas receiving the least water to meet crop requirement excess water is applied to other areas. Distribution uniformity (DU) can range widely. Typical DU values range from sixty to ninety percent. Eighty percent was used in **Tables 7 and 8** to estimate gross amounts required.

Several management practices can increase or decrease water demand. For example, during late winter or early spring soil may be maintained wet to provide frost protection. Several irrigations and substantial additional water would be applied. Net water consumption will not be as great because water not consumed by plants of evaporated will percolate to the water table where it can be recovered. Another cultural practice that would use additional water would be to maintain moist soil during periods of seed germination. Soil is dried prior to raisin grape harvest to allow for preparation of the soil surface for grape drying. Less water would be used for raisin grapes that for grape grown for wine or table use. No allowance is made in these estimated for these practices.

Water application must occur in advance of crop use. Delivery will most likely occur several days to two weeks prior to crop usage. Application volumes will be greater in dry and less in wet years than in average years.

Table 6. Reference Evapotranspiration (Eto) Crop Factors (Kc) and Crop Evapotranspiration (Etc) For The SKF Area.

			Almond		Deciduous		Grape		Walnut		Small Grains		Sorghum	
	Date	ETo	Kc	ETc in/14 d	Kc	ETc in/14 d	Kc	ETc in/14 d	Kc	ETc in/14 d	Kc	ETc in/14 d	Kc	ETc in/14 d
JAN	1-15	0.03									0.43	0.18		
	16-31	0.04									0.65	0.36		
FEB	1-15	0.06									0.85	0.71		
	16-28	0.08									1.04	1.16		
MAR	1-15	0.10									1.17	1.64		
	16-31	0.13	0.54	0.98	0.53	0.96	0.32	0.58	0.12	0.22	1.17	2.13		
APR	1-15	0.17	0.60	1.43	0.58	1.38	0.41	0.98	0.53	1.26	1.17	2.78		
	16-30	0.19	0.66	1.76	0.66	1.76	0.50	1.33	0.68	1.81	1.03	2.74		
MAY	1-15	0.22	0.73	2.25	0.72	2.22	0.59	1.82	0.79	2.43	0.78	2.40		
	16-31	0.24	0.79	2.65	0.78	2.62	0.69	2.32	0.86	2.89	0.50	1.68		
JUN	1-15	0.26	0.84	3.06	0.86	3.13	0.78	2.84	0.93	3.39				
	16-30	0.27	0.86	3.25	0.86	3.25	0.82	3.10	1.00	3.78			0.16	0.60
JUL	1-15	0.27	0.93	3.52	0.86	3.25	0.82	3.10	1.14	4.31			0.16	0.60
	16-31	0.25	0.94	3.29	0.86	3.01	0.82	2.87	1.14	3.99			0.28	0.98
AUG	1-15	0.24	0.94	3.16	0.86	2.89	0.82	2.76	1.14	3.83			0.72	2.42
	16-31	0.22	0.94	2.90	0.86	2.65	0.77	2.37	1.11	2.99			1.05	3.23
SEP	1-15	0.19	0.94	2.50	0.86	2.29	0.66	1.76	0.97	2.34			1.05	2.79
	16-30	0.15	0.91	1.91	0.86	1.81	0.55	1.16	0.88	1.07			1.05	2.21
OCT	1-15	0.13	0.85	1.55	0.83	1.51	0.44	0.80	0.51	0.51			0.87	1.58
	16-31	0.09	0.79	1.00	0.80	1.01			0.28				0.70	0.88
NOV	1-15	0.07	0.70	0.69	0.73	0.72							0.53	0.52
	16-30	0.04												
DEC	1-15	0.03									0.22	0.09		
	16-31	0.02									0.22	0.06		
Annual Total				35.88		34.45		27.77		34.82		15.95		15.83

Table 7. Estimated Water Use For Fields Near The SKF Plant.

Crop Acres	Date	Almond 185.00	Deciduous 425.00	Grape 1735.00	Walnut 10.00	Small Grains 20.00	Sorghum 20.00	Total7 2395.00	Average8	Average Rainfall Historical 9	Useful 10	Net11 Crop need	Adjusted for Efficiency 0.80
		Evapotransporation Summary6 -- Acre Feet							Ac-in	in/14 d	in/14 d	in/14 d	in/14 d
JAN	1-15					0.30		0.30	0.00	1.14	0.80	0.00	0.00
	16-31					0.61		0.61	0.00	1.14	0.80	0.00	0.00
FEB	1-15					1.19		1.19	0.01	1.06	0.73	0.00	0.00
	16-28					1.94		1.94	0.01	1.05	0.72	0.00	0.00
MAR	1-15					2.73		2.73	0.01	1.15	0.42	0.00	0.00
	16-31	15.15	34.16	84.21	0.18	3.55		137.25	0.69	1.00	0.30	0.39	0.49
APR	1-15	22.02	48.89	141.08	1.05	4.64		217.68	1.09	1.15		1.09	1.36
	16-30	27.07	62.18	192.30	1.51	4.57		287.61	1.44	1.15		1.44	1.80
MAY	1-15	34.66	78.54	262.74	2.03	4.00		381.97	1.91	0.41		1.91	2.39
	16-31	40.92	92.82	335.20	2.41	2.80		474.15	2.38	0.41		2.38	2.97
JUN	1-15	47.14	110.87	410.50	2.82			571.33	2.86	0.12		2.86	3.58
	16-30	50.12	115.13	448.15	3.15		1.01	617.56	3.09	0.11		3.09	3.87
JUL	1-15	54.20	115.13	448.15	3.59		1.01	622.08	3.12	0.10		3.12	3.90
	16-31	50.72	106.60	414.95	3.33		1.63	577.24	2.89	0.09		2.89	3.62
AUG	1-15	48.69	102.34	398.36	3.19		4.03	556.61	2.79	0.09		2.79	3.49
	16-31	44.63	93.81	342.89	2.49		5.39	489.22	2.45	0.10		2.45	3.06
SEP	1-15	38.55	81.02	253.83	1.95		4.66	380.00	1.90	0.90		1.90	2.38
	16-30	29.46	63.96	166.99	0.89		3.68	264.99	1.33	0.90		1.33	1.66
OCT	1-15	23.85	53.50	115.78	0.42		2.64	196.20	0.98	0.31		0.98	1.23
	16-31	15.35	35.70		0.00		1.47	52.52	0.26	0.31		0.26	0.33
NOV	1-15	10.58	25.34				0.87	36.78	0.18	0.59	0.28	0.00	0.00
	16-30							0.00	0.00	0.59	0.28	0.00	0.00
DEC	1-15					0.15		0.15	0.00	0.77	0.45	0.00	0.00
	16-31					0.10		0.10	0.00	0.78	0.46	0.00	0.00
Annual Total		553.09	1220.00	4015.14	29.01	26.59	26.38	5870.20	29.41	15.42	5.25	28.90	36.12

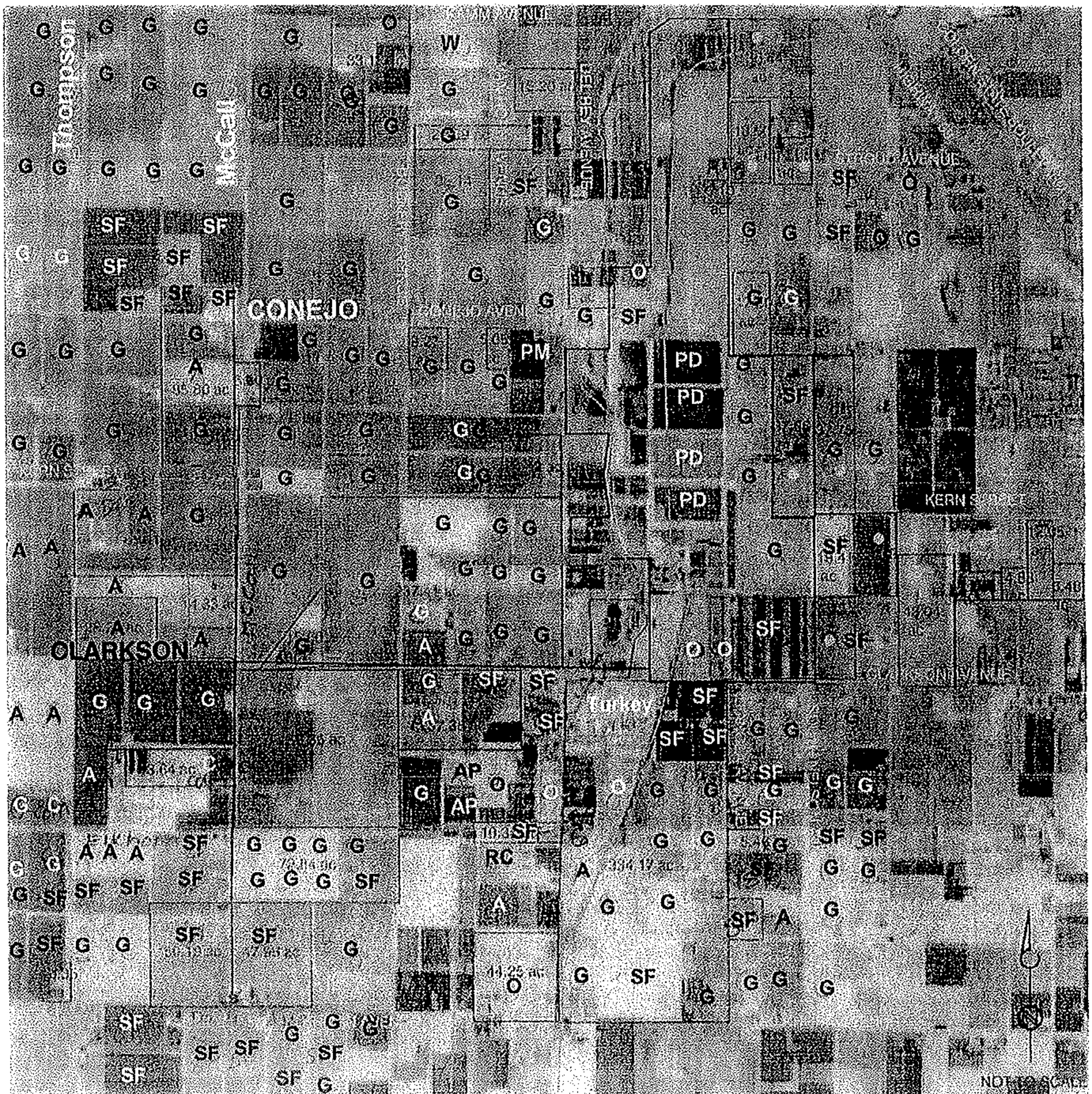
Table 8. Estimated Water Use For Fields In The Elkhorn area.

Crop Acres	Date	Evapotransporation Summary Almond 130.00 Acre-feet	Deciduous 2065.00	Grape 1590.00	Walnut 45.00	Small Grains 425.00	Sorghum 425.00	Total 4680.00	Average Ac-in	Average Rainfall Historical 3/ in/14 d	Useful 4/ in/14 d	Net Crop need/ in/14 d	Adjusted for Efficiency 0.80 in/14 d
JAN	1-15					6.40		6.40	0.02	1.14	0.80	0.00	0.00
	16-31					12.89		12.89	0.03	1.14	0.80	0.00	0.00
FEB	1-15					25.29		25.29	0.06	1.06	0.73	0.00	0.00
	16-28					41.25		41.25	0.11	1.05	0.72	0.00	0.00
MAR	1-15					58.01		58.01	0.15	1.15	0.42	0.00	0.00
	16-31	10.65	165.99	77.17	0.82	75.42		330.04	0.85	1.00	0.30	0.55	0.69
APR	1-15	15.47	237.54	129.29	4.73	98.62		485.66	1.25	1.15		1.25	1.56
	16-30	19.02	302.11	176.23	6.78	97.03		601.17	1.54	1.15		1.54	1.93
MAY	1-15	24.36	381.61	240.78	9.12	85.09		740.96	1.90	0.41		1.90	2.37
	16-31	28.76	451.00	307.19	10.84	59.50		857.28	2.20	0.41		2.20	2.75
JUN	1-15	33.12	538.69	376.19	12.69			960.70	2.46	0.12		2.46	3.08
	16-30	35.22	559.41	410.70	14.18		21.42	1040.92	2.67	0.11		2.67	3.34
JUL	1-15	38.08	559.41	410.70	16.16		21.42	1045.77	2.68	0.10		2.68	3.35
	16-31	35.64	517.97	380.28	14.96		34.71	983.56	2.52	0.09		2.52	3.15
AUG	1-15	34.22	497.25	365.06	14.36		85.68	996.58	2.56	0.09		2.56	3.19
	16-31	31.36	455.81	314.24	11.20		114.54	927.16	2.38	0.10		2.38	2.97
SEP	1-15	27.09	393.66	232.62	8.78		98.92	761.06	1.95	0.90		1.95	2.44
	16-30	20.70	310.78	153.04	4.02		78.09	566.63	1.45	0.90		1.45	1.82
OCT	1-15	16.76	259.95	106.11	1.91		56.08	440.80	1.13	0.31		1.13	1.41
	16-31	10.78	173.46		0.00		31.24	215.48	0.55	0.31		0.55	0.69
NOV	1-15	7.43	123.11				18.40	148.94	0.38	0.59	0.28	0.10	0.12
	16-30							0.00	0.00	0.59	0.28	0.00	0.00
DEC	1-15					3.27		3.27	0.00	0.77	0.45	0.00	0.00
	16-31					2.18		2.18	0.00	0.78	0.46	0.00	0.00
Annual Total		388.7	5927.8	3679.6	130.6	565.0	560.5	11,252.0	28.8	15.4	5.3	27.9	34.9

Footnotes to Tables 6, 7 & 8

1. ETo is reference evapotransporation for the Parlier CIMIS station taken from Hanson 1999, Table C-1.
2. Kc is the crop coefficient taken from Hanson 1999 Table A-2 for annual crops and B-1 for tree and Vine crops.
3. ETc is acre-inches of crop evapotransporation for the two week period calculated using ETc =ETo * Kc.
4. Several Kc values are given for deciduous trees. This one is for peaches, apricots, pears, plumbs and pecans without a cover crop. A cover crop will require slightly more water. Three are also sets of values for deciduous tress that leaf out at different times. Similar amounts of water are used but slightly earlier or later.
5. Small grains, wheat, barley, etc., and sorghym are used for the open land. Other crops could be used but similar amounts of water would be used and acreage is small. Most likely these fields will be replanted with tree or vine crops.
6. Total evapotranspiration for each crop for each two week period is calculated using ETc * acres/12 and is expressed as acre-feet.
7. Total evapotranspiration is the sum of evapotranspiration for each crop.
8. Average evapotranspiration is total evapotranspiration divided by total acres.
9. Historical rainfall is derived from CIMIS records for the Parlier station. Data is the average of 19 or 20 years records and has not been smoothed to fit long-term monthly distribution. Monthly data was evenly divided into 14-day segments.
10. Useful rainfall is that portion of precipitation that is likely to be available for crop use. Calculations are from DWR. 1989. *Effective Precipitation, a Field Study top Assess Consumptive use of Winter Rains by Spring and Summer Crops*. California Department of Water Resources.
11. Net crop need is Average crop evapotranspiration less effective precipitation.
12. Crop need adjusted for irrigation efficiency using Net Crop Need divided by 0.8

DATE OF CROP SURVEY: AUGUST 14, 2003



A = Almond
AP = Apple
G = Grape

C = Corn
O = Open
PD = Pond

SF = Stonefruit
W = Walnut

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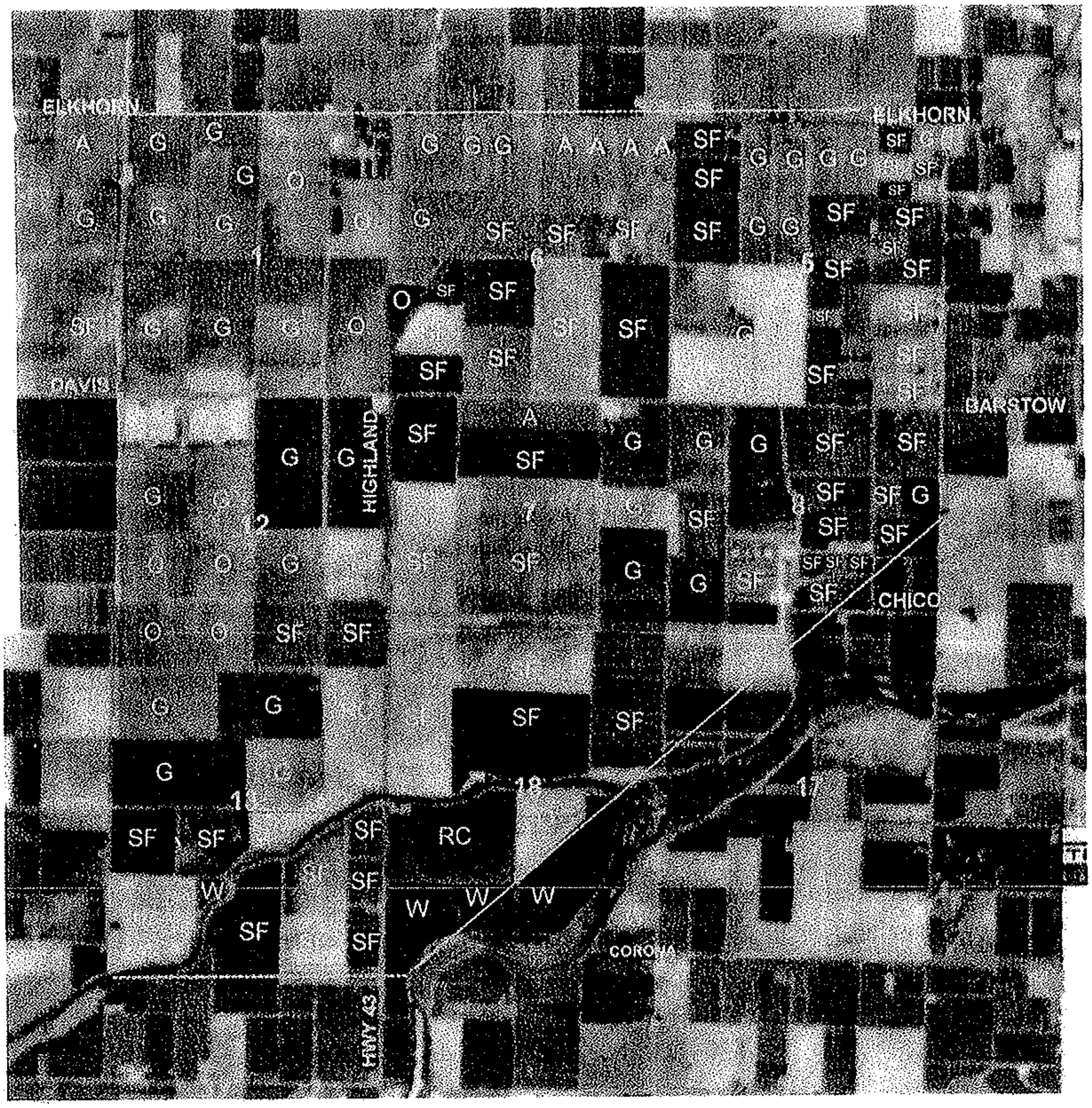
FIGURE 5. SURVEY OF CROPS AROUND SKF PLANT

DATE OF CROP SURVEY: MARCH 14, 2003



LEGEND
A = ALMOND
G = GRAPE
O = OPEN
RC = ROW CROPS
SF = STONE FRUIT
W = WALNUT

NOT TO SCALE

DELLAVALLE Laboratory, Inc.
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FIGURE 6. SURVEY OF CROPS IN ELKHORN AREA

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Chemists and Consultants

1910 W. McKinley, Suite 110, Fresno, CA 93728
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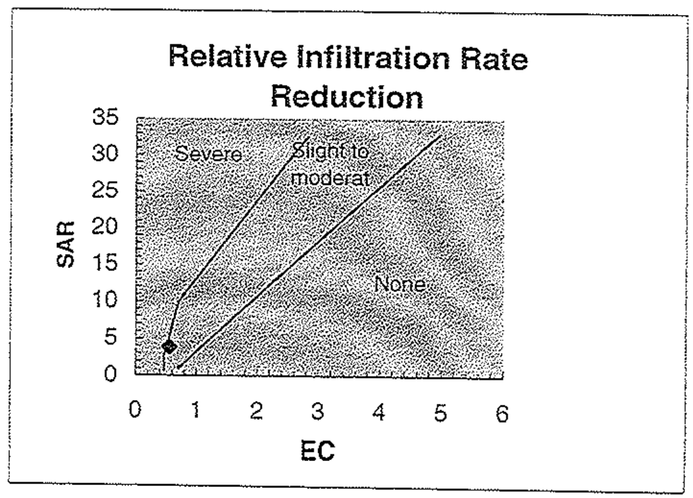
Report of Water Analysis

Selma-Kingsburg-Fowler S. Dist.
P.O. Box 158
Kingsburg, CA 93631
3695
01

Material Submitted: Final Effluent Grab

No.	Description	EC $x10^3$	Ca (meq/l)	Mg (meq/l)	Na (meq/l)	SAR	SAR adj	Cl (meq/l)	CO_3+HCO_3 (meq/l)	SO_4 (meq/l)	B (mg/l)	NO_3-N (mg/l)	Fe (mg/l)	Mn (mg/l)	pH	LI	mg/l TDS
01	Jan 02	0.6	0.9	0.3	3.2	4.2	NR	1.4	NR	0.7	0.2	9.8			7.4	NA	
02	Apr 02	0.6	1.1	0.3	3.7	4.5	6.4	1.7	2.8	0.5	0.2	11.9			7.2	-0.7	
03	Jul 02	0.6	0.9	0.2	3.1	4.1	5.7	1.7	3.0	0.5	3.7	15.7			7.3	-0.6	
04	Oct 02	0.6	1.0	0.3	3.4	4.2	6.2	1.9	3.2	0.4	0.2	4.9			7.2	-0.6	
05	Jan 03	0.6	1.0	0.3	3.4	4.2	5.6	1.6	2.4	0.5	0.2	8.1			7.2	-0.8	
01	April-03	0.6	1.0	0.3	3.2	3.8	5.4	1.6	2.6	0.6	NR	NR			7.2	-0.7	330



NR = Not Reported

WS13/SKF/SKF-agsuit final effluent grab.xls

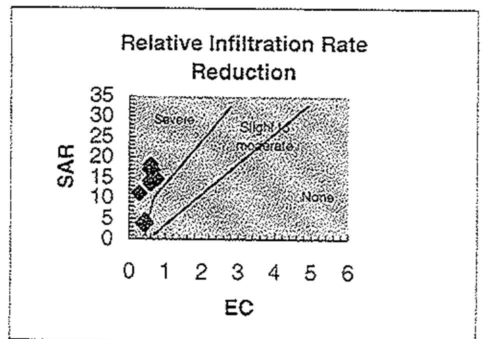
DELLAVALLE Laboratory, Inc.
Chemists and Consultants
1910 W. McKinley, Suite 110, Fresno, CA 93728
FAX (559) 268-8174 - (800) 228-9896 - (559) 233-6129

Report of Water Analysis

Selma-Kingsburg-Fowler S. Dist.
P.O. Box 158
Kingsburg, CA 93631
3695
01

Groundwater monitoring data from wells 10, 11, & 12

No.	Description	EC $x10^3$	Ca (meq/l)	Mg (meq/l)	Na (meq/l)	SAR	SAR adj	Cl (meq/l)	CO_3+HCO_3 (meq/l)	SO_4 (meq/l)	B (mg/l)	NO_3-N (mg/l)	Fe (mg/l)	Mn (mg/l)	pH	LI	TDS mg/l
	Well 10																
01	4-23-02	0.4	2.9		1.0	3.9	2.1	0.3	2.8		0.1	3.4			7.4	-1.3	240
02	7-17-02	0.4	3.1		1.3	4.5	3.0	0.3	3.4		0.1	4.6			7.4	-1.2	320
03	10-11-02	0.5	3.4		1.2	4.2	2.8	0.3	3.2		0.1	5.2			7.3	-1.3	310
04	1-9-03	0.4	3.3		1.0	3.5	2.2	0.4	3.0		0.1	17.6			7.1	-1.6	280
05	4-9-03	0.5	3.5		1.1	3.8	2.7	0.4	3.4		0.1	4.7			7.1	-1.4	300
	Well 11																
01	4-23-02	0.6	2.3		4.1	17.0	8.2	1.8	3.6		0.2	3.4			7.3	-1.4	380
02	7-17-02	0.6	2.1		3.9	16.8	7.1	1.8	3.4		0.3	1.5			6.8	-2.0	380
03	10-11-02	0.6	2.0		3.8	17.1	6.4	1.9	3.2		0.2	1.5			7.3	-1.5	340
04	1-9-03	0.6	1.9		4.0	18.2	4.8	1.7	2.6		0.2	5.6			6.9	-2.1	330
05	4-9-03	0.6	2.3		3.4	14.3	5.5	1.7	2.8		0.2	3.8			6.9	-2.0	340
	Well 12																
01	4-23-02	0.7	2.4		4.1	17.0	10.2	1.9	4.6		0.3	0.1			7.6	-1.1	400
02	7-17-02	0.3	1.0		1.8	11.2	-0.4	0.4	2.2		0.1	0.8			7.5	-1.8	190
03	10-11-02	0.8	3.4		4.3	14.6	12.7	1.7	6.0		0.3	0.1			7.7	-0.7	460
04	1-9-03	0.6	2.6		3.5	13.7	6.9	1.7	3.2		0.2	4.0			7.2	-1.5	380
05	4-9-03	0.6	2.5		3.4	13.5	6.1	1.7	3.0		0.2	5.4			7.2	-1.6	360



F:/1-excelrep/ws13/skf/Well 10, 11, 12.xls

Exhibit 3

DELLAVALLE® Laboratory, Inc.
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www.dellavallelab.com

AGRICULTURAL WATER INTERPRETATION GUIDE

EC mmhos/cm — ELECTRICAL CONDUCTIVITY - This is an estimate of the concentration of soluble salts. The interpretation of EC assumes that 10-20% of the total water applied passes through and below the root zone. In most cases deep percolation losses, due to inefficiency of irrigation practices, will satisfy the leaching requirement for the usual crops.

Below 0.5	Depending on soil texture, water penetration problems may occur due to low salt content.
Below 0.75	Low salinity hazard - can be used for most crops.
0.75 - 1.5	Medium salinity hazard - can be used for moderately salt tolerant crops.
1.5 - 3.0	High salinity hazard - can be used for highly salt tolerant crops.
Above 3.0	Very high salinity hazard - generally not suitable for continual use except under most favorable conditions. Leaching is necessary.

The EC (mmhos/cm) multiplied by 640 is approximately equal to the concentration of total dissolved solids (TDS) in ppms.

Ca, Mg, Na meq/l — CALCIUM, MAGNESIUM, SODIUM - Major cations found in most waters. Solid calcium and magnesium carbonates ($CaCO_3$ and $MgCO_3$) form when the concentrations of these constituents are sufficiently high. For drip systems, preventative maintenance is necessary to avoid emitter clogging from formation of $CaCO_3$ and $MgCO_3$. Sodium is a problem when it is the dominant ion. Calcium, magnesium and sodium are used to calculate SAR.

SAR — SODIUM ADSORPTION RATIO - A calculated value used to *estimate* the exchangeable sodium percentage, ESP, of a soil after long-term use of water.

SAR_{adj} — SODIUM ADSORPTION RATIO ADJUSTED - This ratio takes into consideration the calcium precipitation from carbonates and bicarbonates. Permeability problems are more probable at a given SAR_{adj} with waters of low salinity than at high salinity. The relationship between irrigation water SAR_{adj} and soil ESP (exchangeable sodium percentage) is:

SAR_{adj}	ESP	
Below 6	Below 10	No soil permeability problem expected due to sodium.
7 - 9	10 - 15	Possible permeability problems with fine texture soils. (Saturation percentage above 50)
Above 9	Above 15	Permeability problems likely on all mineral soils, with possible exceptions of very coarse textured soils. (Saturation percentage below 20)

Cl meq/l — CHLORIDE - Fruit crops and many woody ornamentals are chloride sensitive.

Below 2	Satisfactory for all crops.
2 - 10	Range associated with leaf burn on chloride sensitive crops.
Above 10	Generally unsatisfactory for chloride sensitive crops.

CO_3, HCO_3 meq/l	CARBONATE PLUS BICARBONATE - These two major anions are related to the alkalinity of waters and are involved in the formation of $CaCO_3$ and $MgCO_3$. Waters relatively high in carbonate or bicarbonate may present special problems.
B ppm	BORON - Small amounts are required and large amounts are toxic to plants.

Below 0.5	Satisfactory for all crops.
0.5 - 1.0	Satisfactory for most crops. Sensitive crops may show injury, however yields may not be affected.
1.0 - 2.0	Satisfactory for semi-tolerant crops. Sensitive crops are usually reduced in yield and vigor.
2.0 - 4.0	Only tolerant crops produce satisfactory yields.
Above 4.0	Generally unsatisfactory for continued use.

NO_3-N ppm	NITRATE NITROGEN - All or part of the crop's needs can be supplied. This formula is helpful for calculating fertilizer needs: NO_3-N x 2.72 = N in lbs/ac. ft. of water.
Fe, Mn ppm	IRON, MANGANESE - Of concern in drip systems as emitter clogging may occur due to the formation of iron and manganese oxides, ochers (oxides mixed with sand, silt and clay) and hydroxides. Water containing more than 3.5 ppm iron or manganese should probably not be used for drip irrigation. If the iron level is between 1.5 and 3.5 ppm, the pH should be below 6.5 in order to avoid iron deposits.
LI	LANGLIER INDEX (Corrosivity) - The corrosiveness of water, expressed as Langlier Index, is a function of alkalinity, calcium concentration, EC, water temperature and pH. The Index values normally range from -2.0 to +2.0. A negative value indicates a corrosive water; a positive value indicates a tendency to precipitate calcium carbonate ($CaCO_3$).
pH	Degee of ACIDITY or ALKALINITY - Normal range for western irrigation waters is from pH 6.5 to 8.4.

SUMMARY

PROBLEM	DEGREE OF PROBLEM		
	None	Increasing	Severe
Salinity:			
EC, mmhos/cm	0.75	0.75 - 3.0	3.0
Permeability:			
Caused by low salt: EC, mmhos/cm	>0.5	<0.5	----
Caused by sodium: SAR_{adj}	6	6 - 9	9
Toxicity, from root absorption:			
Sodium, SAR_{adj}	3	3 - 9	9
Chloride, meq/1	4	4 - 10	10
Boron, ppm	0.5	0.5 - 2	2
Toxicity, from leaf absorption (sprinklers):			
Sodium, meq/1	3	3	
Chloride, meq/1	3	3	
Excess nutrient: Nitrate-nitrogen, ppm	5	5 - 30	30
"Whitewashing": Calcium or bicarbonate, meq/1, each	<1.5	>1.5	

To obtain interpretation for specific crops or objectives, please call Dellavalle Laboratory, Inc.

References: Water Quality for Irrigation, L. K. Stromberg; 1975 and 1980
Water Quality for Agriculture, F.A.O. 1976

APPENDIX C

PROJECTED MONTHLY FLOW, RAINFALL, EVAPORATION, PERCOLATION, AND IRRIGATION RATES

SELMA-KINGSBURG-FOWLER COUNTY SANITATION DISTRICT
RECYCLED WATER FEASIBILITY STUDY
PROJECTED RATES

Month		Influent Flow Rate (AF/mo)	Rainfall (AF/mo)	Evaporation (AF/mo)	Unit Percolation Rate (in/ft)	Percolation (AF/mo)	Pump from Pond (AF/mo)	Pump from Aquifer (AF/mo)	Average Month Irrigation Rate (ft/mo)	Irrig. Rate (AF/mo)
	Beg									
Nov	End	304	7	12	3.95	92	0	0	0.00	0
	Beg									
Dec	End	306	11	5	3.95	153	0	0	0.00	0
	Beg									
Jan	End	283	19	5	3.95	195	0	0	0.00	0
	Beg									
Feb	End	267	15	10	3.95	220	0	0	0.00	0
	Beg									
Mar	End	278	14	25	3.95	234	0	32	0.04	32
	Beg									
Apr	End	243	7	41	3.95	235	0	208	0.26	208
	Beg									
May	End	288	3	62	3.95	231	0	360	0.45	360
	Beg									
Jun	End	271	3	75	3.95	198	200	296	0.62	496
	Beg									
Jul	End	307	0	79	3.95	139	250	254	0.63	504
	Beg									
Aug	End	336	0	70	3.95	92	300	140	0.55	440
	Beg									
Sep	End	291	1	50	3.95	64	220	52	0.34	272
	Beg									
Oct	End	298	1	11	3.95	59	104	0	0.13	104

APPENDIX D

SUMMARY OF MEETING WITH RICHARD HARGROVE

Selma-Kingsburg-Fowler County Sanitation District
Recycled Water Feasibility Study

Summary of Meeting With Richard Hargrove, SKF Legal Counsel

Prepared by:
Anita Jain, Whitley Burchett & Associates

At the third recycled water study team meeting held at the SKF on May 15, 2003, Mr. Richard Hargrove, SKF Legal Counsel was present to provide direction on potential water rights issues in consideration of distributing recycled water to the Elkhorn Area. The study team's concern was that issues pertaining to water rights may arise if CID water is "transferred" to the Elkhorn area, a non-CID service area.

Mr. Hargrove suggested that SKF effluent may be characterized as "salvaged" water. The term "salvaged water" originates in the Porter Cologne Act to address transfer regulations. Categorizations of salvaged water were derived as a result of implementation of the Water Recycling Act of 1991. Under these Acts, salvaged water is *delivered* to users rather than *transferred*, thereby eliminating the legal issues of transferring water out of a service area.

Recycled water produced from the SKF plant would be discharged to the disposal ponds where ultimately the water would mix with ground water. Since the blended water is not being discharged to another usable water source, it is not subject to blending regulations. The blended water could be considered "salvaged water" since if the water was not extracted and reused, then it would essentially have been "lost". Conversely, if the water was flowing in the Kings River, then it would be considered waters of the state, and not considered "lost" water. If the water was flowing into an irrigation canal, then it would be subject to the rights of a contract agreement and therefore is also not considered "lost" water. However, salvaging the blended water (the mixture of percolated SKF effluent and ground water) is essentially recovering water that would have been "lost".

Salvaged water could be delivered to designated users under a Master Permit issued from the Regional Water Quality Control Board. It was Mr. Hargrove's opinion that SKF could hold a Master Permit for the project even though it is outside of SKF jurisdiction.

Water from this project could be sold to users. A new assessment district may need to be formed in coordination with the Fresno County Board. A contract could be established such that SKF would be in contract with individual land owners using the water. For potential customers in the Elkhorn Area, the cost of the water should be comparable to that of ground water pumping.

Additionally, the possibility of SKF having its own water enterprise, separate from normal wastewater collection and treatment operations, was discussed. Since SKF would be contracting to provide a surface water source to an area where there is currently none, there would be no interference or competition with KRCD or CID operations.

Suggestions were briefly discussed for information which should be included in the contract. Two of the suggestions made were:

1. Specify an amount of water which the user agrees to purchase.

2. Include an indemnification clause holding SKF harmless.

Rather than offering the salvaged water exclusively to users in the Elkhorn Area, a pipeline could be constructed from the SKF plant to the Elkhorn Area, providing water to accepting CID users along the way. In this case, a separate contract would be required since this would be interfering with CID revenues.

As a result of this meeting, it was established that from a legal perspective, it could be possible to provide recycled water to the Elkhorn Area without having to deal with significant water rights issues. The actual decision to pursue delivery of recycled water to the Elkhorn Area though depends upon the reactions of CID, KRCD, and KRWA to the project.

APPENDIX B

WATERSMART: FINAL FUNDING CRITERIA FOR THE TITLE XVI WATER RECLAMATION AND REUSE PROGRAM

RECLAMATION

Managing Water in the West

WaterSMART:

Final Funding Criteria for the Title XVI Water Reclamation and Reuse Program

U.S. Department of the Interior
Bureau of Reclamation

October 2010

Background and Applicability

Title XVI of P.L. 102-575, as amended (Title XVI), directs the Secretary of the Interior, acting through Reclamation's Commissioner, to undertake a program to identify and investigate opportunities to reclaim and reuse wastewaters and naturally impaired ground and surface water in the 17 Western States and Hawaii. Title XVI also provides authority for the Secretary to provide up to the lesser of 25 percent of, or the Federal appropriations ceiling (typically $20 million) for, the cost of planning, design, and construction of specific water recycling projects.

The Title XVI Program is part of the Department of the Interior's WaterSMART (Sustain and Manage America's Resources for Tomorrow) program to work toward a sustainable water strategy to meet the Nation's water needs. For purposes of the Title XVI program, a water reuse project is a project that reclaims and reuses municipal, industrial, domestic, or agricultural wastewater and naturally impaired groundwater and/or surface waters. Reclaimed water can be used for a variety of purposes, such as environmental restoration, fish and wildlife, groundwater recharge, municipal, domestic, industrial, agricultural, power generation, or recreation. Water reuse is an essential tool in stretching the limited water supplies in the West.

Title XVI projects develop and supplement urban and irrigation water supplies through water reuse, thereby improving efficiency, providing flexibility during water shortages, and diversifying the water supply. Title XVI projects provide growing communities with new sources of clean water while promoting water and energy efficiency and environmental stewardship.

Reclamation plans to use the following criteria as part of funding opportunity announcements to identify projects to receive available funding in fiscal year (FY) 2011. In the future, Reclamation plans to use these criteria as part of the process of allocating program funding.

A. Construction Activities

Eligibility

A funding opportunity will be open to sponsors of authorized Title XVI projects. Applications for funding may be submitted for (1) construction activities that can be commenced in FY 2011 and completed within 24 months <u>or</u> (2) construction activities that have been completed previously without Federal funding.

To be eligible to receive funding for construction activities, a water reclamation and reuse project must be specifically authorized under Title XVI. Funds for construction activities associated with an individual project will not be disbursed until all Title XVI pre-construction requirements have been met for that project. These include: (1) a finding that the feasibility study meets the requirements of Title XVI; (2) complete compliance with the National Environmental Policy Act and other environmental clearances; (3) an approved determination of financial capability; and (4) an executed financial assistance agreement between Reclamation and the project sponsor.

If the amount of Federal funds currently received (including obligated funds) for the project is less than 25 percent of the overall expenses, then the project sponsor may request Federal funds greater than 25 percent for the proposed activity as long as the overall Federal cost share does not exceed 25 percent of incurred expenses.

The FY 2011 selection process will be similar to steps used in 2009 to allocate $135 million in funding to Title XVI projects under the American Recovery and Reinvestment Act.

Criteria for Funding of Construction Activities

1a. Stretching Water Supplies – 35 points

Points will be awarded based on the extent to which the project phase is expected to secure and stretch water supplies. Consideration will be given to the amount of water expected to be made available by the project phase and the extent to which the project phase will reduce demands on existing facilities and otherwise reduce water diversions.

(a) How many acre-feet of water are expected to be made available each year upon completion of the project or phase?

(b) Will the project reduce, postpone, or eliminate the development of new or expanded non-recycled water supplies?

(c) How significantly will the demand on existing Federal water supplies be reduced? List the expected reduction to Federal water supply demand (in acre-feet) and the amount of water currently supplied directly or indirectly by a Federal facility to the project sponsor. Provide calculations.

(d) How will the project reduce diversions from natural watercourses or withdrawals from aquifers? Responses should be specific (including number of acre-feet) and should include the percentage by which diversions or withdrawals will be reduced.

(e) What performance measures will be used to quantify actual benefits upon completion of the project phase?

1b. Contributions to Water Supply Sustainability – 20 points

Points will be awarded for projects phases that contribute to a more sustainable water supply.

(a) Will the project make water available to address a specific concern (e.g., water supply shortages due to climate variability, and/or heightened competition for limited water supplies)? Consider the number of acre-feet of water to be made available and explain the specific concern and the role of the project in addressing that concern.

(b) Will water made available by this project phase continue to be available during periods of drought? To what extent is the water made available by this project phase more drought-resistant than alternative water supply options? Explain.

2a. Progress Toward Completion of an Authorized Title XVI Project – 20 points

Points will be awarded for project phases that will bring an authorized Title XVI project to completion (i.e., to full Federal funding levels) or close to completion.

How much Federal funding has been provided for the authorized Title XVI project to date? How much Federal funding is necessary to fully satisfy the authorized Federal cost-share?

2b. Readiness to Proceed – 10 Points

Points will be awarded based on the extent to which the project phase is ready to proceed, including consideration of the following:

(a) What is the status of necessary environmental compliance measures? When is environmental compliance expected to be complete? Provide a detailed schedule of all environmental compliance activities and a schedule that indicates when construction is expected to begin.

(b) What is the status of required State and Federal permits for the project phase? When are all required permits expected to be obtained?

3. Environment and Water Quality – 30 points

Points will be awarded based on the extent to which the project phase will improve surface, groundwater, or effluent discharge quality; will restore or enhance habitat for non-listed species; or will provide water or critical habitat for Federally-listed threatened or endangered species:

(a) Will the project phase improve the quality of surface or groundwater? To what extent will the project phase improve effluent quality beyond levels necessary to meet state or Federal discharge requirements?

(b) Will the project phase improve flow conditions in a natural stream channel? Will the project phase restore or enhance habitat for non-listed species? If so, how?

(c) Will the project phase provide water or habitat for Federally listed threatened or endangered species? If so, how?

4. Renewable Energy and Energy Efficiency – 25 points

Points will be awarded based on the extent to which the project phase incorporates the use of renewable energy and/or addresses energy efficiency:

(a) Will the project phase include installation of low-impact hydroelectric, solar-electric, wind energy, or geothermal power systems, or other facilities that enable use of these or other renewable energy sources to provide power to components of the project phase? Are any energy recovery devices or processes included in the project phase? Provide the amount of energy expected to be generated through renewable energy sources (in kilowatt hours). What percentage of the project's total energy consumption will be provided through the installation of renewable energy components?

(b) If the project phase does not itself include renewable energy, will the project phase facilitate power generation in the water delivery system by making more water available? If so, explain the relationship between this project phase and any potential renewable energy improvements in the water delivery system.

(c) Will completion of the project phase lead to a reduction in energy consumption as compared to current water supply options? Provide calculations and describe assumptions and methodology. Will the project phase include any innovative components to reduce energy consumption or to recover energy?

(d) How does the project phase's energy consumption compare to other water supply options that would satisfy the same demand as the project phase?

5. Cost per Acre-Foot of Water and Other Project Benefits – 25 points

Points will be awarded based on the cost per acre-foot of water expected to be delivered upon completion of the project phase and other benefits of the project phase.

(a) Calculate the cost per acre-foot of the project phase using the following formula: Annualized Life Cycle Cost ($) of this project phase/Average annual volume of water (acre-feet) that will be made available upon completion of the project phase.

(b) Compare the cost per acre-foot of the project phase to the cost per acre-foot of one alternative (i.e., non-recycled water option) that would satisfy the same demand as the proposed project phase.

(c) Some Title XVI project benefits may be difficult to quantify. Describe any economic benefits of the project phase that are not captured by the cost per acre-foot analysis, or that are difficult to quantify.

6a. Legal and Contractual Water Supply Obligations – 10 Points

Points will be awarded for project phases that help to meet Reclamation's legal and contractual obligations.

Does the project phase help fulfill any of Reclamation's legal or contractual obligations such as providing water for Indian tribes, water right settlements, river restoration, minimum flows, legal court orders, or other obligations? Explain.

6b. Benefits to Rural or Economically Disadvantaged Communities – 10 Points

Points will be awarded based on the extent to which the project phase serves rural communities or economically disadvantaged communities in rural or urban areas.

Does the project phase serve a rural or economically-disadvantaged community? (A rural community is defined as a community with fewer than 50,000 people.) Are any economically-disadvantaged communities within the project sponsor's service area? Will any such communities be served by this project phase? Explain.

7. Watershed Perspective – 15 points

Points will be awarded based on the extent to which the project phase promotes or applies a watershed perspective by implementing an integrated resources management approach, implementing a regional planning effort, or forming a collaborative partnership with other entities. A watershed perspective generally means an approach to planning directed at meeting the needs of geographically dispersed localities across a region or a watershed that will take advantage of economies of scale and foster opportunities for partnerships. This approach also takes into account the interconnectedness of water and land resources, encourages the active participation of all interested groups, and uses the full spectrum of technical disciplines in activities and decision-making.

(a) Does the project phase implement a regional or state water plan or an integrated resource management plan?

(b) Does the project phase promote collaborative partnerships to address water-related issues? Explain.

Total– 200 points

B. Development of Title XVI Feasibility Studies

Eligibility

A second funding opportunity will be open for development of Title XVI feasibility studies. Project sponsors typically complete a Title XVI feasibility study and submit that study to Reclamation prior to seeking Congressional authorization for construction of a new Title XVI project.

Proposed activities should begin in FY 2011 and be completed within 12 months. Applicants may request up to 50 percent of the cost of the development of a feasibility study.

Criteria for Funding of Title XVI Feasibility Study Development

1. Statement of Problems and Needs – 10 points

Points will be awarded based on the presence of watershed-based water resource management problems and needs for which water reclamation and reuse may provide a solution.

2. Water Reclamation and Reuse Opportunities – 15 points

Points will be awarded based on the extent to which the proposal demonstrates that the Title XVI feasibility study will explore opportunities for water reclamation and reuse in the study area.

(a) Describe how the feasibility study will investigate potential uses for reclaimed water (e.g., environmental restoration, fish and wildlife, groundwater recharge, municipal, domestic, industrial, agricultural, power generation, and recreation).

(b) Describe the potential water market available to use any recycled water that might be produced upon completion of a Title XVI project, as well as methods to stimulate recycled water demand and methods to eliminate obstacles to the use of reclaimed water.

(c) Describe the sources of water that will be investigated for potential reclamation, including impaired surface and ground waters.

3. Description of Potential Alternatives – 15 points

Points will be awarded based on the extent to which the proposal demonstrates that the Title XVI feasibility study will develop descriptions of water supply alternatives, including a proposed Title XVI project and other water supply alternatives.

(a) Describe the objectives all alternatives will be designed to meet. What other water supply alternatives will be investigated as part of the Title XVI feasibility study?

(b) Provide a general description of the proposed project that will be the subject of a Title XVI feasibility study.

(c) Describe alternative measures or technologies for water reclamation, distribution, and reuse that will be investigated as part of the Title XVI feasibility study.

4. Stretching Water Supplies – 15 points

Points will be awarded based on the extent to which the proposal demonstrates that the Title XVI feasibility study will address activities that will help to secure and stretch water supplies.

(a) Describe the potential for the project to reduce, postpone, or eliminate the development of new or expanded water supplies. Include description of any specific issues that will be investigated or information that will be developed as part of the Title XVI feasibility study.

(b) Describe the potential for the project to reduce or eliminate the use of existing diversions from natural watercourses or withdrawals from aquifers. Include description of any specific issues that will be investigated or information that will be developed as part of the Title XVI feasibility study.

(c) Describe the potential for the project to reduce the demand on existing Federal water supply facilities. Include description of any specific issues that will be investigated information that will be developed as part of the Title XVI feasibility study.

5. Environment and Water Quality – 15 points

Points will be awarded based on the extent to which the proposal demonstrates that the Title XVI feasibility study will address the potential for a water reclamation and reuse project to improve surface, groundwater, or effluent discharge quality; restore or enhance habitat for non-listed species; or provide water or critical habitat for Federally-listed threatened or endangered species.

(a) Describe the potential for the project to improve the quality of surface or groundwater, including description of any specific issues that will be investigated or information that will be developed as part of the Title XVI feasibility study.

(b) Describe the potential for the project to improve flow conditions in a natural stream channel, including description of any specific issues that will be investigated or information that will be developed as part of the Title XVI feasibility study.

(c) Describe the potential for the project to provide water or habitat for Federally listed threatened or endangered species, including description of any specific issues that will be investigated or information that will be developed as part of the Title XVI feasibility study.

6. Legal and Institutional Requirements – 10 Points

Points will be awarded based on the extent to which the proposal demonstrates that the Title XVI feasibility study will address legal or institutional requirements or barriers to implementing a project, including water rights issues and any unresolved issues associated with implementation of a water reclamation and reuse project.

7. Renewable Energy and Energy Efficiency – 10 points

Points will be awarded based on the extent to which the proposal demonstrates that the Title XVI feasibility study will address methods to incorporate the use of renewable energy or will otherwise address energy efficiency aspects of the water reclamation and reuse project being investigated.

8. Watershed Perspective – 10 points

Points will be awarded based on the extent to which the proposal demonstrates that the Title XVI feasibility study will address alternatives that promote and apply a regional or watershed perspective to water resource management.

Total– 100 points

APPENDIX C

GLOSSARY OF TERMS

WaterSMART Glossary of Terms

A

acre-feet: the volume contained by an acre, one foot deep.

advanced treatment: treatment processes used to clean wastewater even further following primary, secondary and tertiary treatment; often refers to the use of membrane treatment.

aerobic: (of an organism or tissue) requiring air for life; pertaining to or caused by the presence of oxygen.

anaerobic: (of an organism or tissue) living in the absence of air or free oxygen; pertaining to or caused by the absence of oxygen.

anthropogenic: made by or arising from man, not of natural origin.

artesian aquifer: a geologic formation in which water is under sufficient hydrostatic pressure to be discharged to the surface without pumping.

artesian well: a water well drilled into a confined aquifer where enough hydraulic pressure exists for the water to flow to the surface without pumping.

B

biological treatment: using microorganisms such as bacteria and fungi to biodegrade (break down) organic matter.

C

chlorination: the process of using chlorine gas, hypochlorite or other chlorine compound for disinfection.

coliforms: bacteria found in the intestinal tract of warm-blooded animals; used as indicators of fecal contamination in water.

concentration: amount of a chemical or pollutant in a particular volume or weight of air, water, soil, or other medium.

cone of depression: the cone-shaped area formed when the underground spaces in the rock or soil are emptied as underground water is pumped from a well.

confined aquifer (artesian aquifer): an aquifer, or area of soil, sand, or gravel that is saturated with water, and overlain with a dense layer of compacted clay or other similar material that blocks vertical passage of underground water.

conserve: to avoid wasteful or destructive use of a natural resource, such as water, through intelligent management and use.

constructed wetlands: areas of land that are developed to allow coverage with a shallow layer of water with different kinds of plants that act as natural treatment systems to further purify water. Roots and stems of the wetland plants form a dense mat where biological and physical processes occur to treat the water.

contaminant: an impurity affecting air, soil, or water.

cumulative: increasing or enlarging by successive addition.

D

decomposition: the process of rotting and decay which causes the complex organic materials in plants and animals to break down into simpler elements.

degradable: capable of decomposition; chemical or biological.

detection limit: the lowest level that can be determined by a specific analytical procedure or test method.

dilution: the act of making thinner or less concentrated by adding to the mixture; the act of diminishing the strength, flavor, or brilliance of by adding to the mixture.

direct injection: the pumping of surface water into the underground water through a well.

discharged: released into a water body.

disinfection: to kill or inactivate microorganisms.

disinfection-by-products: chemicals resulting from the addition of a disinfectant to the water source being treated.

dissolved organic carbon: material from plants and animals broken down into such a small size that it is "dissolved" into water.

dissolved oxygen (DO): oxygen gas dissolved in water.

dissolved solids: materials that enter a water body in a solid phase and dissolve in water; usually refers to salt.

domestic sewage (residential wastewater): wastewater produced from household use (examples: toilets, showers, laundry).

downstream: down in the direction of a flow of a stream.

drinking water standards: requirements set to protect water used for human consumption (potable or drinking water).

drought: a lack of rain or water; a long period of dry weather.

E

effluent: product from a process, such as water from a wastewater recycling plant, discharged into the environment.

endocrine disruptors (endocrine disrupting chemicals or EDCs): chemicals that interfere with the synthesis, transport, and/or action of natural hormones responsible for the reproduction, development, and/or behavior of an organism. EDCs also are contained in anthropogenic substances such as detergent, pesticides (a category that includes herbicides, insecticides, and fungicides), plasticizers, natural and synthetic hormones, among many other substances. Potential EDCs are contained in natural agricultural products such as soybeans, alfalfa, and natural hormones in animals.

enteric viruses: a category of viruses related to human excreta found in waterways.

F

filtration: the process of passing a liquid or gas through a porous substance (paper, membrane, sand, etc.) to separate out material in suspension.

flocculation: the process of forming larger particles out of smaller ones, usually to help in their removal.

fresh water: water containing an insignificant amount of salts, such as in inland streams, rivers and lakes.

G

gradient: the rate of ascent or descent, in a highway, road, river, etc.

greywater: domestic wastewater that does not contain human wastes such as tub, shower, or washing machine water (excludes toilets and garbage disposals).

groundwater: underground water; water that has infiltrated the earth's surface, filling pore spaces between rock grains or soil underground, where it is stored.

groundwater basin: an area underground where there exists a large amount of underground water.

groundwater recharge: the addition of surface water to an underground supply.

groundwater replenishment: the act of replacing stored water that has been pumped out of an aquifer.

groundwater storage: the act of storing water supplies in the porous underground material for later withdrawal and use (also called conjunctive use).

groundwater transport: the movement of water through the underground aquifer.

H

heterotroph: an organism that must consume other organic material for food and is unable to make its own food.

hydrologic (water) cycle: the cycle of the earth's water supply from the atmosphere to the earth and back which includes precipitation, transpiration, evaporation, runoff, infiltration, and storage in water bodies and underground water.

I

impermeable: impassable; not permitting the passage of a fluid through it.

imported surface water (imported water): water from lakes, streams or rivers that is transported for use in distant areas.

infiltration: the gradual downward flow of water from the surface of the earth into the soil.

infiltration basins: specially constructed ponds that collect surface water in order that it might percolate through the soil into the underground water (also called spreading or recharge basins).

injection wells: a well in which water is pumped into the ground, rather than out of it, for the purpose of storing the water in the aquifer and/or preventing a degraded water source (example, seawater) from entering into and contaminating the aquifer's water.

inorganic material: material derived from nonliving sources.

inorganic nitrogen: nitrogen in the form of ammonia, ammonium, nitrates, nitrites, nitrogen gas, or nitrogen oxides .

L

landscape irrigation: water used to grow plants that are used for aesthetics, and not as a food source.

local storm water: water from rainfall that has runoff from local area into the various water courses.

M

maximum contaminant levels: the highest content levels of certain substances allowable by law for a water source to be considered safe; usually referring to health-related drinking water standards.

membrane: a thin barrier that allows some compounds or liquids to pass through, and retards others; the ability of a compound to pass through a membrane is determined by size or special nature of the particles.

microbe: a general term for microorganism (see below).

microorganisms: organisms too small to be seen with the unaided eye, including bacteria, protozoans, yeasts, viruses, and algae; may be helpful or harmful.

monitoring: scrutinizing and checking systematically with a view to collecting data.

monitoring well: a well used to gather underground water for analysis.

municipal sewage: sewage/ wastewater originating from urban areas (not industrial).

N

National Pollutant Discharge Elimination System (NPDES): part of the Clean Water Act requiring municipal and industrial water recycling facilities to obtain permits which specify the types and amounts of pollutants that may be discharged into water bodies.

NDMA: N-Nitrosodimethylamine is a chemical used for the production of liquid rocket fuel, and can be formed as a disinfection-by-product during water and wastewater chlorination; it has also been reported to be present in foods, beverages, drugs, and tobacco smoke.

neutralization: A reaction in which the characteristics of an acid or base disappear.

nitrates: a generic group of materials containing nitrogen and oxygen; sources include animal wastes and some fertilizers; can seep into groundwater; linked to human health problems, including "blue baby" syndrome (methemoglobinemia).

nonbiodegradable: materials that cannot be broken down biologically into simpler chemicals.

non-permeable surfaces: surfaces which will not allow water to penetrate, such as sidewalks and parking lots.

non-potable: cannot be safely consumed by people.

nutrient: an element or compound, such as nitrogen, phosphorus, and potassium, that is necessary for growth.

O

organic material: material containing carbon that is derived from living things.

organism: any living being; plants and animals.

oxidation: the addition of oxygen, removal of hydrogen, or the removal of electrons from an element or compound. In the environment, organic matter is oxidized to more stable substances. The opposite of reduction.

P

pathogens: disease-causing microorganisms.

percolation: to drain, filter or seep through a porous substance.

permeable: passable; allowing fluid to penetrate or pass through it.

permeability: the property of a membrane or other material that permits a substance to pass through it.

personal care products (PCPs): anthropogenic products such as shampoos, fragrances, over-the-counter medications, and herbal remedies.

pharmaceuticals: substances that are aimed to cure, prevent, or recognize diseases and relieve pains through their application.

pharmaceutically active compounds (PhACs): encompasses some of the hormone-based compounds already noted as EDCs, and includes antibiotics, anti-epileptic medications, heart medications, pain medications, and cancer medications generally used to treat symptoms rather than underlying disease; this category also covers veterinarian drugs and feed additives used for livestock.

pollutant: an impurity (contaminant) that causes an undesirable change in the physical, chemical, or biological characteristics of the air, water, or land that may be harmful to or affect the health, survival, or activities of humans or other living organisms.

pollution: undesirable change in the physical, chemical, or biological characteristics of the air, water, or land.

pollution prevention: preventing the creation of pollutants or reducing the amount created at the source of generation.

porosity: degree to which soil, gravel, sediment, or rock is permeated with pores or cavities through which water or air can move; sandy soils have large pores and a higher porosity than clays and other fine-grained soils.

potable: fit or suitable for human consumption, as in potable water.

ppb - parts per billion: number of parts of a chemical found in one billion parts of a solid, liquid, or gaseous mixture; equivalent to micrograms per liter (ug/L).

ppm - parts per million: number of parts of a chemical found in one million parts of a solid, liquid, or gaseous mixture; equivalent to milligrams per liter (mg/L).

ppt – parts per trillion: number of parts of a chemical found in one trillion parts of a solid, liquid or gaseous mixture; equivalent to nanograms per liter (ng/L).

primary treatment: the first stage of wastewater treatment in which solids and floating matter are removed from raw sewage using screening, skimming and sedimentation (settling by gravity).

production well: a well that pumps underground water for distribution and use.

purification: the process of making pure, free from anything that debases, pollutes, or contaminates.

R

recharge: the process to replenish a water body or an underground water basin with water.

recharge areas: an area where water flows into the earth to refill an underground water basin.

recharge basins: see "infiltration basins".

recharge water: surface water used to replenish a water body or groundwater basin.

reclaim: to return to original condition.

reclaimed water (or recycled water): municipal wastewater that has been treated to a level that makes it available to be beneficially reused.

reclamation project (or recycling project): a system of pumps, pipes, tanks and other facilities that are used to deliver "recycled water" to places where it can be beneficially reused.

redox reaction: a term for an oxidation-reduction reaction; a redox reaction is any reaction in which electrons are removed from one molecule or atom and transferred to another molecule or atom; in such a reaction one substance is oxidized (loses electrons) while the other is reduced (gains electrons).

reduction: the addition of hydrogen, removal of oxygen, or the addition of electrons to an element or compound.

regulation: a governmental order having the force of law.

repurified water: see "reclaimed water"

reservoir: a body of water collected and stored.

reverse osmosis: a process where water is cleaned by forcing the water through an ultra-fine semi-permeable membrane that allows only the water to pass though and retains the contaminants; these filters are sometimes used to remove salt from seawater to make potable water.

river: a large natural stream emptying into an ocean, lake, or other water body.

riprap: large rocks placed along the bank of a waterway to prevent erosion.

runoff: water (originating as precipitation) that flows across surfaces rather than soaking in; eventually enters a water body; may pick up and carry a variety of pollutants.

S

saline intrusion: the movement of saltwater into freshwater aquifers in coastal areas, can occur when groundwater is withdrawn faster than it is being recharged and the water table drops below sea level.

salinity: an indication of the amount of salt dissolved in water.

saturated zone: underground layer in which every available pore space is filled with water.

secondary treatment: the second stage of wastewater treatment consisting of a biological process in which bacteria consume organic matter, then settle out as sludge.

settling: the process of a solid substance sinking or being deposited from a liquid.

settling basin (or settling pond): see "infiltration basins."

sewer system: an underground system of pipes used to carry off sewage from where it is made to where it will be treated.

sludge: solid matter that settles to the bottom of wastewater treatment plant sedimentation tanks.

soil aquifer treatment (SAT): the natural physical, chemical and biological processes that occur as water infiltrates downward to groundwater that results in an additional polishing of the water.

soil percolation zone: the vertical expanse of soil from the surface of an infiltration basin to a groundwater aquifer.

spreading basin: see "infiltration basin."

spreading grounds: see "recharge area."

surface water: water that flows in streams and rivers and in natural lakes, in wetlands, and in reservoirs constructed by humanst.

T

tertiary treatment: the treatment of wastewater beyond the secondary or biological stage; for water recycling involves the removal of solids through filters; may also refer to the removal nutrients, such as phosphorous and nitrogen.

total dissolved solids (TDS): the sum or all inorganic and organic particulate material; TDS is a measure of the mineral content of water.

total organic carbon (TOC): a measure of the concentration of organic carbon in water, determined by oxidation of the organic matter into carbon dioxide (CO2).

toxic: having the characteristic of causing death or damage to humans, animals, or plants; poisonous.

toxic chemical: a chemical with the potential of causing death or damage to humans, animals, or plants; poison.

toxin: any of various poisonous substances produced by certain plant and animal cells, including bacterial toxins, phytotoxins, and zootoxins.

trace organics: organic compounds present at very low concentrations.

transpiration: water evaporating from the leaves of living plants or the skins of animals into the atmosphere.

treatment: a method of cleaning water or wastewater.

treatment plant: facility for cleaning and treating water or wastewater.

treatment process: a specific method of cleaning water or wastewater.

tributary: a stream or river that flows into a larger river or lake.

turbidity: the cloudy or muddy appearance of a naturally clear liquid caused by suspended particulate matter.

U

ultraviolet irradiation (or UV): a water treatment that involves exposing water to intense ultraviolet light to kill bacteria and other microorganisms; ultraviolet light is similar to light produced by the sun that is above the visible spectrum; produced by special lamps.

unconfined aquifer: an aquifer without a confining layer of soil or clay above it; the top surface of water in an unconfined aquifer is the water table.

underflow: movement of water through subsurface material.

unsaturated zone: an area underground between the ground surface and the water table where the pore spaces are not filled with water, although some water may be present.

upstream: toward the source of a stream or current.

V

vadose zone: see "unsaturated zone."

virus: a small microorganism that is made up of only genetic material surrounded by a protein cover and which cannot reproduce without the help of a host.

W

wastewater: water that has been used for domestic or industrial purposes.

wastewater treatment: physical, chemical, and biological processes used to remove pollutants from wastewater before discharging it into a water body.

waterborne disease: a disease spread by contaminated water.

water conservation: practices which reduce water use.

water cycle: see "hydrologic cycle."

water pollution: the act of making water impure or the state of water being impure.

water quality: the condition of water with respect to the amount of impurities in it.

water reclamation (or water recycling): the process by which wastewater is treated to a high enough level to make it usable again.

water resources: water supplies from various places (groundwater, surface water, reclaimed water) that are available for use.

water reuse: the beneficial use of reclaimed water.

watershed: land area from which water drains to a particular water body.

water system: a river and all its branches.

water table: the upper surface of the zone of saturation of groundwater.