Appendix D: Wastewater Disposal and Treatment Study

Kennedy/Jenks Consultants

1000 Hill Road, Suite 200
Ventura, California 93003
805-658-0607
805-650-1522 (Fax)

Wastewater Disposal and Treatment, September Ranch

23 April 2004

Prepared for

Michael Brandman Associates
2000 Crow Canyon Place, Suite 415
San Ramon, CA 94583

K/J Project No. 034813.09

Kennedy/Jenks Consultants

Engineers and Scientists
1000 Hill Road, Suite 200
Ventura, California 93003
805-658-0607
FAX 805-650-1522

23 April 2004

Mr. Jason Brandman
Michael Brandman Associates
2000 Crow Canyon Place, Suite 415
San Ramon, CA 94583

Subject: Wastewater Disposal and Treatment
September Ranch
K/J 034813.09

Dear Mr. Brandman:

The technical memorandum for the wastewater element of the proposed September Ranch project is submitted herewith. The original evaluation by Cuesta Engineers generally addresses the requirements for alternative systems to comply with the State's Basin Plan (Central Coast Basin Plan). Both onsite and connection to a regional public agency wastewater system were fundamentally addressed. The potential concerns for the discharge of tertiary effluent into the local aquifer can be mitigated by the use of reverse osmosis and a suitable companion process such as microfiltration between tertiary filtration and the reverse osmosis. This report is a revised document that incorporates a discussion and costs of those process additions.

There are some concerns about the design implementation for the proposed facilities but the design criteria include meeting the current requirements for unrestricted reuse as defined by the State Department of Health Services and that alone suffices for this stage of the project. At later stages, issues regarding operation, maintenance, reliability, and odor control should be taken under review to assure a safe, stable operation.

The technical memorandum presents a review of the wastewater element of the September Ranch project in several areas including the cost area. Based on our evaluation, the connection to the Carmel Area Wastewater District appears to be the most viable alternative.

Very truly yours,

KENNEDY/JENKS CONSULTANTS

Robert L Owens II

Robert L. Owens, II
Senior Engineer

Enclosure

cc: Sachi Itagaki, Kennedy/Jenks
Les Chau, Kennedy/Jenks

Table of Contents

List of Tables

List of Figures

Table of Contents (cont'd)

List of Appendices

Section 1: Introduction

1.1 Authorization and Scope

Kennedy/Jenks was authorized by Michael Brandman Associates on January 27, 2003, to conduct multiple investigations related to the proposed September Ranch project in Monterey County. This technical memorandum is prepared specifically to address the project's proposed means for collecting, treating and disposing of wastewater. The County of Monterey, Planning and Building and Inspection Department, in their request for proposals stated the wastewater disposal and treatment element of the project should be peer reviewed. The existing studies that propose onsite wastewater disposal and treatment should be reviewed, including implications for groundwater recharge. The review they expect, should include an examination of the estimated amount of proposed water demand and runoff from the project including secondary units that may be constructed. The evaluation should also analyze the connection to the Carmel Area Wastewater District as an alternative to the proposed treatment system and the implications of that alternative.

Kennedy/Jenks was authorized on April 1, 2004 to perform a supplemental investigation of alternative treatment and disposal technologies; to add reverse osmosis to the tertiary process with the objective of allowing effluent disposal to percolate into the aquifer below the spreading ground. The investigation is primarily to determine what the capital and operating costs would be added to the tertiary costs. Another important factor is the means of disposing a brine waste stream which would be rejected from the reverse osmosis process. This waste would have to be either piped or trucked to a suitable receiving location. Any inland discharge of the brine waste would represent an unfavorable increase in the salinity of surface water. The only solution that avoids this unfavorable condition is to contain/isolate the brine until it can be safely discharged to the ocean.

1.2 Project Summary

The project would provide wastewater service to a proposed development of 100 residential lots, 17 units of inclusionary housing on 3.2 acres, and a 20.2 acre equestrian center on an existing 891-acre property in the Carmel Valley, on the north side of Carmel Valley Road within a range of 2.1 and 3.4 miles east of California Highway Route 1.

The project site is illustrated on tow maps presented in Appendix A. One map presents the proposed subdivision of parcels and in-tract roads. The second map presents the site topography.

1.3 Review of Existing Documents

This memorandum is based on a review of existing documents, a field survey (refer to Appendices B and C), and the experience in the technical field of wastewater collection, treatment, and design, The purpose of reviewing the following documents is to assess the adequacy of the proposed means and effects for collecting, treating, and disposing of wastewater from the proposed residential development.

1.3.1 Wastewater Feasibility Study

The wastewater feasibility study (Cuesta, 1995), represents that the total wastewater generated by the residential development will result in one of two disposal options, either an onsite system or an offsite, publicly-owned system. Under either of these two scenarios, the ultimate result of the water will be to remove the water from the possible availability of a project water resource other than surface landscape irrigation.

The study detailed two systems. Each includes biological treatment and a permitted discharge. The difference between the two is primarily an issue of reliability and confidence in the operation and maintenance of a publicly-safe system.

The proposed facilities include:

- A pipeline collection system; each housing unit would have a septic tank and a connection to a project pipeline that brings all septic tank discharges to a common point
- A means of treatment; either onsite or off-site
- A means of disposal; either onsite or off-site

1.3.2 Water Quality Control Plan

The Basin Plan identifies the Carmel River Hydrologic unit and agencies which own and operate wastewater systems. The Basin Plan defines sludge disposal limitations (method, quality, moisture to solids ratios) and is linked to the EPA regulations from 40 CFR 503. The Basin Plan defines the requirements for onsite wastewater management to protect the basin water quality. The Basin Plan includes methods, criteria, guidelines for onsite system evaluation, design, installation, and maintenance. Excerpts of this Basin Plan are presented in Appendix D.

The Basin Plan does not address a matter of emerging contaminant constituents. These include the categories of endocrine disruptors and pharmaceuticals. These constituents have been associated with health hazards to both humans and wildlife. The EPA is on a timetable to address the specific constituents and concentration limits for these constituents by 2005 in keeping with a consent decree between EPA and the National Resources Defense Council.

The Basin Plan does include a specific requirement to address nutrient and heavy metal constituents: "Nutrient and heavy metal removal should be facilitated by planting ground cover over shallow subsurface drainfields. The plants must have the following characteristics:
(1) evergreen, (2) shallow rooted systems, (3) numerous leaves, (4) salt resistant, (5) ability to grow in soggy soils, and (6) low or no maintenance. Plants downstream or leaching area may also be effective in nutrient removal."

For evapotranspiration systems, The Basin Plan requires, ". . . each month of the highest precipitation year and lowest evaporation year within the previous ten years of record should be used for design." Thus, onsite disposal requires substantial conservatism.

The Central Coast RWQCB has not found sufficient basis for incorporating these emerging contaminant constituents into current waste discharge requirements (WDR) where similar circumstances of a disposal-to-resource connection may occur as was illustrated by their determination for the Los Osos Community Services District (LOCSD). This illustration is presented in their recent Waste Discharge/Recycled Water Requirements presented in Appendix E. However, where a water agency has the authority to control the effects of waste discharge (Calleguas Municipal Water District), they have already assumed a proactive defense against future discharges and their emerging contaminant constituents. This proactive approach is illustrated in a report by Kennedy/Jenks for CMWD presented in Appendix F. Thus, while the Central Coast RWQCB may not find precedent for control, this document would not be complete without introducing the issue. Finally, recent presentations by the Water Environment Federation at their annual, international conference (WEFTEC 2003), present a perspective from a broader view than California's on the future for regulating these emerging contaminant constituents (Appendices G and H).

1.4 Project Comments

Comments from several parties were added to the EIR relating to the technical evaluation of the proposed wastewater collection, treatment, and disposal facilities.

CalEPA[1] emphasized the reliability aspects of a small onsite system expressing concern about potential "accidental failure or maintenance problems, improper or inadequate treatment of waste, and associated discharge of pollutants to groundwater."

Monterey County Department of Health[2], raised the concern that if wastewater is transported offsite through CAWD, then the pasture irrigation source needs to be addressed as part of the water mass balance. Conversely, they also said, "Wastewater flows shall be monitored and the final acreage of irrigated pasture shall be limited to that sustainable from wastewater generated onsite at buildout. The infrastructure shall be designed so as to prevent the connection of the irrigation system to groundwater supplies. The any irrigable land without a water supply shall be rezoned, or placed under permanent easement to prevent expansion of consumptive water use." Thus, this means that irrigated vegetation must be flexible enough to absorb the water for which peak flow years are expected in the system design and yet be tolerant of reduced water during average and dry years so that no potable water resource is used to supplement the wastewater effluent for irrigation. This would suggest use of native grass species that are normally subject to wide annual swings in their survival from rainfall alone.

Anthony Lombardo & Associates[3] both supports and challenges the proposed plan for irrigation onsite using the wastewater effluent. On the side supporting, they referenced the States policies to reuse effluent in favor of potable water. On the side challenging the project they expressed

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[1] CalEPA. November 24, 1997. Letter - Response to EIR.
[2] Monterey County Department of Health. December 15, 1997. Memorandum - Response to EIR.
[3] Anthony Lombardo & Associates. December 15, 1997. Letter - Response to EIR.

concern over the potential for nitrate to reach the groundwater aquifer. The assumption being made is that water will reach the aquifer.

Section 2: Field Inspection

The purpose and scope of the field investigation are to visit the September Ranch property to evaluate the proposed wastewater treatment and disposal system. This investigation was conducted at the site on Friday, May 23rd, 2003.

The proposed facilities include collection pipelines, small capacity- wastewater treatment facility, possible outfall interceptor to a public sewer, and an onsite spray disposal system. Of all these elements, the onsite spray disposal system has more to do with site-specific constraints than the other elements. Thus, in the onsite visit, appraising the site conditions vis-à-vis the spray disposal is most important.

The investigation included observing the former quarry site to determine the conditions where the proposed central treatment plant would be located. This is also where a three-day volume storage basin "pond or tanks" would be constructed. Also, the proposed collection system would have pumping stations, each with a one-day storage capacity. There is also proposed a long term (120 day-14 acre-feet) wet weather storage facility.

Pasture irrigation is proposed in the equestrian area. Total area proposed for irrigation is 19 acres. The area for the treatment and storage is near the front (adjacent to Carmel Valley Road) and includes a disturbed area which was once worked as a rock quarry. The area for spray irrigation is also near the front and is distributed in several locations all used as pasture.

The area is generally covered with mixtures of native and non-native plant species and has all been disturbed either by grazing or equipment.

The site observations include the following:

- The areas proposed for storage appear to be adequate in area for the volume calculated
- The soils appear to be consistent with a rock quarry for the storage area
- The area designated for spray irrigation appears to have a cover soil adequate for growing vegetation which will uptake (evaporate and evapo-transpirate the recycled water)
- The topography is hilly and will facilitate a gravity type collection system

Refer to Appendices B and C for the field memorandum and site photographs.

FIGURE 2-1
SEASONAL STORAGE SITE

The photograph above illustrates the scarred condition of the soil (lacking a topsoil) which is prevalent in the areas where the storage facility is proposed and the type of subsoil in that particular area. The background is the bottom of the proposed seasonal storage basin.

Section 3: Evaluation of Alternative Wastewater Systems

The two alternative systems differ by the means of treatment and effluent disposal. Onsite treatment and disposal, as described in the Cuesta report suggests that the water will be treated to conventional tertiary standards, disinfected, and applied for surface spray irrigation on a seasonal basis that limits percolation no deeper than can be completely absorbed by vegetation for evaporation and evapo-transpiration. Under this premise, neither source augmentation nor contamination of groundwater will occur from the effluent. The accompanying project element that affords this premise is a seasonal storage facility that will allow effluent to be accumulated during the winter rainfall period and discharged during the dry, warm season of the year.

The issues then become of practicality, durability, and maintenance. The proposed system, although philosophically sound, leads to questions of continuing maintenance and resources for the long term.

3.1 Onsite Collection System

Whether treatment and effluent disposal are onsite or offsite, an onsite collection system will be present. The topography and the soils of the site facility a combination of relatively shallow (less than 15-feet deep) gravity pipelines, force mains, and collection sumps that serve one or more residences each. The proposed septic tank effluent pump (STEP) system is a logical approach to the proposed development pattern (low density, hilly terrain, somewhat linear configuration). It offers the benefit of minimal construction costs. It also requires a number of maintenance procedures:

- Sumps and sum pumps need to be periodically checked for blockages and pulled for inspection,
- Septic tanks must be checked for grease accumulation
- Check valves must be checked for operation performance
- Force mains must be checked for air leaks

3.2 Onsite Treatment and Effluent Disposal

Onsite treatment and disposal would consist of primary treatment (occurs in septic tanks), biological secondary treatment including nitrification and denitrification, secondary clarification, and tertiary filtration followed by a wide area spray irrigation system to dispose of the treated effluent, and a storage system to account for the periods when irrigation is not feasible but effluent needs to be received.

With the addition of reverse osmosis after tertiary treatment, an intermediate filtration is necessary to protect the reverse osmosis membranes from catastrophic plugging; microfiltration would fulfill this function.

3.2.1 Treatment

The treatment goal is to meet a Title 22, non-restricted reuse quality. This means a series of biological and physical processes that meet the quality standards of BOD, TSS, turbidity and coliform. These are the requirements of the State through both the Department of Health Services and the RWQCB.

What has not been addressed, but is not yet established by the EPA or the State in effluent quality requirements are the emerging contaminant constituents. The Central Coast RWQCB has recently in a similar situation (new permit for a local system where effluent may be considered a source for groundwater), has declined to structure the permit around these emerging contaminants.

Another somewhat subtle issue relates to the process train and the effluent objectives. The process train incorporates a septic tank ahead of the biological treatment for carbonaceous reduction coupled with nitrification and denitrification. The problem is one of quantity. In denitrification, one of the essential elements that is required to fuel the denitrification bacteria is carbon. Typically, a treatment system includes primary treatment and this removes two-thirds of the suspended solids and about 20 to 35 percent of the carbon (identified at biochemical oxygen demand). When this carbon reduction approaches the higher end of this range, the issue arises about having sufficient carbon remaining to adequately fuel the denitrification process to reduce the total nitrogen to 8 or even 10 mg/l. A septic tank, due to its highly variable and lengthy residence time, can push the carbon reduction to a high level, thus exacerbating the nutrient removal issue.

In the Cuesta ('95) report, the need for carbon was addressed by proposing the use of methanol. This provides a solution to meet the requirement. It also implies a fairly regular and costly effort to attend the treatment plants' operation and maintenance. The report suggest that the method of biological treatment would be a three-stage fixed film reactor (trickling filter). This method offers the advantage of minimizing the operator attention and electrical power consumption compared to the methods of suspended growth reactors. However, it also means that a much higher air-to-wastewater interface will occur and thus increase the need for foul air control.

Today, a far more compact and reliable means of achieving the process requirements between the septic tank and the effluent disposal is a type of process referred to as membrane bioreactor. There are many commercial systems available and three have become popular in the United States. Appendix I is a technical presentation at the WEFTEC 2003 which summarizes the status of the commercially available systems. The system incorporates biological reduction of carbonaceous compounds, can incorporate biological nitrification and denitrification, and both clarification and filtration all in a single vessel. This type of system is becoming more acceptable especially in small systems for remote communities. An example of this is at a gaming casino near San Diego. It is rated for 0.20 mgd. There are several other systems in Colorado and northern California. Their acceptance has occurred only in the past 5 years by the wastewater industry.

A compact wastewater biological treatment plant followed by the Microfiltration membrane treatment will address potential current and/or future contaminations by emergent contaminants such as 42 pharmaceutically active compounds (PhACs), found in the United States, endocrine disruptors, personal care products (PCPs) and others, the Microfiltration can be followed by the Reverse Osmosis. In this case about 25% (depending on the water chemistry and it has to be confirmed upon availability of this information) of the Microfiltration effluent has to be discharged to the waste, and Carmel Area Wastewater District is one of the possible solutions for this. Microfiltration reject can be recycled back to the head of the wastewater plant to maximize overall recovery of the Microfiltration system.

3.2.2 Effluent Disposal

The proposed concept for disposal is spray irrigation. This represents the most critical aspect of the wastewater system in terms of health issues. The current concern in several projects in California is whether the water is completely retained in the root zone of the area of irrigation, or not. To alleviate future concerns that emerging contaminants will not be transported into an aquifer, care has to be taken to be conservative in not over watering. It also emphasizes the need for seasonal storage. As a secondary issue, the seasonal storage of tertiary effluent has to be managed properly to avoid nuisance odors and algae-type spray clogging problems.

Another aspect of the storage is the environmental effect of providing an open water body that may attract migrating wildlife. The concern, may be that existing migratory pathways may be altered by the presence of an artificial water body. The potential environmental effects of this prospect are discussed in the biological site assessment.

Under the scenario of adding the microfiltration and reverse osmosis process units, the effluent disposal directly onto the soil onsite would not have to be restricted as described above. The combination of microfiltration and reverse osmosis will remove the bacteria, viruses, salts, and the PCP's and PhAC's.

3.3 Public Treatment and Effluent Disposal

The treatment and disposal by a publicly-owned system, Carmel Area Wastewater District involves offsite facilities. The facility is a community system and is operated and maintained by a full-time staff of certified operators.

3.3.1 Treatment

The Carmel Area Wastewater District (CAWD) owns a 3.0 mgd tertiary facility that is operating sufficiently below its capacity to add the September Ranch flow of 0.04 mgd (34,700 gpd, average daily flow). The CAWD facility treats wastewater to a standard similar to that proposed for the onsite treatment except that it lacks nitrification and denitrification. However, this is not an issue for an ocean discharge as it has little effect on the ocean environment. The important aspect of treatment by CAWD is the removal of coliform bacteria and the heavy metals. Coliforms are a measure of pathogenic organisms that affect marine life organisms. Heavy metals are also known for their bio-accumulative effects on marine organisms.

The CAWD has indicated that for their wastewater system, to accept the brine into their may become problematic as it would increase the total salinity of their effluent. Although the quantity of salt rejected would make a nominal impact on the CAWD salt concentration, the issue with the CAWD has more to do with philosophy than with quantity. The CAWD is operating under a restriction to their effluent quality for reuse on golf courses. They must control sodium (Na) below 150 ppm and total dissolved solids (TDS) below 1,000 ppm. The present well water salinity values range between TDS values of 1,300 – 1,600 (monitoring well number 1), 950 – 1,250 (monitoring wells 2, 3, 4, and 5), and 700 – 800 ppm (monitoring well number 6). These monitoring wells are representative of the range of TDS to be expected in the raw water used by the customers at September Ranch. Following use of the water, the TDS will be increased to even higher concentrations because of the addition of salt in cooking and other domestic uses.

By separating the salt from the water in a reverse osmosis process, the salt concentration will increase several fold. If the average effluent TDS from customers' wastewater is 1,500 ppm and 75 percent of the salt is removed from a daily average discharge of 34,700 gallons, then the daily brine mass discharge would include 326 pounds of salt. This salt, assuming negligible liquid quantity, would increase the average concentration of a 3.0 mgd flow in the CAWD system by 13 ppm. This is not a significant increase..

3.3.2 Disposal

The CAWD system is a coastal facility and their effluent is discharged to the ocean.

3.3.3 Connection Requirements

For the September Ranch project to discharge to the CAWD, they would incur initial capital and ongoing costs as follows:

- Connection Fee - $2,052 per residential unit; 117 units x $2,052/unit = $240,084)
- Processing Fees for the State Board of Equalization, County, and CAWD (Estimate = $5,000)
- Cost of Connecting Pipeline ($50,000)
- Annual Fee of $265/residential unit (117 units x $265/unit-year = $31,005/year)

Section 4: Probable Life Cycle Costs

In order to provide collection, treatment, and disposal, either method will have a common cost element, the collection system. The difference in cost between the two alternatives is treatment and disposal.

For the onsite facilities, the coasts have been estimated based on the facilities proposed by Cuesta. If the alternative of a membrane bioreactor is chosen, the costs may be approximately the same except the O&M costs would be higher on power but lower on chemicals. On a life-cycle basis, the project onsite costs would be approximately the same within the accuracy range attendant with a planning level of detail.

It is assumed that site work is involved in each of the facilities but that no unusual problems would occur (e.g., severe groundwater problems, unusual soil foundation requirements. unusual noise level requirements). O&M includes the typical categories of cost items. The assumed labor is a part-time operator and maintenance person making site visits 3 times per week for two to four hours per visit. Contract services include construction repairs, laboratory test fees, and outside consulting for process evaluation and control. The basis for power and chemicals is a running power load of 35 to 40 horsepower for all motors plus lighting and a unit cost of $0.10 per kwhr. The chemical costs is based on a hypochlorite dosage of 20 mg/l and a methanol dosage of 7 mg/l per 1 mg/l of Nitrate - Nitrogen to be reduced. The assumed reduction is 10 mg/l of Nitrate requiring supplemental chemical reduction to assist the biological reduction. The unit cost of hypochlorite and methanol is $1.00 per pound, each.

The comparison of capital costs is presented in the table below:

TABLE 4-1
PROBABLE LIFE CYCLE COSTS OF ALTERNATIVES

Description	Onsite[(a)]	Onsite[(b)]	Off-Site
Capital			
Treatment	$500,000	$900,000	$300,000
Effluent Storage	$500,000	$500,000	
Brine Storage		$100,000	
Effluent Disposal	$100,000	$100,000	
Total Capital Cost	$1,100,000	$1,500,000	$300,000
Operation & Maintenance			
Plant/Spray/Solids	$25,000	$25,000	
Labor	$50,000	$50,000	
Materials & Supplies	$5,000	$15,000	
Power & Chemicals	$25,000	$30,000	
Solids Removal/Brine Removal	$5,000	$25,000	
Total O&M	$110,000	$145,000	$31,005

Description	Onsite[a]	Onsite[b]	Off-Site
Present Worth			
Capital	$1,100,000	$1,500,000	$300,000
O&M	$1,261,700	$1,663,150	$355,600
Total	$2,361,700	$3,163,150	$655,600

Notes:
(a) Tertiary Treatment
(b) Microfiltration and Reverse Osmosis

Based on 20-year life and 6 percent discount rate.

Based on these costs presented above, it appears that on a life-cycle cost basis, the off-Site Treatment and Disposal Alternative is most prudent. The assumed costs for the onsite project have a more significant range because of the many unknowns compared to the offsite facilities. However, regardless of the potential range of the onsite costs, the obvious difference between the offsite and onsite costs is so significant that the decision should be relatively easy, if cost is the sole concern.

Alternative A represents the onsite treatment up to the tertiary level. Alternative B represents the onsite treatment up to the level of reverse osmosis. Because of the reluctance of the CAWD to commit to taking the brine from a reverse osmosis process, onsite storage of brine would be necessary for this in addition to the effluent storage. However, because the effluent reuse can be more liberal with the reverse osmosis product, the storage holding capacity may be somewhat reduced from the capacity otherwise required. The water can be applied even when wet weather occurs and this will reduce the peak volume necessary.

The costs for the Alternative B include those costs associated with Alternative A plus the following:

Microfiltration – $ 150,000 (2 membrane modules PALL Aria packaged system)
Reverse Osmosis – $ 50,000 (skid mounted system)
Installation, piping, electrical, controls, etc. - $200,000

MF cost is higher as MF is equipped with all required chemical injections and CIP cleaning system, which can be used for the RO cleaning as well.

Conceptual probable O&M (power and cleaning) Costs:

MF – $ 2,000 /year
RO – $ 3,500 /year

Replacement membrane costs would be added to the basic cost of power to operate these systems.

References

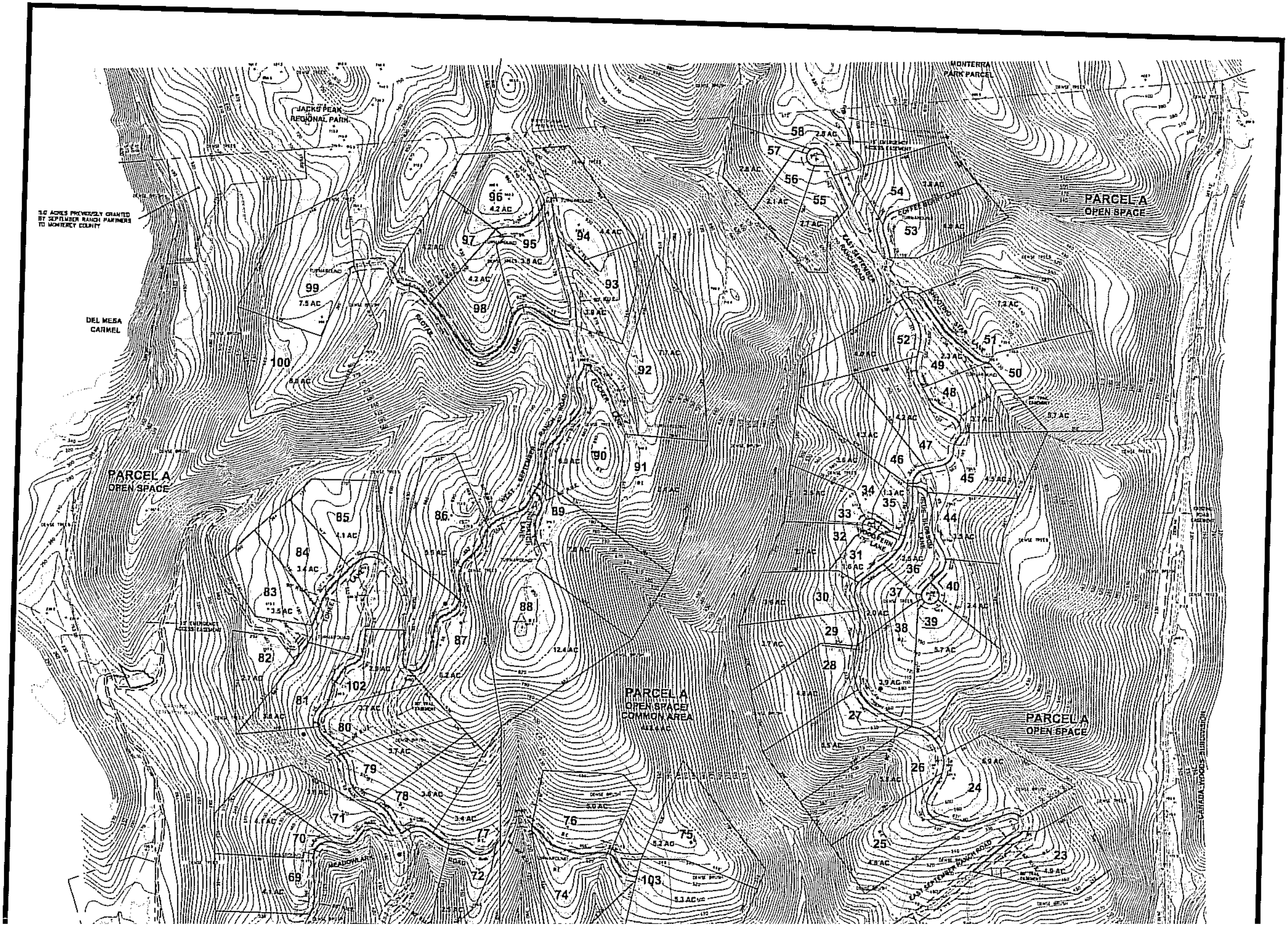
Anthony Lombardo & Associates. December 15, 1997. Letter - Response to EIR.

CalEPA. November 24, 1997. Letter - Response to EIR.

Monterey County Department of Health. December 15, 1997. Memorandum - Response to EIR.

Appendix A

Site Parcel Map and Topography Map, Whitson Engineers


MONTERRA PARK PARCEL
JACKS PEAK REGIONAL PARK
5.0 ACRES PREVIOUSLY GRANTED BY SEPTEMBER RANCH PARTNERS TO MONTEREY COUNTY
DEL MESA CARMEL
PARCEL A OPEN SPACE
PARCEL A OPEN SPACE
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PARCEL A OPEN SPACE/ COMMON AREA 453.4 AC
CANADA WOODS SUBDIVISION
EAST SEPTEMBER RANCH ROAD
WEST SEPTEMBER RANCH ROAD
COFFEE BERRY LANE
SHOOTING STAR LANE
BLUE BLOSSOM LANE
WOODFERN LANE
FLICKER LANE
NUTHATCH LANE
PLOVER LANE
TOHEE LANE
MEADOWLARK
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TURNAROUND
DENSE TREES
DENSE BRUSH
12' EMERGENCY ACCESS EASEMENT
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6.7 AC
69
4.1 AC
2.5 AC

Appendix B

Field Investigation Memorandum, May 2003

Kennedy/Jenks Consultants

May 23, 2003

Memorandum

To: Jason Brandman, Alana Knaster

From: Bob Owens

Subject: September Ranch – Wastewater Element
K/J 034813.09

Field Investigation

The purpose and scope of the field investigation are to visit the September Ranch property to evaluate the proposed wastewater treatment and disposal system. The scope is a one-day visit. (Budgeted 12 hours for this task, including preparation for site visit, e.g., preparing this memo and a fraction of my travel time.) I met Trish Tatarian at the site at 0900 on Friday, May 23rd and we traveled the site together until my departure at 1,430 hours.

The proposed facilities include collection pipelines, small wastewater treatment facility, possible outfall interceptor to a public sewer, and an onsite spray disposal system. Of all these elements, the onsite spray disposal system has more to do with site-specific constraints than the other elements. Thus, in the onsite visit, appraising the site conditions vis-à-vis the spray disposal is most important.

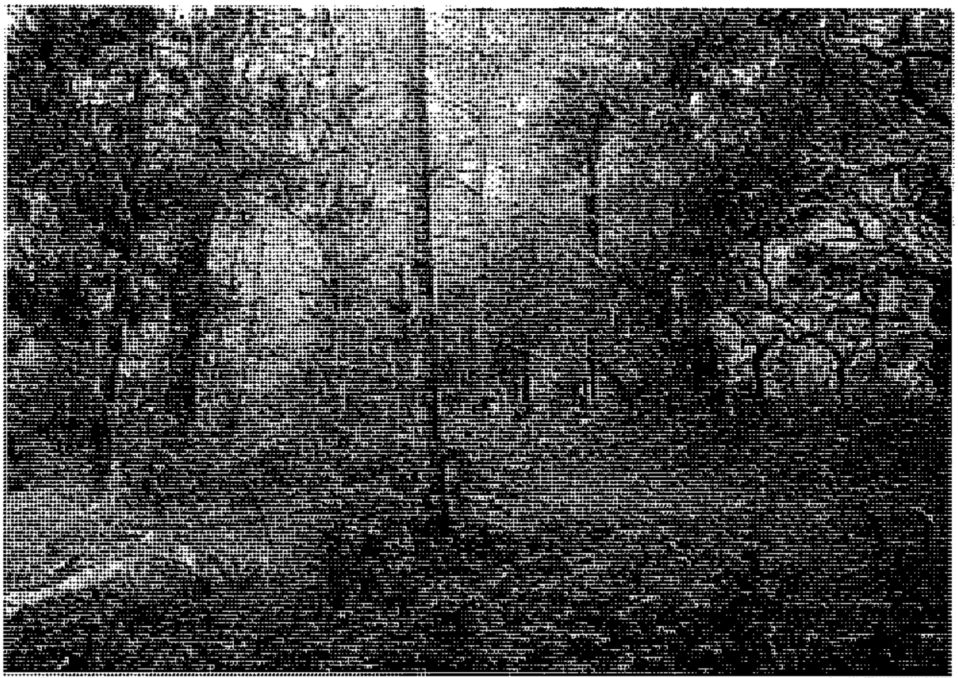
Investigate the former quarry site to observe the conditions where the proposed central treatment plant would be located. This is also where a three-day volume storage basin "pond or tanks" would be constructed. Also, the proposed collection system would have pumping stations, each with a one-day storage capacity. There is also proposed a long term (120 day- 14 acre-feet) wet weather storage facility.

Pasture irrigation is proposed in the equestrian area. Total area proposed for irrigation is 19 acres. The area for the treatment and storage is near the front (adjacent to Carmel Valley Road) and includes a disturbed area which was once worked as a rock quarry. The area for spray irrigation is also near the front and is distributed in several locations all used as pasture.

The area is generally covered with mixtures of native and non-native plant species and has all been disturbed either by grazing or equipment.

Appendix C

Site Photographs Taken May 2003



Appendix D

Excerpts from Central Coast Regional Water Quality Control Board,
Basin Plan

APPENDIX D

EXCERPTS FROM CENTRAL COAST RWCQB BASIN PLAN

VI.B.3. CARMEL RIVER HYDROLOGIC UNIT

Summarized municipal dischargers in the Carmel River Hydrologic Unit include Carmel Sanitary District. Table 4-3 displays dischargers summarized for the Carmel River Hydrologic Unit.

The Carmel Sanitary District operates a secondary wastewater treatment plant with ocean disposal serving Carmel-by-the-Sea, Del Monte Forest, and a few adjacent areas. The outfall system terminates within a portion of Carmel Bay that is designated an Area of Special Biological Significance (ASBS). The District is developing a reclamation project for irrigation of Monterey Peninsula Golf Courses. A high concentration of golf courses in a water short area makes reclamation particularly desirable and attractive.

Carmel Valley Sanitation District operates three facilities in Carmel Valley. These include community septic tank/subsurface disposal systems at Village Green and White Oaks and a tertiary type treatment plant with golf course reclamation at Carmel Valley Ranch. No changes are recommended unless public health or water quality problems develop. Should the need arise for specific septic system maintenance in Carmel Valley, local agencies should be considered for management responsibilities.
Comprehensive studies to determine the feasibility of establishing separate treatment plants have been completed for the Carmel Valley area. These studies conclude that on-site septic systems should remain operational until further ground water monitoring data shows sewers are necessary. Wastewater treatment and reuse on the Carmel Valley Ranch Golf Course provides an optimal way of managing waste generated in the area.

Carmel Highlands wastewaters should continue to be treated in on-site wastewater systems except at the Highlands Inn and the Carmel Highlands Sanitary Association. Both of these systems will continue to discharge treated secondary quality effluent to the Pacific Ocean.

VI.K.2. WASTEWATER SLUDGE/SEPTAGE MANAGEMENT

Wastewater sludge (biosolids) is a by-product of wastewater treatment. Treated domestic sludge is now referred to as biosolids to encourage using this material for fertilizer and soil amendment. Raw sludge usually contains 93 to 99.5 percent water with the balance being solids present in the wastewater and added to or cultured by wastewater treatment processes. Most Publically Owned Treatment Works treat the sludge prior to ultimate use or disposal. Normally, this treatment consists of dewatering and/or digestion.

Treated and untreated sludges may contain high concentrations of heavy metals, organic pollutants, pathogens, and nitrates. Improper storage and disposal of municipal sludges on land can result in degradation of ground and surface water. Therefore, sludge handling and disposal must be regulated.

Septage and grease are usually considered liquid waste, so landfill disposal is usually restricted. Septage, the residual solids periodically pumped from septic tanks, is commonly applied to farm land as fertilizer. Grease waste is usually recycled, but grease trap pumpings are commonly rejected by grease recyclers. Grease and septage usually must be disposed in a Class I or II waste management unit.

The Regional Board will regulate disposal of sludge and septage pursuant to Chapter 15 and Department of Health Services standards for sludge management.

Sludge containing less than 50% solids by weight may be placed in a Class III landfill (see section on Chapter 15) if it can meet the following requirements, otherwise it must be placed in a Class II surface impoundment:

1. The landfill is equipped with a leachate collection and removal system;

2. The sludge must contain at least 20 percent solids if primary sludge, or at least 15 percent solids if secondary sludge, mixtures of primary and secondary sludges, or water treatment sludge; and

3. A minimum solids-to-liquid ratio of 5:1 by weight must be maintained to ensure that the co-disposal will not exceed the initial moisture-holding capacity of the nonhazardous solid waste. The Regional Board may require that a more stringent solids-to-liquid ratio be maintained, based on site-specific conditions.

4. Non-hazardous sludge containing greater than 50% solids by weight is generally considered solid waste.

Beneficial reuse of sludge/septage is increasing in popularity. Sludges and septage, (including composted, liquid, dewatered and dried sludges) have been successfully used as a soil amendment/fertilizer on farmland, orchards, forest lands, pasture, land reclamation projects (e.g., strip mines and landfills), parks and home gardens. As the concentrations of heavy metals has dropped in municipal sludge, and as advanced sludge treatment methods are utilized, the public's acceptance of beneficial reuse projects has improved. However, improper land application of sludge/septage can cause significant odor nuisance, attract flies, contain high levels of pathogens and heavy metals, and be aesthetically offensive due to the presence of plastics.

Currently, regulation of sludge and septage management projects is under the jurisdiction of the Regional Board. Handling and disposal of sludge/septage can be regulated under Chapter 15 of Title 23, California Code of Regulations and California Department of Toxic Substance Control Standards for hazardous waste management. If sludge is used beneficially, the project may be exempted from Chapter 15, but the Regional Board may issue waste discharge requirements.

The U.S. Environmental Protection Agency (U.S. EPA) has promulgated a policy of promoting those municipal sludge management practices that provide for the beneficial use of sludge and septage while maintaining or improving environmental quality and protecting public health. On February 19, 1993, the U.S. EPA published final sewage sludge regulations in 40 Code of Federal Regulations 503. The 503 regulations are intended to assure that use and disposal of sewage sludges and septage comply with federal sludge use and disposal criteria developed by the U.S. EPA. The State Board or the California Integrated Waste Management Board may develop a State sludge management program consistent with the U.S. EPA's policy and criteria for land application, surface disposal, and incineration of sludge to seek federal authorization to implement the 40 Code of Federal Regulations 503 sludge regulations.

VIII.D.2.b ON-SITE WASTEWATER MANAGEMENT PLANS

On-site wastewater management should be implemented in urbanizing areas to investigate long-term cumulative impacts resulting from continued use of individual, alternative, and community on-site disposal systems. A wastewater disposal study should be conducted to determine the best Wastewater Management Plan that would provide site or basin specific wastewater re-use. This study should identify basin specific criteria to prevent water quality degradation and public health hazards and provide an evaluation of the effects of existing and proposed developments and changes in land use. These plans should be a comprehensive planning tool to specify on-site disposal system limitations to prevent ground or surface water degradation. Wastewater management plans should:

- • Contain a ground/surface water monitoring program.
- • Identify sites suitable for conventional septic systems.
- • Project on-site disposal system demand.
- • Determine sites and methods to best meet demand.
- • Project maximum population densities for each subdrainage basin to control degradation or contamination of ground or surface water.
- • Recommend establishment of septic tank maintenance districts, as needed.
- • Identify alternate means of disposing of sewage in the event of irreversible degradation from on-site disposal systems.

For areas where watershed-wide plans are not developed, conditions could be placed on new divisions of land or community systems to provide monitoring data or geologic information to contribute to the development of a Wastewater Management Plan.

Wastewater disposal alternatives should identify costs to each homeowner. A cost-effectiveness analysis, which considers socio-economic impacts of alternative plans, should be used to select the recommended plan.

On-site wastewater disposal zones, as discussed in Section 6950-6981 of the Health and Safety Code, may be an appropriate means of implementing on-site Wastewater Management Plans.

On-site Wastewater Management Plans shall be approved by the Regional Board.

VIII.D.2.c. SEPTIC TANK MAINTENANCE DISTRICTS

It may be appropriate for unsewered community on-site systems to be maintained by local sewage disposal maintenance districts. These special districts could be administered through existing local governments such as County Water Districts, a Community Services District, or a County Service Area.

Septic tank maintenance districts should be responsible for operation and maintenance in conformance with this Water Quality Control Plan. Administrators should insure proper construction, installation, operation, and maintenance of on-site disposal systems. Maintenance districts should establish septic tank surveillance, maintenance and pumping programs, where appropriate; provide repairs to plumbing or leachfields; and encourage water conservation measures.

VIII.D.3. CRITERIA FOR NEW SYSTEMS

On-site sewage disposal system problems can be minimized with proper site location, design, installation, operation, and maintenance. The following section recommends criteria for all new individual subsurface disposal systems and community sewage disposal systems. Local governing jurisdictions should incorporate these guidelines into their local ordinances. These recommendations will be used by the Regional Board for Regional Board regulated systems and exemptions.

Recommendations are arranged in sequence under the following categories: site suitability; system design; construction; individual system maintenance; community system design; and local agencies.

Mandatory criteria are listed in the "Individual, Alternative, and Community Systems Prohibitions" section.

VIII.D.3.a. SITE SUITABILITY

Prior to permit approval, site investigation should determine on-site system suitability:

1. At least one soil boring or excavation per on-site system should be performed to determine soil suitability, depth to ground water, and depth to bedrock or impervious layer. Soil borings are particularly important for seepage pits. Impervious material is defined as having a percolation rate slower than 120 minutes per inch or having a clay content 60 percent or greater. The soil boring or excavation should extend at least 10 feet below the drainfield[1] bottom at each proposed location.

2. An excavation should be made to detect mottling or presence of underground channels, fissures, or cracks. Soils should be excavated to a depth of 4-5 feet below drainfield bottom.

3. For leachfields, at least three percolation test locations should be used to determine system acceptability. Tests should be performed at proposed subsurface disposal system sites and depths.

4. If no restrictive layers intersect, and geologic conditions permit surfacing, the setback distance from a cut, embankment, or steep slope (greater than 30 percent) should be determined by projecting a line 20 percent down gradient from the sidewall at the highest perforation of the discharge pipe. The leachfields should be set-back far enough to prevent this projected line from intersecting the cut within 100 feet, measured horizontally, of the sidewall. If restrictive layers intersect cuts, embankments or steep slopes, and geologic conditions permit surfacing, the setback should be at least 100 feet measured from the top of the cut.

5. Natural ground slope of the disposal area should not exceed 20 percent.

6. For new land divisions, lot sizes less than one acre should not be permitted.

VIII.D.3.b. SYSTEM DESIGN

On-site systems should be designed according to the following recommendations:

1. Septic tanks should be designed to remove nearly 100 percent of settleable solids and should provide a high degree of anaerobic decomposition of colloidal and soluble organic solids.

2. Tank design must allow access for inspection and cleaning. The septic tank must be accessible for pumping.

3. If curtain drains discharge diverted ground water to subsurface soils, the upslope separation from a leachfield or pit should be 20 feet and the down slope separation should be 50 feet.

4. Leachfield application rate should not exceed the following:

Percolation Rate min./in	Loading Rate g.p.d./sq.ft.
1 - 20	0.8
21 - 30	0.6
31 - 60	0.25
61 - 120	0.10

5. Seepage pit application rate should not exceed 0.3 gpd/sq. ft.

6. Drainfield[1[1]] design should be based only upon usable permeable soil layers.

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7. The minimum design flow rate should be 375 gallons per day per dwelling unit.

8. In clayey soils, systems should be constructed to place infiltrative surfaces in more permeable horizons.

9. Distance between drainfield trenches should be at least two times the effective trench depth.[1]

10. Distance between seepage pits (nearest sidewall to sidewall) should be at least 20 feet.

11. Dual disposal fields (200 percent of original calculated disposal area) are recommended.

12. For commercial systems, small institutions, or sanitary industrial systems, design should be based on daily peak flow.

13. For commercial and institutional systems, pretreatment may be necessary if wastewater is significantly different from domestic wastewater.

14. Commercial systems, institutional systems, or domestic industrial systems should reserve an expansion area (i.e. dual drainfields must be installed and area for replacement of drainfield must be provided) to be set aside and protected from all uses except future drainfield repair and replacement.

15. Nutrient and heavy metal removal should be facilitated by planting ground cover vegetation over shallow subsurface drainfields. The plants must have the following characteristics: (1) evergreen, (2) shallow root systems, (3) numerous leaves, (4) salt resistant, (5) ability to grow in soggy soils, and (6) low or no maintenance. Plants downstream of leaching area may also be effective in nutrient removal.

VIII.D.3.c. DESIGN FOR ENGINEERED SYSTEMS

1. Mound systems should be installed in accordance with criteria contained in <u>Guidelines for Mound Systems</u> by the State Water Resources Control Board.

2. Evapotranspiration systems should be installed in accordance with criteria contained in <u>Guidelines for Evapotranspiration Systems</u> by the State Water Resources Control Board. Exceptions are:

    a. For evapotranspiration systems, each month of the highest precipitation year and lowest evaporation year within the previous ten years of record should be used for design.

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b. Systems shall be designed by a registered civil engineer competent in sanitary engineering.

VIII.D.3.d. CONSTRUCTION

Water quality problems resulting from improper construction can be reduced by following these practices:

1. Subsurface disposal systems should have a slightly sloped finished grade to promote surface runoff.

2. Work should be scheduled only when infiltrative surfaces can be covered in one day to minimize windblown silt or rain clogging the soil.

3. In clayey soils, work should be done only when soil moisture content is low to avoid smeared infiltrative surfaces.

4. Bottom and sidewall areas should be left with a rough surface. Any smeared or compacted surfaces should be removed.

5. Bottom of trenches or beds should be level throughout to prevent localized overloading.

6. Two inches of coarse sand should be placed on the bottom of trenches to prevent compacting soil when leachrock is dumped into drainfields. Fine sand should not be used as it may lead to system failure.

7. Surface runoff should be diverted around open trenches/ pits to limit siltation of bottom area.

8. Prior to backfilling, the distribution system should be tested to check the hydraulic loading pattern.

9. Properly constructed distribution boxes or junction fittings should be installed to maintain equal flow to each trench. Distribution boxes should be placed with extreme care outside the leaching area to insure settling does not occur.

10. Risers to the ground surface and manholes should be installed over the septic tank inspection ports and access ports.

11. Drainfield should include an inspection pipe to check water level.

Additional construction precautions are discussed within the Environmental Protection Agency's Design Manual: <u>On-Site Wastewater Treatment and Disposal Systems</u>.

VIII.D.3.e. INDIVIDUAL SYSTEM MAINTENANCE

Individual septic tanks should be maintained as follows:

1. Septic tanks should be inspected every two to five years to determine the need for pumping. If garbage grinders or dishwashers discharge into the septic tank, inspection should occur at least every two years.
2. Septic tanks should be pumped whenever: (1) the scum layer is within three inches of the outlet device; or (2) the sludge level is within eight inches of the bottom of the outlet device.
3. Drainfields should be alternated when drainfield inspection pipes reveal a high water level.
4. Disposal of septage (solid residue pumped from septic tanks) should be accomplished in a manner acceptable to the Executive Officer. In some areas, disposal may be to either a Class I or Class II solid waste site; in others, septage may be discharged to a municipal wastewater treatment facility.

VIII.D.3.f. COMMUNITY SYSTEM DESIGN

Community systems should be designed and maintained to accommodate the following items:

1. Capacities should accommodate build-out population.
2. Design should be based upon peak daily flow estimates.
3. Design should consider contributions from infiltration throughout the collection system.
4. Septic tanks should be pumped when sludge and scum levels are greater than 1/3 of the depth of the first compartment.
5. Operation and maintenance should be in accordance with accepted sanitary practice.
6. Maintenance manuals should be provided to system users and maintenance personnel.
7. Discharge should not exceed 40 grams per day total nitrogen, on the average, per acre of total development overlying ground water recharge areas, unless local governing jurisdictions adopt Wastewater Management Plans subsequently approved by the Regional Board.

VIII.D.3.g. LOCAL AGENCIES

Recommendations for local governing jurisdictions:

1. Adopt a standard percolation test procedure.

   The California State Water Resources Control Board Guidelines for Evapotranspiration Systems provides a percolation test method recommended for use to standardize test results. A twelve-inch diameter percolation test hole may be used.

2. Percolation tests should be continued until a stabilized rate is obtained.

3. Percolation test holes should be drilled with a hand auger. A hole could be hand augered or dug with hand tools at the bottom of a larger excavation made by a backhoe.

4. Percolation tests should be performed at a depth corresponding to the bottom of the subsurface disposal area.

5. Seepage pits should be utilized only after careful consideration of site suitability. Soil borings or excavations should be inspected either by permitting agency or individual under contract to the permitting agency.

6. Approve permit applications after checking plans for erosion control measures.

7. Inspect systems prior to covering to assure proper construction.

8. Require replacements or repairs to failing systems to be in conformance with Basin Plan recommendations, to the extent practicable.

9. For new land divisions, protect on-site disposal systems and expansion areas from encroachment by provisions in covenants, conditions, and restrictions.

10. Inform property buyers of the existence, location, operation, and maintenance of on-site disposal systems. Prospective home or property buyers should also be informed of any enforcement action (e.g. Basin Plan prohibitions) through the County Record.

11. Conduct public education programs to provide property owners with operation and maintenance guidelines.

12. Alternative system owners shall be provided an informational maintenance or replacement document by the appropriate governing jurisdiction. This document shall cite homeowner procedures to ensure maintenance, repair, or replacement of critical items within 48 hours following failure.

13. Where appropriate, septic tank systems should be maintained by local septic tank maintenance districts.

14. Wastewater Management Plans should be prepared and implemented for urbanizing and high density areas, including applicable portions of San Martin, San Lorenzo Valley, Carmel Valley, Carmel Highland, Prunedale, El Toro, Shandon, Templeton, Santa Margarita/Garden Farms, Los Osos/Baywood Park, Arroyo Grande, Nipomo, upper Santa Ynez Valley, and Los Olivos/Ballard.

15. Ordinances should be updated to reflect Basin Plan criteria.

VIII.D.3.h. ADDITIONAL CONSIDERATIONS

1. Water conservation and solids reduction practices are recommended. Garbage grinders should not be used in homes with septic tanks.

2. Metering and water use costs should be used to encourage water conservation.

3. Grease and oil should not be introduced into the system. Bleach, solvents, fungicides, and any other toxic material should not be poured into the system.

4. Reverse osmosis unit blow-down should not be discharged to on-site wastewater treatment systems overlying usable ground water. Off-site (factory regeneration) practices are recommended for water softeners.

5. If on-site water softener regeneration is necessary, minimum salt use in water softeners is recommended. This can be accomplished by minimizing regeneration time or limiting the number of regeneration cycles.

VIII.D.3.i. INDIVIDUAL, ALTERNATIVE AND COMMUNITY SYSTEMS PROHIBITIONS

Discharges from new soil absorption systems installed after September 16, 1983 in sites with any of the following conditions are prohibited:

1. Soils or formations contain continuous channels, cracks, or fractures.[1]

2. For seepage pits, soils or formations containing 60 percent or greater clay (a soil particle less than two microns in size) unless parcel size is at least two acres.

3. Distances between trench bottom and usable ground water, including perched ground water, less than separation specified by appropriate percolation rate:

Percolation Rate, min/in	Distance, ft
<1	50[1]
1-4	20[1]
5-29	8
>30	5

4. For seepage pits, distances between pit bottom and usable ground water, including perched ground water, less than separation specified by appropriate soil type:

Soil	Distance,ft.
Gravels[2]	50[1]
Gravels with few fines[3]	20[1]
Other	10

5. Distances between trench/pit bottom and bedrock or other impervious layer less than ten feet.

6. For leachfields, where percolation rates are slower than 120 min/in, unless parcel size is at least two acres.

7. For leachfields, where soil percolation rates are slower than 60 min./in. unless the effluent application rate is 0.1 gpd/ft^2 or less.

8. Areas subject to inundation from a ten-year flood.

9. Natural ground slope of the disposal area exceeds 30 percent.

10. Setback distances less than:

	Minimum Setback Distance, ft
Domestic water supply wells in unconfined aquifer	100
Watercourse[4] where geologic conditions permit water migration	100
Reservoir[5] spillway elevation	200
Springs, natural or any part of man-made spring	100

11. While new septic tank systems should generally be limited to new divisions of land having a minimum parcel size of one acre, where soil and other physical constraints are particularly favorable, parcel size shall not be less than one-half acre.

12. Within a reservoir[1] watershed where the density for each land division is less than 2.5 acres for areas without approved Wastewater Management Plans.

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[1] Unless a set-back distance of at least 250 feet to any domestic water supply well or surface water is assured.

[2] Gravels - Soils with over 95 percent by weight coarser than a No. 200 sieve and over half of the coarse fraction larger than a No. 4 sieve.

[3] Gravels with few fines - Soils with 90 percent to 94 percent coarse fraction larger than a No. 4 sieve.

[4] Watercourse - (1) A natural or artificial channel for passage of water. (2) A running stream of water. (3) A natural stream fed from permanent or natural sources, including rivers, creeks, runs, and rivulets. There must be a stream, usually flowing in a particular direction (though it need not flow continuously) in a definite channel, having a bed or banks and usually discharging into some stream or body of water.

[5] Reservoir-A pond, lake, tank, basin, or other space either natural or created in whole or in part by the building of engineering structures, which is used for storage, regulation, and control of water, recreation, power, flood control, or drinking.

13. For individual systems on new land divisions, and commercial, institutional, and sanitary industrial systems without an area set aside for dual leachfields (100 percent replacement area).

14. Commercial, institutional, or sanitary industrial systems not basing design on daily peak flow estimate.

15. Any site unable to maintain subsurface disposal.

16. Any subdivision unless the subdivider clearly demonstrates the use of the system will be in the best public interest, that beneficial water uses will not be adversely affected, and compliance with all Basin Plan prohibitions is demonstrated.

17. Lot sizes, dwelling densities or site conditions causing detrimental impacts to water quality.

18. Any area where continued use of on-site systems constitutes a public health hazard, an existing or threatened condition of water pollution, or nuisance.

Discharges from community subsurface disposal systems (serving more than five parcels or more than five dwelling units) are prohibited unless:

1 Seepage pits have at least 15 vertical feet between pit bottom and highest usable ground water, including perched ground water.

2. Sewerage facilities are operated by a public agency. (If a demonstration is made to the Regional Board that an existing public agency is unavailable and formation of a new public agency is unreasonable, a private entity with adequate financial, legal, and institutional resources to assume responsibility for waste discharges may be acceptable).

3. Dual disposal systems are installed (200 percent of total of original calculated disposal area).

4. An expansion area is included for replacement of the original system (300 percent total).
5. Community systems provide duplicate individual equipment components for components subject to failure.

6. Discharge does not exceed 40 grams per day of total nitrogen, on the average, per 1/2 acre of total development overlying ground water recharge areas excepting where a local governing jurisdiction has adopted a Wastewater Management Plan subsequently approved by the Regional Board.

In order to achieve water quality objectives, protect present and future beneficial water uses, protect public health, and prevent nuisance, discharges are prohibited in the following areas:

1. Discharges from individual sewage disposal systems are prohibited in portions of the community of Nipomo, San Luis Obispo County, which are particularly described in Appendix A-27.

2. Discharges from individual sewage disposal systems within the San Lorenzo River Watershed shall be managed as follows:

a. Discharges shall be allowed, providing the County of Santa Cruz, as lead agency, implements the "Wastewater Management Plan for the San Lorenzo River Watershed, County of Santa Cruz, Health Services Agency, Environmental Health Service", February 1995 and "San Lorenzo Nitrate Management Plan, Phase II Final Report", February 1995, County of Santa Cruz, Health Services Agency, Environmental Health Service (Wastewater Management Plan) and assures the Regional Board that areas of the San Lorenzo River Watershed are serviced by wastewater disposal systems to protect and enhance water quality, to protect and restore beneficial uses of water, and to abate and prevent nuisance, pollution, and contamination.

In fulfilling the responsibilities identified above, the County of Santa Cruz shall submit annual reports beginning on January 15, 1996. The report shall state the status and progress of the Wastewater Management Plan in the San Lorenzo River Watershed. The County of Santa Cruz annual report shall document the results of:

a. Existing disposal system performance evaluations,
b. Disposal system improvements,
c. Inspection and maintenance of on-site systems,
d. Community disposal system improvements,
e. New development and expansion of existing system protocol and standards,
f. Water quality monitoring and evaluation,
g. Program administration management, and
h. Program information management.

The report shall also document progress on each element of the Nitrate Management Plan, including:

a. Parcel size limit,
b. Wastewater Management Plan implementation,
c. Boulder Creek Country Club Wastewater Treatment Plant Upgrade,
d. Shallow leachfield installation,
e. Enhanced wastewater treatment for sandy soils,
f. Enhanced wastewater treatment for large on-site disposal systems,
g. Inclusion of nitrogen reduction in Waste Discharge Permits,
h. Livestock and stable management,
i. Protection of ground water recharge areas,
j. Protection of riparian corridors and erosion control,
k. Nitrate control for new uses,
l. Scotts Valley nitrate discharge reduction, and
m. Monitoring for nitrate in surface and ground water.

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[1] Reservoir-A pond, lake, tank, basin, or other space either natural or created in whole or in part by the building of engineering structures, which is used for storage, regulation, and control of water, recreation, power, flood control, or drinking.

3. Discharges from individual and community sewage disposal systems are prohibited effective November 1, 1988, in the Los Osos/Baywood Park area depicted in the Prohibition Boundary Map included as Attachment "A" of Resolution No. 83-13 which can be found in Appendix A-30.

VIII.D.3.j. SUBSURFACE DISPOSAL EXEMPTIONS

The Regional Board or Executive Officer may grant exemption to prohibitions for: (1) engineered new on- site disposal systems for sites unsuitable for standard systems; and (2) new or existing on-site systems within the specific prohibition areas cited above. Such exemptions may be granted only after presentation by the discharger of sufficient justification, including geologic and hydrologic evidence that the continued operation of such system(s) in a particular area will not individually or collectively, directly or indirectly, result in pollution or nuisance, or affect water quality adversely.

Individual, alternative, and community systems shall not be approved for any area where it appears that the total discharge of leachate to the geological system, under fully developed conditions, will cause: (1) damage to public or private property; (2) ground or surface water degradation; (3)nuisance condition; or, (4) a public health hazard. Interim use of septic tank systems may be permitted where alternate parcels are held in reserve until sewer systems are available.

Requests for exemptions will not be considered until the local entity has reviewed the system and submitted the proposal for Regional Board review. Dischargers requesting exemptions must submit a Report of Waste Discharge. Exemptions will be subject to filing fees as established by the State Water Code.

Engineered systems shall be designed only by registered engineers competent in sanitary engineering. Engineers should be responsible for proper system operation. Engineers should be responsible for educating system users of proper operation and maintenance. Maintenance schedules should be established. Engineered systems should be inspected by designer during installation to insure conformance with approved plans.

Some engineered systems may be considered experimental by the Regional Board. Experimental systems will be handled with caution. A trial period of at least one year should be established whereby proper system operation must be demonstrated. Under such an approach, experimental systems are granted a one year conditional approval.

Further information concerning individual, alternative, or community on-site sewage disposal systems can be found in Chapter 5 in the Management Principals and Control Actions sections. State Water Resources Control Board Plans and Policies, Discharge Prohibitions, and Regional Board Policies may also apply depending on individual circumstances.

CalEPA commented that the Basin Plan identifies improperly managed onsite sewage disposal systems as a potential source of odors, nuisance, a mechanism for disease transmission, and can result in pollution of surface and ground waters destroying beneficial uses. The Basin Plan discourages satellite systems and recommends sewerage facilities be consolidated for long-range economic and water quality benefits.

CalEPA also commented that the Basin Plan incorporates by reference a Resolution No. 69-01, a Board Policy that City and County governments are requested to prohibit development of any subdivision that will use its own community system unless the City and County has developed a master plan for sewage, pursuant to Section 65300, et sec. of the California Government Code, which includes the subdivision.

CalEPA recommends the County require the project connect to the CAWD collection system.

Monterey County Department of Health also commented in favor of a second wastewater alternative. Conversely, they commented that by transferring the wastewater to Carmel Area Wastewater District, this would adversely impact the water balance for the Ranch. They also commented on a quantitative discrepancy. They commented that the acreage of irrigated pasture land should be reported as 11.6 acres, not 21.

The County also commented that all known impacts either are less-than-significant or can be reduced to a less- than- significant level. Therefore, either of the wastewater treatment alternatives is viable in terms of environmental considerations.

Appendix E

Waste Discharge/Recycled Water Requirements, Order No. R3-2002-0108
and Staff Report for Los Osos Community Services District,
Los Osos Wastewater Facilities, San Luis Obispo County

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD
CENTRAL COAST REGION
81 Higuera Street, Suite 200
San Luis Obispo, California 93401-5427

WASTE DISCHARGE/RECYCLED WATER REQUIREMENTS
ORDER NO. R3-2002-0108

Waste Discharger Identification No. 3 401078001

For

LOS OSOS COMMUNITY SERVICES DISTRICT
LOS OSOS WASTEWATER FACILITY
San Luis Obispo County

The California Regional Water Quality Control Board, Central Coast Region (hereafter Board), finds that:

PURPOSE OF ORDER

1. The purpose of the Order is to issue new Waste Discharge and Recycled Water Requirements for the Los Osos Community Services District (hereafter Discharger). The Discharger submitted a report of waste discharge (application) on July 8, 2002, for authorization to discharge treated municipal wastewater from the proposed Los Osos Wastewater Facilities serving the communities of Cuesta-by-the-Sea, Baywood Park and Los Osos, in San Luis Obispo County.

FACILITY OWNER AND LOCATION

2. The Discharger's Wastewater Treatment Plant will be located on property owned by the Discharger in San Luis Obispo County at the intersection of Ravenna Avenue and Los Osos Valley Road (Latitude 50°18'40" Longitude 120°50'24"), as shown on Attachment A, included as part of this Order.

FACILITY/SITE DESCRIPTION

3. **Treatment** - The proposed treatment system consists of grit removal, secondary treatment (extended aeration process), denitrification, secondary sedimentation, filtration and disinfection. Solids will be aerobically digested, dewatered and disposed of at an approved biosolids disposal site. The treatment plant's annual average dry weather flow (ADWF) design capacity is 1.4 million gallons per day (MGD), peak capacity is 1.6 MGD and daily average capacity is 1.3 MG. A diagram of the treatment processes is shown on Attachment B, included as part of this Order.

4. **Disposal and Reuse** - Treated municipal wastewater will be discharged to leachfields or reused for landscape irrigation within the community. Discharge areas are depicted on Attachment C of this Order. Details of the Discharger's reuse program are not yet available, therefore reuse provisions are included in this Order as guidance for development of that program and may be updated and/or revised to address reuse program specifics.

5. **Geology and Soils** - The primary disposal area is located in sandy soils on moderately sloping terrain, overlying 150 feet separation to ground water in the Los Osos Valley Ground Water Basin. Other disposal and reuse areas are located on level to gently sloping terrain with depth to ground water varying from 30 to 150 feet.

6. **Water Supply** – Domestic water supply for Los Osos is ground water distributed by three purveyors (Los Osos CSD, California Cities Water Co. and S&T Water Co.) Larger lots surrounding the community use individual

wells. Well water is blended to maintain quality of the domestic supply generally as follows:

Nitrate	ND – 3.3 mg/l
Total Dissolved Solids	160 – 420 mg/l
Sodium	21 – 47 mg/l
Chloride	33 – 60 mg/l

7. **Watershed and Surface Waters** - Morro Bay State and National Estuary abuts the community of Los Osos along the northern and western perimeters. Los Osos Creek meanders east of the community and discharges to Morro Bay at the northeastern tip of Los Osos. Both water bodies are depicted on Attachment C of the proposed Order. Water quality in Morro Bay is impacted by excess coliform bacteria, nutrients, metals and other constituents. A DNA study completed in 2002 for Morro Bay identified humans as the primary source of coliform bacteria in freshwater seeps along the estuarine edge of Los Osos. Los Osos Creek is impacted by bacteria and other constituents. However, based on local topography and direction of ground water flow, such impacts are likely the result of surface runoff to Los Osos Creek rather than seepage of ground water.

8. **Ground Waters** - Recent ground water quality in the uppermost aquifer in Los Osos is as depicted in the following table (well sites depicted on Attachment C). Similar to historical data, the monitoring data continues to show ground water impacted by nitrates (15 wells exceeding the MCL for drinking water and 5 wells approaching the MCL).

Well ID #	Depth to Water (ft)	Nitrate as N (mg/l)	TDS (mg/l)	Na (mg/l)	Cl (mg/l)	Sample Date
7K3	NA	12	340	48	67	06/24/02
7L3	35	15	430	100	81	06/24/02
7N1	5	3	160	32	37	06/28/02
7Q1	1*	16	360	34	73	06/26/02
7R1	20	12	340	60	57	06/24/02
8N2	30	2.4	150	17	21	06/25/02
13A7	5	12	270	44	73	07/02/02
13G	40	9.3	360	56	110	06/26/02
13H	20	1	220	9.9	20	06/26/02
13L5	20	19	1100	110	350	06/26/02
13Q1	80	20	480	96	110	06/27/02
17D	NA	17	340	45	76	07/09/02
17F4	40	3	330	61	86	06/28/02
17N4	10	7.6	230	46	61	06/28/02
18B1	15	6.9	340	60	78	06/24/02
18C1	20	15	380	59	81	06/24/02
18E1	25	11	250	48	54	06/27/02
18H3	60	11	290	35	64	07/09/02
18J6	15	6.9	360	51	85	06/25/02
18L3	NA	9.2	290	46	62	06/25/02
18L4	15	19	350	48	61	06/26/02
18N1	80	18	420	94	100	06/27/02
18R1	10	14	320	65	85	07/02/02
20B	60	5.7	290	36	82	07/02/02
24A	150	11	240	58	48	06/27/02

Data Source: Los Osos Community Services District
NA – Data not available at time of report preparation
*Data from San Luis Obispo County 1998 Monitoring Report

The direction of ground water flow is predominantly northwest toward Morro Bay, however localized flow impacts occur due to pumping of ground water. Historically, shallow ground water was the predominant source of domestic supply for Los Osos. However, due to nitrate contamination in the shallow zones beyond state drinking water standards, ground water use has shifted to the better quality, deeper zones. Both upper and lower ground water zones are needed to meet the community's long-term water supply needs.

BASIN PLAN

9. The Water Quality Control Plan, Central Coast Basin (Basin Plan), was adopted by the Board on and approved on September 8, 1994. The Basin Plan incorporates statewide plans and policies by reference and contains a strategy for protecting beneficial uses of surface and ground waters in the vicinity of the discharge.

10. **Surface Water Beneficial Uses** - Present and anticipated beneficial uses of Morro Bay include:

    a. Industrial Process Supply
    b. Water Contact Recreation
    c. Non-contact Water Recreation
    d. Wildlife Habitat
    e. Cold Fresh Water Habitat
    f. Migration of Aquatic Organisms
    g. Spawning, Reproduction and/or Early Development
    h. Preservation of Biological Habitats of Special Significance
    i. Rare, Threatened or Endangered Species
    j. Estuarine Habitat
    i. Commercial and Sport Fishing
    x. Aquaculture
    y. Shellfish Harvesting

    Present and anticipated beneficial uses of Los Osos Creek include:

    a. Municipal
    b. Agricultural
    c. Ground Water Recharge
    d. Water Contact Recreation
    e. Non-contact Water Recreation
    f. Wildlife Habitat
    g. Cold Fresh Water Habitat
    h. Warm Fresh Water Habitat
    i. Migration of Aquatic Organisms
    j. Spawning, Reproduction and/or Early Development
    k. Rare, Threatened or Endangered Species
    l. Fresh Water Replenishment
    m. Commercial and Sport Fishing

11. **Ground Water Beneficial Uses** - Present and anticipated beneficial uses of ground water in the vicinity of Los Osos include:

    a. Municipal,
    b. Domestic,
    c. Agricultural and
    d. Industrial supply.

12. **Recycled Water** – Title 22, Chapter 3 of the California Code of Regulations specifies State Deptartment of Health Services' criteria for use of recycled water. The Regional Board has consulted with the State and County Health Departments regarding these reuse requirements.

13. **Stormwater** - Federal Regulations for stormwater discharges were promulgated by the U.S. Environmental Protection Agency on November 19, 1990. The regulations [40 Code of Federal Regulations (CFR) Parts 122, 123, and 124] require specific categories of industrial activities including Publicly Owned Treatment Works (POTWs) which discharge stormwater to obtain a NPDES permit and to implement Best Available Technology Economically Achievable (BAT) and Best Conventional Pollutant Control Technology (BCT) to control pollutants in industrial stormwater discharges. Stormwater flows from the wastewater treatment facility process areas are directed to an onsite retention pond for percolation. These stormwater flows constitute all industrial stormwater at this facility and consequently separate NPDES permit is not necessary to address this industrial stormwater discharge.

MONITORING PROGRAM

14. Monitoring and Reporting Program (MRP) No. R3-2002-0108 is part of the proposed Order. The MRP requires routine wastewater influent and effluent, and receiving water (ground water) sampling and analysis to verify compliance with this Order. Monitoring reports are required monthly and an annual report is required by January 30th of each year.

CALIFORNIA ENVIRONMENTAL QUALITY ACT (CEQA)

15. The Los Osos Community Services District certified a Final Environmental Impact Report (EIR) on March 1, 2002, in accordance with CEQA (Public Resources Code, Section 21000, et seq.) and the California Code of Regulations.

    Pursuant to CEQA guidelines Section 15096, the Regional Board, as a responsible agency, has a more limited role than the lead agency. The Regional Board is responsible for mitigating or avoiding only the direct or indirect environmental effects of those parts of the project which it approves. The EIR does not identify any significant unavoidable environmental impact resulting from proposed wastewater treatment or discharge. Impacts relating to construction erosion, odors, biosolids disposal and wastewater discharge shall be mitigated by the proposed Order. Potentially significant impacts which fall within the purview of the Regional Board are as follows:

    Potential impacts to surface water quality from construction related erosion are identified. Mitigation measures are proposed including compliance with the statewide stormwater permit for construction activities. Another potential source of water quality impacts is from construction dewatering. Such discharges will also be regulated by the Board through separate order.

    In addition, there is potential for significant impacts to surface waters from an accidental spill of untreated wastewater from the collection system or treatment plant. Prevention and rapid response to such spills is addressed in the proposed Order.

    Potential impacts to air quality form periodic odors and air emissions from the collection, treatment or disposal facilities are considered unavoidable. The EIR does not identify negative impacts to ground water quantity or quality which cannot be mitigated to a level of insignificance. Mitigation measures to prevent nuisance and assure protection of beneficial uses of surface and ground waters will be implemented through this Order.

EXISTING ORDERS AND RESOLUTIONS

16. **Resolution No. 83-13** – In 1983, the Regional Board adopted Resolution 83-13, which amended the Basin Plan and prohibited, effective November 1, 1988, discharges of waste from individual and community sewage systems within portions of the Los Osos area of San Luis Obispo County. At the time of adoption of Resolution No. 83-13, the County represented that it could design and complete a wastewater, collection treatment and disposal system that would eliminate the need for individual and community on-site sewage systems by the prohibition date of November 1, 1988.

17. **Cease and Desist Orders** – The Discharger replaced the County as the agency responsible for implementing the community wastewater project and developed a plan and schedule for project implementation. In May 1999, the Regional Board issued Cease and Desist Orders (Nos. 99-53, 99-54, 99-55 and 99-56) to the Discharger and included the project implementation into those Orders. At the time of adoption, the project implementation schedule appeared reasonably attainable.

18. **Time Schedule Order** – To address uncertainties in the original CSD project, the Discharger embarked on an evaluation of multiple collection, treatment, disposal and management alternatives. This evaluation resulted in modifications to the proposed project and the project implementation schedule. In October 2000, the Regional

Board adopted Time Schedule Order No. 00-131 based on Section 13308 of the California Water Code. Time Schedule Order No. 00-131 contains a date-specific compliance schedule and a daily penalty of $10,000 for failure to meet the scheduled compliance dates.

GENERAL FINDINGS

19. A permit and the privilege to discharge waste into waters of the State are conditional upon the discharge complying with provisions of Division 7 of the California Water Code and of the Clean Water Act (as amended or as supplemented by implementing guidelines and regulations) and with any more stringent effluent limitations necessary to implement water quality control plans, to protect beneficial uses and to prevent nuisance. Compliance with this Order should assure conditions are met and mitigate any potential changes in water quality due to the discharge.

20. On **September 6, 2002,** the Board notified the Discharger and interested agencies and persons of its intent to consider adoption of waste discharge requirements for the discharge and has provided them with a copy of the proposed Order and an opportunity to submit written comments and scheduled a public hearing.

21. In a public hearing on **December 6, 2002**, the Board heard and considered all comments pertaining to the discharge and found this Order consistent with the above findings.

22. Any person affected by this action of the Regional Board may petition the State Water Resources Control Board (State Board) to review the action in accordance with Sectin 13320 of the California Water Code and Title 23, California Code of Regulations, Section 2050. The petition must be received by the State Board within 30 days of the date of this Order. Copies of the law and regulations applicable to filing petitions will be provided upon request.

IT IS HEREBY ORDERED, pursuant to authority in Section 13377 of the California Water Code, that Los Osos Community Services District, its agents, successors, and assigns, may discharge waste from the Los Osos Wastewater Facility providing compliance is maintained with the following:

All technical and monitoring reports submitted pursuant to this Order are required pursuant to Section 13267 of the California Water Code. Failure to submit reports in accordance with schedules established by this Order or attachments to this Order, or failure to submit a report of sufficient technical quality to be acceptable to the Executive Officer, may subject the Discharger to enforcement action pursuant to Section 13268 of the California Water Code. The Regional Board will base all enforcement actions on the date of Order adoption.

(Note: General permit conditions, definitions and the method of determining compliance are contained in the attached "Standard Provisions and Reporting Requirements for Waste Discharge Requirements," dated January 1984, referenced in paragraph D.2. of this Order.)

Throughout these requirements footnotes are listed to indicate the source of requirements specified. Requirement footnotes are as follows:

BP = Basin Plan
T22= California Code of Regulations, Title 22, Recycled Water Criteria

Requirements without footnotes are based on staff's professional judgment.

A. PROHIBITIONS

1. Discharge to areas other than the disposal facilities shown on Attachment C of this Order or reuse sites approved by the Executive Officer, is prohibited. ^{T22}

2. Discharge of any wastes including overflow, bypass and runoff from transport, treatment or disposal systems to adjacent drainageways or adjacent properties is prohibited. ^{T22}

3. Discharge of untreated or partially treated wastewater is prohibited.

4. Discharge of wastewater within 100 feet of any well used for domestic supply or irrigation of food crops is prohibited. [BP]

B. EFFLUENT LIMITATIONS

(Discharge to Leachfields)

1. Effluent flow averaged over each month shall not exceed a monthly average of 1.4 MGD.

2. Effluent discharged to the disposal system shall not exceed the following limitations:

Constituent	Units	Monthly (30-Day) Average	Daily Maximum
Settleable Solids	ml/l	0.1	0.5
BOD, 5-Day	mg/l	60	100
Suspended Solids	mg/l	60	100
Total Nitrogen (as N)	mg/l	7	10

C. RECYCLED WATER SPECIFICATIONS

(Reuse Requirements apply in addition to Effluent Limitations specified above)

1. Discharger shall develop an Engineering Report on the Production, Distribution and Use of Recycled Water in conformance with Title 22 of the California Code of Regulations, for review and approval of the Executive Officer (after consultation with State and local Health Departments). The Engineering Report must be submitted no less than six months in advance of proposed reuse of wastewater.

2. Recycled water production and use shall at all times be in conformance with recycled water criteria established in Title 22, Division 4, Chapter 3 of the California Code of Regulations[T22]. Recycled water shall be adequately oxidized, coagulated, clarified, filtered, disinfected[T22] and not exceed the following limitations:

Parameter	Units	Monthly Mean	Max.
BOD_5	mg/l	30	90
Suspended Solids	mg/l	30	90
Turbidity [T22]	NTU	2*	5**
pH[BP]	units	In range 6.5-8.4	

* 24-hr mean value. [T22]

**Turbidity must not exceed 5 NTU more than 5% of the time within a 24-hr period and must not exceed 10 NTU. [T22]

3. The median number of coliform organisms in recycled water shall not exceed 2.2 MPN per 100 ml, as determined from the bacteriological results of the last 7 days for which analyses have been completed. The number of coliform organisms shall not exceed 23 MPN per 100 ml in more than one sample in any 30 day period and shall not exceed 240 MPN per 100 ml in any single sample. [T22]

4. Unless an alternative, comparable disinfection process may be approved by Califonrnia Department of Health Services and the Executive Officer. Recycled water subject to a chlorine disinfection process shall include a CT (chlorine concentration times model contact time) of not less than 450 milligram-minutes per liter at all times with a model contact time of at least 90 minutes, based on peak dry weather design flow. [T22]

5. Chlorine residual in reclaimed water shall equal or exceed 0.5 mg/l, as measured immediately after the chlorine contact zone.

6. Delivery of reclaimed water for irrigation purposes shall cease and all wastewater shall be returned to the treatment and/or disposal system if:

   a. Disinfection of wastewater ceases at any time; or,

   b. Reclamation specifications are violated or threaten to be violated.

7. Recycled water shall be confined within the authorized reuse areas (approved by the Executive Officer after consultation with State and local health departments).

8. Recycled water shall not be used for irrigation

during extended periods of rainfall and/or runoff.

9. Personnel involved in producing, transporting or using recycled water shall be informed of possible health hazards that may result from contact and use of recycled water.

10. Use of recycled water shall occur at a time and in a manner to prevent or minimize public contact with recycled water and to prevent ponding in irrigation areas.

11. Areas irrigated with recycled water shall be posted in English and Spanish to warn the public that recycled water is being used. Signs shall be no less than four inches high by eight inches wide and include the wording "RECYCLED WATER – DO NOT DRINK".

12. Recycled water valves shall be of a design to prevent public access.

13. Drinking fountains shall be protected from contact with recycled water, spray, mist or runoff.

14. Tank trucks used to transport recycled water shall be appropriately labeled and shall not leak.

D. RECEIVING WATER LIMITATIONS
(Ground Water Limitations)

(Receiving water quality is a result of many factors, some unrelated to the discharge. This permit considers these factors and is designed to minimize the influence of the discharge to receiving waters.)

The discharge shall not cause:

1. The nitrate-nitrogen (NO_3 as N) level of ground water to exceed 10 mg/l.

2. Significant increase of mineral constituent concentrations in underlying ground water, as determined by comparison of samples collected from wells prior to and post discharge commencement. Ultimately, decrease in shallow ground water constituent concentrations shall be demonstrated.

3. Concentrations of chemicals and radionuclides in ground water to exceed limits set forth in Title 22, Chapter 15, Articles 4 and 5 of the California Code of Regulations.[BP]

E. PROVISIONS

1. Discharger shall comply with "Monitoring and Reporting Program No. R3-2002-0108" (included as part of this Order), as ordered by the Executive Officer.

2. Discharger shall comply with all items of the attached "Standard Provisions and Reporting Requirements for Waste Discharge Requirements," dated January, 1984 (included as part of this Order).

3. Treatment and discharge shall not cause pollution or nuisance as defined in Section 13050 of the California Water Code.

4. All accumulated biosolids or solid residue shall be disposed in a manner approved by the Executive Officer.

5. Treatment, storage and disposal facilities shall be managed to exclude the public and posted to warn the public of the presence of wastewater.

6. Discharger shall develop and implement an on-site wastewater management plan to assure ongoing operations, maintenance and monitoring of on-site disposal systems within the unsewered areas in the community of Los Osos.

7. Pursuant to Title 23, Division 3, Chapter 9, of the California Code of Regulations, the Discharger must submit a report to the Executive Officer, not later than **June 6, 2007, addressing:**

    a. Whether there will be changes in the continuity, character, location or volume of the discharge; and,

    b. Whether, in their opinion, there is any portion of the Order that is incorrect, obsolete or otherwise in need of revision.

I, ROGER W. BRIGGS, Executive Officer, do hereby certify the foregoing is a full, true, and correct copy of an order adopted by the California Regional Water Quality Control Board, Central Coast Region, on December 6, 2002.

Executive Officer

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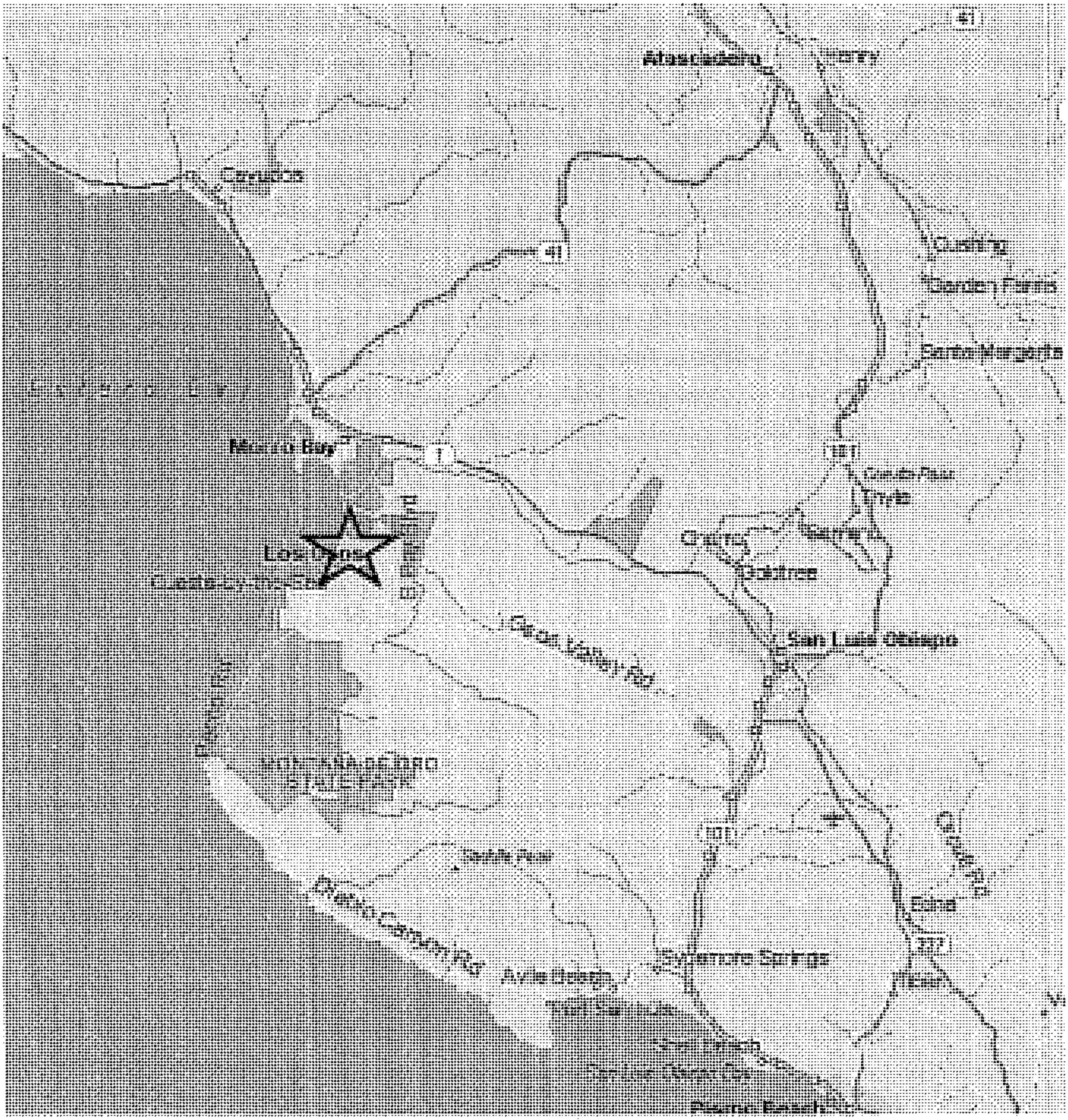
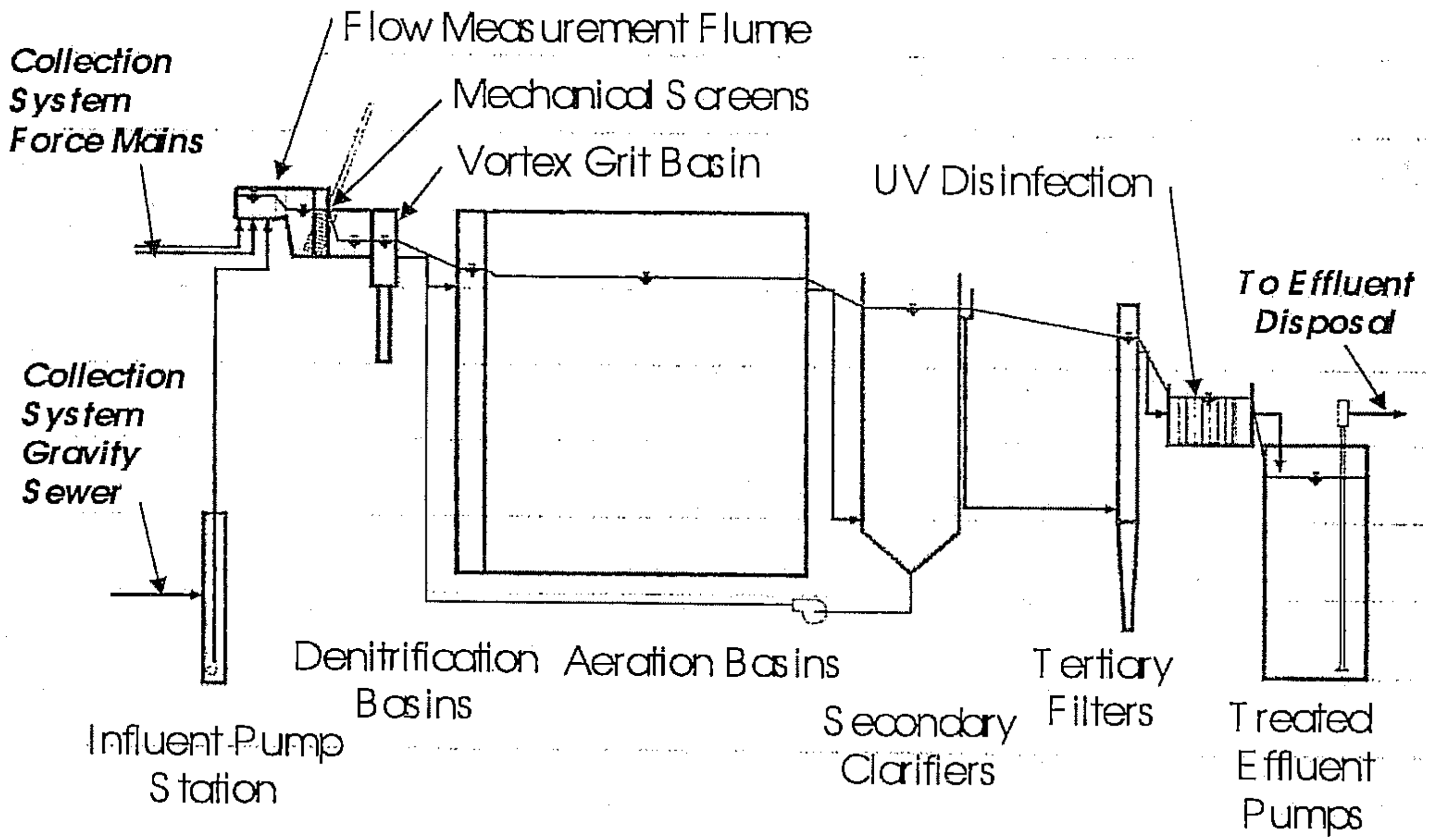
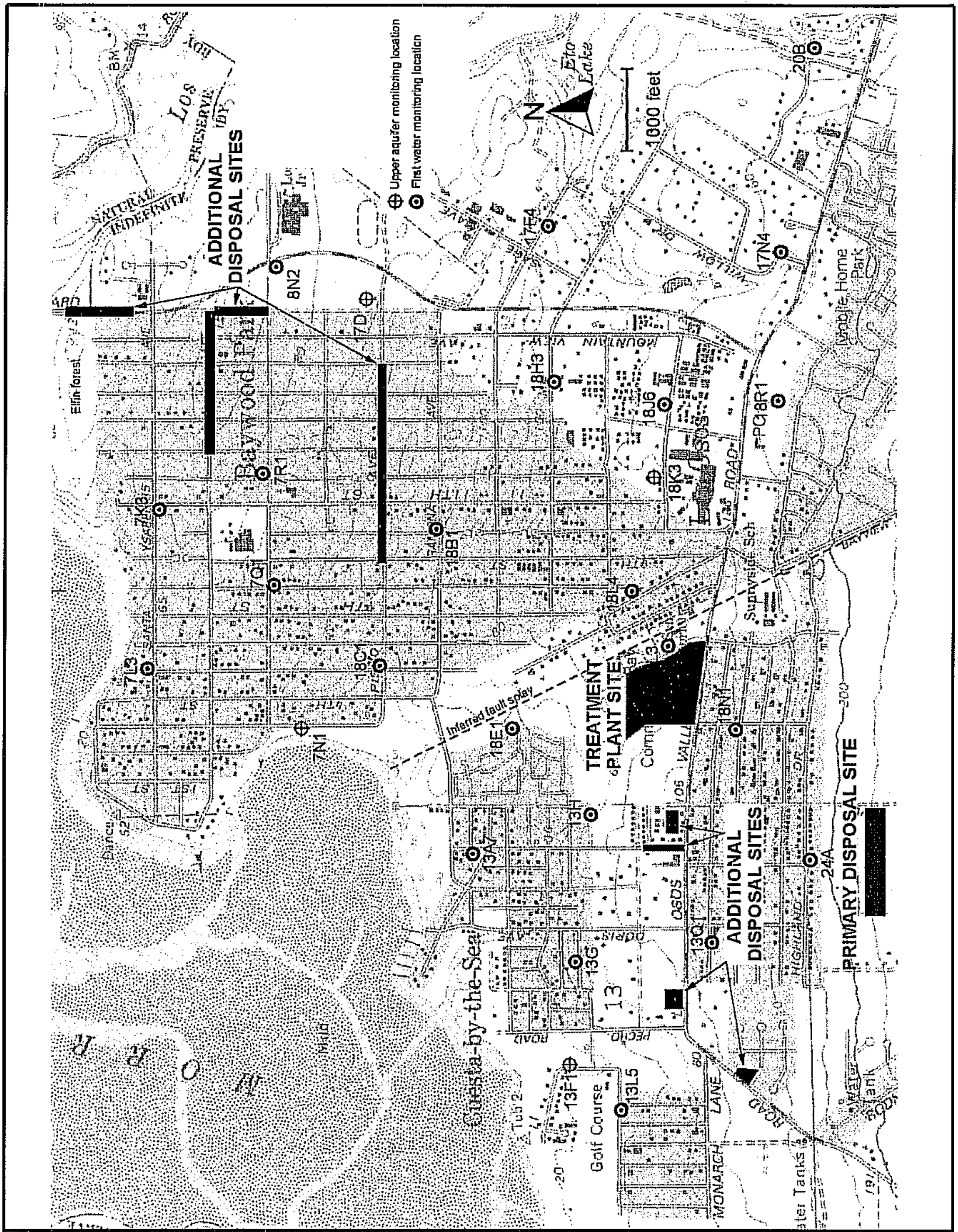


ATTACHMENT A
LOS OSOS COMMUNITY SERVICES DISTRICT
ORDER NO. R3-2002-0108



ATTACHMENT B
LOS OSOS COMMUNITY SERVICES DISTRICT
ORDER NO. R3-2002-0108



ATTACHMENT C
LOS OSOS COMMUNITY SERVICES DISTRICT
ORDER NO. R3-2002-0108

STATE OF CALIFORNIA
CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD
CENTRAL COAST REGION

STAFF REPORT FOR REGULAR MEETING OF DECEMBER 6, 2002

Prepared on July 30, 2002

ITEM NUMBER:

SUBJECT: **New Waste Discharge Requirements for Los Osos Community Services District, Los Osos Wastewater Facilities, San Luis Obispo County, Order No. R3-2002-0108**

KEY INFORMATION

Facility/Owner:	Los Osos Wastewater Facilities/Los Osos Community Services District
Location:	Intersection of Ravenna Avenue and Los Osos Valley Road
Discharge Type:	Municipal/Domestic
Design Capacity:	1.4 MGD Annual Average (1.3 MGD Daily Average, 1.6 MGD Peak Day)
Treatment Type:	Tertiary (extended aeration process with nitrogen reduction followed by coagulation, filtration and disinfection), aerobic digestion of solids
Disposal:	Leachfields (subsurface infiltration)
Recycling:	Future plans, but not addressed in this Order
Existing Orders:	Time Schedule Order No. 00-131, Cease and Desist Order Nos. 99-53, 99-54, 99-55 and 99-56

SUMMARY

Los Osos Community Services District (CSD) proposes to construct a wastewater collection, treatment, disposal and recycling system to serve the communities of Cuesta-by-the-Sea, Baywood Park and Los Osos. The CSD's community wastewater project is needed to comply with requirements specified in Resolution No. 83-13 and Time Schedule Order No. 00-131. The proposed Waste Discharge/Recycled Water Requirements Order is for the long awaited community sewer system.

BACKGROUND

The Setting – The Baywood Park/Los Osos area of San Luis Obispo County is located on the southern edge of Morro Bay National Estuary, approximately ten miles west of the City of San Luis Obispo (shown on Attachment A of proposed Order). The community has a population of approximately 15,000 people, and contains about 5,000 individual lots (many of which are only 25 or 37.5 feet wide). Throughout the community, on-site septic systems are used for treatment and disposal of wastewater. Because many of the lots are too small for conventional leachfields, deeper seepage pits are frequently used for wastewater disposal. Depth to ground water varies throughout the community, however in shallow areas many of the seepage pits discharge directly to ground water (with no separation).

Water Quality Impacts - Inadequate treatment and disposal of wastewater in Los Osos impacts surface and ground water beneficial uses of water in a number of ways. Ground water (drinking water supply) has been so degraded by nitrates that use of the shallow portions of the aquifer is now limited primarily to non-domestic supply (irrigation). Because shallow ground water is so degraded, domestic supply is pumped from the deeper portions of the aquifer. Pumping from the deeper zone creates additional water quality problems by increasing the potential for seawater intrusion. Also, since septic tank effluent is discharged into the shallow aquifer, ground water elevations are higher exacerbating shallow ground water problems (inadequate separation from seepage pits, and flooding).

Surfacing ground water, especially during the wet season, creates a public health threat by forcing wastewater to the ground surface. Surfacing water (ground water mixed with wastewater) flows and/or is pumped into roadside ditches and storm drains, which then flows into Morro Bay. In less adequately drained areas, surfacing wastewater remains ponded until it can soak back into the soil. This situation is hazardous to children who are tempted to play in these puddles. Increased bacteria in Morro Bay have contaminated shellfish and resulted in shellfish growing areas being downgraded by the State Department of Health Services. Furthermore, DNA testing of bacteria laden seepage from the Los Osos shoreline (due to ground water seeps) into Morro Bay has confirmed the largest source is from humans.

The Regional Board has been concerned with the high-density use of septic systems in Baywood Park/Los Osos since before 1971. However, early efforts to get the County to voluntarily embark on a solution to water quality and public health problems from the septic systems were unsuccessful, other than some increased monitoring of the area.

Discharge Prohibition - In 1983, the Regional Board adopted Resolution No. 83-13, which amended the Water Quality Control Plan, Central Coast Basin (Basin Plan) and prohibited, effective November 1, 1988, discharges of waste from individual and community sewage systems within portions of the Baywood Park/Los Osos area of San Luis Obispo County (Basin Plan prohibition area). The prohibition means that the existing septic systems are discharging illegally (and have been for 14 years) and that no new discharges (e.g., from potential homes on vacant lots) are allowed.

At the time the Regional Board adopted Resolution No. 83-13, the County represented that it could design and complete a wastewater collection and treatment system that would eliminate the need for individual and community on-site sewage systems by the prohibition date of November 1, 1988.

Community Wastewater Project - After many years of facilities planning punctuated by delays from litigation and multiple alternatives studies, the County Board of Supervisors voted unanimously to proceed with the community wastewater project for Los Osos in October 1995. The Regional Board reviewed the proposed project and found it acceptable as a means of resolving water quality problems in the community. The County then proceeded with design plans and completion of the environmental review and permitting process. The community sewer system was (in 1997) on schedule to begin construction in 1997. However, the project was prevented from proceeding by the Coastal Commission's action (and then indefinitely postponement) on an appeal of the Coastal Development Permit.

In November 1998, voters in Los Osos formed a Community Services District (CSD) to replace San Luis Obispo County as the governing body for community services. The CSD chose not to proceed with the County's wastewater project, and developed a revised project for wastewater collection, treatment and disposal. Unfortunately, development of the revised project included significant time delays from what had previously been envisioned by the CSD.

Cease and Desist Orders - The CSD submitted a schedule for implementing its wastewater project and the Regional Board included that schedule in Cease and Desist Orders issued for CSD facilities discharging within the prohibition area (Cease and Desist Order Nos. 99-53, 99-54, 99-55 and 99-56 adopted in May 1999). Milestone dates specified in the Cease and Desist Orders are based on significant and measurable steps in the project.

At the time of Cease and Desist Orders adoption, the schedule itself appeared reasonably attainable, however the schedule was developed by the CSD based on implementing a project, which was unlikely to provide for acceptable resolution of water quality problems. The original proposal included sewering approximately half the community and treating the wastewater (and septage from remaining tanks in use) in an Advanced Integrated Wastewater Pond System (AIWPS).

To address uncertainties in the original CSD project, the District embarked upon an evaluation of multiple wastewater project alternatives. This evaluation of alternatives examined not only the CSD's original wastewater project, but also variations/combinations of it, and several other potential wastewater project alternatives. In addition, the CSD's consultants examined other potential wastewater and septic tank technologies. This evaluation resulted in a wastewater project which appears technically sound as well as viable. Initially, the AIWPS pond proposal was popular with community residents because of its perceived low estimated cost. However, careful and detailed evaluation of alternatives demonstrated the current wastewater project to be superior due to: 1) being in line with community goals, values and acceptance, 2) ability to meet regulatory requirements, 3) ability to address the community's water quality problems (ground water and Morro Bay), 4) ability to sustain the ground water basin and primary drinking water supply, and 5) long term cost-effectiveness.

Unfortunately, delays due to re-evaluating alternative technologies and facility sites resulted in violations of the milestones of progress scheduled in the Cease and Desist Orders.

Time Schedule Order - In an effort to assure timely completion of the wastewater project, the Board adopted Time Schedule Order No. 00-131 at its October 27, 2000 public meeting. The Time Schedule Order, based on Section 13308 of the Water Code, is similar to that issued to the County in 1996. The Time Schedule Order contains a date-specific compliance schedule and a dollar amount, which would be assessed for each day the CSD fails to meet the schedule. The daily penalty amount specified in Order No. 00-131 is the maximum allowable amount, $10,000. Time Schedule Order No. 00-131 includes the following compliance dates:

Task	Completion Date
Circulate draft EIR	12/15/00 (done)
Final CEQA document	04/01/01 (done)
Form assessment district or comparable financing for wastewater system	07/29/01 (done)
Complete approved design plans	07/15/02
Submit County Use and Coastal Development permits	07/15/02
Begin construction	09/06/02
Complete construction	08/30/04

Status Reports due quarterly and two weeks after each above date.

Based on current progress on the project and delays due to litigation, the project is expected to be completed approximately 18 months behind the specified schedule. However, Time Schedule Order No. 00-131 provides that delays beyond the CSD's ability to control may be accepted by the Board without imposition of monetary penalties.

DISCUSSION

As described in the background information above, construction of the community sewer system has been a hotly contested issue for more than two decades. The CSD, and its design consultants, are eager to have formalized requirements to facilitate final design work on the wastewater collection, treatment, disposal and recycling facilities.

Treatment Facilities - The proposed treatment facility will be located at the intersection of Ravenna Avenue and Los Osos Valley Road. Facilities will include tertiary treatment (extended aeration process followed by coagulation, filtration and disinfection) and aerobic digestion of solids. Facilities will be designed to treat wastewater from the equivalent of 18,428 people (expected build-out population in 2020 per the Estero Area Specific Plan). The proposed treatment method (a type of activated sludge process) is designed specifically for its nitrogen removal capabilities. Treatment capacity is designed for 1.3 million gallons per day (MGD) daily average, 1.6 MGD peak day and 1.4 MGD annual average flow. A diagram of treatment processes is included as Attachment B of the proposed Order.

Disposal and Reuse - Constructed leachfields located throughout the community will be used to dispose/recharge the highly treated effluent. According to hydrogeologic modeling conducted by consultants for the CSD, effluent needs to be discharged at a variety of locations in order to maintain the water balance of the community's ground water basin. Leachfield disposal will be located primarily at the intersection of Highland Drive and Broderson Avenue but also at other locations throughout the community. Recycling of treated wastewater for landscape irrigation is also included in the proposed project. Disposal locations are depicted on Attachment C of the proposed Order.

Project Development - The thirty-plus year history of water quality problems in Los Osos has been the source of material for volumes of technical reports prepared by federal, state and local agencies, private consultants, citizen action groups and others. Water quality problems associated with ongoing discharges from septic systems on small lots with very little (if any) separation to ground water range from nitrate and pathogen contamination in ground water to surfacing effluent. The CSD's community-wide wastewater management plan is designed to resolve these issues over the long-term.

In addition to providing sewer service to most of the developed area of Baywood Park/Los Osos, the CSD plans to develop and implement an On-site Wastewater Management Plan to assure adequate design, operation, maintenance and monitoring of on-site systems which remain in use outside of the prohibition boundary and in areas authorized by the Regional Board in Order No. 00-012 (General Waste Discharge Requirements for the Bayview Heights and Martin Tract Areas of Los Osos). Although details of the On-site Wastewater Management Plan have yet to be defined, staff continue to work with the CSD to facilitate development of an effective plan.

During early project development, staff provided the CSD with draft Waste Discharge Requirements so that the CSD could make informed decisions regarding facility designs. The draft Waste Discharge Requirements provided to the CSD were those which had been developed for San Luis Obispo County and considered by the Regional Board in 1997. Proposed Order No. R3-2002-0108 reiterates similar, but not identical requirements to those specified in the draft requirements developed for San Luis Obispo County. The proposed Order also includes recycled water specifications to assure protection of water quality and public health from potential impacts associated with use of recycled water. The proposed requirements are described below.

PROPOSED REQUIREMENTS

The proposed Order is based on Title 22 of the California Code of Regulations, Basin Plan requirements and recommendations, and staff's professional judgment. It is consistent with comparable discharge requirements within our Region and designed to protect existing and anticipated beneficial uses of surface and ground waters in the vicinity of the discharge. Specifically, requirements are proposed to protect, and ultimately restore, ground water (which is the local source of domestic supply) and nearby surface waters (Morro Bay State and National Estuary).

Prohibitions and Effluent Limitations - Proposed prohibitions limit the discharge to wastewater receiving full treatment and disposed of approved disposal and reuse areas depicted on Attachment C of the Order. Effluent limitations are based on the design capacity of the treatment facilities (1.4 million gallons per day) and constituent concentrations common for subsurface disposal (settleable solids, suspended solids and biochemcial oxygen demand) to assure long-term function of the disposal system. An effluent limitation for nitrogen of 7 mg/l monthly average and 10 mg/l daily maximum is proposed to assure protection and ultimately restoration of underlying ground water. The drinking water standard (Maximum Contaminant Level or MCL) for nitrate (as nitrogen) is 10 mg/l. Therefore, effluent concentrations of 7 mg/l will eventually lead to restoration of ground water to drinkable quality with some margin of safety (due to effluent limit being lower than drinking water limit, and dilution with other sources of ground water). It should be noted that the proposed nitrogen limitation is expected to be the lowest long-term performance level for the proposed treatment processes.

[illegible] Term
3 [illegible]
DHS Regs

Recycled Water Specifications - The CSD ultimately plans to reuse treated wastewater for landscape irrigation. Therefore, recycled water specifications are included in the proposed Order. Recycled water specifications are based on Title 22 of the California Code of Regulations and designed to protect water quality and public health. Details of the CSD's recycled water project are not yet complete. Therefore, the proposed Order requires an Engineering Report on the Production, Distribution and Use of Recycled Water (required by Title 22 and describing the reuse project entirety) be submitted for approval of the Executive Officer after consultation with State and local Health Departments.

Receiving Water Limitations – Ground water is the potential receiving water for the proposed discharge. As described above, much of the shallow zone of the Los Osos ground water basin is degraded due to excess nitrate. The proposed community wastewater treatment system is specifically designed to restore ground water for domestic use and to preserve ground water quality for the long-term. Receiving water limitations in the proposed Order limit the discharge to that which will not degrade receiving (ground) waters based on comparison to historical (pre-discharge) monitoring data. Surface water impacts are addressed by the prohibition of runoff, overflow or any other discharge to areas other than approved disposal and reuse sites (Prohibitions A.1 and A.2.). Surface waters will be further protected by the long-term restoration of ground water, since surface water is in communication with ground water.

Provisions – The proposed Order requires compliance with a Monitoring and Reporting Program and with Standard Provisions and Reporting Requirements. Provisions regarding proper disposal of biosolids, nuisance prevention and public safety are also included in the proposed Order. As indicated above, the Order also requires development and implementation of an On-site Wastewater Management Plan to assure ongoing operations, maintenance and monitoring of on-site systems within the unsewered areas of the community.

Monitoring Requirements – The proposed Order includes a Monitoring and Reporting Program to assure ongoing protection of water quality and compliance with specified requirements. Requirements include daily, weekly and monthly effluent and recycled water monitoring and semi-annual ground water monitoring. Submittal of self-monitoring reports is required monthly with an annual summary report due January 30th of each year.

For many years, San Luis Obispo County implemented a ground water monitoring program in Los Osos. The CSD recently developed a revised ground water monitoring program which is incorporated (in part) into the proposed Order. The CSD's ground water monitoring program is designed to detect and evaluate ground water constituent concentrations, trends and potential impacts relating to the discharge. Many aspects of the County's former program have been incorporated into the CSD's monitoring program to provide for long-term continuity and comparisons of data. Recent ground water monitoring results are provided in the following table and monitoring wells are depicted on Attachment C of the proposed Order. Similar to historical data, the monitoring data continues to show ground water impacted by nitrates (15 wells exceeding the MCL for drinking water and 5 wells approaching the MCL).

Well ID #	Depth to Water (ft)	Nitrate as N (mg/l)	TDS (mg/l)	Na (mg/l)	Cl (mg/l)	Sample Date
7K3	NA	12	340	48	67	06/24/02
7L3	35	15	430	100	81	06/24/02
7N1	5	3	160	32	37	06/28/02
7Q1	1*	16	360	34	73	06/26/02
7R1	20	12	340	60	57	06/24/02
8N2	30	2.4	150	17	21	06/25/02
13A7	5	12	270	44	73	07/02/02
13G	40	9.3	360	56	110	06/26/02
13H	20	1	220	9.9	20	06/26/02
13L5	20	19	1100	110	350	06/26/02
13Q1	80	20	480	96	110	06/27/02
17D	NA	17	340	45	76	07/09/02
17F4	40	3	330	61	86	06/28/02
17N4	10	7.6	230	46	61	06/28/02
18B1	15	6.9	340	60	78	06/24/02
18C1	20	15	380	59	81	06/24/02
18E1	25	11	250	48	54	06/27/02
18H3	60	11	290	35	64	07/09/02
18J6	15	6.9	360	51	85	06/25/02
18L3	NA	9.2	290	46	62	06/25/02
18L4	15	19	350	48	61	06/26/02
18N1	80	18	420	94	100	06/27/02
18R1	10	14	320	65	85	07/02/02
20B	60	5.7	290	36	82	07/02/02
24A	150	11	240	58	48	06/27/02

Data Source: Los Osos Community Services District
NA – Data not available at time of report preparation
*Data from San Luis Obispo County 1998 Monitoring Report

ENVIRONMENTAL SUMMARY

Los Osos Community Services District certified a Final EIR for the project on March 1, 2001, in accordance with the California Environmental Quality Act (Public Resources Code, Section 21000, et seq. and the California Code of Regulations.

Pursuant to CEQA guidelines Section 15096, the Regional Board, as a responsible agency, has a more limited role than the lead agency. The Regional Board is responsible for mitigating or avoiding only the direct or indirect environmental effects of those parts of the project which it approves. The EIR does not identify any significant unavoidable environmental impact resulting from proposed wastewater treatment or discharge. Impacts relating to construction erosion, odors, biosolids disposal and wastewater discharge shall be mitigated by the proposed Order. Potentially significant impacts which fall within the purview of the Regional Board are as follows.

Potential impacts to surface water quality from construction related erosion are identified. Mitigation measures are proposed including compliance with the statewide stormwater permit for construction activities. Another potential source of water quality impacts is from construction dewatering. Such discharges will also be regulated by the Regional Board through separate order.

In addition, there is potential for significant impacts to surface waters from an accidental spill of untreated wastewater from the collection system or treatment plant. Prevention and rapid response to such spills is addressed in the proposed Order.

Potential impacts to air quality form periodic odors and air emissions from the collection, treatment, or disposal facilities are considered unavoidable. The EIR does not identify negative impacts to ground water quantity or quality which cannot be mitigated to insignificance. Mitigation measures to prevent nuisance and assure protection of beneficial uses of surface and ground waters will be implemented through this Order.

COMMENTS

(pending)

RECOMMENDATION

(pending)

ATTACHMENTS

1. Draft WDR/WRR Order No. R3-2002-0108 with Monitoring and Reporting Program
2. Standard Provisions and Reporting Requirements

S:/wb/coastal watershed/staff/sorrel/lososos-general/los osos csd.itm

Appendix F

Kennedy/Jenks Consultants, Feasibility Evaluation for Wastewater Treatment and Disposal, Tract 5277, 2003

Section 3: Wastewater Characterization

In order to evaluate potential wastewater treatment and disposal systems for the proposed Tract 5277 development, assumptions must be made about the composition and flow of the wastewater from the development. As 23 single-family homes are planned, it can be assumed that wastewater generation would be typical of that from entirely domestic sources, with no industrial influences.

3.1 Composition of Wastewater

The wastewater from the proposed Tract 5277 development would likely contain traditional wastewater constituents such as BOD and TDS, and pathogenic microorganisms such as viruses and bacteria, as well as endocrine disrupters and pharmaceutically active compounds, which are less well-known and understood.

3.1.1 Traditional Wastewater Constituents

Typical domestic wastewater contains a variety of contaminants, including TDS, TSS, and BOD. The typical composition of untreated domestic wastewater is summarized in Table 3-1.

TABLE 3-1
TYPICAL COMPOSITION OF UNTREATED DOMESTIC WASTEWATER

Constituent	Unit	Concentration
Total Solids (TS)	mg/L	720
Total Dissolved Solids (TDS)	mg/L	500
Fixed Dissolved Solids	mg/L	300
Volatile Dissolved Solids	mg/L	200
Total Suspended Solids (TSS)	mg/L	220
Fixed Suspended Solids	mg/L	55
Volatile Suspended Solids	mg/L	165
Settleable Solids	mL/L	10
Biological Oxygen Demand (BOD_5), 20°C	mg/L	220
Total organic carbon (TOC)	mg/L	160
Chemical oxygen demand (COD)	mg/L	500
Nitrogen (total as N)	mg/L	40
Organic Nitrogen	mg/L	15
Free ammonia	mg/L	25
Nitrite	mg/L	0
Nitrate	mg/L	0
Phosphorous (total as P)	mg/L	8
Organic Phosphate	mg/L	3
Inorganic Phosphate	mg/L	5
Chlorides(a)	mg/L	108
Sulfate(a)	mg/L	94
Alkalinity (as $CaCO_3$)	mg/L	100
Grease	mg/L	100
Total coliform	no/100 mL	$10^7 - 10^8$
Volatile Organic Compounds (VOCs)	µg/l	100 – 400

Notes: (a) Assumes domestic water supply from Calleguas MWD.
Source: Metcalf and Eddy, Inc., "Wastewater Engineering Treatment, Disposal, and Reuse," Third Edition, 1991.

Of the traditional constituents of wastewater, nitrogen is of particular concern. Nitrogen in soil typically includes five separate nitrogen species: ammonia, nitrate, nitrite, organic nitrogen, and gaseous nitrogen. In wastewater, most of the nitrogen is in the form of ammonium ions. Once an effluent enters the soil, a sequence of biological and chemical reactions converts much of the ammonia to other forms of nitrogen. Therefore, while raw wastewater or partially treated effluent from a septic tank may contain very little nitrate, much of the ammonia may be converted to nitrate in the soil. According to a study performed by the Sanitation Districts of Los Angeles County using reclaimed water, removal of nitrogen compounds in soils is highly variable and unpredictable. The general trends show that there is a reduction in ammonia concentrations of approximately 55 percent and a resultant increase in nitrate concentrations. Approximately 30 percent of the nitrate is then being denitrified.[3]

3.1.2 Microorganisms

Table 3-2 presents the microorganisms, such as bacteria and viruses, found in typical domestic wastewater. Most NPDES permits address microorganism content of the discharged effluent through coliform, in units of Most Probable Number (MPN) per 100 milliliters (ml). Coliform is considered an indicator organism, in that its presence indicates the presence of other less easily detectable disease causing organisms. Microorganisms are eliminated through disinfection.

TABLE 3-2
MICROORGANISMS FOUND IN TYPICAL DOMESTIC WASTEWATER

Organisms	Concentration
Total Coliform	$10^5 - 10^8$
Fecal Coliform	$10^4 - 10^5$
Fecal Streptococci	$10^3 - 10^4$
Enterococci	$10^2 - 10^3$
Shigella	Present [(a)]
Salmonella	$10^0 - 10^2$
Pseudomonas aeroginosa	$10^1 - 10^2$
Clostridium perfringens	$10^1 - 10^3$
Myobacterium tuberculosis	Present [(a)]
Protozoan Cysts	$10^1 - 10^3$
Giardia cysts	$10^{-1} - 10^2$
Cryptosporidium cysts	$10^{-1} - 10^1$
Helminth ova	$10^{-2} - 10^1$
Enteric Virus	$10^1 - 10^2$

Notes: (a) Results from these tests are typically reported as positive or negative rather than being quantified.
Source: Metcalf and Eddy, Inc., "Wastewater Engineering Treatment, Disposal, and Reuse," Third Edition, 1991.

3.1.3 Endocrine Disrupters and Pharmaceutically Active Compounds

Over the past decade, research has indicated that anthropogenic compounds that are routinely discarded in society's waste streams are finding their way into the environment. Two overlapping subsets of these compounds are Endocrine Disrupting Compounds (EDC) and Pharmaceutically Active Compounds (PhAC). Also, collectively known as "xenobiotics". EDCs

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[3] Sanitation Districts of Los Angeles County. 25 August 1993. Experimental Studies of Nitrogen and Organic Carbon Removal from Reclaimed Water by the Soil Vadose Zone.

are of particular concern as a few compounds have shown health effects in animals or humans at very low concentrations (i.e., ng/l or parts per trillion).

The vast majority of the compounds in these chemical families are not currently regulated. Although there is significant research being conducted throughout the world regarding their occurrence, fate and transport through natural systems, and treatability through engineered processes, there are few commercial analytical labs that have the capability to accurately measure these compounds. Those that do provide services only measure select compounds and analytical costs are high.

Recent advances in analytical chemistry have allowed the detection and quantification of these compounds in wastewaters and wastewater impacted receiving waters at very low concentrations. Simultaneously, on-going investigations in animal and human toxicology are trying to determine the deleterious effects of EDC and PhAC. EDC are loosely grouped families of organic compounds that have various uses, physical-chemical properties, and activity levels within animals or humans. EDC all share a proven or suspected risk of disrupting animal or human endocrine systems, which can affect growth, reproduction, and intelligence. PhAC are an overlapping set of families of primarily organic compounds that are found in wastewaters and are currently not suspected to disrupt endocrine activity. Current conventional treatment processes, although effective, do not completely remove certain compounds. Recently it has been shown that certain compounds are also persistent in the environment, albeit at very low concentrations.

Table 3-3 presents a partial list of anthropogenic compounds that have been detected and quantified in either municipal wastewaters (domestic and industrial sources) and/or waterways impacted by wastewaters. The table is a compilation of ongoing research at Stanford University, the University of California at Berkeley, and a study performed by the U.S. Geological Survey (USGS). Also included in the list are certain persistent metabolites of particular compounds as these compounds have been detected and may have potential health risks.

Table 3-3 is not a complete summary of research results obtained throughout the U.S. and internationally, but a sampling of the most predominant by concentration or activity level within the body. These compounds, or families of compounds, tend to be similar throughout the industrialized world, although there are documented minor differences between the U.S. and Europe. The summary below encompasses findings within the U.S., while focusing on the Southwest.

TABLE 3-3
ANTHROPOGENIC COMPOUNDS OR THEIR METABOLITES FOUND IN WASTEWATERS AND IMPACTED WATERWAYS IN THE U.S.

Compound	Source	Concentration-mean (max) µg/l	Comments
Detergent Metabolites			
Alkyl Phenols (APs)(a)	Nonionic surfactant metabolite	0.8 (40)	High concentrations, high frequency of detection
Alkyl Phenoxy Ethoxylates (APEs)(a)	Nonionic surfactant metabolite	2.3 (32)	High concentrations, high frequency of detection
Alkyl Phenoxy Ethoxy Carboxylates (APECs)(a)	Nonionic surfactant metabolite	12.6 (20)	High concentrations, high frequency of detection
Steroids or Hormones			
Coprostanol	Fecal Steroid	0.70 (9.8)	Highest frequency – USGS survey
Cholesterol	Plant/Animal Steroid	1 (10)	
17a-Ethynyl Estradiol(a,b)	Ovulation inhibitor	0.073 (0.83)	Active ingredient in birth control pill
17b-Estradiol(a)	Reproductive hormone	0.16 (0.2)	Naturally occurring, concentrated in wastewaters
Prescription Drugs			
Carbamazepine	Anti-epileptic	<1	Persistent in the environment
Non-prescription Drugs			
Caffeine(b)	Stimulant	0.1 (5.7)	
Cotrimine(b)	Nicotine metabolite	0.05 (0.57)	
Acetaminophen(b)	Antipyretic	0.11 (10)	Common pain reliever
Other Wastewater related compounds			
N-N-diethyltoluamide (DEET)	Insect repellent	0.06 (1.1)	
Ethylene diamine tetraacetic acid (EDTA)	Industrial chemical and food additive	<50	No known health risk
Tri(2-chloroethyl)phosphate	Fire retardant	0.1 (0.54)	
Triclosan(a)	Antimicrobial disinfectant	0.14 (2.3)	
Bisphenol A(a)	Plasticizer	0.14 (12)	

Notes:
(a) Known or suspected EDCs in animals or humans
(b) PhACs
(c) None of the EDCs and PhACs listed above have primary MCLs.

The compounds in the Table 3-3, and others less frequently found, possess different structural, physical, and chemical properties. These properties determine their removal efficacy during biological or chemical processes. Therefore, not one economically viable treatment method can assure the complete removal of all EDCs and PhACs. The field of research regarding removal of these compounds is currently in its infancy, yet membranes, oxidation by chemicals and/or UV light, biodegradation, and absorption have shown some success. Currently, it appears that membrane separation or oxidation by ozone and/or chlorine will be the most effective at EDC and PhAC removal and adsorption and biodegradation less effective. The long-term treatment processes of adsorption and biodegradation in soil during groundwater recharge has been shown to reduce the EDC and PhAC levels significantly yet very low levels can persist under normal geologic conditions.

3.2 Wastewater Flows

In order to evaluate potential wastewater treatment and disposal systems for the proposed development of Tract 5277, the quantity of wastewater to be treated must be estimated. For the proposed development containing 23 single-family homes, the expected daily flow rate is estimated at 6,325 gpd. This is based on a typical design range for wastewater from single-family residences of 200 to 275 gallons per day. The higher rate of 275 gpd is used, because these homes are expected to contain more bedrooms and plumbing fixtures than average based on the lot size. In addition, this provides for conservative estimates of required treatment designs. According to Metcalf & Eddy, the peak day flow for small communities is on the order of 3.6 times average dry weather flow. This peaking factor is used with the nominal flow to calculate the hydraulic retention volume required for the treatment system. Table 3-4 presents the recommended flow criteria for the analysis.

TABLE 3-4
TRACT 5277 ANALYSIS FLOW CRITERIA

	Flow	
Description	**gpd**	**gpm**
Average Daily Flow	6,325	4.4
Peak Daily Flow	22,770	15.8

Section 4: Alternative Treatment System Descriptions

There is a growing interest in "Decentralized Wastewater Treatment Systems," also known as "Onsite Treatment," or "Small Community" wastewater treatment. In the February 2002 publication "Onsite Wastewater Treatment Systems Manual," EPA states that about 4 billion gallons of treated effluent per day is released from onsite wastewater treatment systems from an estimated 26 million homes, businesses, and recreational facilities nationwide. In addition, there is a growing movement toward the increased use of onsite treatment systems as a viable, low-cost, long-term, decentralized approach to wastewater treatment. However, these systems must be planned, designed, installed, operated, and maintained properly to mitigate the potential impacts of nitrate and bacterial contamination to groundwater and surface waters.

4.1 Treatment Options

This section describes the typical treatment technologies that are employed to treat portions of these contaminants, including systems provided by various vendors. The following treatment technologies are discussed:

- Primary Treatment
  - Septic Tanks
- Biological Treatment
  - Recirculating Sand Filters
  - Sequencing Batch Reactor
  - Fluidized Film Reactor
  - Submerged Membrane Bioreactor
  - Fixed Film and Thermal Decomposition
- Disinfection
  - Chlorination
  - Ultraviolet
  - Ozone
- Advanced Treatment
  - Reverse Osmosis

4.1.1 Primary Treatment

In primary treatment, physical operations such as screening and sedimentation are used to remove the floating and settleable solids found in wastewater. Septic tanks are the typical method of primary treatment for single-family homes or small communities without wastewater treatment systems.

4.1.1.1 Septic Tanks

The most basic system usually employed for single-family residences is the installation of a septic tank with the discharge flowing into a leachfield. Septic tanks are used as the first (or only) pretreatment step in nearly all onsite systems regardless of daily wastewater flow rate or strength. Septic tanks provide primary sedimentation of suspended solids and grit by creating quiescent conditions inside the tank. In addition, they provide anaerobic biological treatment of the solids and liquids. This can reduce the sludge and scum volumes by as much as 40 percent, and condition the wastewater by hydrolyzing organic molecules for subsequent treatment. Excess floating scum and greases also collect at the surface of the tank. In the traditional design, suspended solids are settled within the septic tank, and the biologically treated liquid is allowed to overflow and migrate into the subsurface through a leaching system. Collected solids are routinely pumped out every three to five years, or when the accumulated solids exceed 30 percent of the tank volume. Usually, septic tanks are gravity flow systems, made of concrete or thick-wall fiberglass. They should be constructed to be watertight and structurally sound. Gases require venting to the atmosphere or an odor control device.

Based on County of Ventura septic tank size requirements and a house size of five bedrooms, it is assumed that a 1,500-gallon septic tank would be required for each residence. With 1,500 gallons of volume, and at a flow rate of 275 gpd, there would be a hydraulic retention time of 5.45 days. However, some of the volume of the septic tank would be occupied by accumulated sludge and effectively reduce the retention time. Even so, this is more than adequate for design. The other typical design criteria are presented in Table 4-1.

TABLE 4-1
TYPICAL DESIGN CRITERIA FOR SEPTIC TANKS

Design Parameter	Unit	Range	Typical
Liquid Volume (5 Bedroom)	Gal	1,200 – 2,000	1,500
Compartments	No.	1-3	2[a]
Volume Distribution	% 1st, 2nd	67,33	67,33
Length to Width	Ratio	2:1 to 4:1	3:1
Depth	Feet	1-6	4
Clear space above liquid	In	10-12	10
Depth of Water surface below inlet	In	3-4	3
Inspection ports	No.	2-3	2

Notes: (a) Two- or three-compartment tanks are used when a screen vault is not used.
Source: Metcalf and Eddy, Inc., "Wastewater Engineering Treatment, Disposal, and Reuse," Third Edition, 1991.

The organic material that settles to the bottom of the tank is decomposed by facultative and anaerobic bacteria. The organics are converted to carbon dioxide (CO_2), methane (CH_4), and hydrogen sulfide (H_2S). The hydrogen sulfide odors are usually not a problem, because the sulfide combines with metals present in the wastewater and forms insoluble metallic sulfides. Small quantities of gases are also vented to the atmosphere. Table 4-2 shows the typical performance of septic tanks.

TABLE 4-2
TYPICAL TREATMENT PERFORMANCE OF SEPTIC TANKS

Parameter	Raw Waste	Septic Tank Effluent
BOD_5, mg/l	220	140-200
TSS, mg/l	720	50-90
Nitrogen, mg/l		
Total	40	25-60
Ammonia (NH_4^+)	25	20-60
Nitrate (NO_3^-)	0	<1
Total Phosphorus, mg//	8	10-30
Fecal Coliforms, MPN/100 ml	10^7 - 10^8	10^3-10^6
Viruses, PFU/ml	Unknown	10^5-10^7

Baffles are used to help separate the solids from the wastewater and prevent carryover of solids into the effluent. Tank geometry helps too, in that tanks with shallow liquid depths better reduce peak outflow rates and velocities, so solids are less likely to remain in suspension and be carried out of the tank in the effluent. Other designs employ the use of screen vaults to filter the water prior to exiting the tank.

Fiberglass-reinforced polyester (FRP) tanks usually have a wall thickness of about ¼ inch. Most are gel- or resin-coated to provide a smooth finish and prevent exposure of glass fibers, which can cause wicking. Polyethylene (PE) tanks are more flexible than FRP tanks, but are susceptible to deformation if not properly designed. Concrete tank walls are usually 4 inches thick and reinforced with no. 5 rods on 8-inch centers. Sulfuric acid and hydrogen sulfide gases, which are generated in the septic tanks, can corrode exposed rods and the concrete itself over time. FRP and PE tanks are resistant to corrosion, and are much lighter and easier therefore to install. Concrete tanks are more structurally sound.

Costs for a 1,500-gallon septic tank range from $1,500 to $6,000 each for PE, FRP, or concrete. Pumping septic tanks costs approximately $200 for 2,000 gallons. It is assumed that for this project, each home would have a septic tank installed for initial treatment of the wastewater before being further treated.

4.1.2 Biological Treatment

Biological treatment processes are typically those that provide removal of BOD and perform nitrification. Some also provide denitrification. Many of these systems are package units with proprietary treatment systems. Most systems can be used in conjunction with septic systems for initial treatment and equalization; they can also be followed by additional treatment processes for disinfection or advanced treatment.

To enhance treatment, in addition to septic tanks, a biological treatment system to remove BOD and ammonia and nitrate through nitrification could be used. The biologically treated effluent can be either filtered or clarified to remove biomass and excess biosolids from the effluent. The biosolids are recycled or collected for separate disposal.

As an option to a biological reactor treatment system, some systems employ recirculating packed-bed filters. These have the capability to induce biological treatment, including nitrification and denitrification, as well as filtration.

In general, most prepackaged plants that are designed to treat small community wastewaters employ one of several types of biological treatment. The typical biological treatment systems are: 1) aeration processes, 2) submerged membrane reactors or 3) sequencing batch reactors (SBR). These processes rely on the presence of microbiological organisms to degrade the organic material. Oxidation products include carbon dioxide (CO_2); methane (CH_4), and hydrogen sulfide (H_2S) are produced in reducing (anaerobic) environments. Depending on process configuration and operation, ammonia and nitrate removal can also be accomplished. Phosphorus may be reduced some, but usually only slightly.

Adding biological treatment to any process increases the complexity and requirements for process control and maintenance. The major design and operational issues associated with employing small biological treatment systems include:

- Flow equalization to absorb shock loads of flow, high BOD and TSS, or changes in wastewater pH and temperature.
- Recirculation of biosolids.
- Nitrification and denitrification steps.
- Inadequate removal and collection of waste biosolids.
- Control of foaming in the aeration tanks.
- Control of the proper air supply rate.
- Adequate design under organic and solids loading.

Each manufactured design incorporates different methods for handling these design and operational issues. Each of the technologies considered and their capabilities are discussed in this section.

4.1.2.1 Recirculating Sand Filtration

Recirculating sand filters (RSF) are also employed to further treat effluent from a septic tank. These filters enable biological treatment as well as filtration, and are therefore an effective treatment technology. The basic system collects septic tank effluent in the recirculation tank. Wastewater is pumped from the recirculation tank through the sand filter, and back into the recirculation tank. Wastewater leaves the system when the recirculation tank is full and overflows. In this manner the septic tank effluent is diluted by the treated and filtered wastewater. Typical designs allow for the wastewater to be recirculated three to five times before exiting the system. The filter media is usually made of sand, with a 2-foot deep bed, which allows physical, chemical, and biological treatment of the wastewater. Typical BOD and TSS removal is 85 to 95 percent of the septic tank effluent. Ammonia can be oxidized to nitrate.

The main drawback to RSFs is the requirement for frequent maintenance, although the maintenance is not difficult. Required routine maintenance involves monitoring the influent and effluent, inspecting the dosing equipment, maintaining the filter surface, checking the discharge head on the inlet orifices, and flushing the distribution manifold annually. In addition, the recirculation tank should also be inspected and maintained. In general, this requires weekly maintenance visits at 30 minutes each.

The recirculation tank is sized for 1 day of retention time, which equals the average daily flow times the peaking factor. The sand bed (2-foot depth) is designed with a hydraulic loading rate of 3.0 to 5.0 gpd/ft^2. The recirculation ratio is 3:1 to 5:1. The wastewater is usually dosed into the filter for 2 to 3 minutes at a time, for 48 to 120 times per day.

A 20,000 gallon system (suitable for this project) is estimated to cost $152,000 for equipment and engineering, not including site preparation or electrical, and $10,000 annually for O&M.

4.1.2.2 Sequencing Batch Reactors

Aqua-Aerobic Systems is one manufacturer of Sequencing Batch Reactors (SBR). This technology originated in the remote regions of Australia, and is applicable for flow rates of 5 MGD or less. It involves intermittent operator attention. The SBR is a fill-and-draw activated sludge system for wastewater treatment. In an SBR system, wastewater is added to a single "batch" reactor, treated to remove undesirable components, and then discharged. The individual steps of equalization, aeration, and clarification can all be achieved using a single batch reactor. To optimize the performance of the system and to handle continual flows, two or more batch reactors are used in a predetermined sequence of operations. SBR systems are suited for wastewater treatment under low or intermittent flow conditions. A septic system would be appropriate for equalization upstream of the SBR units.

Equalization may be required after the SBR, depending on the downstream process. If equalization is not used prior to filtration, the filter system would need to be sized in order to receive the entire batch of wastewater from the SBR, resulting in a large surface area required for filtration. Separate equalization following the biological system is generally not required for most conventional activated sludge systems, because the flow occurs on a continuous and more constant basis.

The Aqua-Aerobic system consists of the following:

1. A pre-SBR equalization basin of 2,100 gallons, 10 feet long, 8 feet wide, and 5 feet deep. The basin would be equipped with coarse air diffusers at 60 SCFM/1000 CF.

2. AquaSBR unit consisting of one 14,700-gallon rectangular basin, 14 feet long by 10 feet wide by 14 feet deep. The unit runs on 3 cycles per day with 8 hours in each cycle. The solids retention time is designed for 19 days. The effluent would be treated to a BOD and TSS of 10 mg/l each, and a Total Kjeldahl Nitrogen (TKN) of 5 mg/l. During the aeration phase, the air would be pumped at 1.25 pounds of O_2 per pound of BOD_5. The power required is 63.8 kW-hours/day.

3. A sludge aerobic digester unit, with an effective volume of 10 ft^3, or 7,480 gallons. The solids loading would be a sludge concentration of 1 percent, equal to 10.9 pounds per day. The retention time would be 114.3 days, with oxygen supplied at 6.4 pounds per day. The wet solids removal rate is 46.2 gal/day. The airflow required for mixing is 40 SCFM, with a power consumption of 16.1 kW-hours/day.

4. An AquaDisk tertiary filtration system consisting of a cloth media disk and processing 6,000 gpd. The hydraulic loading would be 3.3 gpm/ft^2 on a single filter unit with dual filters, each containing 12 ft^2 of filter surface area.

5. Auxiliary equipment consisting of transfer pumps, coarse bubble diffusers, positive displacement blowers, level sensor assemblies, valves, aerator/mixer, instrumentation, Sequential Logic Controller (SLC) programmable controller, remote access modem, backwash pump, and filter control package.

The complete equipment cost for this system, sized for the Tract 5277 development, is $265,000. This system assumes grit removal is performed upstream of the SBR. Annual O&M costs are estimated to be $20,000.

4.1.2.3 Fluidized Film Reactors

Hydroxyl manufactures a fluidized fixed film reactor (F^{3}R) biological treatment system for small communities, called the Hydroxyl-MBS-Jr. This system is truly compact in that the entire system is skid mounted within one container and capable of treating 10,000 gpd of sewage. The system can treat sewage to 10 mg/l for both BOD and TSS. The unit accommodates a total of approximately 13,465 gallons in a series of individual chambers. Due to the fixed film feature, the manufacturer claims that the biological retention times are reduced to 4 to 6 hours from what is normally required. The system also includes Positive Flotation Mechanism (PFM) modules on both the inlet and outlet streams from the system. In addition, a combined UV and ozone disinfection system are included. These chambers are arranged in the process order of:

1. Pre-treatment by flotation, termed PFM-1, for the removal of floatable solids, oils and grease. Flotation is affected by the injection of oxygen and ozone-infused water from the recirculating pump, and injected through nozzles. The dissolved gases also provide a high rate of digestion in the "sludge cap" that forms at the top of the PFM. This initial flotation is expected to reduce the BOD by 30 to 40 percent.

2. An Equalization (EQ) compartment.

3. An anoxic reactor compartment. This compartment is kept under anoxic conditions by recycling the nitrified recycle from the third biological F^{3}R treatment stage. High surface area plastic media are included to provide area for the growth of microbes that convert nitrate to nitrogen gas. The denitrified water then flows to the subsequent F^{3}R reactors.

4. First stage F^{3}R biotreatment for BOD reduction. Sloughed biofilm is carried through to the next stage.

5. Second stage F^{3}R biotreatment with further BOD reduction and some nitrification.

6. Third stage F^{3}R biotreatment for polishing BOD reduction and nitrification. Effluent from this stage exits the screens and flows by gravity into the PFM-2.

7. Post-treatment for removal of particulate (mostly biomass) in the PFM-2.

8. Effluent polishing and disinfection by a combination of UV light and ozone in an oxidation contact tank.

The plastic media used in the F^3R processes are neutrally buoyant plastic media and provide a base for the growth of a diverse population of microorganisms. The attached growth media have a very high surface-to-volume ratio, allowing for a high concentration of biological growth to thrive within the internally protected areas. This increases the mass transfer of oxygen to the bacterial growth. Therefore, the required hydraulic retention time (HRT) of an extended aeration treatment process can be reduced.

The MBS-Jr. achieves separate stage nitrification by first bio-treating to minimize BOD. This is accomplished with a three-staged F^3R bioreactor designed for optimal BOD reduction and nitrification.

Denitrification is accomplished by recycling the nitrified effluent in the third stage F^3R reactor to the anoxic reactor. In the presence of organic matter, the nitrates are converted in the fixed film anoxic reactor and released as nitrogen gas. No information is available from the manufacturer on the expected effluent nitrate concentration.

Hydroxyl suggests that approximately every two months, a portion of the sludge cap should be manually removed from the PFM-1 compartment. Due to the use of oxygen and ozone in the flotation gas, the sludge cap is heavily digested, and results in a slow rate of net buildup of solids. In addition, the solids removed in the two PFM units must be stored and properly disposed. No storage tank is provided from Hydroxyl in this design.

Air is applied to each aeration tank by means of a blower and coarse bubble diffusion grid located in each aeration tank. The quantity of air applied to the tank can be varied to maintain a minimum dissolved oxygen (DO) level of at least 2-3 mg/l in stage 1, and 4-6 mg/l in stages 2 and 3 as required for nitrification. Each tank has built in sensors and a variable speed blower with control valves. It is not clear if the DO levels are automatically controlled, or if the blower levels and valves are just manually set. Hydroxyl states that only infrequent adjustment of the air supply should be required.

The footprint size of a single unit is 8 feet wide by 25 feet long by 9 feet high, for a total unit volume of 13,500 gallons. The total power requirements are 12 kW, 240 V 1-phase.

The system is designed to handle 10,000 gpd and costs $90,000. However, conservatively, the system should be sized to handle nearly 23,000 gpd. In addition, if service is required on the unit, there is no equalization tank to provide storage, and having two units in parallel would provide redundancy for maintenance and repairs. It is also not clear what the exact volumes are for each reactor, and these appear lower in volume than usual due to the fixed film media. Therefore, it may be recommended to use two of these units in parallel for the Tract 5277 development, at a system cost of $180,000. Annual O&M costs are estimated at $30,000.

Units have been installed in Avalon, Texas; Nimmo Bay on Vancouver Island in British Columbia; and at the Burnaby Lake Green House.

4.1.2.4 Submerged Membrane Bioreactor

Zenon and Kubota both manufacture submerged membrane bioreactor (MBR) systems. In general, submerged MBR processes combine biological aeration with membrane filtration. The combination produces higher quality effluent with systems that are able to work effectively under varying influent conditions. Separate chambers are built into the design to allow for an anoxic zone along with the aeration zone to promote nitrification and denitrification. These systems also typically operate with higher solids loading, referred to as the mixed liquor suspended solids (MLSS). This helps to minimize the size and footprint of the required treatment reactor. A membrane bioreactor could be used in conjunction with an upstream septic system to provide some treatment and equalization.

4.1.2.4.1 Zenon

The Zenon submerged membrane bioreactor process consists of a suspended growth biological reactor integrated with a microfiltration membrane system. Essentially, the ultrafiltration system replaces the solids separation function of a secondary clarifier and sand filters in a conventional activated sludge system. The ultrafilter employed is the ZeeWeed® ZW500-WW hollow fiber membrane, which has a 0.1-micron pore size that ensures that no particulate matter is discharged in the effluent.

The ultrafiltration membranes are submerged in the aeration tank, in direct contact with the mixed liquor. By applying a suction duty pump, a vacuum is applied to the header connecting the membranes. Treated water is drawn by the vacuum through the hollow fiber microfiltration membranes, into the pump and then discharged. The energy required for pumping through the membrane is reduced by applying vacuum as opposed to positive pressure. An airflow is introduced to the bottom of the membrane module producing turbulence which scours the external surface of the hollow fibers transferring rejected solids away from the membrane surface. This airflow also provides a portion of the biological process oxygen requirements, the remainder is provided by a diffused aeration system. Waste sludge is pumped directly from the aeration tank.

The Zenon technology is designed to overcome typical problems associated with poor settling of sludge in conventional activated processes. This technology permits bioreactor operation with considerably higher mixed liquor solids concentrations than conventional activated sludge systems, which are limited by sludge settling. The Zenon process is typically operated at a mixed liquor suspended solids (MLSS) concentration in the range of 8,000 to 10,000 mg/l. The elevated biomass concentrations allow for highly effective removal of both soluble and particulate biodegradable material in the waste stream. The process combines the unit operations of aeration, secondary clarification and filtration into a single process, simplifying operation and greatly reducing space requirements.

The treated effluent is expected to have less than 5 mg/l of both BOD and TSS, and less than 2 mg/l of ammonia. The system components are:

1. Biological process tank of 6,500 gallons.
2. Permeate pumps.
3. Submersible grinder transfer pumps for fluid transfer between equalization and the process reactor.
4. Process control system.
5. Clean in Place (CIP) membrane cleaning system.
6. pH control system.
7. Air scour distribution header pipes.
8. Membrane air scour and process air blowers with valves.

9. Aeration diffuser system.
10. Anoxic Mixing.
11. Sludge recirculating pump.
12. Motor Control Equipment.

The budgetary price for this system is estimated at $195,500, with annual O&M costs between $15,000 and $20,000.

4.1.2.4.2 Kubota

Kubota is a Japanese company that specializes in submerged membrane bioreactor technology and is represented by Enviroquip, Inc. in the United States. They manufacture small units of 10,000 to 12,000 gpd that are suitable for small community treatment. By maximizing sludge age and mixed liquor suspended solids (MLSS) concentrations, both the solids handling and treatment unit footprint are reduced. With the inclusion of membrane filtration in the aeration reactor, the need for secondary clarification of filtration is eliminated.

The basic unit is an aeration chamber combined with flat-plane membrane filtration of the wastewater. It is assumed that grit removal is achieved upstream of this unit. The MBR basin can be constructed of concrete, epoxy coated steel, or stainless steel. The stainless steel tanks are recommended for this project because they require much less maintenance. The filters are installed in banks and slide in and out of the reactor on guide rails. Membranes are manufactured with an average pore size of 0.4 microns, but the manufacturer claims an effective pore size of 0.1 microns due to biofilms that form on the membrane. The manufacturer also claims to be able to remove 99.9 percent of viruses and bacteria as demonstrated in some studies.

Generally, the membrane does not require backwashing, but must be cleaned in sodium hypochlorite two or three times per year. The MBR membranes are cleaned-in-place by pouring or injecting the cleaning solution into the membrane case. This process can be conducted while the plant is on-line and takes between one and two hours to complete per membrane case.

This design can be gravity operated or utilize low suction head permeate pumps to drive the filtration process. Gravity operation simplifies system controls and reduces operating costs. The unit is capable of nitrification/denitrification to reduce the nitrate levels to below 10 mg/l. Effluent turbidities are expected to be 0.2 NTU. Solids are retained at a Solids Retention Time of 25 days.

Kubota has three units installed in the U.S, including one in Oregon, one in La Jolla, California, and one in Texas. An additional 0.6 MGD plant is planned to be installed in September in Running Springs, California.

A typical Enviroquip design includes: two membrane reactors housed in stainless steel tanks; a stainless steel equalization tank; built in anoxic tanks; a waste activated sludge tank with fine screen; a chlorine tablet feed disinfection system; process control system; all required pumps, blowers, and air diffusers; interconnecting piping and valves; dissolved oxygen probes; and an on-line turbidimeter. The two reactor design provides for operational redundancy, and allows one reactor to be shut down while the other operates. The equalization tank and feed pump could be eliminated by selecting slightly larger membrane reactors. The Enviroquip design requires grit removal upstream of the membrane reactors, which the septic tanks would provide.

Since, some equalization would be provided by the septic tank, eliminating the equalization tank and utilizing slightly larger reactors, would reduce complexity and provide more operational flexibility.

The budgetary estimate for the basic Enviroquip system designed for this project is estimated at $250,000, with annual O&M costs between $15,000 and $20,000.

4.1.2.5 Fixed Film and Thermal Decomposition

Fixed Film and Thermal Decomposition systems, such as that manufactured by MicroSepTec, combine biological treatment with the thermal decomposition of excess solids for a complete self-enclosed treatment of wastewaters. Three models are available based on processing capacity: 600, 1,200, or 1,500 gpd. In general, these units are smaller sized units that are primarily designed for treatment of individual homes instead of small communities. Several units would be required to treat the combined flows for the Tract 5277 development. Typically, these are stand-alone units and are not used in conjunction with septic tanks.

The design incorporates aeration diffusers and an aeration chamber, recycling of biosolids for promotion of denitrification, sludge collection and thermal decomposition, an exhaust scrubber, a disinfection unit, and process control system designed for remote access. In general, the units are capable of reducing the BOD and TSS concentrations to below 10 mg/l. Nitrification and denitrification processes are incorporated as the final effluent is expected to be below 10 mg/l for total nitrogen. The system does not require a septic tank or other prior treatment. The system components are:

1. Primary clarification occurs as raw sewage from the home enters and settles in the primary clarifier.

2. Biological organic removal is accomplished in a second chamber using pressure blowers and bubble diffusers.

3. Biological ammonia conversion (nitrification) occurs in the third chamber. This chamber is also aerated. Biomedia are utilized to optimize the contact time and support biological growth.

4. Clarification and settling of suspended solids occurs in a clarification chamber.

5. Nitrate removal (denitrification) is accomplished as wastewater is recirculated from the fourth chamber back to the first chamber.

6. Solids removal and destruction controls the build-up of sludge (dead biomass) in the system. Sludge is periodically pumped from the bottom of the first chamber. The sludge is filtered through a screen inside the thermal processor and the water drains back to the first chamber. The thermal processor dehydrates, pyrolizes, and gasifies the sludge. The exhaust is routed back into the liquid in the first compartment to scrub the gas. The ash from the thermal decomposition process is flushed out with the wastewater and leaves the system as dissolved and suspended solids.

7. The final effluent is disinfected with chlorine, using a contact time of 90 minutes, creating an effluent with 0.5 mg/l residual of chlorine and a coliform count of less than 2.2 CFU/100 ml. The chlorine is added by means of solid tablets, which eliminates the

need for liquid storage on site. The tablets must be replaced on a regular basis to ensure continued disinfection.

Each system is designed with an aerobic chamber that is twice the size of the expected nominal flow, so the 1,500-gpd unit has a 3,000-gallon aerobic chamber. The 600-gallon unit is designed for a single-family home, which in this project's design would generate 275 gpd. Under peak load conditions, the 1,200-gallon tank provides for a peaking factor of 4.36, which is more than adequate. To process the wastewater from the entire Tract 5277 development, 23 individual 600 gpd units or 10 of the 1,500-gpd units would be required. Each 600-gpd system costs $14,950; 23 of these would cost a total of $344,000. Using 10 of the 1,500-gpd systems would cost a total of $220,000 at a cost of $21,950 for each unit. Therefore, it would be more cost effective to treat the wastewater in clusters of units. This would involve additional piping costs to manifold these units together. O&M costs are estimated at $15,000 to $20,000 annually.

While this unit is convenient in that there is no biosolids stream to manage or handle, the ash residue from the decomposition of the biosolids is put back into the liquid effluent. This would cause the TDS of the wastewater effluent to be higher than the other biological treatment systems and create an undesirable quality for reuse.

4.1.3 Disinfection

Although undisinfected wastewater is reused for certain applications, properly disinfected wastewater can be reused in a much wider variety of settings. The organisms of concern in domestic wastewater include enteric bacteria, viruses, and protozoan cysts. Disinfection is the primary means for inactivating or destroying these organisms. For a disinfectant to work effectively, the wastewater must be adequately treated prior to the disinfection process. In addition, the California Title 22 regulations discussed in Section 2.2 for recycled water set specific requirements for contact time and dose for disinfection.

The typical methods employed for disinfection are chlorination, ozonation, and UV disinfection. Chlorine may be applied as chlorine gas, sodium hypochlorite, or chlorine tablets. Due to the hazards and cumbersome management requirements associated with chlorine gas, it would not be practical to consider its use for this project.

Optimum disinfection is dependent on the degree to which the wastewater has already been treated, the concentration of pathogens, other water quality parameters, and the level of disinfection desired. Solids or particles that are present in the wastewater can inhibit the disinfection process. Typically, microorganisms are not free floating organisms, but attach themselves to particles. The particles inhibit the disinfection by reducing the likelihood of contact between the bacteria and the disinfection molecule or energy source.

The effectiveness of disinfection is usually demonstrated by the measurement of total Coliforms in units of Mean Probable Number (MPN) per 100 milliliters (ml). Coliform is considered an indicator organism, in that if it is reduced to low numbers, then the other bacteria, protozoa, and viruses are expected to be even lower. Title 22 requires the disinfection to either 2.2 MPN/100-ml or 23 MPN/100-ml, depending on the intended use of the recycled water.

4.1.3.1 Chlorination

Chlorination is the most widely used disinfectant for municipal wastewater because it destroys target organisms by oxidizing cellular material. Chlorination is also usually less expensive than UV or ozone disinfection. The advantages of chlorine disinfection generally are:

- Chlorination is a well-established technology.
- Currently, chlorine is more cost effective than either UV or ozone disinfection.
- The chlorine residual that remains in the wastewater effluent can prolong disinfection even after initial treatment and can be measured to evaluate the effectiveness.
- Chlorine disinfection is reliable and effective against a wide spectrum of pathogenic organisms.
- Chlorine is effective in oxidizing certain organic and inorganic compounds.
- Chlorination has flexible dosing control.
- Chlorine can eliminate certain noxious odors during disinfection.

The disadvantages of chlorine generally are:

- The chlorine residual is toxic to aquatic life.
- All forms of chlorine are highly corrosive and toxic. Therefore, storage, shipping, and handling pose a risk, requiring increased safety precautions.
- Chlorine oxidizes certain types of organic matter in wastewater, creating hazardous compounds like trihalomethanes (THMs).
- The level of TDS is increased in the treated effluent (with hypochlorite only).
- The chloride content of the wastewater is increased.
- The chlorine residual is unstable in the presence of high concentrations of chlorine-demanding materials, thus requiring higher doses to effect adequate disinfection.
- Some parasitic species have shown resistance to chlorine, including oocysts of *Cryptosporidium parvum*, cysts of *Endamoeba histolytica* and *Giardia lamblia*, and eggs of parasitic worms.

An additional consideration in using chlorine for disinfection is that the wastewater must be dechlorinated prior to discharge to surface waters. The long–term effects of discharging dechlorinated compounds into the environment are unknown.

The primary design considerations for chlorine disinfection are contact time and chlorine dose. For optimum performance the contact system should exhibit plug flow and be highly turbulent for complete initial mixing in less than one second. The contact chamber should have round corners to prevent dead flow areas and be baffled to prevent short-circuiting. The dose usually ranges from 5 to 20 mg/l. Title 22 requirements for chlorine disinfection are a CT (the product of total chlorine residual and modal contact time measured at the same point) value of not less than 450 mg-min/l at all times, with a modal contact time of at least 90 minutes. A common practice is to provide 120 minutes of modal contact time and a minimum initial residual concentration of 10 mg/l of chlorine for operating flexibility and redundancy. The contact time is provided in a concrete basin or buried pipeline structure which must have a length:width or depth ratio exceeding 40:1 to create plug flow. So if the contact time minimum is 120 minutes, the minimum dose throughout the system must be at least 3.75 mg/l to meet the 450 mg-min/l minimum. For a flow of 6,325 gpd, if a chlorine contactor 10 inches in diameter were used (one possible configuration), it would have to be 129 feet long to obtain the 120-minute contact time. This piping could be laid out in a serpentine fashion, or as part of the discharge piping.

A sodium hypochlorite system is estimated to cost $3,000 in capital costs and $1,200 annually for O&M.

4.1.3.2 UV Disinfection

An UV disinfection system transfers electromagnetic energy from a mercury arc lamp to an organism's genetic material (DNA and RNA). When UV radiation penetrates the cell wall of an organism, it destroys the cell's ability to reproduce. UV radiation is generated by inserting an electrical discharge through mercury vapor.

The effectiveness of a UV disinfection system depends on the characteristics of the wastewater, the intensity of UV radiation, the amount of time the microorganisms are exposed to the radiation, and the reactor configuration. The disinfection success is directly related to the concentration of colloidal and particulate constituents in the wastewater. In order to obtain DHS approval for a UV disinfection system, the treatment dose must correspond to the Ultraviolet Disinfection Guidelines for Drinking Water and Reuse, published by the National Water Research Institute.

The advantages of UV disinfection are:

- UV disinfection is effective at inactivating most viruses, spores, and cysts.
- UV disinfection is a physical process rather than a chemical disinfectant, which eliminates the need to generate, handle, transport, or store toxic/hazardous or corrosive chemicals.
- There is no residual effect that can be harmful to humans or aquatic life.
- UV disinfection is user friendly for operators.
- UV disinfection has a shorter contact time when compared with other disinfectants (approximately 20 to 30 seconds with low-pressure lamps).
- UV disinfection equipment requires less space than other methods.
- UV radiation may treat some endocrine disrupters or pharmaceutically active compounds.

The disadvantages of UV disinfection are:

- Low dosage may not effectively inactivate some viruses, spores, and cysts.
- Organisms can sometimes repair and reverse the destructive effects of UV through a repair mechanism known as photo reactivation, or in the absence of light known as "dark repair."
- A preventative maintenance program is necessary to control fouling of the UV radiation tubes.
- Turbidity and TSS in the wastewater can render UV disinfection ineffective. UV disinfection with low-pressure lamps is not as effective for secondary effluent with TSS levels above 30 mg/l.
- UV disinfection is not as cost effective as chlorination, but costs are competitive when the costs of chlorination/dechlorination and meeting fire code requirements for chemical storage are included.

While UV ozone provides excellent disinfection, it does not produce a disinfectant residual in the water. If a residual were desired, chlorination would also be necessary.

The proper operation and maintenance of a UV disinfection system ensures that sufficient UV radiation is transmitted to the organisms to render them sterile. All surfaces that transmit the UV radiation to the wastewater must be clean. Inadequate cleaning is one of the most common causes of a UV system's ineffectiveness. The quartz sleeves or Teflon™ tubes need to be cleaned regularly by mechanical wipers, ultrasonics, or chemicals. Chemical cleaning is most commonly done with citric acid. Other cleaning agents include vinegar solutions and sodium hydrosulfite.

The average lamp life ranges from 8,760 to 14,000 working hours, and the lamps are usually replaced after 12,000 hours of use. The ballasts are usually replaced every 10 years. The quartz sleeves typically last about 5 to 8 years but are usually replaced at 5-year intervals.

While UV provides excellent disinfection, it does not produce a disinfectant residual in the water. In order to create chlorine residual in the final wastewater effluent, sodium hypochlorite could be used in conjunction with UV. This would protect the effluent system from regrowth of microorganisms. The advantage of using UV for the primary disinfection would be to limit the amount of liquid hypochlorite stored on site.

In light of concerns over contaminants like EDCs and PhACs, the UV process may prove beneficial in removing some of those compounds as well.

UV disinfection would cost $120,000 in capital costs, with $5,000 to $10,000 in O&M costs annually.

4.1.3.3 Ozone

Ozone is produced when oxygen molecules (O_2) are dissociated by an energy source into oxygen atoms and subsequently collide with an oxygen molecule to form a highly reactive gas, ozone (O_3). Ozone is generated by imposing a high voltage alternating current (6 to 20 kilovolts) across a dielectric discharge gap that contains air or oxygen. Ozone is highly reactive, yet unstable, and decomposes to elemental oxygen in a short time after generation. Therefore, ozone must be generated onsite.

Ozone is a very strong oxidant and virucide. The mechanisms of disinfection using ozone include:

- Direct oxidation and destruction of the cell wall with leakage of the cellular constituents outside of the cell.
- Reactions with radical by-products of ozone decomposition.
- Damage to the constituents of the nucleic acids (purines and pyrimidines).

When ozone decomposes in water, the free radicals hydrogen peroxy (HO_2) and hydroxyl (OH) are formed, which have additional oxidizing capacity. These free radicals also provide disinfection activity, and are believed to function by protoplasmic oxidation resulting in cell wall disintegration, or cell lysis.

The components of an ozone disinfection system include feed-gas (air or oxygen) preparation, ozone contacting, and ozone destruction. The electrical discharge method is the most common energy source used to produce ozone. Extremely dry air or pure oxygen is exposed to a controlled, uniform high voltage discharge at a high or low frequency. The gas stream generated from air contains about 0.5 to 3.0 percent ozone by weight, whereas pure oxygen forms approximately two to four times that concentration. The ozone generator and power requirements are the expensive portions of ozone disinfection.

Ozone is commonly contacted with the wastewater by diffused bubble (co-current and counter current), through positive pressure injection, negative pressure (Venturi), mechanically agitated, and packed tower mechanisms. Because ozone is consumed quickly, it must be contacted uniformly in a near plug flow contactor.

Excess ozone in the wastewater escapes from the water as off-gas. These off-gases may be recycled to generate ozone or to an aeration tank. The ozone off-gases that are not used must be sent to an ozone destruction unit before being vented to the atmosphere. Therefore, it is essential to maintain an optimal ozone dose, in order to avoid wasting excess ozone.

An ozone disinfection system strives for the maximum solubility of ozone in the wastewater. This maximizes the disinfection potential and minimizes the required contact time. Ozone has limited solubility and decomposes more rapidly in water than in air. This requires that the ozone contactor be well sealed and that the ozone diffuses into the wastewater as effectively as possible. The design dose is between 50 and 200 mg/l. Ozone in the gaseous form is explosive at a concentration of 240 mg/l. The design contact time for ozone is short, usually 10 to 30 minutes.

Ozone disinfection is the least used method in the U.S. while this technology has been widely accepted in Europe for decades. It is not known if ozone treats all EDCs and PhACs, however, due to the highly reactive nature of ozone, it is highly likely that some of these compounds would be oxidized by ozone. Recent studies show that oxidation is an effective transformation process, but considering the wide variety of unregulated organic compounds, it is not possible to predict complete removal of all possible organic contaminants at typical ozone doses. Ozone has the ability to achieve higher levels of disinfection than either chlorine or UV, but the capital costs as well as maintenance expenses are higher.

The advantages of ozone are:

- Ozone is more effective than chlorine in destroying viruses and bacteria.
- The ozonation process utilizes a short contact time (approximately 10 to 30 minutes).
- There are no harmful residuals that need to be removed after ozonation because ozone decomposes rapidly.
- After ozonation, there is no regrowth of microorganisms, except for those protected by the particulates in the wastewater stream.
- Ozone is generated onsite, and thus, there are fewer safety problems associated with shipping and handling.
- Ozonation elevates the dissolved oxygen (DO) concentration of the effluent. The increase in DO can eliminate the need for reaeration and also raise the level of DO in the receiving stream.

The disadvantages of ozone are:

- Low dosage may not effectively inactivate some viruses, spores, and cysts.
- Harmful off-gases can be produced, which must be destroyed or controlled.
- Ozonation is a more complex technology than is chlorine or UV disinfection, requiring complicated equipment and efficient contacting systems.
- Ozone is very reactive and corrosive, thus requiring corrosion-resistant material such as stainless steel.
- Although ozonation does not produce the harmful by-products associated with chlorine disinfection, ozonation creates bromate, a known carcinogen, if bromide is present in the water supply.
- Ozonation is not economical for wastewater with high levels of TSS, BOD, COD, or TOC.
- Ozone is extremely irritating and possibly toxic, so off-gases from the contactor must be destroyed to prevent worker exposure.
- The cost of treatment can be relatively high in capital and in power intensiveness.

Similar to UV, while ozone provides excellent disinfection, it does not produce a disinfectant residual in the water. If a residual were desired, chlorination could be used as a secondary step, minimizing the formation of undesirable disinfection by-products. Ozonation may also prove beneficial in removing certain unregulated contaminants endocrine disrupters and pharmaceutically active compounds. An ozone system for this development is estimated to cost $30,000 with $10,000 to $15,000 annually in O&M costs.

4.1.4 Advanced Treatment

Advanced treatment methods include a wide variety of technologies that perform denitrification or treatment of difficult to remove constituents, such as TDS.

4.1.4.1 Reverse Osmosis

The estimated composition of untreated domestic wastewater includes 500 mg/l of TDS. In general, TDS is considered a "pass through" contaminant. That is, the TDS concentration remains roughly the same through each of the treatment processes. In reality, the various processes either remove or add minor amounts of TDS, but these additions and removals tend to balance each other out. For example, denitrification removes nitrate and lowers TDS, while disinfection with chlorine increases TDS. Therefore, if the estimated inlet TDS concentration is 500 mg/l, then the effluent from the septic tank, biological treatment, and disinfection process, should yield an effluent TDS concentration near 500 mg/l.

The stringency of the Basin Plan objectives discussed in Section 2.1 may lead the RWQCB to issue low or TDS, sulfate, and chloride limits in a reclamation permit for the Tract 5277 site, requiring additional treatment in order to be able to reuse treated wastewater for irrigation or for evapotranspiration. Membrane processes are capable of removing hardness compounds, and in some instances this may also be enough to substantially reduce the TDS. The usual treatment employed for TDS removal is Reverse Osmosis (RO). A detailed analysis of the wastewater chemistry is required to evaluate one treatment technology over another.

RO involves pumping wastewater at high pressures through a selective membrane that allows water to pass through, but rejects most dissolved ions. RO would have the added beneficial result of removing most of the metals present in the portion of the wastewater stream that is treated. In addition, most EDCs and PhACs can at least be partially removed by RO. A typical RO treatment system is sized to treat a portion of the wastewater, which is treated to low TDS levels then blended with untreated effluent, such that the combined effluent meets the effluent standard for TDS. This treatment scenario minimizes the size of the RO treatment system and minimizes the volume of water required for treatment.

Based on the water quality data estimated for the untreated domestic water, and the ensuing treatment processes, an RO system to treat this water would need to be sized for 4 to 5 gpm and cost approximately $20,000. RO systems function best when the inlet flow is relatively constant, therefore an equalization tank prior to the RO would be recommended. This equalization tank, approximately 6,000 gallons in size, would hold the treated effluent from the biological system and then feed to the RO unit. Depending on the level of filtration involved in the biological system, additional filtration may be required to remove TSS prior to the RO unit, to prevent fouling of the RO membranes. RO manufacturers also recommend maintaining 4 mg/l of chloramines in the feed water to the RO to prevent biofouling on the membrane. If chlorine disinfection is used upstream of RO, the chlorine must be breakpointed or removed through dechlorination, as free chlorine is damaging to membranes. The RO system can also remove nitrate from the wastewater.

The main problem with RO treatment for the small community system is the need to handle and properly manage the reject brine from the RO unit. Normally, where a sewer connection exists, this brine would be discharged into the sewer system, but a connection at or near the proposed development site would require a substantial length of pipeline to connect to the Moorpark public collection system. Alternatively, the brine would need to be collected and stored in a tank and then trucked to the Moorpark Wastewater Treatment Plant or evaporated in ponds.

The evaporation ponds would need to be 20,000 to 30,000 square feet (ft^2) and 2 to 3 feet deep. This is based on an annual evapotranspiration (ET) of 45.78 inches and precipitation of 6.37 inches, as determined by the California Department of Water Resources for the Camarillo, Central Coast Valley areas. The settled and dried solids would require periodic collection and could possibly be recycled by a concrete manufacturer.

The other alternative is to collect the reject brine onsite and dispose of through the Montalvo Liquid Waste Treatment Facility (LWTF) owned and operated by the Ventura Regional Sanitation District. At a disposal cost of $0.011 per gallon, the annual cost for disposing of the brine is only $3,820 per year. The annual pumping and trucking costs are estimated to be $210 dollars per 4,500-gallon truckload, and total $16,200 per year. Total brine handling and disposal costs are estimated then to be $20,020 per year. By comparison, disposal of these solids to a landfill facility would cost $517,132 per year.

Capital costs are estimated at $20,000, with annual O&M costs roughly the same.

4.2 Disposal Options

The three main options for recycling and reusing the Tract 5277 development wastewater are spray irrigation, drip irrigation, and evapotranspiration. The following subsections discuss each of these disposal options.

4.2.1 Spray Irrigation

Under spray irrigation uses, the wastewater would be required to meet the Title 22 requirements described in Section 2 and could be used for:

- Some food crop irrigation
- Parks and playgrounds
- School yards
- Residential landscaping
- Unrestricted access golf course

In order to recycle wastewater for the uses mentioned above, the wastewater must meet technical standards for treatment and numeric standards for effluent water quality.

The technical requirements are that the wastewater must be "disinfected tertiary recycled water," which means a filtered and subsequently disinfected wastewater that meets the following criteria per DHS:

1. The filtered wastewater has been disinfected by either:

a. A chlorine disinfection process that provides a "CT" value of not less than 450 mg-min per liter, where CT equals the product of the total chlorine residual and modal contact time measured at the same point. The modal contact time must be at least 90 minutes, based on the peak design flow; or

b. A disinfection process (applies to UV or ozone disinfection processes) that, when combined with the filtration process, has been demonstrated to inactivate and/or remove 99.999 percent of the plaque forming units of F-specific bacteriophage MS2, or polio virus in the wastewater. A virus that is at least as resistant to disinfection as polio virus may be used for purposes of the demonstration.

2. The median concentration of total coliform bacteria measured in the disinfected effluent does not exceed an MPN of 2.2 per 100 ml 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 ml in more than one sample in any 30-day period. No sample shall exceed an MPN of 240 total coliform bacteria per 100 ml.

In addition, in order to use the recycled water for any of the listed irrigation purposes, there are specific requirements for both influent and effluent turbidity. Some type of filtration is therefore required, although RO can be substituted. The inlet to the filters is to be continuously monitored for turbidity in Nephelometeric Turbidity Units (NTU). Provisions must be made to activate chemical addition or divert the wastewater should the filter influent turbidity exceed 5 NTU for more than 15 minutes.

In addition, the recycled wastewater under Title 22 requirements, must also adhere to the following requirements:

- The wastewater effluent must be sampled at least once daily for total coliform bacteria.
- The disinfected tertiary recycled water must be continuously sampled for turbidity using a continuous turbidity meter and recorder following filtration.
- The producer or supplier must conduct the sampling required above.
- An Engineering Report must be filed prior to producing or supplying recycled water.
- "Qualified" personnel are required to operate the recycled water facility.
- A preventative maintenance program must be provided.
- Operating records must be maintained at the recycled water facility.
- Alarms must be installed to provide warnings of failures.
- Redundancy must be built into the design for additional treatment or storage capacity, while maintenance is being performed on equipment.

These requirements are quite stringent and are geared toward municipal wastewater treatment plants where full-time staff, operators, and major equipment already exist. Under the DHS regulations there is no mechanism for small communities to be able to apply for or receive waivers from these requirements.

Based upon the anticipated water volume and the local climate conditions, the planting to use the reclaimed water should be approximately 1.6 acres, including trees, shrubs, and grasses. Selected non-food crop trees that are provided as a windbreak should have a high chloride and TDS concentration tolerance.

Another option would be to use the recycled water for irrigation of the orchards, to the west of the proposed development. Recycled water used for irrigation of orchards, where the recycled water does not come into contact with the edible portion of the crop, can be undisinfected secondary recycled wastewater quality. The recycled water may need to meet certain TDS or salt limits to be permitted or accepted for this use. This could be a source of lower cost irrigation water for the orchard owner. Under this arrangement, the water would still need to be approved as Title 22 water, but the wastewater would only require oxidized biological treatment, and no disinfection or filtering.

An additional consideration in the use of recycled water for orchard crops is the tolerance of the crop to chlorides. The orchards adjacent to the property are planted with citrus, which are not considered a salt-sensitive crop.

4.2.2 Drip Irrigation

Another method of applying the recycled water to the land for irrigation is through a subsurface drip irrigation system. Systems that employ subsurface drip irrigation minimize the potential for public contact with the wastewater and therefore, may not require compliance with the full Title 22 requirements pursuant to DHS approval. This involves pumping the treated wastewater effluent into subsurface soils through a grid system of buried PVC piping and drip line tubing with uniformly spaced emitters. Water is slowly applied at each individual point, enabling the water to move laterally through capillary action and reduce percolation. The drip lines are usually spaced 24-inches apart throughout the application area. The system is usually installed 6- to 10-inches below grade, which maximizes the uptake of nutrients by planted grasses, trees, and vegetation. Systems also include return piping, in-line filters, air-vacuum breakers, pressure regulators, solenoid valves for zone control, and flush valves.

Manufactured systems employ specialty processes to emit herbicide that inhibits root growth right around the drip system. In addition, the drip lines are lined with a bactericide compound that inhibits biological growth. The system is designed to function at turbulent flow conditions to prevent plugging of the emitters. These drip irrigation systems can be installed in the indigenous soils and do not require backfilling with gravel or sands. It is recommended that the soils be ripped and disked prior to installation of the irrigation system.

A system designed for the Tract 5277 development would require approximately 63,250 square feet of land for effluent disposal. This could be accomplished within the proposed agricultural setback area that is approximately 126,000 square feet. Each area of application should be relatively level, so if the topography varies much the wastewater could be discharged into different zone areas. The standard pump controller is capable of controlling flow to four zones. The estimated probable cost for installation of a 63,250 square foot system would be $104,000.

The advantages of this type of effluent discharge system generally are:

- Use of indigenous soils, no excavation or backfilling is required.

- The wastewater is applied subsurface and minimizes the potential for human and animal contact, reducing the health risk and therefore possibly not requiring full compliance with Title 22.
- Disposal of water is maximized by means of evapotranspiration.
- The system minimizes deep percolation.
- Application requires a relatively small surface area compared to other alternatives.
- Consumption of nitrates by the plant material is increased.
- The system is non-intrusive, it allows use of the space while operating.

The main disadvantage generally is that there may be regulatory concerns over migration of TDS and salt compounds into the deeper groundwater table. Since no impermeable liner is employed in the drip irrigation system, the potential exists for migration of compounds that are not taken up by the planted vegetation. However, the groundwater table is approximately 800 feet below grade surface (bgs). In addition, the TDS, chlorides, and sodium compounds in the effluent are not expected to be high, due to the low TDS water supply. The irrigation beds should also be designed with a crown to dissipate any storm water and minimize the infiltration of the storm water. If it can be demonstrated that TDS and other salt compounds are not expected to migrate into the groundwater table, then the RWQCB may be able to permit the waste discharge. This will most likely involve negotiations with the RWQCB.

4.2.3 Evapotranspiration

Onsite evapotranspiration (ET) is a process designed to disperse wastewater effluent by direct evaporation of the water and by plant transpiration. The influent to the ET unit enters through a series of distribution pipes to a porous bed made of gravel and sand. In ET systems, a liner is placed below the bed to prevent water loss via infiltration unless the soil is impermeable. The surface of the sand bed is planted with salt-tolerant plants. Effluent is drawn up through fine media by capillary wicking and evaporated or transpired into the atmosphere.

Modifications to ET include mechanical evaporating devices and a broad array of different designs and means of distribution, storage of excess influent, wicking, and containment or infiltration prevention. Some newer studies are using drip irrigation with distribution to wooded areas.

ET systems are best suited for arid climates where evapotranspiration exceeds precipitation, and where normal leaching or spray irrigation is not practical. Based on weather station data from the Camarillo Central Coastal Valleys area, the annual average evapotranspiration equals 45.78 inches and precipitation averages 6.37 inches. Therefore, ET is feasible in this area. ET does however, require large surface areas for dispersal of the wastewater. The required surface area for this project is expected to range from 92,000 to 150,000 ft^2. The area contained in the designed agricultural setback area is approximately 126,000 ft^2.

The agricultural setback is designed to mitigate dust migration, and so is intended to be planted with eucalyptus trees and possibly other vegetation. Since this area is privately-owned and a designated landscape area, it may be classified as an area that does not have public access, and therefore may not be required to adhere to Title 22 pursuant to DHS approval. Alternatively, the agricultural area may be required to be fenced off to restrict public access. In addition, if a liner were placed beneath the ET bed, the RWQCB may allow higher TDS levels in the applied wastewater. The ET bed would need to be designed so that a buildup of TDS and/or salts is minimized by utilizing the maximum available land and/or soil conditioning methods.

An ET bed for the Tract 5277 development would involve excavating the bed, backfilling with gravel, sand, and topsoil. The estimated installed cost for the ET bed is approximately $865,000.

Appendix G

Kavanaugh, Michael C., Unregulated and Emerging Contaminants:
Technical and Institutional Challenges,
from Water Environment Federation, WEFTEC 2003

UNREGULATED AND EMERGING CHEMICAL CONTAMINANTS: TECHNICAL AND INSTITUTIONAL CHALLENGES

Michael C. Kavanaugh, Ph.D., P.E., DEE
Vice President and National Science and Technology Leader
Malcolm Pirnie, Inc.
2000 Powell St., Suite 1180
Emeryville, CA 94608

ABSTRACT

Unregulated and emerging chemical contaminants present numerous technical and institutional challenges to society and to environmental and public health professionals. Over the past four decades, ever increasingly sensitive analytical techniques have chronicled the emergence of specific chemical, microbial and radiological agents in actual or potential sources of drinking water. As our ability to detect these agents has increased, the number of contaminants regulated under various environmental statutes has also increased, and the universe of regulated agents has grown dramatically in the past 25 years. Despite these advances, many contaminants remain unregulated, and the universe of such regulated contaminants will only grow slowly over the next several decades. Thus, environmental engineers and other environmental professionals must make difficult risk management decisions regarding water resource and water supply management issues in the face of considerable regulatory uncertainty. Emerging chemical contaminants such as solvent stabilizers, methyl tertiary butyl ether (MTBE), N-nitrosodimethylamine (NDMA), perchlorate and pharmaceutical and personal care products illustrate many of the technical and institutional challenges. While technologies are available to produce any desired water quality, such technologies are expensive, and costs may not balance the estimated reduction in risk. Risk management decisions in the future will require more complex assessments of the vulnerability of a water supply source to unregulated contaminants, and an analysis of the appropriate combination of treatment processes in the context of water quality uncertainties to meet both current and future hazards arising due to these contaminants taking cost into consideration.

KEYWORDS

Unregulated chemical contaminants, emerging contaminants, indirect potable reuse, volatile organic chemicals, MTBE, NDMA, perchlorate, cyanide, contaminated groundwater, drinking water standards.

INTRODUCTION

Over the past several decades, environmental professionals and public health officials have faced many technical and institutional challenges to provide safe drinking water to the public and to protect the aquatic environment. One of the most significant drivers of these challenges has been the slow emergence of specific chemical, microbial and radiological agents whose presence has been revealed by ever increasingly sensitive analytical techniques. As our ability to detect these agents has increased, the number of contaminants regulated under various environmental statutes has also increased, and the universe of regulated agents has grown dramatically in the past 25 years. Despite these advances, many contaminants remain unregulated and possibly undetected. In particular, federal drinking water standards for individual chemicals or agents have not kept pace with the discoveries in water supply sources of new chemical and microbial threats to human health and the environment. The detections of unregulated chemicals and microbial agents in drinking water sources, including both surface and groundwater sources are posing new challenges to the environmental profession and both the regulated and regulatory communities. In this paper, I will explore how these challenges have been met in the past, how they are currently being addressed, and whether the current strategies for addressing issues surrounding unregulated chemical contaminants need to be reconsidered for the future.

ENVIRONMENTAL CONTEXT

Unregulated contaminants, also known as new or emerging contaminants, pose a serious impediment to achieving overall water resource goals of meeting the quantity and quality demands of the public, while complicating the balancing act between cost and reliability in the context of scarce public funds. These contaminants are drawn from the many thousands of chemicals currently in use, with an unknown number of these chemicals posing potential risks to human health and the environment. Generally, there is limited information on the fate, transport, occurrence, treatment and health and ecological effects of these contaminants. Increasing demands on water resources in the U.S. and around the world are much in evidence in the technical and not-technical press (e.g., see Gleick et al., 2001). In addition to well-documented limitations on water availability, water quality constraints due in part to the presence of unregulated and emerging contaminants, both known and unknown, may further exacerbate water quantity problems. For example, traditional safe yield analyses for groundwater basins rely primarily on a water balance methodology. The presence of unregulated contaminants at levels requiring costly treatment may further limit the "safe" yield from these basins, such as the San Gabriel or San Fernando groundwater basins in southern California.

Other trends that pose threats to meeting water resource goals include the continued discovery and production of chemicals for industrial, pharmaceutical, personal care, and agricultural use worldwide, and a growing unwillingness of the public to pay for increase in public services. With increasing sensitivity and scope of analytical techniques, information can now be obtained for chemicals present in water below a part per billion. Opening this analytical window into the parts per trillion zone further complicates a myriad of environmental management decisions including the design of treatment systems for drinking water, wastewater reuse for groundwater recharge, compliance with discharge standards set at levels near analytical detection limits, and establishing and achieving groundwater cleanups at contaminated sites. When combined with public perceptions and general fears of human health risks from exposure to chemicals (e.g., see Wall Street Journal, 2003) and the public mistrust of experts (Rampton and Stauber, 2002), these risk management decisions are becoming increasingly more difficult.

Unregulated chemical contaminants are thus increasing the challenges regarding problem characterization, prediction of future impacts on engineered systems, performance assessment and compliance monitoring. The overall cost impacts of dealing with these unregulated chemical contaminants are unknown. On a qualitative scale, sources of these contaminants are known, and include point and non-point discharges to surface waters, discharges from municipal and industrial wastewater treatment facilities, releases to the subsurface from leaking underground storage tanks, surface impoundments and landfills, concentrated animal feed operations (CAFOs), and ex-filtration from sewers, among others. Some fraction of all chemicals used for a variety of purposes will ultimately be found in both surface and groundwater sources that currently or potentially could serve as sources of drinking water. This fraction is likely to be quite small for most chemicals that are consumed during use (e.g., PCE in dry cleaning, fuel oxygenates such as methyl tertiary butyl ether [MTBE] added to gasoline, or pharmaceutical and personal care products) but because of the annual level of consumption, detection of these chemicals in water sources is inevitable in most cases. Nonetheless, an increasing share of the overall annual public and private expenditures for water resources management is likely to be devoted to addressing the myriad of challenges presented by these contaminants.

ALTERNATIVE STRATEGIES ADDRESSING EMERGING CONTAMINANTS

Regulatory Strategy

The problem of emerging and unregulated chemical contaminants is not new to the regulatory community responsible for assuring that safe drinking water is provided to consumers (see e.g., NRC, 1977). In general, and oversimplifying a very complex process, the overall federal strategy evolved from establishing a limited set of standards addressing microbial contaminants and certain inorganic contaminants such has heavy metals. With respect to organic contaminants, prior to 1970, alkyl benzene sulfonate (ABS), a detergent compound, was the only specific organic chemical regulated by the U.S. Public Health Service in treated drinking water at a level of 0.5 mg/L. In addition, a standard of 0.2 mg/L was established for a collective parameter, the carbon chloroform extract (CCE), presumed to measure the total concentration of organic contaminants in a sample that would adsorb on granular activated carbon (GAC). With the passage of the Safe Drinking Water Act (SDWA) in 1974, the federal government expanded the organic standards to include six pesticides and the U.S. Environmental Protection Agency (EPA), then responsible for standard setting, established Maximum Contaminant Levels (MCLs) for each of these compounds. By 1986, the number of organic compounds regulated in drinking water had risen to 10, four trihalomethanes, and six chlorinated volatile organic chemicals. The current (2002) federal drinking water standards designate primary standards (MCLs) for 53 additional organic compounds, and by 2003, up to five additional contaminants may be proposed for regulation. In the future, as specified in the 1996 Amendments to the SDWA, the U.S. EPA is required to regulate at least five new contaminants every five years. This act lead to the development of a Contaminant Candidate List (CCL) published in 1998, which included 50 chemical contaminants and 10 microbial agents. Overall, the time required for a new contaminant to be regulated and receive a MCL exceeds eight years.

Given the large number of potential chemical contaminants that could be present in water supply sources, the U.S. EPA faces continued challenges using the current regulatory strategy to keep pace with the detection of new contaminants and the potential for undetected contaminants to be present in drinking water sources.

Water and Wastewater Utilities

Water and wastewater utilities have also struggled with issues raised by new and emerging contaminants. As standards have been established, water utilities have expanded their monitoring systems, undertaken studies to determine the appropriate treatment or watershed management strategy to meet the new standards, and have supported research on analytical techniques, treatment options and other management strategies to meet the changing requirements established by both state regulatory agencies and the federal U.S. EPA (e.g., www.werf.org; www.awwarf.org). Best practices have evolved over time, and currently, utilities are required to submit reports to consumers on the water quality conditions in the water provided to customers, including data on all regulated contaminants, based on approved sampling frequencies. The expanding universe of unregulated chemical contaminants that have been detected in water sources continues to challenge utility management who must make decisions on how to ensure that delivered water is safe, even if the water quality currently meets federal and state drinking water standards. The threat of these unregulated chemicals must be evaluated and decisions made as to the level of treatment required to address current and future threats from emerging and unregulated contaminants. Wastewater utilities face similar problems in meeting new discharge standards for unregulated contaminants, and in managing pretreatment programs to limit the discharges of unregulated contaminants to the treatment facilities, particularly in those utilities currently supplying treated wastewater for a variety of non-potable uses, and for groundwater recharge resulting in planned indirect potable reuse.

Potentially Responsible Parties

Potentially responsible parties (PRPs) encompass all private and public entities designated as legally responsible for remediation of contaminated soil and groundwater. Various federal statutes, regulations and case law define who is a potentially responsible party depending upon the type of contaminated site in question. Since the passage of the Comprehensive Environmental Response and Liability Act (CERCLA) in 1980, and other statutes, thousands of sites with contaminated groundwater have undergone detailed studies to select and implement cleanup actions. The dominant technology used for groundwater cleanup is groundwater extraction followed by treatment and reuse or disposal of the treated groundwater (MacDonald and Kavanaugh, 1994; NRC, 1994). Cleanup standards are established on a case-by-case basis, for both the contaminated groundwater and for the treatment system. In most cases where the groundwater is considered a potential source of drinking water, the cleanup standards are based on drinking water standards (MCLs) established either by U.S. EPA or by the respective state, whichever is more stringent. Problems arise, however, when the chemicals of concern in the groundwater are unregulated contaminants. In these situations, risk assessment methodologies (NRC, 1983) are used to establish standards.

In a manner analogous to a water purveyor, PRPs must select a strategy for cleanup that, at a minimum, meets federal and state requirements, but which also must account for unregulated contaminants that have been detected at levels that may pose risks to human health and the environment. In addition, some water utilities relying on groundwater must determine if the continued use of the extracted and treated water is sufficiently safe for continued domestic production. Many contaminated aquifers in the southwestern U.S. are designated as sole source aquifers, and loss of this water resource due to contamination is generally not economically or politically acceptable (e.g., see EPA, 2003). The challenges in this setting are determining the drinking water standards for the regulated contaminants and determining the unregulated contaminants that should be considered as influencing any selected cleanup options.

In many cases, for remedies selected and implemented in the 1980's and early 1990's, the spectrum of contaminants evaluated may not have included new and emerging contaminants. For example, at the Stringfellow Superfund Site in Southern California, a former disposal site for liquid industrial and hazardous wastes, extensive analytical tests failed to detect high levels of perchlorate, which has only recently (in the last three years) been detected. The perchlorate plume emanating from the site is nearly twice as long as the trichlorethylene (TCE) plume identified in the 1980's emanating from the site. Failure to detect MTBE at many leaking underground fuel tanks is an analogous example of missing a chemical that, at the time, was not regulated at the state or federal level.

Consulting Engineers

New, emerging and unregulated contaminants present serious technical challenges for consulting engineers advising private and public sector clients on the selection, design and operation of engineered systems. Historically, consulting engineers operating in a competitive environment provide advice to clients that is strongly influenced by the clients' desire to minimize costs, while fully protecting human health and the environment. In a drinking water context, goals for providing a safe drinking water to consumers with a high degree of reliability may conflict a goal of maintaining an acceptable cost of services, which would increase due to the costs of advanced treatment technologies such as the use of granular activated carbon or membrane technologies for removal of unregulated chemical contaminants. In this context, the responsibility for addressing known but unregulated compounds and potential future contaminants is unclear. This conundrum occurs also in the design of treatment systems for contaminated groundwater. In such cases, the groundwater basin is clearly vulnerable to chemical contamination from a variety of sources. To what extent should the consultant be responsible for addressing the impacts of unregulated contaminants on the performance of the proposed engineered system? The universe of unregulated chemical contaminants thus becomes a major uncertainty that must be accounted in providing design recommendations for these systems, and must be part of a new level of risk analysis to be provided to the owner.

TECHNICAL CHALLENGES – CASE STUDIES

With the evolution of analytical techniques that permitted characterization of a wide array of primarily organic chemical contaminants in water, the environmental profession has been required to address the technical challenges posed by the discovery of these chemical contaminants in surface waters, discharged wastewaters and groundwater. Each new contaminant or groups of contaminants tells a different story but with some common elements. In 1974, the discovery of byproducts formed during free chlorine disinfection of drinking water dramatically changed the engineering approach to the design and operation of drinking water treatment facilities. Nearly 30 years later, drinking water engineers and scientists continue to be challenged to meet expanding and increasingly stringent standards for disinfection byproducts. New and lower standards have recently been established for total trihalomethanes and for haloacetic acid compounds. Meeting these lower standards will likely result in major changes to treatment strategies. A similar sequence of events has occurred over the past three decades as discoveries of other new chemical contaminants have challenged environmental professionals. A few examples serve to illustrate the past, current and potential future technical challenges posed by these unregulated and emerging chemical contaminants.

Control of VOCs

Volatile organic chemicals (VOCs) were first identified as significant threats to groundwater supplies with the advent of gas chromatography, and occurrence data developed by various monitoring programs conducted by regulatory agencies, the U.S. EPA, and other federal and state agencies. By 1977, six of these VOCs, namely, trichloroethylene (TCE), perchloroethylene (PCE), 1,1,1-trichloroethane (TCA), carbon tetrachloride, 1,2-dichloroethane and vinyl chloride were considered a sufficient threat to water quality to warrant regulation, and MCLs were proposed. U.S. EPA and other organizations undertook the necessary research to demonstrate that established treatment technologies, namely adsorption on granular activated carbon (GAC) and air stripping in packed towers (PTA), could remove these chemicals to levels well below the proposed MCLs which ranged from 2 µg/L for vinyl chloride to 200 µg/L for TCA. All of these VOCs happen to be chlorinated solvents, which were first used in large quantities by industry since the late 1930's with increasing volume of use corresponding to the major shifts in economic and industrial expansion since the 1950's. Two of these chemicals, TCE and PCE have the highest incidence of occurrence in groundwater at Superfund sites, which currently number over 1,400 sites in the U.S. These chemicals have also been widely reported in surface and groundwater sources (e.g., see Squillace et al., 2002) and in municipal wastewaters both before and after physical and biological treatment, and they are likely present in all municipal wastewater effluents at levels ranging from below current detection limits of tens of parts per billion to 0.1 mg/L.

Despite much progress and knowledge regarding the treatment of these early "emerging" contaminants, there are still major unresolved technical issues associated with engineered systems removing these chemicals from drinking water. Many utilities do not consider MCLs sufficiently protective, and choose to establish treated water standards below the current MCLs. This, in fact, may be an appropriate strategy as new toxicological data are developed that may indicate that current standards are not sufficiently protective of human health. Currently, for example, the U.S. EPA has completed a new toxicological study of TCE (www.epa.gov), indicating that the current standard may be too high by a factor of five. If this proves correct, the MCL for TCE could be reduced to 1 ppb. This controversy is unresolved at this writing. Another unresolved issue is the risk of mixtures of these compounds. Other technical challenges include whether the frequency of sampling for these VOCs in the treated water is sufficient to demonstrate continued compliance with the standards, and whether the presence of these chemicals in the water source indicate a vulnerability of the system to as yet undiscovered and unregulated contaminants.

Recent experiences in the San Fernando Valley in California (EPA, 2003) and other locations in the southwestern U.S. suggest that unexpected contaminants will occur in such vulnerable basins more often than not. The City of Burbank, CA, installed packed tower air stripping followed by GAC columns to remove TCE and PCE to levels well below the current standards. Recently, a new contaminant, 1,2,3-trichloropropane was discovered in the groundwater, causing excessive costs for operation of the GAC system. This required major modifications to the drinking water treatment system. Whether other chemicals may impact the system in the future is a continued cause for concern. One such unregulated contaminant is 1,4-dioxane, a chemical added to TCA to stabilize this chlorinated solvent. Unfortunately, this chemical is not sufficiently volatile or easily adsorbable, and alternative treatment technologies, such as advanced oxidation processes (AOP), will be required to meet expected treated water standards. Currently, 1,4-dioxane has been included in the 1998 CCL, but federal regulatory standards may not be available for several years.

In summary, the six VOCs regulated by the U.S. EPA in the 1970's generated a significant applied research effort, and engineered systems were developed that cost-effectively and reliably provided drinking water exceeding all MCLs permitting continued use of the contaminated groundwater source. Despite these engineering successes, technical challenges remain because of the unintended consequences of improper industrial disposal practices in the past. It should be noted that almost 40 years passed from the initial production and use of these chemicals until they were regulated at the federal level.

Fuel Oxygenates

A more recent example of the technical challenges presented by emerging contaminants is the case of methyl tertiary butyl ether (MTBE), a chemical widely used as an additive in gasoline to increase octane ratings and, since 1990, to meet gasoline specifications for oxygen content in air basins with air quality out of compliance with the requirements specified in the Clean Air Act Amendments (CAAA) passed by Congress in 1990. MTBE was initially added to gasoline at levels of less than 2 percent by volume, but beginning in 1990, levels were increased up to 15 percent by volume to meet the Clean Air Act oxygenate requirements.

In contrast to the long lag time between occurrence and regulation observed for VOCs, MTBE was relatively quickly considered a major threat to water supplies. MTBE was detected in groundwater supplies in the early 1980's, and both GAC and air stripping technologies were employed to remove the chemical, with some success. MTBE has a very low taste and odor threshold (Stocking et al., 1999), and thus could be detected by consumers when present in the treated water. MTBE also has physical and chemical characteristics (low volatility, hydrophilic organic compound with low octanol-water partition coefficient) that result in relatively rapid movement with groundwater (i.e., very little retardation in the subsurface). Finally, MTBE is relatively recalcitrant to biodegradation under either aerobic or anaerobic conditions.

However, the primary event that signaled major concerns over MTBE was the discovery of significant levels of the contaminant in the water supply of the City of Santa Monica, CA. Levels rose quickly in the mid 1990's requiring shutdown of the treatment system, and replacement of water with surface supplies at a significant cost increase. MTBE is more difficult to remove from water compared to VOCs, and as a result, alternative technologies are being evaluated. In the case of Santa Monica, nearly eight years after the discovery of significant contamination, the parties have not yet agreed on an acceptable combination of technologies to provide the City with drinking water meeting desired standards. Although the U.S. EPA has still not regulated MTBE, the chemical is included on the 1998 CCL, and the State of California has established both a secondary and primary standard for MTBE (5 μ/L [ppb] and 13 μ/L [ppb], respectively). Because of the lack of a federal standard, drinking water standards vary dramatically throughout the U.S., ranging from the low levels established in California to over 200 ppb in Wyoming, New Mexico and a few other states. The lack of a federal standard poses a significant challenge to water purveyors and regulators in some states to determine an appropriate standard for groundwater treatment, groundwater remediation and wastewater discharges to POTWs or to surface waters. Defaulting to the lowest standard in any of the 50 states may or may not be the prudent approach.

Further unresolved technical issues associated with MTBE include a continued debate over the most appropriate technologies for water and wastewater treatment, the unresolved issue of the rate of biodegradation under aerobic or anaerobic conditions, selection of the most cost-effective remediation technologies, and developing effective strategies for treating tertiary butyl alcohol (TBA), a microbial breakdown product of MTBE, and an impurity in MTBE-blended fuels. TBA is also a fuel oxygenate, and occurs concurrently at most leaking underground fuel storage sites where MTBE containing gasoline has been released to the subsurface. Removal of TBA, another unregulated chemical contaminant, poses difficult treatment challenges because it is neither volatile nor adsorbable. Presence of this compound in the groundwater at the City of Santa Monica is one of the reasons why no agreement has yet been reached on an acceptable treatment process.

MTBE illustrates many of the technical challenges caused by emerging chemical contaminants. Because of the rapid and widespread impact of this chemical on water supplies, regulators were required to impose standards with a limited amount of information on the toxicology of the chemical and treatment options. The relatively slow development of a federal standard results in highly variable standards in different state jurisdictions. In the early stages of the discovery of this chemical in water supplies, the perception was that MTBE could not be treated, and this resulted in a high degree of public anxiety about MTBE, and major political efforts to ban the use of the chemical, a decision that, in fact, has now been made by a number of states over the past two years. Traditional technologies including GAC and PAT are capable of removing MTBE to acceptable levels (Deeb et al., 2001; NWRI, 2000) but uncertainties persist over long term performance of these technologies, and their effectiveness for the treatment of TBA, an unregulated co-contaminant associated with MTBE. The release of TBA has also resulted in widespread litigation between impacted parties and the users and producers of MTBE.

N-nitrosodimethylamine (NDMA)

In 1994, Canadian researchers, using highly sensitive analytical techniques, were able to detect the chemical N-nitrosodimethylamine (NDMA) in drinking water in Canada in 1994 at part per trillion (ppt) levels (OMEE, 1994). The health implications of this finding were unknown. More recently, NDMA has been identified in chlorinated wastewater effluents from biological systems and as a co-contaminant in groundwater with perchlorate, a chemical now widely found in water sources in areas where rocket fuel and explosive materials are produced or used. NDMA is now reasonably anticipated to be a human carcinogen, according to the National Toxicology Program. Reported levels are as high as several hundred parts per trillion. NDMA is also found in a variety of foods and beverages, included smoked food products, beer and whiskeys. EPA regulates NDMA under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), the Clean Water Act (CWA) and the Resources Conservation and Recovery Act (RCRA). However, NDMA has not yet been regulated at the federal level in drinking water, but the California EPA has established an action level (AL) of 10 ppt. While ALs are not enforceable standards, they provide a basis for design of engineered systems, and 10 ppt has been used as a de facto MCL in California where treated water is used for drinking purposes or where treated wastewater is recharged into groundwater.

NDMA is one of the more recent emerging contaminants and research is currently ongoing regarding the mechanisms of formation (Mitch and Sedlak, 2002; Choi and Valentine, 2002), the fate of NDMA in treatment plants, and the efficacy of treatment options (see WateReuse, 2003). This emerging contaminant is both an industrial chemical and also a chemical generated during wastewater and water treatment, in the presence of chloramines and/or chlorinated nitrogen species. Various precursors have been identified in wastewater that appear to control the magnitude of NDMA formation under various chlorination conditions (Gerecke and Sedlak, 2002), but at this time, it appears that post chlorination treatment using UV technologies will be required to reduce NDMA below the AL of 10 ppt. Removal of NDMA by membrane technologies is less effective than UV (WateReuse, 2003).

In summary, NDMA illustrates the full spectrum of technical challenges of unregulated contaminants. For many years, this contaminant was present in chlorinated wastewater effluents, but remained undetected because of lack of sufficiently sensitive analytical techniques. Once discovered, the potential effects on human health and ecosystems were largely unknown. Because of the presence of this chemical in foods, the relative overall threat to human health from long-term exposure to very low levels of NDMA in drinking water is uncertain. The fact that NDMA appears to be formed during chloramination of water (Choi and Valentine, 2002) raises concerns over the growing use of chloramination by water utilities to meet more stringent disinfection byproduct drinking water standards. NDMA is not removed from water by most physical, chemical and microbial processes, but research has shown that UV technologies can achieve required standards. Finally, the fate of this chemical in chlorinated secondary effluents after discharge to soil systems is uncertain, and currently a research focus of a research project funded in part by the WateReuse Foundation (2003).

Perchlorate

Perchlorate (ClO_4^-) is a highly oxidized form of chlorine that is used as an oxidizer in rocket fuel, and is also found in explosives, fireworks, highway flares and other devices requiring release of energetic materials. Prior to 1997, because of high detection limits (approximately 400 ppb), detections of perchlorate in ground or surface waters were limited to sites where substantial releases had occurred (e.g., San Gabriel Basin in southern California and certain sites in Nevada where rocket fuel was produced). In 1997, new analytical techniques lowered the detection limit to 4 ppb, and the widespread occurrence of perchlorate in drinking water sources was revealed. According to K. Mayer of the U.S. EPA, Region 9, recent monitoring data in a number of states indicates that perchlorate is a widespread chemical contaminant, occurring in groundwater and surface waters at an alarming rate. Further detections are likely as more groundwater systems are monitored. For example, as of late 2002 in California, perchlorate has been detected in 239 groundwater sources out of over 3500 tested, with levels exceeding 18 ppb in 49 wells (Mayer, 2002). Toxicological studies indicate that perchlorate affects the thyroid system, and California and other states have established action levels at 4 ppb. There are some indications that the California AL may be reduced to 1 ppb in the future. Perchlorate is not regulated federally, but is included on the 1998 CCL, and may be regulated at the federal level within the next few years. Concerns over widespread contamination of water resources by perchlorate are growing as the number of existing or potential sources of drinking water containing detectable levels of perchlorate grows. Recent revelations that perchlorate occurs in agricultural products subjected to irrigation of waters containing low levels (< 10 ppb) of perchlorate have further raised anxiety over the chronic effects of this contaminant.

Perchlorate also presents major treatment challenges. Currently, two technologies, ion exchange and anaerobic reduction, have been demonstrated to remove perchlorate to levels below the California action level of 4 ppb. However, both of these technologies present technical uncertainties. In the case of ion exchange, process reliability and operational concerns, including the ultimate disposal of regeneration waste streams containing high levels of perchlorate, may limit more extensive use of this technology. Anaerobic reduction processes, using fluidized bed bioreactors with ethanol as the feedstock, have been demonstrated to achieve low levels of perchlorate reliably without the production of waste streams requiring disposal. The California Department of Health Services has approved this technology for use in potable water treatment systems (Sakaji, 2002; Harding Lawson, 2001). However, water utilities appear to be reluctant to use this technology for water treatment due to long standing concerns over the use of engineered microbial processes in drinking water treatment.

Perchlorate also illustrates the technical challenges of emerging contaminants at groundwater cleanup sites. Prior to 1997, remedial systems installed at groundwater sites where perchlorate contamination was possible did not include technologies capable of perchlorate removal. As mentioned, the Stringfellow site is a current example of this problem. As a consequence, an unknown number of sites may require additional characterization, and modifications to existing remedial action systems to address this undetected contaminant, thus substantially increasing the costs of these systems, and causing major uncertainties in allocation of responsibilities for these costs.

Pharmaceuticals, Personal Care Products and Hormones

Pharmaceuticals and personal care products (PPCPs), hormones and their respective metabolites and transformation byproducts collectively represent a very large and growing number of individual chemical contaminants that have the potential to impact drinking water sources. Likely sources of these chemicals to the water environment include municipal wastewater discharges, releases from concentrated animal feeding operations (CAFOs), illegal discharges from illicit drug laboratories, on-site waste treatment systems (septic systems) and industrial waste discharges from legal manufacturing facilities. With the advent of analytical techniques within the last five years that can detect these chemicals at the sub parts per billion level, this threat to water supplies has been quantified, to some degree. Recent reviews (e.g., Daughton and Ternes, 1999; Drewes and Shore, 2001; Verstraeten et al., 2002) have summarized the fate, transport and occurrence data for a substantial number of highly used PPCPs, with much of the data obtained from European studies on these chemicals in wastewater effluents and in the aquatic environment. The U.S. Geological Survey recently published the results of the first nationwide reconnaissance of the occurrence of these and other wastewater organic contaminants, surveying the concentrations of 95 chemicals in 139 streams in 30 states within the U.S. (Kolpin et al., 2002). These data confirm that PPCPs, hormones and other chemicals used to stimulate physiological responses in humans, plants and animals are widespread in the aquatic environment at sub ppb levels, with uncertain chronic impacts on humans and ecosystems.

At first glance, the risks to human health of exposure to sub part per billion levels of these compounds in drinking water would appear remote. For example, the nonprescription drug, ibuprofen, the active ingredient in many over the counter drugs for the common cold, flu and pain reduction, was detected in 9.5 percent of the 84 samples collected in the USGS survey at a median value of 0.2 μg/L (ppb). Each tablet of Advil contains 200 mg of this ingredient. Assuming consumption of 2 liters of water per day per person, an individual would receive a dose of ibuprofen after 500 days of exposure via drinking water equivalent to the dose in one Advil tablet. Such comparisons could be made for all pharmaceuticals, but whether the conclusions would be the same is highly chemical specific. There may be instances where the total exposure to humans of PPCPs and other organic chemicals via drinking water exposure exceeds some prescribed risk level, such as a one in a million excess cancer risk. The technical challenge will be to demonstrate that this risk is credible and that risk management will be required or prudent for any proposed reuse plan or use of a surface water source heavily impacted by wastewater discharges.

The presence of these compounds in wastewaters and receiving waters poses additional technical challenges to environmental professionals. Clearly, we need to know more about the fate of these chemicals in wastewater treatment systems, and in the environment to allow for rational decisions on the need for and type of engineered systems to limit exposure to humans and the environment. Recent work by several research groups have demonstrated that many of these compounds can be removed from water by nanofiltration or reverse osmosis membranes (Drewes et al., 2002). The extent to which wastewaters should be subjected to membrane treatment, however, remains a site-specific decision regarding the ultimate use of the treated wastewater. Given the obvious health benefits from the use of pharmaceuticals, in general, it is difficult to see these compounds being banned from commercial use, as is the case for MTBE, where several states have already banned the use of this oxygenate, and the federal government is currently considering such a ban nationwide. Thus, we can expect increasing levels of PPCPs and hormones in treated wastewaters, and in groundwaters subject to direct or indirect recharge from treated wastewaters. Judgment will be required to determine whether engineered systems are necessary to limit releases of these chemicals to the environment.

Indirect Potable Reuse

In 1963, John D. Parkhurst of the Los Angeles Sanitation District proposed a major reuse project to meet the growing water quantity demands of the Los Angeles Basin. (Parkhurst, 1963). This document became a blueprint for numerous wastewater reuse projects involving percolation of wastewater into groundwater basins following secondary or biological treatment. At the time, very little information was available on the organic contents of such waste streams, beyond an understanding of the total organic levels based on Chemical or Biochemical Oxygen Demand (COD or BOD) measurements. It was presumed that the benefits from water reclamation and indirect potable reuse outweighed the uncertainties regarding the removal of trace organic chemicals by percolation through the vadose zone, and subsequent fate in the aquifer. With the construction of Water Factory 21, incorporating a larger number of treatment processes, including GAC and reverse osmosis membranes, the fate of many organic chemicals of potential health concerns in treatment systems was better understood (Reinhard et al., 1986). Nonetheless, despite significant investment in research (e.g., see CaSWRCB, 1980) and monitoring programs, uncertainties on the fate of some organic and inorganic contaminants in the subsurface persists, and a full accounting of all potential chemicals is lacking. Whether this represents a threat to human health is therefore uncertain, and resolution of the degree of risk being posed by such indirect reuse projects remains illusive. The emergence of NDMA in chlorinated wastewater effluents illustrates the continuing problem. NDMA is poorly removed from wastewater by RO membranes, and thus, the presumption that additional treatment trains as applied at Water Factory 21 would resolve issues surrounding trace organics or other undetected chemicals is not valid for all potential contaminants.

Groundwater recharge with treated wastewater is perhaps the best-known example of planned indirect potable reuse. Unplanned indirect reuse is, however, much more widespread, and issues related to use of surface or groundwater sources impacted by wastewater discharges are still highly controversial, as discussed in a National Research Council study, addressing water supply issues caused by potable reuse, either direct or indirect (NRC, 1998). Based on this report, and other early studies on indirect reuse, there have not been any recent nationwide assessments of the number of consumers who are provided drinking water from surface or groundwater sources that are significantly impacted by waste discharges. In 1980, a U.S. EPA funded study (Swayne, 1980) indicated that approximately 15 million people in the U.S. were served potable water from a surface water source containing more that 10 percent treated wastewater. Other studies indicate similar levels of potential exposure via indirect potable reuse of wastewaters (EPA, 1979; NRC, 1998), and some streams in the U.S. and other parts of the world used as sources of drinking water consist of 100 percent treated wastewater during some portion of the year under drought hydrologic conditions.

In a study of indirect potable reuse funded by the Army Corps of Engineers in the early 1980s, a 1 million gallon per day (MGD) treatment facility was operated for three years, to test the hypothesis that the quality of the treated water from the facility could meet or exceed the quality of water provided from three water utilities in the Washington D.C. area. The water treated in this facility, known as the Potomac Estuary Experimental Water Treatment Plant (PEEWTP), consisted of a 50:50 mixture of water from the Potomac river and secondary effluent from the nitrification plant at the Blue Plains Wastewater Treatment Plant, in Washington D.C. Over 400,000 sample results were amassed, and the plant influent and effluent streams were tested for a wide range of known organic chemicals, numerous microbial contaminants including viruses and Giardia, and two toxicological tests. The water quality produced by the water treatment plant, consisting of conventional drinking water treatment but incorporating GAC following filtration, was shown to be superior to the water quality in the three local area drinking water plants. All systems produced a water whose quality met the federal primary and secondary MCLs, but the water from the PEEWTP consistently showed lower levels of trihalomethanes, total organic carbon (TOC), total organic halogens (TOX), and levels of other trace organics. (James M. Montgomery, 1983). A subsequent National Academy of Sciences review of the 1983 report confirmed these results, but concluded that because only a small percentage of the TOC and TOX had been identified (less than 1 percent and less than 10 percent, respectively), the Corps funded study did not confirm that the water was of a potable quality.

In essence, the NAS concluded that uncertainties still exceeded the potential benefits of using this water for potable use. The question posed at the time has remained unanswered, i.e., at what point does a surface water source become unacceptable as a drinking water source assuming conventional treatment systems (coagulation/filtration/disinfection)? And when does such a source require the application of GAC or other more advanced treatment processes for removal of the known or unidentified chemicals of concern?

Compliance Issues using Cyanide as example

One of the significant technical challenges raised by unregulated and emerging contaminants is meeting compliance requirements for drinking water, wastewater discharge, groundwater recharge, and discharge of treated waters from groundwater remediation systems using pump-and-treat technologies. In all these cases of engineered systems, regulators impose criteria or standards developed through various regulatory programs. In many cases, these standards are established at a level near or at the current analytical detection limits. Furthermore, in the case of some contaminants that may be present in various chemical forms, the standards may be established based on the total amount of the chemical of concern rather than the most toxic or dangerous specie of the chemical group.

An example of this challenge is cyanide in wastewater discharges from POTWs or industrial facilities. A recent study conducted by Malcolm Pirnie for the Water Environment Research Foundation (WERF, 2003), with extensive collaboration from two university research groups (Carnegie Mellon and Clarkson), 14 wastewater utilities nationwide, and two industry groups addressed the many complexities associated with water quality management of cyanide in effluents. Traditionally, cyanide standards for wastewater discharges to or from wastewater treatment plants such as POTWs are based on the total cyanide analysis. In the San Francisco

Bay Area, cyanide standards have been established for some municipal dischargers at 5 ppb total cyanide levels, the approximate current detection limit for the total cyanide analysis. In a number of case studies at Bay Area POTWs, it has been difficult to determine if exceedances of these low standards has been due to analytical artifacts, or to trace level formation of cyanide during wastewater chlorination, or to cyanide generation within the treatment system, e.g., during treatment of incineration off-gases. Under the current California toxics rule, failure to meet discharge requirements can result in substantial fines of up to $3,000 per day of non-compliance. Thus, false positives can have serious financial consequences for utilities. As noted in the WERF study, and summarized recently (Deeb et al., 2003) strategies to meet these very stringent cyanide standards include 1) careful assessment of potential analytical artifacts, 2) thorough evaluation of industrial discharges to the POTWs, 3) moving the point of compliance to post-dechlorination, 4) obtaining a site specific variance to the cyanide standard based on analytical speciation of the cyanide and/or showing that higher standards would not have unacceptable impacts on the test species of choice. Similar issues are faced by industrial dischargers of small quantity wastewaters that are not subject to permit, except for the fact that the total cyanide levels may exceed pretreatment standards. Resolution of this conflict is on a case-by-case basis, and development of appropriate cyanide analytical techniques that can identify the cyanide species can provide a rational basis for these regulatory decisions.

INSTITUTIONAL CHALLENGES

Unregulated and emerging contaminants present difficult institutional issues, many of which are currently being adjudicated in one forum or another. One of the more challenging questions is whether the consumer is adequately protected from exposure to these contaminants if the drinking water supplied by community and non-community water systems meets all state and federal drinking water standards, given that these standards regulate a limited, but substantial, number of contaminants that could be present in water.

This institutional challenge is being addressed in part by the U.S. EPA who is required to increase the number of regulated contaminants on a schedule prescribed by the 1996 amendments to the Safe Drinking Water Act. Section 1412 specifies the process that must be followed to increase the number of these contaminants for which a MCL should be established. The U.S. EPA has requested assistance from the National Research Council to advise the agency on the optimum process for determining which of the many chemicals that are potentially present in the aquatic environment need to be regulated under the SDWA. The NRC has provided this guidance (NRC, 1999a, 1999b, 2001), suggesting a process to be used by the Agency in establishing the next CCL, due sometime in 2003, and future CCLs that will be established every five years. Despite this intense level of effort, the number of contaminants likely to regulated over the next two decades will not exceed ten contaminants, leaving many chemical contaminants unregulated, despite increased documentation of occurrence, e.g., pharmaceuticals and personal care products, endocrine disruptors and other organics of wastewater origin (Koplin et al., 2002).

There is no question that this institutional task is large, and complex. The reported number of chemicals in the world registered by the Chemical Abstracts Service exceeds 20 million but of these, only about 3,000 are produced at levels exceeding 10,000 pounds per year (EPA, 2002). Nonetheless, EPA considers the potential list of chemical contaminants to exceed 227,000 (CHEMLIST, 2002). One could question whether this effort will succeed in answering those voices who claim that the standard setting approach is fundamentally flawed, that there can be no guarantee that drinking water is safe if the water quality meets the current standards and thus, the standards setting approach should be replaced with a technology based regulatory system (e.g., Sullivan et al., 2002).

The issue of the safety of drinking water also raises a series of unresolved institutional conflicts on allocation of responsibility for alleged impacts on human health. The question recently addressed through the court system was whether a water utility can be held liable for alleged damages if the water supplied to consumers meets all appropriate drinking water standards established by public health agencies at the state level. In the Hartwell decision in California, the Superior Court ruled that customers of utilities regulated by the Public Utility Commission are bared from filing personal injury suites if the water quality meets all California Department of Health Services standards. (Hartwell, 2002). The Court also ruled that the current standards are adequate for protection of the public health, but left unresolved any liability associated with exposure to unregulated or emerging contaminants. Thus, the issue remains uncertain, and the burden of risk management remains with the regulated utilities.

Other institutional challenges include 1) liabilities for past exposures to unregulated contaminants if the water met all appropriate standards, 2) cost allocation between responsible parties where groundwater cleanup standards are imposed that exceed MCLs for regulated contaminants, i.e., who pays for costs to exceed standards, if requested by the stakeholder entities, and 3) whether modifications to federal regulations for permitting use of chemicals are needed to minimize the risks for human health exposure via drinking water ingestion.

STRATEGIES FOR THE FUTURE

When viewed with hindsight over the past 40 years or so, the environmental profession has responded appropriately to the technical and institutional challenges of emerging contaminants. As our analytical tools have improved in sensitivity, and as data on the human toxicological and ecotoxicological have been developed, both the regulated and the regulatory communities have developed the necessary data and technologies to ensure that new drinking water and waste discharge requirements could be meet in a cost effective manner. Methods to control disinfection byproducts from drinking water disinfection, various VOCs found primarily in groundwater, and other synthetic organic chemicals and various inorganic chemicals have been developed and employed. I am unaware of any epidemiological studies since 1974 that suggest that drinking water is a significant cause of various cancers, if the water delivered meets all current primary drinking water standards. A major epidemiological study in southern California found that risks to human health from use of groundwater impacted by recharge of treated wastewater was below limits of detection for the study methodologies (Nellor et al., 1985; Sloss et al., 1996, 1999).

Nonetheless, data from more recent environmental surveys, and the consequences of the discovery of the wide spread occurrence in drinking water sources of emerging contaminants mentioned in this paper (MTBE, TBA, NDMA, perchlorate, PPCPs), suggest that reliance on a standard setting approach alone to ensure the safety of the drinking water supply will not be adequate to the task. Many state agencies have already reached this conclusion, having developed various strategies or policies to protect human health in those cases where a potential water supply source is "severely" impacted. The California DHS policy on permit applications for producing potable water from such an extremely impaired source (Spath, 1997) is an example of an approach to ensuring that human exposure to unregulated and regulated contaminants is minimized. Included in this policy are various major requirements for assessing the potential for occurrence of unregulated contaminants and for assessing the impacts on human health should the drinking water treatment systems fail.

These types of vulnerability assessments, failure analyses, and overall risk analyses must become an integral part of water system planning in the future where the water source is vulnerable to impacts from unregulated contaminants. The consultant's job has become more challenging, because costs of excessively conservative designs can be substantial, particularly for smaller water supply systems. The technical and institutional challenges of these emerging and unregulated contaminants will require a much greater degree of interaction between all specialties within the environmental profession to ensure the optimum allocation of financial resources to meet current and future water supply needs without exposing consumers to unacceptable health risks.

ACKNOWLEDGEMENTS

I wish to acknowledge a number of individuals who have been instrumental in my involvement with emerging contaminant issues over the past 30 years and have provided encouragement and support at various times during my career. Without extensive discussion on when and how these individuals have assisted me, they include my former associates at Montgomery Watson, R. Rhodes Trussell now of Trussell Technologies, Inc., and Larry Leong now of Kennedy/Jenks Consultants; Paul Roberts, Jim Leckie, Dick Luthy, Martin Reinhard and Perry McCarty of Stanford University, Jim Morgan of Cal Tech, Dave Jenkins, Jim Hunt, Lisa Alvarez-Cohen and Dave Sedlak of UC Berkeley, Walter Giger, Marcus Boller and Willi Gujer of the EAWAG, Switzerland, Dave Dzombak of Carnegie Mellon, John Crittenden of Michigan Technology University, Bill Ball of Johns Hopkins University, Jerry Gilbert of Gilbert Associates, Herb Ward of Rice University, Andy Stocking of Care2.Com, and Rula Deeb, Neven Kresic and Doug Owen of Malcolm Pirnie, Inc..

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Appendix H

McDonald, S., McGovern, P., The Removal of Selected Endocrine Disrupting Compounds Through Conventional and Advanced Wastewater Treatment Processes, from Water Environment Federation, WEFTEC 2003

THE REMOVAL OF SELECTED ENDOCRINE DISRUPTING COMPOUNDS THROUGH CONVENTIONAL AND ADVANCED WASTWATER TREATMENT PROCESSES

Steve McDonald, Patricia McGovern, Carollo Engineers, P.C., Walnut Creek, CA

INTRODUCTION

A number of studies have confirmed the presence of Endocrine Disrupting Chemicals (EDCs) in wastewater in sufficient quantity to cause hormonal changes in aquatic life. EDCs are compounds that can block, mimic, stimulate, or inhibit the production of natural hormones, disrupting the body's natural endocrine system, which controls our reproduction, growth, and development, from functioning properly. EDCs are common in the environment because they are used in every aspect of our society. They can be found in pharmaceuticals, personal care products, industrial by-products, plastics, and pesticides. They are also commonly found in wastewater effluents.

Research on the treatment of EDCs in wastewater is just beginning. Several issues must be resolved for any conclusive decisions to be made in the wastewater industry. First, many chemicals have not been evaluated as to their as endocrine disrupting potential. Second, valid laboratory analysis methods do not exist to quantify the endocrine disrupting levels of most chemicals, even those that have been identified as EDCs. Finally, even if all endocrine disruptors are quantified, threshold values have yet to be determined for most chemicals.

Nevertheless, detection and quantification methods for a number of EDCs have recently been developed. As a result, studies have come forward providing insight on the treatability of some known EDCs. This paper provides an overview of EDCs and presents a summary of the findings from a number of studies regarding the treatability of known or suspected EDCs through conventional and advanced wastewater treatment processes

KEYWORDS

Endocrine disruptor chemicals (EDCs), emerging pollutants of concern, pharmaceutically active compounds, xenobiotics, organic wastewater contaminants (OWCs), hormones, endocrine system, estrogen.

TREATABILITY OF KNOWN AND SUSPECTED EDCs

Overall, much more research is needed to get a better understanding of how EDCs would be removed in conventional treatment facilities. Although parent compounds (i.e. alkylphenol polyethoxylates) may be eliminated through existing conventional treatment controls, breakdown products (i.e. nonlyphenol and octylphenol) with greater endocrine disrupting potential may result. Additionally, there are so many different types of compounds, each with their own characteristics that it is difficult to generalize on the removal of EDCs as a whole.

Some broad generalizations came be made that characterize groups of compounds and suggest possible treatment methods that would specifically target their removals in conventional and advanced treatment plants. Hormones may be strongly retarded in soil aquifer systems due to the high organic matter present. In contrast, it is likely that little hormone removal would occur in effluent dominated waters, where particulate organic matter concentrations are much lower. Treatment processes that use phase partitioning will probably not be very effective in removal of microcontaminants in effluents. Microfiltration and nanofiltration remove colloids and particles, forms in which these constituents rarely occur.

Research suggests that biotransformation is probably the most important removal mechanism in engineered ecosystems (i.e. engineered wetlands and soil aquifer treatment systems). Reactive compounds may be transformed more due to long residence times and high biological activity that offer increased opportunities for biotransformation. Current research suggests that removals in activated sludge treatment plants results in removals due to sorption onto organic matter-rich sludge particles.

A summary of the removal efficiencies reported for some estrogens is presented in Table 1.

Table 1. Reported Removals of Estrogens in Various Wastewater Treatment Facilities

Country of Study - Process	**Estrone**	**17-beta Estradiol**	**Ethinylestradiol**
Brazil - Trickling Filter *(1)*	67 %	92 %	64 %
Brazil - Activated Sludge *(1)*	83 %	99.9 %	78 %
Germany - Activated Sludge *(1)*	0 %	64 %	0 %
Italy - Activated Sludge *(2)*	85 %	87 %	61 %
Italy/Denmark - Activated Sludge *(3)*	74 %	88 %	No Data

References/Notes:

(1) samples taken over a 6 day period (Ternes, T. A.; Stumpf, M.; Mueller, J.; Haberer, K.; Wilken, R. D.; Servos, M. *Sci. Total Environ.* **1999**, 225, 81)

(2) 6 treatment plants, 30 samples total over five month period (Baronti, C.; Curini, R.; D'Ascenzo, G.; Di Corcia, A.; Gentili, A.; Samperi, R. *Environ. Sci. Technol.* **2000**, 34, 5059)

(3) 5 treatment plants sampled (Johnson, A. C.; Belfroid, A.; Di Corcia, A. *Sci. Total Environ.* **2000**, 256, 163)

In the Brazilian study, it appears that the activated sludge treatment is more effective than the trickling filter system. At the German plant, Ternes *et al.* suggest that the low removal efficiencies might be temperature related (20°C in Brazil versus -2°C in Germany during sampling) *(16)*. However, preliminary tests by Johnson et al. suggest that temperature does not correlate to varying removal efficiencies (*9*). A similar study was conducted Cargouet *et al.* in France at four wastewater treatment plants. This study found a reduction of estrone, 17-beta estradiol, estriol, and ethynylestradiol ranging from 50% to 80%, and an overall decrease in estrogenic activity in the effluent ranging from 60% to 90%. (*26*)

Mulroy et al. studied the removal efficiencies through various filtration processes of three antibiotic drugs, Penicillin, Tetracycline, and Vancomycin. River water samples from the Ohio River and tributary sites were leached into three testing columns. The results of the study are presented in Table 2.

Table 2. Reported Removals of Antibiotic Drugs in the Ohio River

Column	Filter Media	Percent Reductions (1)
Column A	Sand	No removals
Column B	sand and brewer's yeast	17%, 20%, 33%
Column C	sand and activated charcoal	77%, 96%, 93%

Notes: (1) Penicillin, Tetracycline, and Vancomycin, respectively.
Reference: *(11)*

A laboratory study in Switzerland found that conventional ozone treatment was effective in removing common pharmaceuticals, including ethynylestradiol, from drinking water. The EPA's National Risk Management Research Laboratory (NRMRL) conducted a literature review (*20*) to evaluate the applicability of granulated activated carbon (GAC) to the removal of EDCs from drinking water. NRMRL recommended GAC as best available technology for the removal of DDT, DDE, endosulfan, nonylphenol, diethyl phthalate, diethylhexyl phthalate, and two types of PCBs (*20*).

Overall, much more research is needed to get a better understanding of how endocrine disruptors would be removed in conventional treatment facilities. Although parent compounds (i.e. alkylphenol polyethoxylates) may be eliminated through existing conventional treatment controls, breakdown products (i.e. nonylphenol and octylphenol) with greater endocrine disrupting potential may result. For example, in one study by Hu et al., the estrogenic potential of an aqueous solution containing bisphenol A was found to increase by 24 times after exposure to 60 minutes of chlorination.

Sedlak et al. characterizes groups of compounds and suggests possible treatment methods that would specifically target their removals in conventional treatment plants. He suggests that significant removals in activated sludge treatment plants could result due to sorption onto organic matter-rich sludge particles. He further postulates that hormones should be strongly retarded in soil aquifer systems due to the high organic matter present. In contrast, it is likely that little hormone removal would occur in effluent dominated waters, where particulate organic matter concentrations are much lower *(15)*.

Sedlak et al. further suggests that treatment processes that use phase partitioning will probably not be very effective in removal of microcontaminants in effluents. Microfiltration and nanofiltration remove colloids and particles, forms in which these constituents rarely occur. Regarding disinfection or advanced oxidation, he states that further research would need to be conducted to determine if extended contact times for UV disinfection might transform microcontaminants of concern, other than the most photo-reactive species currently targeted.

Finally, Sedlak et al. state that biotransformation is probably the most important removal mechanism in engineered ecosystems (i.e. engineered wetlands and soil aquifer treatment systems). Reactive compounds may be transformed more due to long residence times and high biological activity that offer increased opportunities for biotransformation *(15)*.

POTENTIAL IMPACT ON WASTEWATER FACILITIES PLANNING AND DESIGN

An important aspect for the wastewater industry will be a bioassay screening test that will determine the endocrine-disrupting potency of treated wastewater effluent. A test of this sort will assess the cumulative effects of endocrine disrupting compounds found in wastewaters without having to quantify unknown chemicals individually. Several major universities in the United States are looking into developing and refining this test.

The possibility of new regulations governing the discharge of endocrine disruptor compounds must be considered within a typical 10 to 20 year planning horizon for new wastewater facilities. In fact, many of the 'suspect' compounds also appear in the US EPA National Toxics Rule, and in state regulations governing discharges of toxic substances. Therefore, additional source control measures and/or treatment to reduce many of these compounds in the environment will probably be implemented sooner than regulations related specifically to endocrine disruptors. Therefore, it is clear that endocrine disrupting chemicals will have real impacts on the planning and design of wastewater treatment facilities in the coming years.

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Appendix I

Wong, J.M., A Survey of Advanced Technologies and Their Applications in Water Reuse Projects, from Water Environment Federation, WEFTEC 2003

A Survey of Advanced Membrane Technologies and Their Applications in Water Reuse Projects

Joseph M. Wong, P.E., DEE
Black & Veatch
Concord, California

WEFTEC 2003
Los Angeles, California
October 11-15, 2003

Water Reuse Trends Throughout the World

- Becoming More and More Popular
- Incentives for Water Reuse
    - Water Shortage
    - Stringent Discharge Requirements
    - Economics
    - Government Requirements
    - Resource Conservation
- Advances in Treatment Technologies Especially Membranes

Forms of Municipal and Industrial Water Reuse

- Tertiary Effluent for Use in Irrigation
- Tertiary Effluent for Use as Cooling Tower Makeup
- Groundwater Recharge or Indirect Potable Reuse
- In-Plant Recycling According to Quality Requirements
- Reuse of Highly-Treated Industrial Effluent for Process and Boiler Makeup

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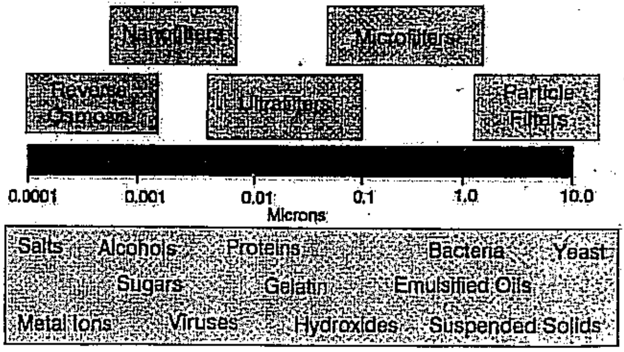
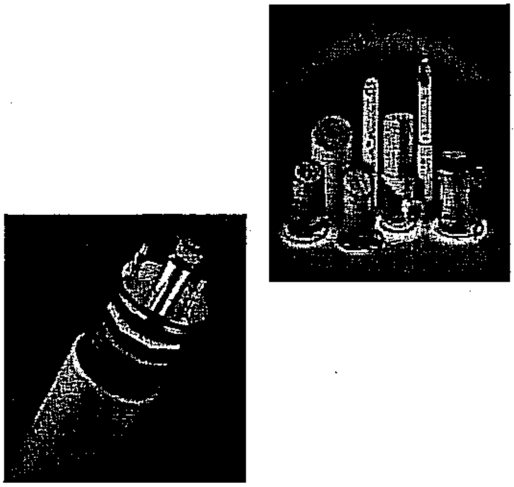
Filtration Spectrum



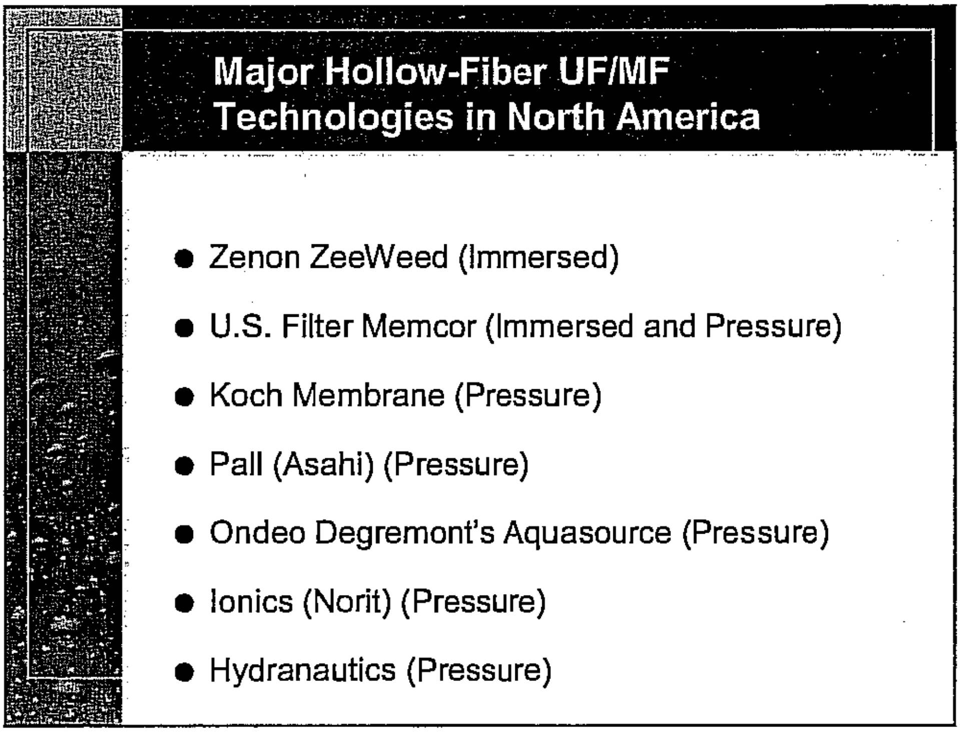
Microfiltration/Ultrafiltration Configurations

- Tubular
- Hollow-Fiber
- Spiral Wound
- Disk



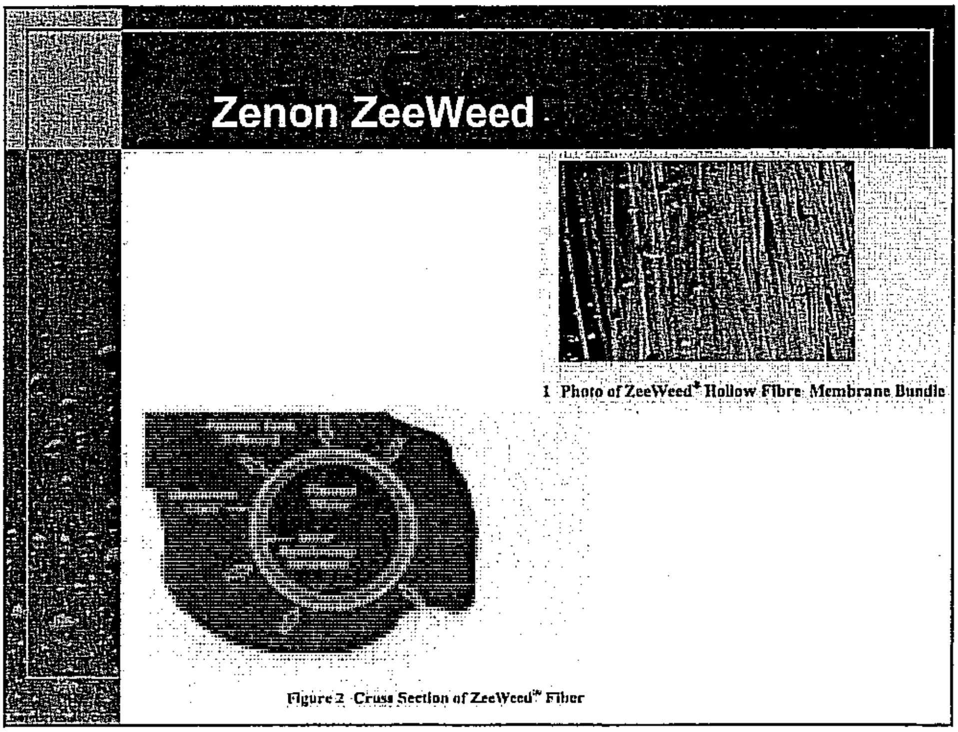
Hollow-Fiber MF/UF Membranes

- Most Popular In Water Treatment/Wastewater Reuse
- Frequent Backwash Capability
- Membrane Materials Resistant to Chlorine Attack
- Cost Reduction with Larger Modules



Major Hollow-Fiber UF/MF Technologies in North America

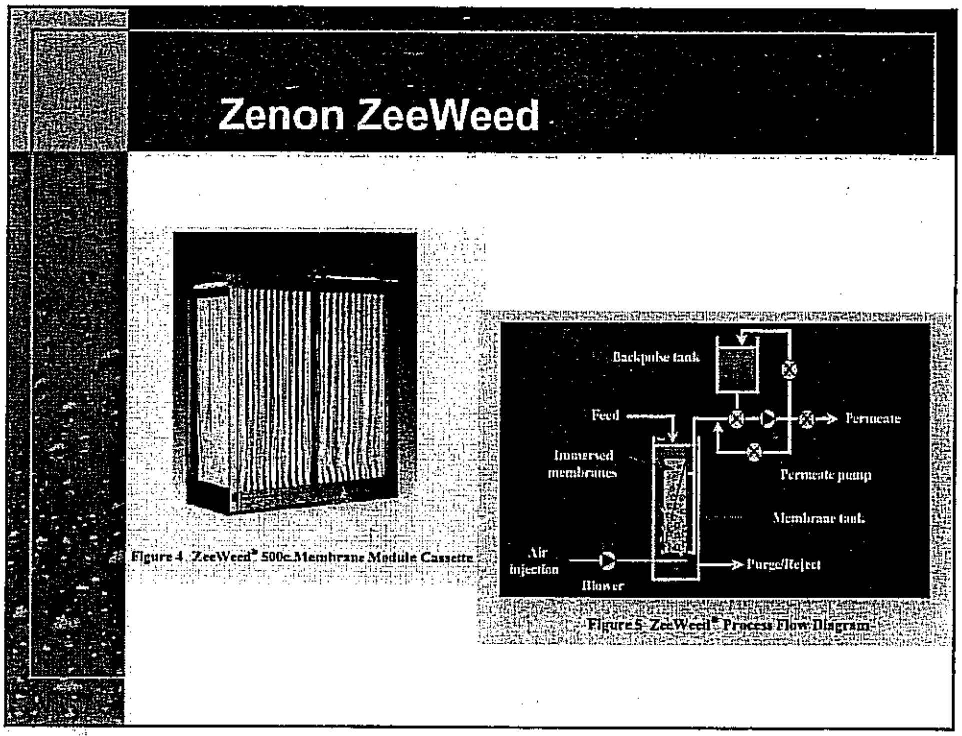
- Zenon ZeeWeed (Immersed)
- U.S. Filter Memcor (Immersed and Pressure)
- Koch Membrane (Pressure)
- Pall (Asahi) (Pressure)
- Ondeo Degremont's Aquasource (Pressure)
- Ionics (Norit) (Pressure)
- Hydranautics (Pressure)



Zenon ZeeWeed

1 Photo of ZeeWeed* Hollow Fibre Membrane Bundle

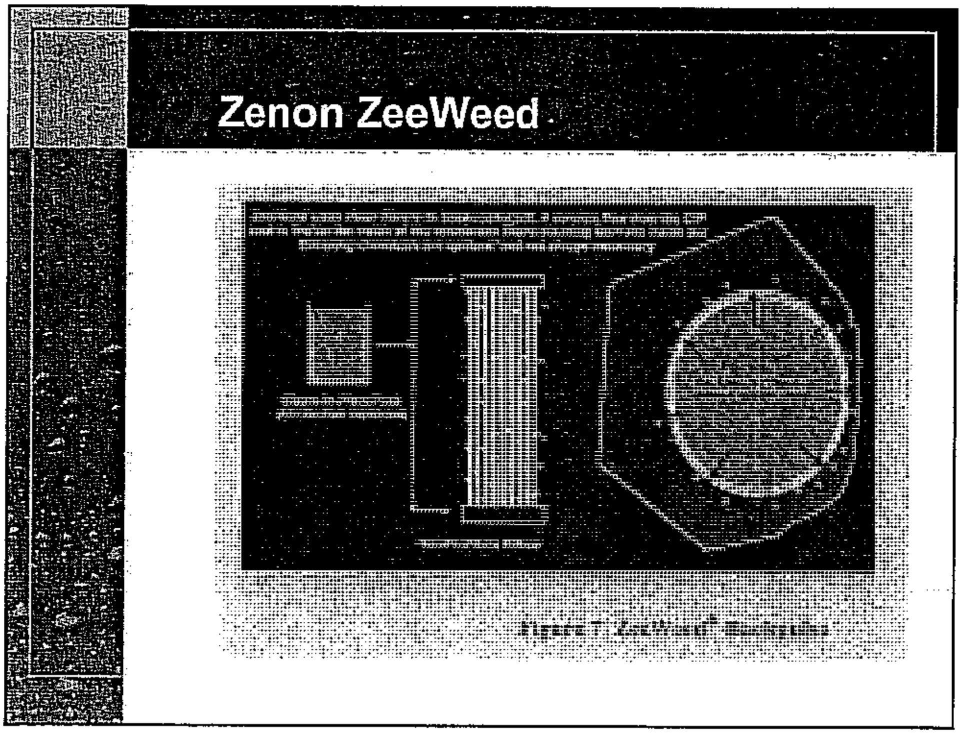
Figure 2 Cross Section of ZeeWeed* Fiber



Zenon ZeeWeed

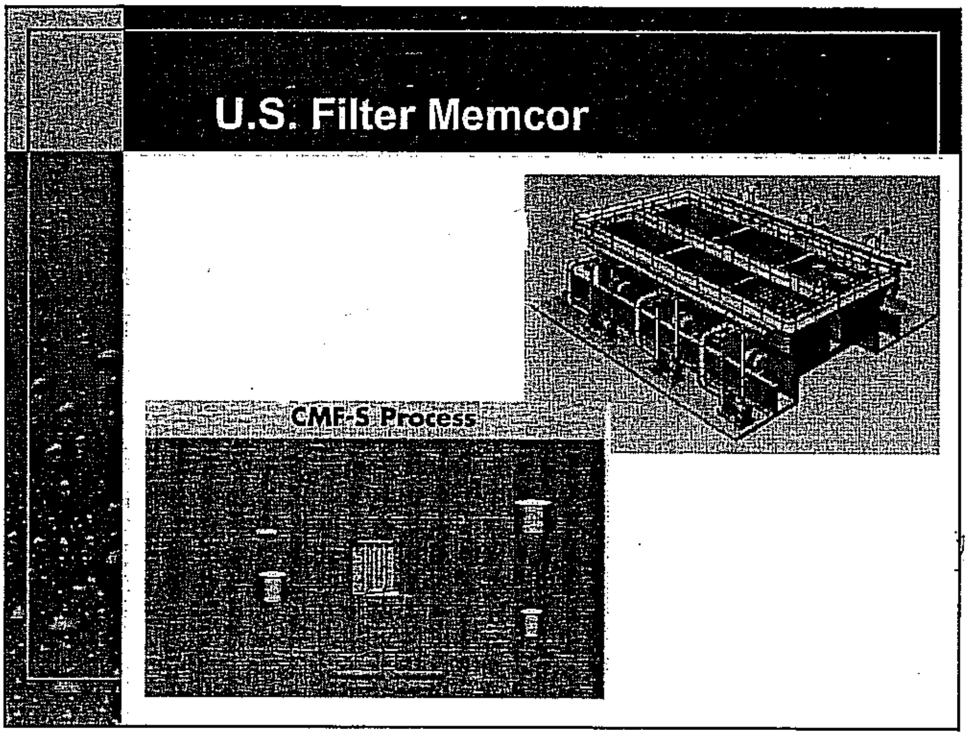
Figure 4. ZeeWeed® 500c Membrane Module Cassette

Figure 5. ZeeWeed® Process Flow Diagram



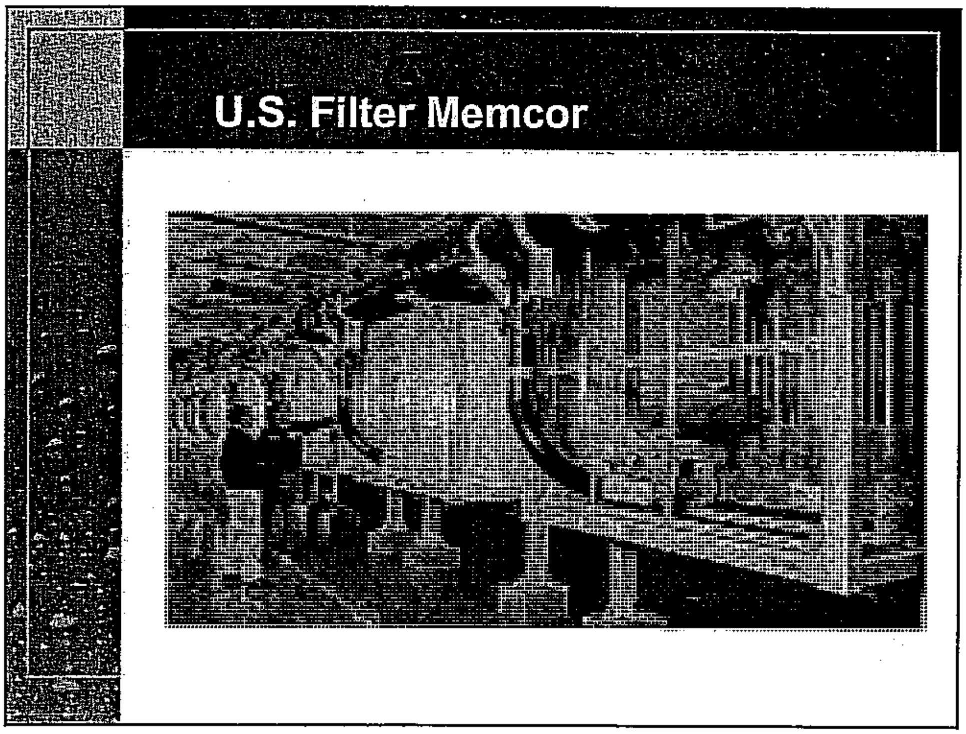
Zenon ZeeWeed

Figure 7. ZeeWeed® Backpulse

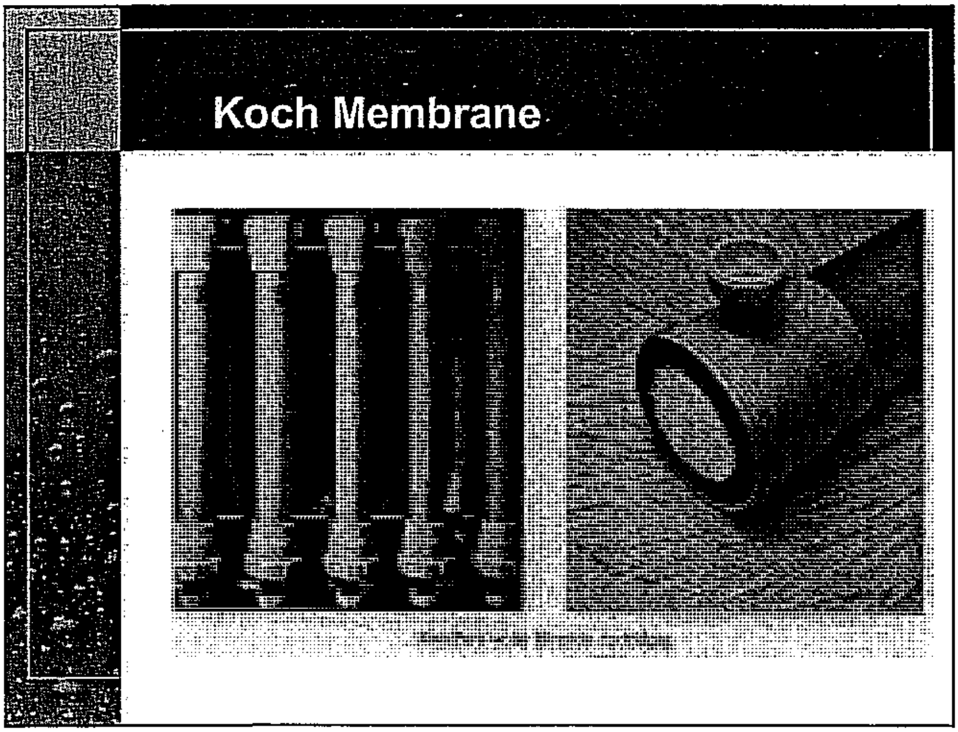


U.S. Filter Memcor

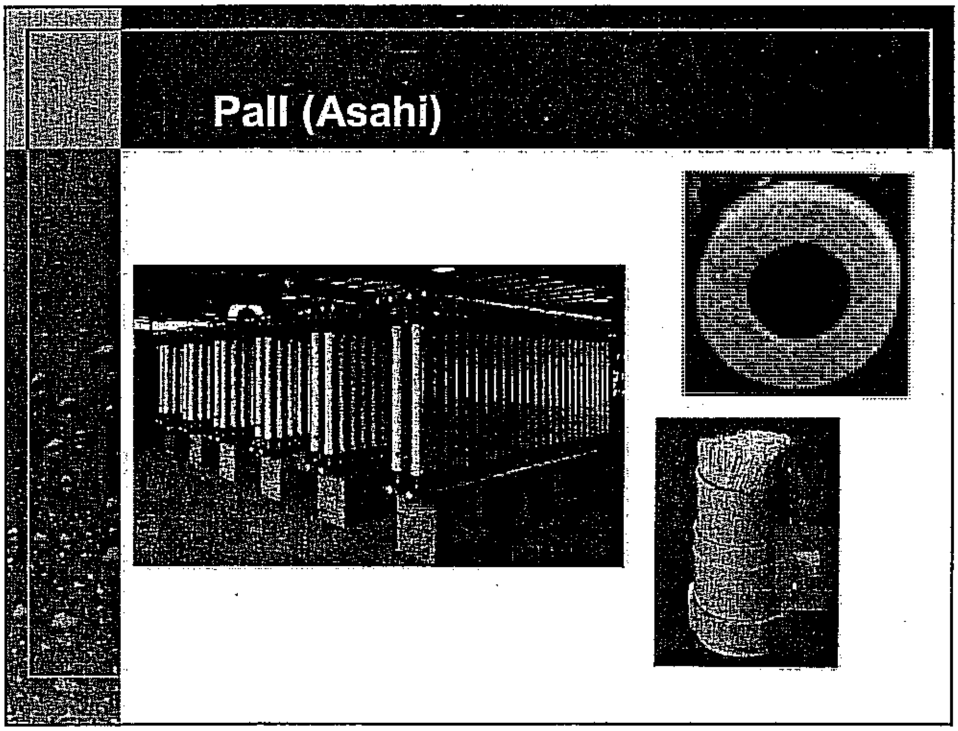
CMF-S Process



U.S. Filter Memcor

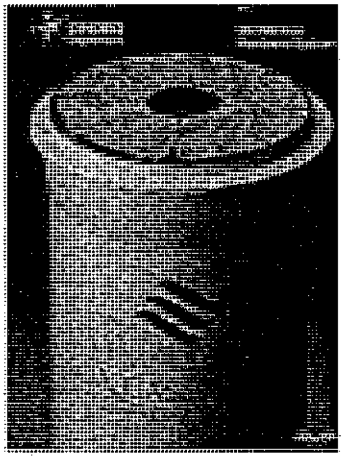


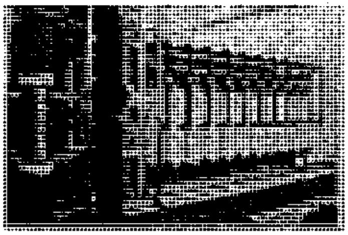
Koch Membrane



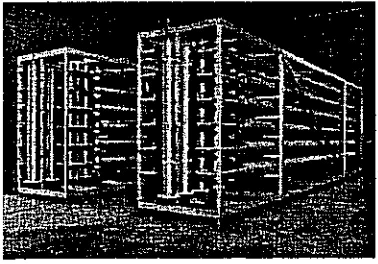
Pall (Asahi)

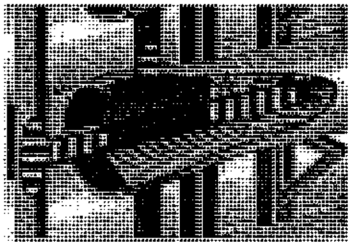
Ondeo Degremont's Aquasource



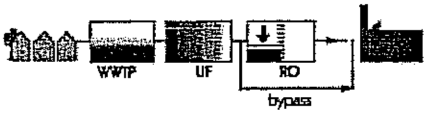


Ionics (Norit)



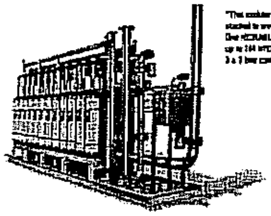


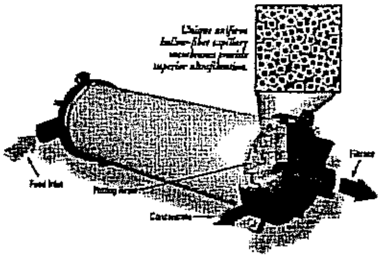
Municipal waste water effluent recycling



Hydranautics HYDRAcap

HYDRAcap 60 24-module configuration*

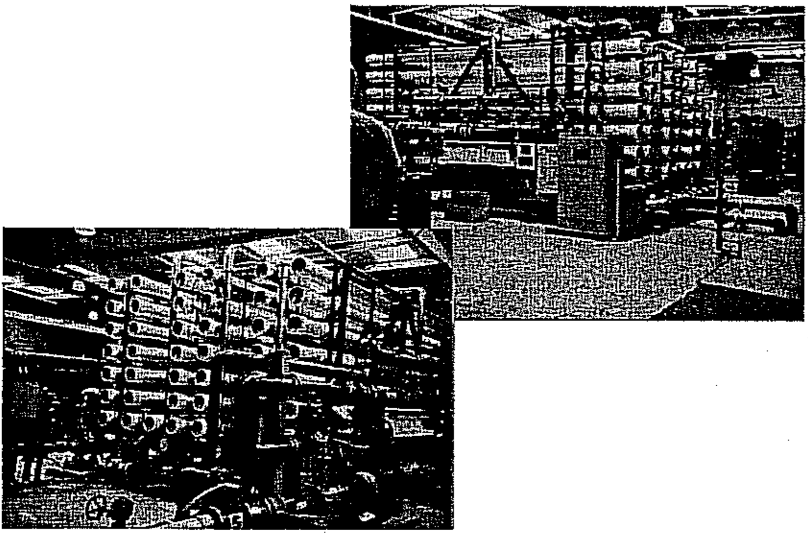




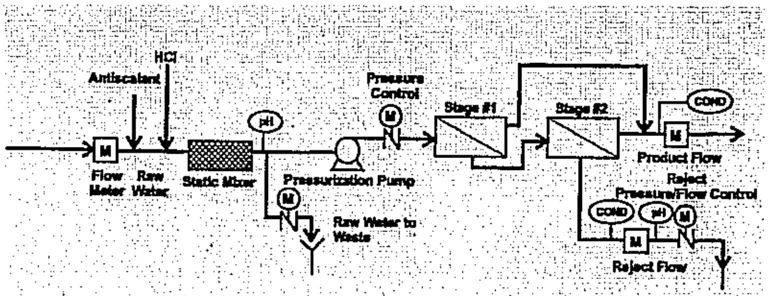
Summary of Major Hollow-Fiber MF/UF Technologies

Technology Vendor/	MF or UF	Pressure or Submerged	Membrane Material	Pore Size or MWCO	Backwash Procedures	Flow Pattern
Zenon ZeeWeed®	UF	Submerged	Proprietary	0.03 µm	Air/water	Outside-In
U.S.Filter Memcor	MF	Pressure/ Submerged	PPL and PVDF	0.2 µm	Air/water	Outside-In
Pall (Asahi) Microza	MF/UF	Pressure	PVDF/PAN	0.2 µm/ 13,000 or 80,000	Air/water	Outside-In
Ondeo Degremont Aquasource	UF	Pressure	Cellulose Acetate	0.01 µm	Water only	Inside-Out
Koch Romicon®	UF	Pressure	Polysulfone	10,000 to 100,000	Water only	Inside-Out
Ionics (Norit) XIGA™	UF	Pressure	PVP/PES	0.03 µm	Water only	Inside-Out
Hydranautics HYDRAcap	UF	Pressure	PES	100,000 to 150,000	Water only	Inside-Out

RO/NF Pictures



RO/NF Process Flow Diagram

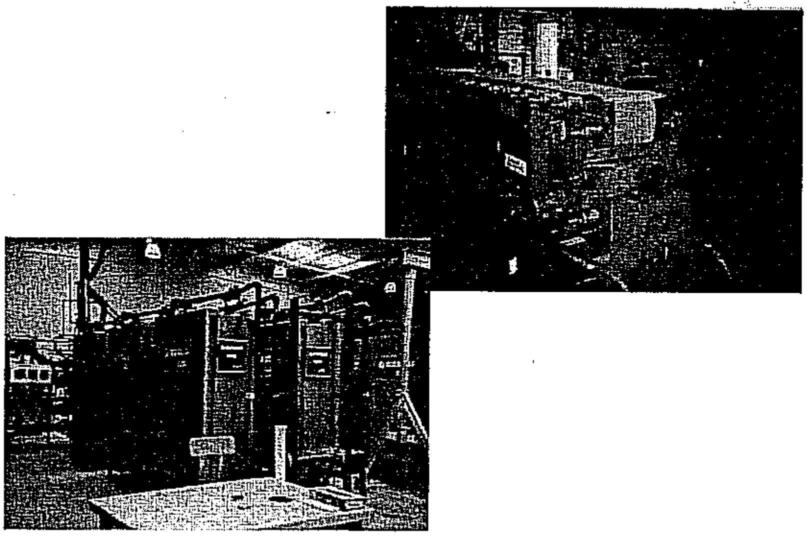


RO and NF Membrane System

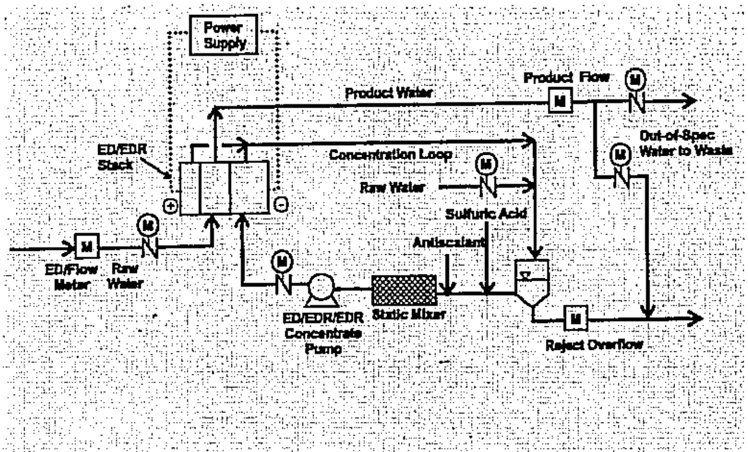
RO/NF Advances

- Use of Polyamide Membrane in Reuse with MF/UF as Pretreatment
  - Lower Pressure and O&M Cost
  - Higher Permeate Quality
- Ultra-low Pressure RO Membranes <100 psig
  - e.g. Dow FILMTECXLE-440, Hydranautics ESPA4
- Low Fouling or Fouling Resistant RO Membranes
  - e.g. Hydranautics LFC-1, LFC-3, Dow BW30-4040FR
- Larger Diameter to 10-Inch Module (Koch)
- NF is Similar to Low Pressure RO
- Pall Rochem Disc Tube RO (High Pressure)

ED/EDR Pictures



ED/EDR Process Flow Diagram

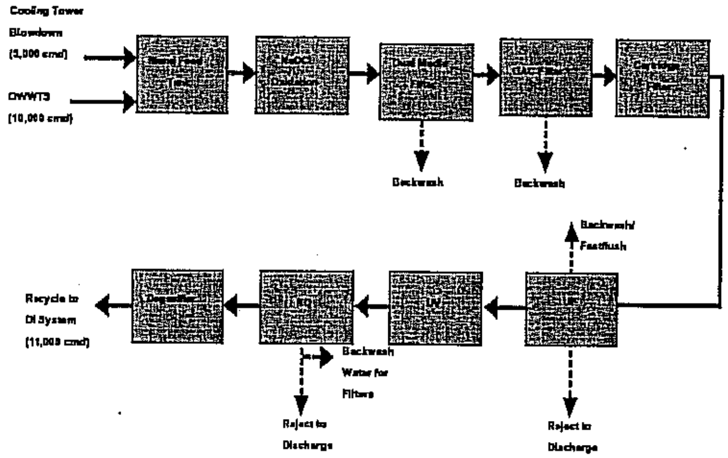


ED/EDR Membrane System

Case Histories of Wastewater Reclamation Using Integrated Membranes

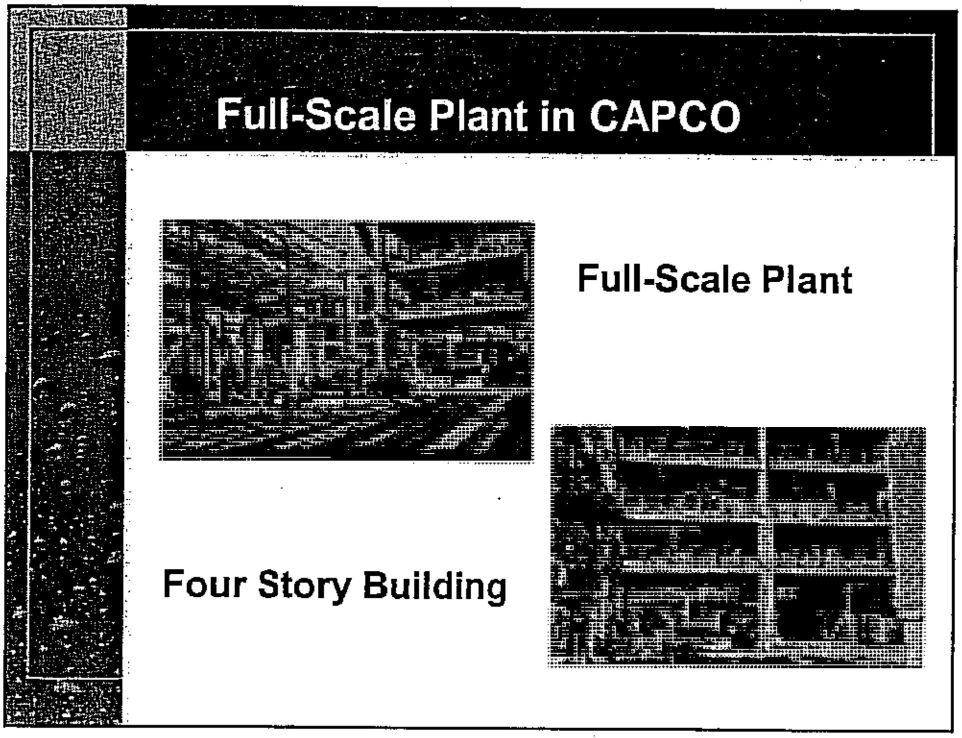
- CAPCO Petrochemical Plant (UF/RO)
- Scottsdale Water Campus (MF/RO)
- PEMEX Refinery Wastewater Reclamation (UF/RO)
- Chandler Groundwater Recharge (MF/RO)
- Los Medanos Power Plant Effluent Reuse (UF/RO)

CAPCO WW Reclamation Block Flow Diagram



CAPCP PTA Plant Wastewater Recovery Project

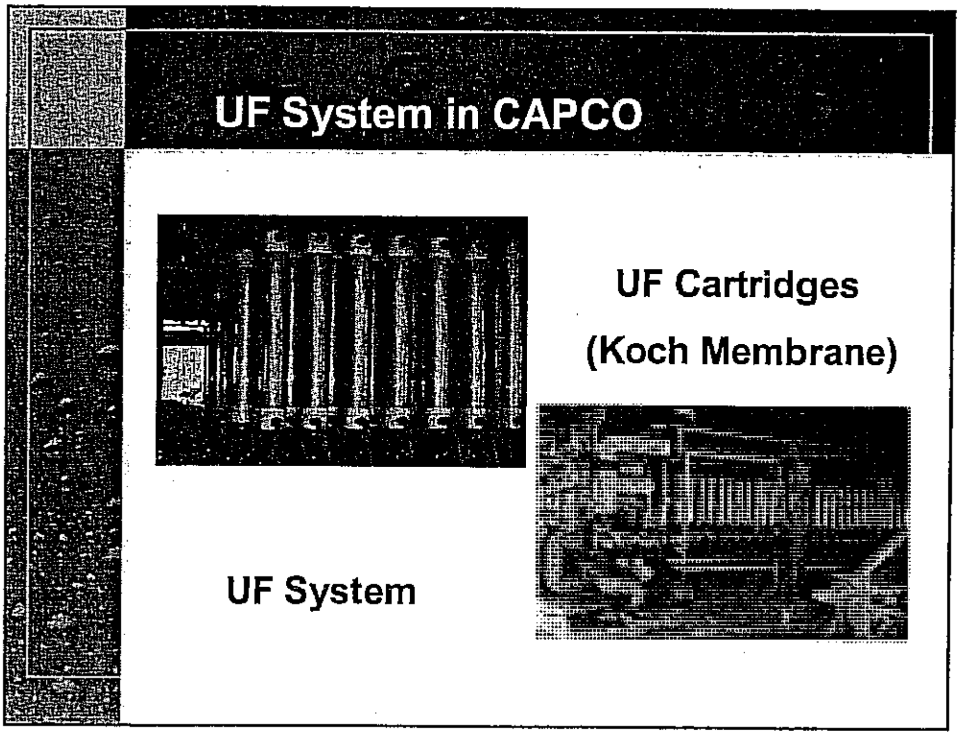
- Design Flow Rate of 9,000 CMD at 74% Recovery
- Combination of OWWTS Effluent and Cooling Tower Blowdown
- Recycled Water Conductivity <200 uS/cm
- Reuse As Feed Water For Existing DI System
- Successful Operation for >2 Years



Full-Scale Plant in CAPCO

Full-Scale Plant

Four Story Building

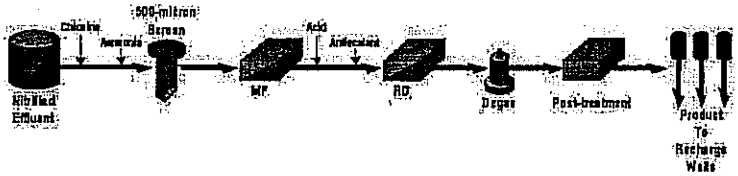


UF System in CAPCO

UF Cartridges
(Koch Membrane)

UF System

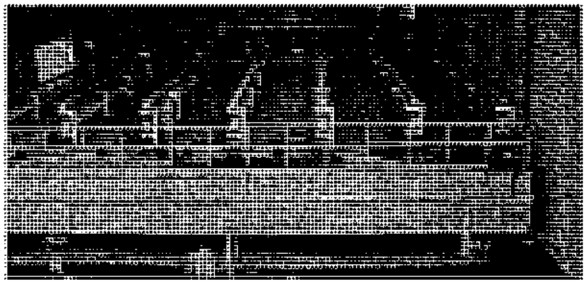
Scottsdale Water Campus Reuse Facility



PEMEX Refinery Wastewater Reclamation Project (Minatitilan)

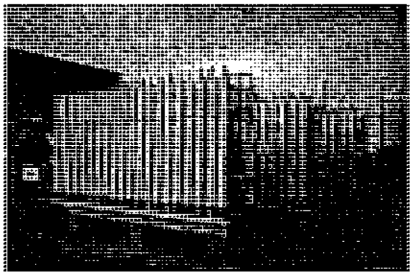
- Wastewater Flow Rate of 27,000 CMD
- WWTP: API Separator – DAF – Activated Sludge
- Tertiary Treatment: ZeeWeed UF - Reverse Osmosis
- Reclaimed Water Used in Boilers and Cooling Towers
- System Commissioned in November 2001
- Seven Trains of ZeeWeed UF at 90-95% Recovery

ZeeWeed UF Trains at PEMEX Refinery, Mexico



Intel Chandler (AZ) Semiconductor Fab Groundwater Recharge

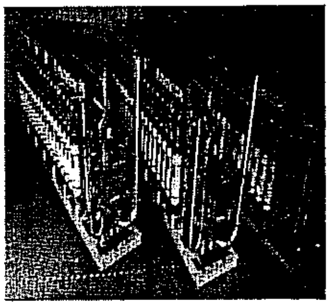
- Wastewater Included DI Rinse and Other Effluent Streams
- Treated Effluent Flow Rate is 9,000 CMD
- Treatment Processes: pH Adjustment – Filtration – MF – NF/RO – NaOH Addition - Chlorination
- Treatment Objective: Drinking Water Quality for Groundwater Recharge
- Operational Since 1998



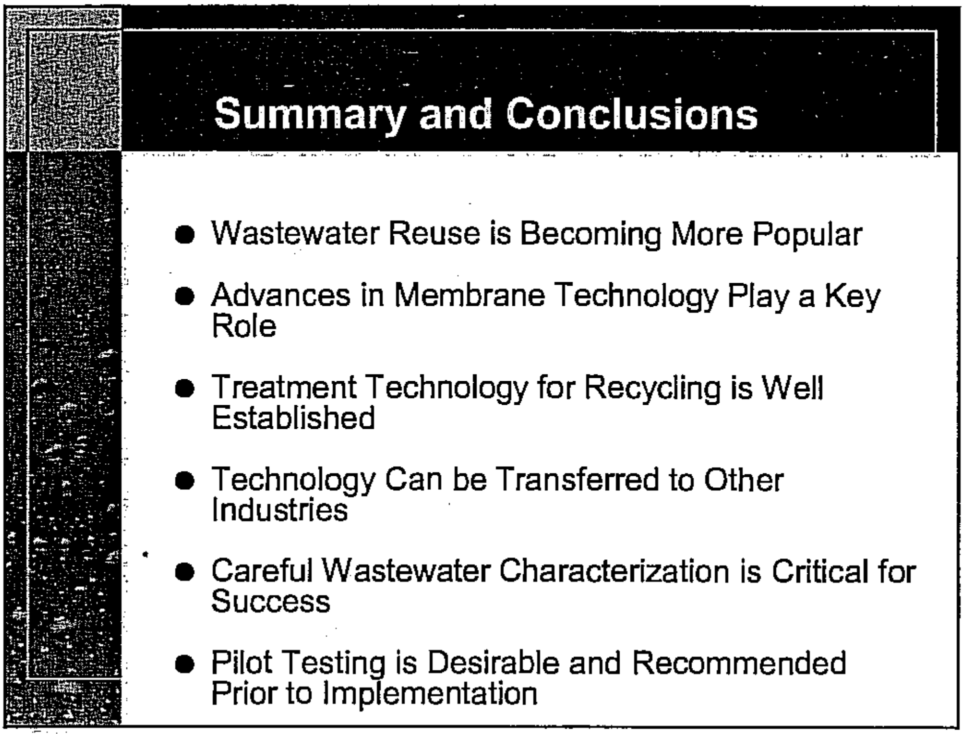
Los Medanos Energy Center Water Reuse Project

- Reuse Tertiary Effluent for Cooling and Boiler Makeup
- Actiflo and Filtration as Tertiary Treatment or Pretreatment for UF
- 2.1 MGD HYDRAcap UF System
- 1.2 MGD RO Followed by Mixed Bed Polishing

HYDRAcap UF Racks for Wastewater Reuse at Power Plant



- 3 UF Racks Produce 2.1 MGD Product Water



Summary and Conclusions

- Wastewater Reuse is Becoming More Popular
- Advances in Membrane Technology Play a Key Role
- Treatment Technology for Recycling is Well Established
- Technology Can be Transferred to Other Industries
- Careful Wastewater Characterization is Critical for Success
- Pilot Testing is Desirable and Recommended Prior to Implementation