# NATIONAL FACILITIES SURVEY

prepared by

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Final Report
September 1994

conducted for

Bureau of Reclamation
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Water Treatment Technology Report No. 12

U.S. Department of the Interior
Bureau of Reclamation
Denver Office
Technical Service Center
Environmental Resources Team
Water Treatment Engineering and Research Group

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This report is a survey of publicly and privately owned laboratories, facilities, and pilot plant equipmalt in the united State capable of undertaking water research and technology development. The survey was initiated by the National Water Researcl nstitute and the Bureau of Reclamation as its first step in the development of the National Centers for Separation and Therma Systems Research (cams). The Centers concept will facilitate water purification research through optimization of use o esearch resources, including facilities, making existing resources, facilities, and equipment available for investigators t conduct research. Thesurvey contains information on 66 facilities in the United States.

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## NATIONAL FACILITIES SURVEY

## EXECUTIVE SUMMARY

This survey of publicly and privately owned laboratories, facilities and pilot plant equipment in the United States capable of undertaking water research and technology development was initiated by the National Water Research Institute and the U.S. Bureau of Reclamation. It is the first step to developing National Centers for Separation and Thermal Systems Research, where investigators can utilize existing equipment to conduct research.

The mission of the program is to facilitate, coordinate and integrate national research to develop and promote water purification technology. The goals of the program are

- To develop and implement a strategy that will create and cultivate partnerships between Government, university, and industry that will facilitate research and enhance technology transfer of research products.
- To promote the cost-effective allocation of financial, human, and facilities resources.
- To establish and maintain an information and data exchange system to improve the coordination between engineering and technology research.

In addition, a key element is the need to develop a technology transfer strategy. In today's eumomic environment, research deliverables or products must have "real world" application if the investment of resources is to be perceived as worthwhile. Hence, this initial survey is intended to identify those institutions with pilot plant scale equipment, considered the critical link between the laboratory and "real world" application of technology and products.

During the course of the survey, many institutions were identified with strong backgrounds in water research with bench scale equipment, who are amenable to cooperative efforts in water research projects. These are identified in this report.

Mare than one hundred institutions and agencies were contacted in assembling this survey. Due to short time available for the survey, it is probable that not all locations with pilot plant equipment were identified. It is the intention of the sponsoring organizations that this initial survey serve as a living document to be updated as additional test sites become identified and surveyed. Private sector engineering companies are manufacturing companies were also contacted, who have pilot plant equipment available far rental or lease, The sampling of membrane manufacturing companies contacted indicates their strong support for the program.

Sites were initially identified through directories and proceedings identified in References. Others were established through networking with industry colleagues and still others by discussions with principal investigators at already identified research sites Thirty seven sites with pilot plant equipment were identified which are located in 15 states. Seven sites are state or federal locations. Seventeen are owned by cities or water districts. Eight are maintained by universities.

The extent of facilities, equipment and support services varied considerably among the surveyed sites. They ranged fiom a single membrane pressure tube to multiple process facilities with capacity up to 1 million gallons per day. Several locations were identified which do not have pilot

scale equipment, but possess excellent facilities and/or full scale equipment which can easily facilitate pilot plant testing, and are anxious to participate in this program.

Many universities were found to have laboratories and bench-scale equipment for water research, but not pilot scale equipment. A few universities were interviewed who previously had pilot scale equipment, but have now abandoned pilot plant testing, and in one case, is now entirely out of the water technology research picture. Although many universities were contacted by either telephone communication, many inquiries were unanswered. A short summary is provided for those who provided information. Several sites were eliminated due to non-interest or non-reply.

The pilot plant facilities, laboratory facilities, and private sector equipment companies listed in this report represent 25 different states. A total of 66 facilities and companies are included in this first national facilities survey. It is anticipated that many others may request inclusion after its publication.

The institutions contacted expressed overwhelming support of the Centers concept. Researchers around the United States appear ready and willing to embrace the partnering of universities, private industry, and govemment.

# 1.0 BACKGROUND

# NATIONAL CENTERS FOR SEPARATION AND THERMAL SYSTEMS RESEARCH

## NATIONAL FACILITIES SURVEY

## 1.0 BACKGROUND

Many communities in the United States and throughout the world rely on water supplies containing high levels of dissolved salts, and/or other contaminants that may present health risks. Presently, many desalting and water purification processes, which include separation and thermal systems, are too expensive or impractical for general use in alleviating the problems in these water supplies. There is presently no united effort to coordinate the research efforts of Government, academia, and industry in order to efficiently advance the science and engineering encompassing the water purification technologies to make them more cost effective and practical The National Center for Separation and Thermal Systems Research would champion this effort

The mission of the program is to facilitate, coordinate and integrate national research to develop and promote water purification technology.

Thegoaloftheprogramis

- To develop and implement a strategy that will create and cultivate partnerships between Government, university, and industry that will facilitate research and enhance technology transfer of research products.

- To promote the cost-effective allocation of financial, human, and facilities resources.

- To establish and maintain an information and data exchange system to improve the coordination between engineering and technology research.

The National Centers for Separation and Thermal Systems Research Concept (see following figure) is predicated upon a joint venture (as defined by the Steven-Wydler Technology Transfer Act of 1978, as amended) and recognizes that many organizations do not have the singular ability to underwrite the costs of research in today's economic climate. However, by bringing together organizations with mutual interests, a partnership can be fostered whereby cost sharing can enable project to be funded at levels to accomplish what each partner would find difficult to achieve alone. In addition, utilization of existing facilities can be optimized by coordinating their availability to the wider research community.

Principal partners in the National Centers concept are the U.S. Bureau of Reclamation (Reclamation) and the National Water Research Institute (NWRI). Further, the concept envisions three levels of associate partners: governments, universities, and industry. The Government partners, e.g. Environemnatl Protection Agency, National Institute of Standards and Technology, National Institutes of Health, as well as the university and industry partners will all be contributing members to the Centers.

A key element within this concept is the need to develop a technology transfer strategy. In today's economic environment research deliverables or products must have "real world" application if the investment of resources is to be perceived as worthwhile.

It is envisioned that a number of Centers could be established throughout the country and made available to the partners. As examples:

- Reclamation has two facilities, one in Denver, Colorado, and another in Yuma, Arizona, which could contribute small- and large-scale pilot testing research, operational, and field testing capabilities.

- Orange County Water District's facility, Water Factory 2 1, would be made available as well as its research, testing, and operational capabilities.

This is an extremely important moment in the history of our Nation's research programs. A decisive step is required to redesign the manner in which national research is carried out in order to maintain the quality of the past. The concept of National Centers is not new, but joint venture partnerships can provide a viable alternative to single source funding.

There are significant benefits and values of the National Centers Concept:

- Advancement of science and engineering
- Shared resources
- Enhanced technology transfer
- Shared information and data
- Avoidance of duplicate research

The preliminary strategy to accomplish these goals:

- Undertake a national inventory of current and projected facilities, personnel, and financial resources involved in separation and thermal systems research.

- Identify and organize a consortium of partners (investors) to cost share in the development of the National Centers' program

- Identify and describe the set of current and projected national needs.

- Develop a financial strategy based upon the principles of asset allocation including selection criteria and methodologies.

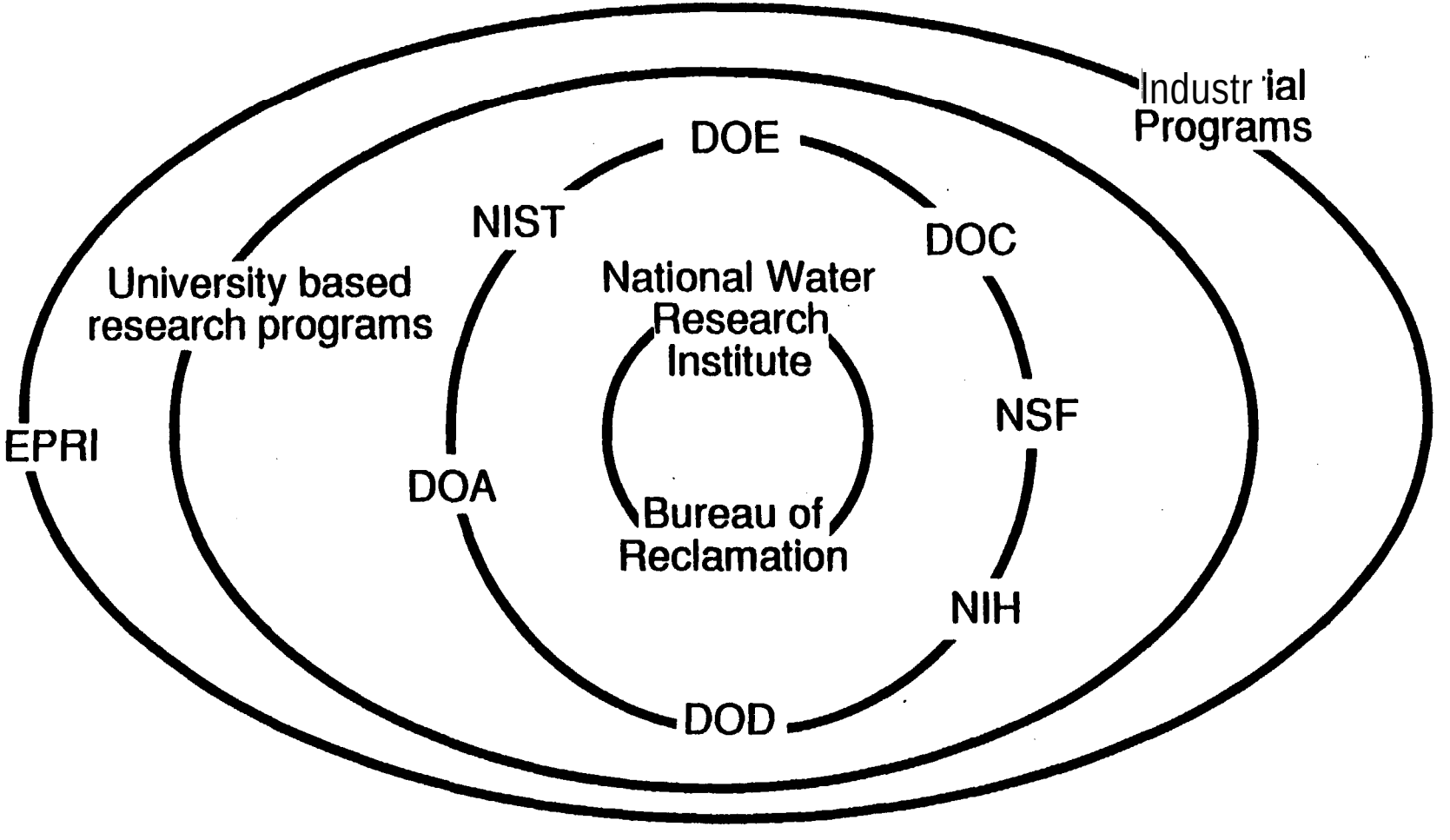
- Design a methodology to track, measure, and document accomplishments on a regular basis.

The following report is the first step in accomplishing these goals.

This is a progmm of the National Water Research Institute in cooperation with the U.S. Bureau of Reclamation. It is an outgrowth of the Membrane Research and Development cooperative program between NWRI and BOR. The program was the result of reflection on the history of desalting in the United States. No major breakthroughs have occurred since the mid- to late-1970's, when thin film composite membranes became commercially available.

The Centers concept is an important step to bring together universities, industry, and federal agencies, to concentrate on common goals. Bringing diverse sources of funding together and encouraging the use of under utilized existing facilities will foster the initiation of significant water-related research and development

# NATIONAL CENTERS FOR SEPARATION AND THERMAL SYSTEMS RESEARCH



# 2.0 PILOT PLANT FACILITIES

## 2.0 PILOT PLANT FACILITIES

The primary focus of this survey was to inventory those sites where pubicly and privately owned laboratories, facilities and pilot plant scale equipment are available. This section describes those locations where pilot scale equipment is available for research purposes. The equipment, facilities, and research support services available at the sites listed in this section varied widely, from a single 4" membrane element pressure vessel with little research support to a large facility with multiple processes which can be operated singly or in any combination, with complete analytical laboratories and research staff support.

Most facilities demurred on the quèstion of cost of facilities and services, as they would prefer to negotiate those costs on a case by case basis. Note that three of the facilities listed in this section are not currently in the possession of pilot plant equipment, but have conducted pilot plant tests in the past and have offered their facilities and services for pilot plant testing.

The sites are listed by state. A summary of the facilities by ownership can be found in the Appendix as Tables 7 through 10. The summary provides a quick reference to the type of processes which can be found at the facility, and an approximation of cost of equipment and/or facilities, where information was provided.

## ARIZONA

### CITY OF SCOTTSDALE

**Water Resources Department**
**Scottsdale, Arizona**

**Administrator: Roger Klingler**
**Telephone: 602-391-5681** **Fax: 602-391-5615**

**The City of Scottsdale recently purchased two** pilot plants to further study microfiltration and **ultrafiltration** prior to construction of their wastewater **treatment** facilities. The pilot plants will be utilized for their own research purposes for some unspecified period of time. At some point in the **future,** the pilot plant equipment may be available for further research and development. The city has indicated their interest in **future** research and in the National Centers program.

## US BUREAU OF RECLAMATION

**Research Center at Yuma Desalting Plant**
**P.O. Box D**
**Yuma, Arizona 85366**

**Administrator: Ed Lohman**
**Telephone: 602-343-8448** **Fax: 602-343-8320**

In addition to water desalination research and development in their Denver laboratories since the late 1950's, the BOR has engaged in research at Yuma, Arizona in conjunction with the design, construction, and operation of their 72 mgd reverse osmosis desalting facility. The Yuma desalting plant is the largest single reverse osmosis facility in the world

The research activities investigated most effective pretreatment methods, proper long-term storage procedures, among other subjects directly related to the main facility. More recently a successful program was carried out to determine the cause of "front-end" deterioration of cellulose acetate membrane elements. The likely cause was found, a remedy was established, and a potential major problem was diverted.

The research building houses a reverse osmosis system and supporting pm-treatment capable of producing 1 mgd of product (proof test unit). The pm-treatment in place consists of a solids contact reactor, dual media gravity filters, and chemical feed equipment. Supporting equipment is in place to check single membrane elements Three additional test units are available which utilize 2-1/2" diameter membrane elements, which allow pilot scale testing with less membrane area

The proof test units are well controlled and instrumented, The building has a separate operations room and laboratory. Sufficient clear space is available for additional small pilot scale plants if other equipment is needed to augment existing equipment

Office space and a state-of-the-art water laboratory and experienced staff are available in the main operations building. YDP operations and data collection are performed by a central computer system called the Programmable Master Supervisory Control system and consists of two MODCOMP 9250 computers with 29 remote terminal units.

The YDP research staff has successfully conducted studies in optimizing recovery, trihalomethane removal, membrane life studies, membrane drying, instrumentation development and evaluation, and have developed a handbook for autopsying membranes (destructive testing to determine extent of and types of fouling, and determination of membrane condition). The staff consists of researchers, engineers, operators, and maintenance workers who are familiar with desalting technology.

In additional to the traditional infrastructure features (intake/discharge, etc.), extensive services exist including welding and machine shops.

The YDP and research facility are available for joint research and development projects to further the desalination state-of-the-art, water quality technology, and commercialization of related products.

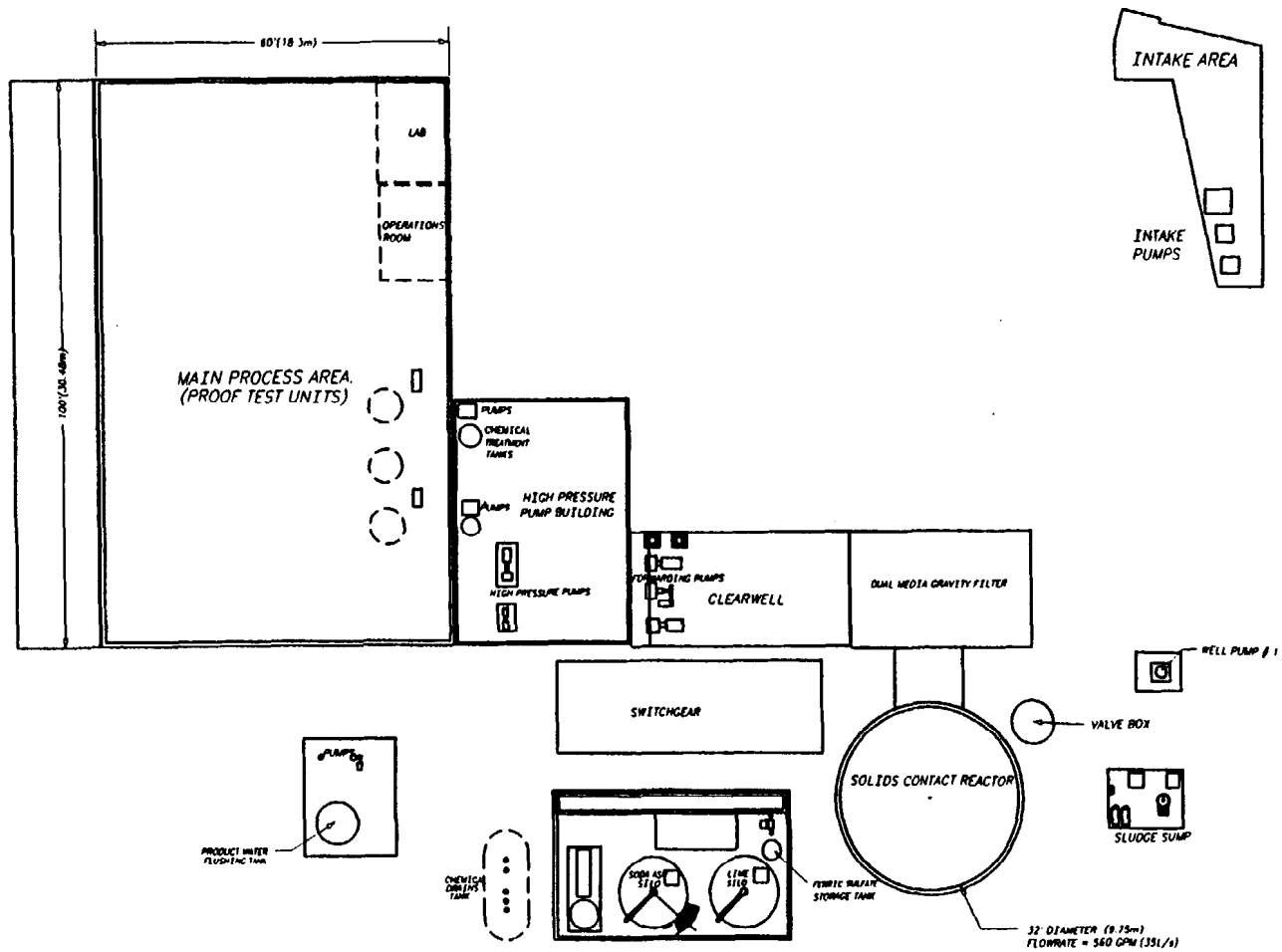
The cost of facilities and services are determined after examining the needs of the research project. A cooperative research agreement is established on this basis.

## Table 1. BOR Yuma Desalting Plant Pilot Facilities

**CENTER:** US BUKEAU **OF** RECLAMATION
**LOCATION:** **Yuma,** Arizona
FEED STREAMS: Irrigation **return** flow, tapwater, synthetic solutions

| **PROCESS:** | **Reverse** Osmosis | **Dual Media** Gravity Filters | Solids Contact Reactor | **Clearwell** | Element **Check Apparatus** | Test Units |
|---|---|---|---|---|---|---|
| No. of systems | 1 | 1 | 1 | 1 | 1 | 3 |
| Avg feed flow, gpm | 494 | **903** | **903** | | **60** | |
| Pressure, psi | **450** | | | | **450** | 450 |
| size, gallons | | | | **60000** | | |
| No of stages | 2 | | | | 1 | 2 |
| Elements per stage | | | | | 1 | |
| Recovery, **%** | | | | | | |
| Element type: | **8.5",** 12" | | | | **8.5",** 12" | 2.5" |

CONTROL SYSTEM: 24 hour a day operation.
Automated control.




SAFETY

YUMA DESALTING PLANT

TEST FACILITY

## ARLINGTON DESALTING PLANT

**Santa Ana Watershed Project Authority**
**11615 Sterling Avenue**
**Riverside, CA**

**Administrator: Neil Cline, G.M.**
**Telephone: 909-785-5411** **Fax: 909-785-7076**

The Arlington Desalting Plant is owned by the Santa Ana Watershed Project Authority. It operates a 6 mgd reverse osmosis desalter, with the cocentrate disposed to the Santa Ana Regional Interceptor, which conveys wastes to the Change County **Sanitary District** for treatment and ocean disposal. The plant utilizes brackish groundwater with micron filtration and was installed to reduce the level of nitrates in the groundwater.

Sufficient space is available on-site for conduct of pilot plant testing with telephone and fax available. Although the availability of on-site research support is uncertain at this time, office space is available.

Previous pilot plant studies have been carried out at the plant, including one with a new electrodialysis membrane. The general manager has been a long time proponent of technological advancement and would welcome additional research efforts. The cost of facilities is negotiable and institutions or companies wishing to engage in R&D would be expected to assume any costs incurred by SAWPA in support of the R&D effort.

The site would provide a good test site with supportive management.

## CAMBRIA COMMUNITY SERVICES DISTRICT

**2200 Center Street**
**Cambria, California**

**Administrator: David Andres**
**Telephone: 805-927-3050** **Fax: 805-927-0178**

The Cambria Community Services District is currently constructing a 1 mgd seawater reverse osmosis facility. Alternative phases 2 and 3 will consider groundwater recharge with effluent recovery using brackish water reverse osmosis. The brackish water reverse osmosis system is rated at 10 gpm with Signet instrumentation and controls. The district has a moderate laboratory facility, and its equipment is in good condition.

Brackish water, seawater and wastewater effluent are available, which makes this facility versatile. PC computer facilities are available along with telephone, and fax. Direct research staff availability is doubtful, but supervision and facility caretakers and maintenance are available.

The district has a licensed, experienced staff. Office space is not available and the cost for facilities and services must he **negotiated with the district.**

## CITY OF LOS ANGELES

**Liquid Waste Management Division**
**Terminal Island Treatment Plant**
**445 Terminal Way**
**San Pedro, California 90731**

**Administrator:** **Kris Flaig (LWMD); Clarence Mansell, Jr. (TITP Plt. Mgr)**
**Telephone:** 3 1 0-548-7751 **Fax:**31 O-548-7772

The Terminal Island Treatment Plant lacks existing pilot plant equipment, but has excellent facilities available to accommodate pilot plant testing. Connections exist for electrical, water and other utilities. The plant has an existing concrete pad, 30' x 60', pumps, and other equipment which can be bon-owed from current research projects at other plants. The facilities will be made available as finances will allow and with management approval.

Supporting instrumentation and analytical equipment includes: on-line evaluation with Nissin Electric BOD-2000, on-line Alka-Pro multi-line alkalinity analyzer, Respirometer to determine BOD and toxicity, particle counter, turbidimeters, flow meters, Hach kits, fluorometer, samplers, in-plant laboratory (wet chemistry, microbiology, TOC).

All equipment is in fair conditions and wastewater and wastewater effluent are readily available as feedsource. Other feedstreams can be accommodated. PC computer facilities are utilized and communications include phone and fax.

Research support is available including supervision, staff, caretakers and maintenance. Limited office space is available. The daily rate for facilities is negotiable and support services may be available at cost, including standard overhead

## CITY OF SAN DIEGO

**San Pasqual Aquatic Treatment Facility (Aqua III)**
**Department of Water Utilities**
**14103 Highland Valley Road**
**San Diego, California 92128**

**Administrator: Mr. Paul Gagliardo**
**Telephone: 619-668-2072 Fax: 619-668-2062**

The City of San Diego has been active in the development of processes for wastewater reclamation since the late 1960's when a tubular reverse osmosis system was installed at Point Loma Wastewater Treatment Plant for treatment of raw sewage. Through the years, other processes such as ultrafiltration and water hyacinths have been examined. A small facility was built in Mission Valley (Aqua II) to demonstrate the applicability of water hyacinths as a natural secondary wastewater treatment process prior to use of reverse osmosis.

After successful operation in Mission Valley, a new, larger facility was built in the San Pasqual area, on Highland Valley Road in north San Diego (Aqua III). The equipment from Aqua II was moved to the new site to accommodate additional research to support the new Aqua III facility. It has not been operated since being moved to the new site. Some refurbishment would be required to attain good operating condition, but all equipment is in fair to good condition.

The pilot plant equipment is designed to produce 1 mgd and includes clarification, dual media filtration, ultraviolet, reverse osmosis, granualr activated carbon, air stripping. The existing membranes are thin film composites, but require replacement. A cleaning skid is also available on -site The equipment is installed on a concrete pad with a protective roof. Additional pilot skids could be moved on site for testing.

The site provides an excellent opportunity to perform R&D using residential wastewater. Raw, secondary and tertiary effluent are available on site.

The City is willing to make electricity and space available for R&D, as long as it does not interfere with ongoing activities. Laboratory and limited office facilities are available. PC computers are on site and some supervision is available. Facility caretakers and maintenance are available on site. Telephone, facsimile, e-mail are available.

No specific charges have been established for use of the facility. The City would probably not charge for electricity and space as long as the research does not encroach upon daily requirements of existing staff. They would consider exchange of facilities for data aquistion depending upon the circumstances.

## CITY OF SAN FRANCISCO

**Southeast Water Pollution Control Plant**
**Reverse Osmosis Pilot Plant**
**750 Phelps** St.
**San Francisco, California 94124**

**Administrator: Paul Pitt**
**Telephone: 415-648-6882** **Fax: 415-282-5280**

The City and County of San Francisco owns a 30 gpm reverse osmosis pilot plant and a 30 gpm microfiltration pilot plant at their Southeast Water Pollution Control Plant. The are fed with chlorinated/dechlorinated secondary effluent. Instrumentation, controls, and analytical equipment include chlorine analyzers, turbidimeters, programmable logic controllers for both MF and RO, pH analyzers, and reverse osmosis software. Computer facilities for both PC and MAC are available. All equipment is in good condition.

Communications include telephone and fax. Research support is available with staff support, supervision, facility caretakers and maintenance. Both environmental and mechanical engineers are available on-site. Office space is available. Use and cost of facilities must be negotiated with the City and County of San Francisco.

## CONTRA COSTA WATER DISTRICT

**Water Quality Section**
**201 Bates Ave.**
**Concord, California 94.520**

**Administrator: Larry J. McCollum**
**Telephone:. 510-674-8127** **Fax: 510-689-5936**

The Contra Costa Water District has a modular pilot plant which is a scaled down version of their existing plant and is located adjacent to the main plant. It is a dual train system capable of 9 gpm through each train through the flocculation step. Thereafter it is reduced somewhat. It also contains a full scale sedimentation section. The dual train was established to facilitate parallel studies. For example, studies were conducted comparing alum and ferric hydroxide treatment. Granular activated carbon filters are available as well as ozonation.

The water district is amenable to establishing collaborative research programs with their staff and facilities representing in-kind contributions to the cost of the research program. Their own overhead rates are about 30%.

## CALIFORNIA

### DEPARTMENT OF WATER RESOURCES

**3374 E. Shields Ave.**
**Fresno, California 93726**

**Administrator:** **Kurt Kovac, Sr. Engr., DWR**
**Dr. Larry Ownes, CSU Fresno**
**Telephone:** **209-445-5370** **Fax:** **209-445-5509**

The California DWR maintains a small test facility at their Adams Avenue site in conjunction with Fresno State University. A small volume (10-15 gpm) of agricultural drain water of about 10,000 ppm is available for testing. Several small (2 gpm) reactors are available for conducting tests. They are two upflow, fluidized bed reactors. They were designed to investigate the reduction/removal of selenium from agricultural drainage.

The facility would be made available for a nominal cost, probably direct cost of utilities. If research staff assistance is required, graduate students from Fresno State University could be made available at direct cost plus 25 % overhead DWR staff assistance would be at no charge unless a specific task was required Office space is available in the trailer provided at the test facility.

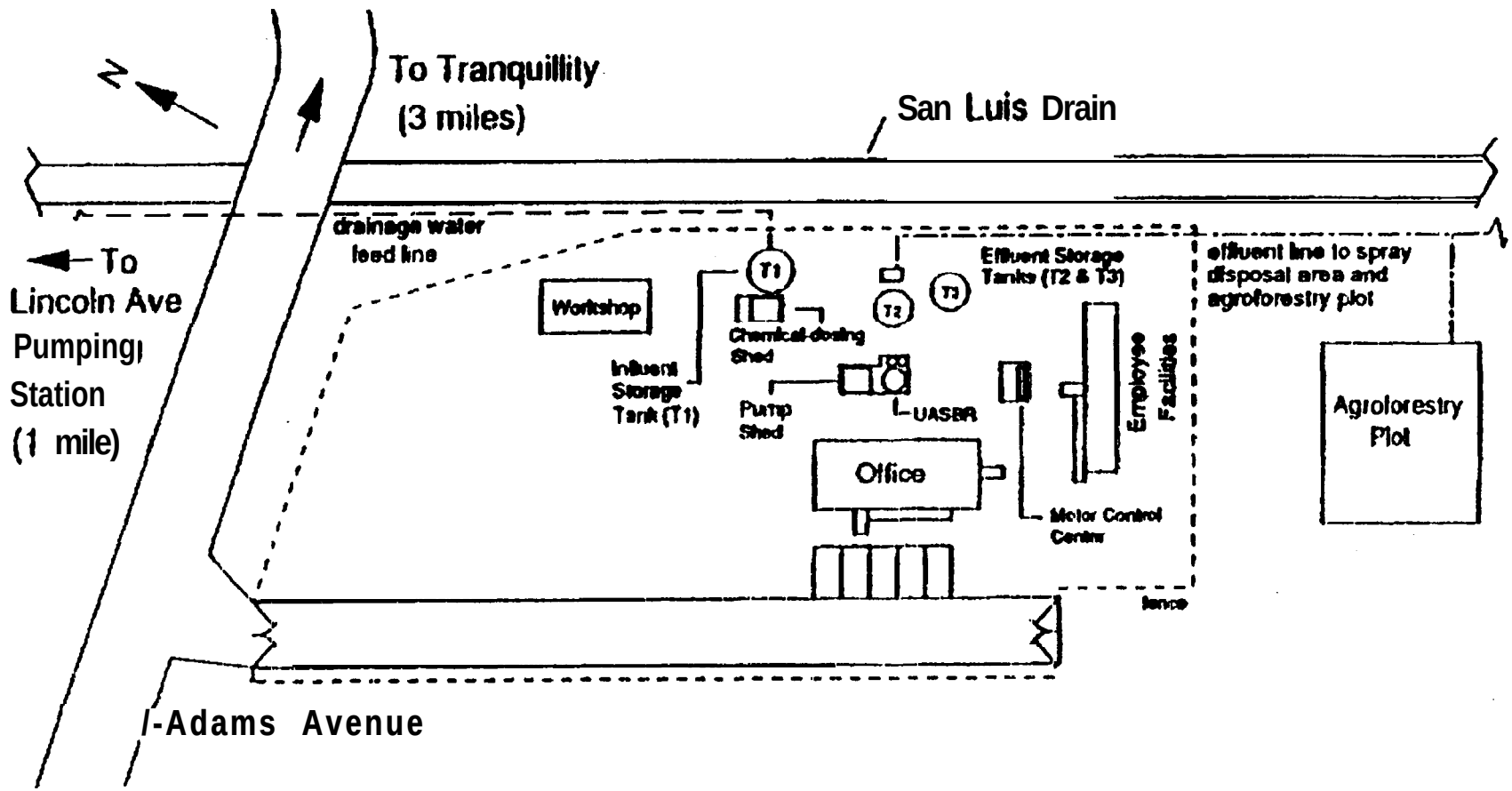
Although the test facility at Los Banos has been closed and is being dismantled, a vapor compression evaporator rated at 50,000 gpd is available at nominal cost. Originally purchased at a cost of $600,000 plus installation, the plant may require tube replacement and would require moving from the premises. The DWR is anxious to cooperate in order to facilitate its use in further research efforts.

The electrodialysis reversal unit installed at Los Banos is also available, but the wear and tear from exposure to the elements probably make refurbishment more costly than a new pilot plant.

Also available from DWR are a 1,100 gallon clarifier and a 10 kw Rankine cycle engine.

**CALIFORNIA DWR, continued**

**Figure 3. Adams Avenue Test Facility Layout - California DWH**



## IRVINE RANCH WATER DISTRICT

**Organic Removal Pilot Facility**
**3232112 So. Greenville**
**Santa Ana, California 92704**

**Administrator: Ken Thompson**
**Telephone: 714-453-5620** **Fax:** 714-453-0228

The Irvine Ranch Water District established a water research test facility at a site with access to a highly colored groundwater aquifer, the Dyer Road Well Field The Organic Removal Pilot Facility was designed and constructed in 1992 to examine the feasibility of turning this highly-colored groundwater into high quality potable water. The facilities are comprised of the following unit processes:

- Conventional ozonation
- In-line ozonation
- Membrane separation
- Granular activated carbon adsorption
- Biological activated carbon filtration
- [illegible] clarification
- Deep-bed filtration

The process characteristics and description are summarized in the following table. Pre-treatment for the membrane section is by cartridge filter, acid and/or anti-scalant addition. Post-treatment is by ozonation and chemical addition. A skid mounted unit is available for membrane cleaning.

On-line continuous monitoring of low rate, color, turbidity, pH, electrical conductivity, temperature, ozone residual, percent ozone, and pressure levels from multiple sample locations is provided. The control system is comprised of a Modicon 984-685 PLC that collects instrumentation signals and a PC operating with Wonderware In-Touch Operator Interface Package and Microsoft Excel. The system has three functions: data acquisition, displays of all current values, and datalogging every 10 minutes into a mater spreadsheet and optionally logged at desired frequencies into three other spreadsheets.

Analytical equipment includes: Amicon UF separation, UVMS HP spectrophotometer, Cole Parmer pH meter, HF Sci. Turbidimeter, alkalinity, hardness, dissolved oxygen and ozone kits, Silt Density Index kit.

In addition to two groundwater sources, wastewater effluent and other feedstreams are possible. Telephone and facsimile are available on site for communication and PC computers are available. Limited office space is available and excellent support staff are present, including process engineers, full service laboratory staff, and supervisory engineers. Special disciplines include advanced water and wastewater treatment, environmental engineering, microbial and biologic sciences, regulatory compliance, project management.

The study of colored groundwater treatment was conducted with a grant from the Nation@ Water Research Institute[1].

[1]Thompson, K., et al, "A Membrane Pilot Study on Highly Colored Groundwater in Southern California," Irvine Ranch Water District, 1993.

## Table 2. Irvine Ranch Water District DRWF Pilot Plant Equipment

| CENTER: | IRVINE RANCH WATER DISTRICT | | | | | |
|---|---|---|---|---|---|---|
| LOCATION: | IRVINE, CALIFORNIA | | | | | |
| FEED STREAMS: | High color brackish water, low color brackish water | | | | | |
| | | | | | | |
| PROCESS: | Ozonation | GAC absorption | In-line ozonation | Conventional Clarification | Deep- bed Filtration | Membrane Filtration |
| | | | | | | |
| No. of systems | 2 | 4 | 1 | 1 | 6 | 1 |
| Avg feed flow, gpm | 7.8 | 0.18-0.71 | 40 | 40 | 0.35-1.05 | 20 |
| Avg ozone dosage, mg/l | 8 | | 8 | | | |
| Avg ozone usage, lb/d | 0.75 | | 3.84 | | | |
| Process type | Bubble diffusion | | In-line eductor | Roberts Reliant 60 | | |
| Maximum filtration rate, gpm/ft2 | | | | 5 | 8 | |
| Dimensions, | 8"dx16'h | 4"dx20'h | 16"dx16'h | | 4"dx20'h | |
| Media type | | | | | mono/dual | |
| Media depth, ft | | 3-8 | | | | |
| Detention time, min | 4 | | 3.6 | | | |
| Material | acrylic/PVC | clear PVC | PVC | | PVC | |
| Diffuser | ceramic disk | | | | | |
| Avg alum dose, mg/l | | | | 25 | | |
| Avg polymer dose, mg/l | | | | 2 | | |
| Avg PAC dose, mg/l | | | | 20 | | |
| No of stages | | | | | | 2 |
| Elements per stage | | | | | | 3 |
| Recovery, % | | | | | | 75 |
| Membrane type: | | | | | | spiral uf/nf |

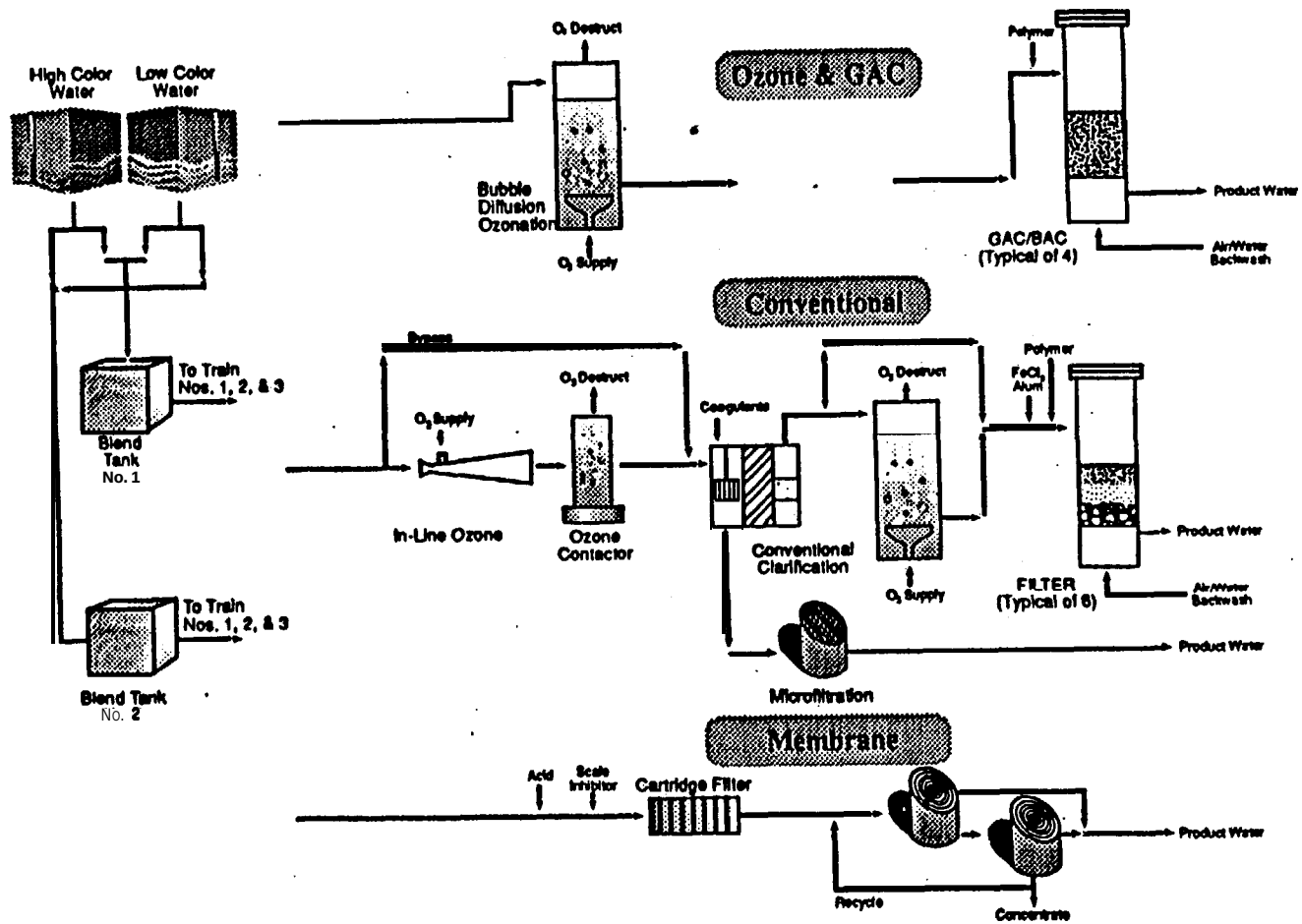



**Figure 4. Organic Removal Pilot Testinp Eauipment. IRWD**

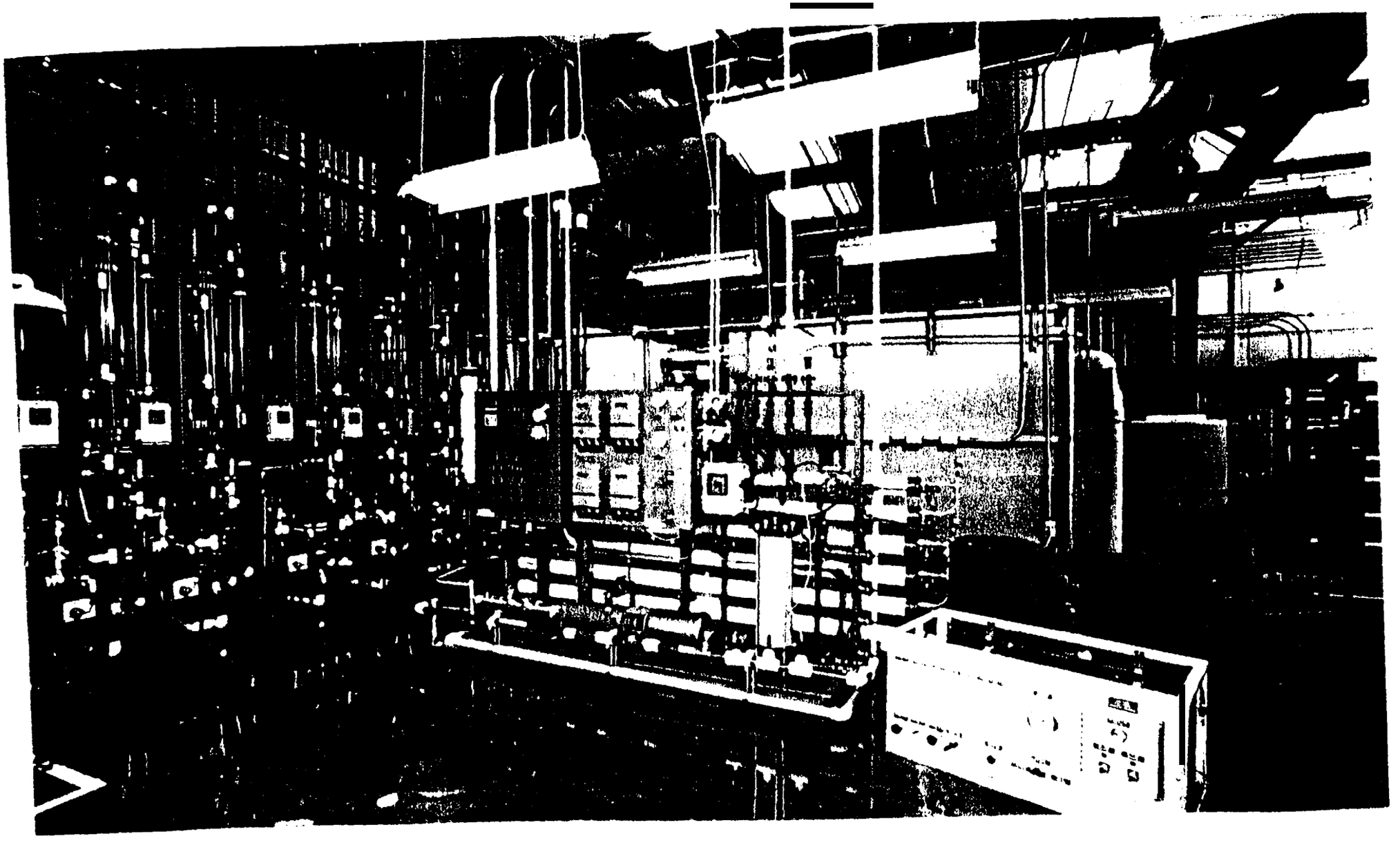


Figure 5. Photograph: Process Treatment Trains, IRWD

## METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA

**La Verne Water Treatment Plant**
**700 Moreno Ave.**
**La Verne, California 91750**

**Administrator: Dr. Sun Liang**
**Telephone: 909-392-2914** **Fax:** 909-392-2995

At their La Verne facility the Metropolitan Water District maintains pilot plant membrane equipment for testing. They have a single element membrane test unit, capable of 350 psi, which will test single membranes, producing approximately 2 gpm product. They also have a mobile reverse osmosis test unit capable of operation to 1200 psi for brackish water testing. Current membranes on hand include nanofiltration and ultrafiltration. Reverse osmosis tests are planned later. Feed sources planned far use are brackish water, State Project water and Colorado River water. The equipment will be in excellent condition, as the test unit is scheduled for completion in October, 1994 and the mobile unit completed by January 19%.

The mobile unit contains conventional 5 micron cartridge filtration with chemical cleaning. Process instrumentation includes flowmeters, chlorine analyzer, conductance meter, turbidimeter, pressure gages. Analytical equipment includes chlorine analyzer, turbidimeter, conductance meter and pH meter.

Both PC and MAC computers are available. Office space is available. Research support is available with two associate engineers, one assistant engineer, one engineering technician as well as senior and associate engineers for supervision. Facility and equipment are maintained by staff technicians. All of the staff members have extensive water treatment backgrounds with some having additional background in membrane processes.

Telephone, facsimile and e-mail services are on-site. Charges for facilities and services are negotiable.

## ORANGE COUNTY WATER DISTRICT
## WATER FACTORY 21

**10500 Ellis Ave., P.O. Box 8300**
**Fountain Valley, California 92728-8300**

**Administrator: William R. Mills, Jr., G.M.; Bill Dunivin, Plant Manager**
**Telephone: 714-378-3266** **Fax:** 714-378-3374

Water Factory 21, owned and operated by the Orange County Water District has become the premier advanced wastewater treatment facility in the United States. The District has consistently been on the leading edge of technology in finding improved methods for water reclamation. Through a pro-active strategy with regulators and legislators, they were the first to obtain a permit for direct injection of reclaimed water into groundwater aquifers. Their concept of injecting reclaimed water into barrier wells to prevent the intrusion of seawater has served as a model throughout the Los Angeles basin.

WF 21 is a 15 mgd advanced wastewater treatment facility incorporating a 5 mgd reverse osmosis plant, featuring extensive membrane testing, and evaluation facilities, a state certified analytical laboratory, and a Biotechnology Research Department with active research programs in bacterial attachment and biofilm formation on separations membranes.

Reverse osmosis, ultrafiltration, nanofiltration, microfiltration, vacuum distillation, ozonation, and filtration process are available in pilot plant size. Flow capacities for these processes range from 1 to 500 gpm. Cellulose acetate, polyamide, and experimental polymers are available for research testing. In addition. alternative flow spacer designs and module configurations are on hand.

Supporting equipment includes high-pH lime clarification, disinfection (UV, $O_3$, $Cl_2$), microfiltration, multi-media filtration. Cleaning skids are available for membrane cleaning and disinfection. A complete state certified analytical laboratory is on site to support the 15 mgd AWT plant and the research activity. A separate Biotechnology Research department is established on-site which is described on a separate page.

A variety of feed streams are available including brackish water (well), seawater (limited quantity), wastewater, wastewater effluent, groundwater. Concentrates are disposed via city sewer. The Orange County Wastewater Treatment Plant is next door.

Excellent computer facilities are available including PCs. The equipment on-site is all in excellent condition and is well maintained. The facility is serviced by 3 shifts of the operations and maintenance department Supervision is available, but limited. The Biotechnology Research Group provides exceptional capabilities. Office space is limited.

The cost for use of facilities is essentially the cost of expendable supplies (chemicals, power, etc.) and the salaries of personnel utilized for the research plus expendable supplies. No overhead costs are anticipated for research at OCWD.

## ORANGE COUNTY WATER DISTRICT, continued

**Biotechnology Research Department Facilities**
**10500 Ellis Ave.**
**Fountain Valley, CA 92728-8300**

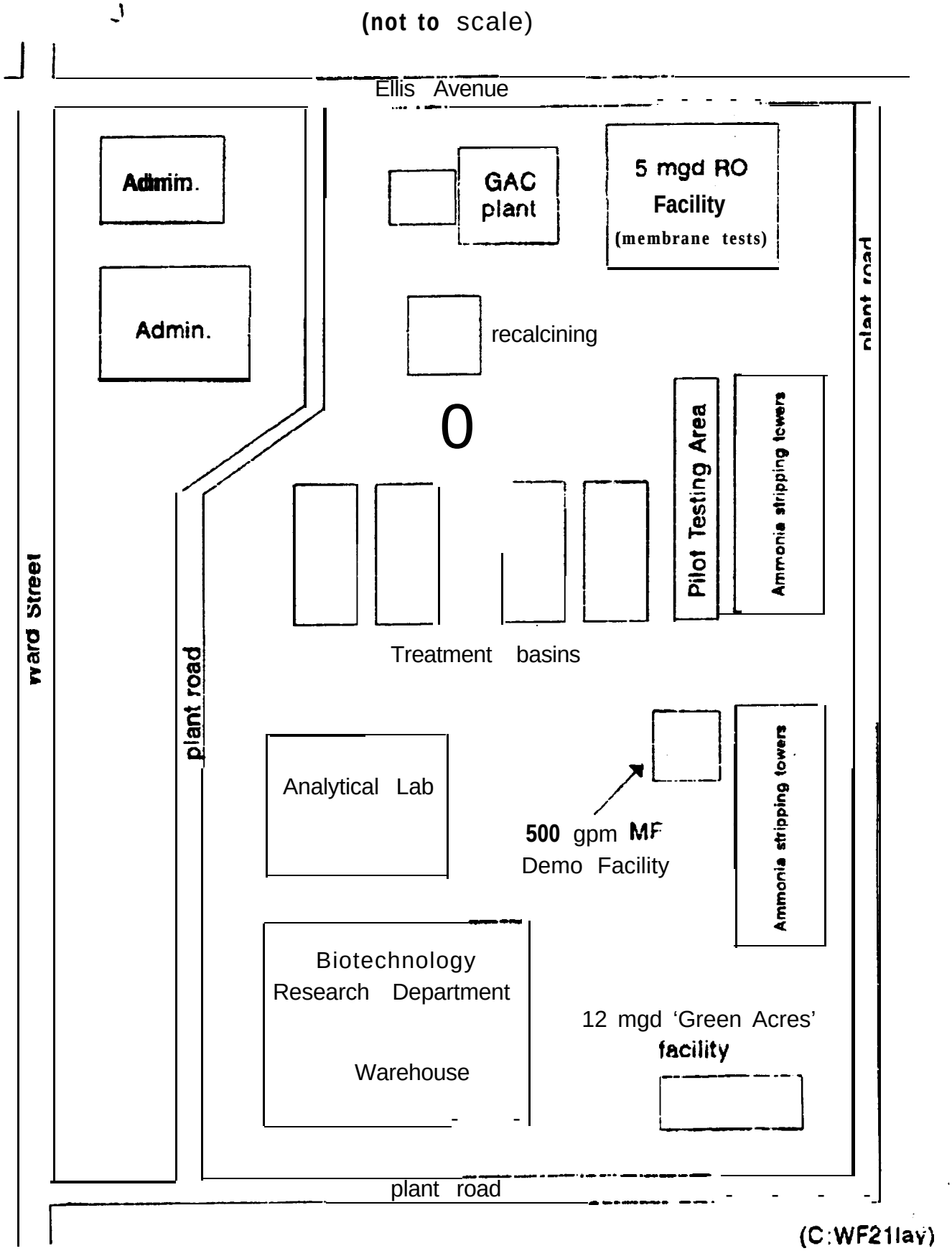
**Administrator: Dr. Harry F. Ridgway, Director**
**Telephone:** 714-378-3266 Fax: 714-378-3374

Several research and development programs related to membrane separations are currently underway within the Biotechnology Research Department. These programs include (1) studies on the identification and analysis of chemical biocides fix retarding biological fouling of membranes, (2) analysis of biocide penetration and transport in membrane biofilms, and (3) investigation of the mechanism of bacterial attachment and biofilm growth in membrane systems.

The Department is a state-of-the-art facility designed to meet the needs of scientists and engineers engaged in fundamental and applied studies related to water treatment and groundwater management. Analytical capabilities within the Department include digital confocal microscopy coupled with 3D specimen reconstruction/manipulation, conventional epifluorescence light microscopy, attenuated total reflection Fourier transform infrared spectrometry, electronic particle distribution analysis, ion chromatography, total organic carbon and organohalide analysis, spectrofluorometry, digital image processing and analysis, protein and nucleic acid electrophoretic separations, ultracentrifugation, performing gene probing and other molecular genetic techniques. Electron microscopy may be performed in the Department of Biology, University of California, Irvine, located approximately 10 minutes. from OCWD.

Approximately 15 scientific and technical personnel comprise the Biotechnology Research Department. Education backgrounds range from the bachelors to the doctoral in microbiology and chemical engineering.

**Figure 6. Water Factorv 21 Facilities Lavout. OCWD**



PADRE DAM MUNICIPAL WATER DISTRICT

P.O. Box 719003
Santee, California 92072-9003

**Administrator: Harold Bailey**
**Telephone: 619-448-8601** **Fax: 619-258-8774**

The Padre Dam Municipal Water District currently owns a 4 mgd secondary plant (of which 1 mgd is currently utilized), followed by oxidation pond effluent polishing. They are proposing to build a 2 mgd "Bardenpho" process with denitrification filters, phosphorous precipitation, chlorine contact, with dechlorination with sulfur dioxide.

The facility has two concrete tanks available, concrete pads, and a control/office building. A basic water and wastewater laboratory conducts all of the analysis required on-site. The equipment is in fair condition. Both wastewater and wastewater effluent are available as feed sources.

Telephone, fax, and e-mail communications are available. Research support may be available, but certainly supervision and facilities caretakers and maintenance are available. Office space is available. Facilities and services cost is negotiable.

## SANTA CLARA VALLEY WATER DISTRICT

**5750 Almaden Expressway**
**San Jose, California 95118**

**Administrator: Ms. Sandy Oblonski**
**Telephone: 408-927-0710** **Fax:** 408-268-7687

**The Santa Clara Valley** Water District conducted pilot plant tests at their Los Gatos pumping plant **to determine viability** of using ozone for disinfection. This was done to **determine** the future direction to meet DBP regulations.

The pilot scale equipment includes a 3 train ozonation system with an output of 0.5 lb/day. The modular sections **are** capable of accommodating 4 gpm per train. The trains can be assembled in parallel or in series.

Since their primary tests were **completed,** 3 or 4 additional tests have been conducted there as part of AWWARF projects.

The equipment is available at the pumping plant for additional testing, with costs to be negotiated with theinterestedparties.

## UNIVERSITY OF CALIFORNIA - LOS ANGELES

**Lake Arrowhead Community Services District Facility**
**#1 Pilot Rock Road, Grass Valley WWTP**
**Lake Arrowhead, California 92352**

**Administrator: Prof. Michael Stenstrom; Kapal Madireddi**
**Telephone: 909-336-5261 Fax: 909-337-5847**

The University of California at Los Angeles, Department of Civil Engineering, owns and operates a fully equipped pilot plant for reclaiming municipal secondary effluent. The Treatment processes include denitrification, clarification, f&ration, carbon adsorption, ozonation (10,000 gpd), ultrafiltration (4500 gpd) and reverse osmosis (3000 gpd).

The equipment is instrumented and controlled with G.E. Fanuc automation featuring programmable logic controllers. Analytical equipment includes GC/MS, IC, AA, Visible spectrum UV spectrophotometry, biological testing. Equipment is in excellent condition and the site features wastewater effluent.

Both PC and MAC computer facilities are available with telephone and facsimile communication. The university can offer their research support and office space is available. The cost for these facilities has not yet been determined.

**US NAVY**

**NAVAL FACILITIES ENGINEERING SERVICE CENTER**
**560 Center Drive**
**Port Hueneme, California 93043-4328**

**Administrator: Ted Kuepper**
**Telephone: 805-982-1631 Fax: 805-982-l 409**

The seawater desalination test facility at Port Hueneme is an excellent test bed for pilot plants, membranes and pretreatment. They consider themselves one of the premier sites for conduct of long term testing, stressing "real world" conditions. About 15 percent of their testing at the present time is done for private companies.

The seawater intake is an underwater pipe which reaches out only 15 feet from the shoreline and lies about 12 feet deep. In spite of this nearness to shore, little variation in TDS is noted The main seawater intake pump is capable of delivering 300 gpm (432,000 gpd). This site produces real world situations throughout the year, including the worst case condition of "red tide" which occurs once or twice a year for one or two weeks duration.

Virtually all of the units on hand are US Army Reverse Osmosis Water Purification Units (ROWPU). At the present time two of them are being operated in parallel for a test. Ten additional ROWPUs are available. All of the units are modified slightly to allow safe 24 hours a day unattended operation. Each unit comes packaged with its own operational controls and safeguards.

The facility has a permit to recombine the product with the brine and discharge back into the ocean. A complete water analysis laboratory is located on the premises, equipped with most of the standard analytical instrumentation.

One of the ongoing tests is a long term test of reverse osmosis membrane preservatives. A series of tests far the US Army is planned in the near future to test various methods for pre-treating prior to reverse osmosis.

The facility is flexible in developing a working relationship with outside parties. They are amenable to providing only space, electricity, feed stream, and monitoring personnel to companies desiring to bring in their own complete units. Most agreements for testing are a combination of daily charge for the ROWPU, electrical charges, machinery charges far maintenance as required, and personnel time.

| CENTER: | US NAVY CIVIL ENGINEERING LABORATORY | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **LOCATION:** | Port Hueneme, California | | | | | | | | |
| FEEDSTREAMS: | Seawater | | | | | | | | |
| PROCESS: | Reverse Osmosis (a) | Reverse Osmosis (a) | Cartridge Filter Test | Single Element Test Stand | Dual Element Test Stand | Multi-media Filtration | Cartridge Filtration | | |
| | 1200 gph | 600 gph | | | | | | | |
| No. of systems | 2 | 10 | 1 | 1 | 1 | 1 | 2 | 1 | several |
| Avg feed flow, gpm | 20 | 10 | | 24 | 44 | | | | |
| Dimensions, | | | | | | 30"d | | | |
| Media type | | | | | | varied | | | |
| No of stages | 1 | 1 | | 1 | 2 | | | | |
| Elements per stage | 9 | 9 | 1 | 1 | 6 | | 12 | 3 | 1 |
| Recovery, % | 30 | 30 | | 30 | 30 | | | | |
| Element type: | 6"x40"TFC | 6"x40"TFC | 10" | 6"x40" | | | 40" | 20" | 10", 20" |
| CONTROL SYSTEM: | 24 hour a day operation. | | | | | | | | |
| | Automatic shutdown on hi/lo pressure. | | | | | | | | |
| (a) Each ROWPU is skid mounted and packaged with a multi-media filter and cartridge filter which matches the throughput of the RO unit. | | | | | | | | | |

## Table 3. US Navy CEL Pilot Plant Equipment

## Table 4. US Navy CEL Laboratory Instrumentation and Specialized Equipment

1. Particle size distribution analyzer
   Hiac/Royco Model 8000 with automatic batch sampler, l-150 micron size range sensor.

2. Turbidimeters
   Hach Ratio 2000 (Process style)
   Hach Model 1720C - Low Range (Process style)
   Hach Ratio/XR (Laboratory style)
   H F Instruments, Model DRT 200A (Process style)

3. Conductivity meters
   YSI - Model 34 (Laboratory style)
   Rosemount - Model 1054C (Process style)
   Great Lakes - Model 605 (Laboratory style)
   Balsbaugh - Model 910 (Process style)
   Balsbaugh - Model 1200 (Process style)
   Lakewood (hand held)

4. pH meters
   Great Lakes -671 (Process style)
   Hach Model 2278 (Laboratory style)
   Rosemount - Model 1054pH (Process style)
   Chemtrix - Type 40 (Laboratory style)
   Beckman - Model 960 (Process style)

5. Silt Density Index Test Apparatus (2 units)

6. Dataloggers
   Orion - Model 3530
   Metrosonics - Model 714

7. Phipps & Bird Jar Test Apparatus

8. Variety of Pressure, Flow and Temperature instruments

9. Analytical equipment
   Atomic absorption spectrophotometer
   UV/VIS/NIR Spectrophotometer, Lambda 9
   Infrared Spectrometer (FTIR)
   X-Ray spectrometer, TN5502 (Noran)
   Emission Spectrometer, Plasma 40
   Gas Chromatograph
   Ion Chromatograph, Dionex
   Scanning Electron Microscope
   Thermal Gravimetric Analyzer

10. Simulated Environment Test Facilities
    Seawater Corrosion Facility
    Salt Spray Test Chamber

## CITY OF DENVER

**Department of Water Utilities**
**Denver, Colorado**

**Administrator: William Lauer**
**Telephone:** 3034284000 **Fax:** **303-795-2495**

About ten years ago, the City of Denver construct& with the support of EPA funds, an extensive multiple process pilot plant to demonstrate the effectiveness of state of the art technology in reclaiming potable water from wastewater. The conventional secondary treatment section was sized at 1 mgd, and the specialized processes such as reverse osmosis, ultrafiltration, and ion exchange were sized at 100,000 gpd.

It was a superb example of modem technology and produced high quality water. Extensive toxicological tests and animal studies were conducted and the product was proven to be as good, if not better, than the current supply.

Once the funding ran out, the demonstration plant was shutdown. Although several attempts were ma& to save the facility, including a consortium of local universities, the plant was never re-started. In the past few years, the equipment has fallen into disarray, and a significant investment will be required to re-activate the plant in its entirety. It is estimated that approximately $1 million per year will be required to maintain the facility.

A private company is now attempting to re-activate the plant, asking congressional representatives to support legislation to obtain funds for refurbishment and operating expenses. Although the future is still unclear, any attempts by other organizations at this time to re-activate the plant will be blocked by the current effort.

## COLORADO STATE UNIVERSITY

**Engineering Research Center**
**Fort Collins, Colorado 80523**

**Administrator: Prof. David W. Hendricks**
**Telephone: 303-491-8273 Fax: 303-484-3899**

The facilities at Colorado State University include a wide variety of processes commonly used in water treatment. They include: ozonation, carbon absorption, air stripping, rapid mixing, flocculation, settling, filtration, ion'exchange and membrane separation. The individual processes and the entire treatment train are capable of operation at 20 gpm (28800 gpd). The processes can be used individually for research or in any combination or series. The facility is based upon the original design of the Denver Water Reuse Demonstration Plant, but at smaller volumetric throughput.

The primary feed stream available is from Horsetooth Reservoir, adjacent to the campus, which is a drinking water reservoir. The pilot facilities were built with funds provided by the U.S. Army Corps of Engineers, but belongs to CSU. The original intent was to study advanced treatment technologies for removal of contaminants including toxic organic compounds, metals, and conventional contaminants such as viruses, bacteria, cysts, biodegradable organic compounds and salts.

Secondary effluent may be available from a nearby facility, but construction of a pipeline would be required.

Except for the filter columns which were built in 1985, the equipment is in new condition as described in their report in December 19931, describing the design and construction of the facility.

The administrator of the facility, Dr. Dave Hendricks is keen to work with NWRI in establishing a center at CSU. He has good working relationships with Dr. JoAnn Silverstein (University of Colorado, Boulder) and William Lauer (City of Denver Water Utilities Department) and others in the water treatment community.

Rather than a daily "rental cost" for the facility, the university prefers to develop a contract with the interested party, manage the research with a faculty member, with work done by graduate students. Overhead rates for facilities and support services are in line with most large universities; 45% and 19.8% respectively.

Although lacking in a variety of feedstreams, the facilities are outstanding and the process control is excellent. The facility should allow conduct of excellent water treatment research at a reasonable cost.

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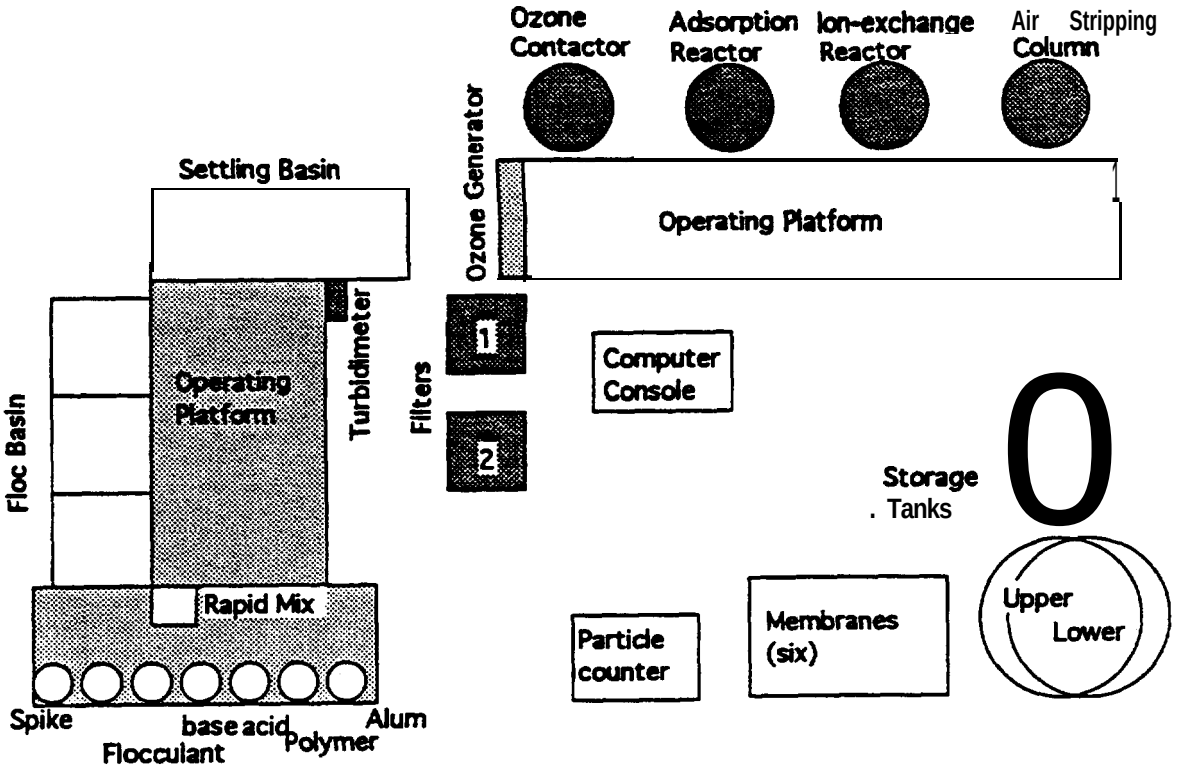
1Environmental Engineering Technical Report, "Treatment Train Modeling for Aqueous Contaminants," by Carlson, K.H., et al, Department of Civil Engineering, Colorado State University, Fort Collins, Colorado, 53-2415-93-1, December 1993.

| CENTER: | COLORADO STATE UNIVERSITY | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| LOCATION: | Ft. Collins, Colomdo | | | | | | | | |
| FEED STREAMS: | Horsetooth reservoir | | | | | | | | |
| PROCESS: | Ozonation | Carbon absorption | Air stripping | Rapid mix Basin | Flocculation | Settling Basin | Filtration | Ion Exchange | Membrane Process |
| No. of systems | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Avg feed flow, gpm | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 |
| Avg ozone dosage, mg/l | | | | | | | | | |
| Avg ozone usage, lb/d | 2 | | | | | | | | |
| Process type | column contactor | | | | | lamella | | | |
| Filtration rate. gpm/ft2 | 5 | | 350 | | | | 5 | | |
| Dimensions | 14'h | 2.5'dx18'h | 2.5'd | | 31"x93" | 4'wx4'hx8'l | 2.5'dx18'h | | |
| Mediatype | | granular | | | | | dual | cationic | |
| Media depth ft | | 10 | | | | | | 10 | |
| Detention time, min | | | | 0.5 | 30 | | | | |
| Material | | | | | acrylic/ss | | acrylic/PVC | | |
| Diffuser | ceramic | | rubberized | | | | | | |
| No of stages | | | | | | | | | 2 |
| Elements per stage | | | | | | | | | 3 (4x40) |
| Recovery, % | | | | | | | | | 75 |
| CONTROL SYSTEM: | 24 hour a day operation. | | | | | | | | |
| | 26 digital I/O points: pumps, solenoids, valves, blowers, ozone generator and proximity switches. | | | | | | | | |
| | 15 analog points: temperature, pressure, flow rate, conductivity, pH, turbidity, gaseous ozone concentration and filter liquid level. | | | | | | | | |
| | Host communicates with A/D multiplexer board, RS-232 serial connection; digital I/O boards with RS-422 connection. | | | | | | | | |
| | Software: Windows, ITouch by Wonderware; data compiled in Excel. | | | | | | | | |

**Table 5. Colorado state University Pilot Plant Equipment**

Figure 7.




RESEARCH PILOT PLANT
ENVIRONMENTAL ENGINEERING
COLORADO STATE UNIVERSITY

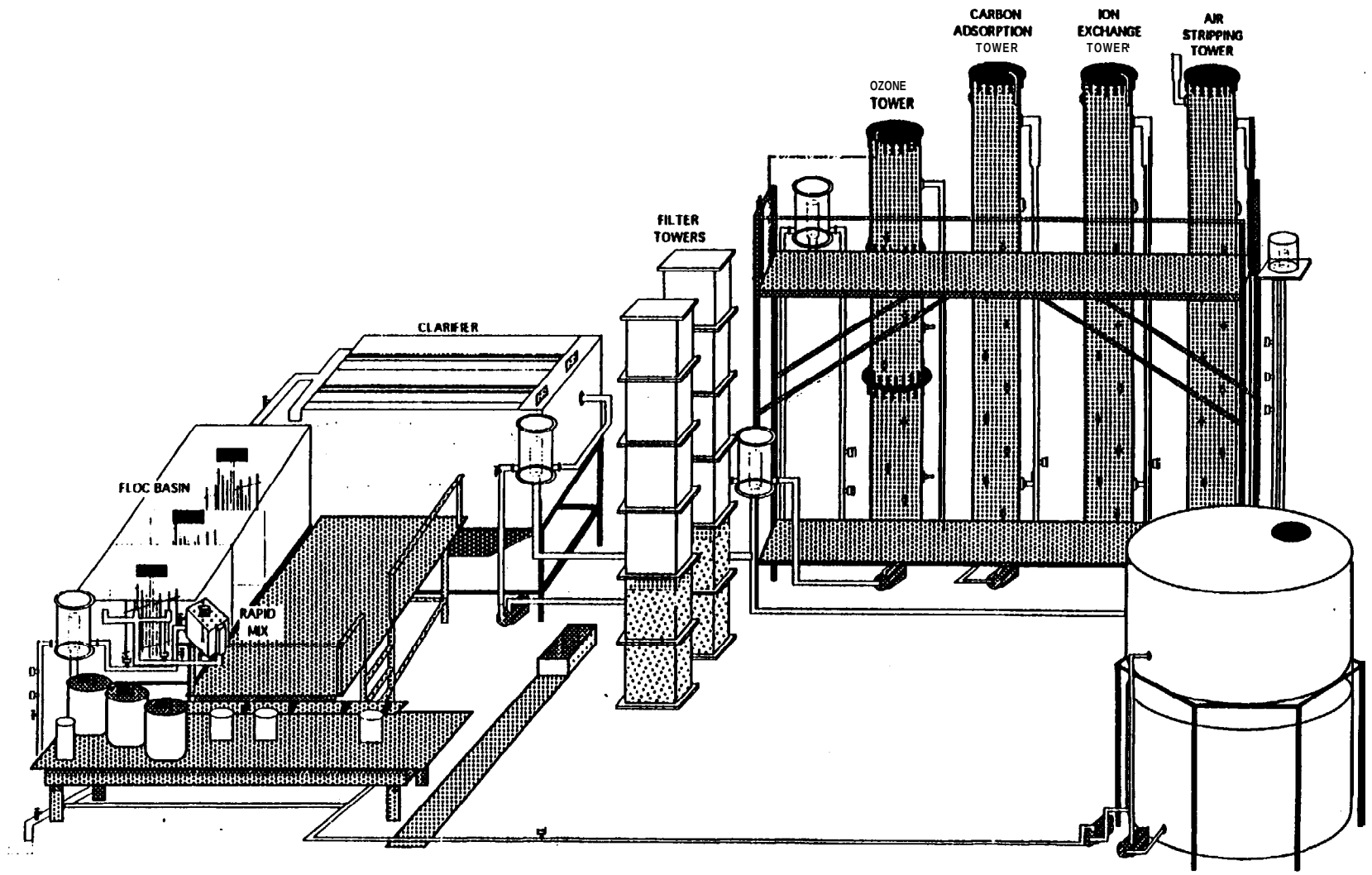
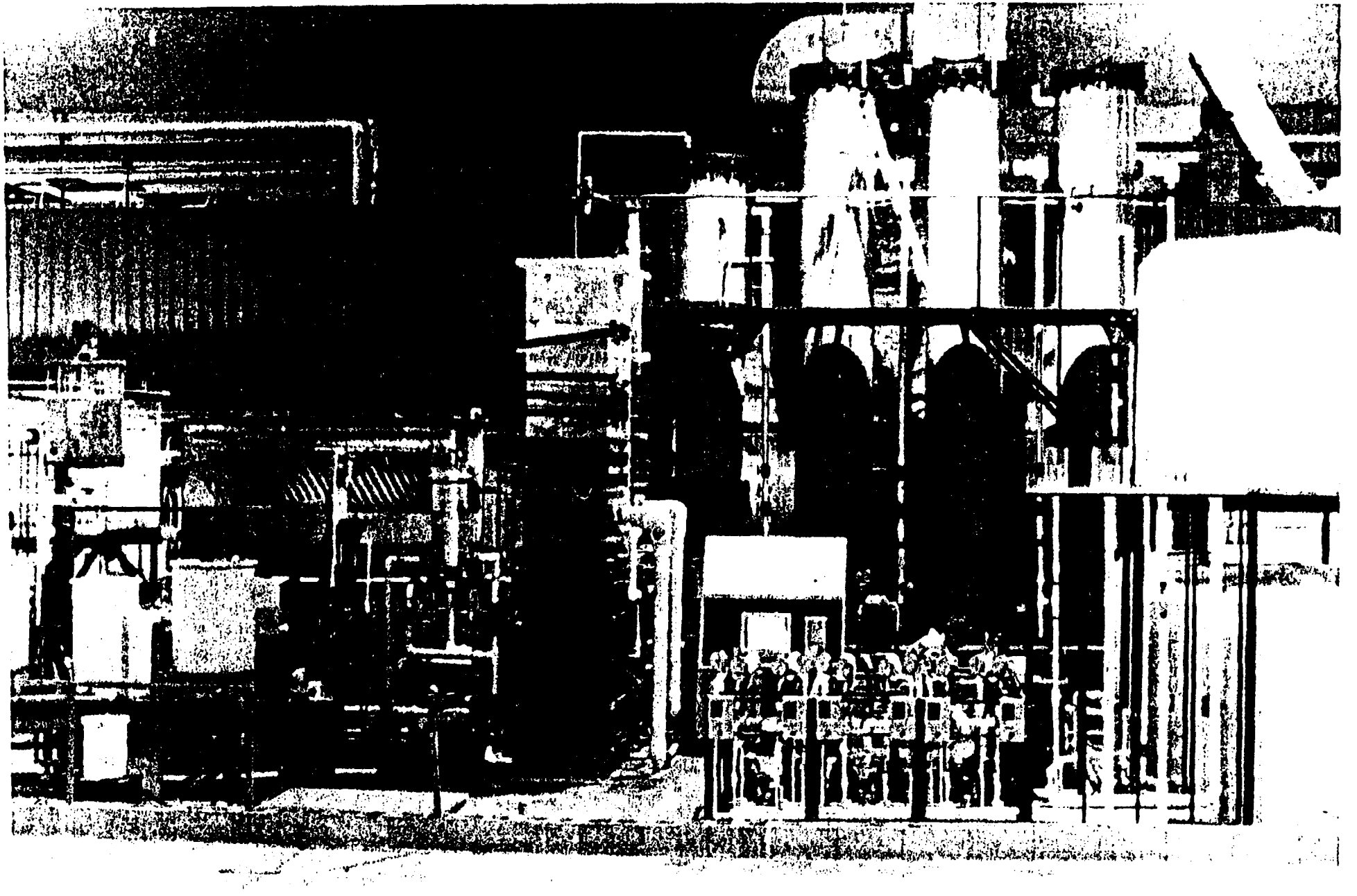



**Figure 8.**

Overview of Advanced Water Treatment Pilot Plant, Engineering Research Center, Colorado State University (membrane system not shown)



**Fipure 9. Advanced Water Treatment Pilot Plant, Engineering Research Center, Colorado State University.**

## US BUREAU OF RECLAMATION

**Technical Service Center**
**Water Treatment Engineering and Research Laboratories**
**P.O. Box 25007**
**Denver, Colorado 802250007**

**Administrator: Stan Hightower**
**Telephone: 303-236-6203** **Fax:** 303-236-8862

The Bureau of Reclamation has engaged in water desalination research and development on both laboratory and pilot scale equipment in their Denver laboratories since the late 1950's. The early R&D was conducted for the Office of Saline Water and later far the Office of Research and Technology. Nearly every electrodialysis and reverse osmosis design commercially available was tested at one time or another by the BOR.

The facilities have since expanded their interests to general water treatment and desalination. Over the years, they have developed an outstanding analytical laboratory for water.

The strongest asset at the Denver labs is the research personnel. The staff consists of 22 chemical engineers, chemists, physical scientists, environmental engineers, and chemical and civil engineering technicians. Extensive electrical/mechanical maintenance services are available through the Technical Service Center shops personnel.

Pilot scale equipment consists of skid-mounted equipment including: reverse osmosis, pretreatment, membrane cleaning skid Mobile water treatment equipment includes: granular activated carbon system, slow sand filtration, pressure filtration, reverse osmosis, nanofiltration, ultrafiltration, ultraviolet irradiation, ozonation, greensand filtration, ion exchange softening.

The BOR is currently restructuring accounting methods to determine cost of facilities, staff and overheads Current staff favors an umbrella agreement between NWRI and the BOR which would allow all participating institutions to use their facilities, without complicated separate agreements witheach. Charges are likely to be the cost of staff and direct overhead and the direct cost of utilities. Although no building/facilities overhead is anticipated, a final decision on this aspect of charges has not yet been made.

Laboratory instrumentation and specialized equipment:

1. Test cell apparatus - Simultaneous 4 x 24" membrane swatch testing
2. Photovoltaic electrodialysis - Electrodialysis cell that can be coupled to a photovoltaic array.
3. Water storage - Two 15,000 gal *storage tanks connected to* outside pump and one buried 15,000 gal tank.
4. Analytical instrumentation:
   - Scanning electron microscope with low vacuum and EDX
   - GC/MS (gas chromatograph/mass spectrometer)
   - HPLC (High performance liquid chromatography)
   - Ion chromatograph
   - ICPMS (Inductively coupled plasma mass spectrometer)
5. water laboratory
   - Completely equipped water analysis laboratory

## Table 6. BOR Denver Lab Pilot Plant Equipment

| | | | |
|---|---|---|---|
| **CENTER:** | **US BUREAU OF RECLAMATION** | | |
| **LOCATION:** | Denver, Colorado | | |
| **FEED STREAMS:** | Tapwater, synthetic solutions, various field locations | | |
| **PROCESS:** | Reverse Osmosis Skid | **Water** Treatment mobile (a) | Reverse Osmosis Test System |
| No. of systems | 1 | 1 | 2 |
| **Avg feed flow,** gpm | 6 | 6 | |
| No of stages | 1 | 1 | 1 |
| Elements per stage | | | 8 |
| **Recovery, %** | | | |
| Element type: | spiral, 4" | spiral, 4" | spiral, **2-1/2"** |
| Membrane type: | **CA, TFC** | **CA, TFC** | **CA, TFC** |

CONTROL SYSTEM: 24 hour a day operation.
**Automatic shutdown on hi/lo pressure.**

(a) Includes: chemical feed systems (lime, alum, polymer, hypochlorite, acid anti-sealant, biocide, etc.) rapid mix and flocculation system (4 gpm), **GAC system (6 gpm),** slow sand **filter** system (4 gpm), pressure filter system (6 gpm), miscellaneous support pumps, RO, ultra- and **nano-** filtration skid (6 gpm), **UV** and ozonation skids, tankage, generator, **greensand** filter, and ion exchange softener **(6 gpm).**

FLORIDA

CITY OF CAPE CORAL

**Cape Coral, Florida**

**Adminstrator: Sean Kopko**
**Telephone: 813-574-0877**

Prior to construction of a larger plant, the City of Cape Coral installed a single pressure vessel pilot unit with recirculation, to examine the maximum recovery achievable with their reverse osmosis system. Since the test was completed this small pilot plant has not been used, but can be made available for further research testing. Although the extent of research may be limited by the simple design of the unit, it provides a test bed for testing new membranes, additives, and maximum recovery.

The city is willing to work with NWRI and research partners in future research.

**FLORIDA**

**TOWN OF JUF'ITER**

**17403 Central Blvd.**
**Jupiter, Florida 33458**

**Administrator: Mr. David Brown**
**Telephone: 407-746-8343** **Fax:** 407-743-8733

The Town of Jupiter aquired a reverse osmosis pilot plant of approximately 50,000 gpd capacity, to perform tests prior to construction of their full sized plant Additional tests continue as required on the unit. The Town is willing to make the pilot plant available for research purposes as long as the project does not interfere with their day to day operations.

The pilot plant is a 2-stage unit with 4" diameter pressure vessels. It is designed for 75% recovery and has a 4:2 array of six element vessels. It is skid mounted and has rollers for portability; however, they prefer to keep the pilot plant in one location, which is adjacent to the full-sired plant It has adequate instrumentation and controls to allow collection of sufficient data for research projects. Thin film composite spiral wound elements are currently on hand for testing. The unit is designed for automatic operation and has safety switches to protect the system. Manual adjustment is required at startup.

The feedwater can be supplied by a brackish water well, or a surficial aquifer. The former has TDS of approximately 4500 to 4800 ppm; the latter has TDS of about 450 ppm. Use of the brackish water well is very convenient; use of the surficial source would require moving the pilot plant. Waste lime and concentrate are sent to aconcentrate treatment facility.

Office space is available, but limited PC computers are available, but no main frame terminals. Telephone and facsimile service are available. Limited support staff are available.

A simple wet lab is available, with an additional mini-lab for routine monitoring of the main process equipment Simple spectrophotometric analysis are done on site, but more sophisticated analysesaresenttoalocallab.

If the research to be conducted is of benefit to the Town of Jupiter, it is likely that no charges would be incurred.

## UNIVERSITY OF CENTRAL FLORIDA

### Environmental Systems Engineering Institute
### Orlando, Florida

**Administrator: Prof. James Taylor**
**Telephone: 407-375-2785** **Fax: 407-823-3315**

The Environmental Systems Engineering Institute (ESEI) is a Type II institute located within the civil and Environmental Engineering Department in the College of Engineuing at the University of Central Florida Type II institutes are not support4 by any direct funding from the State of Florida ESEI like all State University System (SUS ) institutes is a non-profit organization created specifically to enhance graduate research and education, and serve society by providing access to specific resources of the State University System.

Engineering research is a primary function of ESEI, which provides a central location for coordinating environmental projects utilizing the specific expertise of CEE and other departments at UCF. The Departments of Civil and Environmental Engineering, Biology, Microbiology, Chemistry and other s at UCF have conducted environmental projects individually and collectively that involved research, training, analysis, and education. UCF has significant capital resources invested in laboratory space, advance analytical equipment and computer technology that is available for environmentally oriented problem solving. Specific expertise within the CEE department includes potable water treatment, corrosion control, stormwater abatement, air dispersion modeling, noise abatement, solid waste, incineration, hazardous waste investigation, wastewater treatment and receiving water impacts.

All work conducted within ESEI must be funded by contracting organization as ESEI receives no direct state funding. UCF has graduated hundreds of graduate level engineers and scientists with specific environmental expertise in the past that would not have been possible unless funds from sponsored research were available for their support

The laboratory is equipped to measure trace organic and inorganic contaminants. Equipment is housed in more than 4000 square feet of laboratory space.

**The Institute was created by the** UCF to enhance environmental education and services at UCF and actively seeks interaction with all government and private organizations.

## UNIVERSITY OF SOUTH FLORIDA

**College of Engineering**
**Tampa, Florida 33620-5350**

**Administrator: Dr. Robert P. Carnahan, Associate Dean**
**Telephone: 813-974-3786 Fax: 813-974-5094**

The University of South Florida has several pilot plants, but not all of it is centrally located. A mobile trailer unit is designed to move to different sites for research and contain two 10 gpm reverse osmosis units capable of desalting seawater. The trailer also contains a 3000 gallon holding tank with temperature control. Arrays of 4" spiral wound elements or a B-9 brackish water hollow fiber permeator up to 10" diameter can be tested.

A test stand will accommodate up to 6" elements in either multielement or singleelement pressure vessels. A 100 gallons per day seawater unit for testing 2.5" elements is skid-mounted for portability. Two small hollow fiber microfilter skid-mounted units are available.

In the laboratory two high pressure and one medium pressure cells are available for flat sheet testing with varying spacers for hydrodynamic studies. Many 2.5" diameter fells are in place for quick tests on membranes.

For pre-treatment, clarifiers, filters, and cyclone separators are available in additional to conventional cartridge and media filtration.

Analytical instrumentation includes AA with graphite furnace, SEM, GC/MS, various microbiological tests, ion chromatography, HPLC and optical microscopy. A trailer mounted laboratory can be moved to different sites to support the reverse osmosis trailer.

Approximately 3000 sq. ft. of laboratory space is available. Six professors experienced as principal investigators and 15 to 20 graduate students provide support.

the University typically negotiates a cooperative agreement with the proposed research sponsors. Facilities, supplies, and purchases are indirect costs billed at 45% of faculty and student salaries.

## KAMOLE WATER TREATMENT PLANT

**Maui Department of Water Supply**
**614 Palapala Drive**
**Kahului, Hawaii 96732**

**Administrator: Paul L. Seitz**
**Telephone:** 808-243-7380 **Fax:** 808-243-7544

The Kamole Water Treatment Plant, owned by the Maui Department of Water Supply, currently consists of a 6 mgd direct filtration water treatment facility. They have installed a microfiltration pilot plant with capacity of 34 gpm. The pilot plant is instrumented with flow and turbidity recorders in addition to the standard controls for microfiltration.

The equipment condition is good, and fresh water supply is available for testing. Although there are no computer facilities at the site, both telephone and facsimile communications are in-place. No research support staff is available, but facility caretakers, maintenance, and office space are available.

Details of availability for testing and cost of facilities must be discussed with the management.

## UNIVERSITY OF HAWAII

**Demonstration Desalting Facility**
**91-591 Kalaeloa Blvd.**
**Ewa Beach, Hawaii 96707**

**Administrator: Allison Yim**
**Contact: Dr. Roger Fujioka**
**Telephone:** 808-956-7847 **Fax:** 808-956-5044

Several years ago, a demonstration plant was built near Ewa Beach, Hawaii to demons&ate the viability of reverse osmosis, electrodialysis and electrodialysis reversal for desalination of brackish groundwater. Each of the processes makes up about 1/3 mgd for a total of 1 mgd capacity. The initial tests have been completed and the facility is now run only intermittently.

More recently, a laboratory pilot plant was purchased and installed at the demonstration site for the use of the University of Hawaii. Good laboratory facilities are also available on-site.

The reverse osmosis pilot plant is rated at 2.0 gpm at 200 psi and has two pressure vessels which can be operated in series or in parallel. The plant utilizes 4" x 40" membrane elements, and is pre-treated with a 5 micron pre-filter, anti-scalant injections pumps, acid injection pump and pH control. Although membrane cleaning is not built into the plant, equipment exists on site to allow membrane cleaning when required

The pilot plant is minimally instrumented with a watt-hour meter, pressure gages, and flow meters. The site has good analytical equipment including a carbon analyzer, ion-chromatograph, HPLC, gas chromatograph, atomic absorption.

Two types of naturally occurring water are available: brackish water (caprock) and fresh water (basal). Concentrate is disposed into a conveyance ditch constructed for that purpose and is carried away from the site.

A full staff of research associates, grad students, economists, chemical engineers, chemist, civil engineer, microbiologist are available to support the research. The site is maintained and operated by a private contractor. Both PC and MAC computer facilities are available along with telephone and facsimile connections. Office space is available in the laboratory area

## UNIVERSITY OF ILLINOIS

**Environmental Engineering and Science**
**Department of Civil Engineering**
**Newmark Civil Engineering Laboratory MC 250**
**205 North Mathews Avenue**
**Urbana, Illinois 61801-2397**

**Administrator: Prof. Mark Clark**
**Telephone: 217-333-3629 Fax: 217-3339464**

The Environmental Engineering and Science program, Department of Civil Engineering, University of Illinois, is consistently one of the top four environmental engineering graduate research programs in the U.S. The normal research relationship with outside agencies and private companies is through research grants awarded to the University of Illinois. The grants usually provide graduate student and faculty support, and funds for purchase of supplies and permanent equipment. There are certain indirect costs.

During the past seven years, the university has received nearly $1 million in external grants to support membrane related research. Professors Clark, Snoeyink, and Rittmann are well known for their membrane related research. Professor Cheryan (Food Science Department) is a collaborator on some of their research and has authored a book on ultrafiltration.

The State of Illinois Hazardous Wastes and Information Center has opened extensive laboratory facilities on campus, broadening the capabilities at the university.

The EES laboratories consist of 11,000 sq. ft. of space, fully equipped for experimental research and analyses in the chemical, physical, and biological aspects of drinking water and wastewater treatment The pilot scale equipment includes two hollow fiber ultrafiltration systems. One is fully computer assisted for on-line measurement of pressure, flow, and temperature; computer assist will automatically adjust pump voltage for constant flux operation.

The other system is an automated constant flux system with special pulse dampening capability. Other pilot scale equipment is available for tests of hybrid separative systems. The units are rated between 3 and 15 gpm. Most of the work to date has been accomplished with cellulose derivative hollow fiber membranes of 0.9 mm i.d. and about 200 l/m2-hr flux. Various cartridge sixes from 20 to 100 fibers are available. Other commercial hollow fiber ultrafiltration of microfiltration membrane cartridges can be adapted to the systems.

A variety of pre- and post- treatment options are available for additional studies of complete systems. All equipment is in excellent condition. Wastewater, wastewater effluent, groundwater, and tap water sources are available for testing.

## UNIVERSITY OF KENTUCKY

**Department of Chemical Engineering**
**Lexington, Kentucky 40506**

**Administrator: Prof. D. Bhattacharyya**
**Telephone:** 606-257-2794 **Fax:** 606-257-7251

The University of Kentucky chemical engineering department has conducted pilot plant testing of membrane processes for mom than 15 years. Concentrating primarily on application of membrane technology for industrial processes, their laboratory includes reverse osmosis and nanofiltration units (8 gpm), pervaporation unit (5 gpm), standard commercial grade membrane elements, and specialty products such as the Texaco spiral wound membrane for pervaporation. Configurations include spiral wound and hollow fiber.

The laboratory has the capability of pm-treatment with microfiltration, standard filtration and ozonation. A double-pass heat exchanger is used to control feed source temperature. Adsorption can be utilized for post-treatment and ozonation can be used far disinfection.

The reverse osmosis and nanofiltration units are automated and the pervaporation unit is manually controlled. The laboratory instrumentation and analytical tools include: HP GC/MS, HPLC, TOC analyzer, UV/VIS, XPS, and other more conventional instruments. The condition of all equipment and instrumentation is excellent.

Industrial fluids and brackish water are readily available and wastewater feed source is possible.

Computer facilities include PC, MAC and main frame terminal. Excellent research support is available with graduate students, faculty supervision, and facility and equipment maintenance. The laboratory has telephone, telex, facsimile, Internet, and e-mail. Office space is available.

Tbe university has other facilities available to support research through the Center of Membrane Sciences and their material characterization facility.

Contracts for services can be either fixed price or negotiable. Usual daily rates for facilities are in the $800 to $1000 range and the daily rate for support services about $100 to $200.

## SOUTHERN NEVADA WATER AUTHORITY

### Las Vegas, Nevada

**Administrator: Bill Bellamy (CH2M-Hill)**
**Telephone: 702-369-6175 Fax: 702-369-l 107**

The Southern Nevada Water Authority purchased pilot plant equipment in 1994. It consists of direct filtration and granular activated carbon processes, capable of up to 10 gpm throughput. The pilot plant columns were installed to evaluate water treatment processes for the main plant.

The equipment is new and includes data acquisition instrumentation and particle counters. Communications consist of telephone and facsimile.

Availability of equipment will depend upon completion of ongoing process evaluation. The authority is considering construction of microfiltration and nanofiltxation pilot equipment. User fees and availability will be based upon negotiation with the Southern Nevada Water Authority. Although the pilot plant equipment is currently administered by CH2M-Hill, the equipment will revert to SNWA as soon as ongoing process evaluations are completed.

## LOS ALAMOS NATIONAL LABORATORY

**Industrial Wastewater Treatment Facility (IWTF)**
**P.O. Box 1663**
**Los Alamos, New Mexico 87545**

**Administrator: A.F. Drypolcher; Steve Hanson**
**Telephone: 505-667-4301** **Fax:** 505-665-6320

The Los Alamos National Laboratory is a world reknown laboratory facility operated by the Department of Energy. The Industrial Wastewater Treatment Facility comprises 40,000 sq. ft. of laboratory space and includes parts of plant operation plus pilot test room. Roth interior and exterior space is available. It is fully permitted (including RCRA, CWA) and has analytical, engineering, design, construction, operational personnel associated with its current operations. Several other facilities exist in addition to IWTF which allow for research in other fields.

The pilot scale equipment includes electrodialysis reversal and reverse osmosis (5 - 10 gpm), hollow line fiber ultrafiltration and centrifugal ultrafiltration (5 - 10 gpm), micro&ration and conventional filtration (5 - 200 gpm). Instrumentation and controls include AI (Expert) computer system, programmable logic control/monitoring. The laboratory features virtually every type of analytical equipment required for pilot plant testing including AA, ICP/MS, MS/OES, graphite furnace, radioisotope &termination, etc.

The facility is in fair condition and the equipment and instrumentation is in excellent operating condition. Brackish water, wastewater, wastewater effluent and other feed sources are available for testing, making this a highly versatile pilot plant test facility. The concentrate disposal is fully permitted.

Computer facilities are outstanding and include PC, MAC and terminals for mainframe computers. All types of communications are available including telephone, facsimile, Internet, e-mail and others.

Research support is available including staff, supervision, facility caretakers and equipment maintenance personnel. Since this is a government run facility, the cost of facilities and services are based solely on the facility personnel involved It is well known that the facility personnel embrace many special disciplines, and best known for expertise in radioactive waste handling, toxic wastes, hazardous waste, medical isotopes and risk analysis.

## UNIVERSITY OF NORTH CAROLINA AT CHAPEL HILL

**Department of Environmental Sciences and Engineering**
**CB# 7400, Rosenau Hall**
**Chapel Hill, North Carolina 27599-7400**

**Administrator: Dr. Philip C. Singer**
**Telephone:** 919-9663865 **Fax: 919-966-7911**

The Water Resources Engineering Program has analytical capabilities and Laboratory facilities, including a 3700 sq. ft. high bay engineering laboratory that is available for pilot-scale testing and experimentation. The high-bay laboratory has two 3000 gallon storage tanks that can be used to supply water for preparation of test solutions or suspensions, or that can be filled with the solutions/suspensions to be tested. The wastewater research center is located at a nearby wastewater treatment plant. Raw wastewater, primary or secondary effluent, or wastewater treated for nutrient removal can be piped into the center, as can sludge from any of the units or from the anaerobic sludge digesters.

Although no permanent equipment exists, pilot scale equipment can be easily brought into the facilities to be tested on an as-needed basii. The facilities were recently used to test a buoyant coarse media flocculator at flow rates up to 30 gpm and a mixed oxidant generator, and have been working with a membrane separation module for rejection of natural organic material.

Supporting analytical capabilities in the Department include state-of-the-art GCMS instrumentation, more than a dozen gas chromatographs, a number of liquid chromatographs, an ion chromatograph, particle counting equipment, total organic carbon analyzers, liquid scintillation counters, as well as conventional laboratory equipment. Extensive computer support capabilities are available. Facilities are available for PC computers and a terminal is available.

Research contracts for testing and evaluation of equipment usually have an educationcomponent and are for a period of at least six months. The budget for each contract is developed based on the objectives of the project; the budget includes support for faculty, students, technicians is appropriate, supplies and equipment. An indirect cost of 44.5% is added to the direct costs for use of the facilities.

The Department is a graduate department with 220 graduate students and 35 faculty members that cover all the major aspects of environmental sciences and engineering including water resources engineering, air pollution control, industrial hygiene, aquatic and atmospheric chemistry, aquatic and terrestrial biology, environmental policy, risk assessment, etc. Post-doctoral research associates and technicians are also employed by the Department and are supported by research grants and contracts.

Complete communications are in place including telephone, facsimile, Internet, and e-mail.

## SOUTH CAROLINA

### CLEMSON UNIVERSITY

**Ultrafiltration Laboratory**
**Clemson University**
**Clemson, South Carolina 29834-0921**

**Administrator: Prof. J.L. Gaddis**
**Telephone: 803-656-3294**

The Clemson University ultrafiltration laboratory conducted some of the pioneering investigations in the field of textile dye waste treatment, Theirs is a small research facility for ultrafiltration and microfiltration testing. Pilot plant equipment with capacity up to 16 gpm includes ultrafiltration, microiiltration, and nanofiltration. A heat exchanger is piped into the loop for feed temperature control and pre-treatment consists of a cartridge filter. Disinfection is accomplished with heat or chemical addition. Membranes are cleaned chemically.

Instrumentation on the pilot equipment includes flow rate, temperature, pressure, pressure drop, pH, viscometer. Analytical equipment includes flow, conductivity, on campus support from other departments. Wastewater, wastewater effluent and process water are available feed sources. The condition of the facilities is good.

Both PC and MAC computers as well as a mainframe terminal are available. Communication is by telephone, facsimile, Internet, and e-mail. Office space is available.

Research support staff is available with graduate students and faculty supervision. Facility and equipment are maintained by department technicians.

Availability of facilities and services is usually by special arrangement with an estimated cost of $2000. Charge for facilities and services is by negotiation.

## RICE UNIVERSITY

**Department of Environmental Science and Engineering**
**P.O. Box 1892**
**Houston, Texas 77251**

**Administrator: Prof. Mark R Wiesner**
**Telephone:** 713-527-4951 **Fax:** 713-285-5203

The Department of Environmental Science and Engineering at Rice University has capability for both bench scale and small volume pilot plant testing. A wide variety of membrane filtration equipment is available with flow rates from 1-19 liters/minute (0.26-5.02 gpm). Ceramic and polymeric membranes are available as well as hollow fiber, and tubular configurations. For pre-treatment, standard cartridge filtration with the possibility of coagulation, PAC and others are available. A separate cleaning skid is on-site. The equipment is in good to excellent condition.

**Wastewater, wastewater** effluent, produced waters and industrial waste water feed sources are attainable and **brackish** water or seawater is possible.

Both PC and MAC computer facilities are available. Communications are by telephone, facsimile and **e-mail. Although office space** is not available, good research support can be found. In addition to faculty supervision and graduate student help, a technical editor is on staff. Facility upkeep and maintenance of equipment is handled by graduate students and specialty campus shops.

The standard overhead rate at the department is 50%. The university would envision working on research projects in conjunction with **NWRI.**

## TEXAS A&M UNIVERSITY SYSTEM

**Food Protein Research and Development Center**
**FM Box 183**
**College Station, Texas 77843**

**Administrator: Dr. K.C. Rhee, Director; Prof. Sefa Koseoglu**
**Telephone: 409-845-2741** **Fax:** 409-845-2744

The Food Protein Research and Development Center got its name from the extensive research initiated at the university in food protein research. Since that time, the pilot scale facilities have been expanded to include water and wastewater research and development. Five separate fully-equipped pilot plant facilities are available and additional space is available for expansion and diversification of facilities. The center now has specialized discipline in membrane based separations both aqueous and non-aqueous.

Pilot scale equipment includes extraction (aqueous and non-aqueous), spray drying, membrane systems, thin film evaporators. Flow rates range from small to 150 gpm depending upon the unit operation selected. Membranes available include microfiltration, ultrafiltration, nanofiltration, reverse osmosis in both laboratory and commercial sixes. Several multi-purpose pilot units have explosion proof capability. The laboratory also includes various types of heat exchangers, centrifuges, screens, homogenizers, ion exchange columns, carbon filtration columns. Typical disinfection is by HTST pasteurizer or chemical methods. Membrane cleaning equipment is available based on recommendations from manufacturers.

Instrumentation and controls are available. Analytical equipment includes gas chromatography, HPLC, GC/MS, infrared spectrophotometry, UV-VIS, atomic absorption.

Wastewater and wastewater effluent feed streams are available as well as synthetic solutions. Samples are often shipped from point of origin to the laboratory for tests, Concentrate disposal is via city sewer.

The center has 25 full-time employees and 5 section heads are available for supervision Facility caretakers are on-site and the university provides 24 hr/d maintenance. Computer facilities for both PC and MAC are available as well as terminals for plug in. Telephone, telex, facsimile, Internet, and e-mail are available. Office space is available.

The cost of facilities varies considerably, depending upon circumstances and the number of employees involved in the research. It ranges from $250 to 2500 per day, which includes both facilities and support services. University rules and regulations determine the contract type as it depends upon whether it is a research or a service contract

## UNIVERSITY OF TEXAS • AUSTIN

**Separations Research Program**
**Chemical Engineering Bldg. 4.404**
**Austin, Texas 78712-1062**

**Administrator: Dr. James R Fair**
**Telephone: 512-471-3689 Fax: 512-471-7060**

The Separations Research Program at the University of Texas at Austin is a cooperative industry/university program which performs fundamental research of interest to chemical, biotechnological, petroleum refining, gas processing, pharmaceutical, and food companies. Specific areas of technology covered by the program include: Adsorption/chromatographic separation, liquid/liquid extraction, supercritical fluid technology, membrane technology, flue gas desulfurization and acid gas treating, and water and wastewater treatment,

Equipment and facilities are provided in two research buildings. The Center for Energy Studies/Center for Electromechanics Building at the Balcones Research Center has administrative offices, multiple laboratories, and large-scale separation related equipment including extraction/distillation test system (18" diameter), adsorption/desorption test system (3" diameter), supercritical extraction test system (4" diameter), membrane test system, waste oxidation test systems. The membrane units include a low pressure pure water system, a high pressure water/organic system, and an industrial membrane unit,

The Chemical and Petroleum Engineering Building on the main campus also provides laboratory and office space. This building houses most of the bench-scale equipment including membrane research apparatus for liquid mixtures, high-pressure, single- and multiple-component gas permeation cells, polymer fabrication laboratory, reactors for sulfur dioxide with hydrated lime.

A highly qualified team of University of Texas at Austin faculty, staff and graduate students are available to carry out fundamental separations research. Approximately 50 graduate and postdoctoral personnel are involved in the projects.

Telephone, facsimile, e-mail are accessible.

## U.S. ARMY

**Mobility Technology Center Belvoir (MTCB)**
**AMSTA RBWE, Bldg. 325**
**10115 Gridley Rd., Suite 128**
**Fort Belvoir, Virginia 22060-5843**

**Administrator: Thomas H. Bagwell, Jr.; Fred Balling**
**Telephone: 703-704-3348** **Fax:: 703-704-3360**

The U.S. Army has conducted laboratory and pilot plant testing at their Fort Belvoir location for many years. One of the most well known designs to result from their past work is the Reverse Osmosis Water Purification Unit (ROWPU), which have been used extensively in the recent middle east conflict and at disaster areas such as Somalia and Rwanda

The facility contains a chemistry laboratory, reverse osmosis test room, an indoor test site as well as a Potomac River Test Site and a Fresh Water Pond Site. These sources provide access to a variety of water quality problems. A variety of reverse osmosis and other membrane filtration equipment is available, as well as pre-treatment and post-treatment methods. Facilities are capable of accepting other pilot plant equipment. Flow capacities up 70 gpm are possible with existing pilot plants, which are capable of accepting commercial membranes ranging in size from 2-1/2" x 14" to 8" x 40". Gas/refrigerant, liquid/water, and titanium coil heat exchangers are available.

The equipment is instrumented far flow rate, temperature, pressure, conductivity, and pH measurement. Analytical equipment on site includes SDI, TSS, HPLC, TDS, DO, particle size distribution, pH, turbidity, chloride. Feedstreams include brackish water, seawater, and Potomac River water. Concentmte is disposed via city sewer. Equipment, instrumentation and facilities are in good condition.

Support staff available is limited and researchers should anticipate providing their own supervision. Facility caretakers are available, but maintenance of equipment is the responsibility of those that come on-site. Telephone, facsimile, Internet and e-mail are on-site, but office space is not available. Cost of facilities and limited support must be negotiated on a case by case basis.

## CITY OF EVERETT

**Everett Water Treatment Plant**
Everett, **Washington**

**Adminstrator: Mr. Clair Olivers; Peter Berger, Plant Supervisor**

The City of Everett installed a pilot plant at their Everett Water Treatment Plant as a vehicle to determine the optimum filter media for their feed stream. Originally built at a cost of $100,000, it consists of 4 column filters constructed of 3" PVC, 2 each 4 stage floc basins, and an ozone generation and ozonation section. The ozone process is capable of either multiple or single pass treatment. Other features include an initial flow distribution section and backwash module.

They have jointly participated with University of Washington in earlier tests. Due to the nature of the process, a strong commitment of time and manpower is required to obtain good steady state data. Since it is now in storage, some expense will be incurred to reassemble the pilot plant. It can be broken down into modules and shipped.

The incoming water quality at the Everett Water Treatment Plant is typically high quality, often exhibiting turbidity of <0.5 NTU. Additional data to be attained at this site is limited, but could include analysis of DBPs from ozonation.

## SALT ROCK WATER TREATMENT PLANT

### Salt Rock, West Virginia

**Administrator: Ben Movahed, Boyle Engineering**
**Telephone: 301-925-2700 Fax: 301-925-4783**

The Salt Rock Water Public Service owns and operates a conventional surface water treatment plant. Due to high turbidity, they are in the process of upgrading the plant to include 2.5 mgd microfiltration. A pilot plant test, using rented commercial equipment, was conducted earlier to determine design parameters. Another test is contemplated in the near future.

Although the site is a potential site for future testing, it would not be considered an ideal site due to the intermittent operation; the plant 'operates 12-14 hours per day with shut down at night. Additionally, the power supply has proven inconsistent,

# 3.0 LABORATORY FACILITIES .

## 3.0 LABORATORIES

This section describes those locations where pilot scale equipment is not available for research purposes, but laboratory facilities are available which can facilitate testing. All of those listed indicated a desire to collaborate with NWRI and partners in future research. In general the laboratories identified were owned by universities, with one exception of a privately owned laboratory. All were extensively equipped with instrumentation and sophisticated analytical tools which will greatly aid further thermal and membrane systems researchy. Each can provide highly qualified research staff support.

The laboratories are listed by state. Unfortunately, due to the required publication date for this first National Facilities Survey, some of the contacted institutions could not submit answers to the questionnaire in sufficent time for inclusion in this report. That data will be included in subsequent reports.

## ARIZONA

## UNIVERSITY OF ARIZONA

**Chemical and Environmental Engineering**
**Building 72, Room 306**
**Tucson, Arizona**

**Administrator:** Prof. **Ray Sierka**
**Telephone: 602-621-6044** **Fax: 602-621-6048**

The University of Arizona does not currently own pilot plant equipment that could be utilized in a research testing program. They have extensive analytical and laboratory equipment which could support pilot plant testing and space is available. The environmental engineering laboratory covers 3000 $ft^2$ on the third floor and basement of the civil engineering building on the main campus.

The university is currently engaged in conducting pilot plant research and development with a reverse osmosis system owned by the contracting company. The research is in the field of pulp and paper manufacturing. Extensive testing has already been conducted[1,2].

The general areas of expertise include physical-chemical treatment of water and wastewater for reuse purposes by adsorption with activated carbon, oxidation with ozone and other chemical oxidants, membrane processing including ultrafiltration and reverse osmosis and heterogeneous photocatalysis of toxic and hazardous pollutants.

The director of the environmental engineering program, Dr. Raymond Sierka has participated as a consultant in the development of many innovative and unique processes, including a wastewater treatment pilot system which processed all inclusive liquid wastes from a field army hospital. The project required knowledge of state of the art wastewater treatment processes and equipment as well as unconventional combinations.

UNIVERSITY OF ARIZONA, **continued**

**Laboratory instrumentation and specialized equipment:**

1. Sepa cells for flat sheet testing - 138 cm2

2. Membranes - all commercial flat sheet membrane

3. Heat exchangers: cooling water

4. Pre-treatment:
   Ozone generator
   Hydrogen peroxide injector
   Ultraviolet irradiator

5. Disinfection:
   Ozone generator
   Chlorine injector

6. Instrumentation
   Liquid chromatograph
   Liquid scintillation counter
   Ultra low level dissolved organic carbon analyzer
   Low level dissolved organic carbon analyzer
   Total Organic Haline Analyzers
   Gas chromatograph with ECD detector and 3390A integrator
   Gas chromatograph with flame ionization detector and 3392 integrator
   Atomic absorption spectrophotometer with HGA-40 graphite furnace
   Scanning WMS spectrophotometer
   Particle counter
   Phase contrast and epifluorescence microscopes
   Image analysis system with 386 comuter interface
   Two ozone generators
   Biostat MD benchtop fermentor
   Seven benchtop fermentors
   Biological oxygen monitor
   Manometric respirometers
   French hydraulic press and biological cell
   Automatic titration pH-stat
   Refreigerated centrifuge
   Benchtop microcentrifuge
   Ultrafiltration cells
   Reverse osmosis/ultrafiltration flat sheet test cells
   various other lab instruments.

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[1]Sierka, R.A. and H.G. Folster, JJ. Avenell, "The Treatment of Whitewaters by Adsorption and Membrane Techniques," 1994 International Environmental Conference proceedings, Technical Association of the Pulp and Paper Industry.
[2]Sierka, R.A. and J.A. Avenell, HJ. Angell, "An Evaluation of Membrane Treatment of a Sulfide Kraftmill Wastewater," 1992 Environmental Conference Proceedings, Technical Association of the Pulp and Paper Industry.

## CALIFORNIA

### SAN DIEGO STATE UNIVERSITY ,

**College of Engineering, Mechanical Engineering**
**San Diego, California 92182-0191**

**Administrator: Dr. Preston Lowrey**
**Telephone: 619-594-5652 Fax: 619-594-6005**

The San Diego State University mechanical engineering department is engaged in the laboratory scale batch testing of a novel concept to drive distillation, using an open cycle chemical heat pump and saturated calcium chloride solutions. The laboratory testing is to prove the concept, The equipment is instrumented with data logger, pressure gages, and other necessary instruments.

The facilities are equipped with both PC and MAC equipment and the staff is composed of associate professor, graduate students, seniors and one technician. Telephone, facsimile, and e-mail comprise the laboratory communications.

The work at the university is unique and innovative; the university is actively contacting industry to market this invention[1].

[1] Lowrey, Preston, "Salinity Powered Distillation of Freshwater from Seawater Using Plastic Sheet Heat Exchangers," San Diego State University, R/OE-18, 1990-92.

## SEPARATION SYSTEMS TECHNOLOGY

**4901 Morena Blvd, Bldg. 809**
**San Diego, California**

**Administrator: Mr. Robert L. Riley**
**Telephone: 619-581-3765** **Fax: 619-581-1211**

Separation Systems Technology is one of the few privately held research laboratories. The company occupies 2400 ft2 in a fully equipped laboratory and testing facility. All equipment in the facility is of latest state of the art design and is in excellent condition. Following is the pilot equipment available at the facility:

- Twenty element reverse osmosis test system. The system can be operated in either once through or recirculation mode. Elements, 2" x 12", are tested in the parallel mode. The system is mobile and accommodates pressure up to 200 psi.
- Twelve element reverse osmosis test system. The system operates in the once through mode only. Chemical addition is optional. Usual element size is 2" x 12" and normally tested at line pressure.
- Reverse osmosis flat sheet test cell system; brackish water and seawater testing, capable of operation up to 800 psi.
- MF, UF, RO single element test system; 2.5" x 40" spiral wound elements, 250 psi maximum pressure.
- MF, UF, RO single element test system; 2.5" x 26" sprial wound elements, 250 psi maximum pressure.
- MF, UF pilot plant; mobile, cross flow system; 150 psi maximum pressure.
- Three MF flat sheet test cell systems, cross-flow, for determining pure water flux and MW cutoff.
- Spiral element rolling machines and associated equipment,
- Spiral element autopsy equipment for all sizes. Dye testing, vacuum testing, foulant analysis, etc. Detailed analysis reports are provided.
- Laboratory scale membrane casting machine for processing MF, UF and RO membranes.
- Continuous large scale membrane casting machine for processing MF, UF and RO membranes.
- Spiral element test systems for microbiological evaluations.
- Transparent membrane test cell system for evaluation of spiral element spacer materials, cleaning solutions, etc.

The instrumentation and analytical equipment at the facility is extensive and facility has MAC computer facilities. Communications are by telephone and facsimile. Research support is available from scientists and technicians as well as supervision by the owners. The company is owned by Rob Riley, Clyde Milstead and Ken Tagami, all well known scientists and practitioners in the membrane industry.

Limited office space is available. Additional space is available in the laboratory for' placement of pilot plant skids if required. The laboratory has completed numerous membrane separations contracts for both private companies and public agencies.

## CALIFORNIA

### STANFORD UNIVERSITY

### UNIVERSITY OF SOUTHERN CALIFORNIA

Both of these prestigious universities have extensive capabilities in water resources and desalination research. Both have participated in National Water Research Institute studies and are committed to the program.

Questionnaire responses were not received in sufficient time to include in this first printing of the National Facilities Survey.

## CALIFORNIA

### UNIVERSITY OF CALIFORNIA

**Berkeley, California**
**Davis, California**
**Irvine, California**
**Riverside, California**
**San Diego, California**

The University of California system has participated in water and wastewater treatment research for many years. One or more of the above mentioned campus locations have participated with the National Water Research Institute in research programs and have indicated a strong interest in continuing the relationship. Although none of the above are known to have pilot scale facilities, they have laboratory facilities capable of supporting research programs and could facilitate small pilot scale experimentation.

Due to the imminent deadlines for this first Facilities Survey, written documentation from these locations was not received in time for publication.

## UNIVERSITY OF COLORADO

**Civil Engineering Department**
**Chemical Engineering Department**
**Boulder,** Colorado 80309-0424

**Administrator:** **Prof. Jo Ann Silverstein, Civil Engineering**
**Prof. Richard Noble, Chemical Engineering**
**Telephone:** **303-492-7211** (Civil) **Fax: 303-492-7317**
**303--492-6100(Chem)** **303-492-4341**

Two departments at the University of Colorado are currently engaged in water resources research. The Civil Engineering Department, under Dr. Silverstem, has conducted research in biological systems and will have a pilot facility installed at a field location in northern Colorado. The Chemical Engineering Department has established an NSF Industrial/University Center for Separations Using Thin Films, under the chairs of Drs. Krantz and Noble, where they are focused in four major areas: reversible chemical compkxation, membrane morphology and performance, catalytic membrane reactors, and membrane fouling.

Both departments have extensive facilities, instrumentation and analytical tools. These include:

Scanning electron microscopy
Transmission electron microscopy
Wavelength dispersive X-my analysis
Energy dispersive X-ray analysis
Auger electron spectroscopy
Low energy electron diffraction
X-ray photoelectron diffraction
High resolution electron energy loss spectroscopy
Infrared thermal video imaging
Nuclear magnetic resonance spectroscopy
High resolution mass spectroscopy
Automatic X-ray spectroscopy
Fourier transform ifrared spectroscopy
High pressure liquid chromatography
Differential scanning calorimetry
Thermal gravimetric analysis
Ellipsometry
Temperature programmed reaction systems
Low and high pressure membrane flow lsystems
Static chemisorption system
Ultrasonic time domain reflectometry

Both departments support the NWRI National Centers concept and would participate in joint programs.

## ILLINOIS INSTITUTE OF TECHNOLOGY

**Department of Chemical and Biological Science**
**Chicago, Illinois 60616**

**Administrator:** Prof. **Dale Webster**
**Telephone: 312-567-3491** **Fax: 312-567-3494**

Although IIT does not have pilot scale equipment available, the institute has an extensive laboratory with state of the art instrumentation and analytical equipment. The laboratory is equipped to do modern biological and chemical research.

An innovative research project initiated at IIT, in collaboration with General Atomics, embraces the concept of a sodium ion pump utilizing proteins to move sodium ions. It is one of the projects funded by NWFU and represents one of the few new, innovative approaches to separation membranes.

Wastewater, wastewater effluent and synthetic solutions can be utilized to conduct separations research Well qualified research support staff are available including the following disciplines: biochemistry, microbiology, molecular biology and genetics, analytical chemistry.

The laboratory is fully equipped with PC, MAC and main frame terminal and has excellent communication facilities.

## JOHNS HOPKINS UNIVERSITY

**Department of Geography and Environmental Engineering**
**Baltimore, Maryland 21218**

**Administrator: Dr. Charles O'Melia**
**Telephone: 410-516-7092 Fax: 410-516-8996**

The Johns Hopkins University Department of Geography and Environmental Engineering has a complete analytical laboratory with full capability for inorganic and organic constituent analyses in water. Bench-scale testing equipment is available to conduct both batch and flow reaction process research. Column-scale equipment is available for simulation of groundwater flow and direct filtration processes including ultrafiltration membranes. The bench-scale equipment is capable of up to 200 ml/min.

Laboratory pretreatment resulting in distilled water or deionized tap water is available at several locations. Disinfection can he accomplished with ozonation and chlorination.

They have extensive capability for organic and inorganic chemical analysis, microbiologic research, particle measurement, and radiotracer analysis. In addition to more standard instrumentation, the laboratory includes refrigerated centrifuge, Lambda 3 spectmphotometer, ion chromatograph, particle counting and sizing analyzer, atomic absorption spectrophotometer with graphite furnace and auto sampler, *W* visible recording spectmphotometer, electrophoresis system, photon correlation spectrophotometer, liquid scintillation counter. Organic analysis instrumentation is even more extensive than the inorganic analyzers detailed above.

The environmental engineering and science laboratories total 5000 sq. ft. Four environmental chambers are installed for controlled temperature research (4°C, 20°C, 22°C, 35°C). Computer resources are available in the Department Computer Laboratories. Personal computers and terminals with access toethernet and mainframe computers (IBM, Digital (VAX), and AT&T). Adequate office space is available.

## MONTANA STATE UNIVERSITY

**Center for Biofilm Engineering**
**409 Cobleigh Hall**
**Bozeman, Montana 59717-0398**

**Administrator: Dr. Nick Zeiver**
**Telephone: 406-994-4770 Fax: 406-994-6098**

The Center for Biofilm Engineering does not possess pilot plant equipment, but it is imminently qualified to perform biofilm research and development. The engineering research center has the capability to do bench scale evaluation of the impact of biofilms on separations equipment.

The Center's mission is to address industrial environmental and medical aspects of biofilm processes. It conducts basic and applied research to resolve industrial problems to strengthen U.S. competitiveness. Industrial participation is an essential part of research planning. Some of the Center's industrial associates include AWWARF, Amoco, Aramco, ARCO, Calgon Corp., Chevron, Clorox, Ccmoco, Dow Chemical, Exxon, Idaho National Engineering Laboratory, Nalco Chemical, Olin Chemical, Orange County Water District, Procter & Gamble, Johnson Wax, Union Carbide.

Approximately 30 research staff and 40 students are available to support projects, with about 10 PhD principal investigators. They specialize in biofilm research, biofilm measurements, biofilm simulation and modeling.

## RENSSELAER POLYTECHNIC INSTITUTE

**Membrane Separations**
**Chemical Engineering Department**
**Troy, New York 12180-3590**

**Administrator: Dr.** Georges **Belfort**
**Telephone: 518-276-6948 Fax: 518-276-6376**

Rensselaer Polytechnic Institute has been involved in fundamental hydrodynamic and membrane separations research far many years. Dr. Belfot is globally recognized for his work in this field The membrane separations laboratory conducts fundamental studies with sophisticated analytical tools.

Although no pilot scale equipment is currently on-site, the facilities can be easily modified to accommodate pilot testing. The laboratory equipment includes reverse osmosis, nanofiltration, ultrafiltration, microfiltration (cross flow), Taylor Vortex Units. The flow rates are small laboratory type flows with variable cross-flow velocities. Flat sheet, tubular or any commercial membranes can be tested. The laboratory equipment, instruments and facilities are in excellent condition.

Brackish water, seawater, wastewater, wastewater effluent and synthetic solutions are available for testing. Instrumentation and analytical equipment include ATR/IR, ESCA, SEM, UV among others.

The research staff includes one professor principal investigator and eight graduate students. Special disciplines of the staff are membrane fouling and cleaning, module design and improvement Office space is available, but limited. All types of communications are available, and both PC and MAC computers as well as terminals are on site.

Charge rates for facilities and services are by negotiated agreement with the university.

## UNIVERSITY OF PENNSYLVANIA

**Department** of **Mechanical Engineering**
29'7 **TB/6315**
**Philadelphia, PA 19124-6315**

**Administrator: Dr. Noam Lior**
**Telephone: 215-898-4825 Fax: 215-573-2065**

The University of Pennsylvania was one of the early institutions to conduct experimentation for the desalination industry. Led by **Professor Lior,** it is also one of the few who have the capability to study evaporative processes such as flash evaporation. The department has particular expertise in **desalination,** heat transfer, fluid mechanics, thermodynamics, and instrumentation.

The test **facility** contains both small and large reactors for the fundamental study of flash evaporation, with complete instrumentation. Components for a facility for fundamental study of reverse osmosis and membrane distillalion are also in place. Although currently not in use, the equipment can be made operable quickly, if funding is available.

**Various** heat exchangers (condensers) are available as well as complete instrumentation for precise **temperature** and pressure measurement, conductivity, and flow rates. Analytical equipment includes gas chromatography and conductivity in addition to the normal analytical equipment common to modem day university laboratories.

A support staff of principal investigator, **technicians,** graduate and undergraduate students as well as **facility** and **maintnenance** personnel are **avaialble.** All communications except telex are available, and office space is available on a limited basis.

Brackish water **feed** source is available in addition to tap water. The rate **for** facilities and services is negotiated by the university on a case by case basis. The **university** is anxious to participate in the centers concept.

## UNIVERSITY OF TENNESSEE I OAK RIDGE NATIONAL LABORATORY

**Center for Environmental Biotechnology**
**10515 Research Drive, Suite 300**
**Knoxville, Tennessee 37932-2575**

**Administrator: Dr. David C. White**
**Telephone: 615-974-8030** Fax: **615-974-8086**

The Center for Environmental Biotechnology does not have any pilot scale equipment, but is very much interested in continued involvement in the analysis of biofilms that foul membranes. They use the signature lipid biomarker technology developed by the Center for the in situ analysis of the viable biomass, community structure, and the nutritional/physiological status of the biofouling membranes in collaboration with samples from the Orange County Water District

They would welcome samples for analysis from the Yuma, Arizona BOR facility as well as others.

Assay types offered by the Center and their affiliated analytical company, Microbial Insights, Inc., include: phospholipid fatty acids (viable biomass, community structure, nutritional status, toxicity Eukaryote/prokaryote ratio), poly ß-hydroxy alkanoate (unbalanced growth/Nutritional Status), steroids (microeukaryote community structure, fungi, protozoa, algae), Lipopolysaccharide (identifies gram-negative bacteria), diglyceride (DC/PLFA dead to viable cells; community structure of each), triglyceride (Steroid/TG eukaryote nutritional status), respiratory quinones (proportions of aerobes anaerobic fermenters, and anaerobic respirers).

# 4.0 PRIVATE SECTOR COMPANIES

## COMMERCIAL COMPANIES

In addition equipment available through governmental facilities, cities and water districts, and universities, many commercial companies own pilot scale equipment which they use in validating applications for their own produced product, or in completing engineering studies. The fall into the general categories of product or systems related companies and engineering consultant companies.

The companies represented below have indicated their willingness to participate in the "Centers" concept. A short synopsis of the company an&r pilot scale equipment, if available, follows. The following list of companies is not intended to be a complete list, but rather a representative list of companies who were contacted in the time available for this initial survey. The use of the equipment, via rental, lease, or cooperative agreement, will depend upon its availability.

### AMERICAN ENGINEERING SERVICES
**Tampa, Florida**

AES has manufactured membrane systems for several years from their California manufacturing facility. They recently moved to Tampa, Florida to be closer to their main business activity. They currently have a seawater desalting pilot plant with nominal 8000 gpd capacity. It is a simple one stage system with manual controls. It rents for about $200 per day.

### DOW CHEMICAL COMPANY
**Midland, Michigan**

The Dow Chemical Company acquired FilmTec Corporation nearly 10 years ago and is the largest manufacturer of spiral wound membrane elements. They offer thin film composite membranes for reverse osmosis and nanofiltration. Ultrafiltration is also offered. Their focus is on membrane production and distribution and they leave most of the applications research requiring pilot plant testing in the hands of their OEMs. They are currently testing a commercial prototype at the Orange County Water District, and have expressed a strong interest in the NWRI progmms since their inception. They have a 60,000 gpd trailer mounted membrane system available for rent or lease which accommodates either nanofiltration or brackish water desalting membranes. It is manually operated, with chemical pm-treatment, cartridge filtration and a cleaning skid

### DUPONT DE NEMOURS
**Wilmington, Delaware**

The DuPont Company manufactures hollow fiber reverse osmosis membrane permeators for seawater and brackish water desalination. Their current focus is on seawater membranes, for which they have the largest installed capacity of all membrane manufacturers. They have been particularly successful in the middle eastern countries. Although the company does not possess pilot plant equipment far research and development, it is likely that many of their licensees do. Time did not permit contacting all of the licensees, but it is safe to assume that the size of equipment available is approximately the same as with other commercial companies. DuPont is willing to participate in research progmms which fit their current research direction.

## FLUID SYSTEMS / ANGLIAN WATER
**San Diego, California**

The Fluid Systems Company, recently acquired by Anglian Water Company (UK), manufactures spiral wound ultrafiltration, nanofiltration, and reverse osmosis membranes for use in various water related applications. They manufacture both cellulose acetate and thin film composite membranes. Two skids are available which can utilize commercial membranes of 2-1/2" and 4" design. They contain pressure vessels in 2:2: 1: 1 array, each housing 3 membrane elements. This allows either parallel or series connection, with up to 75+/-% recovery. The usual commercial rate for rental is $1500 per month, plus the cost of membranes. Cellulose acetate membranes (4") are typically $225 and thin film composite membranes (4") are typically $300.

## H'ARN RO SYSTEMS
**Venice, Florida**

Ham has manufactured small to medium sized plants far many years and in more recent years have manufactured multi-million gallons per day systems. Their pilot plant is nominally rated at 13-21 gpm and is a microprocessor based system, fully automated and multiple data point data collection. Data can be telemetered to a central location, allowing operational flexibility. Their pilot plant systems are typically mounted on fibre reinforced plastic frames to prevent corrosion, and stainless steel tubing is electropolished. Standard rental rates are about $5000 per month plus membrane cost.

## HYDRANAUTICS
**San Diego, California**

Hydranautics is a commercial company which sells reverse osmosis, nanofiltration and ultrafiltration membranes. Owned by Nitto Denko (Japanese), Hydranautics offers both cellulose acetate blend and thin film composite membranes. Their product mix includes tubular and hollow fiber devices in addition to spiral wound, and is the broadest product mix offered in the industry. Their mobile trailer unit is a nominal 20,000 gpd unit with a simple 2:1 array. Cost of rental or lease is about $2000 per month.

## IONICS, INC.
**Watertown, Massachusetts**

Ionics is the pioneer in the desalting industry, having begun commercial sale of electrodialysis desalting equipment in the late 1950's. In recent years they have diversified by moving into reverse osmosis systems, water production, water sales, privatized plants, instrumentation and several other areas which make them them a versatile company. They have several pilot plants, including both electrodialysis reversal and reverse osmosis.

## OSMONICS, INC.
**Minnetonka, Minnesota**

Osmonics is one of the early manufacturers of cellulose acetate membranes. They have historically specialized in the industrial markets and have many pilot plants for testing purposes. In recent years they have broadened their product line to include pumps, instrumentation, cartridge filters, and others. They are one of the larger corporations in the business.

## ENGINEERING COMPANIES

Consulting engineers often conduct on-site pilot plant testing to verify performance prior to final design of large water treatment and purification plants. Most of the leading companies have pilot plant equipment, both skid-mounted for shipment, or mobile for rapid transfer. Although they are primarily used to aid them in customer related engineering tests, they are not always utilized. When they are not in use, they can be made available for use by researchers, on a rent or lease basis, or by negotiating a cooperative agreement.

Listed below are some of the companies contacted during the initial phase of this survey. The list is not a comprehensive one, but it does indicate the types of pilot plant equipment available and the extent of their availability.

### CAMP DRESSER MCKEE
**Walnut Creek, California**

CDM has established a capability to design and construct pilot plant facilities, and has done so for municipalities and water districts. They also maintain their own pilot plants for use at various project sites.

### CH2M-HILL
**Gainesville, Florida**

CH2M-Hill have conducted pilot scale testing throughout the U.S. and particularly in Florida, where membrane softening has dominated the scene for new water treatment plant construction. Both skid-mounted and mobile equipment are available from this company. Typical charge for a complete, sophisticated mobile trailer mounted unit is about $4500 per mouth. Exact charges are a function of the situation and cooperative effort negotiated. Both conventional and advanced treatment pilot plants are available.

### MALCOLM PIRNIE, INC.
**Newport News, Virginia**

Malcolm Pirnie has several plants which they utilize for engineering studies. They include: (1) skid mounted RO, 3-stage, nominal 30 gpm flow rate, designed for pressures up to 600-800 psi. Estimated rental fee is $2500 per month. (2) Single element test stand for 2-1/2" membrane elements for testing nanofiltration or reverse osmosis membranes. (3) Microfiltration hollow fiber test skid, nominal 2 gpm flow rate. Simulates full scale operation. (4) Hollow fiber ultrafiltration membrane skid with nominal 4 gpm flow rate.

### MONTGOMERY WATSON
**Pasadena, California**

One of the largest consulting engineering firms, Montgomery Watson has a wide array of pilot scale equipment available, including reverse osmosis (mobile), ultrafiltration, ozonation, ultraviolet,ozonation, coagulation/sedimentation/filtration, media filters, air stripping, chlorine contact chambers, granular activated carbon. Sizes range from 5 gpm to 1 mgd The company has an Applied Research Department, fully staffed to support research and development projects.

Table 6. TYPICAL COMMERCIAL PILOT PLANTS

| CENTER: | COMMERCIAL COMPANIES | | | | | |
|---|---|---|---|---|---|---|
| LOCATION: | united states | | | | | |
| COMPANY: | Fluid Systems | CH2M-Hill | CH2M-Hill | CH2M-Hill | Ionics, Inc. | Memtek |
| PROCESS: | Reverse osmosis | Membrane | Membrane | Conventiona Treatment | Electrodialysis Reversal | Microfiltration |
| No. of systems | 2 | 1 | 1 | 1 | 1 | 1 |
| Skid mounted | x | x | | | | |
| Mobile | | | x | x | x | x |
| Rated flow, gpm | 15 | 15 | 15 | 5 | 17 | 30 |
| No of stages | 4 | 3 | 3 | | | 1 |
| Elements per stage | 3 | 3 | 6 | | | |
| Element size | 2-1/2", 4" | 2-1/2", 4" | 4" | | Aquamitev . | 30M10 |
| Recovery, % | 75 | 75 | 75 | | | |
| Membrane type: | CA, TFC | CA. TFC | CA, TFC | | ED | |
| Approximate cost (per mo) | $1500.00 | | $4500.00 | | $7000.00 | $3000.00 |

NOTE: This represents a small sampling of commercially available water purification equipment, which are available for rental or lease.

# 5.0 APPENDIX

| SITE | LOCATION | AVAILABILI | LAB | PP | FAC ONLY | MEMB | BIOL | PRETR | DISIN | THERM | COST |
|---|---|---|---|---|---|---|---|---|---|---|---|
| California DWR | Fresno, CA | yes | | x | | | x | | | | OH=25% |
| Los Alamos National Laboratory | Los Alamos, NM | yes | | x | | x | | x | x | | TBN |
| NIST | Boulder, CO | doubtful | x | | | | | | | | n/a |
| US Army Tank Automotive R&D Ctr | Ft. Belvoir, VA | yes | | x | | x | | x | x | | nominal |
| USBR R&E Laboratory | Denver, CO | yes | | x | | | | | | | TBN |
| USBR Yuma Desalter | Yuma, AZ | yes | | x | | x | | x | x | | n/a |
| USN Civil Eng Lab | Pt. Hueneme, CA | yes | | x | | x | | x | | | ~$25-50/day |

TBN = To Be Negotiated

## Table 7. State or Federal Facilities

| SITE | LOCATION | AVAILABILITY | LAB | PP | FAC ONLY | MEMB | BIOL | THERM | PRETRT | DISINF | COST |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Arlington Desalting Plant | Riverside, CA | yes | | | x | | | | | | TBN |
| City of Cape Coral | Cape Coral, FL | needs work | | x | | x | | | | | TBN |
| City of Denver | Denver, CO | on hold | | x | | x | | x | x | x | TBN |
| City of Everett | Everett, WA | yes, future * | | x | | | | | x | x | TBN |
| City of Jupiter | Jupiter, FL | yes * | | x | | x | | | | | TBN |
| City of Los Angeles | Angeles, CA | yes | | | x | | | | | | TBN |
| City of San Diego | San Diego, CA | yes * | | x | | x | | | x | x | TBN |
| City of San Francisco | San Francisco, CA | yes | | x | | x | | | | | TBN |
| City of Scottsdale | Scottsdale, AZ | future | | x | | x | | | | | TBN |
| Contra Costa Water | Concord, CA | yes | | x * | | | | | x | | TBN |
| Irvine Ranch Water District | Irvine, CA | yes | | x | | x | | | x | | TBN |
| Metropolitan Water District | Los Angeles, CA | future | | x | | x | | | x | | TBN |
| Metropolitan Water District | La Verne, CA | future | | x * | | x | | | x | | TBN |
| Orange County Water District | Fountain Valley, CA | yes | | x | | | | | | | TBN |
| Salt Rock WTP | Salt Rock, WVA | yes | | | x | | | | | | TBN |
| Santa Clara Valley Water District | Santa Clam, CA | questionable | | x | | | | | | x | TBN |
| So, Nevada 'Water Authority | Las Vegas, NV | future | | x | | | | | x | | TBN |

TBN = To Be Negotiated

## Table 8. City or Water District Facilities

| SITE | LOCATION | AVAILABL | LAB | PP | FAC ONLY | THERM | MEMB | BIOL | PRETR | DISINF | COST |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Arizona State Universit | Tempe, AZ | doubtful | | | | | | | | | |
| Cal Tech | Pasadena, CA | no | x | | | | | | | | |
| Clemson University | Clemson, SC | yes | x | x | | | x | | | | $2000/day negotiable |
| Colorado School of Mir | Golden, CO | no | x | | | | | | | | |
| Colorado State Universi | Ft. Collins, CO | yes | | x | | x | x | x | x | x | 45/19.8% (fac./lbr)OH |
| Illinois Institute of Tec | Chicago, IL | yes | x | | | | | | | | |
| Johns Hopkins Univers | Baltimore, MD | yes | x | | | | | | | | |
| MIT | Cambridge, MA | no | | | | | | | | | |
| Montana State Universi | Bozeman, MO | yes | x | | | | x | | | | |
| Renssalear Polytechnic | Troy, NY | yes | x | | | | | | | | |
| Rice University | Houston, TX | yes | x | | | | | | | | |
| San Diego State Univer | San Diego, CA 92182-( | yes | x | | | x | | | | | |
| Stanford University | Stanford, CA 94305-40 | yes | x | | | | | | | | |
| Texas A&M University | College Station, TX | yes | | x | | x | x | x | x | x | $250-2500/day |
| UC Berkeley | Berkeley, CA | no reply | x | | | | | | | | |
| UC Davis | Davis, CA 95616 | no reply | | | | | | | | | |
| UC Irvine | Irvine, CA | no reply | | | | | | | | | |
| UC Irvine Wtr Res | Irvine, CA 92717 | no reply | | | | | | | | | |
| UC Los Angeles | Los Angeles, CA | yes | | x | | | x | | x | x | |
| University of Arizona | Tucson, AZ | doubtful | x | x | | | | | | | |
| University of Central Fl | Orlando, FL | yes | x | x | | | x | | x | x | |
| University of Colorado | Boulder, CO | yes | | x | | | | x | | x | |
| University of Colorado | Boulder, CO | yes | x | | | | x | | x | x | |

## Table 9. University Owned Facilities

| SITE | LOCATION | AVAILABL | LAB | PP | FAC ONLY | THERM | MEMB | BIOL | PRETRT | DISINF | COST |
|---|---|---|---|---|---|---|---|---|---|---|---|
| University of Hawaii | Honolulu, HI 96822 | yes | | x | | | | | | | |
| University of Illinois | Urbana, IL | yes | | | | | | | | | |
| University of Kentucky | Lexington, KY | yes | | x | | x | x | | | | $800/day negotiable |
| University of Nebraska | Lincoln, NE | yes | | x | | | | x | | | |
| University of North Car | Chapel Hill, NC 27599 | yes | | x | | | | | | | |
| University of Pennsylv | Philadelphia, PA | yes | x | x | | x | | | | | |
| University of So. Califc | Los Angeles, CA | yes | x | | | | | | | | |
| University of South Flo | | yes | | x | | | | | | | |
| University of Tennessee | | yes | x | | | | | | | | |
| University of Texas | Austin, TX | yes | | x | | x | x | | | | |
| Virginia Commonwealth | Richmond, VA | no | | | | | | | | | |
| Virginia Tech Universit | | no | | | | | | | | | |
| Washington State Univ | Pullman, WA 99164-65 | no reply | | | | | | | | | |

## Table 9. University Owned Facilities

| SITE | LOCATION | AVAILABI | LAB | PP | FAC ONLY | THERM | MEMB | BIOL | PRETRT | DISINI | COST |
|---|---|---|---|---|---|---|---|---|---|---|---|
| American Engineering Services | Tampa, FL | yes | | x | | | x | | | | $200/day |
| Aqua Chem | Waukesha, WI | probable | | x | | x | | | | | TBN |
| Boyle Engineering Corp | Newport Bch, CA | yes | | x | | | x | | x | | TBN |
| Camp Dresser McKee | Walnut Creek, CA | yes | | x | | | x | | | | TBN |
| CH2M-Hill Engineers | Gainesville, FL | yes | | x | | | x | | x | x | $4500/month |
| Dow Chemical | Midland, MI | yes | | x | | | x | | | | TBN |
| DuPont de Nemours | Wilmington, DE | yes | | x | | | x | | | | TBN |
| Fluid Systems/Anglian Water | San Diego, CA | yes | | x | | | x | | x | | $1500/mo |
| Ham RO Systems | Venice, FL | yes | | x | | | x | | | | $5000/mo |
| Hydranautics | San Diego, CA | yes | | x | | | x | | | | $2000/mo |
| Ionics, Inc. | Watertown, MA | yes | | x | | | x | | | | $7000/mo |
| Malcolm Pimie | Newport News, VA | yes | | x | | | x | | | | TBN |
| Montgomery Watson | Pasadena, CA | yes | | x | | | x | | x | x | TBN |
| Osmonics, Inc. | Minnetonka, M N | yes | | x | | | x | | | | TBN |
| Separation systems Technology | San Diego, CA | yes | x | x | | | x | | | | TBN |

TBN = To Be Negotiated

## Table 10. Privately Owned Facilities

# R&D FACILITIES SURVEY

One of the goals of the NWRI facilities survey is to identify institutions having pilot scale equipment, which can be made available for others to use for thermal and membrane separation R&D. If you have pilot scale facilities available and would like to participate in the NWRI R&D program, please provide the following information:

. Name of facility: _____

Address: _____

Name, title of manager, professor, administrator in charge:

_____

. Owner of facility: _____

. Physical description of facility: _____

_____

_____

Pilot scale equipment

Processes available for testing: _____

Flow capacity (GPM): _____

Membranes available (type, size): _____

Auxiliary equipment

Heat exchangers (type, capacity): _____

Pre-treatment: _____

Post-treatment: _____

Disinfection: _____

Membrane cleaning: _____

Instrumentation: _____

Analytical equipment: _____

Feedstreams available:

Brackish water- Seawater- Wastewater___ WW effluent- Other-

Concentrate disposal:

City sewer- Surcharge **Off-site___** Special **conditions____**

Computer facilities:

**PC_x__** M A C - **Terminal available___**

. Condition of equipment, instrumentation, **facilities:** _____

_____

• [illegible] **support:**

**Staff:** _____

Supervision available: _____

Facility **caretakers:** _____

Maintenance: _____

. **Special** [illegible] _____

. Special conditions: _____

• [illegible]

**Telephone____ telex___** facsimile- **Internet___ E-mail___ Other services___**

. **Photographs** of facilities

. physical layout (drawings where available)

. **Office space:** Available-

* Approximate cost to NWRI for use of facilities

Daily rate for facilities: _____

Daily rate for support **services:** _____

. Overheadrate: _____

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