State of California
The Resources Agency
DEPARTMENT OF WATER RESOURCES
San Joaquin District
Planning Branch

TECHNICAL INFORMATION RECORD ON THE ION-EXCHANGE SYSTEM AT THE LOS BANOS DEMONSTRATION DESALTING FACILITY

by

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This Technical Information Record (TIR) was prepared to document information developed between March 1, 1984, and September 1, 1986. It should be considered preliminary and subject to revision. This is primarily an internal office document with distribution limited to interested individuals and cooperating agencies. The use of trade names is not to be construed as an endorsement of any product or firm.

June 1994

CONVERSIONS

Measurement	To Convert	To	Multiply By
Concentration	mg/L of Ca	meq/L	0.050
	mg/L of Mg	meq/L	0.082
	mg/L of Na	meq/L	0.0435
	mg/L of total hardness	meq/L	0.02
	mg/L of Cl	meq/L	0.0282
	mg/L of SO_4	meq/L	0.0208
	meq/L (any ion)	mg/L as $CaCO_3$	50
	ppm	mg/L	1
	grains/gallon	mg/L	17.12
	grains/gallon	lb/million gallons	142.86
Volume	liters	milliliters	1,000
	gallons	liters	3.785
	cubic feet	gallons	7.48
Mass	grams	milligrams	1,000
	grains	milligrams	64.80
	pounds	grams	453.59
	grams	grains	15.43
	pounds	grains	7,000
Resin capacity	eq/L of resin	lb/cubic foot (as $CaCO_3$)	3.129
	eq/L of resin	lb/cubic foot (as NaCl)	3.661
	lb/cubic foot	grains/gallon	935.8

DEFINITIONS OF CHEMICAL CONSTITUENT ABBREVIATIONS

Abbreviation	Definition
Ca	Calcium
CO_3	Carbonate
Cl	Chloride
Cl_2-F	Free chlorine
DOC	Dissolved organic carbon
EC	Electrical conductivity
Mg	Magnesium
Na	Sodium
SiO_2	Silica
SO_4	Sulfate
TDS	Total dissolved solids
TH	Total hardness
TOC	Total organic carbon
Turb.	Turbidity

FOREWORD

This is one in a series of reports that presents the results of operations conducted by the California Department of Water Resources (DWR) at its demonstration desalting facility in Los Banos, California, between 1984 and 1986.

The Los Banos Demonstration Desalting Facility was the principal feature of DWR's Reverse Osmosis Demonstration Project, which was designed to test the feasibility of disposing of agricultural drainage water by reclamation and reuse in California's San Joaquin Valley.

The Valley contains large areas of agricultural land with subsurface drains. These drains collect brackish water that cannot, generally, be recycled for on-farm use. Consequently, large quantities of drainage water in the Valley must be disposed of in an environmentally safe manner. Reclamation of drainage water by desalting and solar salt-gradient ponds is one acceptable disposal technique. At its Los Banos facility, DWR experimented with a combination of pretreatment, desalting, and brine disposal methods to facilitate reclamation.

One fact that emerged clearly after extensive study of the drainage water disposal problem is that a solution (or solutions) will be expensive. Still, the cost of reclaiming drainage water and reducing its annual volume to manageable quantities could possibly be offset by the production -- at an integrated facility -- of salable water, salts, and solar energy.

The Reverse Osmosis Demonstration Project was formulated to study this possibility. The project began in 1980 with (1) preparation of a conceptual design for a test facility and (2) selection of an engineering consultant to design and build the facility. Construction began at Los Banos in the spring of 1982 and was completed in the summer of 1983 -- the same year that testing of the facility's drainage water pretreatment systems began. Small-scale ion-exchange and reverse-osmosis unit operations commenced in the summer of 1985, and full-scale operations of these units were initiated later that year.

The summer of 1985 also witnessed the filling and stratifying of the facility's solar salt-gradient pond, which reached full operating temperature (190 degrees Fahrenheit) in the summer of 1986. A vapor-compression-evaporator type of desalting unit also went on line in April 1986.

Activities at the desalting facility concluded in the fall of 1986 except the solar pond test operations, which continued through 1989.

LABeck

Louis A. Beck, Chief
San Joaquin District

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Recognition is also given to Los Banos Demonstration Desalting Facility
personnel whose hard work and dedication made this report possible.

CHAPTER I. INTRODUCTION

The basic objective of ion exchange (IX) as a pretreatment process at the Los Banos Demonstration Desalting Facility was to remove calcium ions from the feedwater and thereby reduce calcium sulfate and calcium carbonate scaling tendencies within the reverse-osmosis (RO) and electrodialysis (EDR) desalting units. The unique feature of the Los Banos IX system which was tested was the use of reject desalting brine for regeneration of the resin. Conventional IX systems regenerate resin using sodium chloride brine.

IX for calcium removal is commonly referred to as softening, and the IX process consists of passing hard water through the resin bed of an ion exchanger. In the bed, hardness components (calcium, magnesium, and other divalent cations) are removed from solution and replaced by sodium ions. In practice, the exchange rate is so rapid that most water can be easily and completely softened at normal flowrates regardless of hardness. The IX process removes both calcium and magnesium ions, although magnesium ion removal is not necessary for RO pretreatment.

The IX process uses synthetic resins as carriers for the exchange of sodium ions and divalent cations. Such resins, with their high exchange capacities and controllable properties, make large-scale IX both practical and feasible. Some exchange resins have a high affinity for a particular ion, while others do not. Commercial resins are broadly classified as strong acid, weak acid, strong base, and weak base. Several combinations of the various cation- and anion-exchange resins can be used to demineralize water through the removal of both cations and anions. Strong-acid cationic resins are best for treating water with high total electrolyte levels.

Other conditions being equal, adequate contact during both regeneration and softening phases of the IX process is the most important requisite in successful cation-exchange water softening. Other important factors include hardness of the process water, chemical composition of the regenerant brine, depth of resin in the column, sufficient flowrates, and composition of the exchanger (resin). In addition, if continued maximum contact is to be secured, reasonably clear water must be applied to the exchanger to prevent colloidal or suspended matter from fouling the exchanger's surface.

Besides softening water, the IX process removes varying amounts of multivalent cations -- including barium, strontium, iron, and manganese. Even an IX unit whose softening capacity is exhausted will continue to remove these potentially troublesome ions from water. Periodic special flushing and regeneration procedures are required to remove iron and manganese from IX resins.

IX resins are confined in vessels where flows of water and regenerants are accurately controlled. Softening equipment is designed to operate with either pressure or gravity flows. Pressure vessels for softeners are made of steel or fiberglass, while gravity softeners are generally made of concrete or steel. Gravity softeners are usually used where a large water capacity is required; they are similar to gravity filters in that they can be readily inspected and maintained. The pressure softeners generally operate downflow, while gravity units commonly operate either downflow or upflow. Large municipal water-softening plants use gravity-flow softeners.

IX operations are classified as concurrent (conventional) or counter-current. Concurrent operation is when regeneration and service flows occur through the IX column in the same direction. In counter-current operation, flows for service and regeneration occur in opposite directions. Both operations usually use sodium chloride brine for regeneration. Operations at the Los Banos facility tested counter-current operation with upflow regeneration using RO reject brine as the regenerant. Sodium chloride brine was used in bench-unit testing and during the initial startup operations of the main units.

A perceived advantage of using RO reject brine instead of sodium chloride brine is reduction of the amounts of water and sodium chloride salt required for regeneration. In addition, RO reject brine can be used more than once since the amount of new regenerant available per cycle is fixed by the amount of water produced in the service mode and concentrated as reject by the desalting process. Figure 1 shows a simplified flow schematic for the IX process with RO brine regeneration.

There are several other advantages of using RO brine in the counter-current upflow regeneration process. For one, the fully exhausted resin containing the highest concentration of absorbed calcium ion is atop the resin bed. When calcium breakthrough occurs at the bottom of the bed, upflow regeneration minimizes the average depth of bed through which the eluting calcium ions must pass. This, in turn, minimizes the average contact time between the resin and the portion of eluting regenerant containing the highest levels of supersaturated calcium sulfate. In addition, if the regeneration flowrate is sufficient, the supersaturated spent regenerant is removed from the column before scaling of the resin occurs. Furthermore, due to the upward flow, the bed becomes fluidized and allows any recently formed calcium sulfate precipitate to be removed easily.

Another advantage of counter-current flow operation is that effluent from the column during service consists of water in equilibrium with the most fully regenerated resin at the bottom of the bed. This fact results in lower calcium leakage than with the concurrent flow operation.

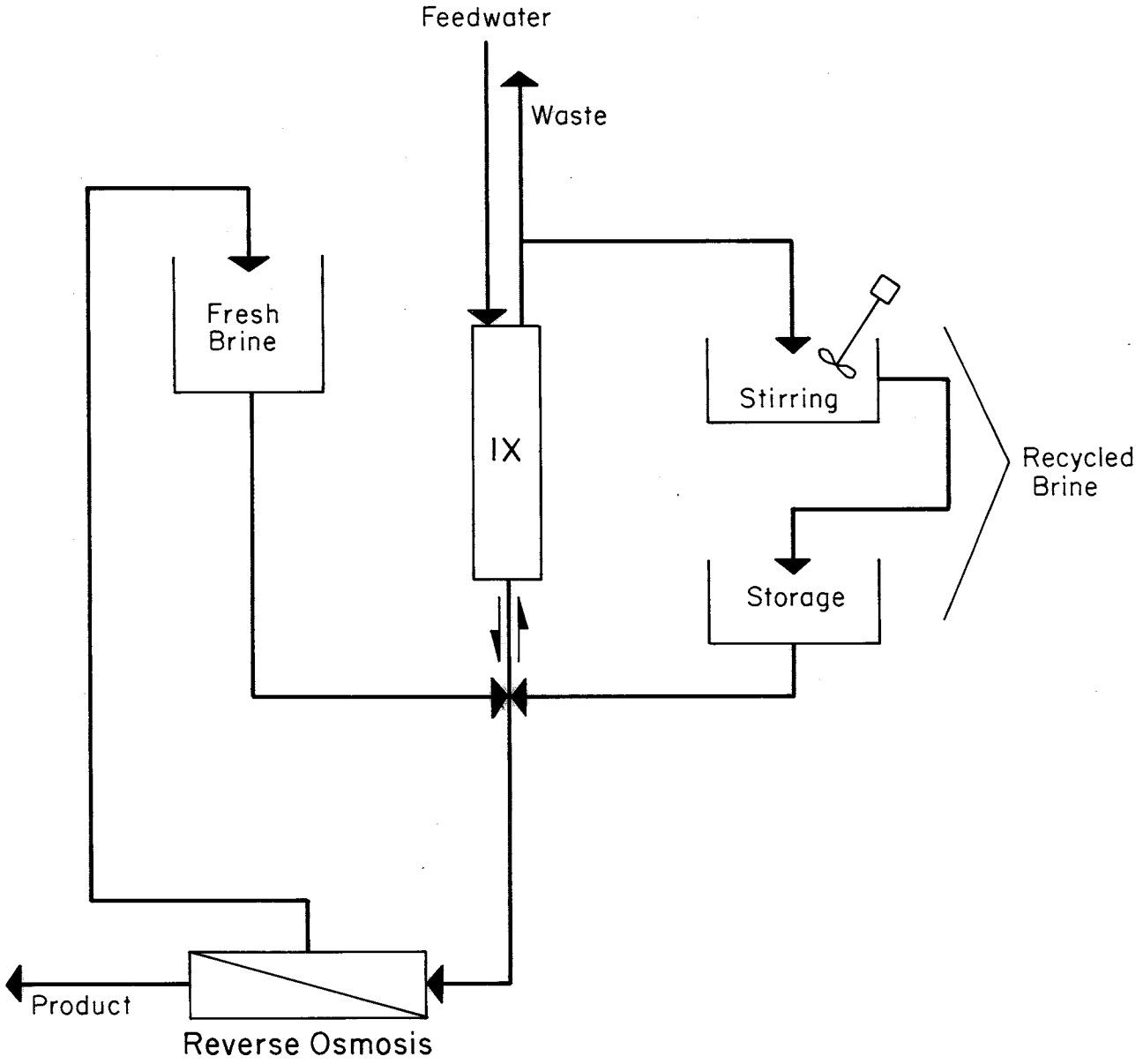


Figure I. Simplified Flow Schematic for Ion Exchange Process with Reverse Osmosis Brine Regeneration

CHAPTER II. REQUIREMENTS

IX softening was the final pretreatment process prior to desalting of agricultural drainage water by RO. The base study for the Los Banos project projected the quality of the San Luis Drain water to be around 6,000 total dissolved solids (TDS), but the drain remained at 9,000 TDS for the duration of the project. Design of the RO system was based on IX effluent of the design 6,000-TDS water, but RO membrane manufacturers provided requirements for water at 150-percent design quality. Typical constituent concentration of the San Luis Drain water and the recommended RO influent requirements at 150-percent design water quality are shown in Table 1.

TABLE 1

SAN LUIS DRAIN WATER QUALITY AND
RECOMMENDED REVERSE-OSMOSIS INFLUENT REQUIREMENTS
(mg/L)

Chemical Component	San Luis Drain Water Quality (3-13-85)	Recommended RO Influent Requirements*
Calcium (Ca)	514	15.0
Magnesium (Mg)	268	6.0
Sodium (Na)	1,990	3,150
Iron (Fe)	0.02	0.01
Potassium (K)	5.6	6.0
Manganese (Mn)	0.25	0.01
Ammonium (NH_4)	0.05	--
Bicarbonate (HCO_3)	168.4	172.5
Sulfate (SO_4)	4,280	2,073
Chloride (Cl)	1,380	2,073
Nitrate (NO_3)	190	138
Boron (B)	15	22.5
Silica (SiO_2)	8.6	18.0
Total dissolved solids	9,220	9,261

*Based on 90-percent fresh water recovery and 150-percent design water quality.

The IX process is primarily concerned with removing calcium ions to prevent calcium sulfate from scaling RO membranes. The RO system can be operated at higher calcium concentrations than those listed in Table 1 with use of a threshold inhibitor or operation at a lower fresh water (permeate) recovery rate.

CHAPTER III. FACTORS AFFECTING THE ION-EXCHANGE PROCESS

The effectiveness of the IX process depends principally on softening and regeneration factors. These factors, along with a brief explanation of the probable effects they have on the hardness removal capacity of the resin, are discussed below.

1. Softening factors

   a. Hardness ion concentration. For a given hydraulic loading rate, as the hardness concentration of influent feedwater increases, the capacity of the resin (total amount of hardness removed) decreases while the leakage (amount of hardness in the effluent process water) through the bed increases. The lower the hardness leakage, the better the system's performance.

   b. Sodium-to-hardness ion ratio. Sodium ions compete with hardness ions for space on the resin. As the sodium-hardness ratio increases, the resin's ability to remove hardness decreases and hardness leakage through the bed increases.

   c. Total dissolved solids. As the total dissolved solids concentration increases, the resin's capacity decreases and leakage through the bed increases.

   d. Temperature. An increase in temperature generally increases the resin's ability to remove hardness and decreases hardness leakage.

   e. Hydraulic loading rate. High loading rates may cause channeling through the IX columns, resulting in lower service (softening) durations because the entire bed is not being used for softening.

2. Regeneration factors

   a. Type of brine. The brine (sodium chloride or a desalting process reject) used for regeneration determines the regeneration mode. Standard softening practices use sodium chloride brine for regeneration. The use of a desalting process' reject brine for regeneration is experimental in nature and requires a special regeneration procedure in which a portion of the reject brine is used more than once. Some constituents of the reject brine may inhibit the regeneration process.

   b. Concentration of brine. As the concentration of sodium within the brine increases, the capacity of the resin is generally increased until a concentration is reached that results in a maximum resin capacity. Once past this "optimum" concentration, the brine approaches saturation and tends to cause resin shrinkage and inhibit the migration of ions both into and out of the solid phase. At brine strengths below optimum range, fewer sodium ions are available at any one time to displace hardness ions, and regeneration is less efficient.

c. Brine contact time. Contact time is the interval between the first contact of the brine with the resin and the moment the brine is rinsed from the resin bed. Resin capacity increases as the contact time increases, until contact time provides no additional advantage for a given brine concentration and hydraulic loading rate.

d. Hydraulic loading rate. High loading rates may cause channeling through the bed and result in unequal resin regeneration.

CHAPTER IV. DESCRIPTION OF FACILITIES

The IX system was comprised of two identical skid-mounted units. Process water was pumped from the filter clearwells, dechlorinated, processed through the IX units, and rechlorinated before entering the IX clearwells. Regeneration of the IX units was accomplished by pumping brine (recycled and fresh) through the IX units. Design of the system also allowed for upflow, counter-current regeneration.

Each unit had two vertical, cylindrical columns (5 feet in diameter and 8 feet high) in parallel. Internally, each column was fitted with three water distribution manifolds at the top, middle, and bottom levels. The manifolds were designed to maintain even flow distributions through the bed to prevent channeling of the flows through the tanks. The manifolds consisted of a 3-inch-diameter header with 1-inch-diameter laterals. The upper and middle manifold headers were made of Schedule 80 PVC; the bottom header was made of steel. All laterals were made of Schedule 80 PVC and wrapped with PVC screen to prevent resin loss.

Each column contained the high-capacity, polystyrene-sulfonated, strong-acid, cationic exchange resin. The depth of the exchange resin was 5 feet, which corresponded to a volume of 85 cubic feet per column.

Control valves regulated flows into the columns. Each unit had five control valves with different flowrates. Two valves regulated service and rinse event flows; the remaining three regulated flows for various regeneration and backwashing events. All flow valves were interchangeable. For testing purposes, three auxiliary control valves were supplied for both units.

The units werre capable of upflow regeneration without fluidization using air as the method of resin holddown. An advantage of resin holddown over fluidized-bed regeneration is closer contact between regenerant and resin, resulting in higher mass transfer rates and increased resin capacities. In addition, higher regenerant flowrates allow for faster regeneration and higher service factor time.

The IX units contained numerous electrically operated valves and pumps. During the IX cycle, the resin bed underwent servicing, backwashing, regenerating, draining, and rinsing. A microprocessor unit controlled most functions of the IX system. Flow schematics for softening and regeneration for the IX system at the Los Banos facility are shown in Figures 2 and 3, respectively.

The two IX units were designed to be operated in sequence so that one unit was always in service while the other was in regeneration or standby, thus ensuring a continuous supply of softened process water.

Because the presence of excessive amounts of chlorine in the process water can result in gradual swelling and subsequent capacity decline of exchange resin, each IX unit was equipped with a dechlorination system consisting of a chemical injection pump and a 100-gallon batch solution tank. A sodium bisulfite solution was injected into the process water during backwashing, rinsing, and servicing before the water entered the IX unit columns.

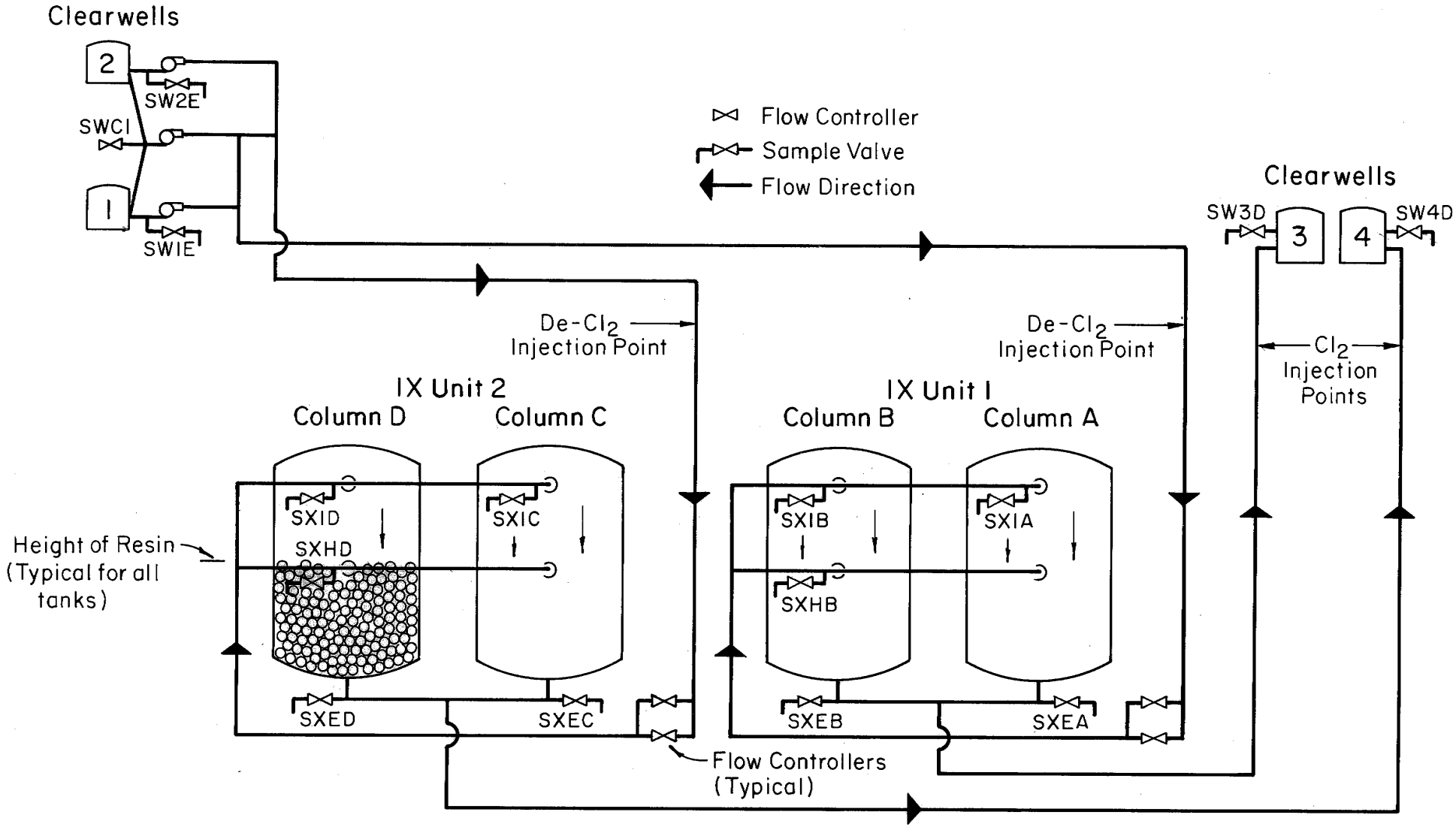


Figure 2. Ion Exchange Process Flow - Softening

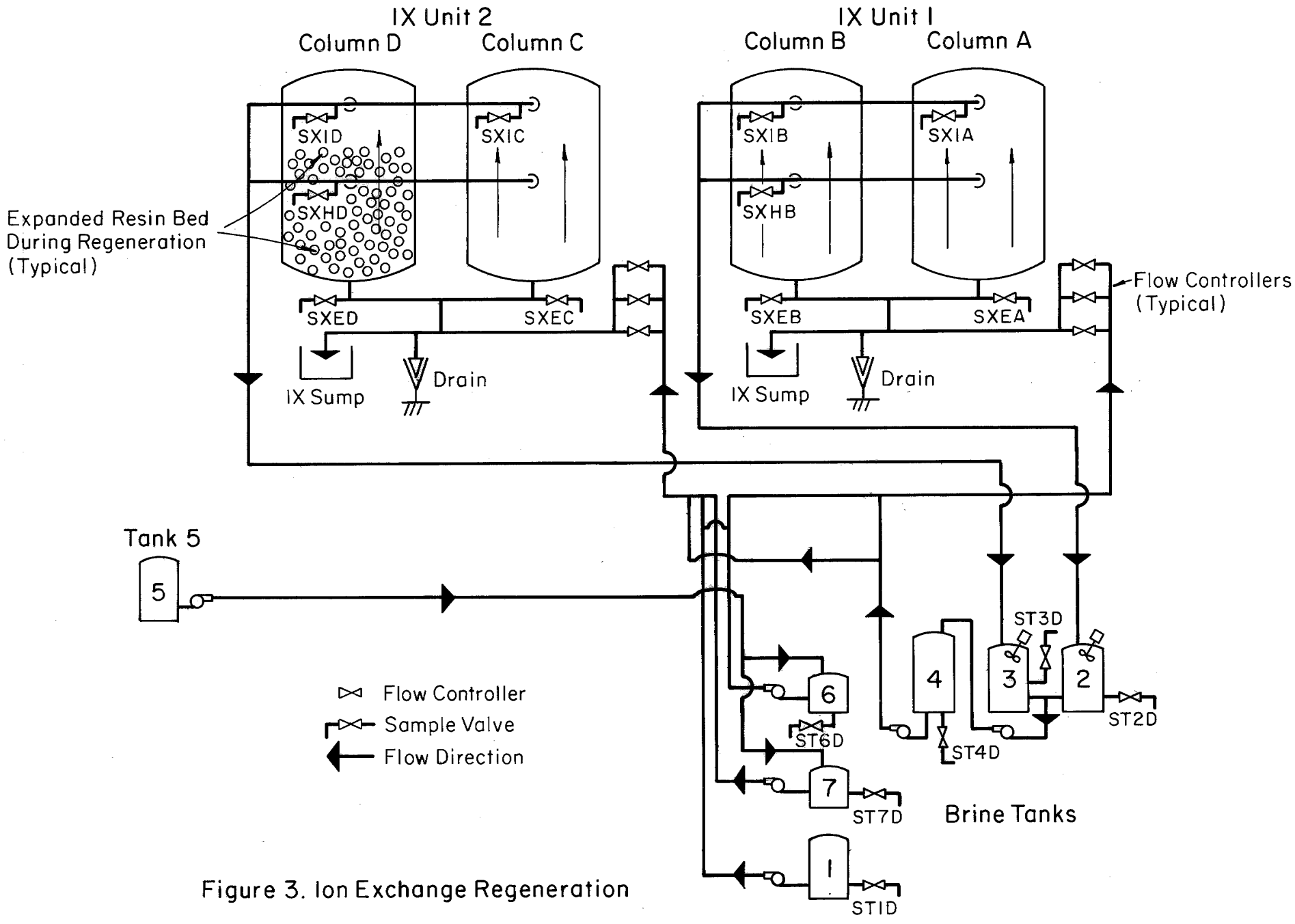


Figure 3. Ion Exchange Regeneration

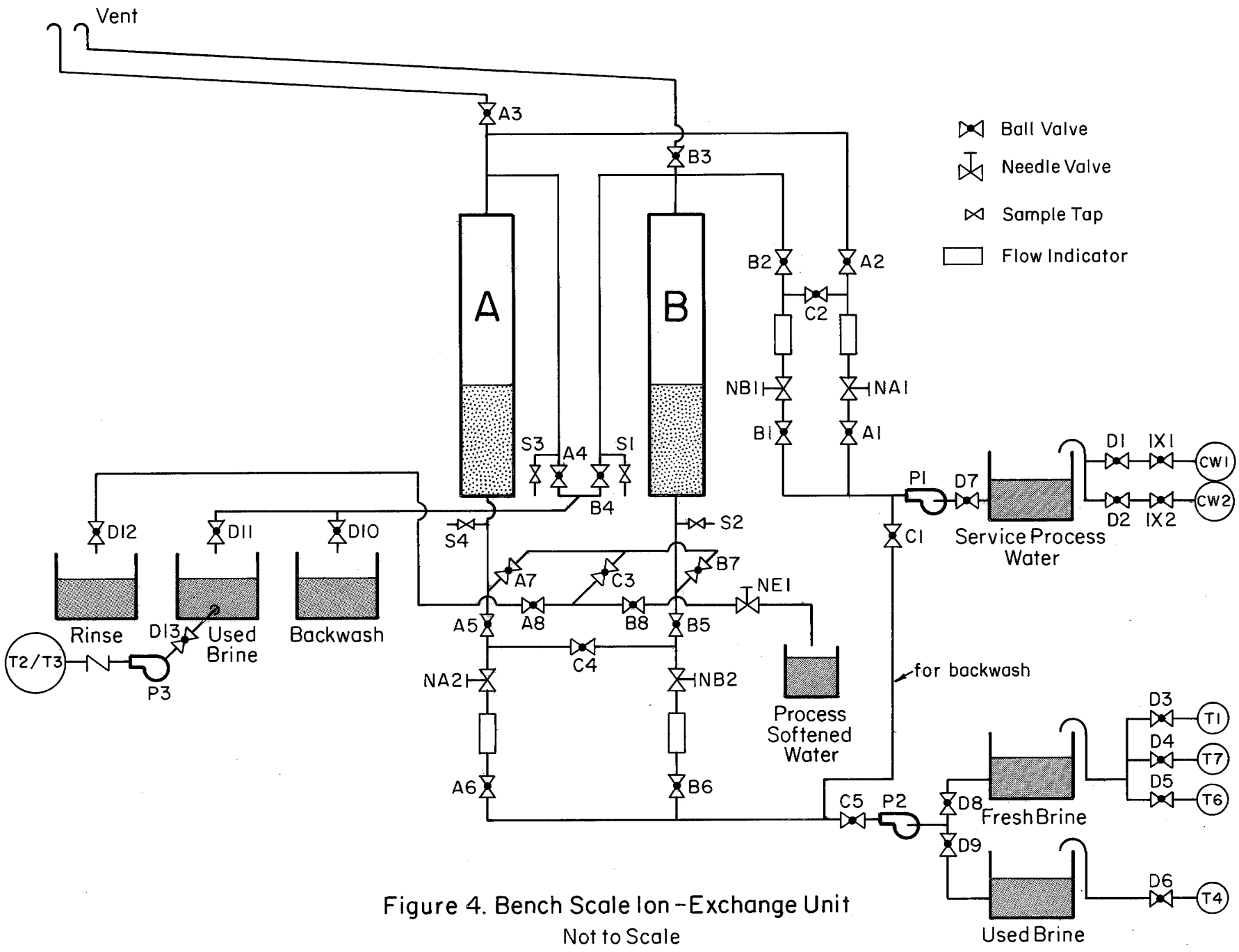


Figure 4. Bench Scale Ion-Exchange Unit
Not to Scale

A bench-scale IX unit was installed at the plant when the main units were not in operation because of the construction of the IX sump and associated facilities. The bench unit was used extensively to simulate and develop the main unit's eventual operation cycles.

The bench unit consisted of two columns 3 inches in diameter, 8 feet high, and plumbed so that they could be operated separately or in parallel. The depth of resin in each column was approximately 5 feet. A schematic of the bench unit is shown on Figure 4.

CHAPTER V. ION-EXCHANGE TEST PROGRAM

Softening water (removal of calcium) through the IX process is a proven technology that has been used in industry for years. The physical design of the Los Banos facility's IX system used hydraulic loading rates similar to those used in typical softeners. The use of RO reject brine for regeneration was studied and successfully tested in pilot investigations (Department of Water Resources, 1978 and 1983; U.S. Bureau of Reclamation, 1983 and 1984). The unique aspects of the Los Banos facility's system were (1) its scale and the need for continuous operation of the system to soften water using desalting reject brine for regeneration and (2) the softening and regeneration of water with very high concentrations of hardness, sodium, and total dissolved solids coupled with high sodium-to-hardness ratio to the degree as required for use in this particular desalting system.

IX test program activities were grouped into two phases. The first phase involved startup of the main units and development of working cycles through main unit operation and testing performed with the bench unit. This phase included modifications, calibration of equipment, and other work needed to ready the main units for continuous operation in concert with the desalting systems. The second phase involved operating the IX system on a continuous basis to supply the desalting systems with softened water and gather information necessary to evaluate the IX process as part of the treatment scheme of desalting agricultural drainage water for reuse. This work included computer program development and minor modifications to the IX system.

Activities performed during each phase of development are summarized below:

Phase I Initial main unit startup
Bench unit testing -- development of working cycles

- Series 100 -- sodium chloride working cycle
- Series 200 -- reject brine working cycle
- Series 300 -- resin capacity tests

Phase II Main unit operations

- Period 1 (June through August 1985)
- Period 2 (January through February 1986)
- Period 3 (May through June 1986)
- Period 4 (July through August 1986)

Initial Main Unit Startup

Testing with the main IX system began in early March 1984. The units were manually operated to (1) test pipelines, valves, and other system equipment and (2) acquire data to help plan the operation schedule of the IX runs that would be necessary when the RO units were put on-line. Pumps and electrically operated valves were checked and adjusted after their prolonged inactivity

during clarification and filtration testing. Leaks in piping were detected and repaired, and influent and effluent clearwells and brine processing tanks were flushed and cleaned. The safety relief valves supplied with the units were found to be inappropriately sized and thus were replaced. The laterals of the upper flow distributors, which were covered with PVC screen to prevent resin loss during backwash and regeneration, were plugged by fine sediment and broken resin beads. Unit 1 was cleaned by a local water service firm; Unit 2 was cleaned by plant personnel. Cleaning consisted of backwashing the unit through the top access hole with clarified filtered water until the effluent was clear of sediment and resin. In addition to the plugging of the upper distributors, several of the lower distributor laterals in Column C were found to be broken.

Unit 1 was returned to service in early April after its laterals were repaired and the unit was cleaned. Despite the cleaning, regeneration and backwashing events again led to plugging of the upper distribution lateral screens. Also, a leak was found in the brine tank (T1) and subsequently repaired.

Testing resumed after upper distributor lateral screens were removed. There was no sign of distributor plugging during testing, but both units experienced further mechanical difficulties. A few more lower distributor laterals in one column of both units separated from the distributor, resulting in some loss of IX resin. The units were shut down for repair, and additional resin was ordered to replace the lost resin.

Repairs to the lower distribution laterals were completed in early June 1984, and testing was resumed until June 14, when an additional 1 foot of resin was added to each column.

On June 21, severe oxidation and corrosion were discovered on the galvanized steel bottom collector manifold of IX column D. Since all four columns had been used equally, it was assumed that all bottom manifolds would have to be replaced. To avoid a recurrence of this deterioration, stainless-steel pipes and fittings were ordered for the new manifolds. The screens were plastic. Unit 1 continued in operation until June 29. Data from these initial operations are shown in Table 2.

In July 1984, requirements by the California Department of Fish and Game (to keep additional salt out of the San Luis Drain) resulted in restrictions being placed on plant operations. Testing with the main IX system could not be resumed until the system was modified to eliminate waste (salt) discharges into the San Luis Drain. These modifications, shown on Figure 5, included construction of a brine sump and installation of piping, valves, and other necessary appurtenances. These modifications were completed in February 1985.

A bench-scale unit was designed to simulate operation of the main units, since the main units could not be operated until they were modified. Installation of the bench-scale unit began in late August; testing commenced in early November.

TABLE 2

INITIAL MAIN UNIT STARTUP
OPERATION PARAMETERS AND RESULTS*
March through June 1984

Date	Sodium Chloride Brine Regeneration (volume = 3,750 gallons)		Service				
			Water Type	Duration (minutes)	Total Hardness (meq/L)		Resin Capacity (eq/L of resin)
	Duration (minutes)	Concentration (percent)			Influent	Effluent	
3-28	54	12	Clarifier	70	NA	1.4	NA
3-30	54	12	Clarifier	60	NA	1.2	NA
4-02	58	12	Clarifier	65	NA	1.4	NA
4-02	62	12	Clarifier	60	NA	1.1	NA
4-03	32	12	Clarifier	55	50.6	1.6	0.55
4-03	38	12	Clarifier	60	50.6	1.6	0.60
4-05	40	8	Clarifier	55	NA	1.8	NA
4-07	62	10	Clarifier	60	48.8	1.8	0.58
4-08	56	10	Clarifier	40	51.6	1.8	0.20
5-04	40	11	Clarifier	50	46.6	1.9	0.46
5-05	54	11.2	Clarifier	67	52.2	1.0	0.70
5-06	52	12	Clarifier	60	54.4	1.2	0.66
5-08	52	11.5	Clarifier	65	52.4	1.8	0.68
5-10	53	11.5	Clarifier	55	52.4	1.5	0.57
5-19	50	19	Clarifier	60	52.8	1.0	0.64
5-19	50	12	Clarifier	40	52.8	1.4	0.42
6-11	50	6	Marshpond	NA	58.0	5.4	NA
6-12	50	12	Marshpond	60	56.4	3.4	0.65
6-12	32	12.5	Marshpond	70	56.4	4.0	0.75
6-26	31	10	Clarifier	63	51.2	3.0	0.49
6-26	32	12	Clarifier	18	51.2	3.0	0.14
6-27	44	12	Clarifier	60	52.4	1.0	0.50
6-27	44	12	Clarifier	60	52.4	0.8	0.50
6-27	50	12	Clarifier	60	52.4	1.8	0.49
6-28	50	12	Clarifier	60	50.8	1.0	0.49
6-28	50	12	Clarifier	60	50.8	0.8	0.49

* All service flows were at 230 gpm except on April 8, when it was at 110 gpm.
One foot of resin was added to each column on June 14.

NA = not available.

Bench Unit Testing -- Development of Working Cycles

This portion of Phase I activities involved operation of the bench-scale units at operations parameters similar to those required of the main units. The primary objective of Phase I was to develop a working cycle for both sodium chloride and reject brine regenerations.

The method of experimentation in Phase I was to vary one parameter at a time and collect discrete samples for chemical analysis. The results were then evaluated to observe the effect the parameter variations had on the volume of process water softened and the leakage of calcium.

Additionally, resins from manufacturers other than the supplier for the main IX units were tested on process water taken from the marshponds, the clarifier, and the San Luis Drain. The scope and extent of testing were dictated by results of each test as well as by plant priorities.

Sodium Chloride Working Cycle Experiment (Series 101 Through 126)

The first major task of bench unit testing was to develop a sodium chloride working cycle for use during RO system startup.

The purpose of developing the sodium chloride cycle was to find a combination of independent regeneration parameters (brine contact time and concentration) that would give a consistent service event volume (shown on Figure 6). A secondary objective was to limit the volume of brine and amount of salt used in manufacturing the brine, since space for brine disposal was limited at the plant site.

The development of the sodium chloride cycle involved 26 separate experiments, labeled Experiment Series 101 through 126. The first 12 experiments were single tests that carried the service event past the calcium breakthrough point to determine the volume of process water "softened" for a given regenerant brine concentration. The cycle for these 12 runs consisted of backwash, regeneration, slow rinse, fast rinse, and service steps. The flowrates (per cross-sectional area of bed) used correspond to those used in the main units, and initial event durations were derived from manufacturers' literature. Feedwater came from the marshponds.

Results of the first 12 runs showed that, with upflow regeneration, backwash was not necessary. In fact, this step reduced the amount of water softened. The backwash step, while designed to remove particulates from the resin bed accumulated during service, only further depleted the IX bed. Backwash used clarified, unsoftened water. This step resulted in additional brine being used in regeneration to replace hardness removed during backwash.

The last 14 experiments consisted of operating the bench unit for a number of consecutive cycles to test the resin's ability to continue to soften process water through a number of cycles for a given brine contact time and concentration. The working cycle developed and verified for ten complete runs (Experiment Series 121) consisted of the following events:

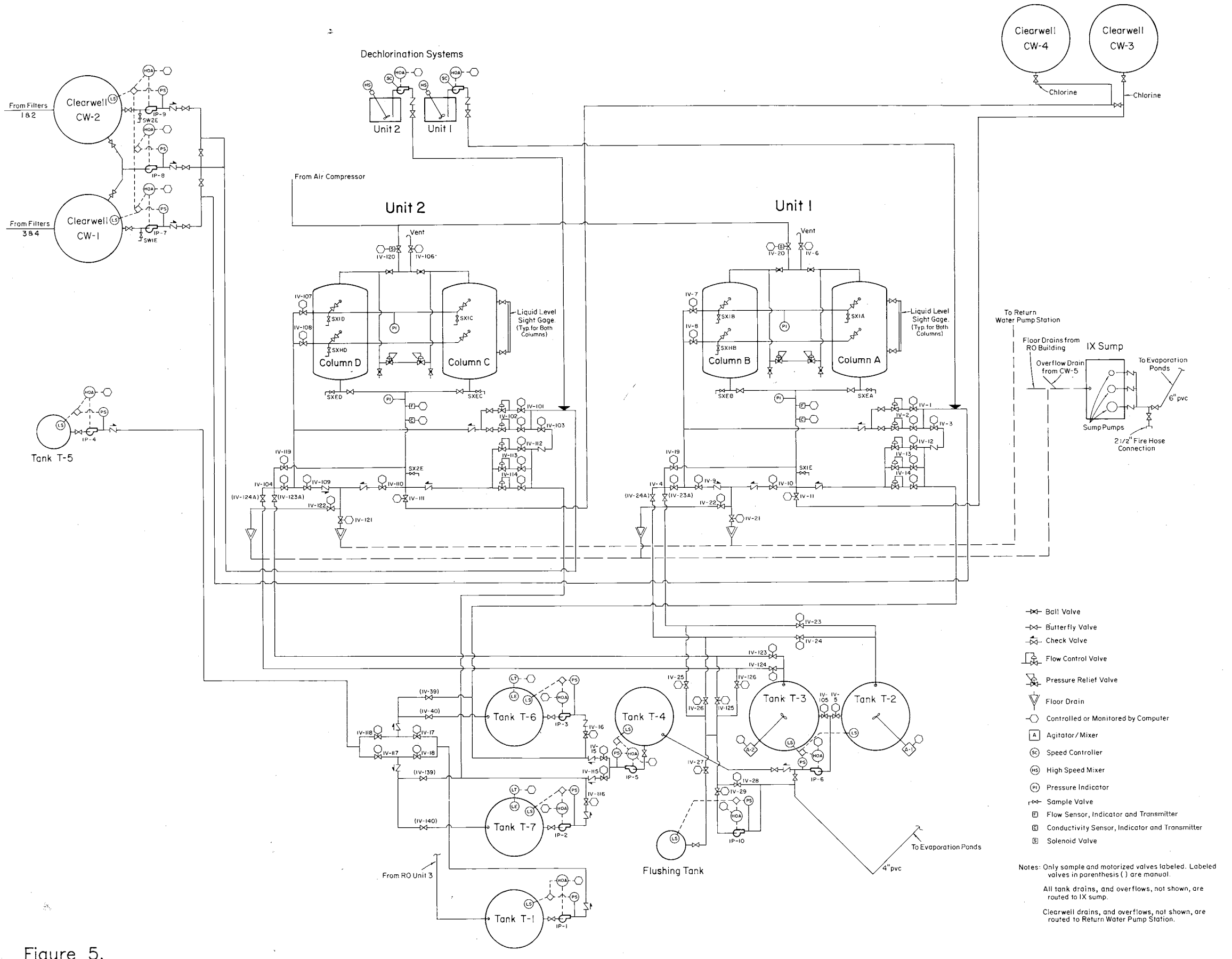
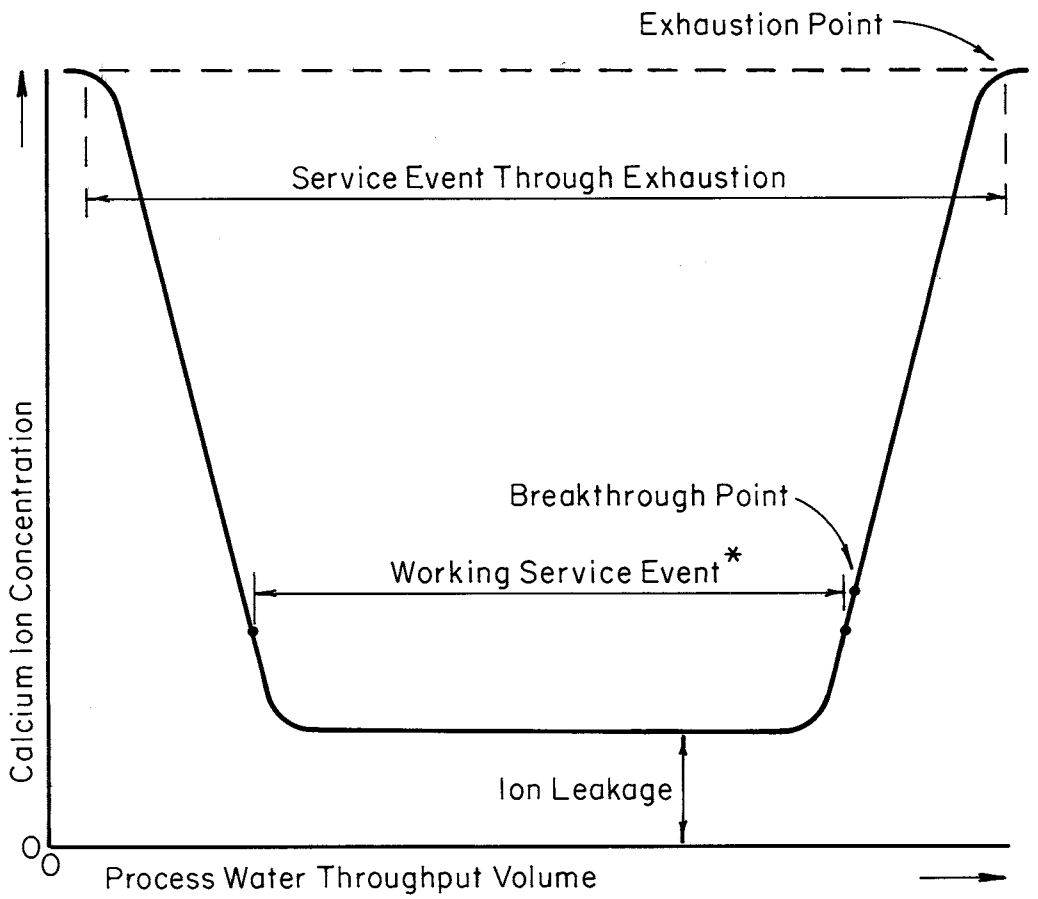


Figure 5.
Los Banos Demonstration Desalting Facility: Ion-Exchange System -- Working Schematic



*Note: The most efficient service event time is not necessarily the time to breakthrough.

Figure 6. Ion Exchange - Idealized Service Event

Event	Duration (minutes)
Regeneration	50*
Slow rinse	5
Fast rinse	15
Service	120

*12-percent brine.

Table 3 (resin performance) and Table 4 (regenerant brine composition) give the results of softening and the regenerant characteristics for the 26-experiment series. Other operational data and chemical analyses are presented in Appendix A.

Reject Brine Working Cycle Experiment (Series 201 Through 210)

The second activity in bench-unit testing involved developing an initial working cycle using brine produced by a desalting process.

Brine used in these tests was generated by a wiped-film rotating-disk evaporator (an evaporative type of desalting unit). This brine was used because RO brine was not available. The rotating evaporator disk (RED) process produced a brine similar to that produced by reverse osmosis, but at a more concentrated level. RED brine was diluted to match the projected concentration of RO brine. The brine for these tests was produced during batch-type operation of the RED.

Ten single-run experiments were conducted with RED brine. The events in this cycle are listed below:

Recycled brine regeneration
Fresh brine regeneration
Slow rinse
Fast rinse
Service

To generate an adequate volume of recycled brine for testing, regeneration for the first three runs was conducted only with fresh brine. Resin tested was taken from the main IX units for all runs except test 208, which used new C20 resin. The last portion of the fast rinse event of the cycle was diverted into a separate rinse tank. This was performed to save a maximum amount of the initial fresh brine and to prevent dilution of the brine with the rinse feedwater. This feature was incorporated into the RO brine cycle of the main units. Operation parameters are shown in Table 5.

Recycled brine tests showed that the integrated softening/regeneration system had the ability to soften process water as required for use in a continuous mode in an RO system. Product calcium leakages, which are indications of the average leakage for a working cycle, ranged between

TABLE 3

BENCH-UNIT SERIES 100 TEST
SOFTENING RESULTS
(sodium chloride brine regeneration)

Experiment Series	Run	Bed Volumes Softened	Resin Leakage (meq/L)		Resin Capacity (eq/L of resin)		Ratio (total to calcium)			Sodium Gained (eq/L of resin)	Ratio (sodium to total hardness)	
			Calcium	Total	Calcium	Total	Capacity	Leakage	Influent		Capacity	Influent
101	a	25.2	0.44	0.96	0.633	1.187	1.88	2.18	1.88	0.439	0.37	2.27
102	a	22.7	0.48	1.18	0.562	1.082	1.93	2.46	1.94	0.395	0.37	2.32
103	a	22.0	0.44	1.12	0.598	1.032	1.73	2.55	1.74	1.054	1.02	2.90
104	a	23.0	0.64	1.42	0.564	1.014	1.80	2.22	1.81	0.998	0.98	2.86
105	a	23.0	0.80	1.28	0.552	1.065	1.93	1.60	1.92	1.601	1.50	3.38
106	a	22.0	0.72	1.12	0.548	1.032	1.88	1.56	1.88	0.670	0.65	2.54
107	a	22.5	0.76	1.16	0.531	1.052	1.98	1.53	1.97	0.977	0.93	2.81
108	a	20.9	0.70	1.48	0.530	0.991	1.87	2.11	1.88	1.002	1.01	2.85
109	a	20.9	0.72	1.62	0.513	0.971	1.89	2.25	1.90	1.184	1.22	3.08
110	a	8.7	0.76	1.80	0.216	0.401	1.86	2.37	1.88	0.264	0.66	2.54
111	a	23.4	0.34	0.64	0.572	1.107	1.94	1.88	1.94	1.118	1.01	2.99
112	a	22.4	0.60	1.12	0.559	1.048	1.88	1.87	1.88	1.264	1.21	3.08
113	a	24.7	0.48	0.84	0.610	1.155	1.89	1.75	1.89	1.074	0.93	3.02
	b	22.0	0.64	1.42	0.540	1.015	1.88	2.22	1.89	0.956	0.94	2.92
	c	18.6	0.76	1.44	0.462	0.859	1.86	1.89	1.86	0.809	0.94	3.02
	d	18.6	0.80	1.56	0.450	0.872	1.94	1.95	1.94	0.648	0.74	2.70
	e	18.3	0.88	1.76	0.419	0.846	2.02	2.00	2.02	0.955	1.13	3.08
114	a	19.0	0.66	1.24	0.435	0.856	1.97	1.88	1.97	0.742	0.87	3.00
	b	19.1	0.70	1.44	0.460	0.874	1.90	2.06	1.90	1.246	1.43	3.32
	c	18.2	0.68	1.66	0.455	0.823	1.81	2.44	1.83	0.793	0.96	3.25
	d	11.1	0.68	1.66	0.268	0.507	1.89	2.44	1.90	0.436	0.86	2.86
	e	16.1	0.64	1.58	0.388	0.732	1.89	2.47	1.90	0.977	1.33	3.23
115	a	13.7	0.74	1.90	0.330	0.638	1.93	2.57	1.95	0.776	1.22	3.06
	b	14.4	1.32	3.04	0.356	0.643	1.81	2.30	1.83	0.817	1.27	3.11
116	a	20.5	0.84	1.44	0.508	0.980	1.93	1.71	1.92	1.160	1.18	3.01
	b	14.0	0.96	2.40	0.344	0.653	1.90	2.50	1.92	0.607	0.93	2.74
	c	21.0	0.64	1.24	0.523	1.005	1.92	1.94	1.92	1.185	1.18	3.01
	d	19.6	0.64	1.44	0.489	0.935	1.91	2.25	1.92	0.937	1.00	2.83
117	a	25.2	0.40	0.38	0.625	1.200	1.92	0.95	1.90	1.096	0.91	2.90
	b	23.2	0.48	1.00	0.574	1.091	1.90	2.08	1.90	1.211	1.11	3.08
	c	23.6	0.68	1.28	0.578	1.102	1.91	1.88	1.90	1.334	1.21	3.17
	d	22.8	0.72	1.08	0.558	1.069	1.92	1.50	1.90	1.288	1.21	3.17
	e	20.9	0.52	1.20	0.515	0.977	1.90	2.31	1.90	1.272	1.30	3.26
118	a	25.7	0.44	0.76	0.779	1.172	1.50	1.73	1.51	1.228	1.05	3.00
	b	23.6	0.52	1.08	0.716	1.071	1.50	2.08	1.51	1.542	1.44	3.37
	c	25.0	0.52	0.96	0.757	1.136	1.50	1.85	1.51	1.522	1.34	3.28
	d	22.8	0.56	1.12	0.691	1.034	1.50	2.00	1.51	1.391	1.34	3.28

TABLE 3 (continued)

BENCH-UNIT SERIES 100 TEST
SOFTENING RESULTS
(sodium chloride brine regeneration)

Experiment Series	Run	Bed Volumes Softened	Resin Leakage (meq/L)		Resin Capacity (eq/L of Resin)		Ratio (total to calcium)			Sodium Gained (eq/L of resin	Ratio (sodium to total hardness)	
			Calcium	Total	Calcium	Total	Capacity	Leakage	Influent		Capacity	Influent
119	a	24.5	0.68	1.20	0.619	1.115	1.80	1.76	1.80	1.915	1.72	3.62
	b	20.7	1.28	2.16	0.511	0.924	1.81	1.69	1.80	1.080	1.17	3.35
	c	23.1	1.12	1.88	0.574	1.036	1.81	1.68	1.80	1.505	1.45	3.44
	d	21.5	1.44	2.04	0.529	0.964	1.82	1.42	1.80	1.405	1.46	3.53
121	a	19.1	0.60	0.92	0.523	0.868	1.66	1.53	1.66	0.706	0.81	2.67
	b	19.1	0.52	0.88	0.525	0.869	1.66	1.69	1.66	0.830	0.96	2.81
	c	18.9	0.88	1.44	0.513	0.851	1.66	1.64	1.66	0.865	1.02	2.86
	d	17.8	0.64	1.16	0.488	0.807	1.65	1.81	1.66	0.737	0.91	2.77
	e	19.6	1.16	1.92	0.525	0.870	1.66	1.66	1.66	1.021	1.17	3.00
	f	19.3	0.60	1.00	0.529	0.876	1.66	1.67	1.66	0.923	1.05	2.91
	g	19.1	0.44	0.76	0.526	0.871	1.66	1.73	1.66	0.789	0.91	2.77
	h	19.1	0.40	0.64	0.526	0.872	1.66	1.60	1.66	0.829	0.95	2.81
	i	19.1	0.68	1.08	0.522	0.865	1.66	1.59	1.66	0.830	0.96	2.81
	j	19.1	0.80	1.20	0.519	0.863	1.66	1.50	1.66	0.996	1.15	3.00
122	a	19.1	1.00	1.80	0.485	0.844	1.74	1.80	1.74	0.955	1.13	3.03
	b	19.1	0.96	1.60	0.486	0.848	1.75	1.67	1.74	0.830	0.98	2.88
	c	18.0	0.92	1.68	0.458	0.796	1.74	1.83	1.74	0.860	1.08	2.98
	d	19.1	1.00	2.04	0.485	0.839	1.73	2.04	1.74	0.664	0.79	2.69
	e	19.1	1.04	1.84	0.484	0.843	1.74	1.77	1.74	0.955	1.13	3.03
123	a	20.1	1.04	1.60	0.517	0.891	1.72	1.54	1.72	0.829	0.93	2.79
	b	19.7	1.28	2.20	0.503	0.863	1.72	1.72	1.72	0.729	0.84	2.69
	c	19.7	1.24	2.16	0.504	0.864	1.72	1.74	1.72	0.814	0.94	2.79
	d	20.0	1.48	2.40	0.506	0.872	1.72	1.62	1.72	0.870	1.00	2.84
	e	19.4	1.24	2.28	0.496	0.849	1.71	1.84	1.72	0.887	1.04	2.88
124	a	21.8	0.32	0.70	0.464	1.110	2.39	2.19	2.39	1.233	1.11	2.98
125	a	27.0	0.24	0.52	0.561	1.402	2.50	2.17	2.50	2.086	1.49	3.38
126	a	24.8	0.80	1.76	0.505	1.194	2.36	2.20	2.36	1.873	1.57	3.65

TABLE 4

BENCH-UNIT SERIES 100 TEST
REGENERANT BRINE COMPOSITION
(sodium chloride brine regeneration)

Series	Run	Calcium (meq/L)	Total Hardness (meq/L)	Sodium (meq/L)	EC (uS/cm)	Turbidity (NTU)	pH	Chloride (meq/L)	Sulfate (meq/L)	Sodium Throughput (eq/L of resin)
101	a	8.20	14.40	1,565.22	126,000	2.6	7.7	2,016.36	6.25	7.728
102	a	10.00	14.80	1,689.57	135,000	3.6	7.8	1,615.06	6.66	8.116
103	a	9.20	14.80	1,608.70	133,900	7.3	7.9	1,728.29	6.04	7.728
104	a	8.40	14.80	1,486.96	133,900	7.1	7.7	1,692.05	6.45	6.349
105	a	9.60	15.20	1,730.43	135,000	7.0	7.7	1,706.15	5.62	7.158
106	a	8.40	13.20	1,178.26	99,000	4.0	7.6	1,201.35	5.41	5.660
107	a	9.20	12.80	1,100.00	94,800	6.0	7.8	1,142.13	5.41	5.137
108	a	8.40	14.40	1,147.83	92,800	5.0	7.6	1,183.87	5.41	5.054
109	a	7.20	12.80	1,091.30	95,000	3.5	7.9	1,178.23	5.00	3.349
110	a	9.60	13.60	1,152.17	96,300	5.7	7.8	1,197.97	5.21	3.844
111	a	8.80	12.40	1,630.43	126,900	2.3	7.8	1,615.06	5.62	8.746
112	a	8.00	12.40	1,013.04	128,000	2.9	7.8	1,691.20	5.41	3.880
113	a	6.40	11.60	1,543.48	94,000	2.0	7.6	1,169.77	4.37	NA
	b	7.20	11.20	1,334.78	94,000	1.3	7.6	1,161.31	4.58	NA
	c	7.20	11.60	1,282.61	94,000	2.5	7.9	1,164.13	4.79	NA
	d	7.20	11.20	1,282.61	98,800	2.5	7.8	1,150.03	4.79	NA
	e	7.00	11.20	956.52	94,000	2.6	7.7	1,141.57	4.79	NA
114	a	6.20	10.40	91.30	12,300	2.9	7.6	1,374.22	3.96	0.273
	b	7.20	10.80	1,152.17	98,100	1.8	7.9	1,550.48	10.62	4.889
	c	6.40	11.20	1,386.96	99,300	1.3	7.7	1,155.67	4.79	5.497
	d	6.40	11.20	1,243.48	99,900	1.6	7.6	1,155.95	4.79	4.596
	e	6.40	10.80	1,204.35	99,900	1.4	7.7	43.71	7.91	4.741
115	a	7.60	12.00	1,017.39	9,400	0.5	7.5	NA	NA	2.851
	b	8.00	12.00	1,117.39	88,800	1.5	7.2	NA	NA	2.982
116	a	10.80	18.00	2,265.22	16,400	1.5	7.6	NA	NA	6.045
	b	10.80	18.00	2,265.22	16,400	1.5	7.6	NA	NA	5.138
	c	10.80	18.00	2,265.22	16,400	1.5	7.6	NA	NA	6.045
	d	10.80	18.00	2,265.52	16,400	1.5	7.6	NA	NA	6.045
117	a	10.00	17.20	2,056.52	150,500	2.9	7.7	NA	NA	6.586
	b	10.00	17.20	2,056.52	150,500	2.9	7.7	NA	NA	6.586
	c	10.00	17.20	2,056.52	150,500	2.9	7.7	NA	NA	6.915
	d	10.00	17.20	2,056.52	150,500	2.9	7.7	NA	NA	6.586
	e	10.00	17.20	2,056.52	150,500	2.9	7.7	NA	NA	6.257
118	a	7.60	11.60	1,252.17	88,000	0.8	7.6	NA	NA	7.001
	b	7.60	11.60	1,252.17	88,000	0.8	7.6	NA	NA	7.307
	c	7.60	11.60	1,252.17	88,000	0.8	7.6	NA	NA	7.428
	d	7.60	11.60	1,252.17	88,000	0.8	7.6	NA	NA	7.181
	UB	91.20	152.00	691.30	62,100	1.2	7.2	NA	NA	

TABLE 4 (continued)

BENCH-UNIT SERIES 100 TEST
REGENERANT BRINE COMPOSITION
(sodium chloride brine regeneration)

Series	Run	Calcium (meq/L)	Total Hardness (meq/L)	Sodium (meq/L)	EC (uS/cm)	Turbidity (NTU)	pH	Chloride (meq/L)	Sulfate (meq/L)	Sodium Throughput (eq/L of resin)
119	a	11.20	16.80	2,282.61	154,300	1.2	7.5	NA	NA	5.563
	b	11.20	16.80	2,282.61	154,300	1.2	7.5	NA	NA	5.563
	c	11.20	16.80	2,282.61	154,300	1.2	7.5	NA	NA	6.120
	d	11.20	16.80	2,282.61	154,300	1.2	7.5	NA	NA	5.531
	e	11.20	16.80	2,282.61	154,300	1.2	7.5	NA	NA	5.565
	UB	136.00	234.00	573.91	62,400	1.6	7.1	NA	NA	
120	a	11.20	18.00	2,108.70	155,000	1.8	7.8	NA	NA	5.895
	b	11.20	18.00	2,108.70	155,000	1.8	7.8	NA	NA	6.167
	c	11.20	18.00	2,108.70	155,000	1.8	7.8	NA	NA	6.046
	d	11.20	18.00	2,108.70	155,000	1.8	7.8	NA	NA	6.016
	e	11.20	18.00	2,108.70	155,000	1.8	7.8	NA	NA	6.319
	UB	174.00	262.00	608.70	73,500	2.5	7.1	NA	NA	
121	a	8.40	15.60	2,260.87	15,300	NA	7.7	NA	NA	4.943
	b	8.40	15.60	2,260.87	15,300	NA	7.7	NA	NA	5.213
	c	8.40	15.60	2,260.87	15,300	NA	7.7	NA	NA	5.213
	d	8.40	15.60	2,260.87	15,300	NA	7.7	NA	NA	5.213
	e	8.40	15.60	2,260.87	15,300	NA	7.7	NA	NA	5.510
	f	8.40	15.60	2,260.87	15,300	NA	7.7	NA	NA	5.510
	g	8.40	15.60	2,260.87	15,300	NA	7.7	NA	NA	5.510
	h	8.40	15.60	2,260.87	15,300	NA	7.7	NA	NA	5.781
	i	8.40	15.60	2,260.87	15,300	NA	7.7	NA	NA	5.510
	j	8.40	15.60	2,260.87	15,300	NA	7.7	NA	NA	5.510
122	a	9.20	14.40	1,760.87	134,400	NA	7.6	NA	NA	4.965
	b	9.20	14.40	1,760.87	134,400	NA	7.6	NA	NA	5.133
	c	9.20	14.40	1,760.87	134,400	NA	7.6	NA	NA	4,292
	d	9.20	14.40	1,760.87	134,400	NA	7.6	NA	NA	4.502
	e	9.20	14.40	1,760.87	134,400	NA	7.6	NA	NA	4.502
123	a	8.80	13.60	1,652.17	129,300	1.6	7.8	NA	NA	4.204
	b	8.80	13.60	1,652.17	129,300	1.6	7.8	NA	NA	4.027
	c	8.80	13.60	1,652.17	129,300	1.6	7.8	NA	NA	4.619
	d	8.80	13.60	1,652.17	129,300	1.6	7.8	NA	NA	3.810
	e	8.80	13.60	1,652.17	129,300	1.6	7.8	NA	NA	4.027
124	a	3.80	16.00	3,141.30	168,700	NA	NA	NA	NA	6.176
	UB	162.00	354.00	1,186.96	103,800	NA	NA	NA	NA	
125	a	7.80	20.40	1,273.91	180,100	NA	NA	NA	NA	2.415
	UB	174.00	384.00	1,000.00	165,500	NA	NA	NA	NA	
126	a	9.60	19.60	3,176.09	175,200	NA	NA	NA	NA	5.616
	UB	244.00	600.00	1,169.57	107,100	NA	NA	NA	NA	

EC = electrical conductivity.
NA = not available.
UB = used brine.

TABLE 5

BENCH-UNIT SERIES 200 TEST
OPERATION PARAMETERS
(rotating evaporator disk brine)

Series*	Date	Resin**	Process Water	Hour	Comment
201	3-04-85	C20a	Marsh	12	All regeneration with fresh brine; run to total hardness breakthrough to influent total hardness.
202	3-07-85	C20a	Marsh	10	All regeneration with fresh brine; run to total hardness breakthrough to influent total hardness.
203	3-11-85	C20a	Marsh	10	All regeneration with fresh brine; run to total hardness breakthrough to influent total hardness.
204	3-12-85	C20a	Marsh	10	First run with recycled brine; run to total hardness breakthrough to influent total hardness.
205	3-19-85	C20a	Marsh	9	Second run with recycled brine; run to total hardness breakthrough to influent total hardness.
206	3-25-85	C20a	Marsh	10	Third run with recycled brine; run to total hardness breakthrough to influent total hardness.
207	3-26-85	C20a	Marsh	9	Fourth run with recycled brine; run to total hardness breakthrough to influent total hardness.
208	3-29-85	C20b	Marsh	9	Fifth run with recycled brine; run to total hardness breakthrough to influent total hardness.
209	4-16-85	C20a	Clarifier	9	Sixth run with recycled brine; run duration for 120 minutes.
210	4-24-85	C20a	Clarifier	11	Seventh run with recycled brine; run duration for 120 minutes.

Series*	Recycled Brine Regeneration				Fresh Brine Regeneration					Slow Rinse		Fast Rinse		Service	
	Loading Rate 1 (gpm/ft^2)	Bed Expansion (percent)	Duration (minutes)	Concentration (percent)	Loading Rate 1 (gpm/ft^2)	Bed Expansion (percent)	Duration (minutes)	Concentration (percent)	Temperature (°C)	Loading Rate 1 (gpm/ft^2)	Duration (minutes)	Loading Rate 1 (gpm/ft^2)	Duration (minutes)	Loading Rate 2 (gpm/ft^3)	Duration (minutes)
201	4.89	50	30	7.0	3.77	38	20	7.0	9.5	2.85	5	6.11	15	1.18	190
202	5.00	50	30	7.0	3.77	38	20	7.0	9.0	2.85	5	6.11	15	1.18	207
203	5.68	55	30	7.0	3.65	NA	20	7.0	13.0	3.54	5	5.54	15	1.22	210
204	5.41	55	30	5.5	3.70	40	20	6.5	12.0	2.85	5	5.63	15	1.19	150
205	5.93	top	50	5.0	3.89	37	20	6.5	12.0	5.36	5	5.36	15	1.20	180
206	5.89	top	50	5.0	3.81	35	20	6.5	10.5	2.95	5	5.48	15	1.18	180
207	5.43	50	50	5.0	3.71	30	20	6.5	10.0	3.71	5	5.60	15	1.08	189
208	5.76	50	50	5.0	3.69	30	20	6.5	9.5	4.48	5	5.50	10	1.19	165
209	5.37	50	70	5.0	3.71	37	20	6.5	17.0	3.46	5	5.66	15	1.19	142
210	5.31	40	40	NA	3.85	50	50	6.5	20.0	3.54	5	4.96	15	1.21	120

*All were Run a.

**C20a resin was taken from main IX columns.
C20b resin is new C20 resin that was also used in the first series of tests.

NA = not available.

0.5 and 4.0 milliequivalents per liter (meq/L) for the recycled brine tests. These tests showed that the average leakage could be kept to acceptable levels when adequate amounts of sodium were passed through the bed during regeneration and a minimum brine contact time was maintained. Hardness leakages for a specific process water throughput volume for the test series are shown in Table 6. Detailed operation data, chemical analyses, and other information concerning these tests are included in Appendix B.

Resin Capacity Tests (Series 301 Through 313)

Resin capacity experiments were conducted to (1) determine the effects of various regenerant brines and feed source waters on a resin's total softening capacity and (2) compare the resulting capacities of resins from several manufacturers. Sodium chloride brine, RED brine, and a brine taken from the salt-gradient solar pond were used for regeneration. Water from the marshponds, filtered clarifier, and San Luis Drain was used as feedwater for softening. The resins tested were Rohm and Haas' Amberlite IR 120, Dow Chemical's Dowex HCR-5, and Diamond Shamrock's Duolite C20. The Duolite resin was extracted from the main IX units. The criteria for the resins tested were that they be standard, off-the-shelf, sodium form, gel-type, strong acid cation products with 8-percent cross-linking. Such resins are used for softening in domestic and industrial applications.

The method of operation for the capacity tests called for fully regenerating the resin and running the service event until the effluent total hardness (or leakage) equaled that of the influent and totally exhausted the IX column (see Figure 6). Samples were taken throughout the entire cycle and analyzed for various constituents.

Thirteen tests were conducted to demonstrate the effect of the feedwater's sodium concentration on the resin's ability to soften water. As the feedwater's sodium concentration increased, the resin's ability to remove hardness decreased. The feedwater's sodium ions inhibited the exchange of the feedwater's hardness ions with the resin's sodium ions and resulted in an increase in hardness leakage and a reduction in hardness removal capacity. The same principal applied to regeneration, but the constituents of sodium and hardness were reversed.

The tests also demonstrated the condition of the main unit's resin. There was concern that the main unit's resin had become fouled, either biologically or with iron, or had degraded due to past tests or through the prolonged inactivity of the system. The main unit's resin performed as well as new resin. Results for the tests are shown below in Table 7. Detailed operation data, chemical analyses, and other information concerning these tests are included in Appendix C.

TABLE 6

BENCH-UNIT SERIES 200 TEST
HARDNESS LEAKAGE VS. THROUGHPUT
(rotating evaporator disk brine regeneration)

Series	Run	Type	Influent	Product Water*	Instantaneous Hardness Leakages at Throughput During Service (meq/L)													
201	a	Calcium	27.40	0.56	0.48	0.60	0.52	0.52	0.48	0.44	0.48	0.48	0.68	0.80	0.88	2.00	3.00	3.40
		Total hardness	52.60	0.80	0.76	0.76	0.72	0.72	0.84	0.76	0.80	0.92	1.44	2.00	3.92	9.20	19.00	26.00
	Throughput	Bed volume	NA	19.7	1.6	5.2	7.9	11.0	15.0	18.1	19.7	21.3	22.1	23.7	25.2	26.8	28.4	30.0
202	a	Calcium	29.20	0.80	0.64	0.72	0.64	0.60	1.20	2.80	5.40	9.00						
		Total hardness	46.80	1.56	1.52	1.32	1.32	1.70	10.80	24.80	33.90	41.20						
	Throughput	Bed volume	NA	22.1	3.3	5.4	15.1	21.5	24.0	27.1	30.0	32.7						
203	a	Calcium	34.40	0.68	0.68	0.64	0.64	0.64	0.64	0.68	1.40	2.88	7.40	9.20	11.60			
		Total hardness	46.80	1.48	1.28	1.24	1.28	1.28	1.28	2.28	10.28	26.20	32.80	41.20	43.00			
	Throughput	Bed volume	NA	19.6	1.6	4.9	8.2	11.9	17.1	21.2	24.5	26.9	29.4	31.8	34.3			
204	a	Calcium	24.80	4.00	2.04	1.80	1.20	1.24	1.36	1.68	3.00	6.40	11.00					
		Total hardness	45.80	15.64	4.16	2.64	2.40	2.52	2.56	5.12	15.12	29.60	39.60					
	Throughput	Bed volume	NA	19.1	0.0	1.6	4.8	8.0	11.1	16.7	19.1	21.3	23.9					
205	a	Calcium	25.00	2.16	1.56	0.96	0.88	0.96	0.88	1.04	1.76	3.52	6.80	9.00	10.80	13.00		
		Total hardness	46.40	12.00	3.44	2.08	1.88	1.88	2.08	4.96	13.60	24.80	35.40	40.40	42.00	44.00		
	Throughput	Bed volume	NA	19.2	0.0	0.8	4.8	8.0	11.2	17.6	19.2	21.7	24.1	25.7	27.3	28.9		
206	a	Calcium	27.60	1.28	1.40	1.16	1.08	1.12	1.24	1.12	1.20	1.28	1.68	2.84	5.60	7.40	10.40	
		Total hardness	50.00	3.44	2.96	2.68	2.56	2.60	2.56	2.84	3.44	4.32	9.52	21.00	34.60	38.80	42.40	
	Throughput	Bed volume	NA	18.9	0.0	1.6	2.4	4.7	7.9	11.8	15.8	17.1	18.9	21.3	23.7	26.1	28.4	
207	a	Calcium	26.20	1.40	1.68	1.28	1.36	1.24	1.28	1.40	1.40	6.60	10.40	11.20				
		Total hardness	47.20	4.20	3.76	2.88	3.28	2.96	3.12	4.12	29.60	35.80	41.00	43.00				
	Throughput	Bed volume	NA	18.7	0.0	2.2	4.3	7.2	10.1	15.1	21.6	19.6	25.9	27.2				
208	a	Calcium	25.60	2.08	1.68	1.52	1.44	1.52	1.68	1.80	2.88	4.20	7.00	9.60	13.40			
		Total hardness	46.80	7.80	3.52	3.80	3.80	3.80	4.12	6.72	16.24	27.00	35.60	41.00	45.20			
	Throughput	Bed volume	NA	19.2	0.8	2.4	4.8	8.0	11.2	14.8	17.6	19.2	21.5	23.9	26.3			
209	a	Calcium	26.80	1.04	0.88	0.76	0.76	0.80	0.76	1.28	2.28	3.60						
		Total hardness	48.40	3.40	2.32	2.32	2.16	2.32	2.40	NA	24.80	31.40						
	Throughput	Bed volume	NA	19.2	0.0	1.6	6.4	11.2	12.8	19.2	20.7	22.7						
210	a	Calcium	27.20	0.48	0.50	0.46	0.36	0.36	0.44									
		Total hardness	51.60	1.04	1.04	1.00	0.80	0.88	1.24									
	Throughput	Bed volume	NA	19.4	0.0	1.6	9.7	14.6	19.4									

*Analysis of sample taken from the entire service batch 120 minutes after being mixed. Other readings are instantaneous.

NA = not available.

TABLE 7

BENCH-UNIT SERIES 300 TEST
RESIN CAPACITY RESULTS

Test Number	Regenerant Brine	Process Water	Resin Type[1]	Process Water Influent (meq/L)			Resin Capacity (eq/L of resin)	
				Calcium	Total	Sodium	Calcium	Total
301	RED	Marshpond	C20-1	35.0	91.6	196.5	0.45	1.09
302	RED	Marshpond	C20-2	31.0	94.7	196.5	0.37	1.11
303	NaCl	Marshpond	C20-1	35.4	89.0	209.6	0.49	1.17
304	NaCl	Filtered clarifier	C20-1	26.4	50.8	122.3	0.90	1.51
305	NaCl	Filtered clarifier	C20-2	26.3	52.1	117.9	1.06	1.91
306	NaCl	San Luis Drain	C20-2	28.9	52.8	109.2	0.88	1.52
307	NaCl	San Luis Drain	C20-1	31.8	54.2	78.6	1.08	1.69
308	NaCl	San Luis Drain	C20-2	28.0	53.0	480.4[2]	0.84	1.46
309	None[3]	Filtered clarifier	HCR-S	22.0	40.9	78.6	0.74	1.38
310	None[3]	Filtered clarifier	IR 120	21.5	39.9	74.2	1.20	1.73
311	RED	Filtered clarifier	C20-2	25.2	41.4	96.1	1.05	1.68
312	RED	Filtered clarifier	IR 120	23.1	42.3	104.8	0.85	1.50
313	Solar pond	Filtered clarifier	C20-2	27.4	41.7	74.2	1.04	1.42

[1]C20-1 is resin taken from main Unit 1; C20-2 is resin taken from main Unit 2.
[2]Sodium analysis was noted questionable by laboratory.
[3]New resin was used in testing (no regeneration).

Main Unit Operations

There were four periods during which the IX system was operated for prolonged periods to provide soft water for desalting units. Operation of the IX system for Period 1 (June through August 1985) involved regeneration with NaCl brine. The remaining three periods (Periods 2, 3, and 4 -- January through February 1986, May through June 1986, and July through August 1986, respectively) involved regeneration with brine derived from desalting processes. The IX system was operated manually in Period 1 and automatically in Periods 2, 3, and 4.

The chemical concentrations of total hardness (TH), calcium (Ca), and sodium (Na) in the process influent water for the four periods of operation are shown on Figures 7, 8, 9, and 10. The TH and Ca concentrations remained relatively constant at around 50 and 24 meq/L, respectively, until Period 4 when they decreased and eventually leveled to around 12 and 7 meq/L. The decrease was due to the halting of Westlands Water District's subsurface drainage discharges into the San Luis Drain and the flushing of the drain with "fresh" Delta-Mendota Canal water. The Na concentrations fluctuated throughout the course of each period. As Figure 11 shows, the constituent trends tended to match the overall historical monthly San Luis Drain concentration trends.

Figure 7
IX Influent Process Water TH, Ca and Na Conc.
June, July and August, 1985

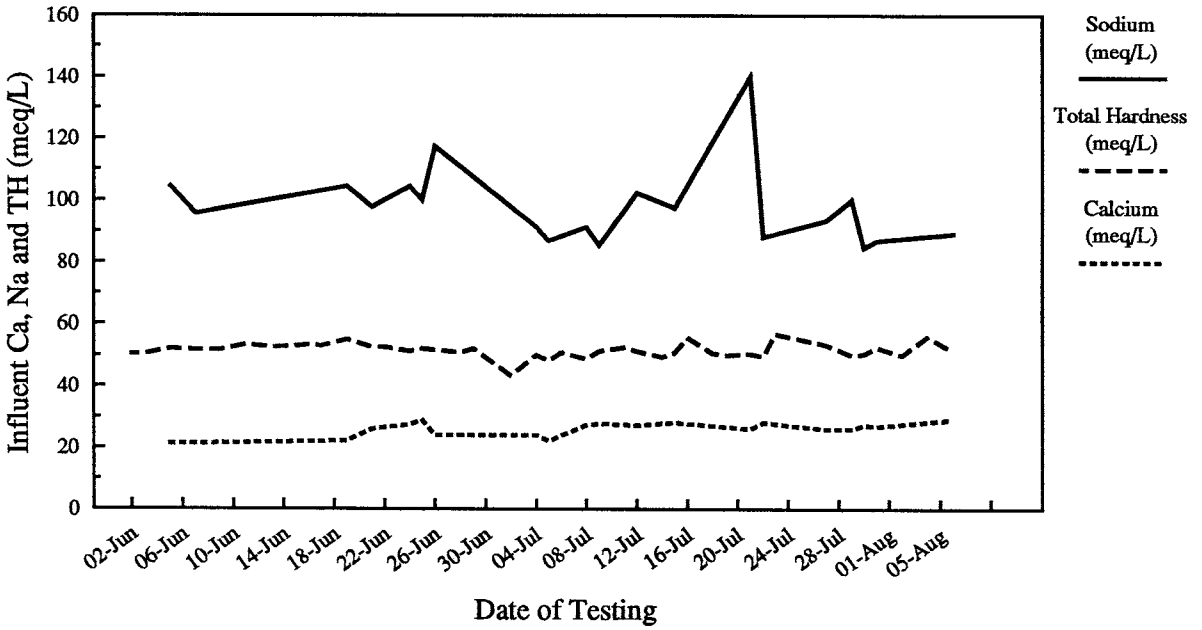


Figure 8
IX Influent Process Water TH, Ca and Na Conc.
January and Febuary, 1986

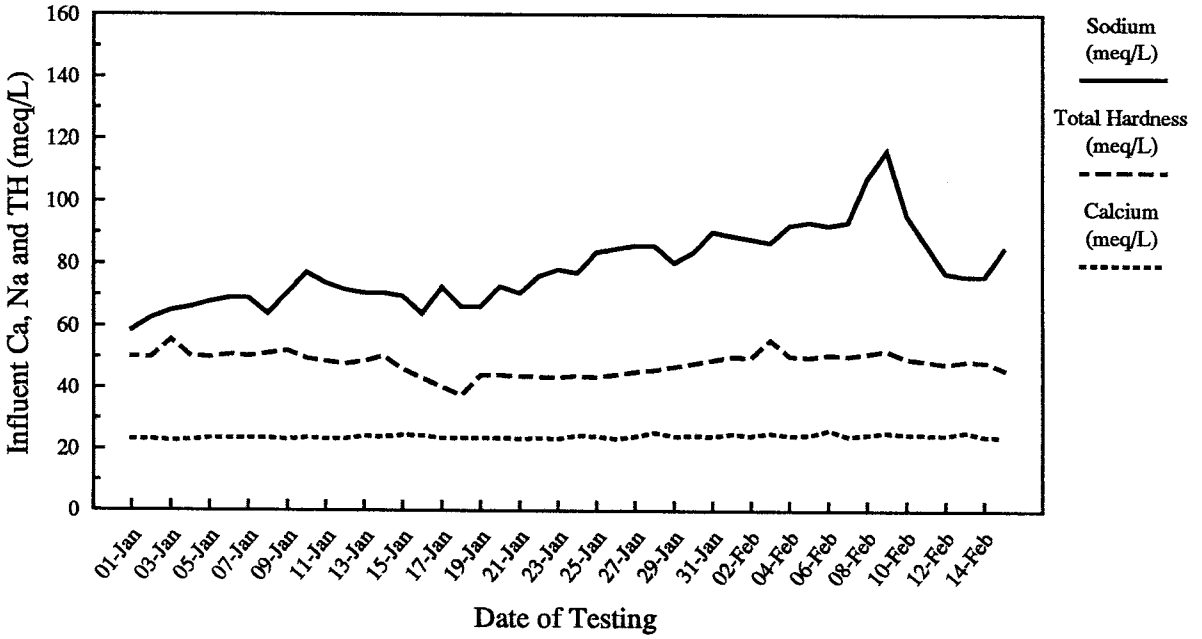


Figure 9
IX Influent Process Water TH, Ca and Na Conc.
May and June, 1986

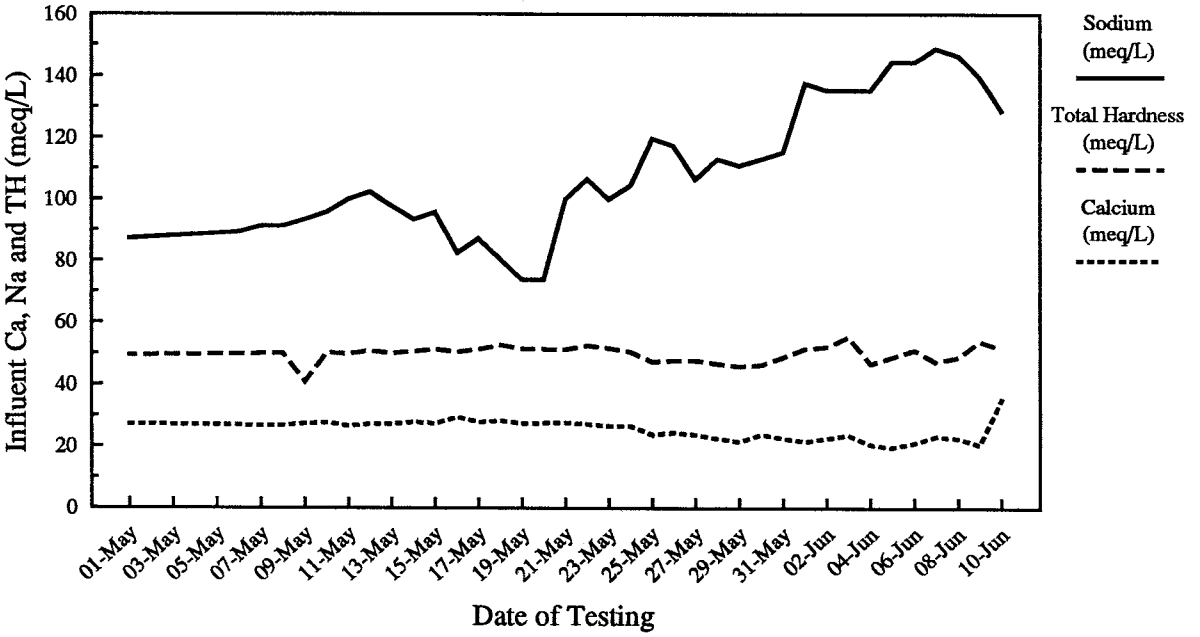


Figure 10
IX Influent Process Water TH, Ca and Na Conc.
July and August, 1986

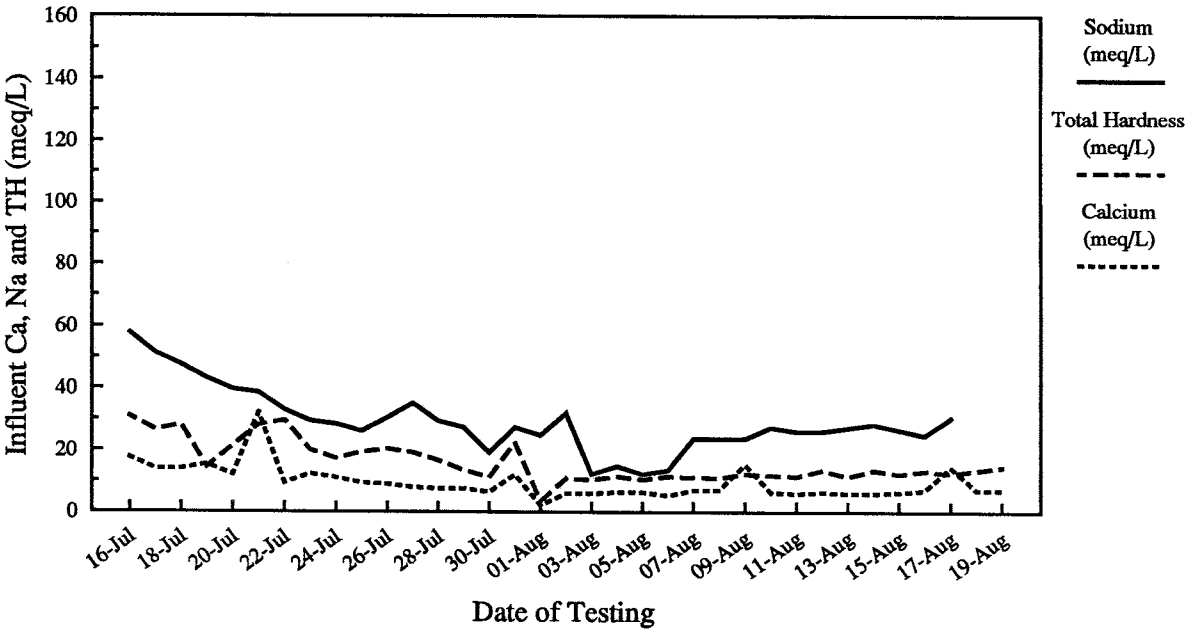
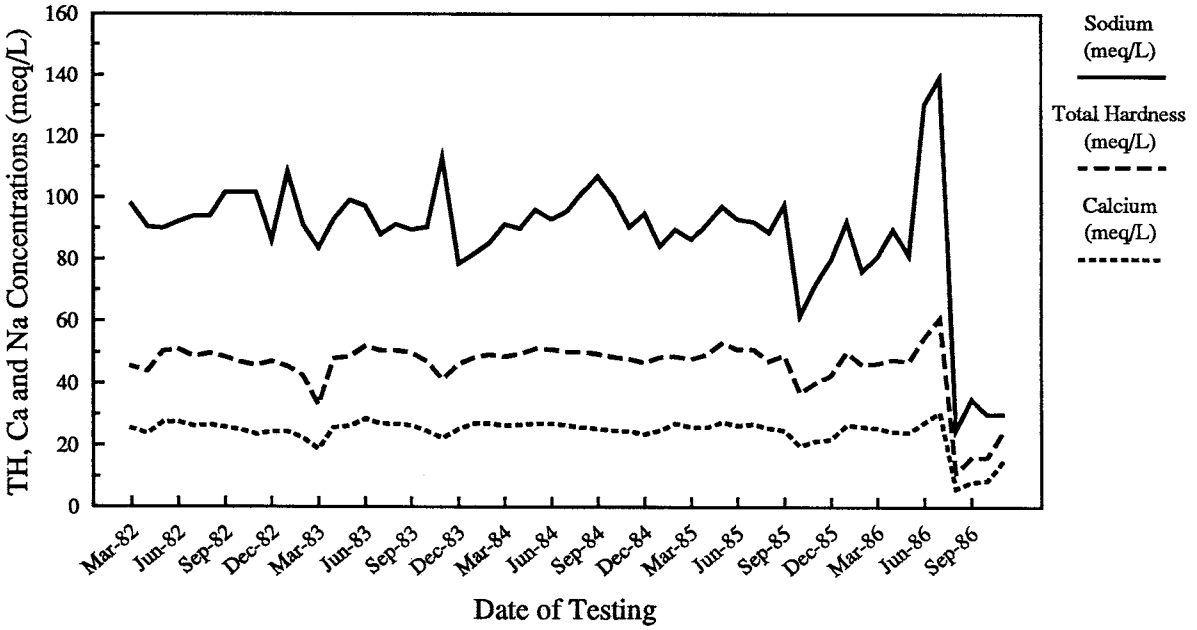


Figure 11
Monthly San Luis Drain TH, Ca, and Na Conc.
March 1982 through November 1986



Period 1 (June Through August 1985)

The main units were put into manual operation in June 1985. Period 1 operations formed (1) a baseline against which the results of other operation periods could be compared and (2) a basis for the computer control programs in the periods of automatic operation that came later. Regeneration was performed with specific volumes and concentrations of sodium chloride brine determined by the bench-unit tests.

Period 1 operation was initiated to verify and further develop the sodium chloride cycle as determined by the bench tests. The period coincided with the startup of a small (10-gpm) RO unit supplied by Hydranautics Water Systems, Inc., which was operated for 1,500 hours as a final check of pretreatment operations performance.

Since the check required softened water, the IX system was operated manually to supply it. (The IX control program for automatic operation was not complete at the beginning of the test program.) Only one IX unit had to be in operation to deliver the required flow. This allowed plenty of time for researchers to collect operational data and experiment with IX procedures.

Unit 1 supplied soft water to the Hydranautics RO unit by gravity flow. Unit 2 was operated periodically to fill clearwell 4 for use when Unit 1 was regenerating. Service ended when calcium leakage passed 1.0 meq/L. The basic schedule for operations is shown in Table 8. Other pertinent information was recorded throughout the entire cycle.

TABLE 8

ION-EXCHANGE OPERATIONS SCHEDULE
MANUAL OPERATIONS
(sodium chloride brine regeneration,
regeneration flow at 75 gpm with 12 percent brine)

Used brine to IX sump
Rinses A and B to IX sump

Rinse C to RWPS
Service to RO

Event Number	Event Description	Duration (minutes)	Component Operation (valve open)		Process Flow		
			Unit 1	Unit 2	Unit	From	To
1	Recirculation of NaCl brine	20	IP 3 IV 16, 39m, 40m	IP 2 IV 116, 139m, 140m	1 2	T6 T6	T6 T6
Recirculation to be performed just prior to regeneration.							
2	Drain	3	IV 6, 10, 22	IV 106, 110, 122	1 2	T6 T7	RWPS RWPS
Columns to be three-quarters full of liquid at end of event.							
3	NaCl brine regeneration	*	IP 3 IV 16, 14, 7, 9, 21	IP 2 IV 116, 114, 107, 109, 121	1 2	T6 T7	IX sump IX sump
4	Drain	3	IV 6, 10, 21	IV 106, 110, 121	1 2	T6 T7	IX sump IX sump
Columns to be three-quarters full of liquid at end of event.							
5	Rinse A	5	IP 7, DP 1 IV 1, 7, 10, 21	IP 9, DP 2 IV 101, 107, 110, 121	1 2	CW1 CW2	IX sump IX sump
6	Rinse B	10	IP 7, DP 1 IV 2, 7, 10, 21	IP 9, DP 2 IV 102, 107, 110, 121	1 2	CW1 CW2	IX sump IX sump
7	Rinse C	**	IP 7, DP 1 IV 2, 7, 10, 22	IP 9, DP2 IV 102, 107, 110, 122	1 2	CW1 CW2	RWPS RWPS
8	Service	***	IP 7, DP 1 IV 1, 7, 11	IP 9, DP 2 IV 101, 107, 111	1 2	CW1 CW2	RO unit RO unit
9	Set-up for regeneration		IP 4 IV 118	IP 4 IV 117	1 2	T5 T5	T6 T7
To be performed manually during service event.							

* Regeneration calls for using 3,740 gallons (2 feet, 10 inches of tank depth for tanks T6 and T7) of 12 percent brine. If at the end of 50 minutes less than 2 feet, 10 inches of brine was used, extend regeneration duration to encompass the entire 2 feet, 10 inches. If less than 12 percent brine was used for regeneration, extend regeneration duration an additional 3.5 inches for every percent reduction of brine concentration. Record all pertinent information of data sheet.

** Duration to be determined in field. Event ends when calcium leakage is less than 50 mg/L as $CaCO_3$.

*** Total service volume is expected to be 27,600 gallons.

Key

A	agitator mixer	IX	ion exchange
CW	clearwell	NaCl	sodium chloride
DP	dechlorination pump	RWPS	return water pump station
IP	ion-exchange pump	T	brine tank
IV	ion-exchange valve		

Problems were experienced in the making of sodium chloride regeneration brine. Although a special mixing-recirculation process was developed, it did not always mix the brine completely. The process consisted of pumping the layered fresh water and saturated brine contents of the mixing tank (T6 or T7) through a maze of piping and back into the mixing tank.

The results of Period 1 operations are shown in Table 9 and on Figures 12 and 13. Figure 12 shows that calcium leakage remained below 1.0 meq/L even though the sodium throughput fluctuated during regeneration. Figure 13 shows the volume of process water that was softened and the concentration of the regenerant brine as determined by two different methods. For operation, the salinity of the brine was determined on site with a hydrometer; the actual sodium content was determined in a laboratory by atomic adsorption spectroscopy. As shown on Figure 13, the actual sodium content and resulting total sodium throughput in regeneration varied for a relatively constant hydrometer measurement of 12 percent.

Other operation parameters developed in Period 1 included initial rinsing requirements and verification of flowrates through the flow control valves. Service, regeneration, and operator's log data are shown in Appendix D.

Period 2 (January Through February 1986)

The main units were restarted on January 2, 1986, to supply the RO unit with softened feedwater. This restarting was the first attempt to operate the system automatically with the Analog Devices, Inc., MACSYM computer. The system remained in operation until shutdown on February 17, when resin was found in the cartridge filters downstream from the IX units.

The objectives of Period 2 operations were to debug the system, further develop rinsing requirements, and provide low-calcium water to the RO units. As Table 10 shows, the units were operated on a conservative cycle to pass a more-than-adequate amount of sodium through the bed during regeneration for the volume of water to be softened. As data were collected and experience developed, the amount of sodium passed through the bed during regeneration was reduced to develop an efficient operation cycle. Initially, event durations were determined by bench unit and Period 1 test results and adjusted as required. Brine used for regeneration was pumped over from the south solar pond, which was acting as a holding pond for plant reject brine.

There were numerous shutdowns because of equipment failure and computer program development. Along with the passage of resin from the IX columns, other problems encountered included brine leaks from tanks T1 and T7 and precipitation of calcium sulfate in the recycled brine tank T4. These tanks were drained, cleaned, and repaired. Tanks T6 and T7 were not required for the reject brine mode of operations; therefore, they were taken out of the operations program. Resin was found to be leaking from a lower manifold of one IX column. The plastic screens on the underdrain laterals had eroded from the repetitive cycles and high velocities. The PVC screens were replaced with stainless-steel screens on all laterals of both units.

TABLE 9

MAIN UNIT OPERATIONS
PERIOD 1 RESULTS
June, July, and August 1985

Date	Softening									Regeneration			Ratio of Soft Water Produced to Sodium Throughput in Regeneration
	Ion-Exchange Influent (meq/L)				Ion-Exchange Effluent (meq/L)		Resin Operating Capacity (eq/L of resin)		Soft Water Produced (bed volume)	Sodium Chloride Brine		Total Sodium Throughput (eq/L of resin)	
	Total Hardness	Calcium	Sodium	Ratio of Sodium to Total Hardness	Total	Calcium	Total Hardness	Calcium		Sodium (meq/L)	EC (µS/cm)		
6-02	50.40	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
6-03	50.40	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
6-05	52.00	21.20	104.35	2.0	NA	0.58	NA	0.321	15.6	3,217.4	168,100	8.836	1.76
6-07	51.60	21.20	96.65	1.9	NA	0.62	NA	0.319	15.5	2,678.0	155,600	7.603	2.04
6-09	51.60	NA	NA	NA	NA	0.62	NA	NA	3.4	NA	NA	NA	NA
6-09	51.60	NA	NA	NA	NA	NA	NA	NA	14.6	NA	NA	NA	NA
6-11	53.20	NA	NA	NA	NA	0.52	NA	NA	8.4	NA	NA	NA	NA
6-12	52.80	NA	NA	NA	NA	0.46	NA	NA	NA	1,730.4	160,200	4.896	NA
6-13	52.40	NA	NA	NA	NA	0.56	NA	NA	14.2	NA	NA	NA	NA
6-15	52.80	NA	NA	NA	NA	NA	NA	NA	10.6	NA	NA	NA	NA
6-16	53.20	NA	NA	NA	NA	0.56	NA	NA	9.8	NA	NA	NA	NA
6-17	52.80	NA	NA	NA	NA	0.50	NA	NA	13.6	NA	NA	NA	NA
6-19	54.80	22.00	104.35	1.9	NA	0.52	NA	0.357	16.6	2,904.3	161,300	8.218	2.02
6-21	52.40	26.00	97.83	1.9	NA	0.58	NA	0.342	13.5	3,382.6	156,200	9.571	1.41
6-22	52.40	NA	NA	NA	NA	0.56	NA	NA	13.6	NA	NA	NA	NA
6-24	51.20	27.40	104.35	2.0	NA	0.46	NA	0.153	5.7	2,817.4	156,600	7.972	0.71
6-25	52.00	29.00	100.00	1.9	NA	0.64	NA	0.400	14.1	2,695.7	153,400	7.628	1.85
6-29	50.80	24.00	117.39	2.3	NA	0.30	NA	0.432	18.2	3,321.7	153,000	8.293	2.20
6-29	52.00	NA	NA	NA	NA	0.60	NA	NA	14.0	NA	NA	NA	NA
7-02	43.20	NA	NA	NA	NA	0.42	NA	NA	15.7	NA	NA	NA	NA
7-04	50.00	24.00	91.30	1.8	NA	0.60	NA	0.366	15.7	2,013.0	149,000	5.696	2.75
7-05	48.00	22.00	86.96	1.8	NA	0.62	NA	0.308	14.4	2,147.8	157,300	6.077	2.37
7-06	50.80	NA	NA	NA	NA	0.52	NA	NA	13.4	NA	NA	NA	NA
7-08	48.60	27.20	91.30	1.9	NA	0.62	NA	0.357	13.4	2,069.6	147,400	5.856	2.29
7-09	51.20	27.60	85.43	1.7	NA	0.62	NA	0.397	14.7	2,556.5	155,300	6.808	2.16
7-11	52.40	NA	NA	NA	NA	0.50	NA	NA	13.0	NA	NA	NA	NA
7-12	51.20	27.20	102.17	2.0	NA	0.62	NA	0.348	13.1	2,060.9	148,200	5.831	2.24
7-14	49.20	NA	NA	NA	NA	0.56	NA	NA	12.2	NA	NA	NA	NA
7-15	50.80	28.00	97.61	1.9	NA	0.64	NA	0.261	9.5	2,615.2	159,200	6.312	1.51
7-16	55.40	NA	NA	NA	0.70	NA	1.049	NA	19.2	NA	NA	NA	NA
7-18	50.60	NA	NA	NA	1.26	NA	0.826	NA	16.7	NA	NA	NA	NA
7-19	50.00	NA	NA	NA	1.26	0.72	0.723	NA	14.8	NA	NA	NA	NA
7-21	50.40	26.00	140.00	2.8	0.70	0.44	0.786	0.404	15.8	2,087.0	136,600	5.905	2.68
7-22	49.60	28.00	88.26	1.8	NA	NA	NA	NA	NA	3,543.5	179,500	10.027	NA
7-23	56.80	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
7-27	53.20	26.00	93.48	1.8	0.84	0.56	0.755	0.367	14.4	2,217.4	131,000	6.274	2.30
7-29	50.00	26.00	100.00	2.0	1.04	0.56	0.658	0.342	13.4	2,087.0	127,600	5.905	2.28
7-30	50.40	27.20	84.78	1.7	NA	NA	NA	NA	NA	1,956.5	123,300	5.699	NA
7-31	52.40	26.80	86.96	1.7	0.92	0.54	0.818	0.417	15.9	2,217.4	160,200	6.274	2.53
8-02	50.00	NA	NA	NA	0.92	0.52	0.657	NA	13.4	NA	NA	NA	NA
8-04	56.00	NA	NA	NA	0.90	0.56	0.855	NA	15.5	NA	NA	NA	NA
8-05	NA	NA	NA	NA	0.90	0.72	NA	NA	15.5	3,217.4	168,100	8.301	1.87
8-06	51.20	29.20	89.13	1.7	1.08	0.72	1.025	0.582	20.4	2,217.4	153,000	6.274	3.26

EC = electrical conductivity.
NA = not available.

Figure 12: Resin Capacity and Calcium Leakage Resulting from Sodium Throughput in Regeneration June, July and August, 1985

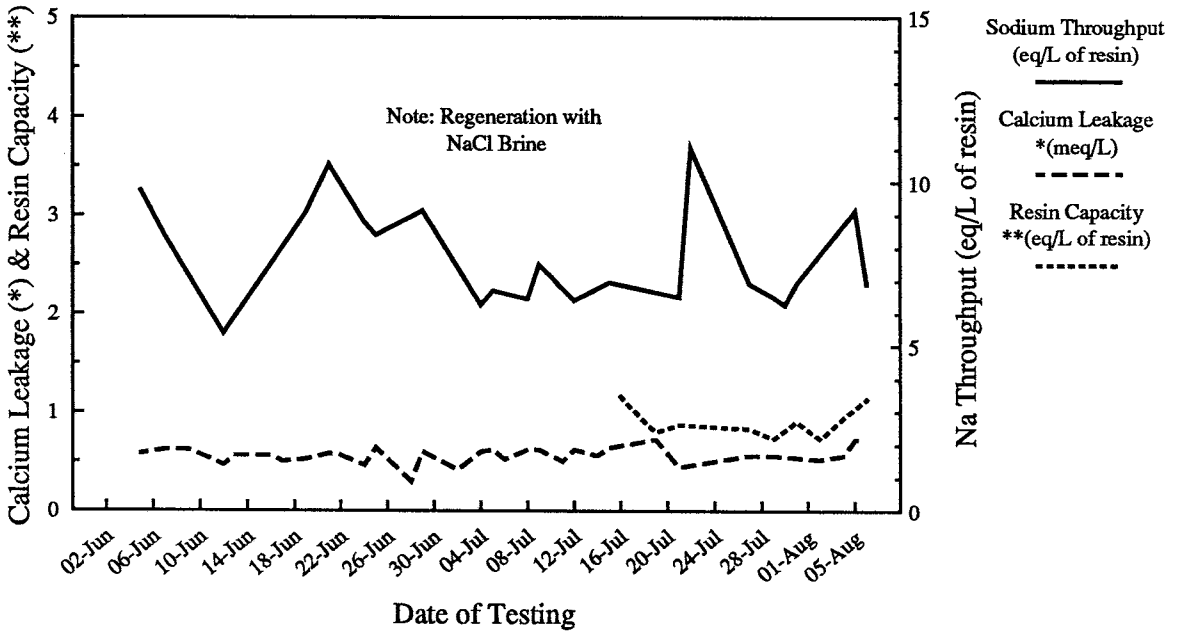


Figure 13: Volume of Softened Water Produced Resulting from Sodium Throughput in Regeneration June, July and August, 1985

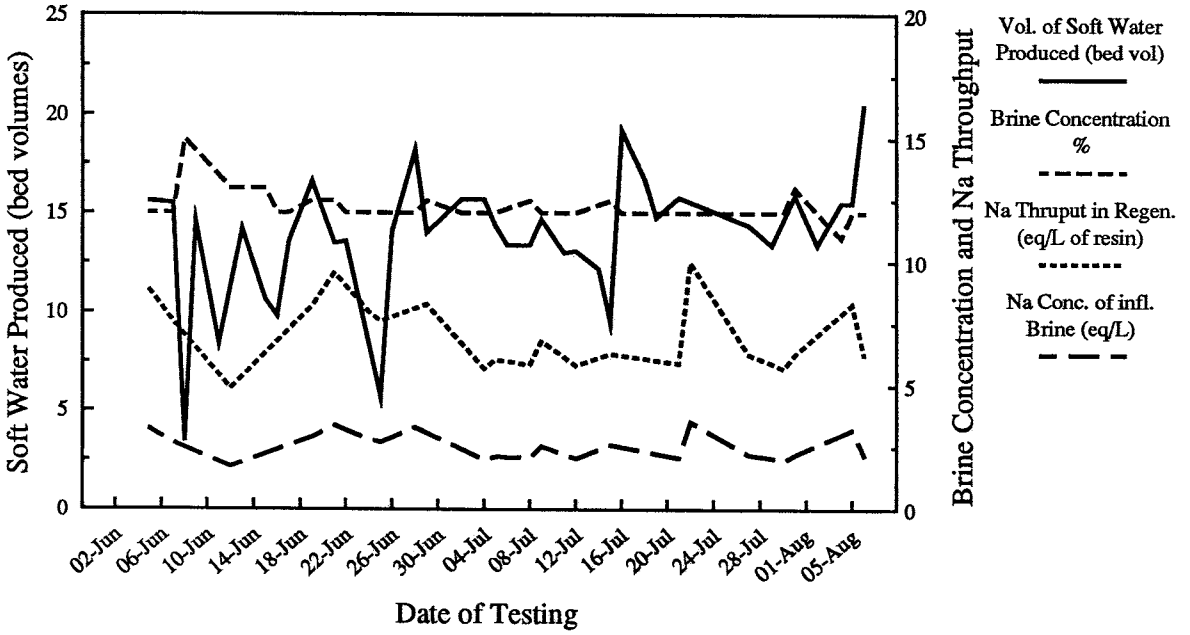


TABLE 10

ION-EXCHANGE OPERATIONS SCHEDULE*
PERIOD 2
(reverse osmosis/electrodialysis brine regeneration,
service flow at 110 gpm)

Waste brine to IX sump
Used brine to T2 or T3
Rinse to IX sump

December 3, 1985

Event Number	Event Description	Duration (minutes)	Component Operation (valve open)		Process Flow		
			Unit 1	Unit 2	Unit	From	To
1	Recycled brine regeneration 1	14	IP 5 IV 15, 12, 7, 9, 22	IP 5 IV 115, 112, 107, 109, 122	1 2	T4 T4	IX sump IX sump
2	Recycled brine regeneration 2	27	IP 5 IV 15, 12, 7, 4, 23	IP 5 IV 115, 112, 107, 104, 123	1 2	T4 T4	T2 T3
3	Fresh brine regeneration	9	IP 3 IV 16, 13, 7, 4, 23	IP 2 IV 116, 113, 107, 104, 123	1 2	T6 T7	T2 T3
4	Rinse A	5	IP 7 IV 1, 7, 19, 23	IP 9 IV 101, 107, 119, 123	1 2	CW1 CW2	T2 T3
5	Rinse B	4	IP 7 IV 2, 7, 19, 23	IP 9 IV 102, 107, 119, 123	1 2	CW1 CW2	T2 T3
6	Rinse C	11	IP 7 IV 2, 7, 10, 22	IP 9 IV 102, 107, 110, 122	1 2	CW1 CW2	IX sump IX sump
7	Rinse D	0	IP 7 IV 2, 7, 10, 21	IP 9 IV 102, 107, 110, 121	1 2	CW1 CW2	RWPS RWPS
8	Service	190	IP 7 IV 1, 7, 11	IP 9 IV 101, 107, 111	1 2	CW1 CW2	CW5 CW5
9	Mixing in T2 or T3	35	A 1	A 2	1 2	Mixing in T2** Mixing in T3**	
10	Set-up for regeneration	40	IP 6 IV 5	IP 6 IV 105	1 2	T2 T3	T4** T4**
11	Set-up for regeneration	6	IP 1 IV 17	IP 1 IV 18	1 2	T1 T1	T6** T7**
12	Drain	3	IV 6, 10, 21	IV 106, 110, 121	1 2	Unit 1 Unit 2	RWPS RWPS

* Error flag: incorrect operation schedule for service flow.
Revised from November 11, 1985 schedule.
Connecting line from CW2 to CW1 open.

** To be performed during service event.

Key

A	agitator mixer	IV	ion-exchange valve
CW	clearwell	IX	ion exchange
DP	dechlorination pump	RWPS	return water pump station
IP	ion-exchange pump	T	brine tank

Table 11 and Figure 14 present the results of Period 2 operations. Calcium leakage remained relatively stable at around 1.0 meq/L until near the end of the period when a gradual increase in leakage occurred. The increase is believed to be a result of the reduction of sodium throughput and the passage of calcium sulfate precipitate through the unit during regeneration.

It should be noted that, for all computer operations, process water effluent volumes (and resulting concentrated ions) included water used for chlorination along with any other water (brine) that inadvertently found its way into the effluent tank. Chlorination water was a combination of RO product water and City of Los Banos water. Flowrates required for chlorination injection were in the range of 7 through 12 gpm as compared to service flow of 110 gpm.

Detailed daily logs which describe the problems encountered in operations and other data collected during Period 2 are located in Appendix E.

Period 3 (May Through June 1986)

The IX and RO systems were restarted in early May following repairs to the columns, initiating a six-week test plan. The objective of the plan was to complete the loop of softening feedwater used in the desalting process and using the reject brine from the desalting process for regeneration of the IX process.

Period 3 operations were a continuation of Period 2 operations, and the IX system was coordinated with the RO units. The purpose of this coordination was to use, during a cycle, the entire volume of reject brine produced by the third-stage desalting unit for the fresh brine regenerant volume -- a minimum of 1 bed volume. The operations schedule for Period 3 is shown in Table 12. The service flowrate was 110 gpm until May 27, when it was increased to 230 gpm.

During Period 3, numerous shutdowns occurred due to service pump bearing failure, valve malfunctions, periodic brine shortages, computer program malfunctions, and problems with the electrodialysis (EDR) unit. By June, most of these problems were overcome and a host of new options were added to the computer operations program to make it more flexible. These options allowed for:

1. Transfer of recycled brine from mixing tanks T2 and T3 to the recycled brine tank (T4) without interrupting the other activities the computer was performing.
2. Choice of a single or continuous cycle.
3. Selection of service pumps.
4. Choice of service flowrates of 110 or 230 gpm.
5. Delay of regeneration to allow for service to begin directly after regeneration and rinse.
6. Choice of brine line from IX unit to mixing tank.
7. Choice of recycled brine regeneration flowrates of 150 or 200 gpm.
8. Choice of fresh brine regeneration flowrates of 75 or 150 gpm.

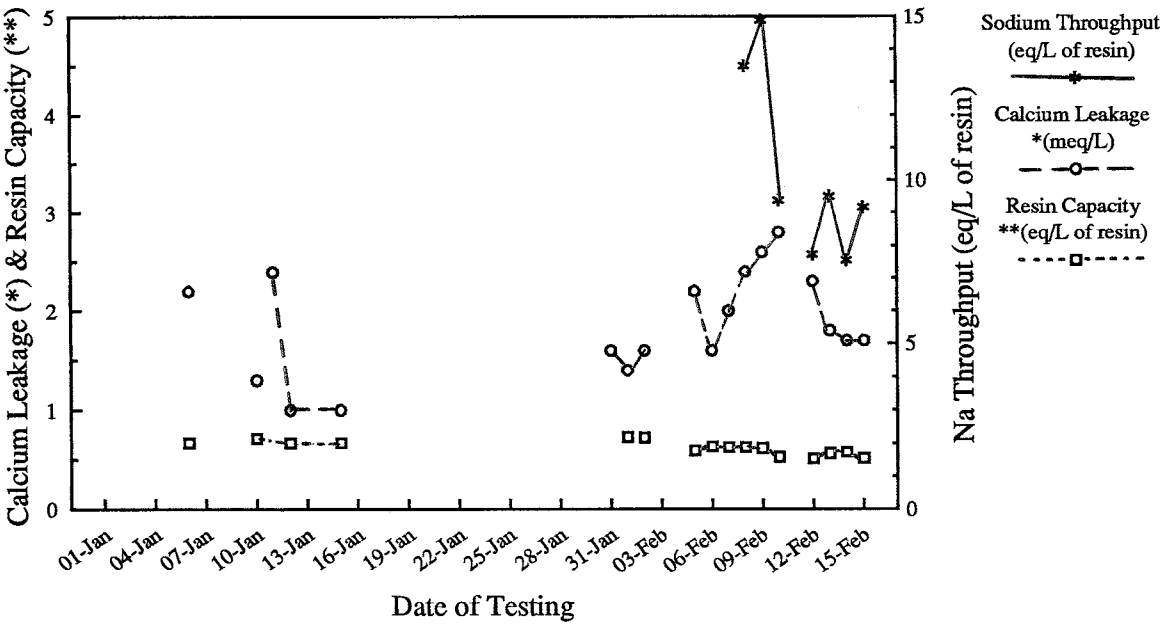
TABLE 11

MAIN UNIT OPERATIONS
PERIOD 2 RESULTS
January and February 1986

Date	Softening									Regeneration				
	Ion-Exchange Influent (meq/L)				Ion-Exchange Effluent (meq/L)			Resin Operating Capacity (eq/L of resin)		Recycled Brine		Fresh Brine		Total Sodium Throughput (eq/L of resin)
	Total Hardness	Calcium	Sodium	Ratio of Sodium to Total Hardness	Total Hardness	Calcium	Sodium	Total Hardness	Calcium	Sodium (meq/L)	EC (µS/cm)	Sodium (meq/L)	EC (µS/cm)	
1-01	50.1	23.1	58.7	1.2	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1-02	49.8	23.2	62.6	1.3	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1-03	55.5	22.7	65.2	1.2	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1-04	50.3	22.9	66.1	1.3	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1-05	49.8	23.5	67.8	1.4	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1-06	50.8	23.6	69.1	1.4	7.6	2.2	100.0	0.671	0.332	NA	NA	NA	NA	NA
1-07	50.3	23.6	69.1	1.4	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1-08	51.2	23.5	64.1	1.3	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1-09	51.9	23.2	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1-10	49.4	23.8	77.2	1.6	3.5	1.3	108.7	0.714	0.350	NA	NA	NA	NA	NA
1-11	NA	23.3	73.9	NA	9.2	2.4	102.2	NA	0.325	NA	NA	NA	NA	NA
1-12	47.8	23.3	71.7	1.5	4.8	1.0	108.7	0.668	0.347	NA	NA	NA	NA	NA
1-13	48.7	24.2	70.7	1.5	2.7	1.2	NA	NA	NA	NA	NA	NA	NA	NA
1-14	50.4	24.0	70.7	1.4	2.9	1.1	NA	NA	NA	NA	NA	NA	NA	NA
1-15	46.1	24.5	69.6	1.5	2.8	1.0	106.5	0.672	0.366	NA	NA	NA	NA	NA
1-16	NA	24.3	64.1	NA	3.2	0.9	115.2	NA	0.363	NA	NA	NA	NA	NA
1-17	NA	23.5	72.6	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1-18	37.5	23.6	66.3	1.8	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1-19	44.1	23.4	66.3	1.5	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1-20	44.2	23.4	72.8	1.6	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1-21	43.6	23.3	70.7	1.6	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1-22	NA	23.4	76.1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1-23	43.5	23.3	78.3	1.8	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1-24	44.0	24.3	77.2	1.8	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1-25	43.5	24.1	83.7	1.9	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1-26	44.4	23.3	84.8	1.9	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1-27	45.1	24.1	85.9	1.9	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1-28	45.7	25.3	85.9	1.9	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1-29	NA	24.1	80.4	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1-30	NA	24.3	83.7	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1-31	NA	24.2	90.2	NA	3.3	1.6	147.8	NA	0.352	NA	NA	NA	NA	NA
2-01	50.1	25.0	NA	NA	3.2	1.4	NA	0.730	0.367	NA	NA	NA	NA	NA
2-02	49.8	24.3	NA	NA	3.3	1.6	NA	0.721	0.353	NA	NA	NA	NA	NA
2-03	55.5	25.2	87.0	1.6	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2-04	50.3	24.4	92.4	1.8	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2-05	49.8	24.6	93.5	1.9	11.6	2.2	141.3	0.593	0.348	1,500.0	99,800	NA	NA	NA
2-06	50.8	26.2	92.4	1.8	10.3	1.6	141.3	0.629	0.381	1,760.9	98,800	1,652.2	100,500	15.1
2-07	50.3	24.1	93.5	1.9	10.1	2.0	123.9	0.625	0.343	3,913.0	65,600	1,913.0	72,300	32.0
2-08	51.2	24.7	107.6	2.1	11.1	2.4	158.7	0.623	0.346	1,521.7	77,400	1,934.8	75,300	13.5
2-09	51.9	25.4	116.3	2.2	12.5	2.6	171.7	0.613	0.355	1,673.9	77,200	2,173.9	77,400	14.9
2-10	49.4	24.8	95.7	1.9	15.5	2.8	121.7	0.528	0.342	1,043.5	73,400	1,478.3	73,000	9.4
2-11	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	72,100	NA	76,000	NA
2-12	47.8	24.6	77.2	1.6	15.0	2.3	108.7	0.510	0.346	934.8	86,500	456.5	90,800	7.7
2-13	48.7	25.5	76.1	1.6	12.5	1.8	113.0	0.563	0.369	1,065.2	81,800	1,413.0	89,400	9.5
2-14	48.4	24.2	76.1	1.6	11.4	1.7	108.7	0.575	0.350	826.1	80,600	1,326.1	90,500	7.5
2-15	46.1	24.0	84.8	1.8	13.2	1.7	106.5	0.511	0.346	978.3	80,000	1,869.6	82,100	9.2

EC = electrical conductivity.
NA = not available.

Figure 14: Resin Capacity and Calcium Leakage Resulting from Sodium Throughput in Regeneration January and Febuary, 1986



In addition, a printer was installed on the Analog computer to record the duration and time of the events performed. This printer was required for restarting the system because, during power outages of less than a second, the computer lost track of the event being performed. The power outages, which mostly occurred at night, were believed to be a result of the electrical purveyor's operations.

The IX/RO systems were shut down June 10, 1986, due to high silt density index in the feedwater to the desalting units. This condition was attributed to the changing chemistry of the San Luis Drain water as its volume was reduced by Westlands Water District in conformance with Westlands' agreement with the U. S. Department of Interior.

Period 3 results, shown in Table 13 and on Figure 15, are indicative of the various problems encountered. Sodium throughput in regeneration declined and eventually leveled off to approximately 7 equivalents of sodium per liter of resin, while the calcium leakage was high and erratic compared to previous operations. Calcium leakage ranged from a low of 4 meq/L to a high of over 11 meq/L. Other data collected in Period 3 are presented in Appendix F.

Period 4 (July Through August 1986)

The IX operations program was further modified in late June 1986 to provide upflow rinsing for rinsing events A and B. This modification was necessary in order to pass the complete fresh brine volume through the entire resin bed. Other modifications included expanded choice of flowrates for events 2, 3, 4, 5, and 8. The modified operation schedule is shown in Table 14.

TABLE 12

ION-EXCHANGE OPERATIONS SCHEDULE
PERIOD 3
(reverse osmosis/electrodialysis brine regeneration,
service flow at 110 gpm)

Waste brine to IX sump
Used brine to T2 or T3
Rinse to RWPS

Two-unit continuous operation
Test 1, Week 1
April 28, 1986

Event Number	Event Description	Duration (minutes)	Component Operation (valve open)		Process Flow		
			Unit 1	Unit 2	Unit	From	To
1	Recycled brine regeneration 1	10	IP 5 IV 15, 12, 7, 9, 22	IP 5 IV 115, 112, 107, 109, 122	1 2	T4 T4	IX sump IX sump
2	Recycled brine regeneration 2	32	IP 5 IV 15, 12, 7, 4, 23	IP 5 IV 115, 112, 107, 104, 123	1 2	T4 T4	T2 T3
3	Fresh brine regeneration	8	IP 3 IV 16, 13, 7, 4, 23	IP 2 IV 116, 113, 107, 104, 123	1 2	T6 T7	T2 T3
4	Rinse A	5	IP 7 IV 1, 7, 19, 23	IP 9 IV 101, 107, 119, 123	1 2	CW1 CW2	T2 T3
5	Rinse B	4	IP 7 IV 2, 7, 19, 23	IP 9 IV 102, 107, 119, 123	1 2	CW1 CW2	T2 T3
6	Rinse C	0	IP 7 IV 2, 7, 10, 22	IP 9 IV 102, 107, 110, 122	1 2	CW1 CW2	IX sump IX sump
7	Rinse D	16	IP 7 IV 2, 7, 10, 21	IP 9 IV 102, 107, 110, 121	1 2	CW1 CW2	RWPS RWPS
8	Service	180	IP 7 IV 1, 7, 11 CSOV 1	IP 9 IV 101, 107, 111 CSOV 6	1 2	CW1 CW2	CW5 CW5
9	Settling in T2 or T3	120	A 1*	A 2*	1 2	Settling in T2** Settling in T3**	
10	Set-up for regeneration to T4	28	IP 6 IV 5	IP 6 IV 105	1 2	T2 T3	T4** T4**
11	Drain	3	IV 6, 10, 21	IV 106, 110, 121	1 2	Unit 1 Unit 2	RWPS RWPS
12	Delay	32	A 1	A 2	1 2		

* Agitators are not in operation during Event 7 and part of Event 8.
Agitators are placed back into operation after Event 10 is completed during Event 8.
(During all other events, agitators are in operation.)

** To be performed during service event.

Key

A	agitator mixer	IV	ion-exchange valve
CW	clearwell	IX	ion exchange
CSOV	chlorine solenoid valve	RWPS	return water pump station
IP	ion-exchange pump	T	brine tank

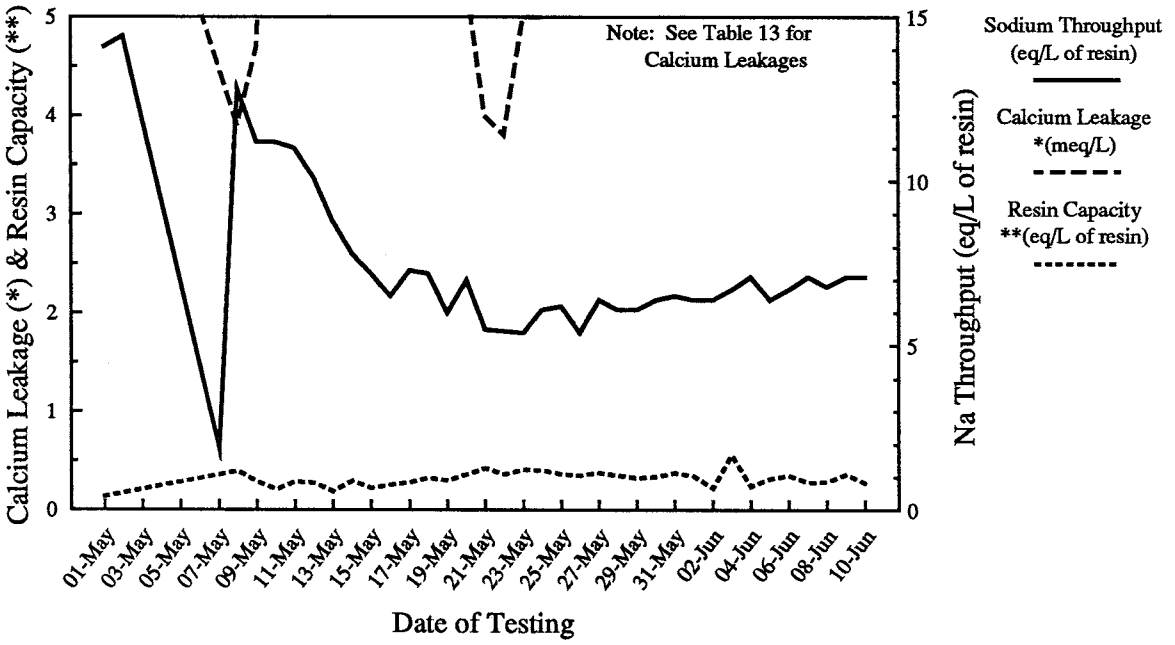
TABLE 13

MAIN UNIT OPERATIONS
PERIOD 3 RESULTS
May and June 1986

Date	Softening									Regeneration				
	Ion-Exchange Influent (meq/L)				Ion-Exchange Effluent (meq/L)			Resin Operating Capacity (eq/L of resin)		Recycled Brine		Fresh Brine		Total Sodium Throughput (eq/L of resin)
	Total Hardness	Calcium	Sodium	Ratio of Sodium to Total Hardness	Total Hardness	Calcium	Sodium	Total Hardness	Calcium	Sodium (meq/L)	EC (µS/cm)	Sodium (meq/L)	EC (µS/cm)	
5-01	49.2	27.0	87.0	1.8	39.8	8.1	178.3	NA	NA	1,956.5	75,700	2,130.4	73,400	NA
5-02	NA	NA	NA	NA	NA	NA	NA	NA	NA	2,000.0	76,700	2,173.9	74,400	15.2
5-03	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
5-04	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
5-05	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
5-06	NA	NA	89.1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
5-07	NA	NA	91.3	NA	NA	NA	89.1	NA	NA	134.8	68,100	1,217.4	74,700	2.0
5-08	50.0	26.7	91.3	1.8	23.2	3.9	128.3	0.415	0.352	1,391.3	65,700	2,260.9	82,000	13.4
5-09	40.8	27.2	93.5	2.3	21.4	4.7	143.5	0.300	0.348	1,173.9	57,100	2,347.8	77,600	11.8
5-10	50.2	27.5	95.7	1.9	36.2	8.0	139.1	0.217	0.302	1,173.9	54,000	2,434.8	78,000	11.8
5-11	49.8	26.5	100.0	2.0	30.6	6.0	137.0	0.297	0.317	1,130.4	52,000	2,565.2	78,000	11.6
5-12	50.8	27.0	102.2	2.0	32.1	6.3	137.0	0.289	0.321	1,043.5	49,000	2,782.6	77,000	10.6
5-13	50.0	27.1	97.8	2.0	37.2	7.2	137.0	0.199	0.308	956.5	48,000	2,304.3	77,000	9.3
5-14	50.6	27.7	93.5	1.8	30.7	6.8	123.9	0.308	0.324	826.1	44,200	2,087.0	65,400	8.2
5-15	51.2	27.3	95.7	1.9	36.3	7.2	119.6	0.230	0.311	782.6	44,000	1,869.6	61,000	7.6
5-16	50.3	29.3	82.6	1.6	33.4	8.3	100.0	0.263	0.326	652.2	47,600	1,652.2	71,000	6.9
5-17	51.2	27.7	87.0	1.7	32.1	6.8	100.0	0.295	0.324	739.1	44,500	1,782.6	67,700	7.7
5-18	52.6	28.0	NA	NA	30.4	6.0	104.3	0.344	0.340	739.1	45,000	1,695.7	64,000	7.6
5-19	51.4	27.2	73.9	1.4	31.3	6.8	82.6	0.312	0.315	652.2	46,000	1,043.5	68,000	6.3
5-20	NA	NA	73.9	NA	NA	NA	87.0	NA	NA	652.2	49,600	2,173.9	112,700	7.3
5-21	51.2	27.5	100.0	2.0	22.6	4.0	126.1	0.443	0.364	521.7	50,100	1,608.7	89,100	5.8
5-22	52.3	27.1	106.5	2.0	27.6	3.8	139.1	0.382	0.360	NA	53,900	NA	92,800	NA
5-23	51.6	26.5	100.0	1.9	23.8	5.0	126.1	0.430	0.333	565.2	58,300	1,130.4	71,800	5.7
5-24	50.4	26.5	104.3	2.1	22.8	5.0	130.4	0.427	0.333	608.7	56,600	1,521.7	101,500	6.4
5-25	47.2	23.6	119.6	2.5	22.6	5.2	143.5	0.381	0.285	608.7	63,000	1,652.2	107,000	6.5
5-26	47.6	24.4	117.4	2.5	23.8	5.4	137.0	0.369	0.294	521.7	64,000	1,565.2	112,000	5.7
5-27	47.6	23.7	106.5	2.2	23.2	5.4	126.1	0.395	0.295	652.2	60,900	1,521.7	107,500	6.7
5-28	46.6	22.5	113.0	2.4	23.6	5.6	128.3	0.372	0.274	608.7	62,800	1,565.2	109,100	6.4
5-29	45.8	21.5	110.9	2.4	24.6	11.5	121.7	0.343	0.162	608.7	63,900	1,521.7	112,300	6.4
5-30	46.2	23.7	113.0	2.4	24.2	6.0	143.5	0.356	0.286	652.2	67,100	1,565.2	106,800	6.8
5-31	48.8	22.5	115.2	2.4	24.4	6.0	150.9	0.395	0.266	652.2	69,700	1,608.7	108,700	6.8
6-01	51.4	21.5	137.4	2.7	29.0	10.0	155.2	0.363	0.186	652.2	68,800	1,565.2	97,600	6.8
6-02	52.0	22.5	135.2	2.6	37.4	10.0	148.7	0.236	0.202	652.2	75,300	1,565.2	106,600	6.8
6-03	55.2	23.5	135.2	2.4	19.0	7.0	150.9	0.586	0.267	695.7	77,300	1,434.8	107,400	7.0
6-04	46.6	20.5	135.2	2.9	30.8	5.0	159.6	0.256	0.251	739.1	79,100	1,521.7	108,300	7.4
6-05	48.8	19.5	144.3	3.0	28.2	8.0	157.4	0.333	0.186	652.2	75,200	1,565.2	107,800	6.8
6-06	51.0	21.0	144.3	2.8	28.2	7.5	157.4	0.369	0.219	695.7	67,700	1,521.7	88,400	7.1
6-07	47.2	23.0	148.7	3.2	29.2	9.0	159.6	0.291	0.227	739.1	68,800	1,521.7	89,200	7.4
6-08	48.6	22.5	146.5	3.0	30.2	11.5	166.5	0.298	0.178	695.7	70,800	1,565.2	94,800	7.1
6-09	53.8	20.5	139.6	2.6	30.0	8.0	159.6	0.385	0.202	739.1	72,900	1,521.7	98,000	7.4
6-10	51.6	35.0	128.7	2.5	33.8	9.0	150.9	0.288	0.421	739.1	74,700	1,521.7	97,600	7.4

EC = electrical conductivity.
NA = not available.

Figure 15: Resin Capacity and Calcium Leakage Resulting from Sodium Throughput in Regeneration May and June, 1986



IX Unit 2 was restarted during the latter part of July when the silt density index was lowered to acceptable levels by the clarification/filtration system. The IX system was operated according to the new schedule. The process scheme was IX Unit 2 to RO Unit 2 to EDR and the EDR's reject brine to the fresh brine tank as shown on Figure 16. The process scheme did not change until August 5, 1986, when RO Unit 1 was brought on-line. Figure 17 shows the changes that occurred when RO Unit 1 was introduced. On August 8, 1986, the process scheme was returned to the previous scheme when RO Unit 1 was shut down to repair a pump seal. These systems remained in operation until August 20, 1986, when the system was completely shut down because of high silica and silt density index levels.

Results of Period 4 operations are shown in Table 15 and graphed on Figure 18. Calcium leakage remained around 1.0 meq/L for the entire period except from August 5 to 10, 1986. During this period, calcium leakage rose to as high as 4.0 meq/L, due to the phasing in of RO Unit 1 and the reduction of the sodium content of the regenerant brine.

Other information -- including data from operation logs, daily chemical analyses, and test plans concerning Period 4 operations -- is located in Appendix G.

TABLE 14

ION-EXCHANGE OPERATIONS SCHEDULE
PERIOD 4
(default durations and flows,
reject brine regeneration,
upflow rinse)

Waste brine to IX sump
Used brine to T2 or T3

Rinse to San Luis Drain

Event Number	Event Description	Duration* (minutes)	Component Operation (valve open)		Process Flow		
			Unit 1	Unit 2	Unit	From	To
1	Recycled brine regeneration 1	13	IP 5, A 1 IV 15, 12, 7, 9, 22	IP 5, A 2 IV 115, 112, 107, 109, 122	1 2	T4 T4	IX sump IX sump
2	Recycled brine regeneration 2	40	IP 5, A 1 IV 15, 7, 4, 23 **	IP 5, A 2 IV 115, 107, 104, 123 **	1 2	T4 T4	T2 T3
3	Fresh brine regeneration	9	IP 1, A 1 IV 17, 7, 4, 23, 39m **	IP 1, A 2 IV 18, 107, 104, 123, 139m **	1 2	T1 T1	T2 T3
4	Rinse A, upflow	6	IP 7, A 1 IV 3, 7, 4, 23 **	IP 9, A 2 IV 103, 107, 104, 123 **	1 2	CW1 CW2	T2 T3
5	Rinse B, upflow	5	IP 7, A 1 IV 3, 7, 4, 23 **	IP 9, A 2 IV 103, 107, 104, 123 **	1 2	CW1 CW2	T2 T3
6	Rinse C	5	IP 7, A 1 IV 1, 7, 10, 21	IP 9, A 2 IV 101, 107, 110, 121	1 2	CW1 CW2	RWPS RWPS
7	Rinse D	9	IP 7 IV 2, 7, 10, 21	IP 9 IV 102, 107, 110, 121	1 2	CW1 CW2	RWPS RWPS
8	Service	120	IP 7 IV 7, 11 ** CSOV 1	IP 9 IV 107, 111 ** CSOV 6	1 2	CW1 CW2	CW3 CW4
9	Settling in T2 or T3	50			1 2	Settling in T2 *** Settling in T3 ***	
10	Set-up for regeneration to T4 from T2 or T3	35	IP 6 IV 5	IP 6 IV 105	1 2	T2 T3	T4 *** T4 ***
11	Drain	3	IV 6, 10, 21 A 1	IV 106, 110, 121 A 2	1 2	Unit 1 Unit 2	RWPS RWPS
12	Delay	0	A 1	A 2			

* Durations based upon two-unit operation for one bed volume of brine produced during service and flows of 200, 150, 75, 200, and 230 for Events 2, 3, 4, 5, and 8, respectively (default flows and durations). See operation instructions for current flows and durations. Process water EC at 7,500 µS/cm.

** Flow variables:
Events 2, 3, 4, and 5: IV 14 or 114 for 75 gpm or IV 13 or 113 for 150 gpm or IV 12 or 112 for 200 gpm.
Event 8: IV 1 or 101 for 110 gpm or IV 2 or 102 for 230 gpm.

*** To be performed during service event.

Key

A	agitator mixer	IX	ion exchange
CW	clearwell	m	manual
CSOV	chlorine solenoid valve	RWPS	return water pump station
IP	ion-exchange pump	T	brine tank
IV	ion-exchange valve		

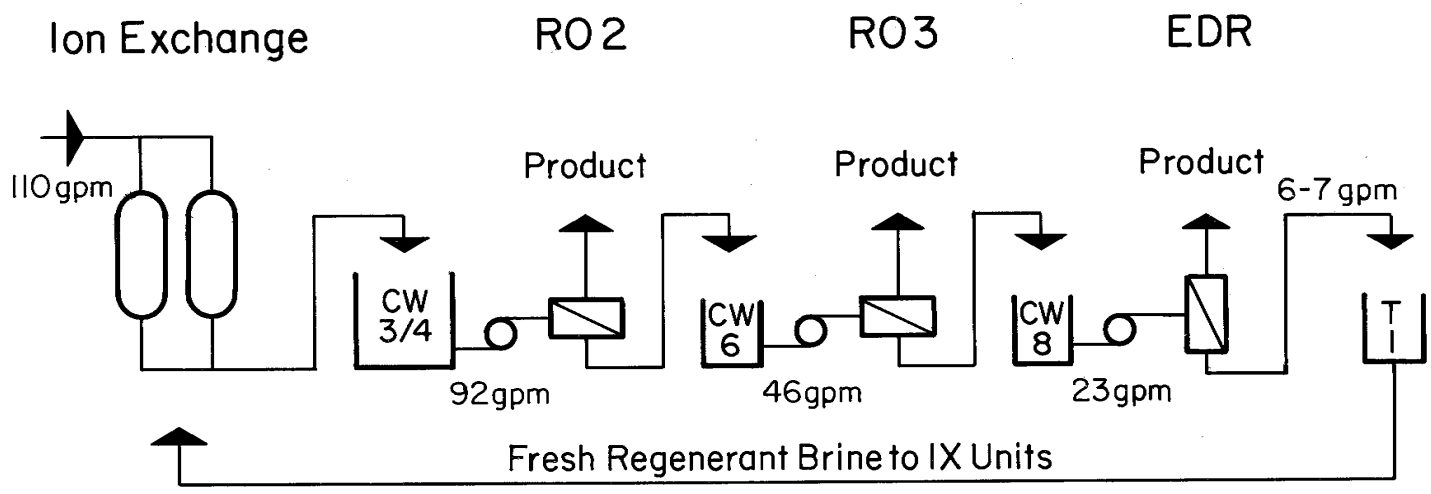


Figure 16. Flow Schematic IX to RO2 to RO3 to EDR

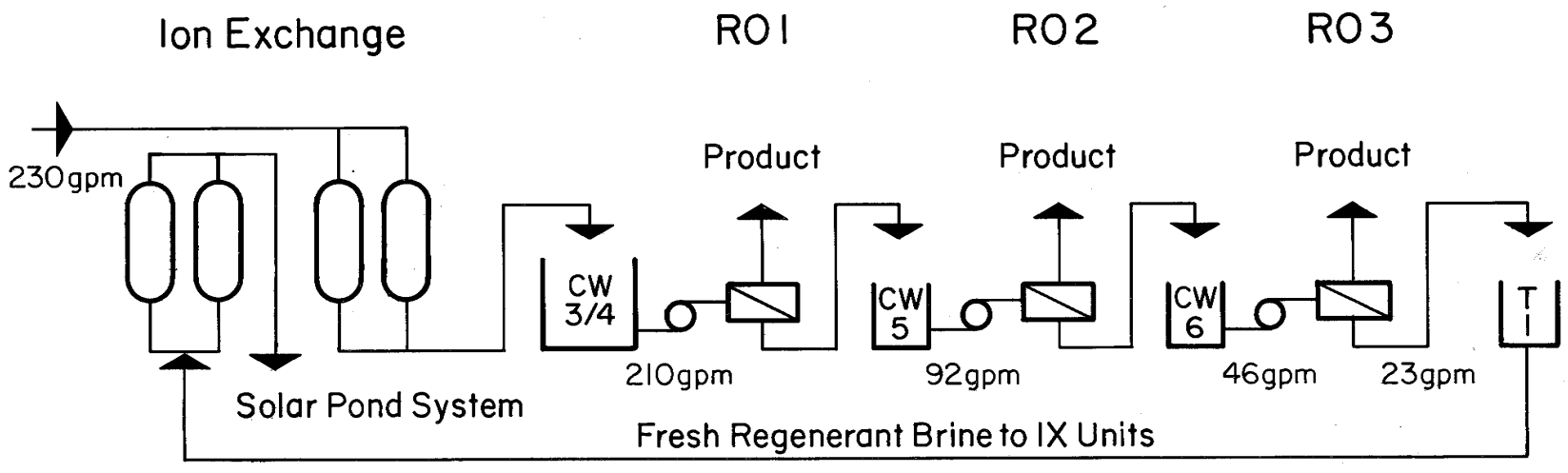


Figure 17. Flow Schematic IX to RO1 to RO2 to RO3

TABLE 15

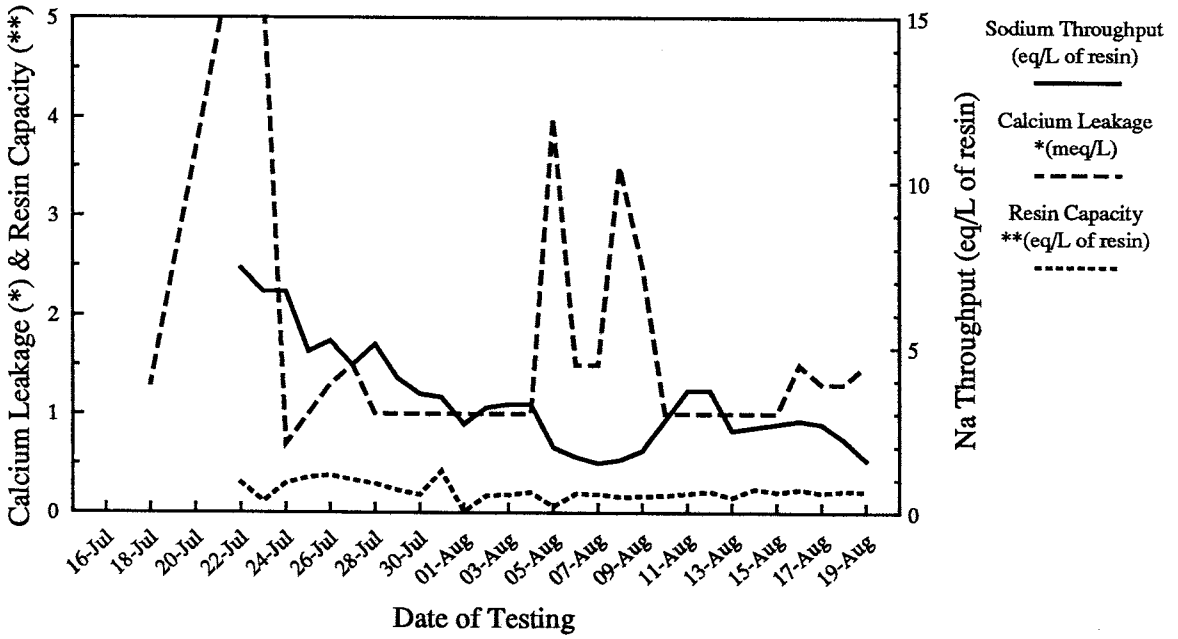
MAIN UNIT OPERATIONS
PERIOD 4 RESULTS
July and August 1986

Date	Softening									Regeneration				
	Ion-Exchange Influent (meq/L)				Ion-Exchange Effluent (meq/L)			Resin Operating Capacity (eq/L of resin)		Recycled Brine		Fresh Brine		Total Sodium Throughput (eq/L of resin)
	Total Hardness	Calcium	Sodium	Ratio of Sodium to Total Hardness	Total Hardness	Calcium	Sodium	Total Hardness	Calcium	Sodium (meq/L)	EC (µS/cm)	Sodium (meq/L)	EC (µS/cm)	
7-16	30.8	17.5	57.6	1.9	*									
7-17	26.4	14.0	51.1	1.9	*									
7-18	28.0	14.0	47.4	1.7	NA	1.3	NA	NA	0.274	NA	NA	NA	NA	NA
7-19	14.6	15.5	43.0	2.9	*									
7-20	NA	12.0	39.6	NA	*									
7-21	28.2	32.0	38.5	1.4	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
7-22	29.6	9.5	32.8	1.1	15.6	6.0	71.3	0.301	0.075	739.1	85,200	1,260.9	108,900	7.4
7-23	20.0	12.3	29.3	1.5	14.4	5.5	48.7	0.120	0.145	652.2	19,300	1,260.9	8,600	6.7
7-24	17.2	11.0	28.3	1.6	3.2	0.7	44.3	0.301	0.221	652.2	81,000	1,217.4	10,100	6.7
7-25	19.4	9.5	26.1	1.3	2.6	1.0	37.2	0.361	0.183	521.7	70,300	565.2	51,400	4.9
7-26	20.4	9.0	30.4	1.5	2.8	1.3	44.3	0.378	0.167	565.2	65,800	521.7	44,900	5.2
7-27	19.2	8.0	35.0	1.8	3.6	1.5	42.2	0.335	0.140	478.3	60,400	478.3	40,800	4.5
7-28	16.6	7.5	29.3	1.8	2.8	1.0	37.6	0.297	0.140	565.2	70,200	434.8	40,800	5.1
7-29	13.5	7.5	27.2	2.0	2.8	1.0	40.0	0.230	0.140	434.8	56,800	478.3	38,400	4.1
7-30	11.2	6.5	19.2	1.7	2.6	1.0	28.8	0.185	0.118	347.8	44,700	695.7	36,100	3.6
7-31	22.4	12.0	27.2	1.2	2.8	1.0	28.9	0.421	0.236	369.6	52,900	434.8	37,400	3.5
8-01	3.6	2.0	24.8	6.9	2.8	1.0	42.2	0.017	0.021	291.3	37,400	391.3	38,100	2.7
8-02	10.8	6.0	31.7	2.9	2.6	1.0	28.3	0.176	0.107	347.8	37,600	413.0	39,500	3.2
8-03	10.4	6.0	12.4	1.2	1.8	1.0	33.3	0.185	0.107	347.8	41,200	478.3	40,700	3.3
8-04	11.6	6.5	14.8	1.3	1.8	1.0	21.5	0.211	0.118	347.0	42,700	478.3	41,000	3.3
8-05	10.4	6.5	12.4	1.2	7.2	4.0	48.7	0.069	0.054	245.9	31,000	184.3	17,600	2.0
8-06	11.4	5.5	13.5	1.2	2.2	1.5	55.4	0.198	0.086	197.6	23,300	193.3	17,200	1.7
8-07	11.2	7.0	23.7	2.1	2.4	1.5	49.8	0.189	0.118	109.8	23,900	391.3	20,200	1.5
8-08	11.0	7.0	NA	NA	3.4	3.5	NA	0.163	0.075	167.0	21,400	217.4	20,800	1.6
8-09	12.4	15.5	23.7	1.9	4.6	2.5	31.1	0.168	0.279	153.9	27,100	478.3	29,700	1.9
8-10	11.8	6.5	27.2	2.3	3.6	1.0	39.6	0.176	0.118	NA	NA	NA	NA	NA
8-11	11.4	6.0	26.1	2.3	NA	NA	NA	NA	NA	326.1	17,600	826.1	31,200	3.7
8-12	13.6	6.5	26.1	1.9	3.6	1.0	36.1	0.215	0.118	326.1	17,300	847.8	32,200	3.7
8-13	11.6	6.0	NA	NA	4.2	1.0	NA	0.159	0.107	260.9	24,300	413.0	31,100	2.5
8-14	13.6	6.5	28.3	2.1	2.4	1.0	39.6	0.241	0.107	NA	NA	NA	NA	NA
8-15	12.4	6.5	NA	NA	2.6	1.0	NA	0.211	0.118	282.6	32,500	391.3	29,900	2.7
8-16	13.4	7.0	24.8	1.8	2.4	1.5	31.7	0.236	0.118	304.3	33,200	369.6	30,200	2.8
8-17	12.6	14.5	30.4	2.4	3.2	1.3	38.5	0.202	0.285	304.3	30,900	347.8	27,300	2.7
8-18	13.6	7.0	NA	NA	3.2	1.3	NA	0.224	0.124	239.1	29,400	304.3	25,620	2.2
8-19	14.6	7.0	NA	NA	4.6	1.5	NA	0.215	0.118	144.8	17,900	326.1	25,900	1.6
8-20	12.4	7.0	NA	NA	*									
8-21	13.4	7.0	NA	NA	*									

*IX system off.

EC = electrical conductivity.
NA = not available.

Figure 18: Resin Capacity and Calcium Leakage Resulting from Sodium Throughput in Regeneration July and August, 1986



CHAPTER VI. DISCUSSION

Overall assessments of the IX system's performance are based on the quality and quantity of process water softened for an amount of salt used for regeneration. The terms "quality" and "quantity" refer to calcium leakage and volume of water softened for a volume of resin, respectively, while the amount of salt used in regeneration refers to sodium volume passing through the bed in regeneration.

IX system performance is actually a measure of total plant performance, since the IX process is dependent on upstream clarification and filtration processes and downstream desalting processes. For the IX system to have low calcium leakages, the brine generated for regeneration must meet both volumetric and quality requirements.

Performance results for Los Banos operations were presented and briefly discussed in the previous section. These results were based on daily samples taken from clearwell or brine tanks, including all chlorinated and brine waters which inadvertently entered the clearwells. Generally, the chlorination flowrate was in the range of 7 to 11 gpm. Periodically, calcium and hardness analyses were also performed on the effluent to verify actual leakage.

Due to the changing feedwater conditions, development of the process, and other planned and unplanned activities that introduced a myriad of variables, the IX desalting process was never operated under steady-state conditions for the process to reach an equilibrium condition. The process needs to be operated in a steady-state condition to further refine operation parameters and determine the resin's operating capacity and life when subjected to extreme conditions as would be encountered. The information gathered from operations at Los Banos forms the basis for future studies and has given significant knowledge in the areas of programming and controlling, modeling, monitoring, selection of equipment, and identification of problems encountered.

Programming and Controlling

The initial computer operations program was a fairly simple one that allowed only for durations of the events to be input for a two-unit operation. Through operations, this program proved to be too inflexible to coordinate the batch process of the IX system between the two continuous processes -- clarification/filtration and desalting. The control program was modified as necessary based on the information in the previous section. The operations program was based upon the following criteria:

1. Limiting of waste volumes to be disposed of. (Waste consists of rinse water and waste brine.)

2. Setting a maximum process water concentration limit at one bed volume. The time frame in which the bed volume is generated is dependent on the volume of water softened in a cycle and the flowrates of the desalting units.

3. Establishing a minimum service factor of 50 percent at maximum softening flowrate.

4. Determining that the amount of sodium in the volume of fresh reject brine used in regeneration equals the amount of total hardness removed during softening. Inherent in this condition is the knowledge that the sodium concentration must be "N" times the total hardness concentration to provide the driving force necessary for the exchange of ions to occur. "N" depends upon resin, feedwater, and brine characteristics.

5. Determining that the total duration of brine settling and transfer of the used brine to the recycled brine tank is equal to or less than the duration of the softening (service) event.

By the time the system was shut down, the system could be run reliably for a variety of test conditions. The operations program had the capability to:

1. Operate one or both units continuously or just a single cycle for either or both units.

2. Change any of the cycle event durations.

3. Provide service flowrates of 110 or 230 gpm.

4. Provide fresh brine regeneration event flowrates of 75 or 150 gpm.

5. Delay regeneration when the unit or units were run in the continuous mode. This feature allowed for the service event to be performed directly after regeneration and rinsing. Experience dictated that this delay was necessary because leaving the rinse water in contact with the resin for any length of time after regeneration resulted in an early hardness breakthrough. "Regeneration delay" is Option 4 in the special options menu of the IX operations program and only necessary for the 110-gpm flowrate.

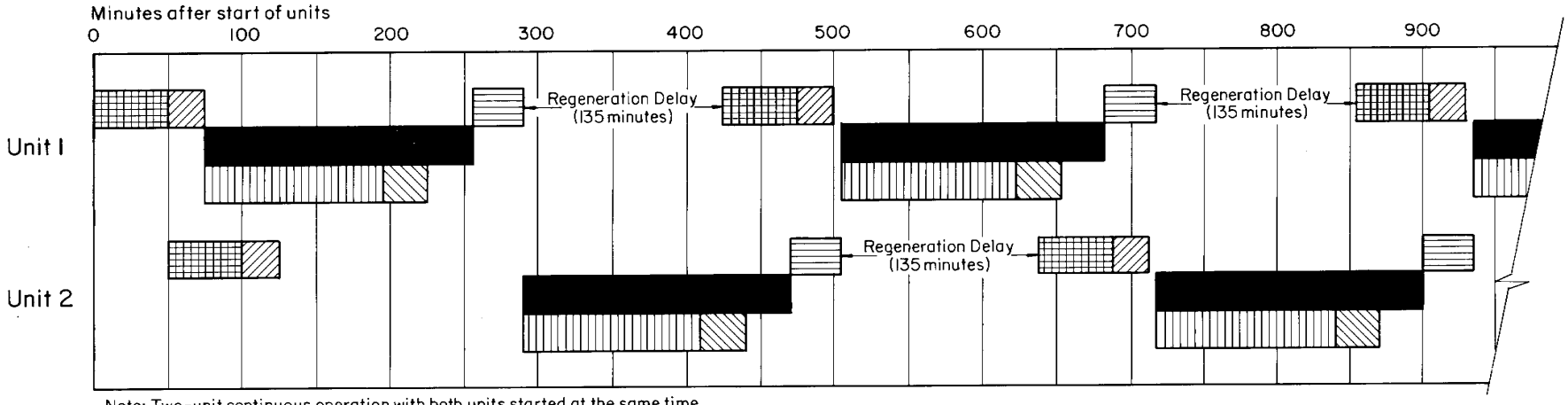
6. Delay the start of the IX cycle to coordinate the operation of the IX with desalting system operations. This delay is Event 12 of the IX cycle.

The flexibility of operating the IX system under various desalting scenarios is shown by the bar graphs of Figures 19 and 20. Figure 19 shows the 92-gpm desalting scenario as shown on Figure 16, whereas Figure 20 shows the 210-gpm desalting scenario as shown on Figure 17. Event durations corresponding to the bar graphs are shown on Table 16 and were developed as part of the testing program for Tests 1 and 3 previously described and found in Appendix F. Both IX units were started at the same time.

Another important feature of the operations program was the capability to transfer brine from either tank T2 or T3 to tank T4. This transfer was done by computer without interrupting other activities the computer was performing simultaneously.

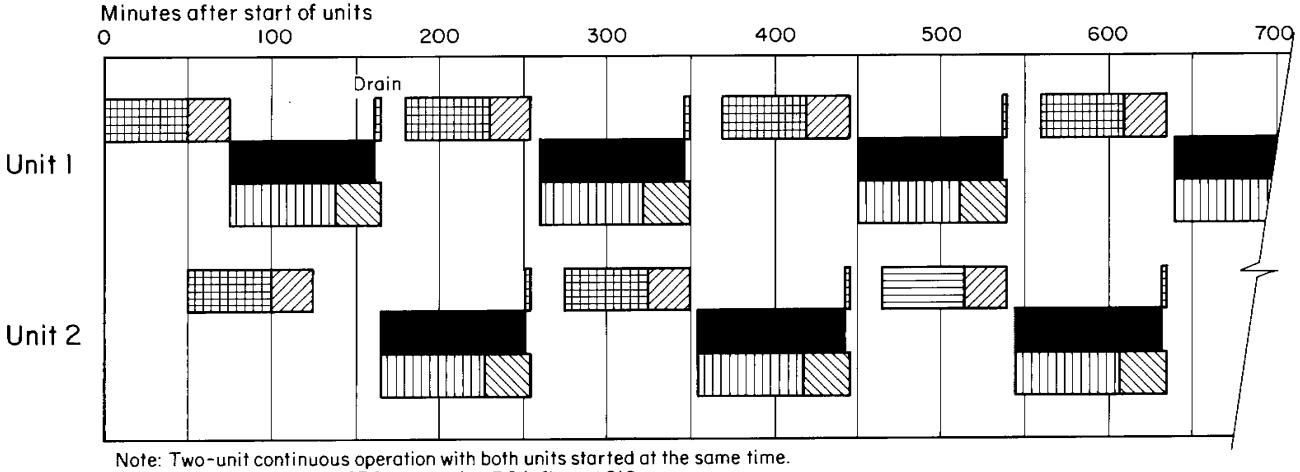
The IX cycle developed consisted of 12 events -- three regenerations, four rinses, service, settling of brine, brine transfer, drain, and delay. The three regenerations and four rinses (two upflow and two downflow) were necessary to route the waters and brines to appropriate locations. This

Figure 19. IX Cycle for Desalting Test 1



Note: Two-unit continuous operation with both units started at the same time.
IX service flow at 110gpm to give RO 2 flow at 92gpm.

Figure 20. IX Cycle for Desalting Test 3



Note: Two-unit continuous operation with both units started at the same time.
IX service flow at 230gpm to give RO 1 flow at 210gpm.

Legend

- Total Regeneration; events 1, 2 and 3
- Rinses A, B, C and D; events 4, 5, 6 and 7
- Service; event 8
- Settling in T2 or T3; event 9
- Set-up for regeneration; event 10
- Drain and delay; events 11 and 12

TABLE 16

EVENT DURATIONS

Event Number	Event Description	Duration (minutes)	
		Figure 19	Figure 20
1	Recycled brine regeneration 1	10	13
2	Recycled brine regeneration 2	32	23
3	Fresh brine regeneration	8	14
4	Rinse A (upflow)	5	5
5	Rinse B (upflow)	4	4
6	Rinse C	0	0
7	Rinse D	16	16
8	Service	180	87
9	Settling in T2 or T3 during service	120	60
10	Setup for regeneration during service	28	28
11	Drain	3	3
12	Delay	32	0
--	Regeneration delay (secondary menu)	135	0

routing minimized dilution effects of rinse water on the used brine. Also, the upflow rinses allowed for the full volume of fresh brine to be pushed through the columns and saved for use in regeneration. For more information concerning the IX cycle, consult the three test plan schedules in Appendix F.

Modeling

A model was developed to simulate the operation of the IX desalting loop. The model calculated event durations and volumes of softened water and brines generated for an input IX desalting scenario. The program also determined operation schedules and flagged system constraints. An output of the model is located in Appendix H.

Monitoring

The addition of a printer helped detect programming bugs, equipment malfunctions, and other problems. The printer recorded the unit, event, and time that the event was put into operation. These data were extremely helpful in operations and system evaluation.

Selecting Equipment and Materials

Each IX column contained three manifolds or distributors -- top, middle, and bottom -- to equally distribute flow across the columns' cross-sections. Each manifold consisted of a 3-inch header and 1-inch PVC laterals projecting at right angles from the header. The bottom header was made of wrought steel, while the middle and top headers were fashioned from PVC. The laterals were covered with a PVC screen to prevent resin loss. The bottom manifold was located 10 inches above the concave-shaped column bottom. The interiors of the columns were coated with epoxy.

During the course of operations, all bottom manifolds made of PVC were replaced with stainless steel manifolds and screens on the laterals of top manifolds were taken off to allow solids to be removed from the columns during regeneration. In addition, interiors of the columns were resurfaced to repair corrosion damage while the bottom manifolds were being replaced.

There were two types of process control valves involved in the operation of the IX system. The original contract supplied butterfly valves, while ball valves were installed in the IX sump contract.

The computer-controlled butterfly valves operated as signaled after they were manually broken free following a long period of inoperation. Leakage through the butterfly valves did occasionally occur as a result of the contamination of the IX effluent clearwell with regenerant brine. The leakage was corrected when discovered and could have been detected by continuous monitoring for conductivity of the line.

The large ball valves (3 to 4 inches in size) were not reliable. They continually jammed and eventually had to be taken out of the operations program.

The flow control valves used to regulate flows through the columns were of the constant-rate, spring-loaded, pressure-differential type. Of the ten flow control valves used, only one failed to deliver flows within its specified range, and that condition lasted but a short time. Flows were determined by tank level differentials.

The flow monitoring sensors were of the paddlewheel type and were located to register flows from both directions. Although paddlewheel flow sensors were used to monitor one-directional flows in a number of places around the plant with good results, they did not register a constant flowrate for any reasonable length of time with the two-direction application even after being cleaned.

A sample of the IX resin was extracted from each of the columns in July 1986 and sent to the manufacturer for testing. The tests evaluated the condition of the resin as compared to new resin. Results of the tests indicated that the resin was in good condition, despite some indications of iron fouling. Three of the samples showed some slight chemical deterioration as measured by moisture content. The moisture content for the three samples were 49.0, 49.7, and 51.3 percent, while the typical range is from 44 to 48 percent. Performance problems do not normally occur until the moisture content exceeds 55 percent.

Many of the bolted steel tanks did not survive the course of testing without repair. Corrosion appeared in two forms -- sheet and spot. Sheet corrosion began at the edges of the steel tank plates and worked its way along the sheet under the coating. The coating could be peeled off in sheets or large flakes. Spot corrosion formed as spots on the bottom or sides of the tank where the coating was damaged during construction and maintenance activities. This corrosion created pinholes in the steel.

Precipitation in tank T4 caused regeneration to become less efficient when precipitate (calcium sulfate) was passed through the resin bed. Delayed precipitation resulted from either the addition of threshold inhibitors to the process water during the desalting process or a scheduling problem or from both.

The time allotted for mixing and settling was inadequate for the cycle developed. Also the precipitation process methodology and design were inadequate for this application.

The operations program and other information concerning the IX equipment are included in Appendix H.

CHAPTER VII. CONCLUSIONS

Ion exchange using brine from a desalting system for regeneration is a relatively simple concept, but extensive control and monitoring are required. The Los Banos facility's IX program demonstrated the capabilities of the process and identified a multitude of process and operational-related issues or problems to be resolved prior to design of a full-scale system.

The IX desalting process was unable to be demonstrated as a complete IX desalting "loop" and obtain a steady-state condition. Persistent problems encountered in the third desalting stage (EDR) impeded generation of regenerant brine in either concentration or volume, along with various other mechanical and operational difficulties. These problems prevented steady-state loop operation. Despite these problems, the IX system performed as expected. Calcium leakages were below 1 meq/L for an influent hardness of over 50 meq/L and sodium-to-hardness ratios of approximately 2:1 when the resin was properly regenerated.

Despite all the mechanical and process difficulties encountered, the operations at Los Banos successfully demonstrated and developed:

1. Removal of calcium by IX under extreme conditions such as high total hardness, sodium, and TDS concentrations.

2. Regeneration of the IX resin using a reject brine from desalting processes. This use of reject brine alleviates both the need to import regeneration salt and disposal of such.

3. An IX operation cycle which minimizes wastes.

4. Operation constraints and parameters for a process treatment train to desalt agricultural drainage water. These constraints and parameters involve operation of the process train to "manufacture" brine sufficient in quality and quantity for use in the regeneration of the IX resin.

5. A model for the IX desalting process.

CHAPTER VIII. RECOMMENDATIONS

The Los Banos project was the result of years of study in the treatment and disposal of agricultural drain water. The IX desalting process is a unique process which was never before tested on this scale. Many of the problems encountered were design and operation oriented. With these problems identified, the overall recommendation is to continue to develop the IX desalting process and operate it at steady-state loop conditions. Future testing should investigate limits of the process (not equipment or operations) and include:

1. Determination of the limit to which the process water can be concentrated and yet maintain adequate calcium leakage.

2. Investigation of resin life and ability of resin to maintain removal capacity with time.

3. Determination of the effect of anti-scaling chemicals on regeneration and in the precipitation of salts of the recycle brine.

4. Determination of the effects of alum, cationic polymers, and other flocculation/coagulation aid carryover from the clarification/filtration processes on the IX process.

5. Investigation of salt-harvesting schemes to precipitate salts from the brines.

In addition to the recommendations stated above, modeling should be included as an integral portion of the testing program. The IX desalting model developed at Los Banos should be expanded to include the entire IX desalting (loop) treatment process. Provisions should be made to calculate constituent concentrations, salt saturation, or any other indices at various points in the process to determine where problems arise. The model could form the basis for an operations control program for the entire IX desalting treatment process.

As previously stated, many of the problems encountered in the IX system were design and operational based. Design recommendations for IX systems used in future testing should include:

1. Proper selection of material and equipment for the intended use.

2. Viewing ports on IX columns to verify flow regimes.

3. A bottom manifold placed as close to the bottom of the column as possible so that the entire resin can be utilized.

4. Monitoring of all flows, in-line process water effluent conductivity, and brine tank levels.

5. Location of flow sensors where flows can be accurately and reliably measured.

6. Operation and monitoring of the IX process by computer. The computer should be equipped with an individual power supply and printer.

7. Facilities to precipitate calcium sulfate from the recycle brine stream(s).

8. Facilities to make and adequately mix sodium chloride brine for start-up and emergency purposes.

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APPENDIX A

SERIES 100 ION-EXCHANGE BENCH UNIT TESTS

Development of Sodium Chloride Brine Regeneration Cycle
Operation Parameters and Results

SERIES 100 OPERATION PARAMETERS PHASE 1 - BENCH UNIT TESTING
SODIUM CHLORIDE BRINE REGENERATION

SERIES	DATE	RESIN	P. WATER	RUN	HOUR	OTHER
101	841120	C.20.a	marsh	a	8	single cycle; investigate service duration for TH to > 2.0 meq/l; 12 foot column
102	841121	C.20.a	marsh	a	9	single cycle; investigate service duration for TH to > 2.0 meq/l; 12 foot column
103	841124	C.20.a	marsh	a	7	single cycle; investigate service duration for TH to > 2.0 meq/l; 12 foot column
104	841125	C.20.a	marsh	a	12	single cycle; investigate service duration for TH to > 2.0 meq/l; 12 foot column
105	841126	C.20.a	marsh	a	7	single cycle; investigate service duration for TH to > 2.0 meq/l; 12 foot column
106	841127	C.20.a	marsh	a	10	single cycle; investigate service duration for TH to > 2.0 meq/l; 12 foot column
107	841129	C.20.a	marsh	a	9	single cycle; investigate service duration for TH to > 2.0 meq/l; 12 foot column
108	841130	C.20.a	marsh	a	8	single cycle; investigate service duration for TH to > 2.0 meq/l; 12 foot column
109	841204	C.20.a	marsh	a	8	single cycle; investigate service duration for TH to > 2.0 meq/l; 12 foot column
110	841204	C.20.a	marsh	a	12	single cycle; investigate service duration for TH to > 2.0 meq/l; 12 foot column
111	841207	C.20.b	marsh	a	17	single cycle; investigate service duration for TH to > 2.0 meq/l; 12 foot column
112	841209	C.20.b	marsh	a	17	single cycle; investigate service duration for TH to > 2.0 meq/l; 12 foot column
113	841206	C.20.a	marsh	a	13	five consecutive cycles w/o backwash
				b	17	investigate service dur. for TH to > 2.0meq/l
				c	21	unused Duolite C20 resin
	841207			d	2	
				e	6	

BENCH UNIT NOMENCLATURE:

Sampling identification: numbers after event indicate time sample was taken

-instantaneous samples: rega, regb, rina (slow rinse), and rinb (fast rinse). Rina (slow rinse) and rinb (fast rinse) without numbers are batch samples.
-batch samples: feed, fr.brine, recycle brine, combined backwash, combined regeneration, combined rinse and product.
-influent samples: feed, fr.brine and recycle brine.
-effluent samples: combined backwash, combined rinse, combined regeneration (comb.used brine), rega, regb, rina, rinb, service and product.

bv: bed volume of resin
CV: column voids volume or entire column volume minus actual volume of resin.

Resin C.20.a: resin extracted from main units.
Resin C.20.b: new, previously unused resin

LR1: loading rate in gpm/ft2 (cross sectional area of column)
LR2: loading rate in gpm/ft3 of resin

SERIES 100 OPERATION PARAMETERS PHASE 1 - BENCH UNIT TESTING
SODIUM CHLORIDE BRINE REGENERATION

SERIES	DATE	RESIN	P. WATER	RUN	HOUR	OTHER
114	841212	C.20.b	marsh	a	12	five consecutive cycles w/o backwash
				b	17	investigate service dur. for TH to > 2.0meq/l
				c	20	unused Duolite C20 resin
	841213			d	12	
				e	2	
115	841227	C.20.a	marsh	a	9	two consecutive cycles w/o backwash
				b	13	investigate service dur. for TH to > 2.0meq/l
116	841227	C.20.a	marsh	a	20	four consecutine cycles w/o backwash
	851228			b	1	investigate service dur. for TH to > 2.0meq/l
				c	4	
				d	8	
117	850103	C.20.a	marsh	a	12	five consecutive cycles w/o backwash
				b	19	investigate service dur. for TH to > 2.0meq/l
				c	23	
	850104			d	3	
				e	8	
118	850108	C.20.a	marsh	a	8	four consecutine cycles w/o backwash
				b	13	investigate service dur. for TH to > 2.0meq/l
				c	18	
				d	22	
119	850116	C.20.b	marsh	a	8	five consecutive cycles w/o backwash
				b	13	investigate service dur. for TH to > 2.0meq/l
				c	16	unused Duolite C20 resin
				d	21	
	850117			e	1	
120	850123	C.20.b	marsh	a	10	five consecutive cycles w/o backwash
				b	15	investigate service dur. for TH to > 2.0meq/l
				c	19	unused Duolite C20 resin
				d	23	
	850124			e	4	
121	850124	C.20.a	marsh	a	17	ten consecutive cycles w/o backwash
				b	21	verification of developed sodium chloride
	850125			c	1	
				d	4	
				e	7	
				f	11	
				g	15	
				h	18	
				i	22	
	850126			j	1	
122	850204	C.20.a	marsh	a	15	five consecutive cycles w/o backwash
				b	19	investigate service dur. for TH to > 2.0meq/l
				c	22	
	850205			d	1	
				e	5	
123	850206	C.20.b	marsh	a	17	five consecutive cycles w/o backwash
				b	21	investigate service dur. for TH to > 2.0meq/l
	850207			c	1	unused Duolite C20 resin
				d	3	
				e	8	
124	850517	C.20.a	clarifier	a	14	investigate service dur. for TH to > 2.0meq/l
125	850522	C.20.a	clarifier	a	11	investigate service dur. for TH to > 2.0meq/l
						resin stored in 16% NaCl brine previous to run
126	850524	C.20.a	clarifier	a	11	investigate service dur. for TH to > 2.0meq/l

OPERATION PARAMETERS PHASE 1 - BENCH UNIT TESTING

SODIUM CHLORIDE BRINE REGENERATION

		BACKWASH			REGENERATION					SLOW RINSE		FAST RINSE		SERVICE	
SERIES	RUN	LR1	B.E.	Duration	LR1	B.E.	Duration	CONC.	Temp.	LR1	Duration	LR1	Duration	LR2	Duration
		gpm/ft2	%	minutes	gpm/ft2	%	minutes	%	C	gpm/ft2	minutes	gpm/ft2	minutes	gpm/ft3	minutes
101	a	5.1	n.r.	10	3.7	n.r.	50	9.0	13.0	2.8	5	5.9	15	1.02	185
102	a	5.1	30	10	3.6	n.r.	50	9.5	12.0	2.8	5	5.9	15	1.00	170
103	a	5.1	n.r.	10	3.6	n.r.	50	9.8	12.5	2.8	5	5.9	15	0.54	305
104	a	5.1	n.r.	10	3.2	n.r.	50	9.5	17.5	2.8	5	5.9	15	1.04	165
105	a	5.1	n.r.	10	3.1	n.r.	50	9.5	10.0	2.8	5	5.9	15	1.00	172
106	a	5.1	n.r.	10	3.6	28	50	7.0	11.0	2.8	5	5.9	15	1.22	135
107	a	5.1	n.r.	10	3.5	26	50	6.0	10.0	2.8	5	5.9	15	1.20	140
108	a	5.1	28	10	3.3	25	50	7.0	9.0	2.8	5	5.9	15	1.16	135
109	a	5.1	27	10	2.3	25	50	7.0	9.0	2.8	5	5.9	15	1.16	135
110	a	5.1	27	10	2.5	27	50	7.0	9.0	2.8	5	5.9	15	1.18	55
111	a	4.60	n.r.	10	4.02	n.r.	50	9.0	13.0	4.0	5	8.2	15	1.15	152
112	a	3.79	n.r.	10	2.87	n.r.	50	9.5	12.0	8.3	5	5.6	15	1.10	152
113	a	none	none	none	NA	21	50	6.5	11.0	2.80	5	5.90	15	1.14	162
	b	none	none	none	NA	NA	50	6.5	12.0	2.80	5	5.90	15	1.20	137
	c	none	none	none	NA	20	50	6.5	11.5	2.80	5	5.90	15	1.14	122
	d	none	none	none	NA	NA	50	6.5	10.0	2.80	5	5.90	15	1.16	120
	e	none	none	none	NA	NA	50	6.5	10.0	2.80	5	5.90	15	1.14	120
114	a	none	none	none	2.24	NA	50	6.5	12.0	2.24	5	5.68	15	1.09	130
	b	none	none	none	3.18	NA	50	6.5	12.0	8.19	5	8.19	15	1.19	120
	c	none	none	none	2.97	NA	50	6.5	12.0	8.45	5	5.89	15	1.24	110
	d	none	none	none	2.77	NA	50	6.5	12.0	8.51	5	5.99	15	1.04	80
	e	none	none	none	2.95	27	50	6.5	12.0	8.64	5	5.76	15	1.20	100
115	a	none	none	none	2.10	7	50	6.5	7.0	NA	5	5.99	15	1.14	90
	b	none	none	none	2.00	13	50	6.5	7.5	3.00	5	5.65	15	1.20	90
116	a	none	none	none	2.00	18	50	12.0	7.0	3.67	5	6.01	15	1.18	130
	b	none	none	none	1.70	13	50	12.0	7.0	3.54	5	5.76	15	1.16	90
	c	none	none	none	2.00	NA	50	12.0	6.0	NA	5	5.70	15	1.34	117
	d	none	none	none	2.00	NA	50	12.0	6.0	3.46	5	6.41	15	1.22	120
117	a	none	none	none	2.00	13	60	12.0	6.0	3.69	5	5.84	15	1.20	157
	b	none	none	none	2.00	13	60	12.0	6.0	3.26	5	6.31	15	1.24	140
	c	none	none	none	2.10	17	60	12.0	5.5	3.63	5	6.33	15	1.26	140
	d	none	none	none	2.00	20	60	12.0	5.0	3.26	5	6.05	15	1.20	142
	e	none	none	none	1.90	20	60	12.0	5.0	3.20	5	6.21	15	1.28	122

OPERATION PARAMETERS PHASE 1 - BENCH UNIT TESTING
SODIUM CHLORIDE BRINE REGENERATION

		BACKWASH			REGENERATION					SLOW RINSE		FAST RINSE		SERVICE	
SERIES	RUN	LR1	B.E.	Duration	LR1	B.E.	Duration	CONC.	Temp.	LR1	Duration	LR1	Duration	LR2	Duration
		gpm/ft2	%	minutes	gpm/ft2	%	minutes	%	C	gpm/ft2	minutes	gpm/ft2	minutes	gpm/ft3	minutes
118	a	none	none	none	3.90	30	60	6.5	8.5	3.16	5	6.09	10	1.20	160
	b	none	none	none	4.07	30	60	6.0	9.5	3.18	5	5.68	10	1.14	155
	c	none	none	none	4.07	37	61	6.0	NA	3.26	5	5.80	10	1.10	170
	d	none	none	none	4.00	30	60	6.0	12.0	3.25	5	5.80	10	1.22	140
119	a	none	none	none	2.04	NA	50	12.5	5.0	2.93	5	5.96	10	1.18	155
	b	none	none	none	2.04	NA	50	12.5	6.0	2.89	5	6.01	10	1.19	130
	c	none	none	none	2.20	NA	51	12.0	5.0	2.83	5	5.89	10	1.19	145
	d	none	none	none	1.95	14	52	12.0	5.0	1.95	5	5.98	10	1.15	140
	e	none	none	none	1.79	19	57	12.0	5.0	2.85	5	5.62	10	1.16	140
120	a	none	none	none	1.95	NA	60	12.5	7.0	3.06	5	6.13	10	1.26	150
	b	none	none	none	2.04	8	60	12.5	7.0	2.95	5	6.05	10	1.29	145
	c	none	none	none	2.00	13	60	12.5	6.0	2.93	5	5.80	10	1.24	145
	d	none	none	none	1.99	19	60	12.5	6.0	1.99	5	5.93	10	1.26	150
	e	none	none	none	2.09	NA	60	12.5	7.0	1.91	5	5.27	10	1.15	160
121	a	none	none	none	1.83	15	50	12.0	6.5	2.83	5	5.91	15	1.17	122
	b	none	none	none	1.93	15	50	12.0	6.5	2.93	5	5.90	15	1.18	121
	c	none	none	none	1.93	15	50	12.0	7.0	2.71	5	5.78	15	1.18	120
	d	none	none	none	1.93	15	50	12.0	7.0	2.83	5	6.15	15	1.27	105
	e	none	none	none	2.04	15	50	12.0	6.5	3.07	5	6.23	15	1.17	125
	f	none	none	none	2.04	17	50	12.0	7.0	3.13	5	5.93	15	1.21	120
	g	none	none	none	2.04	17	50	12.0	7.0	3.06	5	6.05	15	1.19	120
	h	none	none	none	2.14	17	50	12.0	7.0	2.85	5	5.91	15	1.14	125
	i	none	none	none	2	16	50	12.0	7.0	3.24	5	5.93	15	1.19	120
	j	none	none	none	2	15	50	12.0	7.0	3.21	5	5.91	15	1.18	121
122	a	none	none	none	2	12	50	10.0	7.5	3.26	5	6.07	15	1.19	120
	b	none	none	none	2	13	50	10.0	8.0	3.18	5	6.01	15	1.19	120
	c	none	none	none	2	13	50	10.0	7.5	3.12	5	5.82	15	1.12	120
	d	none	none	none	2	13	50	10.0	7.5	3.97	5	6.19	15	1.19	120
	e	none	none	none	2	14	50	10.0	7.5	3.71	5	5.80	15	1.19	120
123	a	none	none	none	2	17	50	10.0	6.0	4.38	5	6.02	15	1.25	120
	b	none	none	none	2	17	50	10.0	6.0	4.34	5	6.03	15	1.34	110
	c	none	none	none	2	14	50	10.0	6.0	2.85	5	5.89	15	1.34	110
	d	none	none	none	2	13	50	10.0	6.0	3.03	5	6.09	15	1.36	110
	e	none	none	none	2	14	50	10.0	6.0	3.16	5	6.17	15	1.32	110
124	a	none	none	none	2	20	40	16.0	16.0	2.71	5	3.87	10	1.16	140
125	a	none	none	none	2	NA	40	16.0	21.0	3.18	5	4.48	10	1.26	160
126	a	none	none	none	2	NA	40	16.0	21.0	2.64	5	5.40	10	1.23	150

VOLUMES AND FLOW RATES USED IN PHASE 1 TESTING

PHASE 1 - BENCH UNIT TESTING
SODIUM CHLORIDE BRINE REGENERATION

		VOLUME in bed volumes				TOTAL RINSE	SR+FR-CV	FLOW RATE in bv/minute			
		NaCl	SLOW	FAST		bed volumes		NaCl	SLOW	FAST	
SERIES	RUN	BRINE	RINSE	RINSE	SERVICE			BRINE	RINSE	RINSE	SERVICE
101	a	4.95	0.37	2.37	25.23	2.74	1.82	0.099	0.075	0.158	0.136
102	a	4.81	0.37	2.37	22.73	2.74	1.82	0.096	0.075	0.158	0.134
103	a	4.81	0.37	2.37	22.02	2.74	1.82	0.096	0.075	0.158	0.072
104	a	4.28	0.37	2.37	22.95	2.74	1.82	0.085	0.075	0.158	0.139
105	a	4.15	0.37	2.37	23.00	2.74	1.82	0.083	0.075	0.158	0.134
106	a	4.81	0.37	2.37	22.02	2.74	1.82	0.096	0.075	0.158	0.163
107	a	4.68	0.37	2.37	22.46	2.74	1.82	0.093	0.075	0.158	0.160
108	a	4.41	0.37	2.37	20.94	2.74	1.82	0.088	0.075	0.158	0.155
109	a	3.08	0.37	2.37	20.94	2.74	1.82	0.061	0.075	0.158	0.155
110	a	3.34	0.37	2.37	8.68	2.74	1.82	0.067	0.075	0.158	0.158
111	a	5.38	0.54	3.29	23.37	3.83	2.91	0.107	0.107	0.219	0.154
112	a	3.84	1.12	2.25	22.36	3.36	2.44	0.077	0.223	0.150	0.147
113	a	NA	0.37	2.37	24.69	2.74	1.02	NA	0.075	0.158	0.152
	b	NA	0.37	2.37	21.98	2.74	1.02	NA	0.075	0.158	0.160
	c	NA	0.37	2.37	18.60	2.74	1.02	NA	0.075	0.158	0.152
	d	NA	0.37	2.37	18.61	2.74	1.02	NA	0.075	0.158	0.155
	e	NA	0.37	2.37	18.29	2.74	1.02	NA	0.075	0.158	0.152
114	a	3.00	0.30	2.28	18.95	2.58	0.86	0.060	0.060	0.152	0.146
	b	4.25	1.10	3.29	19.09	4.38	2.66	0.085	0.219	0.219	0.159
	c	3.97	1.13	2.36	18.24	3.49	1.77	0.079	0.226	0.157	0.166
	d	3.70	1.14	2.40	11.13	3.54	1.82	0.074	0.227	0.160	0.139
	e	3.94	1.16	2.31	16.05	3.47	1.75	0.079	0.231	0.154	0.160
115	a	2.81	NA	2.40	13.72	NA	NA	0.056	NA	0.160	0.152
	b	2.67	0.40	2.27	14.44	2.67	0.95	0.053	0.080	0.151	0.160
116	a	2.67	0.49	2.41	20.51	2.90	1.18	0.053	0.098	0.160	0.158
	b	2.27	0.47	2.31	13.96	2.78	1.06	0.045	0.095	0.154	0.155
	c	2.67	NA	2.29	20.96	NA	NA	0.053	NA	0.152	0.179
	d	2.67	0.46	2.57	19.58	3.03	1.31	0.053	0.092	0.171	0.163
117	a	3.21	0.49	2.34	25.19	2.84	1.12	0.053	0.099	0.156	0.160
	b	3.21	0.44	2.53	23.21	2.97	1.25	0.053	0.087	0.168	0.166
	c	3.37	0.49	2.54	23.59	3.02	1.30	0.056	0.097	0.169	0.168
	d	3.21	0.44	2.43	22.78	2.86	1.14	0.053	0.087	0.162	0.160
	e	3.05	0.43	2.49	20.88	2.92	1.20	0.051	0.085	0.166	0.171
118	a	0.00	0.00	0.00	0.00	0.00	-1.72	0.000	0.000	0.000	0.000
	b	6.53	0.43	1.52	23.63	1.94	0.22	0.109	0.085	0.152	0.152
	c	6.64	0.44	1.55	25.00	1.99	0.27	0.109	0.087	0.155	0.147
	d	6.42	0.43	1.55	22.84	1.99	0.27	0.107	0.087	0.155	0.163
119	a	2.73	0.39	1.59	24.46	1.99	0.27	0.054	0.078	0.159	0.158
	b	2.73	0.39	1.61	20.69	1.99	0.27	0.054	0.077	0.160	0.159
	c	3.00	0.38	1.58	23.07	1.95	0.23	0.059	0.076	0.157	0.159
	d	2.71	0.26	1.60	21.53	1.86	0.14	0.052	0.052	0.160	0.154
	e	2.73	0.38	1.50	21.72	1.88	0.16	0.048	0.076	0.150	0.155

VOLUMES AND FLOW RATES USED IN PHASE 1 TESTING

PHASE 1 - BENCH UNIT TESTING
SODIUM CHLORIDE BRINE REGENERATION

		VOLUME in bed volumes				TOTAL RINSE	SR+FR-CV	FLOW RATE in bv/minute			
		NaCl	SLOW	FAST		bed volumes		NaCl	SLOW	FAST	
SERIES	RUN	BRINE	RINSE	RINSE	SERVICE			BRINE	RINSE	RINSE	SERVICE
120	a	3.13	0.41	1.64	25.27	2.05	1.13	0.052	0.082	0.164	0.168
	b	3.27	0.39	1.62	25.01	2.01	1.09	0.054	0.079	0.162	0.172
	c	3.21	0.39	1.55	24.04	1.94	1.02	0.053	0.078	0.155	0.166
	d	3.19	0.27	1.59	25.27	1.85	0.93	0.053	0.053	0.158	0.168
	e	3.35	0.26	1.41	24.60	1.66	0.74	0.056	0.051	0.141	0.154
121	a	2.45	0.38	2.37	19.09	2.75	1.83	0.049	0.076	0.158	0.156
	b	2.58	0.39	2.37	19.09	2.76	1.84	0.052	0.078	0.158	0.158
	c	2.58	0.36	2.32	18.93	2.68	1.76	0.052	0.072	0.154	0.158
	d	2.58	0.38	2.47	17.83	2.85	1.93	0.052	0.076	0.164	0.170
	e	2.73	0.41	2.50	19.56	2.91	1.99	0.054	0.082	0.166	0.156
	f	2.73	0.42	2.38	19.42	2.80	1.88	0.054	0.084	0.158	0.162
	g	2.73	0.41	2.43	19.09	2.84	1.92	0.054	0.082	0.162	0.159
	h	2.86	0.38	2.37	19.05	2.75	1.83	0.057	0.076	0.158	0.152
	i	2.73	0.43	2.38	19.09	2.81	1.89	0.054	0.087	0.158	0.159
	j	2.73	0.43	2.37	19.09	2.80	1.88	0.054	0.086	0.158	0.158
122	a	3.16	0.44	2.43	19.09	2.87	1.95	0.063	0.087	0.162	0.159
	b	3.26	0.43	2.41	19.09	2.84	1.92	0.065	0.085	0.160	0.159
	c	2.73	0.42	2.33	17.97	2.75	1.83	0.054	0.083	0.155	0.150
	d	2.86	0.53	2.48	19.09	3.01	2.09	0.057	0.106	0.165	0.159
	e	2.86	0.50	2.33	19.09	2.82	1.90	0.057	0.099	0.155	0.159
123	a	2.85	0.59	2.41	20.06	3.00	2.08	0.057	0.117	0.161	0.167
	b	2.73	0.58	2.42	19.71	3.00	2.08	0.054	0.116	0.161	0.179
	c	3.13	0.38	2.36	19.71	2.74	1.82	0.062	0.076	0.157	0.179
	d	2.58	0.41	2.44	20.00	2.85	1.93	0.052	0.081	0.163	0.182
	e	2.73	0.42	2.48	19.42	2.90	1.98	0.054	0.084	0.165	0.176
124	a	2.20	0.36	1.03	21.81	1.40	0.48	0.055	0.072	0.103	0.156
125	a	2.12	0.42	1.20	27.02	1.62	0.70	0.053	0.085	0.120	0.169
126	a	1.98	0.35	1.44	24.75	1.80	0.88	0.049	0.070	0.144	0.165

CHEMICAL ANALYSES PHASE 1 - BENCH UNIT TESTING

SERIES	Cycle No	Event	Calcium	THardness	Sodium	Elec.Cond.	Turbidity	pH	Chloride	Sulfate
			meq/l			uS/cm	N.T.U.		meq/l	
101	a	feed	25.52	48.00	91.30	11600	1.0	7.8	43.12	87.45
		fr.brine	8.20	14.40	1565.22	126000	2.6	7.7	2016.36	6.25
		bw0	28.00	48.00	95.65	11500	1.1	7.9	56.40	83.28
		bw10	38.00	86.40	173.91	22500	3.7	7.7	183.31	66.63
		reg5	81.00	164.00	613.04	60700	4.0	7.5	789.62	56.21
		reg15	45.20	90.80	465.22	47200	4.2	7.8	479.41	56.21
		reg30	104.00	173.20	1673.91	135000	5.0	7.4	1931.75	10.41
		reg45	61.00	81.20	1743.48	137200	4.6	7.7	1903.55	16.66
		rina5	22.40	34.00	1882.61	136100	2.9	7.8	1931.75	12.49
		rinb5	30.00	44.80	1817.39	135000	2.9	7.8	1833.05	14.57
		rinb10	0.80	1.00	217.39	18600	0.9	7.8	98.70	83.28
		rinb15	0.36	0.48	143.48	18600	1.2	8.3	49.92	93.69
		prod	0.44	0.96	108.70	12800	0.5	8.1	43.71	72.87
102	a	feed	25.20	48.80	95.65	11400	0.8	8.0	42.27	87.45
		fr.brine	10.00	14.80	1689.57	135000	3.6	7.8	1615.06	6.66
		bw8	28.40	50.00	95.65	12400	1.6	8.1	43.68	83.28
		reg5	202.80	480.00	739.13	95600	6.3	7.4	1252.12	41.64
		reg15	120.00	256.00	543.48	67600	5.1	7.6	724.76	60.38
		reg30	160.00	284.00	1382.61	124100	5.2	7.5	1689.23	10.41
		reg45	90.80	145.00	1395.65	135000	4.0	7.7	1689.23	12.49
		rina5	31.60	54.00	1604.35	135000	2.2	7.9	1717.43	12.49
		rinb5	1.44	2.40	213.04	22500	0.6	8.4	120.98	77.04
		prod.	0.60	0.84	113.04	13700	0.5	8.3	39.48	83.28
103	a	feed	27.60	48.00	91.30	12100	6.0	7.7	42.30	74.95
		fr.brine	9.20	14.80	1608.70	133900	7.3	7.9	1782.29	6.04
		bw5	28.80	55.20	100.00	13700	1.2	8.1	45.12	81.20
		bw10	360.00	800.00	482.61	95600	6.6	7.3	1283.14	12.49
		reg5	182.00	348.00	673.91	84400	5.7	7.4	998.31	47.89
		reg15	97.00	190.00	504.35	60700	5.7	7.5	640.16	56.21
		reg30	136.00	236.00	1591.30	129400	3.4	7.5	1717.43	6.87
		reg45	90.00	124.00	1613.04	133900	3.4	7.7	1717.43	7.50
		rina5	31.00	51.00	1734.78	133900	1.8	7.9	1773.83	6.87
		rinb3	28.00	40.40	1347.83	109000	3.2	7.8	1291.60	27.90
		prod.60	0.48	0.80	138.13	13500	1.3	7.7	40.89	70.79
		prod285	0.52	0.80	139.13	12900	1.0	7.7	38.07	83.28
104	a	feed	25.20	45.60	86.96	11800	1.5	7.5	42.30	79.12
		fr.brine	8.40	14.80	1486.96	133900	7.1	7.7	1692.05	6.45
		bw5	25.60	47.60	104.35	12900	1.4	7.5	45.12	81.20
		bw10	25.20	45.60	73.91	12000	2.6	7.6	42.30	83.28
		reg5	36.40	70.40	113.04	15300	16.8	7.5	91.65	83.28
		reg15	38.80	78.00	104.35	16900	7.9	7.5	104.34	ns
		reg30	282.00	525.00	1056.52	123700	5.8	7.2	1658.21	7.08
		reg45	132.00	240.00	1269.57	132700	4.4	7.4	1686.41	7.08
		rina5	32.80	73.00	1291.30	133900	2.8	7.7	1686.41	6.45
		rinb10	1.60	3.40	160.87	19800	1.3	8.0	106.88	89.53
		prod60	0.60	1.12	126.09	13500	1.0	7.7	45.12	79.12
		prod120	0.60	1.12	130.43	13200	0.9	7.6	45.12	83.28

CHEMICAL ANALYSES PHASE 1 - BENCH UNIT TESTING

SERIES	Cycle No.	Event	Calcium	THardness	Sodium	Elec.Cond.	Turbidity	pH	Chloride	Sulfate
			meq/l			uS/cm	N.T.U.		meq/l	
105	a	feed	24.80	47.60	91.30	11800	1.5	7.5	42.30	79.12
		fr.brine	9.60	15.20	1730.43	135000	7.0	7.7	1706.15	5.62
		bw5	24.80	47.60	95.65	12300	2.6	7.7	42.30	81.20
		bw10	27.60	51.60	100.00	12300	2.5	7.6	49.35	81.20
		reg5	170.00	351.00	456.52	67500	6.0	7.2	775.52	56.21
		reg15	118.00	218.00	447.83	49500	4.8	7.3	516.07	64.54
		reg30	212.00	395.00	1330.43	124900	5.1	7.2	1644.11	7.08
		reg45	117.20	188.00	1395.65	132700	4.2	7.5	1692.05	6.25
		rina5	36.00	64.00	1613.04	133900	2.7	7.7	1692.05	6.45
		rinb10	3.20	5.20	317.39	27000	1.2	8.0	181.90	85.36
		prod60	0.60	1.04	121.74	13400	0.9	7.9	42.30	85.36
		prod120	0.60	1.04	160.87	13000	1.1	7.8	42.30	81.20
106	a	feed	25.60	48.00	91.30	11700	1.8	7.6	42.30	83.28
		fr.brine	8.40	13.20	1178.26	99000	4.0	7.6	1201.35	5.41
		bw7	252.00	510.00	330.43	69700	5.9	7.0	803.72	37.48
		reg7	170.00	342.00	760.87	86600	5.0	7.2	1043.43	41.64
		reg18	87.00	176.00	578.26	64100	4.3	7.4	676.82	56.21
		reg30	94.00	192.00	934.78	95600	3.6	7.4	1170.33	20.82
		reg44	68.00	121.00	956.52	99000	3.5	7.5	1192.89	5.41
		rina5	20.40	36.40	1004.35	100100	2.0	7.7	1184.43	5.62
		rinb10	1.20	2.00	160.87	17400	0.9	8.0	81.78	85.36
		prod	0.72	1.12	121.74	13500	0.9	7.8	42.30	83.28
107	a	feed	24.40	48.00	91.30	10900	1.3	7.7	42.30	85.36
		fr.brine	9.20	12.80	1100.00	94800	6.0	7.8	1142.13	5.41
		bw5	190.00	362.00	230.43	51600	5.5	7.2	591.93	39.56
		reg10	92.00	170.00	308.70	46800	4.8	7.5	476.31	49.97
		reg20	102.00	186.00	600.00	62400	4.9	7.4	732.94	31.23
		reg30	150.00	240.00	834.78	91200	4.3	7.3	1166.95	5.62
		reg40	112.00	16.00	921.74	94800	3.8	7.5	1183.87	4.79
		rina5	22.80	34.00	1165.22	96000	1.9	7.7	1183.87	5.83
		rinb10	0.92	2.00	147.83	14200	1.4	8.0	53.58	72.87
		prod.	0.76	1.16	134.78	13000	1.1	7.9	40.89	85.36
108	a	feed	26.00	48.80	91.30	10300	8.0	7.5	40.89	74.95
		fr.brine	8.40	14.40	1147.83	92800	5.0	7.6	1183.87	5.41
		bw5	24.40	52.00	91.30	11700	1.6	7.6	42.30	139.50
		bw10	24.80	51.00	91.30	11000	1.5	7.5	39.48	81.20
		reg10	112.00	217.00	234.78	38800	4.9	7.2	408.63	58.30
		reg20	98.00	184.00	265.22	38800	3.9	7.2	394.81	62.46
		reg30	176.00	296.00	560.87	86900	3.4	7.2	1183.87	16.66
		reg40	134.00	222.00	856.52	82300	3.4	7.3	1183.87	18.74
		reg50	104.00	176.00	986.96	90500	3.8	7.4	1183.87	14.57
		rin0	22.40	42.00	991.30	90500	2.3	7.5	1141.57	20.82
		rin15	0.88	1.60	143.48	13200	2.1	7.9	45.12	74.95
		prod60	0.96	2.28	139.13	12200	1.1	7.6	42.30	72.87

CHEMICAL ANALYSES PHASE 1 - BENCH UNIT TESTING

SERIES	Cycle No.	Event	Calcium	THardness	Sodium	Elec.Cond.	Turbidity	pH	Chloride	Sulfate
			meq/l			uS/cm	N.T.U.		meq/l	
109	a	feed	25.20	48.00	91.30	11700	3.0	7.9	40.89	77.04
		fr.brine	7.20	12.80	1091.30	95000	3.5	7.9	1178.23	5.00
		bw5	24.40	48.40	91.30	11100	2.6	7.6	40.89	102.02
		bw10	94.00	182.00	165.22	29300	5.6	7.3	296.11	64.54
		reg5	158.00	322.00	421.74	58700	6.9	7.2	727.30	45.80
		reg15	80.00	166.00	260.87	40000	5.5	7.4	380.43	60.38
		reg30	152.00	28.00	860.87	92500	2.7	7.3	1183.87	6.25
		reg45	96.00	156.00	1000.00	95000	2.7	7.5	1195.15	5.21
		rina	18.00	36.00	1030.43	95000	1.8	7.7	1183.87	5.83
		rinb	34.00	66.00	978.26	92500	1.7	7.7	1099.27	16.66
		ser60	0.76	1.40	147.83	13500	1.2	7.9	40.89	87.45
110	a	feed	22.40	48.00	91.30	11000	3.0	7.7	40.89	85.36
		fr.brine	9.60	13.60	1152.17	96300	5.7	7.8	1197.97	5.21
		bw5	25.20	48.80	95.65	12000	1.5	7.9	42.30	89.53
		bw10	25.20	48.80	91.30	11300	3.9	7.8	40.89	77.04
		reg5	46.00	80.00	108.70	15400	8.2	7.6	100.11	70.79
		reg15	30.80	62.00	95.65	13700	7.5	7.7	67.68	85.36
		reg30	230.00	434.00	708.70	90000	2.7	7.2	1152.85	6.04
		reg45	136.00	212.00	900.00	94800	3.2	7.5	1169.77	5.62
		rina	16.00	38.00	986.96	97200	1.6	7.8	1166.95	5.83
		rinb	46.00	79.60	1004.35	97200	1.8	7.7	1192.33	5.21
		prod	ns	ns	121.74	13300	1.1	8.1	ns	ns
111	a	feed	24.80	48.00	95.65	11300	1.4	7.7	40.89	81.20
		fr. brine	8.80	12.40	1630.43	126900	2.3	7.8	1615.06	5.62
		bw5	146.00	350.00	491.30	64600	4.6	7.3	718.84	33.31
		reg5	66.40	142.00	734.78	68700	1.9	7.6	794.70	41.64
		reg15	32.40	67.20	543.48	51700	2.0	7.7	507.33	49.97
		reg30	66.40	115.20	1526.09	119900	2.7	7.7	1600.96	5.00
		reg45	42.40	66.00	1239.13	126900	2.7	7.7	1606.88	4.79
		rina5	22.80	35.00	1708.70	126900	1.8	7.8	1634.80	5.00
		rinb10	0.36	0.48	147.83	13900	1.0	8.0	42.30	74.95
		rinb15	0.24	0.44	143.48	12900	0.7	7.8	40.89	79.12
		prod.	0.32	0.44	143.48	12500	0.6	7.8	40.89	83.28
112	a	feed	25.60	48.00	91.30	11000	0.7	7.6	40.89	81.20
		fr. brine	8.00	12.40	1013.04	128000	2.9	7.8	1691.20	5.41
		bw5	28.00	48.40	95.65	11700	1.2	7.9	42.30	83.28
		reg5	150.00	305.00	608.70	69300	2.6	7.3	831.64	49.97
		reg15	118.00	210.00	521.74	58700	2.0	7.4	620.14	49.97
		reg30	192.00	370.00	1230.43	115100	2.6	7.2	1550.48	6.87
		reg45	116.00	164.00	1465.22	126900	2.5	7.5	1691.48	5.83
		rina5	32.40	54.00	2073.91	129300	2.0	7.7	1691.48	4.79
		rinb10	0.64	2.00	143.48	14300	0.7	8.0	56.40	79.12
		rinb15	0.48	0.76	147.83	12900	0.5	7.8	42.30	79.12
		prod.	0.60	1.12	147.83	12600	0.5	7.8	42.30	70.79

CHEMICAL ANALYSES PHASE 1 - BENCH UNIT TESTING

SERIES	Cycle No	Event	Calcium	THardness	Sodium	Elec.Cond.	Turbidity	pH	Chloride	Sulfate
			meq/l			uS/cm	N.T.U.		meq/l	
113	a	feed	25.20	48.20	100.00	10800	0.6	7.5	36.66	79.12
		fr.brine	6.40	11.60	1543.48	94000	2.0	7.6	1169.77	4.37
		reg5	31.20	63.40	143.48	17600	1.5	7.7	109.70	70.79
		reg15	218.00	408.00	743.48	89300	2.1	7.0	1133.11	27.07
		reg33	88.00	140.00	1034.78	94000	2.3	7.4	1161.31	8.33
		reg45	84.00	116.00	1217.39	95200	2.8	7.4	1155.67	4.79
		rina5	9.60	14.80	1230.43	95200	1.3	7.6	1138.75	5.62
		rinb5	14.40	21.60	1178.26	95200	1.3	7.7	1169.77	4.79
		rinb10	19.20	31.20	1204.35	96300	1.0	7.6	1155.67	5.83
		prod.	0.48	0.84	143.48	13600	0.7	7.9	ns	ns
113	b	feed	25.20	47.60	95.65	11500	0.7	7.6	42.30	77.04
		fr.brine	7.20	11.20	1334.78	94000	1.3	7.6	1161.31	4.58
		reg5	25.60	48.00	91.30	11700	0.7	7.8	42.30	74.95
		reg15	54.40	112.40	152.17	21000	6.2	7.4	183.31	93.69
		reg30	184.00	330.00	821.74	88100	1.8	7.2	1155.67	5.00
		reg45	114.00	192.00	1073.91	89300	1.8	7.4	1155.67	4.16
		rina5	12.80	32.00	1230.43	94000	0.9	7.7	1144.39	5.41
		rinb5	21.20	48.00	1143.48	95200	1.0	7.6	1155.67	4.58
		rinb10	28.80	66.80	1030.43	94000	1.2	7.5	1128.03	11.03
		prod.	0.64	1.36	139.13	13400	0.5	7.7	42.30	83.28
113	c	feed	25.60	47.60	100.00	11300	0.7	8.0	40.89	74.95
		fr.brine	7.20	11.60	1282.61	94000	2.5	7.9	1164.13	4.79
		reg5	24.40	47.60	95.65	11700	0.7	8.0	39.48	70.79
		reg15	26.00	50.00	95.65	11200	1.1	8.0	42.30	72.87
		reg30	230.00	444.00	708.70	86900	1.5	7.3	1141.57	4.58
		reg45	146.00	234.00	956.52	89900	1.5	7.5	1155.67	4.79
		rina5	12.00	24.00	1260.87	94000	1.2	7.9	1150.03	5.00
		rinb10	13.20	30.00	604.35	52900	0.8	8.0	543.99	60.38
		rinb15	0.84	2.40	147.83	14100	0.5	8.2	50.76	74.95
		prod.	0.76	1.44	143.48	12600	0.7	7.9	42.30	79.12
113	d	feed	25.00	48.40	95.65	11200	0.7	7.8	42.30	74.95
		fr.brine	7.20	11.20	1282.61	98800	2.5	7.8	1150.03	4.79
		reg5	26.20	48.40	100.00	12000	0.7	7.9	42.30	81.20
		reg15	25.00	48.80	95.65	11200	0.9	7.9	40.89	74.95
		reg35	180.00	335.00	791.30	88100	3.1	7.4	1138.75	5.00
		reg45	142.00	244.00	630.43	92800	2.1	7.5	1155.67	4.58
		rina5	13.20	54.00	804.35	95200	1.2	7.8	1144.39	4.79
		rinb10	10.40	24.40	465.22	48800	0.8	8.0	445.29	70.79
		rinb15	1.20	1.60	143.48	13400	0.8	8.0	45.12	72.87
		prod.	0.80	1.56	130.43	12600	0.6	7.9	40.89	81.20
113	e	feed	23.80	48.00	95.65	11300	0.7	7.8	40.89	72.87
		fr.brine	7.00	11.20	956.52	94000	2.6	7.7	1141.57	4.79
		reg5	24.00	48.00	86.96	14100	0.7	7.9	43.71	79.12
		rge15	23.80	49.20	91.30	11300	1.1	7.8	40.89	77.04
		reg30	220.00	510.00	630.43	86900	4.0	7.3	1124.65	5.41
		reg45	146.00	260.00	639.13	88700	2.3	7.4	1155.67	4.79
		rina5	14.80	31.20	891.30	94000	1.2	7.8	1147.21	10.89
		rinb10	38.00	87.60	1204.35	95200	1.1	7.7	1155.67	4.58
		rinb15	1.04	4.40	178.26	14500	0.6	8.2	56.40	74.95
		prod.	0.88	1.76	147.83	12700	0.5	7.9	40.89	81.20

CHEMICAL ANALYSES PHASE 1 - BENCH UNIT TESTING

SERIES	Cycle No.	Event	Calcium	THardness	Sodium	Elec.Cond.	Turbidity	pH	Chloride	Sulfate
			meq/l			uS/cm	N.T.U.		meq/l	
114	a	feed	23.60	46.40	100.00	11000	0.6	7.7	45.12	7.50
		fr. brine	6.20	10.40	934.78	91700	2.9	7.6	1374.22	3.96
		reg5	25.20	46.80	91.30	12300	0.4	7.7	45.80	85.36
		reg15	86.80	188.00	178.26	30500	1.2	7.2	324.20	56.21
		reg30	213.60	428.00	865.22	109900	4.2	7.0	1691.48	5.21
		reg45	140.00	248.00	1086.96	105700	2.1	7.3	1409.59	4.58
		rina5	25.60	54.00	1013.04	105700	1.2	7.6	1381.39	5.21
		rinb10	0.80	1.60	160.87	15200	0.3	8.1	65.17	83.28
		rinb15	0.64	1.20	147.83	12300	0.4	7.8	69.09	83.28
		prod60	0.64	1.12	139.13	13200	0.3	7.8	56.12	83.28
	b	feed	24.80	47.20	91.30	11500	0.6	7.8	42.27	95.77
		fr. brine	7.20	10.80	1152.17	98100	1.8	7.6	1550.48	4.37
		reg5	24.80	47.20	104.35	12500	0.4	7.9	45.09	81.20
		reg15	77.20	167.00	273.91	34400	4.0	7.3	338.30	60.38
		reg30	196.00	374.00	856.52	94000	2.1	7.2	1268.64	5.21
		reg45	104.00	186.00	1456.52	99900	1.5	7.5	1268.64	5.00
		rinb5	24.00	56.00	1239.13	101100	1.6	7.6	1268.64	4.58
		rinb10	0.84	1.52	160.87	14600	0.5	8.1	56.37	83.28
		rinb15	0.68	1.16	152.17	12900	0.4	7.9	45.09	91.61
		prod60	0.68	1.20	156.52	12700	0.4	7.8	42.27	85.36
	c	feed	25.60	46.80	108.70	11400	0.5	7.6	40.86	95.77
		fr. brine	6.40	11.20	1386.96	99300	1.3	7.7	1155.67	4.79
		reg5	24.80	46.80	113.04	12000	0.5	7.6	42.27	89.53
		reg15	24.80	46.80	100.00	11500	0.6	7.7	42.27	6.66
		reg30	205.20	413.00	852.17	9400	2.8	7.1	1155.67	4.79
		reg45	106.00	187.00	986.96	98700	1.9	7.4	1155.67	4.58
		rinb5	23.20	56.80	1213.04	101100	1.1	7.6	1183.87	4.79
		rinb10	0.78	1.64	313.04	14600	0.5	8.0	59.22	85.36
		rinb15	0.56	1.24	143.48	13000	0.4	7.9	45.12	72.87
		prod60	0.60	1.28	152.17	12700	0.4	7.8	42.27	85.36
	d	feed	24.80	46.00	95.65	11500	0.7	7.6	42.27	74.95
		fr. brine	6.40	11.20	1243.48	99900	1.6	7.6	1155.95	4.79
		reg25	70.00	148.00	200.00	27600	3.5	7.4	225.61	62.46
		reg30	252.00	530.00	482.61	79900	2.9	7.0	958.54	12.49
		reg45	188.00	364.00	813.04	94000	1.6	7.1	1155.95	5.21
		rinb5	39.20	97.00	1117.39	100500	1.2	7.5	1170.05	5.41
		rinb10	0.96	2.12	169.57	14200	0.4	8.0	46.53	83.28
		rinb15	0.80	1.76	143.48	13200	0.4	7.9	42.27	83.28
		prod60	0.80	1.84	134.78	12700	0.5	7.7	42.27	83.28
	e	feed	24.80	46.80	91.30	11500	0.6	7.6	43.71	7.91
		fr. brine	6.40	10.80	1204.35	99900	1.4	7.7	1156.23	5.41
		reg0	24.40	48.40	100.00	11700	0.5	7.6	45.12	83.28
		reg5	25.20	47.20	86.96	11600	0.5	7.5	45.12	91.61
		reg15	24.00	46.40	91.30	11600	0.8	7.5	42.30	85.36
		reg30	216.00	422.00	813.04	92800	1.5	7.0	1156.23	5.41
		reg45	106.40	180.00	1134.78	99900	1.3	7.3	1156.23	5.62
		rina5	20.40	44.00	1291.30	104600	1.7	7.6	1156.23	8.12
		rinb10	0.80	1.44	173.91	14600	0.6	7.9	53.58	81.20
		rinb15	0.72	1.24	156.52	13400	0.4	7.8	42.30	70.79
		ser60	0.68	1.24	152.17	13000	0.4	7.7	42.30	79.12

CHEMICAL ANALYSES PHASE 1 - BENCH UNIT TESTING

			Calcium	THardness	Sodium	Elec.Cond.	Turbidity	pH	Ratio	
SERIES	Cycle No	Event	meq/l			uS/cm	N.T.U.		Na:TH	Ca:TH
115	a	feed	24.80	48.40	91.30	11500	0.5	7.7	1.89	0.51
		fr.brine	7.60	12.00	1017.39	9400	0.5	7.5	84.78	0.63
		reg10	42.40	91.00	130.43	19000	0.1	7.2	1.43	0.47
		reg20	280.00	602.00	391.30	79200	1.3	6.9	0.65	0.47
		reg30	215.40	414.00	695.65	90000	2.5	6.8	1.68	0.52
		reg40	180.00	346.00	765.22	91200	1.9	6.9	2.21	0.52
		rina5	19.20	44.40	1043.48	94800	1.1	7.3	23.50	0.43
		rinb10	13.00	30.00	560.87	55200	0.8	7.4	18.70	0.43
		rinb15	1.20	1.92	143.48	14200	0.2	7.8	74.73	0.63
		prod60	0.80	1.72	147.83	13100	0.3	7.7	85.95	0.47
	b	feed	24.80	48.40	91.30	11500	0.5	7.7	1.89	0.51
		fr.brine	8.00	12.00	1117.39	88800	1.5	7.2	93.12	0.67
		reg12	26.00	47.60	95.65	12200	0.6	7.7	2.01	0.55
		reg20	24.40	28.00	100.00	11800	1.0	7.6	3.57	0.87
		reg30	88.80	174.00	230.43	31200	1.9	7.2	1.32	0.51
		reg42	270.00	520.00	586.96	84000	1.8	6.8	1.13	0.52
		reg50	220.00	410.00	730.43	90000	1.9	6.9	1.78	0.54
		rina5	31.60	74.40	991.30	96000	1.8	7.2	13.32	0.42
		rinb10	2.80	4.40	221.74	16000	0.3	7.8	50.40	0.64
		rinb15	2.00	2.72	147.83	13100	0.4	7.6	54.35	0.74
		prod60	1.36	2.96	147.83	13100	0.3	7.8	49.94	0.46
116	all	feed	25.60	49.20	91.30	11600	0.2	7.6	1.86	0.52
		fr.brine	10.80	18.00	2265.22	16400	1.5	7.6	125.85	0.60
	a	reg10	24.80	48.40	95.65	12100	0.4	7.8	1.98	0.51
		reg20	25.60	47.60	91.30	11500	0.6	7.8	1.92	0.54
		reg30	171.20	354.00	256.52	51600	1.4	7.1	0.72	0.48
		reg40	498.00	904.00	1195.65	14400	1.7	6.8	1.32	0.55
		rina5	30.00	54.40	2378.26	16800	1.4	7.5	43.72	0.55
		rinb10	28.40	46.40	734.78	72000	1.0	7.8	15.84	0.61
		rinb15	1.44	2.28	178.26	16700	0.4	8.0	78.18	0.63
		prod	0.84	1.48	147.83	13100	0.2	8.0	99.88	0.57
	b	reg10	24.80	48.00	100.00	12200	0.3	7.7	2.08	0.52
		reg20	25.20	47.60	95.65	11500	0.5	7.7	2.01	0.53
		reg30	24.40	47.60	100.00	13700	0.7	7.7	2.10	0.51
		reg40	272.80	554.00	352.17	70800	1.8	6.9	0.64	0.49
		rina5	107.00	220.00	2047.83	15600	1.8	7.2	9.31	0.49
		rinb10	10.60	21.60	413.04	40800	0.9	7.7	19.12	0.49
		rinb15	1.16	2.48	152.17	14400	34.0	7.9	61.36	0.47
		prod	0.96	2.00	134.78	13000	0.3	7.9	67.39	0.48
	c	reg10	25.20	48.40	104.35	11800	0.3	7.6	2.16	0.52
		reg20	25.20	47.60	91.30	11500	0.6	7.6	1.92	0.53
		reg40	316.00	526.00	1726.09	15400	1.7	7.0	3.28	0.60
		reg50	282.00	456.00	1856.52	15600	1.9	7.0	4.07	0.62
		rina5	28.80	58.00	2186.96	16200	1.5	7.5	37.71	0.50
		rinb10	4.08	7.20	343.48	30600	0.7	7.9	47.71	0.57
		rinb15	0.88	1.44	160.87	15100	0.3	8.0	111.71	0.61
		prod	0.64	1.24	147.83	13000	0.3	7.8	119.21	0.52
	d	reg10	24.80	49.20	104.35	12100	0.3	7.7	2.12	0.50
		reg20	24.80	48.40	100.00	11600	0.7	7.7	2.07	0.51
		reg30	209.00	458.00	317.39	57600	1.6	7.0	0.69	0.46
		reg40	463.00	856.00	1330.43	14600	1.9	6.8	1.55	0.54
		rina5	26.80	65.20	2239.13	16200	1.3	7.5	34.34	0.41
		rinb10	18.40	36.40	647.83	60000	1.0	7.7	17.80	0.51
		rinb15	1.00	1.84	165.22	15200	0.6	8.0	89.79	0.54
		prod	0.64	1.48	139.13	13200	0.3	7.9	94.01	0.43

CHEMICAL ANALYSES PHASE 1 - BENCH UNIT TESTING

SERIES	Cycle No.	Event	Calcium	THardness	Sodium	Elec.Cond.	Turbidity	pH	Ratio	
			meq/l			uS/cm	N.T.U.		Na:TH	Ca:TH
117	all	feed	25.20	48.00	95.65	10500	0.9	7.8	1.99	0.53
		fr.brine	10.00	17.20	2056.52	150500	2.9	7.7	119.57	0.58
	a	reg10	24.40	48.00	100.00	11800	0.7	7.9	2.08	0.51
		reg20	530.00	984.00	630.43	107600	2.4	6.7	0.64	0.54
		reg30	321.00	580.00	1639.13	143000	3.1	6.9	2.83	0.55
		reg40	188.00	324.00	1860.87	151600	3.4	7.2	5.74	0.58
		reg50	159.00	258.00	1900.00	151600	4.1	7.3	7.36	0.62
		rina5	20.80	36.00	1630.43	150500	2.7	7.6	45.29	0.58
		rinb10	9.00	66.00	1360.87	126900	1.6	7.7	20.62	0.14
		rinb15	0.44	0.68	152.17	14000	0.6	8.3	223.79	0.65
		prod	0.40	0.68	139.13	12500	0.5	8.2	204.60	0.59
	b	reg15	26.00	46.00	91.30	10900	3.2	8.0	1.98	0.57
		reg30	28.00	51.20	108.70	11500	4.0	7.9	2.12	0.55
		reg45	442.00	810.00	1273.91	134400	3.8	6.9	1.57	0.55
		reg55	250.00	428.00	1813.04	147300	2.7	7.2	4.24	0.58
		rina5	20.00	47.20	2369.57	150500	2.8	7.7	50.20	0.42
		rinb10	12.00	22.80	665.22	58100	4.4	7.9	29.18	0.53
		rinb15	0.64	1.16	169.57	14000	0.6	8.2	146.18	0.55
		prod	0.48	1.00	147.83	12400	0.5	8.2	147.83	0.48
	c	reg15	30.00	47.60	91.30	1100	2.5	7.8	1.92	0.63
		reg30	410.00	912.00	456.52	101100	3.1	6.8	0.50	0.45
		reg45	192.00	314.00	1986.96	102100	2.7	7.2	6.33	0.61
		reg55	166.00	260.00	1969.57	150500	2.8	7.3	7.58	0.64
		rina5	20.40	46.80	2317.39	155900	1.8	7.8	49.52	0.44
		rinb10	12.40	24.00	704.35	62300	2.4	8.1	29.35	0.52
		rinb15	0.60	1.04	1569.57	13700	0.6	8.3	1509.20	0.58
		prod	0.68	1.28	152.17	12400	0.5	8.0	118.89	0.53
	d	reg15	26.00	46.80	108.70	11100	1.4	7.8	2.32	0.56
		reg30	162.00	320.00	269.57	44100	4.5	7.3	0.84	0.51
		reg45	325.00	560.00	1647.83	150500	2.6	7.0	2.94	0.58
		reg55	185.00	320.00	1847.83	150500	2.4	7.2	5.77	0.58
		rina5	20.40	48.00	2321.74	19900	2.0	7.6	48.37	0.43
		rinb10	10.00	18.80	656.52	49500	1.9	8.1	34.92	0.53
		rinb15	0.64	1.20	173.91	14300	0.6	8.2	144.93	0.53
		prod	0.72	1.08	152.17	12500	0.8	8.1	140.90	0.67
	e	reg15	26.00	46.80	95.65	11000	2.5	7.9	2.04	0.56
		reg30	85.00	165.00	208.70	27900	4.7	7.5	1.26	0.52
		reg45	418.00	752.00	1326.09	139700	3.4	6.8	1.76	0.56
		reg55	256.00	416.00	1708.70	145100	2.9	7.1	4.11	0.62
		rina5	28.00	62.00	2160.87	150500	2.1	7.6	34.85	0.45
		rinb10	1.88	3.20	265.22	19900	1.7	8.2	82.88	0.59
		rinb15	0.72	1.44	169.57	14000	2.2	8.2	117.75	0.50
		prod	0.52	1.20	156.52	12400	0.7	8.1	130.43	0.43

CHEMICAL ANALYSES PHASE 1 - BENCH UNIT TESTING

SERIES	Cycle No.	Event	Calcium	THardness	Sodium	Elec.Cond.	Turbidity	pH	Ratio	
			meq/l			uS/cm	N.T.U.		Na:TH	Ca:TH
118	all	feed	30.80	46.40	91.30	10500	0.5	7.9	1.97	0.66
		fr.brine	7.60	11.60	1252.17	88000	0.8	7.6	107.95	0.66
		cb.us.br.	91.20	152.00	691.30	62100	1.2	7.2	4.55	0.60
	a	reg15	204.60	358.00	786.96	90300	1.8	7.2	2.20	0.57
		rge25	115.00	158.00	995.65	86300	1.3	7.3	6.30	0.73
		reg35	94.00	132.00	1091.30	86300	1.2	7.4	8.27	0.71
		reg45	82.80	105.20	1039.13	96600	1.3	7.4	9.88	0.79
		reg55	58.00	73.20	1152.17	85700	1.2	7.5	15.74	0.79
		reg60	48.80	67.20	1143.48	85700	1.1	7.5	17.02	0.73
		rina5	13.60	18.80	1126.09	82800	1.1	7.6	59.90	0.72
		rinb5	7.20	9.72	665.22	47700	0.7	7.9	68.44	0.74
		prod	0.44	0.76	139.13	12300	0.4	7.7	183.07	0.58
	b	reg10	27.60	46.00	95.65	10700	0.6	7.7	2.08	0.60
		reg20	186.00	344.00	286.96	48300	1.3	7.1	0.83	0.54
		reg30	168.00	242.00	717.39	74700	1.0	7.2	2.96	0.69
		reg40	102.00	170.00	760.87	76500	1.0	7.3	4.48	0.60
		reg50	87.00	142.00	882.61	76500	1.1	7.3	6.22	0.61
		reg60	62.00	96.00	960.87	78800	1.0	7.3	10.01	0.65
		rina5	9.60	2.00	1017.39	77100	0.8	7.5	508.70	4.80
		rinb5	14.40	31.20	1030.43	78200	0.9	7.4	33.03	0.46
		prod	0.52	1.08	156.52	12300	0.4	7.7	144.93	0.48
	c	reg10	51.20	96.00	130.43	16800	1.1	7.3	1.36	0.53
		reg20	169.00	300.00	686.96	74200	1.1	7.1	2.29	0.56
		reg30	105.60	182.00	769.57	77100	1.0	7.2	4.23	0.58
		reg40	83.20	128.00	882.61	78200	1.1	7.3	6.90	0.65
		reg50	62.00	100.00	939.13	79300	1.0	7.3	9.39	0.62
		reg60	91.60	161.00	647.83	64400	1.1	7.4	4.02	0.57
		rina5	11.20	20.00	1030.43	78800	0.8	7.4	51.52	0.56
		rinb5	13.60	26.40	995.65	79300	0.8	7.5	37.71	0.52
		prod	0.52	0.96	152.17	12400	0.4	7.7	158.51	0.54
	d	reg10	46.80	93.20	147.83	17300	1.2	7.3	1.59	0.50
		reg20	233.00	456.00	517.39	67900	1.0	6.9	1.13	0.51
		reg30	155.00	266.00	782.61	75300	1.0	7.1	2.94	0.58
		reg40	104.00	172.00	908.70	77100	1.0	7.2	5.28	0.60
		reg50	81.00	130.00	943.48	78200	1.0	7.3	7.26	0.62
		reg60	68.00	102.00	978.26	79300	1.0	7.3	9.59	0.67
		rina5	11.20	20.00	1000.00	80500	0.8	7.5	50.00	0.56
		rinb5	15.20	34.80	1000.00	81700	1.0	7.4	28.74	0.44
		prod	0.56	1.12	152.17	12700	0.5	7.5	135.87	0.50

CHEMICAL ANALYSES PHASE 1 - BENCH UNIT TESTING

			Calcium	THardness	Sodium	Elec.Cond.	Turbidity	pH	Ratio	
SERIES	Cycle No.	Event	meq/l			uS/cm	N.T.U.		Na:TH	Ca:TH
119	all	feed	26.00	46.80	91.30	10200	0.8	7.5	1.95	0.56
		fr.brine	11.20	16.80	2282.61	154300	1.2	7.5	135.87	0.67
		cb.us.br.	136.00	234.00	573.91	62400	1.6	7.1	2.45	0.58
	a	reg6	24.80	54.00	95.65	11300	0.6	7.6	1.77	0.46
		reg15	26.00	47.00	104.35	11400	0.9	7.6	2.22	0.55
		reg30	46.00	86.00	943.48	78400	1.9	7.3	10.97	0.53
		reg40	109.60	204.00	1743.48	129900	1.5	7.1	8.55	0.54
		reg50	106.00	164.00	2256.52	150700	1.6	7.2	13.76	0.65
		rina5	30.40	42.00	2373.91	154300	1.4	7.5	56.52	0.72
		rinb5	41.20	76.80	2491.30	156800	1.4	7.4	32.44	0.54
		prod	0.68	1.20	169.57	13400	0.8	7.8	141.30	0.57
	b	reg5	26.00	45.60	104.35	10900	0.7	7.6	2.29	0.57
		reg12	26.00	45.60	100.00	10500	1.1	7.6	2.19	0.57
		reg30	28.00	51.20	108.70	10900	2.6	7.6	2.12	0.55
		reg40	506.00	880.00	852.17	113900	2.5	6.7	0.97	0.58
		reg50	342.00	556.00	1886.96	143300	1.7	6.9	3.39	0.62
		rina5	24.80	48.00	2347.83	151900	1.3	7.3	48.91	0.52
		rinb5	70.00	135.60	2256.52	153100	1.2	7.3	16.64	0.52
		prod	1.28	2.16	156.52	1300	0.6	7.8	72.46	0.59
	c	reg5	26.00	46.80	95.65	10800	0.6	7.6	2.04	0.56
		reg12	28.00	46.40	95.65	10400	1.2	7.6	2.06	0.60
		reg30	206.00	356.00	243.48	47200	2.6	6.9	0.68	0.58
		reg40	396.00	666.00	1534.78	142100	1.5	6.7	2.30	0.59
		reg50	230.00	342.00	2056.52	151900	1.5	6.9	6.01	0.67
		rina5	20.40	40.00	1760.87	132300	3.0	7.5	44.02	0.51
		rinb5	91.00	145.20	2204.35	155600	1.3	7.2	15.18	0.63
		prod	1.12	1.88	160.87	13400	0.7	7.8	85.57	0.60
	d	reg5	28.00	46.40	100.00	11000	0.6	7.6	2.16	0.60
		reg15	28.00	47.20	95.65	10700	1.1	7.6	2.03	0.59
		reg30	27.20	45.20	95.65	10600	1.3	7.6	2.12	0.60
		reg40	500.00	880.00	639.13	105300	1.8	6.4	0.73	0.57
		reg50	354.00	548.00	1673.91	147000	1.5	6.7	3.05	0.65
		rina5	30.00	58.00	821.74	153600	1.4	7.3	14.17	0.52
		rinb5	83.00	148.00	2300.00	154800	1.3	7.2	15.54	0.56
		prod	1.44	2.04	165.22	13600	0.8	7.7	80.99	0.71
	e	reg5	28.40	46.40	86.96	11200	0.8	7.5	1.87	0.61
		reg15	28.00	46.00	82.61	10800	1.1	7.5	1.80	0.61
		reg30	28.80	46.00	91.30	10700	1.3	7.5	1.98	0.63
		reg40	508.00	952.00	708.70	116400	1.7	6.5	0.74	0.53
		reg50	386.00	572.00	1591.30	146400	1.6	6.7	2.78	0.67
		rina5	32.40	50.00	1586.96	156000	1.4	7.3	31.74	0.65
		rinb5	78.00	147.60	1373.91	156000	1.8	7.2	9.31	0.53
		prod	1.32	2.00	152.17	13600	0.9	7.9	76.09	0.66

CHEMICAL ANALYSES PHASE 1 - BENCH UNIT TESTING

SERIES	Cycle No.	Event	Calcium	THardness	Sodium	Elec.Cond.	Turbidity	pH	Ratio	
			meq/l			uS/cm	N.T.U.		Na:TH	Ca:TH
120	all	feed	30.00	46.40	86.96	10200	1.2	7.8	1.9	0.65
	all	fr.brine	11.20	18.00	2108.70	155000	1.8	7.8	117.1	0.62
	a	reg5	30.40	45.20	82.61	10900	0.9	8.0	1.8	0.67
		reg15	27.20	46.00	78.26	10500	1.1	7.9	1.7	0.59
		reg30	48.00	85.00	108.70	15600	2.9	7.7	1.3	0.56
		reg40	444.00	776.00	1160.87	135000	2.2	7.0	1.5	0.57
		reg50	294.00	434.00	1613.04	147500	2.2	7.2	3.7	0.68
		reg60	198.00	248.00	1878.26	151300	1.8	7.4	7.6	0.80
		rina5	26.00	44.00	2082.61	153700	1.8	7.7	47.3	0.59
		rinb10	20.00	30.40	756.52	69400	3.6	7.9	24.9	0.66
		prod	0.64	1.16	134.78	12700	0.8	8.2	116.2	0.55
	b	reg5	27.20	46.40	84.78	10700	1.3	8.0	1.8	0.59
		reg15	26.80	46.40	86.96	10500	1.7	7.7	1.9	0.58
		reg30	134.00	232.00	217.39	33700	2.7	7.3	0.9	0.58
		reg40	472.00	778.00	1260.87	135000	2.3	6.9	1.6	0.61
		reg50	290.00	466.00	1173.91	142500	2.1	7.1	2.5	0.62
		reg60	162.00	282.00	1847.83	150000	1.8	7.3	6.6	0.57
		rina5	27.60	46.00	2152.17	152500	2.0	7.6	46.8	0.60
		rinb10	58.00	112.40	2043.48	152500	1.9	7.5	18.2	0.52
		prod	0.60	1.36	132.61	12700	0.7	8.1	97.5	0.44
	c	reg5	28.00	46.00	82.61	10600	0.7	7.8	1.8	0.61
		reg15	28.00	45.60	86.96	10300	1.3	7.8	1.9	0.61
		reg30	33.00	52.00	913.04	11500	2.8	7.6	17.6	0.63
		reg40	660.00	950.00	978.26	131300	2.1	6.6	1.0	0.69
		reg50	352.00	510.00	1630.43	145000	2.1	6.8	3.2	0.69
		reg60	200.00	258.00	1913.04	150000	1.8	7.1	7.4	0.78
		rina5	22.00	40.00	2304.35	152500	1.5	7.4	57.6	0.55
		rinb5	56.00	105.00	2152.17	152500	1.5	7.3	20.5	0.53
		prod	1.28	2.36	147.83	13500	0.8	7.9	62.6	0.54
	d	reg5	26.00	46.00	93.48	10500	0.9	7.7	2.0	0.57
		reg15	27.60	46.40	84.78	10300	1.8	7.6	1.8	0.59
		reg30	52.40	94.40	123.91	16500	3.6	7.4	1.3	0.56
		reg40	506.00	852.00	1173.91	131300	2.1	6.6	1.4	0.59
		reg50	286.00	442.00	1913.04	145000	2.0	6.9	4.3	0.65
		reg60	158.00	230.00	2086.96	152500	2.3	7.1	9.1	0.69
		rina5	23.60	50.00	2260.87	154300	1.6	7.4	45.2	0.47
		rinb5	67.00	120.00	2108.70	155600	1.8	7.3	17.6	0.56
		prod	0.72	1.40	150.00	13100	1.1	7.9	107.1	0.51
	e	reg5	27.60	46.00	95.65	11100	1.6	7.7	2.1	0.60
		reg15	26.80	45.60	91.30	10500	1.5	7.6	2.0	0.59
		reg30	85.00	150.00	147.83	23900	3.8	7.3	1.0	0.57
		reg40	470.00	824.00	1108.70	134700	2.4	6.7	1.3	0.57
		reg50	278.00	412.00	1739.13	148200	1.9	6.9	4.2	0.67
		reg60	174.00	254.00	1978.26	154300	2.0	7.0	7.8	0.69
		rina5	29.60	48.00	2130.43	156800	1.8	7.4	44.4	0.62
		rinb5	62.00	118.80	2152.17	156800	2.0	7.2	18.1	0.52
		prod	1.24	1.88	132.61	13600	0.8	7.8	70.5	0.66
	all	cb.us.br.	174.00	262.00	608.70	73500	2.5	7.1	2.3	0.66

CHEMICAL ANALYSES PHASE 1 - BENCH UNIT TESTING

			Calcium	THardness	Sodium	Elec.Cond.	Turbidity	pH	Ratio	
SERIES	Cycle No.	Event	meq/l			uS/cm	N.T.U.		Na:TH	Ca:TH
121	all	feed	28.00	46.40	86.96	10100	0.5	7.6	1.87	0.60
		fr.brine	8.40	15.60	2260.87	15300		7.7	144.93	0.54
	a	reg15	29.20	49.20	84.78	11500		7.8	1.72	0.59
		reg50	134.00	224.00	500.00	57400		7.4	2.23	0.60
		prod.	0.60	0.92	123.91	12000	0.4	7.9	134.69	0.65
	b	reg15	27.60	45.20	82.61	10300		7.5	1.83	0.61
		reg50	276.00	420.00	1804.35	146300		7.0	4.30	0.66
		prod.	0.52	0.88	130.43	12100	0.6	7.9	148.22	0.59
	c	reg15	31.20	45.20	84.78	10300		7.6	1.88	0.69
		reg50	344.00	554.00	1630.43	142900		6.9	2.94	0.62
		prod.	0.88	1.44	132.61	11900	0.5	7.9	92.09	0.61
	d	reg15	25.60	45.20	84.78	10500		7.6	1.88	0.57
		reg50	220.00	334.00	1956.52	149500		7.1	5.86	0.66
		prod.	0.64	1.16	1282.61	12200	0.5	7.9	1105.70	0.55
	e	reg15	26.40	44.80	86.96	10600		7.5	1.94	0.59
		reg50	254.00	400.00	1847.83	147200		7.0	4.62	0.64
		prod.	1.16	1.92	139.13	12600	1.5	8.0	72.46	0.60
	f	reg15	26.40	44.80	80.43	10800		7.7	1.80	0.59
		reg50	238.00	382.00	189.13	151200		7.0	0.50	0.62
		prod.	0.60	1.00	134.78	12500	0.3	7.9	134.78	0.60
	g	prod.	0.44	0.76	128.26	11900	0.2	7.8	168.76	0.58
	h	prod.	0.40	0.64	130.43	11900	0.2	7.8	203.80	0.63
	i	reg15	28.00	46.00	82.61	10800		7.6	1.80	0.61
		reg50	276.00	534.00	1717.39	148800		7.0	3.22	0.52
		prod.	0.68	1.08	130.43	12500	0.2	7.9	120.77	0.63
	j	reg15	432.00	660.00	1543.48	144500		6.8	2.34	0.65
		reg50	232.00	384.00	1891.30	151600		7.0	4.93	0.60
		prod.	0.80	1.20	139.13	12300	0.2	8.0	115.94	0.67
122	all	feed	26.40	46.00	89.13	10200	0.4	7.7	1.94	0.57
		fr.brine	9.20	14.40	1760.87	134400	NA	7.6	122.28	0.64
	a	reg15	26.00	46.00	76.09	11200	NA	7.9	1.65	0.57
		reg50	348.00	592.00	1021.74	120000	NA	6.9	1.73	0.59
		prod.	1.00	1.80	139.13	12000	0.5	8.1	77.29	0.56
	b	rge15	26.00	46.00	82.61	10300	NA	7.8	1.80	0.57
		reg50	240.00	348.00	139.13	130800	NA	7.1	0.40	0.69
		prod.	0.96	1.60	132.61	12100	0.4	8.1	82.88	0.60
	c	reg15	26.00	45.60	89.13	10800	NA	7.8	1.95	0.57
		reg50	246.00	344.00	1413.04	133200	NA	7.1	4.11	0.72
		prod.	0.92	1.68	136.96	12500	0.5	8.0	81.52	0.55
	d	reg15	26.40	45.60	84.78	10900	NA	7.7	1.86	0.58
		reg50	157.20	270.00	369.57	55200	NA	7.2	1.37	0.58
		prod.	1.00	2.04	123.91	12000	0.6	8.0	60.74	0.49
	e	reg15	26.00	45.60	76.09	10800	NA	7.7	1.67	0.57
		reg50	300.00	458.00	1152.17	129600	NA	6.9	2.52	0.66
		prod.	1.04	1.84	139.13	12400	0.9	8.0	75.61	0.57

CHEMICAL ANALYSES PHASE 1 - BENCH UNIT TESTING

			Calcium	THardness	Sodium	Elec.Cond.	Turbidity	pH	Ratio	
SERIES	Cycle No	Event	meq/l			uS/cm	N.T.U.		Na:TH	Ca:TH
123	all	feed	26.80	46.00	86.96	10100	0.4	7.8	1.89	0.58
		fr.brine	8.80	13.60	1652.17	129300	1.6	7.8	121.48	0.65
	a	reg15	26.00	45.20	847.83	10200	NA	8.0	18.76	0.58
		reg50	214.00	312.00	1369.57	117500	NA	7.3	4.39	0.69
		prod.	1.04	1.60	126.09	11600	0.5	8.2	78.80	0.65
	b	reg15	26.00	47.20	86.96	10100	NA	7.7	1.84	0.55
		reg50	354.00	552.00	978.26	112800	NA	7.0	1.77	0.64
		prod.	1.28	2.20	123.91	11700	0.4	8.1	56.32	0.58
	c	reg15	26.40	46.00	86.96	10100	NA	7.8	1.89	0.57
		reg50	398.00	434.00	113.04	112800	NA	7.1	0.26	0.92
		prod.	1.24	2.16	84.78	12000	0.4	8.1	39.25	0.57
	d	reg15	29.20	46.00	84.78	10300	NA	7.8	1.84	0.63
		reg50	334.00	492.00	1043.48	114000	NA	7.0	2.12	0.68
		prod.	1.48	2.40	130.43	11500	0.3	8.0	54.35	0.62
	e	reg15	27.60	45.60	82.61	10000	NA	7.8	1.81	0.61
		reg50	286.00	412.00	1217.39	112800	NA	7.1	2.95	0.69
		prod.	1.24	2.28	132.61	11500	0.3	7.9	58.16	0.54
124	a	feed	21.60	51.60	96.96	11400	0.5	7.6	1.88	0.42
		fr.brine	3.80	16.00	3141.30	168700	NA	NA	196.33	0.24
		reg15	56.00	226.00	254.35	37700	NA	NA	1.13	0.25
		reg40	100.00	278.00	2686.96	169400	NA	NA	9.67	0.36
		ser0	0.50	1.80	205.43	18000	NA	NA	114.13	0.28
		prod130	0.50	0.92	153.48	13500	0.7	8.6	166.82	0.54
		used brin	162.00	354.00	1186.96	103800	NA	NA	3.35	0.46
125	a	feed	21.20	50.00	100.00	11100	0.6	7.6	2.00	0.42
		fr.brine	7.80	20.40	1273.91	180100	NA	NA	62.45	0.38
		reg15	198.00	430.00	2641.30	161400	NA	NA	6.14	0.46
		reg40	78.00	122.00	3665.22	179100	NA	NA	30.04	0.64
		rina5	23.00	43.60	3997.83	180000	NA	NA	91.69	0.53
		ser0	0.84	3.40	517.39	36000	1.7	8.9	152.17	0.25
		ser10	<0.5	0.56	203.26	NA	NA	NA	362.97	NA
		ser60	<0.5	0.44	NA	NA	NA	NA	NA	NA
		ser120	<0.5	0.44	177.17	13400	0.4	NA	402.67	NA
		ser140	<0.5	0.64	NA	NA	NA	NA	NA	NA
		ser160	<0.5	5.20	NA	NA	NA	NA	NA	NA
		prod120	<0.5	0.44	177.17	1300	0.3	NA	402.67	NA
		cm.us.br	174.00	384.00	1000.00	165500	NA	NA	2.60	0.45
126	a	feed	21.00	52.40	106.96	11300	3.0	7.7	2.04	0.40
		fr.brine	9.60	19.60	3176.09	175200	NA	NA	162.05	0.49
		reg15	25.40	50.80	101.52	12400	NA	NA	2.00	0.50
		reg40	224.00	420.00	4063.04	181700	NA	NA	9.67	0.53
		rina5	54.00	120.00	3750.00	185100	NA	NA	31.25	0.45
		ser0	0.94	4.40	273.91	23800	NA	NA	62.25	0.21
		ser10	<0.5	1.76	163.70	14500	NA	NA	93.01	NA
		ser60	<0.5	1.48	NA	NA	NA	NA	NA	NA
		ser120	<0.5	2.16	158.04	13700	0.2	NA	73.17	NA
		prod120	<0.5	1.68	182.61	13400	0.1	8.2	108.70	NA
		cm.us.br	244.00	600.00	NA	NA	NA	NA	NA	0.41

APPENDIX B

SERIES 200 ION-EXCHANGE BENCH UNIT TESTS

Development of Desalting Reject Brine Regeneration Cycle
Operation Parameters and Results

SERIES 200 OPERATION PARAMETERS
ROTATING EVAPORATOR DISK BRINE (RED BRINE)

OPERATION INFORMATION:

SERIES	DATE	RESIN*	PROCESS WATER	RUN	HOUR	OTHER
201	850304	C.20.a	marsh	a	12	all regeneration with fresh brine; run to total hardness breakthrough to influent total hardness.
202	850307	C.20.a	marsh	a	10	all regeneration with fresh brine; run to total hardness breakthrough to influent total hardness.
203	850311	C.20.a	marsh	a	10	all regeneration with fresh brine; run to total hardness breakthrough to influent total hardness.
204	850312	C.20.a	marsh	a	10	all regeneration with fresh brine; run to total hardness breakthrough to influent total hardness.
205	850319	C.20.a	marsh	a	9	all regeneration with fresh brine; run to total hardness breakthrough to influent total hardness.
206	850325	C.20.a	marsh	a	10	all regeneration with fresh brine; run to total hardness breakthrough to influent total hardness.
207	850326	C.20.a	marsh	a	9	all regeneration with fresh brine; run to total hardness breakthrough to influent total hardness.
208	850329	C.20.b	marsh	a	9	all regeneration with fresh brine; run to total hardness breakthrough to influent total hardness.
209	850416	C.20.a	clarifier	a	9	sixth run with recycle brine; service run duration for 120 minutes.
210	850424	C.20.a	clarifier	a	11	seventh run with recycle brine; service run duration for 120 minutes

* C.20.a resin taken from main IX columns
C.20.b resin is new C20 resin that was also used in the first series of tests

OPERATION PARAMETERS:

		RECYCLE BRINE REGENERATION				FRESH BRINE REGENERATION				SLOW RINSE		FAST RINSE		SERVICE	
		LR1	B.E.	DUR.	CONC.	LR1	DUR.	CONC.	TEMP.	LR1	DUR.	LR1	DUR.	LR2	DUR.
SERIES	RUN	(gpm/ft2)	(%)	(min.)	(%)	(gpm/ft2)	(min.)	(%)	(C)	(gpm/ft2)	(min.)	(gpm/ft2)	(min.)	(gpm/ft3)	(min.)
201	a	4.89	50	30	7.0	3.77	20	7.0	9.5	2.85	5	6.11	15	1.18	190
202	a	5.00	50	30	7.0	3.77	20	7.0	9.0	2.85	5	6.11	15	1.18	207
203	a	5.68	55	30	7.0	3.65	20	7.0	13.0	3.54	5	5.54	15	1.22	210
204	a	5.41	55	30	5.5	3.70	20	6.5	12.0	2.85	5	5.63	15	1.19	150
205	a	5.93	top	50	5.0	3.89	20	6.5	12.0	5.36	5	5.36	15	1.20	180
206	a	5.89	top	50	5.0	3.81	20	6.5	10.5	2.95	5	5.48	15	1.18	180
207	a	5.43	50	50	5.0	3.71	20	6.5	10.0	3.71	5	5.60	15	1.08	189
208	a	5.76	50	50	5.0	3.69	20	6.5	9.5	4.48	5	5.50	10	1.19	165
209	a	5.37	50	70	5.0	3.71	20	6.5	17.0	3.46	5	5.66	15	1.19	142
210	a	5.31	40	40	NA	3.85	50	6.5	20.0	3.54	5	4.96	15	1.21	120

LR1: loading rate in gpm/ft2 (cross sectional area of column)
LR2: loading rate in gpm/ft3 of resin
B.E.: bed expansion

SERIES 200 BENCH UNIT TEST

RATES AND VOLUMES OF PROCESS WATER AND BRINE USED
ROTATING EVAPORATOR DISK BRINE (RED)

	RATE					VOLUME						
	RECYCLE BRINE	FRESH BRINE	SLOW RISE	FAST RINSE	SERVICE	RECYCLE BRINE	FRESH BRINE	SLOW RISE	FAST RINSE	SERVICE	SR+FR-CV	Calcium at Ser120
SERIES	(bv/minute)					bed volume						(meq/l)
201	0.13	0.10	0.08	0.16	0.16	3.9	2.0	0.4	2.5	30.0	1.9	0.5
202	0.13	0.10	0.08	0.16	0.16	4.0	2.0	0.4	2.5	32.7	1.9	0.6
203	0.15	0.10	0.09	0.15	0.16	4.6	2.0	0.5	2.2	34.3	1.8	0.7
204	0.14	0.10	0.08	0.15	0.16	4.3	2.0	0.4	2.3	23.9	1.7	3.0
206	0.16	0.10	0.08	0.15	0.16	7.9	2.0	0.4	2.2	28.4	1.7	1.7
207	0.14	0.10	0.10	0.15	0.14	7.3	2.0	0.5	2.2	27.2	1.8	1.4
208	0.15	0.10	0.12	0.15	0.16	7.7	2.0	0.6	1.5	26.3	1.1	4.2
209	0.14	0.10	0.09	0.15	0.16	10.0	2.0	0.5	2.3	22.7	1.8	1.3
210	0.14	0.10	0.09	0.13	0.16	5.7	5.1	0.5	2.0	19.4	1.5	1.2

BENCH UNIT NOMENCLATURE:

Sampling identification: numbers after event indicate time sample was taken.

-instantaneous samples: rega, regb, ser , rina (slow rinse) and rinb (fast rinse). Rina (slow rinse) and rinb (fast rinse) without numbers are batch samples.
-batch samples: feed, fr.brine, recycled brine, combined backwash, combined regeneration, combined rinse and product.
-influent samples: feed, fr.brine and recycled brine.
-effluent samples: combined backwash, combined rinse, combined regeneration (comb.used brine), rega, regb, rina, rinb, service and product.

bv: bed volume of resin
CV: column voids volume or entire column volume minus actual volume of resin.
Resin C.20.a: resin extracted from main units
Resin C.20.b: new, previously unused resin.

SERIES 200 BENCH UNIT TESTS CHEMICAL ANALYSES
Analyses for tests 201 through 210

SERIES	RUN	Event	Calcium	THardness	Sodium	Elec.Cond.	Turbidity	pH	Na:TH
			(meq/l)			(uS/cm)	(N.T.U.)		
201	a	feed	27.4	47.2	69.6	9600	0.7	8.1	1.5
		fr.brine	2.0	4.4	804.3	56300	NA	NA	182.8
		rega14	29.2	88.0	565.2	47500	NA	NA	6.4
		regb15	28.4	48.0	782.6	52500	NA	NA	16.3
		usedbr.	31.2	73.6	391.3	26300	NA	NA	5.3
		ser0	0.6	0.9	132.6	11300	0.5	8.6	150.7
		ser10	0.5	0.7	132.6	11900	NA	NA	184.2
		rina5	6.8	14.4	782.6	55000	NA	NA	54.3
		rinb4	9.6	18.0	804.3	55000	1.4	9.0	44.7
		prod125	0.6	0.8	134.8	12300	0.7	8.4	168.5
		prod195	1.4	5.0	128.3	12000	NA	NA	25.7
202	a	feed	29.2	46.8	89.1	10600	0.4	8.0	1.9
		fr.brine	2.4	4.8	869.6	54700	NA	NA	181.2
		rega14	30.0	166.0	413.0	39400	NA	NA	2.5
		regb15	NA	72.0	739.1	50300	NA	NA	10.3
		rina5	14.0	28.0	913.0	53700	NA	NA	32.6
		rinb4	18.0	20.8	804.3	53500	NA	NA	38.7
		ser0	3.0	5.8	232.6	19800	NA	NA	39.8
		ser10	0.7	1.3	260.9	12700	NA	NA	203.8
		comb.reg	31.6	76.8	1521.7	47800	NA	NA	19.8
		combrin	1.8	3.2	189.1	17300	NA	NA	59.1
		combrega	32.8	92.0	221.7	23500	NA	NA	2.4
		prod140	0.8	1.6	137.0	12700	0.3	8.4	87.8
203	a	feed	34.4	46.8	87.0	10800	1.0	7.8	1.9
		fr.brine	2.2	4.8	847.8	52400	NA	NA	176.6
		comb.back	28.8	102.0	217.4	25300	NA	NA	2.1
		rega14	39.0	160.0	413.0	39300	NA	NA	2.6
		regb15	26.4	64.0	717.4	50200	NA	NA	11.2
		rina5	16.0	33.0	147.8	53200	NA	NA	4.5
		rinb4	0.9	0.6	145.7	14000	NA	NA	260.1
		ser3	0.8	1.4	143.5	12400	0.3	NA	105.5
		ser10	0.8	1.3	143.5	12200	NA	NA	108.7
		comb.reg	26.0	54.8	673.9	47700	NA	NA	12.3
		comb.rinse	1.6	2.8	187.0	16300	NA	NA	66.8
		prod120	0.7	1.5	137.0	12300	0.5	8.5	92.5
204	a	feed	28.0	47.2	93.5	10200	0.8	8.0	2.0
		fr.brine	1.8	5.2	869.6	54700	NA	NA	167.2
		recyc.reg	26.8	82.4	630.4	50000	NA	NA	7.7
		rega14	30.4	175.0	369.6	37900	NA	NA	2.1
		regb15	26.4	106.0	630.4	48100	NA	NA	5.9
		rina5	29.2	53.0	739.1	53400	NA	NA	13.9
		rinb4	26.8	57.6	739.1	51100	NA	NA	12.8
		rinb10	2.4	8.4	239.1	20400	1.1	9.0	28.5
		ser0	1.5	3.9	154.3	14100	0.7	9.0	39.8
		ser10	1.4	2.5	134.8	12800	0.3	8.9	53.5
		comb.reg	26.8	108.0	587.0	46000	NA	8.3	5.4
		comb.rinse	4.7	8.4	230.4	20000	NA	8.9	27.4
		comb.back	28.0	110.0	230.4	25000	NA	8.2	2.1
		prod120	4.0	15.6	121.7	12300	0.4	8.2	7.8

SERIES 200 BENCH UNIT TESTS CHEMICAL ANALYSES
Analyses for tests 201 through 210 - Continued

SERIES	RUN	Event	Calcium	THardness	Sodium	Elec.Cond.	Turbidity	pH	Na:TH
			(meq/l)			(uS/cm)	(N.T.U.)		
205	a	feed	26.8	47.2	82.6	10000	0.7	NA	1.8
		fr.brine	1.4	4.8	956.5	52900	NA	NA	199.3
		recyc.br.	30.0	94.0	782.6	47900	NA	NA	8.3
		comb.back	36.0	123.0	210.9	25500	NA	NA	1.7
		comb.reg	26.4	107.0	695.7	44300	NA	NA	6.5
		comb.rinse	7.6	11.6	243.5	21500	NA	NA	21.0
		rega14	77.6	162.0	43.5	36600	NA	NA	0.3
		regb12	28.0	102.0	760.9	47500	NA	NA	7.5
		regb17	26.8	95.0	826.1	49300	NA	NA	8.7
		rina3	20.0	60.0	913.0	52500	NA	NA	15.2
		ser0	1.3	2.3	143.5	13900	NA	NA	62.9
		ser10	2.2	2.1	134.8	12500	NA	NA	64.8
		prod120	2.2	12.0	115.2	11700	0.3	NA	9.6
206	a	feed	27.6	50.0	87.0	10800	0.6	NA	1.7
		fr.brine	2.8	6.4	869.6	55100	NA	NA	135.9
		recyc.br.	30.0	104.8	565.2	47800	NA	NA	5.4
		comb.back	36.8	122.0	232.6	26300	NA	NA	1.9
		comb.reg	28.4	113.0	543.5	44600	NA	NA	4.8
		comb.rinse	6.0	13.6	243.5	21500	NA	NA	17.9
		rega14	37.2	170.0	347.8	36800	NA	NA	2.0
		regb15	26.0	120.0	630.4	48800	NA	NA	5.3
		rinb4	27.2	74.0	717.4	52700	NA	NA	9.7
		rinb15	1.9	5.2	143.5	15600	NA	NA	27.6
		prod120	1.3	3.4	134.8	13600	0.3	NA	39.6
207	a	feed	27.2	50.4	82.6	11200	0.6	7.9	1.6
		fr.brine	2.8	6.0	739.1	54400	NA	NA	123.2
		recyc.br.	30.8	110.8	543.5	46600	NA	NA	4.9
		comb.back	33.2	124.0	234.8	27400	NA	NA	1.9
		comb.reg	27.6	116.0	434.8	41400	NA	NA	3.7
		comb.rinse	10.0	20.0	282.6	25800	NA	NA	14.1
		rega14	34.4	180.0	391.3	39000	NA	NA	2.2
		regb15	27.6	123.0	630.4	48300	NA	NA	5.1
		rina5	28.4	50.0	93.5	12500	NA	NA	1.9
		rinb4	22.0	57.0	717.4	52000	NA	NA	12.6
		rinb15	2.8	6.4	150.0	13900	NA	NA	23.4
		prod130	1.6	4.4	132.6	13800	0.5	8.4	30.4
208	a	feed	28.4	49.6	87.0	10600	1.5	8.1	1.8
		fr.brine	2.8	6.0	760.9	52700	NA	NA	126.8
		recyc.br.	33.6	130.0	500.0	41300	NA	NA	3.8
		comb.back	36.4	125.0	217.4	27600	NA	NA	1.7
		comb.reg	30.0	120.0	565.2	42200	NA	NA	4.7
		comb.rinse	6.4	126.0	273.9	24100	NA	NA	2.2
		rega14	29.2	131.0	391.3	38600	NA	NA	3.0
		regb15	33.2	117.0	456.5	42100	NA	NA	3.9
		rina5	21.2	53.6	760.9	50200	NA	NA	14.2
		rinb15	2.7	4.4	143.5	13700	NA	NA	32.9
		prod120	2.1	7.8	137.0	12800	0.5	8.4	17.6

SERIES 200 BENCH UNIT TESTS CHEMICAL ANALYSES
Analyses for tests 201 through 210 - Continued

SERIES	RUN	Event	Calcium	THardness	Sodium	Elec.Cond.	Turbidity	pH	Na:TH
			(meq/l)			(uS/cm)	(N.T.U.)		
209	a	feed	29.2	49.0	95.7	12200	1.6	8.0	2.0
		fr.brine	2.4	6.0	847.8	56200	NA	NA	141.3
		recyc.br.	28.0	123.0	543.5	47100	NA	NA	4.4
		comb.back	37.6	130.0	204.3	26800	NA	NA	1.6
		comb.reg	40.0	136.0	321.7	42900	NA	NA	2.4
		comb.rinse	10.0	24.0	213.0	25400	NA	NA	8.9
		rega14	36.4	198.0	256.5	38700	NA	NA	1.3
		regb12	35.6	152.0	617.4	51000	NA	NA	4.1
		regb17	24.4	76.0	391.3	53800	NA	NA	5.1
		rina3	1.1	6.0	121.7	14700	NA	NA	20.3
		ser0	0.9	2.6	147.8	13000	NA	NA	57.7
		ser10	0.8	2.4	113.0	12900	NA	NA	47.1
		prod120	1.0	3.4	113.0	12700	0.5	8.4	33.2
210	a	feed	27.2	51.6	99.6	11400	0.4	7.5	1.9
		fr.brine	2.2	6.4	837.0	55900	NA	NA	130.8
		recyc.br.	30.0	126.0	510.9	47200	NA	NA	4.1
		comb.reg	26.0	130.0	563.0	45000	NA	NA	4.3
		rega14	36.5	192.0	320.0	38000	NA	NA	1.7
		regb15	32.5	450.0	584.8	49000	NA	NA	1.3
		rinb4	13.4	32.0	773.9	56400	NA	NA	24.2
		rinb15	0.6	1.2	202.0	18200	NA	NA	168.3
		ser0	0.5	1.0	154.8	14400	NA	NA	148.8
		ser10	0.5	1.0	158.9	13800	NA	NA	158.9
		ser120	0.4	1.2	153.8	13300	NA	NA	124.1
		prod120	0.5	1.0	158.9	13300	1.5	8.7	152.8

APPENDIX C

SERIES 300 ION-EXCHANGE BENCH UNIT TESTS

Resin Capacity
Operation Parameters and Results

Bench Unit Series 300

RESIN CAPACITY TEST - SUMMARY

Test No.	Resin Capacity Test No.	Process Water Influent Calcium (meq/l)	Process Water Influent Total (meq/l)	Process Water Influent Sodium (meq/l)	Average Effluent Calcium (meq/l)	Average Effluent Total (meq/l)	Resin Capacity Calcium (meq/l of resin)	Resin Capacity Total (meq/l of resin)	Regen. Sodium Thruput	RATIO Influent TH:Ca	RATIO Influent Na:TH	RATIO Effluent TH:Ca	RATIO Resin Cap. TH:Ca
301	1	35.00	91.60	196.51	1.15	10.01	0.447	1.089	15.88	2.6	2.1	8.7	2.4
302	2	31.00	94.66	196.51	3.88	13.95	0.374	1.112	11.40	3.1	2.1	3.6	3.0
303	3	35.40	89.00	209.61	0.96	7.61	0.494	1.168	10.53	2.5	2.4	7.9	2.4
304	4	26.40	50.80	122.27	0.44	7.24	0.898	1.507	10.56	1.9	2.4	16.5	1.7
305	5	26.26	52.14	117.90	0.19	5.16	1.057	1.906	16.36	2.0	2.3	27.2	1.8
306	6	28.92	52.80	109.17	0.45	3.79	0.884	1.522	11.01	1.8	2.1	8.4	1.7
307	7	31.80	54.20	78.60	0.62	5.15	1.077	1.694	9.34	1.7	1.5	8.3	1.6
308	8	28.00	53.00	480.35?	0.75	5.75	0.844	1.463	10.34	1.9	0.0	7.7	1.7
309	9	22.00	40.90	78.60	0.05	0.12	0.742	1.378	NA	1.9	1.9	2.4	1.9
310	10	21.50	39.90	74.24	0.26	9.23	1.198	1.730	NA	1.9	1.9	35.5	1.4
311	11	25.20	41.44	96.07	0.71	2.36	1.052	1.680	NA	1.6	2.3	3.3	1.6
312	12	23.06	42.26	104.80	1.32	3.86	0.847	1.495	9.89	1.8	2.5	2.9	1.8
313	13	27.40	41.74	74.24	1.89	6.84	1.041	1.423	13.61	1.5	1.8	3.6	1.4

? Sodium analysis noted questionable by lab.

Test: Series 300 Resin capacity test 1

Date: Sept. 12, 1985

Purpose: Determine resin capacity

Influent process water: Marshpond

Regenerant brine:
- Type: Rotating Evaporator Disk
- Temperature (C): NA
- Concentration (%) NA

Hardness Leakage: Service product water (analysed during event)

Time	Thruput (bv)	Calcium (meq/l)	Total (meq/l)
5	1.76	1.76	NA
10	2.52	1.36	NA
22	4.36	1.20	NA
35	6.36	1.24	2.92
50	8.66	1.24	2.92
80	13.26	1.56	NA
110	17.86	2.28	44.80

Resin data:
- Type: Duolite C 20; resin taken from colunm A of main unit 1
- Depth (cm)(during service) 152
- Volume (liters) : 7.0 (= 1 bed volume)

Operating Conditions:

Event	Input	Output	Duration (min)	Thruput (liters)	Volume (bv)	Average Flow Rate (l/min)	Average Flow Rate (bv/min)	Bed Expansion (%)
Regeneration A	Fr. Regenerant	Waste	10	9.5	1.37	1.0	0.137	
Regeneration B	Fr. Regenerant	Sp. Regenerant	30	28.7	4.13	1.0	0.138	see notes
Regeneration C	Fr. Regenerant	Sp. Regenerant	10	6.5	0.94	0.7	0.094	37
Drain		Waste						
Rinse A	Feed	Waste	5	3.3	0.48	0.7	0.095	
Rinse B	Feed	Waste	5	5.6	0.81	1.1	0.161	
Service	Feed	Product	115	122.9	17.64	1.1	0.153	

Service Performance Summary:

	Influent (meq/l)	Average Effluent (meq/l)	Difference (meq/l)	Removal (%)	Resin Capacity (eq/l of resin)
Calcium	35.0	1.5	33.5	96	0.447
Total Hardness	91.6	10.0	81.6	89	1.089
Sodium	196.5	326.0	-129.5		

Regeneration Performance Summary:

	Brine Influent (meq/l)	Total Thruput (eq/l of resin)	Average Effluent (meq/l)	Difference (inf-eff) (meq/l)	Resin Absorbance (eq/l of resin)
Calcium	36.6	--	40.2	-3.6	-0.020
Total Hardness	90.6	--	115.9	-25.3	-0.140
Sodium	2882.1	15.9	1742.8	1139.3	6.275

Test: Resin capacity test 1

CHEMICAL ANALYSES:	Ca (meq/l)	TH (meq/l)	Na (meq/l)	Ec (uS/cm)	Turb. (NTU)	pH	Chloride (meq/l)	Sulfate (meq/l)	Ratio Cat/Anion
PW Influent	35.0	91.6	196.5	21000	3.6	7.6	91.7	145.7	1.4
Fr. Brine	36.6	90.6	2882.1	108000	NA	NA	859.8	624.6	2.0
Used Brine	34.0	106.4	1615.7	106000	NA	NA	916.0	1145.1	0.9
Product 1at Ser 85	1.4	7.2	327.5	23000	2.2	8.3	98.7	187.4	1.2
Product 2at Ser 115	1.6	13.2	401.7	23000	2.2	8.1	91.7	145.7	1.8

INSTANTANEOUS EFFLUENT SAMPLES:

Regen.	Thruput (bv)	Regen. time	Ca (meq/l)	TH (meq/l)	Na (meq/l)	Ec (uS/cm)	Chloride (meq/l)	Sulfate (meq/l)	Ratio Cat/Anion
	0.45	10	46.0	144.0	1310.0	95000	831.9	676.7	1.0
	1.41	17	50.4	145.4	1528.4	100000	831.9	676.7	1.1
	2.37	24	37.6	108.0	1615.7	105000	958.8	728.7	1.0
	3.33	31	38.0	106.6	1746.7	106000	NA	NA	NA
	4.30	38	34.4	101.4	2052.4	108000	NA	NA	NA
	5.04	45	36.4	101.2	1790.4	108000	NA	NA	NA
	5.51	50	36.0	96.6	2096.1	109000	930.6	1041.0	1.1

Service	Thruput (bv)	Service time	Ca (meq/l)	TH (meq/l)	Na (meq/l)	Ec (uS/cm)	Turb. (NTU)	pH	Chloride (meq/l)	Sulfate (meq/l)	Ratio Cat/Anion
	0.66	0	8.4	18.9	759.8	51000	NA	NA	310.2	333.1	1.2
	1.27	4	1.3	3.7	366.8	24000	NA	NA	84.6	208.2	1.3
	1.73	7	1.2	3.0	292.6	24000	NA	NA	98.7	229.0	0.9
	2.19	10	1.2	2.9	279.5	23000	NA	NA	84.6	187.4	1.0
	2.65	13	1.2	2.9	279.5	24000	NA	NA	NA	NA	NA
	4.49	25	1.2	2.9	358.1	23000	NA	NA	NA	NA	NA
	8.33	50	1.2	3.0	336.2	23000	NA	NA	NA	NA	NA
	12.93	80	1.7	27.0	266.4	23000	NA	NA	NA	NA	NA
	18.30	115	3.2	64.0	279.5	21000	1.9	NA	98.7	166.6	1.3

Notes:

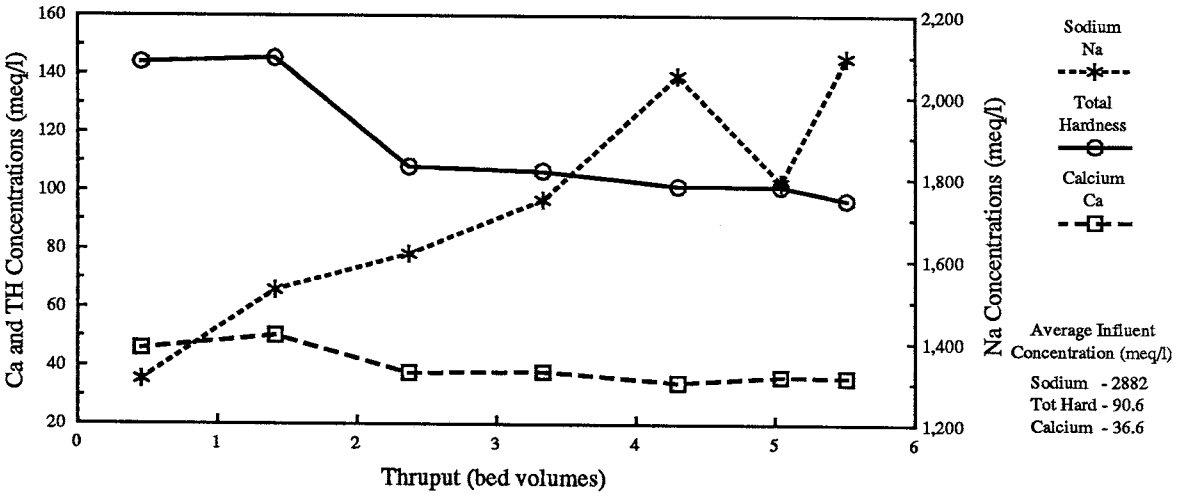
1. Column lost resin during event
2. All flow rates comparible to those of the main units
3. Fresh brine was used during entire regeneration cycle
4. Cycle ends when calcium leakage = 2.0 meq/l. Average effluent values reflect this.

Major Cation Concentrations

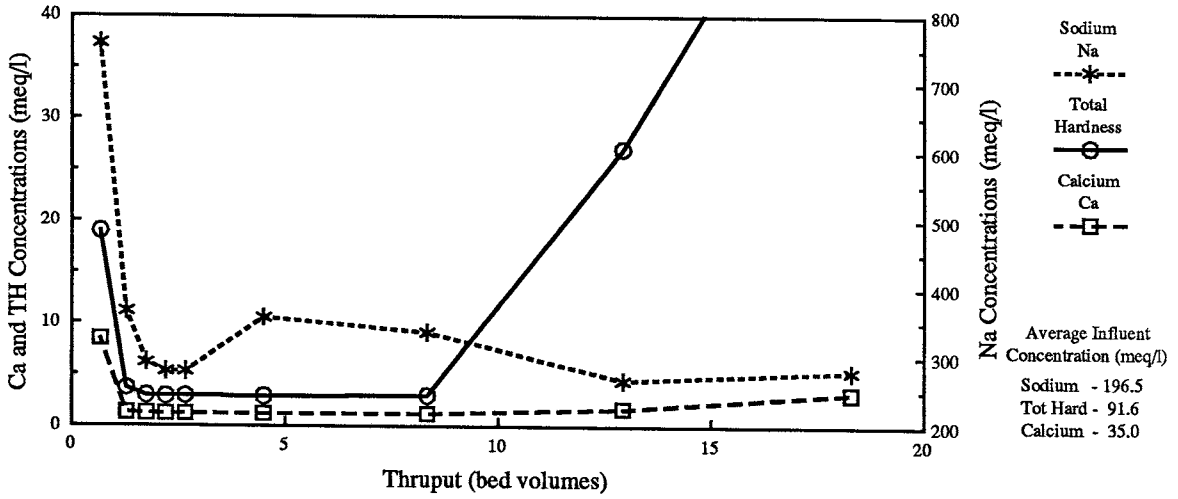
IX Bench Unit

Resin Capacity Test 1

IX Regeneration Effluent



IX Service Effluent



Test: Series 300 Resin capacity test 2

Date: Sept. 13, 1985

Purpose: Determine resin capacity

Influent process water: Marshpond

Regenerant brine:
- Type: Rotating eveporator disk
- Temperature (C): 18
- Concentration (%) NA

Resin data:
- Type: Resin taken from column A of main unit 2
- Depth (cm)(during service) 142.2
- Volume (liters) : 6.5 (= 1 bed volume)

Hardness Leakage Service product water (analysed during test)

Time	Thruput (bv)	Calcium (meq/l)	Total (meq/l)
5.0	1.6	1.9	4.0
10.0	2.4	1.7	3.6
20.0	4.1	1.6	3.5
30.0	5.7	1.6	3.5
40.0	7.3	1.7	3.7
50.0	9.0	1.6	3.8
60.0	10.6	1.8	4.8
80.0	13.9	2.7	35.2
90.0	15.6	3.1	NA

Operating Conditions:

Event	Input	Output	Duration (min.)	Thruput (liters)	Volume (bv)	Average Flow Rate (l/min.)	Average Flow Rate (bv/min.)	Bed Expansion (%)
Regeneration A	Fr. Regenerant	Waste	14	13.5	2.1	1.0	0.1	
Regeneration B	Fr. Regenerant	Sp. Regenerant	26	24.7	3.8	1.0	0.1	
Regeneration C	Fr. Regenerant	Sp. Regenerant	10	7.1	1.1	0.7	0.1	53.6
Drain		Waste						
Rinse A	Feed	Waste	5	5.7	0.9	1.1	0.2	
Rinse B	Feed	Waste	4	3.9	0.6	1.0	0.2	
Service	Feed	Product	100	107.0	16.4	1.1	0.2	

Service Performance Summary:

	Influent (meq/l)	Average Effluent (meq/l)	Difference (meq/l)	Removal (%)	Resin Capacity (eq/l of resin)
Calcium	31.0	3.9	27.1	87.5	0.4
Total Hardness	94.7	14.0	80.7	85.3	1.1
Sodium	196.5	318.2	-121.7		

Regeneration Performance Summary:

	Brine Influent (meq/l)	Total Thruput (eq/l of resin)	Average Effluent (meq/l)	Difference (inf-eff) (meq/l)	Resin Absorbance (eq/l of resin)
Calcium	28.0	--	36.5	-8.5	-0.1
Total Hardness	81.4	--	176.8	-95.4	-0.6
Sodium	1921.4	11.4	1731.0	190.4	1.1

Test: Resin capacity test 2

CHEMICAL ANALYSES:	Ca (meq/l)	TH (meq/l)	Na (meq/l)	Ec (uS/cm)	Turb. (NTU)	pH	Chloride (meq/l)	Sulfate (meq/l)	Ratio Cat/Anion
PW Influent	31.0	94.7	196.5	22700	2.3	7.5	98.7	187.4	1.1
Product 1at Ser60	2.9	7.6	314.4	25600	1.5	7.9	126.9	249.8	0.9
Product 2at Ser100	3.1	22.2	314.4	23200	1.3	7.8	98.7	208.2	1.1
Fr. Brine	28.0	81.4	1921.4	112800	NA	NA	930.6	936.9	1.1
Used Brine	31.0	131.0	1572.1	104700	NA	NA	916.5	832.8	1.0

INSTANTANEOUS EFFLUENT SAMPLES:

Regen.	Thruput (bv)	Regen. time	Ca (meq/l)	TH (meq/l)	Na (meq/l)	Ec (uS/cm)	Chloride (meq/l)	Sulfate (meq/l)	Ratio Cat/Anion
	0.45	10	35.6	296.6	1572.1	92800	803.4	832.8	1.2
	1.48	17	34.0	214.3	1528.4	102300	902.1	832.8	1.0
	2.80	26	41.4	182.7	1659.4	107000	916.5	936.9	1.0
	3.53	31	40.6	154.0	1877.7	107800	NA	NA	NA
	4.55	38	34.6	128.0	1790.4	120600	NA	NA	NA
	5.39	45	34.6	126.6	1965.1	120600	NA	NA	NA
	5.93	50	37.0	114.3	1877.7	110300	1071.3	884.9	1.0

Service	Thruput (bv)	Service time	Ca (meq/l)	TH (meq/l)	Na (meq/l)	Ec (uS/cm)	Turb. (NTU)	pH	Chloride (meq/l)	Sulfate (meq/l)	Ratio Cat/Anion
	0.77	0	40.7	107.4	1877.7	110100	NA	NA	986.7	832.8	1.1
	1.43	4	30.9	8.0	362.4	30900	NA	NA	126.9	208.2	1.2
	1.92	7	3.1	3.8	296.9	24200	NA	NA	91.7	208.2	1.0
	2.41	10	1.8	3.7	283.8	23100	NA	NA	98.7	187.4	1.0
	2.91	13	1.6	3.8	292.6	22300	NA	NA	NA	NA	NA
	4.88	25	1.6	3.7	275.1	22400	NA	NA	NA	NA	NA
	8.99	50	1.6	4.0	292.6	22400	NA	NA	NA	NA	NA
	13.92	80	1.8	35.5	244.5	22200	NA	NA	NA	NA	NA
	17.21	100	2.8	73.9	205.2	20900	1.2	7.7	91.7	187.4	1.0

Notes:

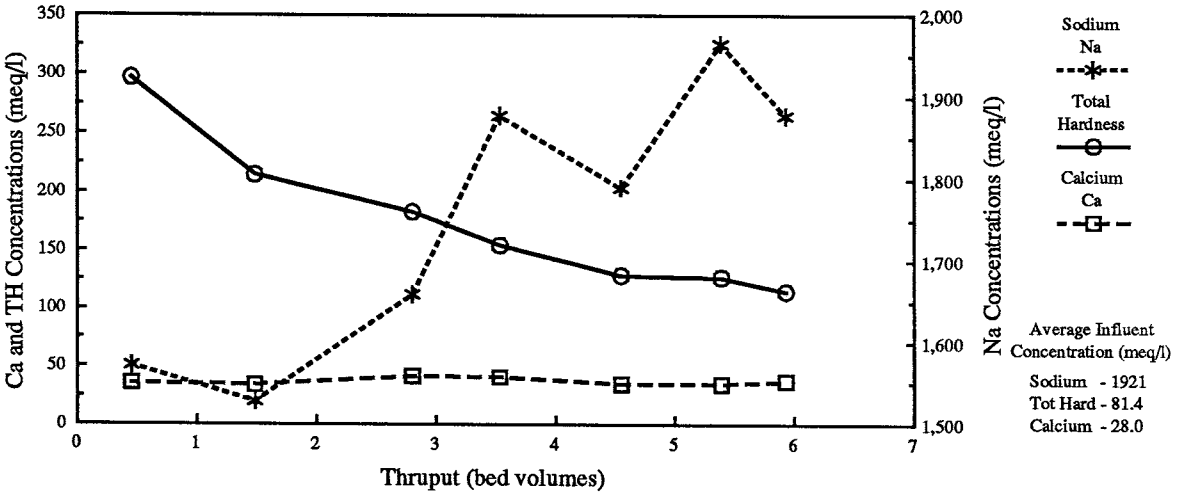
1. Resin level at 147cm. at beginning of test.
2. Lost resin during regenerations A and B. Resin level at end of service at142cm..
3. Stored resin in 12% NaCl brine.

Major Cation Concentrations

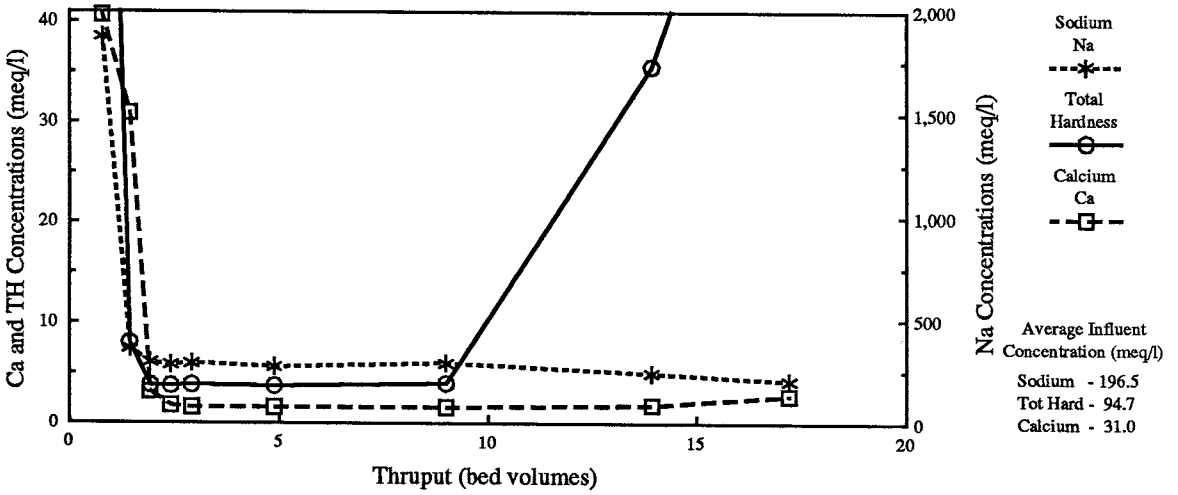
IX Bench Unit

Resin Capacity Test 2

IX Regeneration Effluent



IX Service Effluent



Test: Series 300 Resin capacity test 3

Date: Sept. 18, 1985

Purpose: Determine resin capacity

Hardness Leakage: Service product water

Time	Thruput (bv)	Calcium (meq/l)	Total (meq/l)
5.0	1.7	0.7	NA
35.0	6.7	0.7	1.1
50.0	9.2	0.8	1.2
60.0	10.9	0.9	2.1
80.0	14.3	1.3	29.0
100.0	17.6	2.8	>60

Influent process water: Marshpond

Regenerant brine:
- Type: Sodium Chloride
- Temperature (C): 17
- Concentration (%) NA

Resin data:
- Type: Resin taken from column A of main unit 1
- Depth (cm)(during service) 142.2
- Volume (liters) : 6.5 (= 1 bed volume)

Operating Conditions:

Event	Input	Output	Duration (min.)	Thruput (liters)	Volume (bv)	Average Flow Rate (l/min.)	Average Flow Rate (bv/min.)	Bed Expansion (%)
Regeneration A	Fr. Regenerant	Waste	50	34.7	5.3	0.7	0.1	33.9
Regeneration B	none							
Regeneration C	none							
Drain		Waste						
Rinse A	Feed	Waste	5	5.1	0.8	1.0	0.2	
Rinse B	Feed	Waste	5	5.1	0.8	1.0	0.2	
Service	Feed	Product	100	109.2	16.8	1.1	0.2	

Service Performance Summary:

	Influent (meq/l)	Average Effluent (meq/l)	Difference (meq/l)	Removal (%)	Resin Capacity (eq/l of resin)
Calcium	35.4	1.0	34.4	97.3	0.5
Total Hardness	89.0	7.6	81.4	91.5	1.2
Sodium	209.6	232.5	-22.9		

Regeneration Performance Summary:

	Brine Influent (meq/l)	Total Thruput (eq/l of resin)	Average Effluent (meq/l)	Difference (inf-eff) (meq/l)	Resin Absorbance (eq/l of resin)
Calcium	4.0	--	44.3	-40.3	-0.2
Total Hardness	6.0	--	83.0	-77.0	-0.3
Sodium	2445.4	10.5	2146.2	299.2	1.3

Test: Resin capacity test 3

CHEMICAL ANALYSES:

	Ca (meq/l)	TH (meq/l)	Na (meq/l)	Ec (uS/cm)	Turb. (NTU)	pH	Chloride (meq/l)	Sulfate (meq/l)	Ratio Cat/Anion
PW Influent	35.4	89.0	209.6	22100	1.4	7.7	84.6	156.2	1.4
Product 1	18.8	24.5	235.8	24600	0.9	8.1	105.8	177.0	1.0
Product 2	2.4	18.2	227.1	23700	1.0	8.1	105.8	166.6	0.9
Fr. Brine	4.0	6.0	2445.4	151200	NA	NA	2537.2	3.1	1.0
Used Brine	44.2	81.6	2096.1	137400	NA	NA	1973.5	31.2	1.1

INSTANTANEOUS EFFLUENT SAMPLES:

Regen.	Thruput (bv)	Regen. time	Ca (meq/l)	TH (meq/l)	Na (meq/l)	Ec (uS/cm)	Chloride (meq/l)	Sulfate (meq/l)	Ratio Cat/Anion
	0.03	10	28.0	72.0	759.8	66200	676.8	14.6	1.2
	0.78	17	64.6	129.0	2139.7	148800	2114.5	9.4	1.1
	1.53	24	58.0	106.8	2227.1	150200	2283.6	7.3	1.0
	2.28	31	48.6	82.0	2314.4	151500	NA	NA	NA
	3.03	38	32.0	64.0	2401.7	152200	NA	NA	NA
	3.77	45	32.0	50.6	2314.4	152200	NA	NA	NA
	4.31	50	27.4	42.4	2358.1	150200	2537.2	5.7	1.0

Service	Thruput (bv)	Service time	Ca (meq/l)	TH (meq/l)	Na (meq/l)	Ec (uS/cm)	Turb. (NTU)	pH	Chloride (meq/l)	Sulfate (meq/l)	Ratio Cat/Anion
	0.85	0	1.3	2.1	296.9	29200	NA	NA	162.2	182.2	0.9
	1.52	4	0.7	1.3	240.2	24000	NA	NA	70.5	177.0	1.0
	2.03	7	0.7	1.2	238.0	NA	NA	NA	NA	NA	NA
	2.53	10	0.7	1.1	235.8	23200	NA	NA	84.6	187.4	0.9
	3.03	13	0.7	1.1	253.3	23100	NA	NA	NA	NA	NA
	5.05	25	0.7	1.1	244.5	23000	NA	NA	NA	NA	NA
	9.25	50	0.8	1.3	227.1	23000	NA	NA	NA	NA	NA
	14.28	80	1.5	26.0	214.0	22300	NA	NA	NA	NA	NA
	20.16	115	4.8	70.0	174.7	21500	0.9	NA	91.7	177.0	0.9

Notes:

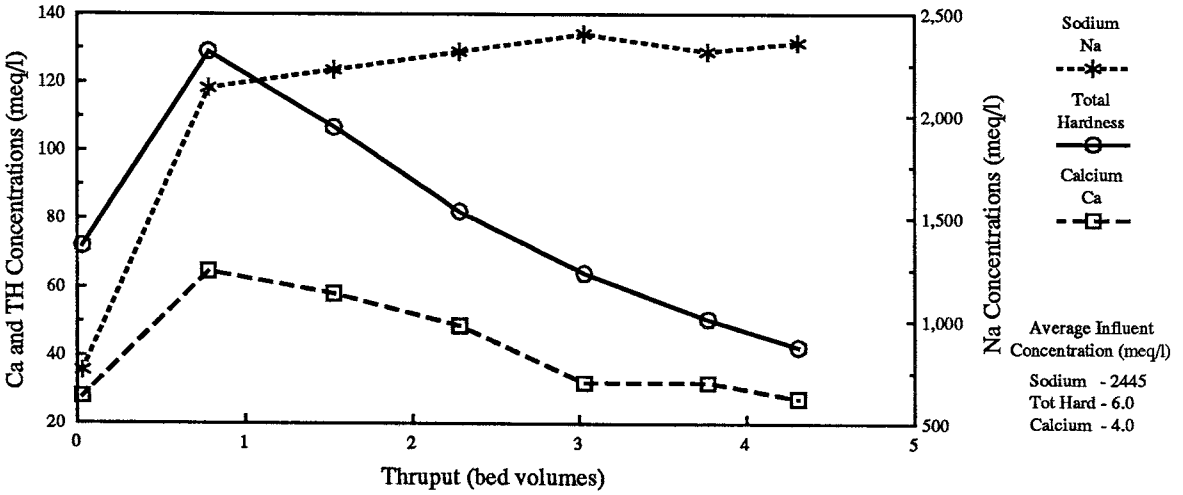
1. Resin stored in 12% NaCl brine.

Major Cation Concentrations

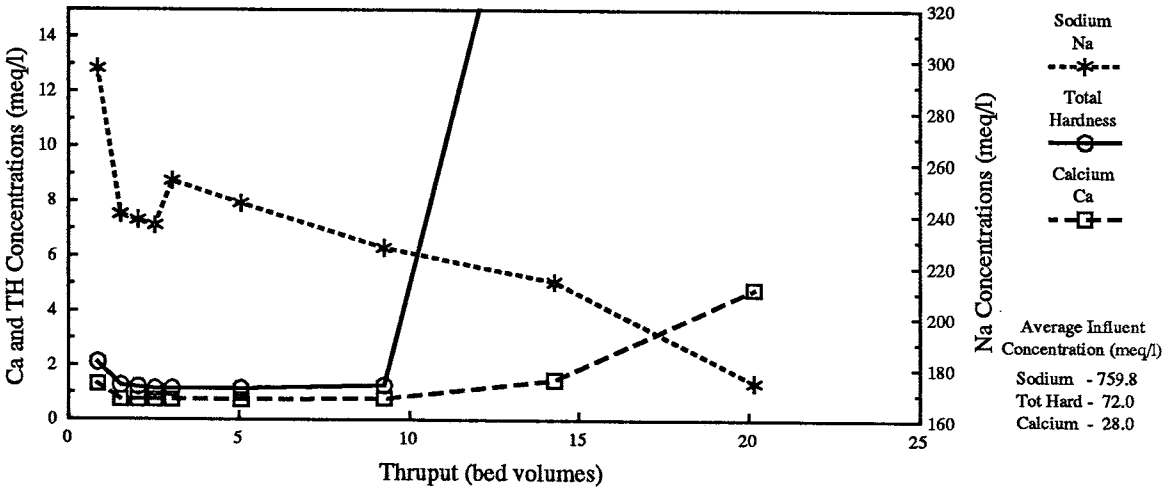
IX Bench Unit

Resin Capacity Test 3

IX Regeneration Effluent



IX Service Effluent



Test: Series 300 Resin capacity test 4

Date: Sept. 19, 1985

Purpose: Determine resin capacity

Influent process water: Filtered clarifier

Regenerant brine:
- Type: Sodium chloride
- Temperature (C): 17
- Concentration (%) 12.0

Resin data:
- Type: Resin taken from column A of main unit 1
- Depth (cm)(during service) 134.6
- Volume (liters) : 6.2 (= 1 bed volume)

Hardness Leakage: Service product water (analysed during event)

Time	Thruput (bv)	Calcium (meq/l)	Total (meq/l)
5.0	1.2	0.3	0.5
10.0	2.0	0.2	0.4
20.0	2.9	0.2	0.4
50.0	4.6	0.3	0.6
70.0	9.8	0.4	0.7
90.0	13.2	0.4	0.6
110.0	16.7	0.4	0.6
130.0	20.1	0.4	0.7
140.0	23.6	0.4	0.6
160.0	25.3	0.4	0.7
170.0	28.7	0.5	1.4
190.0	30.4	0.9	32.4
205.0	33.9	1.5	46.4

Operating Conditions:

Event	Input	Output	Duration (min.)	Thruput (liters)	Volume (bv)	Average Flow Rate (l/min.)	Average Flow Rate (bv/min.)	Bed Expansion (%)
Regeneration A	Fr. Regenerant	Waste	50	36.1	5.9	0.7	0.1	45.3
Regeneration B	none							
Regeneration C	none							
Drain		Waste						
Rinse A	Feed	Waste	5	2.6	0.4	0.5	0.1	
Rinse B	Feed	Waste	4	4.2	0.7	1.1	0.2	
Service	Feed	Product	205	217.2	35.3	1.1	0.2	

Service Performance Summary:

	Influent (meq/l)	Average Effluent (meq/l)	Difference (meq/l)	Removal (%)	Resin Capacity (eq/l of resin)
Calcium	26.4	0.4	26.0	98.3	0.9
Total Hardness	50.8	7.2	43.6	85.7	1.5
Sodium	122.3	189.9	-67.7		

Regeneration Performance Summary:

	Brine Influent (meq/l)	Total Thruput (eq/l of resin)	Average Effluent (meq/l)	Difference (inf-eff) (meq/l)	Resin Absorbance (eq/l of resin)
Calcium	3.2	--	55.5	-52.3	-0.2
Total Hardness	5.7	--	97.1	-91.4	-0.4
Sodium	2227.1	10.6	2993.7	-766.6	-3.6

Test: Resin capacity test 4

CHEMICAL ANALYSES:

	Ca (meq/l)	TH (meq/l)	Na (meq/l)	Ec (uS/cm)	Turb. (NTU)	pH	Chloride (meq/l)	Sulfate (meq/l)	Ratio Cat/Anion
PW Influent	26.4	50.8	122.3	13300	0.1	7.3	47.9	88.5	1.5
Product 1at Ser145	0.4	0.7	187.8	13300	0.4	7.5	56.4	104.1	1.2
Product 2at Ser205	0.6	7.8	183.4	13200	0.1	7.4	50.8	104.1	1.2
Fr. Brine	3.2	5.7	2227.1	150600	1.0	0.0	2396.2	2.1	0.9
Used Brine	70.4	127.7	3100.4	171700	0.0	0.0	2819.2	10.4	1.2

INSTANTANEOUS EFFLUENT SAMPLES:

Regen.	Thruput (bv)	Regen. time	Ca (meq/l)	TH (meq/l)	Na (meq/l)	Ec (uS/cm)	Chloride (meq/l)	Sulfate (meq/l)	Ratio Cat/Anion
	0.86	17	90.4	175.5	2620.1	171600	2819.2	4.2	1.0
	1.69	24	79.5	143.7	3362.4	175400	2960.2	5.2	1.2
	2.51	31	58.5	99.5	3100.4	177500	NA	NA	NA
	3.33	38	44.4	68.7	3231.4	178100	NA	NA	NA
	4.15	45	36.5	56.3	3144.1	177200	NA	NA	NA
	4.74	50	32.8	46.8	2838.4	177200	2678.2	5.2	1.1

Service	Thruput (bv)	Service time	Ca (meq/l)	TH (meq/l)	Na (meq/l)	Ec (uS/cm)	Turb. (NTU)	pH	Chloride (meq/l)	Sulfate (meq/l)	Ratio Cat/Anion
	0.32	0	30.0	45.2	3013.1	178800	NA	NA	2819.2	2.1	1.1
	1.01	4	0.5	0.8	266.4	20800	NA	NA	126.9	135.3	1.0
	1.69	8	0.2	0.3	200.9	15200	NA	NA	63.5	108.3	1.2
	2.04	10	0.2	0.3	196.5	14800	NA	NA	62.0	108.3	1.2
	2.55	13	0.2	0.3	187.8	14600	NA	NA	NA	NA	NA
	4.62	25	0.2	0.3	205.2	14500	NA	NA	NA	NA	NA
	8.92	50	0.3	0.5	179.0	13600	NA	NA	NA	NA	NA
	14.09	80	0.3	0.6	200.9	13100	NA	NA	NA	NA	NA
	20.11	115	0.4	0.6	192.1	13000	NA	NA	45.1	108.3	1.3
	23.55	135	0.4	0.6	205.2	12400	0.2	NA	45.1	108.3	1.3
	29.58	170	6.1	18.8	192.1	13300	NA	NA	NA	NA	NA
	33.02	190	0.8	30.2	148.5	12200	NA	NA	33.8	104.1	1.3
	35.60	205	1.4	44.2	144.1	11600	NA	NA	47.9	104.1	1.2

Notes:

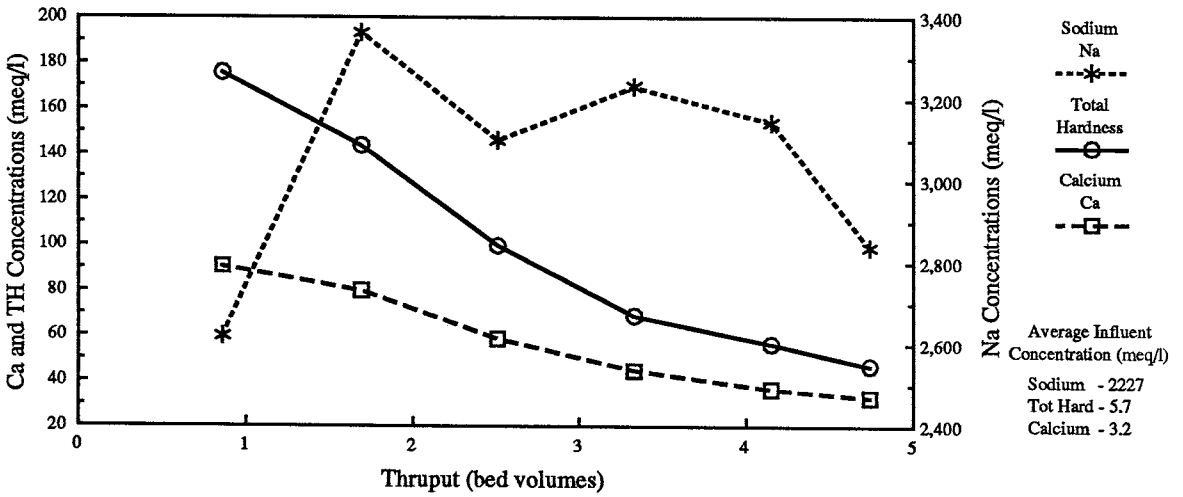
1. Drained pw tank to 20gal. from 40gallons at SER145. Product205 taken from pw tank at 37gallons..
2. Resin stored in 12% NaCl brine.

Major Cation Concentrations

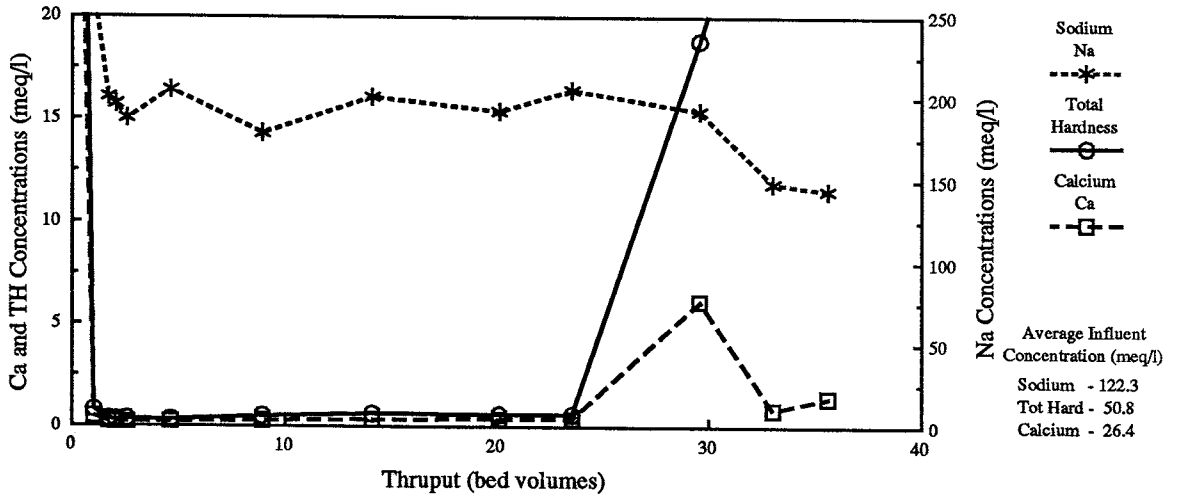
IX Bench Unit

Resin Capacity Test 4

IX Regeneration Effluent



IX Service Effluent



Test: Series 300 Resin capacity test 5

Date: Sept. 20, 1985

Purpose: Determine resin capacity

Influent process water: Filtered clarifier

Regenerant brine:
- Type: Sodium chloride
- Temperature (C): 19
- Concentration (%) 12.0

Resin data:
- Type: Resin taken from column A of main unit 2
- Depth (cm)(during service) 134.6
- Volume (liters) : 6.2 (= 1 bed volume)

Hardness Leakage: Service product water (analysed during test)

Time	Thruput (bv)	Calcium (meq/l)	Total (meq/l)
5.0	1.2	0.1	0.2
14.0	2.8	0.1	0.2
25.0	4.7	0.1	0.2
50.0	9.2	0.1	0.2
80.0	14.6	0.1	0.2
110.0	20.0	0.1	0.2
140.0	25.4	0.1	0.2
180.0	32.6	0.3	3.0
190.0	34.4	0.3	10.8
200.0	36.2	0.6	26.2
210.0	38.0	0.9	37.2
220.0	39.8	1.4	44.8
230.0	41.6	2.2	45.6

Operating Conditions:

Event	Input	Output	Duration (min.)	Thruput (liters)	Volume (bv)	Average Flow Rate (l/min.)	Average Flow Rate (bv/min.)	Bed Expansion (%)
Regeneration A	Fr. Regenerant	Waste	50	34.5	5.6	0.7	0.1	41.5
Regeneration B	none							
Regeneration C	none							
Drain		Waste						
Rinse A	Feed	Waste	5	2.6	0.4	0.5	0.1	
Rinse B	Feed	Waste	4	3.8	0.6	1.0	0.2	
Service	Feed	Product	230	254.4	41.3	1.1	0.2	

Service Performance Summary:

	Influent (meq/l)	Average Effluent (meq/l)	Difference (meq/l)	Removal (%)	Resin Capacity (eq/l of resin)
Calcium	26.3	0.2	26.1	99.3	1.1
Total Hardness	52.1	5.2	47.0	90.1	1.9
Sodium	117.9	116.0	1.9		

Regeneration Performance Summary:

	Brine Influent (meq/l)	Total Thruput (eq/l of resin)	Average Effluent (meq/l)	Difference (inf-eff) (meq/l)	Resin Absorbance (eq/l of resin)
Calcium	3.4	--	26.8	-23.5	-0.1
Total Hardness	6.2	--	33.5	-27.3	-0.2
Sodium	2925.8	16.4	2649.4	276.4	1.5

Test: Resin capacity test 5

CHEMICAL ANALYSES:	Ca (meq/l)	TH (meq/l)	Na (meq/l)	Ec (uS/cm)	Turb. (NTU)	pH	Chloride (meq/l)	Sulfate (meq/l)	Ratio Cat/Anion
PW Influent	26.3	52.1	117.9	15300	<.1	7.6	56.4	124.9	1.1
Product 1 at Ser160	0.1	0.2	113.5	12800	<.1	7.8	45.1	66.6	1.0
Product 2 at Ser230	0.5	13.0	96.1	12500	<.1	7.6	47.9	83.3	0.8
Fr.Brine	3.4	6.2	2925.8	152300	NA	NA	2537.2	1.9	1.2
Used Brine	31.3	39.2	1965.1	151700	NA	NA	2537.2	20.8	0.8

INSTANTANEOUS EFFLUENT SAMPLES:

Regen.	Thruput (bv)	Regen. time	Ca (meq/l)	TH (meq/l)	Na (meq/l)	Ec (uS/cm)	Turb. (NTU)	pH	Chloride (meq/l)	Sulfate (meq/l)	Ratio Cat/Anion
	1.11	10	36.7	48.4	2751.1	151200	NA	NA	2396.2	26.0	1.2
	2.12	19	34.4	43.8	2663.8	153100	NA	NA	2396.2	19.3	1.1
	2.68	24	31.5	38.8	2489.1	153900	NA	NA	2396.2	18.2	1.1
	3.46	31	27.1	32.0	2532.8	154600	NA	NA	NA	NA	NA
	4.25	38	23.0	27.5	2489.1	154000	NA	NA	NA	NA	NA
	5.03	45	20.7	24.5	2794.8	154100	NA	NA	NA	NA	NA
	5.59	50	28.0	32.2	2489.1	154600	NA	NA	2537.2	19.3	1.0

Service	Thruput (bv)	Service time	Ca (meq/l)	TH (meq/l)	Na (meq/l)	Ec (uS/cm)	Turb. (NTU)	pH	Chloride (meq/l)	Sulfate (meq/l)	Ratio Cat/Anion
	0.26	0	0.5	0.8	292.6	31300	NA	NA	126.9	104.1	1.3
	0.98	4	0.2	0.3	170.3	14500	NA	NA	56.4	62.5	1.4
	1.51	7	0.1	0.2	144.1	13100	NA	NA	50.8	87.4	1.0
	2.05	10	0.1	0.2	139.7	12900	NA	NA	47.9	87.4	1.0
	2.59	13	0.1	0.2	148.5	12900	NA	NA	NA	NA	NA
	4.75	25	0.1	0.1	148.5	12800	NA	NA	NA	NA	NA
	9.24	50	0.1	0.2	126.6	12700	NA	NA	NA	NA	NA
	14.63	80	0.0	0.3	122.3	12700	NA	NA	NA	NA	NA
	20.92	115	0.1	0.1	113.5	12800	NA	NA	NA	NA	NA
	26.31	145	0.1	0.1	113.5	12800	NA	NA	NA	NA	NA
	32.60	180	0.1	4.7	109.2	12200	NA	NA	NA	NA	NA
	36.19	200	0.4	27.2	83.0	12000	NA	NA	45.1	72.9	0.9
	39.79	220	1.6	46.1	78.6	11600	NA	NA	47.9	79.1	1.0
	41.59	230	2.3	48.4	95.2	11600	NA	NA	45.1	66.6	1.3

Notes:

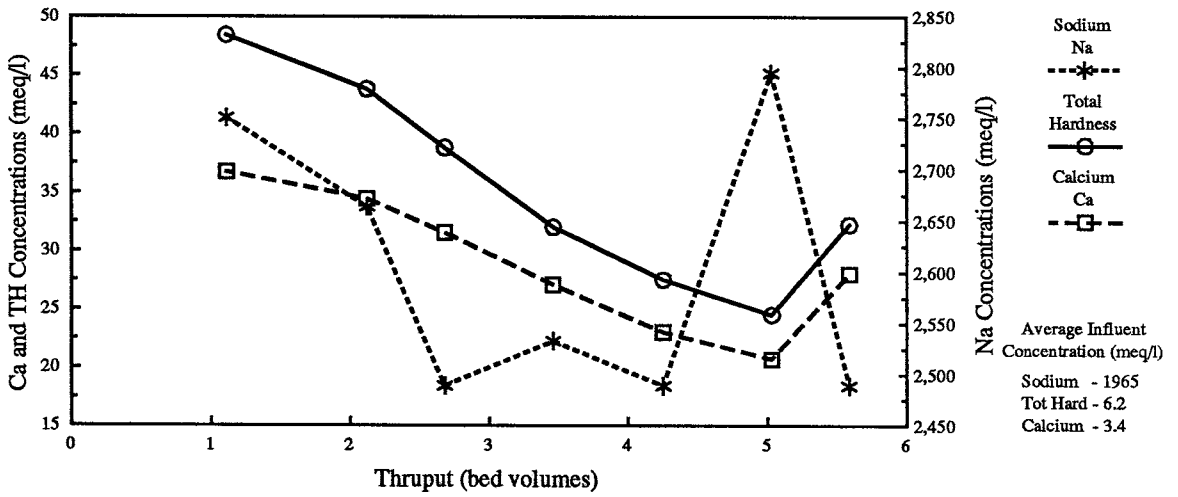
1. Drained PW tank from 45 gallons to 10 gallons at Ser160
2. PW tank at 28.75 gallons at Ser230
3. Resin level at 140cm. at beginning of test
4. Resin level at 142cm. at end of service.
5. Resin stored in 12% NaCl brine.

Major Cation Concentrations

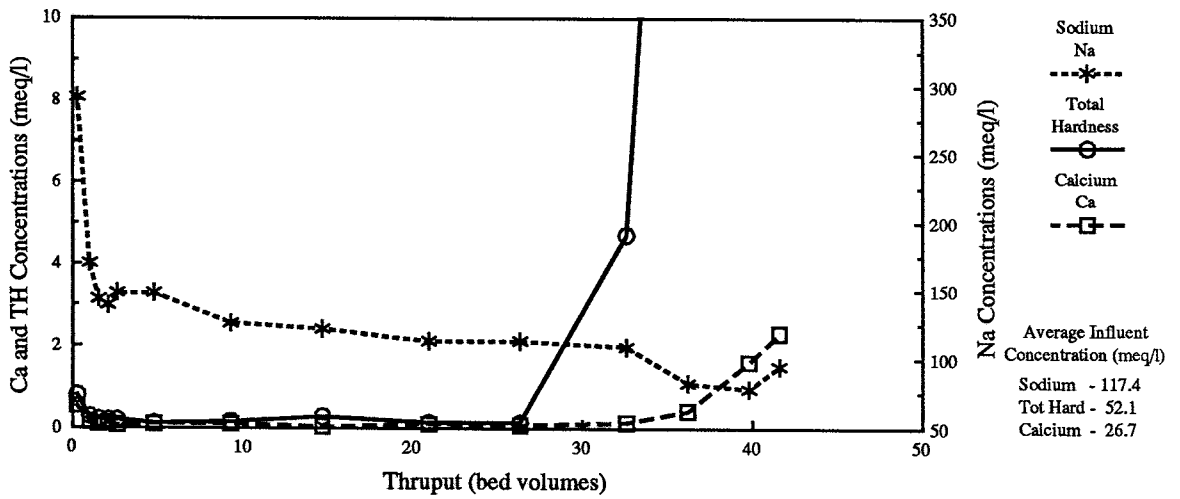
IX Bench Unit

Resin Capacity Test 5

IX Regeneration Effluent



IX Service Effluent



Test: Series 300 Resin capacity test 6

Date: Sept. 24, 1985

Purpose: Determine resin capacity

Influent process water: San Luis drain

Regenerant brine:
- Type: Sodium chloride
- Temperature (C): 23
- Concentration (%) 12.0

Resin data:
- Type: Resin taken from column A of main unit 2
- Depth (cm)(during service) 141.0
- Volume (liters) : 6.4 (= 1 bed volume)

Hardness Leakage: Service product water (analysed during event)

Time	Thruput (bv)	Calcium (meq/l)	Total (meq/l)
5.0	1.3	0.3	0.5
10.0	2.1	0.3	0.4
25.0	4.6	0.3	0.4
50.0	8.8	0.3	0.4
90.0	15.5	0.3	0.4
120.0	20.6	0.2	0.4
140.0	23.9	0.3	0.5
170.0	29.0	0.5	6.8
180.0	30.7	1.2	22.4
190.0	32.3	1.9	35.6

Operating Conditions:

Event	Input	Output	Duration (min.)	Thruput (liters)	Volume (bv)	Average Flow Rate (l/min.)	Average Flow Rate (bv/min.)	Bed Expansion (%)
Regeneration A	Fr. Regenerant	Waste	50	35.3	5.5	0.7	0.1	35.1
Regeneration B	none							
Regeneration C	none							
Drain		Waste						
Rinse A	Feed	Waste	5	2.8	0.4	0.6	0.1	
Rinse B	Feed	Waste	4	4.5	0.7	1.1	0.2	
Service	Feed	Product	190	205.8	31.9	1.1	0.2	

Service Performance Summary:

	Influent (meq/l)	Average Effluent (meq/l)	Difference (meq/l)	Removal (%)	Resin Capacity (eq/l of resin)
Calcium	28.9	0.5	28.5	98.4	0.9
Total Hardness	52.8	3.8	49.0	92.8	1.5
Sodium	109.2	161.6	-52.5		

Regeneration Performance Summary:

	Brine Influent (meq/l)	Total Thruput (eq/l of resin)	Average Effluent (meq/l)	Difference (inf-eff) (meq/l)	Resin Absorbance (eq/l of resin)
Calcium	3.7	--	144.8	-141.1	-0.6
Total Hardness	7.0	--	229.6	-222.6	-1.0
Sodium	2489.1	11.0	2399.5	89.6	0.4

Test: Resin capacity test 6

CHEMICAL ANALYSES:	Ca (meq/l)	TH (meq/l)	Na (meq/l)	Ec (uS/cm)	Turb. (NTU)	pH	Chloride (meq/l)	Sulfate (meq/l)	Ratio Cat/Anion
PW Influent	28.9	52.8	109.2	14000	0.1	8.5	987.0	83.3	0.2
Product at Ser140	0.3	0.7	148.5	13200	0.3	8.7	46.5	83.3	1.2
Product at Ser190	0.8	7.3	152.8	13100	0.1	8.5	45.1	93.7	1.2
Fr.Brine	3.7	7.0	2489.1	150000	NA	NA	2537.2	1.5	1.0
Used brine	163.4	306.0	2227.1	148600	NA	NA	2537.2	7.3	1.1

INSTANTANEOUS EFFLUENT SAMPLES:

Regen.	Thruput (bv)	Regen. time	Ca (meq/l)	TH (meq/l)	Na (meq/l)	Ec (uS/cm)	Turb. (NTU)	pH	Chloride (meq/l)	Sulfate (meq/l)	Ratio Cat/Anion
	0.05	10	316.6	610.6	1659.4	136800	NA	NA	2255.4	3.5	1.1
	0.81	17	214.7	338.0	2314.4	150000	NA	NA	2396.4	5.2	1.2
	1.58	24	173.3	264.6	2401.7	152400	NA	NA	2537.2	4.6	1.1
	2.34	31	119.3	182.6	2532.8	153500	NA	NA	NA	NA	NA
	3.11	38	86.7	116.6	2620.1	153800	NA	NA	NA	NA	NA
	3.88	45	63.7	87.9	2445.4	154100	NA	NA	NA	NA	NA
	4.43	50	54.5	69.2	2620.1	154800	NA	NA	2396.2	1.9	1.1

Service	Thruput (bv)	Service time	Ca (meq/l)	TH (meq/l)	Na (meq/l)	Ec (uS/cm)	Turb. (NTU)	pH	Chloride (meq/l)	Sulfate (meq/l)	Ratio Cat/Anion
	0.41	0	4.8	9.6	786.0	50000	0.1	8.5	704.7	78.1	1.0
	1.08	4	0.4	0.8	192.1	16000	NA	NA	64.9	78.1	1.4
	1.59	7	0.4	0.6	157.2	13700	NA	NA	50.7	83.3	1.2
	2.09	10	0.3	0.5	144.1	13200	NA	NA	45.1	77.0	1.2
	2.60	13	0.3	0.8	139.7	13100	NA	NA	NA	NA	NA
	4.61	25	0.3	0.7	135.4	13100	NA	NA	NA	NA	NA
	8.81	50	0.3	0.7	165.9	13100	NA	NA	NA	NA	NA
	15.53	90	0.3	0.5	165.9	13200	NA	NA	NA	NA	NA
	23.94	140	0.3	0.6	157.2	13300	NA	NA	45.1	83.3	1.2
	28.98	170	0.7	9.0	139.7	13700	0.2	NA	45.1	83.3	1.2
	32.34	190	2.5	37.9	126.6	13200	0.2	NA	45.1	77.0	1.4

Notes:

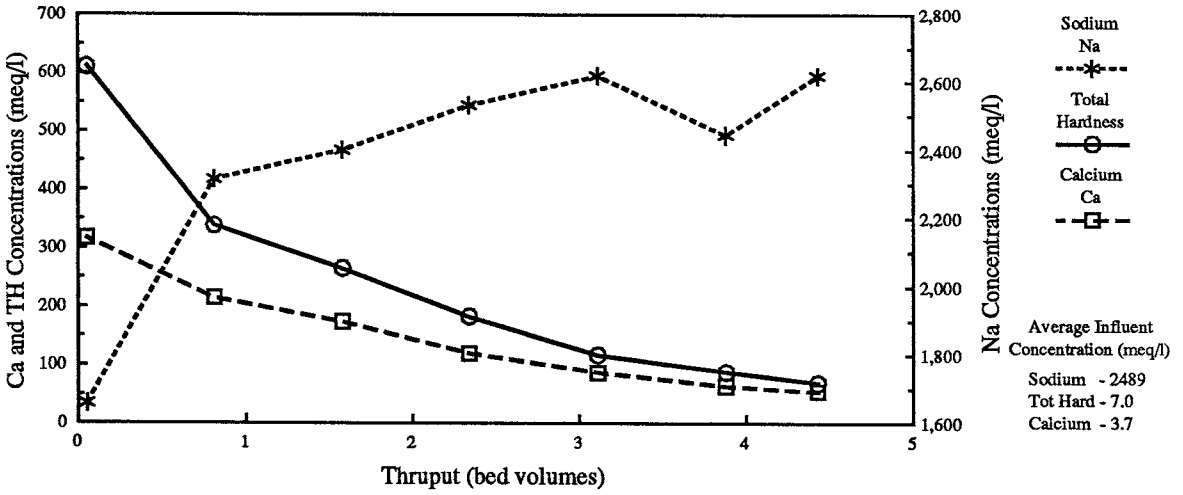
1. PW tank drained from 41 gallons to 10 gallons at Ser145
2. PW tank at about 26.75 gallons ar Ser190
3. Resin level at 137cm. at beginning of test.
4. Resin level at 141cm. at end of service.
5. Resin stored in 12% NaCl brine.

Major Cation Concentrations

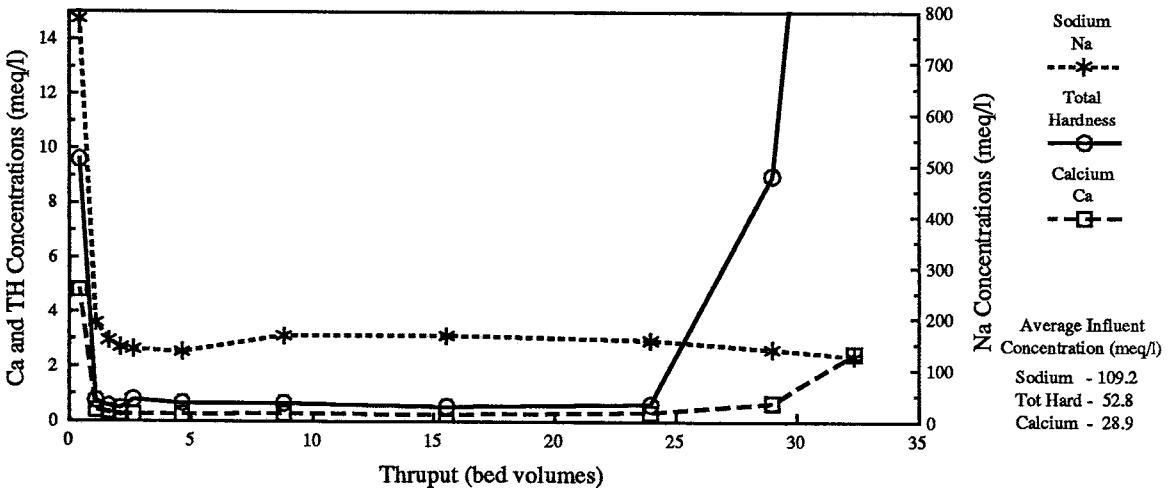
IX Bench Unit

Resin Capacity Test 6

IX Regeneration Effluent



IX Service Effluent



Test: Series 300 Resin capacity test 7

Date: Sept. 25, 1985

Purpose: Determine resin capacity

Influent process water: San Luis drain

Regenerant brine:
- Type: Sodium chloride
- Temperature (C): 21
- Concentration (%) 12.5

Resin data:
- Type: Resin taken from column A of main unit 1
- Depth (cm)(during service) 136.5
- Volume (liters) : 6.2 (= 1 bed volume)

Hardness Leakage: Service product water (analysed during test)

Time	Thruput (bv)	Calcium (meq/l)	Total (meq/l)
5.0	1.3	0.3	0.4
10.0	2.2	0.3	0.4
25.0	4.8	0.3	0.4
50.0	9.3	0.3	0.4
90.0	16.3	0.3	0.4
120.0	21.7	0.3	0.4
150.0	27.0	0.3	0.6
160.0	28.8	0.4	1.9
170.0	30.5	0.6	8.4
180.0	32.3	1.1	29.8
190.0	34.1	1.7	44.2
200.0	35.8	2.3	48.4

Operating Conditions:

Event	Input	Output	Duration (min.)	Thruput (liters)	Volume (bv)	Average Flow Rate (l/min.)	Average Flow Rate (bv/min.)	Bed Expansion (%)
Regeneration A	Fr. Regenerant	Waste	50	34.7	5.6	0.7	0.1	39.5
Regeneration B	none							
Regeneration C	none							
Drain		Waste						
Rinse A	Feed	Waste	5	2.8	0.4	0.6	0.1	
Rinse B	Feed	Waste	4	4.5	0.7	1.1	0.2	
Service	Feed	Product	200	221.2	35.4	1.1	0.2	

Service Performance Summary:

	Influent (meq/l)	Average Effluent (meq/l)	Difference (meq/l)	Removal (%)	Resin Capacity (eq/l of resin)
Calcium	31.8	0.6	31.2	98.0	1.1
Total Hardness	54.2	5.2	49.0	90.5	1.7
Sodium	78.6	135.9	-57.3		

Regeneration Performance Summary:

	Brine Influent (meq/l)	Total Thruput (eq/l of resin)	Average Effluent (meq/l)	Difference (inf-eff) (meq/l)	Resin Absorbance (eq/l of resin)
Calcium	3.5	--	89.0	-85.4	-0.4
Total Hardness	9.5	--	134.1	-124.6	-0.6
Sodium	2139.7	9.5	1992.4	147.3	0.7

Test: Resin capacity test 7

CHEMICAL ANALYSES:	Ca (meq/l)	TH (meq/l)	Na (meq/l)	Ec (uS/cm)	Turb. (NTU)	pH	Chloride (meq/l)	Sulfate (meq/l)	Ratio Cat/Anion
PW Influent	31.8	54.2	78.6	12300	0.8	8.6	49.4	88.5	1.2
Product at Ser160	0.3	0.4	135.4	13100	0.4	8.8	46.5	85.4	1.0
Product at Ser184	0.5	5.8	126.6	12500	0.4	8.8	46.5	67.7	1.2
Fr.Brine	3.5	9.5	2139.7	155550	NA	NA	2396.4	1.5	0.9
UsedBrine	104.7	166.0	1921.4	151900	NA	NA	2396.4	2.1	0.9

INSTANTANEOUS EFFLUENT SAMPLES:

Regen.	Thruput (bv)	Regen. time	Ca (meq/l)	TH (meq/l)	Na (meq/l)	Ec (uS/cm)	Turb. (NTU)	pH	Chloride (meq/l)	Sulfate (meq/l)	Ratio Cat/Anion
	0.01	10	170.0	247.3	1921.4	154400	NA	NA	2466.7	10.4	0.9
	0.79	17	121.3	214.0	2008.7	150900	NA	NA	2537.2	2.1	0.9
	1.56	24	96.0	143.3	2052.4	152200	NA	NA	2396.4	2.1	1.0
	2.34	31	86.0	122.7	1965.1	153200	NA	NA	NA	NA	NA
	3.12	38	64.0	88.7	2008.7	153400	NA	NA	NA	NA	NA
	3.90	45	48.5	63.9	2096.1	153700	NA	NA	NA	NA	NA
	4.46	50	40.5	53.6	1659.4	154000	NA	NA	2396.4	2.1	0.7

Service	Thruput (bv)	Service time	Ca (meq/l)	TH (meq/l)	Na (meq/l)	Ec (uS/cm)	Turb. (NTU)	pH	Chloride (meq/l)	Sulfate (meq/l)	Ratio Cat/Anion
	0.40	0	10.5	14.5	873.4	78100	NA	NA	987.0	88.5	0.8
	1.11	4	0.4	0.4	135.4	13300	NA	NA	47.9	83.3	1.0
	1.64	7	0.3	0.4	131.0	12800	NA	NA	45.1	72.9	1.1
	2.17	10	0.3	0.3	131.0	13100	NA	NA	45.1	72.9	1.1
	2.71	13	0.3	0.3	139.7	13200	NA	NA	NA	NA	NA
	4.83	25	0.3	0.4	139.7	13200	NA	NA	NA	NA	NA
	9.26	50	0.3	0.4	131.0	13200	NA	NA	NA	NA	NA
	21.67	120	0.3	0.4	131.0	13200	NA	NA	NA	NA	NA
	28.75	160	0.4	1.5	131.0	13200	NA	NA	46.5	83.3	1.0
	32.30	180	2.2	28.9	104.8	12400	0.3	NA	39.5	85.4	1.1
	34.07	190	1.6	43.8	87.3	11600	0.3	8.7	42.3	67.7	1.2
	35.84	200	2.4	48.5	83.0	11500	0.3	8.6	46.5	88.5	1.0

Notes:

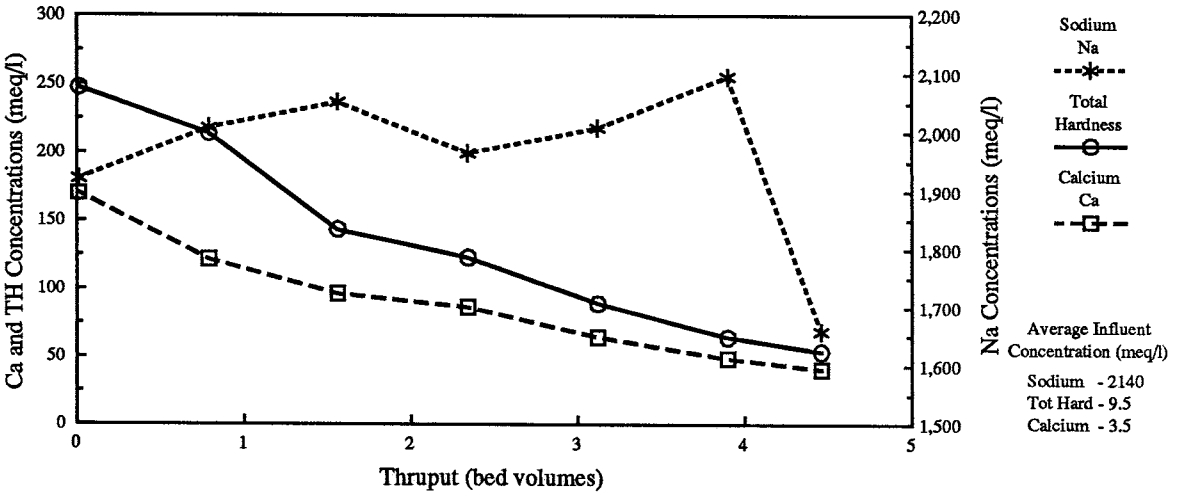
1. PW tank drained from 45 gallons to 10 gallons at Ser160.
2. Level in PW tank at Ser200, 21 gallons.
3. Resin level at beginning of test at 132cm. (12% NaCl brine).
4. Resin level at end of service at 137cm..

Major Cation Concentrations

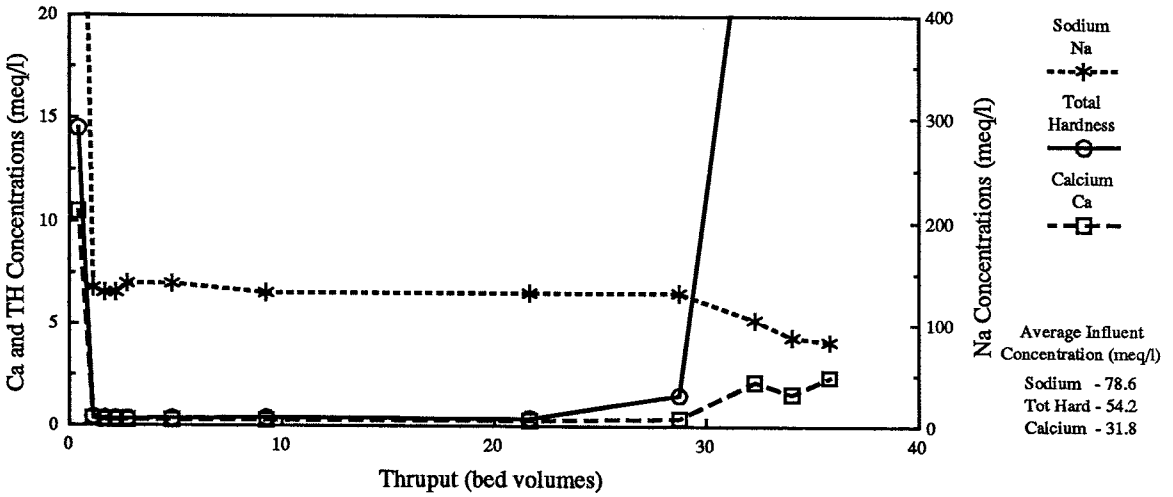
IX Bench Unit

Resin Capacity Test 7

IX Regeneration Effluent



IX Service Effluent



Test: Series 300 Resin capacity test 8

Date: Sept. 26, 1985

Purpose: Determine resin capacity

Influent process water: San Luis drain

Regenerant brine:
- Type: Rotating evaporator disk
- Temperature (C): 22
- Concentration (%) 12.0

Resin data:
- Type: Resin taken from column A of main unit 2
- Depth (cm)(during service) 147.3
- Volume (liters) : 6.7 (= 1 bed volume)

Hardness Leakage: Service product water (analysed during test)

Time	Thruput (bv)	Calcium (meq/l)	Total (meq/l)
5.0	1.1	0.4	1.0
10.0	1.9	0.3	0.8
25.0	4.3	0.3	0.7
50.0	8.3	0.3	0.7
80.0	13.2	0.3	0.7
110.0	18.0	0.3	0.8
130.0	21.2	0.3	0.7
160.0	26.0	0.4	2.2
170.0	27.6	0.6	8.0
180.0	29.2	0.9	18.0
190.0	30.8	1.5	34.0
200.0	32.4	2.4	43.2

Operating Conditions:

Event	Input	Output	Duration (min.)	Thruput (liters)	Volume (bv)	Average Flow Rate (l/min.)	Average Flow Rate (bv/min.)	Bed Expansion (%)
Regeneration A	Fr. Regenerant	Waste	14	13.3	2.0	1.0	0.1	
Regeneration B	Fr. Regenerant	Sp. Regenerant	26	25.0	3.7	1.0	0.1	50.0
Regeneration C	Fr. Regenerant	Sp. Regenerant	10	7.2	1.1	0.7	0.1	36.2
Drain		Waste						
Rinse A	Feed	Waste	5	2.6	0.4	0.5	0.1	
Rinse B	Feed	Waste	4	4.0	0.6	1.0	0.1	
Service	Feed	Product	200	216.2	32.1	1.1	0.2	

Service Performance Summary:

	Influent (meq/l)	Average Effluent (meq/l)	Difference (meq/l)	Removal (%)	Resin Capacity (eq/l of resin)
Calcium	28.0	0.7	27.3	97.3	0.8
Total Hardness	53.0	5.8	47.2	89.1	1.5
Sodium	480.4	288.3	192.0		

Regeneration Performance Summary:

	Brine Influent (meq/l)	Total Thruput (eq/l of resin)	Average Effluent (meq/l)	Difference (inf-eff) (meq/l)	Resin Absorbance (eq/l of resin)
Calcium	23.6	--	40.3	-16.7	-0.1
Total Hardness	64.6	--	158.6	-94.1	-0.5
Sodium	1790.4	10.3	1761.3	29.1	0.2

Test: Resin capacity test 8

CHEMICAL ANALYSES:	Ca (meq/l)	TH (meq/l)	Na (meq/l)	Ec (uS/cm)	Turb. (NTU)	pH	Chloride (meq/l)	Sulfate (meq/l)	Ratio Cat/Anion
PW Influent	28.0	53.0	480.35?	13500	0.7	8.6	42.3	72.9	0.7
Product at Ser160	0.4	0.9	187.8	13500	0.4	8.8	45.1	87.4	1.4
Product at Ser200	0.8	18.3	148.5	13200	0.4	8.8	45.1	72.9	1.4
Fr.Brine	23.6	64.6	1790.4	100100	NA	NA	507.5	499.7	1.9
UsedBrine	42.0	154.7	2008.7	100600	NA	NA	591.9	499.7	2.0

? sodium analysis noted questionable by lab

INSTANTANEOUS EFFLUENT SAMPLES:

Regen.	Thruput (bv)	Regen. time	Ca (meq/l)	TH (meq/l)	Na (meq/l)	Ec (uS/cm)	Turb. (NTU)	pH	Chloride (meq/l)	Sulfate (meq/l)	Ratio Cat/Anion
	0.44	10	38.7	205.4	1659.4	110700	NA	NA	761.1	374.8	1.7
	1.43	17	45.3	236.0	1615.7	105000	NA	NA	591.9	416.4	1.9
	2.43	24	41.3	160.0	1790.4	101700	NA	NA	549.6	499.7	1.9
	3.43	31	42.7	152.0	1790.4	100300	NA	NA	NA	NA	NA
	4.42	38	38.7	125.3	1790.4	100600	NA	NA	NA	NA	NA
	5.24	45	38.1	101.8	1834.1	100900	NA	NA	NA	NA	NA
	5.78	50	38.1	99.0	2052.4	101300	NA	NA	451.1	458.0	2.4

Service	Thruput (bv)	Service time	Ca (meq/l)	TH (meq/l)	Na (meq/l)	Ec (uS/cm)	Turb. (NTU)	pH	Chloride (meq/l)	Sulfate (meq/l)	Ratio Cat/Anion
	0.32	0	34.4	75.0	2052.4	94300	NA	NA	751.8	416.4	1.9
	0.96	4	0.5	1.1	183.4	15400	NA	NA	47.9	87.4	1.4
	1.44	7	0.4	0.9	170.3	14200	NA	NA	42.3	72.9	1.5
	1.92	10	0.3	0.8	157.2	13600	NA	NA	42.3	83.3	1.3
	2.40	13	0.3	0.7	157.2	13500	NA	NA	NA	NA	NA
	4.33	25	0.3	0.7	152.8	13200	NA	NA	NA	NA	NA
	8.34	50	0.3	0.7	152.8	13300	NA	NA	NA	NA	NA
	17.97	110	0.3	0.7	165.9	13200	NA	NA	NA	NA	NA
	25.99	160	0.4	2.2	157.2	13200	NA	NA	43.7	79.1	1.3
	27.60	170	0.4	7.6	148.5	13200	0.4	NA	42.3	72.9	1.4
	29.20	180	0.9	38.7	135.4	12700	0.4	NA	43.7	83.3	1.4
	32.41	200	2.6	42.3	113.5	12000	0.4	NA	43.7	83.3	1.2

Notes:

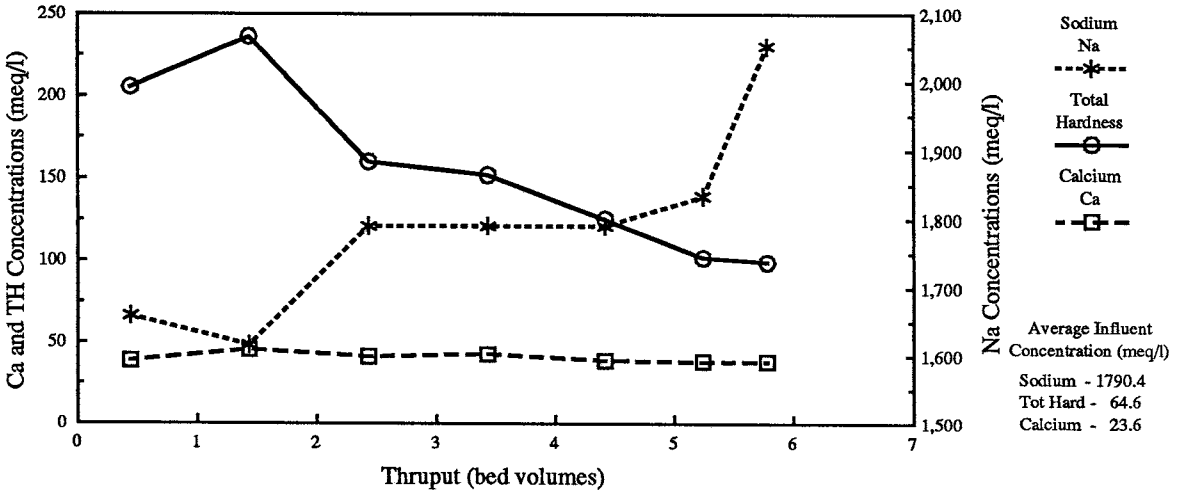
1. PW tank drained from 45 gallons to about 8 gallons at Ser160.
2. Pw tank at about 18.25 gallons at Ser200.
3. Resin level at beginning of test at 137cm.(in 12% NaCl brine).
4. Resin level at end of service at 147cm..

Major Cation Concentrations

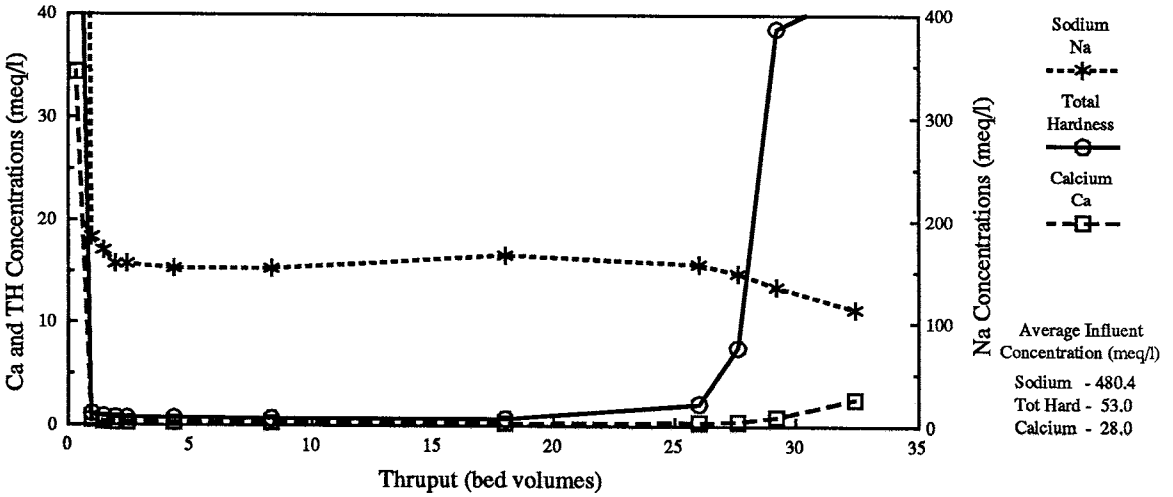
IX Bench Unit

Resin Capacity Test 8

IX Regeneration Effluent



IX Service Effluent



Test: Series 300 Resin capacity test 9

Date: October 30, 1985

Purpose: 1. Determine resin capacity
2. Condition resin for testing

Influent process water: filtered clarifier

Regenerant brine:
Type: none, see notes
Temperature (C): 17 (process water)
Concentration (%)see notes

Resin data:
Type: Dowex HCR-S
Depth (cm)(during service) 147.3
Volume (liters) : 6.7 (= 1 bed volume)

Hardness Leakage: Service product water (analysed during test)

Time	Thruput (bv)	Calcium (meq/l)	Total (meq/l)
5.0	1.4	<0.20	<0.20
10.0	2.2	<0.20	<0.20
15.0	3.0	<0.20	<0.20
25.0	4.6	<0.20	<0.20
80.0	13.4	<0.20	<0.20
80.0	13.4	<0.20	<0.20
120.0	19.9	<0.20	<0.20
180.0	29.5	<0.20	<0.20
240.0	39.2	<0.20	<0.20
285.0	46.4	<0.20	<0.20
315.0	51.2	0.7	NA
375.0	60.9	1.8	NA
435.0	70.5	4.7	NA

Operating Conditions:

Event	Input	Output	Duration (min.)	Thruput (liters)	Volume (bv)	Average Flow Rate (l/min.)	(bv/min.)	Bed Expansion (%)
Regeneration A	Fr. Regenerant	Waste	see note	see note	--	--	--	--
Regeneration B	Fr. Regenerant	Sp. Regenerant	" "	" "	--	--	--	--
Regeneration C	Fr. Regenerant	Sp. Regenerant	" "	" "	--	--	--	--
Drain		Waste						
Rinse A	Feed	Waste	5	4.7	0.7	0.9	0.1	
Rinse B	Feed	Waste	4	3.5	0.5	0.9	0.1	
Service	Feed	Product	210	227.6	33.8	1.1	0.2	

Service Performance Su see notes

	Influent (meq/l)	Average Effluent (meq/l)	Difference (meq/l)	Removal (%)	Resin Capacity (eq/l of resin)
Calcium	22.0	0.0	22.0	99.8	0.7
Total Hardness	40.9	0.1	40.8	99.7	1.4
Sodium	78.6	98.2	-19.6		

Test: Resin capacity test 9

CHEMICAL ANALYSES:	Ca (meq/l)	TH (meq/l)	Na (meq/l)	Ec (uS/cm)	Turb. (NTU)	pH	Chloride (meq/l)	Sulfate (meq/l)	Ratio Cat/Anion
PW Influent	22.0	40.9	78.6	8100	0.2	7.4	42.3	62.5	1.4
Product1 at Ser162	0.1	0.1	104.8	9200	0.3	NA	33.8	60.4	1.1
Fr.Brine	see notes	NA	NA	NA	NA	NA	NA	NA	ERR
Recycle Brine	NA	NA	NA	NA	NA	NA	NA	NA	NA
Used Brine	NA	NA	NA	NA	NA	NA	NA	NA	NA

INSTANTANEOUS EFFLUENT SAMPLES:

Service	Thruput (bv)	Service time	Ca (meq/l)	TH (meq/l)	Na (meq/l)	Ec (uS/cm)	Turb. (NTU)	pH	Chloride (meq/l)	Sulfate (meq/l)	Ratio Cat/Anion
	0.55	0	0.1	0.2	122.3	10600	NA	NA	47.9	66.6	1.1
	1.19	4	0.1	0.2	96.1	9200	NA	NA	33.8	62.5	1.0
	1.68	7	0.1	0.1	100.4	9200	NA	NA	33.8	64.5	1.0
	2.16	10	0.1	0.2	104.8	9500	NA	NA	NA	NA	NA
	2.64	13	0.0	0.1	100.4	9100	NA	NA	NA	NA	NA
	4.57	25	0.0	0.1	104.8	9000	NA	NA	NA	NA	NA
	15.03	90	0.0	0.1	100.4	8700	NA	NA	NA	NA	NA
	26.29	160	0.1	0.1	87.3	9400	NA	NA	NA	NA	NA
	34.33	210	0.0	0.1	104.8	9400	NA	NA	31.0	66.6	1.1

Notes:

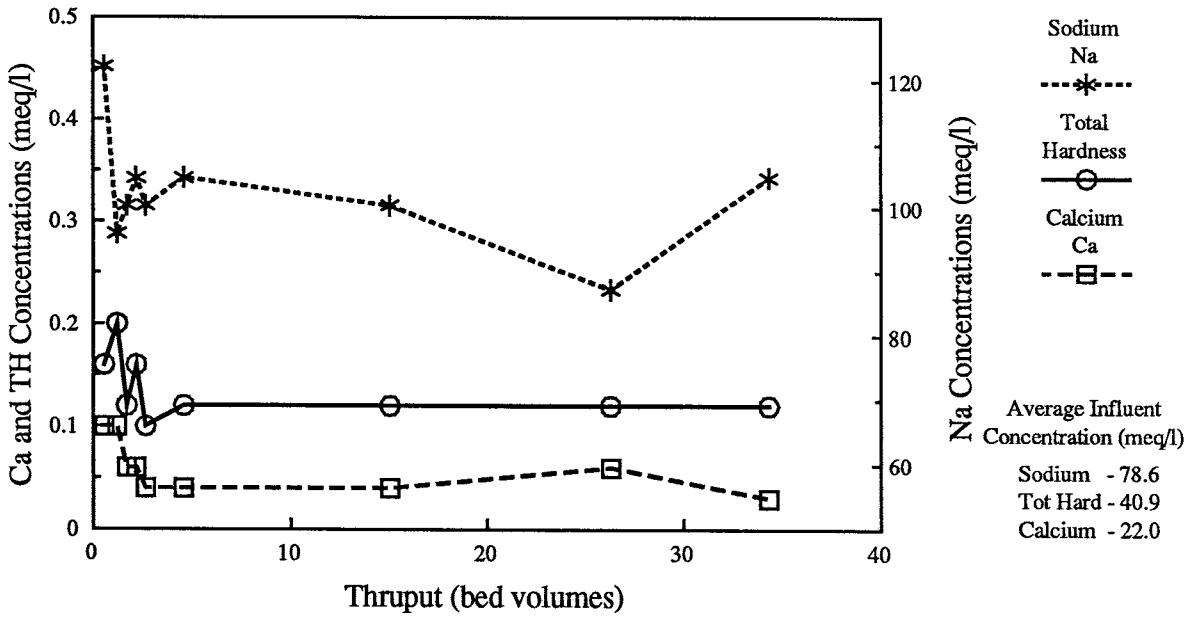
1. New resin. No regeneration. Resin stored in 6% NaCl brine previous to first run.
2. Resin stored in process water after test.
3. PW tank drained from 41 gal. to 10 gal. at Ser162
4. Product1 taken at Ser162.
5. Resin capacities as shown on page 1 in The Service Performance Summary are to service at 210 minutes.

Major Cation Concentrations

IX Bench Unit

Resin Capacity Test 9

IX Service Effluent



Test: Series 300 Resin capacity test 10

Date: October 31, 1985

Purpose: 1. Determine resin capacity
2. Condition resin for testing

Influent process water: filtered clarifier

Regenerant brine:
Type: none, see notes
Temperature (C): 16 (process water)
Concentration (%) --

Resin data:
Type: Amberlite IR-120
Depth (cm)(during service) 145.5
Volume (liters) : 6.7 (= 1 bed volume)

Hardness Leakage: Service product water (analysed during test)

Time	Thruput (bv)	Calcium (meq/l)	Total (meq/l)
5.0	0.4	<0.20	<0.20
10.0	1.2	<0.20	<0.20
15.0	2.0	<0.20	<0.20
25.0	3.5	<0.20	<0.20
80.0	12.1	<0.20	<0.20
80.0	12.1	<0.20	<0.20
120.0	18.4	<0.20	<0.20
180.0	27.8	<0.20	<0.20
245.0	38.0	<0.20	<0.20
300.0	46.6	18.0	18.6
310.0	48.2	30.0	NA

Operating Conditions:

Event	Input	Output	Duration (min.)	Thruput (liters)	Volume (bv)	Average Flow Rate (l/min.)	(bv/min.)	Bed Expansion (%)
Regeneration A	Fr. Regenerant	Waste	see note	see note	--	--	--	--
Regeneration B	Fr. Regenerant	Sp. Regenerant	" "	" "	--	--	--	--
Regeneration C	Fr. Regenerant	Sp. Regenerant	" "	" "	--	--	--	--
Drain		Waste						
Rinse A	Feed	Waste	5	3.0	0.4	0.6	0.1	
Rinse B	Feed	Waste	4	4.2	0.6	1.0	0.2	
Service	Feed	Product	300	325.1	48.9	1.1	0.2	

Service Performance Summary:

	Influent (meq/l)	Average Effluent (meq/l)	Difference (meq/l)	Removal (%)	Resin Capacity (eq/l of resin)
Calcium	21.5	0.3	21.2	98.8	1.2
Total Hardness	39.9	9.2	30.7	76.9	1.7
Sodium	74.2	114.4	-40.1		

Test: Resin capacity test 10

CHEMICAL ANALYSES:	Ca (meq/l)	TH (meq/l)	Na (meq/l)	Ec (uS/cm)	Turb. (NTU)	pH	Chloride (meq/l)	Sulfate (meq/l)	Ratio Cat/Anion
PW Influent	21.5	39.9	74.2	47100	0.1	7.4	33.8	58.3	1.5
Product1	NA	NA	NA	NA	NA	NA	NA	NA	NA
Product2	NA	NA	NA	NA	NA	NA	NA	NA	NA
Fr.Brine	NA	NA	NA	NA	NA	NA	NA	NA	NA
Recycle Brine	NA	NA	NA	NA	NA	NA	NA	NA	NA
Used Brine	NA	NA	NA	NA	NA	NA	NA	NA	NA

INSTANTANEOUS EFFLUENT SAMPLES:

Service	Thruput (bv)	Service time	Ca (meq/l)	TH (meq/l)	Na (meq/l)	Ec (uS/cm)	Turb. (NTU)	pH	Chloride (meq/l)	Sulfate (meq/l)	Ratio Cat/Anion
	0.39	0	0.9	2.1	655.0	9800	NA	NA	521.7	60.4	1.1
	1.04	4	0.1	0.1	126.6	45800	NA	NA	49.4	60.4	1.2
	1.53	7	0.1	0.1	117.9	12100	NA	NA	36.7	58.3	1.2
	2.02	10	0.1	0.1	117.9	10400	NA	NA	33.8	79.1	1.0
	4.46	25	0.1	0.1	113.5	9600	NA	NA	NA	NA	NA
	15.05	90	0.1	0.2	113.5	9500	NA	NA	NA	NA	NA
	29.70	180	0.1	0.1	113.5	9500	NA	NA	NA	NA	NA
	39.47	240	0.0	0.1	117.9	9600	NA	NA	31.0	64.5	1.2
	49.24	300	0.5	20.1	100.4	9100	0.1	NA	33.8	68.7	1.2
	50.87	310	0.5	25.9	96.1	8900	0.1	NA	31.0	70.8	1.2
	52.50	320	1.2	30.7	91.7	8600	0.1	NA	31.0	70.8	1.2
	54.13	330	1.5	33.4	96.1	8700	0.1	7.6	33.8	79.1	1.2
		Ave.leak	0.3	9.2	114.4						

Notes:

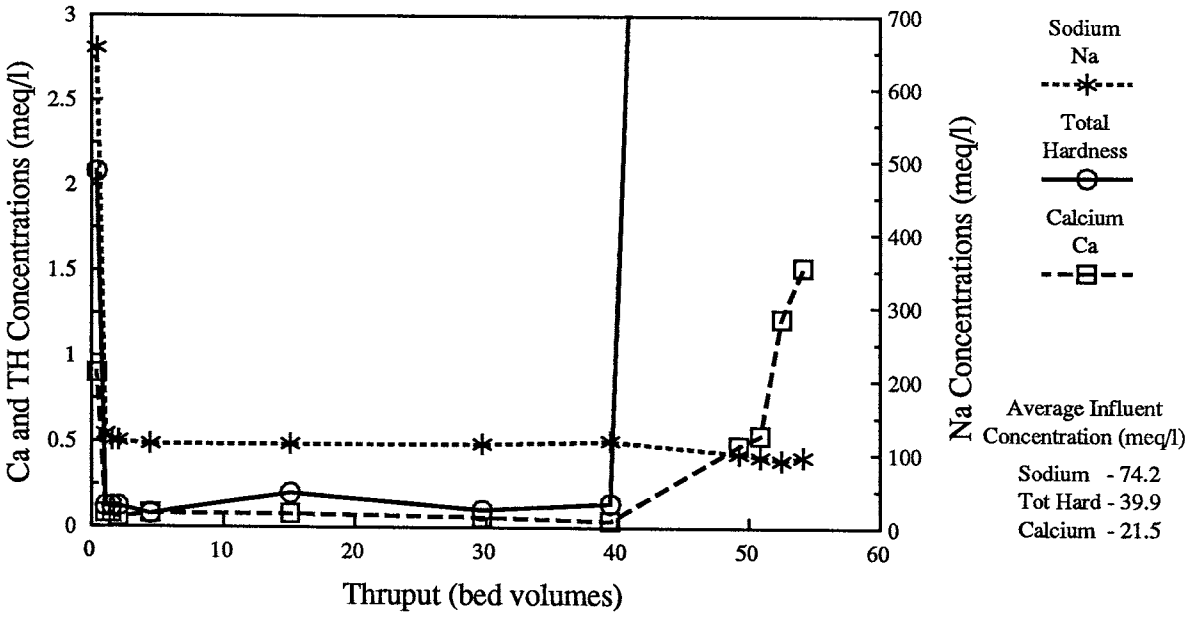
1. New resin. No regeneration. Resin stored in 6% NaCl brine previous to first run.
2. Resin stored in process water after test.

Major Cation Concentrations

IX Bench Unit

Resin Capacity Test 10

IX Service Effluent



Test: Series 300 Resin capacity test 11

Date: Oct. 4, 1985

Purpose: Determine resin capacity

Influent process water: filtered clarifier

Regenerant brine:
- Type: Rotating Evaporator Disk
- Temperature (C): 18
- Concentration (%) 12.0

Resin data:
- Type: Resin taken from column A of main unit 2
- Depth (cm)(during service) 148.6
- Volume (liters) : 6.8 (= 1 bed volume)

Hardness Leakage: Service product water (analysed during test)

Time	Thruput (bv)	Calcium (meq/l)	Total (meq/l)
5.0	0.2	0.7	0.9
15.0	1.8	0.6	0.8
25.0	3.4	0.6	0.9
65.0	9.9	0.5	0.8
120.0	18.7	0.5	0.9
180.0	28.4	0.6	0.9
210.0	33.3	0.6	1.0
220.0	34.9	0.6	1.2
230.0	36.5	0.7	1.9
240.0	38.1	1.0	4.4
250.0	39.7	1.2	9.8
260.0	41.4	1.8	17.2
270.0	43.0	2.6	25.2

Operating Conditions:

Event	Input	Output	Duration (min.)	Thruput (liters)	Volume (bv)	Average Flow Rate (l/min.)	Average Flow Rate (bv/min.)	Bed Expansion (%)
Regeneration A	Fr. Regenerant	Waste	see notes					
Regeneration B	Fr. Regenerant	Sp. Regenerant	" "					
Regeneration C	Fr. Regenerant	Sp. Regenerant	" "					
Rinse A	Feed	Waste	" "					
Rinse B	Feed	Waste	" "					
Service	Feed	Product	270	296.5	43.6	1.1	0.2	

Service Performance Summary:

	Influent (meq/l)	Average Effluent (meq/l)	Difference (meq/l)	Removal (%)	Resin Capacity (eq/l of resin)
Calcium	25.2	0.7	24.5	97.2	1.1
Total Hardness	41.4	2.4	39.1	94.3	1.7
Sodium	96.1	125.4	-29.4		

Test: Resin capacity test 11

CHEMICAL ANALYSES:	Ca (meq/l)	TH (meq/l)	Na (meq/l)	Ec (uS/cm)	Turb. (NTU)	pH	Chloride (meq/l)	Sulfate (meq/l)	Ratio Cat/Anion
PW Influent	25.2	41.4	96.1	9100	0.1	7.7	36.7	108.3	1.1
Product1	0.6	4.4	139.7	10300	0.1	7.8	39.5	99.9	1.0
Product2	0.9	3.5	144.1	10200	0.1	7.8	33.8	108.3	1.0
Fr.Brine	see notes								
Recycle Brine	" "								
Used Brine	" "								

INSTANTANEOUS EFFLUENT SAMPLES:

Service	Thruput (bv)	Service time	Ca (meq/l)	TH (meq/l)	Na (meq/l)	Ec (uS/cm)	Turb. (NTU)	pH	Chloride (meq/l)	Sulfate (meq/l)	Ratio Cat/Anion
	3.39	25	0.8	0.9	131.0	10200	NA	NA	36.7	99.9	1.0
	12.27	80	0.7	0.9	131.0	10200	NA	NA	36.7	93.7	1.0
	18.74	120	0.5	1.0	139.7	10300	NA	NA	36.7	89.5	1.1
	28.44	180	0.6	0.8	144.1	10300	NA	NA	33.8	93.7	1.1
	33.28	210	0.5	0.9	139.7	10300	NA	NA	NA	NA	NA
	34.90	220	0.6	1.1	139.7	10300	NA	NA	NA	NA	NA
	36.52	230	0.7	2.0	131.0	10300	NA	NA	NA	NA	NA
	38.13	240	1.6	4.0	135.4	10200	NA	NA	NA	NA	NA
	39.75	250	1.4	8.7	135.4	10100	NA	NA	33.8	104.1	1.1
	41.36	260	1.9	18.0	126.6	9700	NA	NA	36.7	89.5	1.2
	42.98	270	2.3	23.2	117.9	9600	NA	NA	33.8	91.6	1.1

Notes:

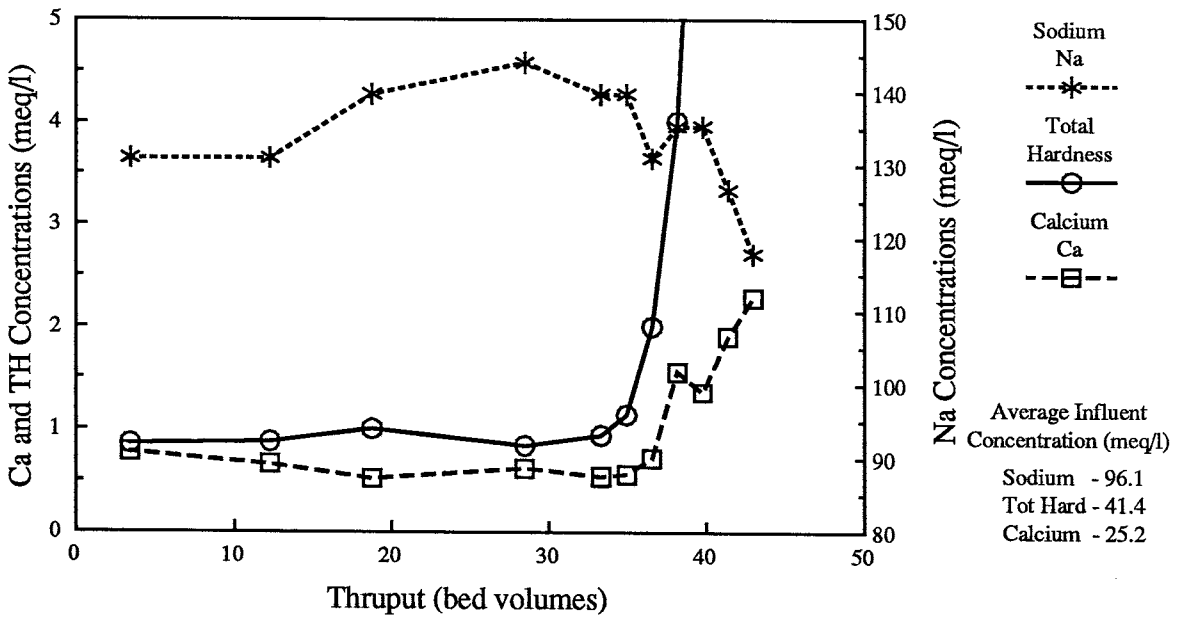
1. Air pocket formed in column during regeneration causing resin to be pushed up and out of the column. While performing a series of up/downflow operations to work out the air pocket, a white precipitate (presumedly CaSO4) formed in the column. Cleaned bed with about 9.5 gallons of 13.5% NaCl brine at a flow rate of approximately 1.4 l/minute. The white preciptate appeared to have dissolved with the cleaning. The resin soaked in the NaCl brine for about two hours before continuing the test. The test was restarted at service.
2. Product 1 sample at Ser 180 and then drained PW tank from 45 to 10 gallons.
3. Product 2 at Ser 270 with 33.5 gallons in PW tank.

Major Cation Concentrations

IX Bench Unit

Resin Capacity Test 11

IX Service Effluent



Test: Series 300 Resin capacity test 12

Date: Nov. 7, 1985

Purpose: Determine resin capacity

Influent process water: filtered clarifier

Regenerant brine:
- Type: Rotating evaporator disk
- Temperature (C): 16
- Concentration (%) 12.0

Resin data:
- Type: Amberlite IR 120
- Depth (cm)(during service) 149.9
- Volume (liters) : 6.9 (= 1 bed volume)

Hardness Leakage: Service product water (analysed during test)

Time	Thruput (bv)	Calcium (meq/l)	Total (meq/l)
5.0	1.1	2.4	4.4
7.0	1.5	2.2	3.2
10.0	1.9	1.5	3.0
13.0	2.4	1.1	2.0
25.0	4.4	0.7	1.3
70.0	11.6	0.5	1.0
110.0	18.0	0.5	1.0
170.0	27.6	0.5	1.0
180.0	29.2	0.5	1.2
190.0	30.8	0.7	1.9
200.0	32.4	0.8	5.0
210.0	34.0	1.2	9.4
220.0	35.6	1.6	17.6
225.0	36.4	2.0	23.6

Operating Conditions:

Event	Input	Output	Duration (min.)	Thruput (liters)	Volume (bv)	Average Flow Rate (l/min.)	Average Flow Rate (bv/min.)	Bed Expansion (%)
Regeneration A	Fr. Regenerant	Waste	14	13.7	2.0	1.0	0.1	see notes
Regeneration B	Fr. Regenerant	Sp. Regenerant	26	24.7	3.6	0.9	0.1	" "
Regeneration C	Fr. Regenerant	Sp. Regenerant	10	6.9	1.0	0.7	0.1	39.0
Drain		Waste			0.3			
Rinse A	Feed	Waste	5	2.8	0.4	0.6	0.1	
Rinse B	Feed	Waste	4	3.9	0.6	1.0	0.1	
Service	Feed	Product	225	247.2	36.1	1.1	0.2	

Service Performance Summary:

	Influent (meq/l)	Average Effluent (meq/l)	Difference (meq/l)	Removal (%)	Resin Capacity (eq/l of resin)
Calcium	23.1	1.3	21.7	94.3	0.8
Total Hardness	42.3	3.9	38.4	90.9	1.5
Sodium	104.8	170.5	-65.7		

Regeneration Performance Summary:

	Brine Influent (meq/l)	Total Thruput (eq/l of resin)	Average Effluent (meq/l)	Difference (inf-eff) (meq/l)	Resin Absorbance (eq/l of resin)
Calcium	21.6	--	30.4	-8.8	-0.0
Total Hardness	59.0	--	163.4	-104.4	-0.6
Sodium	1746.7	9.9	1591.9	154.9	0.9

Test: Resin capacity test 12

CHEMICAL ANALYSES:	Ca (meq/l)	TH (meq/l)	Na (meq/l)	Ec (uS/cm)	Turb. (NTU)	pH	Chloride (meq/l)	Sulfate (meq/l)	Ratio Cat/Anion
PW Influent	23.1	42.3	104.8	10800	0.5	7.5	36.7	108.3	1.2
Product1	NA	NA	NA	NA	NA	NA	NA	NA	NA
Product2	NA	NA	NA	NA	NA	NA	NA	NA	NA
Fr.Brine	21.6	59.0	1746.7	98300	3.3	8.6	668.4	395.6	1.7
Recycle Brine	none								
Used Brine	NA	NA	NA	NA	NA	NA	NA	NA	NA

INSTANTANEOUS EFFLUENT SAMPLES:

Regen.	Thruput (bv)	Regen. time	Ca (meq/l)	TH (meq/l)	Na (meq/l)	Ec (uS/cm)	Turb. (NTU)	pH	Chloride (meq/l)	Sulfate (meq/l)	Ratio Cat/Anion
	0.48	10	33.2	344.0	960.7	72100	NA	NA	NA	NA	NA
	1.47	17	NA	NA	NA	NA	NA	NA	NA	NA	NA
	2.43	24	30.1	149.4	1659.4	97400	NA	NA	NA	416.4	NA
	3.04	33	28.9	113.6	1790.4	95400	NA	NA	NA	NA	NA
	3.73	38	28.8	101.0	1790.4	98600	NA	NA	NA	NA	NA
	5.16	45	31.2	99.6	1834.1	97300	NA	NA	745.6	NA	NA
	5.66	50	33.9	96.8	1877.7	97800	NA	NA	775.5	905.7	1.2

Service	Thruput (bv)	Service time	Ca (meq/l)	TH (meq/l)	Na (meq/l)	Ec (uS/cm)	Turb. (NTU)	pH	Chloride (meq/l)	Sulfate (meq/l)	Ratio Cat/Anion
	0.34	0	38.0	81.9	1746.7	88300	NA	NA	662.7	999.4	1.1
	0.98	4	3.4	5.1	266.4	20200	NA	NA	49.4	270.7	0.9
	1.47	7	2.1	3.0	200.9	14600	NA	NA	36.7	143.7	1.1
	1.95	10	NA	NA	179.0	12800	NA	NA	36.7	131.2	NA
	2.43	13	NA	NA	165.9	11700	NA	NA	NA	NA	NA
	4.35	25	NA	NA	157.2	10900	NA	NA	NA	NA	NA
	11.57	70	NA	NA	157.2	10500	NA	NA	NA	NA	NA
	17.98	110	NA	NA	157.2	10400	NA	NA	NA	NA	NA
	24.40	150	NA	NA	152.8	10400	NA	NA	36.7	114.5	NA
	30.81	190	0.6	1.9	157.2	10300	NA	NA	36.7	104.1	1.1
	32.41	200	0.8	4.2	157.2	10200	NA	NA	33.8	95.8	1.3
	34.02	210	1.1	8.9	152.8	10200	0.1	7.9	33.8	89.5	1.3
	37.06	225	1.9	23.0	139.7	9900	0.1	7.8	33.8	83.3	1.4

Notes:

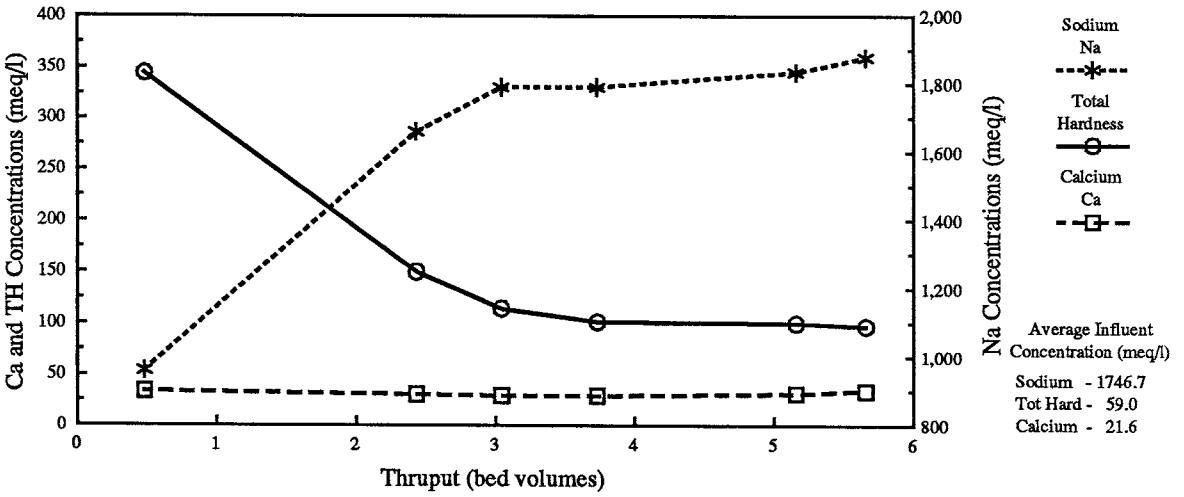
1. Lost resin in regeneration at 12 minutes.
2. White precipitate formed in resin bed during entire regeneration cycle in resin bed.
3. Two inches of white precipitate on top of resin bed during service.
4. PW tank drained from 45 gallons to 10 gallons at Ser 175.
5. PW tank at 24 gallons at Ser225.

Major Cation Concentrations

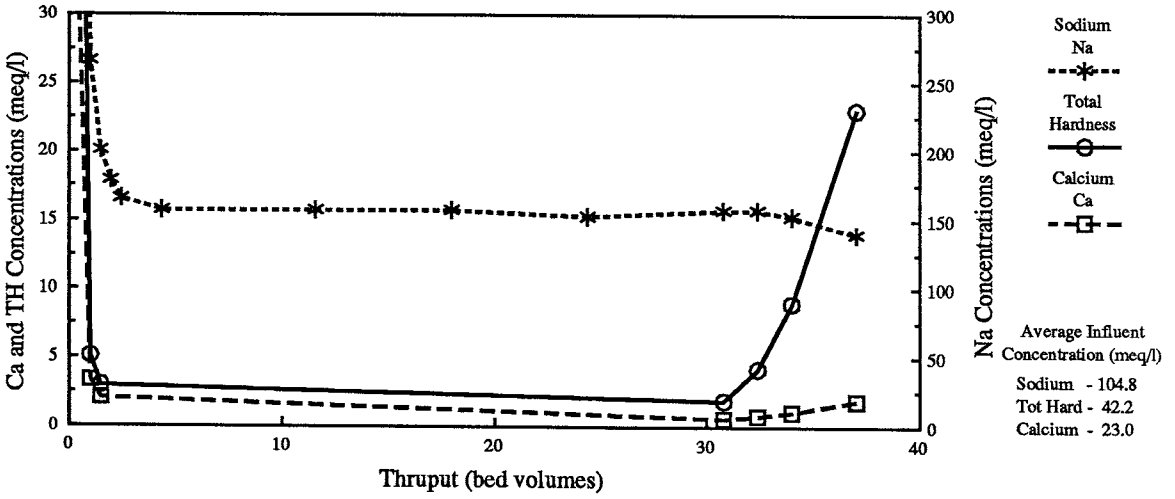
IX Bench Unit

Resin Capacity Test 12

IX Regeneration Effluent



IX Service Effluent



Test: Series 300 Resin capacity test 13

Date: November 14, 1985

Purpose: Determine the ability of the main units' resin to remove using solar pond brine. The solar pond brine will be used during start-up of the main units.

Influent process water: filtered clarifier

Regenerant brine:
- Type: solar pond
- Temperature (C): 9
- Concentration (%) 15.0

Resin data:
- Type: Resin taken from column B of main unit 2
- Depth (cm)(during service) 132.1
- Volume (liters) : 6.0 (= 1 bed volume)

Hardness Leakage: Service product water (analysed during test)

Time	Thruput (bv)	Calcium (meq/l)	Total (meq/l)
0.0	0.7	1.4	4.1
5.0	1.7	0.3	1.1
10.0	2.7	0.3	1.0
25.0	5.6	0.3	0.9
50.0	10.4	0.3	0.9
90.0	18.2	0.3	0.9
120.0	24.0	0.3	0.9
140.0	27.9	0.3	0.9
160.0	31.8	0.3	1.0
180.0	35.6	0.4	2.0
190.0	37.6	0.5	7.0
205.0	40.5	1.0	22.4
215.0	42.4	1.4	31.6

Operating Conditions:

Event	Input	Output	Duration (min.)	Thruput (liters)	Volume (bv)	Average Flow Rate (l/min.)	Average Flow Rate (bv/min.)	Bed Expansion (%)
Regeneration A	Fr. Regenerant	Waste	0					
Regeneration B	Fr. Regenerant	Used Regenerant	43	39.2	6.5	0.9	0.2	
Regeneration C	Fr. Regenerant	Used Regenerant	7	4.7	0.8	0.7	0.1	59.6
Drain		Waste		2.9	0.5			
Rinse A	Feed	Waste	5	4.1	0.7	0.8	0.1	
Rinse B	Feed	Waste	6	5.4	0.9	0.9	0.1	
Service	Feed	Product	207	242.3	40.1	1.2	0.2	

Service Performance Summary:

	Influent (meq/l)	Average Effluent (meq/l)	Difference (meq/l)	Removal (%)	Resin Capacity (eq/l of resin)
Calcium	27.4	1.9	25.5	93.1	1.0
Total Hardness	41.7	6.8	34.9	83.6	1.4
Sodium	74.2	113.8	-39.5		

Regeneration Performance Summary:

	Brine Influent (meq/l)	Total Thruput (eq/l of resin)	Average Effluent (meq/l)	Difference (inf-eff) (meq/l)	Resin Absorbance (eq/l of resin)
Calcium	79.3	--	78.6	0.7	0.0
Total Hardness	275.3	--	263.3	12.0	0.1
Sodium	2227.1	13.6	1991.0	236.1	1.4

Test: Resin capacity test 13

CHEMICAL ANALYSES:	Ca (meq/l)	TH (meq/l)	Na (meq/l)	Ec (uS/cm)	Turb. (NTU)	pH	Chloride (meq/l)	Sulfate (meq/l)	Ratio Cat/Anion
PW Influent	27.4	41.7	74.2	9600	0.1	7.5	338.4	145.7	0.3
Product1	0.3	1.0	122.3	10000	NA	NA	338.4	95.8	0.3
Product2	1.3	12.2	109.2	9800	NA	NA	338.4	124.9	0.3
Fr.Brine	79.3	275.3	2227.1	142200	NA	NA	225.6	603.8	3.1
Recycle Brine	NA	NA	NA	NA	NA	NA	NA	NA	NA
Used Brine	92.0	248.7	1965.1	143800	NA	NA	169.2	562.1	3.2

INSTANTANEOUS EFFLUENT SAMPLES:

Regen.	Thruput (bv)	Regen. time	Ca (meq/l)	TH (meq/l)	Na (meq/l)	Ec (uS/cm)	Turb. (NTU)	pH	Chloride (meq/l)	Sulfate (meq/l)	Ratio Cat/Anion
	0.34	10	41.3	110.0	873.4	68100	NA	NA	NA	NA	NA
	1.40	17	64.7	272.7	2052.4	136200	NA	NA	NA	NA	NA
	2.46	24	82.0	278.0	2139.7	138100	NA	NA	NA	NA	NA
	2.60	31	87.3	294.7	2270.7	142600	NA	NA	NA	NA	NA
	3.66	38	90.7	284.7	2052.4	143100	NA	NA	NA	NA	NA
	5.89	45	88.7	288.0	2227.1	144300	NA	NA	NA	NA	NA
	6.11	50	89.3	284.7	2270.7	144300	NA	NA	NA	NA	NA

Service	Thruput (bv)	Service time	Ca (meq/l)	TH (meq/l)	Na (meq/l)	Ec (uS/cm)	Turb. (NTU)	pH	Chloride (meq/l)	Sulfate (meq/l)	Ratio Cat/Anion
	0.74	0	3.4	15.3	262.0	24100	NA	NA	NA	NA	NA
	1.52	4	1.1	4.1	122.3	11100	NA	NA	NA	NA	NA
	2.10	7	0.8	5.1	113.5	10300	NA	NA	NA	NA	NA
	2.68	10	0.8	1.9	113.5	10100	NA	NA	NA	NA	NA
	3.26	13	1.1	1.9	113.5	10100	NA	NA	NA	NA	NA
	5.59	25	0.9	2.1	113.5	9800	NA	NA	NA	NA	NA
	10.43	50	0.7	4.5	117.9	9700	NA	NA	NA	NA	NA
	18.19	90	0.9	1.6	113.5	9800	NA	NA	NA	NA	NA
	27.88	140	0.9	2.0	113.5	9800	0.1	NA	NA	NA	NA
	35.63	180	8.0	9.3	113.5	9800	NA	NA	NA	NA	NA
	38.54	195	0.9	14.8	109.2	9600	NA	NA	NA	NA	NA
	40.48	205	1.6	26.5	100.4	9400	NA	NA	NA	NA	NA

Notes:

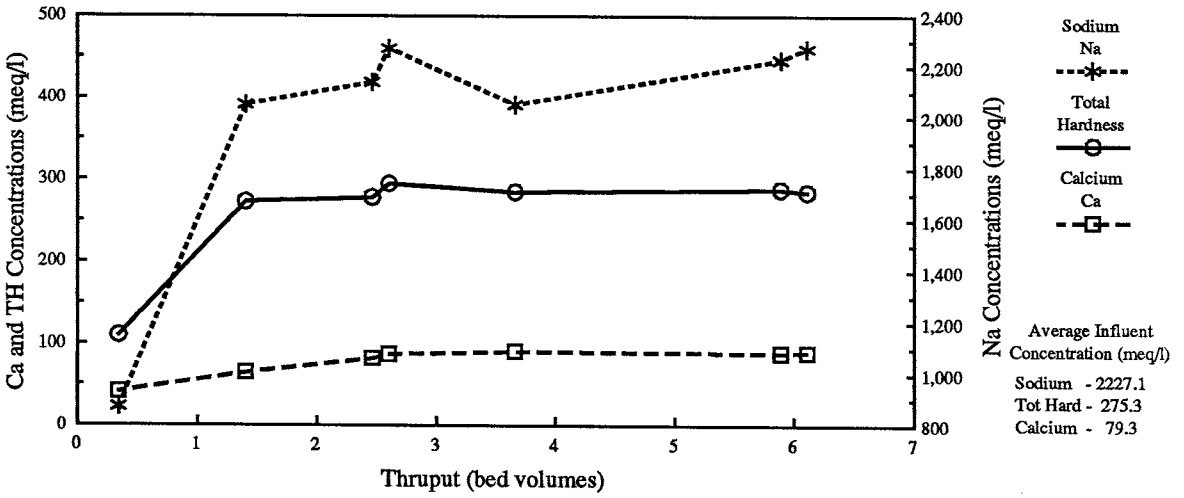
1. Resin stored in process water prior to test.
2. Resin level at 48.5 inches at beginning of test.
3. Lost resin 12 minutes into regeneration.
4. Stopped losing resin 28 minutes into regeneration.
5. PW tank drained to 10 gal. from 50 gal. 170 minutes into Service.
6. PW tank level at 23.5 gallons when shut-down at Ser220.

Major Cation Concentrations

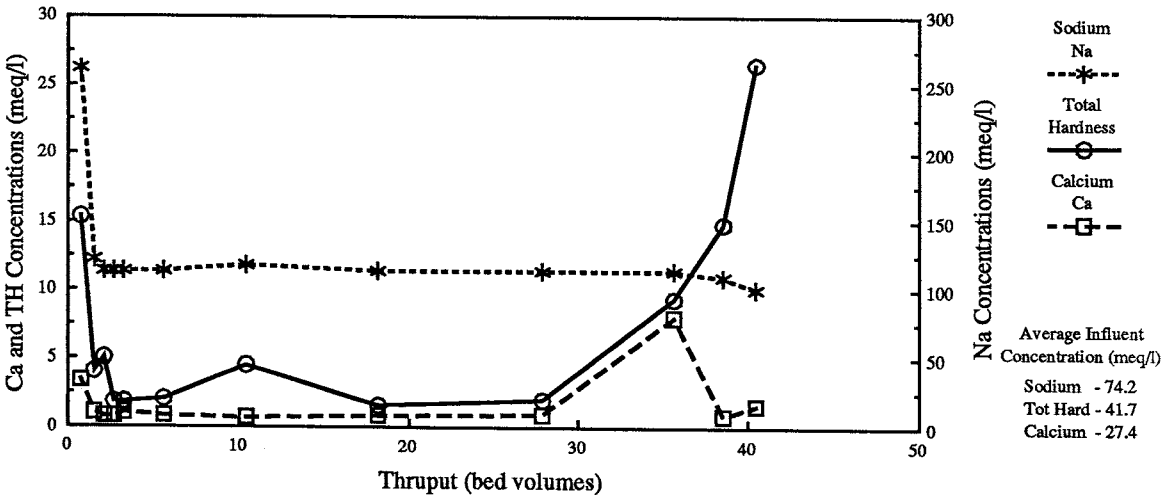
IX Bench Unit

Resin Capacity Test 13

IX Regeneration Effluent



IX Service Effluent



APPENDIX D

MAIN UNIT PERIOD 1 OPERATIONS

Ion-Exchange System
June, July, and August 1985

Sodium Chloride Regeneration
Operation Parameters and Results
Test Plan

OPERATIONS LOG - 1985

Date	Time	Unit	Operation	Data Sheet	Regeneration and Service Information
May 31	1143	2	Regeneration start	yes	Regen: 12.0% brine,50 min. for 3520 gal.
	1311	2	Regeneration finished, to drain		= 70 gpm, Drain for 3 min to .75 full column
	1337	2	to CW 4, Ca 50		reading at 150 gpm, RinA 5 min, RinB 10 min
	1405	2	to drain		Ca 56 at Ser0, Ca 56 at 30 min., 52 at 60,
	1640	1	Regeneration start 12.5% brine	no	58 at 90, 54 at 120, 60 at 150, 104 at 180
	1815		Regeneration finished - in service		
			Gravity to RO		
June 2	1320	1	Regeneration start 11.0% brine	no	
	1435		" " finished		
			Gravity to RO		
June 3	1612	1	Regeneration start 12.0% brine	no	
	1720		" " finished		
	1725		Gravity to RO		
June 4	920		Shut down RO and acid pump	no	
	1250		Restart RO with new membrane		
	1320		RO feed 7 gpm		
June 5	1030	2	Regeneration start 12.0% brine	yes	Regen.: 12.0% brine, 53 min. for 3630 gal.
	1203	2	" " finished		= 68 gpm
	1206	2	to RO		RinC Ca level: 124 at 0 min, 60 at 5, 34 at 10
	1206	1	Shut down		Service: not available
	1235	1	Regeneration start 13.5% brine	yes	Regen.: 13.5% brine, 55 min. for 3630 gal.
	1402	1	" " finished		= 67 gpm.
	1405	1	Gravity to RO		RinC Ca level: 80 at 0 min., 40 at 5,
	1410	2	to CW 4		Service: 20580 gal., Ca leakage 29
	1740	2	to RWPS		
	2030	2	Backwash and slow rinse		
June 7	735	1	Regeneration start 12.0% brine	yes	Regen.: 12.0% brine, 54 min. for 3740 gal.
	855	1	" " finished		= 69 gpm
	900	1	to RO, CW 4 S/O		RinC Ca level: 66 at 0 min., 36 at 5
					Service: 20510 gal., Ca leakage 31
	1040	2	Regeneration start	no	
	1130	2	" " finished		
June 8	1630	2	Backwashed and filled w/brine f/T 4		
June 9	5	1	RO feed Ca = 100		
	55	1	Regeneration start 15.0% brine	yes	Regen.: 15.0% brine, 50 min. for 3475 gal.
	215	1	" " finished		= 69 gpm
	225	1	RO placed back into service		RinC Ca level: 55 at 0 min.
	1600	1	Unit and RO S/D, Ca = 100		Service: 4500 gal., Ca leakage 31
	1700	1	IV 7 failed to operate		
	1800	1	IV 7 adjusted		
	1800	1	Regeneration start	no	Service: 19300 gal.
	1820	1	" " finished, to RO		

Note: Ca TH stated in mg/l as CACO3, Leakages are average

OPERATIONS LOG - 1985 (Continued)

Date	Time	Unit	Operation	Data Sheet	Regeneration and Service Information
June 10	1035	2	IV 111 leaking, reg. S/D		
continued	1400	2	Regeneration finished		
	1435	2	to CW 4 for flushing		
	1640	2	S/D		
	1740	2	Regeneration start	no	
	2050	2	S/D, Ca above 200		
	2130	2	regeneration complete, Ca 240		
	2200	2	to CW 4 to 5 feet with Ca 240, for RED		
June 11	705	1	to RO and CW 3		
	743	1	S/D, RO feed from CW 3		
	800		CW 3 Ca 360, RO S/D		
	819	1	Regeneration start, 14.0% brine	yes	Regen.: 14.0% brine, 56 min. for 3740 gal.
	915	1	Regeneration finished		= 67 gpm
	945	1	to RO		RinC Ca level: 42 at 0 min., 35 at 5, 26 at 10
					Service: 11070 gal., Ca leakage 26
	1338	2	Regeneration start, 13.5% brine	yes	Regen.: 13.5% brine, 59 min. for 3740 gal.
	1437	2	Regeneration finished		= 63 gpm
	1930	2	to CW 4 with drain open		RinC Ca level: 48 at 0 min, 32 at 5, 24 at 10,
	2000	2	CW 4 drain closed		18 at 15
	2130	2	CW 4, 7 feet water, Ca 50		Service: 24640 gallons, Ca leakage 23
	2130	2	Ca 24		
	2314	2	Ca 51, S/D		
June 12	600	1	to RO, Ca 64		
	605		feed to RO from CW 3, Ca 21		
			CW 3 at 7 feet 11 inches		
	739	1	Regeneration start	yes	Regen.: 13.0% brine, 55 min. for 3740 gal.
	940	1	to CW 3, Ca 33		= 68 gpm
	1142	1	to RO, CW 3 valve closed		RinC Ca level: 40 at 0 min., 33 at 5
					Service: volume not available, Ca leakage 23
June 13	1300	1	S/D, Ca 90, RO feed from CW 3		
	1320	1	Regeneration start	yes	Regen.: 13.0% brine, 60 min. for 3740 gal.= 62
	1605	1	to RO feed only		= 62 gpm
					RinC Ca level: 54 at 0 min., 39 at 5, 30 at 10
					Service: 18750 gal., Ca leakage 28
June 15	310	1	S/D, Ca 90, RO feed from CW 3		
	320	2	Regeneration start	yes	Regen.: 13.0% brine, 50 min. for 3025 gal.
	620	2	Regen. finished, unable to soften water		= 61 gpm
	710	2	Regeneration start	no	
	905	2	Regen. finished, unable to soften water		
	1045	1	Regeneration start	no	Service: 14040 gal.
	1220	1	Regeneration finished, Ca 44		
June 16	1428	1	S/D, Ca 55, RO feed from CW 3		
	1430	1	Regeneration start	yes	Regen.: 12.0% brine, 55 min. for 3740gal.
	1800	1	to RO only, Ca 25		= 68 gpm

Note: Ca TH stated in mg/l as CACO3, Leakages are average

OPERATIONS LOG - 1985 (Continued)

Date	Time	Unit	Operation	Data Sheet	Regeneration and Service Information
June 16 continued	1930		T 6 filled and recirculated, 12.0% brine		RinC Ca level: 50 at 0 min., 37 at 5, 25 at 10 Service: 12910 gal., Ca Leakage 28
	1945		T 5 filled with city water		
June 17	1845	1	S/D, Ca 54, RO feed from CW 3		
	1850	1	Regeneration start	yes	Regen.: 12.0% brine, 53 min. for 3740 gal. = 71 gpm
	2055	1	to RO only, Ca 34		
	2215		T 6 filled and recirculated, 12.0% brine		RinC Ca level: 60 at O min., 48 at 5, 34 at 10 Service: 17930 gal., Ca leakage 25
June 19	600	1	Ca 56		
	604	1	S/D	yes	Regen.: 12.5% brine, 54 min. for 3740 gal. = 69 gpm
	628	1	Regeneration start		
	802	1	to RO, Ca 27		RinC Ca level: 73 at 0 min., 36 at 5, 27 at 10 Service: 21950 gal., Ca leakage 26
June 20	928	1	to RO, Ca22		
June 21	820	1	Ca 56, S/D		
	910	1	Regeneration start	yes	Regen.: 12.0% brine, 54 min. for 3740 gal. = 69 gpm
	1046	1	to RO, Ca 37		
	1300	2	stored resin in 15.0% brine		RinC CA level: 60 at 0 min., 40 at 5, 32 at 10 Service: 17800 gal., Ca leakage 29
June 22	2030	1	Ca 51, RO feed from CW 4		
	2100	1	Regeneration start	yes	Regen.: 12.0% brine, 50 min. for 3520 gal. = 70 gpm
	2225	1	Regeneration finished, to RO, Ca 43		RinC Ca level: 54 at 0 min., 43 at 3 Service: 18010 gal., Ca leakage 28
June 24	842	1	S/D, Ca 51, CW 4 to RO		
	845	1	Regeneration start	yes	Regen.: 12.0% brine, 57 min. for 3740 gal. = 66 gpm
	1043	1	Regeneration finished, to CW 3 and RO Cl2 to CW3 @ 4#/24 hrs.		RinC Ca level: 60 at 0 min., 35 at 5
	1345	1	to RO only		Service: 7500 gal., Ca leakage 23
June 25	602	1	S/D, Ca 57		
	630	1	Regeneration start	yes	Regen.: 12.0% brine, 55 min. for 3740 gal. = 68 gpm
	844	1	Regeneration finished, not in service till acid pump change		RinC Ca level: 85 at 0 min., 59 at 5, 36 at 10
	935	1	to RO		Service: 18640 gal., Ca leakage 32
June 26	1815	1	S/D, RO feed from CW4 level 13 ft. 7 in.	yes	Resin soaking in 12.0 % NaCl brine
	1925	1	store resin in 12.0 % NaCl brine		
June 27	2315	1	S/D CW4 feed to RO, level 2 ft.; I/S CW3 to RO, level 15 ft. 5 in.		
June 29	718	1	Regeneration start	yes	Regen.: 12.0% brine, 50 min. for 3300 gal. = 66 gpm
	910	1	Regeneration finished		
	915	1	to RO and CW3, level 2ft., Cl2 I/S		RinC Ca level: 44 at 0 min. Service: 24100 gal., Ca leakage 15
	2030	1	S/D, Regeneration start RO feed from CW3, level 18ft. 10 in.	yes	Regen.: 12.5% brine, 55 min. for 3740 gal. = 68 gpm
	2250	1	to RO, Ca 37		RinC Ca level: 50 at 0 min., 46 at 5, 36 at 10 Service: 18480 gal., Ca leakage 30

Note: Ca TH stated in mg/l as CACO3, Leakages are average

OPERATIONS LOG - 1985 (Continued)

Date	Time	Unit	Operation	Data Sheet	Regeneration and Service Information
July 1	637	1	S/D, Ca 53; CW3 to RO, level 18 ft. 10 in.		
	800	1	Soaking resin in 12.0% NaCl brine		
July 2	1105	2	Obtained resin levels in columns Column C 44 in., D 42.5 in. from bottom of top manifold		
	1610	1	Regeneration start	yes	Regen.: 12.0% brine, 60 min. for 3740 gal. = 62 gpm
	1845	1	to service, Ca 28		RinC Ca level: 56 at 0 min., 28 at 5 Service: 20820 gallons; Ca leakage 21
July 4	920	1	S/D, RO feed from CW3 level 4 ft. 6 in.		
	922	1	Regeneration start	yes	Regen.: 12.0% brine, 56 min. for 3740 gal. = 67 gpm
	1050	1	I/S to RO and CW3 level 3ft. 11in., CA 32		RinC Ca Level: 66 at 0 min., 44 at 5, 32 at 10
	1530	1	to RO only; Cw3 level 12 ft.		Service: 20700 gallons; Ca leakage 30
July 5	730	1	S/D, RO feed from CW3 level 11ft. 10in.		
	731	1	Regeneration start	yes	Regen.: 12.0% brine, 54 min. for 3740 gal. = 69 gpm
	855	1	I/S to RO only, CW3 level 11ft. 4 in.		RinC Ca level: 60 at 0 min., 42 at 5 Service: 19080 gallons; Ca leakage 31
July 6	2020	1	S/D,Ca 56; RO feed from CW3		
	2050	1	Regeneration start	yes	Regen.: 12.0% brine, 55 min. for 3740 gal. = 68 gpm
	2235	1	to RO		RinC Ca level: 108 at 0 min., 44 at 5 Service: 20250 gallons, Ca leakage 26
July 8	1214	1	S/D, RO feed from CW3		
			Regeneration start	yes	Regen.: 12.5% brine, 54 min. for 3740 gal. = 69 gpm
	1355	1	Regeneration finish; CW3 S/D level 10ft. 1in.		RinC Ca level: 56 at 0 min., 42 at 5 Service: 17740 gallons, Ca leakage 31
July 9	2305	1	S/D		
	2335	1	Regeneration start	yes	Regen.: 12.0% brine, 50 min. for 3520 gal. = 70 gpm
July 10	100	1	Regeneration finish to RO; CW3 S/D, level at 9ft. 6in.		RinC Ca level: 70 at 0 min., 51 at 5, 44 at 8 Service: 17600gal., Ca leakage 31
July 11	1030	1	S/D; RO feed from CW3, level 9ft. 6in.		
			Regeneration start	yes	Regen.: 12.0% brine, 55 min. for 3740 gal. = 68 gpm
	1205	1	I/S to RO; CW3 S/D, level 8ft. 11in.		RinC Ca level: 104 at 0 min., 75 at 5, 58 at 10, 37 at 15 Service: 17160 gal., Ca leakage 25
July 12	2015	1	S/D, Ca69; RO from CW3		
	2025	1	Regeneration start	yes	Regen.: 12.0% brine, 56 min. for 3740 gal. = 67 gpm
	2212	1	I/S, Ca 42; CW3 S/D		RinC Ca level: 212 at 0 min, 56 at 5, 42 at 10 Service: 17290 gal., Ca leakage 31
July 14	830	1	S/D; RO feed from CW3, level 8ft., 3in.		
			Regeneration start	yes	Regen.: 51 min. for 3740 gal.= 73 gpm
	1018	1	I/S to RO; CW3 S/D, level 7ft., 7in.		RinC Ca level: 110 at 0 min., 56 at 5

Note: Ca TH stated in mg/l as CACO3, Leakages are average

OPERATIONS LOG - 1985 (Continued)

Date	Time	Unit	Operation	Data Sheet	Regeneration and Service Information
July 15	1755	1	S/D, Ca 50; RO from CW3		
	1808	1	Regeneration start	yes	Regen.: 12.5% brine, 50 min. for 3190 gal.
	2014	1	Regeneration finish		= 64 gpm
			I/S to RO and CW3, level 7ft., 1in.		RinC Ca level: 55 at 0 min., 46 at 5
					Service: 12610 gal., Ca leakage 34
July 16	755	1	S/D for maint., measure resin bed		Bottom of t.manifold to resin: A 38 inches (81.87cf), B 40.5in (77.78cf) (east column)
	1300	1	Regeneration start	yes	Regen.: 12.0% brine, 50 min. for 3740 gal.
	1542	1	Regeneration finish		= 75 gpm
	1547	1	I/S; S/D CW3, level 8ft., 8in.		RinC Ca level: 63 at 0 min., 43 at 2
					Service: 25350 gal., TH leakage 35
July 18	1305	1	S/D, Ca 110; CW3 to RO		
	1310	1	Regeneration start	yes	Regen.: 12.0% brine, 55 min. for 3740 gal.
	1500	1	Regeneration finish		= 68 gpm
	1505	1	I/S to RO; CW3 S/D, level 7ft., 11in.		RinC TH level: 110 at 0 min., 84 at 4
	1710	1	Mix of T6 brine complete, 12.0%		Service: 22140 gal., TH leakage 63
July 19	1502	1	CW3 I/S, 7ft., 11in.		
	1816	1	S/D, TH 613, Ca 60; CW3 13ft., 6in.		
	1819	1	Regeneration start	yes	Regen.: 12.0% brine, 50 min.
	2010	1	Regeneration finish		RinC Ca level: 64 at 0 min., 45 at 5
	2013	1	I/S to RO and CW3, level 12ft., 10in.		Service: 19610 gal.; leakages: Ca 36, TH 63
	2200	1	S/D CW3, level 15ft.		
July 20	700	1	IP7 I/S to unit to CW3		
	850	1	S/D, Ca 60		
July 21	1130	1	Regeneration start	yes	Regen.: 12.0% brine, 64 min. for 3740 gal.
	1325	1	I/S to RO		= 59 gpm
	1515	1	Mix of T6 brine complete, 12.0%		RinC level: 61 at 0 min., 38 at 5
					Service: 20920 gal., leakage: Ca 22, TH 35
July 22	1640	1	IP7 to RO and CW3, level 11ft., 3in.		
	1738	1	IP7 S/D, Ca49; CW3 level 15ft., 9in.		
			CW3 to RO		
	1755	1	Regeneration start	yes	Regen.: 16.5% for 1870 gal. and 12.0% for
	1955	1	Regeneration finish, Ca 43		1870 gal.
			S/D CW3, level 15ft., 1in.		RinC Ca level: 76 at 0 min., 44 at 5
	2005	1	IP7 to RO and CW3		Service: volume and leakages not available
	2115		Mix of T6 brine complete, 12.0%		
	2137	1	S/D CW3, level 22ft.; I/S CW4,		
	2230		level 7 inches, CW3 leaking		
July 23	2	1	S/D, Ca 61		
	15	1	Regeneration start	yes	Regen.: 12.0% brine, 57 min. for 3740 gal.
	250	1	I/S to CW4, Ca31		= 66 gpm
	625	1	S/D, Ca 53; CW3 to RO		RinC Ca level: 100 at 0 min, 64 at 5, 31 at 10
	745		Start drain CW3		Service: volume and leakages not available
	800		RO feed from CW4		
	1205		Salt delivery for T5		
	1327		salt delivery finished		

Note: Ca TH stated in mg/l as CACO3, Leakages are average

OPERATIONS LOG - 1985 (Continued)

Date	Time	Unit	Operation	Data Sheet	Regeneration and Service Information
July 24	1355	2	Backwash from CW1 for 50 min. then filled with 12.0% brine		
July 25	805	2	Regeneration start	yes	Regen.: 50 min. for 3355 gal.= 67 gpm
	922	2	Regeneration finished		RinC Ca level: 350 at 0 min., 201 at 5,
	1005	2	Service to CW4, level 3ft., 4in.		69 at 10, 45 at 15
	1150	2	to RO only; S/D CW4, level 6feet		Service: volume and leakages not available
July 26	815	2	S/D, calibration of flow sensor CW4 to RO		
	830	2	Calibration complete		
	910	2	Prepared T7 brine, 12.0%		
	945	2	I/S; S/D CW4, level 5ft. 9inches		
	1050	2	S/D; RO feed from CW4		
	1320	2	Column B lost resin during rinsing		
	1321	2	I/S, Column A; S/D CW4		
July 27	1043	2	S/D, Ca 58; CW4 to RO, level 4ft. 11in.		
	1158	1	Regeneration start	yes	Regen.: 12.0% brine; 74 min. for 3795 gal.
	1312	1	Flow rate irregularities during regen.		= 51 gpm
	1340	1	Regeneration finished		RinC Ca level: 100 at 0 min., 45 at 5
			I/S to RO and CW4, level 3ft. 10in.		Service: 19070 gal.; leakage: Ca 28, TH 42
	1415		S/D CW4, level 5feet		
July 28	900		Mixing of T6 brine complete, 12.0%		
July 29	1	1	S/D, Ca 52; RO feed from CW4		
	5	1	Regeneration start	yes	Regen.: 12.0% brine; 58 min. for 3740 gal.
	140	1	I/S to RO, Ca 40		= 65 gpm
					RinC Ca level: 62 at 0 min., 40 at 5
					Service: 17770 gal.; leakage: Ca 28, TH 52
July 30	1155	1	S/D, Ca 49; RO feed from CW4, level 4ft. 4inches		
	1420	1	Regeneration complete	yes	Regen.: 12.0% brine; 62 min. for 3850 gal.
	1720	1	I/S to RO		= 62 gpm
	1730		Drained 2.5ft. from CW4, TH 135		RinC Ca level: 60 at 0 min., 50 at 2, 46 at 10
	1930	1	I/S to CW4, filling to 3.5ft.		Service: volume and leakages not available
	2105	1	I/S to RO; CW4 3.5ft.		
July 31	2150	1	S/D, RO feed from Cw4		
	2245	1	Regeneration start	yes	Regen.: 13.0% brine; 57 min. for 3740 gal.
					= 66 gpm
					RinC Ca level: 64 at 0 min., 36 at 5
					Service: 21010 gal.; leakage: Ca27, TH 46
Aug. 1	15	1	Regeneration finished; I/S to RO	yes	see July 31 log
	836	1	I/S to RO and CW4, level 2ft. 8in.		
	910		resin found in CW4		
	930	1	S/D RO, change cartridge filters		
	1035		S/D CW4, level 6ft. 10in.		
	1040	1	I/S to RO		

Note: Ca TH stated in mg/l as CACO3, Leakages are average

OPERATIONS LOG - 1985 (Continued)

Date	Time	Unit	Operation	Data Sheet	Regeneration and Service Information
Aug. 2	530	1	S/D, Ca 55; CW4 to RO, level 6ft. 10in.		
	610		S/D IP3, brine leak		
	1220		Replaced IP3 with IP1		
	1735	1	Regeneration start	yes	Regen.: 12% brine; 57 min. for 3740 gal. = 66 gpm
	1940	1	Regeneration finished, I/S to RO and CW4		RinC Ca level: 140 at 0 min., 100 at 5, 59 at 10, 42 at 15
	2300	1	I/S to CW4, level 3ft. 5in.		Service: 17690 gal.; leakage: Ca 26, TH 46
Aug. 3	5		S/D CW4, level 5ft. 8in.		
	718		S/D RO to repair leak		
	915		I/S RO		
Aug. 4	215	1	S/D, Ca 52; CW4 to RO, level 5ft. 8in.		
	500	1	Regeneration start	yes	Regen.: 11% brine; 72 min. for 4400 gal. = 61 gpm
	710	1	I/S to RO		RinC Ca level: 52 at 0 min., 48 at 5
	825	1	to CW4, level 3ft. 4in.		Service: 20520 gal.; leakage: Ca 28, TH 45
	935		S/D CW4, level 6feet		
Aug. 5	1425	1	S/D; RO feed from CW4		
	1830	1	Regeneration start	yes	Regen.: 12% brine; 12 min. for 3410 gal. = 284 gpm
	2020	1	I/S to RO and CW4, level 3ft. 6in.		RinC Ca level: 104 at 0 min, 62 at 5, 48 at 10
	2312	1	S/D CW4, level 8ft. 10in.		Service: 20470 gal.; leakage: Ca 36, TH 45
Aug. 6	2215	1	S/D, Ca 49; CW4 to RO		
	2225	1	Regeneration start	yes	Regen.: 12% brine; 62 min. for 3740 gal. = 60 gpm
Aug. 7	5		RO S/D, high pH 8.7 from CW4, level 8 feet		RinC Ca level: 100+ at 0 min., 100+ at 5, 59 at 10, 44 at 15
	18	1	Regeneration finish, resin in 12% brine		Service: 27030 gal.; leakage: Ca 36, TH 54
	907	1	I/S to RO, Ca 44		
	2230	1	S/D, Ca 300; CW4 Ca 37, level full		
Aug. 8	105		RO S/D, malfunction acid pump; CW4 level 20ft. 5.5in., pH 8.5		
	220	1	complete filling with 12% brine		
	1020	1	start manual resin cleaning schedule		
	1300	1	complete resin cleaning schedule to step 12		
Aug. 12	800	1	check resin levels		
	830		CW4 to drain		
Aug. 14	930	1	complete resin storage, 12% brine level at 75% full		
	1300		numbers remarked on all IX and evap. pond associated valves		

Note: Ca TH stated in mg/l as CACO3, Leakages are average

ION EXCHANGE UNIT 1
SODIUM CHLORIDE BRINE REGENERATION
JUNE, JULY and AUGUST - 1985

REGENERATION DATA

	INFLUENT BRINE											EFFLUENT BRINE									
												at 20 minutes					at 45 minutes				
Date	Dur.	Vol.	Conc.	Elect. Cond.	Ca	TH	Na	Total Sodium Thruput		Average Flow Rate		Thu-put	Elect. Cond.	Ca.	TH	Na	Thruput	Elect. Cond.	Ca	Total Hardnes	Na
	(min)	(gal.)	(%)	(uS/cm)	(meq/l			(eq/l of resin)	(bv)	(bv/min)	(gpm/ft2)	(bv)	(uS/cm)	(meq/l)			(bv)	(uS/cm)	(meq/l)		
June 2	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
5	53	3630	12	168100	1.4	7.6	3218.8	9.74	3.03	0.057	1.74	1.14	39800	96.0	260.0	369.7	2.57	157300	138.0	296.0	2492.4
7	54	3740	12	155600	3.6	7.6	2688.1	8.38	3.12	0.058	1.76	1.15	32000	98.0	180.0	247.9	2.60	145200	216.0	380.0	2114.0
8	50	3475	15	NA	NA	NA	NA	NA	2.90	0.058	1.77	1.16	142500	398.0	780.0	900.4	2.61	152000	214.0	360.0	1200.5
9	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
11	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
12	55	3740	13	160200	3.5	7.6	1731.2	5.40	3.12	0.057	1.73	1.13	142500	398.0	780.0	900.4	2.55	152000	214.0	360.0	1200.5
13	60	3740	13	NA	NA	NA	NA	NA	3.12	0.052	1.59	1.04	NA	NA	NA	NA	2.34	NA	NA	NA	NA
15	50	3025	13	NA	NA	NA	NA	NA	2.53	0.051	1.54	1.01	NA	NA	NA	NA	2.27	NA	NA	NA	NA
16	55	3740	12	NA	NA	NA	NA	NA	3.12	0.057	1.73	1.13	NA	NA	NA	NA	2.55	NA	NA	NA	NA
17	53	3740	12	NA	NA	NA	NA	NA	3.12	0.059	1.80	1.18	NA	NA	NA	NA	2.65	NA	NA	NA	NA
19	54	3740	12.5	161300	2.8	7.6	2905.6	9.06	3.12	0.058	1.76	1.15	85000	376.0	740.0	522.0	2.60	155600	166.0	252.0	3049.2
21	54	3740	12.5	156200	2.3	6.4	3384.1	10.55	3.12	0.058	1.76	1.15	44500	148.0	296.0	256.6	2.60	147600	170.0	336.0	2166.2
22	50	3520	12	NA	NA	NA	NA	NA	2.94	0.059	1.79	1.17	NA	NA	NA	NA	2.64	NA	NA	NA	NA
24	57	3740	12	156600	1.54	6.4	2818.6	8.79	3.12	0.055	1.67	1.09	34500	106.0	188.0	252.3	2.46	147300	154.0	268.0	2270.6
25	55	3740	12	153400	3.74	6.8	2696.8	8.41	3.12	0.057	1.73	1.13	47800	142.0	368.0	291.4	2.55	146600	226.0	348.0	2470.6
29	50	3300	12	153000	3	6.0	3323.2	9.14	2.76	0.055	1.68	1.10	31000	110.0	248.0	265.3	2.48	146400	154.0	308.0	2396.7
29	55	3740	12.5	NA	NA	NA	NA	NA	3.12	0.057	1.73	1.13	NA	NA	NA	NA	2.55	NA	NA	NA	NA
July 2	60	3740	12	NA	NA	NA	NA	NA	3.12	0.052	1.59	1.04	NA	NA	NA	NA	2.34	NA	NA	NA	NA
4	56	3740	12	149000	3.3	6.2	2013.9	6.28	3.12	0.056	1.70	1.11	60100	174.0	372.0	395.8	2.50	140400	190.0	346.0	1853.0
5	54	3740	12	157300	3.4	6.6	2148.8	6.70	3.12	0.058	1.76	1.15	43400	144.0	292.0	247.9	2.60	149200	200.0	364.0	1935.6
6	55	3740	NA	NA	NA	NA	NA	NA	3.12	0.057	1.73	1.13	NA	NA	NA	NA	2.55	NA	NA	NA	NA
8	54	3740	12.5	147400	4	6.8	2070.5	6.46	3.12	0.058	1.76	1.15	58600	204.0	444.0	321.9	2.60	140000	190.0	332.0	1831.2
9	50	3520	12	155300	3.4	13.6	2557.6	7.51	2.94	0.059	1.79	1.17	43500	146.0	322.0	262.7	2.64	148200	166.0	256.0	1546.3
11	55	3740	12	NA	NA	NA	NA	NA	3.12	0.057	1.73	1.13	NA	NA	NA	NA	2.55	NA	NA	NA	NA
12	56	3740	12	148200	3.8	12.8	2061.8	6.43	3.12	0.056	1.70	1.11	114800	390.0	866.0	769.9	2.50	141400	120.0	244.0	1833.4
14	51	3740	NA	NA	NA	NA	NA	NA	3.12	0.061	1.87	1.22	NA	NA	NA	NA	2.75	NA	NA	NA	NA
15	50	3190	12.5	159200	4.6	9.6	2616.4	6.96	2.66	0.053	1.62	1.06	48000	162.0	346.0	236.6	2.39	150000	154.0	278.0	2420.6
16	50	3740	12	NA	NA	NA	NA	NA	3.12	0.062	1.90	1.25	NA	NA	NA	NA	2.81	NA	NA	NA	NA
18	55	3740	12	NA	NA	NA	NA	NA	3.12	0.057	1.73	1.13	NA	NA	NA	NA	2.55	NA	NA	NA	NA

ION EXCHANGE UNIT 1
SODIUM CHLORIDE BRINE REGENERATION
JUNE, JULY and AUGUST - 1985 (Continued)

REGENERATION DATA

	INFLUENT BRINE											EFFLUENT BRINE									
												at 20 minutes					at 45 minutes				
Date	Dur.	Vol.	Conc.	Elect. Cond.	Ca	TH	Na	Total Sodium Thruput		Average Flow Rate		Thu-put	Elect. Cond.	Ca.	TH	Na	Thruput	Elect. Cond.	Ca	Total Hardnes	Na
	(min)	(gal.)	(%)	(uS/cm)	(meq/l			(eq/l of resin)	(bv)	(bv/min)	(gpm/ft2)	(bv)	(uS/cm)	(meq/l)			(bv)	(uS/cm)	(meq/l)		
July 19	50	NA	12	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
21	64	3740	12	136600	4.8	9.0	2087.9	6.51	3.12	0.049	1.49	0.97	111900	392.0	76.8	185.1	2.19	130300	162.0	27.0	1663.8
22	NA	3740	mixed	179500	4.4	8.0	3545.0	11.05	3.12	NA	NA	NA	61400	236.0	504.0	321.9	NA	168700	370.0	660.0	2577.2
23	57	3740	12	NA	NA	NA	NA	NA	3.12	0.055	1.67	1.09	NA	NA	NA	NA	2.46	NA	NA	NA	NA
27	74	3740	12	131000	4.2	7.6	2218.4	6.92	3.12	0.042	1.29	0.84	68500	306.0	634.0	456.7	1.90	126800	216.0	310.0	1826.9
29	58	3740	12	127600	6	7.6	2087.9	6.51	3.12	0.054	1.64	1.07	33300	80.0	180.0	239.2	2.42	123700	196.0	298.0	1631.1
30	62	3850	12	123300	5	7.8	1957.4	6.28	3.22	0.052	1.58	1.03	65900	312.0	722.0	391.5	2.33	121500	188.0	358.0	1696.4
31	57	3740	13	160200	7	8.6	2218.4	6.92	3.12	0.055	1.67	1.09	22000	64.0	430.0	1761.6	2.46	149000	208.0	430.0	1761.6
Aug. 2	57	3740	12	NA	NA	NA	NA	NA	3.12	0.055	1.67	1.09	NA	NA	NA	NA	2.46	NA	NA	NA	NA
4	72	4400	11	NA	NA	NA	NA	NA	3.67	0.051	1.56	1.02	NA	NA	NA	NA	2.29	NA	NA	NA	NA
5	12	3410	12	168100	1.4	7.6	3218.8	9.15	2.85	0.237	7.24	4.74	NA	NA	NA	NA	10.66	NA	NA	NA	NA
6	62	3740	12	153000	13.4	17.6	2218.4	6.92	3.12	0.050	1.54	1.01	132100	471.2	840.0	1239.7	2.26	152600	52.8	85.1	2218.4

ION EXCHANGE UNIT 1 SERVICE DATA
SODIUM CHLORIDE BRINE REGENERATION
JUNE, JULY and AUGUST - 1985

	INFLUENT PROCESS WATER						EFLUENT PROCESS WATER					
							Aveage Leakage		Softened Water		Resin Capacity	
Date	Ca	Total Hardness	Sodium	Elect. Cond.	Turbidity	pH	Ca	Total	Produced		Ca	Total
	(meq/l)			(uS/cm)	N.T.U.		(meq/l)		(gallons)	(bed vol.)	(eq/l of resin)	
June 2	NA	50.4	NA	10800	NA	NA	NA	NA	NA	NA	NA	NA
3	NA	50.4	NA	10900	NA	NA	NA	NA	NA	NA	NA	NA
5	21.2	52.0	104.3	10700	.1	7.3	0.6	NA	20580	17.19	0.35	NA
7	21.2	51.6	95.7	11400	.4	7.3	0.6	NA	20510	17.13	0.35	NA
9	NA	51.6	NA	11400	NA	NA	0.6	NA	4500	3.76	NA	NA
9	NA	51.6	NA	11400	NA	NA	NA	NA	19300	16.12	NA	NA
11	NA	53.2	NA	11000	NA	NA	0.5	NA	11070	9.25	NA	NA
12	NA	52.8	NA	11100	NA	NA	0.5	NA	NA	NA	NA	NA
13	NA	52.4	NA	11000	NA	NA	0.6	NA	18750	15.66	NA	NA
15	NA	52.8	NA	11100	NA	NA	NA	NA	14040	11.73	NA	NA
16	NA	53.2	NA	11700	NA	NA	0.6	NA	12910	10.78	NA	NA
17	NA	52.8	NA	11300	NA	NA	0.5	NA	17930	14.97	NA	NA
19	22.0	54.8	104.3	11800	.1	7.5	0.5	NA	21950	18.33	0.39	NA
21	26.0	52.4	97.8	11300	.1	7.5	0.6	NA	17800	14.87	0.38	NA
22	NA	52.4	NA	11000	NA	NA	0.6	NA	18010	15.04	NA	NA
24	27.4	51.2	104.3	11300	.1	7.3	0.5	NA	7500	6.26	0.17	NA
25	29.0	52.0	100.0	11100	.2	7.3	0.6	NA	18640	15.57	0.44	NA
29	24.0	50.8	117.4	11100	.1	7.3	0.3	NA	24100	20.13	0.48	NA
29	NA	52.0	NA	10600	NA	NA	0.6	NA	18480	15.43	NA	NA
July 2	NA	43.2	NA	10700	NA	NA	0.4	NA	20820	17.39	NA	NA
4	24.0	50.0	91.3	11800	<.1	7.6	0.6	NA	20700	17.29	0.40	NA
5	22.0	48.0	87.0	12400	<.1	7.5	0.6	NA	19080	15.93	0.34	NA
6	NA	50.8	NA	10700	NA	NA	0.5	NA	17740	14.82	NA	NA
8	27.2	48.6	91.3	11500	NA	NA	0.6	NA	17740	14.82	0.39	NA
9	27.6	51.2	85.4	11100	NA	NA	0.6	NA	19440	16.24	0.44	NA
11	NA	52.4	NA	12500	NA	NA	0.5	NA	17160	14.33	NA	NA
12	27.2	51.2	102.2	11400	NA	NA	0.6	NA	17291	14.44	0.38	NA
14	NA	49.2	NA	11600	NA	NA	0.6	NA	16110	13.45	NA	NA
15	28.0	50.8	97.6	11500	NA	NA	0.6	NA	12614	10.53	0.29	NA
16	NA	55.4	NA	11600	NA	NA	NA	0.7	25350	21.17	NA	1.16
18	NA	50.6	NA	11800	NA	NA	NA	1.3	22140	18.49	NA	0.91
19	NA	50.0	NA	11500	NA	NA	0.7	1.3	19610	16.38	NA	0.80
21	26.0	50.4	140.0	10800	<.1	7.3	0.4	0.7	20922	17.47	0.45	0.87
22	28.0	49.6	88.3	10800	<.1	7.6	NA	NA	NA	NA	NA	NA
23	NA	56.8	NA	10700	NA	NA	NA	NA	NA	NA	NA	NA
27	26.0	53.2	93.5	10300	<.1	7.6	0.6	0.8	19070	15.93	0.41	0.83
29	26.0	50.0	100.0	11400	<.1	7.8	0.6	1.0	17770	14.84	0.38	0.73
30	27.2	50.4	84.8	10900	<.1	7.2	NA	NA	NA	NA	NA	NA
31	26.8	52.4	87.0	10500	<.1	7.2	0.5	0.9	21010	17.55	0.46	0.90
Aug. 2	NA	50.0	NA	10800	NA	NA	0.5	0.9	17690	14.77	NA	0.73
4	NA	56.0	NA	10900	NA	NA	0.6	0.9	20520	17.14	NA	0.94
5	NA	NA	NA	10700	NA	NA	0.7	0.9	20470	17.10	NA	NA
6	29.2	51.2	89.1	10700	<.1	7.2	0.7	1.1	27030	22.57	0.64	1.13

ION EXCHANGE UNIT 2
SODIUM CHLORIDE BRINE REGENERATION
MAY, JUNE and JULY - 1985

REGENERATION and SERVICE DATA

REGENERATION DATA:

			INFLUENT BRINE					Total Sodium Thruput		Average Flow Rate	
Date	Dur.	Volume	Conc.	Elect. Cond.	Ca	Total Hardness	Sodium	(eq/l of resin)	(bv)	(bv/min)	(gpm/ft2)
	(min)	(gal)	(%)	(uS/cm)	(meq/l)						
May 31	50	3520	12	147300	9	17.2	2479.3	7.276	2.940	0.059	1.79
June 5	53	3630	12	149900	6	12.0	2622.9	7.938	3.032	0.057	1.74
7	NA	NA	NA	190200	22	30.4	3627.7	NA	NA	NA	NA
10	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
10	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
11	59	3740	14	164200	3	8.8	1722.5	5.371	3.123	0.053	1.61
15	50	3025	13	NA	NA	NA	NA	NA	NA	NA	NA
15	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
July 25	50	3355	NA	152900	6	9.2	2348.8	6.570	2.802	0.056	1.71

	EFFLUENT BRINE									
	at 20 minutes									
Date	Thruput	Elect. Cond.	Calcium	Total Hardness	Sodium	Thruput	Elect. Cond.	Calcium	Total Hardness	Sodium
	(bv)	(uS/cm)	(meq/l)			(bv)	(uS/cm)	(meq/l)		
May 31	1.17	58100	148.0	380.0	395.8	2.64	132500	130.0	268.0	1872.6
June 5	1.14	144300	354.0	368.0	2662.0	2.57	147900	116.0	168.0	3027.4
7	NA	150200	100.0	156.0	2335.8	NA	166300	100.0	160.0	2866.5
10	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
10	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
11	1.06	140600	380.0	670.0	935.2	2.38	151500	192.0	340.0	1496.3
15	1.01	NA	NA	NA	NA	2.27	NA	NA	NA	NA
15	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
July 25	1.12	139900	106.0	224.0	1826.9	2.52	147300	70.0	122.0	2022.6

SERVICE DATA:

	INFLUENT PROCESS WATER						EFFLUENT PROCESS WATER					
							Average Leakage		Softered Water Produced		Resin Capacity	
Date	Ca	Total Hardnes	Sodium	Elect. Cond.	Turbidit	pH	Calcium	Total			Ca	Total
	(meq/l)			(uS/cm)	N.T.U.		(meq/l)		(gal)	(bv)	(eq/l of resin)	
May 31	21.2	45.2	101.5	11100	.7	NA	NA	NA	NA	NA	NA	NA
June 5	21.0	51.2	108.7	11700	.1	7.5	NA	NA	NA	NA	NA	NA
7	21.4	52.0	100.0	11400	.1	7.5	NA	NA	NA	NA	NA	NA
10	NA	53.6	NA	10900	NA	NA	NA	NA	NA	NA	NA	NA
10	NA	53.6	NA	10900	NA	NA	NA	NA	NA	NA	NA	NA
11	NA	53.2	NA	11000	NA	NA	NA	NA	NA	NA	NA	NA
15	NA	52.8	NA	11100	NA	NA	NA	NA	NA	NA	NA	NA
15	NA	52.8	NA	11100	NA	NA	NA	NA	NA	NA	NA	NA
July 25	28.0	50.8	91.3	10400	.1	7.5	NA	NA	NA	NA	NA	NA

OPERATION PLAN FOR ION-EXCHANGE SYSTEM UNIT 1 AT LOS BANOS DEMONSTRATION DESALTING FACILITY

This is the operation plan for ion-exchange system unit 1 for the time period through June 16. The primary purpose of the plan is to schedule operations in order to deliver "softened" water to the Hydranautics reverse-osmosis unit.

IX unit 1 is to be operated according to the instructions as shown on the operation schedule. Instructions concerning regeneration and sampling and other instructions relevant to operation of the system are listed below.

Calcium Leakage

The level of calcium in the IX process water effluent that is to be desalted is to be no greater than 50 milligrams per liter as $CaCO_3$. Specific instructions to verify calcium leakage throughout the cycle are as follows:

1. Rinse C to service. Verify calcium leakage (sample tap SX1E) during event in 5-minute intervals. End point of rinse C is when leakage is less than 50 mg/L. Record leakages and times on data sheet.

2. End of service. Verify calcium leakages (sample tap SX1E) on hourly basis starting 10 hours before scheduled regeneration. Regenerate early if calcium leakage is greater than 50 mg/L. Record leakages and times on data sheet.

Regeneration

Regeneration calls for using 3,750 gallons of 12-percent brine (3,750 gallons equals 2 feet 10 inches of tank depth for tanks 6 and 7). If, at the end of 50 minutes, less than 2 feet 10 inches of brine was used, extend regeneration duration to encompass the entire 2 feet 10 inches. If less than 12-percent brine is used for regeneration, extend regeneration duration an additional 3.5 inches for every percent reduction of brine concentration from 12 percent (for 10- and 11-percent brines, regeneration volume is to be 3 feet 5 inches and 3 feet 1.5 inches, respectively). Record all pertinent information on data sheet.

The schedule for regeneration is dependent upon flowrate at which the Hydranautics RO unit is operating. The volume of process water "softened" by the IX system is expected to be 27,600 gallons. Regeneration is to be scheduled accordingly. Verification of calcium leakage is to be performed as previously discussed.

IX unit 2 is to be in service or a supply of "softened" process water is to be stored in CW4 in order to keep the Hydranautics RO unit in operation while IX unit 1 is being regenerated. The process water stored in CW4 may require dechlorination before desalting with the RO unit. Dechlorination is required when the free chlorine residual is 1.0 mg/L or higher.

Sampling

Laboratory Analysis

One-pint samples are to be taken at various times in the cycle. The sample bottles are to be marked and taken to the laboratory for analysis. A laboratory analysis sheet shall accompany the samples.

The schedule for sample times, analyses performed, and other pertinent information are listed below.

Sample 1. IX influent (SW1E) -- calcium, total hardness, electrical conductivity, sodium, turbidity, and pH.

Sample 2. Fresh brine after mixing (STE6) -- sodium, electrical conductivity, calcium, and total hardness.

Sample 3. Used brine 20 minutes into regeneration (SX1B) -- sodium, electrical conductivity, calcium, and total hardness.

Sample 4. Used brine 45 minutes into regeneration (SX1B) -- sodium, electrical conductivity, calcium, and total hardness.

Sample 5. Service 0 (SX1E) -- calcium, total hardness, electrical conductivity, sodium, turbidity, and pH.

Other Analyses

Calcium. Samples are to be collected during the rinse and service events and immediately analyzed for calcium. This section was previously discussed under the heading calcium leakage.

Salinity. A sample is to be taken from STE6 after mixing but before regeneration and is to be analyzed for salt content using the hygrometer. The volume of brine to be used for regeneration depends upon the salinity and is to be adjusted if necessary. This procedure is as previously discussed in the regeneration section.

ION-EXCHANGE OPERATIONS SCHEDULE -- UNIT 1
MANUAL OPERATION
SODIUM CHLORIDE BRINE REGENERATION

Service flow by gravity.
Regeneration flow at 75 gpm with 12% brine.

Used brine to IX sump.
Rinses A and B to IX sump.
Rinse C to RWPS.
Service to RO.

Number	Event Description	Duration (minutes)	Unit 1	Process Flow			Comment or Explanation
				Unit	From	To	
1	Recirculation of sodium chloride brine	20	IP 3 IV 16, 39m, 40m	1	T6	T6	Recirculation to be performed during service just before regeneration.
2	Drain	3	IV 6,10,22	1	Unit 1	RWPS	Verify event duration (see note below).
3	Sodium chloride regeneration	50	IP 3 IV 16,14,7,9,21	1	T6	IX sump	See regeneration instructions.
4	Drain	3	IV 6,10,21	1	Unit 1	IX sump	Verify event duration (see note below).
5	Rinse A	5	IP 7 IV 1,7,10,21	1	CW1	IX sump	
6	Rinse B	10	IP 7 IV 2,7,10,21	1	CW1	IX sump	
7	Rinse C	*	IP 7 IV 2,7,10,22	1	CW1	RWPS	Verify calcium leakage during event from sample tap SX1E.
8	Service	**	Gravity IV 1,7,11	1	CW1	RO	Verify calcium leakage throughout event from unit 1 (SX1E).
9	Set up for regeneration		IP 4 IV 118	1	T5	T6	To be performed during service event.

*Duration to be determined in field. Event ends when calcium leakage is less than 50 mg/L as $CaCO_3$.

**Total service volume is expected to be about 27,600 gallons.

Note: Level of fluid in columns to be 3/4 full at end of event.

Abbreviations:
m = manual value
CW = clearwell
IP = ion-exchange pump
IV = ion-exchange valve
IX = ion exchange
RO = reverse osmosis (Hydranautics)
T = brine tank
RWPS = return water pump station

OPERATION PLAN FOR ION-EXCHANGE SYSTEM UNIT 2 AT LOS BANOS DEMONSTRATION DESALTING FACILITY

This is the operation plan for ion-exchange system unit 2 for the time period through June 16. The objectives of the plan are to determine the durations required for rinsing (rinse C) and for service.

IX unit 2 is to be operated according to the instructions as shown on the operation schedule. Instructions concerning regeneration and sampling and other instructions relevant to operation of the system are listed below.

Duration of Rinse C

In order to determine the duration of rinse C, samples are to be taken during the event in 5-minute intervals from sample tap SX2E and immediately analyzed for calcium hardness. End point of rinse C occurs when calcium hardness is less than 50 milligrams per liter as $CaCO_3$. Record calcium levels and times on data sheet.

Duration of Service

The duration of the service event is expected to be 250 minutes at a flowrate of 110 gallons per minute. Samples are to be taken from SX2E and analyzed for calcium hardness at 15-minute intervals starting at 160 minutes into the event. End of service occurs at duration 250 minutes or when calcium hardness is greater than 100 mg/L as $CaCO_3$. Record all calcium levels and times on data sheet.

Schedule of Operations

The schedule of operations for IX unit 2 is as follows:

Tuesday, June 11
Thursday, June 13
Saturday, June 15

If possible, regeneration of unit 1 should coincide when unit 2 is in service in order supply "soft" water to the Hydranautics reverse-osmosis unit. During this time unit 2 is to be softening process water by gravity. If circumstances do not permit this, an adequate supply of water softened by unit 2 is to be available in CW4 in order to feed the RO unit. All water stored in CW4 is to be chlorinated.

Regeneration

Regeneration calls for using 3,750 gallons of 12-percent brine (3,750 gallons equals 2 feet 10 inches of tank depth for tanks 6 and 7). If, at the end of 50 minutes, less than 2 feet 10 inches of brine was used, extend regeneration duration to encompass the entire 2 feet 10 inches. If less than 12-percent brine is used for regeneration, extend regeneration duration

an additional 3.5 inches for every percent reduction of brine concentration from 12 percent (for 10- and 11-percent brines, regeneration volume is to be 3 feet 5 inches and 3 feet 1.5 inches, respectively). Record all pertinent information on data sheet.

Sampling

Laboratory Analysis

One-pint samples are to be taken at various times in the cycle. The sample bottles are to be marked and taken to the laboratory for analysis. A laboratory analysis sheet shall accompany the samples.

The schedule for sample times, analyses performed, and other pertinent information are listed below.

Sample 1. IX influent (SW2E) -- calcium, total hardness, electrical conductivity, sodium, turbidity, and pH.

Sample 2. Fresh brine after mixing (STE7) -- sodium, electrical conductivity, calcium, and total hardness.

Sample 3. Used brine 20 minutes into regeneration (SX2B) -- sodium, electrical conductivity, calcium, and total hardness.

Sample 4. Used brine 45 minutes into regeneration (SX2B) -- sodium, electrical conductivity, calcium, and total hardness.

Sample 5. Service 0 (SX2E) -- calcium, total hardness, electrical conductivity, sodium, turbidity, and pH.

Other Analyses

Calcium. Samples are to be collected during the rinse and service events and immediately analyzed for calcium. This section was previously discussed.

Salinity. A sample is to be taken from STE7 after mixing but before regeneration and is to be analyzed for salt content using the hygrometer. The volume of brine to be used for regeneration depends upon the salinity and is to be adjusted if necessary. This procedure is as previously discussed in the regeneration section.

ION-EXCHANGE OPERATIONS SCHEDULE -- UNIT 2
MANUAL OPERATION
SODIUM CHLORIDE BRINE REGENERATION

Service flow at 110 gpm.
Regeneration flow at 75 gpm with 12% brine.

Used brine to IX sump.
Rinses A and B to IX sump.
Rinse C to RWPS.
Service to RWPS.

Number	Event Description	Duration (minutes)	Unit 2	Process Flow Unit	Process Flow From	Process Flow To	Comment or Explanation
1	Recirculation of sodium chloride brine	20	IP 2 IV 116, 139m, 140m	2	T7	T7	Recirculation to be performed during service just before regeneration.
2	Drain	3	IV 106,110,121	2	Unit 2	IX sump	Verify event duration (see note below).
3	Sodium chloride regeneration	50	IP 2 IV 116,114,107,109,121	2	T7	IX sump	
4	Drain	3	IV 106,110,121	2	Unit 2	IX sump	Verify event duration (see note below).
5	Rinse A	5	IP 8 IV 101,110,107,121	2	CW1	IX sump	
6	Rinse B	10	IP 8 IV 2,7,10,21	2	CW1	RWPS	
7	Rinse C	*	IP 8 IV 2,7,10,22	2	CW1	RWPS	Verify calcium leakage at end of event from unit 2 (SX1E).
8	Service	**	IP 8 IV 101,107,111 SOV 6	2	CW1	RWPS	Verify calcium leakage throughout event from unit 2 (SX1E).
9	Set up for regeneration		IP 4 IV 117	2	T5	T7	To be performed during service event.
10	Storage	15	IP 2 IV 116,114,107,109,122	2	T7	RWPS	

*Duration to be determined in field. Event ends when calcium leakage is less than 50 mg/L as $CaCO_3$.

**Total service volume is expected to be about 27,600 gallons. Event ends when calcium leakage is greater than 100 mg/L as $CaCO_3$ or 250 minutes.

Note: Level of fluid in columns to be 3/4 full at end of event.

Abbreviations:
m = manual value
CW = clearwell
IP = ion-exchange pump
IV = ion-exchange valve
IX = ion exchange
T = brine tank
RWPS = return water pump station

MAIN UNIT CHEM-ANALYSIS DATA SHEET
ION-EXCHANGE SYSTEM

Water Type Clarifier

MANUAL OPERATION

IX Unit _____

Date ___/___/___

LAB NUMBER	EVENT TIME	TURB-IDITY	E.C. us/cm	pH	TOTAL HARDNESS (ppm as $CaCO_3$)	SODIUM (ppm)	CALCIUM (ppm as $CaCO_3$)	CHLORIDE (ppm)	SULPHATE (ppm)	CHLORINE FREE (ppm)
	Sample 1 IX infl.							X	X	X
	Sample 2 fr. brine	X		X				X	X	X
	Sample 3 u. brine20	X		X				X	X	X
	Sample 4 u. brine45	X		X				X	X	X
	Sample 5 service 0							X	X	X

SODIUM CHLORIDE REGENERATION DATA SHEET
ION-EXCHANGE SYSTEM
CLARIFIER WATER

Unit 1 Date_____

Event Description	Begin Time	End Time	Other
Mixing			_____-percent brine after mixing.
Drain			Level in IX columns _____ full.
Regeneration			Flow reading: _____ Level in T6: _____ begin, _____ end
Drain			Level in IX columns _____ full.
Rinse A			Flow reading: _____
Rinse B			Flow reading: _____
Rinse C			Flow reading: _____ Calcium at: _____ 0 minutes, _____ 5 minutes _____ 10 minutes, _____ 15 minutes _____ 20 minutes
Service			Calcium at hours before scheduled regeneration: _____10 hours, _____ 9 hours, _____ 8 hours, _____ 7 hours, _____ 6 hours, _____ 5 hours, _____ 4 hours, _____ 3 hours, _____ 2 hour _____ 1 hour _____ 5 minutes before regeneration

Remarks:

SODIUM CHLORIDE REGENERATION DATA SHEET
ION-EXCHANGE SYSTEM
CLARIFIER WATER

Unit 2 Date_____

Event Description	Begin Time	End Time	Other
Mixing			_____-percent brine after mixing.
Drain			Level in IX columns _____ full.
Regeneration			Flow reading: _____ Level in T6: _____ begin, _____ end
Drain			Level in IX columns _____ full.
Rinse A			Flow reading: _____
Rinse B			Flow reading: _____
Rinse C			Flow reading: _____ Calcium at: _____ 0 minutes, _____ 5 minutes _____ 10 minutes, _____ 15 minutes _____ 20 minutes
Service			Flow reading: _____ Calcium at hours before scheduled regeneration: _____ 160 minutes, _____ 175 minutes _____ 190 minutes, _____ 205 minutes _____ 220 minutes, _____ 235 minutes _____ 250 minutes

Remarks:

APPENDIX E

MAIN UNIT PERIOD 2 OPERATIONS

Ion-Exchange System
January and February 1986

Operation Log
Operation Parameters and Results

OPERATION LOG - 1986

Date	Unit	Time	Action/Comments
Jan. 1	1,2	MN Cond.	off
2	1,2	MN Cond.	off
		13:00	RO2 I/S
		15:19	RO3 I/S
		15:35	Transfer brine from T3 to T4
	1	16:05	I/S @ event1 by computer. IX2 will follow
		20:10	Problems experienced with IX computer
3	1	10:15	flushed with process water
		11:31	RO2 & 3 I/S
	2	12:30	I/S to CW5 by computer operation
		16:00	crossover brine pipe to IV27 broke
		16:20	IV23 stuck (ball Valve). Switched with IV24
	1,2	17:00	I/S - auto mode
		17:40	IP6 started manually when failed to operate IX1 event 10
	1,2	18:53	S/D to reprogram IV117 to IV17 event11
	1,2	19:12	I/S
4	1,2	MN Cond.	I/S to CW5, RO2, CW6, RO3, T1
		4:30	reprogrammed computer
	1,2	16:35	S/D, IP6 discharge line to T4 broke
		16:45	RO2 & 3 S/D
5	1,2	MN Cond.	off
6		9:45	IP9's coupling replaced
		11:50	Transferred brine from T2 & 3 to T4
		11:21	RO2 & 3 I/S
	1,2	14:06	I/S auto mode, IX2 @ event8
		17:05	EDR reject to T1
	2	17:45	S/D, IV123 (ball) would not open causing relief valve to open
		21:15	Installed modified operations program from new tape - AUTO START IX OP.S
		22:30	RO2, 3 and EDR S/D per instructions
7	1,2	NM Cond	off
		10:20	repair completed on IX1 relief valve piping
8	1,2	MN Cond.	off
		15:00	repair completed on line from T2/3 to T4
9	1,2	MN Cond	off. Worked on valves IV4, 17 and 22
10	1,2	MN Cond	off
	1,2	10:21	I/S auto mode - Regeneration
		11:45	RO2 & 3 I/S
		12:15	EDR I/S
		12:55	EDR S/D - abnormalities in operation
		13:23	EDR I/S
	1	14:30	TH @ 110 and Ca @ 44 as CaCO3
11	1,2	MN Cond	I/S to CW5, RO2 ... EDR, T1
	2	7:22	S/D in event8 - CW5 overflow
		9:27	Restarted computer after turning off to corredt some error
		10:54	IP1 S/D, IV17 remained closed during event 11 of IX1
	1	12:45	S/D to fill T6 with brine

Date	Unit	Time	Action/Comments
Jan. 11	2	21:30	S/D, CW5 @ 20 ft, IX2 regenerated
	2	22:00	I/S, CW5 @ 16 ft. 5 in.
12	1,2	MN Cond	I/S to CW5, RO2 ... EDR, T1
	1,2	4:23	S/D, CW5 @ 23 ft.
	1	7:04	I/S @ regeneration, CW5 @ 13 ft.
	1	11:36	S/D to refill T6 from T1 and T4 from T2/3
	1	12:37	I/S @ event1
		14:00	Changed event10's duration to 40 min. from 24. T4 almost empty after 2 regenerations
	1	14:31	S/D and ready for event8 - service
	2	14:46	S/D
	1,2	17:00	I/S, IX1 @ event8 - CW5 @ 10ft; IX2 @ event1
		18:45	Trouble calls on IP6 (tripped twice), IV17 sticking intermittently and tank level gauges sticking
	1	20:10	S/D, did not go through to event12, drain
	1	22:05	I/S @ event1
13	1,2	MN Cond	I/S to CW5, RO2 ... EDR, T1
		3:00	Brine transfer from T2/3 to T4 by hand
	1	7:00	S/D, ready for event8 - service
		7:30	RO2 & 3 S/D to repair leaky pipes from clearwells
		8:04	EDR S/D
		10:10	Brine transfer from T2 to T4 by hand
14	1,2	MN Cond	off
	1,2	8:30	Dry run of IX system
	1,2	11:10	S/D dry run, transferred brine from s.solar pond to T2 & 3
15	1,2	MN Cond	off
		12:20	RO2 & 3 I/S
		14:40	RO3 S/D, HP relief valve released - 880 psi
		15:00	RO2 S/D, low suction head
	1	16:03	I/S regeneration - auto
	1	20:25	S/D, CW5 @ 23 ft.
16	1,2	MN Cond	off
17	1,2	MN Cond	off
		10:35	IV1 valve maintenance
18	1,2	MN Cond	off
		14:40	IP6 cycling in auto mode, OK in hand mode
19	1,2	MN Cond	off
20	1,2	MN Cond	off
21	1,2	MN Cond	off
		15:50	new RO3 relief valve released and would not reset
22	1,2	MN Cond	off
23	1,2	MN Cond	off
		14:30	IV17 & 18 repair
24	1,2	MN Cond	off
25	1,2	MN Cond	off
26	1,2	MN Cond	off

OPERATION LOG - 1986

Date	Unit	Time	Action/Comments
Jan. 27		10:08	IV18 limit switch adjustment
28	1,2	MN Cond	off, work on RO3 pinch valve regulator
29	1,2	MN Cond	off
		7:45	IV10 & 13 maintenance
		12:10	T2/3 pump cutoff switch maintenance
30	1,2	MN Cond	off
		7:30	RO3 I/S
		10:37	RO2 I/S
	1,2	11:18	I/S - auto; acid pump whenever IX unit is not in service
		19:05	Refilled T4 from T2 - manual
		20:45	Refilled T7 from T1 - manual
31	1,2	MN Cond.	I/S to CW5, RO2 ... EDR, T1
Feb. 1	1,2	MN Cond.	I/S to CW5, RO2 ... EDR, T1
	2	8:33	S/D, acid pump off, CW5 @ 17 ft. 11 in.
2	1	9:56	I/S, acid pump on, CW5 @ 12 ft. 8 in.
	1	13:06	S/D, acid pump off, CW5 @ 16 ft.
	2	14:02	I/S, acid pump on, CW5 @ 12 ft. 4 in.
		15:15	Refilled T6 from T1 manually
2	1,2	MN Cond.	I/S to CW5, RO2 ... EDR, T1
3		18:58	EDR S/D, fire
4		19:19	RO3 S/D
		19:57	RO2 S/D
	1,2	21:18	S/D
3	1,2	MN Cond.	S/D
4		MN Cond.	S/D
5		18:55	RO2, 3 and EDR I/S
	1,2	19:35	I/S IX2 @ event 1. Computer failed to operate IP5 on both units
		20:15	IX2 @ event8, CW5 @ 12ft. 8 in.
5	1,2	MN Cond.	I/S to CW5, RO2 ... EDR, T1
		7:00	EDR tripped and placed back into service
		16:25	EDR tripped. Would not switch to anode mode
		17:00	RO2 & 3 S/D
6	1,2	17:52	S/D
		18:28	EDR I/S
		19:30	RO2 & 3 I/S
	1,2	21:30	I/S, IX1 @ event8, IX2 @ event1, CW5 @ 5ft. 11 in.
6	1,2	MN Cond.	I/S to CW5, RO2 ... EDR, T1
7		7:36	manually refilled T6 from T1
	1	14:50	S/D, IV12 & 14 maintenance
		14:55	EDR S/D to install new volt/amp motor
	1	15:10	I/S @ event1
7	1,2	MN Cond.	I/S to CW5, RO2 ... EDR, T1
		5:30	IX computer lost power when breaker 7 tripped. Breaker reset and IX system I/S
	2	6:54	S/D during event8 and placed in regen., CW5 @ 23 ft.(full)
	1,2	11:20	Placed in manual mode to reprogram computer

OPERATION LOG - 1986

Date	Unit	Time	Action/Comments
Feb. 7		12:05	Refilled T6 & 7 from T1 and T4 from T2 & 3
			Maintenance on IP1 suction line - repair leak
		15:40	RO2 S/D, CW5 low due to trouble shooting of IX oper's program
		18:35	RO3 S/D, low level in CW6
	1,2	22:06	I/S - auto
		23:30	RO2 I/S
8	1,2	MN Cond.	I/S to CW5, RO2 to CW6
		1:17	RO3 I/S
		2:00	EDR I/S to T1
		6:00	EDR S/D, valves 4 and 5 not operating
		10:49	EDR test run
9	1,2	MN Cond.	I/S to CW5, RO2 ... EDR, T1
10	1.2	MN Cond.	I/S to CW5, RO2 ... EDR, T1
		8:15	maintenance on IV2 - repair leakage
11	1,2	MN Cond.	I/S to CW5, RO2 ... EDR, T1
14		12:30	resin discovered on bottom of RWPS
		15:05	resin discovered in cartridge filters
12	1,2	MN Cond.	I/S to CW5, RO2 ... EDR, T1
13	1,2	MN Cond.	I/S to CW5, RO2 ... EDR, T1
14	1,2	MN Cond.	I/S to CW5, RO2 ... EDR, T1
		10:35	adjustment of T2's level switch
15	1,2	MN Cond.	I/S to CW5, RO2 ... EDR, T1
		5:15	IP6 failed to operate in both auto and hand mode. T4 @ 2ft. 6in.
16		6:35	Refilled T4 by hand mode
		9:45	maintenance on IV17
17		9:57	S/D computer, both units in event8 at same time.
		11:08	I/S computer
16	1,2	MN Cond.	I/S to CW5, RO2 ... EDR, T1
	1,2	23:17	S/D with EDR, resin accumulation in cartridge filter
17	1,2	MN Cond.	S/D, RO2 to CW6 to RO3 to CW8
		1:09	RO3 S/D
		2:08	RO2 S/D by tripping low pressure switch
		8:30	Resin found to be coming out of IX1b and IX2a lower manifolds

IX system was S/D for the rest of the month for repair
of manifolds and other modifications

Sodium Throughput during regeneration for operating conditions
Month: January and February, 1986

REGENERATION

Date	Flow		Duration		Sodium		Sodium Throughput		
	Recycle Brine	Fresh Brine	Recycle Brine	Fr. Brine	Recycle Brine	Fresh Brine	Recycle Brine	Fresh Brine	Total
	(gpm)		(minutes)		(meq/l)		(eq/l of resin)		
Jan. 1	IX System OFF				NA	NA	NA	NA	NA
2	IX System OFF				NA	NA	NA	NA	NA
3	200	150	41	9	NA	NA	NA	NA	NA
4	200	150	41	9	NA	NA	NA	NA	NA
5	IX System OFF				NA	NA	NA	NA	NA
6	200	150	41	9	NA	NA	NA	NA	NA
7, 8, 9	IX System OFF				NA	NA	NA	NA	NA
10	200	150	41	9	NA	NA	NA	NA	NA
11	200	150	41	9	NA	NA	NA	NA	NA
12	200	150	41	9	NA	NA	NA	NA	NA
13, 14	IX System OFF				NA	NA	NA	NA	NA
15	200	150	41	9	NA	NA	NA	NA	NA
16	IX System OFF				NA	NA	NA	NA	NA
17	IX System OFF				NA	NA	NA	NA	NA
18	IX System OFF				NA	NA	NA	NA	NA
19	IX System OFF				NA	NA	NA	NA	NA
20	IX System OFF				NA	NA	NA	NA	NA
21	IX System OFF				NA	NA	NA	NA	NA
22	IX System OFF				NA	NA	NA	NA	NA
23	IX System OFF				NA	NA	NA	NA	NA
24	IX System OFF				NA	NA	NA	NA	NA
25	IX System OFF				NA	NA	NA	NA	NA
26	IX System OFF				NA	NA	NA	NA	NA
27	IX System OFF				NA	NA	NA	NA	NA
28	IX System OFF				NA	NA	NA	NA	NA
29	IX System OFF				NA	NA	NA	NA	NA
30	IX System OFF				NA	NA	NA	NA	NA
31	200	150	41	9	NA	NA	NA	NA	NA
Feb. 1	200	150	41	9	NA	NA	NA	NA	NA
2	200	150	41	9	NA	NA	NA	NA	NA
3, 4	IX System OFF				NA	NA	NA	NA	NA
5	200	150	52	8	1500.0	NA	11.60	NA	NA
6	200	150	52	8	1760.9	1652.2	13.61	1.47	15.09
7	200	150	52	8	3913.0	1913.0	30.25	1.71	31.96
8	200	150	52	8	1521.7	1934.8	11.76	1.73	13.49
9	200	150	52	8	1673.9	2173.9	12.94	1.94	14.88
10	200	150	53	7	1043.5	1478.3	8.22	1.15	9.38
11	200	150	53	7	NA	NA	NA	NA	NA
12	200	150	53	7	934.8	456.5	7.37	0.36	7.72
13	200	150	53	7	1065.2	1413.0	8.39	1.10	9.50
14	200	150	53	7	826.1	1326.1	6.51	1.03	7.54
15	200	150	53	7	978.3	1869.6	7.71	1.46	9.17

Total hardness removed during Service Event for operation conditions

Month: January and February, 1986 SERVICE
Bed Volume: 5092 liters

			Total Hardness		Calcium	Influent	T.Hardness
	Flow	Duration	Influent	Effluent	Effluent	Na:TH	Removed
Date	(gpm)	(minutes)	(meq/l)			(ratio)	(eq/l of resin)
Jan. 1		IX System OFF					
2		IX System OFF					
3	110	190	55.5	NA	NA	1.2	NA
4	110	190	50.3	NA	NA	1.3	NA
5		IX System OFF					
6	110	190	50.8	7.6	2.2	1.4	0.67
7, 8, 9		IX System OFF					
10	110	190	49.4	3.5	1.3	1.6	0.71
11	110	190	NA	9.2	2.4	NA	NA
12	110	190	47.8	4.8	1.0	1.5	0.67
13, 14		IX System OFF					
15	110	190	46.1	2.8	1.0	1.5	0.67
16		IX System OFF					
17		IX System OFF					
18		IX System OFF					
19		IX System OFF					
20		IX System OFF					
21		IX System OFF					
22		IX System OFF					
23		IX System OFF					
24		IX System OFF					
25		IX System OFF					
26		IX System OFF					
27		IX System OFF					
28		IX System OFF					
29		IX System OFF					
30		IX System OFF					
31	110	190	NA	3.3	1.6	NA	NA
Feb. 1	110	190	50.1	3.2	1.4	NA	0.73
2	110	190	49.8	3.3	1.6	NA	0.72
3, 4		IX System OFF					
5	110	190	49.8	11.6	2.2	1.9	0.59
6	110	190	50.8	10.3	1.6	1.8	0.63
7	110	190	50.3	10.1	2.0	1.9	0.62
8	110	190	51.2	11.1	2.4	2.1	0.62
9	110	190	51.9	12.5	2.6	2.2	0.61
10	110	190	49.4	15.5	2.8	1.9	0.53
11	110	190	NA	NA	NA	NA	NA
12	110	190	47.8	15.0	2.3	1.6	0.51
13	110	190	48.7	12.5	1.8	1.6	0.56
14	110	190	48.4	11.4	1.7	1.6	0.57
15	110	190	46.1	13.2	1.7	1.8	0.51

CLEARWELL 2 - SAMPLE TAP SW2D ION EXCHANGE INFLUENT

Date	Time	TH	Ca	Cl2-F	SiO2	Turb	EC	pH	Cl	Na	SO4
1986		(meq/l)		(mg/l)		(NTU)	(uS/cm)		(meq/l)		
Jan 1	7:30	41.2	23.1	NA	12	0.1	8600	7.4	36.6	58.7	NA
2	7:30	41.8	23.2	0.6	12	0.1	8500	7.2	36.6	62.6	NA
3	7:30	42.8	22.7	0.5	13	0.4	8100	7.5	36.6	65.2	NA
4	7:30	43.1	22.9	NA	9	0.1	8800	7.7	NA	66.5	NA
5	7:30	44.0	23.5	NA	10	0.1	8700	7.5	NA	67.8	NA
6	7:30	43.3	23.6	NA	10	0.1	8500	7.5	NA	69.1	NA
7	7:30	43.3	23.6	0.2	10	0.1	8800	7.5	33.8	69.1	NA
8	7:30	44.4	23.5	0.5	7	0.1	8850	7.5	36.6	64.1	66.7
9	7:30	44.4	23.2	0.5	10	0.1	9100	7.5	NA	NA	NA
10	7:30	43.9	23.8	0.5	8	0.1	9200	7.3	36.6	77.2	70.8
11	7:30	44.9	23.3	NA	10	0.2	9200	7.5	NA	73.9	NA
12	7:30	45.7	23.3	NA	10	0.1	9400	7	NA	71.7	NA
13	7:30	45.9	24.2	0.7	9	0.1	9600	7	36.6	70.7	83.3
14	7:30	46.3	24.0	0.7	9	0.3	9500	7.4	NA	70.7	NA
15	7:30	43.4	24.5	0.3	10	0.1	9400	7.1	39.4	69.6	67.7
16	7:30	46.5	24.3	1.0	10	0.1	9800	7.5	NA	68.5	NA
17	7:30	45.5	23.5	1.0	11	0.1	9600	7.4	39.4	71.7	81.3
18	7:30	45.7	23.6	NA	12	0.1	9700	7.7	NA	66.3	NA
19	7:30	45.8	23.4	NA	11	0.1	9600	7.7	NA	68.5	NA
20	7:30	45.6	23.4	NA	12	0.1	10000	7.5	45.1	72.8	75.0
21	7:30	47.5	23.3	NA	13	0.1	9800	7.6	NA	70.7	NA
22	7:30	46.6	23.4	0.8	13	0.1	10000	7.5	39.4	76.1	78.1
23	7:30	46.2	23.3	0.7	13	0.1	10100	7.7	NA	78.3	NA
24	7:30	47.9	24.3	1.2	12	0.1	10100	7.2	39.4	77.2	78.1
25	7:30	52.7	24.1	NA	13	0.1	10600	7.4	NA	83.7	NA
26	7:30	48.8	23.3	NA	15	0.1	10400	7.4	NA	84.8	NA
27	7:30	49.3	24.1	1.3	8	0.1	10700	7.2	45.1	85.9	93.8
28	7:30	50.8	25.3	0.6	15	0.1	10800	7.5	NA	85.9	NA
29	7:30	49.6	24.1	0.5	12	0.1	10700	7.4	39.4	80.4	72.9
30	7:30	49.2	24.3	0.7	11	0.1	10800	7.5	NA	85.9	NA
31	7:30	46.0	24.2	0.5	9	0.1	10700	7.7	42.3	90.2	70.8
Feb 1	7:30	50.1	25.0	NA	8	0.1	10900	7.3	NA	NA	NA
2	7:30	49.8	24.3	NA	6	0.1	11300	7.6	NA	NA	NA
3	7:30	55.5	25.2	0.8	7	0.1	11200	7.2	45.1	87.0	78.1
4	7:30	50.3	24.4	0.8	7	0.1	11000	7.5	NA	92.4	NA
5	7:30	49.8	24.6	0.7	6	0.1	11800	7	45.1	93.5	81.3
6	7:30	50.8	26.2	1.5	5	0.1	11400	7.5	NA	92.4	NA
7	7:30	50.3	24.1	1.7	5	0.1	11200	7.4	45.1	93.5	83.3
8	7:30	51.2	24.7	NA	6	0.1	11100	7.6	NA	107.6	NA
9	7:30	51.9	25.4	NA	7	0.1	11000	7.6	NA	116.3	NA
10	7:30	49.4	24.8	2.7	7	0.3	11200	7.4	42.3	95.7	72.9
11	7:30	NA	NA	0.6	7	0.8	10700	7.4	NA	NA	NA
12	7:30	47.8	24.6	NA	6	0.1	10900	7.5	NA	77.2	NA
13	7:30	48.7	25.5	1.8	7	0.2	10700	7.5	39.4	76.1	83.3
14	7:30	48.4	24.2	1.9	6	0.1	10200	7.5	NA	76.1	NA
15	7:30	46.1	24.0	NA	12	0.1	9700	7.4	NA	84.8	NA
Num.of Anal.		45	45	28	46	46	46	46	20	42	16
Mean		47.2	24.0	0.9	9.6	0.1	10042	7.4	40.0	78.5	77.4
StandardDev.		3.2	0.8	0.6	2.7	0.1	943	0.2	3.6	12.2	7.0
Lower95%C.L.		46.2	8.8	0.0	8	0	9764	7	38.4	74.7	73.8
Upper95%C.L.		48.1	24.3	1.1	10.4	0.2	10321	7.5	41.6	82.3	80.9

CLEARWELL 5 - SAMPLE TAP SW5D ION EXCHANGE EFFLUENT

Date	Time	TH	Ca	Cl2-F	SiO2	Turb	EC	pH	Cl	Na	SO4
1986		(meq/l)		(mg/l)		(NTU)	(uS/cm)		(meq/l)		
Jan 1	7:30	2.3	3.1	NA	NA	NA	10000	NA	36.6	104.3	78.1
2	7:30	7.6	2.2	NA	NA	NA	8200	NA	31.0	100.0	114.6
3	7:30	3.5	1.2	0.1	9	0.1	10000	5.7	36.6	97.8	72.9
4	7:30	3.3	1.4	0.1	10	0.1	9300	5.7	NA	117.4	NA
5	7:30	3.5	1.3	0.1	10	0.1	9600	5.5	36.6	104.3	85.4
6	7:30	9.2	2.4	NA	11	0.1	9900	6.5	NA	102.2	NA
7	7:30	4.8	1.5	NA	10	0.1	10000	5.4	NA	108.7	NA
8	7:30	2.7	1.2	0.1	9	0.1	10600	5.4	36.6	NA	78.1
9	7:30	2.9	1.1	0.3	11	0.1	10500	5.8	NA	108.7	NA
10	7:30	2.8	1.0	0.1	8	0.1	10300	5.3	36.6	108.7	81.3
11	7:30	3.2	0.9	0.2	9	0.1	11000	6.9	NA	106.5	NA
12	7:30	3.2	0.9	0.1	10	0.1	10600	6.7	39.4	115.2	78.1
13	7:30	3.1	2.1	NA	9	0.1	10700	7.1	NA	104.3	NA
14	7:30	3.1	0.9	NA	9	0.1	10600	7	NA	106.5	NA
15	7:30	3.1	0.9	NA	10	0.1	10700	7	39.4	113.0	72.9
16	7:30	3.3	0.8	NA	10	0.1	10700	6.8	NA	104.3	NA
17	7:30	3.2	0.9	0.1	10	0.1	10600	6.9	39.4	110.9	72.9
18	7:30	3.2	0.9	0.1	9	0.6	10600	7.1	NA	115.2	NA
19	7:30	3.1	0.8	0.1	10	0.1	10600	6.4	39.4	115.2	78.1
20	7:30	3.2	0.8	NA	10	0.1	10700	6.8	NA	119.6	NA
21	7:30	3.1	0.8	NA	9	0.1	10700	6.8	NA	123.9	NA
22	7:30	3.3	0.9	0.1	11	0.1	10700	6.5	39.4	123.9	65.6
23	7:30	3.2	0.8	0.1	9	0.1	10900	7	NA	123.9	NA
24	7:30	3.3	0.9	0.1	9	0.1	10900	6.8	36.6	115.2	67.7
25	7:30	3.2	0.9	0.1	18	0.1	10700	6.9	NA	123.9	NA
26	7:30	6.2	1.6	0.1	10	0.1	11600	5.9	42.3	147.8	70.8
27	7:30	7.8	1.4	0.4	8	0.1	11750	5.5	NA	NA	NA
28	7:30	9.2	1.6	NA	7	0.2	12200	6	NA	NA	NA
29	7:30	10.3	1.8	NA	7	0.1	12000	5.4	45.1	130.4	75.0
30	7:30	10.1	1.8	0.3	7	0.1	11750	6.1	NA	150.0	NA
31	7:30	11.6	2.2	0.1	6	0.1	12500	5.1	39.4	141.3	83.3
Feb 1	7:30	10.3	1.6	0.5	5	0.1	12000	5.7	NA	141.3	NA
2	7:30	10.1	2.0	0.5	5	0.1	11900	5.6	42.3	123.9	85.4
3	7:30	11.1	2.4	0.7	NA	0.1	12100	6.3	NA	158.7	NA
4	7:30	12.5	2.6	NA	NA	0.1	11900	6.5	NA	171.7	NA
5	7:30	15.5	2.8	NA	NA	0.1	11800	5.8	42.3	121.7	88.5
6	7:30	NA	NA	1.3	NA	0.1	11300	5.8	NA	NA	NA
7	7:30	15.0	2.3	0.1	NA	0.1	11500	6.1	NA	108.7	NA
8	7:30	12.5	1.8	NA	NA	0.2	11600	5.7	39.4	113.0	135.4
9	7:30	11.4	1.7	1.0	NA	0.1	10900	6.1	NA	108.7	NA
10	7:30	13.2	1.7	1.0	NA	0.1	10400	5.9	NA	106.5	NA
Num.of Anal.		40	40	25	31	39	41	39	18	37	18
Mean		6.4	1.5	0.3	9.2	0.1	10888	6.2	38.8	118.9	82.5
StandardDev.		4.1	0.7	0.3	2.3	0.1	875	0.6	3.2	17.1	17.0
Lower95%C.L.		5.1	1.3	0.0	8.0	0.0	10614	5.0	37.3	113.1	74.4
Upper95%C.L.		7.8	1.7	0.4	10.0	0.1	11161	6.4	40.3	124.6	90.5

ION EXCHANGE FRESH BRINE
BRINE TANK 1 - SAMPLE TAP ST1D

Date	Time	Na	TH	Ca	EC	Temp.	TDS	SO4	Cl
1986		(meq/l)			(uS/cm)	(C)	(mg/l)	(meq/l)	
Feb. 6	7:30	1652.2	120.8	25.3	100500	NA	NA	1.1	774.4
7	7:30	1913.0	132.2	22.6	72300	NA	NA	1.5	703.9
8	7:30	1934.8	147.6	24.9	75300	NA	NA	NA	NA
9	7:30	2173.9	142.0	25.7	77400	NA	NA	NA	NA
10	7:30	1478.3	183.6	33.4	73000	NA	NA	0.9	732.1
11	7:30	NA	NA	NA	76000	NA	NA	NA	NA
12	7:30	456.5	191.2	30.8	90800	NA	NA	NA	NA
13	7:30	1413.0	219.8	29.9	89400	NA	NA	1.4	591.5
14	7:30	1326.1	204.0	31.4	90500	NA	NA	NA	NA
15	7:30	1869.6	NA	NA	82100	NA	NA	NA	NA
Num.of Anal.		9	8	8	10	NA	NA	4	4
Mean		1579.7	167.7	28.0	82730	NA	NA	1.2	700.5
StandardDev.		505.4	36.6	3.9	9537	NA	NA	0.3	78.2
Lower95%C.L.		1242.7	141.8	25.3	32767	NA	NA	0.9	622.3
Upper95%C.L.		1916.7	193.5	30.7	88761	NA	NA	1.5	778.7

ION EXCHANGE RECYCLED BRINE
BRINE TANK 4 - SAMPLE TAP ST4D

Date	Time	Na	TH	Ca	EC	Temp.	TDS	SO4	Cl
1986		(meq/l)			(uS/cm)	(C)	(mg/l)	(meq/l)	
Feb. 5	7:30	1500.0	349.2	64.4	99800	NA	NA	229.2	1548.7
6	7:30	1760.9	342.6	63.1	98800	NA	NA	229.2	1267.2
7	7:30	3913.0	331.6	55.6	65600	NA	NA	291.7	1123.5
8	7:30	1521.7	344.4	49.5	77400	NA	NA	NA	NA
9	7:30	1673.9	341.8	53.6	77200	NA	NA	NA	NA
10	7:30	1043.5	360.0	52.6	73400	NA	NA	312.5	1174.4
11	7:30	NA	NA	NA	72100	NA	NA	NA	NA
12	7:30	934.8	354.4	41.8	86500	NA	NA	NA	NA
13	7:30	1065.2	384.6	43.2	81800	NA	NA	270.8	1042.3
14	7:30	826.1	372.2	41.8	80600	NA	NA	NA	NA
15	7:30	978.3	NA	NA	80000	NA	NA	NA	NA
Num.of Anal.		10	9	9	11	0	0	5	5
Mean		1521.7	353.4	51.7	81200	NA	NA	266.7	1231.2
StandardDev.		904.3	16.6	8.6	10505	NA	NA	37.3	195.4
Lower95%C.L.		949.8	342.4	46.0	32767	NA	NA	233.3	923.0
Upper95%C.L.		2093.7	364.5	57.5	87534	NA	NA	300.0	1405.9

APPENDIX F

MAIN UNIT PERIOD 3 OPERATIONS

Ion-Exchange System
May and June 1986

Operation Log
Operation Parameters and Results
Test Plan

OPERATION LOG - 1986

Date	Unit	Time	Action/Comments
May 1	off	12:15	Filled T2 & 3 to 12 feet with brine from south solar pond
		17:00	Start repair of CWs 3 & 4 suction lines
2	1	12:15	Started in auto mode
	1	13:41	S/D to correct program and install printer.
		14:30	Work on IV 123 (ball valve) - stuck.
5		7:30	Replaced IV 123 with 27
		9:05	Equalize Tanks T2 & 3
	1,2	12:07	I/S in computer operation
		15:30	Started tran. pump to CW5 from CWs3 & 4 and acid pump
		15:40	S/D acid and transfer pumps - acid recir. valve would not close
		16:40	I/S acid and transfer pumps
		18:48	RO2 I/S, CW5 @ 10 ft. 5 in.
	1	19:17	IV 23 did not open - event 2
	1	19:30	Opened IV 23 manually
	1	23:59	S/D, IV 23 failed to open for events 2 and 6
6	1,2	MN Cond.	2 I/S, 1 S/D
		00:10	RO3 I/S, CW6 @ 12ft. 6 in.
		00:20	EDR failed to start
	2	3:04	S/D because of valve problems and EDR S/D
		3:10	ROs2 & 3 S/D
	2	10:55	IV 102 repaired
		14:35	ROs2 & 3 I/S
	2	15:25	I/S
	1	20:30	I/S
		22:00	CW4 bottom appears to be leaking
	1	23:30	S/D
7	2	00:05	I/S to CWs3 & 4
	2	3:05	S/D
	1	3:39	I/S to CWs3 & 4
		7:00	S/D inflow to CW4 - leaking bottom
		7:40	EDR I/S
		8:25	EDR S/D - no amp on stages 3 and 4
	1,2	8:27	S/D - CW3 full
		10:15	EDR I/S
	1,2	11:00	I/S, 2 in event 8 and 1 in event 1
		12:18	EDR S/D, no voltage in stages 2, 3 and 4
		12:45	EDR I/S
8	1	MN Cond.	I/S to CW3
	2	6:41	S/D regen out of water
	1	6:50	Service run complete and S/D
		7:00	IP6 would not run
		7:30	IP6 I/S - level probe apparently dirty
	2	8:19	I/S - regeneration
	2	9:35	Regen. complete and in service, CW3 @ 10 ft. 6 in.
9	1,2	MN Cond.	I/S to CW3
		14:00	Programmed brine transfer from T2/3 to T4 into operations program
10	1,2	MN Cond.	I/S to CW3, CW5, RO2 .... EDR, T1

OPERATION LOG - 1986

Date	Unit	Time	Action/Comments
May 10		2:39	IP6 failed to run, event10, T2 to T4 (3ft) during service. Reset breaker
	2	2:42	S/D to transfer brine to T4
	2	3:32	I/S regeneration by computer
		7:55	EDR S/D transfer pump to T1 down
		15:30	EDR I/S
		19:15	EDR transfer pump replaced
11	1,2	MN Cond.	I/S to CW3, CW5, RO2 .... EDR, T1
		00:36	Abnormalities in EDR unit - see Plant Logs
		7:30	EDR S/D , plugged brine line and rotometer
		8:45	Event10 duration changed to 30 min. from 35
		9:20	EDR I/S
12	1,2	MN Cond.	I/S to CW3, CW5, RO2 .... EDR, T1
	1,2	11:27	S/D for RO2 & 3 volumetric tests
		12:00	EDR S/D
	1	16:19	I/S @ event 8
13	1,2	MN Cond.	I/S to CW3, CW5, RO2 .... EDR, T1
		1:00	no brine flow into EDR brine tank
		2:40	EDR S/D
		6:15	T1 level at 1 ft. 9 in.
		10:15	Start repair of CW4
		10:35	EDR I/S
14	1,2	MN Cond.	I/S to CW3, CW5, RO2 .... EDR, T1
		13:30	EDR S/D
15	1,2	MN Cond.	I/S to CW3, CW5, RO2 .... EDR, T1
		8:55	Transferred brine from T2 & 3 to T4
	1,2	14:14	S/D for maintenance on IV11 - leakage through valve
	1,2	15:56	I/S, 2 in service, 1 start regeneration
16	1,2	MN Cond.	I/S to CW3, CW5, RO2 .... EDR, T1
	1,2	00:01	S/D to transfer brine from T2/3 to T4 - programmed option did not work
	1,2	00:28	I/S, 1 @ event1, 2 @ event 8
		03:30	Event12 duration changed to 20 min from 30 -> CW3 @ 2ft. 6in.
		15:08	S/D RO2 & 3 in order to start VCE
		17:00	RO3 I/S
		19:10	RO2 I/S
17	1,2	MN Cond.	I/S to CW3, CW5, RO2 .... EDR, T1
		00:05	EDR S/D, plugged line again. T1 @ 7 ft. 2in.
18	1,2	MN Cond.	I/S to CW3, CW5, RO2 .... EDR, T1
		00:45	EDR S/D - transfer pump. T1 @ 2 ft. 4 in.
	1,2	7:04	S/D, T1 empty
		11:00	EDR I/S
		12:16	RO2 low pressure switch tripped, CW5 @ 12ft. 5in.
	2	15:12	I/S to CW3
		16:16	RO3 low pressure switch tripped, CW6 @ 7ft. 9in.
	1	16:55	I/S regeneration
		18:32	RO2 I/S
		19:17	RO3 I/S
19	2	MN Cond.	I/S to CW3, CW5, RO2 .... EDR, T1

OPERATION LOG - 1986

Date	Unit	Time	Action/Comments
May 19		13:00	started filling T1 from s.solar pond
		14:20	T1 @ 2 ft. 6in.
	1	16:51	I/S
		19:00	Stopped filling T1 - 14 ft. 3 in.
		19:51	IX1 S/D - normal, but IX2 failed to go into service. Stopped and restarted computer - IX2 I/S IX1 regeneration
20	1,2	MN Cond.	I/S to CW3, CW5, RO2 .... EDR, T1
		8:15	EDR S/D for maintenance
		16:10	T1 (11 ft. 6 in.) refill from s.solar pond
		17:15	T1 @ 15 ft.
21	1,2	MN Cond.	I/S to CW3, CW5, RO2....RO3, EDR acid clean
		11:00	CW4 repairs finished - requires a few days for curing.
		13:30	EDR S/D - electrode hose came off
		13:50	EDR I/S
	1	17:28	S/D IV4 stuck
	1	19:00	I/S
22	1,2	MN Cond.	I/S to CW3, CW5, RO2 .... EDR, T1. T1 level at 10ft. 4in.
23	1,2	MN Cond.	I/S to CW3, CW5, RO2 .... EDR, T1
		7:30	EDR S/D - problems with center electrode on stack 1.
		12:00	start refilling T1 from s.solar pond
		14:10	finished refilling T1 (14 ft. 10 in.)
24	1,2	MN Cond.	I/S to CW3, CW5, RO2 ...CW6. EDR S/D
		15:18	start refilling T1 from s.solar pond
		17:00	finished refilling T1 (14 ft. 11 in.)
	1	18:10	110 gpm flow regulator causing line vibration.
25	1,2	MN Cond.	I/S to CW3, CW5, RO2 ...CW6. EDR S/D
		12:30	Note: whenever power goes off and on IX computer resets event durations to default times.
		19:20	start refilling T1 (8 ft 3 in) from south solar pond.
		20:25	finished refilling T1 (12 ft. 6 in.)
26	1,2	MN Cond.	I/S to CW3, CW5, RO2...CW6. EDR S/D
		15:35	start refilling T1 (6 ft 5 in) from south solar pond.
		16:40	finished refilling T1 (10 ft. 2 in.)
27	1,2	MN Cond.	I/S to CW3, CW5, RO2 ...CW6. EDR S/D
	1	9:56	S/D, replaced 110 gpm f.controller with 100 gpm one.
		11:13	Power failure
28	2	MN Cond.	I/S to CW3, CW5, RO2 ...CW6. IX1, EDR. VCE S/D.
		11:00	start refilling T1 from s.solar pond
29	2	MN Cond.	I/S to CW3, CW5, RO2 ...CW6. IX1, EDR. VCE S/D.
	2	11:38	auto S/D by computer to make program modification.
	2	18:26	I/S to CW3
30	2	MN Cond.	I/S to CW3, CW5, RO2 ...CW6. IX1, EDR. VCE S/D.
		10:30	finished refilling T1 (5'8" to 10'2")
31	2	MN Cond.	I/S to CW3, CW5, RO2 ...CW6. IX1, EDR. VCE S/D.
		8:15	start refilling T1 (8 ft) from s.solar pond
		11:45	finished refilling T1 (full)
June 1	2	MN Cond.	I/S to CW3, CW5, RO2 ...CW6. IX1, EDR. VCE S/D.

OPERATION LOG - 1986

Date	Unit	Time	Action/Comments
June 2	2	MN Cond.	I/S to CW3, CW5, RO2 ...CW6. IX1, EDR. VCE S/D.
		8:20	refilled T1 from s.solar pond
		14:25	RO2 & 3 S/D
	2	15:15	S/D after event3. Ready for event4
		17:50	RO2 & 3 I/S
	2	18:55	I/S event4
3	2	MN Cond.	I/S to CW3, CW5, RO2 ...CW6. IX1, EDR S/D
		8:40	refilled T1 from s.solar pond
		11:30	parity chip added to IX computer to facilitate printer.
		12:50	IX printer working
4	2	MN Cond.	I/S to CW3, CW5, RO2 ...CW6. IX1, EDR S/D
	2	00:45	I/S @ 110 gpm
	1	00:47	I/S by hand oper. - regen.
	2	10:00	I/S @ 230 gpm to CW3. Single unit operation until further notice.
		11:30	refilled T1 from s.solar pond
5	2	MN Cond.	I/S to CW3, CW5, RO2 ...CW6. IX1, EDR S/D
		10:30	start refilling T1 (5 ft 5 in) from south solar pond.
		13:30	finished refilling T1 (13 ft 2 in)
6	2	MN Cond.	I/S to CW3, CW5, RO2 ...CW6. IX1, EDR S/D
		10:30	start refilling T1 (7 ft 6 in) from south solar pond.
7	2	MN Cond.	I/S to CW3, CW5, RO2 ...CW6. IX1, EDR S/D
		9:30	changed event12 to 60 min. from 50
		12:30	changed event12 to 80 min. from 60
8	2	MN Cond.	I/S to CW3, CW5, RO2 ...CW6. IX1, EDR S/D
		10:00	changed event12 to 90 min. from 80
		13:35	Installation of Ec probe in IX2's effluent line.
9	2	MN Cond.	I/S to CW3, CW5, RO2 ...CW6. IX1, EDR and RO3-blockB S/D.
		11:00	brine transfer to T1 from s.solar pond
10	2	MN Cond.	I/S to CW3, CW5, RO2 ...CW6. IX1, EDR and RO3-blockB S/D.
		9:15	Changed durations for events1 & 2 to 13 and 39.
		13:30	S/D RO2 & 3
	2	14:03	S/D after event3. Ready for event4

IX System was S/D for rest of month

ION EXCHANGE OPERATION PARAMETERS
Month: May and June, 1986

Date	Service Flow (gpm)	Service Duration (min)	Resin Volume (liters)	Recycle Brine Flow (gpm)	Recycle Brine Duration (min)	Fresh Brine Flow (gpm)	Fresh Brine Duration (min)
May 1			IX System OFF				
2	110	180	4840	200	42	150	8
3	110	180	4840	200	42	150	8
4	110	180	4840	200	42	150	8
5	110	180	4840	200	42	150	8
6	110	180	4840	200	42	150	8
7	110	180	4840	200	42	150	8
8	110	180	4840	200	52	150	8
9	110	180	4840	200	52	150	8
10	110	180	4840	200	52	150	8
11	110	180	4840	200	52	150	8
12	110	180	4840	200	35	150	15
13	110	180	4840	200	35	150	15
14	110	180	4840	200	35	150	15
15	110	180	4840	200	35	150	15
16	110	180	4840	200	52	150	8
17	110	180	4840	200	52	150	8
18	110	180	4840	200	52	150	8
19	110	180	4840	200	52	150	8
20	110	180	4840	200	52	150	8
21	110	180	4840	200	52	150	8
22	110	180	4840	200	52	150	8
23	110	180	4840	200	52	150	8
24	110	180	4840	200	52	150	8
25	110	180	4840	200	52	150	8
26	110	180	4840	200	52	150	8
27	230	90	4840	200	52	150	8
28	230	90	4840	200	52	150	8
29	230	90	4840	200	52	150	8
30	230	90	4840	200	52	150	8
31	230	90	4840	200	52	150	8
Jun 1	230	90	4840	200	52	150	8
2	230	90	4840	200	52	150	8
3	230	90	4840	200	52	150	8
4	230	90	4840	200	52	150	8
5	230	90	4840	200	52	150	8
6	230	90	4840	200	52	150	8
7	230	90	4840	200	52	150	8
8	230	90	4840	200	52	150	8
9	230	90	4840	200	52	150	8
10	230	90	4840	200	52	150	8

OPERATION RESULTS

Comparison of Total Hardness and Sodium in Regenerant Brines
Month: May and June, 1986

	Recycle Brine			Fresh Brine		
	TH	Na	Ratio	TH	Na	Ratio
Date	(meq/l)	(meq/l)	Na:TH	(meq/l)	(meq/l)	Na:TH
May 1		IX System OFF				
2	300.0	2000.0	6.7	220.0	2173.9	9.9
3	NA	NA	NA	NA	NA	NA
4	NA	NA	NA	NA	NA	NA
5	NA	NA	NA	NA	NA	NA
6	NA	NA	NA	NA	NA	NA
7	260.0	134.8	0.5	220.0	1217.4	5.5
8	280.0	1391.3	5.0	220.0	2260.9	10.3
9	280.0	1173.9	4.2	220.0	2347.8	10.7
10	260.0	1173.9	4.5	280.0	2434.8	8.7
11	260.0	1130.4	4.3	300.0	2565.2	8.6
12	252.0	1043.5	4.1	310.0	2782.6	9.0
13	255.0	956.5	3.8	303.4	2304.3	7.6
14	249.2	826.1	3.3	301.0	2087.0	6.9
15	248.0	782.6	3.2	288.0	1869.6	6.5
16	246.0	652.2	2.7	294.0	1652.2	5.6
17	244.0	739.1	3.0	302.0	1782.6	5.9
18	238.0	739.1	3.1	274.0	1695.7	6.2
19	244.0	652.2	2.7	280.0	1043.5	3.7
20	NA	652.2	NA	NA	2173.9	NA
21	260.0	521.7	2.0	220.0	1608.7	7.3
22	NA	NA	NA	NA	NA	NA
23	280.0	565.2	2.0	200.0	1130.4	5.7
24	52.8	608.7	11.5	39.6	1521.7	38.4
25	260.0	608.7	2.3	198.4	1652.2	8.3
26	260.0	521.7	2.0	200.0	1565.2	7.8
27	260.0	652.2	2.5	200.0	1521.7	7.6
28	50.8	608.7	12.0	36.0	1565.2	43.5
29	260.0	608.7	2.3	200.0	1521.7	7.6
30	280.0	652.2	2.3	199.6	1565.2	7.8
31	300.0	652.2	2.2	200.0	1608.7	8.0
June 1	300.0	652.2	2.2	200.0	1565.2	7.8
2	300.0	652.2	2.2	200.0	1565.2	7.8
3	320.0	695.7	2.2	200.0	1434.8	7.2
4	340.0	739.1	2.2	200.0	1521.7	7.6
5	300.0	652.2	2.2	200.0	1565.2	7.8
6	320.0	695.7	2.2	200.0	1521.7	7.6
7	340.0	739.1	2.2	200.0	1521.7	7.6
8	320.0	695.7	2.2	220.0	1565.2	7.1
9	340.0	739.1	2.2	200.0	1521.7	7.6
10	340.0	739.1	2.2	200.0	1521.7	7.6

CLEARWELL 2 - SAMPLE TAP SW2D ION EXCHANGE INFLUENT

Date	Time	TH	Ca	Cl2-F	SiO2	Turb	EC	pH	Cl	Na	SO4	TOC
1986		(meq/l)		(mg/l)		(NTU)	(uS/cm)		(meq/l)			(mg/l)
May 1	7:30	49.2	23.1	0.5	5.0	0.1	10900	7.7	43.4	87.0	84.4	NA
6	7:30	NA	NA	NA	NA	NA	NA	NA	43.6	89.1	93.8	NA
7	7:30	NA	NA	NA	NA	NA	NA	NA	NA	91.3	NA	21
8	7:30	50.0	26.7	0.2	5.0	0.1	11200	7.8	45.1	91.3	83.3	NA
9	7:30	40.8	27.2	0.1	5.0	0.1	11500	7.8	NA	93.5	NA	18
10	7:30	50.2	27.5	0.1	5.0	0.2	11600	7.6	NA	95.7	NA	NA
11	7:30	49.8	26.5	0.1	5.0	0.1	11700	7.6	NA	100.0	NA	NA
12	7:30	50.8	27.0	0.3	5.0	0.2	11500	7.4	NA	102.2	NA	NA
13	7:30	50.0	27.1	0.2	5.0	0.1	11400	7.3	46.5	97.8	89.6	NA
14	7:30	50.1	27.7	0.2	5.0	0.1	11400	5.7	NA	93.5	NA	10
15	7:30	51.2	27.3	NA	5.0	0.1	11400	7.6	46.5	95.7	91.7	NA
16	7:30	50.3	29.3	0.1	5.0	0.1	11900	7.9	NA	82.6	NA	10
17	7:30	51.2	27.7	NA	5.0	0.1	11900	7.7	NA	87.0	NA	NA
18	7:30	52.6	28.0	0.1	5.0	0.1	11900	7.9	NA	NA	NA	NA
19	7:30	51.4	27.2	0.1	5.0	0.1	11900	7.7	NA	73.9	NA	NA
20	7:30	NA	NA	0.1	5.0	0.1	12200	7.9	47.3	73.9	83.3	NA
21	7:30	50.6	27.5	0.1	5.0	0.1	12100	7.6	NA	100.0	NA	10
22	7:30	52.3	27.1	0.1	5.0	0.1	12000	7.6	54.1	106.5	93.8	NA
23	7:30	51.6	26.5	0.1	5.0	0.1	12400	7.9	NA	100.0	NA	10
24	7:30	50.4	26.5	NA	5.0	0.1	12500	7.5	NA	104.3	NA	NA
25	7:30	47.2	23.6	0.1	5.0	0.1	13200	7.7	NA	119.6	NA	NA
26	7:30	47.6	24.4	0.1	5.0	0.1	13300	7.7	NA	117.4	NA	10
27	7:30	47.6	23.7	0.1	5.0	0.1	13800	7.54	67.6	106.5	85.4	NA
28	7:30	46.6	22.5	0.1	5.0	0.1	13200	7.6	NA	113.0	NA	NA
29	7:30	45.8	21.5	0.1	5.0	0.1	13500	7.6	80.3	110.9	93.8	NA
30	7:30	46.2	22.5	0.1	5.0	0.1	13500	7.8	NA	113.0	NA	10
31	7:30	48.8	21.0	NA	5.0	0.1	13800	7.5	NA	115.2	NA	NA
June 1	7:30	51.4	22.5	0.1	5.0	0.1	14400	7.5	NA	137.4	NA	NA
2	7:30	52.0	23.5	0.1	5.0	0.1	14700	7.4	NA	135.2	NA	10
3	7:30	55.2	20.5	0.1	5.0	0.3	14900	6.6	74.6	135.2	95.8	NA
4	7:30	46.6	19.5	0.1	5.0	0.3	15200	6.8	NA	135.2	NA	10
5	7:30	48.8	21.0	0.1	5.0	0.2	14900	7.1	78.9	144.3	102.1	NA
6	7:30	51.0	23.0	NA	5.0	2.1	15000	6.5	NA	144.3	NA	10
7	7:30	47.2	22.5	NA	5.0	1.6	15500	7.8	NA	148.7	NA	NA
8	7:30	48.6	22.5	0.1	5.0	1.6	15400	7.7	NA	146.5	NA	NA
9	7:30	53.8	20.5	0.1	5.0	0.2	15100	7.8	NA	139.6	NA	10
10	7:30	51.6	35.0	0.1	5.0	0.8	14500	8	70.4	128.7	95.8	NA
Num.of Anal.		34	34	29	35	35	35	35	12	36	12	12
Mean		49.7	25.1	0.1	5.0	0.3	13009	7.5	58.2	109.9	924.4	11.6
StandardDev.		2.7	3.3	0.1	0.0	0.5	1464	0.5	14.9	21.6	5.9	3.8
Lower95%C.L		48.7	24.0	0.0	5.0	0.0	12508	7.0	49.6	102.6	87.6	9.0
Upper95%C.L		50.6	26.2	0.2	5.0	0.5	13509	7.7	66.8	117.2	94.5	13.8

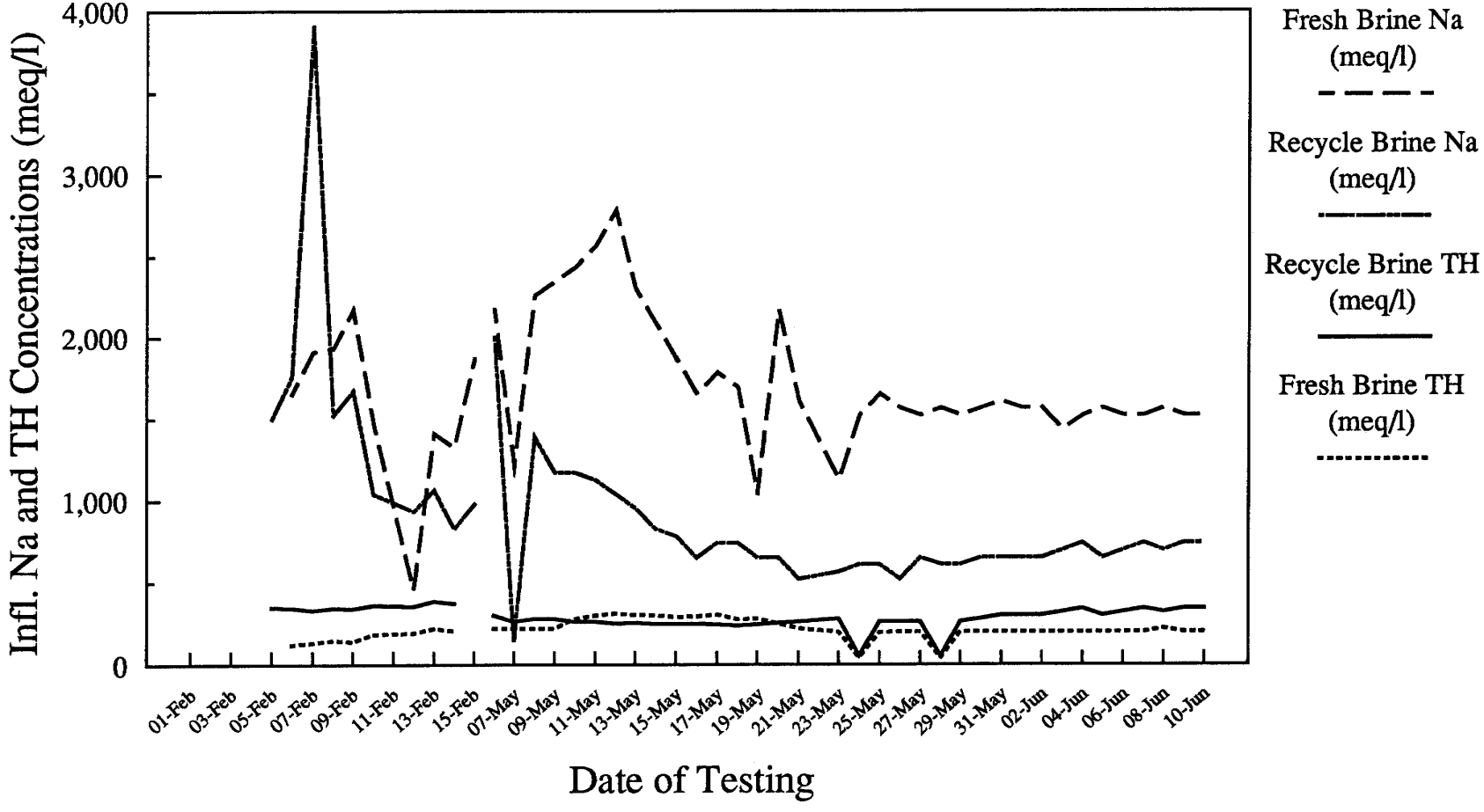
CLEARWELL 5 - SAMPLE TAP SW5D ION EXCHANGE EFFLUENT

Date	Time	TH	Ca	Cl2-F	SiO2	Turb	EC	pH	Cl	Na	SO4
1986		(meq/l)		(mg/l)		(NTU)	(uS/cm)		(meq/l)		
May 1	7:30	39.8	8.1	0.1	NA	0.1	17800	7.7	90.1	178.3	120.8
7	7:30	NA	NA	NA	NA	NA	NA	NA	NA	89.1	NA
8	7:30	23.2	3.9	0.1	NA	0.1	13200	6	56.3	128.3	100.0
9	7:30	21.4	4.7	0.1	NA	0.1	13200	5.3	NA	143.5	NA
10	7:30	36.2	8.0	0.1	NA	0.2	14400	5.6	NA	139.1	NA
11	7:30	30.6	6.0	0.1	NA	0.1	13600	5.5	NA	137.0	NA
12	7:30	32.1	6.3	0.1	NA	0.1	13100	4.7	NA	137.0	NA
13	7:30	37.2	7.2	0.1	NA	0.1	13600	7.3	68.3	137.0	110.4
14	7:30	30.7	6.8	0.1	NA	0.1	12000	5.6	NA	123.9	NA
15	7:30	36.3	7.2	NA	NA	0.1	12500	5.7	51.3	119.6	93.8
16	7:30	33.4	8.3	0.1	NA	0.1	12200	5.4	NA	100.0	NA
17	7:30	32.1	6.8	NA	0.5	0.1	12200	5.1	NA	100.0	NA
18	7:30	30.4	6.0	0.1	0.5	0.1	12300	5.1	NA	104.3	NA
19	7:30	31.3	6.8	0.1	0.5	0.1	12200	5.4	NA	82.6	NA
20	7:30	NA	NA	0.1	NA	0.1	13100	5.5	46.5	87.0	112.5
21	7:30	22.6	4.0	0.1	0.5	0.1	12900	5.7	NA	126.1	NA
22	7:30	21.6	3.8	0.1	NA	0.1	12800	5.4	51.3	139.1	91.7
23	7:30	23.8	5.0	0.1	NA	0.1	12900	5.8	NA	126.1	NA
24	7:30	22.8	5.0	NA	0.5	0.1	12800	4.6	NA	130.4	NA
25	7:30	22.6	5.2	0.1	0.5	0.1	13700	5.5	NA	143.5	NA
26	7:30	23.8	5.4	0.1	0.5	0.4	13700	6.1	NA	137.0	NA
27	7:30	23.2	5.4	0.1	NA	0.1	13800	4.9	67.6	126.1	104.2
28	7:30	23.6	5.6	0.1	0.5	0.1	13700	5.6	NA	126.1	NA
29	7:30	24.6	11.5	0.1	NA	0.1	13900	5.3	80.3	128.3	87.5
30	7:30	24.2	6.0	0.1	0.5	0.7	13900	NA	NA	121.7	NA
31	7:30	24.4	6.0	NA	0.5	0.8	14300	6.1	NA	143.5	NA
Jun 1	7:30	29.0	10.0	0.1	0.5	1.3	14600	6.3	NA	150.9	NA
2	7:30	37.4	10.0	0.1	0.5	0.1	14900	5.2	NA	155.2	NA
3	7:30	34.8	7.0	0.1	NA	0.2	15300	4.6	70.4	148.7	93.8
4	7:30	19.0	5.0	0.1	0.5	0.4	15500	4.8	NA	155.2	NA
5	7:30	30.8	8.0	NA	NA	0.2	15000	5.7	76.1	159.6	97.9
6	7:30	28.2	7.5	NA	0.5	0.1	15400	4	NA	157.4	NA
7	7:30	29.2	9.0	0.1	0.5	0.2	15600	3.8	NA	159.6	NA
8	7:30	30.2	11.5	0.1	0.5	0.6	15800	5.6	NA	166.5	NA
9	7:30	30.0	8.0	0.1	0.5	0.8	15700	6.2	NA	159.6	NA
10	7:30	33.8	9.0	0.1	NA	0.9	15100	5.8	69.0	150.9	83.3
Num.of Anal.		34	34	29	18	35	35	34	11	36	11
Mean		49.7	25.1	0.1	5.0	0.3	13906	5.5	66.1	133.8	99.6
StandardDev.		2.7	3.3	0.1	0.0	0.5	1329	0.8	13.5	23.0	11.4
Lower95%C.L.		48.7	24.0	0.0	5.0	0.0	13451	5.0	57.9	126.1	92.7
Upper95%C.L.		50.6	26.2	0.2	5.0	0.5	13509	5.8	74.3	141.6	106.5

Influent Total Hardness and Sodium Concentration

Ion Exchange Regenerant Brines

February and May through June, 1986



ION EXCHANGE FRESH BRINE
BRINE TANK 1 - SAMPLE TAP ST1D

Date	Time	Na	TH	Ca	EC	Temp.	TDS	SO4	Cl
1986		(meq/l)			(uS/cm)	(C)	(mg/l)	(meq/l)	
May 1	7:30	2130	244	39.0	73400	18.0	NA	NA	NA
2	7:30	2174	220	45.6	74400	NA	NA	NA	NA
7	7:30	1217	220	37.0	74700	NA	NA	NA	NA
8	7:30	2261	220	35.8	82000	NA	NA	NA	NA
9	7:30	2348	220	41.4	77600	NA	NA	NA	NA
10	7:30	2435	280	35.8	78000	NA	NA	NA	NA
11	7:30	2565	300	35.0	78000	NA	NA	NA	NA
12	7:30	2783	310	32.6	77000	NA	NA	NA	NA
13	7:30	2304	303	34.2	77000	NA	NA	NA	NA
14	7:30	2087	301	39.8	65400	NA	NA	NA	NA
15	7:30	1870	288	38.6	61000	NA	NA	813	479
16	7:30	1652	294	32.6	71000	NA	NA	NA	NA
17	7:30	1783	302	31.8	67700	NA	NA	NA	NA
18	7:30	1696	274	34.4	64000	NA	NA	NA	NA
19	7:30	1043	280	30.7	68000	NA	NA	NA	NA
20	7:30	2174	NA	NA	112700	NA	NA	469	1549
21	7:30	1609	220	42.0	89100	NA	NA	NA	NA
22	7:30	NA	NA	NA	92800	NA	NA	521	1268
23	7:30	1130	200	44.0	71800	NA	NA	NA	NA
24	7:30	1522	40	10.1	101500	NA	NA	NA	NA
25	7:30	1652	198	47.4	107000	NA	NA	NA	NA
26	7:30	1565	200	44.2	112000	NA	NA	NA	NA
27	7:30	1522	200	48.4	107500	NA	NA	521	1577
28	7:30	1565	36	48.5	109100	NA	NA	NA	NA
29	7:30	1522	200	55.0	112300	NA	NA	469	1493
30	7:30	1565	200	50.0	106800	NA	NA	NA	NA
31	7:30	1609	200	55.0	108700	NA	NA	NA	NA
June 1	7:30	1565	200	50.0	97600	NA	NA	NA	NA
2	7:30	1565	200	55.0	106600	NA	NA	NA	NA
3	7:30	1435	200	50.0	107400	NA	NA	333	1437
4	7:30	1478	200	55.0	108300	NA	NA	NA	NA
5	7:30	1522	200	55.0	107800	NA	NA	333	1324
6	7:30	1435	200	55.0	88400	NA	NA	NA	NA
7	7:30	1522	200	65.0	89100	NA	NA	NA	NA
8	7:30	1565	220	55.0	94800	NA	NA	NA	NA
9	7:30	1522	200	55.0	98000	NA	NA	NA	NA
10	7:30	1522	200	50.0	97600	NA	NA	354	1408
Num.of Anal.		36	35	35	37	1	0	8	8
Mean		1748	61	43.8	89627	18.0	NA	477	1317
StandardDev.		1425	201	10.7	16710	NA	NA	157	355
Lower95%C.L.		1885	243	40.2	32767	NA	NA	365	923
Upper95%C.L.		1917	243	47.5	95179	NA	NA	588	1568

BRINE TANK 4 - SAMPLE TAP ST4D

Date	Time	Na	TH	Ca	EC	Temp.	TDS	SO4	Cl
1986		(meq/l)			(uS/cm)	(C)	(mg/l)	(meq/l)	
May 1	7:30	1957	296	34.4	75700	NA	NA	NA	NA
6	7:30	2000	300	41.0	76700	NA	NA	NA	NA
7	7:30	1348	260	35.9	68100	NA	NA	NA	NA
8	7:30	1391	280	38.6	65700	NA	NA	NA	NA
9	7:30	1174	280	40.2	57100	NA	NA	NA	NA
10	7:30	1174	260	37.5	54000	NA	NA	NA	NA
11	7:30	1130	260	40.0	52000	NA	NA	NA	NA
12	7:30	1043	252	37.6	49000	NA	NA	NA	NA
13	7:30	957	255	41.8	48000	NA	NA	NA	NA
14	7:30	826	249	42.8	44200	NA	NA	NA	NA
15	7:30	783	248	41.0	44000	NA	NA	229	507
16	7:30	652	246	39.4	47600	NA	NA	NA	NA
17	7:30	739	244	34.8	44500	NA	NA	NA	NA
18	7:30	739	238	37.0	4500	NA	NA	NA	NA
19	7:30	652	244	38.4	4600	NA	NA	NA	NA
20	7:30	652	NA	NA	49600	NA	NA	242	507
21	7:30	522	260	46.0	50100	NA	NA	NA	NA
22	7:30	NA	NA	NA	53900	NA	NA	188	620
23	7:30	565	280	0.0	58300	NA	NA	NA	NA
24	7:30	609	53	9.7	56600	NA	NA	NA	NA
25	7:30	609	260	48.8	63000	NA	NA	NA	NA
26	7:30	522	260	0.0	64000	NA	NA	NA	NA
27	7:30	652	260	65.0	60900	NA	NA	167	845
28	7:30	609	51	60.0	62800	NA	NA	NA	NA
29	7:30	609	260	70.0	63900	NA	NA	133	761
30	7:30	652	280	70.0	67100	NA	NA	NA	NA
31	7:30	739	300	70.0	69700	NA	NA	NA	NA
June 1	7:30	739	300	75.0	68800	NA	NA	NA	NA
2	7:30	739	300	85.0	75300	NA	NA	NA	NA
3	7:30	783	320	90.0	77300	NA	NA	NA	NA
4	7:30	783	340	95.0	79100	NA	NA	NA	NA
5	7:30	826	300	85.0	75200	NA	NA	146	901
6	7:30	652	320	85.0	67700	NA	NA	NA	NA
7	7:30	739	340	95.0	68800	NA	NA	NA	NA
8	7:30	783	320	95.0	70800	NA	NA	NA	NA
9	7:30	696	340	90.0	72900	NA	NA	NA	NA
10	7:30	739	340	95.0	74700	NA	NA	117	1042
Num.of Anal.		35	35	35	37	0	0	7	7
Mean		855	268	83.1	61300	NA	NA	174	740
StandardDev.		351	63	106.8	11241	NA	NA	48	205
Lower95%C.L.		737	247	46.7	32767	NA	NA	138	586
Upper95%C.L.		973	290	119.6	65035	NA	NA	210	895

State of California DEPARTMENT OF WATER RESOURCES The Resources Agency

OFFICE MEMO

TO: Distribution List	DATE: April 23, 1986
	SUBJECT: Six-Week Desalting Test Plan Startup
FROM: Brian Smith	

Attached is a set of three operation test plans that were developed for the Los Banos facility. Please review these and prepare for startup of Desalting Test 1 on Monday, April 28.

General startup and operation instructions and other instructions and information concerning the ion-exchange system are also attached. The ion-exchange system is to be operated in the dry run mode immediately.

Basically each test plan is for a period of two weeks. The first two test plans employ the IX/RO2/RO3/EDR process flow scheme. The third test plan uses IX/RO1/RO2/RO3 process flow scheme.

All three plans will use brine generated from the third desalting stage to regenerate the ion-exchange resin. Test 1 will concentrate brine to the maximum allowable (one bed volume) as dictated by the ion-exchange regeneration process. Test 2 concentrates the brine to a concentration similar to that brine which will be generated in Test 3. Other information concerning operation parameters and other factors are contained in the individual test plan.

If you have any questions in this regard, please phone me at (209) 445-5487 or Kurt Kovac at (209) 445-5578.

Attachments

Distribution List

Tony Castaneda
Bob Clark
Mark Cowin
Sylvia Hedlind
Dale Hoffman-Floerke
Kurt Kovac
Riz Parangalan
Kenji Yamamoto

DWR 100a (Est. 4/80)

☐ OVER

13826-750 250 M - OCP

DESALTING TEST 1

Purpose

The purpose of Test 1 is to operate on a continuous basis during the entire process of softening and desalting of the agricultural drainage water while employing the reject brine from the desalting process to regenerate the softening resin. The volume of reverse-osmosis reject brine produced in Test 1 is the minimum amount as required by the softening process.

Test Period

Test 1 is to last for a period of two weeks. Testing within this time frame will enable the systems to stabilize so that proper evaluation of the systems can be made.

System Operation Parameters

The treatment systems are to be operated according to the parameters that are listed below.

Ion-Exchange: Service flow = 110 gallons per minute.
Fresh brine volume = 1,280 gallons.
Brine contact time = 50 minutes.

The ion-exchange system is to be operated according to the attached schedules. There are two schedules for Test 1, one for each week. Week 1's schedule enables the ion-exchange system to build an adequate volume of recycled regenerated brine in Tanks 2, 3, and 4 by wasting only one-half the volume of brine regenerated during the ion-exchange cycle. Week 2's schedule wastes the entire brine volume that is generated during the cycle.

Desalting:

Unit	Flows (gpm)	
	Influent	Brine
RO2	92	46
RO3	46	23
EDR	23	6

Data Collection and Sampling

The data collected will be as determined by equipment manufacturers and as otherwise directed by plant engineering. The schedule for sampling and analyses performed is listed below.

Location	Tap Number	Analyses Performed
		Sunday, Monday, Wednesday, Friday, and Saturday
CW1	SW1D	Na, TH, Ca, Cl_{2f}, SiO_2, Turb., EC, pH, Temp.
CW2	SW2D	Na, TH, Ca, Cl_{2f}, SiO_2, Turb., EC, pH
CW3	SW3D	Na, TH, Ca, CL_{2f}, SiO_2, Turb., EC, pH
CW5	SW5D	Na, TH, Ca, CL_{2f}, SiO_2, Turb., EC, pH
CW6	SW6D	Na, TH, Ca, CL_{2f}, SiO_2, Turb., EC, pH
CW8	SW8D	Na, TH, Ca, SiO_2, Turb., EC, pH
T1	ST1D	Na, TH, Ca, EC, Temp.
T2	ST2D	Na, TH, Ca, EC
T3	ST3D	Na, TH, Ca, EC
T4	ST4D	Na, TH, Ca, EC
		Tuesday and Thursday
CW1	SW1D	Na, TH, Ca, Cl_{2f}, SiO_2, Turb., EC, pH, Temp., SO_4, Cl
CW2	SW2D	Na, TH, Ca, Cl_{2f}, SiO_2, Turb., EC, pH, SO_4, Cl
CW3	SW3D	Na, TH, Ca, Cl_{2f}, SiO_2, Turb., EC, pH, SO_4, Cl
CW5	SW5D	Na, TH, Ca, Cl_{2f}, SiO_2, Turb., EC, pH, SO_4, Cl
CW6	SW6D	Na, TH, Ca, Cl_{2f}, SiO_2, Turb., EC, pH, SO_4, Cl
CW8	SW8D	Na, TH, Ca, SiO_2, Turb., EC, pH, SO_4, Cl
T1	ST1D	Na, TH, Ca, EC, Temp., SO_4, Cl
T2	ST2D	Na, TH, Ca, EC, SO_4, Cl
T3	ST3D	Na, TH, Ca, EC, SO_4, Cl
T4	ST4D	Na, TH, Ca, EC, SO_4, Cl
		Twice Daily (Morning and Afternoon)
Filter 1	SF1E	SDI
Filter 2	SF2E	SDI
CW2	SW2D	SDI
CW5	SW5D	SDI
CW6	SW6D	SDI

LOS BANOS DEMONSTRATION DESALTING FACILITY
ION-EXCHANGE OPERATIONS SCHEDULE
REVERSE-OSMOSOS/ELECTRODIALYSIS BRINE REGENERATION
April 28, 1986

Test 1, Week 1.
Two-unit continuous operation.
Service flow at 110 gallons per minute.

Waste brine to IX sump.
Used brine to T2 or T3.
Rinse to RWPS.

Event Number	Event Description	Duration (minutes)	Component Operation or Valve Open		Process Flow		
			Unit 1	Unit 2	Unit	From	To
1	Recycled brine regeneration 1	10	IP 5, A 1 IV 15,12,7,9,22	IP 5, A 2 IV 115,112,107,109,122	1 2	T4 T4	IX sump IX sump
2	Recycled brine regeneration 2	32	IP 5, A 1 IV 15,12,7,4,23	IP 5, A 2 IV 115,112,107,104,123	1 2	T4 T4	T2 T3
3	Fresh brine regeneration	8	IP 1, A 1 IV 17,39m,13,7,4,23	IP 1, A 2 IV 18,139m,113,107,104,123	1 2	T1 T1	T2 T3
4	Rinse A	5	IP 7, A 1 IV 1,7,19,23	IP 9, A 2 IV 101,107,119,123	1 2	CW1 CW2	T2 T3
5	Rinse B	4	IP 7, A 1 IV 2,7,19,23	IP 9, A 2 IV 102,107,119,123	1 2	CW1 CW2	T2 T3
6	Rinse C	0	IP 7, A 1 IV 2,7,10,22	IP 9, A 2 IV 102,107,110,122	1 2	CW1 CW2	IX sump IX sump
7	Rinse D	16	IP 7 IV 2,7,10,21	IP 9 IV 102,107,110,121	1 2	CW1 CW2	RWPS RWPS
8	Service	180	IP 7 IV 1,7,11 CSOV 1	IP 9 IV 101,107,111 CSOV 6	1 2	CW1 CW2	CW3 CW3
9	Settling in T2 or T3 during service	120	A 1*	A 2*	1 2	Settling in T2 Settling in T3	
10	Set up for regeneration to T4 during service	28	IP 6 IV 5	IP 6 IV 105	1 2	T2 T3	T4 T4
11	Drain	3	IV 6,10,21 A 1	IV 106,110,121 A 2	1 2	Unit 1 Unit 2	RWPS RWPS
12	Delay	32	A 1	A 2			

*Agitators are not in operation during event 7 and part of event 8. Agitators are placed back into operation after event 10 is completed during event 8. (During all other events, agitators are in operation.)

Abbreviations:
A = agitator
CW = clearwell
CSOV = chlorine solenoid valve
IP = ion-exchange pump
IV = ion-exchange valve
IX = ion exchange
m = manual valve
RWPS = return water pump station
T = brine tank

LOS BANOS DEMONSTRATION DESALTING FACILITY
ION-EXCHANGE OPERATIONS SCHEDULE
REVERSE-OSMOSOS/ELECTRODIALYSIS BRINE REGENERATION
May 5, 1986

Test 1, Week 2.
Two-unit continuous operation.
Service flow at 110 gallons per minute.

Waste brine to IX sump.
Used brine to T2 or T3.
Rinse to RWPS.

Event Number	Event Description	Duration (minutes)	Component Operation or Valve Open: Unit 1	Component Operation or Valve Open: Unit 2	Process Flow: Unit	Process Flow: From	Process Flow: To
1	Recycled brine regeneration 1	13	IP 5, A 1 IV 15,12,7,9,22	IP 5, A 2 IV 115,112,107,109,122	1 2	T4 T4	IX sump IX sump
2	Recycled brine regeneration 2	29	IP 5, A 1 IV 15,12,7,4,23	IP 5, A 2 IV 115,112,107,104,123	1 2	T4 T4	T2 T3
3	Fresh brine regeneration	8	IP 1, A 1 IV 17,39m,13,7,4,23	IP 1, A 2 IV 18,139m,113,107,104,123	1 2	T1 T1	T2 T3
4	Rinse A	5	IP 7, A 1 IV 1,7,19,23	IP 9, A 2 IV 101,107,119,123	1 2	CW1 CW2	T2 T3
5	Rinse B	4	IP 7, A 1 IV 2,7,19,23	IP 9, A 2 IV 102,107,119,123	1 2	CW1 CW2	T2 T3
6	Rinse C	0	IP 7, A 1 IV 2,7,10,22	IP 9, A 2 IV 102,107,110,122	1 2	CW1 CW2	IX sump IX sump
7	Rinse D	16	IP 7 IV 2,7,10,21	IP 9 IV 102,107,110,121	1 2	CW1 CW2	RWPS RWPS
8	Service	180	IP 7 IV 1,7,11 CSOV 1	IP 9 IV 101,107,111 CSOV 6	1 2	CW1 CW2	CW3 CW3
9	Settling in T2 or T3 during service	120	A 1*	A 2*	1 2	Settling in T2 Settling in T3	
10	Set up for regeneration to T4 during service	28	IP 6 IV 5	IP 6 IV 105	1 2	T2 T3	T4 T4
11	Drain	3	IV 6,10,21 A 1	IV 106,110,121 A 2	1 2	Unit 1 Unit 2	RWPS RWPS
12	Delay	32	A 1	A 2			

*Agitators are not in operation during event 7 and part of event 8. Agitators are placed back into operation after event 10 is completed during event 8. (During all other events, agitators are in operation.)

Abbreviations:
A = agitator
CW = clearwell
CSOV = chlorine solenoid valve
IP = ion-exchange pump
IV = ion-exchange valve
IX = ion exchange
m = manual valve
RWPS = return water pump station
T = brine tank

DESALTING TEST 2

Purpose

The purpose of Test 2 is to operate on a continuous basis during the entire process of softening and desalting of the agricultural drainage water while employing the reject brine of the desalting process to regenerate the softening resin. The reverse-osmosis reject brine produced for Test 2 is similar in volume (for regeneration concerns) and concentration as that produced when all three reverse-osmosis systems are in operation.

Test Period

Test 2 is to last for a period of two weeks. Testing within this time frame will enable the systems to stabilize so that proper evaluation of the systems can be made.

System Operation Parameters

The treatment systems are to be operated according to the parameters that are listed below.

Ion-Exchange: Service flow = 110 gallons per minute.
Fresh brine volume = 2,240 gallons.
Brine contact time = 50 minutes.

The ion-exchange system is to be operated according to the attached schedule.

Desalting:

Unit	Flows (gpm)	
	Influent	Brine
RO2	92	46
RO3	46	23
EDR	23	9

Data Collection and Sampling

The data collected will be as determined by equipment manufacturers and as otherwise directed by plant engineering. The schedule for sampling and analyses performed is listed below.

Location	Tap Number	Analyses Performed
		Sunday, Monday, Wednesday, Friday, and Saturday
CW1	SW1D	Na, TH, Ca, Cl_{2f}, SiO_2, Turb., EC, pH, Temp.
CW2	SW2D	Na, TH, Ca, Cl_{2f}, SiO_2, Turb., EC, pH
CW3	SW3D	Na, TH, Ca, CL_{2f}, SiO_2, Turb., EC, pH
CW5	SW5D	Na, TH, Ca, CL_{2f}, SiO_2, Turb., EC, pH
CW6	SW6D	Na, TH, Ca, CL_{2f}, SiO_2, Turb., EC, pH
CW8	SW8D	Na, TH, Ca, SiO_2, Turb., EC, pH
T1	ST1D	Na, TH, Ca, EC, Temp.
T2	ST2D	Na, TH, Ca, EC
T3	ST3D	Na, TH, Ca, EC
T4	ST4D	Na, TH, Ca, EC
		Tuesday and Thursday
CW1	SW1D	Na, TH, Ca, Cl_{2f}, SiO_2, Turb., EC, pH, Temp., SO_4, Cl
CW2	SW2D	Na, TH, Ca, Cl_{2f}, SiO_2, Turb., EC, pH, SO_4, Cl
CW3	SW3D	Na, TH, Ca, Cl_{2f}, SiO_2, Turb., EC, pH, SO_4, Cl
CW5	SW5D	Na, TH, Ca, Cl_{2f}, SiO_2, Turb., EC, pH, SO_4, Cl
CW6	SW6D	Na, TH, Ca, Cl_{2f}, SiO_2, Turb., EC, pH, SO_4, Cl
CW8	SW8D	Na, TH, Ca, SiO_2, Turb., EC, pH, SO_4, Cl
T1	ST1D	Na, TH, Ca, EC, Temp., SO_4, Cl
T2	ST2D	Na, TH, Ca, EC, SO_4, Cl
T3	ST3D	Na, TH, Ca, EC, SO_4, Cl
T4	ST4D	Na, TH, Ca, EC, SO_4, Cl
		Twice Daily (Morning and Afternoon)
Filter 1	SF1E	SDI
Filter 2	SF2E	SDI
CW2	SW2D	SDI
CW5	SW5D	SDI
CW6	SW6D	SDI

LOS BANOS DEMONSTRATION DESALTING FACILITY
ION-EXCHANGE OPERATIONS SCHEDULE
REVERSE-OSMOSOS/ELECTRODIALYSIS BRINE REGENERATION
May 12, 1986

Test 2.
Two-unit continuous operation.
Service flow at 110 gallons per minute.

Waste brine to IX sump.
Used brine to T2 or T3.
Rinse to RWPS.

Event Number	Event Description	Duration (minutes)	Component Operation or Valve Open: Unit 1	Component Operation or Valve Open: Unit 2	Process Flow: Unit	Process Flow: From	Process Flow: To
1	Recycled brine regeneration 1	13	IP 5, A 1 IV 15,12,7,9,22	IP 5, A 2 IV 115,112,107,109,122	1 2	T4 T4	IX sump IX sump
2	Recycled brine regeneration 2	22	IP 5, A 1 IV 15,12,7,4,23	IP 5, A 2 IV 115,112,107,104,123	1 2	T4 T4	T2 T3
3	Fresh brine regeneration	15	IP 1, A 1 IV 17,39m,13,7,4,23	IP 1, A 2 IV 18,139m,113,107,104,123	1 2	T1 T1	T2 T3
4	Rinse A	5	IP 7, A 1 IV 1,7,19,23	IP 9, A 2 IV 101,107,119,123	1 2	CW1 CW2	T2 T3
5	Rinse B	4	IP 7, A 1 IV 2,7,19,23	IP 9, A 2 IV 102,107,119,123	1 2	CW1 CW2	T2 T3
6	Rinse C	0	IP 7, A 1 IV 2,7,10,22	IP 9, A 2 IV 102,107,110,122	1 2	CW1 CW2	IX sump IX sump
7	Rinse D	16	IP 7 IV 2,7,10,21	IP 9 IV 102,107,110,121	1 2	CW1 CW2	RWPS RWPS
8	Service	180	IP 7,2 IV 1,7,11 CSOV 1	IP 9,102 IV 101,107,111 CSOV 6	1 2	CW1 CW2	CW3 CW3
9	Settling in T2 or T3 during service	120	A 1*	A 2*	1 2	Settling in T2 Settling in T3	
10	Set up for regeneration to T4 during service	28	IP 6 IV 5	IP 6 IV 105	1 2	T2 T3	T4 T4
11	Drain	3	IV 6,10,21 A 1	IV 106,110,121 A 2	1 2	Unit 1 Unit 2	RWPS RWPS
12	Delay	32	A 1	A 2			

*Agitators are not in operation during event 7 and part of event 8. Agitators are placed back into operation after event 10 is completed during event 8. (For all other events, agitators are in operation.)

Abbreviations:
A = agitator
CW = clearwell
CSOV = chlorine solenoid valve
IP = ion-exchange pump
IV = ion-exchange valve
IX = ion exchange
m = manual valve
RWPS = return water pump station
T = brine tank

DESALTING TEST 3

Purpose

The purpose of Test 3 is to operate on a continuous basis during the entire process of softening and desalting agricultural drainage water while employing the desalting process reject brine to regenerate the softening resin. Test 3 encompasses the use of all three reverse-osmosis units along with full service flow (230 gpm) through the ion-exchange system.

Test Period

Test 3 is to last for a period of two weeks. Testing within this time frame will enable the systems to stabilize so that proper evaluation of the systems can be made.

System Operation Parameters

The treatment systems are to be operated according to the parameters that are listed below.

Ion-Exchange: Service flow = 230 gallons per minute.
Fresh brine volume = 2,070 gallons.
Brine contact time = 50 minutes.

The ion-exchange system is to be operated according to the attached schedule.

Desalting:

Unit	Flows (gpm)	
	Influent	Brine
RO1	230	92
RO2	92	46
RO3	46	23

Data Collection and Sampling

The data collected will be as determined by equipment manufacturers and as otherwise directed by plant engineering. The schedule for sampling and analyses performed is listed below.

Location	Tap Number	Analyses Performed
		Sunday, Monday, Wednesday, Friday, and Saturday
CW1	SW1D	Na, TH, Ca, Cl_{2f}, SiO_2, Turb., EC, pH, Temp.
CW2	SW2D	Na, TH, Ca, Cl_{2f}, SiO_2, Turb., EC, pH
CW3	SW3D	Na, TH, Ca, CL_{2f}, SiO_2, Turb., EC, pH
CW4	SW4D	Na, TH, Ca, CL_{2f}, SiO_2, Turb., EC, pH
CW5	SW5D	Na, TH, Ca, CL_{2f}, SiO_2, Turb., EC, pH
CW6	SW6D	Na, TH, Ca, CL_{2f}, SiO_2, Turb., EC, pH
CW8	SW8D	Na, TH, Ca, SiO_2, Turb., EC, pH
T1	ST1D	Na, TH, Ca, EC, Temp.
T2	ST2D	Na, TH, Ca, EC
T3	ST3D	Na, TH, Ca, EC
T4	ST4D	Na, TH, Ca, EC
		Tuesday and Thursday
CW1	SW1D	Na, TH, Ca, Cl_{2f}, SiO_2, Turb., EC, pH, Temp., SO_4, Cl
CW2	SW2D	Na, TH, Ca, Cl_{2f}, SiO_2, Turb., EC, pH, SO_4, Cl
CW3	SW3D	Na, TH, Ca, Cl_{2f}, SiO_2, Turb., EC, pH, SO_4, Cl
CW4	SW4D	Na, TH, Ca, Cl_{2f}, SiO_2, Turb., EC, pH, SO_4, Cl
CW5	SW5D	Na, TH, Ca, Cl_{2f}, SiO_2, Turb., EC, pH, SO_4, Cl
CW6	SW6D	Na, TH, Ca, Cl_{2f}, SiO_2, Turb., EC, pH, SO_4, Cl
CW8	SW8D	Na, TH, Ca, SiO_2, Turb., EC, pH, SO_4, Cl
T1	ST1D	Na, TH, Ca, EC, Temp., SO_4, Cl
T2	ST2D	Na, TH, Ca, EC, SO_4, Cl
T3	ST3D	Na, TH, Ca, EC, SO_4, Cl
T4	ST4D	Na, TH, Ca, EC, SO_4, Cl
		Twice Daily (Morning and Afternoon)
Filter 1	SF1E	SDI
Filter 2	SF2E	SDI
CW2	SW2D	SDI
CW4	SW4D	SDI
CW5	SW5D	SDI
CW6	SW6D	SDI

LOS BANOS DEMONSTRATION DESALTING FACILITY
ION-EXCHANGE OPERATIONS SCHEDULE
REVERSE-OSMOSOS BRINE REGENERATION
May 26, 1986

Test 3.
Two-unit continuous operation.
Service flow at 230 gallons per minute.

Waste brine to IX sump.
Used brine to T2 or T3.
Rinse to RWPS.

Event Number	Event Description	Duration (minutes)	Component Operation or Valve Open		Process Flow		
			Unit 1	Unit 2	Unit	From	To
1	Recycled brine regeneration 1	13	IP 5, A 1 IV 15,12,7,9,22	IP 5, A 2 IV 115,112,107,109,122	1 2	T4 T4	IX sump IX sump
2	Recycled brine regeneration 2	23	IP 5, A 1 IV 15,12,7,4,23	IP 5, A 2 IV 115,112,107,104,123	1 2	T4 T4	T2 T3
3	Fresh brine regeneration	14	IP 1, A 1 IV 17,39m,13,7,4,23	IP 1, A 2 IV 18,139m,113,107,104,123	1 2	T1 T1	T2 T3
4	Rinse A	5	IP 7, A 1 IV 1,7,19,23	IP 9, A 2 IV 101,107,119,123	1 2	CW1 CW2	T2 T3
5	Rinse B	4	IP 7, A 1 IV 2,7,19,23	IP 9, A 2 IV 102,107,119,123	1 2	CW1 CW2	T2 T3
6	Rinse C	0	IP 7, A 1 IV 2,7,10,22	IP 9, A 2 IV 102,107,110,122	1 2	CW1 CW2	IX sump IX sump
7	Rinse D	16	IP 7 IV 2,7,10,21	IP 9 IV 102,107,110,121	1 2	CW1 CW2	RWPS RWPS
8	Service	87	IP 7,2 IV 7,11 CSOV 1	IP 9,102 IV 107,111 CSOV 6	1 2	CW1 CW2	CW3 CW4
9	Settling in T2 or T3 during service	60	A 1*	A 2*	1 2	Settling in T2 Settling in T3	
10	Set up for regeneration to T4 during service	28	IP 6 IV 5	IP 6 IV 105	1 2	T2 T3	T4 T4
11	Drain	3	IV 6,10,21 A 1	IV 106,110,121 A 2	1 2	Unit 1 Unit 2	RWPS RWPS
12	Delay	0	A 1	A 2			

*Agitators are not in operation during event 7 and part of event 8. Agitators are placed back into operation after event 10 is completed during event 8. (For all other events, agitators are in operation.)

Abbreviations:
A = agitator
CW = clearwell
CSOV = chlorine solenoid valve
IP = ion-exchange pump
IV = ion-exchange valve
IX = ion exchange
m = manual valve
RWPS = return water pump station
T = brine tank

GENERAL STARTUP AND OPERATION INSTRUCTIONS FOR DESALTING TEST 1

1. Verify that all items on ion-exchange system startup preparation list have been performed.

2. Start ion-exchange units. Operate units according to operation schedule.

3. When CW3 is at 15 feet, transfer the process water from the CW3 to CW5 using one transfer pump. Adjust the flowrate into CW5 by throttling the pump discharge valve. The flowrate from CW3 into CW5 is to be that of the RO2 influent rate (92 gpm).

4. Acidify the process water during transfer to CW5 as required by RO2.

5. Check free chlorine content in CW5. The free chlorine content is to be in the range of 0.5 to 1.0 mg/L. If necessary, inject chlorine into CW5 through CSOV7.

6. Start RO2 and data acquisition system when CW5 reaches 12 feet. Product and reject rates are to be 46 gpm each. Dechlorinate influent as required by manufacturer.

7. Chlorinate the RO2 reject brine as it enters CW6 to the range as stated in Item 5 above.

8. Start RO3 when CW6 reaches 12 feet. Dechlorinate influent process water as required. Product and reject rates are to be 23 gpm.

9. Start EDR unit when adequate supply of feedwater is available in CW8. Operate EDR so that reject brine flowrate is 6 gpm.

10. Periodically check water levels in CW2, CW3, CW5, CW6, and CW8. These levels should remain relatively constant. Adjust flowrates as necessary.

11. Periodically check brine levels in T1, T2, T3, and T4. Levels in T1 and T4 should remain relatively constant when all systems are in operation. Levels in T2 and T3 should be gaining about 4 inches per regeneration for the first week of operation and remain in a constant range for the remainder of the test program.

12. The free chlorine content in CW1, CW2, CW3, CW4, CW5, and CW6 should remain within the range of 0.5 to 1.0 mg/L. Dosage rates are to be adjusted accordingly. For CW1 and CW2, this range is critical due to the degradation of the ion-exchange resin with Cl_2 content over 1.0 mg/L.

13. The data acquisition system is to be initiated whenever the RO system is in operation. Notify computer operations (Sylvia, Tony, or Mark) before RO startup.

14. Scale inhibitor (SHMP) is not to be used in operation of the RO system.

ION-EXCHANGE SYSTEM STARTUP PREPARATION LIST
April 23, 1986

The following items should be checked or performed before operation of the ion-exchange system:

1. CSOV1 and CSOV6 switches in chlorine shed placed in AUTO mode.
2. CW1 and CW2 isolation valves open.
3. IX1 isolation valves open.
4. IX2 isolation valves open.
5. T1, T2, T3, and T4 isolation valves open.
6. Check level of brine in T1, T2, T3, and T4. Transfer brine as necessary.
7. IX valve switches in remote control panel on AUTO position (IV21, IV121, IV22, IV122, IV23, and IV123).
8. CW3 isolation valves open. (Note: CW4 will not be used during Desalting Test 1.)
9. Chlorine pipeline isolation valve into CW3 and CW4 open.
10. Cartridge filter isolation valves open.
11. Main circuit breakers for IX pumps to ON position (IP1, IP5, IP6, IP7, IP8, and IP9).
12. IX valve and pump switches in RO/IX office on AUTO position (except IP2 and IP3 are to be OFF).
13. IX control program on Analog computer initiated.
14. AUTO button on Analog computer pressed in.
15. Adjust event durations according to current schedule.

Preparation complete.

INSTRUCTIONS FOR DRY RUN OF ION-EXCHANGE SYSTEM
April 23, 1986

1. Place main circuit breakers for IP1, IP2, IP3, IP5, IP6, IP7, IP8, and IP9 to OFF position.

2. Close isolation valves for:

   a. CW1, CW2, CW3, and CW4
   b. T1, T2, T3, and T4.
   c. IX1.
   d. IX2.
   e. Cartridge filters.
   f. Chlorine line into CW3 and CW4.

3. Place IX valve switches in remote control panel to AUTO position (IV21, IV121, IV22, IV122, IV23, and IV123).

4. Place IX valve and pump switches in RO/IX office to AUTO position.

5. Initiate IX operations program.

6. AUTO button on Analog computer pressed in.

7. Adjust event times for both IX units according to the following schedule:

Event Number	Description	Duration (minutes)
1	Recycled brine regeneration 1	3
2	Recycled brine regeneration 2	3
3	Fresh brine regeneration	3
4	Rinse A	3
5	Rinse B	3
6	Rinse C	3
7	Rinse D	3
8	Service	33
9	Settling in T2 or T3	3
10	Setup for regeneration: T2 or T3 to T4	13
11	Drain	3
12	Delay	3

8. Start IX1.

9. Start IX2.

10. Verify valve openings and other operations for the cycle.

11. Document malfunctioning valves or errant operations.

ION-EXCHANGE SYSTEM DEFAULT TIMES*
April 23, 1986

Event Number	Description	Duration (minutes)
1	Recycled brine regeneration 1	13
2	Recycled brine regeneration 2	29
3	Fresh brine regeneration	8
4	Rinse A	5
5	Rinse B	4
6	Rinse C	0
7	Rinse D	16
8	Service	180
9	Settling in T2 or T3	120
10	Setup for T4	28
11	Drain	3
12	Delay	32

*Default times are based upon the following criteria:

1. EDR brine flow into T1 is 6 gpm.
2. Influent to RO2 is 92 gpm.

APPENDIX G

MAIN UNIT PERIOD 4 OPERATIONS

Ion-Exchange System
July and August 1986

Operation Log
Operation Parameters and Results
Reverse-Osmosis Reject Brine Analyses
Results of Hardness Leakage Test
Instructions for Dry Run of IX System
General Start-Up Preparation List

OPERATION LOG - 1986

Date	Unit	Time	Action/Comments
July 1	1 & 2	14:30	off
7	1 & 2	7:30	Obtained resin samples from each column.
8	1 & 2	9:05	Backwashed for 50 min. and stored Unit 2 in T1 brine.
	1	12:07	Reinstalled Unit 1's 110 gpm flow valve.
9	1	15:30	Obtained oper. pressures through 110 gpm flow valve.
10	1	15:40	Reinstalled 100 gpm flow valve.
11	1	16:40	Stored in T1 brine.
18	2	18:48	I/S to CWs 3 and 4.
	2	21:50	S/D
21	2	8:07	Column B glass gage leak repaired.
	2	14:37	I/S to CWs 3 and 4
	2	16:05	I/S to CWs 3 and 4
	2	18:08	S/D in regeneration
	2	19:35	I/S to CWs 3 and 4
		19:50	Pumped brine from s.s.pond to T1 to 11 ft..
	2	21:39	S/D -acid pump suction line leaking.
		10:55	CW3 at 20'2",CW4 at 19'11" and CW5 at 18'7".
22	2	12:00	I/S start regeneration
		22:55	EDR I/S
23	2	16:10	I/S regeneration
		16:13	Voltage dip, lost plant operations
	2	17:35	I/S regeneration
25	2	17:00	6" drained from T4 to IX sump
	2	17:45	8" drained from T3 to IX sump
27		20:30	IX computer malfunction, lost program
	2	21:00	start regeneration by hand
	2	23:30	S/D by hand, problems with IX computer and acid pump
		23:37	S/D EDR, RO2, RO3 and acid and transfer pumps
28	2	15:10	I/S
		15:35	I/S RO2, RO3 and EDR
29	2	4:20	IX computer screen found blank, computer not
		12:18	operating. Attempt to halt and restart failed, stuck
		12:45	in run mode.
	2	6:47	I/S by hand
	2	8:22	S/D
30	2	MN Cond.	I/S to CWs 3 and 4 to CW5
		10:13	EDR S/D, leaking electrode line
31	2	MN Cond.	I/S to CWs 3 and 4 to CW5; EDR S/D
		3:30	IX computer not working
	2	9:15	I/S event 8, service
Aug. 1	2	MN Cond.	I/S to CWs 3 and 4 to CW5; EDR to T1
		8:00	EDR S/D for repairs
		12:00	EDR I/S
2	2	MN Cond.	I/S to CWs 3 and 4 to CW5; EDR to T1
3	2	MN Cond.	I/S to CWs 3 and 4 to CW5; EDR to T1
		22:10	EDR S/D; T1 at 12'4"

OPERATION LOG - 1986

Date	Unit	Time	Action/Comments
Aug. 4	2	MN Cond.	I/S to CWs 3 and 4 to CW5; EDR S/D
		9:50	Regeneration times changed according
		7:30	to new operations schedule
		10:55	RO1 I/S
5	2	MN Cond.	I/S to CWs 3 and 4 to RO1, RO3 to T1
6	1 & 2	MN Cond.	I/S to CWs 3 and 4 to RO1, RO3 to T1
	1 & 2	11:27	Tested for leakage through both units
		12:00	in Rinse D and Service
7	1 & 2	MN Cond.	I/S to CWs 3 and 4 to RO1, RO3 to T1
		21:46	Problems with IX computer
8	1 & 2	MN Cond.	I/S to CWs 3 and 4 to RO1, RO3 to T1
	1	9:56	S/D, RO1 pump seal failure
10	2	12:50	IX computer malfunction
	2	14:01	I/S
11	2	13:46	Sample taken at end of service: Ca 1.0 and
	1,2	MN Cond.	TH 3.4 as meq/l
12		14:50	EDR S/D
		17:35	EDR I/S but no voltage on stg 2 in cathode
		8:55	polarity
13		1:00	EDR stg. 2 negative voltage working
		15:00	IX computer screen dark, but regained screen
	1,2	MN Cond.	by tapping return
14		7:20	EDR S/D for service/repair/modifications
		12:20	EDR I/S
18		9:45	IX program change: Event1 to RWPS instead
		15:08	of IX sump
		13:35	EDR S/D due to RO3 S/D
20	2	14:30	S/D with RO2 because of RO3 troubles,
			and high SiO2 and SDI levels

Note: Both units remained OFF for remainder of month due to high SiO2 and SDI.

Total hardness removed during Service Event for operation conditions

Month: July and August, 1986 SERVICE
Bed Volume: 4860 liters

Date	Flow (gpm)	Duration (minutes)	Total Hardness Influent (meq/l)	Total Hardness Effluent (meq/l)	Calcium Effluent (meq/l)	Influent Na:TH (ratio)	T.Hardness Removed (eq/l of resin)
July 16			IX System OFF				
17			IX System OFF				
18	230	120	28.0	NA	1.3	1.69	NA
19			IX System OFF				
20			IX System OFF				
21	230	120	28.2	NA	NA	1.36	NA
22	230	120	29.6	15.6	6.0	1.11	0.301
23	230	120	20.0	14.4	5.5	1.47	0.120
24	230	120	17.2	3.2	0.7	1.64	0.301
25	230	120	19.4	2.6	1.0	1.34	0.361
26	230	120	20.4	2.8	1.3	1.49	0.378
27	230	120	19.2	3.6	1.5	1.82	0.335
28	230	120	16.6	2.8	1.0	1.77	0.297
29	230	120	13.5	2.8	1.0	2.01	0.230
30	230	120	11.2	2.6	1.0	1.72	0.185
31	230	120	22.4	2.8	1.0	1.21	0.421
Aug. 1	230	120	3.6	2.8	1.0	6.88	0.017
2	230	120	10.8	2.6	1.0	2.94	0.176
3	230	120	10.4	1.8	1.0	1.19	0.185
4	230	120	11.6	1.8	1.0	1.27	0.211
5	230	120	10.4	7.2	4.0	1.19	0.069
6	230	120	11.4	2.2	1.5	1.18	0.198
7	230	120	11.2	2.4	1.5	2.12	0.189
8	230	120	11.0	3.4	3.5	NA	0.163
9	230	120	12.4	4.6	2.5	1.91	0.168
10	230	120	11.8	3.6	1.0	2.30	0.176
11	230	120	11.4	6.2	1.0	2.29	0.112
12	230	120	13.6	3.6	1.0	1.92	0.215
13	230	120	11.6	5.0	1.0	NA	0.142
14	230	120	13.6	2.4	1.0	2.08	0.241
15	230	120	12.4	2.6	1.0	NA	0.211
16	230	120	13.4	2.2	1.5	1.85	2.410
17	230	120	12.6	NA	1.3	2.42	NA
18	230	120	13.6	NA	1.3	NA	NA
19	230	120	14.6	NA	1.5	NA	NA
20			IX System OFF				
21			IX System OFF				

Sodium Throughput during regeneration for operating conditions
Month: July and August, 1986

REGENERATION

Date	Flow		Duration		Sodium		Sodium Throughput		
	Recycle Brine	Fresh Brine	Recycle Brine	Fr. Brine	Recycle Brine	Fresh Brine	Recycle Brine	Fresh Brine	Total
	(gpm)		(minutes)		(meq/l)		(eq/l of resin)		
July 16	1540	NA	NA	1325	NA	NA	NA	NA	NA
17	1320	NA	NA	1175	NA	NA	NA	NA	NA
18	1400	NA	25	1090	NA	NA	NA	NA	NA
19	730	NA	30	990	NA	NA	NA	NA	NA
20	NA	NA	NA	910	NA	NA	NA	NA	NA
21	1410	NA	NA	885	NA	NA	NA	NA	NA
22	1480	780	120	755	NA	NA	NA	NA	NA
23	1000	720	110	675	NA	NA	NA	NA	NA
24	860	160	14	650	NA	NA	NA	NA	NA
25	970	130	20	600	NA	NA	NA	NA	NA
26	1020	140	25	700	NA	NA	NA	NA	NA
27	960	180	30	805	NA	NA	NA	NA	NA
28	830	140	20	675	NA	NA	NA	NA	NA
29	676	140	20	625	NA	NA	NA	NA	NA
30	560	130	20	442	NA	NA	NA	NA	NA
31	1120	140	20	625	NA	NA	NA	NA	NA
Aug. 1	180	140	20	570	NA	NA	NA	NA	NA
2	540	130	20	730	NA	NA	NA	NA	NA
3	520	90	20	285	NA	NA	NA	NA	NA
4	580	90	20	340	NA	NA	NA	NA	NA
5	520	360	80	285	NA	NA	NA	NA	NA
6	570	110	30	310	NA	NA	NA	NA	NA
7	560	120	30	545	NA	NA	NA	NA	NA
8	550	170	70	NA	NA	NA	NA	NA	NA
9	620	230	50	545	NA	NA	NA	NA	NA
10	590	180	20	625	NA	NA	NA	NA	NA
11	570	310	20	600	NA	NA	NA	NA	NA
12	680	180	20	600	NA	NA	NA	NA	NA
13	580	250	20	NA	NA	NA	NA	NA	NA
14	680	120	20	650	NA	NA	NA	NA	NA
15	620	130	20	NA	NA	NA	NA	NA	NA
16	670	110	30	570	1500.0	NA	11.60	NA	NA
17	630	NA	25	700	1760.9	1652.2	13.61	1.47	15.09
18	680	NA	25	NA	3913.0	1913.0	30.25	1.71	31.96
19	730	NA	30	NA	1521.7	1934.8	11.76	1.73	13.49
20	IX System OFF				1673.9	2173.9	12.94	1.94	14.88
21	IX System OFF				1043.5	1478.3	8.22	1.15	9.38

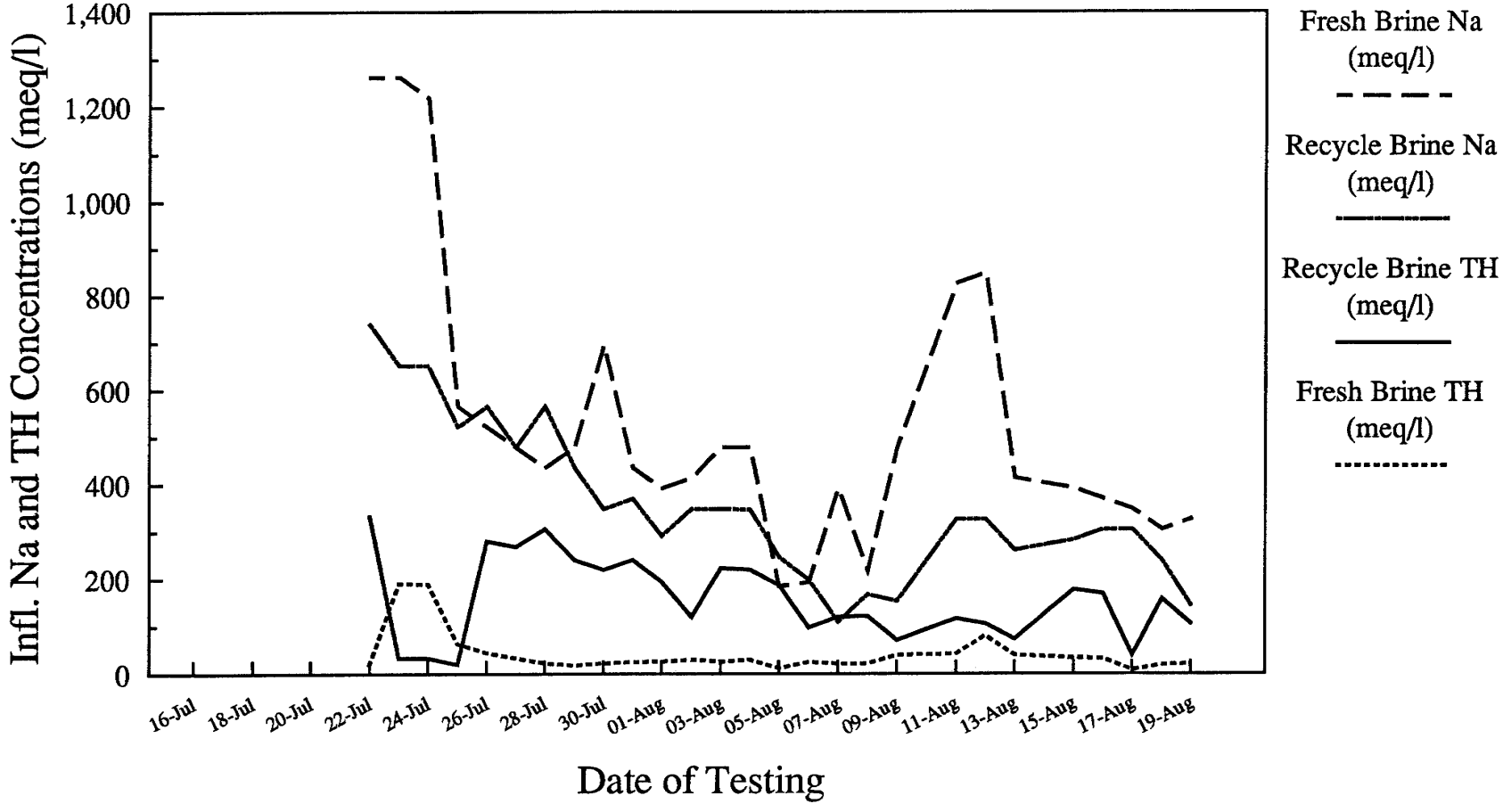
Month: July and August, 1986
IX Unit: 2
Comparison of Total Hardness and Sodium in regenerant brines

	Recycle Brine			Frech Brine		
	TH	Na	Ratio	TH	Na	Ratio
Date			Na:TH			Na:TH
July 16			IX System Off			
17			IX System Off			
18	NA	NA	NA	NA	NA	NA
19			IX System Off			
20			IX System Off			
21	NA	NA	NA	NA	NA	NA
22	332.8	739.5	2.2	20.8	1261.4	60.6
23	34.0	652.5	19.2	190.6	1261.4	6.6
24	34.0	652.5	19.2	190.0	1217.9	6.4
25	20.0	522.0	26.1	63.6	565.5	8.9
26	280.0	565.5	2.0	44.0	522.0	11.9
27	268.0	478.5	1.8	34.0	478.5	14.1
28	306.0	565.5	1.8	22.0	435.0	19.8
29	240.0	435.0	1.8	17.2	478.5	27.8
30	220.0	348.0	1.6	22.0	696.0	31.6
31	240.0	369.7	1.5	24.6	435.0	17.7
Aug. 1	194.0	291.4	1.5	26.0	391.5	15.1
2	120.0	348.0	2.9	30.0	413.2	13.8
3	224.0	348.0	1.6	26.0	478.5	18.4
4	220.0	347.1	1.6	30.0	478.5	15.9
5	186.4	246.0	1.3	12.2	184.4	15.1
6	98.0	197.7	2.0	25.4	193.3	7.6
7	120.8	109.8	0.9	21.0	391.5	18.6
8	121.6	167.0	1.4	21.6	217.5	10.1
9	70.8	154.0	2.2	39.2	478.5	12.2
10	NA	NA	NA	NA	NA	NA
11	116.4	326.2	2.8	42.2	826.4	19.6
12	106.0	326.2	3.1	80.0	848.2	10.6
13	73.6	261.0	3.5	40.0	413.2	10.3
14	NA	NA	NA	NA	NA	NA
15	177.2	282.7	1.6	33.6	391.5	11.7
16	168.0	304.5	1.8	32.0	369.7	11.6
17	40.0	304.5	7.6	8.6	348.0	40.5
18	158.0	239.2	1.5	19.2	304.5	15.9
19	106.0	144.8	1.4	21.8	326.2	15.0
20			IX System Off			

Influent Total Hardness and Sodium Concentration

Ion Exchange Regenerant Brines

July and August, 1986



CLEARWELL 1 - SAMPLE TAP SW1D ION EXCHANGE INFLUENT

Date	Time	TH	Ca	Cl2-F	SiO2	Turb	EC	pH	Cl	Na	SO4	TOC
1986		(meq/l)		(mg/l)		(NTU)	(uS/cm)		(meq/l)			(mg/l)
July 15	7:30	36.0	16.5	0.2	19	0.1	7200	7.4	25.8	60.0	60.4	NA
16	7:30	30.8	14.0	0.2	15	0.6	6600	7.4	NA	51.1	NA	5
17	7:30	28.0	14.0	0.2	13	0.2	6000	7.5	20.7	46.5	56.3	NA
18	7:30	28.0	13.0	0.2	19	0.1	5900	7.5	NA	46.3	NA	7
19	7:30	26.4	13.0	0.2	20	0.7	5400	7.5	NA	41.7	NA	NA
20	7:30	21.0	15.0	0.1	15	0.2	5300	7.2	NA	36.1	NA	NA
21	7:30	35.6	28.0	0.2	5	0.1	4600	7.3	NA	33.9	NA	7
22	7:30	25.6	10.0	0.1	19	0.1	4700	7.3	15.9	36.1	31.3	NA
23	7:30	26.2	12.0	0.5	18	0.1	4200	7.2	NA	30.4	NA	7
24	7:30	18.6	8.0	0.3	19	0.1	4600	7.3	10.8	29.3	29.2	NA
25	7:30	18.4	9.0	0.3	18	0.2	3900	7.2	NA	26.1	NA	6
26	7:30	24.8	11.0	0.3	15	5.2	3800	7.3	NA	30.4	NA	NA
27	7:30	22.8	8.0	0.4	20	0.5	4400	7.2	NA	30.4	NA	NA
28	7:30	15.8	18.0	0.2	20	0.2	3800	7.5	NA	30.4	NA	2
29	7:30	13.2	7.0	0.2	20	0.1	3400	7.5	14.1	26.1	20.8	NA
30	7:30	10.8	6.0	0.2	22	0.1	2560	7.1	NA	18.1	NA	3
31	7:30	31.6	10.5	0.1	21	0.3	3800	7.3	13.1	27.2	25.4	NA
Aug 1	7:30	4.6	1.5	0.2	22	0.2	3800	7.6	NA	27.2	NA	1
2	7:30	11.4	6.0	0.2	18	1.6	2800	7.7	NA	18.0	NA	NA
3	7:30	10.2	5.5	0.2	25	0.6	2600	7.5	NA	12.4	NA	NA
4	7:30	10.8	6.5	0.2	25	0.3	2400	7.5	NA	43.3	NA	1
5	7:30	10.4	6.0	0.2	32	0.3	2200	7.4	32.4	12.4	14.2	NA
6	7:30	10.8	5.5	0.3	32	0.3	2700	7.4	NA	13.5	NA	1
7	7:30	11.0	6.0	0.2	26	0.3	2600	7.2	8.0	20.4	16.3	NA
8	7:30	12.8	7.0	0.2	35	0.2	3000	7.4	NA	NA	NA	NA
9	7:30	13.2	7.0	0.1	35	1.2	3200	7.4	NA	22.6	NA	NA
10	7:30	153.6	6.5	0.2	40	0.4	3500	7.3	NA	24.8	NA	NA
11	7:30	11.2	6.0	0.1	34	0.5	3400	7.1	NA	24.8	NA	NA
12	7:30	12.2	6.0	0.2	35	0.5	3000	7.3	7.0	27.2	21.7	NA
13	7:30	15.4	6.5	0.1	34	1.1	3000	7.5	NA	NA	NA	NA
14	7:30	13.4	6.0	0.2	34	0.9	3100	7	10.3	29.3	19.2	NA
15	7:30	13.0	6.5	0.2	40	1	3075	7.4	NA	NA	NA	NA
16	7:30	13.2	7.0	0.2	52	1.1	3300	7.3	NA	24.8	NA	NA
17	7:30	12.0	7.0	0.2	40	1.1	3900	7.4	NA	28.3	NA	NA
18	7:30	13.8	7.0	0.2	48	3.9	3500	7.2	NA	NA	NA	NA
19	7:30	14.0	7.5	0.3	38	1	3500	7.2	NA	NA	NA	NA
20	7:30	13.6	7.5	0.1	36	1	3570	7	NA	NA	NA	NA
21	7:30	13.8	7.5	0.1	38	0.9	3500	7.1	NA	NA	NA	NA
22	7:30	14.2	7.5	NA	38	0.9	3500	7.3	NA	NA	NA	NA
23	7:30	15.4	7.5	0.1	40	1.1	3600	7.6	NA	NA	NA	NA
24	7:30	15.6	9.0	0.1	48	0.8	4300	7.6	NA	NA	NA	NA
25	7:30	14.2	7.5	0.1	40	1	3700	7.2	NA	NA	NA	NA
Num.of Anal.		42	42	41	42	42	42	42	10	31	10	10
Mean		20.7	9.0	0.2	28.1	0.7	3831	7.3	15.8	30.0	29.5	4.0
StandardDev.		22.4	4.6	0.1	11.1	1	1125	0.2	8.2	11.2	16.1	2.7
Lower95%C.L		13.8	7.6	0.0	24.0	0.0	3483	7.0	10.6	25.9	19.2	2.0
Upper95%C.L		27.6	10.4	0.2	31.6	1.0	4178	7.4	21.0	34.0	39.7	5.7

CLEARWELL 2 - SAMPLE TAP SW2D ION EXCHANGE INFLUENT

Date	Time	TH	Ca	Cl2-F	SiO2	Turb	EC	pH	Cl	Na	SO4	TOC
1986		(meq/l)		(mg/l)		(NTU)	(uS/cm)		(meq/l)			(mg/l)
July 15	7:30	35.2	19.5	0.2	16	1	8600	7.3	29.2	70.9	70.8	NA
16	7:30	30.8	17.5	0.2	16	0.2	7200	7.4	NA	57.6	NA	5
17	7:30	26.4	14.0	0.2	14	0.3	6600	7.4	21.5	51.1	52.1	NA
18	7:30	28.0	14.0	0.2	19	0.6	5600	7.6	NA	47.4	NA	7
19	7:30	24.0	15.5	0.1	20	3.5	5300	7.2	NA	43.0	NA	NA
20	7:30	25.2	12.0	0.1	14	0.4	5300	7.3	NA	39.6	NA	NA
21	7:30	28.2	32.0	0.2	5	0.1	5000	7.2	NA	38.5	NA	9
22	7:30	29.6	9.5	0.1	19	0.3	4600	7.3	14.1	32.8	34.4	NA
23	7:30	20.0	12.3	0.3	18	0.2	4200	7.3	NA	29.3	NA	6
24	7:30	17.2	11.0	0.3	18	0.1	3800	7.3	10.3	28.3	31.3	NA
25	7:30	19.4	9.5	0.3	18	0.5	4000	7.1	NA	26.1	NA	5
26	7:30	20.4	9.0	0.4	17	1.7	3700	7.3	NA	30.4	NA	NA
27	7:30	19.2	8.0	0.4	20	0.4	3900	7.3	NA	35.0	NA	NA
28	7:30	16.6	7.5	0.2	18	0.1	3800	7.5	NA	29.3	NA	2
29	7:30	13.5	7.5	0.2	17	0.1	3500	7.5	11.7	27.2	25.0	NA
30	7:30	11.2	6.5	0.2	22	0.2	2600	7.1	NA	19.2	NA	1
31	7:30	22.4	12.0	0.2	22	0.3	4200	7.2	13.1	27.2	24.6	NA
Aug 1	7:30	3.6	2.0	0.2	22	0.2	3700	7.6	NA	24.8	NA	1
2	7:30	10.8	6.0	0.2	20	2.3	2900	7.6	NA	31.7	NA	NA
3	7:30	10.4	6.0	0.2	25	0.3	2200	7.5	NA	12.4	NA	NA
4	7:30	11.6	6.5	0.2	27	0.2	2400	7.4	NA	14.8	NA	2
5	7:30	10.4	6.5	0.2	32	0.3	2350	7.3	31.0	12.4	14.6	NA
6	7:30	11.4	5.5	0.3	32	0.2	2400	7.4	NA	13.5	NA	1
7	7:30	13.0	7.0	0.2	28	0.2	2600	7.3	8.0	23.7	14.6	NA
8	7:30	11.0	7.0	0.1	35	0.4	2900	7.4	NA	NA	NA	NA
9	7:30	12.4	15.5	0.2	34	0.9	3300	7.3	NA	23.7	NA	NA
10	7:30	11.8	6.5	0.2	44	0.5	3200	7.2	NA	27.2	NA	NA
11	7:30	11.4	6.0	0.2	36	0.4	3000	7	NA	26.1	NA	NA
12	7:30	13.6	6.5	NA	35	0.5	3100	7.3	8.9	26.1	23.3	NA
13	7:30	11.6	6.0	0.2	36	1	3200	7.4	NA	NA	NA	NA
14	7:30	13.6	6.0	0.4	34	0.9	3200	7.1	9.9	28.3	50.0	NA
15	7:30	12.4	6.5	0.3	40	1	3200	7.3	NA	NA	NA	NA
16	7:30	13.4	7.0	0.3	40	1.6	3000	7.2	NA	24.8	NA	NA
17	7:30	12.6	14.5	0.2	32	1.1	3600	7.3	NA	30.4	NA	NA
18	7:30	13.6	7.0	0.1	40	1.2	3500	7.2	NA	NA	NA	NA
19	7:30	14.6	7.0	0.3	38	1.1	3500	7.2	NA	NA	NA	NA
20	7:30	12.4	7.0	0.2	36	1	3570	7.1	NA	NA	NA	NA
21	7:30	13.4	7.0	0.2	36	1	3500	7	NA	NA	NA	NA
22	7:30	14.2	7.5	NA	40	1	3600	7.3	NA	NA	NA	NA
23	7:30	15.0	7.5	0.2	40	1.2	3800	7.5	NA	NA	NA	NA
24	7:30	14.2	7.5	0.2	40	1.1	3800	7.5	NA	NA	NA	NA
25	7:30	14.0	7.5	0.1	40	1.1	3800	7.2	NA	NA	NA	NA
Num.of Anal.		42	42	40	42	42	42	42	10	31	10	10
Mean		16.5	9.5	0.2	27.5	0.7	3834	7.3	15.8	30.7	34.1	3.9
StandardDev.		6.9	5.2	0.1	10.1	0.7	1305	0.2	8.5	12.9	18.2	2.9
Lower95%C.L		14.3	7.8	0.0	24.0	0.0	3431	7.0	10.4	26.1	22.5	2.0
Upper95%C.L		18.6	11.0	0.2	30.6	0.9	4236	7.4	21.1	35.3	45.6	5.7

CLEARWELL 3 - SAMPLE TAP SW3D ION EXCHANGE EFFLUENT

Date	Time	TH	Ca	Cl2-F	SiO2	Turb	EC	pH	Cl	Na	SO4
1986		(meq/l)		(mg/l)		(NTU)	(uS/cm)		(meq/l)		
Aug. 4	7:30	1.8	4.5	NA	27.0	0.5	3600	7.6	NA	22.6	NA
5	7:30	7.2	4.0	NA	30.0	0.3	3000	7.3	14.1	18.1	18.8
6	7:30	2.2	0.5	NA	34.0	0.2	3000	7.5	NA	24.8	NA
7	7:30	2.0	1.5	NA	36.0	0.2	3200	7.4	14.1	29.3	20.8
8	7:30	3.4	1.5	0.1	36.0	0.3	3100	6.9	NA	NA	NA
9	7:30	4.6	2.5	0.4	36.0	0.3	3500	7.3	NA	35.4	NA
10	7:30	3.6	1.0	0.1	33.0	2.2	4300	7.4	NA	760.9	NA
12	7:30	3.6	1.0	0.3	36.0	0.4	3800	7.4	9.4	37.4	28.1
13	7:30	5.0	1.0	NA	39.0	0.5	3500	7.2	NA	NA	NA
16	7:30	2.2	1.5	NA	44.0	0.7	2400	7.2	NA	31.7	NA
Num.of Anal.		10	10	4	10	10	10	10	3	8	3
Mean		3.6	1.9	0.2	35.1	0.6	3340	7.3	12.5	120.0	22.6
StandardDev.		1.7	1.4	0.1	4.7	0.6	521	0.2	2.7	259.0	4.9
Lower95%C.L.		2.5	1.0	0.0	32.0	0.0	3010	7.0	9.4	-63.1	16.9
Upper95%C.L.		4.6	2.8	0.4	38.0	0.9	3670	7.4	15.6	303.2	28.3

CLEARWELL 5 - SAMPLE TAP SW5D ION EXCHANGE EFFLUENT

Date	Time	TH	Ca	Cl2-F	SiO2	Turb	EC	pH	Cl	Na	SO4
1986		(meq/l)		(mg/l)		(NTU)	(uS/cm)		(meq/l)		
July 22	7:30	15.6	6.0	NA	NA	0.3	8200	NA	20.6	71.3	47.9
23	7:30	14.4	5.5	NA	18	0.2	105300	5.9	NA	48.7	NA
24	7:30	3.2	0.7	0.2	NA	0.2	45000	3.4	10.8	44.3	28.1
25	7:30	2.6	1.0	0.2	NA	0.1	4600	5.9	NA	37.6	NA
26	7:30	2.8	1.0	0.2	NA	0.1	4000	5.6	NA	44.3	NA
27	7:30	3.6	1.5	0.2	NA	0.1	4100	6.2	NA	42.2	NA
28	7:30	2.8	1.0	0.2	NA	0.1	4400	6.3	NA	37.6	NA
29	7:30	2.8	1.0	0.1	NA	0.1	4100	6.2	20.7	40.0	21.9
30	7:30	2.6	1.0	0.1	21	0.1	3200	5.1	NA	28.8	NA
31	7:30	2.8	1.0	0.1	NA	0.3	3400	5.9	12.3	28.9	20.8
Aug. 1	7:30	2.8	1.0	0.1	21	0.2	4300	5.4	NA	42.2	NA
2	7:30	2.6	1.0	0.1	NA	0.2	3500	6.4	NA	28.3	NA
3	7:30	1.8	1.0	0.1	NA	0.2	2900	6.5	NA	33.3	NA
4	7:30	2.6	1.0	0.1	NA	0.2	5700	6.6	NA	21.5	NA
5	7:30	10.2	5.0	0.1	NA	0.7	5900	5.8	54.9	48.7	18.8
6	7:30	4.4	1.5	0.2	NA	0.9	6000	6.4	NA	55.4	NA
7	7:30	4.4	1.5	0.2	NA	0.8	6200	5.9	19.7	49.8	46.9
8	7:30	5.0	3.5	0.1	NA	0.4	6600	5.2	NA	NA	NA
9	7:30	5.6	2.5	0.1	NA	0.2	3600	6.7	NA	31.1	NA
10	7:30	3.6	1.5	0.1	NA	0.3	3600	6.8	NA	39.6	NA
11	7:30	6.2	3.0	0.1	NA	0.3	3600	4.8	NA	36.1	NA
12	7:30	3.6	1.5	NA	NA	0.4	3400	7.1	9.4	36.1	26.0
13	7:30	4.2	1.0	0.1	NA	0.5	3500	5.4	NA	NA	NA
14	7:30	2.4	1.0	0.2	NA	0.7	3500	5.6	9.9	39.6	24.0
15	7:30	2.6	1.0	0.2	NA	0.9	3490	5.8	NA	NA	NA
16	7:30	2.4	1.5	0.1	NA	0.9	3500	5.6	NA	31.7	NA
17	7:30	3.2	1.3	0.1	NA	1.1	3800	6	NA	38.5	NA
18	7:30	3.2	1.3	0.2	NA	0.9	3800	6	NA	NA	NA
19	7:30	4.6	1.5	0.3	NA	1	3700	5.7	NA	NA	NA
20	7:30	3.6	1.0	0.1	NA	0.7	3880	5.5	NA	NA	NA
21	7:30	2.4	1.3	0.1	NA	1	3800	5.9	NA	NA	NA
22	7:30	3.4	1.5	NA	NA	1	3900	6	NA	NA	NA
23	7:30	4.0	1.0	0.1	NA	1.3	3900	6	NA	NA	NA
24	7:30	4.8	1.0	0.1	NA	1.1	3900	5.8	NA	NA	NA
25	7:30	3.4	1.0	0.1	NA	0.9	3900	5.9	NA	NA	NA
Num.of Anal.		35	35	31	3	35	35	34	8	24	8
Mean		4.3	1.7	0.1	20.0	0.5	8291	5.9	19.8	39.8	29.3
StandardDev.		3.1	1.3	0.1	1.7	0.4	18265	0.7	15.0	10.4	11.5
Lower95%C.L.		3.2	1.2	0.0	18.0	0.0	2050	0.5	9.2	35.6	21.1
Upper95%C.L.		5.3	2.2	0.2	22.0	0.7	14530	6.1	30.4	44.0	37.5

CLEARWELL 6 - SAMPLE TAP SW6D REVERSE OSMOSIS UNIT 2 EFFLUENT

Date	Time	TH	Ca	Cl2-F	SiO2	Turb	EC	pH	Cl	Na	SO4
1986		(meq/l)		(mg/l)		(NTU)	(uS/cm)		(meq/l)		
July 22	7:30	26.0	9.0	NA	NA	7.2	12800	NA	39.4	124.3	104.2
23	7:30	9.6	7.3	NA	42	0.2	83400	5.3	NA	115.2	NA
24	7:30	12.8	2.0	0.1	39	0.1	5100	5.9	21.1	102.0	85.4
25	7:30	4.2	1.5	0.1	33	0.2	9500	5.7	NA	99.8	NA
26	7:30	2.8	1.0	0.1	30	0.7	8500	5.9	NA	110.9	NA
27	7:30	8.0	2.0	0.1	60	0.1	8900	5.8	NA	110.9	NA
28	7:30	4.8	1.5	0.1	45	0.1	9100	5.9	NA	108.7	NA
29	7:30	3.8	1.5	0.1	45	0.1	8700	5.6	24.8	102.0	52.1
30	7:30	3.8	1.5	0.1	39	0.1	6900	5.3	NA	68.7	NA
31	7:30	3.4	1.0	0.1	48	0.2	6900	5.9	20.7	66.5	46.9
Aug. 1	7:30	3.8	1.5	0.1	48	0.4	8900	5.9	NA	88.7	NA
2	7:30	4.4	1.5	0.1	52	0.4	8000	6.2	NA	64.3	NA
3	7:30	4.0	1.0	0.1	48	0.5	6500	6.3	NA	64.3	NA
4	7:30	2.6	1.5	0.1	64	0.6	5900	6.7	NA	325.2	NA
5	7:30	7.4	4.5	0.1	120	1.9	10600	6.7	36.6	115.2	83.3
6	7:30	9.4	4.0	0.2	145	1	10800	6.5	NA	110.9	NA
7	7:30	6.8	3.5	0.2	112	0.9	11700	7	22.5	133.0	97.9
8	7:30	9.6	4.5	0.1	140	0.7	12200	4.7	NA	NA	NA
9	7:30	12.0	6.5	0.1	78	0.4	7200	6.6	NA	66.5	NA
10	7:30	7.2	3.5	0.1	72	0.4	7300	6.6	NA	84.8	NA
11	7:30	10.6	6.0	0.1	66	0.4	7100	5	NA	78.0	NA
12	7:30	6.2	3.5	NA	140	0.5	6900	7.2	19.7	78.3	58.3
13	7:30	6.0	2.0	0.1	78	1	6900	3.8	NA	NA	NA
14	7:30	4.6	2.0	0.2	78	1.1	7000	5.7	20.7	85.9	56.3
15	7:30	5.6	2.0	0.1	80	1.4	6900	5.6	NA	NA	NA
16	7:30	4.4	2.0	0.1	72	1.6	7000	5.3	NA	68.9	NA
17	7:30	4.2	1.8	0.1	72	1.3	6500	5	NA	71.3	NA
18	7:30	4.8	2.0	0.2	78	1.9	7270	5.8	NA	NA	NA
19	7:30	5.4	2.5	0.5	78	1.3	7100	4.7	NA	NA	NA
20	7:30	5.0	2.5	0.6	7.8	1.3	7750	4.6	NA	NA	NA
21	7:30	5.2	12.5	0.2	78	1.3	7700	4.3	NA	NA	NA
22	7:30	6.6	2.5	NA	78	1.3	7700	4.2	NA	NA	NA
23	7:30	6.4	2.5	0.2	72	1.4	7900	4.1	NA	NA	NA
24	7:30	6.6	2.0	0.2	80	1.3	7800	4.4	NA	NA	NA
25	7:30	5.6	2.5	0.2	78	1.2	7900	4.3	NA	NA	NA
Num.of Anal.		35	35	31	34	35	35	34	8	24	8
Mean		6.7	3.1	0.2	70.5	1.0	10238	5.5	25.7	101.9	73.0
StandardDev.		4.2	2.5	0.1	31.7	1.2	12849	1.0	7.8	52.0	22.3
Lower95%C.L.		5.2	2.3	0.0	59.0	0.0	5848	5.0	20.2	80.6	57.3
Upper95%C.L.		8.1	4.0	0.2	81.5	1.4	14627	5.8	31.2	123.1	88.8

CLEARWELL 8 - SAMPLE TAP SW8D REVERSE OSMOSIS UNIT 3 EFFLUENT

Date	Time	TH	Ca	Cl2-F	SiO2	Turb	EC	pH	Cl	Na	SO4
1986		(meq/l)		(mg/l)		(NTU)	(uS/cm)		(meq/l)		
July 22	7:30	106.8	29.5	NA	NA	1.8	44400	NA	242.3	521.7	416.7
23	7:30	23.2	10.5	NA	75	0.2	83100	4.5	NA	128.9	NA
24	7:30	9.6	2.5	NA	75	0.2	9900	5.6	46.5	201.7	125.0
25	7:30	7.4	3.0	NA	63	0.2	16000	5.4	NA	201.7	NA
26	7:30	5.8	2.0	NA	40	0.1	14600	5.5	NA	195.2	NA
27	7:30	8.0	3.0	NA	60	0.2	15100	5.1	NA	203.9	NA
28	7:30	7.4	3.5	NA	75	0.2	14900	5	NA	199.6	NA
29	7:30	6.4	2.5	NA	66	0.1	15600	4.3	56.3	217.4	108.3
30	7:30	6.4	7.5	NA	80	0.1	14000	2.9	NA	150.9	NA
31	7:30	6.6	4.0	NA	100	0.3	12600	5.9	46.9	137.4	104.2
Aug. 1	7:30	6.4	3.0	NA	96	1	16300	5.1	NA	170.7	NA
2	7:30	8.0	3.0	NA	92	0.7	15600	5.5	NA	168.5	NA
3	7:30	6.0	2.0	NA	92	1	13700	5.6	NA	153.9	NA
4	7:30	5.0	2.5	NA	120	1.1	11800	6.9	NA	148.5	NA
5	7:30	5.8	3.0	NA	130	1.8	11400	6.9	28.2	117.6	83.3
6	7:30	4.2	1.5	NA	130	0.9	10700	7	NA	122.0	NA
7	7:30	98.0	2.5	NA	132	1	12000	6.8	28.2	150.9	112.5
8	7:30	5.0	3.5	NA	150	1	12000	6.6	NA	NA	NA
9	7:30	20.0	13.0	NA	132	0.6	12200	6.8	NA	115.2	NA
10	7:30	12.4	7.0	NA	140	0.4	11700	6.8	NA	148.5	NA
11	7:30	20.4	11.0	NA	132	0.7	12800	4.7	NA	162.0	NA
12	7:30	11.0	6.5	NA	150	0.8	12200	7.4	34.6	146.3	112.5
13	7:30	8.6	4.0	NA	140	1.3	11700	3.5	NA	NA	NA
14	7:30	7.6	4.5	NA	132	2.9	11700	5.6	30.4	146.3	89.6
15	7:30	7.0	3.5	NA	100	1.8	11200	5.2	NA	NA	NA
16	7:30	7.2	3.5	NA	100	2.5	11600	4.8	NA	113.0	NA
17	7:30	6.4	2.5	NA	100	1.9	10800	4.3	NA	130.4	NA
18	7:30	7.4	3.5	NA	100	2.6	11190	5.4	NA	NA	NA
19	7:30	7.2	4.0	NA	114	1.7	10700	3.8	NA	NA	NA
20	7:30	7.6	4.0	NA	120	1.5	12100	3.9	NA	NA	NA
21	7:30	8.2	4.0	NA	119	4.8	11900	3.9	NA	NA	NA
22	7:30	8.0	4.0	NA	126	9.3	11800	3.6	NA	NA	NA
23	7:30	9.4	4.0	NA	112	6.7	11800	3.5	NA	NA	NA
24	7:30	8.2	4.0	NA	128	6.3	11800	4.1	NA	NA	NA
25	7:30	8.2	3.5	NA	126	5.0	12000	3.9	NA	NA	NA
Num.of Anal.		35	35	0	34	35	35	34	8	24	8
Mean		14.0	5.0	NA	106.7	1.8	15503	5.2	64.2	173.0	144.0
StandardDev.		22.5	5.0	NA	27.6	2.1	13039	1.2	72.7	80.5	111.0
Lower95%C.L.		6.3	3.3	NA	97.0	1.0	11048	4.0	12.8	140.1	65.5
Upper95%C.L.		21.7	6.7	NA	116.2	2.5	19957	5.6	115.6	205.9	222.5

BRINE TANK 1 - SAMPLE TAP ST1D ION EXCHANGE FRESH BRINE

Date	Time	Na	TH	Ca	EC	Temp.	TDS	SO4	Cl
1986		(meq/l)			(uS/cm)	(C)	(mg/l)	(meq/l)	
July 22	7:30	1260.9	20.8	56.0	108900	NA	97470	343.8	1239.4
23	7:30	1260.9	190.6	55.0	8600	NA	NA	1.5	703.9
24	7:30	1217.4	190.0	155.0	10100	NA	95300	383.3	1126.8
25	7:30	565.2	63.6	60.0	51400	NA	NA	NA	NA
26	7:30	521.7	44.0	18.5	44900	NA	NA	NA	NA
27	7:30	478.3	34.0	17.5	40800	NA	NA	NA	NA
28	7:30	434.8	22.0	12.5	40800	NA	NA	NA	NA
29	7:30	478.3	17.2	7.5	38400	NA	36300	312.5	147.9
30	7:30	695.7	22.0	8.5	36100	NA	NA	NA	NA
31	7:30	434.8	24.6	10.0	37400	NA	36900	354.2	46.5
Aug. 1	7:30	391.3	26.0	9.0	38100	NA	NA	NA	NA
2	7:30	413.0	30.0	10.5	39500	NA	NA	NA	NA
3	7:30	478.3	26.0	2.5	40700	NA	NA	NA	NA
4	7:30	478.3	30.0	17.0	41000	NA	NA	NA	NA
5	7:30	184.3	12.2	1.5	17600	NA	8800	183.3	56.3
6	7:30	193.3	25.4	8.5	17200	NA	NA	NA	NA
7	7:30	391.3	21.0	0.5	20200	NA	17500	187.5	78.9
8	7:30	217.4	21.6	8.5	20800	NA	NA	NA	NA
9	7:30	478.3	39.2	1.0	29700	NA	NA	NA	NA
11	7:30	826.1	42.2	4.5	31200	NA	NA	NA	NA
12	7:30	847.8	80.0	48.0	32200	NA	31000	245.8	73.2
13	7:30	413.0	40.0	22.5	31100	NA	NA	NA	NA
15	7:30	391.3	33.6	1.5	29900	NA	NA	NA	NA
16	7:30	369.6	32.0	13.0	30200	NA	NA	NA	NA
17	7:30	347.8	8.6	12.0	27300	NA	NA	NA	NA
18	7:30	304.3	19.2	9.5	25620	NA	NA	NA	NA
19	7:30	326.1	21.8	11.0	25900	NA	NA	NA	NA
Num.of Anal.		27	27	27	27	0	7	7	7
Mean		533.3	42.1	21.6	33912	NA	46181	287.2	395.6
StandardDev.		301.0	45.2	31.8	18274	NA	35771	81.6	539.9
Lower95%C.L.		417.4	24.7	9.3	26878	NA	19141	225.5	-12.6
Upper95%C.L.		649.2	59.5	33.8	40945	NA	73222	348.9	803.7

BRINE TANK 4 - SAMPLE TAP ST4D ION EXCHANGE RECYCLE BRINE

Date	Time	Na	TH	Ca	EC	Temp.	TDS	SO4	Cl
1986		(meq/l)			(uS/cm)	(C)	(mg/l)	(meq/l)	
July 22	7:30	739.1	332.8	90.5	85200	NA	71800	120.8	1042.3
23	7:30	652.2	340.0	105.0	19300	NA	NA	NA	NA
24	7:30	652.2	34.0	280.0	81000	NA	72600	120.8	985.9
25	7:30	521.7	20.0	215.0	70300	NA	NA	NA	NA
26	7:30	565.2	280.0	90.0	65800	NA	NA	NA	NA
27	7:30	478.3	268.0	80.0	60400	NA	NA	NA	NA
28	7:30	565.2	306.0	95.0	70200	NA	NA	NA	NA
29	7:30	434.8	240.0	75.0	56800	NA	49200	120.8	619.7
30	7:30	347.8	220.0	65.0	44700	NA	NA	NA	NA
31	7:30	369.6	240.0	80.0	52900	NA	48400	125.0	535.2
Aug. 1	7:30	291.3	194.0	60.0	37400	NA	NA	NA	NA
2	7:30	347.8	120.0	37.5	37600	NA	NA	NA	NA
3	7:30	347.8	224.0	215.0	41200	NA	NA	NA	NA
4	7:30	347.0	220.0	120.0	42700	NA	NA	NA	NA
5	7:30	245.9	186.4	90.0	31000	NA	5800	120.8	259.2
6	7:30	197.6	98.0	33.5	23300	NA	NA	NA	NA
7	7:30	109.8	120.8	55.0	23900	NA	20000	187.5	191.5
8	7:30	167.0	121.6	47.0	21400	NA	NA	NA	NA
9	7:30	281.1	70.8	38.0	27100	NA	NA	NA	NA
11	7:30	326.1	116.4	55.0	17600	NA	NA	NA	NA
12	7:30	326.1	106.0	50.0	17300	NA	16000	129.2	160.6
13	7:30	260.9	73.6	30.5	24300	NA	NA	NA	NA
15	7:30	282.6	177.2	65.0	32500	NA	NA	NA	NA
16	7:30	304.3	168.0	50.0	33200	NA	NA	NA	NA
17	7:30	304.3	40.0	40.0	30900	NA	NA	NA	NA
18	7:30	239.1	158.0	55.0	29400	NA	NA	NA	NA
19	7:30	144.8	106.0	47.5	17900	NA	NA	NA	NA
Num.of Anal.		27	27	27	27	0	7	7	7
Mean		364.8	169.7	83.9	40567	NA	40543	132.2	542.1
StandardDev.		161.7	90.9	60.6	20314	NA	26996	24.6	365.5
Lower95%C.L.		302.5	134.7	60.6	32747	NA	20135	113.5	265.7
Upper95%C.L.		427.0	204.7	107.2	48385	NA	60950	150.8	818.4

BRINE TANK 3 - SAMPLE TAP ST3D ION EXCHANGE USED BRINE

Date	Time	Na	TH	Ca	EC	Temp.	TDS	SO4	Cl
1986		(meq/l)			(uS/cm)	(C)	(mg/l)	(meq/l)	
July 22	7:30	695.7	339.2	93.0	84700	NA	72400	87.5	1014.1
23	7:30	652.2	340.0	90.0	36600	NA	NA	NA	NA
24	7:30	652.2	36.0	270.0	83100	NA	71800	110.4	985.9
25	7:30	608.7	340.0	235.0	76400	NA	NA	NA	NA
26	7:30	565.2	260.0	80.0	61600	NA	NA	NA	NA
27	7:30	478.3	256.0	125.0	57700	NA	NA	NA	NA
28	7:30	434.8	256.0	80.0	57600	NA	NA	NA	NA
29	7:30	391.3	240.0	65.0	53100	NA	46700	125.0	563.4
30	7:30	391.3	242.0	70.0	47400	NA	NA	NA	NA
31	7:30	334.8	228.0	80.0	44200	NA	100000	141.7	450.7
Aug. 1	7:30	321.7	202.0	50.0	37200	NA	NA	NA	NA
2	7:30	294.3	194.0	55.0	33700	NA	NA	NA	NA
3	7:30	307.4	188.0	150.0	34900	NA	NA	NA	NA
4	7:30	263.5	220.0	75.0	35000	NA	NA	NA	NA
5	7:30	259.1	182.4	105.0	31700	NA	6800	141.7	304.2
6	7:30	245.9	154.0	55.0	28700	NA	NA	NA	NA
7	7:30	206.5	146.8	55.0	26800	NA	23000	162.5	206.8
8	7:30	215.2	122.4	50.0	21400	NA	NA	NA	NA
9	7:30	118.7	106.4	48.5	16500	NA	NA	NA	NA
11	7:30	304.3	104.8	46.0	16900	NA	NA	NA	NA
12	7:30	304.3	114.8	55.0	17400	NA	15000	145.8	159.1
13	7:30	149.3	92.0	40.0	17900	NA	NA	NA	NA
15	7:30	136.1	105.2	47.5	18000	NA	NA	NA	NA
16	7:30	193.3	102.8	40.0	18800	NA	NA	NA	NA
17	7:30	180.4	5.0	46.0	18300	NA	NA	NA	NA
18	7:30	140.4	124.0	42.0	19110	NA	NA	NA	NA
19	7:30	153.7	112.0	46.0	18000	NA	NA	NA	NA
Num.of Anal.		27	27	27	27	0	7	7	7
Mean		333.3	178.3	81.3	37508	NA	47957	130.6	526.3
StandardDev.		173.8	88.9	56.4	21107	NA	34830	25.1	351.8
Lower95%C.L.		266.3	144.1	59.6	29383	NA	21627	111.6	260.4
Upper95%C.L.		400.2	212.5	103.0	45632	NA	74286	149.6	792.2

Leakage Test Purpose: To investigate hardness leakage throughout rinsing and service events to determine if rinsing is adequate and verify hardness leakage in service.

Operation Parameters: Both IX units — Bed Vol.: 1286 gallons

Event	Flow Rate Unit 1 (gpm)	Flow Rate Unit 2 (gpm)	Duration (min)	Throughput Unit 1 (bed volume)	Throughput Unit 2 (bed volume)
RecReg1	200	200	19	2.95	2.95
RecReg2	200	200	25	3.89	3.89
FrBrReg	150	150	16	1.87	1.87
UpRinse A	75	75	6	0.35	0.35
UpRinse B	200	200	5	0.78	0.78
Rinse C	100	110	5	0.39	0.43
Rinse D	230	230	9	1.61	1.61
Service	230	230	120	21.46	21.46

Chemical Constituents: (daily samples from CWs and brine tanks)

	Ca (meq/l)	TH (meq/l)	Na (meq/l)	SO4 (meq/l)	Chloride (meq/l)	Ec (uS/cm)	Sample Location
Infl. Water:	5.50	10.40	13.48	NA	NA	2700	CW1
Effl. Water:	0.50	2.20	24.78	NA	NA	3000	CW3
Recycle Brine:	33.50	98.00	197.61	NA	NA	23300	T4
Fresh Brine:	8.50	25.40	193.26	NA	NA	17200	T1

TEST RESULTS:

	Unit 1	Unit2	
	0.17	0.17	Total Hardness Removed during Service (eq/l of resin)
	1.71	1.71	Total Sodium Throughput during Regen. (eq/l of resin)

IX Unit 2 Test Date: Aug. 6, 1986

Event	Time in Event	Leakage Calcium (as CaCO3)	Leakage Total Hard. (as CaCO3)	Total Throughput (bv)	Leakage Calcium (meq/l)	Leakage Total Hard. (meq/l)	TH removed per segment (eq/l of resin)
Influent	NA	288	474	NA	5.76	9.48	
Rinse D	0	498	1158	0.43	9.96	23.16	
" "	4	128	276	1.14	2.56	5.52	
Service	0	68	136	2.04	1.36	2.72	
" "	5	50	88	2.93	1.00	1.76	0.006
" "	10	38	66	3.83	0.76	1.32	0.007
" "	15	42	60	4.72	0.84	1.20	0.007
" "	60	40	64	12.77	0.80	1.28	0.066
" "	110	44	72	21.71	0.88	1.44	0.073
" "	120	42	58	23.50	0.84	1.16	0.015
						Total:	0.174

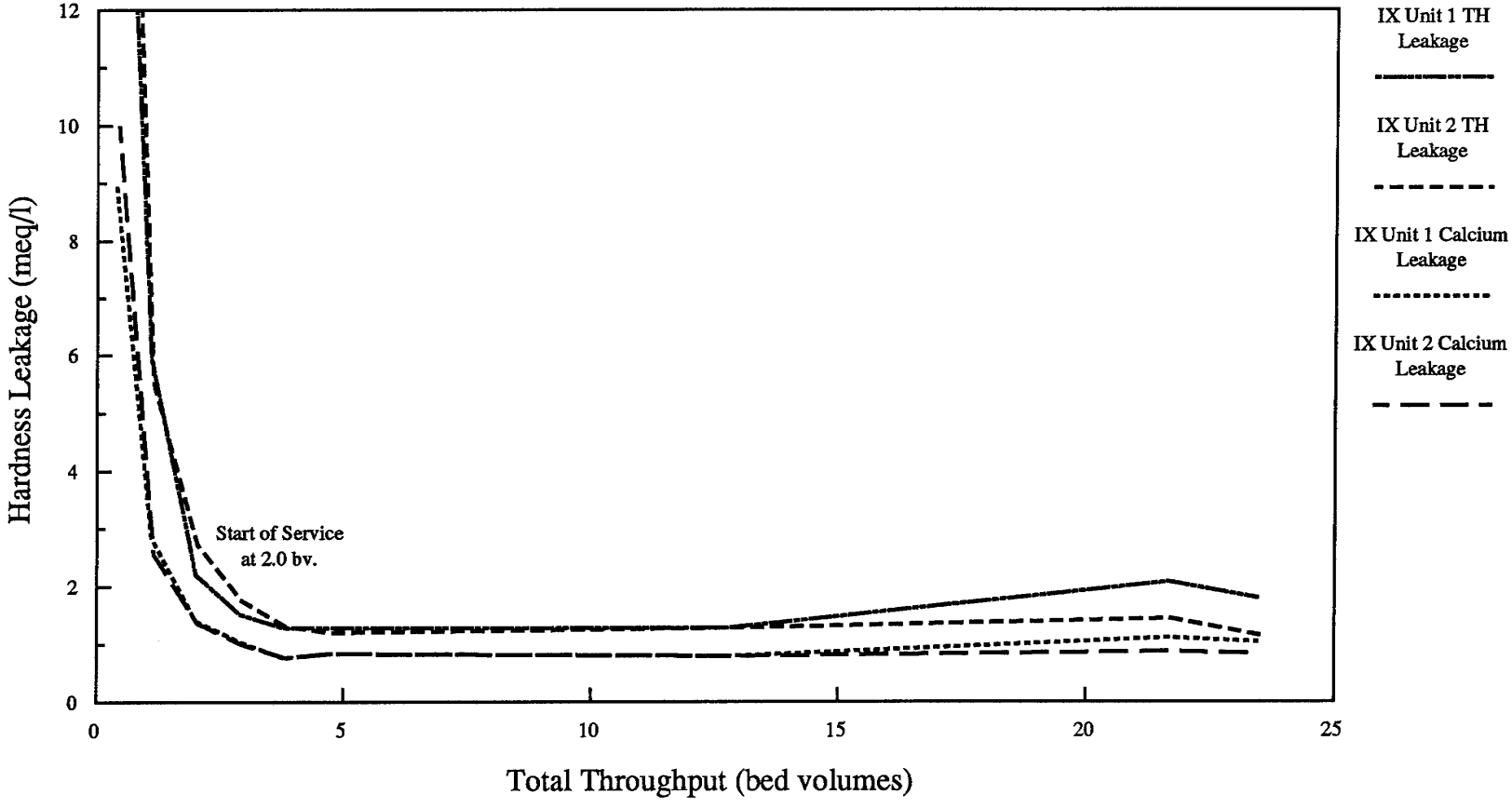
IX Unit 1 Test Date: Aug. 6, 1986

Event	Time in Event	Leakage Calcium (as CaCO3)	Leakage Total Hard. (as CaCO3)	Total Throughput (bv)	Leakage Calcium (meq/l)	Leakage Total Hard. (meq/l)	TH removed per segment (eq/l of resin)
Influent	NA	276	480	NA	5.52	9.60	
Rinse D	0	446	960	0.39	8.92	19.20	
" "	4	142	298	0.42	2.84	5.96	
Service	0	70	110	2.00	1.40	2.20	
" "	5	52	76	2.89	1.04	1.52	0.007
" "	10	38	64	3.79	0.76	1.28	0.007
" "	15	42	64	4.68	0.84	1.28	0.007
" "	60	40	64	12.73	0.80	1.28	0.066
" "	110	56	104	21.67	1.12	2.08	0.070
" "	120	52	90	23.46	1.04	1.80	0.014
						Total:	0.171

Hardness Leakage vs. Process Water Throughput

Leakage Test: IX Units 1 and 2

August 6, 1986



Unit 1	Unit 2
Ca - 5.5	Ca - 5.8
TH - 9.6	TH - 9.5

OPERATION INSTRUCTIONS
REJECT BRINE REGENERATION
UPFLOW RINSE

DATE: 11-Aug-86
SINGLE UNIT OPERATIONS
IX UNIT 2
RO2 infl. flow @ 94 gpm
EDR br. flow @ 7 gpm

EVENT NUMBER	EVENT DESCRIPTION	DURATION (minutes)	FLOW (gpm)	FLOW CONTROL VALVE
1	Recyc.brine regen.1	18	NOT ADJUSTABLE	
2	Recyc.brine regen.2	28	200	IV 112
3	Fr.brine regen.	14	150	IV 113
4	Rinse A Upflow	6	75	IV 114
5	Rinse B Upflow	5	200	IV 112
6	Rinse C	5	NOT ADJUSTABLE	
7	Rinse D	9	NOT ADJUSTABLE	
8	Service	120	230	IV 102
9	Settling in T2 or T3	80	NA	NA
10	Set-up for regen. to T4 from T2/3	30	NA	NA
11	Drain	3	NA	NA
12	Delay	98	NA	NA

Other instructions:

1. Place CSOV 1 and 6 in AUTO position previous to start-up.
2. Place IV 123 in OPEN position previous to start-up.
   VERIFY valve is OPEN.
3. Open manual valves IV 123m and 139m.
4. Adjust Event 12 - Delay as necessary to maintain relatively stable levels in CWs 3 and 4.

INSTRUCTIONS FOR DRY RUN OF IX SYSTEM 7/17/86

1. Place main circuit breakers for pumps IP 1, 2, 3, 5, 6, 7, 8, and 9 to OFF position.

2. Close isolation valves:
   a) CW's 1, 2, 3 and 4
   b) Tanks T 1, 4, 3 and 2
   c) IX Unit 1
   d) IX Unit 2
   e) Cartridge filters
   f) Chlorine line into clearwells 3 and 4.

3. Place IX valve switches in REMOTE control panel to AUTO position (Valves IV 21, 121, 22, and 122).

4. Place valves IV 23 and 123 in Remote control panel to OPEN position.

5. Place IX valve and pump switches in RO/IX office to AUTO position.

6. Initiate IX operations program.

7. AUTO button on Analog computer pressed in.

8. Adjust event times for both IX units according to the following schedule:

Event #	Event	Duration (minutes)
1.	Recycle Brine Reg. 1	3
2.	Recycle Brine Reg. 2	3
3.	Fresh Brine Regeneration	3
4.	Upflow Rinse A	3
5.	Upflow Rinse B	3
6.	Rinse C	3
7.	Rinse D	3
8.	Service	33
9.	Settling in T2 or T3	3
10.	Set-up for Regeneration: T2 or T3 to T4	
11.	Drain	3
12.	Delay	3

9. Start IX Unit 1.

10. Start IX Unit 2.

11. Verify valve openings and other operations for the schedule.

12. Document malfuncting valves or errant operations.

GENERAL START-UP PREPARATION LIST 7/18/86

The following items should be checked or performed previous to operation of the IX system.

1. CSOV #1 and #6 switches in chlorine shed placed in AUTO mode.
2. CW's 1 and 2 isolation valves open.
3. IX Unit 2 isolation valves open.
4. IX Unit 1 isolation valves open.
5. Tanks T 1, 4, 3 and 2 isolation valves open.
6. Check level of brine in tanks T 1, 4, 3 and 2. Transfer brine as necessary.
7. IX valve switches in REMOTE control panel on AUTO position (Valves IV 21, 121, 22 122)
8. IX valves IV 23 and 123 in REMOTE control panel on OPEN position.
   VERIFY valves are OPEN.
9. Open manual valves IV 23m, 123m, 39m and 139m.
10. CW's 3 isolation valves open. (Note: CW4 will not be used during these tests).
11. Chlorine pipeline isolation valve into CW3 and CW4 open.
12. Cartridge filter isolation valves open.
13. Main circuit breakers for IX pumps to ON position.
    (Pumps IP 1, 5, 6, 7, 8 and 9.)
14. IX valve and pump switches in RO/IX office on AUTO position.
    (Except pumps IP 2 and 3 are to be OFF)
15. IX control program on Analog computer initiated.
16. AUTO button on Analog computer pressed in.
17. Adjust event durations according to current schedule.

Preparation complete.

Note: List is for 2 unit operation. Adjust list as necessary for single unit operation.

APPENDIX H

MAIN UNIT MISCELLANEOUS DATA AND OPERATIONS PROGRAM

Ion-Exchange System

Description of Control Software
Operations Program for Analog MACSYM Computer
List of Device Connection to Analog Operation Computer
Output for Worksheet Program to Determine IX Operation Schedule
Volume Information on IX Columns
Manufacturers Resin Reports
List of Report Files

ION EXCHANGE CONTROL SOFTWARE

The ion exchange (IX) installation at the Los Banos demonstration Desalting Facility performs a vital function in plant operations. It removes calcium ion from the incoming process water. These ions can scale the reverse osmosis (RO) membranes in the next stage of plant operations. The IX operation cycle is timed and controlled with an Analog Devices Macsym2 process control computer. The IX units at the desalting facility have a daily capacity of roughly 330,000 gallons per day. They are located outside the facility's RO building.

In terms of IX control software requirements, the IX units must be put through a complex sequence of valve and flowrate "events". A typical event sequence is illustrated in Figure 1.1. Each event can vary in timing, valves, and pumps used. Since the two units share some equipment, equipment conflicts must be detected and avoided. IX cycle status, IX cycle halts,IX unit flushes, brine tank transfers and an emergency halt of all processes must also be available. Lastly, the IX control software must log the start and stop times of units and events to the site's Hewlett-Packard 1000 minicomputer, be simple to understand, and easy to operate.

The IX control software is written in a multi-tasking Macsym2 version of the Basic programming language. Multi-tasking is a term used to describe a computer program which can perform more than one job concurrently. In a multi-tasking program, the task scheduler of the computer's operating utility allocates CPU time to each active job (task). This allows for a single Macsym2 program have more than one section of its Basic code executing at the same time. In the IX control software, as many as five tasks may be executing at the same time, each task performing independently of the others. This allows the control software to closely control the complicated IX cycle.

In the IX control software, the menu serves as a master task, starting and stopping slave tasks which run parallel to it. The slave tasks execute in the background of menu operation. The slave tasks control Unit 2 and Unit 2 operation as well as most of the action choices from the main menu (MM). Typically, the main menu task inputs operation parameters for a requested action and starts a slave task to perform the action. The IX control program is illustrated in Figure 1.2.

In an effort to make the IX control program as flexible in operation as possible, it was necessary to provide options on how it functioned. These options do not change what the program does. Instead, the options change how the program accomplishes some parts of the IX cycle. The IX control program special option menu (SM) is a submenu accessed from the IX main menu as choice #7.

Before displaying the special options menu, the program asks the user to make an IX unit choice. All special options menu choices will change that option for only that unit. To change options for

both units, one must go back to the main menu and choose #7 again. In general, when the program asks the user for an option choice, pressing [return] will simply leave the last chosen option as the default choice.

ION EXCHANGE SYSTEM FIGURE 1.1 LOS BANOS FACILITY

OPERATIONS SCHEDULE 16-Aug-86
REJECT BRINE REGENERATION DEFAULT DURATIONS AND FLOWS WASTE BRINE TO RWPS
UPFLOW RINSE USED BRINE TO T2 OR T3
RINSE TO SL DRAIN

EVENT NUMBER	EVENT DESCRIPTION	DURATION (minutes)	COMPONENT OPERATION/VALVE OPEN Unit 1	Unit 2	PROCESS FLOW Unit	from	to
1	Recyc.brine regen. 1	13	IP 5, A1 IV 15,12,7,9, 21	IP 5, A2 IV 115,112,107, 121	1 2	T4 T4	RWPS RWPS
2	Recyc.brine regen. 2	40	IP 5, A1 IV 15,7,4,23,*	IP 5, A2 IV 115,107,104, 123,*	1 2	T4 T4	T2 T3
3	Fresh brine regen.	9	IP 1, A1 IV 17,7,4,23, 39m, *	IP 1, A2 IV 18,107,104, 123,139m,*	1 2	T1 T1	T2 T3
4	Rinse A Upflow	6	IP 7, A1 IV 3,7,4,23,*	IP 9, A2 IV 103,107,104, 123,*	1 2	CW1 CW2	T2 T3
5	Rinse B Upflow	5	IP 7, A1 IV 3,7,4,23,*	IP 9, A2 IV 103,107,104	1 2	CW1 CW2	T2 T3
6	Rinse C Downflow	5	IP 7, A1 IV 1,7,4,21	IP 9, A2 IV 101,107,110,121	1 2	CW1 CW2	RWPS RWPS
7	Rinse D Downflow	9	IP 7, A1 IV 2,7,4,21	IP 9, A2 IV 102,107,110,121	1 2	CW1 CW2	RWPS RWPS
8	Service	120	IP 7 IV 7,11,* CSOV 1	IP 9 IV 107,111,* CSOV 6	1 2	CW1 CW2	CW3 CW4
9	Settling in T2 or T3	50	**To be performed during service event**		1 settling in T2 2 settling in T3		
10	Set-up for regen. **To be performed during service event**	35	IP 6 IV 5	IP 6 IV 105	1 2	T2 T3	T4 T4
11	Drain	3	IV 6,10,21 A1	IV 106,110,121 A2	1 2	Unit 1 Unit 2	RWPR RWPS
12	Delay	0	A1	A2			

* Flow variables: Events 2, 3, 4 and 5 - IV 14 or 114 for 75gpm or IV 13 or 113 for 150gpm or IV 12 or 112 for 200gpm.
Event 8: IV 1 or 101 for 110gpm or IV 2 or 102 for 230gpm.
** Durations based upon 2 unit operation for 1 bv of brine produced during service and flows of 200, 150, 75, 200, and 230 for Events 2, 3, 4, 5, and 8 respectively. (default flows and durations). See operation instructions for current flows and durations. Feed water at 7500 uS/cm.

Key: A - Agitator Mixer
CW - Clearwell
CSOV - Chlorine solenoid valve
DP - Dechlorination pump
IP - Ion exchange pump
IV - Ion exchange valve
IX Sump - Ion exchange sump
m - manual
RWPS - return water pump station
T - brine tank

FIGURE 1.2 -- IX MAIN MENU

EDR/RO RECYCLE BRINE OPERATIONS MENU

See/set Macsym time 1
Start an IX unit 2
Change times for events 3

Status Report on Ix 4
Stop an IX unit 5
Flush an IX unit 6
Special option menu 7
Start/Stop brine XFER 8
Emergency stop both units ...9

Type your choice (1 - 9) and [return]

MM choice = 1. See/set Macsym time.
1. Prints Macsym time to screen.
2. If "T" is typed at "press [return] to continue", then you are allowed to reset Macsym time.
3. Then return to menu (RTM).

MM choice = 2. Start IX unit.
1. User inputs unit choice.
2. Used inputs startup event.
3. User approves event times.
4. Program prestops unit.
5. Program activates unit cycle.
6. Program activates unit cycle.
7. RTM.

MM choice = 3. Change event times.
1. User inputs unit choice.
2. User approves event times.
3. RTM.

MM choice = 4. Status report in IX.
1. Unit status reported by program.
2. RTM.

MM choice = 5. Stop IX unit.
1. User inputs unit choice.
2. Program stops IX cycle action and performs cold shutdown of all motors and valves.
3. RTM.

MM choice = 6. Stop and flush IX unit.
1. User inputs unit choice.
2. User choosed start or stop flush.
3. Program stops unit.
4. Program performs requested action.
5. RTM.

MM choice = 7. Special options menu.
1. User inputs unit choice.
2. Program displays paramenter menu.
3. User inputs paramenter change choice.
4. Program prints current parameter settings.
5. User inputs paramenter change.
6. If user chooses RTM, RTM. Else go to #2.

MM choice = 8. Brine transfer.
1. User chooses which transfer to do.
2. User chooses to start or stop transfer.
3. User chooses time for transfer.
4. Program stops of performs brine transfer.
5. RTM.

MM choice = 9. Emergency stop (both units)
1. Program performs emergency stop.
2. RTM.

FIGURE 1.3 -- IX SPECIAL OPTIONS MENU

SPECIAL OPTIONS MENU, UNIT

Continue (1) or stop (2) 1
IX pumps used (7, 8, 9) 2
IX flowrate (1 or 2) 3
Regeneration Delay 4
Switch brine runs 5
Regeneration #2 flowrate 6
Regeneration #3 flowrate 7
Go back to main menu 8

Type your choice (1 - 8) and [return]

SM choice = 1. Continuous (1) or stop (2) mode.
1. The program reports current unit and mode.
2. User types in new mode.
3. RTM.

Continuous or stop mode refers to whether the unit is to operate in a continuous loop or stop at end of cycle.

SM choice = 2. IX pumps used (7, 8, 9)
1. The program reports current unit and service pump.
2. The user types in new pump.
3. RTM.

MM choice = 3. IX flowrate (1 or 2).
1. The program reports current unit and flowrate.
2. The user types in new flowrate.
3. RTM.

1 = 110 gpm, 2 = 230 gpm.

MM choice = 4. Regeneration delay.
1. The program reports current unit and regeneration delay.
2. The user types in new delay in minutes.
3. RTM.

If the unit is not in stop mode and if both units are in operation, this delay is experienced between end of cycle and Event 1. It is designed to delay Event 1 for a time period which will help cooordinate the service cycle to 50 percent (no dead time).

MM choice = 5. Switch brine runs.
1. Program reports current unit and brine pipe run used.
2. User types in new pipe new pipe run choice.
3. RTM.

MM choice = 6. Regeneration #2 flowrate.
1. Program reports current unit and flowrate for Event 2.
2. User types in new flowrate.
3. RTM.

1= 200 gpm, 2 = 150 gpm.

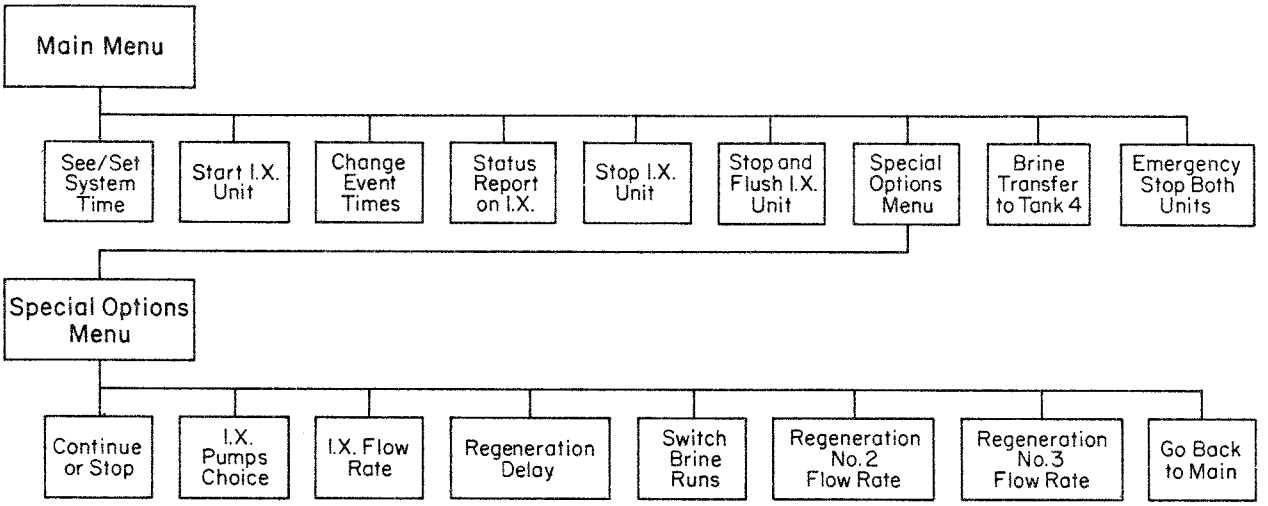
MM choice = 7. Regeneration #3 flowrate.
1. Program reports current unit and flowrate for Event 3.
2. User types in new flowrate.
3. RTM.

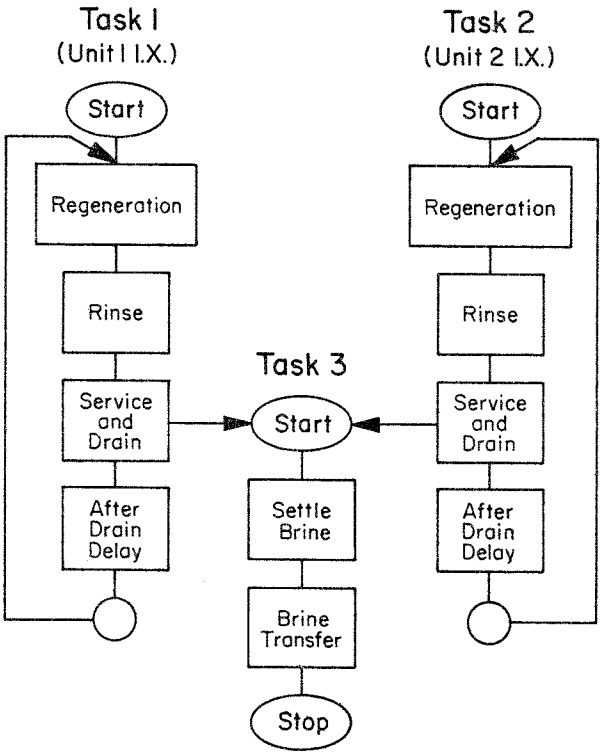
1 = 150 gpm, 2 = 75 gpm.

MM choice = 8. Go back to main menu.
1. Program returns screen control to main menu.

Los Banos Facility Ion Exchange System

Programming Structure Chart





```
 1 REM ** A.D. MEXIX.BAS EDR/RO MACSYM 2 OPERATIONS
 2 REM ** PROG; TONY C.  V$ HAS VERSION DATE
 3 DIM V$(12)  V$=TC 07/28/86
 4 REM ** BEGIN MAIN PROGRAM
 5 ON ERROR X1',12600,X2'  REM ERROR TRAP
10 CLOSE NOMODE REM CLOSE ALL, NO MODE CHKS
20 GOSUB 10300 REM SETUP VAR.S
30 GOSUB 10200 REM SETUP RS-232'S
40 GOSUB 10100 REM TIME SET
45 TASK 1,1000 TASK 2,200 REM MAIN TASKS
50 GOSUB 10500 REM DO MAIN MENU
60 GOSUB 10600 REM ALL INPUT
70 ON A' GOTO 100,200,300,400,500,600,700,800,900
80 GO TO 50

100 REM ** SEE/SET TIME
105 GOSUB 10050 IF R'=1 THEN GOTO 50
110 PRINT "MACSYM SYSTEM TIME BELOW:"
115 PRINT :TYPE T <RET>TO RESET TIME."
120 PRINT PTIME PRINT  PRINT
130 GOSUB 10800  IF A$="T" THEN GOSUB 10100
140 GOTO 50

200 REM ** START IX
220 GOSUB 11000  GOSUB 10600  REM GET UNIT
222 IF A'<1  THEN 12500
224 IF A'>2  THEN 12500
230 U' = A'     IF R'=0 THEM GOSUB 11100
235 PRINT "UNIT:";U';',START EVENT$( 1-";N9';" )";
240 GOSUB 10600
242 IF A'<1 THEN 12500
244 IF A'>W9' THEN 12500
246 E'=A' IF R'=1 THEN GOTO 250
248 GOSUB 11200 GOSUB 10900 IFA$="Y" THEN 625
249 GOSUB 12500 GOTO 248
250 FOR I = 1 TO N9' GOSUB 10600
260 T"(U',I)=A'  NEXT I
265 GOSUB 11500 REM PRESTOP
270 PRINT "STARTING UNIT:";U'
271 PTIME  PRINT  DOT(5,8+U')=1
272 IF U'=2 THEN 280
274 U1'=U' E1'=E' Z1'=1   ACT 1
276 GOSUB 12110(U',E'.Z1')  GOTO 299
280 U2'=U' E1'=E' Z1'=1   ACT 2
282 GOSUB 12111(U'.E',Z1')
299 GOSUB 10800  GOTO 50

300 REM ** CHANGE EVENT TIMES
310 GOSUB 11000 GOSUB 10600
312 IF A'<1  THEN 12500
314 IF A'>2 THEN 12500
340 U'=A'  IF R'=1 THEN GOTO 350
341 GOSUB 11200 GOSUB 10900 IF A$="Y" THEN 370
342 GOSUB 11250 GOTO 341
350 FOR I = 1 TO N9' GOSUB 10600
360 T'(U',I)=A'  NEXT I
370 GOSUB 10050  PRINT "TIMES ARE NOW CHANGED."
399 GOSUB 10800  GOTO 50

400 REM ** REPORT IX STATUS
410 GOSUB 11400
499 GOSUB 10800  GOTO 50

500 REM ** SHUT DOWN
510 GOSUB 11000  GOSUB 10600
512 IF A'<1 THEN 12500
514 IF A'>2 THEN 12500
520 U'=A'   GOSUB 11500REM SHUTDOWN
599 GOSUB 10800 GOTO 50
600 REM ** UPFLOW FLUSH
610 GOSUB 10050
615 PRINT "FLUSH ALSO STOPS UNIT." GOSUB 10050
620 GOSUB 11000 GOSUB 10600
625 IF A'<1 THEN 12500
630 IN A'>2 THEN 12500
635 U'=A'   GOSUB 11500  GOSUB 10050
640 PRINT "TYPE 1 TO STOP, 2 TO START."
645 GOSUB 10600
650 IF A'<1 THEN 12500
655 IF A'>2 THEN 12500
660 E'=A'   IF E'=2 THEN 680
662 PRINT "KILLINJG FLUSH, UNIT:";U'
665 IN U'=1 IF TSTATE(4)>0 THEN KILL 4
670 IN U'=2 IF TSTATE(5)>0 THEN KILL 5
675 GOSUB 11500  GOTO 699
680 PRINT "8 MIN. FLUSH, UNIT :';U'
685 IN U'=1 IF TSTATE(4)<0 THEN TASK 4,12400 ACT 4
690 IN U'=2 IF TSTATE(5)<0 THEN TASK5,12450 ACT 5
699 GOSUB 10800 GOTO 50
700 REM ** SPECIAL OPTIONS
701 GOSUB 11000 GOSUB 10600 IF A'<1 THEN 12500
702 IF A'>2 THEN 12500
703 U'=A'
704 GOSUB 10400 REM ** SPECIAL MENU
705 GOSUB 10600  IN A'=19 THEN R'=1-R' GOTO 50
706 IF A'<1 THEN GOTO 12500
707 IF A'>10 THEN GOTO 12500
708 PRINT PRINT "UNIT=";U'
709 E'=A'  ON E' GOTO 710,720,730,740,750,760,770,
                    780,50
710 REM ** CONT. OR STOP
711 PRINT "MODE=";P1(U')
712 PRINT "CONT.(1) OR STOP.(2)"
714 GOSUB 10600 IF A'<1 THEN 12500
715 IF A'>2 THEN 12500
717 P1(U')=A'  GOTO 704
720 REM ** IX PUMP
721 PRINT "IX PUMP=";P1(2+U')
722 PRINT "NEW PUMP 7/8/9:";  GOSUB 10600
723 IF A'<7 THEN 12500
724 IF A'>9 THEN 12500
725 IF U'=1 IF A'=9 THEN 12500
726 IF U'=2 IF A'=7 THEN 12500
727 IF A'=8 IF U'=1 IF P1(4)=8 THEN 12500
728 IF A'=8 IF U'=2 IF P1(3)=8 THEN 12500
729 P1(2+U')=A'  GOTO 704
730 REM ** FLOW RATE
731 PRINT "IX FLOW RATE=";P1(4+U')
732 PRINT "GPM RATE 1=110,2=230:"
733 GOSUB 10600  IF A'<1 THEN 12500
734 IF A'>2 THEN 12500
735 P1(4+U')=A' PRINT FLOW RATE CHANGED." GOTO 704
740 REM ** REGEN DELAY
742 PRINT "REGEN. DELAY=";P1(6+U')
743 PRINT "DELAY(1 TO 200):";
744 GOSUB 10600  IF A'<1 THEN 12500
746 IN A'>200 THEN 12500
748 P1(6+U')=A'  GOTO 704
750 REM ** REGEN#2 FLOWRATE
751 PRINT "REGEN#2 FLOW =";P1(8+U')
752 PRINT "1=200, 2=150, 3=75 GPM."
753 PRINT "NEW RATE ( 1/2/3 ):"; GOSUB 10600
754 IF A'<1 THEN 12500
755 IF A'>3 THEN 12500
756 P1(8+U')=A' PRINT "RATE CHANGED."
757 GOSUB 10800  GOTO 704
760 REM ** REGEN#3 FLOWRATE
761 PRINT "REGEN#3 FLOW =";P1(10+U')
```

```
762 PRINT "1=200, 2=150, 3=75 GPM."
763 PRINT "NEW RATE ( 1/2/3 ):"; GOSUB 10600
764 IF A'<1 THEN 12500
765 IF A'>3 THEN 12500
766 P1(10+U')=A' PRINT "RATE CHANGED."
767 GOSUB 10800  GOTO 704
770 REM ** RINSE#4 FLOWRATE
771 PRINT "RINSE#4 FLOW =";P1(12+U')
772 PRINT "1=200, 2=150, 3=75 GPM."
773 PRINT "NEW RATE ( 1/2/3 ):"; GOSUB 10600
774 IF A'<1 THEN 12500
775 IF A'>3 THEN 12500
776 P1(12+U')=A' PRINT "RATE CHANGED."
777 GOSUB 10800  GOTO 704
780 REM ** RINSE#5 FLOWRATE
781 PRINT "RINSE#5 FLOW =";P1(14+U')
782 PRINT "1=200, 2=150, 3=75 GPM."
783 PRINT "NEW RATE ( 1/2/3 ):"; GOSUB 10600
784 IF A'<1 THEN 12500
785 IF A'>3 THEN 12500
786 P1(14+U')=A' PRINT "RATE CHANGED."
787 GOSUB 10800  GOTO 704

800 REM ** BRINE TRANSFER
802 GOSUB 10050
804 PRINT "XFER FROM T2 TO T4.....1"
806 PRINT "XFER FROM T3 TO T4.....2"
808 PRINT "BACK TO MENU.........3"
812 GOSUB 10600  IF A'<1 THEN 12500
814 U'=A'  IF A'=3 THEN GOTO 50
820 PRINT "START(1) OR STOP(2) XFER"
822 GOSUB 10600  IF A'<1 THEN 12500
824 IF A'>2 THEN 12500
826 IF A'=2 THEN 850  REM ** STOP IT
828 IF U'=1 IF TSTATE(7)>0 THEN 840
829 IF U'=2 IF TSTATE(8)>0 THEN 840
830 REM** START BRINE XFER
831 PRINT "HOW LONG :"; GOSUB 10600
832 IF A'<1 THEN 12500
833 IF U'=1 THEN TASK 7,12700 ACT 7
834 IF U'=2 THEN TASK 8,12800 ACT 8
835 PRINT "STARTING BRINE XFER."
836 GOSUB 10800 GOTO 50
840 REM ** XFER ALREADY STARTED
842 PRINT "XFER ALREADY ON."
846 GOSUB 10800 GOTO 800
850 REM ** STOP BRINE XFER
851 IF U'=1  IF TSTATE(7)>0 THEN KILL 7 GOSUB 860
852 IF U'=2  IF TSTATE(8)>0 THEN KILL 8 GOSUB 870
854 PRINT "BRINE XFER KILLED."  GOSUB 10800 GOTO 50
860 DOT(5,9)=1  DOT(5,11)=0  DOT(5,5)=0  DOT(6,8,9)=1
865 RETURN
870 DOT(5,10)=1  DOT(5,12)=0  DOT(5,5)=0 DOT(9,9,9)=1
875 RETURN

900 REM ** EMERGENCY SHUTDOWN
910 GOSUB 10050
920 PRINT "EMERGENCY SHUTDOWN."
930 GOSUB 10900 IF A$="N" THEN GOTO 50
940 DOT(5,0,15)=0
960 U'=1 GOSUB 11500 REM CLOSEDOWN U1
970 U'=2 GOSUB 11500 REM CLOSEDOWN U2
990 GOSUB 10800 IF A$="X" THEN STOP
999 GOTO 50

1000 REM ** UNIT 1 RO BRIN OP.S, TASK 1.
1001 IF E1' > 6 THEN 1003
1002 ON E1'-0 GOTO 1050,1100,1150,1200,1250,1300
1003 ON E1'-6 GOTO 1350,1450,1482,1482,1500,1550
1004 PRINT "STOP AT 1000 DUE TO EVENT ERROR."  STOP

1050 REM ** 1 ST REGEN,#1
1051 GOSUB 11600
1052 IF D1'=2 THEN 1052
1054 D1'=1  E1'=1
1060 DOT(5,4)=1
1065 DOT(6,12,13)=2  DOT(7,0,1)=2  DOT(7,6,7)=2
1075 DOT(7,12,13)=2  DOT(11,7,8)=2
1080 GOSUB 12010( U1', E1' )
1082 W1'=T(1,E1')  IF W1'>0 THEN WAIT W1'*60-10
1085 DOT(5,4)=0  DOT(11,7,8)=1

1100 REM **** 2ND REGEN,#2
1101 GOSUB 11600
1102 IF D1'=2 THEN 1102
1104 D1'=1  E1'=2
1110 DOT (5,4)=1
1112 GOSUB 1800 REM FLOWRATE
1115 DOT(6,6,7)=2   DOT(6,12,13)=2
1125 DOT(7,12,13)=2  DOT(2,0,1)=2
1130 GOSUB 12010( U1', E1' )
1132 W1'=T'(1,E1')  IF W1'>0 THEN WAIT W1'*60-10
1135 DOT(5,4)=0  DOT(2,0,1)=1
1150 REM **** 3RD REGEN,#3
1151 GOSUB 11600
1152 IF D1'=2 THEN 1152
1154 D1'=1  E1'=3
1160 DOT (5,0)=1
1162 GOSUB 1800
1165 DOT(6,6,7)=2   DOT(6,12,13)=2
1175 DOT(8,0,1)=2  DOT(2,0,1)=2
1180 GOSUB 12010( U1', E1' )
1182 W1'=T'(1,E1')  IF W1'>0 THEN WAIT W1'*60-10
1185 DOT(5,0)=0  DOT(2,0,1)=1 DOT(8,0,1)=1  D1'=0

1200 REM **** RINSE A,#4
1201 GOSUB 11600
1202 IF D2'=2 THEN 1202
1204 D2'=1  E1'=4
1210 DOT(5,P1(3)-1)=1
1215 GOSUB 1800
1220 DOT(6,4.5)=2  DOT(6,6,7)=2
1225 DOT(6,12.13)=2  DOT(2,0,1)=2
1230 GOSUB 12010(U1',E1')
1232 W1'=T'(1,E1')  IF W1'>0 THEN WAIT W1'*60-10
1235 DOT(5,P1(3)-1)= 0  DOT(2,0,1)=1
1250 REM **** RINSE B,#5
1251 GOSUB 11600
1252 IF D2'=2 THEN 1252
1254 D2'=1  E1'=5
1260 DOT(5,P1(3)-1)=1
1265 GOSUB 1800
1270 DOT(6,4.5)=2  DOT(6,6,7)=2
1275 DOT(6,12.13)=2  DOT(2,0,1)=2
1280 GOSUB 12010(U1',E1')
1282 W1'=T'(1,E1')  IF W1'>0 THEN WAIT W1'*60-10
1285 DOT(5,P1(3)-1)= 0  DOT(2,0,1)=1
1300 REM **** RINSE C,#6
1301 GOSUB 11600
1302 IF D2'=2 THEN 1302
1304 D2'=2  E1'=6
1310 DOT(5,P1(3)-1)=1
1315 DOT(6,0,1)=2  DOT(6,12,13)=2
1325 DOT(7,2,3)=2  DOT(11,5,6)=2
1330 GOSUB 12010(U1',E1')
1332 W1'=T'(1,E1')  IF W1'>0 THEN WAIT W1'*60-10
1335 DOT(5,P1(3)-1)= 0  DOT(11,5,6)=1
1350 REM **** RINSE D,#7
```

```
1351 GOSUB 11600
1352 IF D2'=2 THEN 1352
1354 D2'=1 E1'=7
1360 DOT(5,P1(3)-1)=1 DOT(5,8+1)=0
1365 DOT(6,2,3)=2 DOT(6,12,13)=2
1375 DOT(7,2,3)=2 DOT(11,5,6)=2
1380 GOSUB 12010(U1',E1')
1382 W1'=T'(1,E1') IF W1'>0 THEN WAIT W1'*60-10
1385 DOT(5,P1(3)-1)= 0 DOT(11,5,6)=1 D2'=0

1450 REM **** SERVICE
1452 GOSUB 11600
1454 IF S'=2 THEN 1454
1455 S'=1 E1'=8
1460 DOT(5,P1(3)-1)=1 GOSUB 1900
1465 DOT(8,8)=1 DOT(6,12,13)=2
1470 DOT(7,4,5)=2
1480 GOSUB 12010(U1',E1')
1482 IF P'=2 THEN 1482
1483 IF E1'>8 THEN E3'=E1' S'=1
1484 TASK 3,3000 ACT 3
1486 W1'=T'(1,E1') IF W1'>0 THEN WAIT W1'*60-10
1490 DOT(5,P1(3)-1)=0 DOT(8,8)=0

1500 REM **** DRAIN,#11
1501 GOSUB 11600
1502 IF S'=2 THEN 1502
1504 IF P'=1 THEN 1504
1506 E1'=11 S'=1
1515 DOT(6,10,11)=2 DOT(7,2,3)=2
1525 DOT(11,5,6)=2
1530 GOSUB 12010(U1',E1')
1532 W1'=T'(1,E1') IF W1'>0 THEN WAIT W1'*60-10
1535 DOT(11,5,6)=1

1550 REM **** AFTER DRAIN DELAY, UNLESS SUSPEND.
1552 GOSUB 11600 REM CLOSE VALVES
1560 E1'=12     IF P1(1)=2 THEN GOTO 1600
1570 GOSUB 12010( U1', E1' )
1580 W1'=T'(1,12) IF W1'>0 THEN WAIT W1'*60-10
1585 S'=0 IF U2'=0 THEN GOTO 1050
1587 PRINT "UNIT 1 COORD. DELAY=";P1(7)
1590 IF P1(7)>0 THEN WAIT P1(7)*60
1595 GOTO 1050
1600 REM **** SUSPEND UNIT 1 BPS
1610 W1'=0 GOSUB 12010( U1', E1')
1615 GOSUB 12110( U1', E1', E1')
1620 U1'=0 DOT(5,9)=0 C(3)=0 S'=0
1625 PRINT "UNIT 1 SELF-SUSPEND." PTIME PRINT
1630 SUSPEND SELF

1800 REM ** SUBR: OPEN FLOW RATE
1802 W1'=P1( 8+(E1'*2)-3 )
1810 IF W1' = 1 THEN DOT(7,6,7)=2
1820 IF W1' = 2 THEN DOT(7,8,9)=2
1830 IF W1' = 3 THEN DOT(7,10,11)=2
1849 RETURN
1900 REM ** SUBR: OPEN FLOW VALVE
1910 IF P1(5) = 1 THEN DOT(6,0,1)=2
1920 IF P1(5) = 2 THEN DOT(6,2,3)=2
1930 RETURN

2000 REM ** UNIT 2 RO BRINE OP.S TASK 2.
2001 IF E2' > 6 THEN 2003
2002 ON E2'-0 GOTO 2050,2100,2150,2200,2250,3300
2003 ON E2'-6 GOTO 2350,2450,2482,2482,2500,2550
2004 PRINT "STOP AT 2000 DUE TO EVENT ERROR." STOP

2050 REM **** FIRST REGEN,#1
2051 GOSUB 11650
2052 IF D1'=1 THEN 2052
2054 D1'=2 E2'=1
2060 DOT(5,4)=1
2065 DOT(9,12,13)=2 DOT(10,0,1)=2 DOT(10,6,7)=2
2075 DOT(10,12,13)=2 DOT(11,11,12)=2
2080 GOSUB 12010( U2', E2' )
2082 W2'=T(2,E2') IF W2'>0 THEN WAIT W2'*60-10
2085 DOT(5,4)=0 DOT(11,11,12)=1
2100 REM **** 2ND REGEN,#2
2101 GOSUB 11650
2102 IF D1'=1 THEN 2102
2104 D1'=2 E2'=2
2110 DOT (5,4)=1
2112 GOSUB 2800
2115 DOT(9,6,7)=2   DOT(9,12,13)=2
2125 DOT(10,12,13)=2 DOT(2,2,3)=2
2130 GOSUB 12010( U2', E2' )
2132 W2'=T'(2,E2') IF W2'>0 THEN WAIT W2'*60-10
2135 DOT(5,4)=0 DOT(2,2,3)=1
2150 REM **** 3RD REGEN,#3
2151 GOSUB 11650
2152 IF D1'=1 THEN 2152
2154 D1'=2 E2'=3
2160 DOT (5,0)=1
2162 GOSUB 2800
2165 DOT(9,6,7)=2   DOT(9,12,13)=2
2175 DOT(2,2,3)=2 DOT(8,2,3)=2
2180 GOSUB 12010( U2', E2' )
2182 W2'=T'(2,E2') IF W2'>0 THEN WAIT W2'*60-10
2185 DOT(5,0)=0 DOT(2,2,3)=1 DOT(8,2,3)=1 D1'=0

2200 REM **** RINSE A,#4
2201 GOSUB 11650
2202 IF D2'=1 THEN 2202
2204 D2'=2 E2'=4
2210 DOT(5,P1(4)-1)=1
2215 GOSUB 2800
2220 DOT(9,4.5)=2 DOT(9,6,7)=2
2225 DOT(9,12.13)=2 DOT(2,2,3)=2
2230 GOSUB 12010(U2',E2')
2232 W2'=T'(2,E2') IF W2'> 0 THEN WAIT W2'*60-10
2235 DOT(5,P1(4)-1)= 0 DOT(2,2,3)=1
2250 REM **** RINSE B,#5
2251 GOSUB 11650
2252 IF D2'=1 THEN 2252
2254 D2'=2 E2'=5
2260 DOT(5,P1(4)-1)=1
2265 GOSUB 2800
2270 DOT(9,4.5)=2 DOT(9,6,7)=2
2275 DOT(9,12.13)=2 DOT(2,2,3)=2
2280 GOSUB 12010(U2',E2')
2282 W2'=T'(2,E2') IF W2'>0 THEN WAIT W2'*60-10
2285 DOT(5,P1(4)-1)=0 DOT(2,2,3)=1
2300 REM **** RINSE C,#6
2301 GOSUB 11650
2302 IF D2'=1 THEN 2302
2304 D2'=2 E2'=6
2310 DOT(5,P1(4)-1)=1
2315 DOT(9,0,1)=2 DOT(9,12,13)=2
2325 DOT(10,2,3)=2 DOT(11,9,10)=2
2330 GOSUB 12010(U2',E2')
2332 W2'=T'(2,E2') IF W2'>0 THEN WAIT W2'*60-10
2335 DOT(5,P1(4)-1)= 0 DOT(11,9,10)=1
2350 REM **** RINSE D,#7
2351 GOSUB 11650
2352 IF D2'=1 THEN 2352
2354 D2'=2 E2'=7
2360 DOT(5,P1(4)-1)=1 DOT(5,8+2)=0
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```
2365 DOT(9,2,3)=2  DOT(9,12,13)=2
2375 DOT(10,2,3)=2  DOT(11,9,10)=2
2380 GOSUB 12010(U2',E2')
2382 W2'=T'(2,E2')  IF W2'>0 THEN WAIT W2'*60-10
2385 DOT(5,P1(4)-1)= 0  DOT(11,5,6)=1  D2'=0

2450 REM **** SERVICE,#8
2452 GOSUB 11650
2454 IF S'=1 THEN 2454
2455 S'=2  E2'=8
2460 DOT(5,P1(4)-1)=1  GOSUB 2900
2465 DOT(8,9)=1  DOT(10,4,5)=2
2470 DOT(9,12,13)=2
2480 GOSUB 12010(U2',E2')
2482 IF P'=1 THEN 2482
2483 IF E2'>8 THEN E3'=E2'  S'=2
2484 TASK 3,3000  ACTIVATE 3
2486 W2'=T'(2,E2')  IF W2'> 0 THEN WAIT W2'*60-10
2490 DOT(5,P1(4)-1)=0  DOT(8,9)=0

2500 REM **** DRAIN,#11
2501 GOSUB 11650
2502 IF S'=1 THEN 2502
2504 IF P'=2 THEN 2504
2506 E2'=11  S'=2
2515 DOT(9,10,11)=2  DOT(10,2,3)=2
2525 DOT(11,9,10)=2
2530 GOSUB 12010(U2',E2')
2532 W2'=T'(2,E2')  IF W2'> 0 THEN WAIT W2'*60-10
2535 DOT(11,9,10)=1

2550 REM **** AFTER DRAIN DELAY, OR SUSPEND BELOW.
2552 GOSUB 11650 REM CLOSE VALVES
2560 E2'=12     IF P1(2)=2 THEN GOTO 2600
2570 GOSUB 12010( U2', E2' )
2580 W2'=T'(2,E2')  IF W2'> 0 THEN WAIT W2'*60-10
2585 S'=0  IF U1'=0 THEN GOTO 2050
2587 PRINT "UNIT 2 COORD. DELAY=";P1(8)
2590 IF P1(8)>0 THEN WAIT P1(8)*60-10
2595 GOTO 2050
2600 REM **** SUSPEND UNIT 2
2610 W2'=0 GOSUB 12010( U2', E2' )
2615 GOSUB 12110( U2', E2', E2')
2620 U2'=0 DOT(5,10)=0  C(4)=0  S'=0
2625 PRINT "UNIT 2 SELF-SUSPEND." PTIME PRINT
2630 SUSPEND SELF

2800 REM ** SUBR: RINSE FLOW RATE
2802 W2'=P1( 8+(E2'*2)-2 )
2810 IF W2' = 1 THEN DOT(10,6,7)=2
2820 IF W2' = 2 THEN DOT(10,8,9)=2
2830 IF W2' = 3 THEN DOT(10,10,11)=2
2849 RETURN
2900 REM ** SUBR: OPEN FLOW VALVE
2910 IF P1(6) = 1 THEN DOT(9,0,1)=2
2920 IF P1(6) = 2 THEN DOT(9,2,3)=2
2930 RETURN

3000 REM ** PREP FOR REGENERATION, TASK#3
3002 P'=S'
3004 IF E3'=10 THEN 3200
3100 REM ** SETTLING,#9
3110 E3' DOT(5,8+P1')=0
3120 GOSUB 3900 IF W3'>0 THEN WAIT W3'*60
3200 E3'=10  REM** SETUP,#10
3210 DOT(5,11,12)=0  DOT(3+3*P',8,9)=2
3220 DOT(5,10+P')=1  DOT(5,5)=1
3230 GOSUB 3900 IF W3'>0 THEN WAIT W3'*60
3240 DOT(3+3*P',8,9)=1
3245 DOT(5,10+P')=0  DOT(5,5)=0
3300 REM ** DONE WITH STEP
3310 PRINT "PREP:";P';",DONE." PTIME PRINT
3312 PRINT:7 "PREP:";P';",DONE."; PNT:7 13
3314 PTIME:7  PNT:7 13
3320 DOT(5,8+P')=1  P'=0  E3'=0 KILL SELF
3900 REM ** ANNOUNCE & WAIT
3950 RESERVE:9  RESERVE:7   W3'=T'(P',E3')
3960 PRINT :9 "UNIT,";P';", EVENT:";E3';
3962 PRINT :7 "UNIT,";P';", EVENT:";E3';  PNT:7 13
3970 PTIME :9  PRINT :9 "DUR,";W3';
3972 PTIME :7  PRINT :7 "DUR,";W3';  PNT:7 13
3980 PNT : 7 13  RELEASE :7
3982 PNT : 9 13  RELEASE :9
3999 RETURN

10000 REM ** SETUP PROPER MODES, HOMCLR.
10010 CLOSE NOMODE
10020 PNT 15 PRINT PRINT RETURN
10050 PNT 14 PRINT PRINT RETURN
10100 REM ** GET THE TIME AND DATE SUBR.
10110 GOSUB 10050  PRINT "    "
10115 PRINT "TYPE IN THE DATE LIKE THIS :"
10120 PRINT "MM,DD,YY   THEN TAP <RETURN>"
10130 INPUT X1',X2',X3'  STIME X1',X2',X3'
10140 GOSUB 10050
10145 PRINT "TYPE IN THE TIME LIKE THIS :"
10150 PRINT "HH,MM.SS   THEN TAP <RETURN>"
10160 INPUT X1',X2',X3'  STIME X1',X2',X3'
10199 RETURN
10200 REM ** SETUP FILES
10210 OPENR :3 "$QTI:3" ECHO OFF :3 OPENW :5 "$QTO:3"
10220 OPENW 9: "QTO:2" REM LOGGING PORT 54
10225 OPENW 7: "QTO:0" REM PRINTING PORT
10230 RETURN
10300 REM ** INIT. ARRAYS & VARIABLES
10310 DIM A$(4), K$(4), T'(2,12), C(16), P1(16)
10320 I=0  W1'=0  W2'=0
10330 R'=0  S'=0  P'=0  X'=0  Y'=0  Z'=0
10340 U'=0  U1'=0  U2'=0  Z1'=0
10345 X'=0  X1'=0  X2'=0  X3'=0  X4'=0
10350 E'=0  E1'=0  E2'=0  E3'=0  E4'=0
10352 D1'=0 D2'=0  N9'=12 R'=0
10360 RESTORE REM READ IN PARAM ARRY
10362 FOR I = 1 TO 16  READ P1(I)  NEXT I
10364 DATA  1,1, 7,9, 2,2, 0,0, 1,1, 2,2, 3,3, 1,1
10370 REM ** CLEAR COND. ARRAY
10372 FOR I = 1 TO 16  C(I)=0  NEXT I
10374 FOR I = 1 TO N9' REM READ DEF. TIMES
10376 READ T'(1,I), T'(2,I)  NEXT I
10380 REM DEFAULT TIMES FOR EVENTS
10381 DATE 13,13
10382 DATA 40,40
10383 DATA 09,09
10384 DATA 06,06
10385 DATA 05,05
10386 DATA 05,05
10387 DATA 09,09
10388 DATA 120,120
10389 DATA 50,50
10390 DATA 35,35
10391 DATA 3,3
10392 DATA 0,0
10398 RESTART MAIN,1
10399 RETURN
10400 REM ** SPECIAL OPTIONS MENU
10402 GOSUB 10050 PRINT "SPEC. OPTIONS MENU, UNIT=;U'
10404 PRINT "==========================="
10410 PRINT "CONT.(1) OR STOP (2).....1"
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10420 PRINT "IX PUMPS USED (7,8,9)....2"
10430 PRINT "IX FLOW RATE (1 OR 2)....3"
10440 PRINT "REGENERATION DELAY.......4"
10450 PRINT "REGEN. #2 FLOWRATE.......5"
10460 PRINT "REGEN. #3 FLOWRATE.......6"
10470 PRINT "RINSE  #4 FLOWRATE.......7"
10480 PRINT "RINSE  #5 FLOWRATE.......8"
10490 PRINT "GO BACK TO MAIN MENU.....9"
10495 PRINT "TYPE YOUR CHOICE:=======>"; RETURN
10500 REM ** OPERATOR MENU
10505 ON R'+1 GOSUB 10020,10050
10510 PRINT "EDR/RO RECYC. BRINE IS OP.S MENU."
10515 PRINT "VERS:";V$;" TIME:"; PTIME PRINT
10520 IF R'=1 THEN PRINT "REMOTE CONTROL=ON." RETURN
10525 PRINT "==================================="
10530 PRINT "SEE/SET MACSYM TIME..................1"
10535 PRINT "START AN I.X. UNIT...................2"
10540 PRINT "CHANGE TIMES FOR EVENTS..............3"
10545 PRINT "STATUS REPORT ON IX..................4"
10550 PRINT "STOP AN I.X. UNIT....................5"
10555 PRINT "FLUSH IX UNIT TO IX SUMP.............6"
10560 PRINT "SPECIAL OPTIONS MENU.................7"
10562 PRINT "START/STOP BRINE XFER TO T4..........8"
10564 PRINT "EMERGENCY STOP BOTH UNITS............9"
10570 PRINT "TYPE YOUR CHOICE (1-9) AND <RETURN>."
10580 RETURN
10600 REM ** SUBR: TAKE KEY OF HP INPUT
10610 IF R'=1 THEN 10650
10620 INPUT A$  IF A$="" THEN A$="0"
10625 IF A$="M" THEN RESTE SUB GOTO 50
10630 A = VAL(A$)  A'= VAL(A$)
10640 RETURN
10650 REM ** REMOTE ENTRY
10660 GOSUB 10700  REM ** REMOTE ENTRY
10670 INPUT:3 A$  IF A$"" THEN A$="0"
10675 IF A$="M" THEN RESET SUB GOTO 50
10680 A = VAL(A$)  A'=VAL(A$)
10690 RETURN
10700 REM ** SUBR: REJECT NOISE, EAT KEY
10710 PRINT:5 "GO!!"
10720 INPUT :3  K$
10725 IF LEN(K$)<4 THEN GOTO 10720
10730 IF K$="OK??"  THEN PRINT :5 "OK!!"  GOTO 10700
10740 IF K$<>"KEY!" THEN 10720
10750 RETURN
10800 REM ** SUBR: PRESS <RETURN>
10810 IF R'=1 THEN RETURN
10820 INPUT "PRESS <RETURN> TO CONTINUE."A$
10825 IF A$="M" THEN RESET SUB GOTO 50
10830 RETURN
10900 REM ** SUBR: TYPE Y OR N
10920 INPUT "OK?  Y FOR YES, N FOR NO:" A$
10920 IN A$<>"Y" IF A$<>"N" THEN PNT T GOTO 10900
10930 RETURN

11000 REM ****UNIT # MENU
11010 GOSUB 1005  PRINT "PICK THE UNIT YOU WANT."
11020 PRINT "( TYPE 1 OR 2, TAP <RETURN>.)"
11040 RETURN
11100 REM **** EVENT # MENU
11110 GOSUB 10020 PRINT "START EVENT, UNIT:";U'
11120 FOR I = 1 TO N9'
11130   GOSUB 11410(I)  PRINT I
11140 NEXT I  PRINT  RETURN

11200 REM **** APPROVE EVENT TIMES MENU
11210 GOSUB 10020 PRINT "APPROVE THE TIMES BELOW."
11220 PRINT "TYPE N <RETURN> TO CHANGE A TIME."
11230 FOR I = 1 TO N9' PRINT I;"."; GOSUB 11310(I)
11240 PRINT T'(U',I)  NEXT I  PRINT
11245 RETURN
11250 REM ** CHANGE AN EVENT
11255 PRINT "EVENT # TO CHANGE:";
11260 GOSUB 10600
11262 IF A'<1  THEN RESET SUB GOTO 12500
11264 IF A'>N9' THEN RESET SUB GOTO 12500
11266 X1'=A'
11270 REM ** CHANGE TIME
11275 PRINT "NEW EVENT TIME:";
11280 GOSUB 10600
11282 IF A'<0   THEN RESET SUB GOTO 12500
11284 IF A'>300 THEN RESET SUB GOTO 12500
11286 T'(U',X1')=A'
11290 RETURN

11300 REM ****  PRINT THE ITH EVENT
11310 DECLARE(X)
11315 IF X>6 THEN 11325
11320 ON X-0 GOTO 11350,11351,11352,11353.11354,11355
11325 ON X-6 GOTO 11360,11361,11362,11363.11364,11365
11350 PRINT "RECYC. BRINE REGEN#1....."; RETURN
11351 PRINT "RECYC. BRINE REGEN#2....."; RETURN
11352 PRINT "FRESH BRINE REGEN........"; RETURN
11353 PRINT "RINSE A (CW TO T2,T3)...."; RETURN
11354 PRINT "RINSE B (CW TO T2,T3)...."; RETURN
11355 PRINT "RINSE C (CW TO IX SUMP).."; RETURN
11360 PRINT "RINSE D (CW TO RWPS)....."; RETURN
11361 PRINT "IX MAIN SERVICE.........."; RETURN
11362 PRINT "SETTLING IN T2 OR T3....."; RETURN
11363 PRINT "REGEN SETUP(T2,T3 TO T4)."; RETURN
11364 PRINT "IX UNIT DRAIN............"; RETURN
11365 PRINT "AFTER DRAIN DELAY........"; RETURN

11400 REM **** REPORT UNIT STATUS
11410 GOSUB 10050 PRINT "CYCLE STATUS FOR I.X."
11412 PRINT "TIME:";PTIME  PRINT PRINT
11420 PRINT "UNIT 1:"; IF U1'=1 THEN PRINT "ON ";
11422 IF U1'=0 THEN PRINT "OFF";
11424 PRINT ", AT EVENT#:";E1'
11426 PRINT "EVENT BEGAN:";C(7);":";C(9)
11427 IF P'=1 THEN PRINT "PREP ON, EVENT:";E3'
11428 PRINT "DUR: ";C(11)
11430 PRINT  PRINT "UNIT 2:";
11431 IF U2'=2 THEN PRINT "ON ";
11432 IF U2'=O THEN PRINT "OFF";
11434 PRINT ", AT EVENT#:";E2'
11436 PRINT "EVENT BEGAN:";C(8);":";C(10)
11437 IF P'=2 THEN PRINT "PREP ON, EVENT:";E3'
11438 PRINT "DUR: ";C(12)
11440 IF R'=0 THEN  RETURN
11450 REM ** SEND STATUS TO HP-1000
11452 CTIME X1',X2',X3'
11454 C(1)=X1'  C(2)=X2'
11455 FOR I = 1 TO 12
11460   GOSUB 10700  PRINT:5  C(I)
11499 NEXT I  RETURN
11500 REM **** STOP IX OP.S
11501 GOSUB 10050  PRINT "STOPPING IX UNIT:";U'
11502 PRINT "TIME:";PTIME  PRINT
11503 E4'=E1' Z1'=0  IF U'=2 THEN E4'=E2'
11504 GOSUB 12110(U',E4',Z1')
11505 IF P'=U' THEN GOSUB 11900
11506 ON U' GOSUB 11510,11550
11507 DOT(5,8+U')=0  C(2+U')=0
11508 RETURN
11510 REM **** SHUTDOWN UNIT 1
11512 KILL 1  TASK 1,1000
11515 GOSUB 11800  GOSUB 11600
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11525 U1'=0 E1'=0 GOSUB 11700
11530 RETURN
11550 REM **** SHUTDOWN UNIT 2
11552 KILL 2 TASK 2,2000
11555 GOSUB 11850 GOSUB 11650
11565 U2'=0 E2'=0 GOSUB 11750
11570 RETURN
11600 REM ** CLOSE VALVES, UNIT 1
11610 DOT(6,0,15)=22101 DOT(7,0,15)=21845
11620 DOT(8,0.1) = 1 DOT(11,5,8)=5
11630 DOT(2,0,1) = 1 DOT(2,4,5)=1
11635 IF TSTATE(7)<0 THEN DOT(6,8,9)=1
11640 WAIT 10 RETURN
11650 REM ** CLOSE VALVES, UNIT 2
11660 DOT(9,0,15)=22101 DOT(10,0,15)=21845
11670 DOT(11,0.3)= 5 DOT(11,9,12)=5
11680 DOT(2,2,3) = 1 DOT(2,6,7)=1 DOT(8,2,3)=1
11685 IF TSTATE(8)<0 THEN DOT(9,8,9)=1
11690 WAIT 10 RETURN
11700 REM *** RELEASE UNIT 1
11710 DOT(6,0,15)=0 DOT(7,0,15)=0
11720 DOT(8,0,1)=0 DOT(11,5,8)=0
11730 DOT(2,0,1)=0 DOT(2,4,5)=0
11740 RETURN
11750 REM *** RELEASE UNIT 2
11760 DOT(9,0,15)=0 DOT(10,0,15)=0
11770 DOT(11,0,3)=0 DOT(11,9,12)=0
11780 DOT(2,2,3)=0 DOT(2,6,7)=0 DOT(8,2,3)=0
11790 RETURN
11800 REM ** STOP UNIT 1 PUMPS
11810 IF D1'=1 THEN D1'=0 DOT(5,4)=0 DOT(5,2)=0
11820 IF D2'=1 THEN D2'=0 DOT(5,P1(3)-1)=0
11830 IF S'=1 THEN S'= 0 DOT(5,P1(3)-1)=0 DOT (8,8)=0
11840 RETURN
11850 REM ** STOP UNIT 2 PUMPS
11860 IF D1'=2 THEN D1'=0 DOT(5,4)=0 DOT(5,1)=0
11870 IF D2'=2 THEN D2'=0 DOT(5,P1(4)-1)=0
11880 IF S'=2 THEN S'= 0 DOT(5,P1(4)-1)=0 DOT (8,9)=0
11890 RETURN
11900 REM ** STOP PREP PUMPS
11905 DOT(5,10+P')=0
11910 IF E3'=10 THEN DOT(5,5)=0
11930 KILL 3 E3'=0 P'=0
11940 RETURN
12000 REM **** ANNOUNCE THE UNIT AND EVENT
12010 DECLARE(X',Y')
12012 IF X4'=1 THEN 12012
12015 X4' =1 GTIME X1',X2',X3'
12020 C(1)=X1' C(2)=X2' C(3)=X'
12025 C( 4 + X' ) = Y' C(6+X')=X1'
12030 C(8+X') = X2' C(10+X')= T'(X',Y') PRINT
12035 PRINT "UNIT: ";X';" STARTED EVENT: ";Y'
12040 PRINT "TIME: ";PTIME PTINT " "
12042 IF X'>0 IF Y'>0 THEN PRINT "DUR: ";T'(X',Y')
12045 RESERVE : 9 RESERVE : 7 IF Y'=1 THEN PNT:7 13
12050 PRINT :7 "UNIT,";X';", ENENT,";Y'; PNT:7 13
                    PTIME:7
12052 PRINT :9 "UNIT,";X';",STARTED EVENT,";Y';PTIME:9
12055 IF X'>0 IF Y'>0 THEN PRINT :7 ",DUR,";T'(X',Y');
12057 IF X'>0 IF Y'>0 THEN PRINT :9 ",DUR,";T'(X',Y');
12060 PNT:9 13 RELEASE : 9 PNT:7 13 RELEASE:7 X4'=0
12065 RETURN

12100 REM **** ANNOUNCE UNIT STARTUP/SHUTDOWN
12110 DECLARE(X',Y',Z,) REM UNIT,EVENT,START/STOP
12120 RESERVE:9 RESERVE:7
12130 IF Z'=0 THEN PRINT:7 "UNIT:";X';", SHUTDOWN.";
                    SHUTDOWN."; PNT:7 1
12132 IF Z'=0 THEN PRINT:9 "UNIT:,";X';",
                    SHUTDOWN EVENT:,";Y';
12140 IF Z'=1 THEN PRINT:7 "UNIT:,";X';",
                    STARTUP EVENT:,";Y';
12142 IF Z'=1 THEN PRINT:9 "UNIT:,";X';",
                    STARTUP EVENT:,";Y';
12150 PTIME:9 PTIME:7 PNT:9 13 PNT:7 13
12160 RELEASE:9 RELEASE:7 RETURN
12200 REM **** KEYS
12210 GOSUB 10050
12215 PRINT "KEYBOARD OPERATIONS MODE."
12220 PRINT "ORDER HP-1000 REMOTE CONTROL"
12230 PRINT "FROM THE MAIN MENU."
12240 PNT 7 RETURN
12250 GOSUB 10050
12255 PRINT "REMOTE OPERATIONS MODE."
12260 PRINT "REGAIN KEYBOARD CONTROL FROM"
12270 PRINT "HP-1000 MAIN MENU, OR ABORT"
12280 PRINT "BY TYPING CONTROL-A."
12299 PNT 7 RETURN

12300 REM **** UNIT STARTUP HELP
12310 GOSUB 10050
12320 PRINT "TO START THE IX SYSTEM, YOU"
12330 PRINT "MUST PICK THE UNIT, THE EVENT"
12340 PRINT "TO START THE IX CYCLE WITH, "
12350 PRINT "THEN APPROVE OR CHANGE EACH "
12360 PRINT "EVENT TIME FOR THE IX CYCLE. "
12370 PRINT "THE IX UNIT IS THEN STARTED."
12380 PRINT PRINT RETURN

12400 REM ** FLUSH UNIT 1
12405 GOSUB 11600 DOT(5,P1(3)-1)=1
12410 DOT(6,4,5)=2 DOT(6,12,13)=2 DOT(7,0,1)=2
12415 DOT(7,6,7)=2 DOT(11,7,8)=2 WAIT 8*60
12420 DOT(5,P1(3)-1)=0 GOSUB 11600 PRINT
12425 PRINT "DONE WITH FLUSH." PNT 7 WAIT 5
12430 KILL SELF
12450 REM ** FLUSH UNIT 2
12455 GOSUB 11650 DOT(5,P1(4)-1)=1
12460 DOT(9,4,5)=2 DOT(9,12,13)=2 DOT(10,0,1)=2
12465 DOT(10,6,7)=2 DOT(11,11,12)=2 WAIT 8*60
12470 DOT(5,P1(4)-1)=0 GOSUB 11650 PRINT
12475 PRINT "DONE WITH FLUSH." PNT 7 WAIT 5
12480 KILL SELF
12500 REM ** GENERAL ENTRY ERROR
12510 PNT 14 PRINT PRINT "DATA ENTRY ERROR."
12520 PNT 7 GOSUB 10800 GOTO 50
12600 REM ** GENERAL ERROR TRAP
12605 PRINT "ERROR:";X1';": LINE:";X2' PNT 7
12610 IF X1'=158 IF X2'=274 THEN TASK 1,1000
12615 IF X1'=158 IF X2'=280 THEN TASK 2,2000
12699 WAIT 1 PNT 7 WAIT 1 PNT 7 WAIT 99 GOTO 50
12700 REM ** T2->T4
12710 DOT(5,9)=0 DOT(5,11,12)=0 DOT(6,8,9)=2
12720 DOT(5,11)=1 DOT(5,5)=1
12730 PRINT "XFER:1 FOR:";A' PRINT 7 "XFER:1 FOR:";A'
12740 PTIME PRINT PTIME:7 PRINT:7 " " WAIT A'*60
12750 DOT(5,9)=1 DOT(5,11)=0 DOT(5,5)=0 DOT(6,8,9)=1
12760 PRINT "XFER DONE." PNT 7 KILL SELF
12800 REM ** T3->T4
12810 DOT(5,10)=0 DOT(5,11,12)=0 DOT(9,8,9)=2
12820 DOT(5,12)=1 DOT(5,5)=1
12830 PRINT "XFER:2 FOR:";A' PRINT 7 "XFER:2 FOR:";A'
12840 PTIME PRINT PTIME:7 PRINT:7 " " WAIT A'*60
12850 DOT(5,10)=1 DOT(5,12)=0 DOT(5,5)=0 DOT(9,8,9)=1
12860 PRINT "XFER DONE." PNT 7 KILL SELF
19500 REM ZZZZZZZZ
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ANALOG DEVICES COMPUTER
DEVICE CONNECTION TO ANALOG COMPUTER
MONITORING CARDS

April 21, 1986
Empty slots: 1, 12, 13, 14, and 15.

Card Slot	Device	Channel Input	Comments
0	Flow Sensor IX1	0	on IX Unit 1
	Cond. " IX1	1	on IX Unit 1
	Flow " IX2	2	on IX Unit 2
	Cond. " IX2	3	on IX Unit 2
	Level " IX1	4	tank T6 level
	Level " IX2	5	tank T7 level
	VCE	6	for future VCE tank
	vacant	7 thru 15	spare
3	Open	0 thru 3	spare
	PP1 pump	4	status of MP pump - MP SYSTEM not in service
	PP2 pump	5	status of MP pump - MP SYSTEM not in service
	PP3 pump	6	status of MP pump - MP SYSTEM not in service
	PP4 pump	7	status of MP pump - MP SYSTEM not in service
	Vacant	8 thru 15	
4	vacant	0 thru 3	spare
	SOV1	4	status SOV1
	SOV2	5	status SOV2 - MP system not in service
	SOV3	6	status SOV3 - MP system not in service
	SOV4	7	status SOV4 - Cl2 injection controlled by FP1
	SOV5	8	status SOV5 - Cl2 injection controlled by FP2
	SOV6	9	status SOV6
	SOV7	10	status SOV7
	SOV8	11	status SOV8
	SOV9	12	status SOV9 -Cl2 inject'n controlled by chlorinator
	vacant	13 thru 15	spare
5	Ion Pump 1	0	near tank T1
	Ion Pump 2	1	" " T7
	Ion Pump 3	2	" " T6
	Ion Pump 4	3	" " T5
	Ion Pump 5	4	" " T4
	Ion Pump 6	5	near tanks T2 and T3
	Ion Pump 7	6	near clearwell CW1
	Ion Pump 8	7	near clearwells CW1 and CW2
	Ion Pump 9	8	near clearwell CW2
	Agitator A1	9	near tank T2
	Agitator A2	10	" " T3
	Level sensor T2	11	Level cutoff sensor in T2 for IP6
	Level sensor T3	12	Level cutoff sensor in T3 for IP6
	PP1 pump	13	pond effluent pump - MP system not in service
	PP1 pump	14	pond effluent pump - MP system not in service
	vacant	15	spare

ANALOG DEVICES COMPUTER
DEVICE CONNECTION TO ANALOG COMPUTER
CONTROL CARDS

April 21, 1986

Card Slot	Device	Chan. Output close	Chan. Output open	Comments
2	Ion Valve 23	0	1	between tanks T2 and T3
	123	2	3	between tanks T2 and T3
	24	4	6	
	124	6	8	
	vacant	8 thru 15		spare
6	Ion Valve 1	0	1	on IX Unit 1
	2	2	3	" "
	3	4	5	" "
	4	6	7	" "
	5	8	9	" "
	6	10	11	" "
	7	12	13	" "
	19	14	15	" "
7	Ion Valve 9	0	1	on IX Unit 1
	10	2	3	" "
	11	4	5	" "
	12	6	7	" "
	13	8	9	" "
	14	10	11	" "
	15	12	13	near tank T6
	16	14	15	" " "
8	Ion Valve 17	0	1	btwn. tanks T1 and T5
	18	2	3	" " " "
	120		4	air compressor for Unit1
	CSOV 2		5	MP chlorine injection - MP system not in service
	CSOV 3		6	MP chlorine injection - MP system not in service
	vacant		7	spare
	CSOV 1		8	CW3 injection
	CSOV 6		9	CW4 injection
	CSOV 7		10	CW5 injection
	CSOV 8		11	CW6 injection
	CSOV 9		12	clarifier infl. injec. - Cl2 injection controlled by resid. chlorinator
	vacant	13 thru 15		spare
9	Ion Valve 101	0	1	on IX Unit 2
	102	2	3	" "
	103	4	5	" "
	104	6	7	" "
	105	8	9	" "
	106	10	11	" "
	107	12	13	" "
	119	14	15	" "
10	Ion Valve 109	0	1	on IX Unit 2
	110	2	3	" "
	111	4	5	" "
	112	6	7	" "
	113	8	9	" "
	114	10	11	" "
	115	12	13	near tank T7
	116	14	15	" " "
11	Ion Valve 117	0	1	btwn. tanks T1 and T5
	118	2	3	" " " "
	120		4	air compressor to IX Unit 2
	21	5	6	on IX Unit 1
	22	7	8	" "
	121	9	10	on IX Unit 2
	122	11	12	" "
	Open	13 thru 15		spare

PROGRAM to calculate 1.) Ion Exchange Operation Cycle; and 2.) Volumes and Sodium Concentrations of Reject Brine for a Given Desalting Scheme, IX Influent Process Water Chemical Concentrations and other information. 26-Mar 1986

IX SYSTEM EVENT FLOW RATES:		TH Working Resin Capacity:	0.86	(eq/liter of resin)			
	(gpm)	Volume of Resin in IX Unit:	162.2	(cu.ft.)	equals	4604	(liters)
Service	110	Volume of Voids in IX Unit:	188.7	(cu.ft.)	equals	1.16	(bv)
RecBrReg	200	Reg. Na Thruput to					
FrBrReg	150	Ser. TH Removed Ratio:	6.4	(eq:eq)			
SlowRinse	110	Total Na Thruput Required					
FastRinse	230	During Regen:	25340	(eq.)			

IX Process Water Concentrations	TH (mg/l as CaCO3)	Sodium (mg/l as Na)
influent:	2300	1980
effluent:	100	2990
(leakage)		(projected)

Influent Brine	Na Conc. (mg/l as Na)
Recycle	future
Fresh	use

OPERATION CYCLE:

Event	Duration (min.)	Volume (gal)	Volume (bv)	Output
Service	216	23777	19.55	CW5
Recy. Brine Reg. 1	16	3125	2.57	IXSump
Recy. Brine Reg. 2	23	4600	3.78	T2 or T3
Fr. Brine Reg.	11	1710	1.41	T2 or T3

ERROR FLAGS:
1.Fr. brine vol. > T6 or T7.
2.Fr. brine vol. < 1 bed volume.
3.Ser. duration < total reg. duration.
4.Na thruput for reg. < required.
5.Recycle reg. vol. > T2 or T3.

Volume to IX Sump (gal.):	5730
Duration: Ser to Reg Ratio:	2.97
Na Thruput to Req'd. Ratio:	1.88
Na throughput for Regenerat'n.(eq.):	47750

DESALTING PROCESS:

	Infl. Process Water				Reject Brine			
	Flow	Na Conc.	Recovery	Na Reject	Volume		Na Conc.	Na per IX Cycle
	gpm	mg/l Na	%	%	gal	bv	mg/l as Na	eq.
Stage 1	92	future	50	96.0	9940	8.17	5860	9590
Stage 2	46	use	50	95.4	4970	4.09	11450	9360
Stage 3	24	"	67	94.0	1710	1.41	33300	9370
Stage 4	0	"	0	0.0	1710	1.41	33300	9370

Final Desalting Reject Brine Used for IX Regeneration:
Fresh IX Brine:
Volume: 1710 (gallons)
Na Conc.: 33300 (mg/l Na)

Instructions:

1. Load 123, BRVOL file.
2. Enter actual IX flows in blocks D7, D8, D9, D10 and D11. Flows are in gallons per minute.
3. Enter Total Hardness (TH) working capacity in block J5. Resin capacity in in eq. per liter of resin.
4. Enter volume of resin and voids (cu.ft.) in blocks J6 and J7 for IX Unit.
5. Enter ratio for regeneration sodium thruput to service TH removed (eq.:eq) in block J9.
6. Enter TH (mg/l as CaCO3) and Sodium (mg/l as Na) conc. for IX influent process water in blocks C19 and D19.
7. Enter TH leakage (mg/l as CaCO3) for IX process water effluent in block C20.
8. Enter flow (gpm) of influent process water for each desalting stage in blocks C29, C30, C31, and C32.
9. -future -Enter Na conc. (mg/l as Na) of infl. process water for each desalt. stage in blocks D29, D30, D31, and D32.
10. Enter recovery(%) of process water for each desalting stage in blocks E29, E30, E31 and E32
11. Enter sodium rejection (%) of process water for each desalting stage in blocks F29, F30, F31, and F32.
12. Print block1 for output above with instructions or block4 without instructions.
13. Print block2 (service control valve 1-110gpm) or block3 (control valve 2-230gpm) for complete IX operation schedule.
14. Dur. for events 2, 3, 4, 5, 11 and 12 of operations schedule are to individually entered into schedule and to be determined through actual operation.

Volumes of Main Ion Exchange Columns

Resin: Date measured: July 7, 1986

Distance (in.) from bottom of top manifold to resin.

	Unit	
Column	1	2
A	40.75	40.75
B	41	40.75

Volumes of resin:

	Unit 1		Unit 2		
Column	(cu.ft.)	(liters)	(cu.ft.)	(liters)	
A	85.7	2433	85.7	2433	
B	85.3	2421	85.7	2433	
	171.0	4854	171.4	4866	Total (bv)
	1282 (gallons)		1286 (gallons)		
	154.2	4377	154.6	4388	Total above CL of
	1156 (gallons)		1159 (gallons)		bottom manifold
	162.6	4615	163.0	4627	Average of totals
	1219 (gallons)		1222 (gallons)		above

Time required in minutes to displace Volume of Voids (CVV) for various flows:

	Flow (gpm)			
	200	150	110	230
Unit 1	7.1	9.4	12.8	6.1
Unit 2	7.1	9.4	12.8	6.1

Time required to displace 1 bed volume for various flows: (minutes)

	Flow (gpm)			
	200	150	110	230
Unit 1	6.4	8.5	11.7	5.6
Unit 2	6.4	8.6	11.7	5.6

Flows in bed volumes per minute (bv/min)

	Flow (gpm)			
	200	150	110	230
Unit1	0.156	0.117	0.086	0.179
Unit 2	0.156	0.117	0.086	0.179

Volume of Voids (CVV) within column:
32 Percent voids in resin

	UNIT			
	1		2	
Column	(cu.ft.)	(gallons)	(cu.ft.)	(gallons)
A	94.1	706	94.1	706
B	94.4	708	94.1	706
Total Volume of	188.4	1413	188.2	1411
Voids (CVV):	5350 (liters)			5347 (liters)

History of Resin Levels:

Date	Unit 1		Unit 2	
Measure	Col.A	Col.B	Col.A	Col.B
7/2/85	38	40.5	44	42.5
10/23/85	38.38	38.25	38.25	38.38
3/17/86	41	41	41	41
7/7/86	40.75	41	40.75	40.75

1. Enter 123, Volumes file
2. Enter date measured in block E3.
3. Enter distances in blocks D9, D10, E9 and E10. Distances are in inches from bottom of top manifold to resin.
4. Enter percent of voids in block D31
5. Enter flows in blocks K10, L10, M10 or N10. Flows entered are gallons per minute.
6. Enter new resin levels under History section, blocks below J31.

Duolite International

15 May 1984
TSC-8493

Mr. John Ho
Los Banos Desalting Facility
3400 E. Pacheco Blvd.
Los Banos, CA 93635

Dear John:

Please find enclosed the analysis results of the Duolite C-20 sample submitted to our laboratory for evaluation.

The resin is in excellent condition, display capacity, moisture retention and sphericity exceeding specifications for new material. The iron content is insignificant, indicating iron fouling is not a problem at this time. The sample we received contained a small amount of unidentified spongy white particulate matter. You indicated during our telephone conversation that this may be gypsum carry-over. In any case, it should be removed from the softeners by vigorous backwashing.

As we discussed during your visit, the major limitation in your system in obtaining longer runs is the high sodium-to-hardness ratio (2:1). Based on extrapolation of Figures 5 and 6 in Duolite Data Bulletin 24, you can expect a capacity of ~13 Kgr/cu.ft. (as opposed to the 32 Kgr/cu.ft. capacity quoted in the 4/15/83 letter from PRC to Kurt Kovac) using Duolite C-20 or any other 8% crosslinked strong-acid cation exchanger. This capacity rating with your operating conditions should give a 65-minute run length, as outlined in the following calculations:

2300 ppm = 0.13 Kgr/gal
0.13 Kgr/gal x 115 gpm = 15 Kgr/min
75 ft^3 x 13 Kgr/ft^3 = 97.5 Kgr
$\frac{975 \text{ Kgr}}{15 \text{ Kgr/min}}$ = 65 min

Diamond Shamrock

Duolite International, Inc. A subsidiary of Diamond Shamrock Corporation
800 Chestnut St., Redwood City, California 94063
Telephone: 415-369-0071 Telex: 910-378-5412 Cable: DIASHAMRES

The other major problem you must address is the use of filtered hard water for dilution of brine. If this practice continues you will begin to experience unacceptable hardness leakage.

Please call if I can be of further assistance as we look forward to working with you in optmizing your water treatment system.

Regards,

DUOLITE INTERNATIONAL, INC.

Kathy

Kathleen A. Haddock
Section Leader
Technical Service

KAH:vmr

enclosures

cc: Kurt Kovac - DWR
Steve Andrews - PRC

Diamond Shamrock

Duolite ION EXCHANGE RESINS

Company: Los Banos Desalting Facility

Address: 3400 E. Pacheco Blvd.
Los Banos, CA 93635

Attention: John Ho

Application: Softener

Reason for Work: short runs

Date: 25 April 1984 Ref. MA 1689:83

Reported By: Kathleen A. Haddock

TESTS		RESULTS			
Sample No.	Cust.	used resin			
	DS	84272			
Resin	Duolite	C-20			
Total Capacity, Eq/l					
Salt-splitting Capacity, Eq/l	(Na^+)	2.08			
Moisture Retention Cap, %	(Na^+)	47			
Rinse, Bed Vols., to 40 μMho/cm					
Rinse, Bed Vols., to 10 μMho/cm					
Sphericity, %		98			
Color		dark amber			
Transparency		translucent			
Iron, mg/L resin		156			
Contamination		* notes			
Particle Size Distribution		16 40	16 40	16 40	16 40
U.S. Standard Sieve, Moist		20 50	20 50	20 50	20 50
Percent by Volume		30 Pn	30 Pn	30 Pn	30 Pn

*Sample contained small amount of unidentified spongy white particulate matter.

Duolite International, Inc. A subsidiary of Diamond Shamrock Corporation 800 Chestnut Street, Redwood City, California 94063 phone: 415-369-0071

CABLE ADDRESS: ROHMHAAS TELEX 845-247 TWX 710-670-5335 TELECOPIER (215) 592-3377

REPLY TO:
ONE DUFFEL CENTRE, SUITE 105
39899 BALENTINE DRIVE
NEWARK, CALIFORNIA 94560
(415) 659-0990

ROHM AND HAAS COMPANY

September 30, 1986

Mr. Kurt Kovac
California Department of Water Resources
Los Banos Demonstration Desalting Facility
3400 East Pacheco Boulevard
Los Banos, California 93635

Dear Mr. Kovac:

Attached please find the results of the laboratory work on the resins from your plant. Overall they are in pretty good condition, with just some very low levels of iron fouling. Beds 1 through 3 are showing some slight chemical deterioration as measured by an increasing moisture content. For a softener application, you shouldn't see any performance problems until the moisture content exceeds 55 percent.

Very truly yours,

ROHM AND HAAS COMPANY

E. C. Feeney/so

Eleanor C. Feeney

ECF/so
Encl.

ROHM AND HAAS FLUID PROCESS CHEMICALS SALES SERVICE REPORT

CUSTOMER CA.DEPT.OF WATER RESOURCES LOS BANOS PLANT PROJECT CV5490

START DATE 08/15/86
COMPLETION DATE 08/15/86
RESIN DUOLITE C20
SAMPLE ID CATION #1

PROPERTY	UNITS	VALUE	TYPICAL VALUES
MOISTURE HOLDING CAPACITY	%	51.3	44-48
WHOLE BEADS	%	91	90 MIN.
IRON FOULING	VCS	2	
CATION SALT SPLIT CAPACITY	MEQ/L	4.7	4.4 MIN.

RESIN DUOLITE C20
SAMPLE ID CATION #2

PROPERTY	UNITS	VALUE	TYPICAL VALUES
MOISTURE HOLDING CAPACITY	%	49.0	44-48
WHOLE BEADS	%	90	90 MIN.
IRON FOULING	VCS	3	
CATION SALT SPLIT CAPACITY	MEQ/L	4.47	4.4 MIN.

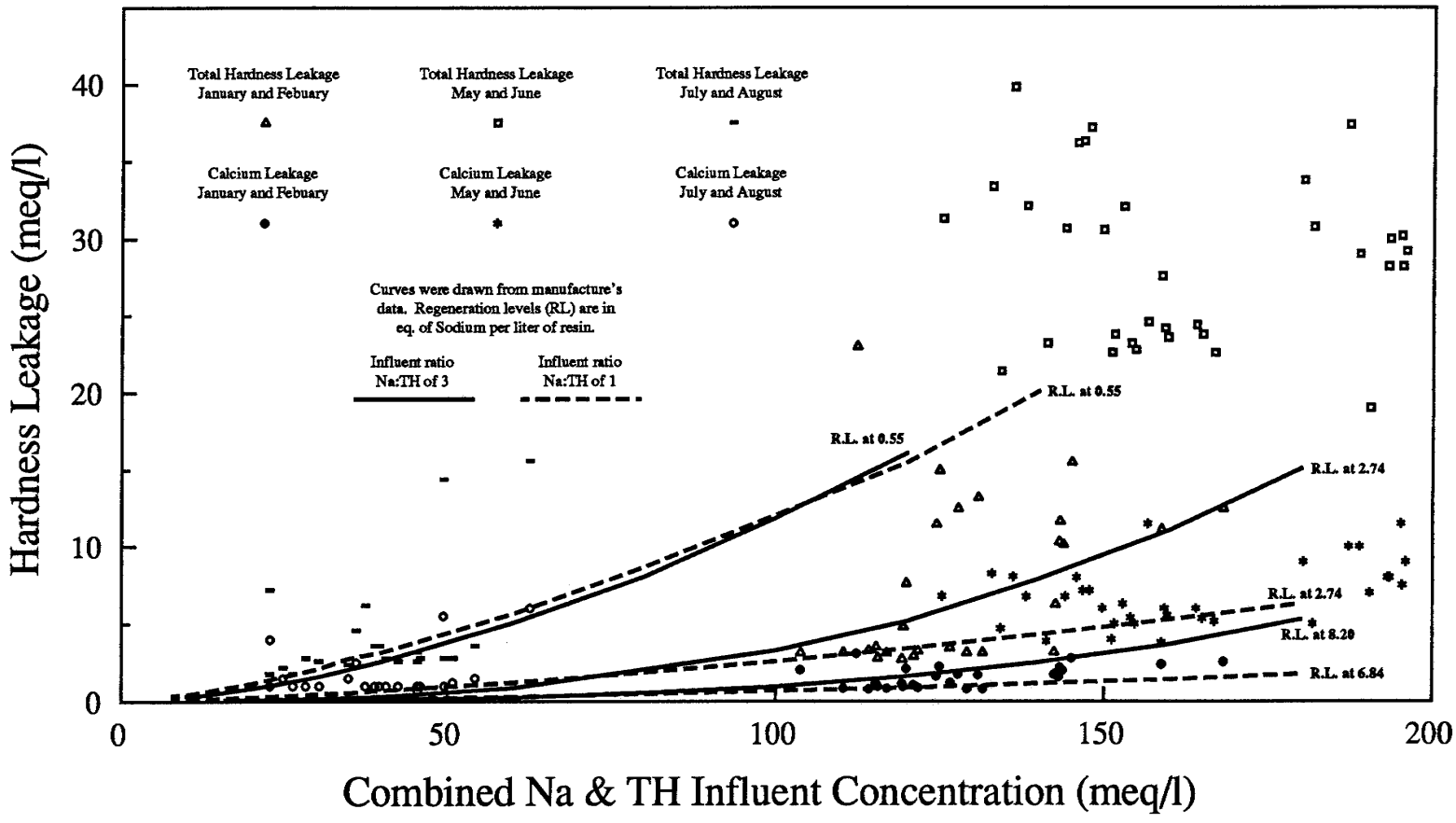
RESIN DUOLITE C20
SAMPLE ID CATION #3

PROPERTY	UNITS	VALUE	TYPICAL VALUES
MOISTURE HOLDING CAPACITY	%	49.7	44-48
WHOLE BEADS	%	91	90 MIN.
IRON FOULING	VCS	2	
CATION SALT SPLIT CAPACITY	MEQ/L	4.52	4.4 MIN.

RESIN DUOLITE C20
SAMPLE ID CATION #4

PROPERTY	UNITS	VALUE	TYPICAL VALUES
MOISTURE HOLDING CAPACITY	%	45.3	44-48
WHOLE BEADS	%	90	90 MIN.
IRON FOULING	VCS	2	
CATION SALT SPLIT CAPACITY	MEQ/L	4.67	4.4 MIN.

Resulting Hardness Leakage for Combined Influent Sodium and Hardness Concentrations January through August, 1986



FILE NAME	FILE TYPE	FILE CONTENTS	DATE	YEAR
REPORT TABLES				
TABLE2	Lotus 123	Initial Main Unit Startup	March - June	1984
TABLE3	Lotus 123	Bench-Unit Softening Results (series 100)		
TABLE4	Lotus 123	Bench-Unit Regenerant Brine Composition (series 100)		
TABLE5	Lotus 123	Bench Unit Operation Parameters (series 200)		
TABLE6	Lotus 123	Hardness Leakage vs. Throughput		
TABLE8	Lotus 123	Ion Exchange Operation Schedule (manual operations)		
TABLE9	Lotus 123	Main Unit Operations		
TABLE10	Lotus 123	Main Unit Operations Schedule	December 3	1985
TABLE11	Lotus 123	Main Unit Operations	January-February	1986
TABLE12	Lotus 123	Main Unit Operations Schedule	April 28	1986
TABLE13	Lotus 123	Main Unit Operations	May - June	1986
TABLE14	Lotus 123	Main Unit Operations Schedule (default)		1986
TABLE15	Lotus 123	Main Unit Operations	July - August	1986
REPORT FIGURES				
FIGURE7	Graphwriter	IX Influent Water TH, CA and NA Conc.	June, July, August	1985
FIGURE8	Graphwriter	IX Influent Water TH, CA and NA Conc.	Jan, February	1986
FIGURE9	Graphwriter	IX Influent Water TH, CA and NA Conc.	May, June	1986
FIGURE10	Graphwriter	IX Influent Water TH, CA and NA Conc.	July, August	1986
FIGURE11	Graphwriter	Monthly S. Luis Drain TH, CA and Na Conc	March - June	1986
FIGURE12	Graphwriter	Resin Capacity and Calcium Leakage	June, July, August	1985
FIGURE13	Graphwriter	Volume of Softened Water Produced	June, July, August	1985
FIGURE14	Graphwriter	Resin Capacity and Calcium Leakage	January, February	1986
FIGURE15	Graphwriter	Resin Capacity and Calcium Leakage	May, June	1986
FIGURE18	Graphwriter	Resin Capacity and Calcium Leakage	July, August	1986
APPENDIX A - BENCH UNIT SERIES 100 TEST DATA				
OPER100	Lotus 123	Operation parameters for series 100 tests		
ANA100A	Lotus 123	Chemical analyses for series 100 tests (101 through 114)		
ANA100B	Lotus 123	Chemical analyses for series 100 tests (115 through 126)		
APPENDIX B - BENCH UNIT SERIES 200 TEST DATA				
OPER200	Lotus 123	Operation parameters for series 200 tests		
ANA200	Lotus 123	Chemical analyses for series 100 tests		
APPENDIX C - BENCH UNIT SERIES 300 TEST DATA				
BU300SUM	Lotus 123	Summary of results for series 300 tests		
BUCAP	Lotus 123	Operation parameters and chemical analyses for tests 301 through 313)		
RC1_HEAD	Graphwriter	Graph heading for test 1		
RC1_REG	Graphwriter	IX Regeneration Effluent test 1		
RC1_SER	Graphwriter	IX Service Effluent test 1		
RC2_HEAD	Graphwriter	Graph heading for test 2		
RC2_REG	Graphwriter	IX Regeneration Effluent test 2		
RC2_SER	Graphwriter	IX Service Effluent test 2		

FILE NAME	FILE TYPE	FILE CONTENTS	DATE	YEAR
APPENDIX C (CONTINUED) - BENCH UNIT SERIES 300 TEST DATA				
RC3_HEAD	Graphwriter	Graph heading for test 3		
RC3_REG	Graphwriter	IX Regeneration Effluent test 3		
RC3_SER	Graphwriter	IX Service Effluent test 3		
RC4_HEAD	Graphwriter	Graph heading for test 4		
RC4_REG	Graphwriter	IX Regeneration Effluent test 4		
RC4_SER	Graphwriter	IX Service Effluent test 4		
RC5_HEAD	Graphwriter	Graph heading for test 5		
RC5_REG	Graphwriter	IX Regeneration Effluent test 5		
RC5_SER	Graphwriter	IX Service Effluent test 5		
RC6_HEAD	Graphwriter	Graph heading for test 6		
RC6_REG	Graphwriter	IX Regeneration Effluent test 6		
RC6_SER	Graphwriter	IX Service Effluent test 6		
RC7_HEAD	Graphwriter	Graph heading for test 7		
RC7_REG	Graphwriter	IX Regeneration Effluent test 7		
RC7_SER	Graphwriter	IX Service Effluent test 7		
RC8_HEAD	Graphwriter	Graph heading for test 8		
RC8_REG	Graphwriter	IX Regeneration Effluent test 8		
RC8_SER	Graphwriter	IX Service Effluent test 8		
RC9HEAD	Graphwriter	Graph heading for test 9		
RC9_REG	Graphwriter	IX Regeneration Effluent test 9		
RC9_SER	Graphwriter	IX Service Effluent test 9		
RC10_HEAD	Graphwriter	Graph heading for test 10		
RC10_REG	Graphwriter	IX Regeneration Effluent test 10		
RC10_SER	Graphwriter	IX Service Effluent test 10		
RC11_HEAD	Graphwriter	Graph heading for test 11		
RC11_REG	Graphwriter	IX Regeneration Effluent test 11		
RC11_SER	Graphwriter	IX Service Effluent test 11		
RC12_HEAD	Graphwriter	Graph heading for test 12		
RC12_REG	Graphwriter	IX Regeneration Effluent test 12		
RC12_SER	Graphwriter	IX Service Effluent test 12		
RC13_HEAD	Graphwriter	Graph heading for test 13		
RC13_REG	Graphwriter	IX Regeneration Effluent test 13		
RC13_SER	Graphwriter	IX Service Effluent test 13		
APPENDIX D - MAIN UNIT OPERATION DATA AND TEST PLAN, 1985				
JJALG85	Lotus 123	Log	June, July, August	1985
JJARG85A	Lotus 123	Operation data	June, July, August	1985
JJASV85A	Lotus 123	Service data	June, July, August	1985
MJJSR85A	Lotus 123	Service and Regeneration data	June, July, August	1985
APPENDIX E - MAIN UNIT OPERATION DATA AND TEST PLAN, JANUARY AND FEBRUARY 1986				
JFLOG86A	Lotus 123	Log	January, Februaty	1986
DAIJF86	Lotus 123	Operation data	January, Februaty	1986
CW2JF86A	Lotus 123	Ion exchange influent	January, Februaty	1986
CW5JF86A	Lotus 123	Ion exchange effluent	January, Februaty	1986
BTF86A	Lotus 123	Brine tanks	January, Februaty	1986

FILE NAME	FILE TYPE	FILE CONTENTS	DATE	YEAR
APPENDIX F - MAIN UNIT OPERATION DATA AND TEST PLAN, MAY AND JUNE 1986				
MJLOG86A	Lotus 123	Log	May, June	1986
DAIMJ86	Lotus 123	Raw Operation Data	May, June	1986
DAIMJ86A	Lotus 123	Operation Data	May, June	1986
CW2MJ86A	Lotus 123	Ion exchange influent	May, June	1986
CW5MJ86A	Lotus 123	Ion exchange effluent	May, June	1986
BTMJ86A	Lotus 123	Brine tanks	May, June	1986
FMJ86BR	Graphwriter	Influent Total Hardness and Sodium Concentration	Feb., May, June	1986
APPENDIX G - MAIN UNIT OPEREATION DATA AND LEAKAGE TEST, JULY AND AUGUST 1986				
JALOG86A	Lotus 123	Log	July, August	1986
DAIJA86	Lotus 123	Raw Operation data	July, August	1986
DAIJA86A	Lotus 123	Operation data	July, August	1986
CW1JA86A	Lotus 123	Ion exchange influent	July, August	1986
CW2JA86A	Lotus 123	Ion exchange influent	July, August	1986
CW3A86A	Lotus 123	Ion exchange effluent	August	1986
CW5JA86A	Lotus 123	Ion exchange effluent	July, August	1986
CW6JA86A	Lotus 123	RO Unit 2 effluent	July, August	1986
CW8JA86A	Lotus 123	RO Unit 3 effluent	July, August	1986
BTJA86A	Lotus 123	Brine tanks	July, August	1986
LEAKTSTA	Lotus 123	Leakage Test	August 6	1986
RJSCUPG	Lotus 123	Operation Instructions	August	1986
PREP_A	Lotus 123	Instructions for Dry Run of IX System	July	1986
JAU86BR	Graphwriter	Influent Total Hardness and Sodium Concentration	July, August	1986
LKAU86	Graphwiter	Leakage vs. Process Water Throughput	August	1986
APPENDIX H - GENERAL AND COMPUTER INFORMATION ON IX OPERATIONS				
RJSCUPH	Lotus 123	Operations Schedule	August	1986
PROGM1_A	Lotus 123	IX Operations Program - Analog Devices MacSym Computer		
ANLGDEVA	Lotus 123	Device Connection to Analog Computer	April	1986
BRVOL2A	Lotus 123	IX/BRINE concentration program	March	1986
VOLUMESA	Lotus 123	Resin & Unit volume data	July	1986
RESNRPTA	Lotus 123	Sales Service Report	August	1986
RPTFILES	Lotus 123	List of report and appendix files		
HLVINF	Lotus 123	Manufacture's data curves		
NACA4.DRW	Freelance	Resulting Hardness Leakage	January - August	1986

FILE NAME	FILE TYPE	FILE CONTENTS	DATE	YEAR
DIR	Lotus 123	Directory of Ion Exchange Data Files		
BENCH UNIT DATA				
OPER100	Lotus 123	Operation parameters for series 100 tests		
ANA100A	Lotus 123	Chemical analyses for series 100 tests (101 through 114)		
ANA100B	Lotus 123	Chemical analyses for series 100 tests (115 through 126)		
OPER200	Lotus 123	Operation parameters for series 200 tests		
ANA200	Lotus 123	Chemical analyses for series 200 tests		
HDLK200	Lotus 123	Hardness and Calcium Leakages for series 200 tests		
BU300SUM	Lotus 123	Summary of results for series 300 tests		
BUCAP__	Lotus 123	Operation parameters and chemical analyses for Series 300 tests		
MAIN UNIT DATA				
JJALG85	Lotus 123	Log of Operations	June, July, August	1985
JJARG85	Lotus 123	Operation data	June, July, August	1985
JJASV85	Lotus 123	Service data	June, July, August	1985
MJJSR85	Lotus 123	Service and Regeneration data	June, July, August	1985
JFLOG86	Lotus 123	Log of Operations	January, Februaty	1986
DAIJF86	Lotus 123	Operation data	January, Februaty	1986
CW2JF86	Lotus 123	Clearwell Chemical Analyses	January, Februaty	1986
CW5JF86	Lotus 123	Clearwell Chemical Analyses	January, Februaty	1986
BTF86	Lotus 123	Brine Tanks Chemical Analyses	January, Februaty	1986
MJLOG86	Lotus 123	Log of Operations	May, June	1986
DAIMJ86	Lotus 123	Operation Data	May, June	1986
CW2MJ86	Lotus 123	Clearwell Chemical Analyses	May, June	1986
CW5MJ86	Lotus 123	Clearwell Chemical Analyses	May, June	1986
BTMJ86	Lotus 123	Brine Tanks Chemical Analyses	May, June	1986
JALOG86	Lotus 123	Log of Operations	July, August	1986
DAIJA86	Lotus 123	Operation data	July, August	1986
CW1JA86	Lotus 123	Clearwell Chemical Analyses	July, August	1986
CW2JA86	Lotus 123	Clearwell Chemical Analyses	July, August	1986
CW3A86	Lotus 123	Clearwell Chemical Analyses	August	1986
CW5JA86	Lotus 123	Clearwell Chemical Analyses	July, August	1986
CW6JA86	Lotus 123	RO Unit 2 effluent	July, August	1986
CW8JA86	Lotus 123	RO Unit 3 effluent	July, August	1986
BTJA86	Lotus 123	Brine Tanks Chemical Analyses	July, August	1986
LEAKTST	Lotus 123	Main Unit Leakage Test	August 6	1986
PROGM1	Lotus 123	IX Operations Program - Analog Devices MacSym Computer		
ANLGDEV	Lotus 123	Device Connection to Analog Computer	April	1986
BRVOL2	Lotus 123	IX/BRINE concentration program	March	1986
VOLUMES	Lotus 123	Resin & Unit volume data	July	1986
RESNRPT	Lotus 123	Sales Service Report	August	1986
RPTFILES	Lotus 123	List of report and appendix files		
HLVINF	Lotus 123	Manufacture's data curves		

GLOSSARY

Bed volume (BV): the volume of resin in an ion-exchange unit.

Breakthrough: rapid increase in the concentration of an absorbed ion in the service effluent water. Breakthrough indicates a nearly exhausted resin with respect to that ion.

Calcium hardness: the amount of calcium in a solution.

Column voids volume (CVV): the volume of liquid that an ion-exchange unit containing resin can hold. CVV = CV - (BV - (BV x VV)) where VV is the percent of resin voids volume.

Column volume (CV): the volume of an ion-exchange unit.

Cycle: sequential steps in events that comprise the ion-exchange process.

Electrodialysis (ED): a desalting process driven by an electromagnetic force (direct-current voltage) applied across a series of alternating cation and anion selective membranes. The voltage causes ion diffusion through the membranes yielding dilute and concentrated streams.

Equivalents per liter (eq/L): (1) the concentration of an element or ion in a solution which is expressed as per liter of solution; (2) the amount of ionic equivalents passed through the resin bed during regeneration or the amount of ionic equivalents absorbed by the resin (resin capacity) during service. These amounts are expressed as equivalents per liter of resin.

Electrodialysis reversal (EDR): an advancement in the electrodialysis process in which the polarity of the applied direct current field is automatically reversed at set intervals. This reversal eliminates many of the operational problems associated with electrodialysis.

Equivalents: the mass of an element or ion present in grams divided by its equivalent mass.

Equivalent weight: the atomic or molecular weight of element or ion divided by its valence.

Hardness leakage or leakage: the amount of calcium, magnesium, and other divalent ions that remains in the effluent of the service event.

Hardness or total hardness: the amount of divalent cations, mainly calcium and magnesium, in a solution.

Loading rate 1 (LR1): hydraulic loading rate expressed in terms of gallons per minute per square foot of cross-sectional area or its metric equivalent.

Loading rate 2 (LR2): hydraulic loading rate expressed in terms of gallons per minute per cubic foot of resin or its metric equivalent.

Regeneration: the phase of the ion-exchange cycle where a solution with a high concentration of sodium is passed through the resin bed. During the passage, sodium ions displace the hardness ions in the resin that were absorbed during service.

Resin capacity: a quantitative measure of equivalents of ion or ions absorbed by a resin per unit volume of resin. Resin capacity is a function of resin properties, water composition, regenerant brine composition, and ion-exchange operating conditions.

Reverse osmosis (RO): a desalting process in which a semipermeable membrane is used to separate dissolved solids from water with an applied pressure greater than the osmotic pressure as the driving force.

Rotating-disk wiped-film evaporator (RED): a distillation process in which the feedwater is spread as a thin film on rotating disks by means of wipers. Separation of the feedwater into distillate and blowdown streams is accomplished by a combination of evaporation and centrifugal force.

Service (softening): that portion of the ion-exchange cycle that removes hardness ions from the process water.

Service factor: the ratio of the ion-exchange cycle's service duration to that of the entire ion-exchange cycle.