APPENDIX C

Project Application Materials

CARLSBAD DESALINATION PROJECT

WASTE STREAM CHARACTERIZATION

APRIL 5, 2005

PLANT WASTE STREAM DESCRIPTION

The desalination plant will generate the following waste streams:

- Concentrated seawater;
- Pretreatment System Sidestreams;
- Used membrane cleaning solution;
- Domestic wastewater;
- Domestic/Municipal solid waste.

Concentrated Seawater

Concentrated seawater will be produced in the RO membrane separation process. Approximately one gallon of concentrated seawater will be created for every gallon of potable drinking water produced; therefore, for the proposed 50-MGD desalination plant, approximately 50 MGD of concentrated seawater will be generated. The salinity of the concentrate will be 67,000 ppm, twice the concentration of the incoming seawater (33,500 mg/L).

The concentrated seawater will be conveyed to the power plant cooling water discharge canal using the desalination plant concentrate pipeline and bended with the power plant cooling water prior to discharge of the blended stream into the ocean via the power plant discharge canal.

Pretreatment System Sidestreams

The type and volume of the pretreatment system sidestreams will depend on the selected pretreatment technology and if microscreens will be installed ahead of the pretreatment system. Two types of pretreatment system technology are considered for implementation at the Carlsbad seawater desalination plant: granular media filtration and membrane filtration. The granular media filtration system may or may not have a microscreening system upstream of it. The efficient and cost effective operation of the membrane filtration system would require the installation of microscreens upstream of the membrane filters.

Microscreening System Sidestream. The purpose of the microscreens is to remove particulates larger than 120 microns from the source seawater in order to reduce the solids loading and biological fouling of the downstream pretreatment facilities. Microscreens can remove particulates (debris and marine organisms) of a very small size. Microscreens are projected to retain between 10% and 30 % of the total suspended solids in the source water and to generate an average and maximum of 2.0 MGD and 3.0 MGD of washwater sidestream. The debris and marine organisms in the washwater collected in the microscreen hoppers would slowly be conveyed via gravity to a wet-well, from where they would be pumped to the power plant outfall canal for release back into the ocean.

Granular Media Filtration System Sidestream. If granular media pretreatment filters are used, they will be cleaned (backwashed) to remove the suspended solids that accumulate in the media beds during source water filtration. The desalination plant will use filtered seawater for backwash. The amount of backwash water used will be between 3 to 6.3 percent (average of 4 percent) of the total intake water flow required for desalination. For a 50-MGD facility, operating at 50-percent recovery, the average and maximum amounts of filter backwash water will be 4.0 MGD and 6.3 MGD, respectively. Because granular media filtration would require source water conditioning with coagulant (ferric chloride or sulfate), in addition to the suspended solids in the filter feed seawater, the backwash waste stream will also contain the additional solids generated as a result of coagulant addition to the source water.

The spent (waste) filter backwash water will flow from the filters to two sedimentation basins. The settled filter backwash water will have the same characteristics as the intake ocean water. This settled backwash water will be either returned to the inlet of the desalination plant, upstream of the pretreatment filters, or will be discharged to the ocean via the concentrate disposal pipeline. The settled filter backwash water will contain approximately 1 percent of the solids retained in the pretreatment filters; 99 percent of the solids will be removed with the sedimentation basins' sludge. As indicated previously, the settled solids (sludge) will be dewatered on site to sludge concentration of 20 % or higher and disposed to a landfill.

Membrane Filtration System Sidestreams

If membrane filtration is selected for source water pretreatment, the membrane filtration system will generate three sidestreams:

- Membrane backwash water, which will contain the solids remaining in the source seawater after microscreening.
- Chemically Enhanced Backwash (CEB) Water - a waste stream generated during the intermittent daily backwashing of the membranes with cleaning chemicals (typically a combination of chlorination and acid and base conditioning of the membrane modules).
- Used Pretreatment Membrane Cleaning Solution - a waste stream generated intermittently during the more elaborate chemical cleaning of the pretreatment membranes completed once per month.

The membrane waste backwash water stream will be generated continuously and will have a volume of approximately 10 to 15 % of the source water intake flow - i.e. the average and maximum membrane waste backwash flows for a 50 MGD plant operated at 50 % recovery would be 10 MGD and 15 MGD, respectively. The membrane waste backwash water will be then treated in a separate set of membrane backwash treatment tanks (concentrators), which are projected to recover/reduce the backwash water volume by 50 %. As a result 50 % of the waste backwash water would be recycled upstream of the pretreatment filters and the remaining 50 % (5 MGD (avg.) / 7.5 MGD (max)) will be disposed as a final backwash water sidestream. Because the membrane pretreatment process does not require addition of chemicals for source seawater conditioning prior to filtration, the final waste backwash water stream will contain only solids naturally occurring in the ocean source water. Therefore, this final backwash water sidestream is proposed to be discharged back to the ocean along with the RO system concentrate and the microscreen washwater.

As indicated previously, CEB of the pretreatment membranes will generate a daily waste stream of approximately 0.3 to 0.6 % of the source water flow. For a 50 MGD plant the CEB water average and maximum daily discharge would be 0.3 MGD to 0.6 MGD, respectively. The waste CEB sidestream will be stored in a separate tank, neutralized and conveyed to the sanitary sewer system for further treatment and ultimate disposal at the Encina Water Pollution Control Facility.

Pretreatment membrane system monthly chemical cleaning will be completed using the same cleaning chemicals as those used for cleaning of the RO membranes (see the "Used Membrane Cleaning Solution" section for further details). In order to be able to clean all membranes once per month and at the same time minimize the number of membrane cells down for cleaning, an average 4 % of the membrane cells will be taken out of service every day and cleaned. Membrane cell cleaning process is projected to take one day per a set of cells of capacity equal to 4 % of the total plant capacity. The average amount of the used pretreatment membrane cleaning solution generated daily is projected to be 110,000 gallons/day. A breakdown of the contaminants in this waste stream volume is presented in Table 1. The pretreatment membrane waste cleaning solution will be conveyed for treatment to the same storage tank used for the CEB sidestream, from where it would be conveyed to the sanitary sewer system for further treatment and disposal at the Encina Water Pollution Control Facility.

Used Membrane RO Cleaning Solution

The accumulation of scale and other foulants on the RO membranes reduce membrane performance. The RO system membranes will be periodically cleaned to remove foulants and extend the membrane useful life. Typical cleaning frequency of the RO membranes is twice per year.

The desalination plant RO membranes will be arranged in 13 individual trains. All membranes contained in the same train will be cleaned at the same time. Typically, one RO train is taken off-line at a time for cleaning.

To clean the membranes, a chemical cleaning solution is circulated through the membrane train for a preset time. After the cleaning solution circulation is completed, the spent cleaning solution is evacuated from the train to a storage tank and the membranes are flushed with RO permeate (flush water). The flush water is used to remove all the residual cleaning solution from the RO train in order to prepare the train for normal operation. The flush water for membrane cleaning is stored separately from the rest of the plant permeate in a flush tank.

Chemicals typically used for cleaning include:

- Citric Acid - (2% solution)
- Sodium Hydroxide B (0.1% solution)
- Sodium Tripolyphosphate B (2 % solution)
- Sodium Dodecylbenzene B (0.25% solution)
- Sulfuric acid B (0.1% solution).

Depending on the nature of membrane fouling, the cleaning chemicals listed above may be combined in one of the following two cleaning solutions:

<u>Cleaning Solution 1 - Low pH Cleaning Solution:</u>
- Citric Acid - (2% solution);
- Sodium Hydroxide - (0. 1 % solution), to adjust pH to 4.0 for cleaning;
- Sodium Hydroxide - (0. I% solution), to adjust pH to 7.0 prior to discharge.

<u>Cleaning Solution 2 - High pH Cleaning Solution:</u>
- Sodium Hydroxide - (0.1 % solution);
- Sodium Dodecylbenzene Sulfonate - (0.25% solution);
- Sulfuric acid to adjust pH to 10.0 for cleaning;
- Sulfuric acid to adjust pH to 7.0 prior to discharge.

The actual cleaning solution selected for a given cleaning of a membrane train will be based on the observed operation and performance of the train once it is placed in operation. The average daily volume of waste streams generated by the cleaning of the RO membrane trains is 6,100 gallons.

The various waste discharge volumes are described below:

- **Concentrated Waste Cleaning Solution** is the actual spent membrane cleaning chemical.

- **Flush Water – Residual Cleaning Solution (First Flush)** is the first batch of clean product water used to flush the membranes after the recirculation of cleaning solution is discontinued. This first flush contains diluted residual cleaning solution.

- **Flush Water – Permeate** is the spent cleaning water used for several consecutive membrane flushes after the first flush. This flush water is of low salinity and contains only trace amounts of cleaning solution.

- **Flush Water – Concentrate Removed During Flushing** is the flush water removed form the concentrate lines of the RO system during the flushing process. This water contains very little cleaning chemicals and is of slightly higher salinity concentration than the permeate used for flushing.

All the membrane cleaning streams listed above will be conveyed to a 200,000 gallon washwater (scavenger) tank for used cleaning solution retention and treatment prior to discharge to the local wastewater collection system. Since the volume of used cleaning solution generated during cleaning of one membrane train is 91,000 gallons, the washwater tank will have adequate capacity to store cleaning solution from two simultaneous RO membrane train cleanings.

The washwater tank will be equipped with mixing and pH neutralization systems. The mixing system will provide complete mixing of all four cleaning solution streams listed above. After mixing with the flush water, the concentration of the cleaning solution chemical will be reduced significantly. The used cleaning solution will be neutralized to pH level compatible with the ocean water pH and pumped out of the washwater tank to the wastewater collection system. A detailed chemical characterization of the used membrane cleaning solution is presented in Table 1.

Domestic Wastewater

Domestic wastewater generated from the restroom and the lunch room at the desalination plant will be discharged to the local wastewater collection system.

Domestic/Municipal Solid Waste

Domestic/Municipal solid waste generated at the facility will consist of non-hazardous wastes suitable for dumpster containment, pickup and transport by a commercial solid waste hauler for disposal at local approved solid waste landfill facilities.

WASTE STREAM CHARACTERIZATION

Desalination plant waste stream concentration and loads were established based on sampling and testing data collected at the desalination pilot plant located at the Encina power plant. The Carlsbad pilot plant is a 25 gpm seawater desalination facility located at the Encina power plant site. The pilot plant consists of the same treatment facilities and uses the same chemicals as these planned to be used at the full-scale Carlsbad desalination plant.

On February 12, 2003 a series of tests we conducted at the pilot desalination plant to generate samples for characterization of the full-scale plant waste streams. The collected intake water quality and waste stream samples were analyzed by a certified lab, and the results of the lab analysis are summarized in Table 1. This table provides information for both the continuous desalination plant waste streams (concentrate and unsettled filter backwash) and for the intermittently generated cleaning solution discharges. After settling, in the desalination plant's sedimentation basins the filter backwash total suspended solids concentration will be the same as the intake seawater concentration.

In order to characterize the intermittent membrane cleaning solution discharge concentrations and waste loads, one laboratory analysis were conducted for each cleaning solution. The cleaning chemicals used to prepare the samples for analysis were commercially available products, identical to these which will be used in the full-scale membrane cleaning. The reverse osmosis permeate and concentrate used for preparation of the cleaning solution samples were generated at the Carlsbad pilot desalination plant during a sampling event on February 12, 2003. One sample for each cleaning solution was prepared at bench-scale. The Cleaning Solution 1 and 2 samples were a mixture of the cleaning chemicals listed in the previous section and of concentrate and permeate. The cleaning solutions were blended with the concentrate and permeate in volumetric ratios proportional to the full-scale operation.

The results of the cleaning solution chemical characterization are presented in Table 1.

Table 2 provides a summary of the continuous waste stream discharges in terms of concentration for all parameters included in the Ocean Plan. This table provides the total solids load contained in the unsettled filter backwash water. After settling in the seawater desalination plant's sedimentation basins, the solids load shown in Table 2 will be reduced by 99 %. Only the remaining 1 % of the backwash solids load provided in Table 2 will be either recycled to the desalination plant intake facilities or conveyed to the plant concentrate pipeline for discharge to the ocean.

TABLE 1

CARLSBAD SEAWATER DESALINATION PROJECT
DESALINATION PLANT TOTAL WASTE STREAM DISCHARGE
(Estimated based on Samples Collected on February 12, 2003)

ANALYTE			CONCENTRATION		TOTAL MAXIMUM PLANT DISCHARGE	
			RO CONCEN-TRATE	PRETREATMENT FILTER BACKWASH (1)	CONCENTRATION mg/L or ug/L	WASTE LOAD lbs/day
GROUP A						
Biochemical Oxygen Demand	SM 5210 B	milligrams/L	<10	<10	10.0	4,695.42
COD	EPA 410.4	milligrams/L	<100	53	94.7	44,484.73
Total Organic Carbon	SM 5310 C	milligrams/L	0.7	1.3	0.77	360.20
Total Suspended Solids	EPA 160.2	milligrams/L	<5	130	18.99	8,915.46
Ammonia (as N)	SM 4500 NH3	milligrams/L	0.12	0.10	0.118	55.29
pH	SM 4500 H B	pH units	7.49	7.63	7.510	NA
GROUP B						
Bromide	EPA 300.0	milligrams/L	120	53	112.5	52,824.73
Boron	EPA 200.8	milligrams/L	7.6	3.8	7.2	3,368.86
Color	EPA 110.2	color units	3	3	3.0	NA
Coliforms, fecal	SM 9221 E	MPN/100ml	<2	130	1.9	NA
Fluoride	EPA 300.0	milligrams/L	2.1	<0.5	1.9	901.97
Nitrate (as N)	EPA 300.0	milligrams/L	<0.5	<0.5	0.5	234.77
Oil and Grease	EPA 1664	milligrams/L	<5	<5	5.0	2,347.71
Phosphorus (as P) Total	EPA 365.3	milligrams/L	<0.05	0.44	0.09	43.97
Radioactivity						
Gross Beta	EPA 900.0	picocuries/L	765	601	747	NA
Total Alpha Radium (226)		picocuries/L	0.128	0.212	0.14	NA
Radium 228		picocuries/L	Not Available	Not Available	Not Available	Not Available
Sulfate	EPA 300.0	milligrams/L	5300	2400	4975	2,336,200.80
Sulfide	SM 4500 S2 D	milligrams/L	<0.1	<0.1	0.10	46.95
Sulfite	SM 4500 SO3	milligrams/L	<2	<2	1.80	844.51
Surfactants	SM 5540 C	milligrams/L	0.08	0.11	0.08	39.14
Aluminum	EPA 200.8	micrograms/L	24	2600	312	146.62
Barium	EPA 200.8	micrograms/L	15	20	15.56	7.31
Cobalt	EPA 200.8	micrograms/L	2.8	2.3	2.74	1.29
Iron	EPA 200.7	micrograms/L	<40	22000	2497	1,172.60
Magnesium	EPA 200.7	milligrams/L	3100	1400	2910	1,366.26
Molybdenum	EPA 200.8	micrograms/L	28	14	26.43	12.41
Manganese	EPA 200.8	micrograms/L	17	40	19.57	9.19
Tin	EPA 200.8	micrograms/L	<2.5	<2.5	2.50	1.17
Titanium	EPA 200.7	micrograms/L	<10	<10	10.00	4.70
SECTION 1						
Antimony	EPA 200.8	micrograms/L	<5	<5	5.00	2.35
Beryllium	EPA 200.8	micrograms/L	<0.3	<0.3	0.30	0.14
Chromium, total	EPA 200.8	micrograms/L	<4	9	4.56	2.14
Lead	EPA 200.8	micrograms/L	<1	2.6	1.18	0.55
Nickel	EPA 200.8	micrograms/L	19	21	19.22	9.03
Silver	EPA 200.8	micrograms/L	<0.5	<0.5	0.50	0.23
Zinc	EPA 200.8	micrograms/L	<10	22	11.34	5.33
Phenols (see individual phenolics)						
Arsenic	EPA 200.8	micrograms/L	<2	27	4.80	2.25
Cadmium	EPA 200.8	micrograms/L	<0.5	<0.5	0.50	0.23
Copper	EPA 200.8	micrograms/L	<2	10	2.90	1.36
Mercury	EPA 245.1	micrograms/L	<0.2	<0.2	0.20	0.09
Selenium	EPA 200.8 Hy	micrograms/L	<0.4	<0.4	0.40	0.19
Thallium	EPA 200.8	micrograms/L	<2.5	<0.5	2.28	1.07
Cyanide	SM 4500 CN E	milligrams/L	<0.05	<0.05	0.05	23.48
SECTION 2						
2,3,7,8-TCDD		picograms/L	Not Available	Not Available	Not Available	Not Available

TABLE 1

CARLSBAD SEAWATER DESALINATION PROJECT
DESALINATION PLANT TOTAL WASTE STREAM DISCHARGE
(Estimated based on Samples Collected on February 12, 2003)

ANALYTE			CONCENTRATION		TOTAL MAXIMUM PLANT DISCHARGE	
			RO CONCEN-TRATE	PRETREATMENT FILTER BACKWASH (1)	CONCENTRATION mg/L or ug/L	WASTE LOAD lbs/day
SECTION 3						
Volatile Organics (all VOCs	EPA 524.2	micrograms/L	ND	ND	ND	ND
in Table 2D-2 are ND, except...)						
2-Butanone	EPA 524.2	micrograms/L	<5	<5	5.00	2.35
Bromoform	EPA 524.2	micrograms/L	1.40	<0.5	1.30	0.61
Acid Compounds						
2-Chlorophenol	EPA 625	micrograms/L	<5	<5	5.00	2.35
2,4-Dimethylphenol	EPA 625	micrograms/L	<5	<5	5.00	2.35
2,4-Dinitrophenol	EPA 625	micrograms/L	<20	<20	20.00	9.39
4-Nitrophenol	EPA 625	micrograms/L	<10	<10	10.00	4.70
Pentachlorophenol	EPA 625	micrograms/L	<5	<5	5.00	2.35
2,4,6-Trichlorophenol	EPA 625	micrograms/L	<10	<10	10.00	4.70
2,4-Dichlorophenol	EPA 625	micrograms/L	<5	<5	5.00	2.35
2-Methyl-4,6-dinitrophenol	EPA 625	micrograms/L	<10	<10	10.00	4.70
2-Nitrophenol	EPA 625	micrograms/L	<10	<10	10.00	4.70
4-Chloro-3-methylphenol	EPA 625	micrograms/L	<5	<5	5.00	2.35
Phenol	EPA 625	micrograms/L	<5	<5	5.00	2.35
Base/Neutrals						
Acenaphthene	EPA 625	micrograms/L	<5	<5	5.00	2.35
Anthracene	EPA 625	micrograms/L	<5	<5	5.00	2.35
Benz(a)anthracene	EPA 625	micrograms/L	<5	<5	5.00	2.35
Benzo(b)fluoranthene	EPA 625	micrograms/L	<5	<5	5.00	2.35
Benzo(k)fluoranthene	EPA 625	micrograms/L	<5	<5	5.00	2.35
bis(2-Chloroethyl)ether	EPA 625	micrograms/L	<5	<5	5.00	2.35
bis(2-Ethylhexyl)phthalate	EPA 625	micograms/L	<5	<5	5.00	2.35
Butylbenzyl phthalate	EPA 625	micrograms/L	<5	<5	5.00	2.35
4-Chlorophenylphenylether	EPA 625	micrograms/L	<5	<5	5.00	2.35
Dibenz(a,h)anthracene	EPA 625	micrograms/L	<5	<5	5.00	2.35
1,3-Dichlorobenzene	EPA 625	micrograms/L	<5	<5	5.00	2.35
3,3'-Dichlorobenzidine	EPA 625	micrograms/L	<5	<5	5.00	2.35
Dimethyl phthalate	EPA 625	micrograms/L	<5	<5	5.00	2.35
2,4-Dinitrotoluene	EPA 625	micrograms/L	<5	<5	5.00	2.35
Di-n-octyl phthalate	EPA 625	micrograms/L	<5	<5	5.00	2.35
Fluoranthene	EPA 625	micrograms/L	<5	<5	5.00	2.35
Hexachlorobenzene	EPA 508	micrograms/L	<0.5	<0.5	0.50	0.23
Hexachlorocyclopentadiene	EPA 508	micrograms/L	<1	<1	1.00	0.47
Indeno(1,2,3-c)pyrene	EPA 625	micrograms/L	<5	<5	5.00	2.35
Naphthalene	EPA 625	micrograms/L	<5	<5	5.00	2.35
N-Nitrosodimethylamine	EPA 625	micrograms/L	<5	<5	5.00	2.35
N-Nitrosodiphenylamine	EPA 625	micrograms/L	<5	<5	5.00	2.35
Pyrene	EPA 625	micrograms/L	<5	<5	5.00	2.35
Acenaphthylene	EPA 625	micrograms/L	<5	<5	5.00	2.35
Benzidine	EPA 625	micrograms/L	<5	<5	5.00	2.35
Benzo(a)pyrene	EPA 625	micrograms/L	<5	<5	5.00	2.35
Benzo(g,h,I)perylene	EPA 625	micrograms/L	<5	<5	5.00	2.35
bis (2-Chloroethoxy)methane	EPA 625	micrograms/L	<5	<5	5.00	2.35
bis(2-Chloroisopropyl)ether	EPA 625	micrograms/L	<5	<5	5.00	2.35
4-Bromophenylphenylether	EPA 625	micrograms/L	<5	<5	5.00	2.35
2-Chloronaphthalene	EPA 625	micrograms/L	<5	<5	5.00	2.35
Chrysene	EPA 625	micrograms/L	<5	<5	5.00	2.35
1,2-Dichlorobenzene	EPA 625	micrograms/L	<5	<5	5.00	2.35
1,4-Dichlorobenzene	EPA 625	micrograms/L	<5	<5	5.00	2.35
Diethyl phthalate	EPA 625	micrograms/L	<5	<5	5.00	2.35
Dibutyl phthalate	EPA 625	micrograms/L	<5	<5	5.00	2.35

TABLE 1

CARLSBAD SEAWATER DESALINATION PROJECT

DESALINATION PLANT TOTAL WASTE STREAM DISCHARGE

(Estimated based on Samples Collected on February 12, 2003)

ANALYTE			CONCENTRATION		TOTAL MAXIMUM PLANT DISCHARGE	
			RO CONCEN-TRATE	PRETREATMENT FILTER BACKWASH [(1)]	CONCENTRATION mg/L or ug/L	WASTE LOAD lbs/day
2,6-Dinitrotoluene	EPA 625	micrograms/L	<5	<5	5.00	2.35
Azobenzene	EPA 625	micrograms/L	<5	<5	5.00	2.35
Fluorene	EPA 625	micrograms/L	<5	<5	5.00	2.35
Hexachlorobutadiene	EPA 625	micrograms/L	<5	<5	5.00	2.35
Hexachloroethane	EPA 625	micrograms/L	<5	<5	5.00	2.35
Isophorone	EPA 625	micrograms/L	<5	<5	5.00	2.35
Nitrobenzene	EPA 625	micrograms/L	<5	<5	5.00	2.35
N-nitrosodi-n-propylamine	EPA 625	micrograms/L	<5	<5	5.00	2.35
Phenanthrene	EPA 625	micrograms/L	<5	<5	5.00	2.35
1,2,4-Trichlorobenzene	EPA 625	micrograms/L	<5	<5	5.00	2.35
PESTICIDES						
Aldrin	EPA 508	micrograms/L	<0.075	<0.075	0.075	0.04
BHC-alpha	EPA 508	micrograms/L	<0.05	<0.05	0.05	0.02
BHC-beta	EPA 508	micrograms/L	<0.05	<0.05	0.05	0.02
4,4'-DDD	EPA 508	micrograms/L	<0.02	<0.02	0.02	0.01
4,4'-DDT	EPA 508	micrograms/L	<0.02	<0.02	0.02	0.01
Endosulfan I	EPA 508	micrograms/L	<0.02	<0.02	0.02	0.01
Endosulfan II	EPA 508	micrograms/L	<0.01	<0.01	0.01	0.005
Endosulfan sulfate	EPA 508	micrograms/L	<0.05	<0.05	0.05	0.02
Endrin	EPA 508	micrograms/L	<0.1	<0.1	0.10	0.05
Endrin aldehyde	EPA 508	micrograms/L	<0.05	<0.05	0.05	0.02
Heptachlor	EPA 508	micrograms/L	<0.01	<0.01	0.01	0.005
Heptachlor epoxide	EPA 508	micrograms/L	<0.01	<0.01	0.01	0.005
Arochlors (PCBs)	EPA 508	micrograms/L	<0.1	<0.1	0.10	0.047
Toxaphene	EPA 508	micrograms/L	<1	<1	1.00	0.47
BHC-delta	EPA 508	micrograms/L	<0.5	<0.5	0.50	0.23
BHC-gamma (Lindane)	EPA 508	micrograms/L	<0.2	<0.2	0.20	0.09
Chlordane-alpha	EPA 508	micrograms/L	<0.1	<0.1	0.10	0.05
Chlordane-gamma	EPA 508	micrograms/L	<0.1	<0.1	0.10	0.05
4,4'-DDE	EPA 508	micrograms/L	<0.01	<0.01	0.01	0.005
Dieldrin	EPA 508	micrograms/L	<0.02	<0.02	0.02	0.009
OTHERS						
1-Methylnaphthalene	EPA 625	micrograms/L	<5	<5	5.00	2.35
1-Methylphenanthrene	EPA 625	micrograms/L	<5	<5	5.00	2.35
2,3,5-Trimethylnaphthalene	EPA 625	micrograms/L	<5	<5	5.00	2.35
2,4'-DDD	EPA 508	micrograms/L	<1	<1	1.00	0.47
2,4'-DDE	EPA 508	micrograms/L	<1	<1	1.00	0.47
2,4'-DDT	EPA 508	micrograms/L	<1	<1	1.00	0.47
2,6-Dimethylnaphthalene	EPA 625	micrograms/L	<5	<5	5.00	2.35
2-Methylnaphthalene	EPA 625	micrograms/L	<5	<5	5.00	2.35
Benzo(e)pyrene	EPA 625	micrograms/L	<5	<5	5.00	2.35
Biphenyl	EPA 625	micrograms/L	<5	<5	5.00	2.35
Methoxychlor	EPA 508	micrograms/L	<10	<10	10.00	4.70
Mirex	EPA 508	micrograms/L	<0.02	<0.02	0.02	0.01
Perylene	EPA 625	micrograms/L	<5	<5	5.00	2.35
Polychlorinated biphenyls (PCBs)	EPA 508	micrograms/L	<0.1	<0.1	0.10	0.05
Tributyltin		micrograms/L	<0.005	<0.005	0.005	0.002
trans-Nonachlor	EPA 508	micrograms/L	<0.01	<0.01	0.01	0.005

TABLE 2

CARLSBAD SEAWATER DESALINATION PROJECT

DESALINATION PLANT TOTAL WASTE STREAM DISCHARGE

(Estimated based on Samples Collected on February 12, 2003)

ANALYTE			CONCENTRATION		TOTAL MAXIMUM PLANT DISCHARGE
			RO CONCEN-TRATE	PRETREATMENT FILTER BACKWASH	CONCENTRATION mg/L or ug/L
GROUP A					
Biochemical Oxygen Demand	SM 5210 B	milligrams/L	<10	<10	10.0
COD	EPA 410.4	milligrams/L	<100	53	94.7
Total Organic Carbon	SM 5310 C	milligrams/L	0.7	1.3	0.77
Total Suspended Solids	EPA 160.2	milligrams/L	<5	130	18.99
Ammonia (as N)	SM 4500 NH3	milligrams/L	0.12	0.10	0.118
pH	SM 4500 H B	pH units	7.49	7.63	7.510
GROUP B					
Bromide	EPA 300.0	milligrams/L	120	53	112.5
Boron	EPA 200.8	milligrams/L	7.6	3.8	7.2
Color	EPA 110.2	color units	3	3	3.0
Coliforms, fecal	SM 9221 E	MPN/100ml	<2	130	1.9
Fluoride	EPA 300.0	milligrams/L	2.1	<0.5	1.9
Nitrate (as N)	EPA 300.0	milligrams/L	<0.5	<0.5	0.5
Oil and Grease	EPA 1664	milligrams/L	<5	<5	5.0
Phosphorus (as P) Total	EPA 365.3	milligrams/L	<0.05	0.44	0.09
Radioactivity					
Gross Beta	EPA 900.0	picocuries/L	765	601	747
Total Alpha Radium (226)		picocuries/L	0.128	0.212	0.14
Radium 228		picocuries/L	Not Available	Not Available	Not Available
Sulfate	EPA 300.0	milligrams/L	5300	2400	4975
Sulfide	SM 4500 S2 D	milligrams/L	<0.1	<0.1	0.10
Sulfite	SM 4500 SO3	milligrams/L	<2	<2	1.80
Surfactants	SM 5540 C	milligrams/L	0.08	0.11	0.08
Aluminum	EPA 200.8	micrograms/L	24	2600	312
Barium	EPA 200.8	micrograms/L	15	20	15.56
Cobalt	EPA 200.8	micrograms/L	2.8	2.3	2.74
Iron	EPA 200.7	micrograms/L	<40	22000	2497
Magnesium	EPA 200.7	milligrams/L	3100	1400	2910
Molybdenum	EPA 200.8	micrograms/L	28	14	26.43
Manganese	EPA 200.8	micrograms/L	17	40	19.57
Tin	EPA 200.8	micrograms/L	<2.5	<2.5	2.50
Titanium	EPA 200.7	micrograms/L	<10	<10	10.00
SECTION 1					
Antimony	EPA 200.8	micrograms/L	<5	<5	5.00
Beryllium	EPA 200.8	micrograms/L	<0.3	<0.3	0.30
Chromium, total	EPA 200.8	micrograms/L	<4	9	4.56
Lead	EPA 200.8	micrograms/L	<1	2.6	1.18
Nickel	EPA 200.8	micrograms/L	19	21	19.22
Silver	EPA 200.8	micrograms/L	<0.5	<0.5	0.50
Zinc	EPA 200.8	micrograms/L	<10	22	11.34
Phenols (see individual phenolics)					
Arsenic	EPA 200.8	micrograms/L	<2	27	4.80
Cadmium	EPA 200.8	micrograms/L	<0.5	<0.5	0.50
Copper	EPA 200.8	micrograms/L	<2	10	2.90
Mercury	EPA 245.1	micrograms/L	<0.2	<0.2	0.20
Selenium	EPA 200.8 Hy	micrograms/L	<0.4	<0.4	0.40
Thallium	EPA 200.8	micrograms/L	<2.5	<0.5	2.28
Cyanide	SM 4500 CN E	milligrams/L	<0.05	<0.05	0.05
SECTION 2					
2,3,7,8-TCDD		picograms/L	Not Available	Not Available	Not Available

TABLE 2

CARLSBAD SEAWATER DESALINATION PROJECT

DESALINATION PLANT TOTAL WASTE STREAM DISCHARGE

(Estimated based on Samples Collected on February 12, 2003)

ANALYTE			CONCENTRATION		TOTAL MAXIMUM PLANT DISCHARGE
			RO CONCEN-TRATE	PRETREATMENT FILTER BACKWASH	CONCENTRATION mg/L or ug/L
SECTION 3					
Volatile Organics (all VOCs	EPA 524.2	micrograms/L	ND	ND	ND
in Table 2D-2 are ND, except...)					
2-Butanone	EPA 524.2	micrograms/L	<5	<5	5.00
Bromoform	EPA 524.2	micrograms/L	1.40	<0.5	1.30
Acid Compounds					
2-Chlorophenol	EPA 625	micrograms/L	<5	<5	5.00
2,4-Dimethylphenol	EPA 625	micrograms/L	<5	<5	5.00
2,4-Dinitrophenol	EPA 625	micrograms/L	<20	<20	20.00
4-Nitrophenol	EPA 625	micrograms/L	<10	<10	10.00
Pentachlorophenol	EPA 625	micrograms/L	<5	<5	5.00
2,4,6-Trichlorophenol	EPA 625	micrograms/L	<10	<10	10.00
2,4-Dichlorophenol	EPA 625	micrograms/L	<5	<5	5.00
2-Methyl-4,6-dinitrophenol	EPA 625	micrograms/L	<10	<10	10.00
2-Nitrophenol	EPA 625	micrograms/L	<10	<10	10.00
4-Chloro-3-methylphenol	EPA 625	micrograms/L	<5	<5	5.00
Phenol	EPA 625	micrograms/L	<5	<5	5.00
Base/Neutrals					
Acenaphthene	EPA 625	micrograms/L	<5	<5	5.00
Anthracene	EPA 625	micrograms/L	<5	<5	5.00
Benz(a)anthracene	EPA 625	micrograms/L	<5	<5	5.00
Benzo(b)fluoranthene	EPA 625	micrograms/L	<5	<5	5.00
Benzo(k)fluoranthene	EPA 625	micrograms/L	<5	<5	5.00
bis(2-Chloroethyl)ether	EPA 625	micrograms/L	<5	<5	5.00
bis(2-Ethylhexyl)phthalate	EPA 625	micograms/L	<5	<5	5.00
Butylbenzyl phthalate	EPA 625	micrograms/L	<5	<5	5.00
4-Chlorophenylphenylether	EPA 625	micrograms/L	<5	<5	5.00
Dibenz(a,h)anthracene	EPA 625	micrograms/L	<5	<5	5.00
1,3-Dichlorobenzene	EPA 625	micrograms/L	<5	<5	5.00
3,3'-Dichlorobenzidine	EPA 625	micrograms/L	<5	<5	5.00
Dimethyl phthalate	EPA 625	micrograms/L	<5	<5	5.00
2,4-Dinitrotoluene	EPA 625	micrograms/L	<5	<5	5.00
Di-n-octyl phthalate	EPA 625	micrograms/L	<5	<5	5.00
Fluoranthene	EPA 625	micrograms/L	<5	<5	5.00
Hexachlorobenzene	EPA 508	micrograms/L	<0.5	<0.5	0.50
Hexachlorocyclopentadiene	EPA 508	micrograms/L	<1	<1	1.00
Indeno(1,2,3-c)pyrene	EPA 625	micrograms/L	<5	<5	5.00
Naphthalene	EPA 625	micrograms/L	<5	<5	5.00
N-Nitrosodimethylamine	EPA 625	micrograms/L	<5	<5	5.00
N-Nitrosodiphenylamine	EPA 625	micrograms/L	<5	<5	5.00
Pyrene	EPA 625	micrograms/L	<5	<5	5.00
Acenaphthylene	EPA 625	micrograms/L	<5	<5	5.00
Benzidine	EPA 625	micrograms/L	<5	<5	5.00
Benzo(a)pyrene	EPA 625	micrograms/L	<5	<5	5.00
Benzo(g,h,I)perylene	EPA 625	micrograms/L	<5	<5	5.00
bis (2-Chloroethoxy)methane	EPA 625	micrograms/L	<5	<5	5.00
bis(2-Chloroisopropyl)ether	EPA 625	micrograms/L	<5	<5	5.00
4-Bromophenylphenylether	EPA 625	micrograms/L	<5	<5	5.00
2-Chloronaphthalene	EPA 625	micrograms/L	<5	<5	5.00
Chrysene	EPA 625	micrograms/L	<5	<5	5.00
1,2-Dichlorobenzene	EPA 625	micrograms/L	<5	<5	5.00
1,4-Dichlorobenzene	EPA 625	micrograms/L	<5	<5	5.00
Diethyl phthalate	EPA 625	micrograms/L	<5	<5	5.00
Dibutyl phthalate	EPA 625	micrograms/L	<5	<5	5.00

TABLE 2

CARLSBAD SEAWATER DESALINATION PROJECT
DESALINATION PLANT TOTAL WASTE STREAM DISCHARGE
(Estimated based on Samples Collected on February 12, 2003)

ANALYTE			CONCENTRATION		TOTAL MAXIMUM PLANT DISCHARGE
			RO CONCEN-TRATE	PRETREATMENT FILTER BACKWASH	CONCENTRATION mg/L or ug/L
2,6-Dinitrotoluene	EPA 625	micrograms/L	<5	<5	5.00
Azobenzene	EPA 625	micrograms/L	<5	<5	5.00
Fluorene	EPA 625	micrograms/L	<5	<5	5.00
Hexachlorobutadiene	EPA 625	micrograms/L	<5	<5	5.00
Hexachloroethane	EPA 625	micrograms/L	<5	<5	5.00
Isophorone	EPA 625	micrograms/L	<5	<5	5.00
Nitrobenzene	EPA 625	micrograms/L	<5	<5	5.00
N-nitrosodi-n-propylamine	EPA 625	micrograms/L	<5	<5	5.00
Phenanthrene	EPA 625	micrograms/L	<5	<5	5.00
1,2,4-Trichlorobenzene	EPA 625	micrograms/L	<5	<5	5.00
PESTICIDES					
Aldrin	EPA 508	micrograms/L	<0.075	<0.075	0.075
BHC-alpha	EPA 508	micrograms/L	<0.05	<0.05	0.05
BHC-beta	EPA 508	micrograms/L	<0.05	<0.05	0.05
4,4'-DDD	EPA 508	micrograms/L	<0.02	<0.02	0.02
4,4'-DDT	EPA 508	micrograms/L	<0.02	<0.02	0.02
Endosulfan I	EPA 508	micrograms/L	<0.02	<0.02	0.02
Endosulfan II	EPA 508	micrograms/L	<0.01	<0.01	0.01
Endosulfan sulfate	EPA 508	micrograms/L	<0.05	<0.05	0.05
Endrin	EPA 508	micrograms/L	<0.1	<0.1	0.10
Endrin aldehyde	EPA 508	micrograms/L	<0.05	<0.05	0.05
Heptachlor	EPA 508	micrograms/L	<0.01	<0.01	0.01
Heptachlor epoxide	EPA 508	micrograms/L	<0.01	<0.01	0.01
Arochlors (PCBs)	EPA 508	micrograms/L	<0.1	<0.1	0.10
Toxaphene	EPA 508	micrograms/L	<1	<1	1.00
BHC-delta	EPA 508	micrograms/L	<0.5	<0.5	0.50
BHC-gamma (Lindane)	EPA 508	micrograms/L	<0.2	<0.2	0.20
Chlordane-alpha	EPA 508	micrograms/L	<0.1	<0.1	0.10
Chlordane-gamma	EPA 508	micrograms/L	<0.1	<0.1	0.10
4,4'-DDE	EPA 508	micrograms/L	<0.01	<0.01	0.01
Dieldrin	EPA 508	micrograms/L	<0.02	<0.02	0.02
OTHERS					
1-Methylnaphthalene	EPA 625	micrograms/L	<5	<5	5.00
1-Methylphenanthrene	EPA 625	micrograms/L	<5	<5	5.00
2,3,5-Trimethylnaphthalene	EPA 625	micrograms/L	<5	<5	5.00
2,4'-DDD	EPA 508	micrograms/L	<1	<1	1.00
2,4'-DDE	EPA 508	micrograms/L	<1	<1	1.00
2,4'-DDT	EPA 508	micrograms/L	<1	<1	1.00
2,6-Dimethylnaphthalene	EPA 625	micrograms/L	<5	<5	5.00
2-Methylnaphthalene	EPA 625	micrograms/L	<5	<5	5.00
Benzo(e)pyrene	EPA 625	micrograms/L	<5	<5	5.00
Biphenyl	EPA 625	micrograms/L	<5	<5	5.00
Methoxychlor	EPA 508	micrograms/L	<10	<10	10.00
Mirex	EPA 508	micrograms/L	<0.02	<0.02	0.02
Perylene	EPA 625	micrograms/L	<5	<5	5.00
Polychlorinated biphenyls (PCBs)	EPA 508	micrograms/L	<0.1	<0.1	0.10
Tributyltin		micrograms/L	<0.005	<0.005	0.005
trans-Nonachlor	EPA 508	micrograms/L	<0.01	<0.01	0.01

CARLSBAD SEAWATER DESALINATION PROJECT

DESCRIPTION OF PLANT ENERGY USE AND EQUIPMENT POWER REQUIREMENTS

APRIL 6, 2005

The Carlsbad seawater desalination project will be designed to produce and deliver an average annual flow of 50 MGD and a daily maximum flow of 54 MGD, and will include the following key facilities with significant power use:

- 50 MGD desalination plant located at the Encina Power Plant
- 50 MGD main product water pump station located at the Desalination Plant.
- 10 MGD Oceanside booster pump station.

Table 1 provides a breakdown of the power use of all key desalination project facilities. The total average and maximum power use of the desalination plant and the main product water pump station will be 29.8 MW and 35.5 MW, respectively. Oceanside booster pump station will be supplied with power from the electrical grid. The power demand of this pump station will be 0.55 MW.

The Seawater Desalination Plant will include the following key treatment facilities which use measurable amounts of power:

- Plant Intake Pump Station;
- Pretreatment Facilities;
- Reverse Osmosis System;
- Product Water Pump Station;
- Membrane Cleaning System;
- Chemical Feed Equipment;
- Solids Handling Equipment;
- Service Facilities.

Desalination Plant Intake Pump Station

The desalination plant intake structure will consist of a pump station with wet well tied-in to the power plant discharge channel. The desalination plant seawater supply pumps will be a vertical-turbine type and will be located in the intake wet well. The purpose of these pumps is to convey the intake seawater from the point of interconnection with the power plant discharge channel to the pretreatment system.

Intake pump station will include 3 duty pumps and 1 standby pump. Three of the pumps will be constant-speed units and one will be equipped with a variable frequency drive. All of the pumps will have average/maximum capacity of 24,200 gpm/29,600 gpm, and will be equipped with 750-hp high-efficiency motors. The pumps and their auxiliary equipment will be installed outdoors on a concrete slab. Pumps' maximum noise level (sound rating) will be 90 DBA at 3 feet away from the motors.

Pretreatment Facilities
The pretreatment facilities will include pretreatment filters, filter service equipment (backwash blowers and pumps) and associated chemical feed facilities for intake seawater conditioning (chlorination, coagulant and polymer addition, and sulfuric acid feed system for pH adjustment). Pretreatment facilities will also include filtered effluent transfer pumps.

The intake pump station will provide adequate head for gravity flow through the pretreatment filters. The pretreatment filter cells will be backwashed with a combination of air and water. Air for filter cell backwash will be delivered by two 150-hp centrifugal blowers located in the reverse osmosis (RO) building. Filter cell backwash water will be provided by two 180-hp vertical turbine pumps also located in the RO Building. These vertical turbine pumps will use filtered seawater to backwash the filter cells. All auxiliary equipment of the pretreatment filter backwash pumps and blowers will also be installed indoors in the RO Building. The maximum noise level (sound rating) of all pumps, blowers and other equipment will be 88 DBA at 3 feet away from the motors.

Reverse Osmosis System
The reverse osmosis treatment system equipment will be arranged in 13 discrete treatment trains of total installed water production capacity of 54 MGD and will be designed to produce annual average flow of 50 MGD of product water with 12 trains in operation. Each of the 13 treatment trains will include the following key facilities:

- Filter Effluent Transfer Pump;
- Cartridge Filter Vessel;
- High Pressure RO Feed Pump Coupled with Energy Recovery Device;
- Reverse Osmosis Membrane Train.

Of these facilities only the filter effluent transfer pumps and high pressure RO feed pumps use electrical energy.

Filter Effluent Transfer Pumps
The purpose of the filter effluent transfer pumps is to convey the pretreatment filter effluent through the RO system cartridge filters into the suction pipe of the high pressure RO feed pumps. Filtered water from the pretreatment system will be collected from the filter effluent channel to a clearwell, which will be located under a portion of the floor of the RO building. A total of 13 vertical turbine pumps (one for each RO train) and their auxiliary equipment will be installed in the RO Building. The suction portion of theses pumps will be submerged in the clearwell under the building. Each pump will have average/maximum capacity of 5,800 gpm/6,500 gpm and will be equipped with a 350-hp constant speed motor. The maximum noise level (sound rating) of all pumps will be 88 DBA at 3 feet away from the motors.

High Pressure RO Feed Pumps

The high pressure pumps will feed the pretreated seawater to the reverse osmosis membrane treatment trains. The purpose of these pumps is to deliver the feed water to the membranes at high-enough pressure (typically 800 to 900 psi) in order to complete the pure water/salt separation process. The RO system will include a total of 13 high-pressure RO feed pumps (one per each RO treatment train). All of these pumps will be equipped with 3,500-hp constant-speed motors and will have average/maximum capacity of 5,800 gpm/6,500 gpm. The high-pressure feed pump motor shafts will be connected to energy recovery equipment which will allow to reuse an average of 25 % of the applied motor power and to reduce the maximum pump power motor demand from 3,500 hp to approximately 2,625 hp. All high-pressure RO pumps will be located in the RO Building. The maximum noise level (sound rating) of all pumps will be 90 DBA at 3 feet away from the motors.

Energy Recovery Turbines

As a result of the reverse osmosis separation process two main streams are generated – permeate and concentrated seawater (concentrate). The permeate is a pure fresh water of low salinity, while the concentrate is a seawater with salinity approximately two times higher than the salinity of the ambient ocean water. The permeate exits the RO membrane system under a relatively low pressure – 10 to 20 psi and carries only a small portion of the energy applied to the feed seawater by the high pressure RO pumps. A significant portion (typically 60 to 70 %) of the energy of the feed seawater introduced to it by the high pressure pumps is used to overcome the osmotic pressure through the RO membranes and the RO system head loss. The remaining energy (30 to 40 %) is contained in the concentrate generated by the RO system. A significant portion (80 to 90 %) of the energy in the concentrate will be recovered and reused to reduce the power demand of the high pressure feed pumps.

The proposed equipment to recover and reuse the energy of the RO system concentrate for this project is an energy recovery turbine (ERT). ERTs typically convert 80 to 90 % of the energy of the pressurized concentrate into a rotating pump shaft energy and reduces motor's total power demand with 20 to 30 % (average 25 %). After passing through the ERT and transferring most of its kinetic energy on the high pressure feed pump, the concentrate looses its pressure and leaves the ERT and is conveyed by gravity to the power plant discharge outfall. For this project, each of the 13 high-pressure RO feed pumps will be provided with a separate ERT to minimize the overall plant energy use. The ERTs will be located on adjacent to the high-pressure RO pumps and motors, and as indicated previously will have coupled shafts with the motors.

The maximum noise level (sound rating) of all the ERTs will be 90 DBA at 3 feet away from the units.

Main Product Water Pump Station

The purpose of this pump station is to convey the potable water produced at the desalination plant to the water distribution system. The product water pump station will include five vertical turbine pumps (four duty and one standby) equipped with 550-hp high-efficiency motors. All of the pumps will have average/maximum unit capacity of 8,700 gpm/9,500 gpm and one of their motors will be controlled by a variable-speed drive. The product water pumps and their auxiliary equipment will be located in the RO Building. The maximum noise level (sound rating) of all pumps will be 88 DBA at 3 feet away from the units.

Membrane Cleaning System

The purpose of the membrane cleaning system is to remove, contain and dispose of fine particulates and other fauling materials that accumulate on the surface of the RO membranes over time during the routine operation of the RO system. Each membrane RO train is cleaned typically two times per year. During the cleaning, the membrane train is taken out of service and cleaning solution is circulated through the membranes to remove the accumulated fauling materials. The particulates removed form the membranes are collected in a storage tank (scavenger tank), treated by neutralization and discharged to the wastewater collection system. The time required for cleaning of one train is typically one day. Typically, one RO train is taken out of service at a time for membrane cleaning. During the time a given RO train is down for cleaning, the 13-th standby train is used to maintain constant desalination plant production capacity of 50 MGD. The membrane cleaning system however is designed with redundant equipment allowing to clean two RO trains simultaneously, if needed.

Membrane cleaning system consists of the following key equipment using electrical power:

- Membrane Cleaning Pumps;
- Storage Tank Mixing Blowers;
- Flush Pumps;
- Mechanical Mixers for the Cleaning Chemical Batch Tank;
- Sewer System Transfer Pumps.

All equipment described above will be installed indoors in the Membrane Cleaning (CIP) Room of the RO Building. The purpose of the membrane cleaning pumps is to circulate cleaning chemicals through the RO train during the cleaning process. Three 80-hp membrane cleaning pumps (two duty and one standby) will be used for this application. One pump is typically used for cleaning of one train.

The storage tank for the spent membrane cleaning solution will be equipped with a coarse-bubble aeration system installed at the tank's bottom. The purpose of this aeration mixing system is to keep the tank content well mixed for adequate treatment. The air for the mixing system will be provided by two 50-hp blowers (one duty and one standby).

After the cleaning is complete, the spent chemicals are flushed out of the RO train using clean non-chlorinated permeate, which is pumped through the membrane train by 150-hp flush pumps. Two duty and one standby flush pumps will be available.

The cleaning chemicals are prepared in a batch tank prior to be initiation of the RO cleaning process. This batch tank will be mixed with a 1-hp mechanical mixer located on the tank. Two batch tanks will be available on site to be able to complete simultaneous cleaning of two RO trains. Two (one duty and one standby) 25-hp transfer pumps will used to convey the treated spent cleaning solution form the Scavenger Tank to the wastewater collection system. The maximum noise level (sound rating) of all pumps and other equipment will be 88 DBA at 3 feet away from the units.

Solids Handling Equipment

The solids removed from the source seawater during the pretreatment processes will be settled and dewatered on site in a solids handling system. The backwash water from the pretreatment system will be settled in two settling tanks. The backwash sludge settling tank equipment which will consume energy is:

- Sludge collection mechanism – 2 units @ 2.0 hp each;
- Sludge removal pumps – 4 units (one duty and one standby per settling tank) @ 50 hp each.

The settling tank sludge removal pumps will convey the solids dewatering building which will consist of two belt filter presses, two sludge conveyors and sludge chemical conditioning system. The number and power demand of each of this equipment is shown in Table 1. The sludge collection mechanism will be located under water. The sludge removal pumps will be located outdoors, adjacent to the settling tanks. All other equipment will be located indoors in the solids handling building. The maximum noise level (sound rating) of all pumps and other equipment will be 88 DBA at 3 feet away from the units.

Chemical Feed Equipment

The seawater desalination plant will use a number of source seawater conditioning chemicals. All chemical feed systems consist of one or more storage tanks, a day tank equipped with mixer and 2 to 4 chemical feed pumps. The chemical storage tanks would be located adjacent to the RO Building. The chemical day tanks and the pumps for all chemical feed systems will be located in the Chemical Feed Room of the RO Building. The number and power demand of the pumps and day-tank mixers which will be used for various chemicals is presented in Table 1. The maximum noise level (sound rating) of all pumps and other equipment will be 88 DBA at 3 feet away from the units.

Service Facilities

The seawater desalination plant will be equipped with a number of service facilities such as:

- Heating, Ventilation and Air Conditioning (HVAC) System;
- Lightning;
- Process Instrumentation and Control Equipment;
- Air compressors servicing valves and other small equipment;

- Other miscellaneous small service equipment such as sump pumps, storm drain pumps, safety alarms, etc.

The amount of power for these facilities is presented in Table 1. All of these service facilities will be located indoors in the RO Building. The maximum noise level (sound rating) of all pumps and other equipment will be 88 DBA at 3 feet away from the units.

Oceanside Booster Pump Station

This pump station will have a total capacity of 10 MGD and will contain five 1,800 gpm pumps (four duty and one standby) equipped with constant speed motors. The pumps will be installed indoors in an enclosed concrete building, which will also contain the pump service facilities (instrumentation, control and power supply systems). The pump station duty and standby power will be supplied from the grid through two separate power connections taking power from independent power grid loops. The maximum noise level (sound rating) of all pumps will be 65 DBA at the property line. The pump building will be designed with adequate sound attenuation to maintain the noise levels within acceptable limits.

TABLE 1
CARLSBAD SEAWATER DESALINATION PLANT
AVERAGE AND MAXIMUM POWER USAGE
FOR 50 MGD WATER PRODUCTION CAPACITY

Unit	Number of Duty Units	Number of Standby Units	Unit Motor Size (Hp)	Average Power Use			Maximum Power Use		
				Total (Hp)	(% of Total)	(kWh/ 1000 gal)	Total (Hp)	(% of Total)	(kWh/ 1000 gal)
Desalination Plant Intake Pump Station									
Seawater Intake Pumps	3	1	750	2,138	5.36	0.77	2,250	5.64	0.81
Pretreatment Facilities								-	-
Filter Backwash Blowers	2	1	150	150	0.38	0.05	300	0.75	0.11
Filter Backwash Pumps	2	1	180	180	0.45	0.06	360	0.90	0.13
Reverse Osmosis System									
Filter Effluent Transfer Pumps	12	1	350	3,990	10.00	1.43	4,550	11.40	1.63
High Pressure RO Feed Pumps	12	1	3500	37,800	94.71	13.53	45,500	114.01	16.29
Energy Recovery Turbine - Pwr. Reduction	12	1	-875	(9,450)	(23.68)	(3.38)	(11,375)	(28.50)	(4.07)
Main Product Water Pump Station									
Product Water Pumps	4	1	550	1,980	4.96	0.71	2,200	5.51	0.79
Membrane Cleaning System									
Membrane Cleaning Pumps	1	2	80	80	0.20	0.03	160	0.40	0.06
Scavenger Tank Blowers	1	1	50	40	0.10	0.01	50	0.13	0.02
Flush Pumps	1	2	150	150	0.38	0.05	300	0.75	0.11
Mechanical Mixers for Chemical Batch Tank	1	1	4	4	0.01	0.00	4	0.01	0.00
Sewer System Transfer Pumps	2	1	25	25	0.06	0.01	50	0.13	0.02
Solids Handling Equipment									
Clarifier Sludge Collection Mechanisms	2	0	2	4.00	0.010	0.001	4.0	0.010	0.001
Clarifier Sludge Removal Pumps	2	2	50	80	0.20	0.03	100	0.25	0.036
Belt Filter Presses	2	0	120	192	0.48	0.07	240	0.60	0.09
Sludge Chemical Conditioning System	2	0	10	16	0.040	0.006	20.0	0.050	0.007
Sludge Conveyors	2	0	60	96	0.24	0.034	120	0.30	0.043
Chemical Feed Equipment									
Coagulant Feed System	3	1	50	150	0.38	0.054	150	0.38	0.054
Polymer Feed System	1	1	15	15	0.04	0.005	15	0.04	0.005
Sulfuric Acid Feed System	3	1	50	150	0.38	0.054	150	0.38	0.054
Lime Feed System	2	1	150	300	0.75	0.107	300	0.75	0.107
Sodium Hypochlorite Feed System	3	1	80	240	0.60	0.086	240	0.60	0.086
Sodium Bisulfide Feed System	2	1	50	100	0.25	0.036	100	0.25	0.036
Ammonia Feed System	1	1	30	30	0.08	0.011	30	0.08	0.011
						-			-
Service Facilities						-			-
HVAC	1	0	250	250	0.63	0.09	340	0.85	0.12
Lightning	1	0	150	150	0.38	0.05	250	0.63	0.09
Controls and Automation	1	0	150	150	0.38	0.05	200	0.50	0.07
Service Air Compressors	1	0	150	150	0.38	0.05	200	0.50	0.07
Other Miscellaneous/Contingency	1	0	750	750	1.88	0.27	800	2.00	0.29
TOTAL DESALINATION PLANT POWER USE				39,910	100.00	14.29	47,608	119.29	17.04
				29.76 MW			35.50 MW		

CARLSBAD DESALINATION PROJECT

PRODUCT WATER QUALITY

APRIL 5, 2005

Regulatory Framework

The California Department of Health Services (DHS) administers all provisions relating to the regulation of drinking water to protect public health. California's Safe Drinking Water Act requires DHS to administer laws relating to drinking water regulation, including setting and enforcing both federal and state drinking water standards, and administering water quality testing programs and permits for public water system operations. The standards established by DHS are found in Title 22 of the California Code of Regulations.

DHS is responsible for ensuring that all public water systems are operated in compliance with drinking water regulations. Current drinking water regulations include both primary and secondary standards. Compliance with primary standards is mandatory, because these standards are based on potential health effects on water users. The primary standards define maximum concentration levels (MCLs) that cannot be exceeded by any public water system. All standards except turbidity are applicable at the water user's tap. Secondary standards are those parameters that may adversely affect the aesthetic quality of drinking water, such as taste and odor. These standards are not federally enforceable, although DHS does reserve the right to enforce secondary standards if warranted.

Under Title 22 of the California Code of Regulations, DHS will regulate the operation of the Carlsbad Seawater Desalination Facility and will oversee the quality of the product water produced. DHS will be responsible for ensuring that the product water will meet all federal and state standards for drinking water that has been established by USEPA.

To comply with the DHS regulatory requirements, the Carlsbad Seawater Desalination Project will obtain a Drinking Water Permit to wholesale desalinated water. Poseidon Resources will apply for a domestic water supply permit pursuant to the Regulations Relating to Domestic Water Systems. This includes the submission of:

1. A Water Quality Emergency Notification Plan (ENP);
2. An Engineering Report describing how the proposed new facilities will comply with the treatment, design, performance and reliability provisions of the Surface Water Treatment Rule (SWTR);
3. Facility operations plan.

Permit provisions for similar municipal water supply projects typically include:

- Submittal of plans and specifications for Department approval prior to construction;
- Compliance with the Surface Water Treatment Rule (SWTR) – including the treated water turbidity, disinfection residuals and CT levels;
- All water must be treated – no bypassing;
- Complete water quality analyses conducted by an approved laboratory;
- Adequate corrosion control;
- Updated watershed sanitary survey every five years;
- Mandatory use of ANSI/NSF approved chemicals;
- Raw water bacteriological monitoring;
- Certified treatment facility operators;
- Submission of monthly operation reports and a report after the first year of operation detailing the effectiveness of the facility's performance, a list of any violations and a list of any needed additions or operational changes.

DHS will issue a permit once the facility is in operations and has proven to meet all Federal and State Safe Drinking Water Standards.

The Carlsbad Desalination Facility will have multiple treatment processes including pretreatment facilities, cartridge filters, reverse osmosis membranes, and product water conditioning and disinfection facilities, and will be capable of meeting all of the drinking water standards.

Intake seawater will be filtered through pretreatment facilities which purpose is to remove solids of size higher than 50 microns. The pretreatment filtration media could be either granular type (sand or combination of sand and anthracite) or membranes with fine pore openings. Micro-screens may be installed upstream of the pretreatment filters to enhance their solids removal capabilities.

The pretreatment filters will be designed to remove over 99.9 percent of all suspended solids and will also retain over 95 percent of the bacteria and other pathogens (such as Cryptosporidium, Giardia, and viruses), if they are present in the source seawater. If the feed water to the pretreatment filters contains total coliform bacteria higher than a preset maximum level, the raw seawater will be chlorinated upstream of the pretreatment facilities to significantly reduce the number of bacteria in the feed seawater to the filters. The pretreatment filtration system effluent will contain only particles of size smaller than 20 microns. Prior to reverse osmosis however, this filtered effluent will be processed through finer 5-micron cartridge filters. These cartridge filters will provide another barrier for pathogens and fine particles, which may be in the seawater. Bacteria, viruses and very fine particles retained on the cartridge filters will be removed with the filters every six to eight weeks. The spent cartridge filters will be disposed off to a sanitary landfill.

After going through the microscreens, pretreatment filters and cartridge filters, the seawater will contain very few particles and microorganisms, and most of them will be of size smaller than 5 microns. The pre-filtered water will be processed through the reverse osmosis membranes, which are an ultimate final barrier for removal of all suspended particles (solids and pathogens) and most dissolved solids in the seawater. The openings of the RO membranes have size of 0.001 microns, which are smaller than the size of most viruses and all bacteria. This ultimate barrier will provide a rejection of over 99.5 % of the salts in the seawater and over 99.99 % of the remaining microorganisms (bacteria, viruses, protozoa, etc.), if they have not been completely removed upstream of the RO system. To provide an additional level of safety and water quality protection, after RO treatment, and prior to conveyance to the water supply system for distribution, the desalinated water will be disinfected using chlorine. The RO system and the disinfection facilities are the fourth and fifth barriers for retaining, removing and inactivating pathogens in the source water. For comparison, the Skinner Filtration plant currently supplying potable water to Carlsbad has only two source water treatment barriers – granular media filters and disinfection. The elaborate multi-barrier water treatment system proposed for the Carlsbad seawater desalination plant will ensure the production of consistent and high-quality drinking water which will meet and in most cases exceed all applicable potable water quality standards.

A comparison between the product water quality of the Carlsbad Seawater Desalination Project and the DHS primary and secondary water quality standards is presented in Table 1. Review of this table indicates that the desalination facility product water quality meets all current DHS water quality MCL standards.

The product water quality data presented in Table 1 are based on sampling of actual desalinated seawater produced at Poseidon's seawater desalination demonstration plant located in Carlsbad, California. The demonstration desalination plant has been in operation for 20 months and has been consistently producing permeate of total dissolved solids TDS concentrations between 200 and 400 mg/L. The results from the long-term operation of the seawater desalination plant provide additional assurance that both product water quality and plant discharge are in compliance with all applicable regulations.

WATER QUALITY PROTECTION

The product water quality of the Carlsbad Seawater Desalination Facility can be influenced by a number of factors such as source water fluctuations, technology performance, and blending of the desalinated water with potable water from other sources (local and imported water supplies). The following discusses the potential for each factor to impact water quality and the multiply physical and chemical barriers being applied to ensure that safe drinking water is delivered to the customers and the integrity of the existing water distribution system is protected.

SOURCE WATER

- ***Source Water Quality Fluctuations*** - The source water for the Carlsbad Desalination Facility might potentially be impacted by natural changes in ocean water salinity, temperature, turbidity, and pathogen concentration, and red tide algal bloom events. Typically, ocean water salinity and temperature changes are triggered by natural seasonal events.

  Protection of Source Water Quality From Elevated Pathogen Content. Poseidon Resources will be required to obtain a drinking water permit from the California Department of Health Services that will address monitoring of source water quality. The desalination facility intake water quality in terms of turbidity (which is a surrogate indicator for potential elevated pathogen content) and salinity will be measured automatically and monitored continuously at the desalination facility intake facilities. Instrumentation for continuous monitoring and recording of these parameters will be installed at the desalination facility intake pump station. In event of excessive increase in intake seawater turbidity and/or salinity, this instrumentation will trigger alarms that will notify desalination facility staff. If the intake turbidity reaches a preset maximum level, this instrumentation will automatically trigger chlorination of the source seawater, thereby reducing the likelihood of elevated pathogens in the source water pathogens before the water reaches the RO treatment facilities. As discussed above the multiple-barrier treatment facilities of the desalination plant will remove over 99.99 % of the source water pathogens. To provide an additional level of safety/protection of the desalinated water quality will be disinfected prior to deliver to the water supply system. In addition to the automation provisions, turbidity and salinity will also be measured manually by the desalination staff at least once a day and the intake seawater will be analyzed for pathogen content at least once per week. In the event of elevated intake seawater turbidity, laboratory pathogen content analysis will be performed more frequently.

  In addition to the intake water quality monitoring instrumentation, the desalination facility pretreatment filtration facilities will be equipped with filter effluent turbidimeters and particle counters. This equipment will allow to continuously monitor pretreatment filter performance and to trigger adjustments of desalination facility operations to accommodate intake water quality changes.

  Desalination facility product water quality will also be monitored continuously for salinity and chlorine residual and will be tested frequently for pathogen content. The desalination plan product water quality will be tested for the parameters in accordance with the requirements set forth in Section 8 of the Draft Water Purchase Agreement (Attachment 1).

  Protection of Product Water Quality From Red Tide Algal Bloom Events. Red-tide algal blooms occur occasionally along the coast. During red-tide events, the number of algae particles and bacteria, which feed on algae is elevated. Some of the red algae produce small amounts of metabolic products, which if elevated to very high levels in the seawater could exhibit toxicity effects on some marine organisms. Although red-tide related algal toxins may have effect on marine organisms, they are not a direct treat to human health when ingested with the ocean water. However, as a precautionary measure, the Carlsbad desalination facility will have a number of provisions/barriers for inactivation of red-tide related algal toxins through the treatment processes:

- Chlorination of Intake Seawater: The desalination facility intake pump station will be equipped with sodium hypochlorite feed system which will be used for intake seawater chlorination on as needed basis. During episodes of red tide/algae blooms chlorine will be applied at elevated dosages. Chlorine is a strong oxidant, which when applied at elevated dosages (1 to 5 mg/L) would reduce the concentration of algal toxins in the seawater, thereby further minimizing their content in the facility product water. In addition, intake seawater chlorination upstream of the pretreatment facilities would significantly decrease algae growth in the filter cells.

  Chlorination of intake source water is a method commonly used for controlling algal blooms in conventional water treatment facilities applying direct filtration. Red-tide events are caused by excessive algal blooms. At present, a significant portion of the intake water sources (reservoirs, lakes, slow-flowing portions of rivers) in the US are occasionally exposed to algal blooms. Typically, conventional treatment facilities applying granular media filtration and elevated pre-and post-filtration disinfection are widely used treatment methods proven to be very effective in treating surface water at times of algae blooms.

- Enhanced Coagulation of Intake Seawater: The desalination facility pretreatment filters will be equipped with coagulant (ferric sulfate or ferric chloride) feed system, which will be used continuous conditioning of the intake seawater with coagulant at dosages of 5 to 10 mg/L. During episodes of red tide/algae blooms coagulation dosage would be increased to up to 20 to 30 mg/L to achieve enhanced coagulation and removal of algae from the intake water.

- Pretreatment Filtration Algae Barrier: Algae conveyed with the intake seawater will be retained in the filter media and removed from the source water during filter cell backwashing. Because algae cells are the carrier of the red-tide toxins, their physical removal in the dual media filters will significantly reduce the potential for toxin release from the algal biomass into the seawater that will be processed in the downstream treatment facilities (cartridge filters and RO membranes). Filter effluent water turbidity is expected to be maintained in a range of 0.05 to 0.3 NTU.

- Pretreatment Filter Covers: The surface of all pretreatment filters and filter channels will be covered to minimize sunlight exposure. Filter cell covers have proven to be an effective measure for minimizing algae growth in the filter cells. In combination with chlorination and enhanced coagulation, this measure will assure that the intake water algae are effectively retained and their growth in the filter media suppressed.

- Cartridge Filter Algae Barrier: The pretreatment filter effluent will be processed through 5-micron cartridge filters located downstream of the granular media filters and ahead of the RO membranes. The size of the openings of these filters is an order of magnitude smaller than the size of the red tide algae cells. Therefore, the cartridge filters will provide an additional protection barrier in terms of algae cell propagation. The cartridge filter effluent will be practically devoid of all red-tide algae and algal particles.

- Reverse Osmosis Membranes: Reverse osmosis membranes are very effective in removing soluble compounds of molecular size smaller than the size of the red-tide algal toxins. The membrane elements that are proposed to be used for the Carlsbad Desalination Project will be capable of removing more than 99.6 % of the chloride ions contained in the seawater. Because the membrane elements work as physical barriers, they would also be very effective in removing organic molecules several times larger than chloride ions, such as these of the red-tide algal toxins. The reverse osmosis membrane system is projected to remove more than 99 % of the red-tide algal toxins remaining in the seawater, which will assure safe and reliable product water quality.

- Final Disinfection: The permeate from the reverse osmosis system will be disinfected with chlorine followed by ammonia addition for chloramination. This final barrier of algal toxin inactivation will provide additional assurance in terms of product water quality and safety.

- Emergency Facility Shutdown: The desalination facility operation can be discontinued within 10 minutes after notification in the case of red-tide/algal blooms of catastrophic proportions or advisory by pertinent local and state heath safety agencies. Red tide genesis and development are closely followed by local agencies. Red tide growth to a level of a major calamity usually happens in a matter of days rather than minutes. Continuous communication with pertinent regulatory agencies in the times of red-tide conditions, will allow ample time for emergency shutdown of the desalination time in extreme cases of red tide occurrence.

- Long Track Record of Desalination Facility Operations: Seawater desalination facilities applying reverse osmosis membranes similar to these proposed for the Carlsbad Desalination Facility have been successfully used for more than 15 years in other parts of the world with scarce alternative water resources (Spain, Cyprus, Israel, the Middle East and the Caribbean). In all of these locations red-tide/algal blooms have occurred occasionally in the past. The fact that there are no documented cases of red-tide health or safety problems associated with the operation of RO seawater desalination facilities worldwide is indicative of the capability of these systems to perform reliably and effectively under red-tide conditions.

Protection of Source Water Quality From Power Plant's Routine and Non-Routine Events. The Carlsbad Desalination Facility will have three different provisions for protection/notification to account for non-routine operations at the power facility:

- Automatic control interlock between power plant's pumps and Carlsbad Desalination Facility's intake pumps: The shutdown controls of the desalination facility intake pumps will be interlocked with power plant's intake pumps, so when power plant pumps' operation is discontinued to prepare for a routine maintenance such as heat treatment, or a non-routine pump shutdown, this will automatically trigger an alarm at the desalination facility along with shutdown of the desalination intake pumps. After this shutdown, the intake pumps will have to be started up manually, and the operations staff will be required to check the reason of shutdown with the power plant staff before restarting the treatment facility intake pumps.

- Continuous Plant Intake Pump Flow Measurement Devices: seawater intake pumps will be equipped with flowmeters, which will record the pumped flow continuously. If the intake flow is discontinued for any reason, including non-routine power facility operations, this will trigger automatic intake pump shutdown.

- Continuous Plant Intake Water Temperature Measurement Devices. The Carlsbad Desalination Facility's intake pump station will be equipped with instrumentation for continuous measurement of the intake temperature. Any fluctuations of the intake temperature outside preset normal limits will trigger alarm and intake pump shutdown. This monitoring equipment will provide additional protection against heat treatment or other unusual intake water quality conditions.

- Continuous Intake Water Salinity/Conductivity Measurement Devices. The Carlsbad Desalination Facility's intake pump station will be equipped with instrumentation for continuous measurement of the intake seawater salinity. Any fluctuations of the intake salinity outside preset normal operational limits will trigger alarm and intake pump shutdown. This monitoring equipment will provide additional protection against unusual fresh water/surface water streams in the Carlsbad Desalination Facility's intake.

- Continuous Intake Water Oil Spill/Leak Detection Monitoring Devices. The Carlsbad Desalination Facility's intake pump station will be equipped with instrumentation for oil spill/leak detection. Detection of oil in the intake water even in extremely low concentrations will automatically trigger alarm and intake pump shutdown. This monitoring equipment will provide additional protection against unusual intake water quality conditions.

- Routine Communication with Power Plant's Staff. The Carlsbad Desalination Facility staff will be required to contact power plant personnel at least once per shift and inquire about unusual planned or unplanned events at the Encina Power Station (EPS). If non-routine operations are planned at the EPS, the Carlsbad Desalination Facility staff will be informed and will modify desalination facility operations accordingly.

RO Technology Performance - As RO membrane elements age, their rejection capabilities decrease, which could trigger change in product water quality.

Protection from RO Membrane Performance Malfunction on Product Water Quality. The RO system membrane performance will be monitored continuously, be measuring feed seawater and permeate conductivity, and the differential pressure through the membranes. If permeate salinity (TDS) concentration exceeds the design level, membranes will be cleaned to recover their original performance. In addition, an average of 10 to 15 percent of the membrane elements will be replaced every year, thereby maintaining the product water quality at a steady level.

In terms of TDS, the desalination facility will produce potable water of quality, which will be better than that delivered by the other product water sources. The TDS product water quality specification included in Schedule 8.2 of Appendix 2 is based on the use of high-rejection seawater desalination membranes at the desalination facility. The desalination facility membrane elements would be replaced as necessary to maintain the product water quality close to the target TDS concentration of 350 mg/L. Membrane replacement is a standard approach commonly used in seawater desalination facility's to maintain product water quality at a long-term steady target level.

The desalination facility will use standard 8-inch desalination membrane elements which are available from a number of specialized membrane manufacturers. The membrane element manufacturers and their products pre-qualified for this project are:

- Hydranautics (SWC3 or better)
- Filmtec/Dow (SW30HR-380 or better)
- Koch/Fluid Systems (TFC2822SS or better)
- Toray (SU820L or better).

Key design membrane element parameters common for the products of these suppliers are:

- Membrane Type: Spiral-wound, thin film composite;
- Applied Flux: 8 to 12 gpd/sf at recovery rate of 45 to 50 %;
- Nominal Salt Rejection: 99.6 % or higher;
- Applied Pressure: 800 to 1,100 psi;
- Maximum Pressure Drop per Element: 10 psi;
- Maximum Feed Water SDI (15 min): 5.0;
- Free Chlorine Resistance: less than 0.1 mg/L;
- Operating pH Range: 2 to 11;
- QA/QC Membrane Production and Testing Procedures.

The actual membrane element that will be used for the Carlsbad desalination facility will be selected during the detailed engineering design phase of this project.

Protection of Product Water Quality From Non-routine Operation of the RO System.

Non-routine operation of the RO system can be caused mainly by the failure of a membrane element or elements caused by manufacturing defect of an individual membrane element or by faulty installation/connection of one or more membrane elements in the vessels. In order to identify non-routine operational condition of the RO system, intake and product water conductivity, feed water pressure, and product water flow rate will be monitored continuously for each of the RO process trains. If a membrane element fails, there will be a simultaneous increase in conductivity, decrease in feed water pressure and increase in product water flow rate. The plant control system will alert the operators to changes in these three parameters. The RO system will be designed so that the operators can quickly isolate the malfunctioning process train and take it off line and then determine which pressure vessel and individual membrane elements are failing. The configuration of the RO process will allow the operators to determine which RO element is leaking using conductivity measurements. Each RO train will consist of 170 to 225 pressure vessels. Each pressure vessel will be equipped with a sampling port so that the conductivity of each pressure vessel can be monitored until the problematic vessel is located. Once the problematic vessel is located the 6 to 8 RO elements contained in the vessel will be tested individually for leaks and repaired or replaced as determined necessary.

The RO system will be designed with one additional stand-by RO train. The standby RO train will be used for water production while the malfunctioning RO train is fixed and returned back to normal service.

<u>Protection from RO System Non-routine Operations Caused By Membrane Element Defects</u>. The membrane supplier for this project will be required to meet strict specifications regarding membrane materials, workmanship, design, and other properties affecting RO membrane performance. The membranes will be required to reject at least 99.6 percent of the salt in the feed water to produce finished water with a TDS concentration of 250 to 350 mg/L. The membrane manufacturer will be required to have a proven history of membrane manufacture and performance. Currently, several manufacturers, including Hydranautics, Filmtech/Dow, Koch/Fluid Systems, and Toray, produce membranes that meet these specifications.

The membrane manufacturer will be required to conduct extensive testing at the factory to ensure that each membrane element, is meeting Poseidon's specifications. The testing will include a pressure test to ensure the integrity of the seals in the membranes and a performance test to ensure that at least 99.6 percent rejection of salt is achieved. The membrane manufacturer will be required to provide a five-to-seven year performance guarantee for the membranes for salt rejection, overall performance, and physical integrity of the elements.

Prior to plant start-up, Poseidon will test, each pressure vessel, and each RO process train to ensure that specifications are met. During the first year of operation Poseidon will systematically conduct membrane integrity checks. Extensive testing of each, pressure vessel, and process train will be conducted on a quarterly basis. After cleaning a membrane unit, it will be tested to ensure that at least 99.6 % removal of salt is being achieved.

When replacement membranes are needed, they will be required to meet the same high specifications of the original membranes. The same extensive testing of membrane elements, pressure vessels, and process trains will be conducted to ensure that the original specifications are met with the replacement membranes.

PRODUCT WATER INTEGRATION AND COMPATIBILITY

The desalinated water quality will be maintained and monitored to ensure a seamless integration of the this water with other potable water sources in the distribution system.

Distribution System Pipeline Protection From Blended Water Corrosivity
Blending the desalinated product water with water from other sources is not expected to change the water quality of the blend in terms of its corrosion effect on the water distribution system.

Similar to other potable water sources, product water from the Carlsbad Desalination Facility will be chemically conditioned at the treatment facility prior to delivery to the distribution system to mitigate its corrosivity. Lime in combination with carbon dioxide addition will be used for post-treatment stabilization of the RO water as a source for pH and alkalinity adjustment and hardness addition. A corrosion control plan describing in detail the type and amount of corrosion control chemicals planned to be used for this project are presented in Attachment 2 (Distribution System Corrosion Control for Desalinated Seawater). Additional testing and monitoring to be undertaken by Poseidon and the City to refine the corrosion control plan is summarized in Attachment 3 (Draft Water Purchase Agreement Distribution System Testing and Monitoring Provisions).

The product water from the seawater desalination facility will be suitable for delivery through the existing water distribution system and will be comparable and compatible to the other water sources currently delivering water to the same system. Prior to delivery to the water distribution system the desalinated water will be conditioned using lime and carbon dioxide to achieve the following corrosion control driven water quality goals:

- PH of 8 to 8.3;
- Langelier Saturation Index (LSI) of 0.0 to 0.5;
- Alkalinity of 40 mg/L or higher.

The corrosion control plan & studies (Attachments 2 and 3), will ensure that the desalinated water delivered by the Project will be a non-corrosive product that can be successfully integrated into the existing water supply systems.

The desalinated water quality goals listed above will be achieved by the addition of the following chemicals:

- Lime at dosage of 25 to 50 mg/L (avg. of 30 mg/L)
- Carbon dioxide at dosage of 0 to 30 mg/L (avg. of 6 mg/L)

The corrosivity effect on mortar lined steel pipe, cast iron fittings and various household pluming materials, including lead and copper will be tested at the Carlsbad seawater desalination demonstration plant. The scope of this study will entail the following:

1. Build pilot system that consists of:
   - Wall-mounted pipe loops composed of new and/or existing (supplied by the City of Carlsbad) mortar lined steel pipe, cast iron fittings, copper pipe, and brass faucets;
   - Pipe loop feed system including feed lines, pumps and reservoir of desalinated and conditioned water.

2. Test two water qualities:
   - 100 % Desalinated Water (after conditioning with lime and chloramination);
   - 100 % Imported Water.

3. Condition new pipes with imported water prior to testing with desalinated seawater

4. Simulate typical flow and stagnation periods in household plumbing – one hour flushing & 23 hours of stagnation.

5. Biweekly monitoring of general chemical/physical parameters and metals.

6. Total study length – 9 months:
   - Three months of pilot system construction and preparation;
   - Six months of monitoring of dynamics of pipeline corrosion.

<u>Distribution System Water Quality Monitoring Program</u>

A product water monitoring program in the distribution system will be implemented to track and document ongoing changes in the water quality in the distribution system and at the customer tap. This program will allow to detect deviations form the target product water quality, and to assess the corrosivity effect of the desalinated water on the distribution system by measuring key water quality parameters at the desalination plant; at the points of interconnection with the distribution system; at key locations within the distribution system, and at the consumer tap. Parameters to be measured would include: metal concentration, chlorine residual, disinfection byproducts, as well as parameters needed to estimate water corrosivity using widely accepted corrosion indices. The general outline of the corrosion control program will include the following:

1. Develop corrosion monitoring system and protocol based on:
   - Customer complaints (Based on City Records for Last 5 Yrs);
   - Materials map (Indicating material type and age);
   - Maintenance map (Indicating Areas of Pipe Replacement and Repair in the last 5 years).
   - Existing lead & copper monitoring data

2. Install corrosion monitoring stations which allow:
   - Collect and analyze water samples for:
     - Key water quality parameters;
     - Trace metals;
     - Rate of corrosion (using electro-chemical rate instruments).
   - Reflect water quality change in the distribution system by measuring water quality at the following locations:
     - At Desalination Plant;
     - At points of interconnection to the City Distribution System;
     - At various locations in the distribution system;
     - At various household service lines throughout the distribution system;
     - At customers' tap – at various locations.

3. Collect Water Quality Data ;

4. Complete electrochemical corrosion rate measurements;

5. Collect 12 months of baseline water quality and corrosion rate data prior to introduction of desalinated water In the distribution system.

6. Complete continuous monthly monitoring for 12 months after the introduction of desalinated water into the distribution system.

If any trends of elevated corrosivity or deviations from the target water quality are detected, the product water quality at the desalination plant will be modified accordingly by implementing treatment system operational changes, and/or by adding commonly used corrosion control chemicals to protect distribution system integrity and water quality.

Blended Water Chlorine Residual

The desalinated product water will be disinfected prior to delivery to the distribution system. Chlorine, in the form of sodium hypochlorite, will be added as a disinfectant to meet DHS water quality standards for potable water disinfection. Controlling biological growth in the transmission pipelines and in the receiving reservoirs in the distribution system will be accomplished by adding ammonia to the chlorinated water to form chloramines. Potable water from Metropolitan Water District also contains chloramines as the final residual disinfectant. Both treated water sources will have compatible chlorine residuals. The desalinated water will be chloraminated by sequential application of sodium hypochlorite and ammonia to achieve a chloramine residual concentration at the point of delivery to the distribution system is in a range of 2 to 2.5 mg/L.

Blended Water Disinfection Byproduct Concentration

Blending desalted water with the existing sources of supply will result in a product that is comparable to existing supplies and meets all disinfection byproduct limits. The desalinated water contains lower levels of organics than the product water from the Metropolitan Water District's Skinner Filtration Facility. Therefore, blending of desalinated water with other source waters in the distribution system would have a beneficial effect - it would lower the overall disinfection byproduct concentration of the blend.

<u>Protection of Blended Water Taste and Odor</u>

The projected quality of the Carlsbad Desalination Facility's product water after reverse osmosis treatment and post-chemical addition is closely comparable with the finished water it would blend with in the distribution system. In terms of odor, the desalination facility product water will meet the respective DHS water quality limits. In terms of regulated volatile organics, and other compounds that may impact product water taste and odor, product water from the Carlsbad Desalination Facility will comply with all drinking water standards and does not differ substantially from the water quality of the other sources of product water in the distribution system. Therefore, the desalinated water will be better or equal in terms of taste and odor as compared to the other water sources in the distribution system.

A recent taste-and-odor survey of over 1500 volunteers that have tested the desalinated water produced at the Carlsbad desalination demonstration plant also confirms the wide acceptance and superior water taste of the desalinated water over the existing tap water. Over 99% of the individuals tested stated that the taste of the desalinated water was good to excellent.

In summary, because of the close chemical compatibility between the desalinated water produced at the Carlsbad Desalination Facility and that of the Imported water, no taste and odor problems are expected. If such problems occur, the desalination facility water quality can be adjusted by controlling the RO membrane system removal efficiency in terms of particular compounds that may cause source water problem, and/or by changing the product water conditioning chemicals.

To protect water users from potential taste and odor problems associated with the startup of facility operations, just prior to startup, a sequential flushing program will be coordinated with the involved water agencies and the City staff to minimize any sediment disturbance that might occur due to flow reversals in the system. A flushing program will minimize any aesthetic issues that might be created through flow reversals.

Attachment 1

Draft Water Purchase Agreement
Water Quality Standards

July 26, 2004

8. WATER QUALITY.

8.1 Water Quality Issues. With respect to Product Water produced by the Project, Poseidon and the District agree to work cooperatively to conduct, prior to determinations of the Delivery Regime and Interconnection Points, mutually acceptable technical studies pertaining to quality, blending, distribution and consumer acceptance (including without limitation customer issues, such as color, cloudiness, taste and odor) of Product Water, the impact of Product Water Quality on customer uses of water, the impact of Product Water on the integrity of existing pipelines, and the impact of additional discharge of municipal and industrial waste from Project facilities (collectively "Water Quality Issues"). These studies shall include advice from a nationally recognized expert on the impact of boron in irrigation water on ornamental plants (the "Boron Expert"). The Boron Expert shall be mutually acceptable to both Parties. Except as provided in Sections 7.2.1, 7.2.2 and 7.2.3, Poseidon, at its cost and expense, shall be responsible for such technical studies related to the Water Quality Issues. The Delivery Regime and any revisions to the Quality Standards for Product Water shall take into account the results of the technical studies described above. Without limiting the generality of the foregoing, Poseidon and the District agree to meet prior to the Commercial Operation Date, and, upon request of the District, during the Term on a periodic basis with the District's major water customers, such as breweries, nurseries, landscape irrigators, agricultural growers, biotechnology companies and cleaners, to discuss and work to resolve issues those customers may have with receiving Product Water. Poseidon shall cooperate with the District in resolving Water Quality Issues. Notwithstanding the foregoing, any change in the Delivery Regime or Quality Standards developed pursuant to this Agreement shall be mutually agreed by the Parties.

8.2 Quality Standards. Compliance with Law, Pressure Parameters and Water Quality Standards. All Product Water produced by the Project and delivered to the Delivery Points must meet all of the following standards (collectively the "Quality Standards"): (a) all drinking water quality standards under Applicable Law (whether now in force or hereafter adopted) and action levels now in force or hereafter adopted by the California Department of Health Services, (b) the water quality specifications set forth in Schedule 8.2. and (c) any mutually-agreed change to the Quality Standars with respect to the Water Quality issues described in Section 8.1 above or otherwise identified in the technical studies performed with respect to such Water Quality Issues. Attached as Schedule 8.2 are the Water Quality Standards with respect to the Project as of the Effective Date. The Water Quality Standards in Schedule 8.2 include permitted variations for each water quality parameter specified. If the Product Water produced by the Project at any time fails to meet all drinking water quality standards under Applicable Law (whether now in force or hereafter adopted), and/or fails to meet the other Quality Standards set forth in Schedule 8.2, then Poseidon immediately shall notify the District, and the District and Poseidon shall meet promptly thereafter to determine corrective measures, if any, that need to be taken. The Parties acknowledge that corrective measures may include, without limitation, segregating Product Water that fails to meet all drinking water quality standards under Applicable Law (whether now in force or hereafter adopted), and/or fails to meet the other Quality Standards set forth in Schedule 8.2. Poseidon shall be responsible for any and all state and federal fines resulting from Product Water that does not meet Applicable Law for drinking water quality.

8.3 Finalization of Water Quality Specification for Boron. The Parties shall use commercially reasonable efforts to determine, within one hundred and eighty (180) days after the Effective Date, mutually-acceptable concentration limits for Boron to be included in Schedule 8.2.

8.4 District's Non-Acceptance. The District shall not be obligated to accept Product Water of quality that does not meet the Quality Standards.

8.5 Compliance with Regulations on Water Quality. As a purveyor of drinking water, the District is required to comply with regulations that address water quality at the consumer's tap ("Consumer Quality Standards"). If, following the introduction of Product Water, the District is in violation of the Consumer Quality Standards, then the District immediately shall notify the Poseidon, and the District and Poseidon shall meet promptly thereafter to determine corrective measures, if any, that need to be taken. If the Product Water causes the District be in violation of the Consumer Quality Standards, then the District, upon written notice to Poseidon, may suspend deliveries of Product Water, and the District shall not be obligated to pay for Product Water that causes the District to be in violation of the Consumer Quality Standards; provided, however that prior to such suspension the District and Poseidon shall use all commercially reasonable efforts to implement alternative corrective measures to address a violation of the Consumer Quality Standards. Poseidon shall be responsible for any and all state and federal fines resulting from Product Water causing the District to be in violation of the Consumer Quality Standards. With respect to the issue of causation of a District violation of the Consumer Quality Standards, nothing set forth in this Section 8.5 shall be deemed or construed to shift the burden of proof to Poseidon, or as a waiver by Poseidon of any claims or defenses.

Schedule 8.2 - Water Quality Specifications

Quality Parameter[10]	Analytical Method[1]	Sampling		Units	Concentration Limits	
		Sample period[2]	Sample Method		Central Tendency[3]	Extreme[4]
Total Dissolved Solids	2540 C	one year	Weekly grab	mg/L	350	400
Chloride	4110 B	one year	Weekly grab	mg/L	180	210
Bromide	4110 B	one year	Weekly grab	mg/L	0.5	0.8
Boron	3120 B	one year	Weekly grab	mg/L	tbd[5]	1[5]
Turbidity	2130 B	one month	Continuous[6]	NTU	0.3	0.5
SDS-THM[9]	5710 C	one year	Monthly Grab: 100% Desal	mg/L	> 70% of MCL[7]	< 100% of MCL[7]
SDS-THM[8, 9]	5710 D	one year	Monthly Grab: 50% desal & 50% Aqued	mg/L	> 70% of MCL[7]	< 100% of MCL[7]
SDS-HAA[9]	5710 D	one year	Monthly Grab: 100% Desal	mg/L	> 70% of MCL[7]	< 100% of MCL[7]
SDS-HAA[8, 9]	5710 D	one year	Monthly Grab: 50% desal & 50% Aqued	mg/L	> 70% of MCL[7]	< 100% of MCL[7]
Temperature	2550	one month	daily grab	˚F	-	85 ˚F

1. All methods taken from *Standard Methods On Line*, published by APHA, AWWA, and WEF.

2. Sample period - concentration limits are calculated for this period

3. Central Tendency - can be exceeded in no more than 50% of samples taken

4. Extreme - can be exceeded in no more than 10% of samples taken

5. Permanent values to be determined prior to commercial operation of the plant.

6. Continuous analysis, values at 15 minute intervals used in all calculations

7. Use the MCL that applies in the District's Distribution system

8. Does not apply if the District is using exclusively Desalinated Water

9. After the first year of testing, frequency of testing shall be per Applicable Law.

10. All samples to assess compliance with Applicable Law and Schedule 8.2 (except for samples for SDS-THM and SDS-HAA analyses) are to be collected at one mutually agreed upon location at the Project site. All SDS-TMM and SDS-HAA samples are to be collected at one mutually agreed upon location In the District's distribution system, unless otherwise specified by Applicable Law.

Examples of interpreting the central tendency and the extreme:

a. TDS - Central tendency requirement: no more than 26 samples among any 52 contiguous weekly samples may exceed 350 mg/L

b TDS – Extreme: no more than 5 samples among any 52 contiguous weekly samples may exceed 400 mg/L

c. Turbidity - central tendency requirement: no more than 1440 measurements among 2880 contiguous measurements recorded at 15 minute intervals may exceed 0.3 ntu.

d. Turbidity - extreme requirement: no more than 288 measurements among 2880 contiguous measurements recorded at 15 minute intervals may exceed 0.5 ntu.

e. SDS-THM - Central tendency requirement: no more than 6 samples among any 12 contiguous samples may exceed the MCL for THMs which is applicable to the water in the District's distribution system at the time the samples are taken.

ATTACHMENT 2

Distribution System Corrosion Control for Desalinated Seawater

Prepared for:
Poseidon Resources

September 27, 2002

Prepared by:

McGuire
Environmental
Consultants, Inc.

3471 Via Lido
Suite 207
Newport Beach, CA 92663

Introduction

The potable water produced at the seawater desalination plant will be distributed through the existing water distribution system and blended with other existing water sources. The purpose of this paper is to determine the desalination plant water quality and corrosion control measures, which will render the desalinated water compatible with the other existing potable water sources in terms of corrosion effect on the water distribution system. The base for establishing water quality compatibility are year 2001 water quality data for the Municipal Water District of Southern California's Diemer and Skinner Water Filtration Plants and the projected water quality to be produced by the seawater desalination plant.

Product Water Quality Parameters Related to Distribution System Corrosion

The key water quality parameters related to distribution system corrosion are:

- pH
- Alkalinity
- Hardness
- Total Dissolved Solids
- Temperature

<u>pH</u>

The potable water pH is a measure of the concentration of hydrogen ions present in the water. Since the hydrogen ions are one of the major substances that accepts the electrons given up by a metal when it corrodes, pH is a very important factor in corrosion control. Water of low pH is associated with corrosion problems for all metals in the distribution system. At pH values below 5, the water is rendered unstable and both iron and copper corrode rapidly. The water corrosivity decreases with pH increase.

The potable water pH range recommended in the Safe Drinking Water Act is 6.5 to 8.5. The pH of the potable water produced at the Diemer and Skinner plants is 8 to 8.1. The desalinated plant product water will have pH of 8.0 to 8.5, which matches the other water sources. Since the permeate produced by the reverse osmosis (RO) system has a relatively low pH (5 to 5.5), this water will be conditioned with lime, which will allow product water pH increase to the target range of 8.0 to 8.5.

<u>Alkalinity</u>

Alkalinity is a measure of water's ability to neutralize acids. In potable water, alkalinity is mostly composed on carbonates (CO3) and bicarbonates (HCO3). Alkalinity relates to water's ability to form a protective carbonate coating on the distribution system pipes, which diminishes pipe material corrosion rate. However, very high alkalinity may result in excessive calcium precipitation and pipeline scaling, especially if water's calcium concentration is relatively high.

Potable water alkalinity is not limited by the water quality regulations. Water alkalinity of the Diemer and Skinner plants is in a range of 100 to 115 mg/L. After lime addition, the product water from the desalination plant will have alkalinity of 50 mg/L or higher. This alkalinity will be adequate to provide protective carbonate coating without causing calcium scaling on the pipelines.

Hardness

Hardness is determined as the total concentration of calcium and magnesium ions in the water, reported as calcium carbonate. The degree of hardness is usually determined as shown on Table 1 [1].

Table 1
Degree of Water Hardness

Hardness (as CaCO3), mg/L	Definition
0 - 50	Soft
50 -150	Moderately Hard
150-300	Hard
>300	Very Hard

The potable water hardness is not regulated by the Safe Drinking Water Act. However, hard water usually consumes more soaps and detergents and tends to create deposits on piping and home appliances.

The potable water currently produced at both the Diemer and Skinner plants can be classified as hard and ranges between 219 to 255 mg/l and 232 to 248 mg/L, respectively. The permeate from the RO system will have very little hardness. This hardness will be increased by lime addition. The finished water from the seawater desalination plant will be moderately hard. Hard waters are less corrosive than soft waters if sufficient calcium ions and alkalinity are present to form a protective calcium carbonate lining on the pipe walls. However, high water hardness is not beneficial for corrosion control because it may create excessive carbonate deposits on the pipes. The moderately hard potable water from the desalination plant will have hardness above 50 mg/L, which will be adequate to provide comparable corrosion control effect.

Total Dissolved Solids

Product water total dissolved solids (TDS) concentration is directly related to ion concentration in the water. The higher TDS/ion content results in increased water conductivity, which in turn increases water's ability to conduct a corrosive current, hence enhances corrosivity.

The product water from the seawater desalination plant will have TDS concentration of 350 to 400 mg/L, which is 10 to 20 % lower than that of the water produced at the Diemer and Skinner plants. This lower TDS concentration will have a positive effect on distribution system piping in terms of corrosivity.

Temperature

Temperature effects on corrosion are complex and depend on the water chemistry and type of the pipeline materials. In general, the rate of all chemical reactions, including corrosion increases with increased temperature. However, the rate of increase is impacted by the other water quality factors discussed above and may be negligible for water of given quality.

On the other hand, temperature significantly affects the dissolving of calcium carbonate. Less calcium carbonate dissolves at higher temperatures, which means that calcium carbonate tends to come out of solution (precipitate) and form protective lining more rapidly at higher temperatures [(2)]. The protective coating resulting from the precipitation can reduce corrosion.

The product water temperature of the Diemer and Skinner plants is expected to be several degrees Celsius lower than that of the seawater desalination plant. However, this difference is not anticipated to have a significant effect on distribution system corrosivity.

Corrosivity and Stability Index

As discussed above, the distribution system corrosion is impacted by many water quality parameters with overlapping effect. Currently, a number of indexes are used to quantify the overall water stability and corrosivity. The most commonly applied index is the Langelier Saturation Index.

The Langlier Saturation Index, or LSI (Equation 1), which describes in terms of pH values how close the water quality matrix is to saturation with respect to carbonate solids:

$$LSI = pH - pH_s \tag{1}$$

where

LSI = Langlier Saturation Index (pH units)
pH = actual pH of system
pH_s = pH of system when saturated with a carbonate solid (typically calcite)

and results in the number of pH units above or below saturation (or the point where the carbonate solid is theoretically predicted to precipitate).

Use of the LSI is premised on observations that slightly positive LSI values result in fewer corrosion problems through the formation of a protective scale that slows down the corrosion process and solidifies existing corrosion scales. The optimal range for the LSI value is between 0 and 0.5, with higher LSI values resulting in excessive scaling, loss of flow and pressure, and operational issues regarding equipment fouling and binding.

A simple method of calculation for the LSI simply involves calcium concentrations, the bicarbonate system pK_a values, and the solubility constant for calcium carbonate (values given are for 25 °C and a TDS of 400 mg/L):

$$pH_s = pK_{a,2} - pK_s + p[Ca^{2+}] + p[HCO_3^-] - \log\gamma_{Ca^{2+}} - \log\gamma_{HCO_3^-} \quad (2)$$

where

$pK_{a,2}$ =negative log of second pK_a of carbonate system = 10.33
pK_s = negative log of calcite solubility constant = 8.48
$p[Ca^{2+}]$ =negative log of free or uncomplexed molar calcium concentration
$p[HCO_3^-]$ = negative log of molar bicarbonate concentration
γ_{Ca2+} = activity coefficient for calcium
γ_{HCO3-}= activity coefficient for bicarbonate

Standard Methods for the Examination of Water and Wastewater can be consulted to obtain corrections for proper activity coefficients and equilibrium constants as a function of temperature, pH and ionic strength, where a combined value for the activity coefficient correction is given ($5\ pf_m = 5 \times 0.044 = -\log\gamma_{Ca2+} - \log\gamma_{HCO3-}$).

The LSI is widely used index because it allows incorporating most of the key water quality parameters that have impact on distribution system corrosion into one quantitative measure:

- Total Alkalinity
- Calcium Hardness
- TDS
- pH
- Temperature

The average LSI for the Diemer and Skinner Plants is 0.36 and 0.41, respectively. Both indexes are in the optimum range of 0.0 to 0.5. The desalination plant product water will have LSI index in the optimum range, as well.

RO Water Conditioning for Corrosion Control

Permeate from the desalination system will have low alkalinity and pH and will be conditioned by lime and carbon dioxide addition to produce stable and non-corrosive product water. The alkalinity addition that is required for desalinated seawater is the primary process variable that can be used to control corrosion, and will also affect pH values due to the interrelationship between CO_2, alkalinity, and pH. The goal of alkalinity addition is to provide buffering capacity against changes in pH and induce the formation (precipitation) of passivating or stabilizing carbonate and hydroxide scales (most likely calcite or calcium carbonate), without exacerbating other aspects of corrosion.

The finished water will approximate the same pH and chlorine residual concentration as the potable water from the existing other sources (Diemer/Skinner water treatment plants) delivering water to the same distribution system, thereby minimizing the pH-related dissolution and scale release and upsets of the biological community in the system. Potable water from the desalinated plant with a pH value of 8 to 8.5 will also balance the various risks of cement dissolution and lead, copper, and iron corrosion. Finally, the finished water from the desalination plant will maintain a positive LSI in a range of 0 to 0.5 and continue to provide the benefits of this time-tested practice.

Lime will be delivered on site in a form of dry powder or pellets, stored in silos and used to prepare liquid lime solution. This liquid lime solution will be fed continuously to the plant reverse osmosis (RO) system permeate line and mixed with the RO permeate in a designated contact vessel. Lime solution will be injected into the permeate lines just ahead of the lime contact vessel. The turbulent mixing during upward and downward movement of the water in the vessel chambers will provide complete mixing. The lime contact vessel will be located upstream of the plant on-site storage tank, which will provide an additional lime contact time.

Carbon dioxide will be delivered to the desalination plant in liquid compressed form and distributed as a gas in the on-side product water storage tank via distribution and diffuser system installed on the bottom of the storage tank. Calculations were performed using the RTW Model [3] and using the water quality for RO permeate listed in Table 2.

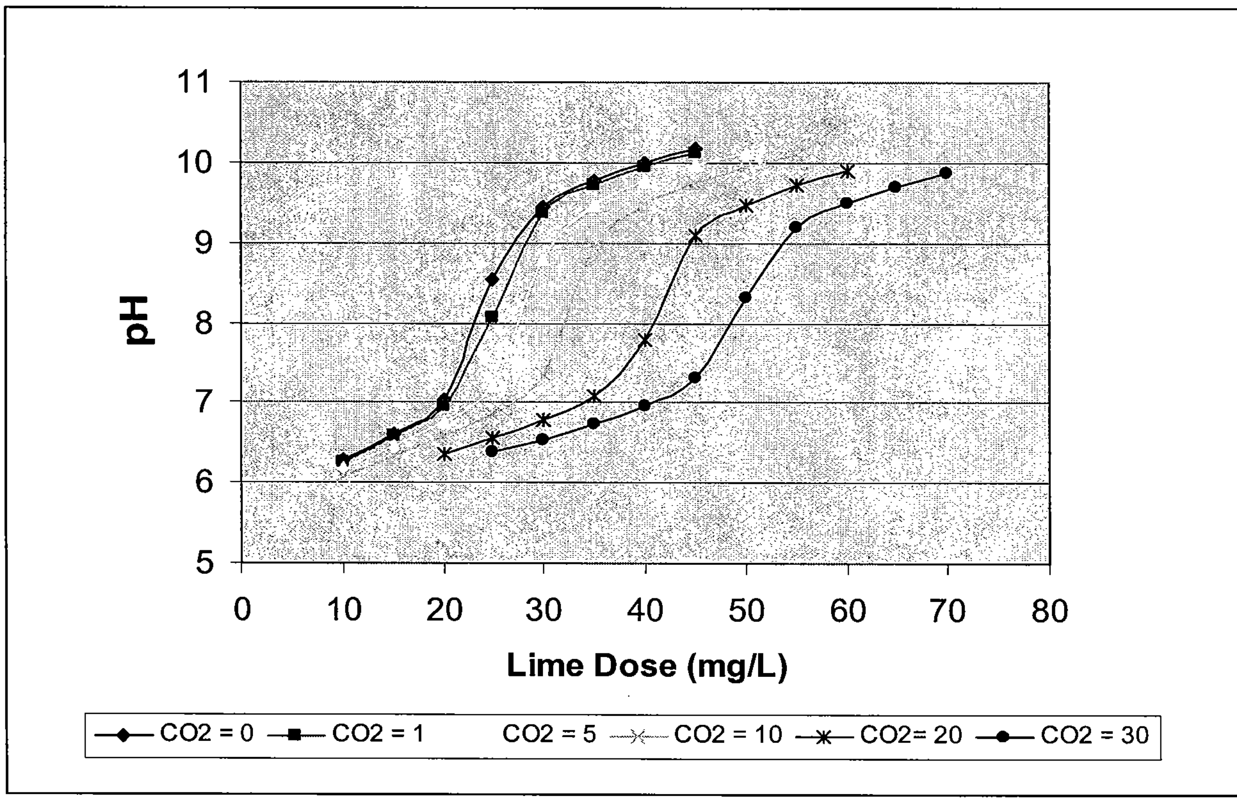

Figure 1. Chemical addition requirements for typical RO product waters. The figure demonstrates that at least 20 – 25 mg/L of lime is required to reach pH 8.0 – 8.5, while adding additional lime to reach alkalinities representative of Southern California surface waters requires the addition of substantial amounts of carbon dioxide.

A LSI close to zero and a pH of 8.5 can be achieved by adding approximately 25 mg/L of lime (Figure 2) without carbon dioxide addition Because lime is a weak base, the addition of more lime to increase alkalinity and the LSI will require the addition of carbon dioxide the maintain target pH values without destroying alkalinity.

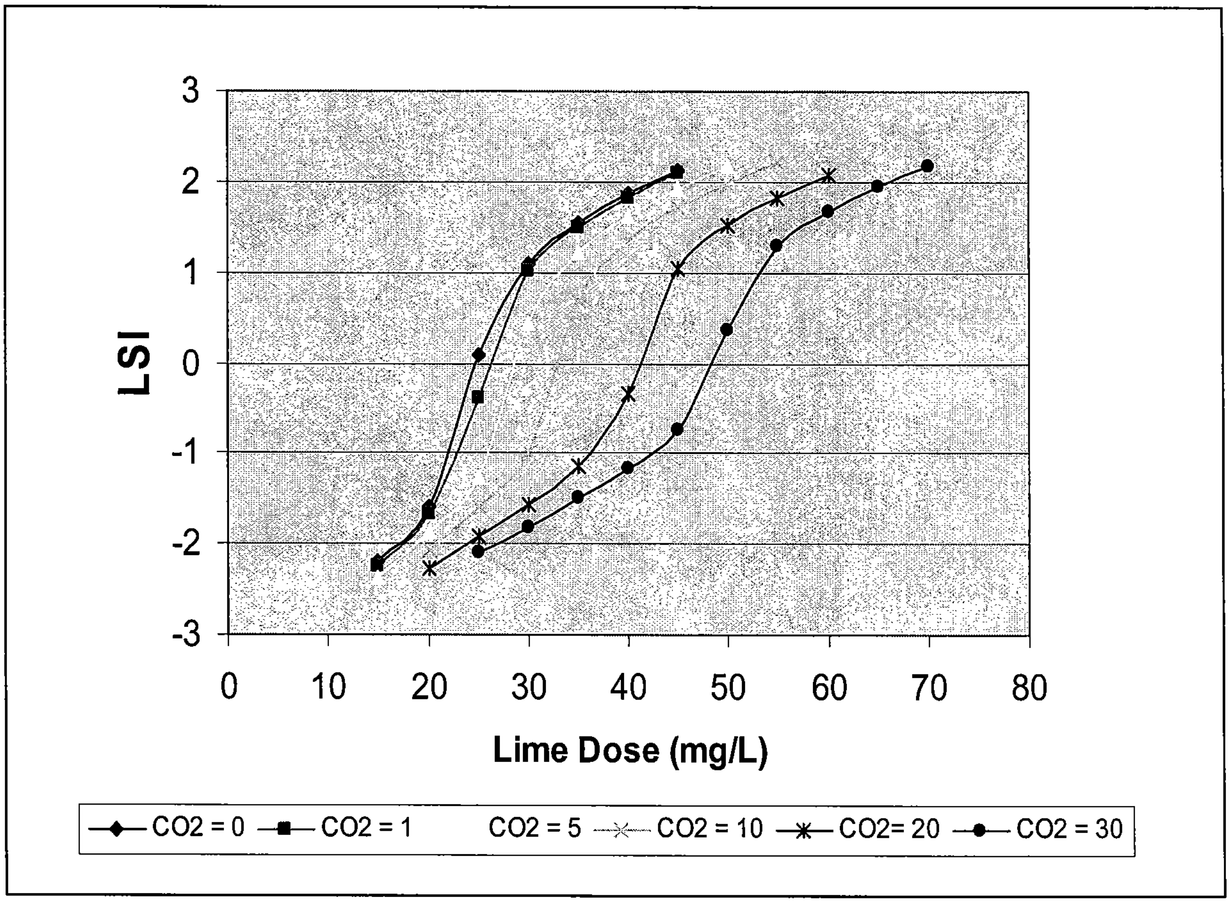

Figure 2. LSI values for a range of lime and carbon dioxide doses. Target LSI values are achieved at nearly the same concentrations of lime addition as target pH values. Both the LSI and pH change very rapidly in the optimum chemical dose range (note the relatively steep slopes of the curves near zero LSI values).

Table 2 shows the key water quality parameters for the Diemer and Skinner Water Filtration Plants and the water quality of the desalination plant at various lime and carbon dioxide dosages. As previously noted, the minimum lime dosage (w/o addition of carbon dioxide) needed to achieve product water of comparable pH and similar LSI is 25 mg/L. At this dosage, the desalination water LSI will be at the lower end of the optimum range (0.11-0.14). The amount of lime and carbon dioxide needed to slightly exceed the water quality of the existing water sources in terms of LSI and reach the upper end of the LSI range of 0.5, is – lime dosage of 50 mg/L and carbon dioxide dosage of 30 mg/L (Table 2). The alkalinity under this maximum dosage is 76 mg/L, which is an indication of moderately hard water.

Based on the results summarized in Table 2, the desalination plant product water conditioning system will be designed to deliver:

- Lime Dosage of 25 to 50 mg/L (avg. of 30 mg/L)
- Carbon Dioxide Dosage of 0 to 30 mg/L (avg. of 6 mg/L)

The desalination plant product water will have:

- pH of 8 to 8.5
- LSI of 0.0 to 0.5
- Alkalinity of 40 mg/L or higher

Parameter or Index	units	Diemer Effluent	Skinner Effluent	RO Permeate			
Lime Addition (@ 27 °C)	mg/L	none	none	none	24.9	30	50
Lime Addition (@ 20 °C)		none	none	none	27.2	32.3	52.3
CO_2 Addition	mg/L	none	none	none	0	6	29.5
ALK	mg/L as $CaCO_3$	113	116	5	39	56	73
HCO_3	mg/L	138	141	6	48	56	89
HCO_3	mM	2.26	2.31	0.10	0.79	0.92	1.46
Cl	mg/L	79	81	180	180	180	180
Cl	mM	2.23	2.28	5.07	5.07	5.07	5.07
SO_4	mg/L	177	176	5	5	5	5
SO_4	mM	1.84	1.83	0.05	0.05	0.05	0.05
Ca	mg/L	56	58	5	18	21.00	32.00
Ca	mM	1.40	1.45	0.13	0.45	0.53	0.80
pH		8.02	8.06	5.5	8.5	8.5	8.5
pHs		7.57	7.54	9.98	8.52	8.39	8.00
LSI (calculated)		0.45	0.52	-4.48	-0.02	0.11	0.50
LSI (RTW)	@ 27 °C	-	-	-4.43	0.02	0.14	0.50
LSI (RTW)	@ 20 °C	0.36	0.41	-4.53	0.01	0.12	0.46

Table 2. Water quality and Langlier Saturation Index values for finished water from the MWDSC Diemer WTP, desalinated seawater using reverse osmosis, and several permutations of stabilized RO permeate. Positive LSI values and target pH values are achieved for RO product water with lime doses greater than approximately 25 mg/L.

The finished product water from the desalinated plant will have comparable and compatible quality to the water quality of the other sources of water delivered to the same distribution system.

The effect of temperature on the CO_2/alkalinity/pH system and the increased solubility of carbonates at lower temperatures is illustrated by evaluating the lime addition requirements at 20 °C and 27 °C, where slightly more lime is required at the lower temperature to achieve similar LSI values. The results presented in Table 2 indicate that the effect of the slightly higher temperature of the desalinated water on the corrosivity is readily compensated with a minimal increase in lime and carbon dioxide dosages and is accounted in the distribution system corrosion control assessment.

Conclusions

The product water from the seawater desalination plant will be suitable for delivery through the existing water distribution system and will be comparable and compatible to the other water sources currently delivering water to the same system. Prior to delivery to the water distribution system the desalinated water will be conditioned using lime and carbon dioxide to achieve the following corrosion control driven water quality goals:

- PH of 8 to 8.5
- LSI of 0.0 to 0.5
- Alkalinity of 40 mg/L or higher

These water quality goals will be achieved by the addition of the following chemicals:

- Lime at dosage of 25 to 50 mg/L (avg. of 30 mg/L)
- Carbon dioxide at dosage of 0 to 30 mg/L (avg. of 6 mg/L)

The proposed on-site mixing and contact facilities will provide adequate conditioning of the finished product water prior to introduction to the distribution system.

References:

1. AWWA Research Foundation, Water Quality Impacts from Blending Multiple Water Types, 2001.
2. AWWA Corrosion Control for Operators, 1986.
3. The Rothberg, Tamburini, and Windsor Model for Corrosion Control and Process Chemistry, Version 2.0, AWWA, 1994

Attachment 3

Draft Water Purchase Agreement
Distribution System Testing and Monitoring Provisions

July 26, 2004

7.2 Distribution System Technical Studies.

7.2.1 System Test. Within one hundred and eighty (180) days after the Effective Date, the Parties shall complete the development of a mutually acceptable test (the "System Test") of the effect of Product Water on the components of the District's water distribution system (the "Distribution System"). The System Test shall include circulating Product Water, meeting the Water Quality Standards, from Poseidon's pilot desalination facility and the water from the District's current imported water supply, in parallel, through two identical systems of pipes, valves and other components provided by the District which are representative of those contained in the Distribution System (the "System Test Components") for a time period sufficient (as mutually agreed by the Parties, but not to exceed six months) to determine the relative effect of the Product Water on the System Test Components. Prior to the end of the one hundred and eighty (180) day period to complete the development of the System Test, the Corrosion Advisory Panel (as defined in Section 7.2.~~5~~4) shall meet with both Parties in Carlsbad, become familiar with the project and review and comment, in writing, on the proposed design and proposed length of the System Test. Following the conduct of the System Test, the results of the System Test shall be transmitted to the Corrosion Advisory Panel and the Corrosion Advisory Panel shall provide written comments on the interpretation of the results to both Parties. In the event that the System Test results show that the Product Water has an adverse effect on the integrity of any System Test Component, Poseidon shall take all commercially reasonable actions to change the proposed operation of the Project to remove such adverse effect. The System Test shall be re-performed until the results thereof do not show that the Product Water has an adverse effect on the integrity of any System Test Component. All costs of performing (and, if necessary, re-performing) the System Test shall be borne by Poseidon; provided, however that the cost of providing System Test Components, imported water and the collection, treatment, and disposal of such imported water in accordance with Applicable Law shall be borne by the District.

7.2.2 Consumer Plumbing Test. Within one hundred and eighty (180) days after the Effective Date, the Parties shall complete the development of a mutually-acceptable test (the "Consumer Plumbing Test") of the effect of Product Water on the components of consumer plumbing used in the District's service area, particularly on the leaching of lead and/or copper from these components. The Consumer Plumbing Test shall include circulating Product Water meeting the Water Quality Standards from Poseidon's pilot desalination facility and the water from the District's current imported water supply, in parallel, through two identical systems of consumer plumbing components (the "Consumer Test Components") for a time period sufficient (as mutually agreed by the Parties, but not to exceed six months) to determine the relative effect of the Product Water on the Test Components. The pipe loop test described in AWWARF, 1991, *Lead Control Strategies*

#406, American Water Works Research Foundation, Denver, CO shall be used as a preliminary model of the Consumer Plumbing Test. Prior to the end of the one hundred and eighty (180) day period to complete the development of the Consumer Plumbing Test, the Corrosion Advisory Panel (as defined in Section 7.2.4) shall meet with both Parties in Carlsbad, become familiar with the project to review and comment in writing on the proposed design and proposed length of the Consumer Plumbing Test. Following the conduct of the Consumer Plumbing Test, the results of the Consumer Plumbing Test shall be transmitted to the Corrosion Advisory Panel and the Corrosion Advisory Panel shall provide written comments on the interpretation of the results to both Parties. In the event that the Consumer Plumbing Test results show that the Product Water has an adverse effect on the integrity of any Consumer Test Component or on the leaching of lead and/or copper from said Consumer Test Component, Poseidon shall take all commercially reasonable actions to implement changes to the proposed operation of the Project_to remove any adverse impacts. The Consumer Plumbing Test shall be re-performed until the results thereof do not show that the Product Water has an adverse effect on the integrity of any Consumer Test Component or the leaching of lead and/or copper from any Consumer Test Component. All costs of performing (and, if necessary, re-performing) the Consumer Plumbing Test shall be borne by Poseidon; provided, however that the cost of providing Consumer Test Components, imported water and the collection, treatment, and disposal of such imported water in accordance with Applicable Law shall be borne by the District.

7.2.3 System Monitoring Plan. Within twelve (12) months after the Effective Date of the Agreement, the Parties shall commence the development of a mutually agreeable methods for monitoring the effect of Product Water on the integrity of the Distribution System (the "System Monitoring Plan"). Before the System Monitoring Plan is final, the Corrosion Advisory Panel (as defined in Section 7.2.4) shall have two weeks to review the final draft System Monitoring Plan and provide written comments. The Parties shall complete the development of the System Monitoring Plan in sufficient time to allow at least one year of data collection prior to the commencement of Commercial Operation, but in no event later than twelve (12) months prior to the Projected Commencement Date. In the event that the District reasonably believes that the integrity of all or a material portion of the Distribution System may be adversely affected by the Product Water, the Parties shall meet to discuss such potential adverse effects Poseidon shall take all commercially reasonable actions to implement changes to the operation of the Project to remove an adverse effect of Product Water on the integrity of all or a material portion of the Distribution System. The cost of the System Monitoring Plan in excess of the cost which would be reasonably incurred by the District to monitor the Distribution System in the absence of the Project shall be equally shared by the Parties up to the first anniversary of the Commercial Operation. Thereafter, any additional system monitoring cost shall be borne by the District..

7.2.4 <u>Corrosion Advisory</u> Panel. Within ninety (90) days after the Effective Date, the Parties shall retain a review panel (the "Corrosion Advisory Panel"), composed of two nationally recognized experts with experience in the design and conduct of tests on the corrosiveness of water to system and consumer plumbing components. Each Party shall have the right to appoint one member of the Corrosion Advisory Panel. The Corrosion Advisory Panel shall be retained to review the design and length of the System Test and the Consumer Plumbing Test, the interpretation of the results said tests and the design of the System

Monitoring Plan, As more specifically provided in Section 7.2.1 and 7.2.2, the Corrosion Advisory Panel shall meet one time in Carlsbad to become familiar with the project, to review and comment, in writing, on the design and the proposed length of the said tests before the design and length of said tests are finalized. Following the conduct of the said tests, the results of said tests shall be transmitted to the Corrosion Advisory Panel and the Corrosion Advisory Panel shall provide written review comments to the Parties. If the members of the Corrosion Advisory Panel do not agree with each other on any advice or recommendation on any matter, each member shall report his or her advice or recommendation on said matter independently. Having reviewed and considered the advice and recommendations of the Corrosion Advisory Panel, the Parties shall make their own independent judgments about the design and length of the System Test and the Consumer Plumbing Test, and the design of the System Monitoring Plan and about the interpretation of the results from the System Test and the Consumer Plumbing Test.

KOMEX

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ENVIRONMENT AND WATER RESOURCES

TO: Mr. Andy Gray, P.E. **DATE:** July 12, 2004

FROM: Duncan McInnis, PhD, P.Eng. **PROJ #:** H0371A000

RE: ***FINAL REPORT: Transient analysis of Alternative Alignments for the Carlsbad Desalination Project Potable Transmission System.***

Andy,

The following is the Final Report for the preliminary transient analysis and surge control design for the proposed alternative transmission and distribution system alignments.

Should you have any concerns or comments regarding the information contained in this memo, do not hesitate to contact me at (403) 247-0200.

Respectfully,

Duncan A. McI

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1 INTRODUCTION

Poseidon Inc. is proposing to design and construct a seawater desalination project in the City of Carlsbad. The plant would produce 22 to 50 million gallons per day (mgd) of finished water using the reverse osmosis process. The proposed project comprises the seawater desalination plant together with pipelines, pumps, and other appurtenant and ancillary water facilities needed to produce and deliver potable water to the City of Carlsbad, City of Oceanside and potentially other customers of the San Diego County Water Authority (SDCWA). The Project would become a significant water supply source to the region. The desalination plant portion of the Project would be constructed on property currently owned by Cabrillo Power I LLC (Cabrillo), co-located on-site at the existing Encina Power Station (EPS), immediately south of the Aqua Hedionda Lagoon.

2 PURPOSE OF THE WORK

One of the factors affecting the feasibility of a proposed pipeline alignment is the hydraulic performance and cost of the completed pumping and conveyance system. The preliminary hydraulic (transient) analysis described in this report will confirm the hydraulic requirements of the pumping plant. In addition, it defines the susceptibility of the system to hydraulic failure due to surge and provides preliminary selection and sizing estimates for mitigation measures (surge protection) needed to ensure safe operation of the pumping and pipeline systems.

3 SOFTWARE

TransAM is a general-purpose, method-of-characteristics based simulation model for calculating hydraulic conditions in pipeline systems. Although emphasis is given to the analysis of "full" transient conditions (compressible flow or water hammer) in pipelines, TransAM can also be used to calculate steady state flows or to model incompressible, unsteady flow conditions. Full graphical output is generated and used in reporting to enhance understanding of the results of the hydraulic analyses.

Possible sources of transients in a system that are treated explicitly by TransAM include pump start-ups or shut-downs, the action of automatic or manual control valves, the fluctuation of reservoir levels and many other actions. TransAM places few restrictions on the analyst about the form of the pipe network—simple series systems with only a few pipes, or large branched and looped networks, can be simulated efficiently.

TransAM is the result of more than 20 years of research and development work at the University of Toronto and the Hong Kong University of Science and Technology. It is a proprietary product of HydraTek & Associates, Toronto and is used by more than 30 consulting firms and utilities world-wide. Komex's Dr. McInnis is the principal author of the TransAM software.

4 SURGE DESIGN CRITERIA

The following criteria were used to select, size and locate surge controls for the 4 alternative alignments:

1. No negative pressures; and,
2. Maximum upsurge no greater than 150% of long-term pipe pressure rating.

Note that the rated hydraulic grade line shown in subsequent figures uses the steady state hydraulic grade line as a surrogate indicator of pipe pressure ratings. Thus, the Rated HGL shown on plots is 150% of the steady state operating pressure. This would usually provide an underestimate of the actual pressure ratings and, thus, is expected to be a conservative measure of maximum allowable surge pressure.

5 SYSTEM DESCRIPTION

Four alternate alignments and Desalination Plant pumping capacities are being considered as follows:

1. NCDP50MGD: The Desalination Plant produces 50 mgd, supplying the Cities of Carlsbad, Oceanside and Vista as well as the San Diego County Water Authority via the North County Distribution Pipe (NCDP) at the very north end of the system. The distribution of water supply is as follows:

- Carlsbad	10 mgd
- Oceanside	15 mgd
- Vista	5 mgd
- SDCWA	20 mgd

   There are three pump stations: one at the Desalination Plant and two at the north end. A booster pumping station supplies 10 mgd to Oceanside, while another supplies 20 mgd to the SDCWA. This scenario corresponds to winter conditions and moves as much water as far away from the plant as possible;

2. TAP50MGD: Same as above except the pump station supplying the SDCWA has been moved south to a location (Junction 70) where it supplies the Tri-Agencies Pipeline;

3. 35MGD: The Desalination Plant supplies 35 mgd as follows:

- Carlsbad	15 mgd
- Oceanside	15 mgd
- Vista	5 mgd

   There is no supply to the SDCWA; and,

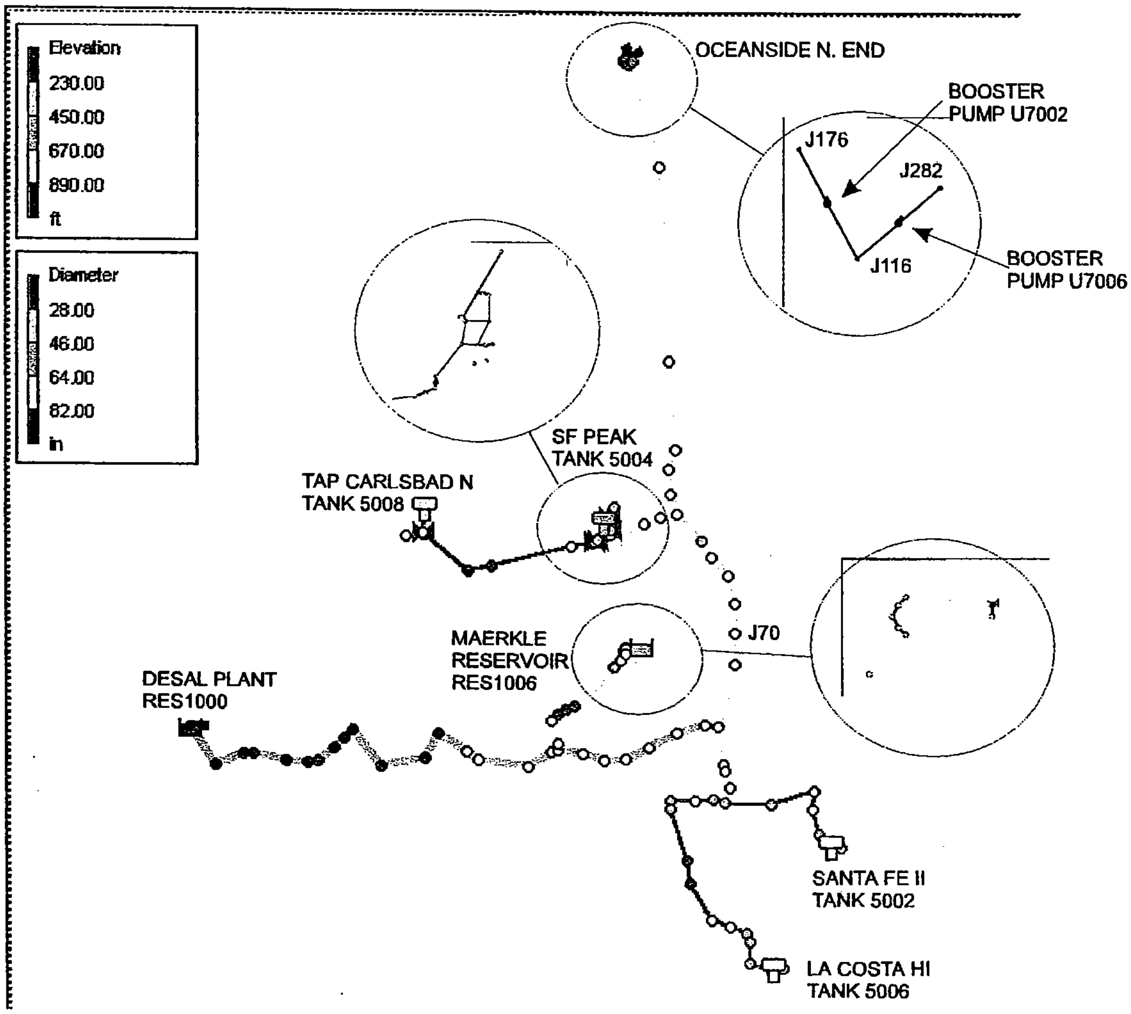

Figure 1. Schematic layout of NCDP50MGD alignment showing major tanks, pumping stations and fixed reservoirs.

4. 22MGD: The Desalination Plant supplies 22 mgd as follows:

   - Carlsbad 12 mgd
   - Oceanside 5 mgd
   - Vista 5 mgd

   Piping does not extend north on Melrose at the Melrose/Cannon Road intersection.

6 NCDP50MGD ALIGNMENT

Figure 1 shows a schematic representation of the NCDP50MGD alignment as derived from the supplied Excel spreadsheets and EPANET input files. Pipe diameters range from 12 to 48 inches. The Desalination Plant (DESAL) is located at an elevation of 40 feet above sea level (f.a.s.l.) while the highest portions of the system are near 1,000 f.a.s.l. In general, elevations range between 300 and 500 feet throughout the system. The booster pumping stations at the north end deliver water to elevations between 900 and 1100 f.a.s.l.

A comprehensive set of transient simulations was carried out to evaluate various surge protection alternatives for the NCDP50MGD alignment. This alignment was selected as the bounding case for the proposed Encina Desalination transmission system because it (i) carries the largest flow rate and (ii) conveys maximum transmission main flows over the longest hydraulic path. Each of the remaining scenarios generally represents a "reduction" or modification of this system, and hence would be expected to require similar or less intervention to control surge pressures. Thus, from a planning perspective *vis a vis* facility locations and space requirements, the NCDP50MGD likely represents the governing case.

6.1 MODEL ASSUMPTIONS

For transient modelling purposes, the following assumptions were made:

1. The DESAL high lift pumps are 3 identical 2660 HP 4-stage vertical turbine units (roughly based on Johnston pumps) with the following characteristics:

Rated Head (ft)	Rated Flow (ft^3/s)	Rated Speed (rpm)	Rated Efficiency (%)	Motor and Pump Inertia (lbf-ft^2)	Approx. Power (HP)
771	25.79	1800	90	5000	2660

2. Wavespeeds for various pipe diameters are as follows:

Diameter (inches)	$D \leq 24$	$24 < D \leq 36$	$36 < D \leq 48$	$D > 48$
Wavespeed (ft/s)	4250	3750	3600	3450

Tabulated values are nominal averages from published test data for lined concrete and unlined steel pipes. Wavespeeds for cement-lined and coated steel pipe are similar to the tabulated values above. Transient heads are relatively insensitive to small errors (±15%) in wavespeed;

3. Booster stations have a single duty pump with characteristics as follows:

Booster Pump Station	Rated Head (ft)	Rated Flow (ft^3/s)	Rated Speed (rpm)	Rated Efficiency (%)	Motor and Pump Inertia (lbf-ft^2)	Approx. Power (HP)
U7002	315	15.47	1800	85	650	550
U7006	462	30.94	1800	85	3060	1625

The pump shape factor (*i.e.*, the dimensionless equivalent of specific speed) for the 4-stage vertical turbine pumps is

$$K_N = \pi N_R \sqrt{Q_R} \Big/ 30(gH_R)^{3/4} \approx 1.44 \quad (1)$$

making the specified pumpsets radial in type. Assuming that the booster pumps are 3-stage pumps, a similar value of K_N is obtained. Hence, documented 4-zone pump curves for $K_N = 1.44$ were used to represent all pumps in the transient model. The transient response is not particularly sensitive to minor differences in shape number;

4. Reservoirs and tanks are assumed to float on the system, *i.e.*, they do not have any directional or altitude flow control valves integral to the reservoir;

5. Air chambers are single units in a horizontal configuration. The minimum initial air charge is 40% or more of the total tank volume. The minimum water depth in the tank under surge conditions is 2 feet for tanks greater than 1000 gallons and 1 foot for tanks less than 1000 gallons;

6. Pressure-sustaining valves (PSVs), pressure reducing valves (PRVs) and flow control valves (FCVs) are assumed to incorporate appropriate check valve action. The valves are assumed to react slowly to changing pressure or flow conditions, *i.e.*, they are assumed to close or open fully in no less than 100 seconds; and,

7. No air and vacuum valves are included in these analyses because one of the design criteria is no negative pressure. Thus, the primary surge controls will be surge tanks or air chambers sized such that negative pressures do not occur.

6.2 MODEL SCENARIOS

Using these assumptions, a debugged data file was developed such that the steady state behaviour of the system agreed closely with the EPANET model. A series of simulations for the power failure condition were carried out to incrementally develop a surge control system that met the design criteria listed in Section 4. Once the key surge control elements were identified, the surge facilities were made incrementally smaller to obtain the minimum required capacity for each element under power failure conditions while still meeting the design criteria. Lastly, the system was tested for all pumps simultaneously starting across-the-line to ensure that the maximum surge criterion was not exceeded. In summary, the following limiting cases were modelled:

1. No protection—The system is simulated under power failure conditions with no vacuum air valves incorporated, no surge protection and with vaporous cavitation disabled such that potential downsurge in all areas of the system can be estimated;

2. Air Chamber(s)—The system is simulated under power failure conditions with no vacuum air valves incorporated, but with air chambers as needed at various locations to control minimum surge pressures;

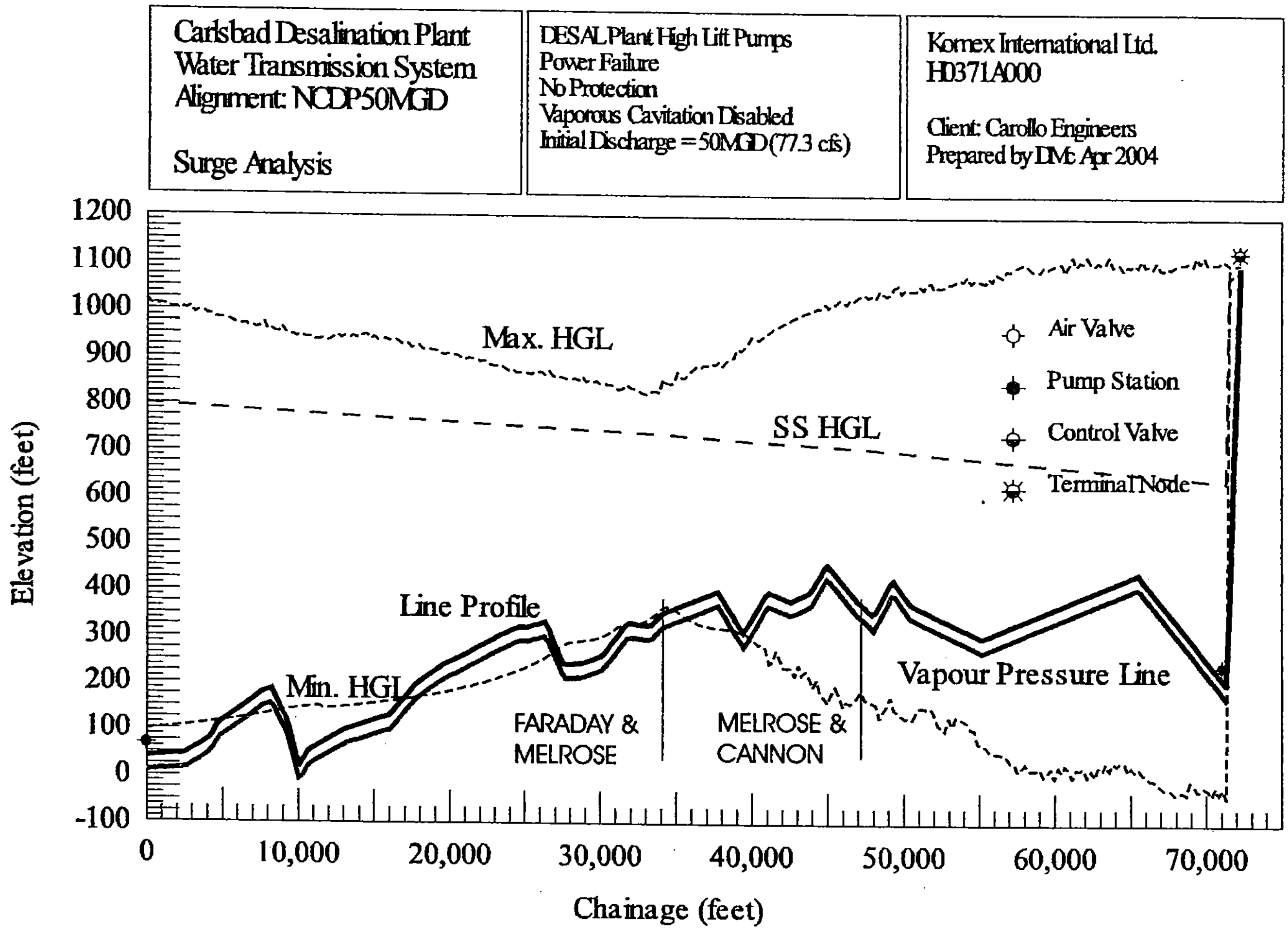

Figure 2. Extreme head summary of main trunk for power failure at 50MGD (77.32 cfs) pumping. No surge protection or vacuum air valves are incorporated in the simulated system. Vaporous cavitation is disabled.

3. Pressure relief valve(s)—Pressure relief valves were added to limit the build-up of pressure on the suction side of booster pumps;

4. Minimum surge control requirements—The selected components developed from the previous runs were down-sized to the smallest possible capacity that still met the surge design criteria; and,

5. All pumps "starting-across-the-line"—This simulation represents the "worst" case for upsurge due to sudden pump starts. Any required adjustments to air chamber volumes or differential inflow/outflow characteristics were identified.

6.3 NCDP50MGD MODEL RESULTS

Figure 2 is an extreme head summary plot along the main trunk leading from the DESAL high lift pumps to the booster pump station discharge at Junction J282. This plot records the maximum and minimum piezometric pressures experienced along the pipeline during the course of the simulated pump trip event. In each case, the transient model was run for a period of 300 seconds, or approximately 6 minutes, to ensure that all relevant transient phenomena were captured.

Two features of the system behaviour are immediately apparent from this plot: (i) Although surge protection will be required in the DESAL pumping station, maximum and minimum transient pressures are not particularly severe over the initial 6½ miles of the trunk main, *i.e.*, from the DESAL plant to Station 34+000 where the branch main leading to San Francisco Peak and Carlsbad (North) TAP tanks is located. While the SF Peak tank may have a mitigating influence on the transient head fluctuation at this location, it is likely that the more severe transient response in the latter 7 miles of the trunk main shown in the figure results from the interaction at the booster pump boundary.

Although not indicated in the figure, negative pressures may tend to occur in those upland areas just upstream of the reservoirs and tanks, including the Santa Fe, La Costa, TAP Carlsbad (North) and especially the SF Peak tanks, and the Maerkle Reservoir. Some of the predicted negative pressures result from representation of system demands as constant outflows at those locations having a specified consumption. Representing these demands as a pressure-dependent demand eliminates the negative pressures associated with most of the demand locations, indicating that these are likely spurious and will not occur. A region of negative pressure does appear to occur however in the vicinity of the SF Peak tank in the pipe downstream of flow control valve V8028. This response and the required surge control is discussed in Section 6.3.6.

6.3.1 Booster Pump Stations

Although full details of the discharge side of the booster pumping stations are less important for steady state models to determine overall pumping head requirements, the transient behaviour of the system depends on pumping capacity, total dynamic head as well as topographic and topologic characteristics of the discharge transmission and distribution components.

As previously noted, significant upsurge (potentially exceeding the upsurge criterion) is predicted to occur on the suction side of the booster pumping stations. This results from the fact that flow through the booster pumps is reduced following power failure as the flow "piles up" on the suction side, and higher pressures build up on the inflow side in response to the flow reduction. Conversely, a negative pressure wave is set up on the discharge side of the booster pumps as flow at the pump is reduced, and the water column continues to move away from the pump to the transmission system. This negative wave may interact with any rising transmission components conveying flow into Oceanside or to the NCD pipeline. The precise nature of this interaction cannot be defined here as the representation of the transmission components is notional and based only on the maximum elevations to which water is pumped in these two zones.

To provide some insight to the potential influence of the downstream pipeline system associated with each of the two booster pumping stations, a "notional" discharge pipe system was added to booster pumping stations U7002 and U7006, which respectively pump to upland reservoirs in Oceanside (North) and to the NCD pipeline. These notional transmission systems are required to garner a more realistic sense of what surge protection may be required on the dis-

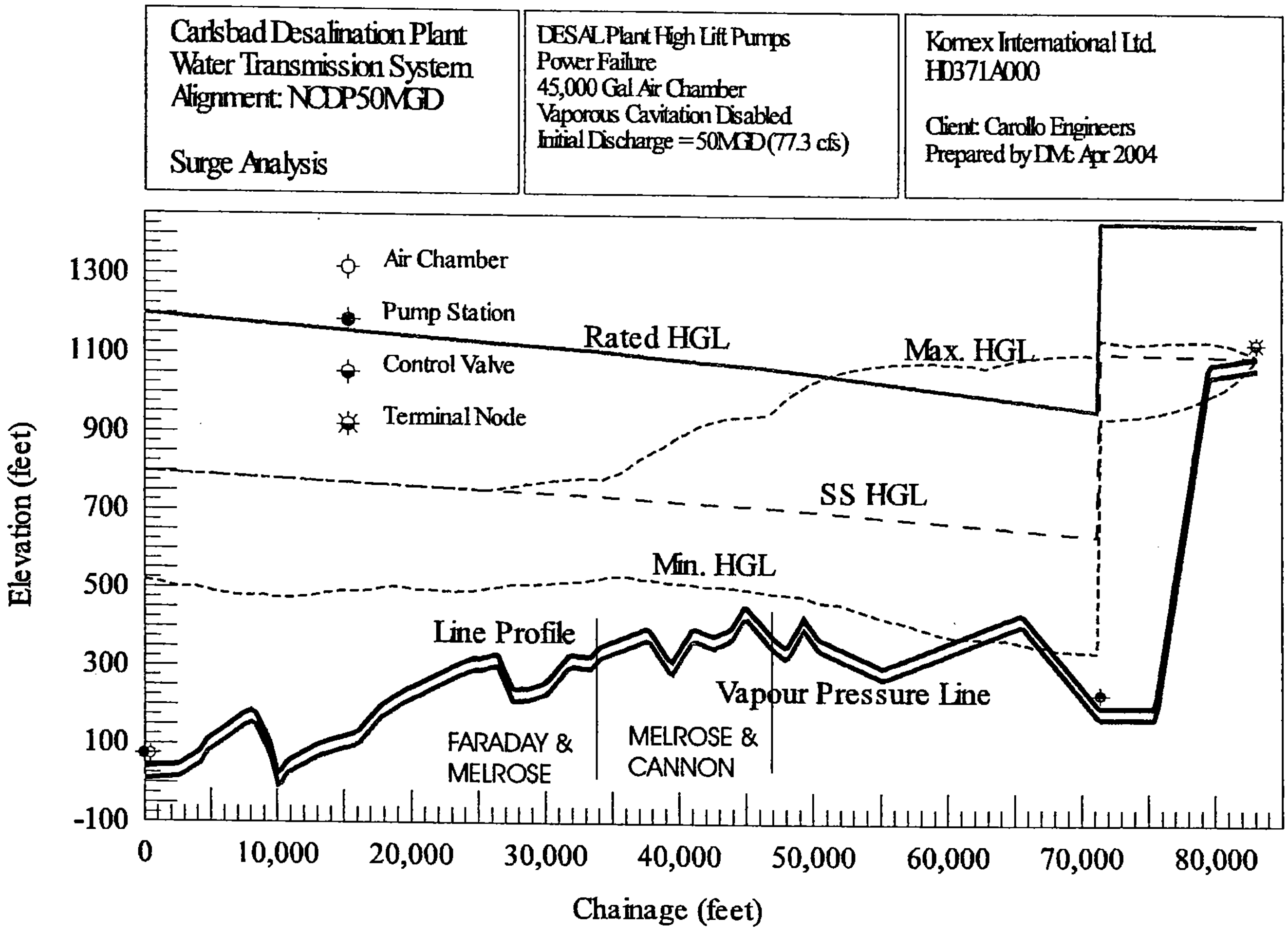

Figure 3. Extreme head summary for power failure with a horizontal 45,000 gallon air chamber on the DESAL pump discharge header.

charge side of the booster pumping stations as the surge protection facilities will be influenced by both the hydraulic length and profile of these system components. Currently, no specific information is available for these portions of the proposed system. The notional transmission system adds a 2-mile length of rising main to the discharge side of each booster pumping station with a terminal reservoir at the approximate elevation indicated in the supplied EPANET data files, *i.e.*, 954 feet and 1,100 feet above sea level for the Oceanside and NCDP zones, respectively. The recommended surge controls associated with these system components are preliminary, at best, but should be sufficient to allow for land acquisition and facility planning. Adequacy of these proposed surge controls should be confirmed by detailed transient modelling if and when final alignments are selected.

6.3.2 DESAL Air Chamber

Figure 3 shows the extreme head summary for the NCDP50MGD trunk main alignment under power failure conditions with the revised representation of the booster pump stations and with a large air chamber (45,000 gallons) present in the DESAL high lift pumping station. The single,

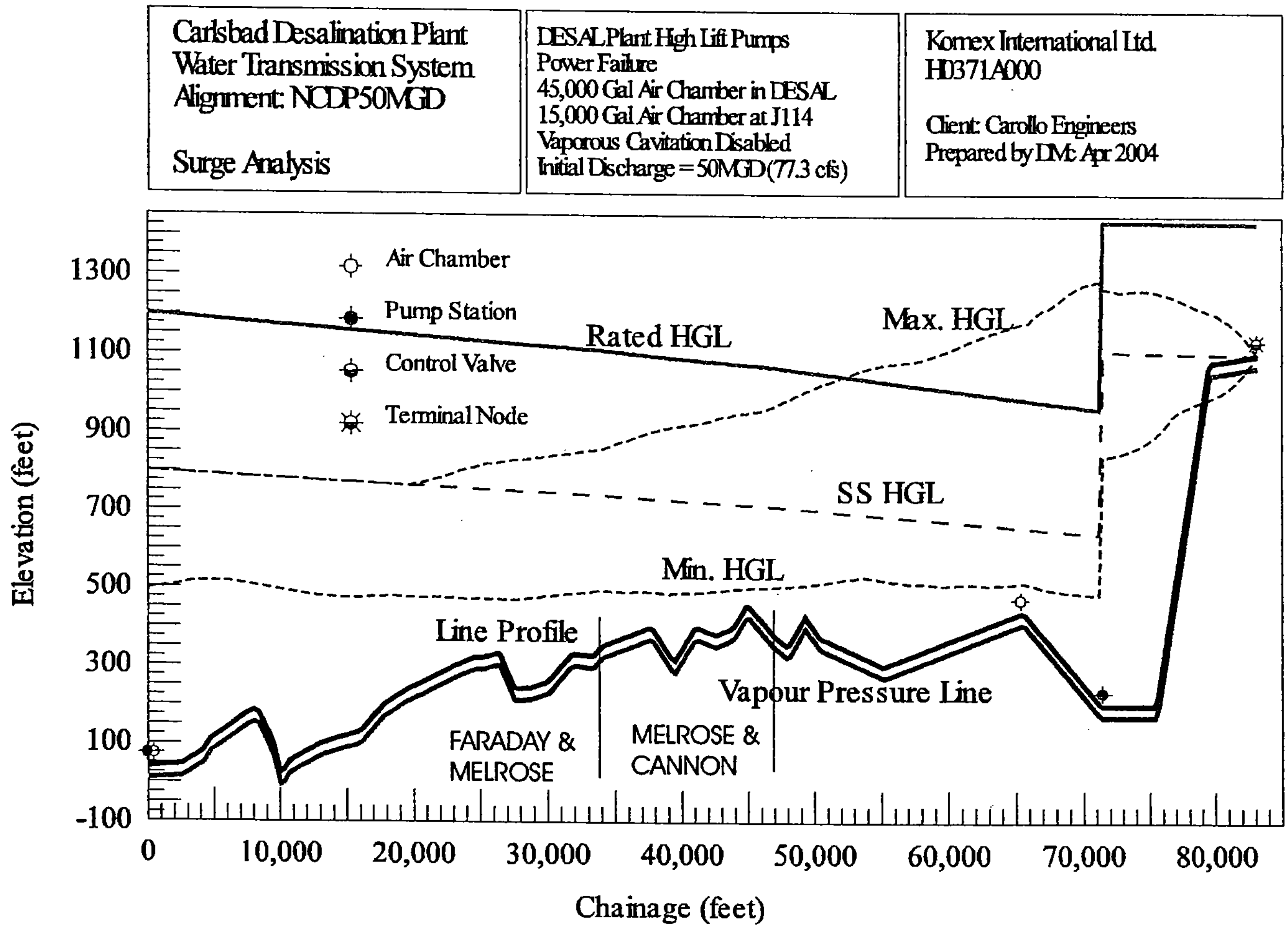

Figure 4. Extreme head summary for power failure with a horizontal 45,000 gallon air chamber on the DESAL pump discharge header and a horizontal 15,000 gallon air chamber at the J114 high point.

horizontal air chamber provides adequate protection against both upsurge and downsurge over the initial 10 miles of the transmission system alignment. Some minor negative pressures (not visible on the plot) may be experienced in higher elevation areas leading to tanks and reservoirs. The downstream 4 miles or so of the system, conveying flow *via* the booster pumping stations to Oceanside and the NCD pipeline, however, still appear to have significant potential for negative pressures, especially near the high point at Junction J114. The interaction with the booster pumping stations and their associated transmission pipeline (though notional and somewhat imprecise as it is based only on the maximum elevations to which water is pumped in these two zones) suggests that surge control on the discharge side of the pumps will be required to limit surge interaction with any downstream, receiving aqueduct or pipeline systems.

6.3.3 High Point Air Chamber

In this scenario (see Figure 4), a second air chamber with a total volume of 15,000 gallons is situated at the Junction J114 high point. This air chamber provides additional downsurge relief along the transmission main leading to the booster pumping stations as well as to some of the

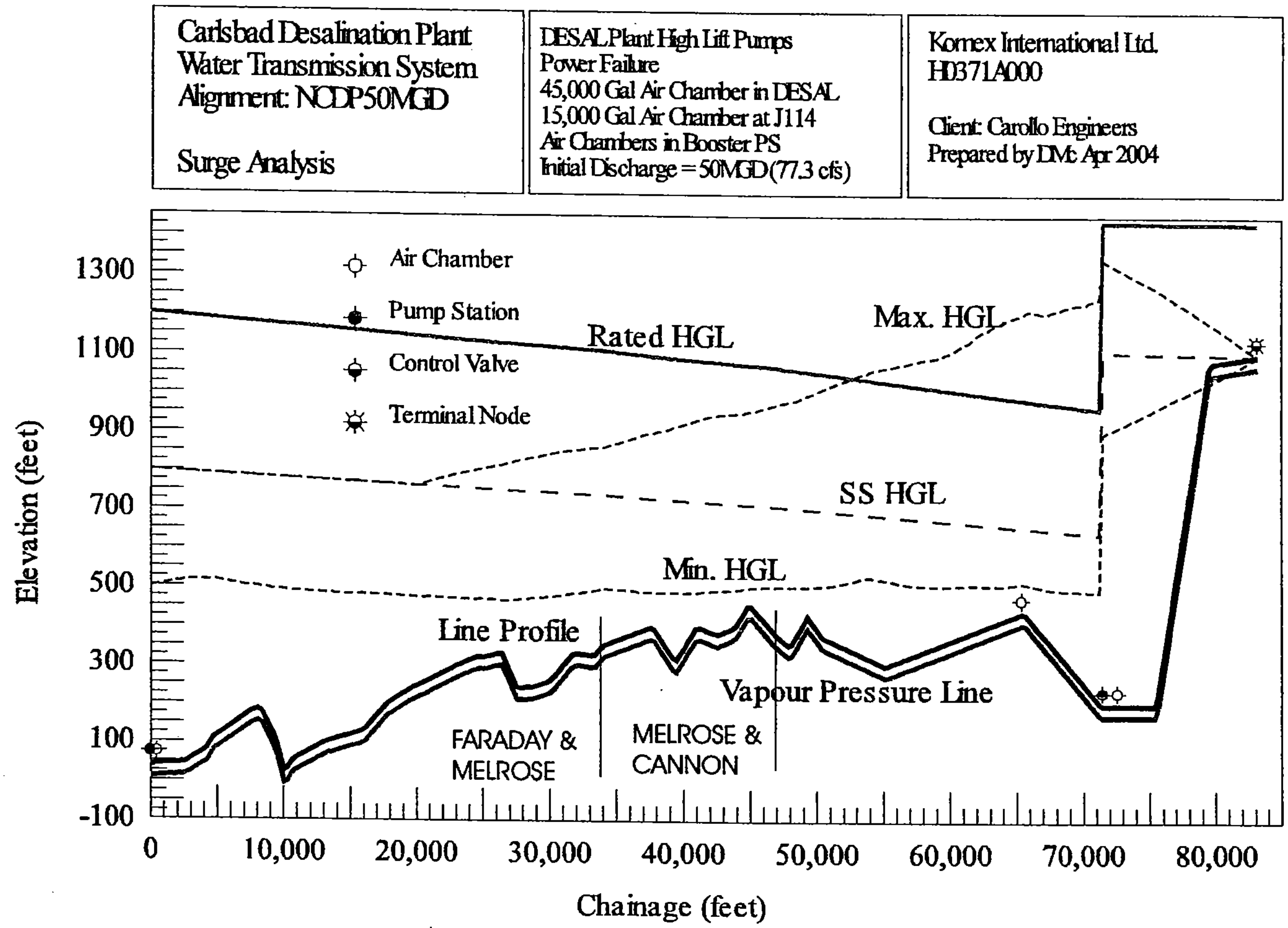

Figure 5. Extreme head summary for power failure with DESAL, high point and booster pump station air chambers.

higher elevation tanks and reservoir inlet pipes. Since it also reduces the superposition interaction of the booster pump upsurge with the initial downsurge from the DESAL high lift pumps, the predicted upsurge in the downstream portion of the pipeline is actually increased slightly. Similarly, the interaction of the high point air chamber with the booster pumping station and associated discharge lines causes greater upsurge and downsurge downstream of the booster station.

6.3.4 Booster Pump Discharge Air Chambers

Figure 5 shows the system response with a 5,000 gallon air chamber incorporated on the discharge header of booster pumping station U7002 (to Oceanside) and a 10,000 gallon air chamber on the discharge of booster pumping station U7006 (to the NCDP transfer station). While the surge response of the system upstream of the booster pumping stations remains relatively unchanged, the potential impact of downsurge on the notional pipelines downstream of the booster pumps is significantly improved. Immediately upstream of the booster pumping sta-

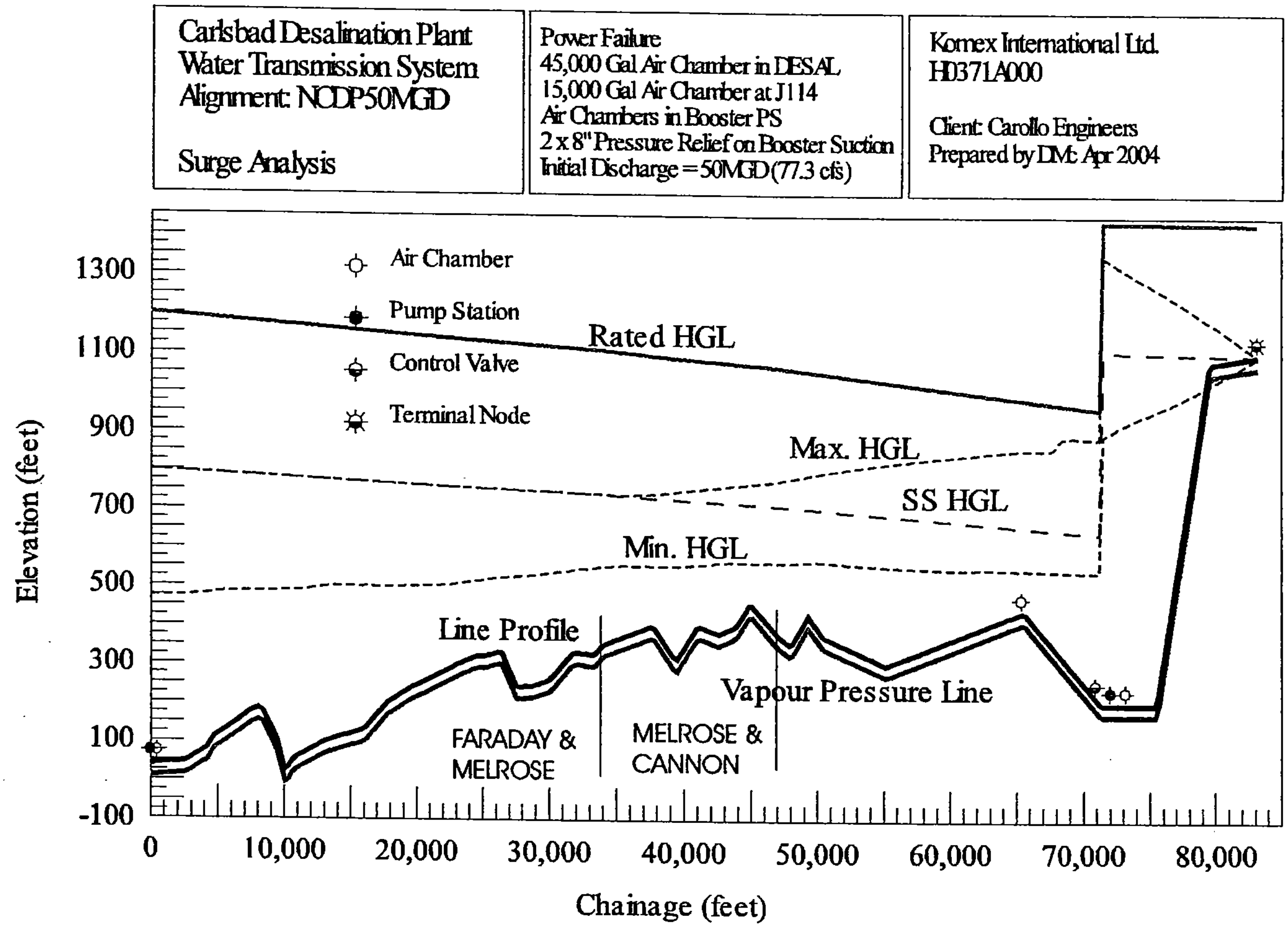

Figure 6. Extreme head summary for NCDP50MGD alignment with 4 air chambers and 2 x 8-inch pressure relief valves installed upstream of the booster pumping stations.

tions, upsurge in excess of the "50% above maximum operating pressure" criterion cannot be controlled by the use of air chambers alone.

6.3.5 Pressure Relief Valve(s) Upstream of Booster Pump Stations

Figure 6 shows the extreme head response of the system with a pair of 8-inch pressure relief valves installed on the upstream (suction) side of the two booster pumping stations. These valves may be installed as a single valve on each booster pump station intake (suction) line or they may be installed as a pair in a separate chamber located at, or upstream of, the junction of pipes leading from Junction J116 to the suction side of each station. These valves should be vented to atmosphere to achieve the necessary discharge capacity to reduce the maximum surge pressure on the upstream side of the booster stations. Due to the large pressure difference generated across the valves, anti-cavitation devices would be required. If multiple valves in series are used to decrease the maximum head loss across any individual valve, the correct sizing of the valves in series should be confirmed by re-running the transient model. Drainage facilities for water discharged by the valves will need to be provided.

The pressure relief valves in the transient model were assumed to open quickly in 3 seconds and to close slowly in 60 seconds. The high pressure setpoint in the model was specified at 880 feet above sea level (equivalent to a gauge pressure of 293 psi for a suction pipe elevation of 200 feet). The total combined discharge volume during the transient event was approximately 1000 ft^3, and the combined peak discharge rate from both valves was 28 ft^3/s.

6.3.6 Negative Pressure Control at Flow Control Valve V8028

The flow control valve V8028, delivering water to Junction J254 (405 gpm) and to Tank 5008 (406 gpm), is affected sequentially by the initial power failure downsurge wave, then by the upsurge caused by flow "buildup" on the suction side of the booster pumping stations. The initial downsurge reduces flow through the valve below its setpoint of 811 gpm. In response, the valve opens, attempting to pass the required flow rate. Subsequently, the positive pressure wave arrives, increasing the pressure difference across the valve, and flow through the control valve exceeds the required amount. The valve then closes to bring the flow rate down to the setpoint flow. The valve closure rapidly reduces the flow rate during the last stages of the closure, thereby inducing a negative pressure wave. Although, the actual opening and closure time for this valve was not provided, the sensitivity of this behaviour to more rapid and slower valve motions was explored. The system response was similar even over a wide range of valve opening and closure rates. Figure 7 shows the headloss across the valve as a function of time in the bottom plot of the figure. The corresponding flow through the valve, as well as its dimensionless opening τ, is also plotted. Note the rapid drop in head as flow through the valve is pinched off at about 130 seconds following power failure. Figure 8 shows the extreme pressure envelopes over this portion of the pipeline system. Note the minimum heads downstream of the valve may be low enough to produce vaporous cavitation.

Placing a small air chamber downstream of the valve will alleviate the negative pressures caused by the valve closure. A 400 gallon tank is sufficient to mitigate the negative pressure. Figure 9 shows the extreme head summary produced when a 400 gallon air chamber is located as close as practicably possible to the downstream side of valve V8028.

6.3.7 Optimal Surge Controls for Alignment NCDP50MGD

The simulations carried out to this point have developed a surge control scheme that mitigates both maximum and minimum surge pressures throughout the proposed NCDP50MGD alignment. In this step, the air chamber volumes are reduced to the minimum capacities that still result in a transient response meeting the design criteria of no negative pressure and maximum transient pressures not exceeding 1.5 times the maximum steady state operating pressure.

Table 1 summarises the optimum surge controls needed to meet the design criteria for the NCDP50MGD alignment. Figure 10 provides a graphical summary of the optimal surge controls by size and approximate location.

6.3.8 Power Failure and Pump Re-Start

For preliminary design or route selection, a final case intended to provide an estimate of the maximum upsurge due to pump start-up was simulated. The scenario starts with power failure

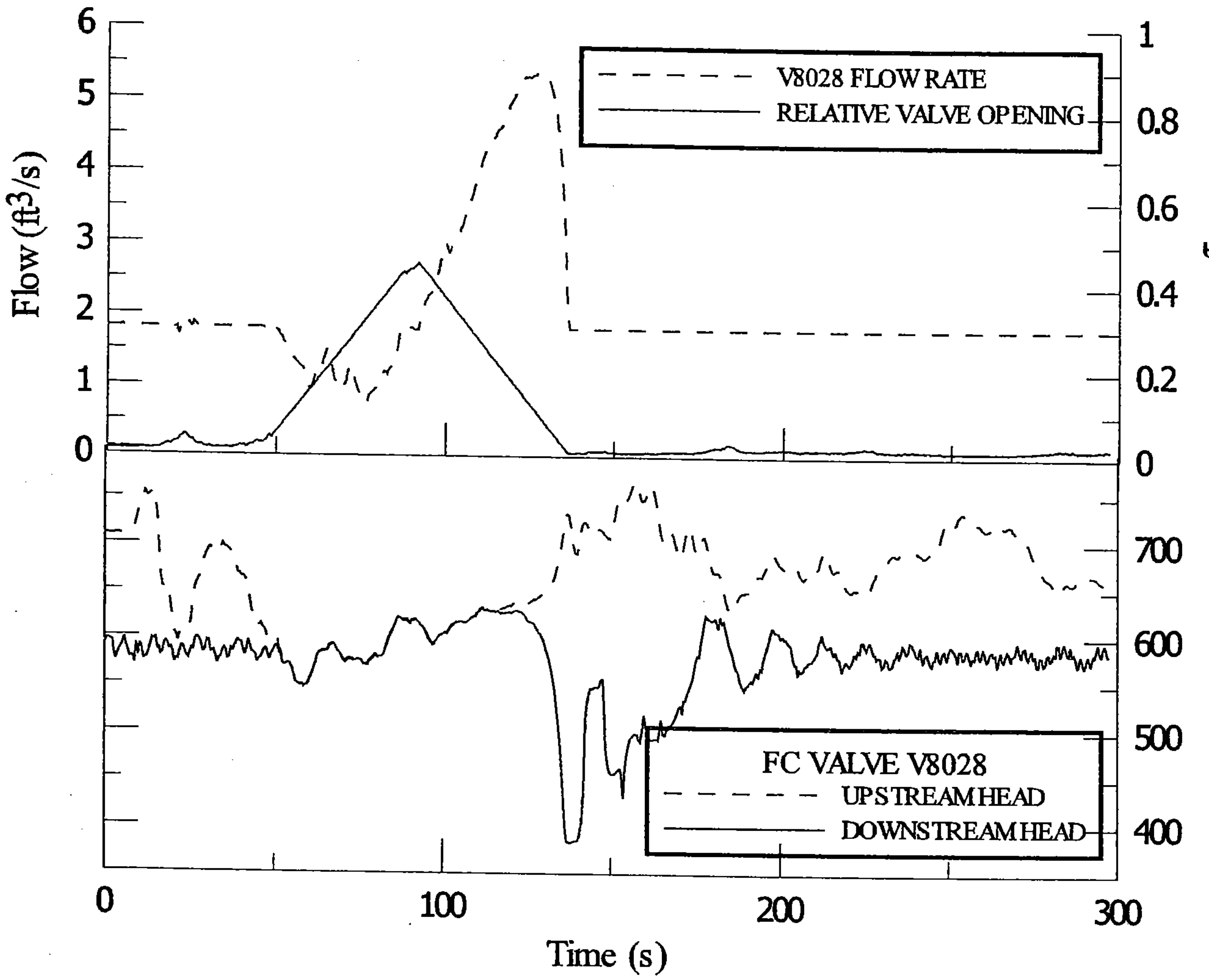

Figure 7. Time history at flow control Valve V8028. Top: Dimensionless valve opening and valve discharge. Bottom: Upstream and downstream piezometric head at V8028.

to all pumps followed by an "across-the-line" start of all pumps. Ordinarily, a simultaneous start of all pumps cannot occur when the controller and relays are functioning properly. The situation can, however, be forced by an operator manually over-riding the programmed controls. As such, it does constitute an extreme case that should be considered to ensure the optimal surge controls previously developed will be adequate to limit upsurge from simultaneous starting of all pumps. Figure 11 shows the extreme head summary that results when the system experiences a power failure followed by pump restart at 300 seconds. The optimal surge control system of Table 1 provides adequate protection against the upsurge caused by a simultaneous start of all pumps.

7 TAP50MGD ALIGNMENT MODEL RESULTS

A similar surge analysis procedure was carried out for each of the remaining three alternative alignments. The extreme head summary for the optimal surge controls for the TAP50MGD

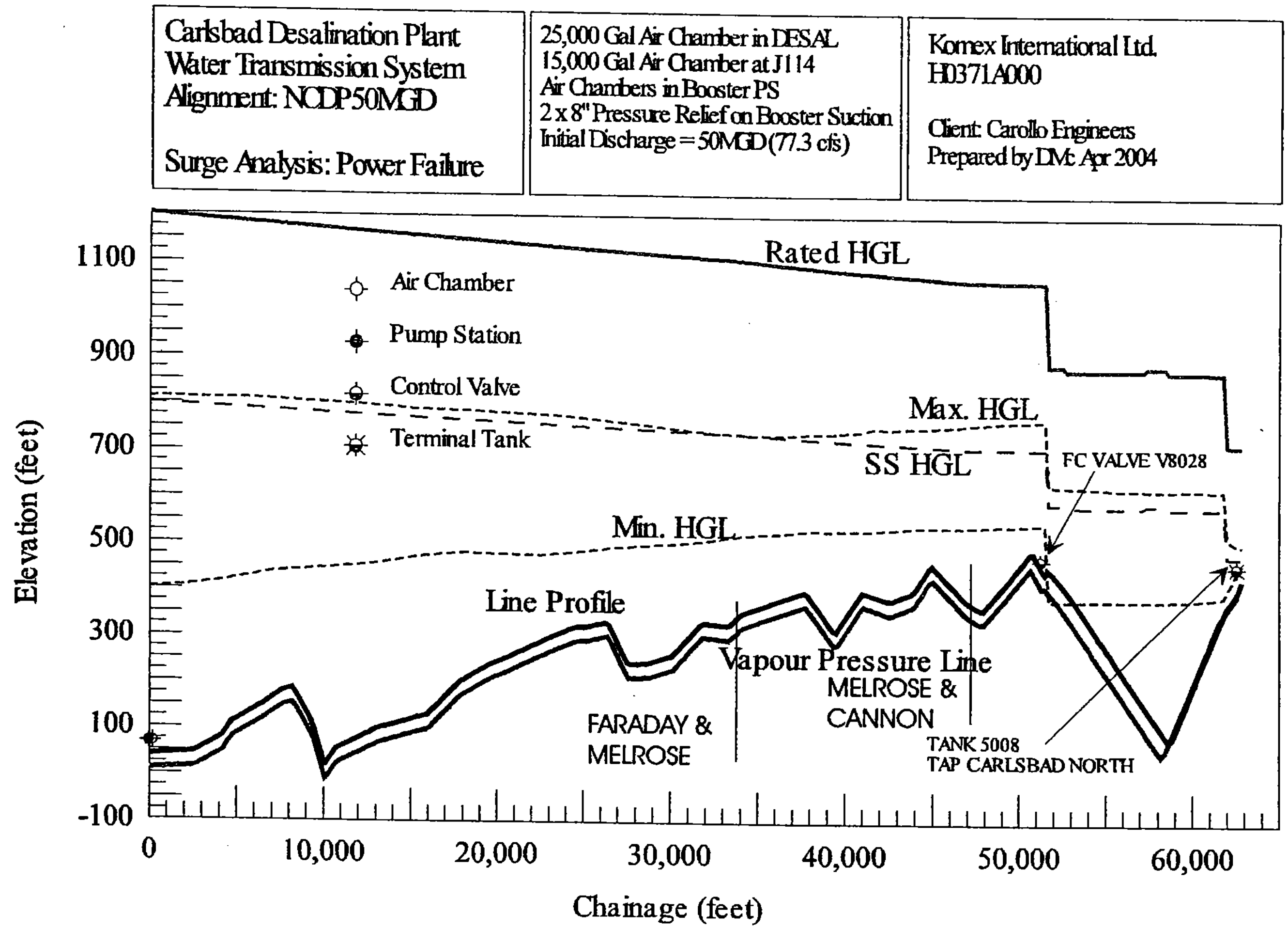

Figure 8. Extreme head summary on branch line to TAP Carlsbad (Tank 5008).

TABLE 1. RECOMMENDED OPTIMAL SURGE CONTROLS FOR NCDP50MGD ALIGNMENT

Surge Facility / Device	Location	Capacity
Air Chamber	Discharge header at DESAL plant	25,000 gallons
Air Chamber	~~High Point Junction J114~~ NOT REQ'd SEE ADDENDUM	~~15,000 gallons~~
Air Chamber	Booster Pump Station Discharge U7002	5,000 gallons
Air Chamber	Booster Pump Station Discharge U7006	10,000 gallons
Air Chamber	Downstream of Valve V8028	400 gallons
Pressure Relief	Booster pump suction side U7002 and U7006	8-inch

Note: A pair of 8-inch pressure relief valves could also be installed in a chamber in the vicinity of Junction J116 rather than a single valve on each booster pump station suction pipe.

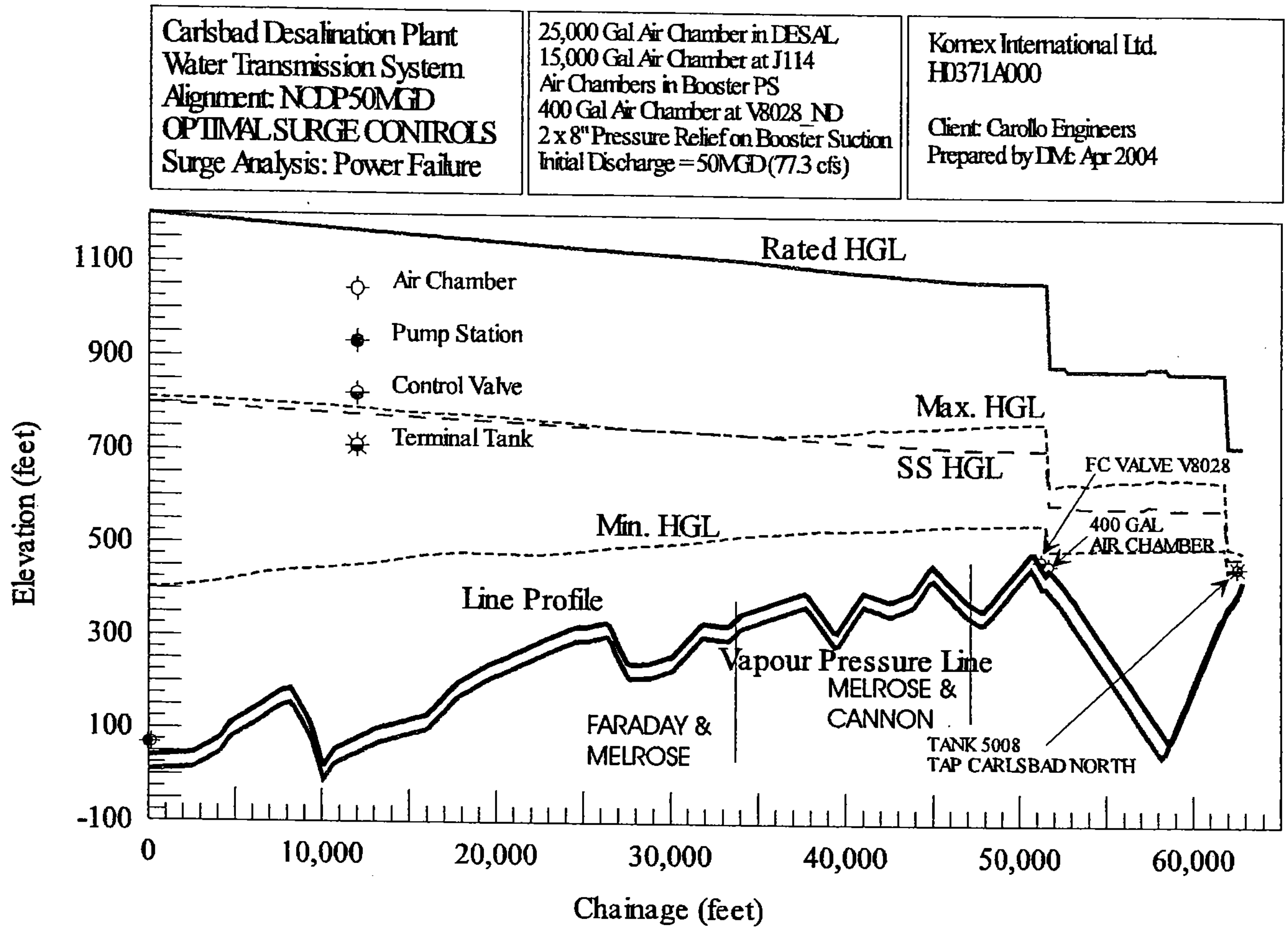

Figure 9. Extreme head summary on branch line to TAP Carlsbad (Tank 5008) with 400 gallon air chamber downstream of V8028.

alignment is shown in Figure 12. Note that the DESAL air chamber capacity has been increased to 45,000 gallons. This somewhat counterintuitive result stems from changes in wave timing and interactions caused by moving booster pumping station U7006 to a more upstream location. The result of the altered wave interactions is an increased tendency for negative pressures to develop in upslope topographic regions, especially near the higher elevation internal service reservoirs. The remedy for these increased negative pressure tendencies is to reduce the DESAL downsurge such that a higher minimum hydraulic grade line is maintained near the upslope tanks and negative pressures cannot occur. A larger air chamber capacity is required at the DESAL pumping station to increase minimum pressures in the affected areas.

Table 2 summarises the optimum surge controls needed to meet the design criteria for the TAP50MGD alignment. Figure 13 provides a graphical summary of the optimal surge controls by size and approximate location.

The recommended optimal surge controls provide adequate protection against upsurge from simultaneous start of all pumps.

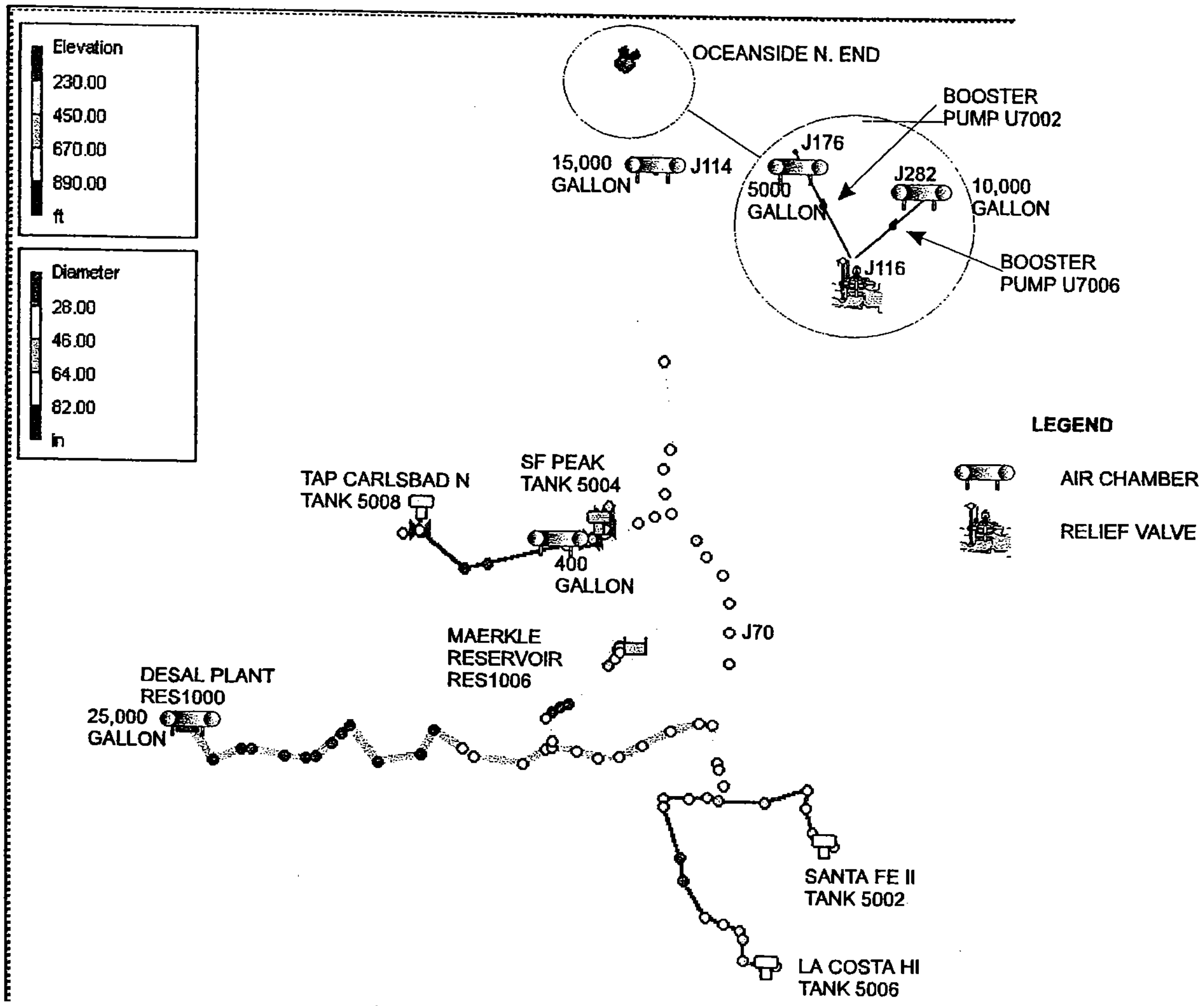

Figure 10. Schematic summary of recommended surge controls for NCDP50MGD alignment.

8 35MGD ALIGNMENT MODEL RESULTS

The extreme head summary for the optimal surge controls for the 35MGD alignment is shown in Figure 14.

Table 3 summarises the optimum surge controls needed to meet the design criteria for the 35MGD alignment. Figure 15 provides a graphical summary of the optimal surge controls by size and approximate location.

The recommended optimal surge controls provide adequate protection against upsurge from simultaneous start of all pumps.

9 22MGD ALIGNMENT MODEL RESULTS

The extreme head summary for the optimal surge controls for the 22MGD alignment is shown in Figure 16.

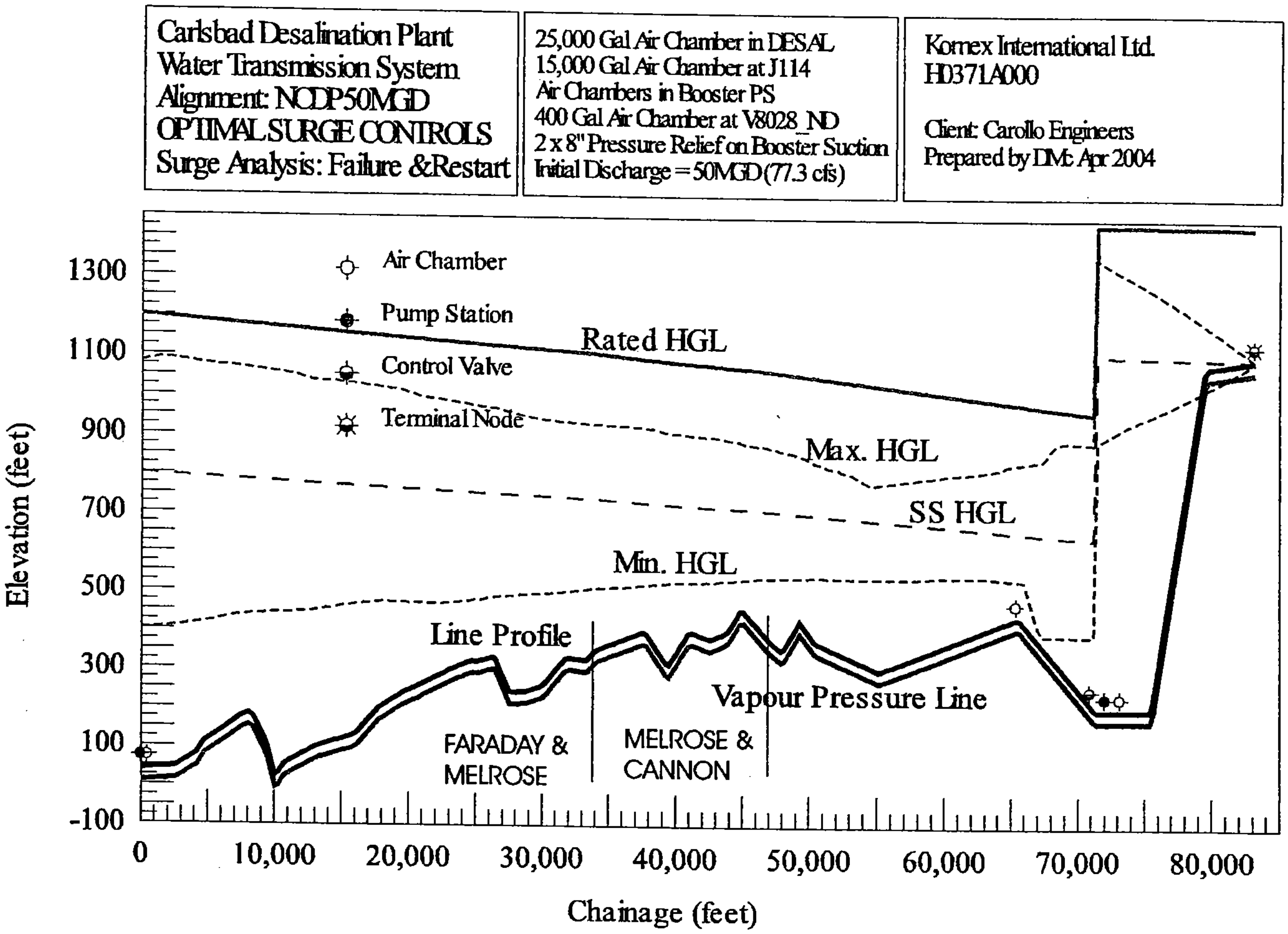

Figure 11. Extreme head summary for power failure followed by simultaneous restart of all pumps.

Table 4 summarises the optimum surge controls needed to meet the design criteria for the 22MGD alignment. Figure 17 provides a graphical summary of the optimal surge controls by size and approximate location.

The recommended optimal surge controls provide adequate protection against upsurge from simultaneous start of all pumps.

10 RECOMMENDATIONS

Based on the results of the analysis presented in this report, the following recommendations are made:

1. Preliminary pipe wall thicknesses should be selected based on a 50% surge allowance above the maximum steady state operating pressure. This design pressure criterion is predicated on the adoption of the surge control measures listed in Tables 1 through 4;

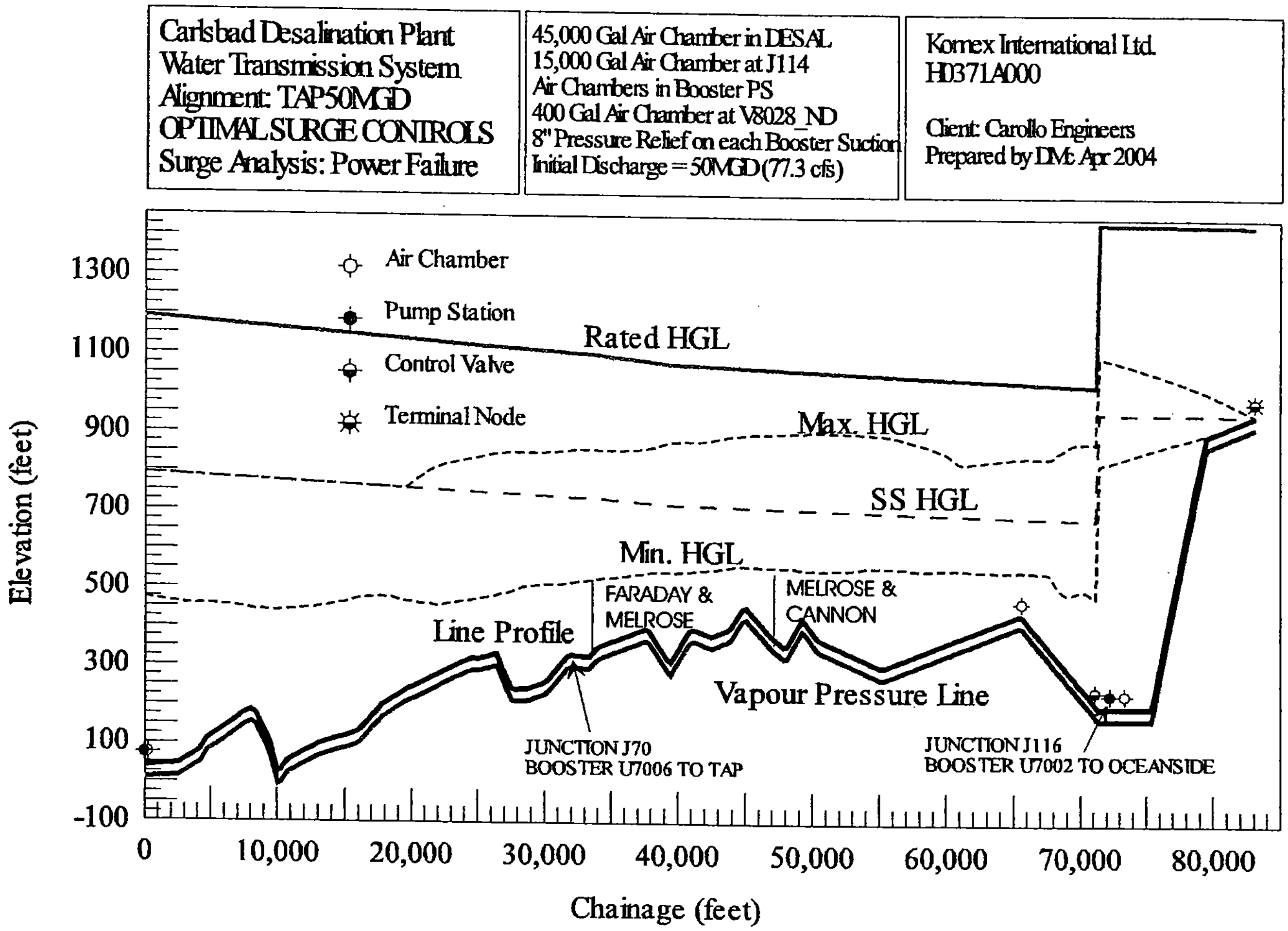

Figure 12. Extreme head summary for optimal surge controls on TAP50MGD alignment.

2. For preliminary design, cost estimating, and right-of-way or property acquisition, surge control locations and capacities should be adopted as listed in Tables 1 through 4. The analyses assume a horizontal air chamber configuration, but a vertical alignment would generally produce similar performance;

3. A nominal 8-inch pressure relief valve should be installed on the suction side of each booster pump station. Each pressure relief valve should be vented to atmosphere to achieve the necessary discharge capacity to reduce the maximum surge pressure on the upstream side of the booster stations. Due to the large pressure difference generated across the valves, anti-cavitation devices would be required. If multiple valves in series are used to decrease the maximum head loss across any individual valve, the correct sizing of the valves in series should be confirmed by re-running the transient model. Drainage facilities for water discharged by the valves will need to be provided.

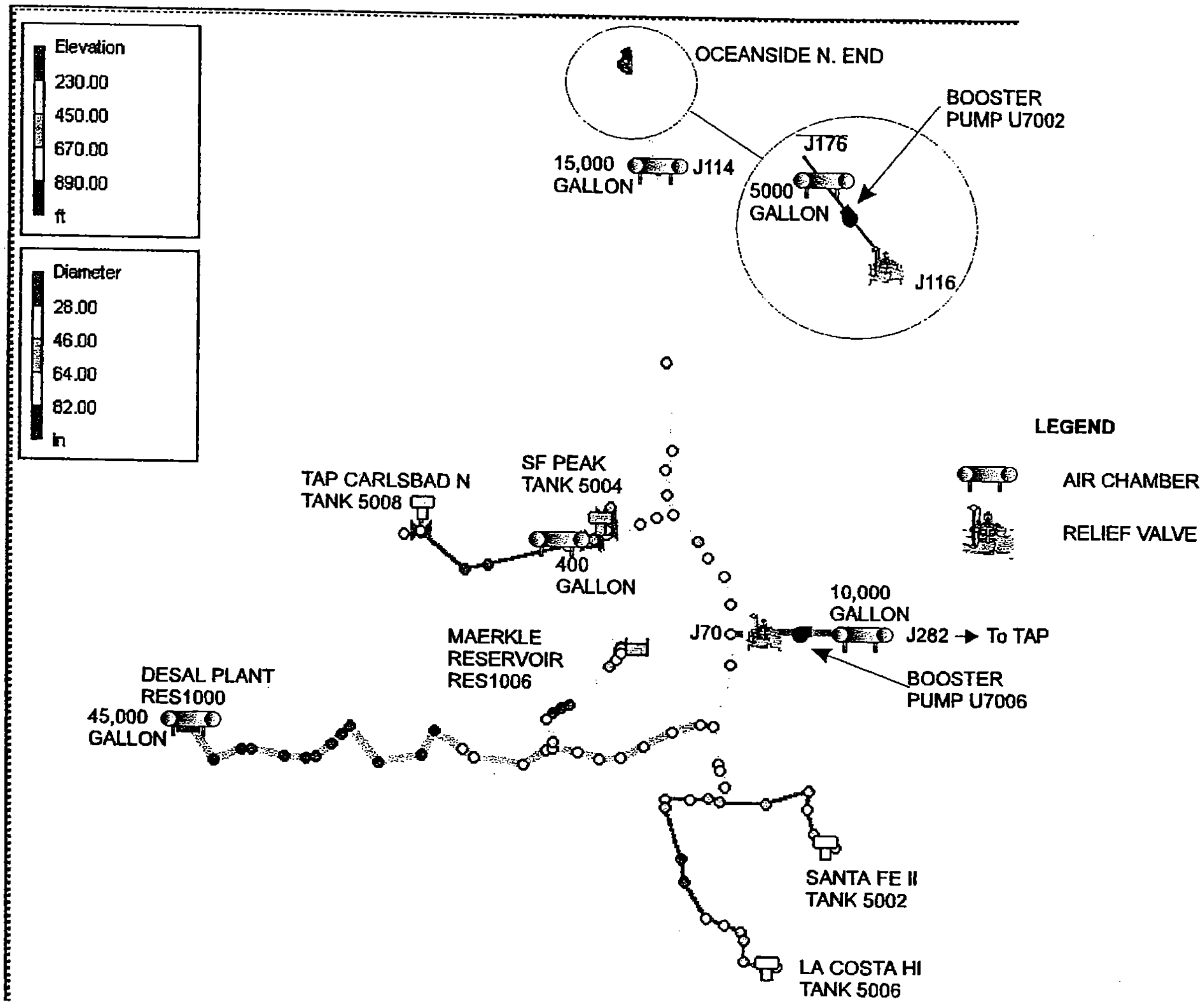

Figure 13. Schematic summary of recommended surge controls for TAP50MGD alignment.

TABLE 2. RECOMMENDED OPTIMAL SURGE CONTROLS FOR TAP50MGD ALIGNMENT

Surge Facility / Device	Location	Capacity
Air Chamber	Discharge header at DESAL plant	45,000 gallons
Air Chamber	High Point Junction J114	15,000 gallons
Air Chamber	Booster Pump Station Discharge U7002	5,000 gallons
Air Chamber	Booster Pump Station Discharge U7006	10,000 gallons
Air Chamber	Downstream of Valve V8028	400 gallons
Pressure Relief	Booster pump suction side U7002 and U7006	8-inch

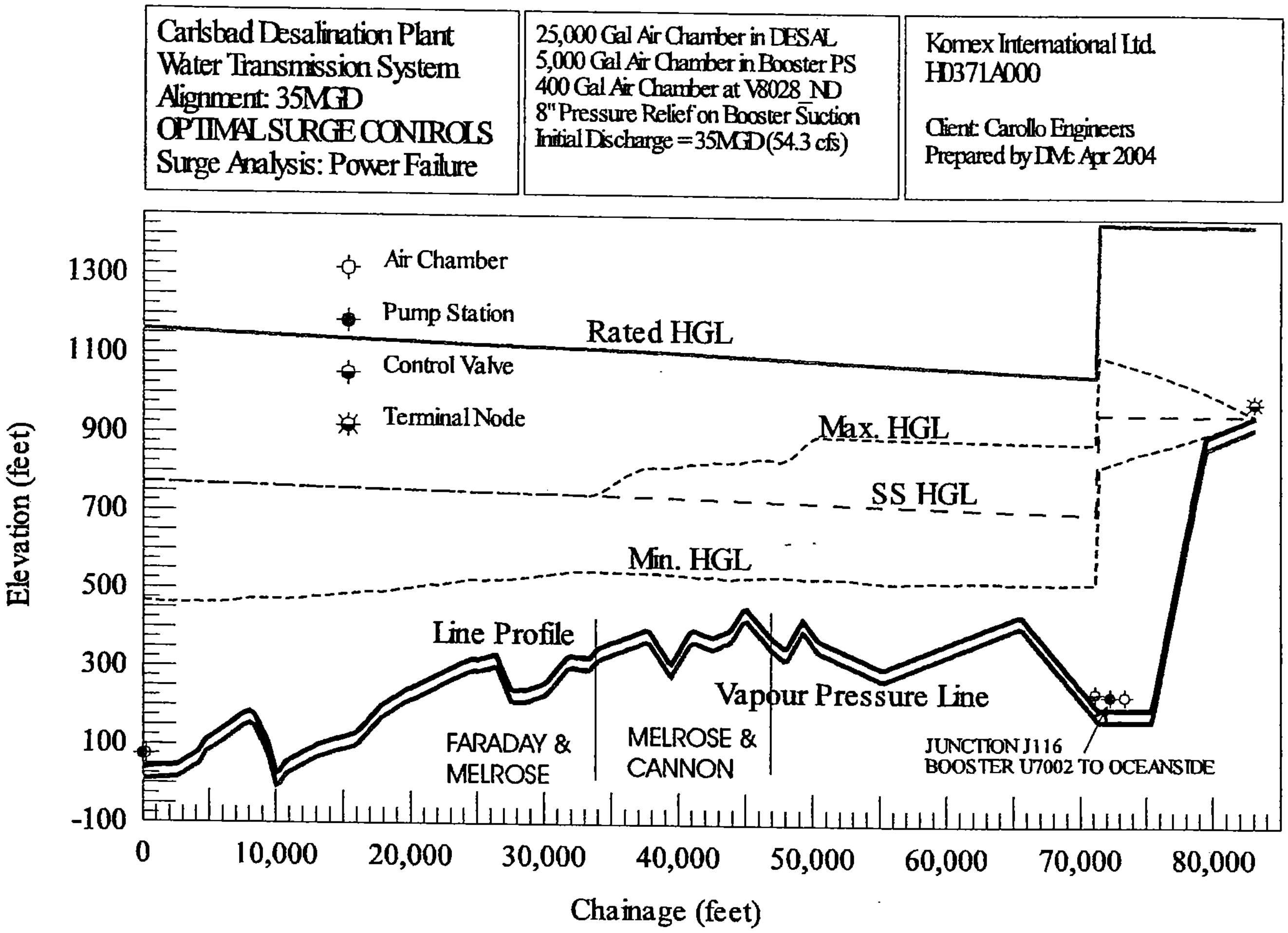

Figure 14. Extreme head summary for optimal surge controls on 35MGD alignment.

The pressure relief valves in the transient model were assumed to open quickly in 3 seconds and to close slowly in 60 seconds. The high pressure setpoint in the model was specified at 880 feet above sea level (equivalent to a gauge pressure of 293 psi for an assumed suction pipe elevation of 200 feet). The total combined discharge volume during the transient event was approximately 1000 ft^3, and the combined peak discharge rate from both valves was 28 ft^3/s;

4. The air chamber capacities recommended in this report are the <u>minimum</u> required to meet the specified design criteria. Should an air chamber be taken off-line, maximum and minimum pressure criteria may be exceeded if a transient event takes place. It is sometimes advisable to supply the required air chamber capacity by using two or more smaller tanks with the same (or some multiplier of the) required capacity. In this way, a tank may be taken off-line for maintenance without severely compromising the efficacy of the surge controls; and,

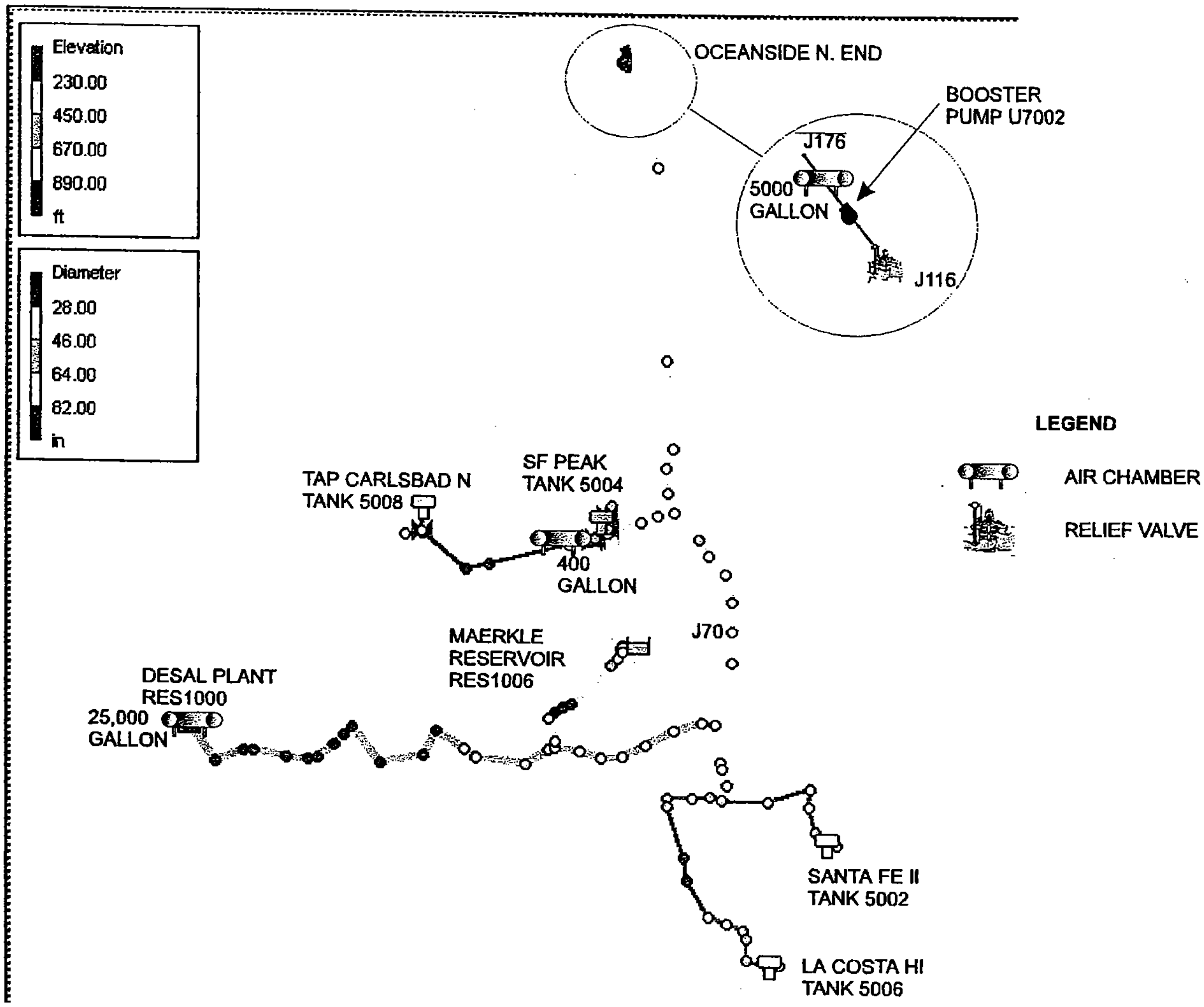

Figure 15. Schematic summary of recommended surge controls for 35MGD alignment.

5. The current analysis is based on preliminary information suitable for route and alignment selection and preliminary cost estimates. The final selected alignment should be subjected to a more rigorous assessment of all relevant transient

TABLE 3. RECOMMENDED OPTIMAL SURGE CONTROLS FOR 35MGD ALIGNMENT

Surge Facility / Device	Location	Capacity
Air Chamber	Discharge header at DESAL plant	25,000 gallons
Air Chamber	Booster Pump Station Discharge U7002	5,000 gallons
Air Chamber	Downstream of Valve V8028	400 gallons
Pressure Relief	Booster pump suction side U7002	8-inch

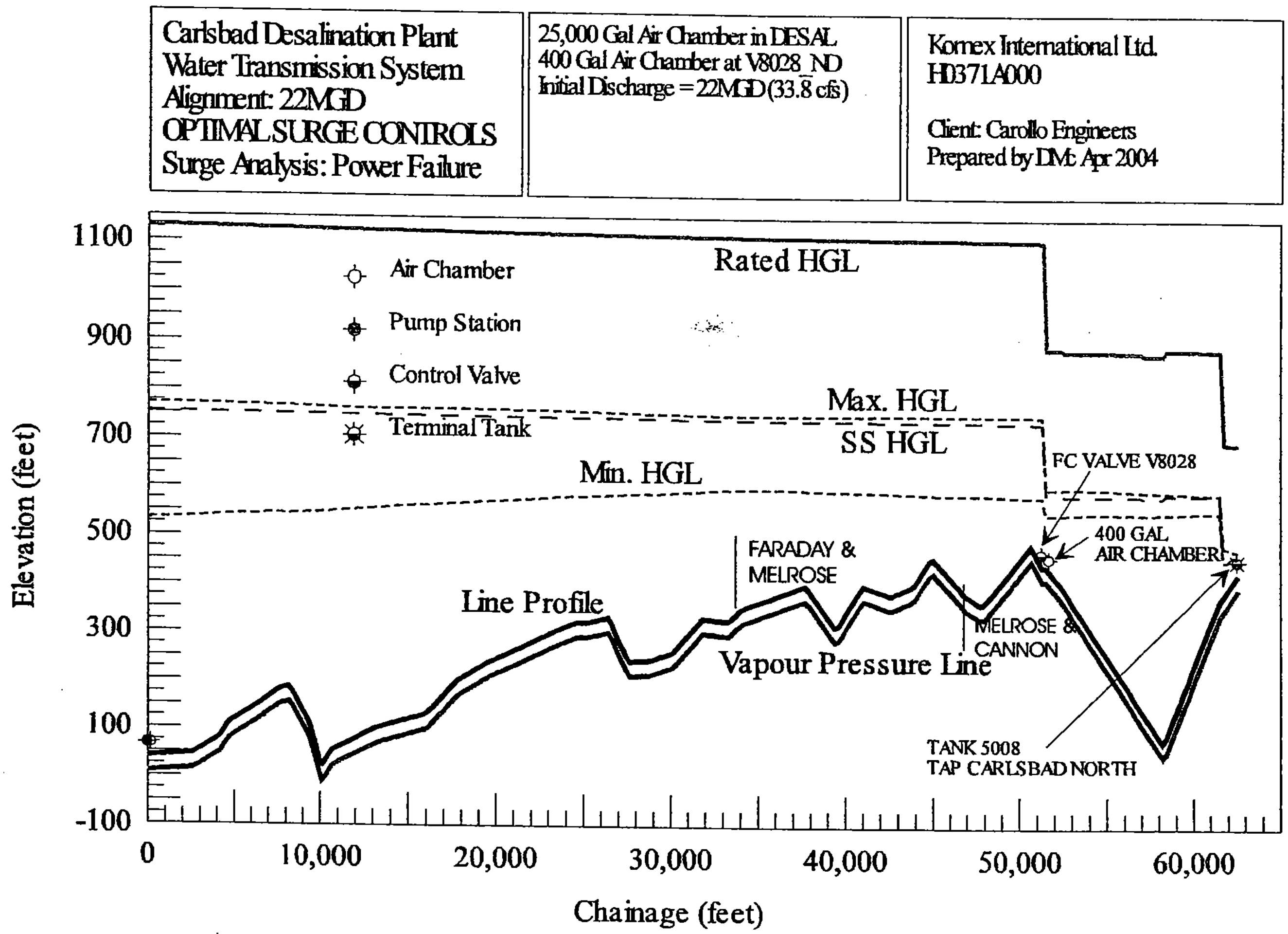

Figure 16. Extreme head summary for optimal surge controls on 22MGD alignment.

phenomena, including normal pump starts and stops, line filling or re-filling, as well as abnormal pump operations. A detailed analysis is necessary to confirm the results provided by this preliminary analysis and to refine assumptions and design parameters for the final surge control system, especially as regards the discharge network components associated with the two booster pumping stations.

TABLE 4. RECOMMENDED OPTIMAL SURGE CONTROLS FOR 22MGD ALIGNMENT

Surge Facility / Device	Location	Capacity
Air Chamber	Discharge header at DESAL plant	25,000 gallons
Air Chamber	Downstream of Valve V8028	400 gallons

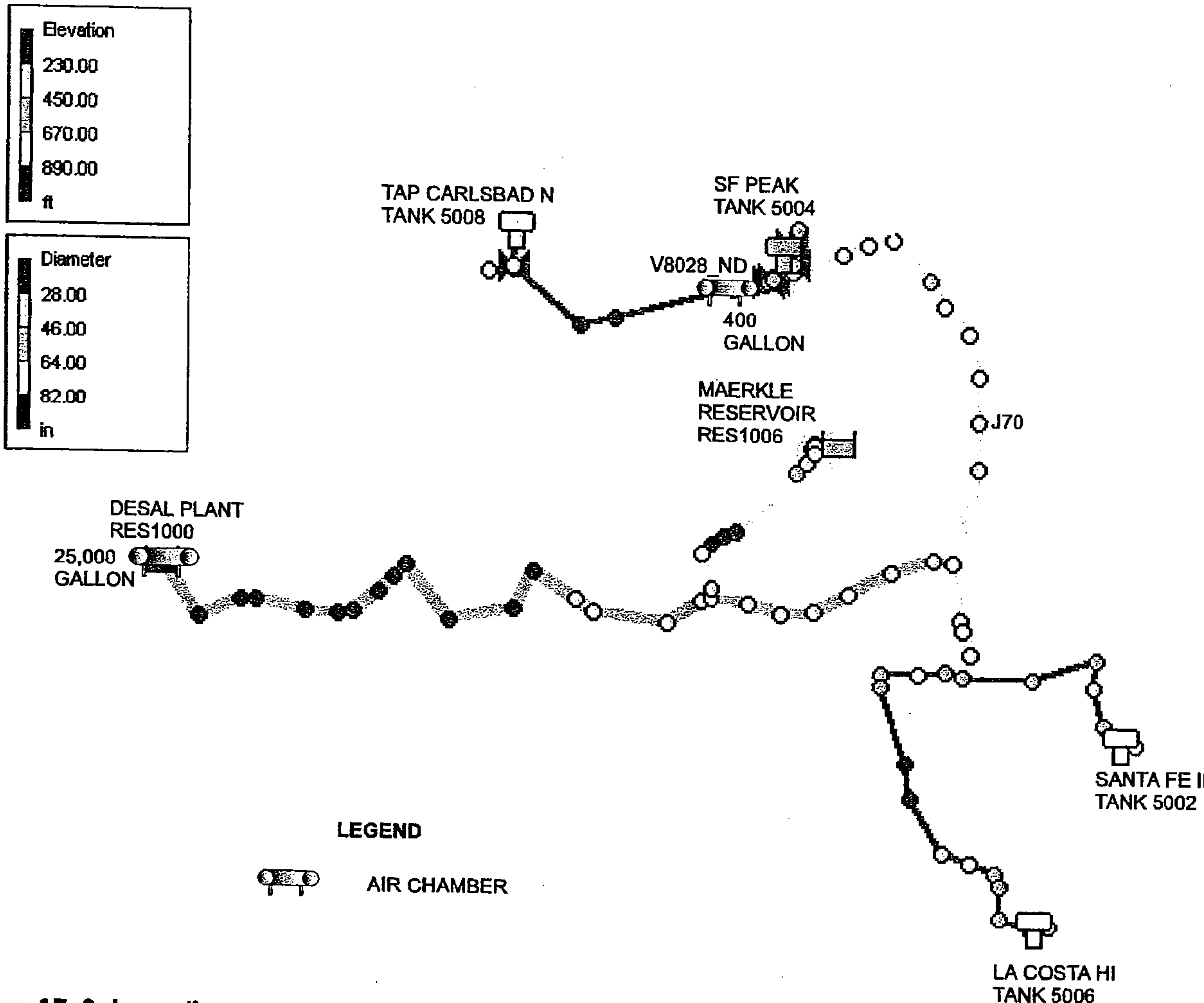

Figure 17. Schematic summary of recommended surge controls for 22MGD alignment.

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Any questions concerning the information or its interpretation should be directed to Duncan McInnis.

12 CLOSURE

Should you have any queries about the contents of this report, please contact the undersigned.

Respectfully,

KOMEX H2O SCIENCE INC.

Andy Gray, M.S., P.E.
VP Engineering

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Engineering Manager (Surface Water)

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ENVIRONMENT AND WATER RESOURCES

August 11, 2004
H0371A000

Carollo Engineers
5575 Ruffin Road, Suite 200
San Diego, CA 92123

Attn: Mr. Donn Wilcox, PE

Re: **ADDENDUM TO FINAL REPORT: Transient analysis of NCDP50mgd with Revised Booster Pump Station Location.**

Mr. Wilcox:

Please find enclosed a technical memorandum as requested addressing the performance of the NCDP50mgd alignment with the revised booster pumping station location. In summary, we find that the performance of the revised pipeline system remains adequate without the 15,000 gallon air chamber at Junction 114.

If you have any questions regarding this report, please call Duncan McInnis at 403.247.5702 or the undersigned at 714.379.1157 x154. We appreciate this opportunity to be of continued service to you and Carollo.

Respectfully Submitted,
KOMEX

Andrew Gray, PE
Project Manager

MEMO

TO: Mr. Donn Wilcox, PE **DATE:** August 10, 2004

FROM: Duncan McInnis, PhD, PEng **PROJ #:** H0371A000

RE: ***Transient analysis of NCDP50mgd with Revised Booster Pump Station Location.***

Introduction

The booster pump stations at the north end of the project have been re-located from Junction 116 to near Junction 114. This significantly reduces the length of the 36" pipe connecting the high point at Junction 114 to the suction side of the NCDP and Oceanside booster pumping stations (Junction 116) by about 5,000 feet. The booster pump stations will now be located approximately 1,000–1,500 feet west of Junction 114 at about the same elevation, *i.e.*, 200 feet above sea level. The transient analysis (Komex 2004) indicated that the interaction of waves between the suction side of the booster pumping stations and some of the higher elevation reaches of the system were sensitive to the location of the booster pump stations. Thus, the maximum flow case of 50 million gallons per day (mgd) using the NCDP alignment has been re-analyzed to assess the minimum surge protection requirements and performance of the revised alignment.

Junction 114 is the location of the recommended 15,000 gallon air chamber. The analysis presented herein addresses the performance of the revised system with and without the 15,000 gallon air chamber located at Junction 114.

Model Assumptions

The revised transient model makes the following additional assumptions:

1. The elevation of the booster pumping stations remains the same as in previous analyses (*i.e.*, 200 feet above sea level);
2. As actual pipe materials and pressure rating are not yet available, a notional rated hydraulic gradeline ("Rated HGL") calculated as 1.5 times the elevation of the steady state hydraulic gradeline has been used as a basis for assessing the adequacy of surge protection. As this definition does not account for the reduction in actual operating pressure due to pipe elevation, final selection of pipeline pressure rating and surge protection design should be confirmed when actual materials are specified;
3. The booster station pumping flows, system head and configuration of "notional" discharge pipelines remains the same as previous analyses; and,
4. The length of pipe connecting the high point at Junction 114 to the suction side of the booster pumping stations is assumed to be 1,250 feet. Pipeline diameter and physical properties such as roughness and wavespeed remain the same as previous analyses.

Transient Analysis

Power failure to all pumps was analyzed as the critical representative case to assess the performance of the revised system. Figure 1 is an extreme head summary for the revised pipeline showing maximum and minimum heads along the shortened profile from the Desalination (DESAL) Plant pumping station to the end of the notional NCDP Booster Pump Station and discharge pipeline.

For comparison, Figure 2 is the extreme head summary for the earlier configuration of the NCDP50mgd alignment with the 15,000 gallon air chamber included at Junction 114. Although some minor differences are visible between the two plots, the behavior of the revised system is similar to the original alignment even though the 15,000 gallon air chamber has been excluded from this configuration. This fortuitous elimination of the Junction 114 air chamber is possible because the shortened length of the segment leading to the booster pump station allows the positive pressure wave created by flow "build-up on the suction side of the pumps to be propagated more rapidly upstream where it interacts with, and reduces, the magnitude of downsurge caused by the negative pressure wave emanating from the DESAL Pumping Plant.

In the original alignment, the Junction 114 air chamber was also required to maintain positive pressures in other upland areas of the transmission and distribution system. Figure 3 shows a plot of all pipe segments within the original alignment and the minimum pressure that occurs at each of these locations in the absence of the Junction 114 air chamber. The key information in the plot is the number of negative pressures values located below the zero pressure (atmospheric pressure) line. The original alignment was predicted to experience more widespread areas of negative pressure during power failure without the addition of the 15,000 gallon air chamber at Junction 114. The reduction in potential for negative pressure to develop in elevated areas of the system is clearly illustrated in Figure 4. The most prominent occurrence of negative pressure relates to the "notional" discharge pipeline from the booster station to the NCDP zone at terminal elevation of 1,100 feet. As the discharge pipeline is notional only, the negative pressure prediction is simply a reflection of the assumed profile of this line rather than any prediction of actual conditions. The remaining occurrences of negative pressure are most likely spurious negative pressures at isolated nodes adjacent to valves and are due to the imperfect nature of numerical modeling scheme at certain boundaries. Close examination of the numerical results did not suggest that these artifacts represented true potential for negative pressures.

Figure 5 shows that the performance of the revised alignment without the Junction 114 air chamber adequately controls the potential for negative pressures in upland areas.

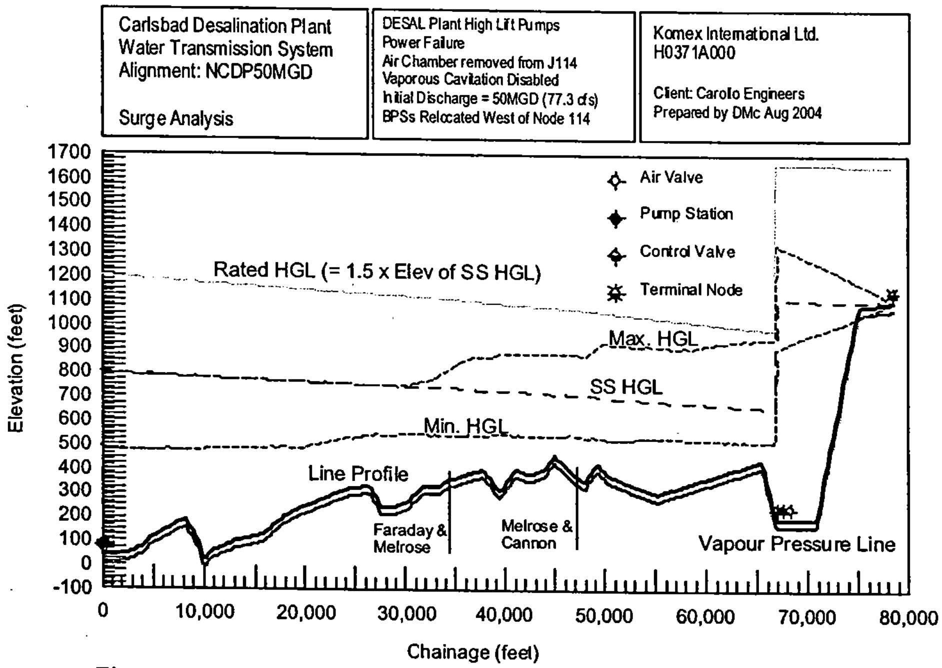

Figure 1. Extreme head summary for revised booster pump station location. 15,000 gallon air chamber removed from Junction 114.

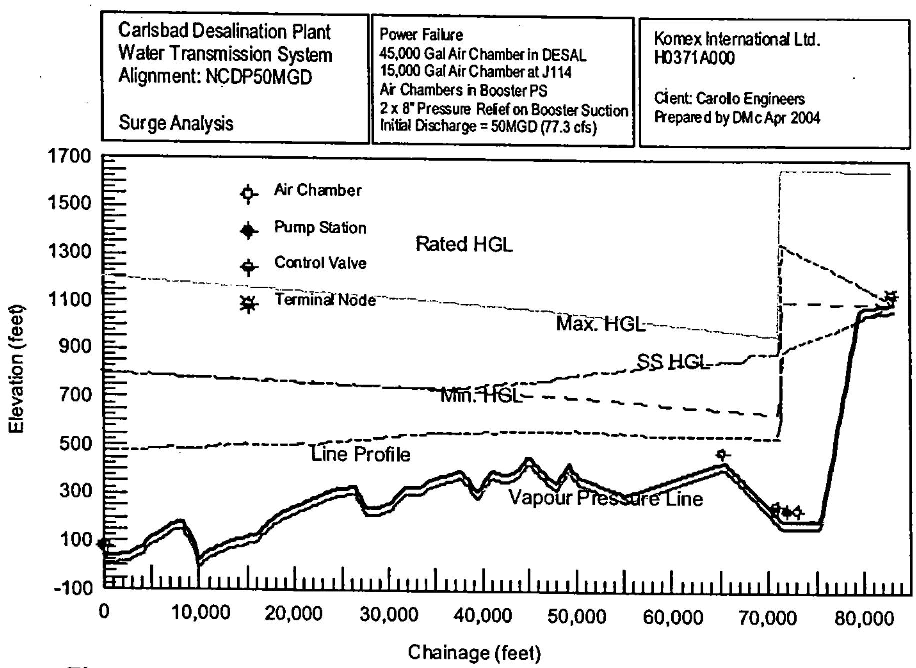

Figure 2. Extreme head summary for original NCDP50mgd alignment with 15,000 gallon air chamber at Junction 114.

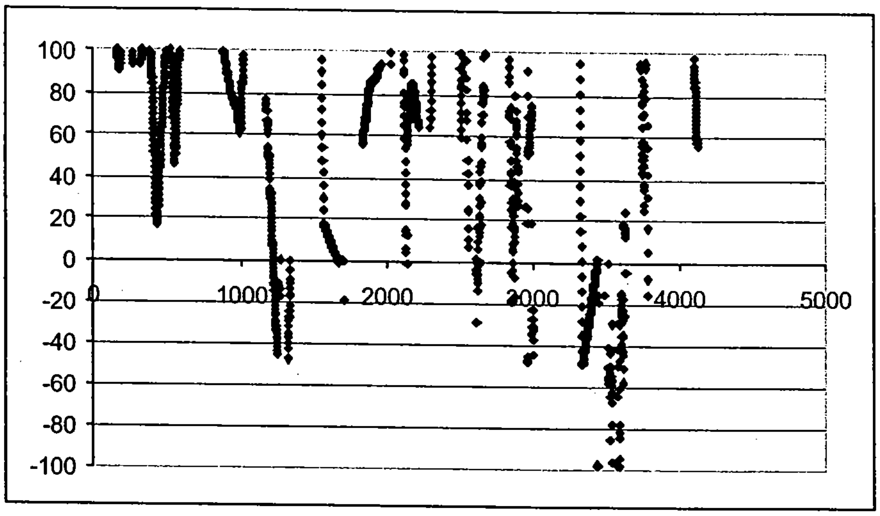

Figure 3. Occurrence of minimum pressure on original NCDP50mgd alignment without Junction 114 air chamber.

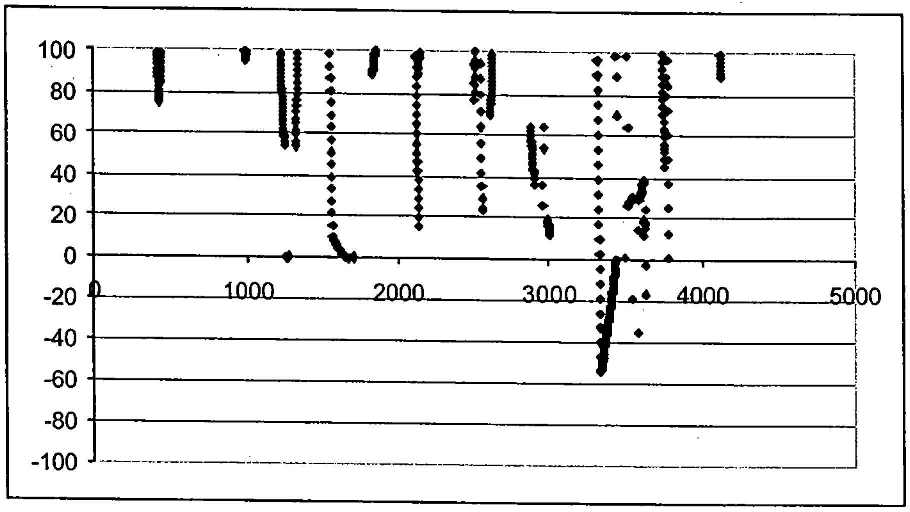

Figure 4. Occurrence of minimum pressure on original NCDP50mgd alignment with Junction 114 air chamber.

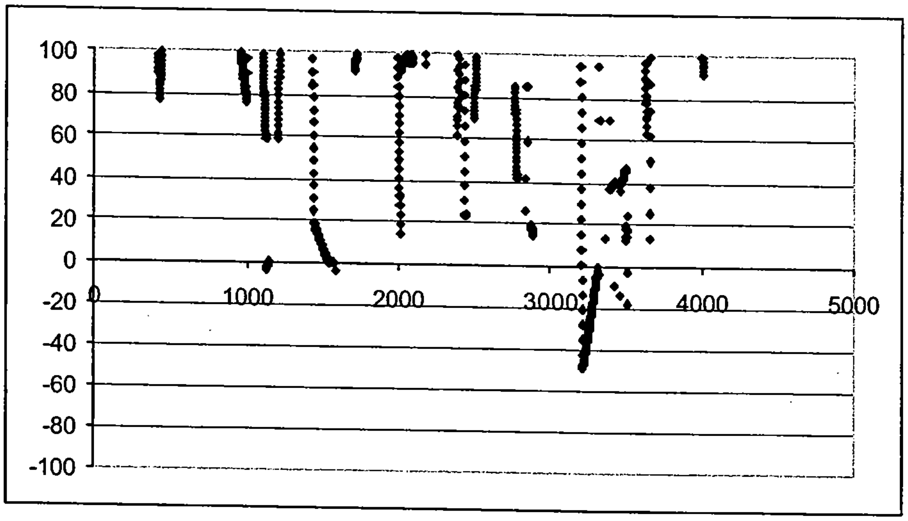

Figure 5. Occurrence of minimum pressure on revised NCDP50mgd alignment without Junction 114 air chamber.

Pressure Relief Valve Discharge

Each of the two pressure relief valves provided on the suction side of the booster pump stations will discharge water as follows:

Peak Discharge Rate	32 ft^3/s
Maximum Head Loss Across Valve	745 ft
Total Discharge Volume[1]	920 ft^3

References

1. Komex (2004). *Transient Analysis for Alternative Alignments of the Carlsbad Desalination Project Potable Transmission System.*

[1] Total for two valves based on a single opening and closure event of approximately 60 seconds duration.