carollo engineers

TECHNICAL MEMORANDUM

Memorandum No. 6

SUBJECT:	Evaluation of Reverse Osmosis By-product Disposal **Alternative H:** Disposal to a Landfill by Thermal Zero Liquid Discharge Processing
TO:	Mark Atencio and Stakeholder Forum Members
COPIES:	Richard Bay, JVWCD Paula Doughty, KUCC Douglas Bacon, UDEQ
FROM:	Thomas F. Seacord, P.E. - Carollo Engineers, P.C.
DATE:	April 13, 2004

EXECUTIVE SUMMARY

This alternative consists of converting the RO by-product water to a solid waste by evaporating and recovering the water in a sequence of mechanically enhanced thermal desalination processes. This conversion is referred to as Zero Liquid Discharge (ZLD) and the final waste product (i.e., salt) is disposed to a landfill. This evaluation considered treating waste from both a combined Zone B and Lost Use facility, referred to as the West Jordan Treatment Plant, and a Lost Use only facility. The net present values and estimated capital and operating costs for each alternative are:

- Combined Zone B and Lost Use ZLD Facility
  - Capital Cost: $22.1-million
  - O&M Cost: $3.2-million
  - Net Present Value: $93.9-million

- Lost Use only ZLD Facility
  - Capital Cost: $10.4-million
  - O&M Cost: $1.1-million
  - Net Present Value: $34.7-million

Due to the high cost of ZLD processing, combined with conflicts with community values (i.e., aesthetics) established during the stakeholder forums, further consideration of this alternative is not warranted.

BACKGROUND

Mining activities in southwestern Salt lake Valley have created groundwater contamination, with elevated sulfate concentrations. A 1995 federal Consent Decree negotiated by Jordan Valley Water Conservancy District (JVWCD), Kennecott Utah Copper Corporation (KUCC) and Utah Department of Environmental Quality (UDEQ), established a natural resource damage Trust Fund which was paid by KUCC. The Consent Decree established purposes for use of the Trust

Fund as:

- remediating the aquifer
- containing the contamination plumes; and
- restoring the beneficial use of the contaminated aquifer by producing municipal quality water through treatment.

Dr. Dianne R. Nielson, Executive Director of UDEQ, has been appointed as Trustee of the Trust Fund and of projects to accomplish the Consent Decree purposes.

JVWCD and KUCC have submitted a Joint Proposal project to the Trustee to accomplish the Consent Decree purposes. The Joint Proposal involves one reverse osmosis (RO) treatment plant and facilities to treat western Zone A deep groundwater; and one RO plant to treat eastern Zone B deep groundwater and Lost Use shallow groundwater. The Trustee held a public information and public comment period during August through November 2003.

As a result of the public comments, JVWCD withdrew its Zone B/Lost Use RO by-product water discharge permit to the Jordan River and renewed efforts to find a better disposal alternative. The Trustee established a Stakeholder Forum for southwest groundwater remediation issues in early 2004. JVWCD has sought input from the Stakeholders Forum as it considers various alternatives for disposal of Zone B/Lost Use RO by-product water.

Zone B/Lost Use by-product water is projected to have the following characteristics:

	Flow Rate	**TDS Concentration**	**Selenium Concentration**
	(cfs)	**(mg/L)**	(µg/L)
Zone B	1.24	8,300	25
Lost Use	0.51	8,200	47
Total	**1.75**		
Weighted Average		**8,240**	**38 - 47**

PURPOSE

The purpose of this memo is to estimate the net present value and feasibility of processing the following RO by-product waters by ZLD treatment and disposing residual salts to a landfill:

- Zone B and Lost Use RO by-product waters from a combine facility referred to as the West Jordan Treatment Plant, and
- Lost Use RO by-product water

AUTHOR'S CREDENTIALS

Thomas Seacord is a licensed professional engineer in the state of Utah and specializes in the field of desalination. Tom is a senior project engineer with Carollo Engineers, P.C. and has a B.S. and M.S. in Civil Engineering from Clarkson University. He has been involved in the planning, design, construction and start-up of desalination plants in California, Florida, Kansas, South Carolina, Texas, and Utah. Tom is a Director of the American Membrane Technology Association (AMTA) and chairs the desalination by-product disposal committee. Tom also serves as a technical advisor for the largest research project the American Water Works Association Research Foundation (AwwaRF) has ever funded on the topic of zero liquid discharge and volume minimization for disposal of desalination by-product waters for inland applications.

DESCRIPTION OF ALTERNATIVE

Zero liquid discharge (ZLD) processing of RO by-product waters consists of a mechanically enhanced thermal evaporation process and a final crystallization process. The final waste product is a solid waste (i.e., 40 dry tons of salt per day, 5 to 15% moisture content) that can be disposed of in a landfill. Typically, the final crystallization process takes place within an evaporation pond that may vary in size from 3 to 5 acres. Evaporation ponds are most frequently used because it is the most cost effective crystallization alternative. However, due to potential environmental impacts such as liner failure and water fowl exposure to toxic inorganic compounds, the District has eliminated evaporation ponds from consideration. Therefore, final crystallization for this project also uses a mechanically enhanced thermal process.

Figure 1 depicts a process flow diagram for a typical ZLD process. As indicated, it consists of a brine concentrator followed by a crystallization process. Each ZLD process equipment supplier has their own variation on this basic concept. However, each supplier's technology uses a combination of heat and pressure (i.e., positive or negative pressure) to enhance the evaporation and crystallization process. The example presented in Figure 1 uses vapor compression (e.g., heat pump) to enhance the thermodynamics of the evaporation/distillation process. A combination of chemical conditioning and a brine slurry recirculation is also commonly used prevent mineral scale build-up within the equipment and on the heat exchanging surfaces.

ESTIMATION METHODS

Since this project will be built using public money, it is in the public interest to make certain that the technologies evaluated are feasible and the supplier of the equipment is capable of providing service for this application. Carollo issued a Request for Budgetary Quotations (Appendix A) to the following ZLD equipment suppliers:

- ALAQUA, Inc., Guttenberg, NJ
- AquaTek, Inc., Canonsburg, PA
- IWS/Equus Environmental, Auckland, New Zealand
- Ionics RCC, Bellevue, WA
- Swenson Technology, Inc., Monee, IL

Only those suppliers providing responsive quotations with the appropriate experience and finances were considered. These responses were comparable to published cost data (Mickley, 2001) and therefore, deemed acceptable for estimating purposes.

[INSERT FIGURE 1]

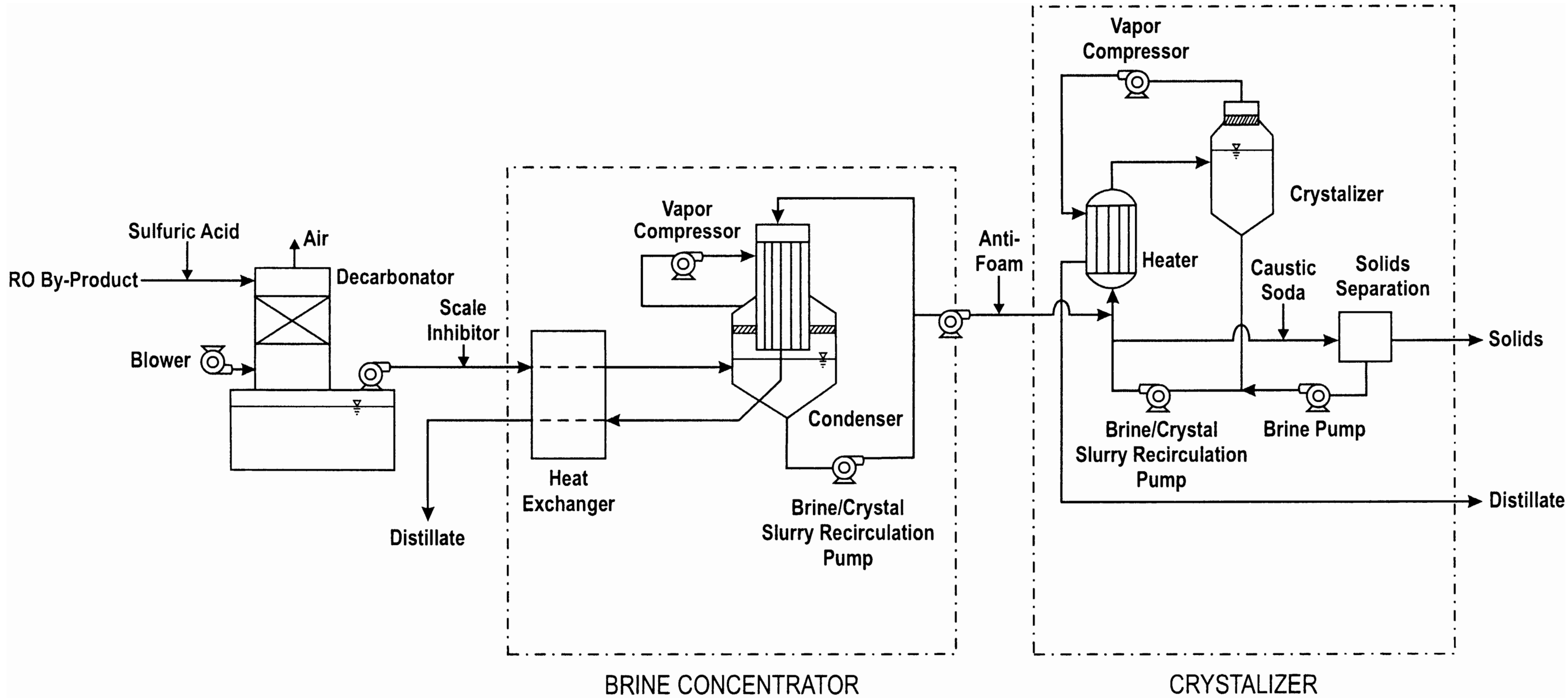

Figure 1
Example ZLD Process Flow Diagram
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DESIGN CRITERIA

Design criteria for a ZLD process used to treat RO by-product from the Southwest Groundwater Treatment Project is presented in Table 1. Unit costs are also presented for key components related to operations and maintenance (O&M) of the ZLD facility.

Table 1 ZLD Process Design Criteria
Southwest Groundwater Treatment Project
Jordan Valley Water Conservancy District

Criteria	Value
Unit Costs	
Power	0.055 per kW-hr
Sulfuric Acid	\$0.10 per pound (as H_2SO_4)
Anti-scalant	\$1.5 per pound
Anti-foam	\$1.5 per pound
Caustic Soda	\$0.21 per pound (as NaOH)
Labor	\$40,000/person/year
Waste Disposal	\$42 per ton
Conditions	
RO Plant Operation	330 days/year
NPV Interest Rate	4%
ZLD Equipment Life	20 years
Operating Power Demand	3800 kW
Sulfuric Acid Demand	18,400 lbs/day
Anti-scalant Demand	45 lbs/day
Anti-foam Demand	12 lbs/day
Caustic Soda Demand	50 lbs/day
Labor	
Operators	3
Mechanics	1
Sludge Production	40 dry tons per day (5 to 15% moisture)

COST ESTIMATE

Estimated capital costs, operations and maintenance (O&M) costs, and Net Present Values (NPV) for a ZLD process used to treat RO by-product produced as a result of the Southwest Groundwater Treatment project are presented in Table 2. These costs reflect the operation costs associated with a typical vapor compression type brine concentrator and crystallizer. Itemized estimates are presented in Appendix B for each alternative.

Table 4	Estimated Costs for RO By-product Disposal via ZLD Processing Southwest Groundwater Treatment Project Jordan Valley Water Conservancy District
	Cost (2004 $)
Combined Zone B & Lost Use ZLD	
Capital Cost	$22,114,000
Annual Operating Costs	$3,197,100
Net Present Value	$93,876,000
Lost Use ZLD	
Capital Cost	$10,405,400
Annual Operating Costs	$1,036,300
Net Present Value	$34,736,600

It is important to note that due to this height of the ZLD process equipment (i.e., up to 90-feet), only the electrical, HVAC and chemical facilities are enclosed within the structure. Also, it is important to note that no redundancy is provided as part of this estimate. Redundancy would include an additional brine concentrator capable of treating 50% of the RO by-product flow and an additional crystallizer capable of treating 100% of the effluent from two brine concentrators. This redundancy would increase the capital cost estimates by the following:

- Combined Zone B & Lost Use Facility: $9.9-million
- Lost Use only Facility: $4.8-million

The NPVs presented in Table 2 can be used to compare the ZLD process to other alternatives. Consistent with the District's methods for calculating NPV, this calculation considers the project life, life of the ZLD equipment, and the interest rate for borrowed money. All of these criteria are specified in Table 1. It is important to note that the this selected method NPV calculation does not account for the impact of inflation over time. If inflation is accounted for, at a rate of 3.2% annually, the NPV for a ZLD process capable of treating both Zone B and Lost Use RO by-product waters is $144,236,000, and $52,000,000 for a ZLD process capable of treating Lost Use RO by-product only.

ENVIRONMENTAL IMPACTS

Salts produced from the ZLD plant are a primary environmental concern. These salts will consist primarily of calcium sulfate, however, trace concentrations of toxic inorganic contaminants (e.g., selenium) will persist. The fate of these toxic contaminants must be evaluated to assess the options available for final disposal of the waste salts produced. For disposal of the waste salts to a landfill, fate of the toxic contaminants is assessed by the following methods:

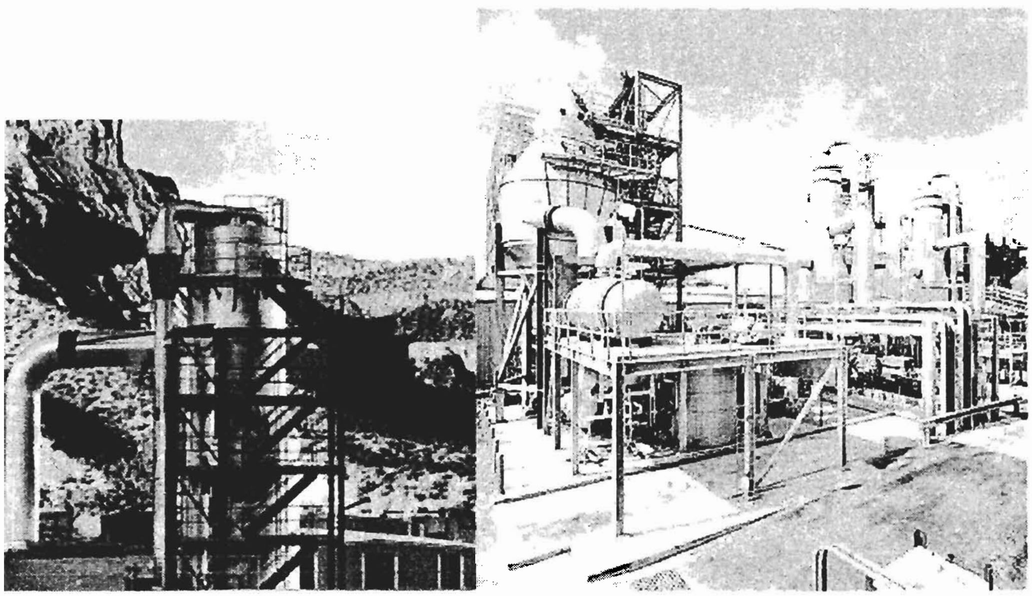
- EPA Paint Filter Test: Determines if the waste is a solid or liquid waste.
- Toxic Contaminant Leachate Potential (TCLP) Test: Determines if the toxic contaminants can leach from the solid waste.

Waste from the ZLD process is expected to pass both of these tests. The TCLP test is expected to be passed since the primary waste constituent is calcium sulfate and not calcium carbonate (carbonate is completely removed during primary chemical conditioning). However, before implementing a ZLD process, we recommend that a sample waste be produced and analyzed by the TCLP method.

AESTHETIC ISSUES

The District is committed to being a good neighbor to those adjacent to all of their treatment facilities. With this in mind, it is important to consider what aesthetic impacts the ZLD process may have and what people near 8215 South 1300 West in West Jordan may see and feel about this type of facility. Such issues as appearance and traffic generated by waste hauling and chemical delivery trucks must therefore be considered.

While the footprint for a ZLD plant can be quite compact, the profile can often be too tall to enclose within a structure. As presented in Figure 2, ZLD process equipment of similar capacity can reach 90 feet in height. Therefore, as presented in previously in the cost estimate, process equipment is proposed to be located outside of building. This profile view will create an industrial appearance to the District's facility, which may not be acceptable to neighbors adjacent to the treatment plant.



225-gpm Brine Concentrator
Utah Power & Light, Huntington, Utah

2, 150-gpm Brine Concentrators
& 1, 50-gpm Crystallizer
Bechtel/US Generating Co., Cedar Bay, Florida

Figure 2
Example Photos of ZLD Process Equipment
Jordan Valley Water Conservancy District

Public opinion may not be limited to the appearance of the ZLD process equipment. Traffic created by chemical delivery and salt hauling trucks, carrying waste from the ZLD plant to a landfill may also draw negative attention and must be considered before implementing this type of disposal alternative.

RECOVERABLE BY-PRODUCTS FROM ZLD

As indicated in Request for Budgetary Quotation (Appendix A), Carollo asked ZLD equipment suppliers to consider recovery of beneficial by-products when developing process concepts. However, only one supplier provided concepts to this effect. This supplier noted that the additional cost for processing the RO by-product to produce a beneficial by-product would not be recovered through sale of such recoverable by-products. Therefore, for the purpose of this evaluation, no cost credits from the sale of recoverable by-products are assumed.

FEASIBILITY

ZLD by the methods described in this memo is a proven technology that has been widely used in the chemical processing and power industries for several decades. Key to the robustness and cost-effectiveness of these processes are chemical conditioning and brine slurry recirculation techniques used to control mineral scale build-up on the heat exchanging surfaces. Based on the methods and concepts presented within this memorandum, ZLD is technologically feasible.

A feasibility assessment must also consider environmental impacts and community values related to the aesthetics of the ZLD process. Fate of the toxic inorganic impurities, found naturally in the Southwest Groundwater is a concern for when considering the final disposal of the salts generated from the ZLD process. To be landfilled, the waste must pass both TCLP and EPA Paint Filter Tests. While we expect these tests may be passed, a sample waste must first be generated and evaluated by these test methods before further consideration may be given to this alternative. However, based on the criteria presented in the District's stakeholder forum memorandum, appearance of the ZLD process equipment and traffic generated by chemical delivery and waste disposal trucks will likely not meet with community values. This combined with the high NPV cost, make ZLD disposal of RO by-product water less feasible than other viable alternatives and further consideration of this alternative is not required.

REFERNCES

Mickley, M. 2001. Membrane Concentrate Disposal: Practices and Regulation. USBR Desalination and Water Purification Program Report No. 69.

APPENDIX A

Request for Budgetary Quotation

To: ZLD Equipment Suppliers

From: Thomas F. Seacord, P.E.

Date: March 24, 2004 **WO#:** 6710C.00 T05

Subject: ZLD Equipment Budgetary Quotation - ***Revision 1***

Carollo Engineers is assisting the Jordan Valley Water Conservancy District with an evaluation of reverse osmosis (RO) by-product disposal via Zero Liquid Discharge at a location adjacent to the District's main office in West Jordan, Utah.

REQUEST FOR INFORMATION

Carollo requests the following information, itemized as presented below, from ZLD equipment suppliers to treat a flow of 557-gpm of Zone B and 229-gpm of Lost Use RO by-product water. Water quality analyses presented in Tables 1 and 2 for Zone B and Lost Use RO by-product, respectively. Waters may be mingled at the discretion of the ZLD equipment supplier.

- **Process Flow Diagram:** Include a description of scale control to protect integrity of the heat transfer surface (e.g., calcium sulfate slurry circulation, acidification/decarbonation, etc.). Note that based upon the District's *Good Neighbor Policy*, discharge to an evaporation pond is not an acceptable means of final stage processing.

- **Budgetary Quotation for ZLD Treatment Equipment:** Complete ZLD trains with all on-skid piping, pumping, valves and instrumentation. All heat transfer surfaces and surfaces exposed to non-recovered RO by-product, brine, and harsh chemicals shall be titanium. All other metallic parts shall be, at a minimum, electropolished 316L stainless steel. Also include chemical feed equipment (include day storage, but not including bulk chemical storage), and chemical cleaning equipment. Assume one redundant chemical feed pump per chemical feed system, per the requirements of *Recommended Standards for Waterworks*. Include as part of the treatment equipment cost, the cost of a warrantee, prorated over the expected life of the equipment. State the expected life of the equipment.

- **Budgetary Quotation for Redundant ZLD Treatment Equipment:** Equal to 20% of the total flow, but not less than the size of the largest treatment train, per the requirements of *Recommended Standards for Waterworks*. Include as part of the treatment equipment cost, the cost of a warrantee, prorated over the expected life of the equipment.

- **Chemical Dose Requirements:** State type of and dose for each chemical used during the continuous operation of the treatment equipment. The engineer will use this information to estimate chemical consumption costs and estimate costs and size of the chemical storage facilities per the requirements of *Recommended Standards for Waterworks*.

- **Electrical Requirements:** Size of electrical power demand in Kilowatts. Include pump or heat transfer inefficiencies in this requirement. Engineer will use this number to estimate the cost of electrical switchgear and other ancillary electrical equipment supplying power to the ZLD process.

- **Shipping and Installation Costs:** State cost of shipping and point of origin. Delivery will be to West Jordan, Utah. Installation costs should include any field service representatives required through start-up of the equipment.

- **Estimated Maintenance Costs:** Estimated annual costs for
    - chemical cleaning,
    - replacement parts, and
    - consumables.

- **Labor Requirements:** State the number of operators and mechanics required to operate your equipment each day. Operators and mechanics are assumed not to perform overlapping duties. This number will be adjusted to reflect staffing for each week.

- **Cost of Performance Bond:** Estimate the cost of providing a performance bond for the:
    - First year of operation.
    - First five years of operation

  Conditions of the performance bond will be based upon annual O&M estimates. If O&M is higher than estimated, bond conditions will require ZLD supplier to pay the difference.

- **Description of Final By-product:** Estimate volume and percent solids of final salt by-products for engineer to determine costs for final disposal.

- **Foot Print Size:** For the ZLD equipment, redundant ZLD equipment, and Chemical Cleaning Equipment.

- **Installation List:** Provide a list of installations treating water of similar quality, their capacity, and year installed.

- **Company Information:** Provide information on your company, including but not limited to:
    - years in business under the name you currently use, and
    - an annual financial statement of earnings.

BENEFICIAL USE OF ZLD BY-PRODUCTS

ZLD Equipment suppliers are encouraged to identify innovative ways to create beneficial use of ZLD by-products. We ask, however, that you assume a 40 ppb concentration of selenium in the by-product. Therefore, any beneficial use must be qualified by the appropriate removal of selenium. If beneficial use is presumed, state its use and estimate the value of the salt product. Provide a reference to qualify any assumed value of salt used for resale.

While the District is open to alternatives that may result in the production of beneficial by-products from ZLD processes, we wish to remind ZLD Equipment Suppliers that we still intend to evaluate disposal of by-products by conventional means. Please be certain to provide a description of the by-products as requested in the above itemized list.

ESTIMATED BY ENGINEER

Using the information provided in the above request, Carollo will estimate the total capital costs including structural, site civil, electrical, HVAC, chemical storage, and cost effective disinfection required to meet appropriate state standards (e.g., UV, chlorine, etc.). Carollo will also estimate annual O&M costs for power and chemicals based upon local conditions. Along with other annual O&M costs/credits provided by the ZLD supplier (i.e., chemical cleaning, maintenance, resale of salts, etc.), a present value analysis will be completed.

QUESTIONS

Please direct your questions to:

Thomas F. Seacord, P.E.
Carollo Engineers, P.C.
12592 West Explorer Drive, Suite 200
Boise, ID 83713
Email: tseacord@carollo.com
Phone: (208) 376-2288
Fax: (208) 376-2251
Mobile: (208) 863-0525

TIME OF RESPONSE

Please respond with the itemized information requested above by April 7, 2004.

Table 1 Zone B Pilot Test - Average Water Quality
Reverse Osmosis Pilot Study
Jordan Valley Water Conservancy District

Parameter	Unit	Well Water	Permeate	By-product
Alkalinity	mg/L as $CaCO_3$	378	13.3	1876
pH	S.U.	6.96	5.76	7.51
Temperature	^{o}C (^{o}F)	16 (61)	-	-
Conductivity	mS/cm	2.37	0.067	9.73
TDS	mg/L	1630	17	8680
Total Hardness	mg/L as $CaCO_3$	1115	7.2	5890
Turbidity	NTU	0.24	NA	NA
Silt Density Index	-	1.02	NA	NA
Calcium	mg/L	305	< 1.0	1500
Magnesium	mg/L	89.5	0.2	540
Sodium	mg/L	130	3.7	500
Potassium	mg/L	4.8	< 1.0	18
Barium	mg/L	0.028	< 0.002	0.15
Strontium	mg/L	0.93	< 0.01	4.7
Carbon Dioxide	mg/L	82 [a]	82 [b]	99 [a]
Carbonate	mg/L	0.2	0.0	2.0
Bicarbonate	mg/L	378	16.2	2010
Sulfate	mg/L	737	< 2.0	3100
Chloride	mg/L	200	2.5	920
Fluoride	mg/L	0.08	< 0.05	0.29
Silica				
Reactive	mg/L as SiO_2	26.0	< 1.0	210
Total	mg/L as SiO_2	33.5	< 1.0	220
LSI		+ 0.2	- 4.8	+ 2.3
$CaSO_4$ Saturation	%	34.4	0.0	256
$BaSO_4$ Saturation	%	332.9	0.0	2430
$SrSO_4$ Saturation	%	6.7	0.0	51
SiO_2 Saturation	%	27.5	0.0	135

Notes:
NA Not available
a Equilibrium concentration of $CO_{2(g)}$ based on alkalinity, pH, and temperature
b Based on feed water concentrations of $CO_{2(g)}$

Table 2	Lost Use Pilot Test - Average Water Quality Reverse Osmosis Pilot Study Jordan Valley Water Conservancy District			
Parameter	**Unit**	**Well Water**	**Permeate**	**By-product**
Alkalinity	mg/L as $CaCO_3$	290	9.6	1930
pH	S.U.	7.15	6.03	7.69
Temperature	°C (°F)	16 (61)	-	-
Conductivity	mS/cm	1.79	0.036	10.0
TDS	mg/L	1200	19	7860
Total Hardness	mg/L as $CaCO_3$	690	7.0	4515
Turbidity	NTU	0.24	NA	NA
Silt Density Index	-	0.76	NA	NA
Calcium	mg/L	176	< 1.0	970
Magnesium	mg/L	59	0.11	390
Sodium	mg/L	146	6.0	860
Potassium	mg/L	6.8	< 1.0	46
Barium	mg/L	0.027	< 0.02	0.180
Strontium	mg/L	0.79	< 0.01	4.5
Carbon Dioxide	mg/L	53 [a]	53 [b]	73 [a]
Carbonate	mg/L	0.2	0.0	3.0
Bicarbonate	mg/L	353	11.7	2144
Sulfate	mg/L	341	< 2.0	1800
Chloride	mg/L	234	5.0	1300
Fluoride	mg/L	0.58	< 0.05	1.3
Silica				
Reactive	mg/L as SiO_2	26.0	< 1.0	220
Total	mg/L as SiO_2	33.5	< 1.0	255
LSI		0.1	- 5.0	+ 2.3
$CaSO_4$ Saturation	%	12.1	0.0	111
$BaSO_4$ Saturation	%	199.9	0.0	2067
$SrSO_4$ Saturation	%	3.5	0.0	38
SiO_2 Saturation	%	28.9	0.0	190

Notes:
NA Not available
a Equilibrium concentration of $CO_{2(g)}$ based on alkalinity, pH, and temperature
b Based on feed water concentrations of $CO_{2(g)}$

APPENDIX B

Cost Estimate Summary

Table 3 ZLD Process Capital Cost - Zone B & Lost Use
Southwest Groundwater Treatment Project
Jordan Valley Water Conservancy District

	Quantity	Units	Unit Cost	Extended Cost
Building				
Foundation	2100	CY	$400	$840,000
Structural/Architectural	3100	SF	$100	$310,000
Electrical	1	LS	$1,200,000	$1,200,000
HVAC/Plumbing	1	LS	$200,000	$200,000
Brine Concentrator	2	EA	$4,000,000	$8,000,000
Crystallizer	1	EA	$1,725,000	$1,725,000
Equipment Installation [a]	1	LS	$7,780,000	$7,780,000
Post Treatment				
Cartridge Filtration	2	EA	$40,000	$80,000
UV Disinfection	2	EA	$150,000	$300,000
Chemical Storage/Feed				
Sulfuric Acid	1	LS	$450,000	$450,000
Scale Inhibitor	1	LS	$100,000	$100,000
Anti-foam	1	LS	$50,000	$50,000
Caustic Soda	1	LS	$100,000	$100,000
Site Work				
Over Excavation	29,500	CY	$12	$354,000
Structural Fill	29,500	CY	$20	$590,000
Other	1	LS	$35,000	$35,000
			Subtotal	**$22,114,000**

a Per vendor quotations, field erection and assembly of ZLD equipment is equal to 80% of the ZLD equipment costs.

Table 4	ZLD Process Annual O&M Cost - Zone B & Lost Use Southwest Groundwater Treatment Project Jordan Valley Water Conservancy District
	Annual O&M Costs (2004 $)
Electrical Costs (Subtotal)	*$1,655,300*
Sulfuric Acid	$607,200
Scale Inhibitor	$22,300
Anti-foam	$6,000
Caustic Soda	$3,500
Chemical Costs (Subtotal)	*$638,900*
Labor [a]	$160,000
Sludge/Salt Disposal	$595,500
Chemical & Mechanical Cleaning	$60,000
Replacement Parts	$90,000
Consumables	$30,000
Indirect Operating Costs (Subtotal)	*$902,900*
Total Annual O&M	**$3,197,100**

a Assumes labor is shared with RO WTP.

Table 5	**ZLD Process Capital Cost - Lost Use Southwest Groundwater Treatment Project Jordan Valley Water Conservancy District**			
	Quantity	**Units**	**Unit Cost**	**Extended Cost**
Building				
Foundation	1400	CY	$400	$560,000
Structural/Architectural	2100	SF	$100	$210,000
Electrical	1	LS	$500,000	$500,000
HVAC/Plumbing	1	LS	$100,000	$100,000
Brine Concentrator	2	EA	$1,750,000	$3,500,000
Crystallizer	1	EA	$750,000	$750,000
Equipment Installation [a]	1	LS	$3,400,000	$3,400,000
Post Treatment				
Cartridge Filtration	2	EA	$20,000	$40,000
UV Disinfection	2	EA	$100,000	$200,000
Chemical Storage/Feed				
Sulfuric Acid	1	LS	$300,000	$300,000
Scale Inhibitor	1	LS	$50,000	$50,000
Anti-foam	1	LS	$50,000	$50,000
Caustic Soda	1	LS	$80,000	$80,000
Site Work				
Over Excavation	19,700	CY	$12	$236,400
Structural Fill	19,700	CY	$20	$394,000
Other	1	LS	$35,000	$35,000
			Subtotal	**$10,405,400**

a Per vendor quotations, field erection and assembly of ZLD equipment is equal to 80% of the ZLD equipment costs.

Table 6	ZLD Process Annual O&M Cost - Lost Use Southwest Groundwater Treatment Project Jordan Valley Water Conservancy District
	Annual O&M Costs (2004 $)
Electrical Costs (Subtotal)	*$483,500*
Sulfuric Acid	$177,400
Scale Inhibitor	$6,600
Anti-foam	$1,800
Caustic Soda	$1,100
Chemical Costs (Subtotal)	*$186,600*
Labor [a]	$160,000
Sludge/Salt Disposal	$173,900
Chemical & Mechanical Cleaning	$17,600
Replacement Parts	$26,300
Consumables	$8,800
Indirect Operating Costs (Subtotal)	*$366,200*
Total Annual O&M	**$1,036,300**

a Assumes labor is shared with RO WTP.