Integrated Regional Water Management Project Information Sheet

Project Name: NCSD Supplemental Water Project

Project Description: Construction of treatment facilities and pipeline to import 3,000 to 6,200 acre feet of supplemental water per year from the Santa Maria Basin to resolve overdraft of groundwater in the Nipomo Mesa Groundwater Management Area. See detailed description in Nipomo Waterline Intertie Project Engineering Memorandum (November 2006) and NCSD Waterline Intertie Draft Environmental Impact Report (May 2006).

Project Manager Information:

Name: Bruce Buel, NCSD General Manager

Phone: (805) 929-1133

E-mail: bbuel@NCSD.CA.GOV

Name of Organization: NIPOMO COMMUNITY SERVICES DISTRICT

CEQA Complete:	Yes		No	X
	Anticipated completion date: 9/2008			

List all communities/cities that will benefit from this project and **bold** any disadvantaged communities. *(Disadvantaged = 80% of statewide annual MHI = $37,994)*

Does the project include any of the following IRWM Program Preferences?
(check all that apply)

X	Provides multiple benefits
X	Supports and improves local and regional water supply reliability
X	Contributes to the long-term attainment and maintenance of water quality standards
	Eliminate or significantly reduce pollution in impaired waters and sensitive habitat areas

Total Project Cost:	$26 million	Amount of Funding Match:	$20 million

Description of project financing mechanism(s): NCSD Board has committed $2 million of Supplemental Water Project Reserves. NCSD would borrow remainder not provided by grants through a Municipal Bonds/COPs and would repay Debt Service on Borrowing with User Fees, Capacity Charges, Purveyor Contributions, and In-Lieu Fees. NCSD has its own Finance Authority and is authorized to issue tax exempt financing.

Project Schedule: Project Selection November 2007; Preliminary Design March 2008; Environmental Determination Fall 2008; Final Design, Permits and Funding Fall 2009; Construction Fall 2009 to Spring 2011.

Integrated Regional Water Management Project Information Sheet

Project Name: Southland Wastewater Treatment Facility Upgrade				
Project Description: Retrofit existing aerated lagoon wastewater treatment facility with wave oxidation technology to reduce nitrate discharge; install headworks to screen out grit, and add tertiary treatment components to allow for irrigation recycling and aquifer storage and recovery. See detailed description in Southland Wastewater Treatment Facility Master Plan (February 2007)				
Project Manager Information:				
Name: Bruce Buel				
Phone: (805) 929-1133				
E-mail: bbuel@NCSD.CA.GOV				
Name of Organization: Nipomo Community Services District				
CEQA Complete:	Yes		No	X
	Anticipated completion date: 11/2008			
List all communities/cities that will benefit from this project and **bold** any disadvantaged communities. *(Disadvantaged = 80% of statewide annual MHI = $37,994)*				
Does the project include any of the following IRWM Program Preferences? (check all that apply)				
X	Provides multiple benefits			
X	Supports and improves local and regional water supply reliability			
X	Contributes to the long-term attainment and maintenance of water quality standards			
	Eliminate or significantly reduce pollution in impaired waters and sensitive habitat areas			
Total Project Cost:	$12 Million	Amount of Funding Match:	$10 Million	
Description of project financing mechanism(s): $6 million available from existing reserves; remainder not available through grants funded through Municipal Bonds/COPs. Debt Service on borrowing repaid through user fees and capacity charges. NCSD has its own Finance Authority and is authorized to issue tax exempt financing.				
Project Schedule: Project Selection October 2007; Preliminary design February 2008; Environmental Determination November 2008; Final Design, permits and funding Summer 2009; Construction Fall 2009 to Fall 2010.				

Integrated Regional Water Management Project Information Sheet

Project Name: NCSD Salt Management Program

Project Description: Identify sources of salt in wastewater collection system, implement pre-treatment program for non-residential dischargers, implement retrofit rebate program to encourage voluntary replacement of residential regenerative water softeners with canister systems; implement a public education program to encourage voluntary mitigation measures; determine strategies for managing water supplies to reduce salt input, and monitor results. This project is intended to decrease the level of salt discharge from NCSD's Southland Wastewater Treatment Facility into Nipomo Groundwater Basin and Nipomo Creek. See description of project in Southland WWTF Recharge/Disposal Action Plan (May 2007).

Project Manager Information:

Name: Bruce Buel

Phone: (805) 929-1133

E-mail: bbuel@NCSD.CA.GOV

Name of Organization: Nipomo Community Services District

CEQA Complete:	Yes	X	No	
	NOTE: Categorically Exempt			

List all communities/cities that will benefit from this project and **bold** any disadvantaged communities. *(Disadvantaged = 80% of statewide annual MHI = $37,994)*

Does the project include any of the following IRWM Program Preferences? (check all that apply)

	Provides multiple benefits
	Supports and improves local and regional water supply reliability
X	Contributes to the long-term attainment and maintenance of water quality standards
X	Eliminate or significantly reduce pollution in impaired waters and sensitive habitat areas

Total Project Cost:	$1 million	Amount of Funding Match:	$500,000

Description of project financing mechanism(s): Remainder of cost not funded through grants would be borrowed through Municipal Bonds/COPS. Debt service on borrowing would be repaid with Sewer User Fees. NCSD has its own Finance Authority and is authorized to issue tax exempt financing.

Project Schedule: Program Design December 2007; Implementation January 2008 through December 2008.

Reverse Osmosis Treatment Technology Applications Seminar
5 June 2007

Santa Ynez Valley
Marriott Hotel
555 McMurray Road
Buellton, California 93427

Layne Christensen strives to provide exceptional service, and we are offering a free workshop to update you on current water quality issues in California with an emphasis on reverse osmosis including salt water desalination. This workshop focuses on the latest technologies available for removing source water contaminants, including well design and pretreatment to reverse osmosis. We will discuss competing technologies, implementation risks and risk management, and selecting an optimal technology from performance, capital expense, and operating expense perspectives. This is a qualifying course for Department of Health Services (DHS) Continuing Education (6 Contact Hours). Directors of Public Works, Maintenance Engineers, Water Treatment Operators, Water Superintendents, and others in the water industry should attend this seminar.

Syllabus

8:00 – 8:30 Continental Breakfast & Check In

8:30 – 9:45 Well Design for Seawater and Groundwater Systems: Collector Wells .
Henry Hunt- Sr. Project Manager/Hydrogeologist, Reynolds Corporation

9:45 – 10:00 Break

10:00 - 11:15 Well Design for Seawater and Groundwater Systems: Directional and Conventional Well Design
Scott Riegert-Hydrogeologist Layne Christensen Company

11:15 – 12:00 Issues Facing the Application of Seawater and Groundwater Reverse Osmosis in California
Jim Elliott- Western Regional Manager, Layne Christensen Membrane Technology Group

12:00 – 1:15 Buffet Luncheon

1:15 – 2:30 Pretreatment Alternatives to Seawater Reverse Osmosis
Bruce Tait-Engineering Manager, Layne Membrane Technology Group

2:30-2:45 Break

2:45 – 3:45 Seawater Reverse Osmosis
Differences between brackish and seawater reverse osmosis systems, operation considerations, capital costs, operating costs. Regulatory issues
Jim Elliott- Western regional Manager

3:45 – 4:00 Questions & Answers, Summary
Questions from the participants will be answered by the speakers, Review and summary of concepts covered during seminar.

There is no charge for this seminar. Lunch will be provided. We welcome your attendance in this important training program designed to familiarize participants with current issues associated with membrane technology design, operating, cost, and selection criteria. Speakers include membrane technology engineers and scientists actively engaged in developing and implementing membrane plants throughout the United States.

To guarantee your acceptance at this seminar, please return the enclosed RSVP card to Layne Christensen Company, 11001 Etiwanda Avenue, Fontana, California 92337, or phone Layne at 909 390 2833.

COLLECTOR WELLS INTERNATIONAL, INC.
Tel: (614) 888-6263 • Fax: (614) 888-9208 • web site: www.collectorwellsint.com • e-mail: collectorwells@collectorwellsint.com

COLLECTOR WELLS FOR FILTERED SEAWATER

Collector Wells Filter Seawater Naturally

Where water supplies are needed along coastlines, it is often cost-effective to develop a filtered raw water supply using some type of infiltration system in a beach setting. These systems can be used to develop water supplies from both freshwater and seawater sources. A radial collector well (shown below in a general schematic drawing) can be used to develop a filtered water supply by projecting well screens laterally adjacent to and underneath the water source from a central caisson.

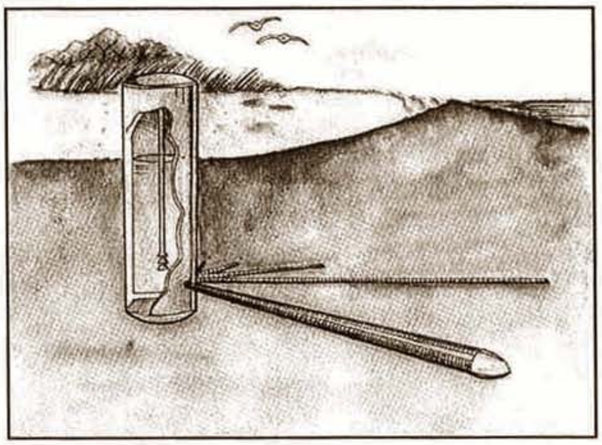


Diagram of Filtered Seawater Collector Well

The central shaft, or caisson, serves as the collection point for the water that enters the system through the network of well screens. This caisson serves as a wet well or pumping station, and allows entry for periodic inspection of the system and permits any required maintenance to be performed at a later date, if required.

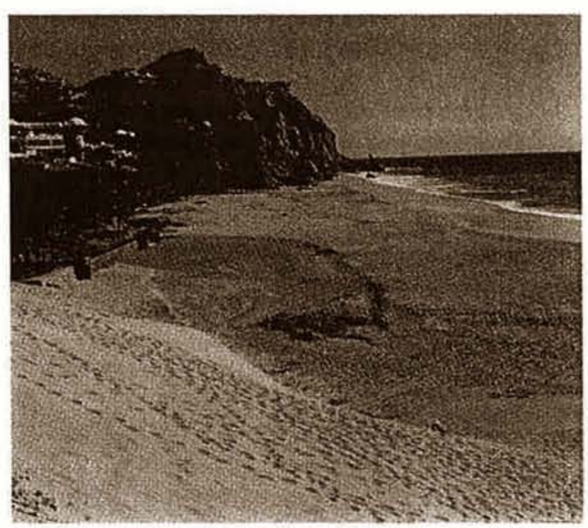
The caisson can be completed with a flush-grade top slab to minimize visual impact on the surroundings, often important in beach settings. Alternately, a pump house structure can be built that blends in with local architectural styles.

In many beach or coastal settings, the geologic deposits are often fairly fine-grained. Typically, it is necessary to install an artificial gravel pack filter around a well screen to develop higher capacities and reduce the plugging of the screen. This permits collector wells with lateral well screens to be used in virtually all geologic settings involving sand or gravel deposits.

Collector well screens can be installed using a variety of materials to be compatible with anticipated water quality, including steel, stainless steel, plastic, alloy and fiberglass materials.

Applications for seawater collectors:

- Desalination systems for drinking water
- Fire water supplies
- Source of sodium to regenerate ion-exchange filters
- Filtered aquarium supplies
- Salt water intrusion control
- Industrial Water Sources
- Recharging of brine



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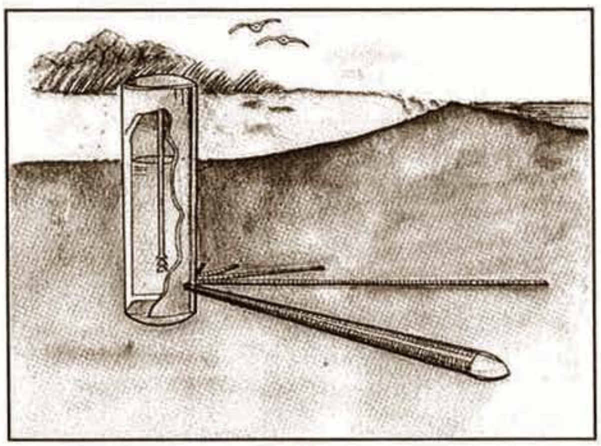
RANNEY METHOD

COLLECTOR WELLS FOR FILTERED SEAWATER

Collector Wells Filter Seawater Naturally

Where water supplies are needed along coastlines, it is often cost-effective to develop a filtered raw water supply using some type of infiltration system in a beach setting. These systems can be used to develop water supplies from both freshwater and seawater sources. A radial collector well (shown below in a general schematic drawing) can be used to develop a filtered water supply by projecting well screens laterally adjacent to and underneath the water source from a central caisson.



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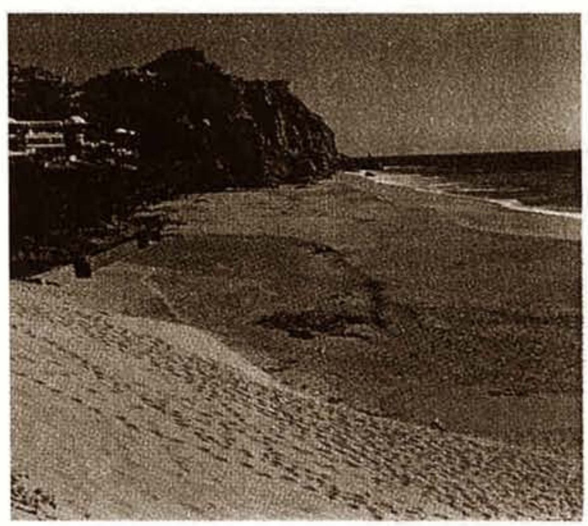

Layne
A Layne Christensen Company

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RADIAL COLLECTOR WELLS

For Ground Water and Infiltration Water Supplies...

Where ground water supplies are needed, it is often cost-effective to consider the use of a radial collector well. Collector wells can be used in almost any geologic setting where the subsurface materials are unconsolidated, consisting of sand and/or gravel deposits. A radial collector well can be used to develop water supplies from both freshwater and seawater sources.

The reinforced concrete central shaft, or caisson, serves as the collection point for the water that enters the system through the network of well screens. This wet well or pumping station, allows entry for periodic inspection of the system and permits any required maintenance to be performed at a later date.

The caisson can be completed with a pump house or flushgrade top slab to minimize visual impact on the surroundings, which is often important in riverfront settings.

Riverbank Infiltration

Riverbank Infiltration (RBI) is the process where water can be induced to infiltrate into local ground water aquifers from a surface water source where favorable hydrogeologic conditions exist near rivers and streams. Since the rate of infiltration is very slow, particles (even microscopic) in the surface waters are filtered. This natural filtration can provide cost-efficient removal of particles, at a lower cost, than many conventional treatment processes. Where suitable geologic deposits exist, collector wells can be used to develop moderate to very high capacities.

Operational Advantages

Collector wells are constructed with longer lengths of well screens projected horizontally near the base of the aquifer formation. This results in lower entrance velocities through the screen which reduce the rate of plugging, and extend the interval between well rehabilitation.

Other advantages include:

- Higher well yields per site: up to 28,000 gpm from a single well
- Reduction of surface water-borne organisms
- Elimination of zebra mussels
- Lower operating & maintenance costs
- Raised caisson offers flood protection
- Simple operator requirements
- Higher efficiency pumps and motors can be used to reduce power costs
- Fewer wells required: less connecting pipelines and electrical service needed
- Minimum property needs
- Minimum environmental impact

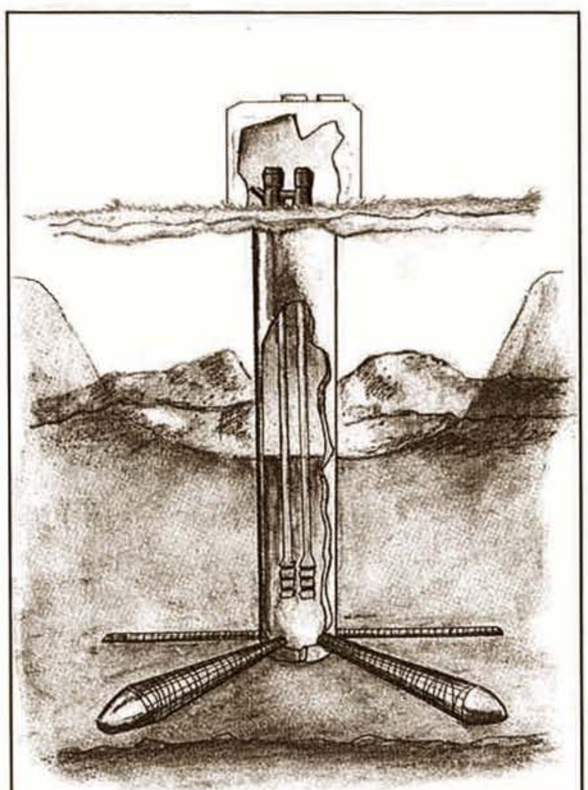

Diagram of Radial Collector Well

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SURFACE WATER INTAKES

For Developing Surface Water Supplies...

Fixed-screen surface intakes have been used successfully since 1960 to develop cost-effective raw water supplies from surface water sources. These intakes typically consist of a reinforced concrete caisson that serves as the wet well/pumping station and one or more intake lines that are projected out into a river, lake or even seawater, as illustrated in the drawing below.

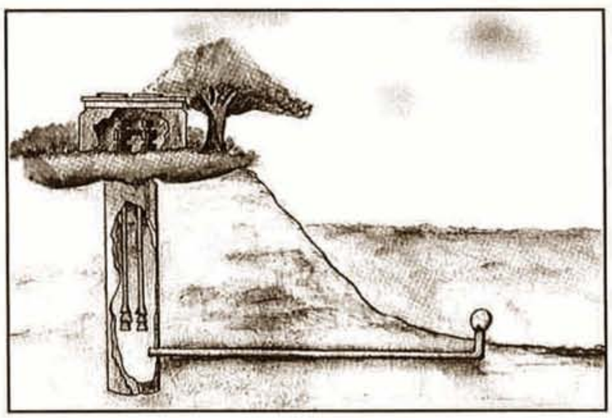

Diagram of Surface Water Intake

Fixed-screen intakes have been designed to produce yields of about 1000 gallons per minute (gpm) to over 450,000 gpm from a single unit. The use of advanced projection methods, including state-of-the-art microtunneling, can minimize the disturbance of local environmental conditions, which often simplifies permitting. The caisson is usually constructed back from the waters' edge, minimizing the impact on the shoreline and often allowing existing tree lines to remain intact, as shown in our project photo at right. This on-shore location also facilitates easier access to the pumping equipment and wet well during high water and flood events. Since construction is largely accomplished from on-shore locations, more expensive excavations, cofferdams and dewatering are not required, minimizing the project costs. Together with minimal O&M costs, this makes this type of intake extremely cost-effective when compared to conventional intakes, such as traveling screen and tower-style intakes.

This style of intake places the intake screens in the surface water body at advantageous points to ensure the most favorable water quality, to minimize impact on aquatic life and to reduce the intake of floating or bed-load debris.

Intake System Advantages

Some of the advantages this system offers:

- Intake yields per unit typically range from 1000 to over 100,000 gpm
- Low screen entrance velocities minimize screen plugging or impingement
- Offshore screen location moves point of withdrawal away from near shore environments-providing maximum protection to aquatic life
- Minimal operating & maintenance costs since no moving parts are involved
- Raised caisson offers flood protection
- Simple operator requirements
- Dewatering, open excavation (trenching), or cofferdams are not required
- Minimum property needs
- Minimum environmental impact since construction takes place away from the river
- Permitting is often simplified
- Automatic backwash systems flush debris from screen face - keeping screen open

Intake screen designs can include standard tee designs, drum-style, or multiple screen arrays, and intake lines can be projected at more than one elevation for selective withdrawals.

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HYDROGEOLOGICAL SERVICES

Water Supply Development & Management

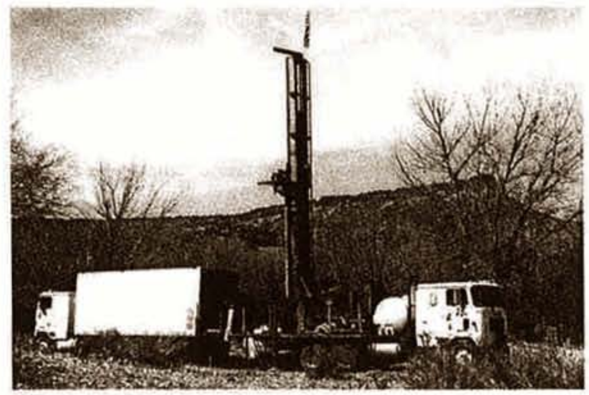
Specialty Expertise

International Water Consultants Inc. (IWC), has extensive, diverse expertise in the development of water supplies. Typical of recent projects our staff has worked on include the following:

- Siting, design and testing of the world's largest alluvial water well – a 40-MGD collector well in Kansas
- Design of three seawater collector wells for an industrial water supply in Central America
- Siting and testing of three 2-MGD carbonate wells
- Evaluation of alluvial aquifer in western Texas for development of 80-MGD potable water supply
- Siting and design of two 3-MGD combination surface water intakes/horizontal collector wells in Puerto Rico
- Siting, design and testing of a 4-MGD collector well with gravel-packed lateral well screens in Missouri

Water Supply

IWC is a wholly-owned subsidiary of Collector Wells International, Inc. and provides professional consulting services for a wide range of hydrogeological and environmental evaluations. The Principals and staff have extensive experience conducting assessments and implementing solutions to a variety of water supply and environmental issues.



IWC staff has worked at sites across the United States and overseas to conduct hydrogeologic investigations to site and design well and wellfields to develop ground water supplies for municipal drinking water, industrial use and cooling water supplies.

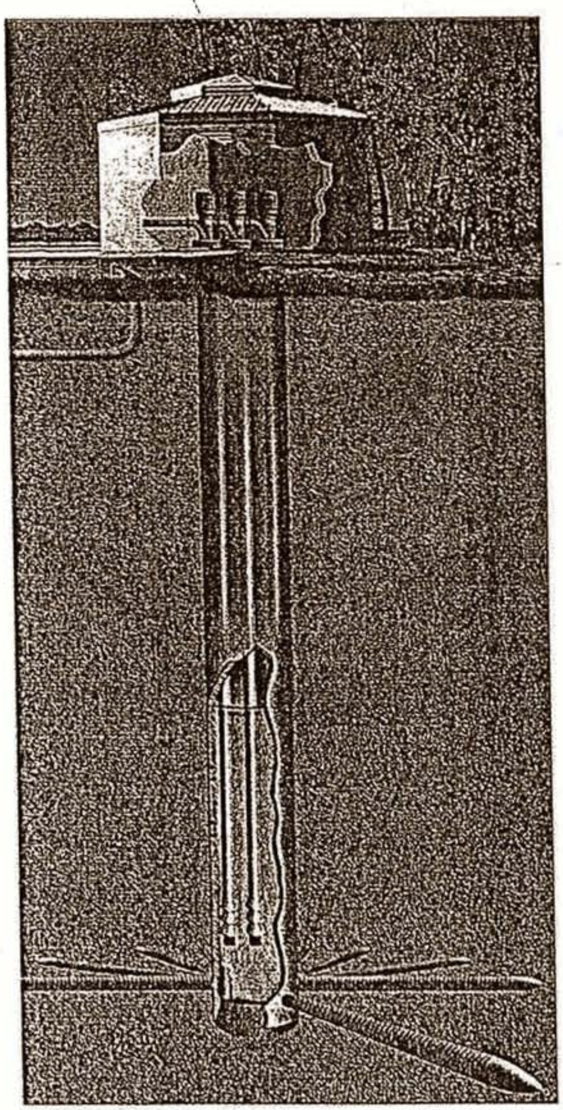
We provide services for:

- Hydrogeological Survey & Studies
- Induced Infiltration Evaluations
- Well Design
  - Vertical Water Wells
  - Radial Collector Wells
  - Infiltration Galleries
  - Seawater Collector Wells / Galleries
  - Dewatering Systems
  - Recharge Wells
- Aquifer Storage & Recovery Systems
- Exploratory Test Drilling
- Environmental Consulting Services
- Well Head Protection / Modeling
- Groundwater Monitoring / Compliance Programs
- Landfill / Solid Waste Consulting Services

Filtered Seawater Supplies — *Naturally*

By Henry C. Hunt

Figure 1
Illustration of a new Ranney Collector Well utilizing current technology



Filtration, naturally?

Seawater comprises over 93 percent of the earth's water, either filling the seas or contained in the polar ice caps. To make it suitable for most uses, seawater requires treatment. As with any surface water source, the cost and feasibility of treatment begins with primary filtration processes designed to remove suspended or floating particles in the water source. In an oceanfront setting, it is possible to pre-filter seawater using an infiltration system such as a Ranney collector well that creates drawdown in the coastal setting, inducing the seawater to infiltrate into the beach sands and flow through the sands into the well screens placed horizontally beneath the beach. In this manner, suspended particulates in the seawater are filtered out before reaching the point-of-use or treatment plant improving the raw water quality, simplifying the treatment process and reducing treatment costs. Development of naturally filtered seawater supplies using Ranney collector wells can provide a low-turbidity raw water supply typically at lower cost than using a conventional seawater intake system.

Introduction

Throughout the world, much of the earth's population, industrial base and recreational areas are located along coastal areas, putting them in close proximity to essentially an inexhaustible source of raw water. Because of the typically high concentrations of total dissolved solids (TDS), in the form of salts, present in seawater, this source does require more extensive treatment than normal fresh water supplies. Seawater in an undiluted condition may contain TDS concentrations as high as 50,000 parts per million (ppm). Brackish water TDS concentrations range from 1,000 to 15,000 ppm. Current water treatment technology however, enables us to consider these salts as a "pollutant" that can be removed from seawater at a predicted cost, thus bringing seawater into consideration as a feasible alternative for developing raw water supplies. Several commercially available treatment processes exist for conversion of seawater or brackish water to fresh water, including distillation, electrodialysis, reverse osmosis and ion exchange.

Typically, the geology in coastal areas consists of fairly permeable sand deposits, often to significant depths. Usually these deposits extend for some distance along the beach. In these situations, it should be possible to utilize an infiltration system constructed in these deposits to pre-filter seawater to develop a raw water supply that can be directed to an appropriate treatment system, after which it is available for a variety of uses.

Collector Well Concept

The collector well, often referred to as a Ranney collector well, was named after its inventor, Leo Ranney, a petroleum engineer, who in the 1920's invented the horizontal collector well to capture oil reserves trapped in relatively shallow oil-bearing deposits. Mr. Ranney applied this technology in Texas, Ohio and Pennsylvania in the 1920's for recovering oil he assumed that if he could drill horizontally into the oil-bearing deposits he could expose more of the borehole to the oil producing formation than he could if he drilled down vertically in the same formation. At the initial horizontal oil well site in southern Ohio, he clearly demonstrated the cost-effectiveness of this approach, developing more oil during a six month period using a single, 952 -foot long horizontal well than a field of vertical wells was able to produce over a period of 15 years. The ability to access the producing zone horizontally enabled higher capacities to be developed, per site, than conventional vertical well technologies allowed. As the price of oil dropped in ensuing years, Mr. Ranney directed this approach to the development of water supplies in unconsolidated sand and gravel formations. The first horizontal collector well installed for developing a water supply was installed in England in 1933 for the City of London. Soon after that he began constructing collector wells throughout Europe, and the first collector well constructed in the United States was in Canton, Ohio in 1936. Since that time hundreds of collector wells have been constructed around the world. In addition to development of ground water supplies, collector wells have also been constructed to artificially recharge ground water, dewater construction sites, and produce filtered seawater along beaches. *Figure 1* is an illustration of a new Ranney collector well, utilizing current technology. The highest capacity alluvial well in the world is of this type. It is located adjacent to the Missouri River in the US and is capable of producing up to 40 million gallons per day (151,000 M^3/D).

In addition to being able to install much more screen horizontally at a site than could be done with a vertical well, producing higher yields, this additional length of screen results in lower entrance velocities through the screen as water enters under pumping conditions. This lower velocity minimizes head losses and reduces the potential for encrustation to form, thus minimizing plugging of the well screens. This typically extends the time period between required well maintenance.

Geological& Hydrogeological Investigation

As with all water supply investigations, the geology and hydrogeologic conditions at prospective sites must be evaluated to determine first if the site conditions appear favorable for developing a water supply (either from ground water or filtered seawater sources). Then site-specific detailed testing must be conducted to calculate the necessary values for the hydraulic characteristics of the formation to enable well design and well yields determinations to be made. This investigation usually includes several steps, which may include:

- Geophysical surveys are often used to screen large areas to identify relative favorability and depth of unconsolidated deposits. This survey may delineate the general extent and depth of permeable materials and identify in which areas the deposits appear to be most permeable. This survey allows larger areas to be screened to narrow down the number of prospective sites for consideration.
- Once prospective sites have been identified, the character of the subsurface materials is verified through a program of test drilling to collect formation deposits for visual classification and grain-size distribution analysis. This data is used to select one or more sites for more detailed testing.
- At the selected site(s), a temporary test pumping well and observation wells are installed and a pumping test is conducted to determine site-specific hydraulic characteristics of the formation necessary for well system design and estimation of yield.
- A computer model may also be used to evaluate the performance of the formation in response to pumping especially if multiple wells are required, or if pumping may influence other water users. A computer model may also be used to evaluate the impact of pumping on the fresh water/saline water interface.

The actual tasks to be completed for each site will vary, and a site-specific program should be developed to meet site conditions and specific project needs for each site to ensure that yield and water quality objectives are reached. Favorable geologic conditions include areas where permeable sand deposits exist in hydraulic connection with the surface water source, in this case, a sea or ocean.

A Ranney collector well essentially consists of a reinforced concrete caisson that extends below the ground surface with water well screens projected out horizontally from inside the caisson into the surrounding aquifer deposits. *Figure 2* shows a conceptual design for a typical collector well

Ranney Collector Well Construction

to produce a filtered seawater supply. This is a design that could be installed in a beach setting.

The caisson is constructed of reinforced concrete that may be from 9 feet to over 20 feet (2.7 m to over 6 m) inside diameter with a wall thickness from about 18 inches to 3 feet (46 cm to 94 cm) or more. The caisson is formed and poured at grade and the soil is excavated out from inside the caisson, allowing the caisson shaft to sink by its own weight. As the top of each section sinks to grade level, the subsequent section is formed, poured and the process is continued until the base of the caisson reaches the predetermined elevation where the well screens are to be installed. A special cutting shoe is constructed into the first section to assist the sinking process and port assemblies are cast into the first section above the shoe to facilitate projecting the screens through the caisson wall and to guide the well screens during projection. Once the base of the caisson reaches the design elevation below ground, a concrete sealing plug is poured in the bottom of the caisson and a top slab is attached to the top of the caisson. The caisson depth will vary according to site-specific geologic conditions, ranging from about 30 feet to over 150 feet (9 m to over 46 m) in existing installations.

In many (fresh) ground water applications, the caisson is extended above known or anticipated flood elevations to protect the pumping equipment and electrical controls and to prevent contaminated surface water from entering the caisson. In a seawater application, the caisson can be completed (water-tight) at or below grade to minimize the visual impact on the shoreline, or the caisson can be carried above grade and completed with a pump house, observation deck, or similar facility. The design of the at-grade or above-grade structure is extremely flexible and can accommodate most completion designs that may be desired.

After the bottom sealing plug has been poured, the well screens are then projected out from within the caisson into the surrounding sands. The number of lateral well screens, their lengths and individual orientations will be determined during the hydrogeological investigation. The diameter of the well screen will range from 8 to12 inches (20 cm to 30 cm) in most cases, and the individual lateral screen lengths can be up to 200 feet (61 m) or more. These well screens are hydraulically jacked out from the caisson using either a direct-screen projection process where the well screen itself is jacked out into the formation deposits, or using a pull-back process where a solid projection pipe is jacked out into the formation and then the well screen is installed within the projection pipe and the projection pipe is withdrawn, exposing the well screen to the formation.

Using the direct jacking process the screen material must be of suitable construction to withstand the forces encountered during jacking. However, using the pull-back methods, screen materials of lower structural strengths can be installed as the screen is not subject to the higher jacking forces, but rather only to collapse. With this flexibility of approaches, essentially all types of screen materials can be used, with any size slot opening to accommodate the grain-size of any formation. If necessary, an artificial gravel-pack filter can be installed around the screen to suit finer-grained deposits.

Environmental Impact

The use of a Ranney collector well in a beach or oceanfront setting can minimize the impact on the local environment. Since the well screen in a collector well is placed horizontally at depth, more drawdown is available, so that higher yields, per well site, are possible. This results in fewer wells being required to meet demand yields, so there will be smaller work sites/lesser construction activity, reducing the disturbance to the shore environment. Fewer well pump houses will also reduce the visual impact on the shoreline. Since the well operates with lower head losses and reduced plugging, maintenance will be required less often, further reducing the impact on the shoreline environment. As shown in *Figure 2,* the collector well can be completed below grade with only a ground level concrete slab attached to the caisson if desired. This slab can actually be constructed below grade to further enhance aesthetics. The well can be designed with jet pumps or submersible pumps to reduce noise levels to a minimum.

In many water supply installations, the collector well is completed with an above-grade structure to house the pumps, motors, above-grade piping and electrical controls. This pump house can be constructed to meet virtually any architectural style to blend in with its surroundings.

As shown in *Figure 2,* the well screens are projected out laterally from the caisson into the surrounding sands. These laterals can be projected in a variety of patterns and at more than one elevation to meet differing design needs. The direction and pattern may influence where the water is pulled from and can affect the water quality that is produced. The location of the well site can also influence the yield of the well and the water quality produced. If it is desired to develop a highly saline water, the collector well can be sited adjacent to the ocean with the lateral well screens projected out beneath the beach deposits to produce water with a higher concentration of dissolved solids. This is the case when a water supply for an aquarium system is needed, such as that installed for the Steinhart Aquarium in Golden Gate Park, San Francisco, California (Rando and Brady, 1966). It may also be desirable to install the caisson in a beachfront area with the lateral screens projected out beneath the beach to access the saline water "wedge" that typically exists in many oceanfront formations.

If it is the intent to develop a water supply for desalination purposes, the collector well can be placed near the ocean with the well screens evenly distributed in all directions or the laterals can be projected solely toward land to reduce the salinity content of the water. It is also possible to install the collector caisson at a location away from the oceanfront if the underlying water and formation deposits have an interconnection with the saline water. It should be noted that pumping in some areas can influence fresh ground water to mix with saline water causing "contamination" of ground waters in some settings. Care should therefore be taken during design to assure that the pumping system does not adversely affect local fresh water supplies. Use of this infiltration-style intake in lieu of a conventional direct seawater intake can also eliminate the intake of aquatic life such as sardines and other fish fry, further protecting the environment.

Operational Advantages

The use of Ranney collector wells in oceanfront areas to develop a saline water supply can offer distinct advantages from an operational standpoint, especially since this well system pre-filters the seawater through the beach deposits, resulting in a much cleaner raw water supply delivered to its point-of-use. This primary filtration results in lower maintenance costs for many desalination processes, since suspended debris is typically removed from the water in this process. For

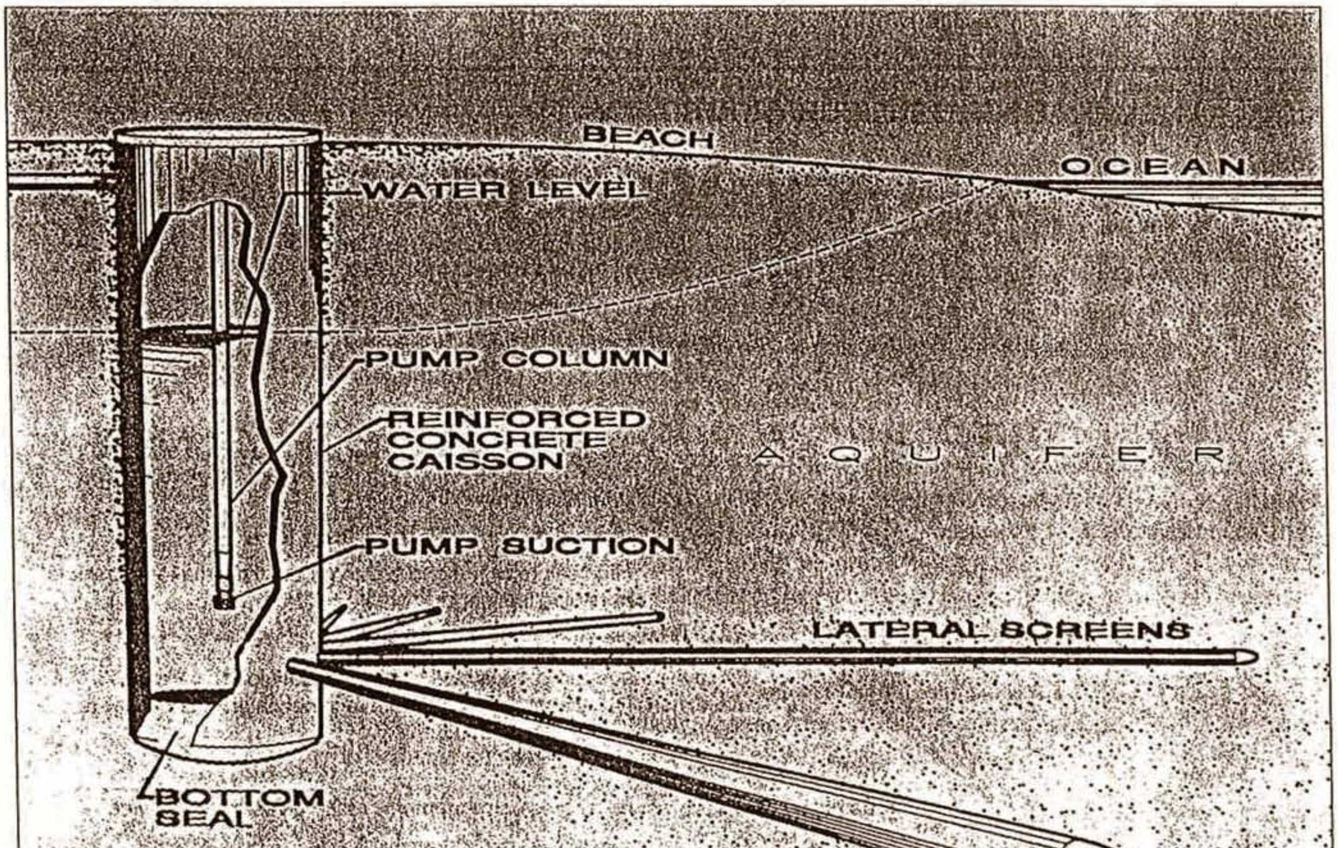


Figure 2 *Typical seawater collector well*

treatment processes such as reverse osmosis (RO), the reduction of suspended particles reduces the fouling sensitivity of the membranes, which enables the RO system to operate with less downtime for backflushing or other maintenance. In addition to delivering a water with lower turbidities, this also eliminates the need for disposal of these particles if they have to be removed in a conventional treatment facility, since these particles have been removed naturally in the infiltration process through the beach deposits.

A study completed in 1983 (Soo-Hoo et al) regarding technical and economic issues related to seawater reverse osmosis desalination plants, evaluated a variety of issues, including construction and operation costs. In the case sited in the article, capital and product water costs are presented for a surface (direct) intake and for a Ranney collector well. Product water costs for the direct seawater intake were 12 to 20% higher than for the collector well, reflecting the additional costs required for a more complete treatment process. The costs shown in *Table 1* are updated to 1996 dollars, using the IDA Seawater Desalting Costs Program, and by private correspondence (Leitner and Associates, Inc.). The costs are "order of magnitude" with actual prices depending upon the specific site conditions, and recognizing that the feasibility of Ranney collectors is a function of the distribution, nature, and permeability of the shallow sediments underlying the site, and the degree of hydraulic communication between these sediments and the adjacent surface water body.

In addition to a more favorable capital cost when a Ranney Collector can be utilized, there would also be savings in maintenance costs, since a surface water intake requires a dual media filter system for removal of suspended solids which would increase maintenance costs.

Summary

Collector wells can be used effectively to develop moderate to high capacity supplies for desalination, aquariums and other saline water needs. The system can be designed to blend in with local settings, minimize environmental impact, simplify operational and maintenance needs, and reduce overall costs to produce a water supply from seawater sources. The ability to pre-filter the raw water source prior to delivery to a treatment plant or other point-of-use, significantly simplifies operation and reduces capital and operating costs. If a seawater source is selected, this supply will be less subject to rainfall and safe yield uncertainties, and will minimize water rights issues that are prevalent for many fresh water sources of supply. ■

TABLE 1: Cost Comparisons for Raw Water Intake and Pretreatment Systems to Serve Seawater Reverse Osmosis Desalination Plants

Product Water Capacity	MGD	0.1		1.0		5.0	
	M^3/D	378		3,785		18,925	
Raw Water Required	GPM	69		694		3,472	
	M^3/H	15.75		158		789	
Raw Water Intake System		Ranney	Surface	Ranney	Surface	Ranney	Surface
Capital Cost ($000's)							
Raw water Intake System		150	200	1,000	1,850	3,750	7,500
Pretreatment Equipment		35	60	50	620	150	3,000
Total ($000's)		$185	$260	$1,050	$2,470	$3,900	$10,500

Selected References

Katz, W. E. And R. Eliassen (1971), *Saline Water Conversion, Water Quality and Treatment*, McGraw-Hill Book Company, Third Edition, pp. 587-624.

Rando, A.J. and C.J. Brady (1966), *Unique Salt Water Supply System Serves Aquarium*, Public Works, August.

Soo-Hoo, R., Awerbuch, L., May, S., Mattson, M., Kremen, S. (1983), *Parametric Study on Seawater Reverse Osmosis Desalting Plants*, Desalination, Vol. 46, pp. 3-15.

International Desalination Association Seawater Desalting Costs, A Computer Software Program for Calculation of Capital and Total Water Costs, developed by Leitner and Asssociates, Inc.

Private Communication on Seawater Intake Costs, Leitner and Associates, Inc.

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