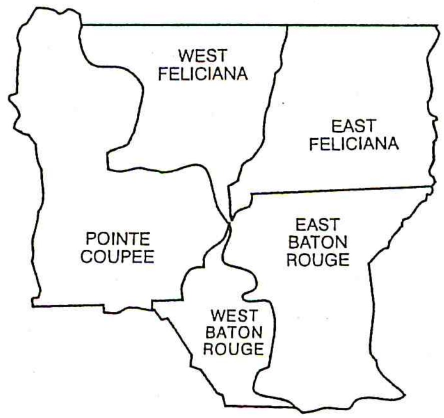
CAPITAL AREA GROUND WATER CONSERVATION COMMISSION

BULLETIN NO. 5



A CONNECTOR WELL TO PROTECT WATER-SUPPLY WELLS IN THE "1,500-FOOT" SAND OF THE BATON ROUGE, LOUISIANA AREA FROM SALTWATER ENCROACHMENT

By
Don C. Dial
George T. Cardwell

A ground-water remediation project supported by a grant under section319(h) of the Clean Water Act.

August 1999

CAPITAL AREA GROUND WATER
CONSERVATION COMMISSION

BULLETIN NO. 5

A CONNECTOR WELL TO PROTECT WATER-SUPPLY WELLS IN THE "1,500-FOOT" SAND OF THE BATON ROUGE, LOUISIANA AREA FROM SALTWATER ENCROACHMENT

By
Don C. Dial
George T. Cardwell

A ground-water remediation project supported by a grant
under section319(h) of the Clean Water Act.

August 1999

CAPITAL AREA GROUND WATER CONSERVATION COMMISSION

Members

Daryl Babin
Brusly

John Barry
Weyanoke

Zahir Bolourchi
Baton Rouge

Keith Casanova
Baton Rouge

Dwayne Coulon
Port Allen

Kevin Gravois
Baton Rouge

Joey Hebert
Zachary

Mitchell Hollier
Baton Rouge

Patrick Kerr
Baton Rouge

Darwin Knochenmus
Jackson

Kevin Martin
Baton Rouge

Elie Part
New Roads

Timothy Stone
Baton Rouge

Richard Soniat
Addis

Mark Walton
Baton Rouge

STAFF

Don C. Dial
Director

Shawn O. Scallan
Administrative Assistant

Table of Contents

A CONNECTOR WELL TO PROTECT WATER-SUPPLY WELLS IN THE "1,500-FOOT" SAND OF THE BATON ROUGE, LOUISIANA AREA FROM SALTWATER ENCROACHMENT

INTRODUCTION

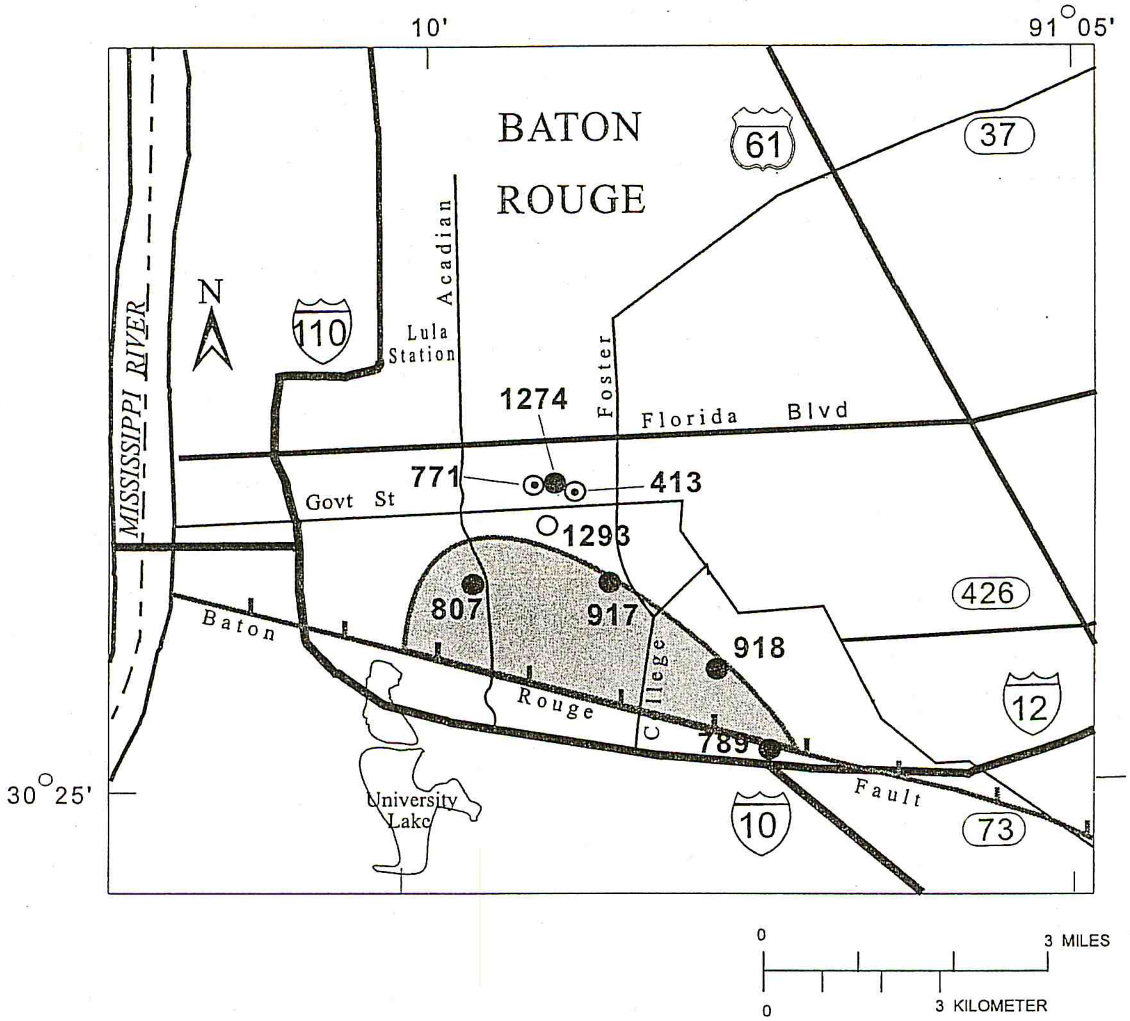
The Capital Area Ground Water Conservation District was established by Act No. 678 of the 1974 Legislature in response to area concerns relating to severe ground-water problems that had developed in the Capital area by the early 1970s. These problems included water-level declines resulting in saltwater encroachment in several major aquifers supplying the area. Included in authority granted to the Board of Commissioners, which governs the District, was the mandate "...to take all necessary steps to prevent intrusion of saltwater or any other form of pollutant into any aquifer or aquifers". This was the basis for the Commission's application for federal funds under the nonpoint source program of the Clean Water Act. It was the Commission's view that a new concept for ground-water remediation would use a connector well to counter the effect of saltwater migration in one of the major aquifers in Baton Rouge. The project focused on the "1,500-foot" sand, a major public-supply aquifer, in which saltwater has been moving toward pumping wells. The area of remediation is shown in figure 1.

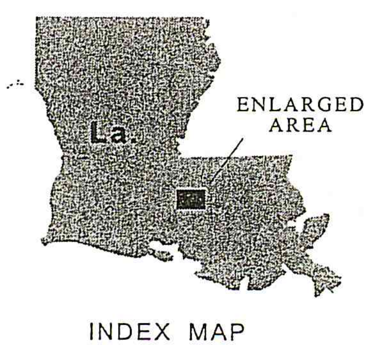
Grant. – This is the final report of a ground-water remediation project completed with the aid of funds granted to the Capital Area Ground Water Conservation District (CAGWCD) under Section 319(h), Non-point Source Implementation, of the Clean Water Act administered by the U.S. Environmental Protection Agency (EPA). The project proposal was submitted to EPA through the Louisiana Department of Environmental Quality (DEQ) June 15, 1994, and funding in the amount of $391,000 (60% EPA, 40% CAGWCD) was approved January 31, 1995. Because of delays related to organizational changes in DEQ, the cooperative project agreement was not signed by the Secretary of DEQ until July 9, 1996, the official starting date of the project. The grant was limited to projects designed to mitigate water problems.

Problem. – Water-supply wells in several key aquifers in the southern part of the Baton Rouge area are vulnerable to contamination from saltwater moving across the Baton Rouge fault and thence northward under the influence of pumping. The extent of saltwater encroachment in the "1,500-foot" sand is indicated in figure 1. Several studies have confirmed this movement and alternative methods of mitigation have been proposed. These include:

1. Installing "scavenger" wells to intercept the saltwater. This is currently considered impractical because of costs for construction, including a disposal pipeline to the Mississippi River. Deep well injection is not feasible because of the well-construction and operating costs related to the large volumes of saltwater involved.

2. Progressively moving production wells northward. This would be costly, in terms of both well construction and infrastructure costs.





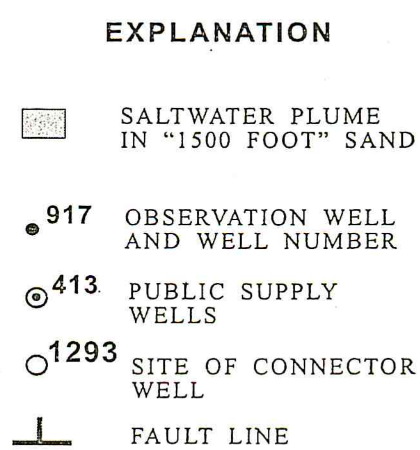


Figure 1. Location of project area

3. Utilizing "barrier" wells. This was suggested by Rollo (1969), who proposed installing a well or wells immediately north of the saltwater front and injecting water to create a pressure ridge to halt movement of the saltwater. This technique has been used in California where a series of barrier wells has been employed to halt encroaching sea water in shallow aquifers.

4. The doublet well concept developed by noted hydrologist C.G. Jacob in the 1960s has been proposed by the staff as a possible method of recovering fresh water underlain by saline water in the base of an aquifer. The doublet well consists of two pumps in the same well. The upper pump produces fresh water while the lower pump produces upconing saline water that is pumped back down to a lower level. Although the concept appears valid, no operational examples are known.

5. The connector well. – The connector well employed in this project is actually a variant of the barrier well concept. The advantage of this type of well is that the exchange of water results from head differences between aquifers and no pumps or pumping costs are involved. Head differences between aquifers in the Baton Rouge area result from areal and local differences in pumpage from the aquifers as related to their differences in hydraulic characteristics. At several locations in the area, where wells are screened in two aquifers with significantly different heads, the beneficial effects of recharge during the periods of non-pumping has been observed. This empirical data aided in development of the connector well concept.

This project was based on sound ground-water hydrology and good preliminary data, but a number of problems had to be overcome before the connector well became a reality, including:

1. Delay in final approval of the project by the state sponsoring agency, which delayed the planned starting date,
2. Problems related to securing a well site adequate to accommodate drilling equipment needed to construct a deep, large-diameter well,
3. Deliberations to frame and negotiations to detail and finalize well specifications,
4. Justifying unforeseen high bid costs and negotiating work-plan changes from the original plan of two connector wells to one,
5. Overcoming well-development problems to ensure a highly efficient well.

THE TEST WELL

Site selection. – The primary factors involved in selecting a site for a well to test the probable efficiency of a connector well included:

1. Selection of a site near production wells in an endangered aquifer,
2. The availability of a source aquifer able to supply a sufficient quantity of water of compatible quality and having a substantially higher water level than the endangered aquifer,
3. An available site for the test, not to preempt the site for the proposed connector well if the test proved favorable.

The aquifers considered as alternatives were (1) the "1,500-foot" sand, (2) the "2,000-foot" sand and

(3) the "1,000-foot" sand. The "1,500-foot" sand was deemed the highest priority because it is most heavily pumped for public supply and because wells in the Government Street well field, which was selected for remediation mitigation, were in more imminent danger than wells in the "2,000-foot" and "1,000-foot" sands. The "800-foot" sand was targeted as the source aquifer. Limitations that had to be to overcome, entering the test-well phase, included the problem of finding an ideal site in an urban area and lack of data to predict the quantity and quality of water available from the "800-foot" sand and the head difference between the aquifers. The site finally selected (fig.2) was near the Baton Rouge public-supply wells EB-413 and EB-771, which pump from the "1,500-foot" sand. If the test well proved suitable, a permanent observation well would be screened in the "800-foot" sand. The construction of the well, EB-1274, is shown in figure 3.

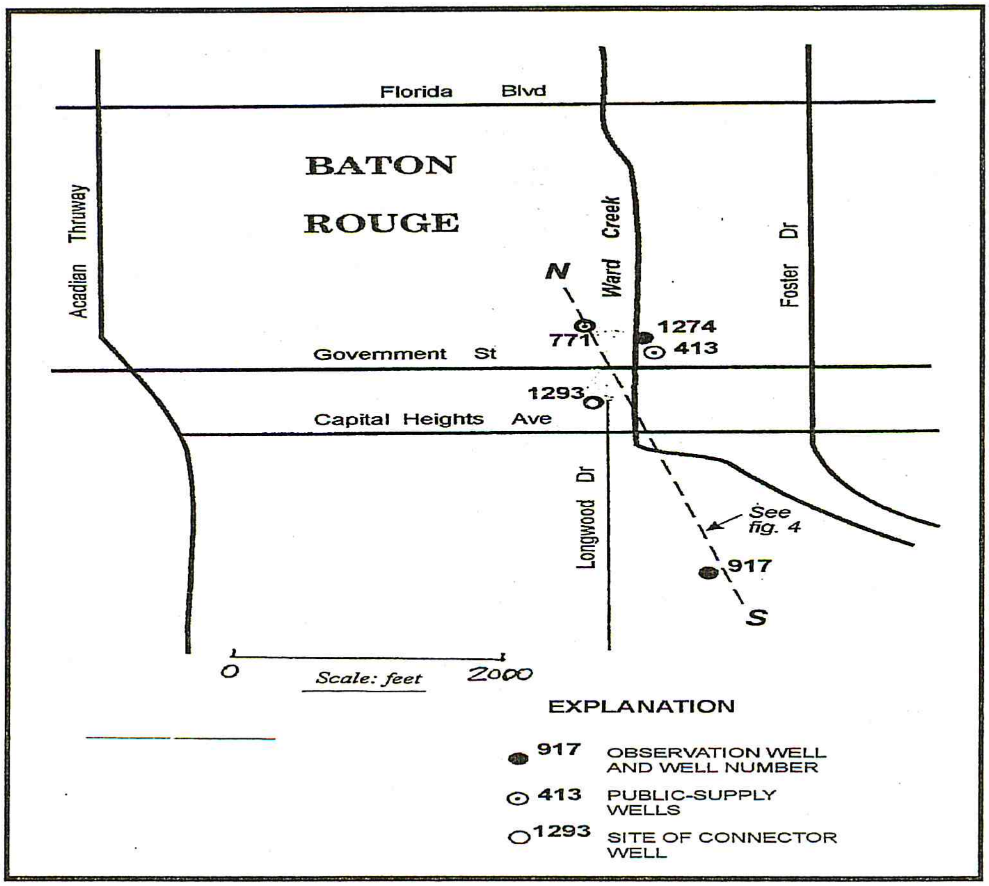


Figure 2. Location of public-supply wells, observation wells and connector well.

Test well results. – The contract for the well to test the "800-foot" sand was awarded to Layne-Central, a division of Layne Christensen Company, on a competitive bid in the amount of $58,950, October 1, 1996. Drilling began November 11, 1996 and the well, including testing, sampling and wellhead construction, was completed February 13, 1997. Final cost was $58,887.50.

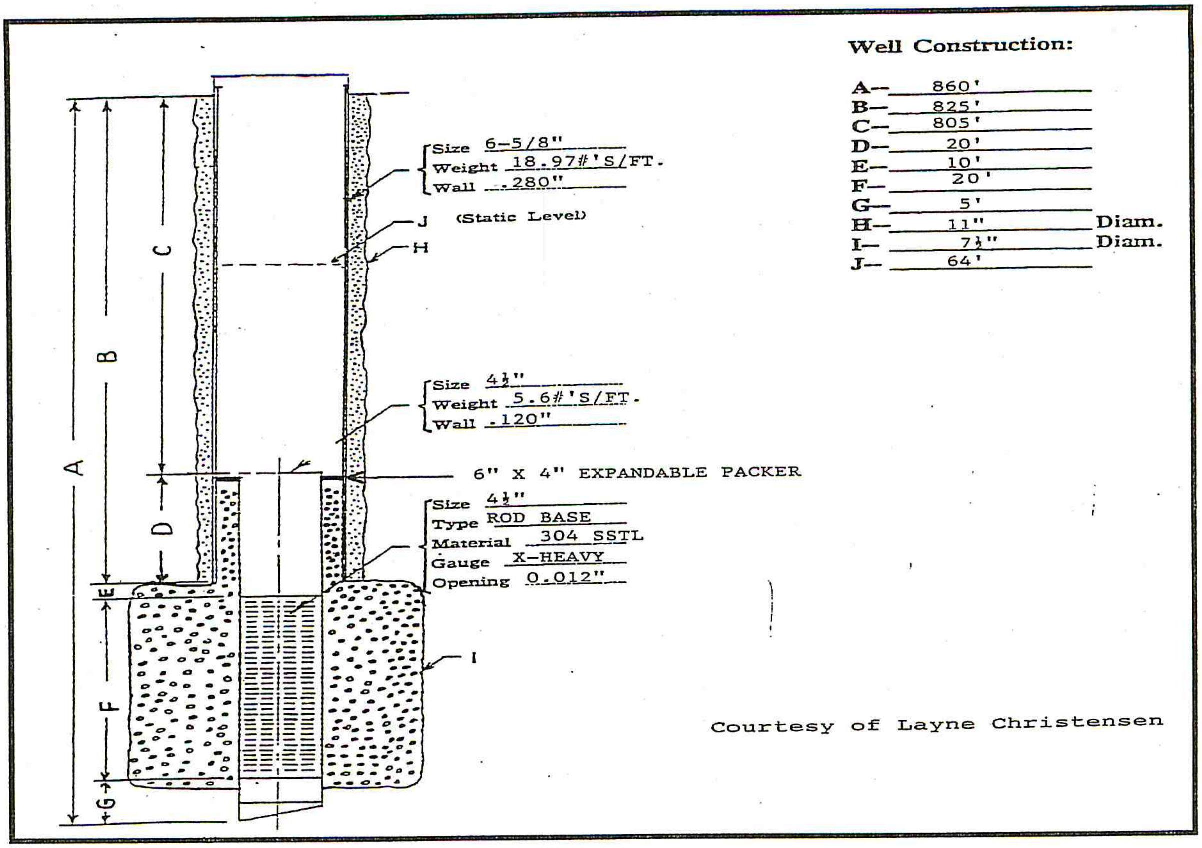


Figure 3. Construction diagram of the "800-foot" observation well, EB-1274.

The test results showed a sand thickness of 40 feet (821'-861') and an initial water level of 63.8 feet (12/07/96) below land surface. Analysis of aquifer sand samples from the "800-foot" sand indicated a productive aquifer, as confirmed by a pumping test that indicated a transmissivity of 2,800 ft^2/day (21,000 gpd/ft). That value corresponds to a specific capacity of approximately 10 gallons per minute per foot of drawdown after pumping for 24 hours. A chemical analysis of the water showed that it was of excellent quality and similar in chemical character to that in the "1,500-foot" sand (See tables 1 and 2.). A bacteriological examination of the water showed that the aquifer was free of bacterial contamination.

The test results closely matched information used for a design basis (figure 3A), which indicated a probable initial head difference of approximately 90 feet between the "800-foot" and "1,500-foot" sands at the Government Street pumping station . That substantial head difference, and the indication of a good potential yield from and good water quality in the "800-foot" sand supported the decision to proceed with construction of the first connector well. The recharge of the "1,500-foot" sand and the accompanying discharge from the "800-foot" sand is portrayed in figure 4, a generalized north-south section across the study area showing the two sands, the well locations and the water levels of the "800-foot" and "1,500-foot" sands.

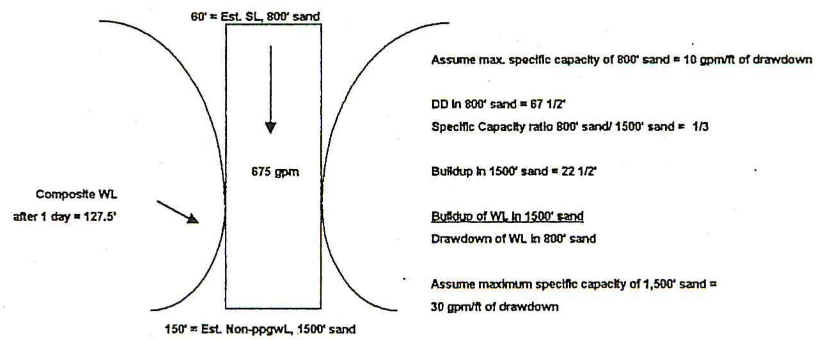
TABLE 1. – CHEMICAL ANALYSIS OF WATER FROM TEST WELL EB-1274, "800-FOOT" SAND OF THE BATON ROUGE AREA

Date Collected: December 18, 1996					
Depth of aquifer interval (ft): 821-861					
Screened interval (ft) 835-855					
Field Measurements		**Laboratory Results (milligrams/liter)**		**Metals (micrograms/liter)**	
Temperature	76°F., 24.6 C	Calcium	12.5	Arsenic (mg/L)	1
pH	8.5	Magnesium	0.1	Barium	13
Alkalintity as $CaCO_3$ (mg/L)	161	Sodium	74	Beryllium	<1
Specific conductance (Microsiemens/cm)	342	Potassium	0.3	Cadmium	<1
		Chloride	2.5	Chromium	<1
		Sulfate	11	Copper	<1
		Fluoride	0.3	Iron	30
		Hardness, total as $CaCO_3$	4	Lead	<1
		Silica	23	Manganese	2.1
		Sum of dissolved solids	190	Mercury	<0.1
				Nickel	<1
				Selenium	<1
				Zinc	<1

TABLE 2. – CHEMICAL ANALYSIS OF WATER FROM PUBLIC-SUPPLY WELL EB-413, "1,500-FOOT" SAND OF THE BATON ROUGE AREA

Date collected: June 5, 1995			
Depth of aquifer interval (ft): 1508-1529, 1588-1745			
Screened interval (ft): 1511-1530, 1620-1690, 1701-1745			
Field Measurements		**Laboratory Results (milligrams/liter)**	
Temperature	88° F	Color	0
pH	8.7	Sodium	49
Alkalintity as $CaCO_3$ (mg/L)	151	Potassium	0.3
Specific conductance (Microsiemens/cm)	322	Hardness, total as $CaCO_3$	4
		Chloride	3.1
		Sulfate	9
		Nitrate	0
		Fluoride	0.3
		Iron	0.02
		Manganese	0.00
		Total dissolved solids	219

THEORETICAL HEAD & YIELD DATA



ASSUMPTIONS:

1. Initial head difference between aquifers = 90'
2. Specific capacity of 8" well in 800' sand after 1 day = 10 gpd/ft
3. Specific capacity of 8" well in 1,500' sand after 1 day = 30 gpd/ft
4. Minimal friction loss

Specific Capacity ratio, 800'/1500'	Head diff (ft.)	DD (ft) 800' sand	Buildup (ft) 1500' sand	Exchange rate (gpm)
10/30	90	67.5	22.5	675
10/20	90	60	30	600
10/15	90	54	36	540
10/30	80	60	20	600
10/20	80	53	27	530
10/15	80	48	32	480
GPM	**400**	**500**	**600**	
Friction	0.4	0.6	0.8	8" csg 100'
	2.8	4.2	5.6	8" csg 700'
Loss (ft.)	0.1	0.2	0.3	10"csg 100'
	0.7	1.4	2.1	10"csg 700'

Figure 3A. Design Basis for 800/1,500' Connector Well

CONNECTOR WELL PLANNING AND DESIGN

The test well, EB-1274, screened in the "800-foot" sand, confirmed a supply source for a connector well to protect the "1,500-foot" sand at the Government Street pumping station; therefore, the search for a permanent connector well site began. A preliminary reconnaissance had indicated two possible sites, one about 650 feet south of pumping well EB-413 and the other about 500 feet northwest of well EB-771 (figure 2). The site to the south was chosen for the first connector well and proved to be the best available location when it subsequently became apparent that only one well could be completed with the available funding. However, the proposed site at the north end of Longwood Drive (a dead end street) proved untenable because of a buried sewer line. A total of five nearby sites were considered and evaluated before a decision was reached to purchase a lot adjacent to the originally planned site at the end of Longwood Drive. The connector well location ended up about fifty feet west of the original site. Calculation of the anticipated hydraulic effect of the proposed connector well, based on data from the nearby test well, indicated that the site was a nearly ideal location to provide protection to the well field, especially considering site procurement problems in an urban area.

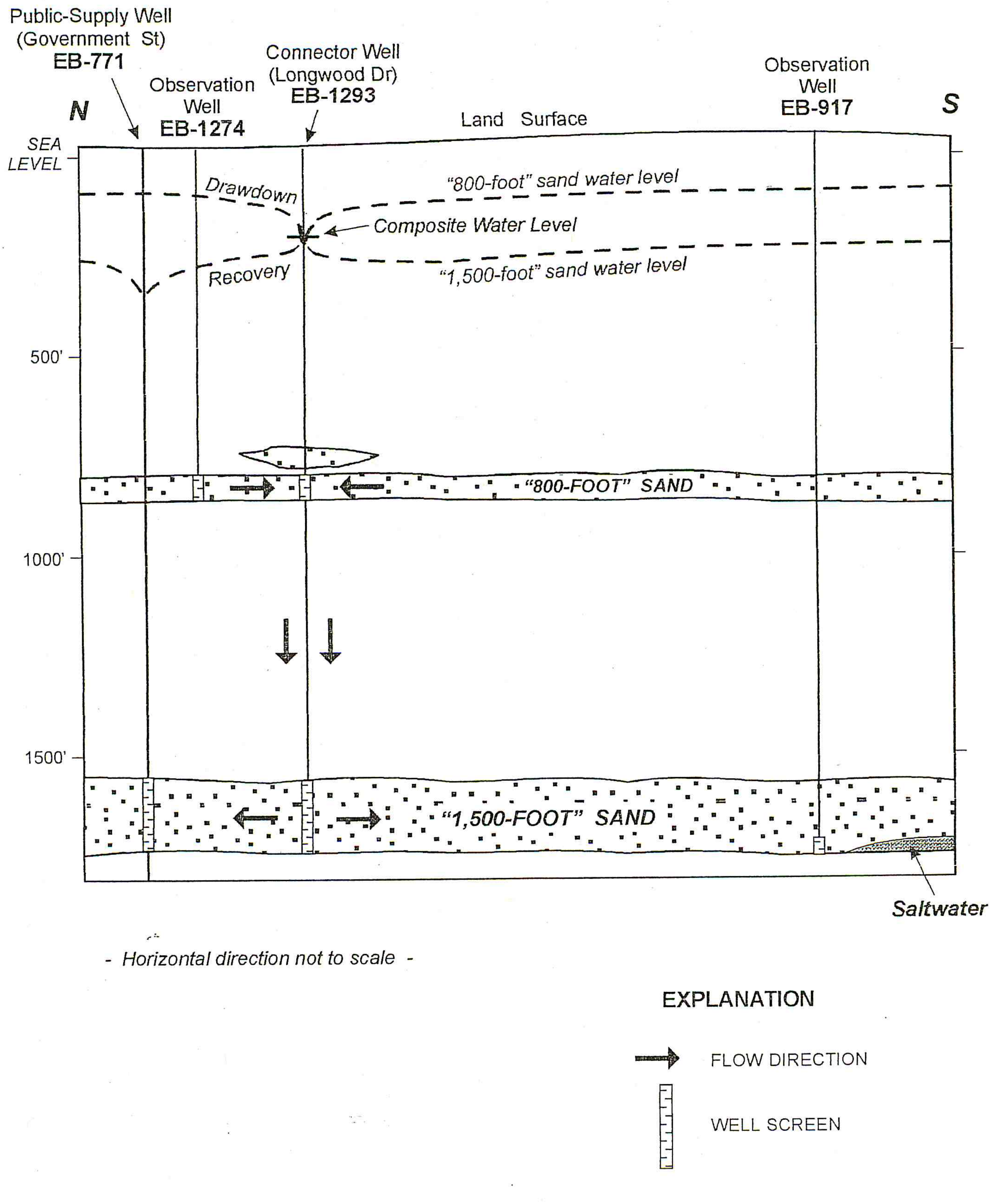


Figure 4. Section across project area (see fig. 2 for location).

Development of well specifications.--The proposed connector well posed some unique design problems, because no wells of this type were known to have been constructed in geohydrologic situations similar to those at Baton Rouge. Recharge wells have been constructed in Florida, mainly open-hole rock wells, and relatively shallow injection-recharge wells have been utilized in California. To maximize the exchange rate from the "800-foot" to the "1,500-foot" sand, it was critical that screens in both aquifers be developed to the fullest extent to obtain maximum possible well efficiency. A minimum well efficiency of 80% was specified.

The design team included the Technical Committee and the District staff of the Commission; engineering personnel of Owen & White, the consultant on the project; representatives of two major water-well drilling firms; and two former Commissioners having considerable experience in water well design and construction. Included among the Technical Committee members were representatives of the Water Resources Section of the Department of Transportation and Development, the State's ground water organization charged with enforcing water well construction standards, and of the Department of Environmental Quality, charged with protecting the State's ground water. The design of the well, as constructed, is shown in figure 5. The final design included maximum well casing sizes to minimize friction loss in casings to ensure an optimum exchange rate. It also included the sealing of the entire annulus between the well casings and the drill hole to obviate any contamination from the surface or inflow from intervening aquifers. The wellhead was also designed to prevent contamination from flooding or possible vandalism.

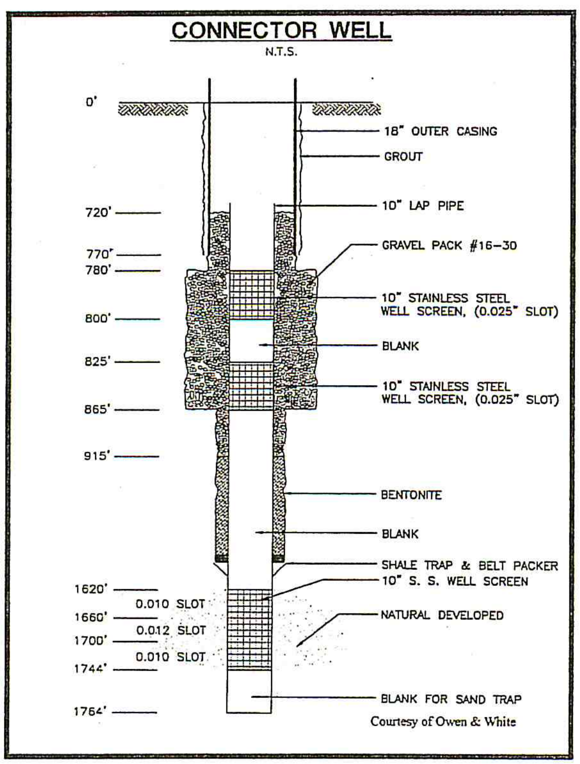


Figure 5. Construction design of the connector well, EB-1293.

Modification of Original Plan.--The original connector well plan called for two connector wells. This plan was based on a conservative estimate of the potential yield of the "800-foot" sand at the Government Street pumping station, and the uncertainty of finding an ideal well site to obtain the maximum protection effect from one well. However, because of the necessarily complex design for construction, development and testing of the connector well and the lack of competitive bidders capable of drilling the well, the bid for one well almost equaled budgetary estimates made for two originally planned wells. The higher of the two bids that were received was about fifty percent higher than the low bid. A review of the bids was made by the Board and staff with the conclusion that the low bid was reasonable, given extant conditions, stated above. The Board agreed to accept the bid contingent on acceptance by DEQ and EPA of a proposal to revise the project work plan to include only one connector well. The justification for one connector well was based on calculations that indicated that the estimated yield of one connector well in the "800-foot" sand at the site chosen would divert ground-water flow around the pumping center.

With the realization that only one connector well could be completed with funds available, the location of the well was crucial to its success. A ground-water flow model was constructed of the "1,500-foot" sand in the area of study using MODFLOW. The purpose of the model was to test the effect of recharge on the "1,500-foot" sand by observing the change in configuration of the water-level surface of the aquifer. Computer simulations were made showing the current conditions before the completion of the connector well and the conditions after the completion of the connector well. Figure 6 emphasizes the maximum area of drawdown at the Lula Street pumping station prior to construction of the connector well. Figure 7 highlights the same water-level surface shown in figure 6, but focuses on the critical area near Government Street. Figure 8 shows the effect of recharge at the rate of 600 gallons per minute (0.8 million gallons per day)on the water-level surface of the "1,500-foot" sand.

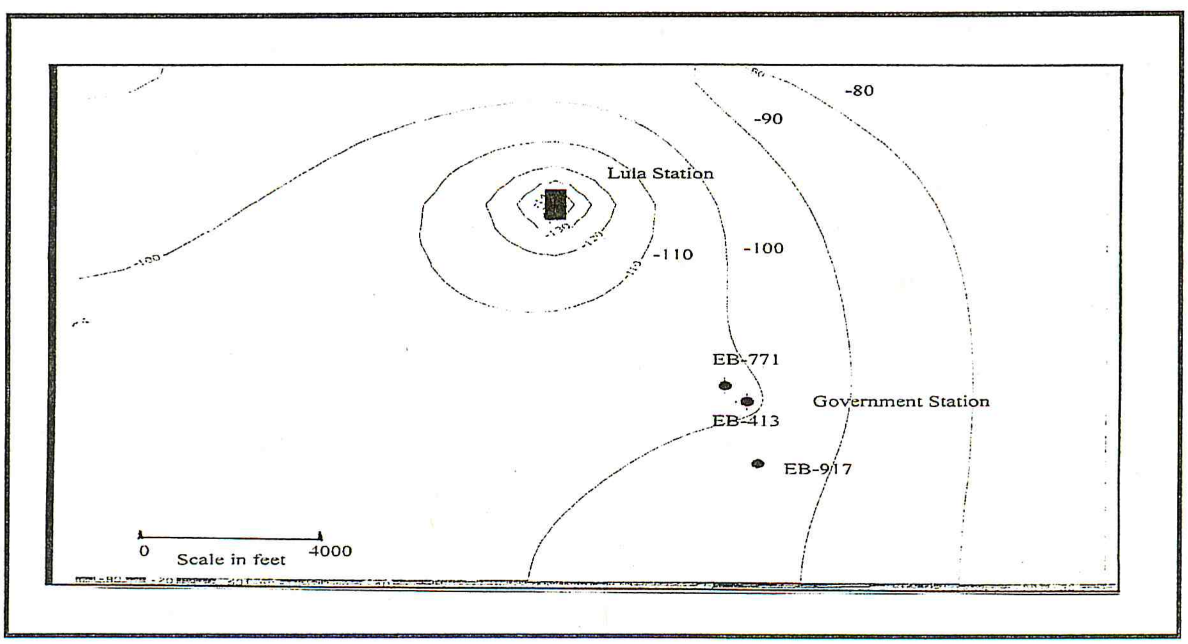


Figure 6. The modeled area of the "1,500-foot" sand.

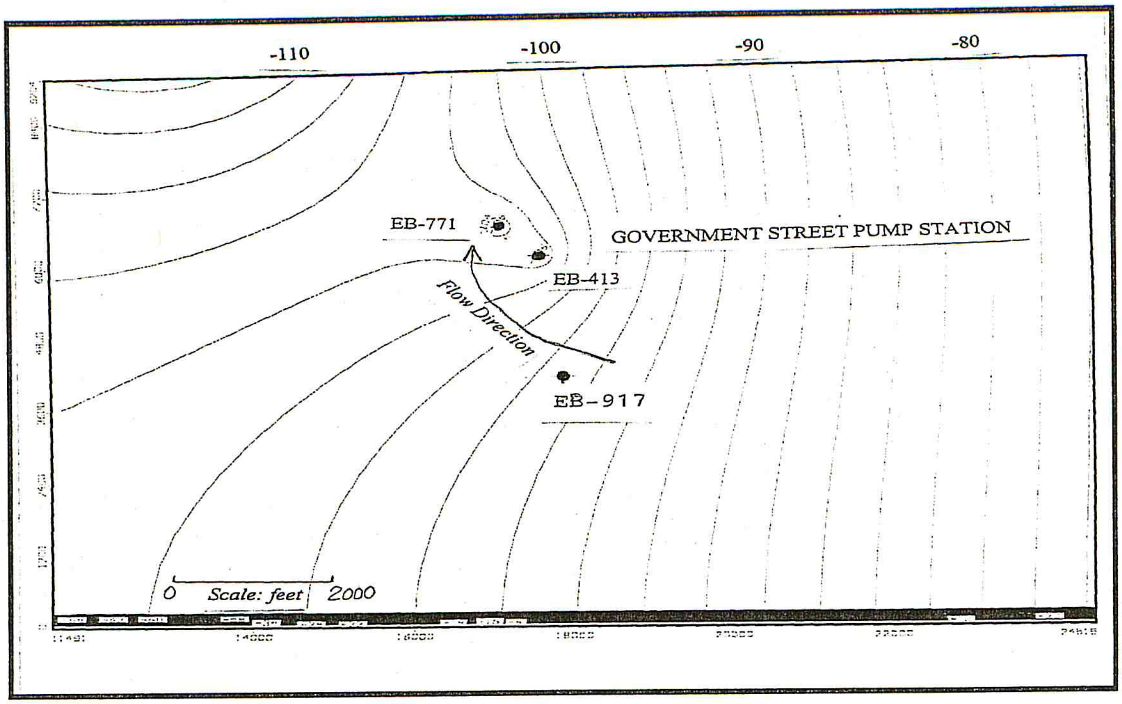


Figure 7. Water-level surface of the "1,500-foot" sand with no connector well.

Flow lines are altered to a more westerly direction on the south side of the pumping wells at Government Street. If the approaching saltwater interface is successfully diverted around Government Street pumping station (see area of saltwater), it will then move northward toward the Lula Street pumping station a little more than a mile away and slightly outside the modeled area (figure 7). At the present rate of pumpage and ground-water flow conditions, it will take decades for saltwater to reach Lula Street. As public-supply wells at Lula Street become older and are gradually phased out, the arrival of saltwater at the well field will be delayed or avoided entirely due to redistribution of new wells to other areas.

CONNECTOR WELL CONSTRUCTION AND TESTING

The Well (EB-1293).-The Commission hired Owen & White, a local engineering firm, to write the specifications for drilling and testing a connector well to be completed in the "800- and 1,500-foot" sands. The deadline for submitting bids was January 14, 1998. The lowest bid of $271,900 was accepted and the contract was awarded to Layne Christensen. The cost estimates that had been prepared previously after consultation with water well contractors had indicated that the price per well would be about half the actual bid received. Because of the complexity of the work involved in this type of well, only one other bidder responded. The high cost of the proposed work also precluded the possibility of drilling a second connector well because of funding limits. However, the location and placement of the single connector well was expected to divert the saltwater away from the pumping wells at Government Street (fig. 8). Computer simulations had shown the effect of recharge on the potentiometric surface of the "1,500-foot" sand and revealed that the flow direction of the northward moving water in the aquifer would be diverted westerly and bypass the Government Street wells as a result of recharge coming from the single connector well installation. If the situation should warrant it, a second connector well will be considered as a possible option for the future.

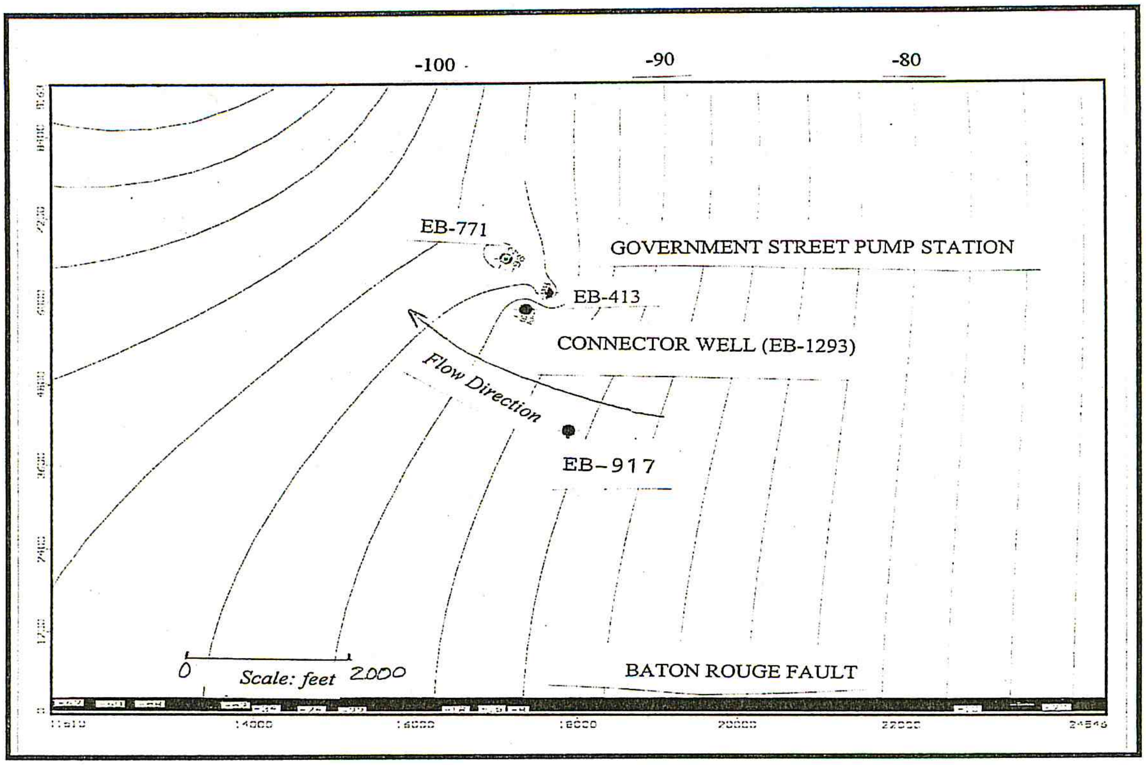


Figure 8. Water-level surface of the "1,500-foot" sand with one connector well in operation.

The work was scheduled to commence on April 6, 1998, with a total of 150 days for substantial completion of the connector well. Drilling of the test hole began May 11, and on May 17 an electrical log was run to a total depth of 1,772 feet. The log revealed two separated sand units in the "800-foot" sand. The upper unit had a sand thickness of 20 feet at a depth of 782 to 802 feet, and the lower unit had a sand thickness of 32 feet at a depth of 832 to 864 feet. Both the "800-foot" and the "1,500-foot" sands were screened throughout their entire thickness. The "1,500-foot" sand, with a thickness of 124 feet, was screened from 1,620 to 1,744 feet. The completed well was constructed according to the design shown in figure 5.

"800-foot" sand - aquifer test results.-The Commission's aim for the connector well was to develop it in such a manner that the upper aquifer recharged the lower aquifer at the maximum possible flow rate. The specifications called for the well to be developed to a minimum of 80- percent efficiency. The test well was pumped at a rate of 752 gallons per minute during a 12-hour drawdown test on the "800-foot" sand. The aquifer test indicated an aquifer transmissivity of about 2,700 ft^2/d or 20,000 gpd/ft. The projected specific capacity of the well after 24 hours of pumping was about 11 gallons per minute per foot of drawdown. When this value was compared to the theoretical specific capacity, the test results indicated the well was operating at greater than 80-percent efficiency.

Although the "800-foot" sand at the connector well site (EB-1293) had a greater thickness (52 feet) than at the test well site (only 40 feet at well EB-1274), the transmissivity values recorded at the two wells were similar. Because of the nearness of the change in thickness, or aquifer boundary, the transmissivity value at well EB-1293 represents the area or regional value, not the value at the well.

Therefore, the specific capacity of the "800-foot" sand at the connector well may be somewhat higher than the 11 gallons per foot of drawdown indicated above.

"1,500-foot" sand aquifer test results.–Following the testing of the "800-foot" sand, a liner pipe was lowered into the well to seal off the "800-foot" sand while the "1,500-foot" sand was being developed. Belt packers were set at the top and bottom of the liner pipe. The first attempt to test the "1,500-foot" sand failed because the aquifer was improperly developed and the large-capacity test pump pulled water from the "800-foot" sand around the packer. Water, along with the gravel pack and material from the wall of the hole, was pulled past the belt packer and entered the 18-inch casing. The pump was shut down and all the suspended material inside the 18-inch upper casing settled to the bottom of the well. This unfortunate event delayed the testing of the "1,500-foot" sand several weeks, while the well was cleaned out and a new gravel pack added to the "800-foot" sand screened interval.

Following extensive development, an aquifer test was conducted for the "1,500-foot" sand. After a 12-hour pumping test, at a pumping rate of 1,879 gpm, a transmissivity of about 16,000 ft^2/d (120,000 gpd/ft) was obtained. A specific capacity of 48 gpm/ft indicated that the well was performing above the required 80-percent efficiency. After completion of the aquifer test, the liner pipe and packers were removed from the well and the two aquifers were connected. The contractor then ran a flow test which indicated a flow of about 475 gallons per minute between the upper and lower screened intervals of the connector well. The average water level in the free flowing well was about 120 feet and denoted that drawdown was occurring in the "800-foot" sand and recovery in the "1,500-foot" sand. The composite water level is depicted in figure 4, which shows drawdown occurring in the "800-foot" sand and recovery occurring in the "1,500-foot" sand.

Subsequent to the final testing of the connector well the contractor was directed to clean out several feet of sediment at the bottom of the well. The sediment had accumulated at the base of the lower screen, and in a blank section of pipe below the screen. However, during the attempt to remove the sediment, some of the sediment went into suspension causing the "1,500-foot" screen to become clogged. The fouled screen was authenticated by observing the water levels recorded in a continuous hydrograph of observation well EB-1274, screened in the "800-foot" sand and located some 500 feet from the connector well. After the connector well became clogged, the composite water level, which had been at 120 feet, rose to about 80 feet below land surface in a short period of time. Clearly, the water level in the connector well now reflected the water level of the "800-foot" sand in well EB-1274. This being the case, the raised water level also indicated the screen in "1,500-foot" sand was probably closed off completely.

CONNECTOR WELL OPERATION

The connector well was officially placed in operation on April 6, 1999 after the final development of the "1,500-foot" sand was considered to be satisfactory. A spinner survey with a calibrated flow meter had been made in December 1998 when the well was first connected and had revealed that the flow from the "800-foot" to the "1,500-foot" sand averaged about 475 gpm. A calibration check of the flow meter that was used for the December test was made prior to the flow test. The flow was measured twice in the connector well, once with the spinner being lowered between the upper and lower screen and again with the spinner being pulled up. There was no repeat of the flow test for the connector well when the re-developed well went into service in April. After the well has been in operation for a few months, another flow test will be made.

When the well was connected in December 1998, the static water levels were approximately 140 feet below land surface for the "1,500-foot" sand and 72 feet below land surface for the "800-foot" sand. The water level in the connected well adjusted to a composite water level of about 120 feet below land surface. After the clogged "1,500-foot" screen was opened up and the connector well was again made operational (April 1999), the composite water level was about the same as in December 1998. Thus, it is reasonable to assume that flow conditions were about the same in April 1999 as in December 1998 when the aquifers were first connected. Water levels were recorded at the connector well (EB-1293) and observation well EB-1274, completed in the "800-foot" sand, on several days after the connector well was placed in operation on April 6.

Hydrographs of wells EB-1274 and EB-1293 have been drawn showing the beginning of operation of the connector well. As expected, the water level in well EB-1274 in the "800-foot" sand declined steadily over the first two weeks of operation (fig.9). Concurrently, the water level in well EB-1293 rose over the same period until it reached its highest level of 119 feet. Although the plots show a general drawdown trend for the "800-foot" sand and recovery for the "1,500-foot" sand, the composite water level in EB-1293 (which is now under continuous monitoring) will constantly adjust to pumping conditions in the "1,500-foot" sand, primarily from public-supply wells EB-413 and EB-771 at Government Street. Seasonal changes in river stage will also affect the water level in the connector well. The "800-foot" sand, like the overlying "600-foot" and "400-foot" sands, is affected hydraulically by the seasonal rise and fall of the Mississippi River stage. This is because of a distinct connection between the "400-foot" sand and the Mississippi River alluvial aquifer, and locally, connections between the "400-foot" and "600-foot" sands and between the "600-foot" and "800-foot" sands. The highest water levels are typically in the spring and lowest levels in the fall for the river and the hydraulically connected aquifers.

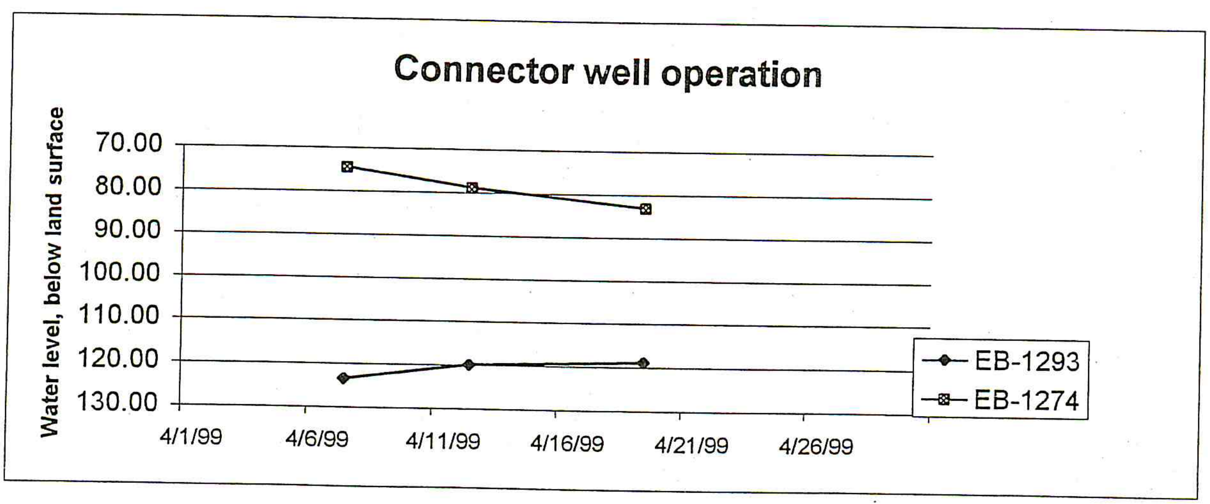


Figure 9. Hydrograph showing short-term effect on the water levels in the "1,500-foot" and "800-foot" sand when the two aquifers were connected.

Proposed Monitoring with Satellite Technology.-- The continuous monitoring of water levels in the connector well (EB-1293) will be observed over the next year with the addition of a data-collection platform at the well site. The satellite hookup with the recorder at the well will transmit up-to-date water-level information on a computer screen. The transmitted information is also available on the Internet and can be downloaded by using the following web site: wwwfs1dlabrg.er.usgs.gov/1500ftsandBR.asp. A hydrograph of the water levels can be reviewed on the computer screen at periods of the previous day, three days or seven days.

In addition to the connector well, EB-1293, satellite transmission of water-level data is also available for observation wells EB-1274, screened in the "800-foot" sand, and EB-917, screened in the "1,500-foot" sand. Thus, the interaction of water levels in the two aquifers that are joined by the connector well shows an immediate response in the water levels of the two observation wells. For example, a seven day period of operation is illustrated in figure 10. The drawdown and recovery curves created by the pumping cycles of wells EB-413 and EB-771 at the Government Street Station are reflected instantaneously in the hydrograph of the connector well, EB-1293, as well as in EB-1274 and EB-917. However, the drawdown and recovery curves of water levels are subdued for the two observation wells. In summary, the connector well is responding not only to the head difference between the two aquifers, but also to the pumping cycles of the public-supply wells at Government Street.

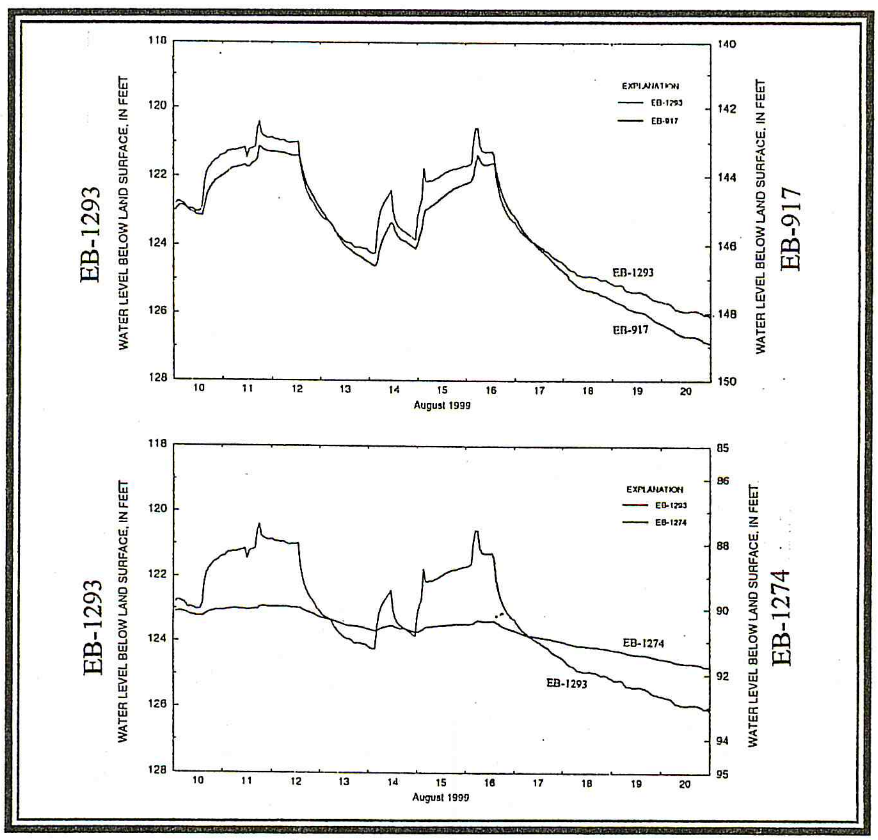


Figure 10. Hyrdrograph comparison of observation well EB-917 with EB-1293 (above) and EB-1274 with EB-1293 (below).

PROJECTIONS OF FUTURE WELL PERFORMANCE

Although the connector well constructed for the project was based on well-established hydrologic principles, the well is experimental in the sense that it is the first known to be completed in the Gulf Coast area. However, because of the ideal design and construction, low flow velocities through the well screens and absence of pump surging, a long and productive life is projected for the well (estimated 50 years or more). Operational costs will be low, only for routine monitoring, as no energy costs are involved. The major concern for future operation is the possibility of a declining head differential between aquifers. At present this problem seems unlikely because pumpage from the "800-foot" sand is small. However, if needed, the exchange rate can be increased by the installation of downward pumping equipment.

REFERENCES

Rollo, J.R., 1969, Saltwater Encroachment in Aquifers in the Baton Rouge Area, Louisiana: Louisiana Department of Conservation, Louisiana Geological Survey, and Louisiana Department of Public Works Water Resources Bulletin No. 13, 45p.

Tomaszewski, Dan J., 1996, Distribution and Movement of Saltwater in Aquifers in the Baton Rouge Area, Louisiana: Louisiana Department of Transportation and Development Water Resources Technical Report No. 59, 44p.

Whiteman, C.D., Jr., 1979, Saltwater Encroachment in the "600-foot" and "1,500-foot" Sands of the Baton Rouge Area, Louisiana, 1966 -78, including a discussion of saltwater in other sands: Louisiana Department of Transportation and Development, Office of Public Works Water Resources Technical Report No. 19, 49p.

Wickersham, Ginia, 1977, Review of C.G. Jacob's Doublet Well: Ground Water, vol. 15, no. 5, p. 344-347.