Excerpt from Christopher Neudeck Testimony in re Phelps, et al., (Term 91) 2003

For the area of concern, Upper Roberts Island, DWR has a recent study which resulted in that agency producing Exhibit "G" entitled "Reclamation District 544 Seepage Monitoring Study 2000 - 2001." This study confirms my prior conclusions that due to the subsurface soils, there is a direct connection between the shallow groundwater and the waters in the neighboring channels. When the river goes up, the groundwater goes up and vice-a-versa.

This hydrologic conductivity is important to understand the local water supplies. The entire Delta is one big pool of water; some in the channel and some in the soils. There is no net difference in the amount of water in the Delta channels when local diverters take from neighboring channels, pump from shallow groundwater, or farm crops which draw from the shallow groundwater. Taking water from one place is virtually the same as from another. This is especially true during summer and fall months when the three tidal barriers are in operation as they hold high tide waters around Upper Roberts Island and thus prevent any depletion of the channel waters from causing low levels which might affect other diverters.

I therefore conclude that if these four diverters which are the subject of this hearing were forced to shift to shallow wells for irrigation, or farm crops which had root zones reaching to the shallow groundwater, there would be no difference in the amount of water available in the surrounding channels.

Excerpt from Christopher Neudeck Testimony in re Draft CDO for Mussi, et. al., 2010

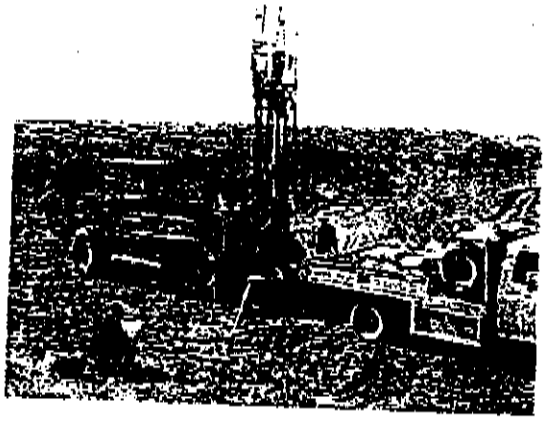
As you can in Exhibit 3V (specifically section II., Exhibit "G") which is my testimony submitted in the Term 91 hearings, the surrounding groundwater is directly connected to the waters in the neighboring channels. As I stated in that proceeding:

> This hydrologic conductivity is important to understand the local water supplies. The entire Delta is one big pool of water; some in the channel and some in the soils. There is no net difference in the amount of water in the Delta channels when local diverters take from neighboring channels, pump from shallow groundwater, or farm crops which draw from the shallow groundwater. Taking water from one place is virtually the same as from another. This is especially true during summer and fall months when the three tidal barriers are in operation as they hold high tide waters around Upper Roberts Island and thus prevent any depletion of the channel waters from causing low levels which might affect other diverters.

WIC EXHIBIT 4D

State of California
The Resources Agency
DEPARTMENT OF WATER RESOURCES
Division of Planning and Local Assistance
Central District

Reclamation District 544
Seepage Monitoring Study
2000-2001



Memorandum Report

July 2001

State of California

The Resources Agency

Memorandum

Date : JUL 11 2001

To : Mike Ford
Office of State Water Project Planning

From : Karl P. Winkler, Chief
Central District
Department of Water Resources

Subject:
Reclamation District 544 Seepage Monitoring Study

Central District is pleased to present the attached report, *Reclamation District 544 Seepage Monitoring Study, 2000-2001.* This report presents seepage monitoring results from Upper Roberts Island. Surface and groundwater level monitoring was initiated in April 2000 to evaluate the effects of the operation of the temporary fish barrier at the head of Old River on shallow groundwater levels on Upper Roberts Island. This work was completed at the request of the Temporary Barriers Project and Land Management Section of the Office of State Water Project Planning with the cooperation of Reclamation District (RD) 544 and several landowners.

Data was collected from seven groundwater monitoring stations and a river stage gage along the San Joaquin River at Upper Roberts Island. During the study period, river stage and groundwater levels did not rise above the Island's land surface and seepage was not observed.

If you have any questions regarding this report, please contact Mark Souverville at (916) 227-7601.

Attachment

SURNAME	Mark Souverville 07/11/01	R. Maxwell 07/11/01	K. Kubeck 7-12-01	

DWR 188 (Rev. 2/86)

01794

Reclamation District 544 Seepage Monitoring Study 2000-2001

This report presents seepage monitoring results from Upper Roberts Island. Surface and groundwater level monitoring was initiated in April 2000 to evaluate the effects of the operation of the temporary fish barrier at the head of Old River on shallow groundwater levels on Upper Roberts Island. This work was completed at the request of the Temporary Barriers Project and Land Management Section of the Office of State Water Project Planning with the cooperation of Reclamation District (RD) 544 and several landowners.

Introduction

Upper Roberts Island is an agricultural area in the south Delta, bounded on the west by Middle River, on the south by Old River and on the east by the San Joaquin River. The north end of the head of Old River barrier rests on the Island's Old River levee at the point where it branches from the San Joaquin River. The head of Old River barrier is operated to benefit fisheries. Studies conducted by the U.S. Fish and Wildlife Service suggest that there may be a higher rate of survival for salmon smolt emigrating through the San Joaquin River rather than Old River (DWR 1998, 1999). The barrier is emplaced to prevent outmigrating salmonids in the San Joaquin River from entering Old River and subsequently the Central Valley and State Water Project pumps. It is constructed in the spring and fall of each year, except during high flows.

Streamflow and stage on the east and west sides of Upper Roberts Island is affected by the barrier. During periods of barrier operation, flow and stage in Old River are reduced while flow and stage along the San Joaquin River are increased.

Landowners on Upper Roberts Island have been concerned that the rise in San Joaquin River stage due to the fish barrier has caused a rise in the groundwater levels on the Island, creating a negative impact on crop production. The fish barrier at the head of Old River is bounded on both ends by private land, and temporary entry permits are required to install the barrier. The landowners on Upper Roberts Island have requested, as a condition of the temporary entry permits, that the Department of Water Resources (DWR) monitor groundwater levels on the Island to evaluate seepage

Monitoring Site Selection

Three seepage monitoring sites were chosen on Upper Roberts Island in coordination with Jerry Robinson, President of RD 544, Bill Darsie of Kjeldsen, Sinnock and Neudeck, and staff from DWR's Office of State Water Project Planning (OSWPP) and Central District (CD). A regional map (Figure 1) shows the location of the three monitoring sites, the San Joaquin River stage gages, and the head of Old River barrier. Well locations at each site were determined after evaluating boring samples and nearby surface features, such as canals. These locations are shown on topographic maps of the three sites (Figures 2-4). Each site has two shallow wells,

one near the levee toe and the other approximately 150 feet inland from the toe, to monitor the groundwater gradients adjacent to the San Joaquin River. An additional deeper well was drilled at Site 1 to attempt to determine the vertical gradient.

Monitoring Network Installation

Seven wells were installed prior to the spring 2000 emplacement of the head of Old River barrier. The well depths range from 18 to 40 feet below the ground surface with each well having a 5-foot screened interval. The goal was to install the wells within a saturated, coarse-grained unit beneath each site. A truck-mounted Central Mine Equipment 750 drill rig was used to drill the borings. All borings were advanced with 8-inch diameter hollow stem augers. Soils were collected for description using a continuous sampling tube. Details of the drilling, descriptions of the soils, and field classifications of the soils are provided on the drill hole logs in Appendix A. The construction details of each monitoring well are included with each well log. Table 1 lists the depth, reference point elevation, and screened interval for each well.

Well	Boring Depth[1]	Well Depth[1]	Screened Interval[1]	Reference Point Elevation[2]
UR1A	30	28	23-28	16.15
UR1B	27	25	20-25	16.24
UR1C	40	40	35-40	16.01
UR2A	20	17	12-17	12.57
UR2B	21	19	14-19	12.21
UR3A	18	17	12-17	9.89
UR3B	20	20	15-20	9.92

1. Depth below ground surface in feet
2. Reference point at top of plastic casing

National Geodetic Vertical Datum 1929

Table 1. Well Depths and Reference Point Elevations

In addition to the groundwater monitoring well installations, a temporary tide gage was installed in April 2000. The gage was mounted on an existing pumping platform in the San Joaquin River about 1,500 feet downstream from the temporary barrier. A permanent station is planned to be constructed by fall 2001. The San Joaquin River stage is compared to groundwater levels on Upper Roberts Island to determine the effect of river stage on groundwater levels.

CD staff surveyed the monitoring network for elevation and horizontal position. The U.S. Army Corps of Engineers (USACE) and U.S. Geological Survey benchmark "Tidal 6," National Geodetic Vertical Datum 29, elevation 16.85 feet, is the datum for

this survey. The "Tidal 6" benchmark is located on the north levee of Old River near the temporary barrier. The elevation survey determined reference point and ground surface elevations at each monitoring well and a reference point elevation on the San Joaquin River tide gage.

Topographic maps of the seepage monitoring sites and adjacent river section, Figures 2 through 7, were constructed using data from USACE, Sacramento District. Ayres Associates, under contract to USACE, collected hydrographic and photogrammetric survey data of the San Joaquin River Basin in 1998. Along with geologic information from boring logs, USACE's data was used to develop cross sections perpendicular to the San Joaquin River at the seepage monitoring sites.

Well	Northing (Meters)	Easting (Meters)	Ground Surface Elevation (Feet)
UR1A	4186190	647406	13.06
UR1B	4186337	647391	13.04
UR1C	4186340	647390	13.01
UR2A	4190671	647506	9.38
UR2B	4190657	647460	8.96
UR3A	4191875	647681	6.67
UR3B	4191887	647639	7.24
CD staff determined geographic coordinates of the wells using a Trimble Pro XR Global Positioning System.			
Universal Transverse Mercator Zone 10 projection			

Table 2. Well Locations

Hydrogeology

The soils encountered at the three sites occur as alternating layers containing varying amounts of clay, silt and/or sand mixtures. Saturated coarse-grained layers were encountered at each site for placement of well screens. For a detailed description, refer to the drill hole logs in Appendix A.

At Site 1, as shown in Figure 5, alternating clay and silt layers were observed from the surface up to 24 feet below ground surface (bgs) during drilling. Total depth of borings for UR1A, UR1B and UR1C were 30 feet, 27 feet and 40 feet respectively. Water bearing sand occurs from 24 feet to the total depth of boring (TD) in UR1A, from 21 to 25 feet in UR1B, and from 20 to 24 feet and 29 feet to TD in UR1C. A clay layer occurs between two water bearing sand layers at depths of 25 feet to TD in UR1B and 24 to 29 feet in UR1C.

At Site 2, as shown in Figure 6, clay was observed from the surface up to 8 feet bgs. Total depth of borings for UR2A and UR2B were 20 feet and 21 feet respectively. Water-bearing sand occurs from 13 to 17 feet in UR2A, and from 15 feet to TD in UR2B. A clay layer occurs between two permeable sand layers at depths of 11 to 13 feet in UR2A and 14 to 15 feet in UR2B. Silt occurs from 17 feet to TD in UR2A.

At Site 3, as shown in Figure 7, alternating clay and silt layers were observed from the surface up to 11 feet bgs. Total depth of borings for UR3A and UR3B were 18 feet and 20 feet respectively. Permeable sand occurring from the surface to a depth of 6 feet in UR3A overlies silty clay that is present to a depth of 11 feet. Water-bearing sand occurs from 11 to 17 feet in UR3A and 10 to 13 feet and 16 feet to TD in UR3B. Clay occurs from 13 to 16 feet in UR3B.

Data from the geologic borings indicate that water bearing sand layers beneath each site likely extend to the left bank of the San Joaquin River (Figures 5 through 7). Groundwater should move freely within these sands, but the soils overlying these sands are primarily silts and clays, except at well UR3A. These silts and clays will impede the vertical movement of groundwater.

Monitoring Activities

The period of record for stage and groundwater elevation data in this report is April 20, 2000 to April 20, 2001. Groundwater elevation levels in each well are measured and recorded hourly using an In-situ Troll datalogger/transducer. The data is collected monthly with a palmtop computer. Stage data is measured and recorded hourly by a Hydrolab Datasonde 3. The data is collected monthly with a laptop computer. The San Joaquin River at Brandt Bridge station, maintained by DWR, measures and records stage data at 15-minute intervals. The river stage gage at Vernalis is operated jointly by the U.S. Geological Survey and DWR. It measures and records hourly stage data and posts it to the California Data Exchange Center web page.

Monitoring Results

The collected data were evaluated by creating hydrographs for each site showing groundwater elevation, ground surface elevation and San Joaquin River stage (Figures 8 through 15). Vertical lines bracket the periods of construction and removal of the head of Old River fish barrier. A solid horizontal line represents the ground surface at the monitoring site.

The following observations can be made from the San Joaquin River hydrograph, Figure 8. Over the period of record, water levels in the monitoring wells and the stage gage on the San Joaquin River at Upper Roberts Island peaked in April 2000, during a period of reservoir releases for the Vernalis Adaptive Management Plan (VAMP). Stage data from Vernalis, located 13 miles southeast and upstream of the barrier, show that the same activities (occurrences) that influence stage at

Vernalis are the primary influences on San Joaquin River stage along Upper Roberts Island.

The following observations can be made from the Site 1 hydrographs, Figures 9 through 13. Changes in groundwater elevation at the site mimic changes in the adjacent river stage but are less pronounced and lag slightly behind. The groundwater elevation in well UR1A was the most responsive to changes in river stage. During the period of record, the highest recorded river stage at the temporary gage on the San Joaquin River was 7.59 feet, coincident with a groundwater elevation of 6.38 feet (depth of 6.68 bgs) in well UR1A. During the period of record, the San Joaquin River maintained stage above groundwater from April 20, 2000 to mid May, the beginning of October to the beginning of December and mid February to mid March. During these periods, groundwater elevations in well UR1A were closer to river stage than to groundwater elevations in wells UR1B and UR1C. From mid May to mid August, the San Joaquin River maintained stage below groundwater elevations and groundwater elevations in well UR1A were predominantly below well UR1B. The elevation of groundwater in well UR1B is consistently slightly higher than in well UR1C, but the water level trends in the two wells are nearly identical. The predominant groundwater elevation gradient has been away from the San Joaquin River.

The following observations can be made from the Site 2 hydrograph, Figure 14. Changes in groundwater elevation at the site mimic changes in the river stage, downstream approximately 1.4 river miles at Brandt Bridge, but are less pronounced. The groundwater elevation in well UR2A was more responsive to changes in river stage than the groundwater elevation in well UR2B. During the period of record, the highest recorded San Joaquin River stage at Brandt Bridge was 5.51 feet, coincident with a groundwater elevation of 4.84 feet (depth of 4.54 bgs) in well UR2A. During the period of record, the San Joaquin River stage at Brandt Bridge was not observed above groundwater elevations in either well for any extended period. When stage did rise above groundwater elevation, however, the groundwater elevation in well UR2A approached river stage at a greater rate than the groundwater elevation in well UR2B. From April 20, 2000 to mid June, the San Joaquin River at Brandt Bridge maintained stage below groundwater elevations. During this period there were two events, at the end of May and beginning of June, when significant dips in stage were observed. As they occurred, the groundwater elevation in well UR2A shifted toward the river stage more than the groundwater elevation in well UR2B. The elevation of groundwater in well UR2B is consistently slightly higher than in well UR2A, and the water level trends in the two wells are nearly identical. The predominant groundwater elevation gradient has been towards the San Joaquin River.

The following observations can be made from the Site 3 hydrograph, Figure 15. Changes in groundwater elevation at the site mimic changes in the river stage at Brandt Bridge, which is just downstream of Site 3, but are less pronounced and lag slightly behind. The groundwater elevation in well UR3A was more responsive than the groundwater elevation in well UR3B to changes in river stage. During the period of record, the highest recorded San Joaquin River stage at Brandt

Bridge was 5.51 feet, coincident with a groundwater elevation of 3.69 feet (depth of 2.98 bgs) in well UR3A. During the period of record, the San Joaquin River stage at Brandt Bridge was above Site 3 groundwater elevations from mid June 2000 to the beginning of February 2001. During this time, groundwater elevations in the wells declined nearly 2 feet from June to mid August while the river stage maintained an elevation range of approximately 2 to 3 feet above sea level. The decline in well UR3B was also greater than well UR3A during this time. The elevation of groundwater in well UR3A is consistently higher than in well UR3B, and the water level trends in the two wells are nearly identical. In May 2000, an irrigation ditch, constructed nearly 50 feet from well UR3A and only 10 feet from well UR3B, was in use. Simultaneously, groundwater elevation levels in both wells rose sharply and, for a brief period, were greater in well UR3B than in well UR3A. The predominant groundwater elevation gradient is away from the San Joaquin River.

Summary

San Joaquin River stage elevation data and groundwater elevation data indicate that permeable strata underlying the Island are laterally continuous and are likely to be in contact with the riverbed. In general, groundwater in permeable strata such as these will fluctuate in response to changes in river stage. This relationship is seen in the hydrographs for each site (Figures 9, 14 and 15) where water levels in the wells respond to changes in river stage. When the stage increases in the San Joaquin River, the groundwater levels will rise towards the land surface, but not as rapidly as the river stage rises. Over the monitoring period, river stage has not reached a level sufficient to raise groundwater levels to the point where seepage may occur.

In some cases, the water levels in the wells may not accurately represent the water levels in the soils. The vertical movement of groundwater at these monitoring sites is likely to be inhibited by fine-grained sediments occurring above the saturated sand zones in which the well screens are completed. Therefore, rising water levels recorded in the wells are likely to be above the level of the surrounding water table. After a period of time, the water table may reach the water level in the well. The time necessary for this to occur is dependent upon the characteristics and distribution of soils that the groundwater must rise through.

A shallow permeable sand zone occurring at well UR3A is unique to the project. The vertical movement of groundwater at this location would not be restricted by overlying silts and clays, unlike other monitoring sites. If the sand layer is laterally continuous and in contact with the riverbed, groundwater at this well could respond quickly to rising river stage. Seepage may occur here soon after the river stage rises above the ground surface.

The stage and duration required for seepage to occur is dependent upon antecedent soil moisture conditions, topography, geology and soils, location and gradient of groundwater table, and local drainage works (DWR Bulletin 125, page 15). The lowest surface water stage necessary for seepage to occur at a particular site is called the critical base level (page 17). Once a site's critical base

level is reached, seepage may occur if the stage is maintained or rises. Critical base levels typically occur at or above the level of the adjacent ground surface. The monitoring system will not indicate when seepage occurs. It can indicate when critical base level is reached and the length of time it is maintained.

Conclusions

1. Over the monitoring period, groundwater levels and river stage did not rise to the land surface.

2. Over the monitoring period, seepage was not observed.

3. Geologic conditions most likely to allow seepage were found at Site 3.

Recommendations

Continue to monitor river stage and groundwater levels until seepage conditions are observed. The data will be used to determine the critical base level when seepage occurs.

References

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California Department of Water Resources (DWR). 1999. *Temporary Barriers Project, 1998 Fishery, Water Quality, and Vegetation Monitoring Report, Sacramento, California.* 80 pp. plus appendices.

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Figures

Study Area and Site Locations

RD 544 Seepage Monitoring Study

Department of Water Resources
Central District
Geology and Groundwater Section

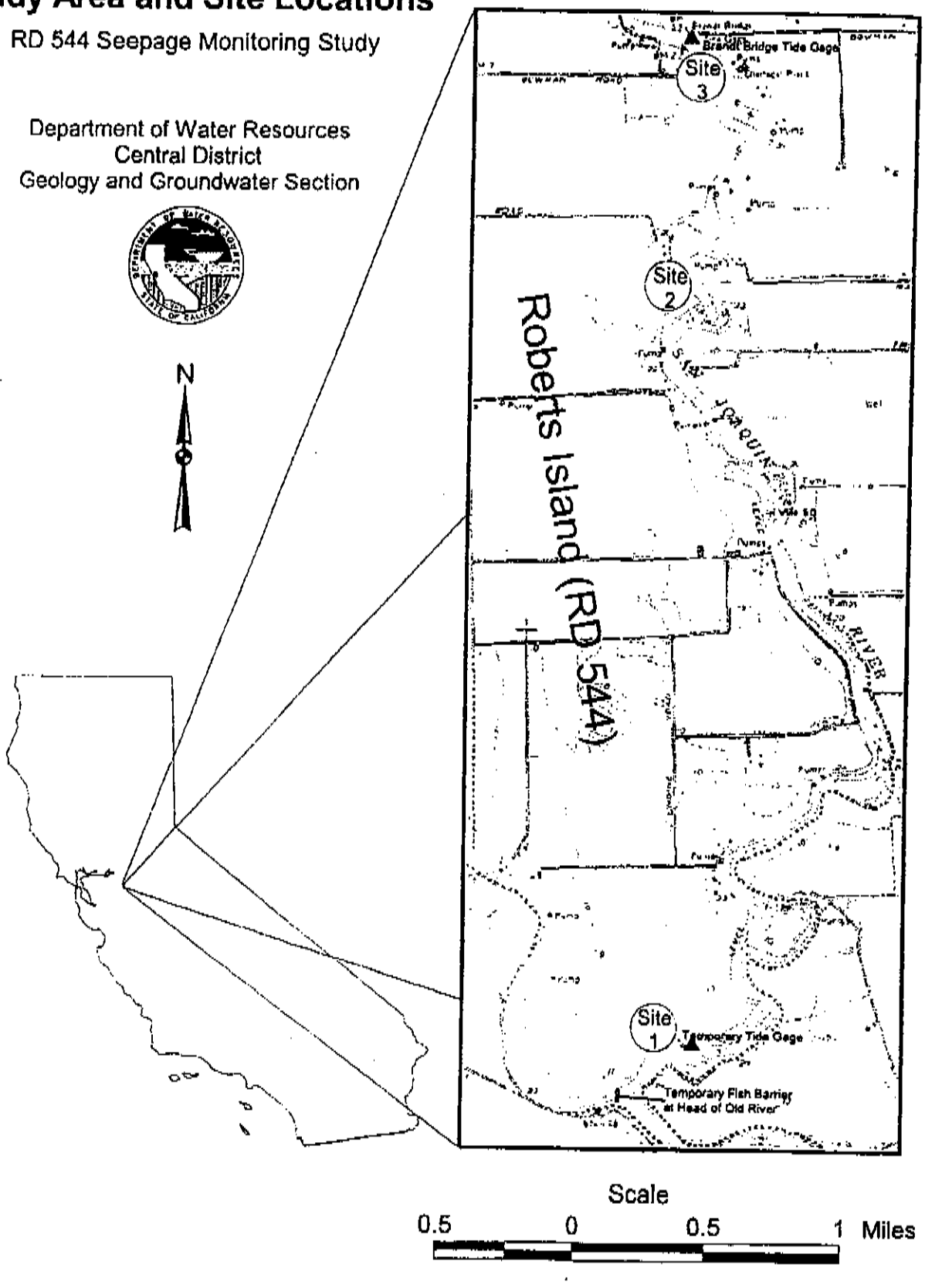


Figure 1

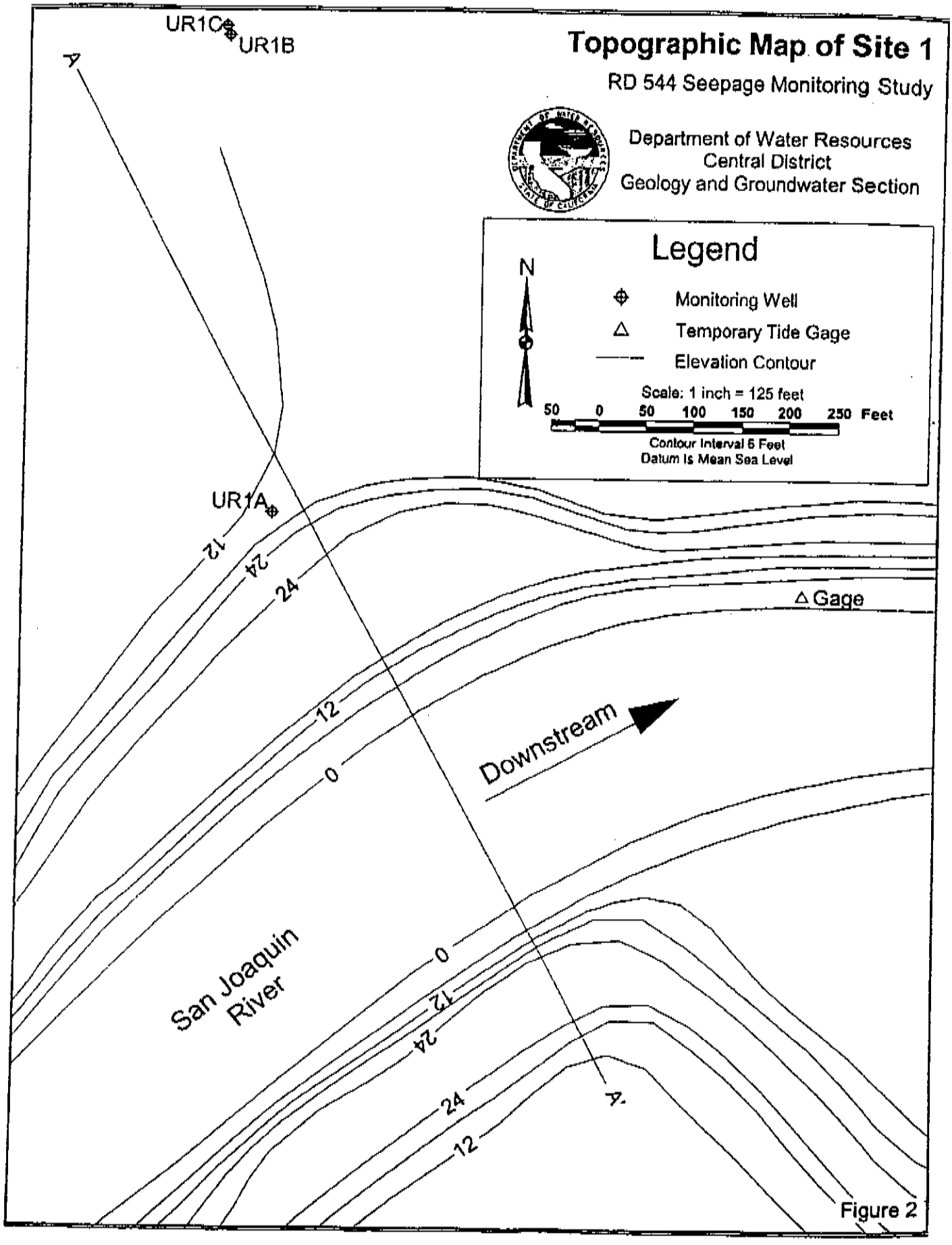
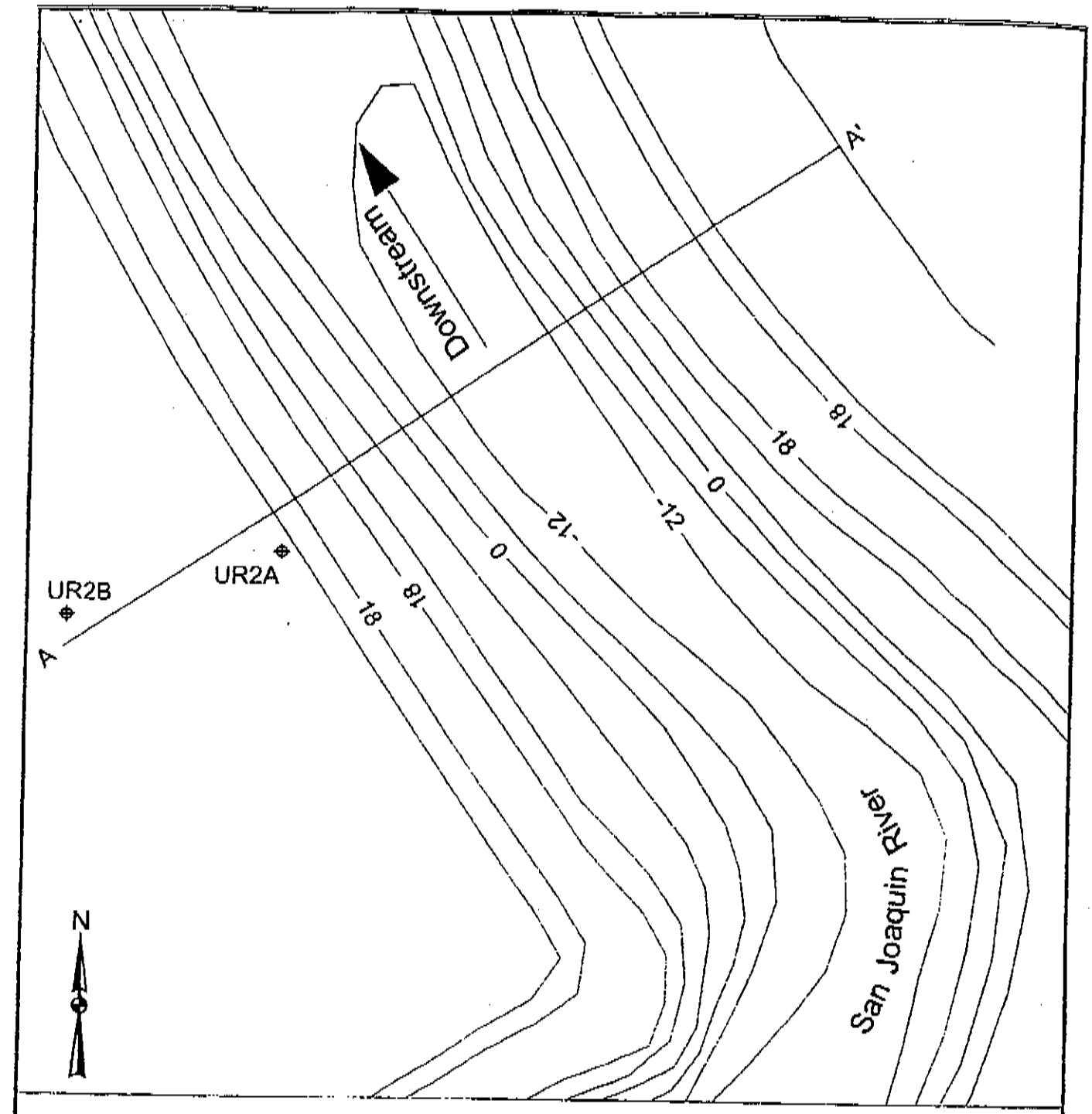

Topographic Map of Site 1
RD 544 Seepage Monitoring Study
Department of Water Resources
Central District
Geology and Groundwater Section
Legend
N
Monitoring Well
Temporary Tide Gage
Elevation Contour
Scale: 1 inch = 125 feet
50 0 50 100 150 200 250 Feet
Contour Interval 6 Feet
Datum Is Mean Sea Level
UR1C
UR1B
UR1A
Gage
Downstream
San Joaquin River
A
A'
12
24
24
12
0
0
12
24
24
12

Figure 2



Legend

Monitoring Well

Elevation Contour

Scale: 1 inch = 100 feet

100 0 100 200 Feet

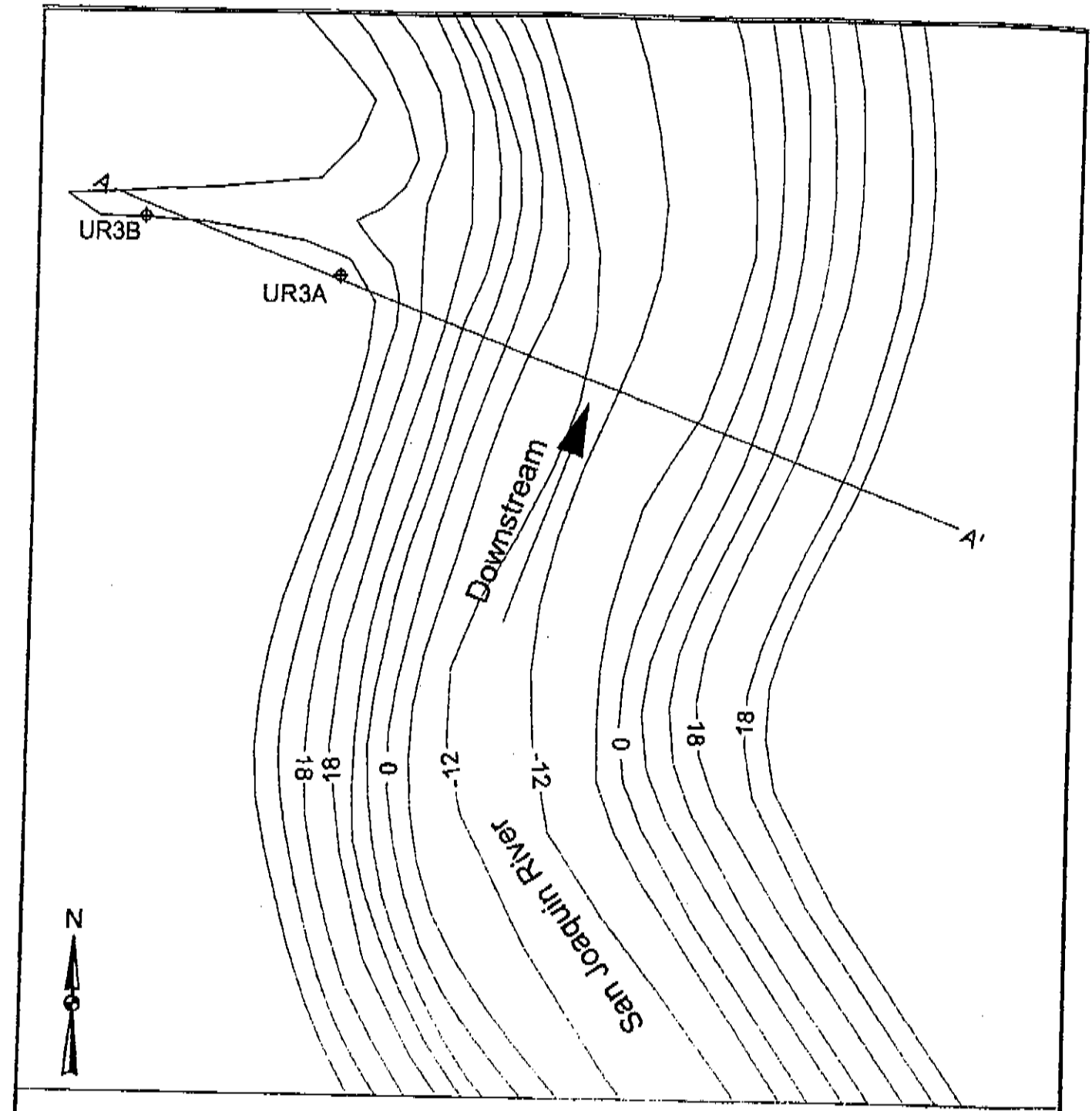
Contour Interval 6 Feet
Datum Is Mean Sea Level

Topographic Map of Site 2

RD 544 Seepage Monitoring Study

Department of Water Resources
Central District
Geology and Groundwater Section

Figure 3



Legend

Monitoring Well

Elevation Contour

Scale: 1 inch = 100 feet

100 0 100 200 Feet

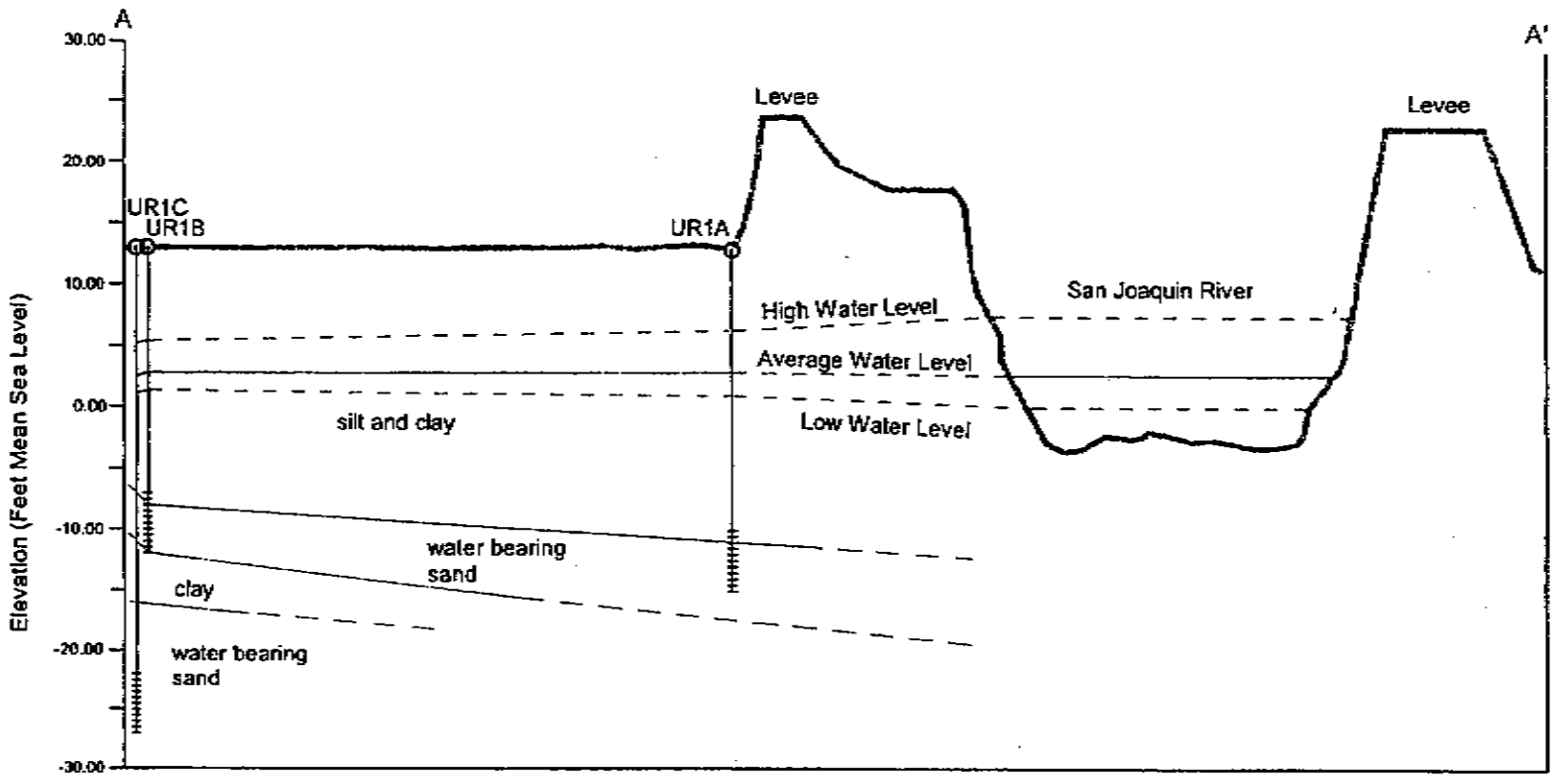
Contour Interval 6 Feet
Datum is Mean Sea Level

Topographic Map of Site 3

RD 544 Seepage Monitoring Study

Department of Water Resources
Central District
Geology and Groundwater Section

Figure 4



Legend

- Surface Profile
- Water Level
- Generalized Lithology
- Projected Lithology
- Well

Horizontal Scale: 1 inch = 150 feet

50 0 50 100 150 200 250 300 Feet

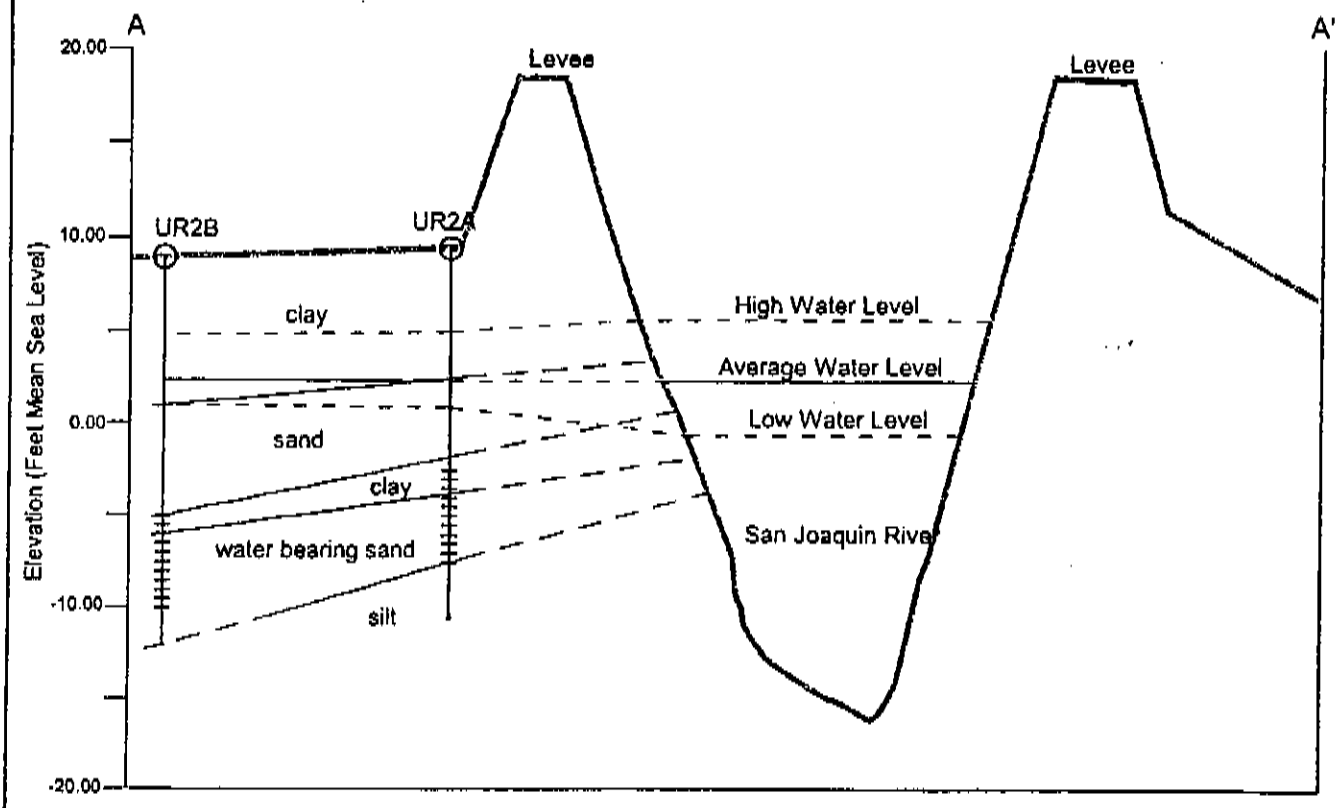
Approximate vertical exaggeration 5X

Hydrogeologic Cross Section A - A' of Site 1

RD 544 Seepage Monitoring Study

Department of Water Resources
Central District
Geology and Groundwater

Figure 5



Legend

- Surface Profile
- Water Level
- Generalized Lithology
- Projected Lithology
- Well

Horizontal Scale: 1 inch = 100 feet

50 0 50 100 150 200 Feet

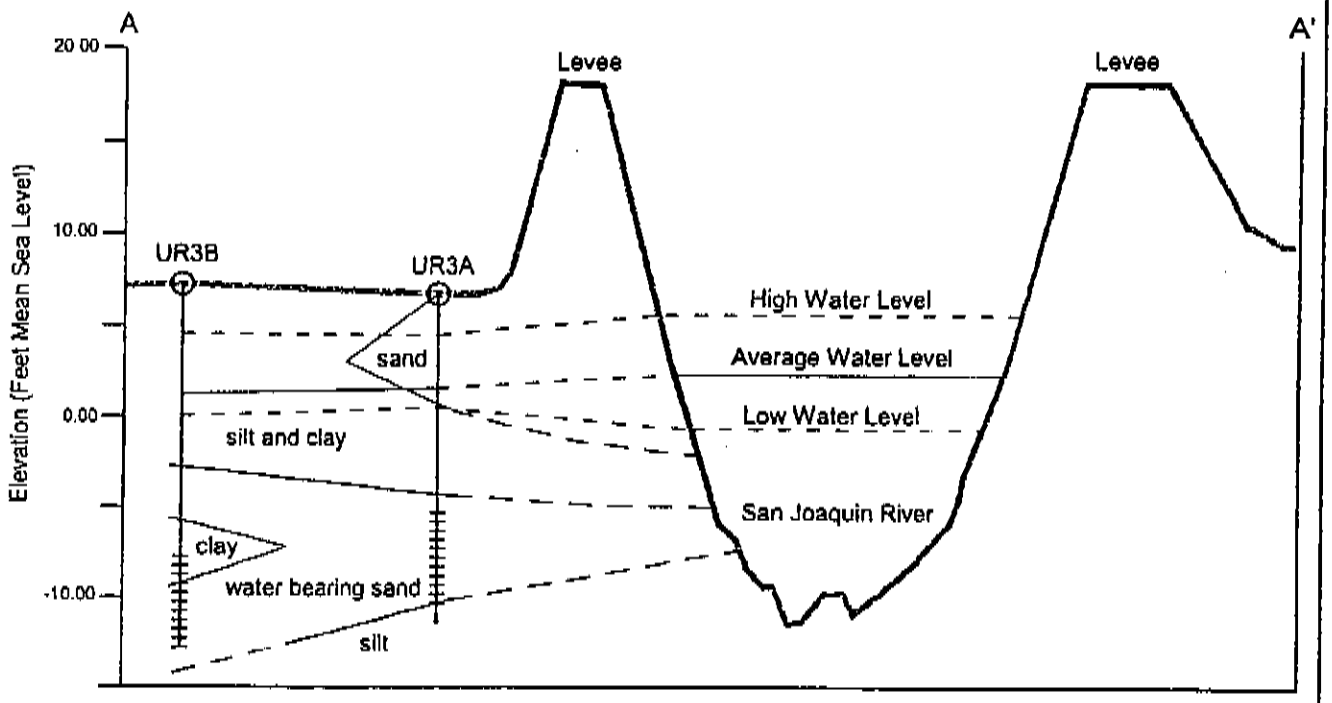
Approximate vertical exaggeration 5X

Hydrogeologic Cross Section A - A' of Site 2

RD 544 Seepage Monitoring Study

Department of Water Resources
Central District
Geology and Groundwater

Figure 6



Legend

- Surface Profile
- Water Level
- Generalized Lithology
- Projected Lithology
- Well

Horizontal Scale: 1 inch = 100 feet

50 0 50 100 150 200 Feet

Approximate vertical exaggeration 5X

Hydrogeologic Cross Section A - A' of Site 3

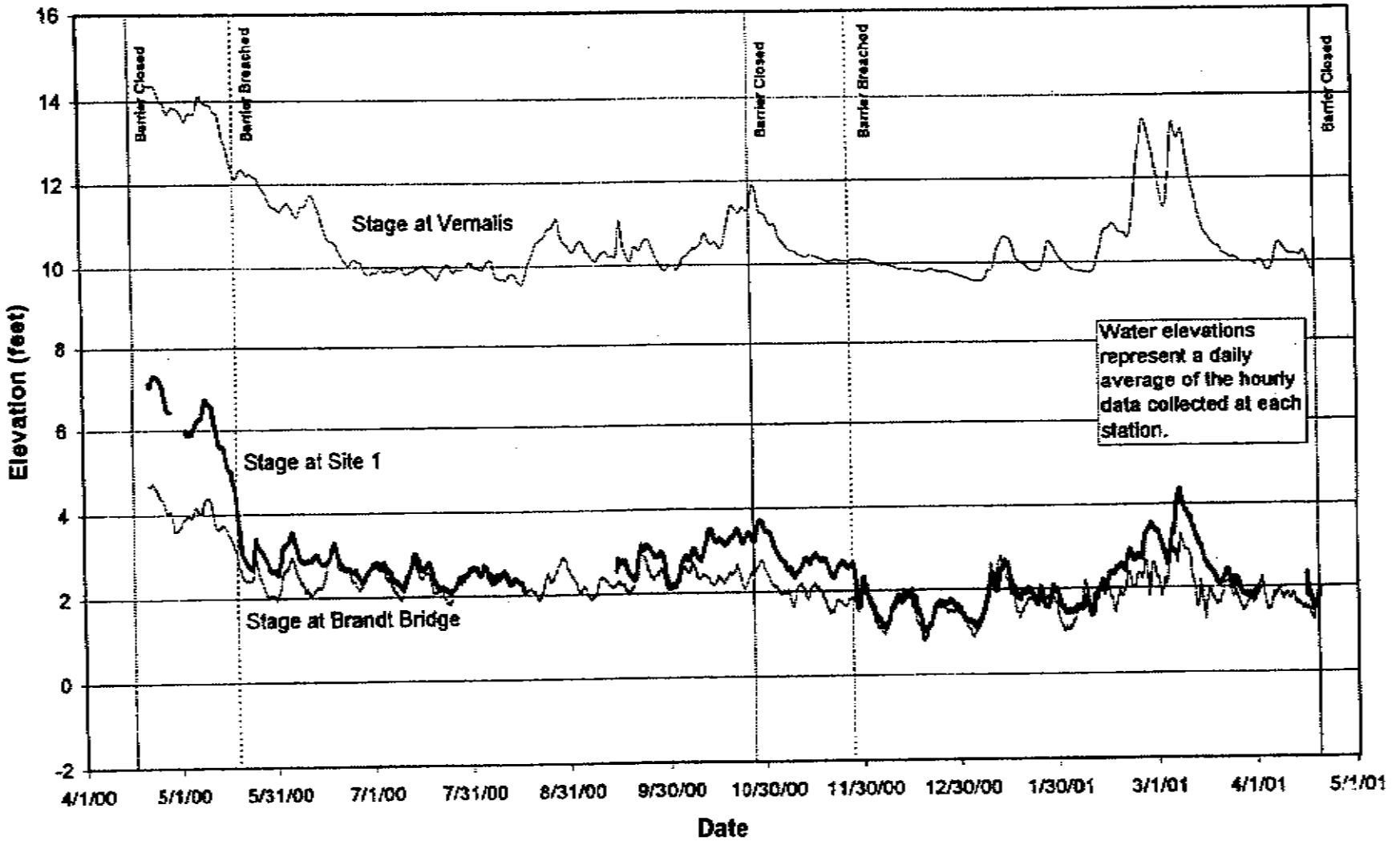
RD 544 Seepage Monitoring Study

Department of Water Resources
Central District
Geology and Groundwater

Figure 7

San Joaquin River Stage

RD 544 Seepage Monitoring Study

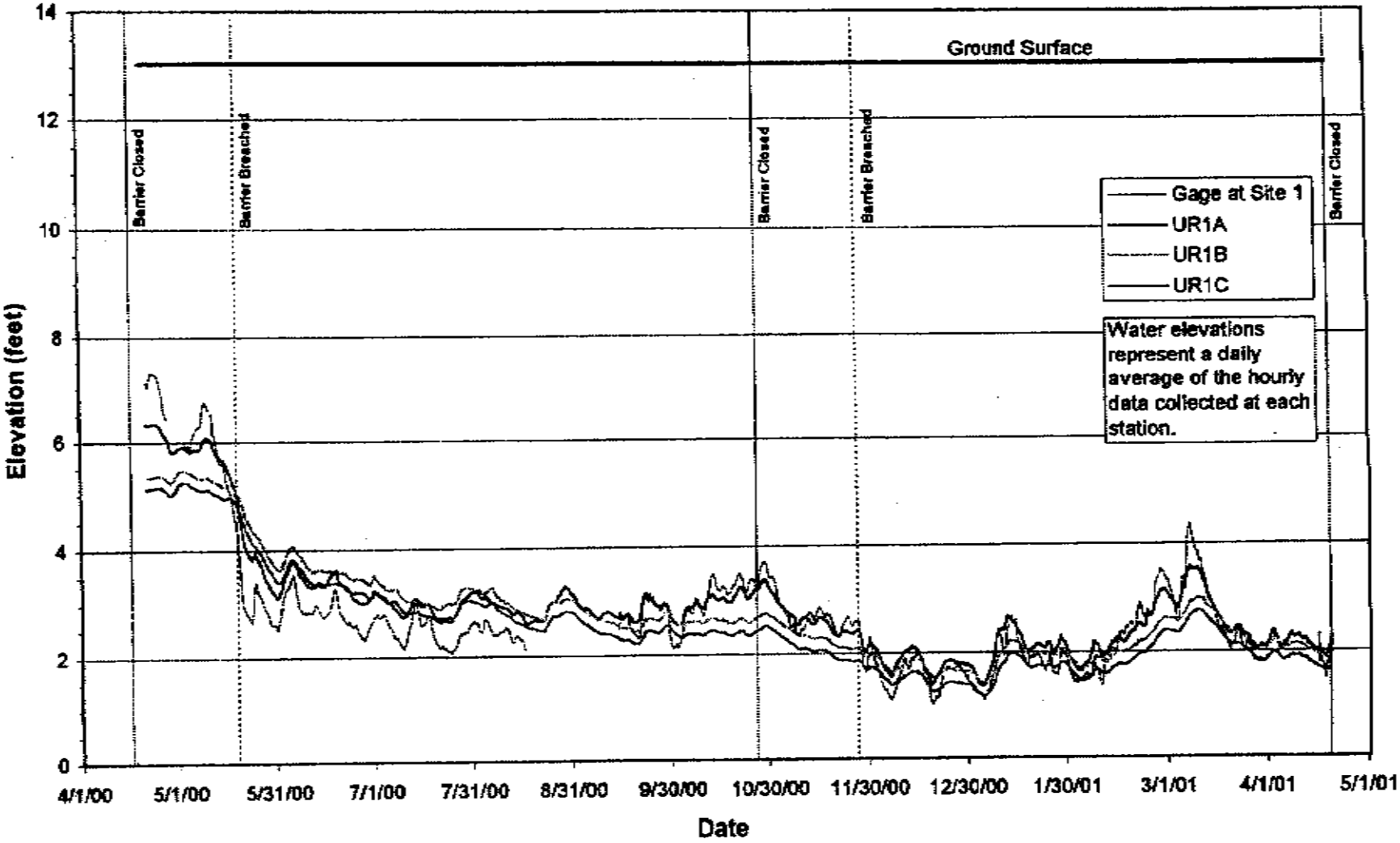


Central District Geology and Groundwater

Figure 8

San Joaquin River Stage and Groundwater Levels at Site 1

RD 544 Seepage Monitoring Study



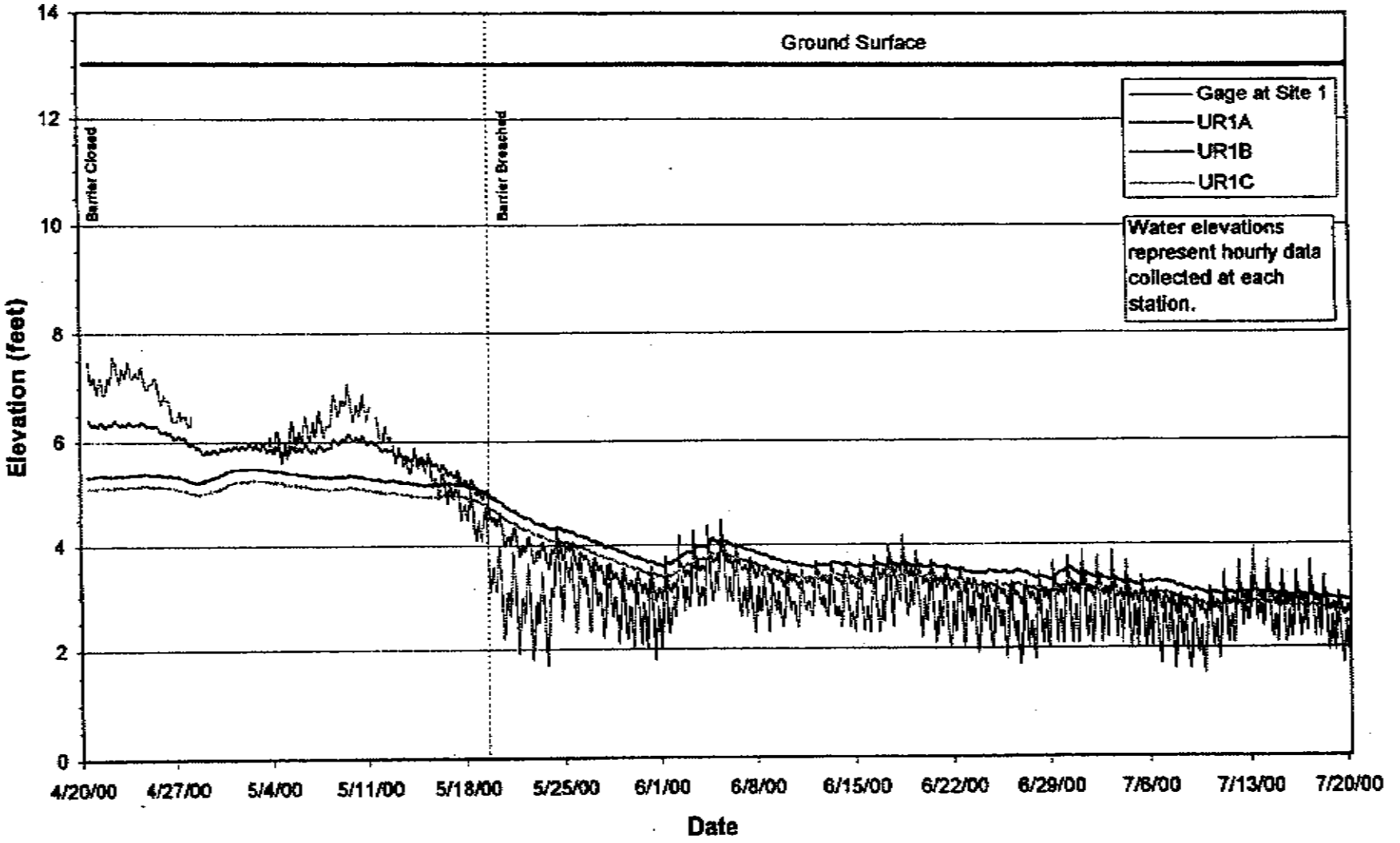
Central District Geology and Groundwater

Figure 9

01811

San Joaquin River Stage and Groundwater Levels at Site 1

RD 544 Seepage Monitoring Study



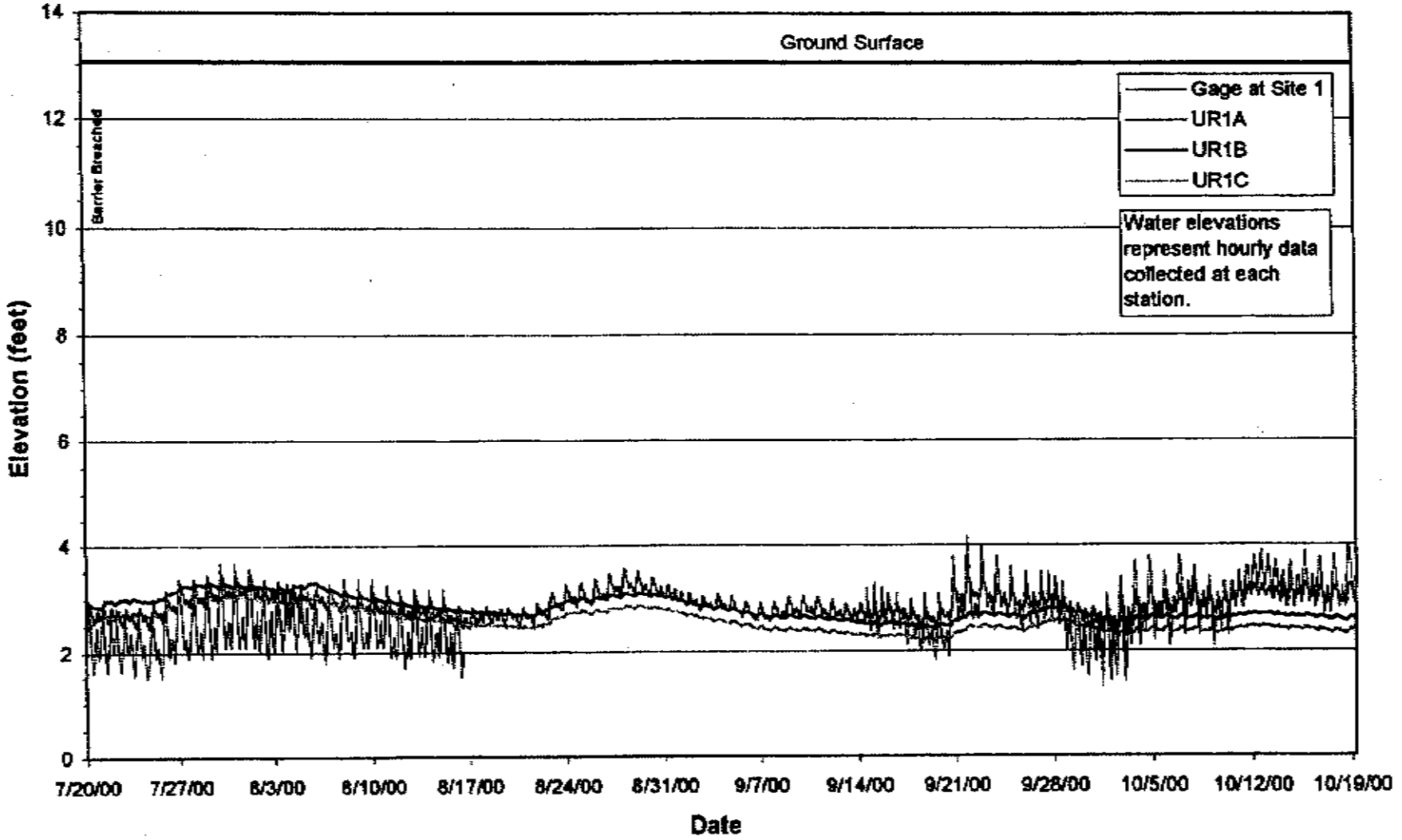
Central District Geology and Groundwater

Figure 10

01812

San Joaquin River Stage and Groundwater Levels at Site 1

RD 544 Seepage Monitoring Study

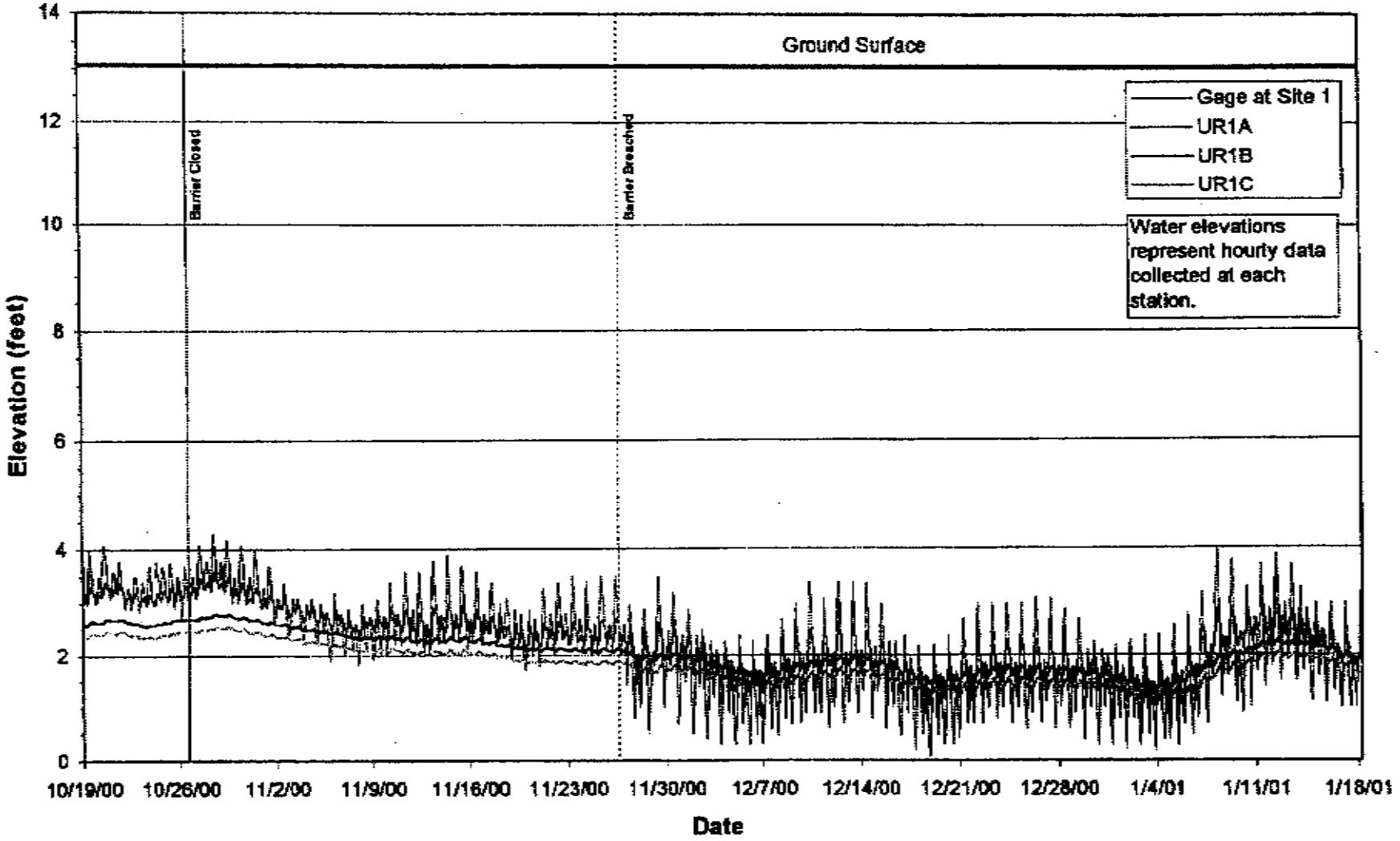


Central District Geology and Groundwater

Figure 11

San Joaquin River Stage and Groundwater Levels at Site 1

RD 544 Seepage Monitoring Study

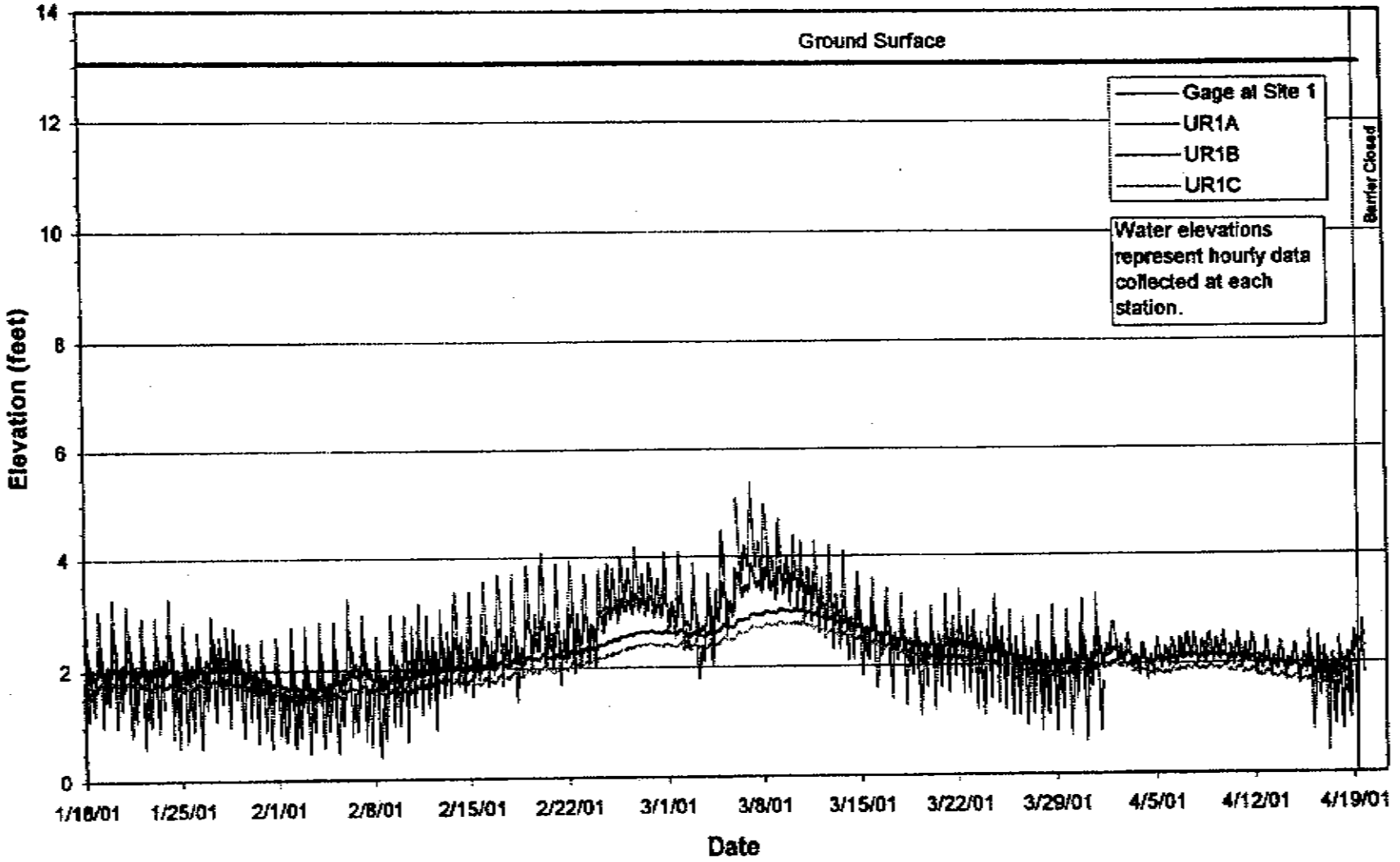


Central District Geology and Groundwater

Figure 12

San Joaquin River Stage and Groundwater Levels at Site 1

RD 544 Seepage Monitoring Study

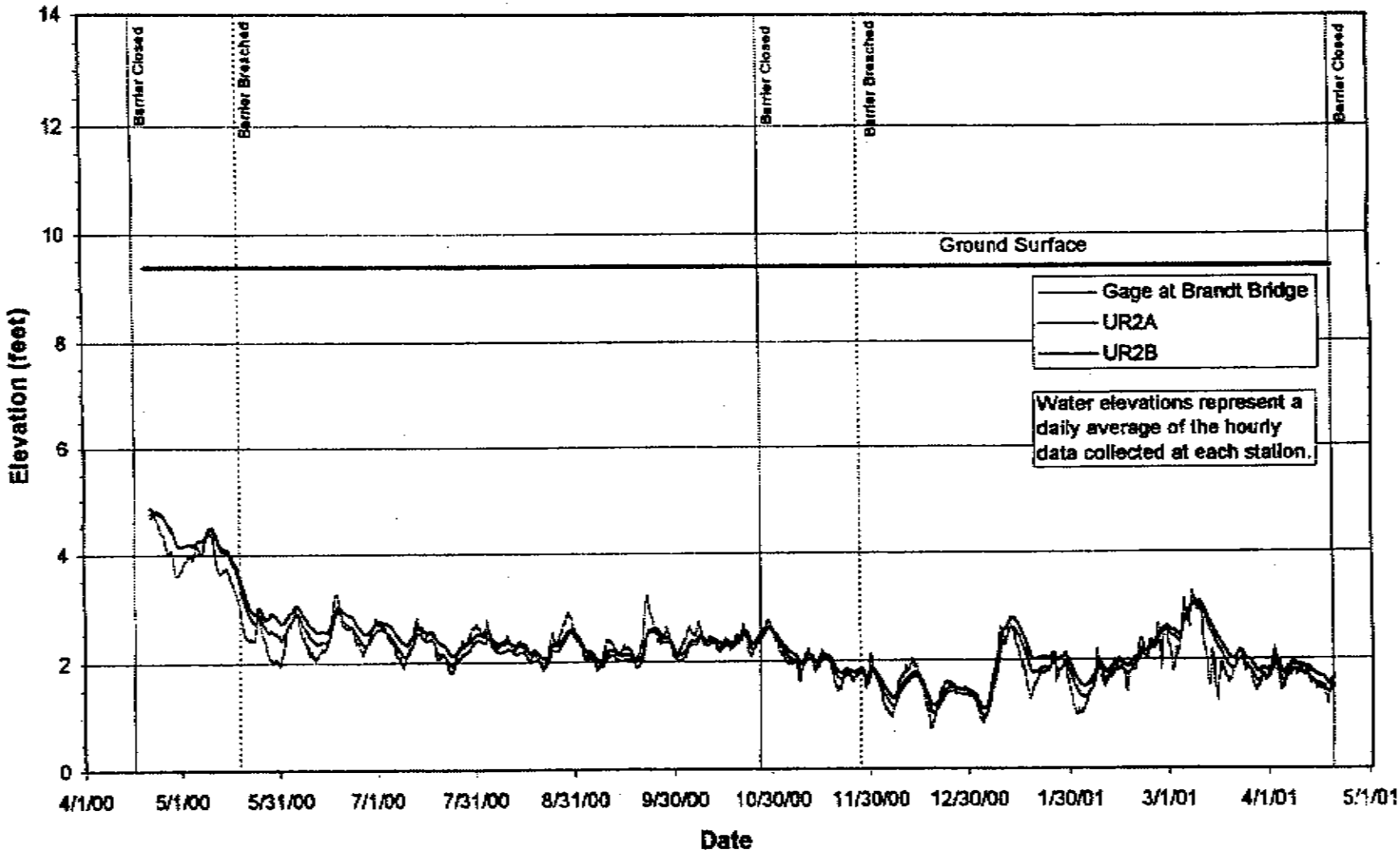


Central District Geology and Groundwater

Figure 13

San Joaquin River Stage and Groundwater Levels at Site 2

RD 544 Seepage Monitoring Study

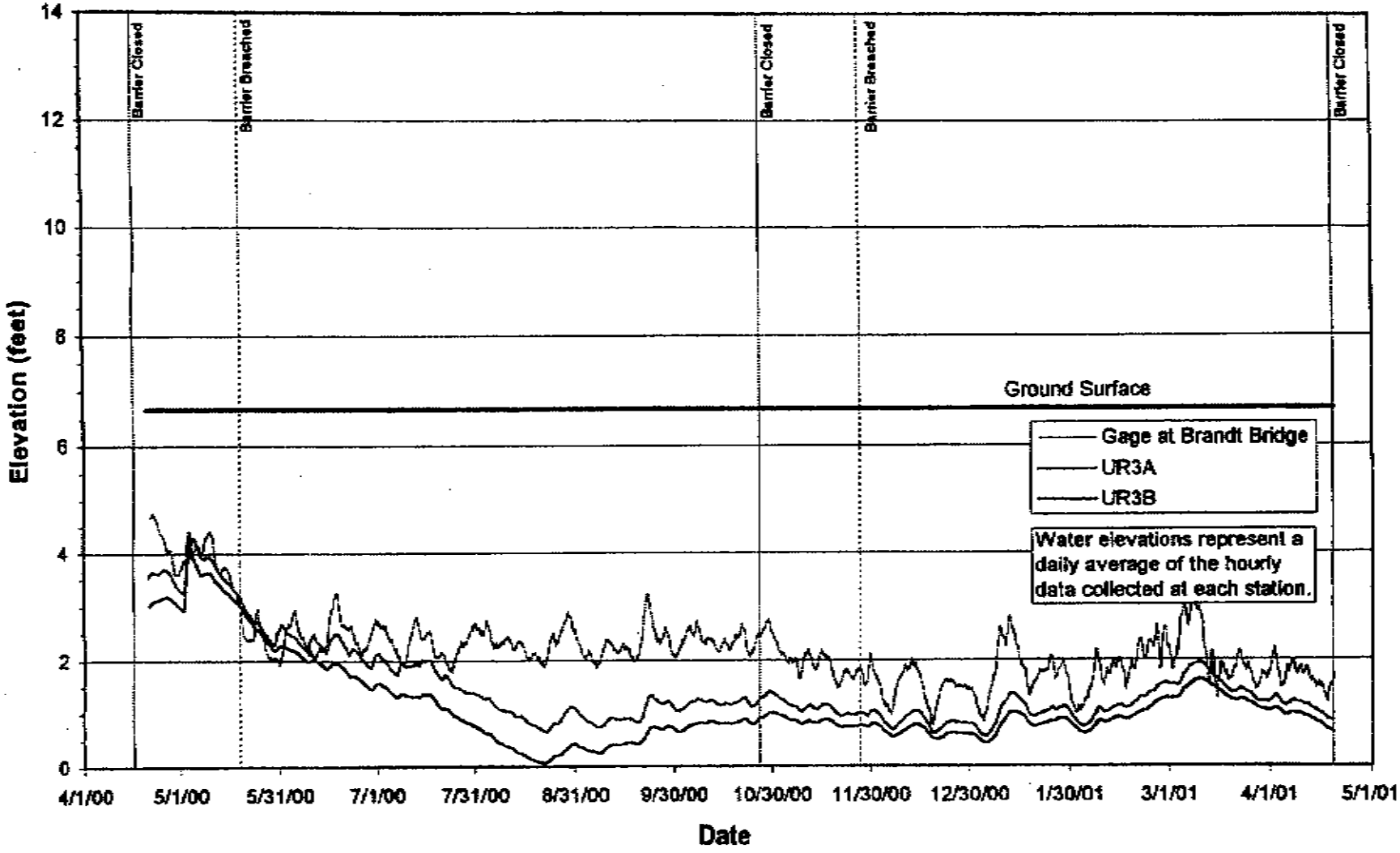


Central District Geology and Groundwater

Figure 14

San Joaquin River Stage and Groundwater Levels at Site 3

RD 544 Seepage Monitoring Study



Central District Geology and Groundwater

Figure 15

Appendix

Drill Hole Logs and Well Completions

State of California
The Resources Agency
DEPARTMENT OF WATER RESOURCES

DRILL HOLE LOG

SHEET 1 of 2
HOLE NO. UR-1-A
ELEV. 13.06 FEET
DEPTH 30.0 FEET

PROJECT Reclamation District 544 Seepage Monitoring Study
FEATURE Monitoring Wells
LOCATION
CONTR. Layne-Christensen DRILL RIG CME 750

DATE DRILLED 04/06/00
ATTITUDE Vertical
LOGGED BY William Brewster
DEPTH TO WATER Not Determined

DEPTH (ELEV.)	LOG	FIELD CLASSIFICATION AND DESCRIPTION	SAMPLE NO.	MODE	REMARKS
0.0 (13.06)		QUATERNARY ALLUVIUM DEPOSITS 0.0 to 30.0'		AD	CME Continuous Sampling
2.0		0.0 - 5.0' No sample obtained Cuttings indicate sandy soil.	NR		0.0 – 5.0' No sample obtained
4.0				0.0 5.0	
6.0	CL	5.0 - 9.0' Silty Clay with Fine Sand, (CL): About 50% medium plasticity clay; about 50% non-plastic fines; reddish gray; moist; soft to medium stiff.	1	2.0 2.0	2-foot sample
8.0			2	3.0 3.0	3-foot sample Clay in bottom of sampler.
10.0	SW	9.0 - 9.5' Medium Sand, (SW): About 95% well sorted, clean, medium sand; about 5% fines; yellowish brown; moist.			
12.0	CL	9.5 - 20.0' Clay with Silt, (CL): About 90% medium plasticity clay; about 10% non-plastic, micaceous fines; dark brown to gray; moist; soft to stiff.	3		
14.0				5.0 5.0	5-foot sample
16.0					Continued on next page.

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DEPARTMENT OF WATER RESOURCES

DRILL HOLE LOG

SHEET 2 OF 2

HOLE NO. UR-1-A

PROJECT & FEATURE Reclamation District 544 Seepage Monitoring Study, Monitoring Wells

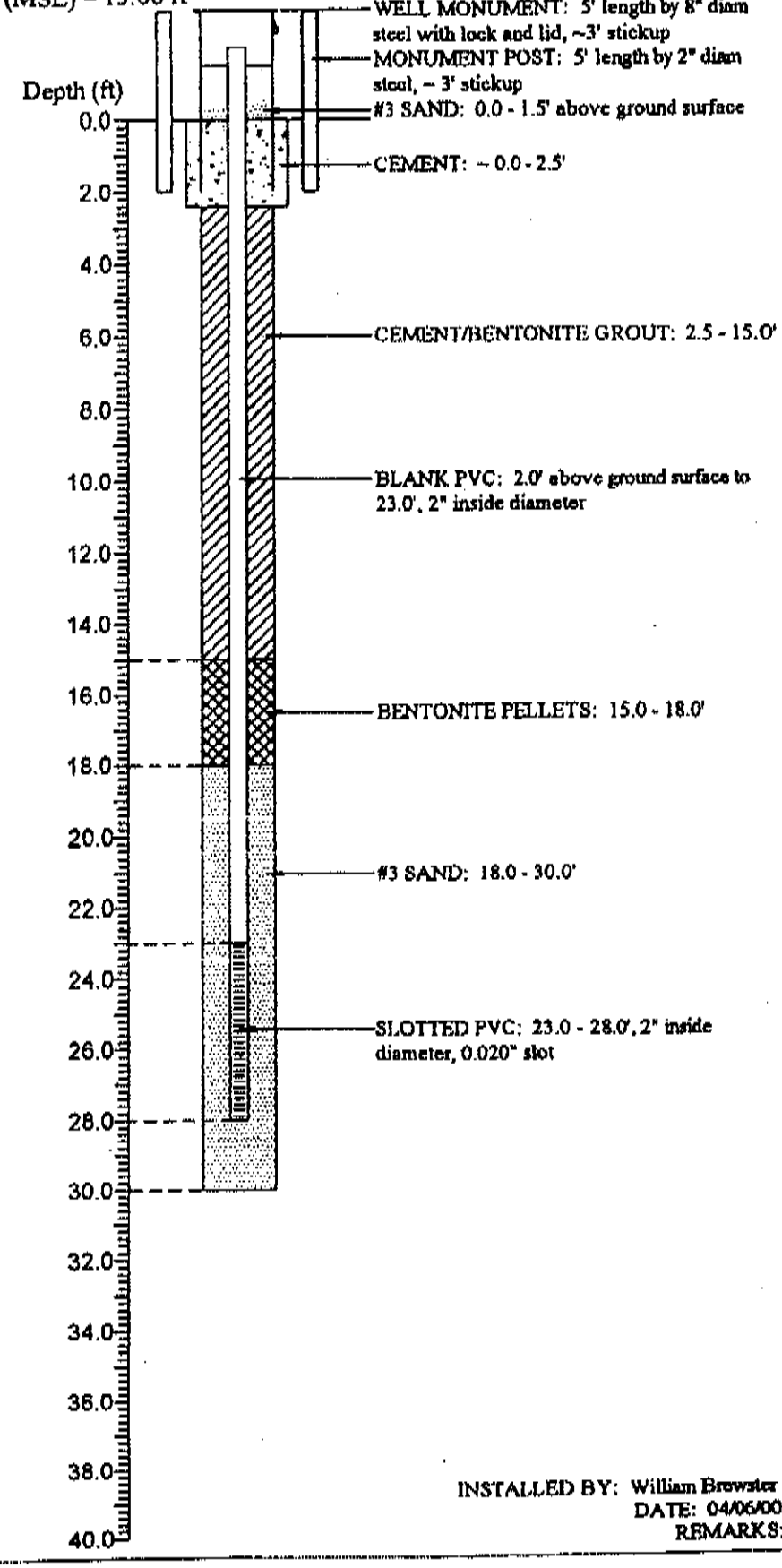
DEPTH (ELEV.)	LOG	FIELD CLASSIFICATION AND DESCRIPTION	SAMPLE NO.	MODE	REMARKS
16.0		QUATERNARY ALLUVIUM DEPOSITS 0.0 to 30.0'		AD	CME Continuous Sampling
		(cont.) 9.5 - 20.0' Clay with Silt, (CL): About 90% medium plasticity clay; about 10% non-plastic, micaceous fines; dark brown to gray; moist; soft to stiff.			
18.0	CL		5	5.0 5.0	5-foot sample
20.0		20.0 - 24.0' Silt with Sand, (ML): About 70% non-plastic fines; about 30% fine sand; olive-gray, wet.			
22.0	ML		6	5.0 5.0	6-foot sample
24.0		24.0 - 30.0' Silty Sand, (SM): About 85% fine to medium micaceous sand; about 15% non-plastic fines; grayish brown, saturated, medium dense.			
26.0			7		
28.0	SM			0.5 5.0	Lost the majority of sample down the hole due to loose, wet sand.
30.0 (-15.9)					Total Depth = 30.0 feet
32.0					
34.0					
36.0					

DWR 955 (2) (Rev. 9-94)

Reclamation District 544 Seepage Monitoring Study

Monitoring Well Completion of UR-1-A

Ground Surface Elevation (MSL) = 13.06 ft
Datum (UTM NAD 83):



INSTALLED BY: William Brewster
DATE: 04/06/00
REMARKS:

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DEPARTMENT OF WATER RESOURCES

SHEET 1 of 2

HOLE NO. UR-1-B

ELEV. 13.04 FEET

DEPTH 27.0 FEET

DRILL HOLE LOG

PROJECT Reclamation District 544 Seepage Monitoring Study

DATE DRILLED 04/07/00

FEATURE Monitoring Wells

ATTITUDE Vertical

LOCATION

LOGGED BY Mark Souverville

CONTR. Layne-Christensen DRILL RIG CME 750

DEPTH TO WATER Approximately 18 ft

DEPTH (ELEV.)	LOG	FIELD CLASSIFICATION AND DESCRIPTION	SAMPLE NO.	MODE	REMARKS
0.0 (13.06)		QUATERNARY ALLUVIUM DEPOSITS 0.0 to 27.0'		AD	CME Continuous Sampling
2.0		0.0 - 7.0' Sandy Silt, (ML): About 80% non-plastic fines; about 20% fine to medium sand; olive-brown, damp, stiff.	1		
4.0	ML			1.0 6.0	1-foot sample Lost majority of sample down hole.
6.0					
8.0		7.0 - 15.5' Sandy Clay, (CL): About 85% reddish gray, medium plasticity clay; about 15% olive-gray, fine sand; damp to moist; soft to medium stiff. Increase in moisture, decrease in clay at 9'. Occurrence of calechey and color change to gray-brown at 12'.	2	5.0 5.0	5-foot sample
10.0	CL				
12.0			3	5.0 5.0	5-foot sample
14.0					
16.0	ML	15.5 - 21.0' Sandy Silt, (ML): About 75% non-plastic fines; about 25% very fine to fine sand; light olive-brown, moist, soft. Wet from 16.0 –18.5'.	4	5.0 5.0	5-foot sample Continued on next page.

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DRILL HOLE LOG

SHEET 2 OF 2

HOLE NO. UR-1-B

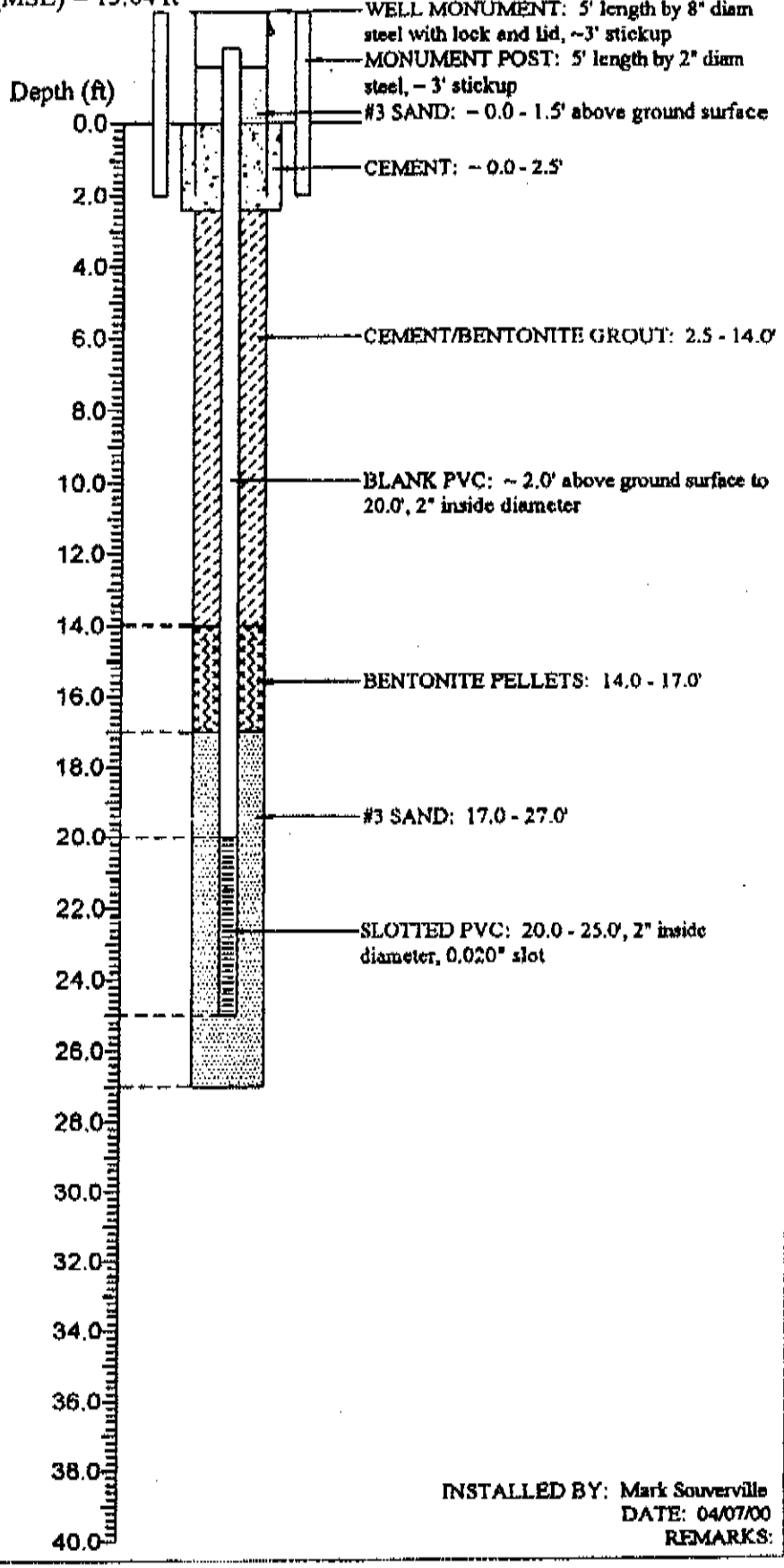
PROJECT & FEATURE Reclamation District 544 Seepage Monitoring Study, Monitoring Wells

DEPTH (ELEV.)	LOG	FIELD CLASSIFICATION AND DESCRIPTION	SAMPLE NO.	MODE	REMARKS
16.0		QUATERNARY ALLUVIUM DEPOSITS 0.0 to 27.0'		AD	CME Continuous Sampling
		(cont.)			
18.0	ML	16.5 - 21.0' Sandy Silt, (ML): About 75% non-plastic fines; about 25% very fine to fine sand; light olive-brown, moist, wet from 18.0 –18.5', soft.	4	5.0 5.0	5-foot sample
20.0					
22.0	SM	21.0 - 25.0' Silty Sand, (SM): About 85% fine to medium micaceous sand; about 15% non-plastic fines; grayish brown, saturated, medium dense.	5	5.0 5.0	5-foot sample
24.0					
26.0	CL	25.0 - 27.0' Sandy Clay, (CL): About 85% medium plasticity clay; about 15% fine to medium sand; light olive-brown, moist to wet, stiff.	6	2.0 2.0	2-foot sample
(-14.0)					Total Depth = 27.0 feet
28.0					
30.0					
32.0					
34.0					
36.0					

DWR 955 (3) (Rev. 9-84)

Monitoring Well Completion of UR-1-B

Ground Surface Elevation (MSL) = 13.04 ft
Datum (UTM NAD 83):



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DATE: 04/07/00
REMARKS:

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The Resources Agency
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DRILL HOLE LOG

SHEET 1 of 3
HOLE NO. UR-1-C
ELEV. 13.01 FEET
DEPTH 40.0 FEET

PROJECT Reclamation District 544 Seepage Monitoring Study
FEATURE Monitoring Wells
LOCATION
CONTR. Layne-Christensen DRILL RIG CME 750

DATE DRILLED 04/07/00
ATTITUDE Vertical
LOGGED BY Mark Souverville
DEPTH TO WATER Approximately 18 ft

DEPTH (ELEV.)	LOG	FIELD CLASSIFICATION AND DESCRIPTION	SAMPLE NO.	MODE	REMARKS
0.0 (13.06)		QUATERNARY ALLUVIUM DEPOSITS 0.0 to 40.0'		AD	CME Continuous Sampling
2.0	ML	0.0 - 5.0' Sandy Silt (ML): About 80% non-plastic fines; about 20% fine to medium sand; olive-brown, damp, stiff.	1		
4.0				1.5/5.0	1.5-foot sample Lost majority of sample down hole.
6.0	CL	5.0 - 14.5' Sandy Clay (CL): About 80% medium plasticity clay; about 20% fine to medium sand; olive-brown, damp to moist, medium stiff, very stiff 12 - 13'.	2	5.0/5.0	Sluff from above fell in sample tube, projected contact from ML to CL 5-foot sample
8.0					
10.0					
12.0			3	5.0/5.0	5-foot sample
14.0					
16.0	ML	14.5 - 20.0' Sandy Silt (ML): About 75% non-plastic fines; about 25% very fine to fine sand; light olive-brown, moist to wet, soft.	4	5.0/5.0	5-foot sample Continued on next page.

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DRILL HOLE LOG

SHEET 2 OF 3
HOLE NO. UR-1-C

PROJECT & FEATURE Reclamation District 544 Seepage Monitoring Study, Monitoring Wells

DEPTH (ELEV.)	LOG	FIELD CLASSIFICATION AND DESCRIPTION	SAMPLE NO.	MODE	REMARKS
18.0		QUATERNARY ALLUVIUM DEPOSITS 0.0 to 40.0' (cont.) 14.5 - 20.0' Sandy Silt, (ML): About 75% non-plastic fines; about 25% very fine to fine sand; light olive-brown, moist to wet, soft.		AD	CME Continuous Sampling
	ML		4	5.0 5.0	5-foot sample
20.0		20.0 - 24.0' Silty Sand, (SM): About 85% fine to medium micaceous sand; about 15% non-plastic fines; grayish brown, wet, medium dense.			
22.0	SM		5	5.0 5.0	5-foot sample
24.0		24.0 - 26.0' Sandy Clay, (CL): About 85% high plasticity clay; about 15% fine to coarse sand; light olive-brown with iron-oxide stains, wet to saturated, stiff.			
26.0	CL	26.0 - 29.0' Clay with Silt, (CL): About 90% high plasticity clay; about 10% non-plastic fines; yellow-brown (iron banding) to light olive-brown, moist to wet, stiff.	6	5.0 5.0	5-foot sample
28.0					
30.0		29.0 - 40.0' Silty Sand, (SM): About 85% fine to medium micaceous sand; about 15% non-plastic fines; light olive-brown to olive-brown, saturated, loose. Mica increases with depth.			
32.0	SM		7	5.0 5.0	5-foot sample
34.0					
36.0			8	5.0 5.0	5-foot sample Continued on next page.

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DRILL HOLE LOG

SHEET 3 OF 3

HOLE NO. UR-1-C

PROJECT & FEATURE Reclamation District 544 Seepage Monitoring Study, Monitoring Wells

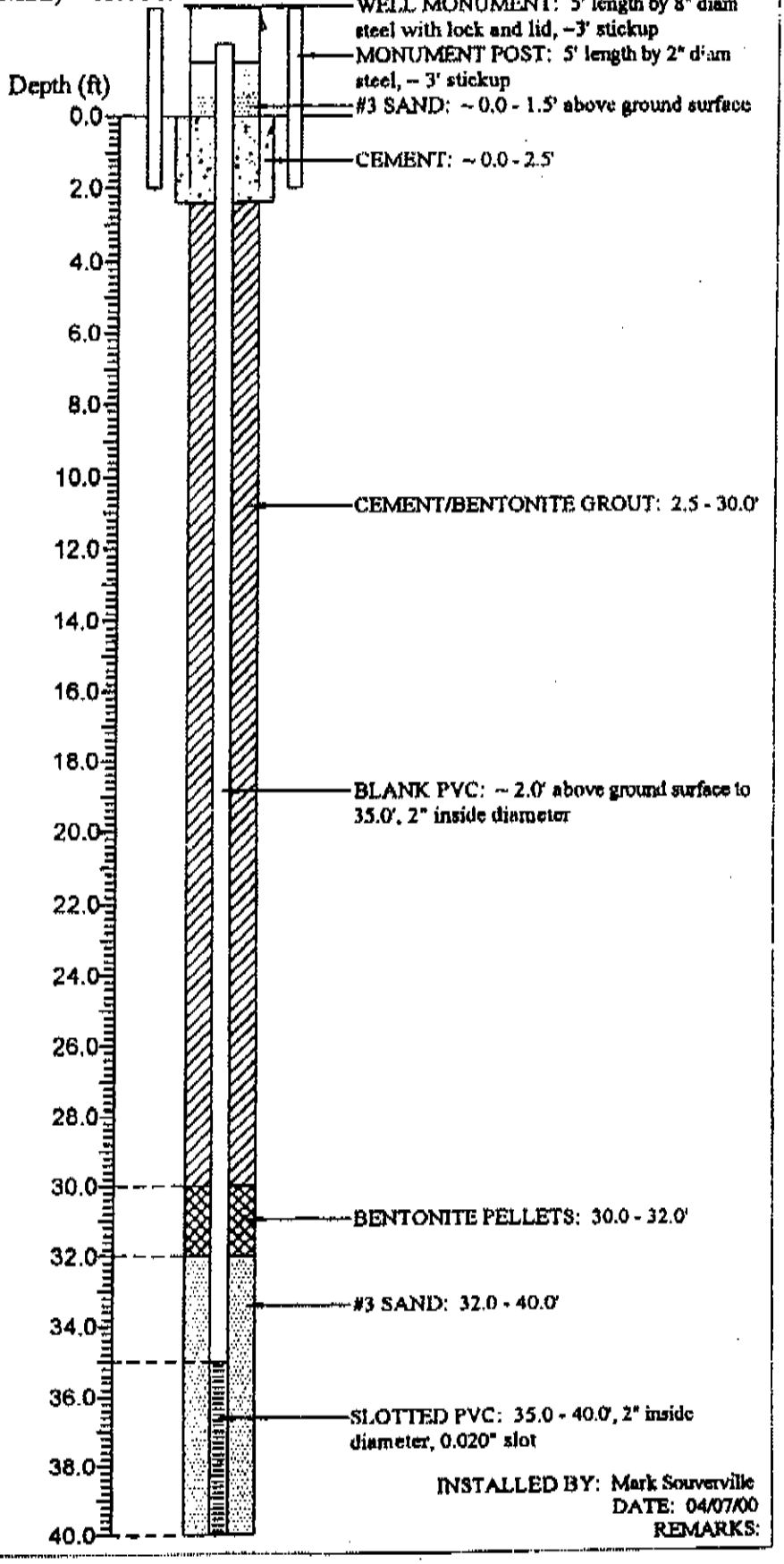
DEPTH (ELEV.)	LOG	FIELD CLASSIFICATION AND DESCRIPTION	SAMPLE NO.	MODE	REMARKS
36.0	(GP)s.c	QUATERNARY ALLUVIUM DEPOSITS 0.0 to 40.0' (cont.) 29.0 - 40.0' Silty Sand, (SM): About 85% fine to medium micaceous sand; about 15% non-plastic fines; light olive-brown to olive-brown, saturated, loose. Mica increases with depth.		AD	CME Continuous Sampling
38.0			8	5.0 5.0	5-foot sample
40.0					Total Depth = 40 feet
(-27.0)'					
42.0					
44.0					

DWR 688 (2) (Rev. 9-94)

01827

Monitoring Well Completion of UR-1-C

Ground Surface Elevation (MSL) = 13.01 ft
Datum (UTM NAD 83):



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DATE: 04/07/00
REMARKS:

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The Resources Agency
DEPARTMENT OF WATER RESOURCES

DRILL HOLE LOG

SHEET 1 of 2
HOLE NO. UR-2-A
ELEV. 9.38 FEET
DEPTH 20.0 FEET

PROJECT Reclamation District 544 Seepage Monitoring Study
FEATURE Monitoring Wells
LOCATION
CONTR. Layne-Christensen DRILL RIG CME 750

DATE DRILLED 04/06/00
ATTITUDE Vertical
LOGGED BY William Brewster
DEPTH TO WATER Approximately 8 ft

DEPTH (ELEV.)	LOG	FIELD CLASSIFICATION AND DESCRIPTION	SAMPLE NO.	MODE	REMARKS
0.0 (13.06)		QUATERNARY ALLUVIUM DEPOSITS 20.0'		AD	CME Continuous Sampling
		0.0 - 5.0' No sample obtained Cuttings indicate sandy soil.	NR	0.0 / 5.0	0.0 - 5.0' No sample obtained, fell out of sampler.
6.0	CL	5.0 - 7.0' Clay, (CL): Brown; damp; stiff.	1	2.5 / 2.5	2.5-foot sample
8.0	SM	7.0 - 11.3' Sand with Silt and Clay, (SM): About 80% fine to medium sand; about 20% fines; light brown; moist.	2	2.5 / 2.5	2.5-foot sample
12.0	CL	11.3 - 13.3' Clay with Silt, (CL): About 90% medium plasticity clay; about 10% non-plastic fines; brown to gray; wet; soft to stiff.	3	5.0 / 5.0	5-foot sample
14.0	SM	13.3 - 17.0' Silty Sand, (SM): About 85% medium to coarse sand; about 15% non-plastic fines; light brown; wet.			
16.0			4		Continued on next page.

DWR 885 (1) (Rev. 6-84)

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The Resources Agency
DEPARTMENT OF WATER RESOURCES

DRILL HOLE LOG

SHEET 2 OF 2

HOLE NO. UR-2-A

PROJECT & FEATURE Reclamation District 544 Seepage Monitoring Study, Monitoring Wells

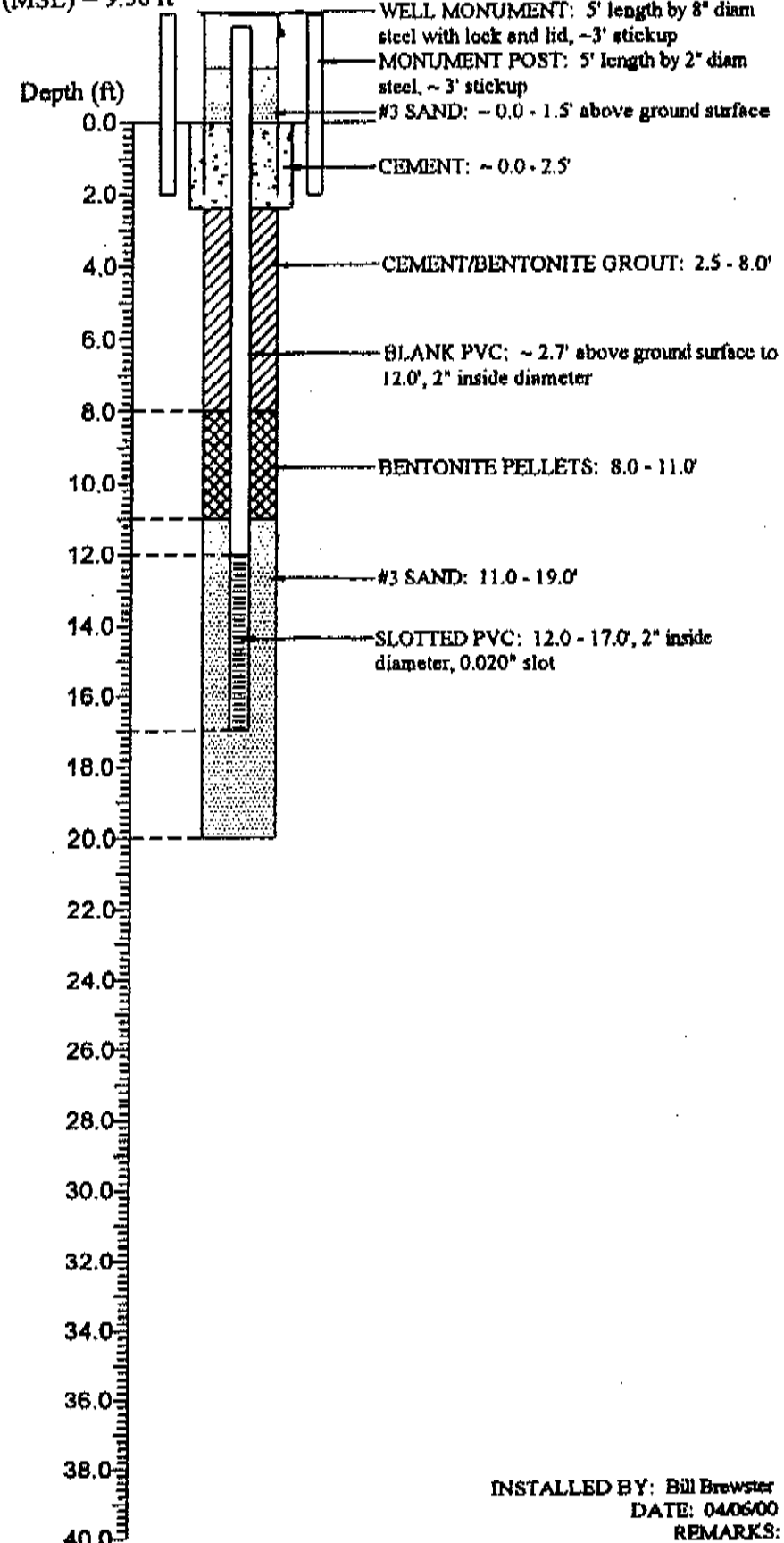
DEPTH (ELEV.)	LOG	FIELD CLASSIFICATION AND DESCRIPTION	SAMPLE NO.	MODE	REMARKS
16.0	SM	QUATERNARY ALLUVIUM DEPOSITS 0.0 to 20.0' (cont.) 13.3 - 17.0' Silty Sand, (SM): About 85% medium to coarse sand; about 15% non-plastic fines; light brown; wet.	5	AD	CME Continuous Sampling
18.0	ML	17.0 - 20.0' Silty Sand with Clay, (ML): About 60% fine sand; about 40% fines with slight plasticity; light brown, wet.		5.0 5.0	5-foot sample
20.0 (-10.6)					Total Depth = 20.0 feet
22.0					
24.0					
26.0					
28.0	SM				
30.0					
32.0					
34.0					
36.0					

DWR 965 (2) (Rev. 8-84)

Reclamation District 544 Seepage Monitoring Study

Monitoring Well Completion of UR-2-A

Ground Surface Elevation (MSL) = 9.38 ft
Datum (UTM NAD 83):



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DATE: 04/06/00
REMARKS:

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DEPARTMENT OF WATER RESOURCES

SHEET 1 of 2

HOLE NO. UR-2-B

ELEV. 8.96 FEET

DEPTH 21.0 FEET

DRILL HOLE LOG

PROJECT Reclamation District 544 Seepage Monitoring Study

DATE DRILLED 04/06/00

FEATURE Monitoring Wells

ATTITUDE Vertical

LOCATION

LOGGED BY William Brewster

CONTR. Layne-Christensen DRILL RIG CME 750

DEPTH TO WATER Approximately 17 ft

DEPTH (ELEV.)	LOG	FIELD CLASSIFICATION AND DESCRIPTION	SAMPLE NO.	MODE	REMARKS
0.0 (8.96)	CL	QUATERNARY ALLUVIUM DEPOSITS 0.0 to 21.0' 0.0 - 5.5' Silty Clay (CL): About 70% low plasticity clay; about 30% non-plastic fines; mottled dark brown, dark grayish brown; moist; soft.	NR	AD 0.0 5.0	CME Continuous Sampling 0.0 – 5.0' No sample obtained
6.0		5.5 - 8.0' Sandy Clay, (CL): About 60% medium plasticity clay; about 40% medium sand; dark gray; moist; stiff.	1	2.5 2.5	2.5-foot sample
8.0	SM	8.0 - 14.0' Silty Sand, (SM): About 80% medium sand; about 20% non-plastic fines; dark brown; moist.	2	2.5 2.5	2.5-foot sample
12.0			3	5.0 5.0	5-foot sample
14.0	CL	14.0 - 15.0' Sandy Silty Clay, (CL): About 50% clay; about 30% non-plastic fines; about 20% fine, micaceous sand; light brown; wet.			
16.0	SM	15.0 - 21.0' Sand with Silt, (SM): About 85% micaceous, fine to medium sand; about 5% non-plastic fines; light brown; moist; loose.	4		2.5-foot sample Continued on next page.

DWR 688 (1) (Rev. 9-84)

State of California
The Resources Agency
DEPARTMENT OF WATER RESOURCES

DRILL HOLE LOG

SHEET 2 OF 2

HOLE NO. UR-2-B

PROJECT & FEATURE Reclamation District 544 Seepage Monitoring Study, Monitoring Wells

DEPTH (ELEV.)	LOG	FIELD CLASSIFICATION AND DESCRIPTION	SAMPLE NO.	MODE	REMARKS
16.0		QUATERNARY ALLUVIUM DEPOSITS 0.0 to 21.0'		AD	CME Continuous Sampling
		(cont.) 16.0 - 21.0' Sand with Silt, (SM): About 95% micaceous, fine to medium sand; about 5% non-plastic fines; light brown; moist, saturated at 17.5'; loose.			
18.0	SM		5	0.0 3.5	No sample retrieved, fell out of sampler due to high water content and loose soil.
20.0					
(-12.0)					Total Depth = 21.0 feet
22.0					
24.0					
26.0					
28.0					
30.0					
32.0					
34.0					
36.0					

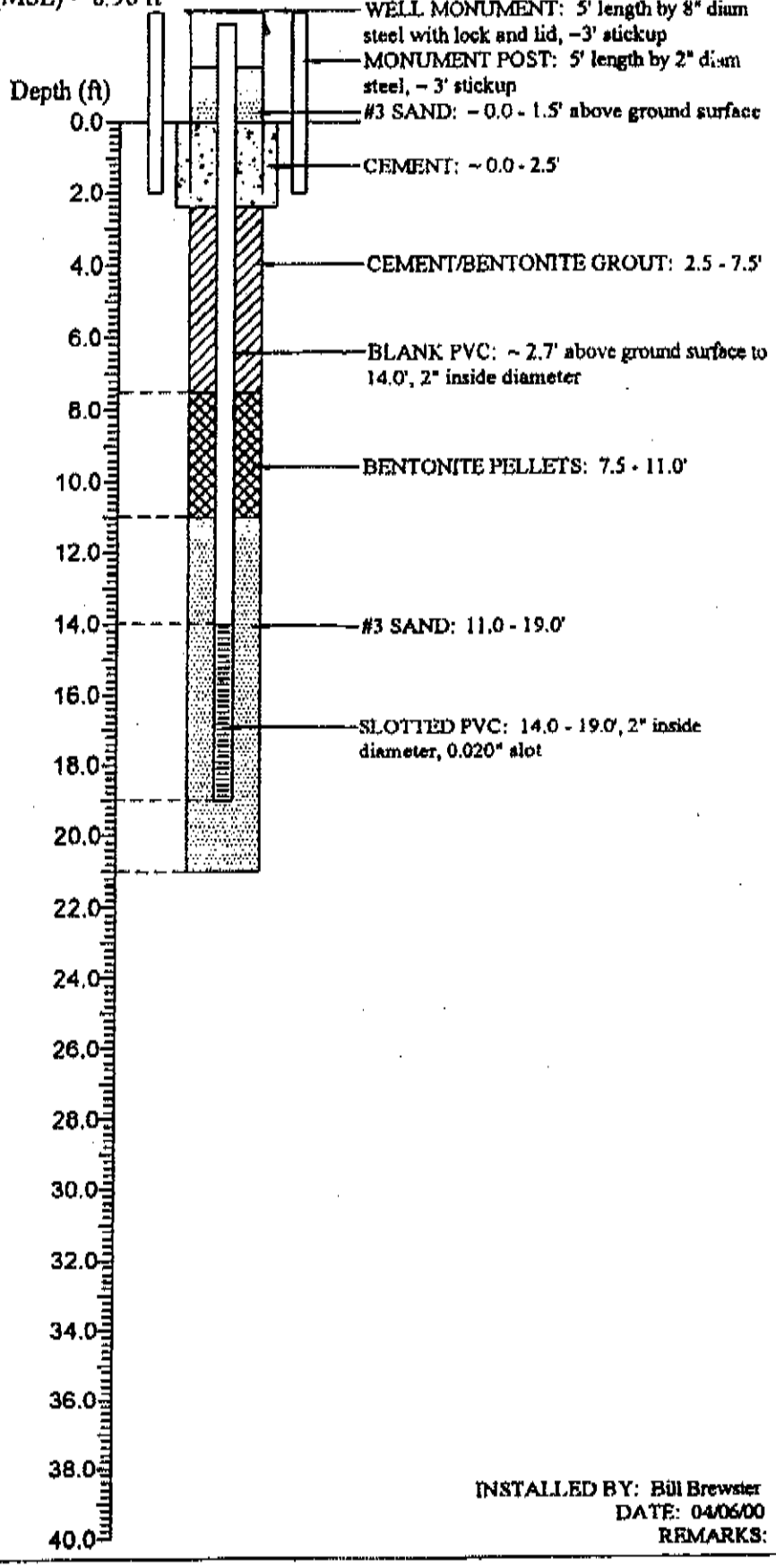
DWR 865 (2) (Rev. 8-94)

Reclamation District 544 Seepage Monitoring Study

Monitoring Well Completion of UR-2-B

Ground Surface Elevation (MSL) = 8.96 ft

Datum (UTM NAD 83):



INSTALLED BY: Bill Brewster
DATE: 04/06/00
REMARKS:

State of California
The Resources Agency
DEPARTMENT OF WATER RESOURCES

SHEET 1 of 2

HOLE NO. UR-3-A

ELEV. 6.67 FEET

DEPTH 18.0 FEET

DRILL HOLE LOG

PROJECT Reclamation District 544 Seepage Monitoring Study

FEATURE Monitoring Wells

LOCATION

CONTR. Layne-Christensen DRILL RIG CME 750

DATE DRILLED 04/05/00

ATTITUDE Vertical

LOGGED BY Mark Souverville

DEPTH TO WATER Approximately 11 ft

DEPTH (ELEV.)	LOG	FIELD CLASSIFICATION AND DESCRIPTION	SAMPLE NO.	MODE	REMARKS
0.0 (8.96)		QUATERNARY ALLUVIUM DEPOSITS 0.0 to 18.0'		AD	CME Continuous Sampling
2.0	SM	0.0 - 4.0' Silty Sand with trace Clay (SM): About 70% very fine to fine sand, some mica; about 30% non-plastic fines; dark grayish brown; moist; medium dense.	1		
4.0		4.0 - 6.0' Silty Sand, (SM): About 85% fine to medium sand, abundant mica; about 15% non-plastic fines; olive-brown; moist, wet from 5.0 - 5.5'; medium dense.		3.5 5.0	3.5-foot sample
6.0	CL	6.0 - 11.0' Silty Clay, (CL): About 85% medium plasticity clay; about 15% non-plastic fines; very dark brown and dark gray; moist; soft.	2	5.0 5.0	5-foot sample
10.0					
12.0	SC	11.0 - 15.5' Sand with Clay, (SC): About 85% fine to medium sand; about 15% medium plasticity clay; olive-brown; wet, loose.	3		
14.0				5.0 5.0	5-foot sample
16.0	SM	15.5 - 17.0' Silty Sand, (SM): About 85% fine to medium sand, abundant mica; about 15% non-plastic fines; light brown; saturated; loose.	4		5-foot sample Continued on next page.

DWR 386 (1) (Rev. 9-84)

State of California
The Resources Agency
DEPARTMENT OF WATER RESOURCES

DRILL HOLE LOG

SHEET 2 OF 2

HOLE NO. UR-3-A

PROJECT & FEATURE Reclamation District 544 Seepage Monitoring Study, Monitoring Wells

DEPTH (ELEV.)	LOG	FIELD CLASSIFICATION AND DESCRIPTION	SAMPLE NO.	MODE	REMARKS
16.0	SM	QUATERNARY ALLUVIUM DEPOSITS 0.0 to 18.0' (cont.) 15.5 - 17.0' Silty Sand, (SM): About 85% fine to medium sand, abundant mica; about 15% non-plastic fines; light brown; saturated; loose.	4	AD 3.0 3.0	CME Continuous Sampling
18.0 (-11.3)	ML	17.0 – 18.0' Sandy Silt, (ML): About 80% non-plastic fines, about 20% fine to medium sand, abundant mica; mottled yellowish brown and olive-gray; damp; medium stiff.			Total Depth = 18.0 feet
20.0					
22.0					
24.0					
26.0					
28.0					
30.0					
32.0					
34.0					
36.0					

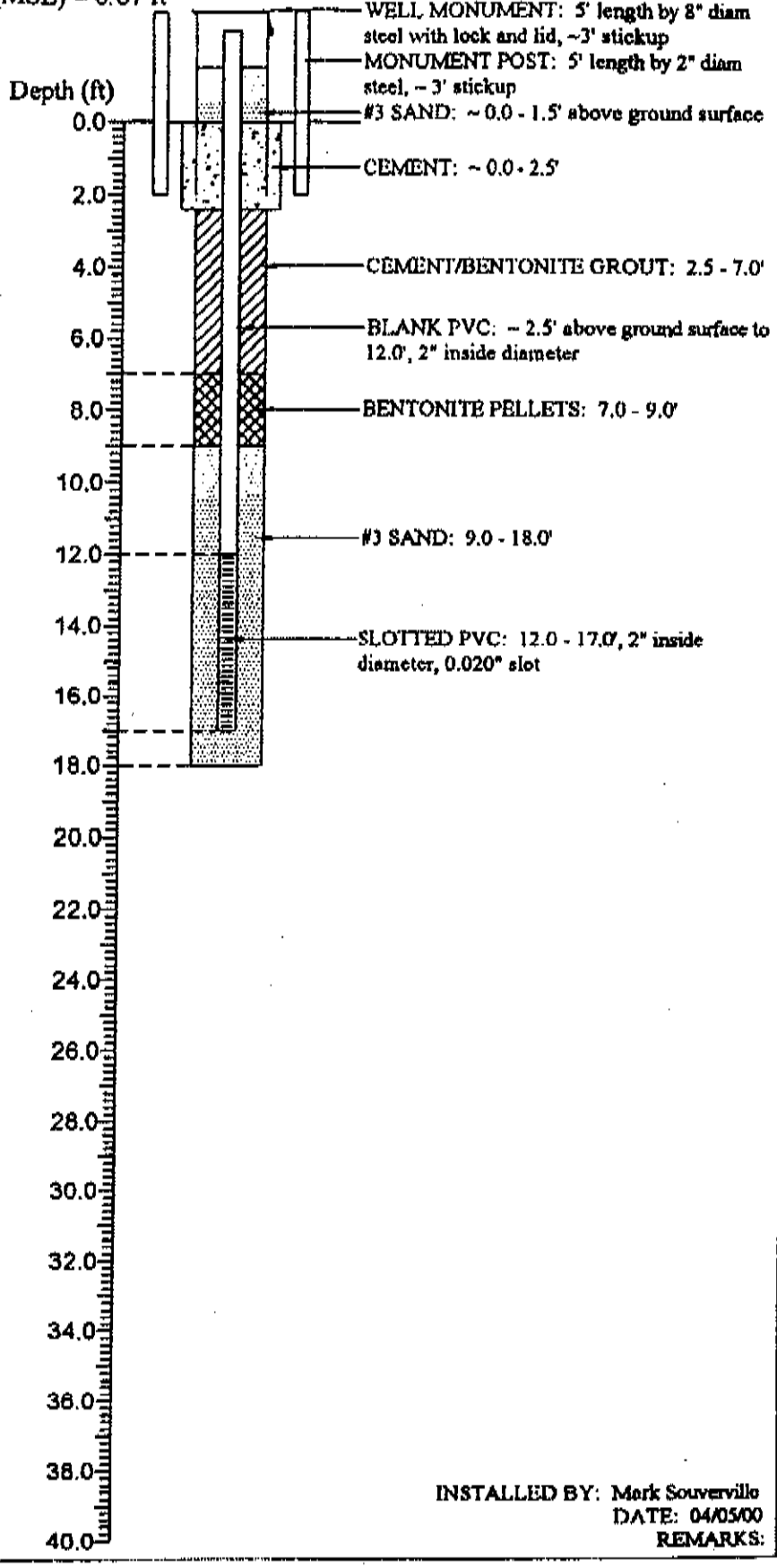
DWR 865 (3) (Rev. 9-94)

Reclamation District 544 Seepage Monitoring Study

Monitoring Well Completion of UR-3-A

Ground Surface Elevation (MSL) = 6.67 ft

Datum (UTM NAD 83):



INSTALLED BY: Mark Souverville

DATE: 04/05/00

REMARKS:

State of California
The Resources Agency
DEPARTMENT OF WATER RESOURCES

SHEET 1 of 2
HOLE NO. UR-3-B
ELEV. 7.24 FEET
DEPTH 20.0 FEET

DRILL HOLE LOG

PROJECT Reclamation District 544 Seepage Monitoring Study
FEATURE Monitoring Wells
LOCATION
CONTR. Layne-Christensen DRILL RIG CME 750

DATE DRILLED 04/05/00
ATTITUDE Vertical
LOGGED BY Mark Souverville
DEPTH TO WATER Approximately 10 ft

DEPTH (ELEV.)	LOG	FIELD CLASSIFICATION AND DESCRIPTION	SAMPLE NO.	MODE	REMARKS
0.0 (8.96)		QUATERNARY ALLUVIUM DEPOSITS 0.0 to 20.0' 0.0 - 5.0' No sample obtained Cuttings indicate sandy soil.	1	AD 0.0 5.0	CME Continuous Sampling 0.0 - 5.0' No sample obtained, fell out of sampler.
6.0	CL	5.0 - 7.0' Sandy Clay, (CL): About 70% low plasticity clay; about 30% fine to medium sand; dark brown; moist; stiff; some organic material; some oxidation.	2	5.0 5.0	5-foot sample
8.0	ML	7.0 - 10.0' Sandy Silt with Clay, (ML): About 65% non-plastic fines; about 35% fine to medium sand; olive-brown; moist to wet; medium stiff; oxidation present.			
10.0					
12.0	SM	10.0 - 13.0' Silty Sand, (SM): About 85% fine sand; about 15% non-plastic fines; olive-gray; wet; medium dense.	3		5-foot sample
14.0	CL	13.0 - 16.5' Silty Clay, (CL): About 85% medium plasticity clay; about 15% non-plastic fines; light gray to olive-gray; moist; medium stiff.		5.0 5.0	
16.0			4		5-foot sample Continued on next page.

DWR 938 (1) (Rev. 9-64)

State of California
The Resources Agency
DEPARTMENT OF WATER RESOURCES

DRILL HOLE LOG

SHEET 2 OF 2

HOLE NO. UR-3-B

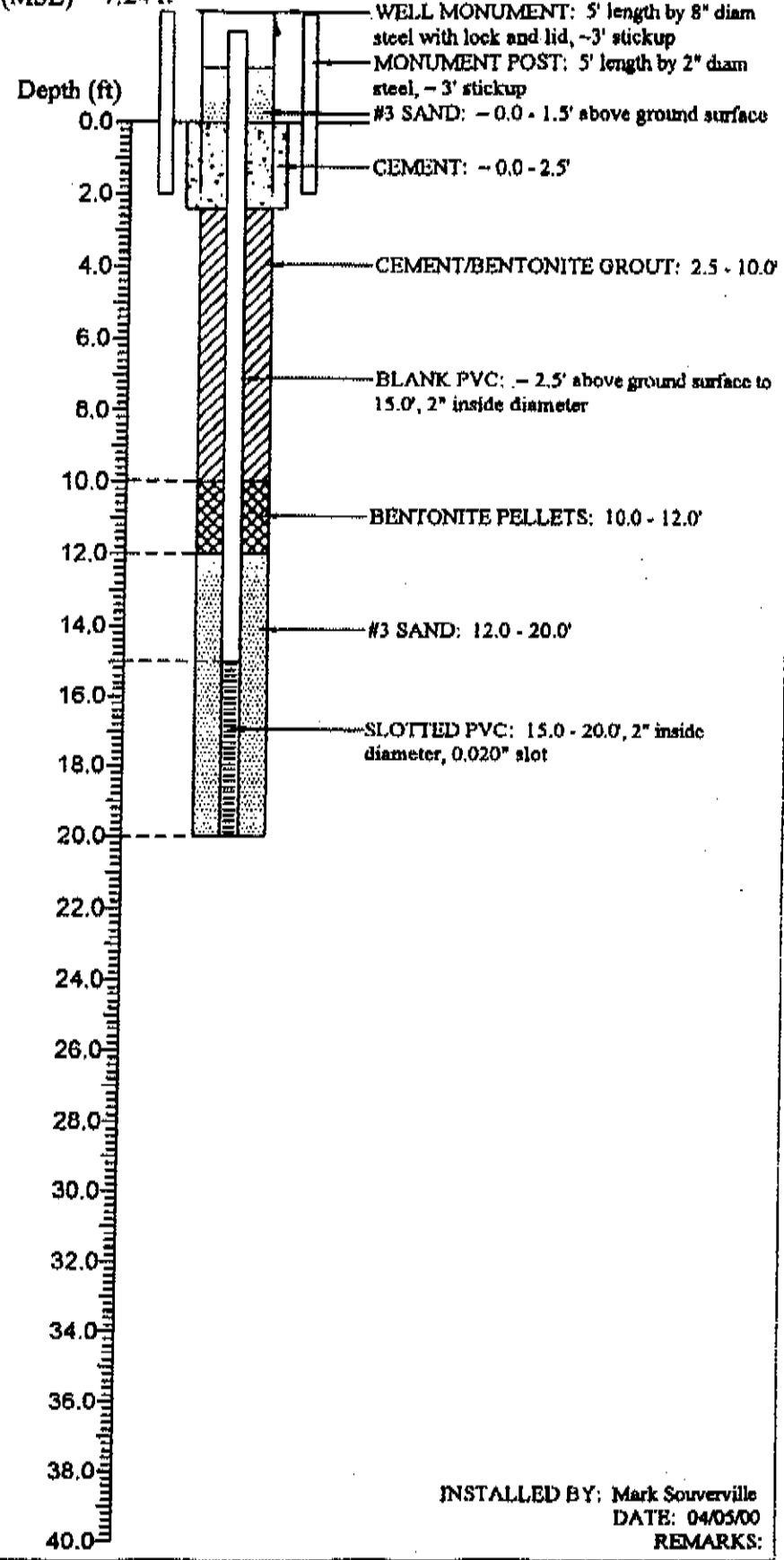
PROJECT & FEATURE Reclamation District 544 Seepage Monitoring Study, Monitoring Wells

DEPTH (ELEV.)	LOG	FIELD CLASSIFICATION AND DESCRIPTION	SAMPLE NO.	MODE	REMARKS
16.0	CL	(cont.) 13.0 - 16.5' Silty Clay, (CL): About 85% medium plasticity clay; about 15% non-plastic fines; light gray to olive-gray; moist; medium stiff.		AD	CME Continuous Sampling
18.0	SM	16.5 - 20.0' Silty Sand, (SM): About 80% fine to medium sand, abundant mica; about 20% non-plastic fines; gray brown; saturated; loose.	4	5.0 5.0	
20.0 (-12.8)					Total Depth = 20.0 feet
22.0					
24.0					
26.0					
28.0					
30.0					
32.0					
34.0					
36.0					

DWR 688 (2) (Rev. 9-84)

Reclamation District 544 Seepage Monitoring Study
Monitoring Well Completion of UR-3-B

Ground Surface Elevation (MSL) = 7.24 ft
Datum (UTM NAD 83):



INSTALLED BY: Mark Souverville
DATE: 04/05/00
REMARKS: