

2008 DWR/USBR Sacramento Valley Subsidence Project

Project Report



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PROJECT REPORT

2008 CALIFORNIA DEPARTMENT OF WATER RESOURCES and U.S. BUREAU OF RECLAMATION SACRAMENTO VALLEY GPS SUBSIDENCE PROJECT

September 30, 2008

Introduction

A. Purpose

The primary purpose of the project is to provide a comprehensive Sacramento Valley GPS subsidence network to serve as a framework for monitoring land subsidence resulting from underground water withdrawal. The California Department of Water Resources (DWR) is interested in monitoring land subsidence as part of its groundwater management activities.

The secondary purpose of the project is to extend high-accuracy geodetic control to facilities operated by the U.S. Bureau of Reclamation (USBR). Toward this end, the network encompasses portions of Shasta and Folsom Lakes.

B. Time Period

The observations began on March 17, 2008 and were concluded on June 17, 2008. The project consisted of three primary phases and two sub-phases. The first phase was the Primary Base Station observations. These were observed from March 17 through March 25. These observations were completed by California Department of Water Resources personnel from the Precise Unit, the Sacramento Office and the Red Bluff North Region.

The second phase was completed by a number of observers from numerous public and quasi-public agencies. A complete listing of observers is provided in **Appendix D**. The first portion of this phase was observed from April 1 through April 28 and included most

of the northern part of the Sacramento Valley. The second portion was observed from May 5 through May 22 and included the remainder of the Valley.

The two sub-phases included networks adjacent to the subsidence network. One of these was a network around Lake Oroville. There were 12 additional stations observed concurrently with the subsidence network observations by DWR Precise Unit personnel. The second was a small four station network in the vicinity of the proposed Sites Reservoir in Colusa County. The observations were also performed concurrently with the subsidence network observations.

The third phase was the re-observations performed to measure baselines not meeting the 2-centimeter guidelines or for other reasons explained in **Section F**. Re-observations were begun on May 28 and completed on June 17.

The Primary Base Station and Local Network Station schedules are included in **Appendix B**. Re-observation schedules for the Local Network Stations are included in **Appendix C**.

C. Points of Contact

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D. Accuracy Standard

The project was conducted according to the National Geodetic Survey's "Guidelines for Establishing GPS-Derived Ellipsoid Heights" NOAA TM NOS NGS-58, July, 1997, Zilkoski, Frakes & D'Onofrio and "Guidelines for Establishing GPS-Derived Orthometric Heights" NOAA TM NOS NGS-59, Zilkoski, Carlson & Smith. The 2-centimeter standard was followed for the project. There were two variations from the Guidelines: local network sessions were observed for 60 minutes and **all** adjacent baselines were observed at least twice. Both variations exceeded the Guideline requirements. There were generally at least ten stations per Local Network Station observing session. Coupled with geographic issues which lengthened inter-station drive times we decided to increase session lengths in the event observers could not reach their respective stations on time. Several observers were late to their stations but usually managed to exceed the minimum Guideline requirements.

E. Location

The project included most of the Sacramento Valley from central Shasta County on the north to the south end of Yolo and Sacramento Counties. All existing Continuous GPS (CGPS) sites in the valley were included in the network. All stations in the valley that were part of the 2004 California Department of Transportation Height Modernization Project were included. The project also included all stations in Glenn and Yolo Counties that were part of the 2004 and 2005 (respectively) Height Modernization Projects.

F. Conditions Affecting Operations

All observations were obtained using fixed-height (constant height) poles. All poles were 2.000 meters. One of the Trimble integrated receiver/antennas used in the project required an adapter in order to mount properly on the fixed-height pole. The adapter length was carefully measured and added to the pole height to obtain the correct antenna height.

All receivers and antennas were used in the same pairings throughout the project with one exception. A different antenna was used in session M185-169-1. See **Appendix E** for a complete listing of all equipment used during the project.

On April 7 (JD98) the observer arrived at station MICHIGAN to find a GPS system over the station with no observer present. We were unable to occupy the stations but were later able to determine the owner of the equipment and obtain the data for the period of our session. Baseline processing using this data was successful. The equipment at station MICHIGAN is owned by a firm in southern California, Airborne One. The receiver and antenna types used at the station are included in **Appendix E**.

On April 24 (JD119) the observer was unable to locate the station due to construction at the site. The station was ultimately recovered but too late to save the session. In the same session another observer did not observe the planned station. All missed adjacent baseline observations were observed during the re-observation phase.

On May 19 (JD140) almost all baselines scheduled for session 2 failed the 2-centimeter criterion. We were unable to resolve the issue and scheduled all of the affected baselines for re-observation. Also on the same day a schedule error had two observers showing up at the same station in session 4. The resulting missed baseline was re-observed during the re-observation phase.

One new station (PUMP RESET) and one existing station (M 1078) replaced stations PUMP and LOGAN respectively in Glenn County. Station PUMP is at the downstream end of a spillway and the foundation under the mark is being eroded somewhat. Station LOGAN was replaced as it was deemed a little too difficult to occupy with a fixed-height pole. A double-run level tie was made between each pair of stations to perpetuate the elevation of the original stations.

Data downloading was accomplished at various locations throughout the project. Efforts were made to download data at locations as close to the ending station locations of the last session of the day.

No other significant conditions affected the operations.

G. Agency Participation

Numerous agencies participated in the project. The listing of these agencies and the personnel who participated in the project are included in **Appendix D**. The project included personnel from David Greenwell Associates and Veterans, a Disabled Veteran Business Enterprise (DVBE). The DWR contract requires a 3% DVBE component and Greenwell staff helped to meet that requirement.

Other than equipment provided by participating agencies, additional equipment was provided by the University of California Davis (UCD) and Caltrans. The UCD has provided equipment in support of almost all Height Modernization projects in the Sacramento Valley since 1999.

The California Department of Water Resources provided fully equipped observers for all Primary Base Station observations and some of the re-observations. The DWR also provided some support during the Local Network observations. The USBR provided one fully equipped observer for the second portion of the Local Network observations.

H. Field Work

Chronology – Reconnaissance for the project was begun in September. All stations that were part of earlier Height Modernization Projects in the valley were included in the network. New monuments were established as necessary to meet spacing requirements. USA tickets were obtained for all new stations requiring the establishment of driven rod monuments. Remaining new stations were established in existing concrete foundations. Primary Base Stations were observed beginning on April 17 and ending April 24. Local Network stations were observed beginning April 1 and ending May 22. There was a short break in observations from April 25 through May 4 to allow for training and transfer of equipment to the south portion personnel.

Re-observations were performed from May 28 through June 17. The schedule of re-observations is included in **Appendix C**.

Instrumentation – A complete listing of equipment used in the project included in **Appendix E**.

I. Data Processing

Baseline processing was performed by Frame Surveying & Mapping using Trimble Geomatics Office software. All project data will be processed and adjusted by Mike Potterfield of Geodetic Solutions. The results of this processing and adjustment will be forwarded to the National Geodetic Survey for review and publication.

J. Statistics

Stations Occupied – There were a total of 346 stations in the project. Of these, 330 stations were observed for the base subsidence project and 16 were observed by DWR as part of two supplemental surveys, the Sites Reservoir project (four stations) and the Lake Oroville project (12 stations). A complete listing of stations can be found in **Appendix A**.

NSRS stations (not including CGPS stations)	226
New stations set:	62
Disks in concrete	33
Class B rod marks	29
New stations recovered (not in NGS IDB):	17
CGPS stations:	14
CORS, PBO in NGSIDB	6
PBO not in NGSIDB	9
New DWR stations (Lake Oroville, Sites Reservoir)	<u>16</u>
Total Stations:	335

Total Observing Days and Sessions – There were a total of 43 observing days during the project: six days for Primary Base Station occupations; 28 days for Local Network Station occupations; and, nine days for re-observations. There were a total of 1250 station occupations: 48 for Primary Base Stations; 1090 for Local Network Stations; and, 112 for re-observations. 58 separate downloads were made for Continuous GPS stations.

The Lake Oroville and Sites Reservoir observations were performed by DWR personnel. The Sites Reservoir observations were performed as part of the ongoing project operations. The four Sites reservoir stations were observed in eight sessions of two receivers requiring 14 station occupations to ensure that all necessary adjacent station baselines were observed. The Lake Oroville observations were made separately from 12 stations over a two day period. DWR wanted to ensure the highest practical accuracy for these stations and they were occupied for eight hours on each of the two days (JD106 and JD108).

Re-observations – There were a total of 884 baselines measured in the project. Of these, 49 failed the 2 centimeter criterion, as follows:

- 11 baselines – 2.5 to 2.9cm
- 26 baselines – 3.0 to 3.9cm
- 8 baselines – 4.0 to 4.9cm
- 4 baselines - >5cm

It should be noted that eight of these baseline failures came from Session 4 on May 19 (JD140).

There were 20 additional baselines that were re-observed due to human error (6 for missed occupation) and 14 for baselines where the second set of observations would not process.

K. Comments and Recommendations

Observers were visited throughout the course of the observing phases to ensure that project guidelines and safety procedures were being followed. Guidelines and safety procedures were discussed in formal training sessions prior to the beginning of the Primary Base Stations observations in Sacramento, the north phase of Local Network observations in Red Bluff and the south phase of Local Network observations in Yuba City.

Data downloading was accomplished in various participants' offices or local motels nearby to the location of stations occupied at the end of each observing day.

We decided to opt for 60 minute sessions with a minimum of 75 minutes between sessions. There are several areas in the valley where a move between stations involved excessive drive times. This was a result of having to cross features like the Sutter Bypass or the Sacramento River where road crossings significantly lengthened distances and drive times. Several occupations were late starting due to this issue but all met or exceeded the minimum observing time required by the Guidelines.

This was the first time many observers had been exposed to these types of operations or to the GPS surveys. They all demonstrated exemplary attitude and professionalism throughout the project. Nine DWR personnel participated in the Primary Base Station

observations and 19 different personnel participated in each of the two Local Network Station observation phases (north and south).

The original Observation Logs were digitized and forwarded to Mike Potterfield at Geodetic Solutions. The NGS-format digital description file (D-File) for all stations was also submitted to Mike Potterfield. Data processing and adjustment will be performed by Geodetic Solutions and forwarded to NGS for final review and publication.

A digital file of the observation data and baseline comparison results will also be forwarded along with a digital copy of the free adjustment prepared by Frame Surveying & Mapping.

Appendix A. Station List



Appendix B. Project Observation Schedule



Appendix B

2008 CADWR/USBR Sacramento Valley Subsidence Project

PRIMARY BASE STATION OCCUPATION SCHEDULE

SCENARIO #1 (NORTH)

MONDAY, MARCH 17 (JD 77)

START: 12:00PM (UTC 1900) STOP 5:00PM (UTC 2400)

TUESDAY, MARCH 18 (JD 78)

START: 9:00AM (UTC 1600) STOP: 2:00PM (UTC 2100)

WEDNESDAY, MARCH 19 (JD 79)

START: 9:00AM (UTC 1600) STOP: 2:00PM (UTC 2100)

SCENARIO #2 (SOUTH)

THURSDAY, MARCH 20 (JD 80)

START: 9:00AM (UTC 1600) STOP: 2:00PM (UTC 2100)

MONDAY, MARCH 24 (JD 84)

START: 12:00PM (UTC 1900) STOP 5:00PM (UTC 2400)

TUESDAY, MARCH 25 (JD 85)

START: 9:00AM (UTC 1600) STOP: 2:00PM (UTC 2100)

SCENARIO # 1 (North)

RECEIVER	STATION
PRECISE 1	GLEN
PRECISE 2	B107
PRECISE 3	HMBT
PRECISE 4	ORLA
NORTH 1	0212
CENTRAL 1	U345
CENTRAL 2	02JK
CENTRAL 3	02JH
CENTRAL 4	CORN
CGPS	P345, P344, CHO1

SCENARIO # 2 (South)

RECEIVER	STATION
PRECISE 1	KUST
PRECISE 2	BIRD
PRECISE 3	COUR
PRECISE 4	BLAI
NORTH 1	GLEN
CENTRAL 1	B107
CENTRAL 2	C200
CENTRAL 3	SHEL
CGPS	CHO1, P270, P272, P208, LNC1, P271, P265

LOCAL NETWORK STATION OCCUPATION SCHEDULE

SESSION NUMBER	START TIME PDT (UTC)	STOP TIME PDT (UTC)
1	8:00AM (1500)	9:00AM (1600)
2	10:15AM (1715)	11:15AM (1815)
3	12:45PM (1945)	1:45PM (2045)
4	3:00PM (2200)	4:00PM (2300)

NOTE: RE-OBSERVATIONS WILL BE SCHEDULED AS APPROPRIATE.

Observations are scheduled Monday through Thursday.

DAY 1	TUESDAY, APRIL 1 (JD 92)			
OBSERVER	SESSION 1	SESSION 2	SESSION 3	SESSION 4
Glenn 1	BOWM	BOWM	RBNK	RBNK
Glenn 2	02FJ	02FJ	G143	G143
DWR 1	G142	JELL	2EK3	WLOW
Green 1	2HJ2	OPEN	0222	RAWS
Butte 1	2HK3	M185	C430	MCCL
Butte 2	02GH	HESS	HESS	BRHM
Butte 3	U345	SCLE	SCLE	02CJ
Tehama 1	ASHH	2EK4	2EK4	MICH
Tehama 2	OKSL	OKSL	2DK4	2CK1
Tehama 3	EGRN	BNBR	FLOR	FLOR
CGPS		P345		P344

DAY 2	WEDNESDAY, APRIL 2 (JD 93)			
OBSERVER	SESSION 1	SESSION 2	SESSION 3	SESSION 4
Glenn 1	RBNK	RBNK	BOWM	BOWM
Glenn 2	G143	G143	02FJ	02FJ
DWR 1	2EK3	WLOW	G142	JELL
Green 1	0222	RAWS	2HJ2	OPEN
Butte 1	C430	MCCL	2HK3	M185
Butte 2	HESS	BRHM	02GH	HESS
Butte 3	SCLE	02CJ	U345	SCLE
Tehama 1	2EK4	MICH	ASHH	2EK4
Tehama 2	2DK4	2CK1	OKSL	OKSL
Tehama 3	FLOR	FLOR	EGRN	BNBR
CGPS		P344		P345

DAY 3	THURSDAY, APRIL 3 (JD 94)			
OBSERVER	SESSION 1	SESSION 2	SESSION 3	SESSION 4
Glenn 1	SRGS	SRGS	NORD	ORLA
Glenn 2	LBRL	LBRL	VIOL	CREE
DWR 1	Q106	L143	PMPR	V380
Green 1	CORN	MICH	CAPA	W215
Butte 1	MCCL	P143	P143	SRGS
Butte 2	BRHM	B635	N852	N852
Butte 3	02CJ	02CJ	FARM	Y380
Tehama 1	K276	271F	271F	K276
Tehama 2	BUTG	B130	B130	BUTG
Tehama 3	EUCA	B728	B728	2966
CGPS		P344		

DAY 4	MONDAY, APRIL 7 (JD 98)			
OBSERVER	SESSION 1	SESSION 2	SESSION 3	SESSION 4
Glenn 1	NORD	ORLA	SRGS	SRGS
Glenn 2	VIOL	CREE	LBRL	LBRL
DWR 1	PMPR	V380	Q106	L143
Green 1	CAPA	W215	CORN	MICH
Butte 1	P143	SRGS	MCCL	P143
Butte 2	N852	N852	BRHM	B635
Butte 3	FARM	Y380	02CJ	02CJ
Tehama 1	271F	K276	K276	271F
Tehama 2	B130	BUTG	BUTG	B130
Tehama 3	B728	2966	EUCA	B728
CGPS				P344

DAY 5 TUESDAY, APRIL 8 (JD 99)				
OBSERVER	SESSION 1	SESSION 2	SESSION 3	SESSION 4
Glenn 1	V380	2085	WALK	PUMP
Glenn 2	W215	ORLA	Q107	FARM
Glenn 3	S106	CHER	CHER	WILD
Glenn 4	WINS	H285	H285	KAIS
Butte 1	Y380	FREN	FREN	2085
Butte 2	B107	K852	K852	K852
Butte 3	A107	A107	U107	PETE
Tehama 1	BIGW	BIGW	WILN	HAMI
Tehama 2	AGUI	AGUI	ARTO	VIOL
Tehama 3	CREE	CAPA	P30W	P30W

DAY 6 WEDNESDAY, APRIL 9 (JD 100)				
OBSERVER	SESSION 1	SESSION 2	SESSION 3	SESSION 4
Glenn 1	WALK	PUMP	V380	2085
Glenn 2	Q107	FARM	W215	ORLA
Glenn 3	CHER	WILD	S106	CHER
Glenn 4	H285	KAIS	WINS	H285
Butte 1	FREN	2085	Y380	FREN
Butte 2	K852	K852	B107	K852
Butte 3	U107	PETE	A107	A107
Tehama 1	WILN	HAMI	BIGW	BIGW
Tehama 2	ARTO	VIOL	AGUI	AGUI
Tehama 3	P30W	P30W	CREE	CAPA

DAY 7	THURSDAY, APRIL 10 (JD 101)			
OBSERVER	SESSION 1	SESSION 2	SESSION 3	SESSION 4
Glenn 1	NORD	FREX	FREX	GLEN
Glenn 2	FARM	DHAM	L191	L191
Glenn 3	WILD	WILD	WILD	JACI
Glenn 4	MERI	G434	KAIS	WILN
Butte 1	HMBT	HMBT	1118	PROV
Butte 2	C434	C434	BEND	BEND
Butte 3	MORE	MORE	PETE	WALK
Tehama 1	HAMI	7MIL	7MIL	7MIL
Tehama 2	B 728	PEN2	EXT1	EXT1
Tehama 3	EATO	B428	P30W	BCEX
Frame			JACI	P30W

DAY 8	MONDAY, APRIL 14 (JD 105)			
OBSERVER	SESSION 1	SESSION 2	SESSION 3	SESSION 4
Glenn 1	FREX	GLEN	NORD	FREX
Glenn 2	L191	L191	FARM	DHAM
Glenn 3	WILD	JACI	WILD	WILD
Glenn 4	KAIS	WILN	MERI	G434
Butte 1	1118	PROV	HMBT	HMBT
Butte 2	BEND	BEND	C434	C434
Butte 3	PETE	WALK	MORE	MORE
Tehama 1	7MIL	7MIL	HAMI	7MIL
Tehama 2	EXT1	EXT1	B 728	PEN2
Tehama 3	P30W	BCEX	EATO	B428
Frame	JACI	P30W		

DAY 9 TUESDAY, APRIL 15 (JD 106)				
OBSERVER	SESSION 1	SESSION 2	SESSION 3	SESSION 4
Glenn 1	7MIL	GLEN	JOHN	JOHN
Glenn 2	DHAM	1122	D14R	D14R
DWR 1	PEN2	NELS	NELS	BIGB
Green 1	J143	JACI	SHEP	SHEP
Butte 1	G434	NLD8	NLD8	CRST
Butte 2	TALL	B109	TALL	F853
Butte 3	55BB	WLMS	WLMS	WLMS
Tehama 1	GORR	GORR	J847	BUZZ
Tehama 2	FENN	FENN	PARK	PARK
Colusa 1	B428	BCEX	55BB	V853
CGPS			ORVB	ORVB
CGPS			CHO1	CHO1

DAY 10 WEDNESDAY, APRIL 16 (JD 107)				
OBSERVER	SESSION 1	SESSION 2	SESSION 3	SESSION 4
Glenn 1	JOHN	JOHN	7MIL	GLEN
Glenn 2	D14R	D14R	DHAM	1122
DWR 1	NELS	BIGB	PEN2	NELS
Green 1	SHEP	SHEP	J143	JACI
Butte 1	NLD8	CRST	G434	NLD8
Butte 2	TALL	F853	TALL	B109
Butte 3	WLMS	WLMS	55BB	WLMS
Tehama 1	J847	BUZZ	GORR	GORR
Tehama 2	PARK	PARK	FENN	FENN
Colusa 1	55BB	V853	B428	BCEX
CGPS	ORVB	ORVB		
CGPS	CHO1	CHO1		

DAY 11 THURSDAY, APRIL 17 (JD 108)

OBSERVER	SESSION 1	SESSION 2	SESSION 3	SESSION 4
Glenn 1	WALK	GLEN	STEG	GRAY
Glenn 2	Q107	1122	DODG	DODG
Glenn 3	OWEN	Y852	NORM	HOWA
Glenn 4	6064	WILL	WILL	F853
Butte 1	W850	1500	W850	1500
Butte 2	C200	BIGB	C200	BIGB
Butte 3	U107	PROV	F200	NLD7
Tehama 1	MINO	MINO	FINK	ADOB
Tehama 2	NORM	GORD	GORD	GORD
Colusa 1	M107	LARK	DELE	CRCO
Frame			SR65	
CGPS			P270	

DAY 12 MONDAY, APRIL 21 (JD 112)

OBSERVER	SESSION 1	SESSION 2	SESSION 3	SESSION 4
Glenn 1	STEG	GRAY	WALK	GLEN
Glenn 2	DODG	DODG	Q107	1122
Glenn 3	NORM	HOWA	OWEN	Y852
Glenn 4	WILL	F853	6064	WILL
Butte 1	W850	1500	W850	1500
Butte 2	C200	BIGB	C200	BIGB
Butte 3	F200	NLD7	U107	PROV
Tehama 1	FINK	ADOB	MINO	MINO
Tehama 2	GORD	GORD	NORM	GORD
Colusa 1	DELE	CRCO	M107	LARK
Frame	SR65			
CGPS	P270			

DAY 13	TUESDAY, APRIL 22 (JD 113)			
OBSERVER	SESSION 1	SESSION 2	SESSION 3	SESSION 4
Glenn 1	121B	GRAY	STEG	H62U
Glenn 2	HONC	FARR	DODG	D850
Glenn 3	S381	CRCO	PTNM	HPKN
Glenn 4	CRST	F853	HARB	HARB
Butte 1	S853	S853	SR65	T644
Butte 2	B743	B743	NLD7	LONE
Butte 3	TWSP	FLEE	FLEE	FINK
Tehama 1	BUZZ	HARR	LAUX	DELE
Tehama 2	BLOC	BLOC	WR18	HAHN
Colusa 1	V853	V853	ADOB	DLP2
Frame			PASS	
CGPS	CHO1		P270	P270
CGPS				P208

DAY 14	WEDNESDAY, APRIL 23 (JD 114)			
OBSERVER	SESSION 1	SESSION 2	SESSION 3	SESSION 4
Glenn 1	STEG	H62U	121B	GRAY
Glenn 2	DODG	D850	HONC	FARR
Glenn 3	PTNM	HPKN	S381	CRCO
Glenn 4	HARB	HARB	CRST	F853
Butte 1	SR65	T644	S853	S853
Butte 2	NLD7	LONE	B743	B743
Butte 3	FLEE	FINK	TWSP	FLEE
Tehama 1	LAUX	DELE	BUZZ	HARR
Tehama 2	WR18	HAHN	BLOC	BLOC
Colusa 1	ADOB	DLP2	V853	V853
Frame	PASS			
CGPS	P270	P270	CHO1	
CGPS		P208		

DAY 15	THURSDAY, APRIL 24 (JD 115)			
OBSERVER	SESSION 1	SESSION 2	SESSION 3	SESSION 4
Glenn 1	SECO	0304	MRSN	WDRF
Glenn 2	WBND	TARK	HONC	BLAI
Glenn 3	WAYN	G117	G117	EAGR
Glenn 4	HARB	WR18	LOAK	03HJ
Butte 1	GRNO	SUTA	SUTA	HALL
Butte 2	LONE	WHEA	LOMO	LOMO
Butte 3	NLD6	FLEE	TWSP	CANL
Tehama 1	LAUX	BLOC	BLOC	S214
Tehama 2	HAHN	PASS	RAMZ	RAMZ
Colusa 1	COLI	COLI	R276	R276
Frame	WHEA			
CGPS	P272	P272		
CGPS		SUTB		

DAY 16	MONDAY, APRIL 28 (JD 119)			
OBSERVER	SESSION 1	SESSION 2	SESSION 3	SESSION 4
Glenn 1	MRSN	WDRF	SECO	0304
Glenn 2	HONC	BLAI	WBND	TARK
Glenn 3	G117	EAGR	WAYN	G117
Glenn 4	LOAK	03HJ	HARB	WR18
Butte 1	SUTA	HALL	GRNO	SUTA
Butte 2	LOMO	LOMO	LONE	WHEA
Butte 3	TWSP	CANL	NLD6	FLEE
Tehama 1	BLOC	S214	LAUX	BLOC
Tehama 2	RAMZ	RAMZ	HAHN	PASS
Colusa 1	R276	R276	COLI	COLI
Frame			WHEA	
CGPS			P272	P272
CGPS				SUTB

NOTE: NO OBSERVATIONS THROUGH MAY 5, 2008

DAY 17 MONDAY, MAY 5 (JD 126)

OBSERVER	SESSION 1	SESSION 2	SESSION 3	SESSION 4
UCD	MRSN	PWRL	PWRL	WBND
PCWA	TARK	K435	WISE	PELG
DAVIS	F114	EAGR	ALGO	ALGO
SACTO	ENNS	OSTR	OSTR	ENNS
SUTTER	SUTA	HALL	BEAR	WASH
YCWA	WHEA	OSWD	B144	OSWD
ROSE1	CANL	CANL	ROSO	TSDL
USBR	BOGE	BLAI	COON	BOGE
RD108	HPIN	HPIN	H380	HPIN
YCFCWCD	WBND	03FH	03FH	WILK

DAY 18 TUESDAY, MAY 6 (JD 127)

OBSERVER	SESSION 1	SESSION 2	SESSION 3	SESSION 4
UCD	PWRL	WBND	MRSN	PWRL
PCWA	WISE	PELG	TARK	K435
DAVIS	ALGO	ALGO	F114	EAGR
SACTO	OSTR	ENNS	ENNS	OSTR
SUTTER	BEAR	WASH	SUTA	HALL
YCWA	B144	OSWD	WHEA	OSWD
ROSE1	ROSO	TSDL	CANL	CANL
USBR	COON	BOGE	BOGE	BLAI
RD108	H380	HPIN	HPIN	HPIN
YCFCWCD	03FH	WILK	WBND	03FH

DAY 19 WEDNESDAY, MAY 7 (JD 128)

OBSERVER	SESSION 1	SESSION 2	SESSION 3	SESSION 4
UCD	T143	SUTX	SUTX	SUTX
PCWA	WISE	FIDY	WISE	VARN
DAVIS	DOWD	WALE	BEAR	VNON
SACTO	MOOR	MOOR	MOOR	TYND
SUTTER	W147	W147	SAWT	SAWT
YCWA	COLM	PHLP	WASH	WASH
ROSE1	120P	0309	TRBR	JRM4
USBR	COON	BREW	ROSO	PELG
RD108	G120	G120	03EH	03EH
YCFCWCD	INDU	INDU	KUST	KUST
CGPS	LNC1	LNC1		

DAY 20 THURSDAY, MAY 8 (JD 129)

OBSERVER	SESSION 1	SESSION 2	SESSION 3	SESSION 4
UCD	SUTX	SUTX	T143	SUTX
PCWA	WISE	VARN	WISE	FIDY
DAVIS	BEAR	VNON	DOWD	WALE
SACTO	MOOR	TYND	MOOR	MOOR
SUTTER	SAWT	SAWT	W147	W147
YCWA	WASH	WASH	COLM	PHLP
ROSE1	TRBR	JRM4	120P	0309
USBR	ROSO	PELG	COON	BREW
RD108	03EH	03EH	G120	G120
YCFCWCD	KUST	KUST	INDU	INDU
CGPS			LNC1	LNC1

DAY 21 MONDAY, MAY 12 (JD 133)

OBSERVER	SESSION 1	SESSION 2	SESSION 3	SESSION 4
UCD	REGO	CSUS	CSUS	FERR
PCWA	BREW	ZINF	ELKH	FREM
DAVIS	WALE	BURO	CRES	CRES
SACTO	0309	LROY	HOWE	SUTX
SUTTER	GRBK	SHEL	03AA	VNON
YCWA	GIBS	EXCL	ELVT	ELVT
ROSE1	ELKH	BRAD	BRAD	RIVE
USBR	R208	DOUG	R208	SM15
ROSE2	FAIO	FAIO	REGO	REGO
WOODLND	GARF	GARF	GARF	SNKY
FRAME				PHLP

DAY 22 TUESDAY, MAY 13 (JD 134)

OBSERVER	SESSION 1	SESSION 2	SESSION 3	SESSION 4
UCD	CSUS	FERR	REGO	CSUS
PCWA	ELKH	FREM	BREW	ZINF
DAVIS	CRES	CRES	WALE	BURO
SACTO	HOWE	SUTX	0309	LROY
SUTTER	03AA	VNON	GRBK	SHEL
YCWA	ELVT	ELVT	GIBS	EXCL
ROSE1	BRAD	RIVE	ELKH	BRAD
USBR	R208	SM15	R208	DOUG
ROSE2	REGO	REGO	FAIO	FAIO
WOODLND	GARF	SNKY	GARF	GARF
FRAME		PHLP		

DAY 23 WEDNESDAY, MAY 14 (JD 135)

OBSERVER	SESSION 1	SESSION 2	SESSION 3	SESSION 4
UCD	SECO	1075	MADI	MADI
PCWA	LUSA	GW17	GW17	B849
DAVIS	WAYN	T849	T849	YCAP
SACTO	TYND	TYND	WOOD	WOOD
SUTTER	DRAI	VINC	VINC	CANA
YCWA	X200	X200	BRID	RUSS
ROSE1	JRM4	CODY	COTT	COTT
USBR	HERS	HERS	1699	ABUT
ROSE2	BIRD	BIRD	GW32	1069
WOODLND	WILK	CVAP	KEAT	DAVE
CGPS				P265
CGPS				UCD1

DAY 24 THURSDAY, MAY 15 (JD 136)

OBSERVER	SESSION 1	SESSION 2	SESSION 3	SESSION 4
UCD	MADI	MADI	SECO	1075
PCWA	GW17	B849	LUSA	GW17
DAVIS	T849	YCAP	WAYN	T849
SACTO	WOOD	WOOD	TYND	TYND
SUTTER	VINC	CANA	DRAI	VINC
YCWA	BRID	RUSS	X200	X200
ROSE1	COTT	COTT	JRM4	CODY
USBR	1699	ABUT	HERS	HERS
ROSE2	GW32	1069	BIRD	BIRD
WOODLND	KEAT	DAVE	WILK	CVAP
CGPS		P265		
CGPS		UCD1		

DAY 25 MONDAY, MAY 19 (JD 140)

OBSERVER	SESSION 1	SESSION 2	SESSION 3	SESSION 4
UCD	SYCA	KEAT	FERR	PLAI
PCWA	VARN	DUFO	EX11	EX11
DAVIS	F859	T849	03DG	03DG
SACTO	TYND	ZAMX	WOOD	CONA
SUTTER	VNON	CODY	CANA	CANA
YCWA	FREM	0308	0308	RWF1
ROSE1	CODY	1031	1031	YCAP
USBR	FORD	FORD	FORD	DAVE
GREEN	SM15	SM15	CHUR	COY1
WOODLND	CVAP	CVAP	LIBR	RIVE
CGPS		P271	P271	P271
CGPS				UCD1

DAY 26 TUESDAY, MAY 20 (JD 141)

OBSERVER	SESSION 1	SESSION 2	SESSION 3	SESSION 4
UCD	FERR	PLAI	SYCA	KEAT
PCWA	EX11	EX11	VARN	DUFO
DAVIS	03DG	03DG	F859	T849
SACTO	WOOD	CONA	TYND	ZAMX
SUTTER	CANA	CANA	VNON	CODY
YCWA	0308	RWF1	FREM	0308
ROSE1	1031	YCAP	CODY	1031
USBR	FORD	DAVE	FORD	FORD
GREEN	CHUR	COY1	SM15	SM15
WOODLND	LIBR	RIVE	CVAP	CVAP
CGPS	P271	P271		P271
CGPS		UCD1		

DAY 27 WEDNESDAY, MAY 21 (JD 142)

OBSERVER	SESSION 1	SESSION 2	SESSION 3	SESSION 4
UCD	CSUS	GAFF	GAFF	CAST
PCWA	PALA	PALA	ANDR	DAVE
DAVIS	RIVE	CAST	2068	ALHA
SACTO	CONA	CONA	SURV	SURV
SUTTER	03AA	03BG	MILL	RWF1
YCWA	T462	T462	COUR	WILS
GREEN	COY1	COY1	CALD	CALD
FRAME				COY1
CGPS		P268	P268	P268
CGPS				UCD1
CGPS			P267	P267

DAY 28 THURSDAY, MAY 22 (JD 143)

OBSERVER	SESSION 1	SESSION 2	SESSION 3	SESSION 4
UCD	GAFF	CAST	CSUS	GAFF
PCWA	ANDR	DAVE	PALA	PALA
DAVIS	2068	ALHA	RIVE	CAST
SACTO	SURV	SURV	CONA	CONA
SUTTER	MILL	RWF1	03AA	03BG
YCWA	COUR	WILS	T462	T462
GREEN	CALD	CALD	COY1	COY1
FRAME		COY1		
CGPS	P268	P268		P268
CGPS		UCD1		
CGPS	P267	P267		

Appendix C. Project Re-observation Schedule



Appendix C

Re-observation Schedules

Day 1, Wednesday, May 28 (JD 149)

Observer	8:30 – 9:30	10:00 – 11:00	11:30 – 12:30	1:00 – 2:00
Frame	CANA	PLAI	PLAI	PLAI
D’Onofrio	YCAP	YCAP	03DG	RWF1

Day 2, Thursday, May 29 (JD 150)

Observer	TBD	TBD	TBD	TBD	TBD
Frame	SM15	ELVT	BREW	0309	W147
D’Onofrio	FERR	FERR	WALE	G120	G120

Day 3, Tuesday, June 3 (JD 155)

9:00 to 10:00am 11:30 to 12:30pm 2:00 to 3:00pm

Observer	Session 1	Session 2	Session 3
Frame	Open	WILK	HAHN
D’Onofrio	LUSA	TSDL	NLD6
DWR 1	TARK	BOGE	COLI
DWR 2	WHEA	ENNS	LONE
DWR 3	GRNO	PELG	GRNO
DWR 4	SECO	WBND	SECO

Day 4, Wednesday, June 4 (JD156)

9:00 to 10:00 11:30 to 12:30 2:00 to 3:00 4:00 to 5:00

Observer	Session 1	Session 2	Session 3	Session 4
Frame	FINK	FREM	T849	JRM4
D’Onofrio	H62U	FORD	CVAP	PELG
DWR 1	HPKN	CODY	DUFO	
DWR 2	D850	ZAMX	ZAMX	
DWR 3	03FH	F859	KEAT	
DWR 4	BEAR	SNKY	0308	

Day 5, Thursday, June 5 (JD 157)*

Observer	Session 1	Session 2	Session 3	Session 4	Session 5
D’Onofrio	HALL	S214	S214	R276	HONC
GREEN	BLAI	BLAI	03HJ	03HJ	R276

Day 6, MONDAY, JUNE 9 (JD 161)

8:00 to 9:00 10:00 to 11:00 12:00 to 1:00 2:00 to 3:00

RECEIVER	SESSION 1	SESSION 2	SESSION 3	SESSION 4
D'ONOFRIO	BIGB	BCEX	B109	C434
GREEN	HOWA	HARR	WLMS	PEN2
GLENN	ADOB	CRCO	1500	G434
FRAME	1122	7MIL		

Day 7, TUESDAY, JUNE 10 (JD 162)

7:30 to 8:30 9:15 to 10:15 11:00 to 12:00 12:45 to 1:45 2:15 to 3:15

RECEIVER	SESSION 1	SESSION 2	SESSION 3	SESSION 4	SESSION 5
D'ONOFRIO	S106	V380	SRGS	SRGS	PMPR
GREEN	CREE	2966	2966	271F	B130
GLENN		ORLA	N852		

Day 8, WEDNESDAY, JUNE 11 (JD 163)

7:30 to 8:30 9:15 to 10:15 11:00 to 12:00 12:30 to 1:30 2:15 to 3:15

RECEIVER	SESSION 1	SESSION 2	SESSION 3	SESSION 4	SESSION 5
D'ONOFRIO	MCCL	BRHM	0222	0222	M185
GREEN	WLOW	G143	2EK3	SCLE	HESS
DWR/WEST	RAWS	2CK1	C430		

Day 9, Tuesday, June 17 (JD 169)

RECEIVER	SESSION 1	SESSION 2
Observing period	9:00am to 10:00am	11:00am to 12:00 noon
D'ONOFRIO	C434	B109
GLENN 1/Kline	G434	1500
GLENN2/Hubbard	PEN2	WLMS

Day 9, Tuesday, June 17 (JD 169)

RECEIVER	SESSION 1
Observing period	11:00am to 12:00 noon
DWR/West	M185
DWR/Hummer	HESS

Appendix D. Participating Observers



Jim Frame, Frame Surveying & Mapping

Don D'Onofrio, Project Coordinator

Appendix D

2008 CADWR/USBR Sacramento Valley Subsidence Project

Observing Personnel and Agency

I. Cooperating Agencies

Personnel	Agency
Ron Almeida	Sacramento County Survey
Reed Bekins	UC Davis
Chris Burdick	David Greenwell Associates & Veterans
Norman Cote	Sutter County
Tom Dixon	Yuba County Water Agency
Todd DiAngelo	RD 108
Brad Elliot	Tehama County Public Works
Jordana Ellis	Glenn County Dept. of Agriculture
Todd Estes	Butte County Public Works
Allan Fulton	UCD Coop Extension
Tim Gomes	Colusa County Public Works
David Greenwell	David Greenwell Associates & Veterans
Kristen Hard (McKillop)	Butte County Water & Resource Conservation
Larry Hatch	City of Woodland
Jon Heisler	City of Roseville Engineering
Carrie Hubbard	Glenn County Dept. of Agriculture
Wyatt Jenkins	Butte County Public Works
Jarvis Jones	Sutter County
Robert Keller	U.S. Bureau of Reclamation
Jennifer Kline	Glenn County Dept. of Agriculture
Dottie Lacroix	Glenn County Dept. of Agriculture
Dave Landon	Butte County Public Works
Tomas Loera	Glenn-Colusa Irrigation District
Jennifer Masters	Colusa County RCD
Leslie Morgan	Yuba County Water Agency/Yuba RCD
Jerry Orr	Sutter County
Gerald Peatross	Placer County Water Agency
Jon Picou	Glenn-Colusa Irrigation District

Clint Raimer	Tehama County Public Works
Rosie Salas	City of Woodland
Bob Schoech	City of Davis Public Works
Ron Scott	City of Woodland
Gary Simpson	City of Roseville Engineering
John Stotts	Yolo County Flood Control & Water Cons. District
Brad Wiggins	Tehama County Public Works

II. California Department of Water Resources

Observing Personnel

Precise Unit

Jim Harlan
Joe Mello
Charles Mussett
James Santos
Forrest Smith

Sacramento Office

Wayne Blackburn
David Bradley
Russell Brunkhorst
Tim Johnston
Abe Magdaleno
Scott Rebelo
Greg SanFillipo

Red Bluff Office

Sean Hummer
Jim West

