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Project Report

Sacramento Valley Height Modernization Network

DWR Standard Agreement No. 4600007950, Task Order Nos. 1 and 3
June 22, 2010

Introduction

The Sacramento Valley Height Modernization Network (SVHMN) is a collection of geodetic control stations comprising both passive marks and active stations spanning California's Sacramento Valley within 10 counties: Butte, Colusa, Glenn, Placer, Sacramento, Solano, Sutter, Tehama, Yolo and Yuba. Positioning of the stations was accomplished by means of GPS observations conducted in the spring of 2008. The primary purpose of the network is to provide accurate orthometric heights throughout the valley for use in monitoring groundwater levels and ground subsidence.

The project was initiated by the California Department of Water Resources (DWR). Frame Surveying & Mapping (Davis, CA) was selected as the prime contractor. The project team included Geodetic Consultant Don D'Onofrio (Carmichael, CA), Geodetic Solutions (Carmel Valley, CA), and DGA&V (Marysville, CA). The latter is a Disabled Veteran Business Enterprise.

At the request of the U.S. Bureau of Reclamation (USBR), the initial implementation of the network was extended north to incorporate Lake Shasta in Shasta County. USBR, which owns and operates Lake Shasta, was interested in modernizing the geodetic control at the lake in anticipation of large-scale improvement projects. USBR contributed substantial funding and staff time for the project in return for updated control at the lake. Due to USBR staff availability, the Lake Shasta subnetwork was observed in 2009, almost a year after the Sacramento Valley network observations.

Observation of the network was planned and implemented as a cooperative project incorporating staff from federal, state and local agencies. A list of partner agencies can be found in the Sac Valley Project Report to NGS at http://members.dcn.org/jhframe/DWR/.

A primary deliverable for the project was publication of the adjusted station data and metadata by the National Geodetic Survey (NGS) through its Integrated Data Base (IDB). The NGS IDB is the authoritative repository of geodetic control information for the United States and its territories.

Network Description

The base network comprises 316 stations, including 16 active stations. The passive network stations are stable physical monuments set in the ground or embedded in bedrock or massive concrete structures. The active network stations are continuously-operating GPS receiver/antenna installations operated by the Plate Boundary Observatory (PBO) and the Bay Area Regional Deformation Network (BARD Network).

DWR requested additional stations in 2 locations: 4 stations near the proposed Sites Reservoir in Colusa County, and 12 stations in the Lake Oroville area of Butte County.

The Lake Shasta extension includes 14 stations: 12 in the immediate vicinity of the lake, and 2 to bridge the gap between the lake and the base network to the south.

The network was designed and observed in accordance with NOAA Technical Memoranda NOS NGS-58 (Guidelines For Establishing GPS-Derived Ellipsoid Heights) and NOS NGS 59 (Guidelines for Establishing GPS-Derived Orthometric Heights). The 2-centimeter specifications were followed in both cases.

Network Design

The primary control network comprised 26 stations (17 passive, 9 active). NGS guidelines specify that control stations and primary base stations be spaced no more than 40 km apart. Primary network baselines in this project range from 18.5 km to 47.5 km, with an average of 34.0 km. 7 of the baselines exceed 40 km in length.

NGS guidelines call for a local network station spacing of 10 km or less, with an average spacing of 7 km. For this project the spacing ranges from 0.7 km to 24 km, with an average of 7.4 km. Of the 940 local network baselines, 447 are shorter than 7 km, 375 are between 7 and 10 km, 117 are between 10 and 20 km, and 1 is over 20 km. The longer baselines are generally located in areas along the edges of the Sacramento Valley and in the Lake Shasta area, where the road network is sparse.

See the attached figures for depictions of the network configuration.

Network Observations

See the Sac Valley Project Report to NGS at http://members.dcn.org/jhframe/DWR/ for a description of observation details including equipment, personnel and schedules.

Geoid Model Issues

The North American Vertical Datum of 1988 (NAVD 88) is the official geodetic vertical datum of the United States. In order to transform GPS-derived ellipsoid heights to NAVD 88 orthometric heights (elevations), the separation between the reference ellipsoid of the GPS survey and the NAV88 surface at each observation station must be known or estimated. NGS guidelines recognize the use of a high-accuracy geoid model as the most practical approach to obtaining these separations.

NGS publishes geoid models for this purpose, and has been improving the accuracy of the model with each revision. At the time this project was observed and initially adjusted, the NGS geoid model in effect was GEOID03. However, during the analysis of the survey data, significant errors – varying from zero to 0.1 meter within the project area – were found in GEOID03. Adjusting the survey using GEOID03 would thus compromise the accuracy of the station orthometric heights. In order to obviate this problem, a custom geoid model – based upon GEOID03, but without the gross errors – was developed for the project. (This model will be referred to as Custom03.) At the request of DWR staff, preliminary adjusted positions for the project stations were provided to contractors working on DWR floodplain mapping projects.

NGS data handling processes do not provide a means of incorporating custom geoid models in the IDB. It initially appeared as though the only way to publish the station positions via the IDB was to use the flawed GEOID03. The orthometric heights thus published would not agree with those used in the floodplain mapping effort, creating potential for confusion or even costly conflicts to end users.

In the months that followed the initial adjustment, various methods of getting the GEOID03 station data published by NGS while also making the more-accurate Custom03 positions reliably available to the public were discussed. While those discussions were in progress, NGS announced the impending release of GEOID09, billed as a substantial improvement to GEOID03. The promise of GEOID09 offered another potential solution to the publication problem. After GEOID09 was released, Geodetic Solutions was retained to adjust the survey using GEOID09 and to provide an analysis of the orthometric height differences between the GEOID09 adjustment and the custom geoid model adjustment.

The results of this analysis showed a general bias on the order of 0.1 m between GEOID03 and GEOID09 in the project area. It also showed that the residuals between the Custom03 adjustment and the GEOID09 adjustment range from -0.04 m to +0.1 m. Of the 335 stations in the base network, 60 have residuals of magnitude greater than 0.02 m, but only 19 of these have residuals of magnitude greater than 0.04 m. This level of difference was considered acceptable under the circumstances, and the project was published as adjusted using the GEOID09 model.

Further details can be found in the Geodetic Solutions Adjustment Report at http://members.dcn.org/jhframe/DWR/.

Station Data

Adjusted position data and metadata for the network stations are published by NGS in the form of datasheets. A datasheet is the presentation form of information found in the NGS IDB. There are several ways to access the datasheets for this project. Archived copies of the project datasheets have been compiled into two PDFs, one for the Sacramento Valley network and one for the Shasta subnetwork. These files can be found at http://members.dcn.org/jhframe/DWR/. The datasheets can also be retrieved directly from the NGS IDB, either individually or for the entire project. The instructions below describe the most convenient way to obtain all current datasheets for the project.

1. Go to http://www.ngs.noaa.gov/cgi-bin/ds_proj.prl

2. Enter "GPS2516" (for the Sacramento Valley network) or "GPS2548" (for the Shasta subnetwork) in the Survey Project ID box. This is the NGS project ID number, and it must be entered as shown – all capitals, no spaces. The defaults for "Marks to include," "Data Type Desired" and "Stability Desired" are acceptable unless you wish to filter the results.

3. Click the Submit button.

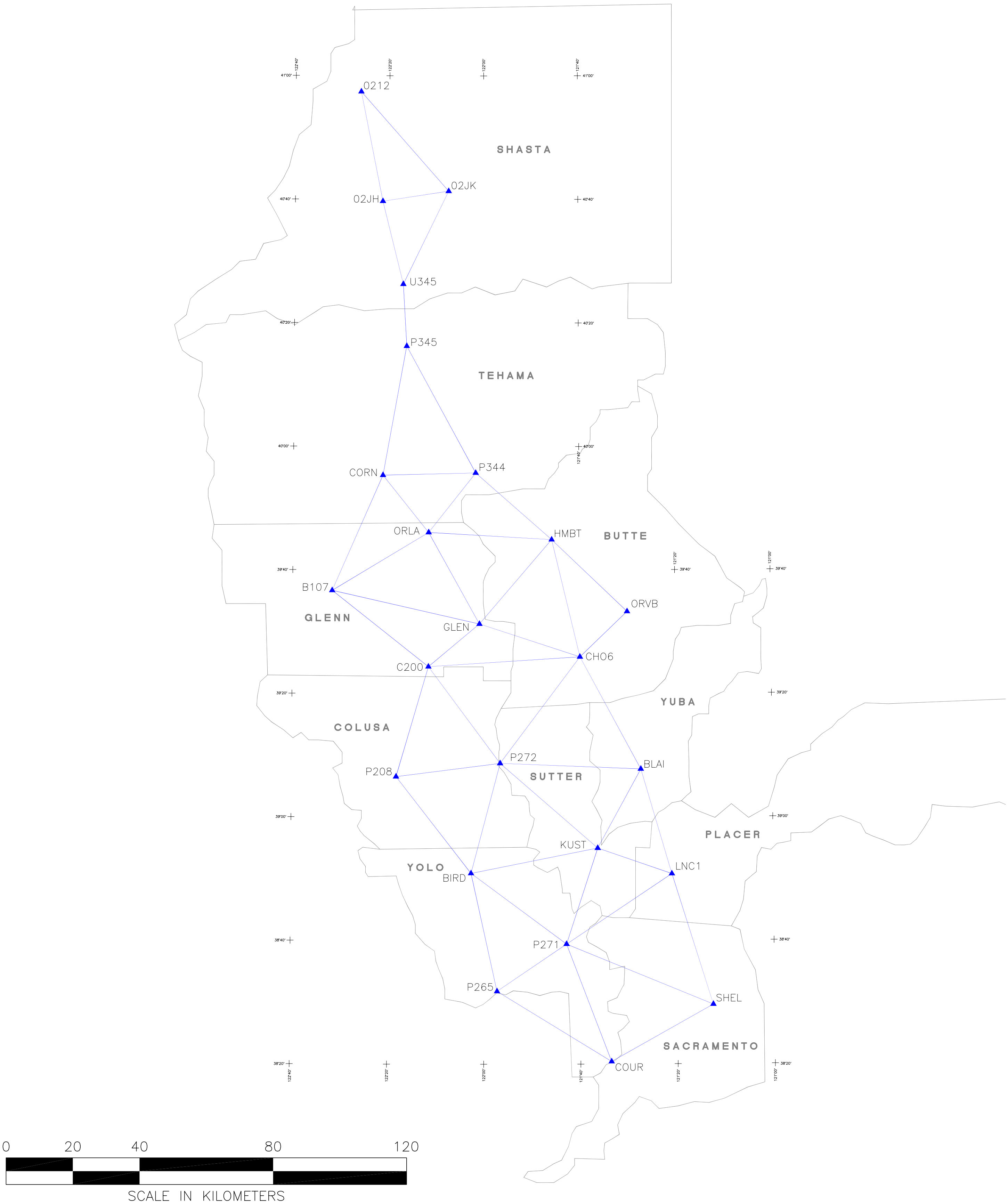
4. When the Station List Results page appears, clicking the Move button will display the abbreviated station data in the browser window so that it can be copied, printed or saved as a file if desired. To obtain all the datasheets for the project, on the Station List Results page click the Select All button. (If the Move button was previously clicked, click on the browser's Back button to go back to the Station List Results page first.) After the page refreshes and shows the highlighted station list, click the Get Datasheets button.

5. Because of lot of data is being retrieved, it may take a minute or two for the transfer to complete. When it does, the datasheets for the project will be displayed as a single page. At this point the page may be saved as a text file, or you may "select all" and copy/paste the datasheets into a word processing document or print it as a single document, as desired.

Contact

As of the date of this report, the DWR manager for this project is Laura Peters. Questions or comments may be directed to Ms. Peters at mailto:lpeters@water.ca.gov.

Figure 1



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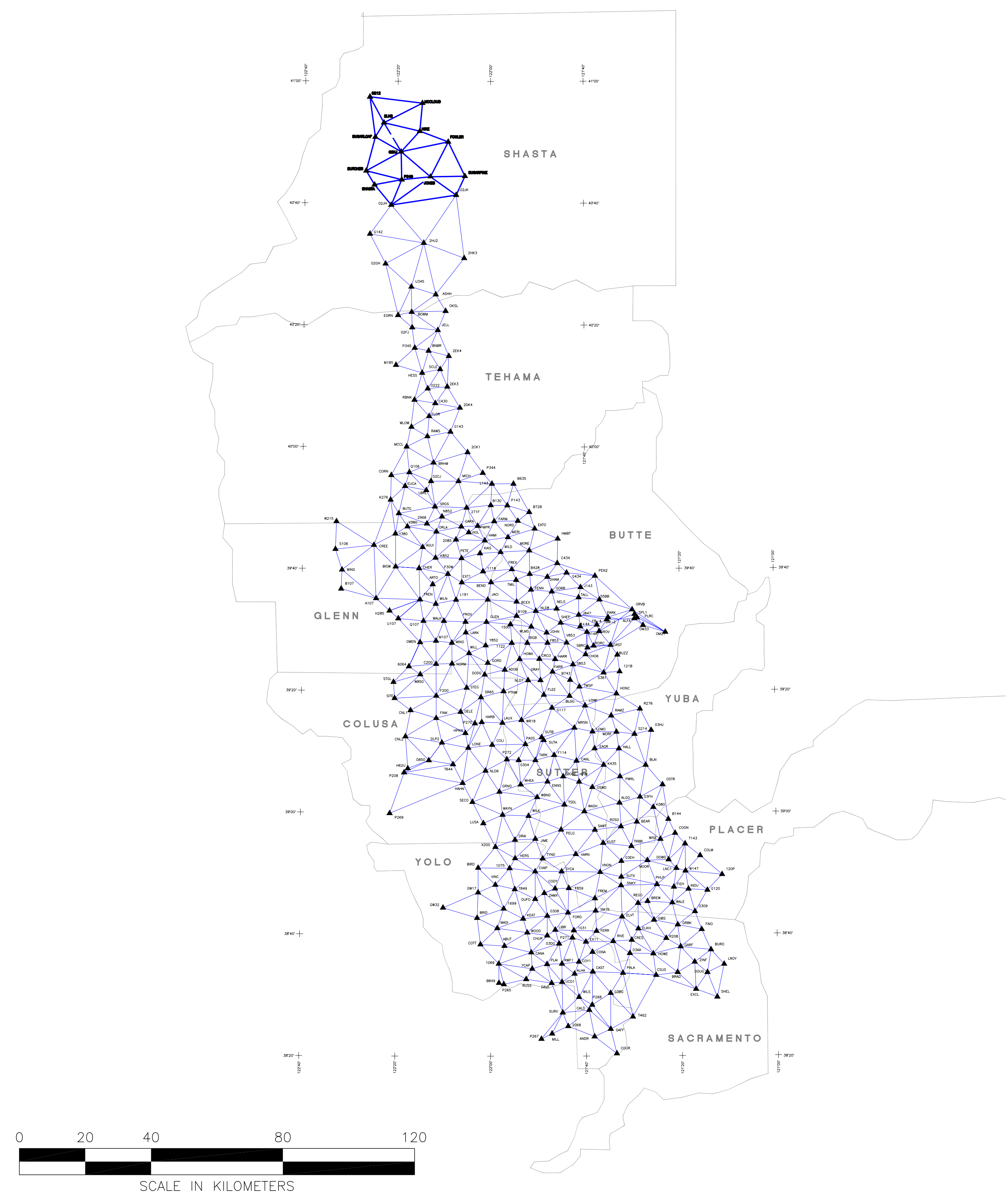
0825-001

PRIMARY NETWORK DIAGRAM

SACRAMENTO VALLEY HEIGHT MODERNIZATION NETWORK
A MULTI-AGENCY COOPERATIVE PROJECT
JUNE, 2010 SCALE: 1"= 40KM

Figure 2



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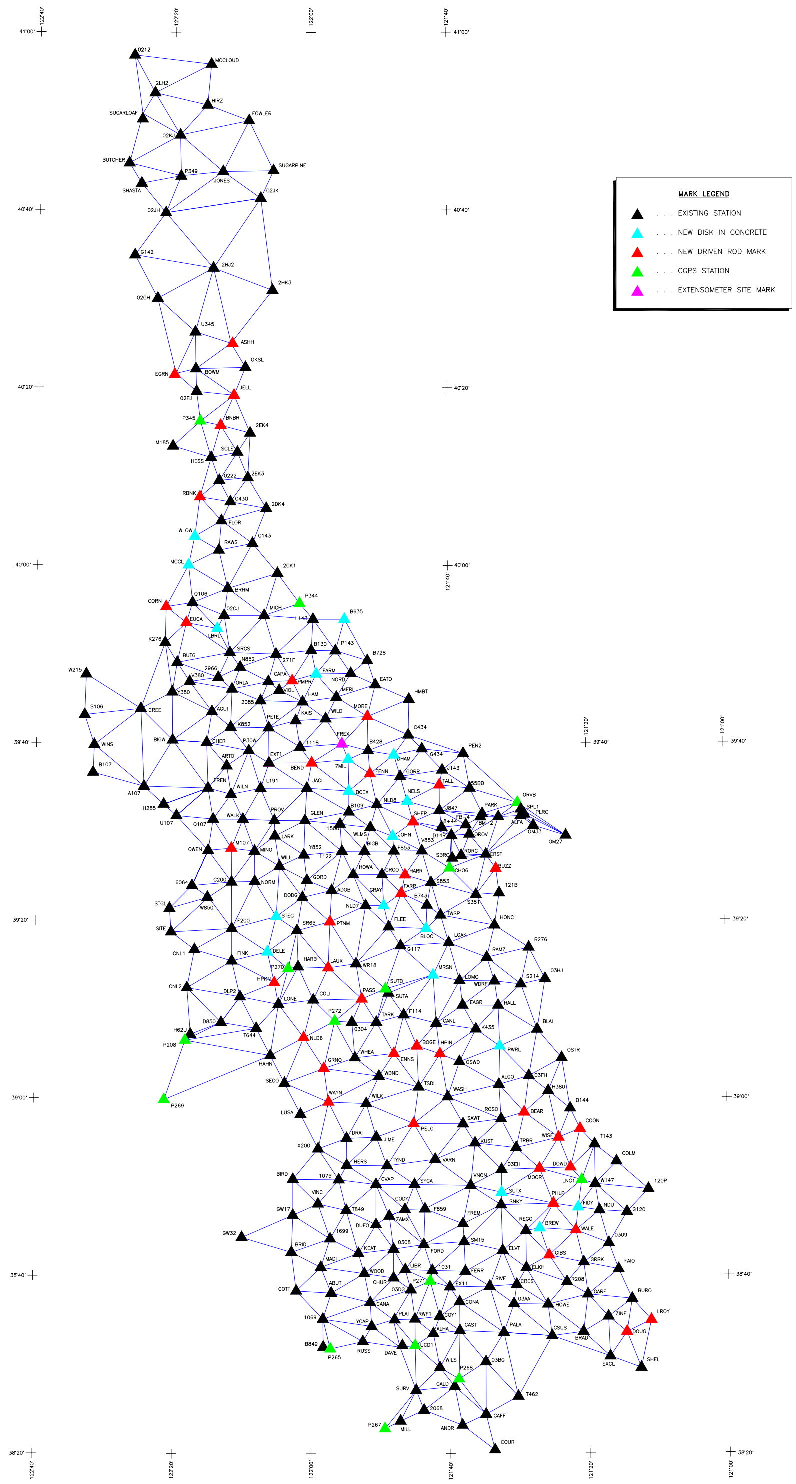
NETWORK DIAGRAM

SACRAMENTO VALLEY HEIGHT MODERNIZATION NETWORK
A MULTI-AGENCY COOPERATIVE PROJECT
JUNE, 2010 SCALE: 1"= 40KM

Figure 3



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0825-001

NETWORK BY MARK TYPE

SACRAMENTO VALLEY HEIGHT MODERNIZATION NETWORK
A MULTI-AGENCY COOPERATIVE PROJECT
JUNE, 2010 SCALE: 1"= 40KM

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-centimenter 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

Project Administrators – Chuck Owens
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Prime Contractor - Jim Frame
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Project Consultant - Don D'Onofrio
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dondonofrio@comcast.net

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)		16
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.

	A	B	C	D	E	F	G
1	SSN	STATION NAME	4 CH	PID	LATITUDE	LONGITUDE	ELEV.
2	1	121 BB USGS	121B	KS1029	39 23 07.7	121 32 43.1	
3	2	169	1699	JS2170	38 44 12.69568	121 57 15.85660	52.5
4	3	11-227 CADH	1122	DH3655	39 30 54.05117	121 55 48.12986	29.84
5	4	1500	1500	DH3654	39 27 50.60515	121 55 31.40277	26.59
6	5	208.56 USBR	2085	DH3676	39 44 47.88751	122 07 21.69182	64.56
7	6	2655 BB USGS	55BB	KS1187	39 34 51.8	121 37 10.1	
8	7	296.66 USBR	2966	DH3671	39 47 25.23009	122 13 33.09142	91.11
9	8	36 TEH 48.89	2EK4	DH6582	40 14 55.50432	122 08 57.52231	188.9
10	9	44 SHA 15.59	2HK3	DH6393	40 31 00.04638	122 05 41.25229	309.7
11	10	44 SHA 6.94	2HJ2	DH6602	40 33 28.91529	122 14 22.18058	141.3
12	11	5 SHA 26.01	2JJ4	DH6604	40 43 49.18314	122 19 10.78643	300.6
13	12	60.64 USDI	6064	DH3649	39 23 58.70593	122 17 16.91750	65.75
14	13	7 MILE	7MIL		39 38 10.7	121 54 35.9	
15	14	99 TEH 17.88	2DK4	DH6619	40 06 26.6	122 06 34.3	74.2
16	15	99 TEH 22.63	2EK3	DH6620	40 09 54.04106	122 09 16.26592	82.6
17	16	99 TEH 9.22	2CK1	DH6621	39 59 08.54708	122 04 55.26423	62.5
18	17	A 1079	A107	KT0126	39 35 08.29629	122 24 17.70358	151.06
19	18	ABUT	ABUT	AI5050	38 38 05.70584	121 57 06.70255	53.01
20	19	ADOBE	ADOB	DH3657	39 23 26.69919	121 57 00.54559	21.87
21	20	AGUIAR	AGUI	DH3669	39 43 33.88201	122 14 26.10054	83.65
22	21	ALGONDON	ALGO	DH6487	39 01 34.25531	121 32 52.74356	14.7
23	22	ALHAMBRA	ALHA	AI5051	38 33 31.09757	121 42 26.68762	12.97
24	23	ANDREW	ANDR	AE9864	38 23 12.17743	121 38 18.71969	3.68
25	26	ARTOIS	ARTO	DH3672	39 37 27.53289	122 12 17.01165	59.07
26	27	ASH	ASHH		40 25 01.8	122 11 46.5	
27	28	B 1079	B107	KT0737	39 36 40.90269	122 31 42.87259	215.44
28	29	B 1446	B144	JS4598	38 58 51.60288	121 22 38.16021	33.215
29	30	B 849	B849	JS2151	38 32 01.29090	121 58 15.18331	39.68
30	31	BARHAM	BRHM	DH6090	39 57 25.74374	122 12 10.79851	90.2
31	32	BASEWALE	WALE		38 45 05.7	121 21 54.7	
32	34	BC 1090	B109		39 32 16.9	121 54 29.9	
33	35	BC 1305	B130		39 50 27.1	121 59 58.0	
34	36	BC 428	B428		39 39 10.1	121 51 42.0	
35	37	BC 635	B635		39 53 58.3	121 55 08.0	
36	38	BC 728	B728		39 49 19.2	121 51 47.4	
37	39	BC 743	B743		39 21 46.1	121 43 12.1	
38	40	BC EXTN 2 (Extensometer site)	BCEX		39 34 37.4	121 54 29.9	
39	41	BEAR	BEAR		38 58 26.0	121 29 15.3	
40	42	BEND BRIDGE	BNBR		40 15 47.6	122 13 16.8	
41	43	BIG BUTTE	BIGB	DH3658	39 27 51.24509	121 52 13.93581	26.31
42	44	BIG W	BIGW	DH3670	39 40 21.14573	122 20 10.15729	139.51
43	45	BIRD	BIRD	AI5052	38 50 54.73498	122 02 37.47696	94.11
44	46	BLAIR	BLAI		39 07 45.8	121 27 19.5	
45	47	BLOCK	BLOC		39 19 08.2	121 43 19.8	
46	48	BOGUE	BOGE		39 05 54.8	121 44 42.9	
47	49	BOWMAN	BOWM	DH6091	40 22 08.87125	122 16 55.59034	126
48	50	BRADSHAW	BRAD	DH6483	38 33 42.05654	121 20 53.68120	17.6
49	51	BREWER	BREW		38 45 22.8	121 27 04.1	
50	52	BRIDGE	BRID	AI5053	38 42 41.39518	122 02 50.18340	64.2
51	53	BUREAU	BURO		38 37 22.9	121 13 53.1	
52	54	BUTTE GAGE	BUTG		39 49 05.7	122 19 32.2	
53	55	BUZ	BUZZ		39 25 52.6	121 33 11.1	
54	56	C 1430	C430	LU2280	40 07 10.7	122 11 50.1	86.627
55	57	C 1434	C434	KS1937	39 40 56	121 45 51	
56	58	C 200	C200	KT0343	39 24 22.66349	122 11 32.19634	28.73

	A	B	C	D	E	F	G
57	59	CALDWELL	CALD	AE9863	38 27 33.51280	121 39 24.21307	5.42
58	60	CANAL	CANL	KS1836	39 08 28.88940	121 41 54.56820	16.3
59	61	CANAL	CANA	AI5054	38 37 02.05407	121 51 30.11560	29.79
60	62	CAPAY	CAPA	DH3675	39 46 56.78971	122 06 14.48483	60.87
61	63	CAPITOL RESERVOIR	CRES	DE9128	38 39 02.32516	121 30 26.67010	4.8
62	64	CARRICO	CRCO		39 25 14.3	121 49 38.6	
63	65	CASTRO AZ MK RESET	CAST	JS4556	38 33 50.77536	121 38 37.80288	5.27
64	66	CHEROKEE	CHER	DH3673	39 40 05.34934	122 15 11.41713	70.13
65	67	**CHICO 1 CORS ARP**	CHO1	AI1402	39 25 57	121 39 54	
66	68	CHURCH	CHUR	AI5055	38 39 48.00509	121 48 09.05752	24.12
67	69	CITY OF LINC MON 109	COLM		38 52 51.57	121 15 59.68	
68	71	CODY	CODY	AI5056	38 47 30.59722	121 46 29.01978	12.75
69	72	COLIND	COLI		39 11 06.5	121 59 40.6	
70	73	CONAWAY	CONA	AI5057	38 37 05.49414	121 38 40.42822	7.71
71	74	CONTROL MONUMENT LR 208	R208	AC9237	38 39 18.54312	121 23 14.17816	23.39
72	75	COON	COON	JS4144	38 56 33.44121	121 21 13.73560	50.194
73	76	CORNBUTTE	CORN		39 55 22.0	122 21 10.4	
74	77	COTTON	COTT	AI5058	38 38 20.24426	122 02 08.12167	91.52
75	78	COURTLAND	COUR	JS4311	38 20 24.75925	121 33 40.05033	8.06
76	79	COY DUMP	COY1	AI5059	38 35 28.05097	121 41 31.83411	8.55
77	80	CREEK	CREE	DH3668	39 43 53.37337	122 24 47.93526	157.82
78	81	CREST RM 2	CRST	DB7123	39 27 29.40155	121 34 37.33815	
79	82	CVAP 02 USGS	CVAP	AI5060	38 50 19.76338	121 50 39.17593	8.01
80	83	D 146 RESET	D14R	KS1013	39 29 37.19840	121 39 36.31547	
81	84	D 850 RESET 1971	D850	KT0487	39 08 33.63006	122 13 02.10476	37.2
82	86	DAVEPORT	DAVE	JS4617	38 31 59.46429	121 47 14.17621	19.39
83	88	DELEVAN	DELE		39 16 31.0	122 06 20.1	
84	89	DELPHOS RM 2	DLP2	KT0310	39 11 28.05130	122 10 16.52848	23.8
85	90	DODGE	DODG	DH6519	39 22 38.58663	122 01 14.53220	24.2
86	91	DOUGLAS	DOUG		38 33 39.7	121 14 40.1	
87	92	DOWD	DOWD		38 52 13.0	121 22 37.9	
88	93	DRAIN	DRAI	AI5061	38 55 31.04473	121 54 52.46219	12.97
89	94	DUFOUR	DUFO	JS2238	38 45 48.09569	121 50 39.06776	20.25
90	95	DURHAM	DHAM		39 38 41.0	121 47 57.8	
91	96	DWR18	WR18		39 15 10.8	121 53 30.0	
92	97	EAGER	EAGR	DH6500	39 10 30.16150	121 38 05.30841	18.9
93	98	EATON	EATO		39 46 35.9	121 50 38.6	
94	99	ELKHORN	ELKH	DH6491	38 40 54.09676	121 29 03.49524	10.8
95	101	ELVERTA	ELVT	DH6489	38 42 52.27573	121 32 27.54593	5.1
96	102	ENNIS	ENNS		39 05 04.0	121 48 01.4	
97	103	EUCALYPTUS	EUCA		39 53 34.6	122 18 13.4	
98	104	EVERGREEN	EGRN		40 21 37.0	122 19 51.2	
99	105	EX-1	EX11	AI5073	38 38 46.40916	121 40 03.02450	7.86
100	106	EXCELSIOR	EXCL	DH6506	38 30 54.64180	121 17 03.89418	37.5
101	107	EXT1	EXT1	DH3661	39 37 46.82529	122 06 07.90976	46.08
102	108	F 114	F114	KS0953	39 09 25.19342	121 46 36.67405	18.3
103	109	F 200	F200	KT0329	39 19 09.12178	122 11 29.55030	26.3
104	110	F 853	F853	KS0997	39 27 52.11192	121 47 57.49784	
105	111	F 859 RESET	F859	AI5062	38 47 34.20043	121 43 36.01698	14.21
106	112	FAIR	FAIO		38 40 43.5	121 15 47.6	
107	113	FAIRLEE	FLEE		39 19 19.6	121 48 45.4	
108	114	FARMLAND	FARM		39 47 48.7	121 59 14.7	
109	115	FARRIS	FARR		39 23 06.9	121 46 54.6	
110	116	FARWELL (Extensometer site)	FREX		39 39 55.9	121 55 30.2	
111	117	FENN	FENN		39 36 34.9	121 51 26.4	
112	118	FERRY	FERR	JS2338	38 40 32.00674	121 37 49.18003	12.13

	A	B	C	D	E	F	G
113	119	FINKS	FINK	DH6518	39 15 29.80322	122 11 29.32274	28.4
114	120	FLORES	FLOR	DH6623	40 05 02.95277	122 13 08.47380	88.9
115	121	FORD RM 2	FORD	AI5046	38 43 33.23507	121 43 47.39158	17.53
116	123	FREMONT	FREM	AI5063	38 45 52.89327	121 38 08.00521	12.56
117	124	FRENCH	FREN	DH3667	39 34 56.73960	122 14 58.85423	49.96
118	125	FWS 271	271F		39 50 02.2	122 05 06.5	
119	126	G 1175	G117	KS1066	39 17 12.4	121 47 04.0	28.3
120	127	G 1200	G120	JS0755	38 47 09.87346	121 14 32.09509	77.38
121	128	G 1429	G142	LU1871	40 34 56.64205	122 25 57.29345	218.563
122	129	G 1430	G143	LU2284	40 02 29.98057	122 08 34.41298	69.034
123	130	G 1434	G434	KS1939	39 39 22	121 43 53	
124	131	GAFFNEY	GAFF	AE9851	38 24 25.68438	121 34 56.13556	1
125	132	GARFIELD	GARF		38 37 54.6	121 20 13.8	
126	133	GIBSON	GIBS		38 42 19.3	121 25 46.4	
127	134	GLENN	GLEN	KT0178	39 31 17.92685	122 00 53.29	29.64
128	135	GORDON	GORD	DH3656	39 24 34.42540	122 00 35.87826	26.27
129	136	GORRILL	GORR		39 36 09.8	121 47 04.8	
130	137	GRAINO	GRNO		39 03 23.9	121 58 08.9	
131	138	GRAY	GRAY		39 21 43.1	121 49 27.5	
132	139	GREENBACK	GRBK	DH6485	38 41 31.13545	121 20 47.91721	46.6
133	140	GWM 17	GW17	JT0105	38 46 52.25771	122 02 38.10735	84.79
134	141	GWM 32	GW32	JT0026	38 44 21.97065	122 09 59.02755	112.58
135	142	H 285 USGS	H285	KT0120	39 33 07.29767	122 21 26.02164	104.78
136	143	H 380	H380	KS0752	39 00 49.80100	121 25 46.20379	24.907
137	144	H 62 USGS	H62U	KT0414	39 07 14.13691	122 17 27.38995	68.8
138	145	HAHN	HAHN	DH6516	39 04 50.45269	122 05 54.15171	27.1
139	146	HALLWOOD	HALL	DH6522	39 10 28.68777	121 32 57.31460	28.1
140	147	HAMILTON	HAMI	KT1807	39 44 39.73296	122 01 14.04332	47.96
141	148	HARBISON	HARB	DH6520	39 14 50.41643	122 01 52.59696	17.9
142	149	HARRIS	HARR		39 25 15.8	121 45 47.6	
143	150	HERSHEY	HERS	AI5064	38 52 28.84718	121 54 51.96511	13.97
144	151	HESS	HESS	LU1960	40 12 10.19710	122 14 38.93614	97.16
145	152	HONCUT	HONC	KS1035	39 19 30.36003	121 33 25.38509	
146	153	HOPKINS	HPKN		39 13 03.8	122 05 19.8	
147	154	HOPPIN	HPIN		39 05 01.8	121 41 22.0	
148	155	HOWARD	HOWA	DH3659	39 25 12.40826	121 53 52.38358	22.82
149	156	HOWE	HOWE	DH6484	38 36 47.57405	121 25 57.71853	14.7
150	157	HPGN CA 02 12	0212	LU2288	40 57 25.62074	122 26 05.71210	428
151	158	HPGN CA 02 22	0222	LU2291	40 09 35.65424	122 13 26.31262	95.4
152	159	HPGN CA 03 04	0304	KS2014	39 08 35.78963	121 54 06.26967	12.7
153	160	HPGN CA 03 08	0308	JS4668	38 43 01.99778	121 48 07.54090	23.73
154	161	HPGN CA 03 09	0309	JS4669	38 43 40.44881	121 17 10.61451	52.3
155	162	HPGN D CA 02 CJ	02CJ	AE9295	39 54 23.48732	122 12 41.99237	89.1
156	163	HPGN D CA 02 FJ	02FJ	AE9985	40 19 36.36692	122 16 48.62627	174.84
157	164	HPGN D CA 02 GH	02GH	AE9980	40 30 04.45170	122 22 34.14721	146.03
158	165	HPGN D CA 02 JH	02JH	AE9983	40 39 42.34289	122 21 24.42949	206.24
159	166	HPGN D CA 02 JK	02JK	AF8158	40 41 20.86805	122 07 26.10096	328.9
160	167	HPGN D CA 02 KJ	02KJ	AF8159	40 48 26.66267	122 19 18.42941	419.68
161	168	HPGN D CA 03 AA	03AA	AC9226	38 36 52.10409	121 30 52.07494	6.08
162	169	HPGN D CA 03 BG	03BG	AC9219	38 30 20.00860	121 34 55.09118	9.91
163	170	HPGN D CA 03 DG	03DG	AC9223	38 38 27.43690	121 45 39.59540	24.09
164	171	HPGN D CA 03 EH	03EH	JS4847	38 51 59.61225	121 32 32.95659	10.73
165	172	HPGN D CA 03 FH	03FH	KS2035	39 02 32.12082	121 28 33.65920	22.73
166	173	HPGN D CA 03 HJ	03HJ	KS2038	39 13 28.63289	121 26 07.89575	59.4
167	174	HPGN D CA CSUS	CSUS	AC9218	38 33 14.56895	121 25 23.72001	13.31
168	175	HUMBOLT ROAD	HMBT	KS1898	39 44 56.68029	121 45 44.95346	

	A	B	C	D	E	F	G
169	176	INDUSTRIAL	INDU	DH6533	38 47 22.39871	121 18 30.17431	42.3
170	177	J 1434	J143	KS1942	39 36 58.45	121 40 55.09	
171	178	J 847	J847	KS1155	39 32 26.40299	121 41 19.92163	
172	179	JACINTO	JACI	DH3660	39 34 56.70003	122 00 36.01111	34.05
173	180	JELLYS	JELL		40 19 10.8	122 11 19.1	
174	181	JIMENO RM 4	JRM4	AI5047	38 55 39.86130	121 50 35.87435	12.3
175	182	JOHNSON	JOHN		39 29 31.6	121 48 08.1	
176	183	K 1435	K435	KS1971	39 07 48.26132	121 36 10.80790	18.843
177	184	K 276	K276	KT0091	39 51 20.1	122 21 17.7	153.4
178	185	K 852	K852	KT0183	39 41 48.97195	122 11 42.87	70.32
179	186	KAISER	KAIS	DH3680	39 42 33.01005	122 02 14.80423	48.62
180	187	KEATON	KEAT	AI5065	38 42 33.52245	121 53 11.08244	35.83
181	188	KUSTER	KUST	DH6493	38 54 58.56217	121 36 21.42083	11.2
182	189	L 1430	L143	KS1919	39 53 58.25944	121 59 43.71676	63.606
183	190	L191	L191	DH3663	39 34 55.29444	122 07 20.25610	41.91
184	191	LARKINS	LARK	DH3652	39 29 33.92838	122 05 15.35250	31.04
185	192	LAUX	LAUX		39 14 43.7	121 57 31.2	
186	193	LEROY	LROY		38 34 59.8	121 11 09.7	
187	194	LIBERAL	LBRL		39 52 54.5	122 13 41.6	
188	195	LIBRARY	LIBR	AI5066	38 40 44.18419	121 46 28.10008	19.9
189	196	**LINCOLN 1 CORS GRP**	LNC1	DF7465	38 50 47.42500	121 21 00.79097	36.47
190	197	LIVE OAK	LOAK	DH6524	39 17 32.29344	121 40 03.10859	24.6
191	198	LOMO	LOMO	KS1832	39 13 16.44991	121 38 30.20106	20.759
192	199	LONESTAR	LONE	DH6517	39 10 37.25468	122 04 42.66473	16.3
193	200	LUSA RM2	LUSA	JT0091	38 58 14	122 01 32	46.63
194	201	M 1078	M107	KT0356	39 28 11.3	122 11 34.3	33.57
195	202	M 185	M185	LU0322	40 13 26.68599	122 20 15.38537	139.1
196	203	MADISON	MADI	JS2364	38 41 00.22740	121 58 36.36010	47
197	204	MCCLURE	MCCL		40 00 03.5	122 17 55.0	
198	205	MERIDIAN	MERI	DH6532	39 45 11.55598	121 56 18.44859	
199	206	MI 11.18	1118	DH3662	39 39 34.81830	122 01 36.97533	45.2
200	207	MICHIGAN	MICH	DH6625	39 54 23.62087	122 06 51.25814	65.8
201	209	MINOR	MINO	DH3651	39 27 51.90595	122 08 11.90272	30.64
202	210	MOORE	MOOR		38 52 05.7	121 27 06.3	
203	211	MOREHEAD	MORE		39 43 01.1	121 51 47.9	
204	212	MORRISON	MRSN		39 13 53.9	121 42 20.3	
205	213	N 852	N852	KT0195	39 48 34.52910	122 10 21.16347	75.35
206	214	NELSON	NELS		39 33 32.2	121 46 02.5	
207	215	NEWFIDDY	FIDY		38 47 44.7	121 21 31.4	
208	216	NLD 126	NLD6		39 06 51.9	122 01 05.8	
209	217	NLD 127	NLD7		39 21 43.7	121 52 05.1	
210	218	NLD 128	NLD8		39 33 05.7	121 50 25.7	
211	219	NORD	NORD	KS1918	39 47 52.36476	121 54 12.94494	
212	220	NORMAN 1	NORM	DB5555	39 24 27.02092	122 08 10.64965	24.2
213	221	OAK SL	OKSL		40 22 19.0	122 09 39.8	
214	222	ORDBEND	BEND		39 37 47.5	121 59 53.9	
215	223	ORLAND SOUTH BASE	ORLA	KT0189	39 46 06.53326	122 11 32.38423	81.56
216	224	**ORVB OROVILLE DAM CORS GRM**	ORVB	AI4496	39 33 16.64301	121 30 00.99282	368
217	225	OSTROM	OSTR		39 04 32.5	121 23 47.8	
218	226	OSWALD	OSWD	DH6498	39 04 08.45028	121 38 35.20704	12.9
219	227	OWENS	OWEN	DH3648	39 27 56.35451	122 14 56.20685	44.36
220	228	P 1031	1031	JS2344	38 40 38.14441	121 42 34.07731	10.26
221	229	P 1075	1075	JS2130	38 50 51.29489	121 56 00.25761	14.87
222	230	P 1200	120P	JS0768	38 49 43.37051	121 11 25.70317	127.675
223	231	P 1430	P143	KS1922	39 50 25.16138	121 56 26.97724	
224	232	**P208 PBO**	P208		39 06 33.5	122 18 13.9	

	A	B	C	D	E	F	G
225	233	**P265 PBO**	P265		38 31 48.7	121 57 15.1	
226	234	**P267 PBO**	P267		38 22 49.21	121 49 23.64	
227	235	**P268 PBO**	P268		38 28 24.69	121 38 47.08	
228	237	**P270 PBO**	P270		39 14 37.6	122 03 18.8	
229	238	**P271 PBO**	P271	DG8215	38 39 26.44585	121 42 52.32283	
230	239	**P272 PBO**	P272		39 08 43.7	121 56 35.0	
231	240	P30W	P30W	DH3674	39 39 09.85869	122 09 04.27055	54.68
232	241	**P344 PBO**	P344		39 55 44.8	122 01 40.6	
233	242	**P345 PBO**	P345		40 16 16.4	122 16 14.9	
234	243	PALA	PALA	DH6510	38 33 38.01407	121 32 19.52129	13
235	244	PARK	PARK	KS2045	39 32 03.17236	121 35 08.27986	
236	245	PASSBUTTE	PASS		39 11 13.0	121 52 39.6	
237	246	PELGER	PELG		38 57 10.5	121 45 11.6	
238	247	PENTZ RM 2	PEN2	DB7511	39 38 50.12701	121 37 52.46635	
239	248	PETER	PETE	DH3677	39 41 44.95290	122 06 10.75190	55.36
240	249	PHILLIP	PHLP		38 48 09	121 25 07	
241	250	PLAINFIELD	PLAI	AI5068	38 35 05.49717	121 48 11.62107	19.96
242	251	POWER LINE	PWRL		39 05 53.1	121 32 44.8	
243	252	PROVIDENT	PROV	DH3665	39 31 18.60562	122 05 18.95473	30.05
244	253	PUMP RESET	PMPR		39 47 03.5	122 02 45.5	49.55
245	254	PUTNAM	PTNM		39 19 54.5	121 57 16.3	
246	255	Q 1065	Q106	KT0073	39 55 50.4	122 17 19.4	114.54
247	256	Q 1078	Q107	KT0155	39 31 27.18281	122 14 14.24862	45.45
248	257	R276	R276		39 16 59.8	121 28 28.8	
249	258	RAMIREZ	RAMZ	DH6539	39 15 52.80318	121 34 32.90976	25
250	260	RD2068	2068	none	38 24 54.2	121 43 48.6	12.4
251	261	REDBANK	RBNK		40 07 44.0	122 16 16.3	
252	262	RIEGO RM 4	REGO	AC9218	38 45 05.18965	121 29 05.75088	14.34
253	263	RIO OSO	ROSO	DH6488	38 57 41.12175	121 32 35.74809	13
254	264	RIVER	RIVE	AI5069	38 38 50.46071	121 34 20.06216	12.02
255	265	RUSSELL RANCH 2	RUSS	AC9893	38 32 38.06502	121 52 33.83768	29.37
256	266	RWF1	RWF1	none	38 35 10	121 45 05.1	14.6
257	267	S 1067	S106	KT0814	39 43 11.19745	122 32 58.14211	276.14
258	268	S 214	S214	KS0774	39 12 51.33858	121 29 39.08819	28.569
259	269	RAWSON	RAWS	DH6540	40 01 44.82871	122 13 30.24340	94.8
260	269	S 381	S381	KS1056	39 22 57.18199	121 36 05.92495	
261	270	S 853	S853	KS0895	39 24 18.45426	121 42 35.21821	
262	271	SANKEY	SNKY	DH6490	38 48 00.00769	121 32 38.49142	7.8
263	272	SAWTELLE	SAWT	DH6495	38 57 08.19763	121 38 05.25825	10.8
264	273	SCALE	SCLE	LU1967	40 12 45.99403	122 10 47.96287	125.1
265	274	SECO	SECO	KT0274	39 01 43.79854	122 03 50.15218	39
266	275	SHELDON	SHEL	JS1177	38 29 36.45431	121 12 38.98999	59.49
267	276	SHEPPARD	SHEP		39 31 09.1	121 45 09.2	
268	278	SM NO 15	SM15	AI5070	38 43 51.60375	121 37 59.39187	7.33
269	279	SOUR GRASS	SRGS	DH6628	39 50 13.21155	122 11 51.22382	83.3
270	281	SR 65	SR65	DH6632	39 18 55.05085	122 02 02.41256	22.4
271	282	STEGEMAN	STEG		39 20 29.4	122 05 03.3	
272	283	SURVEYOR	SURV	AE9862	38 27 08.54400	121 44 56.17263	13.54
273	285	SUTEXN	SUTX		38 49 24.2	121 32 34.8	
274	286	**SUTTER BUTTES CORS ARP**	SUTB	AF9711	39 12 20.99460	121 49 14.10094	645.89
275	287	SYCAMORE	SYCA	AI5071	38 50 19.12265	121 45 06.38892	7.66
276	288	T 1069	1069	JS2157	38 35 09.99936	121 58 17.45546	54.71
277	289	T 1435	T143	JS4600	38 54 48.09197	121 19 08.98884	44.565
278	290	T 462	T462	JS1556	38 26 25.99174	121 30 17.76157	9.14
279	291	T 644	T644	KT0293	39 07 54.60347	122 07 55.53112	27.5
280	292	T 849	T849	JS2177	38 47 24.93233	121 54 56.34425	36.17

	A	B	C	D	E	F	G
281	293	TALLOW	TALL		39 35 18.2	121 41 21.3	
282	294	TARKE	TARK	DH6499	39 08 35.48277	121 50 33.52674	18.7
283	295	TISDALE	TSDL		39 01 17.3	121 44 28.5	
284	296	TOWNSHIP	TWSP	DH6525	39 20 39.15123	121 41 14.03640	
285	297	TROWBRIDGE	TRBR		38 54 26.2	121 30 16.4	
286	298	TYNDALL	TYND	AI5072	38 52 26.17670	121 49 03.81149	9.08
287	299	U 1078	U107	KT0116	39 31 51.03425	122 19 34.37085	94.01
288	300	U 345	U345	LU0205	40 26 17.61262	122 17 00.50632	139.963
289	301	**UCD1 UC DAVIS GEOL 1 CORS ARP**	UCD1	AI4467	38 32 10.44759	121 45 04.37720	31.44
290	302	V 380 RESET	V380	KT0221	39 46 56.35785	122 17 41.94286	112.96
291	303	V 853	V853	KS0890	39 27 52.90319	121 43 54.95176	
292	304	VARNEY	VARN	DH6494	38 53 09.54029	121 42 06.92178	7.3
293	305	VERNON	VNON	DH6492	38 50 11.64766	121 37 00.84343	7.5
294	306	VINCOR	VINC	DE9127	38 48 08.11883	121 59 00.32187	48.28
295	307	VIOLICH	VIOL	DH3678	39 45 58.92839	122 04 39.34770	56.57
296	308	W 1474	W147	DG6522	38 50 20.9	121 19 03.5	38.79
297	309	W 215 AZ MK	W215	KT0827	39 47 44.85033	122 32 47.50215	207.1
298	310	W 850	W850	KT0506	39 22 40	122 14 53	34.9
299	311	WALKER	WALK	DH3666	39 31 27.11458	122 09 53.88023	38.54
300	312	WASHINGTON	WASH	DH6497	39 00 10.75983	121 40 17.31471	12.1
301	313	WAYNE	WAYN		38 59 36.9	121 57 29.5	
302	314	WHEAT	WHEA	DH6501	39 04 35.82711	121 53 39.35604	20.5
303	315	WILDLIFE	WILD	DH3681	39 42 45.69673	121 57 52.89610	41.14
304	316	WILKENS	WILK	DH6502	38 59 26.07953	121 52 01.52515	9
305	317	WILLIAMS	WLMS		39 30 13.0	121 51 23.5	
306	318	WILLOW	WILL	DH3653	39 26 09.36203	122 04 34.02790	25.52
307	319	WILLOW	WLOW		40 03 18.2	122 17 01.0	
308	320	WILSON	WILN	DH3664	39 34 15.03996	122 11 37.65164	43.91
309	321	WILSON	WILS	AE9857	38 29 41.85081	121 41 31.51403	9.6
310	322	WILSON BEND	WBND	DH6521	39 02 30.73376	121 50 12.69724	18.5
311	323	WINSLOW	WINS	KT0803	39 39 48.63502	122 31 33.45841	200.01
312	324	WISE	WISE		38 55 34.9	121 24 18.7	
313	325	WOODPORT	WOOD	JS3886	38 40 17.76114	121 52 20.38066	39.74
314	326	WOODRUFF	WDRF	DH6523	39 13 12.50553	121 33 27.22561	23.9
315	327	X 200 RESET	X200	JS2144	38 54 20.73108	121 58 59.79141	29.88
316	328	Y 380	Y380	KT0225	39 45 45.77832	122 20 14.55393	141.03
317	329	Y 852	Y852	KT0518	39 27 25.84476	122 01 03.38263	27.39
318	330	YOLO CO AP BASE LINE PT 6	YCAP	DE9129	38 34 20.34417	121 51 18.37282	29.61
319	331	ZAMX	ZAMX	AI5074	38 46 45.78460	121 48 44.62949	13.03
320	332	ZINFANDEL	ZINF	DH6482	38 35 23.60701	121 17 18.80164	30.5

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	**Sacramento Office**	**Red Bluff Office**
Jim Harlan	Wayne Blackburn	Sean Hummer
Joe Mello	David Bradley	Jim West
Charles Mussett	Russell Brunkhorst	
James Santos	Tim Johnston	
Forrest Smith	Abe Magdaleno	
	Scott Rebelo	
	Greg SanFillipo	

Appendix E. Equipment

Appendix E

Observing Equipment

Instrumentation – There was a large number of instruments used during the project. The equipment is listed by project segment. There were four segments: Primary Base Station observations; local network observations; re-observations; and DWR observations at Lake Oroville and the proposed Sites Reservoir.

Primary Base Station observation equipment:

Receiver S/N	Manufacture/Model	Antenna S/N	Manufacture/Model
3335A03908	Trimble/4000SSi	0220058981	Trimble/Comp. L1/L2 w/GP
3335A03912	Trimble/4000SSi	0220059298	Trimble/Comp. L1/L2 w/GP
3435A07618	Trimble/4000SSi	0220004072	Trimble/Comp. L1/L2 w/GP
0220247401	Trimble/5700	12214629	Trimble/Zephyr
0440104047	Trimble/5700	11885846	Trimble/Zephyr
0220247428	Trimble/5700	12236998	Trimble/Zephyr
0220247429	Trimble/5700	12214607	Trimble/Zephyr
4347129359	Trimble/5800	(internal)	
4550103919	Trimble/R8	(internal)	

Local Network Station observation equipment (other than listed above):

Receiver S/N	Manufacture/Model	Antenna S/N	Manufacture/Model
3518A10659	Trimble/4000SSi	0220018946	Trimble/Comp. L1/L2 w/GP
3608A14632	Trimble/4000SSi	0220050361	Trimble/Comp. L1/L2 w/GP
3535A12148	Trimble/4000SSi	0220030718	Trimble/Comp. L1/L2 w/GP
3325A03396	Trimble/4000SSi	0220012123	Trimble/Comp. L1/L2 w/GP
3335A03908	Trimble/4000SSi	0220058981	Trimble/Comp. L1/L2 w/GP
3325A03397	Trimble/4000SSi	0080094425	Trimble/Comp. L1/L2 w/GP
3335A03912	Trimble/4000SSi	0220059298	Trimble/Comp. L1/L2 w/GP
3719A19275	Trimble/4000SSi	0220133316	Trimble/Comp. L1/L2 w/GP
3608A14594	Trimble/4000SSi	0220050501	Trimble/Comp. L1/L2 w/GP
3724A19609	Trimble/4000SSi	0220050362	Trimble/Comp. L1/L2 w/GP
3608A14631	Trimble/4000SSi	0220050490	Trimble/Comp. L1/L2 w/GP
3637A16905	Trimble/4000SSi	0220068632	Trimble/Comp. L1/L2 w/GP
3647A17633	Trimble/4000SSi	0220166597	Trimble/Comp. L1/L2 w/GP
4526152560	Trimble/R8	(internal)	
0220161902	Trimble/4700	0220166597	Trimble/Microcentered L1/L2

Re-observation equipment (other than listed above);

Receiver S/N	Manufacture/Model	Antenna S/N	Manufacture/Model
45145-46	Trimble/5800	(internal)	
4602105531	Trimble/R8	(internal)	
200695	Trimble/R8	(internal)	
3335A03827	Trimble/4000SSi	0220058985	Trimble/Comp. L1/L2 w/GP
3435A07613	Trimble/4000SSi	0220004054	Trimble/Comp. L1/L2 w/GP
3435A07618 **(1)**	Trimble/4000SSi	0220003263	Trimble/Comp. L1/L2 w/GP

(1) Note: Antenna not previously paired with another receiver. This receiver previously paired with Compact L1/L2 0220004072. This pair, 7618 and 3263, only used for session M185-169-1.

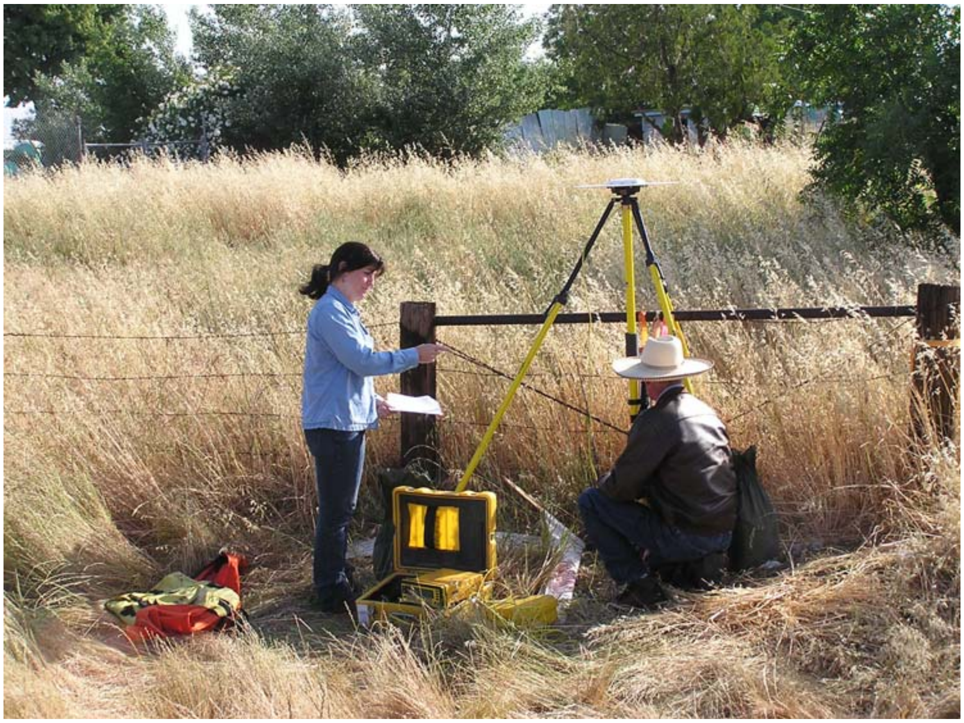
DWR Oroville and Sites Reservoir equipment (other than listed above):

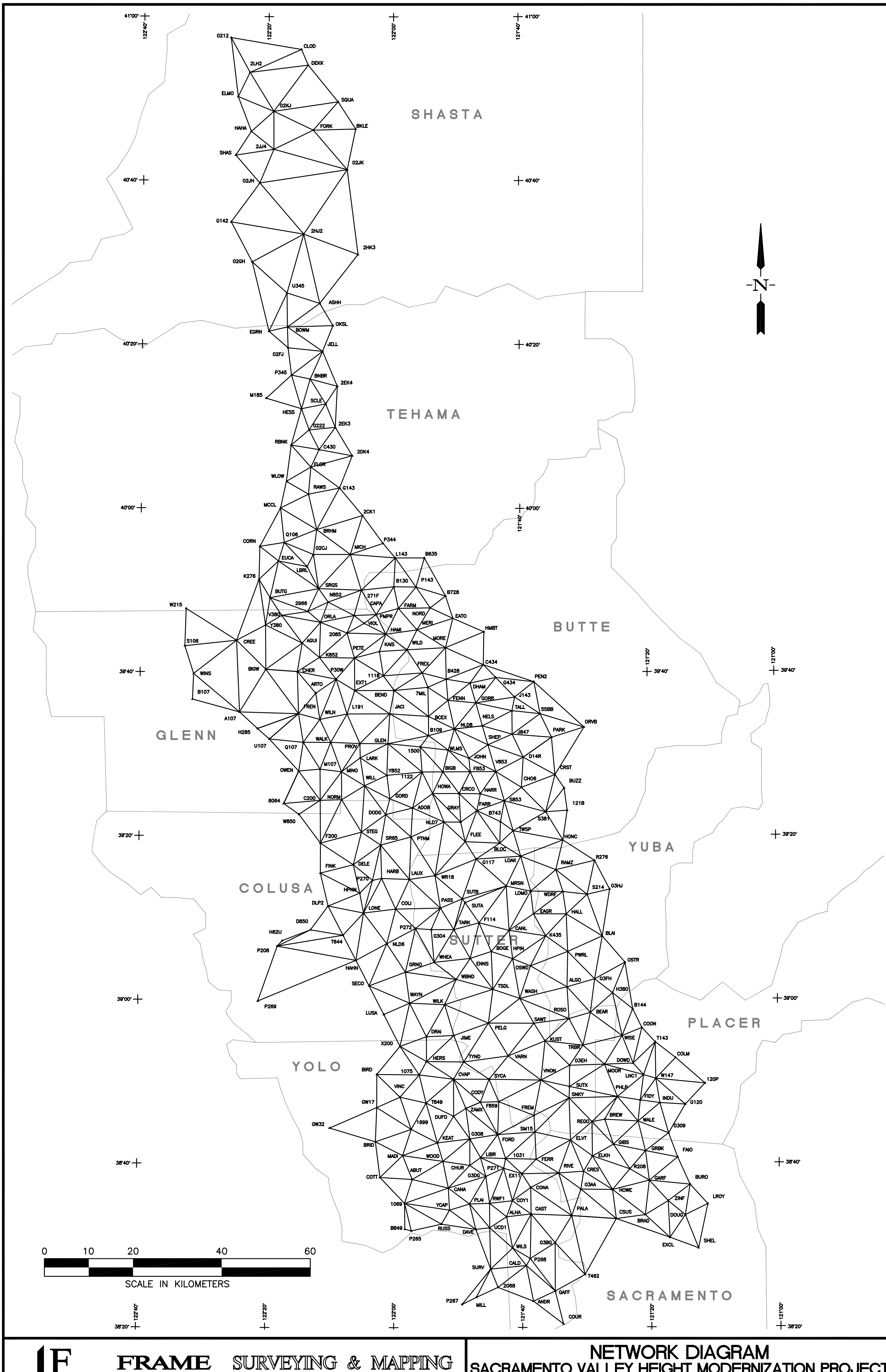
Receiver S/N	Manufacture/Model	Antenna S/N	Manufacture/Model
4312119115	Trimble/5800	(internal)	
4451141825	Trimble/5800	(internal)	
4346128749	Trimble/5800	(internal)	
4450141470	Trimble/5800	(internal)	
0220208590	Trimble/4700	0220202377	Trimble/choke ring
0220209147	Trimble/4700	0220202385	Trimble/choke ring
0220208999	Trimble/4700	0220214129	Trimble/choke ring
0220208300	Trimble/4700	0220214128	Trimble/choke ring

Equipment at station MICHIGAN on Session 4, April 7 (JD98):

Novatel receiver – P/N 01016551 REC BP2 CNS00180387
Sokkia Pinwheel Antenna – SK-600, P/N 500-0-0005, S/N NRK00420265

Appendix F. Project Map





FSLM

FRAME SURVEYING & MAPPING

609 A Street Davis, CA 95616
(530) 756-8584 (TEL) (530) 756-8201 (FAX)

NETWORK DIAGRAM

SACRAMENTO VALLEY HEIGHT MODERNIZATION PROJECT

CALIFORNIA DEPARTMENT OF WATER RESOURCES
U.S. BUREAU OF RECLAMATION
OCTOBER, 2008 SCALE: 1"= 5KM

SUPPLEMENTAL PROJECT REPORT

Shasta Lake (2009) Portion of the 2008 California Department of Water Resources and U.S. Bureau of Reclamation Sacramento Valley GPS Subsidence Project

March 19, 2009

Introduction

A. Purpose

The purpose of the project was to complete the Shasta Lake portion of the Sacramento Valley GPS Subsidence project. This portion was delayed due to emergency personnel requirements for other USBR projects. This project allows the USBR to inter-relate geodetic control between two major water projects, Shasta Lake and Folsom Lake. The latter project was observed using GPS Height Modernization guidelines in 2004.

B. Time Period

All observations were completed during the week of March 9, 2008. There was one suspect station occupation on Day 1 (JD 069). A re-observation of this station and the three connecting baselines was completed on Day 4 (JD 072). See section **F. (below).**

In March 2008 three Primary Base Stations surrounding the Shasta Lake Project were observed. These same three stations were observed as part of the 2009 observations. They were observed for five hours on Day 3 (JD 071) and for four hours on Day 4 (JD 072).

C. Points of Contact

Project Administrators - Terri Reaves
Branch Chief, Surveys & Mapping
U.S. Bureau of Reclamation

2800 Cottage Way
Sacramento, CA 95825
(916) 978-5306
treaves@mp.usbr.gov

Chuck Owens
California Department of Water Resources
Division of Planning & Local Assistance HQ
Conjunctive Water Management Branch
901 P Street, 2nd Floor
Sacramento, CA 95814-5511
(916) 651-9224
owens@water.ca.gov

Prime Contractor - Jim Frame
Frame Surveying & Mapping
609 A Street
Davis, CA 95616
(530) 756-8584
jhframe@dcn.org

Project Consultant - Don D'Onofrio
7228 Willowbank Way
Carmichael, CA 95608
(916) 944-7879
dondonofrio@comcast.net

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. Several stations were in somewhat remote locations. To preclude or at best eliminate the need for re-observations, we decided to schedule longer observation periods. Two-hour periods were selected.

E. **Location**

The project surrounded Shasta Lake. It was bounded on the south by State Highway 299 (stations HPGN D CA 02 JH and HPGN D CA 02 JK) and on either sides of Interstate Highway 5 around Shasta Lake to post mile 703 (station HPGN CA 02 12). These were the three Primary Base Stations observed during the project.

Station List

LAKE SHASTA USBR	SSN	4-Ch ID	PID	Lat.	Long.	Elev.
5 SHA 40.65	7001	2LH2	DH6395	40 53 11.57549	122 23 02.73969	332.6
BUTCHER	7002	BUTR		40 45 17.3	122 26 48.9	
FOWLER	7003	FOWL		40 50 05.0	122 09 09.6	
HIRZ	7004	HIRZ		40 51 49.4	122 15 17.8	
HPGN CA 02 12	1101	0212	LU2288	40 57 25.62074	122 26 05.71210	428
HPGN D CA 02 JH	1109	02JH	AE9983	40 39 42.34289	122 21 24.42949	206.24
HPGN D CA 02 JK	1110	02JK	AF8158	40 41 20.86805	122 07 26.10096	328.9
HPGN D CA 02 KJ	1111	02KJ	AF8159	40 48 26.66267	122 19 18.42941	419.68
JONES	7005	JONE		40 44 21.0	122 12 58.8	
MCCLOUD	7006	CLOD		40 56 25.6	122 14 44.6	
P349 (PBO CGPS)	7007	P349		40 43 51.8	122 19 09.5	
SHASTA	7008	SHAS		40 42 58.4	122 24 59.1	
SUGARLOAF	7009	LOAF		40 50 51.2	122 24 59.8	
SUGARPINE	7010	PINE		40 44 27.1	122 05 32.8	

F. **Conditions Affecting Operations**

All observations were obtained using fixed-height (constant height) poles. All poles were 2.000 meters except for the observations at station 5 SHA 40.65. This station was observed by Caltrans and used a 1.800 meter fixed-height pole.

All receivers and antennas were used in the same pairings throughout the project with one exception. On Day 3 (JD071) at station SHASTA, a strong gust of wind knocked the fixed-height pole over in spite of the use of sandbags stabilizing the pole. The observer re-plumbed the pole and completed the observation. There appeared to be some damage to the antenna and a different antenna was used with this receiver on Day 4 (JD 072).

On Day 1 (JD 069) the observer noted that only three and four satellites were being tracked for a significant portion of the observing period. That evening Jim Frame ran the data through the NGS OPUS program and the results were questionable. A re-observation of this station and its neighboring baseline stations was completed on Day 3 (JD 071).

On Day 3 (JD 071) Session 1 the observer noted that power was lost at about 10:24am (UTC 1724). The receiver was re-started and the session completed without further issue.

Data downloading was performed at the Oxford Suites in Redding, CA. Two sets of data were downloaded, one to the computer hard drive and the other to a memory stick. No problems were encountered during the downloading.

No other significant conditions affected the operations.

G. Agency Participation

The U.S. Bureau of Reclamation provided five observers. One of the observers served as a back-up. Caltrans provided one observer to occupy station 5 SHA 40.65. This station is in the Interstate Highway 5 right-of-way. Caltrans refused to allow non-Caltrans personnel to work in the right-of-way but they were gracious enough to perform the observations for the project. Frame Surveying & Mapping provided the remainder of observing personnel.

Personnel	Agency
Dave Mello	USBR
Art Aguirre	USBR
Jack Worsley	USBR
Adrian Verhagen	USBR
Jillian Baber	USBR
John Lehti	Caltrans
Jim Frame	Frame Surveying & Mapping
Don D'Onofrio	Frame Surveying & Mapping

H. Field Work

Chronology – Reconnaissance for the project was completed during the week of January 18. Mark setting was performed during the same week.

All observations were performed during the week of March 9, including re-observations.

Instrumentation – A complete list of equipment follows:

Receiver S/N	Manufacture/Model	Antenna S/N	Manufacture/Model
3719A19275	Trimble/4000SSi	0220133316	Trimble/comp. L1/L2 w/GP
3637A16898	Trimble/4000SSi	0220067408	Trimble/comp. L1/L2 w/GP
3637A16905	Trimble/4000SSi	0220068632	Trimble/comp. L1/L2 w/GP
3637A16895	Trimble/4000SSi	0220068628	Trimble/comp. L1/L2 w/GP
(paired with above receiver on Day 4 – JD 072)		00038	Trimble/comp. L1/L2 w/GP
3518A10659	Trimble/4000SSi	0220018946	Trimble/comp. L1/L2 w/GP
3535A12148	Trimble/4000SSi	0220030718	Trimble/comp. L1/L2 w/GP
0220308800	Trimble/5700	12467714	Trimble/1249-00 DC4313

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 Observed - There were a total of 14 stations occupied in the project.

NSRS stations		5
New stations set:		7
Disks in foundations	1	
FENO rod marks	6	
New stations recovered (not in NGSIDB):		1
CGPS stations (PBO not in NGSIDB)		1
Total stations:		**14**

Total Observing Days and Sessions – All observation were completed in four days including one re-observation session. There were 52 station occupations: three for Primary Base Station observations; 37 for Local Network observations; four for re-observations; and, 8 separate downloads for Continuous GPS observations (station P349). When all baseline data were processed no baseline failed the nominal 2-cm criterion except for the baselines listed below (in **Re-observations)**. The project sketch is included in **Appendix A**. The observation schedule is included in **Appendix B**.

Re-observations – Based on the NGS OPUS processing for station PINE on Day 2 (JD 069) we decided to re-observe station PINE and its connecting baselines. The re-observations were scheduled for Day 3 (JD 071). These baselines met the 2-cm criterion.

K. Comments and Recommendations

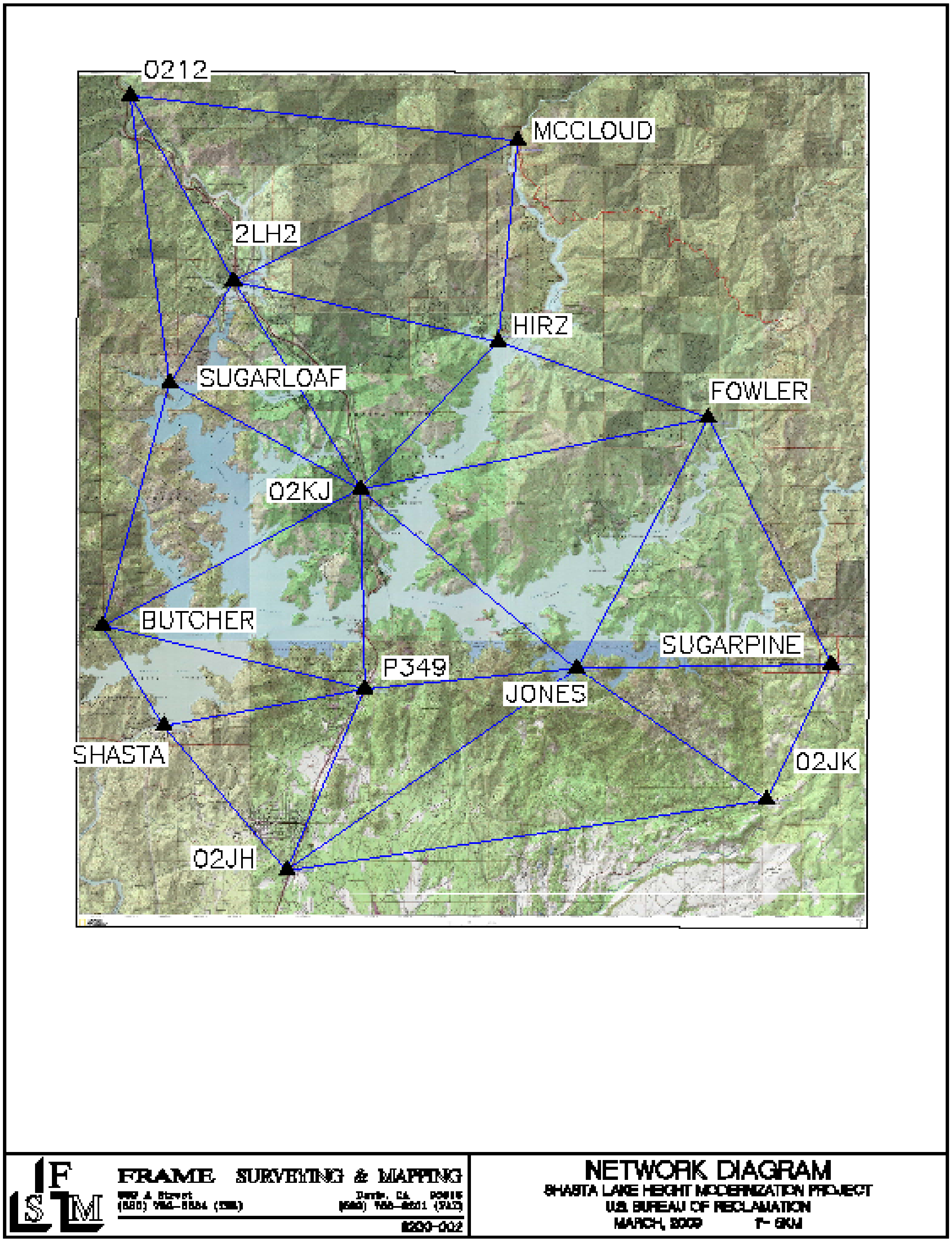
In the preliminary planning for the project it appeared that most of the new stations would be reconned, established and observed using boat-based operations. At a follow-up meeting it was decided that due to the extreme low lake levels this approach would not be feasible. Further discussions indicated that stations could be reached by vehicle but a few required long slow trips. We discussed the types of monumentation to be established. The usual Class B rod monuments would have provided significant logistic issues. We decided that FENO style monuments with standard survey disks would be appropriate. These new stations are in relatively remote locations not otherwise subject to subsidence.

Due to the remoteness of the stations it was decided to observe for longer sessions to preclude the need to go back for re-observations. With the minor issue at station PINE this approach appeared to be the correct approach. Coupled with the minimal number of stations and the relatively few days required for observations this approach also seemed appropriate.

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. Project Sketch



Appendix B. Observation Schedule

DAY 1, Tuesday, March 10 (JD 069)

	8:30am to 10:30am	1:00pm to 3:00pm
RECEIVER	SESSION 1	SESSION 2
USBR-1	FOWL	CLOD
USBR-2	HIRZ	HIRZ
USBR-3	JONE	BUTR
USBR-4	PINE	LOAF
CALTRANS	2LH2	2LH2
FRAME	02KJ	02KJ
DONOFRIO	02JK	0212
CGPS	P349	P349

DAY 2, Wednesday, March 11 (JD 070)

	8:30am to 10:30am	1:00pm to 3:00pm
RECEIVER	SESSION 1	SESSION 2
USBR-1	CLOD	FOWL
USBR-2	HIRZ	HIRZ
USBR-3	BUTR	JONE
USBR-4	LOAF	PINE
CALTRANS	2LH2	2LH2
FRAME	02KJ	02KJ
DONOFRIO	0212	02JK
CGPS	P349	P349

DAY 3, Thursday, March 12 (JD 071)

	10:00am to 1:00pm	1:00pm to 3:00pm
RECEIVER	SESSION 1	SESSION 1A
USBR-1	02JK	02JK
USBR-2	02JH	02JH
USBR-3		BUTR
USBR-4		SHAS
DONOFRIO	0212	0212
CGPS	P349	P349

Note: USBR-1, USBR-2 and DONOFRIO continuous tracking from 10:00am to 3:00

DAY 4, Friday, March 13 (JD 072)

	8:00am to 10:00am	10:00am to 12:00noon
RECEIVER	SESSION 1	SESSION 1A
USBR-1	02JK	02JK
USBR-2	02JH	02JH
USBR-3	BUTR	
USBR-4	SHAS	
DONOFRIO	0212	0212
CGPS	P349	P349

Note: USBR-1, USBR-2 and DONOFRIO continuous tracking from 8:00am to 12:00

RE-OBSERVATION
DAY 3, THURSDAY, March 12 (JD 071)

	8:30am to 11:00am
RECEIVER	SESSION 1
USBR-1	02JK
USBR-3	JONE
USBR-4	PINE
FRAME	FOWL

SUPPLEMENTAL PROJECT REPORT

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March 19, 2009

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A. Purpose

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B. Time Period

All observations were completed during the week of March 9, 2008. There was one suspect station occupation on Day 1 (JD 069). A re-observation of this station and the three connecting baselines was completed on Day 4 (JD 072). See section **F. (below).**

In March 2008 three Primary Base Stations surrounding the Shasta Lake Project were observed. These same three stations were observed as part of the 2009 observations. They were observed for five hours on Day 3 (JD 071) and for four hours on Day 4 (JD 072).

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3518A10659	Trimble/4000SSi	0220018946	Trimble/comp. L1/L2 w/GP
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0220308800	Trimble/5700	12467714	Trimble/1249-00 DC4313

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Total stations:		**14**

Total Observing Days and Sessions – All observation were completed in four days including one re-observation session. There were 52 station occupations: three for Primary Base Station observations; 37 for Local Network observations; four for re-observations; and, 8 separate downloads for Continuous GPS observations (station P349). When all baseline data were processed no baseline failed the nominal 2-cm criterion except for the baselines listed below (in **Re-observations)**. The project sketch is included in **Appendix A**. The observation schedule is included in **Appendix B**.

Re-observations – Based on the NGS OPUS processing for station PINE on Day 2 (JD 069) we decided to re-observe station PINE and its connecting baselines. The re-observations were scheduled for Day 3 (JD 071). These baselines met the 2-cm criterion.

K. Comments and Recommendations

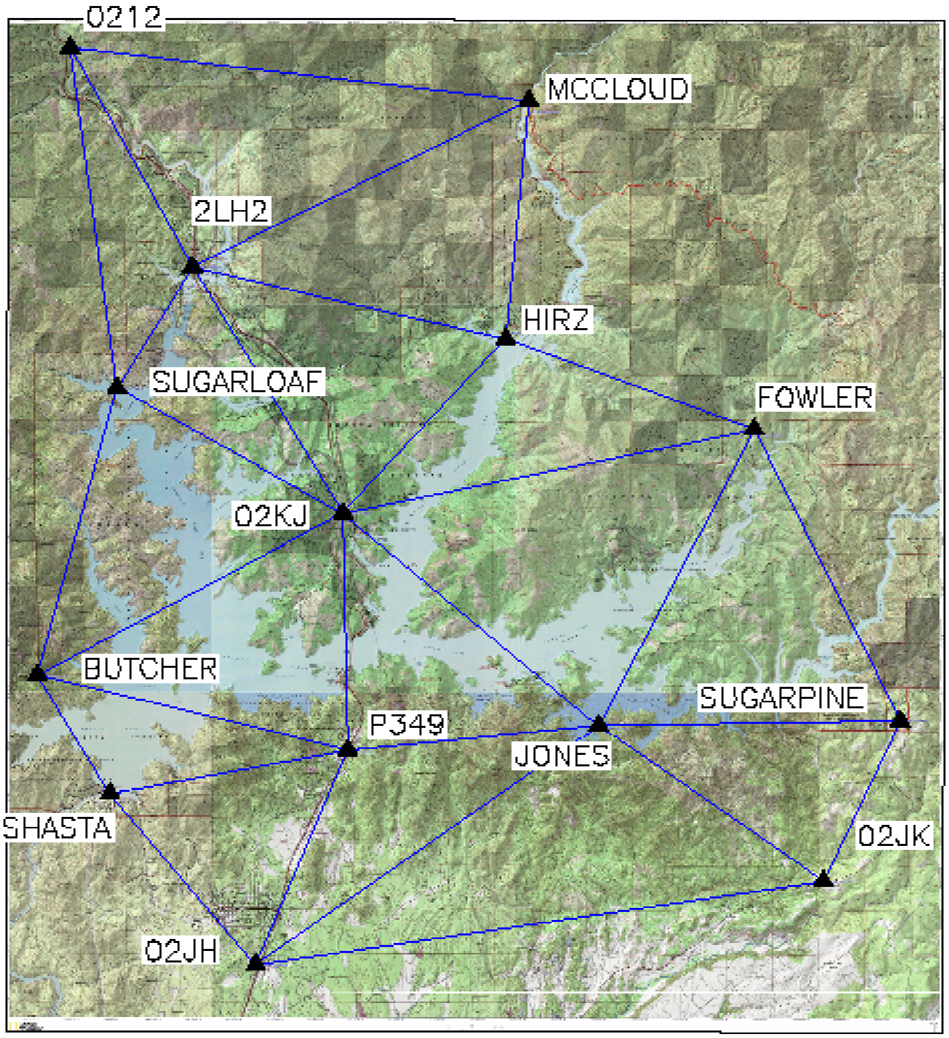
In the preliminary planning for the project it appeared that most of the new stations would be reconned, established and observed using boat-based operations. At a follow-up meeting it was decided that due to the extreme low lake levels this approach would not be feasible. Further discussions indicated that stations could be reached by vehicle but a few required long slow trips. We discussed the types of monumentation to be established. The usual Class B rod monuments would have provided significant logistic issues. We decided that FENO style monuments with standard survey disks would be appropriate. These new stations are in relatively remote locations not otherwise subject to subsidence.

Due to the remoteness of the stations it was decided to observe for longer sessions to preclude the need to go back for re-observations. With the minor issue at station PINE this approach appeared to be the correct approach. Coupled with the minimal number of stations and the relatively few days required for observations this approach also seemed appropriate.

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. Project Sketch



FRAME SURVEYING & MAPPING

NETWORK DIAGRAM
SHASTA LAKE HEIGHT MODERNIZATION PROJECT
U.S. BUREAU OF RECLAMATION
MARCH, 2009

Appendix B. Observation Schedule

DAY 1, Tuesday, March 10 (JD 069)

	8:30am to 10:30am	1:00pm to 3:00pm
RECEIVER	SESSION 1	SESSION 2
USBR-1	FOWL	CLOD
USBR-2	HIRZ	HIRZ
USBR-3	JONE	BUTR
USBR-4	PINE	LOAF
CALTRANS	2LH2	2LH2
FRAME	02KJ	02KJ
DONOFRIO	02JK	0212
CGPS	P349	P349

DAY 2, Wednesday, March 11 (JD 070)

	8:30am to 10:30am	1:00pm to 3:00pm
RECEIVER	SESSION 1	SESSION 2
USBR-1	CLOD	FOWL
USBR-2	HIRZ	HIRZ
USBR-3	BUTR	JONE
USBR-4	LOAF	PINE
CALTRANS	2LH2	2LH2
FRAME	02KJ	02KJ
DONOFRIO	0212	02JK
CGPS	P349	P349

DAY 3, Thursday, March 12 (JD 071)

	10:00am to 1:00pm	1:00pm to 3:00pm
RECEIVER	SESSION 1	SESSION 1A
USBR-1	02JK	02JK
USBR-2	02JH	02JH
USBR-3		BUTR
USBR-4		SHAS
DONOFRIO	0212	0212
CGPS	P349	P349

Note: USBR-1, USBR-2 and DONOFRIO continuous tracking from 10:00am to 3:00

DAY 4, Friday, March 13 (JD 072)

	8:00am to 10:00am	10:00am to 12:00noon
RECEIVER	SESSION 1	SESSION 1A
USBR-1	02JK	02JK
USBR-2	02JH	02JH
USBR-3	BUTR	
USBR-4	SHAS	
DONOFRIO	0212	0212
CGPS	P349	P349

Note: USBR-1, USBR-2 and DONOFRIO continuous tracking from 8:00am to 12:00

RE-OBSERVATION
DAY 3, THURSDAY, March 12 (JD 071)

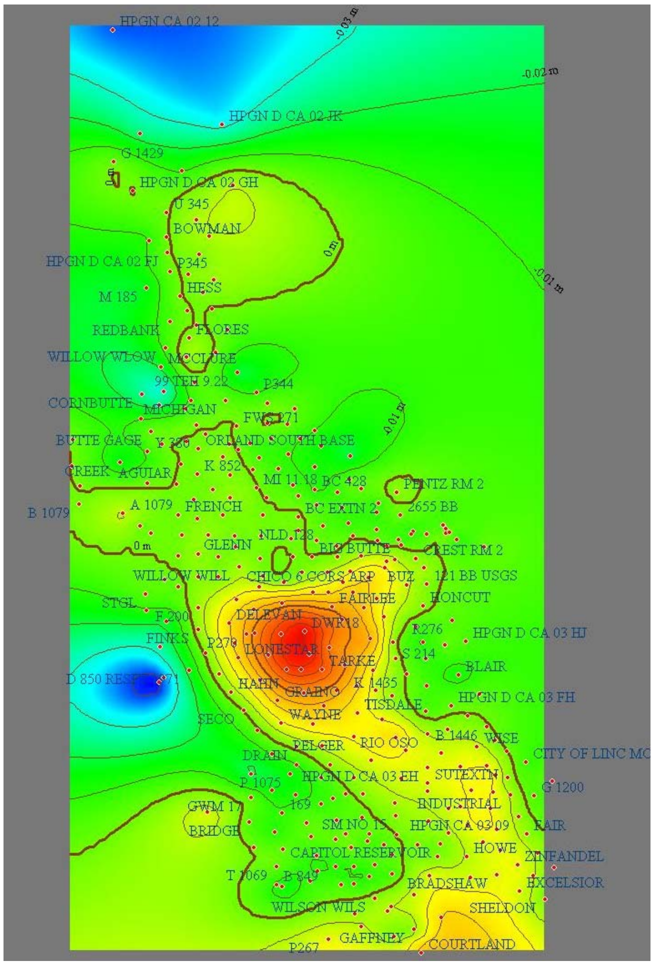
	8:30am to 11:00am
RECEIVER	SESSION 1
USBR-1	02JK
USBR-3	JONE
USBR-4	PINE
FRAME	FOWL

Frame Surveying & Mapping

609 A Street
Davis, CA 95616
(530) 756-8584
jhframe@dcn.org

June 1, 2010

Project Report
Sacramento Valley HMP Using GEOID09



Geodetic Solutions

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Background

(The cover sheet of this report shows a contour map of the differences between orthometric heights derived from the custom geoid model based on GEOID03 and the blue-booked orthometric heights based on the unmodified GEOID09 model.)

In March of 2009 the Sacramento Valley Height Modernization Project (SVHMP) was submitted (blue-booked) by Geodetic Solutions to the National Geodetic Survey on behalf of Frame Surveying & Mapping for inclusion in the National Geodetic Survey Integrated Database (NGSIDB). At that time, NGS approved the project, but uploading to the NGSIDB was postponed until issues related to computed orthometric heights throughout the SVHMP were resolved in some fashion.

A key ingredient in the computation of orthometric heights using GPS technology is the use of a geoid model that can transform ellipsoid heights to orthometric heights. In March 2009 the official NGS geoid model was GEOID03. At that time, and also at present, NGS treats the geoid heights (differences between orthometric and ellipsoid heights) extracted from its official geoid models as being without error.

However, in an immediately preceding height modernization project (California North Region Height Modernization Project) computed by Geodetic Solutions on behalf of the California Spatial Reference Center (CSRC) and the California Department of Transportation (Caltrans), and covering the northern half of California, the geoid heights extracted from GEOID03 were found to be in error by as much as several decimeters. These errors were discovered by differencing constrained orthometric heights (published first-order NGS bench marks) and computed ellipsoid heights (using published horizontal coordinates), producing observed geoid heights, against the geoid heights extracted from GEOID03. In order to remedy these errors, Geodetic Solutions computed a revised (improved) geoid model based initially upon GEOID03, but then improved by adding a residual model of geoid heights to the official version of GEOID03. This custom geoid model will be called GEOID03 Custom in this document, although it has been given several different names (such as the North Region Custom Model) depending upon the geographical extent of the usage of this custom model.

GEOID03 Custom was used to provide CSRC/Caltrans with the most accurate possible orthometric heights derived from GPS observations. The North Region HMP was submitted to NGS with the provision that publication of computed orthometric heights should be postponed until the errors in GEOID03 could be properly addressed. The use of the official version of GEOID03 produced GPS-derived orthometric heights known to be in error by several decimeters.

The issue of the publication of North Region orthometric heights has not yet been resolved.

However, shortly after the conclusion of the North Region HMP, Frame Surveying & Mapping undertook the observations and analysis of the Sacramento Valley Height Modernization Project, on behalf of the California Department of Water Resources (DWR). DWR required the height modernization project in order to pursue a Flood Plain Mapping project throughout the region of the valley of the Sacramento River in northern California. As part of the Flood Plain Mapping project, several LIDAR/photogrammetric companies carried out aerial surveys of the Sacramento Valley, and they were instructed to make use of the orthometric heights produced by Frame's computation of the SVHMP.

As part of the SVHMP, Geodetic Solutions processed the GPS observations provided by Frame in two ways: using the official version of GEOID03, and using the GEOID03 Custom model computed for CSRC/Caltrans. It was found that the official version of GEOID03 produced the expected errors approaching a decimeters throughout the Sacramento Valley, whereas GEOID03 Custom fit so well with the GPS observations that no additional improvements to GEOID03 Custom were necessary.

The use of GEOID03 Custom for the SVHMP was successful, insofar as the aerial mapping contractors for the DWR Flood Plain Mapping project made use of the orthometric heights produced by GEOID03 Custom for the SVHMP, finding that the resulting computed GPS-derived orthometric heights proved to be consistently accurate when compared against known vertical constraints (published first-order bench marks).

The revealed problems with GEOID03 caused DWR, Frame Surveying & Mapping, and the NGS State Advisor for California, Marti Ikehara, to postpone the final steps of blue-booking the SVHMP until the discrepancies in computed orthometric heights could be resolved. The crux of the problem was that NGS, in its final blue-booking procedures, would compute and publish orthometric heights throughout the SVHMP (as well as the North Region HMP) using the uncorrected version of GEOID03, whereas the DWR projects were using more accurate GPS-derived orthometric heights computed using GEOID03 Custom. One of the options considered at this time by DWR/Frame/Ikehara was to publish an alternative set of computed orthometric heights in a different place (different web site) than those to be found in the NGS data sheets that would be published as a result of the final blue-booking steps for the SVHMP with NGS.

Around March of 2009, NGS released a “beta” version of a new geoid model (which ultimately would be called GEOID09). This beta version is known as GEOID09 BETA, and it has never been released as an official geoid model. At this time, the SVHMP surveyors entertained the hope that this new official geoid model would be so superior to GEOID03 that the publication of an alternative set of GPS-derived orthometric heights (computed using GEOID03 Custom) would not be necessary.

Geodetic Solutions, working outside of any contracts, examined GEOID09 BETA within the context of the North Region HMP. It was found that GEOID09 BETA, like GEOID03, contained errors in the range of several decimeters, which would find their way into any GPS-derived orthometric heights computed using an unimproved version of GEOID09 beta. One of the root causes of these problems with GEOID09 BETA was found to be the use of published ellipsoid heights resulting from the NGS readjustment of the National Spatial Reference System in 2007 (NSRS2007). The geodesists at NGS responsible for producing GEOID09 BETA and eventually the official GEOID09 models are required to make use of the NSRS2007 published ellipsoid heights throughout Northern California as part of the model-building process. Geodetic Solutions found that these NSRS2007 ellipsoid heights are internally inconsistent with the ellipsoid heights produced by the North Region and Sacramento Valley HMPs, and this inconsistency made it virtually impossible to make use of any uncorrected GEOID09 BETA geoid heights to produce accurate GPS-derived orthometric heights for either the North Region or the Sacramento Valley Height Modernization Projects.

At this point, any further work on the SVHMP, including finalization of blue-booking, was put on hold indefinitely.

The work done by Geodetic Solutions on both the North Region HMP and the Sacramento Valley HMP as been documented in reports delivered to NGS/Frame/DWR for these projects.

GEOID09

In the latter half of 2009 NGS released the official version of GEOID09. This official version replaces GEOID03 as the official NGS geoid model throughout the continental US.

Subsequent to the release of GEOID09, Geodetic Solutions was retained by Frame Surveying & Mapping, on behalf of the DWR, to recompute the Sacramento Valley HMP using GEOID09. This document describes the results of this effort.

Comparing GEOID09 against GEOID09 BETA

Upon the release of GEOID09, Geodetic Solutions first compared the geoid heights produced by both GEOID09 BETA and the official version of GEOID09. It was found that the differences between these two geoid models are large (ranging between + 1 decimeter and - 1 decimeter)and pervasive, and for this reason GEOID09 BETA will not be discussed further in this document.

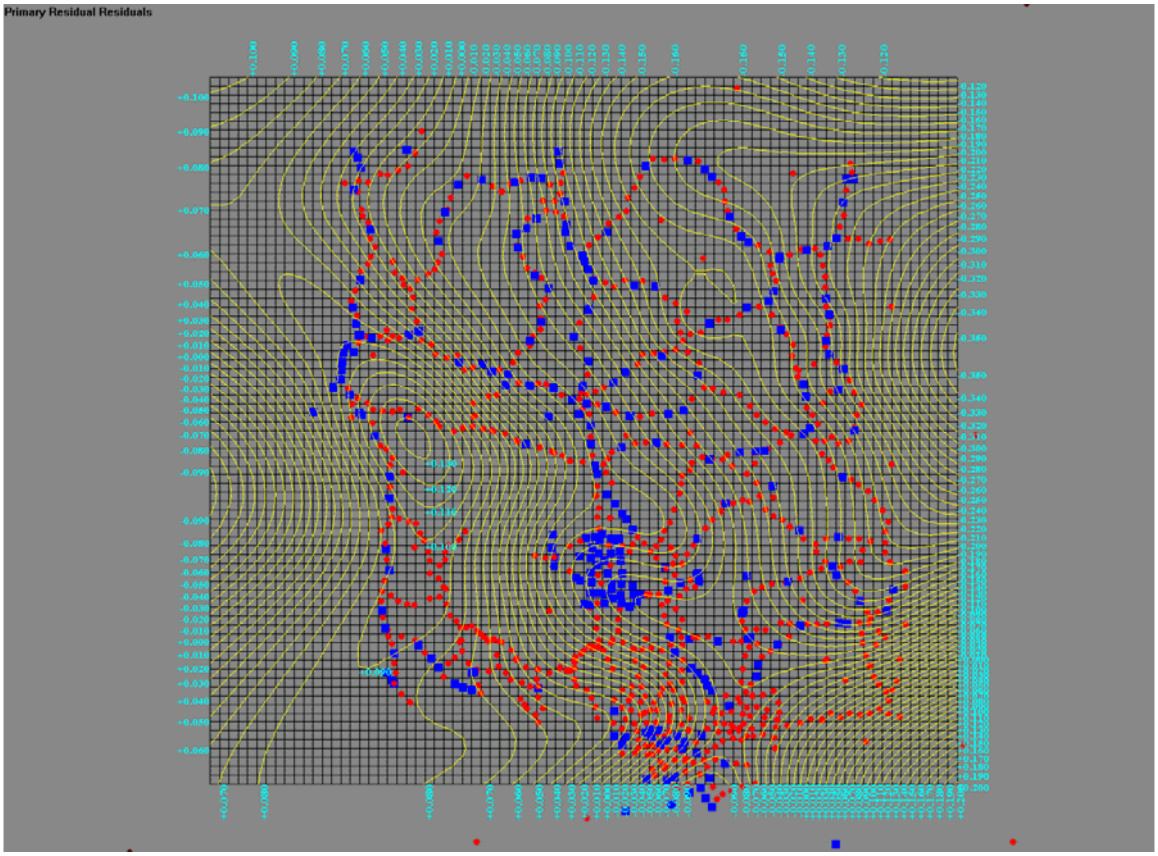
From this time forward, all tests using GEOID09 use the geoid heights taken from the official release of GEOID09.

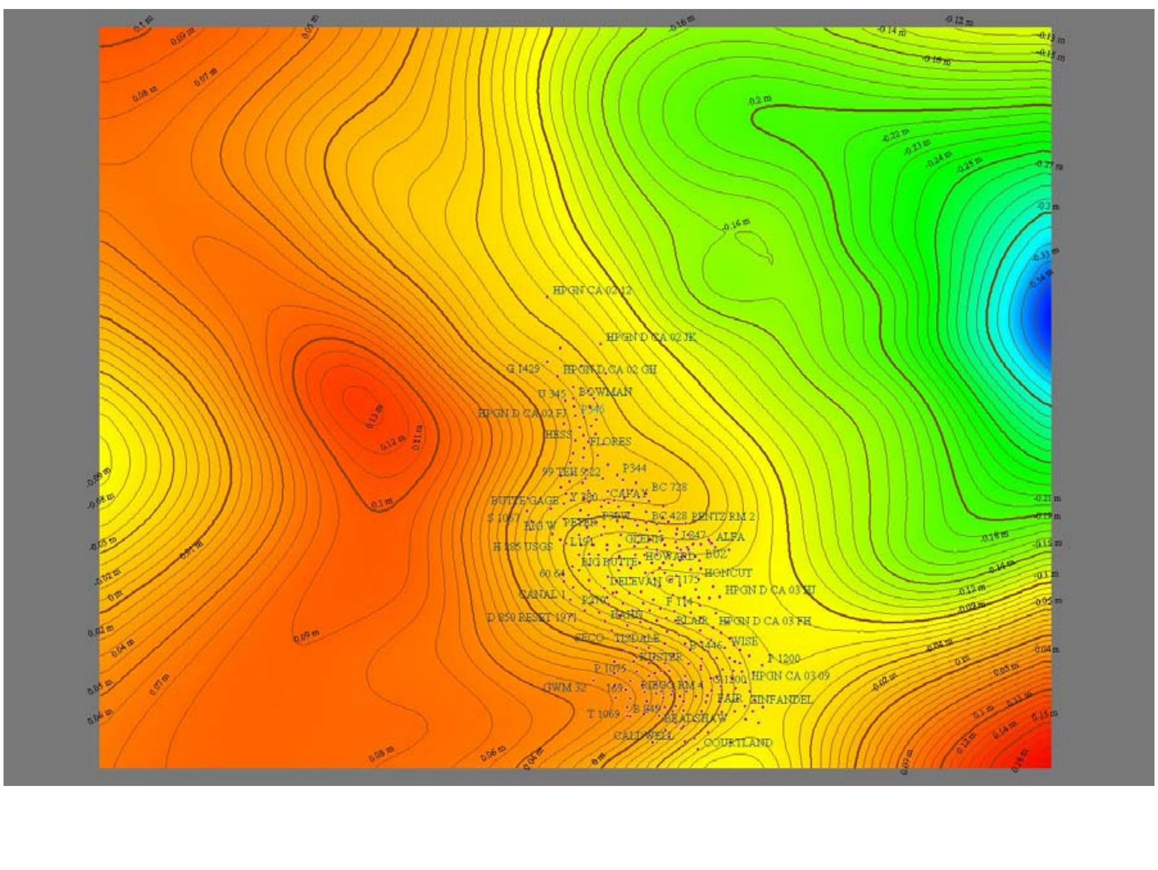
NORTH REGION

Geodetic Solutions software does not use the biquadratic interpolation method used by the NGS software INTG, but instead creates vectors of correlates for use in least squares prediction algorithms for smoother interpolations. The official version of GEOID09 was first converted into the vectors of correlates for further use in Geodetic Solutions software.

To test GEOID09, the new geoid heights were inserted into the network adjustment (using Geodetic Solutions laboratory software) for the North Region. The comparison is made against the original GEOID03 adjustment. Apart from the replaced geoid heights, no other modifications were made to the contents of the network, including variance component and parameter groups.

It was found that the new model produced a standard error of unit weight (seuw) for the geoid heights of 2.269, slightly less than the seuw from the original network of 3.037. This indicates that the GEOID09 model fits the GPS observations and published bench marks slightly better than GEOID03. However, the residuals to the geoid heights computed for GEOID09 are still too large to allow for the use of unmodified geoid heights from GEOID09. A plot of the residuals to GEOID09 for the North Region is shown below.

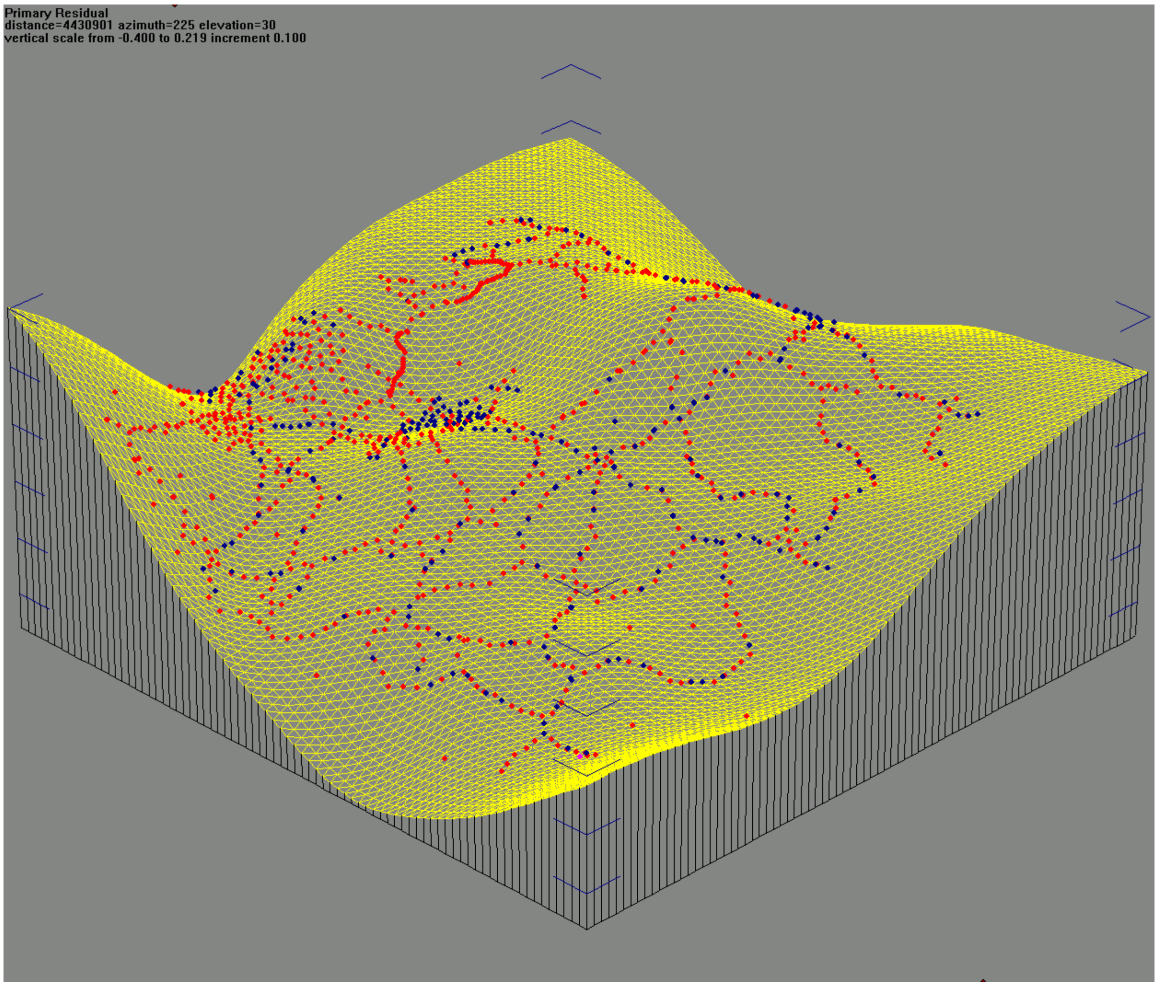

Primary Residual Residuals


BOWMAN
FLORES
CAPAY
ALFA
HONCUT
WISE
ZINFANDEL
CALDWELL
COURTLAND

These two bitmaps show exactly the same data. The first bitmap was produced by Geodetic Solutions lab software and the second one was generated using Global Mapper on data files produced by the new adjustment of the North Region using GEOID09. The regions covered in both images include most of the entire North Region network. In the first image, the square blue point symbols represent the orthometric height constraints for the entire North Region. In the second image, the control stations shown are taken from the SVHMP.

In these images it can be seen that the residuals to GEOID09, in the vicinity of the SVHMP, range between + 5 cm to -10 cm.

The wire frame image of these residuals is shown below:



NRCustom09 geoid model

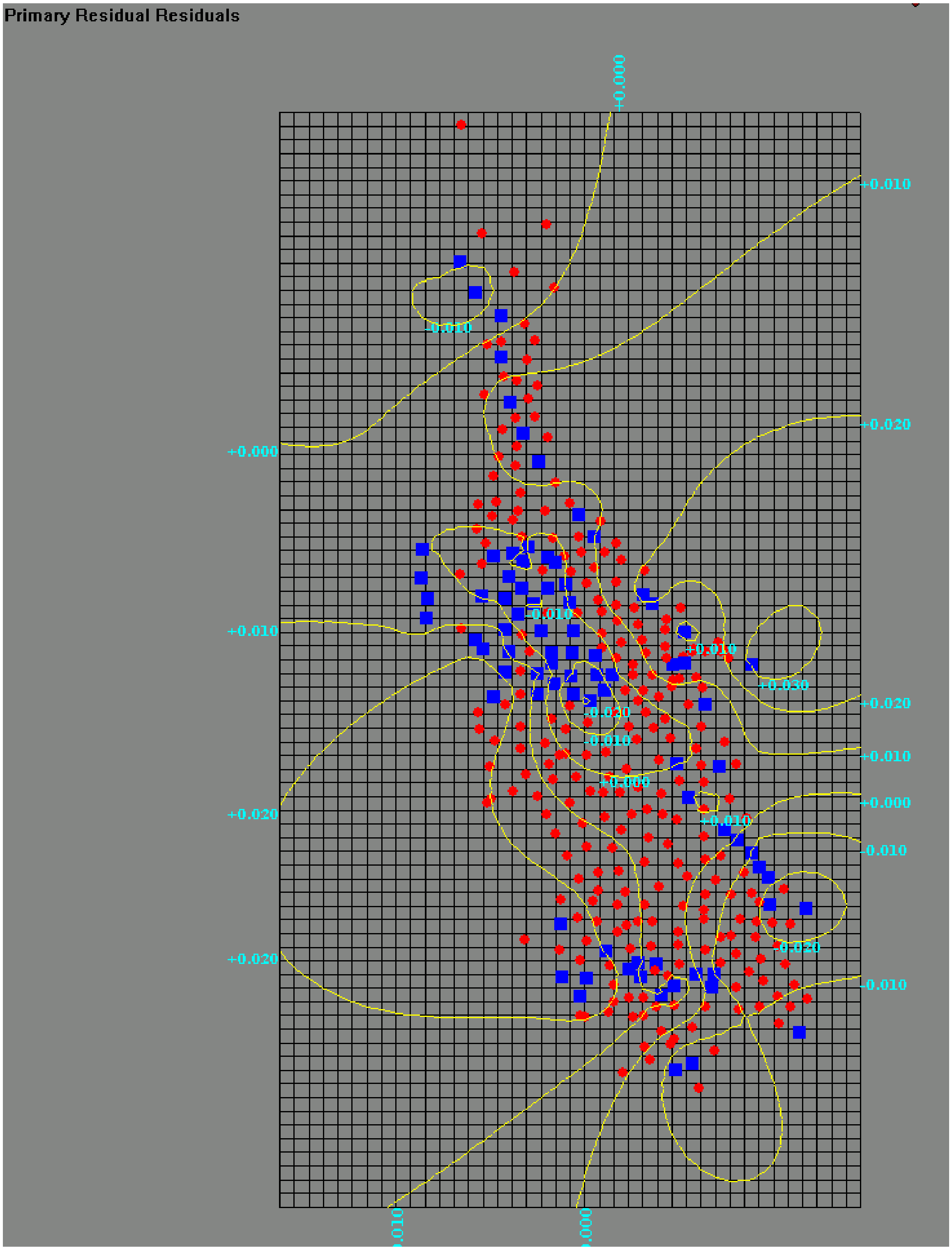
The new North Region adjustment was used to create a new custom geoid model based on GEOID09, which here is called NRCustom09B (NR represents North Region). A new GGF file called NRCustom09B.ggf has been created for further use in the SVHMP.

This new custom geoid model was inserted into the SVHMP network, and a new adjustment generated. As with the North Region network, no other changes were made to the data or adjustment controls for this new adjustment apart from replacing the geoid heights. When the GEOID03 custom model was used with the SVHMP, the seuw for geoid heights was 1.884. When the NRCustom09B model was used, the seuw for geoid heights has become 2.592, indicating that the NRCustom09B model does not work as well with SVHMP constraints and observations as did the Custom03 model. However, NRCustom09B does work fairly well, as is shown in plots of the residuals to NRCustom09 below.

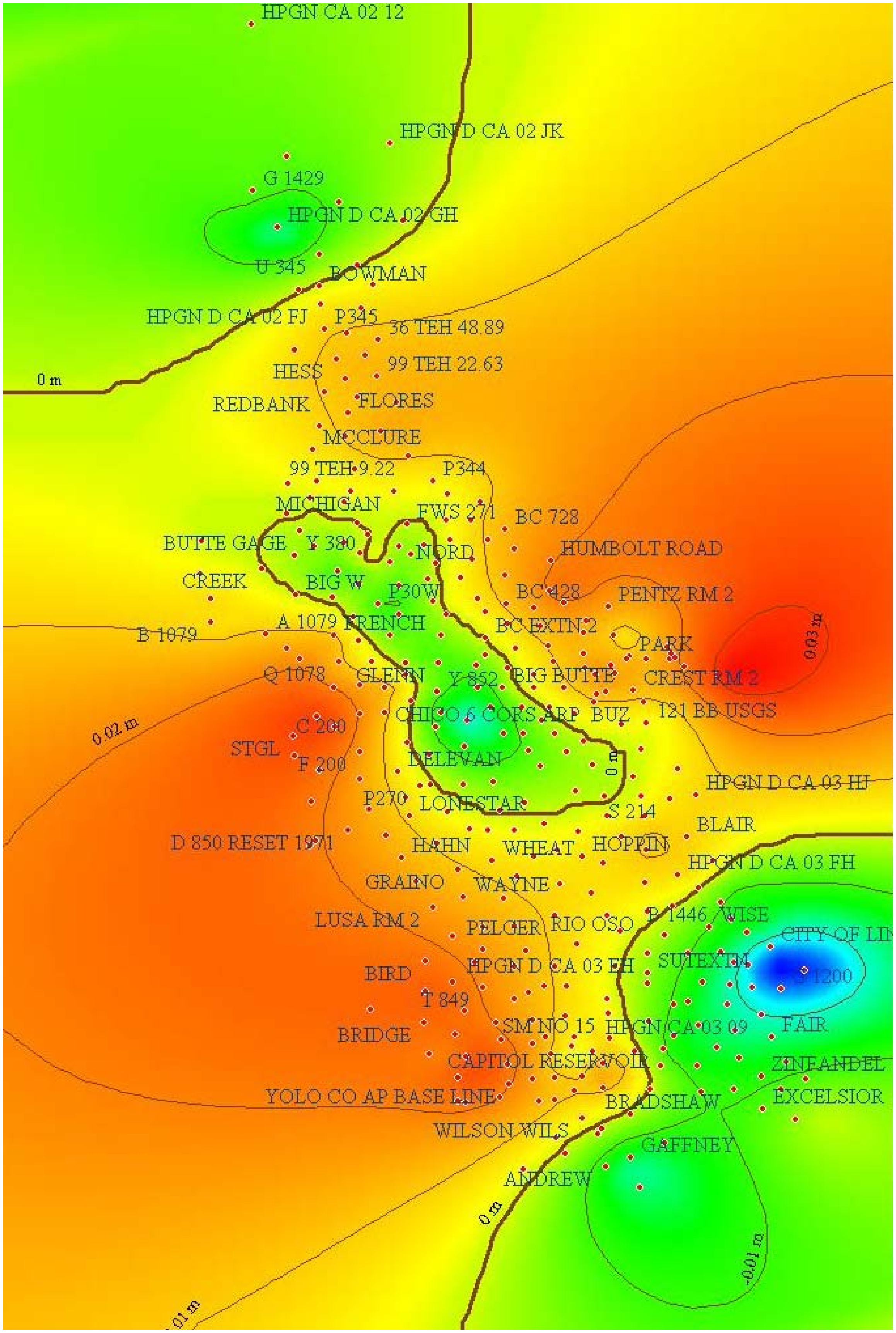
As above, these two plots show the same data, the first plot having produced by Geodetic Solutions software and the second plot generated by GlobalMapper. It can be shown that the vast majority of control stations within the SVHMP receive geoid height residuals of 2 cm or less, with minima/maxima approaching 3 cm in one isolated location. Because the NRCustom09 model worked so well with the SVHMP, no further improvements to NRCustom09 are contemplated.

Blue-booking

It will be necessary to re-submit the SVHMP to NGS using B-files that contain the GEOID09 (unmodified) geoid model. To do this, it has only been necessary to pass the original SVHMP B-files (containing GEOID03 geoid heights) through INTG, which then replaces GEOID03 geoid heights with GEOID09 geoid heights. The next step has been to regenerate all of the ADJUST adjustments required, using the same A-files and G-files used for the original submission. The Cover Letter accompanying the original submission has been modified to reflect the use of GEOID09.



Primary Residual Residuals
+0.000
+0.010
-0.010
+0.020
+0.000
+0.010
+0.020
-0.010
+0.030
+0.020
-0.030
-0.010
+0.010
+0.000
+0.000
+0.010
+0.020
-0.010
-0.020
+0.020
-0.010


HPGN CA 02 12
HPGN D CA 02 JK
G 1429
HPGN D CA 02 GH
U 345
BOWMAN
HPGN D CA 02 FJ
P345
36 TEH 48.89
99 TEH 22.63
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REDBANK
FLORES
MCCLURE
99 TEH 9.22
P344
MICHIGAN
FWS 271
BC 728
BUTTE GAGE
Y 380
NORD
HUMBOLT ROAD
CREEK
BIG W
P30W
BC 428
PENTZ RM 2
A 1079
FRENCH
B 1079
BC EXTN 2
PARK
0.03 m
Q 1078
GLENN
Y 852
BIG BUTTE
CREST RM 2
CHICO 6 CORS ARP
BUZ
121 BB USGS
0.02 m
C 200
STGL
F 200
DELEVAN
0 m
HPGN D CA 03 HJ
P270
LONESTAR
S 214
BLAIR
D 850 RESET 1971
HAHN
WHEAT
HOPPIN
HPGN D CA 03 FH
GRAINO
WAYNE
LUSA RM 2
PELGER
RIO OSO
P 1446
WISE
CITY OF LIN
HPGN D CA 03 EH
SUTEXTM
BIRD
S 1200
T 849
SM NO 15
HPGN CA 03 09
FAIR
BRIDGE
CAPITOL RESERVOIR
ZINFANDEL
YOLO CO AP BASE LINE
BRADSHAW
EXCELSIOR
WILSON WILS
GAFFNEY
ANDREW
0 m
-0.01 m
0.01 m

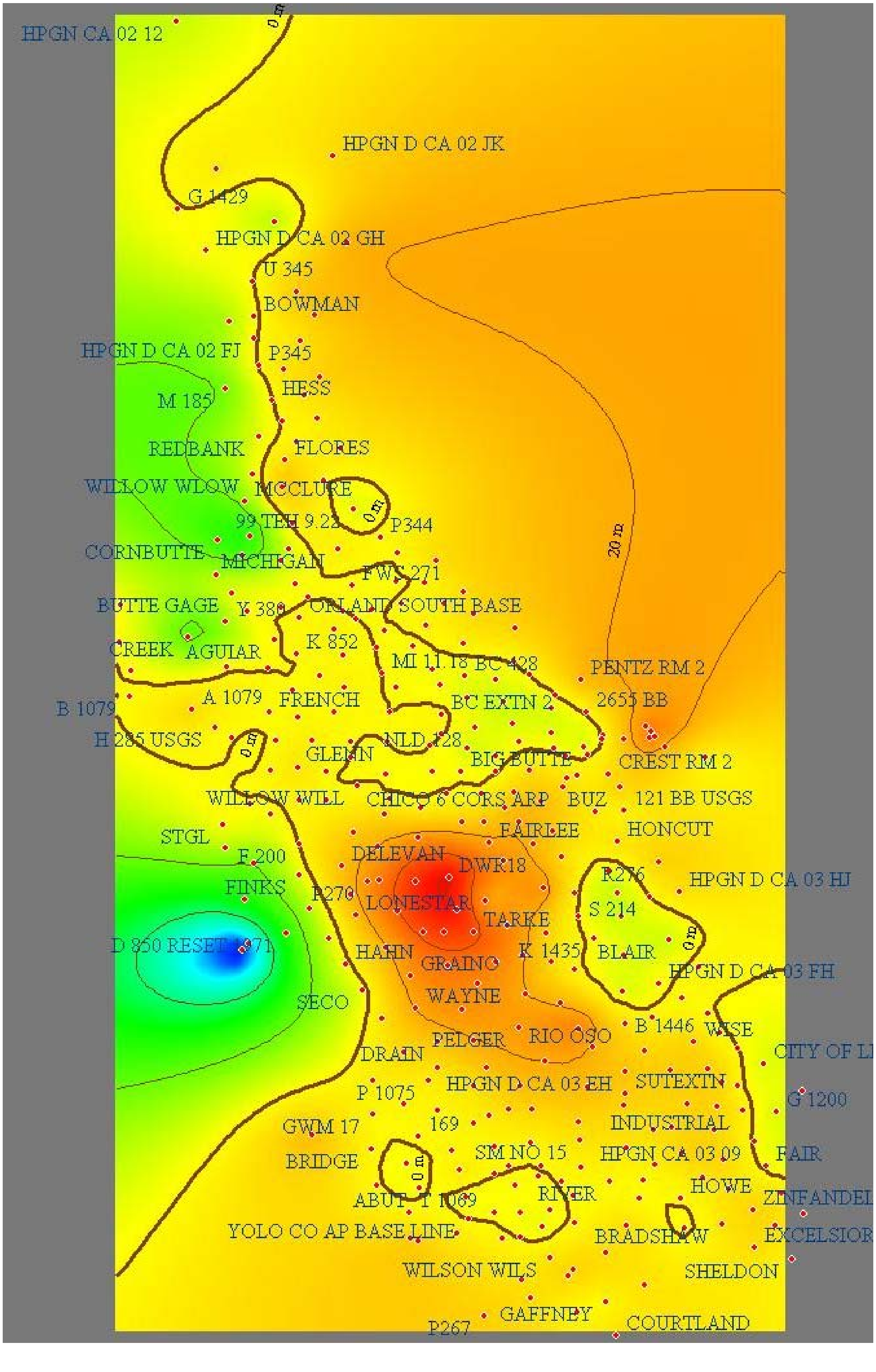
Comparison of results

The new adjustment of SVHMP using NRCustom09B produced virtually no significant changes to the adjusted IRTF2005 horizontal coordinates and ellipsoid heights from those generated for the original submission. For this reason my recommendation is to continue to use the ITRF2005 coordinates supplied by Geodetic Solutions last year.

A tabulated comparison of adjusted values for orthometric heights can be found in 03_vs_09_orthos.xls. In this file, the first column represents last year's Custom03 adjustment of the SVHMP orthometric heights, and the second column represents the NRCustom09 adjusted ortho heights. The differences between these adjusted ortho heights are shown in the third column, represented in millimeters. All absolute differences greater than 20 mm (2 cm) are shown in red. The largest ortho height differences are less than 7 cm. Because the only change to the SVHMP network is the different geoid model, these differences can be attributed to the differences between GEOID03 and GEOID09.

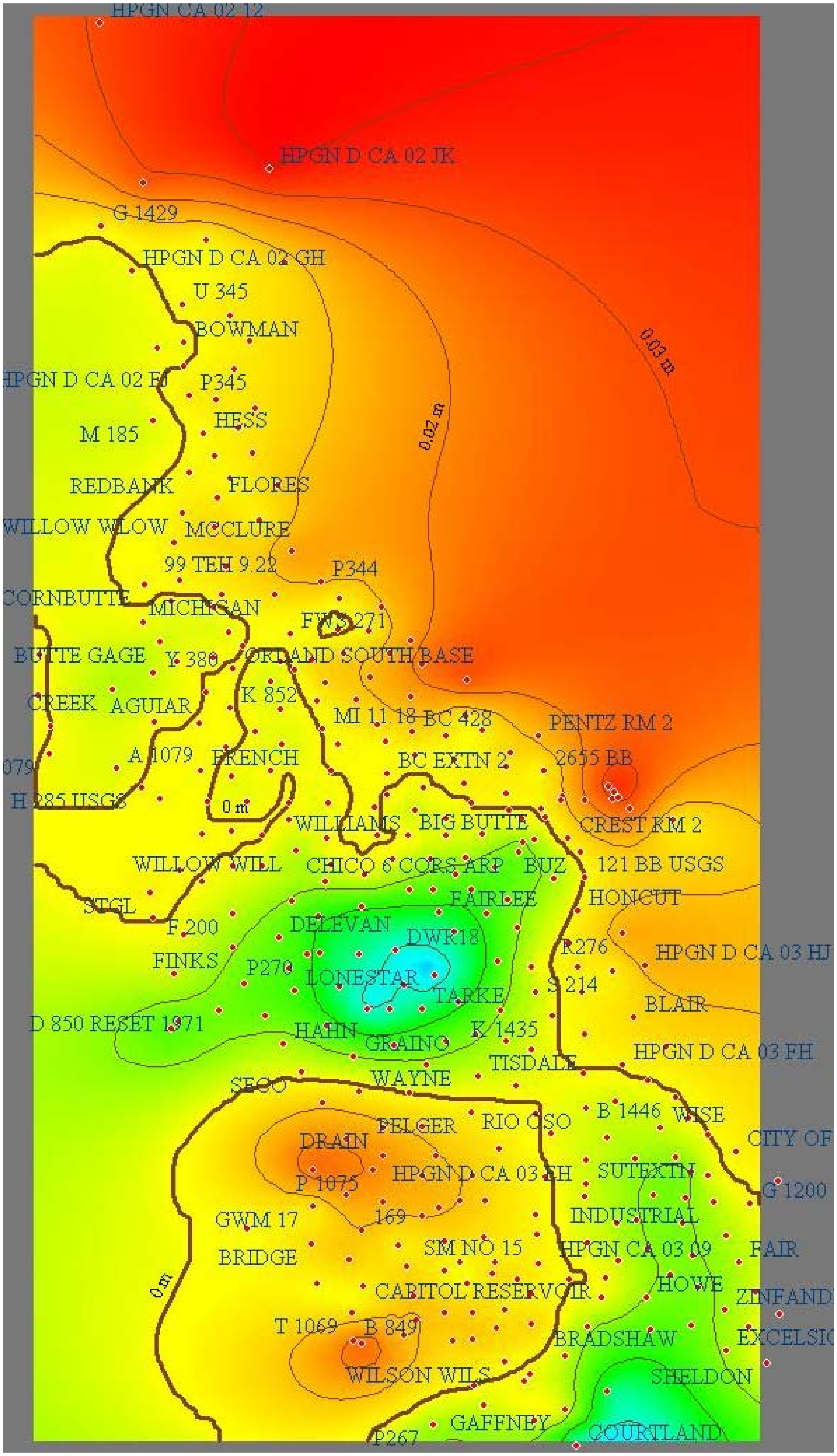
I have attempted to generate a contour map showing these differences (in ortho height between the Custom03 and NRCustom09 models) in the next image: Because this contour map was generated using only spot elevations at the control stations, and a rough grid of 80 x 40 cells, it should not be viewed as having the same accuracy as the numerical values shown in the tabulated heights. The labels on this plot shown as meters actually refers to mm.

It can be seen from this image that the largest differences in adjusted ortho heights between Custom03 and NRCustom09 are centered around DWR18, which shows a 6 cm difference in ortho heights. This is strictly a result of the difference in geoid models.


HPGN CA 02 12
0 m
HPGN D CA 02 JK
G 1429
HPGN D CA 02 GH
U 345
BOWMAN
HPGN D CA 02 FJ
P345
HESS
M 185
REDBANK
FLORES
WILLOW WLOW
MCCLURE
0 m
99 TEH 9.22
P344
20 m
CORNBUTTE
MICHIGAN
FWS 271
BUTTE GAGE
Y 380
ORLAND SOUTH BASE
K 852
CREEK
AGUIAR
MI 11.18
BC 428
PENTZ RM 2
B 1079
A 1079
FRENCH
BC EXTN 2
2655 BB
H 285 USGS
0 m
NLD 128
GLENN
BIG BUTTE
CREST RM 2
WILLOW WILL
CHICO 6 CORS ARP
BUZ
121 BB USGS
STGL
FAIRLEE
HONCUT
F 200
DELEVAN
DWR18
R276
HPGN D CA 03 HJ
FINKS
P270
LONESTAR
S 214
TARKE
0 m
D 850 RESET 1971
HAHN
K 1435
BLAIR
GRAINO
HPGN D CA 03 FH
WAYNE
SECO
B 1446
WISE
PELGER
RIO OSO
DRAIN
CITY OF LI
HPGN D CA 03 EH
SUTEXTN
P 1075
G 1200
GWM 17
169
INDUSTRIAL
SM NO 15
HPGN CA 03 09
FAIR
BRIDGE
0 m
ABUT
T 1069
RIVER
HOWE
ZINFANDEL
YOLO CO AP BASE LINE
BRADSHAW
EXCELSIOR
WILSON WILS
SHELDON
GAFFNEY
COURTLAND
P267

The next two columns in 03_vs_09_orthos.xls shows blue-booked ortho heights as computed by the NGS ADJUST software using unmodified geoid models. Care should be taken in interpreting these numbers. The ellipsoid heights that were used in conjunction with the unmodified models are different from those used in the Geodetic Solutions software, because the NGS adjustments require holding the published NSRS2007 ellipsoid heights for each station, whereas the ellipsoid heights used in the Geodetic Solutions adjustments are based upon the internal agreement of delta ellipsoid heights during the HMP survey campaigns.

The seventh column in 03_vs_09_orthos.xls is of interest because it shows the differences in adjusted orthometric heights between those produced by NRCustom09B in conjunction with the SVHMP surveying campaign as opposed to the GPS-derived ortho heights from the unmodified GEOID09 that NGS will publish in its data sheets. DWR is interested to know how big these differences are, because this will help determine whether or not it is necessary to publish adjusted orthometric heights for the SVHMP separately from the NGS data sheets. Using the same technique as above, I have created a contour map showing these ortho height differences:


HPGN CA 02 12
HPGN D CA 02 JK
G 1429
HPGN D CA 02 GH
U 345
BOWMAN
0.03 m
HPGN D CA 02 EJ
P345
HESS
0.02 m
M 185
REDBANK
FLORES
WILLOW WLOW
MCCLURE
99 TEH 9.22
P344
CORNBUTTE
MICHIGAN
FWS 271
BUTTE GAGE
Y 380
ORLAND SOUTH BASE
CREEK
AGUIAR
K 852
MI 11.18
BC 428
PENTZ RM 2
A 1079
FRENCH
BC EXTN 2
2655 BB
H 285 USGS
0 m
WILLIAMS
BIG BUTTE
CREST RM 2
WILLOW WILL
CHICO 6 CORS ARP
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121 BB USGS
STGL
FAIRLEE
HONCUT
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FINKS
P270
LONESTAR
TARKE
S 214
BLAIR
D 850 RESET 1971
HAHN
GRAINO
K 1435
HPGN D CA 03 FH
SECO
WAYNE
TISDALE
B 1446
WISE
PELGER
RIO OSO
CITY OF
DRAIN
P 1075
HPGN D CA 03 EH
SUTEXTN
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169
INDUSTRIAL
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CAPITOL RESERVOIR
HOWE
ZINFAND
T 1069
B 849
BRADSHAW
EXCELSIO
WILSON WILS
SHELDON
GAFFNEY
P267
COURTLAND

The largest difference between the GEOID09 blue-booked ortho heights, and the ortho heights computed from the NRCustom09B model, is 0.041 m. The vast majority of differences are less than 2 cm.