Finding Large Aperture Fractures in Geothermal Resource Areas Using a Three-Component Long-Offset Surface Seismic Survey, PSInSAR and Kinematic Structural Analysis

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1 EXECUTIVE SUMMARY

1.1 U.S. Geothermal, Inc. (USG) executed a geothermal exploration and development program at the San Emidio geothermal resource, Washoe County, Nevada. The program was funded on a cost-shared basis by USG and the US Department of Energy (DOE) through the American Recovery and Reinvestment Act (ARRA).

1.2 The purpose of the program was to develop a suite of innovative geological and geophysical methods to identify and map large aperture fractures (LAFs) within a geothermal system that are likely to be prolific production zones. Because of the large N-S lateral extent of the San Emidio resource encompassing two separate structural regimes, the exploration area was divided into a northern and southern exploration area. Targets in both areas were then drilled and tested to confirm efficacy of the methodology.

1.3 The program consisted of three phases: Phase 1- geological and geophysical exploration using innovative techniques; Phase 2 – drilling and testing to confirm efficacy of targeting generated in Phase 1; and Phase 3 – reporting of program results through report submittals to DOE, publication of technical papers in the geothermal literature and submittal of program datasets to the National Geothermal Repository.

1.4 All field work and data processing for Phase I Exploration was completed for the San Emidio southern and northern exploration areas. The exploration team completed final data correlations, interpretation, and figures and submitted a final report containing the drilling targets for Phase 2 on 9/21/2011 (Teplow et al, 2011).

1.5 Phase 1 studies revealed a complexly faulted structural environment which yielded numerous production drilling targets. USG petitioned DOE to change the drilling program from one production well in each of the two exploration areas. The modified program, approved by DOE in November 2011, consisted of up to 5 slimhole exploration wells for each of the two exploration areas in order to test several of the identified targets.

1.6 Slimhole drilling commenced on 8/17/2011 and continued through September, 2014 with drilling of seven slimholes in the southern exploration area and one in the northern exploration area.

1.7 Five of the southern exploration wells encountered temperatures above the commercial target temperature of 280F. Three of the seven wells encountered both commercially exploitable temperature and permeability. Two wells encountered temperatures that were 10 to 20°F higher than the maximum previously observed in the San Emidio resource.

1.8 The highest temperature yet observed in the San Emidio resource was encountered in the southwesternmost of the exploration wells at a depth of 2300'. This result confirms the existence of a thermal anomaly of higher temperature as compared to the existing wellfield extending southwestward from the southernmost exploration well.

1.9 Additional geophysical surveys including gravity, ground magnetics and self-potential were used to characterize the newly identified area of higher resource temperature. The surveys revealed both a due south extension of the main range front fault and a SSW trending structural basin and ridge. The latter is coincident with the strike of maximum dilational faulting and highest observed temperature at production depths.

1.10 The DOE funded exploration program concluded with the siting and initial permitting activities for up to 10 one-thousand foot gradient holes to further map the extent of the newly discovered higher temperature area.

1.11 A single slimhole exploration well was drilled in the northern exploration area to a depth of 3643'. Low temperatures, low temperature gradients, and lack of permeability below the shallow thermal aquifer led to abandonment of the northern exploration area as a viable production target.

1.12 Slimhole exploration well OW-10 (61-21) was completed to a depth of 3050' in March, 2012 and encountered commercial productivity in the 2300' to 2600' depth interval at a temperature of 300°F. A production pump was installed in the well for long-term testing purposes. The well was placed in commercial production on September 22, 2014, supplying the existing USG power plant. The well currently generates 1.5 MWe net to the grid. Total potential productivity for all DOE cost share exploration wells that encountered significant permeability is estimated to be 5.5 MWe net.

1.13 Total expenditures for the program were $7,929,301.76 The DOE contribution was $3,772,560.00 (44.84%). US Geothermal, Inc. matching funds totaled $4,156,741.76 (55.15%).

2 INTRODUCTION

The San Emidio geothermal resource, located in Washoe County, Nevada (Figure 1), has been producing electricity continuously since 1987. US Geothermal Inc. (USG) acquired the entire San Emidio leasehold in 2007. Since then, USG has pursued the thorough exploration of the extensive San Emidio thermal anomaly in order to maximize electrical generation from the resource. To that end, USG applied for and received a cost-share grant from the U.S. Department of Energy, Golden Field Office under the American Recovery and Reinvestment Act: Geothermal Technologies Program, *Topic Area 1: Validation of Innovative Exploration Technologies* Funding Opportunity Announcement Number: DE-FOA-0000109, CFDA Number: 81.087.

Owing to the large N-S lateral extent of the San Emidio geothermal resource, the area was divided into separate northern and southern exploration areas as shown in Figure 2. Phase 1 exploration activities covered both the northern and southern exploration areas. The two areas are separated by a lower temperature, low permeability area defined by previous deep exploration drilling.

The DOE cost-share program applied innovative and cutting edge seismic surveying and processing, permanent scatter interferometry-synthetic aperture radar (PSInSAR) and structural kinematics to the exploration problem of locating and mapping large-aperture fractures (LAFs) for the purpose of targeting geothermal production wells. The San Emidio geothermal resource area, which is under lease to USG, contains production wells that have encountered and currently produce from LAFs in the southern half of the resource area (Figure 2). The USG lease block, incorporating the northern extension of the San Emidio geothermal resource, extends 3 miles north of the operating wellfield. The northern lease block was known to contain shallow thermal waters but was previously unexplored by deep drilling. Results of the Phase 1 exploration program are described in detail in the Phase 1 Final Report (Teplow et al., 2011). The DOE cost shared program was completed as planned on September 30, 2014. This report summarizes results from all of Phase 1 and 2 activities.

3 PHASE 1 GEOPHYSICAL EXPLORATION

3.1 Kinematic Structural Analysis

All available geological, geophysical and wellbore data including the known large aperture fracture (LAF) intersections were integrated into a 3-D geologic reservoir model. Detailed surface mapping was carried out with an emphasis on fault orientation and slip direction (Rhodes, 2011). All available borehole geology and geophysical well logs, including a well recently drilled by USG (SE-2, Figure 2) in the San Emidio wellfield, were incorporated into the 3-D geologic model. A finite-element kinematic structural model was then generated using the constraints supplied by the 3-D geologic and geophysical modeling. This structural analysis delineated those fault segments which are most likely to exhibit maximum dilational tendency. Figure 3 shows the dilational fault segments overlain on the complete Bouguer gravity map.

Figure 3 shows a two-mile long NNE-trending trace of recent extensional faulting in the southern end of resource area. This fault is closely associate with currently exploited production zones in wells 75-16, 75B-16, and 76-16 at its north end as well as with commercial production discovered in OW-10 and the highest temperature (321F) observed within the resource area in well 45A-21. The fault also correlates closely with a NNE trending gravity ridge that deviates from the main N-S trending gravity gradient of the main range front fault system.

3.2 Permanent Scatter Synthetic Aperture Radar Interferometry (PSInSAR)

PSInSAR was used to determine the direction and magnitude of ongoing ground surface movement along the hydrothermally active range front fault system within the San Emidio thermal anomaly (Teplow et al, 2011). PSInSAR can achieve precision of ground deformation measurements of <0.1mm which is an order of magnitude greater precision than for conventional InSAR. It was expected that natural and production-induced subsidence would be detected in all the hydrothermally active areas of the San Emidio study area. PSInSAR results in the southern exploration area showed strong correlation with mapped faults and areas affected by fluid withdrawal from ongoing production (Figure 5A). Spatial correlation of subsidence with gravity, magnetic, thermal and low seismic velocity anomalies are evident in the E-W geophysical profiles Figures 6, 7 and 8.

A clear correlation between ground surface deformation, mapped faults, gravity anomalies and the shallow thermal anomaly was also seen in the northern exploration area, where neither production nor injection activity have taken place. However, ground deformation in the north is likely effected by past open-pit mining activities and redistribution of rock mass from pits to heap-leach pads.

3.3 Three Component, Long-Offset Seismic Refraction and Reflection Survey

Optim Software, a subcontractor to USG, executed a three-component, long-offset active source seismic survey in the two separate exploration areas within the San Emidio geothermal resource (Teplow et al, 2011). Two of the seismic lines passed directly over known LAF occurrences encountered by production and exploration wells in the 1700 to 1900 foot depth range and served as the type sections. One passed in close proximity to SE-2 and Kosmos 1-9 to serve as a type section for sub-commercial permeability in the range-front fault system. Velocity models with high lateral resolution were generated from the seismic refraction data. These velocity models showed strong correlation with LAF locations, large range front fault offsets, and vertical distribution of temperature within the producing zones (Figures 6, 7 and 8).

The resulting reflection profiles generated a clear image of the main range front fault in the southern extent of the exploration area. The range front fault trace was confirmed in several exploration wells as shown in Figures 8A and 8B.

3.4 Correlation of Phase 1 Results with Previous Geophysical Surveys.

Previously collected geophysical and geological datasets including detailed gravity, ground magnetic surveys, production well lithology and temperature logging were incorporated into the Phase 1 data synthesis and interpretation. Original gravity data were reprocessed by Bell Geospace to produce a first vertical derivative map to sharpen and highlight shallow, potentially drillable, features. The correlation of dilational faulting with gravity and magnetic maps are shown in Figures 3, 4 and 5.

3.5 Data Synthesis and Interpretation for Siting Exploration Drill Holes

Strong correlations were observed across all datasets generated in the Phase 1 program (Teplow et al, 2011). Clear spatial correlations between geophysical anomalies and known producing fractures were established along seismic line 7

(Figure 6). The highly productive fractures encountered in operating production wells 75-16, 75B-16 and 76-16 were clearly associated with rapid ongoing subsidence, a positive gravity residual, and a low seismic velocity zone that penetrated deeply through the entire Tertiary volcanoclastic section and into the Triassic phyllite (Nightingale Formation) basement.

The correlations of known producing fractures with distinct geophysical anomalies formed the basis for siting ten 2000-4000 foot slimhole exploration wells. Each hole was targeted to test one of the possible LAF occurrences indicated by the correlative datasets. A total of 8 exploration slimholes were drilled to test the indicated targets, thus completing part of Phase 2 of the DOE cost-shared program (Fig. 2). The targeting strategy for each of the slimhole exploration wells drilled in the program is discussed in the following section.

3.6 Stage Gate Decision

The DOE technical committee administering the cost-shared program reviewed the final Phase 1 report and authorized proceeding with Phase 2 slimhole exploratory and development drilling on November 19, 2011.

4 PHASE 2 EXPLORATION DRILLING

4.1 Phase 2 Strategy and Scope

The objective of Phase 2 drilling was to test targets generated by the exploration results of Phase 1. Phase 2 wells that encountered commercial production were to be placed in service supplying geothermal fluid to the currently operating USG San Emidio power plant. Phase 2 exploration drilling was originally proposed to consist of two full diameter production wells, one to be drilled in the northern exploration area and one to be drilled in the southern exploration area (Figure 2). However, Phase 1 geophysical surveys and structural analysis defined several attractive structural targets in both the northern and southern areas (Teplow et al, 2011). Previously drilled shallow temperature gradient holes showed that all the new targets were contained within an area of high shallow thermal gradients. The results of Phase 1 led USG to propose a modification of the original DOE cost share program in order to test several of the indicated targets. Rather than drilling a single full diameter well in each exploration area, USG proposed to drill and test up to five slimhole exploration wells in each of the two areas. This program change was approved by DOE in November 2011.

4.2 Phase 2 Exploration Drilling Results

Initially, five Phase 2 exploration slimholes were drilled in the Southern Exploration Area including OW-6, 8, 9, 10, and 45A-21 (Fig. 2). Well 45A-21 was a rework and deepening of existing large diameter well 45-21. After completion of 45A-21 a single exploration slimhole, OW-12, was drilled in the northern exploration area. Negative results from OW-12 led to abandonment of the northern exploration area as a prospect for commercial power production. Remaining DOE cost shared funds and drilling efforts were then diverted back to the southern exploration area. Two additional wells, OW-14 and OW-15, were drilled to explore the resource between the newly discovered production zone in OW-10 and the highest temperature observed in the field which was found in 45A-21 (321 deg.F).

All the wells were planned for completion with 8" casing cemented to a minimum depth of 400 feet and perforated liner to total depth. This design allows for flow testing and possible future installation of submersible production pumps. As-built completion schematics for each of the completed Phase 2 wells are shown in Figures 11 through 18. Wells that did not encounter significant permeability were completed with 2-7/8" gradient tubing instead of perforated liner. The following is a discussion of drilling and testing results for each completed well.

4.2.1 OW-6 Drilling Strategy and Testing Results

The first well drilled in the Phase 2 program, OW-6 (Figure 2), was sited to explore two possible targets indicated by the Phase 1 geophysics (Figure 6). OW-6 was drilled to a total depth of 2542' and completed with 2-7/8" gradient tube (Figure 11). The first target in OW-6 was to penetrate the low P-wave velocity zone associated with existing production zones. After penetrating the low velocity zone, drilling continued to the Tertiary volcanic/Triassic basement fault contact at one of several range-front step faults.

The first target zone proved to be highly permeable in fractured and silicified basalt in the same structural block containing operating production wells 75-16, 75B-16 and 76-16. Figure 9 shows the OW-6 static temperature profile (violet trace and crosses). Similar to the currently producing wells, OW-6 exhibited a pattern of discrete temperature zones with the hottest zone at 298F at a depth of 1700' overlying a fractured and permeable interval extending from 1800' to 2600' at a temperature of 276F.

Wellhead pressure response in OW-6 to changes of flowrate in the operating production wells showed that OW-6 was producing from the same fracture system as 75B-16 and 76-16 (Figure 19). Because of the relatively low temperature (276F) and the direct hydraulic connection with existing wells, it was expected that producing OW-6 would further exacerbate the cooling problem observed in 76-16. Hence, OW-6 was not considered as a candidate for pump installation and production.

4.2.2 OW-8 Drilling Strategy and Testing Results

The temperature reversal observed in OW-6 precluded the possibility that a high temperature fluid feed zone was located directly down-dip from the operating wellfield. Furthermore, previous drilling results from Exploration Well SE-2 (Figure 2 and 9) showed that the deeper, high temperature reservoir was not present immediately to the north of the currently operating wellfield. Hence, OW-8 was sited to explore the possibility that high temperature fluid was propagating from the south and west to feed the known production zones. The specific OW-8 drilling target was derived from the geophysical correlations shown in Figure 7. OW-8, drilled to a depth of 3990' (Figure 12), encountered temperatures as high as 315F at a depth of 3800' (Figure 9), thus confirming increasing temperature to the south and west. During a short-term rig test, OW-8 exhibited subcommercial permeability and flowed small amounts (~100 gpm) of 320F fluid (Figure 10). Reservoir pressure drawdown during that flow was excessive at ~100 psi.

OW-8 was equipped with a wellhead pressure (WHP) data logger in November 2012. WHP was observed to react immediately to shutdown and startup of the operating wellfield located 2200' to the NE (Figure 19). Total pressure buildup was ~1.5 psi during shutin of the wellfield. These observations imply that the induced pressure gradient caused by the production wells is drawing 320F fluid from a deeper, large volume, low permeability reservoir located to the south and west.

4.2.3 OW-9 Targeting Strategy and Testing Results

Since OW-8 had proven the existence of a reservoir exceeding 300F to the south but failed to encounter commercial permeability, it was concluded that the location was too far to the west and had not penetrated fractured rock associated with the range front fault system. Based on this assumption, OW-9 was targeted along strike of the producing range front fault and ~1200' to the south of the production wellfield (Figures 2 and 7). OW-9 was completed to a depth of 2686' (Figure 13). It confirmed the extension of high permeability along strike to the south by encountering total lost circulation zones in the 1835' to 2090' depth interval.

Flow testing confirmed that OW-9 would be a prolific producer, but the flowing temperature was relatively low at 280F (Figure 10). This temperature was too low to justify pump installation to supply the operating power plant. The OW-9 static temperature profile (Figure 9) showed a maximum temperature of 293F at the shallowest lost circulation zone (1830') but deeper, cooler entries dominated flow. Casing damage with a parted 6" liner at 1520' precluded further use of the well without major rework.

OW-9 was completed with a bubble tube to monitor downhole pressure. The well showed 4.5 psi of drawdown resulting from production from the existing wellfield (Figure 19). This confirmed direct high permeability hydraulic connectivity with the producing fractures.

4.2.4 OW-10 (61-21) Targeting Strategy and Testing Results

The large temperature reversal observed in OW-9 indicated that a high permeability feed zone with temperatures in excess of 300F was located farther to the south rather than in close proximity to OW-9. OW-10 was targeted and drilled to confirm this hypothesis. OW-10 was drilled to a total depth of 3050' (Figure 14) and encountered two zones at 2320' and 2600' which produced 303F fluid in commercial quantities. Specific drilling targets were derived from the geophysical correlations shown in Figures 8, 8A, and 8B.

Preliminary flow testing showed the well was capable of producing between 500 and 1000 gpm of 300F fluid using a submersible pump. This would be sufficient to provide an additional 1-2 MWe net power to the grid if fed through the operating power plant.

A wellhead pressure data logger was installed on OW-10 in November 2012. The well exhibited a static artesian WHP of 16 to 21 psi. The total drawdown due to production from the existing wellfield was 5 psi as measured during wellfield shutdown and startup (Figure 19). The relatively high static artesian pressure of OW-10 and direct hydraulic response to production from existing production wells demonstrates a relatively high horizontal negative pressure gradient from OW-10 to 75B-16 and 76-16 under normal wellfield operating conditions. This confirms that the source for higher temperature fluid (>300F) feeding the currently operating production wellfield is located southward from OW-10.

Additional well testing of OW-10 was performed in March and April 2013. The purpose of the testing was to determine the basic well parameters of flowing temperature, transmissivity and productivity index in order to design the proposed submersible production pump. Pressure and temperature transient history during the drawdown, shut-in and recovery periods are shown in Figure 20.

Reservoir parameters generated by Lovekin and Acedera (2013) include a very high transmissivity of ~1 million millidarcy–feet and a productivity index in the range of 10-12 gpm/psi of drawdown. Both parameters are well within the range of commercial productivity. However, a high skin factor of 10 indicates that the well is hydraulically inefficient and is therefore limited in capacity. The initial well configuration with 5" perforated liner top set at 402' limits the pump setting depth and hence well capacity to a maximum of 550 gpm.

In an effort to mitigate the well inefficiency problem, USG reworked OW-10 by pulling the 5" perforated liner and replacing it with a 6-5/8" perforated liner. Additional flow testing of OW-10 during the period from July 17 to 20, 2014 confirmed the well is tapped into a high transmissivity reservoir (700,000 md-ft) but continues to suffer from a very high skin factor. The well flowed a maximum of 530 gpm of 300F brine with air assist but the high skin factor limited calculated pump deliverability to ~650 gpm.

An additional attempt to stimulate OW-10 was made in August 2014 using Precise Propellant Stimulation LLC downhole deflagration technology. A ten-foot propellant charge was set in the 2246' to 2256' depth interval. The target interval was chosen based on the primary fluid entry observed during flowing temperature and spinner surveys. OW-10 was flow tested immediately prior to and after the propellant discharge. No improvements in OW-10 flowing parameters including flow rate, pressure drawdown or flowing temperature were observed as a result of the propellant discharge. However, after the well was put on long-term production it performed at the maximum possible flow rate determined possible from pre- and post-deflagration flow tests. Some minor benefit may have been realized, which is consistent with anecdotal reports of deflagration in other wells (oil, gas, and geothermal) resulting in increased productivities over time. If there is another technique that might be able to improve OW-10's performance, it is likely to be hydraulic stimulation. The premise behind such an operation would be that existing or newly created fractures need to be further opened so as to create a more efficient connection to the reservoir.

4.2.5 OW-10 (61-21) Commercial Production Capacity and Production History

A production pump was installed in OW-10 and the well was placed in production on September 22, 2014, supplying the existing USG power plant. Downhole pressure and wellhead temperature behavior during commercial operation is shown in Figure 21. Initial production temperature was 299F. Initially the production temperature showed a decline rate of 12.6 degF/year at a flow rate of 650 gpm. On November 1, 2014 the flow rate was reduced to 620 gpm in an effort to mitigate the unsustainably high temperature decline rate. This change reduced the temperature decline rate to 4.2 degF/year (Figure 21). The last week of monitoring prior to issuing this report shows a continuously slowing decline rate. The well currently yields 1.5 MWe net to the grid.

4.2.6 45A-21 Targeting Strategy and Testing Results

The high permeability and flowing temperature encountered in OW-10 confirmed that the San Emidio geothermal reservoir with temperatures in excess of 300F was unconstrained to the south of OW-10. High conductive thermal gradients observed in several older gradient holes to the south of OW-10 gave further confirmation that this was the case (Figure 2). Well 45-21, previously drilled by Ormat in 1987, had a temperature of 250F at 671' and a bottom hole conductive gradient of 5.1 degF/100'. This gradient extrapolated to depth indicated that a temperature of 300F would be reached at 1700'. Based on these observations and the success in OW-10, it was decided to deepen 45-21 to a target depth of 4000' to reach the Triassic basement and penetrate deeper extensions of the range front fault system. Reentry of 45-21 was considered a preferable strategy because it eliminated the necessity to obtain a new drilling permit on federal land, a process that was expected to take between six months and one year.

The deepening of 45-21, designated as 45A-21, was completed to a depth of 3186' (Figure 15) in Triassic phyllites of the Nightingale Formation (Figure 8, 8A, and 8B). The deepened well encountered a maximum temperature of 322F in the 2200' to 2300' depth interval, the highest temperatures yet encountered in the San Emidio resource. Below 2400' the temperature profile reverses, reaching 310F at TD (Figure 9). No significant permeability was observed in the well. Attempts to air lift the well through the annulus and by perforating the 2-7/8" tubing at the zone of maximum temperature did not yield any flow.

A bubble tube was installed in the well to monitor reservoir pressure. The WHP pressure showed no response to wellfield shutdown and startup (Figure 19). This result indicates that 45A-21 penetrated a relatively undeformed, unfractured structural block. This is consistent with the P-wave velocity model and geophysical profiles shown in Figure 8, 8A and 8B. Based on these results it was concluded that fracture permeability was more likely to be encountered by drilling 500' to 1500' eastward from the 45A-21 location. Following the completion of 45A-21, additional geophysical surveys were run to map possible permeable structures south of OW-10 and east of 45A-21. Results of those surveys are described Section 5.

5 GEOPHYSICAL SURVEY RESULTS - SOUTHERN FIELD EXTENSION

Drilling and testing of OW-6, 8, 9, 10 and 45A-21 established the existence of a higher temperature thermal anomaly located to the south and west of the operating wellfield. This area was initially indicated by temperature gradient holes drilled in the late 1970s Gradient holes 3-77, A-76, 4-77, 5-77, and 74-4 (Figure 2) had conductive gradients ranging from 9.0 to 13.8 deg.F/100' at depths between 400' and 500'. These wells extend the thermal anomaly more than a mile south of OW-10. The static temperature profiles in 45A-21 and OW-10 (Figure 9) show the absence of a shallow thermal aquifer thus suggesting that the earlier gradient holes were reflecting heat flow from a reservoir in excess of 300F located at depths below 2000'.

The geophysical surveys comprising Phase 1 did not cover the southward extension of the higher temperature reservoir confirmed by the drilling of OW-10 and 45A-21. To aid in more precise targeting of additional production wells in the southern extension of the exploration area, USG proceeded with additional geophysical surveys in the Fall of 2012. The purpose of the surveys was to identify and map structures that are controlling the distribution of heat and permeability in that area. The additional surveys included gravity, ground magnetics and self potential (SP). The following is a discussion of those survey results.

5.1 Ground Magnetics

In August, 2012, thirty eight miles of ground magnetics profiling were run by USG staff in the southern extension of the field, covering the same area as the extended gravity survey described below. Results of the survey are shown in Figure 22. The total magnetic field map reveals a strong SSW trending magnetic ridge extending from known high permeability zones defined by OW-9 and OW-10. The ridge extends SSW from OW-10 for a distance of more than one mile. The SW end of the ridge contains three shallow temperature gradient holes, 74-4. 5-77 and 4-77. Of these three wells, 74-4, located at the SW terminus of the magnetic ridge, is significantly hotter with 171F measured at a depth of 400'. The hottest temperature observed in the field, 322F, was measured in 45A-21 which lies along the western flank of the same SSW trending magnetic ridge. The hottest shallow gradient well, 74-4, is associated with a possible stepover fault that truncates the aforementioned SSW trending magnetic ridge. This possible stepover fault zone is shown in Figure 22.

5.2 Gravity

In August 2012 USG contracted MWHGeo of Reno, Nevada to add 213 gravity stations extending 1.5 miles south of the southern boundary of the previously completed gravity survey. Results of the extended survey are shown in Figure 25 and 26. The survey extension defined a graben-like structure striking SSW and extending approximately one mile to the south of well OW-10 (61-21). The graben is bounded to the west by a SSW trending splay of the range front fault and bounded to the east by the N-S trending continuation of the fault encountered in Section 16 production wells. The SSW trending gravity ridge is closely correlated with the SSW trending magnetic ridge described above, and an extensional fault of the same orientation which was mapped by Rhodes (2011) (Figure 25).

The gravity 1st vertical derivative map (Figure 25A) shows the same right lateral offset of the SSW trending gravity ridge as seen in the ground magnetic survey.

A 3-D model of the basement was constructed based on gravity modeling (Figure 26). This model depicts the basement surface of the area extending southward from the operating wellfield. The highly productive wells including operating wells 75-16, 75B-16, and 76-16 (red traces) together with exploration wells OW-6, 9, and 10 (black traces) are closely associated with the center axis and eastern margin of the graben. Wells OW-8 and 45A-21 exhibited the highest temperatures in the field but failed to encounter commercial levels of permeability. Their position to the west of the western graben boundary may explain why neither of these wells encountered significant permeability.

5.3 Self Potential

Six self potential (SP) profiles, A through F, were run in an E-W direction covering the area from OW-10 southward to 45A-21 (Figure 22). The resulting SP profiles are plotted in Figure 23. The survey identifies two separate negative SP anomalies with amplitudes ranging from 15 to 40 mV, which are potentially related to subsurface fluid flow. The two separate anomalies labeled Anomaly A and B can be differentiated in the 3-D oblique view of the profiles shown in Figure 25.

6 STEPOUT DRILLING IN SAN EMIDIO RESOURCE SOUTHERN EXTENSION

6.1 Stepout Drilling from OW-10

Two wells, OW-14 and OW-15, were targeted as relatively short stepouts to commercially successful OW-10. OW-14 was sited 1300’ due south of OW-10 to test the southward extension of permeability along the main, N-S striking, range front fault. OW-15 was sited 1100’ SSW from OW-10 to test the extension of permeability along the SSW trending structure defined in the previously discussed gravity and magnetic surveys.

6.2 OW-14 Targeting Strategy and Test Results

OW-14 was spudded on June 27, 2014 and was drilled to a total depth 3501' (Figure 17). The equilibrated static temperature profile of OW-14 (63-21) (Figure 9) shows that the well is both anomalously cool and lacking in significant permeability. The due-south extension of the main range front fault which OW-14 targeted was accurately predicted by seismic line 9 (Figure 8B) and the gravity modeling, with OW-14 encountering the Triassic basement fault contact within a few feet of the model. However, that fault extension shows only minor hydrothermal activity with a marked absence of pervasive silicification that is characteristic of known production zones to the N and W. The temperature profile is cooler by 40 to 80 degF as compared to wells located as close as 639' (Ormat 63-21) to the W and N. The low temperature, lack of mineralization and lack of permeability in OW-14 effectively eliminate the due-south extension of the main range front fault as a viable exploration target.

6.3 OW-15 Targeting Strategy and Drilling Results

OW-15(53A-21) was spudded on August 22, 2014 and drilled to a total depth of 3716' (Figure 18). The well targeted the SSW trending structure defined by the gravity and magnetic surveys and by the high observed temperature along this trend observed in 45A-21. The well also targeted the down-dip extension of a fault mapped by Rhodes (2011) (Figures 22 and 25).

OW-15 did not encounter any significant permeability. Mineralization throughout the Tertiary basalt section was weak to moderate in comparison to the pervasive silicification, chloritization and pyrite alteration observed in OW-10. The temperature profile reversed below a depth of 2600'. Maximum temperature in the basalt target lithology was measured at 303F and is projected to reach 306F after full equilibration. This is ~4 degrees F higher than temperatures observed in the basalt in both OW-8 and OW-10 (Figure 9).

6.4 Southern Extension Temperature Distribution within Tertiary Basalt Aquifer

Based on equilibrated static temperature surveys from the seven southern exploration wells drilled as part of the DOE cost-shared program, it was possible to place some constraints on temperature distribution within the targeted basalt aquifer in the 2300'-2600' depth range. The resulting temperature contour map within the basalt aquifer is shown in Figures 22, 25 and 25A in relation to gravity and magnetic surveys.

The OW-14 static temperature profile defines a steep negative temperature gradient southeastward from the axis of basalt aquifer temperatures defined by OW-10, OW-15, and 45A-21. The latter three wells define an axis of increasing temperature within the basalt aquifer, increasing 20 degrees F over a distance of 2880'. This horizontal gradient trends SSW parallel to the correlative magnetic and gravity features as well as the extensional fault mapped by Rhodes (Figures 22, 25 and 25A). The SSW extension of the 300F contour is based on the extrapolation of conductive gradients observed in shallow TG wells 74-4 and 5-77.

The temperature contours as drawn in Figures 22, 25 and 25A imply an open ended thermal anomaly within the basalt aquifer located to the SSW of 45A-21. USG is currently permitting ten 1000-foot temperature gradient (TG) holes, numbered SES-1 through SES-10, as shown in Figures 22, 25 and 25A, in order to further constrain the areal extent and shape of the high temperature anomaly identified in 45A-21 and thereby generate an additional production well drilling target. Because of the low permeability observed in OW-15 and 45A-21, this new target may represent a distinct reservoir, hydrologically separated from the currently operating wellfield to the northeast.

7 NORTHERN EXPLORATION AREA DRILLING RESULTS

Slimhole exploration well drilling commenced in October 2013 in the San Emidio northern exploration area with the completion of OW-12 (58A-33) (Figure 2). The well was targeted to penetrate the NW plunging intersection of the main range front fault system and the NNE trending cross fault. The geological and geophysical exploration techniques used to target the wells is described in detail in the Phase 1 Final Report (Teplow et al, 2011).

Drilling of OW-12 was terminated at a total depth (TD) of 3643' on October 11, 2013 in Triassic phyllite of the Nightingale Formation. No significant lost circulation or drill breaks were observed. Upon reaching TD, the drill string became stuck 30' off bottom. Several attempts to free the string were made without success. The string was backed off at 3500' leaving 27' of bottomhole assembly in the hole (Figure 16).

Upon completion of OW-12, temperature logging was performed in the open hole until temperature equilibrium was reached. The resulting equilibrated temperature profile is shown in Figure 9. Temperature and temperature gradients below the shallow thermal aquifer were anomalously low. The equilibrated bottomhole temperature was 177F and bottomhole gradient was nearly isothermal. This is far below levels considered prospective for commercial development. As seen in Figure 9, the OW-12 temperature profile deviates markedly from the temperature profiles of wells drilled in the southern exploration area. In-house thermal modeling of the temperature profile was performed to match the observed temperature profile. The modeling showed that it was not likely to have permeable fractures containing commercially exploitable fluid (>280F) within the northern exploration area while maintaining the observed OW-12 temperature profile. Based on this result, US Geothermal decided not to pursue further exploration in the northern San Emidio lease block.

Table 1: Summary of Observation Well Completions

Well No.	Total Depth (ft)	Maximum Temperature (F)	8" Casing Depth (ft)	Permeable Zones Depths (ft)	Estimated Productivity (MWe-net)	Cost
OW-6	2542	298	400	1930, 2480	1.5	$575,237.80
OW-8	3990	BHT 318F, 302F at 2600'	412	2800	0.5	$902,910.63
OW-9	2686	BHT 279F, 295F at 1850'	427	1835, 1880, 2090	2.0*	$607,824.05
OW-10	3050	302F at 2300'	420	2325, 2520,2700, 3030	1.5	$690,194.84
45A-21	3186	BHT 283F, 322F at 2300'	836	n/a	0	$720,970.74
OW-12	3643	210 @ 250' 177 @ 3600'	3643	n/a	0	$469,000
OW-14	3501	BHT 265F, 260F at 2600'	436 (7")	n/a	0	$301,860
OW-15	3716	BHT 293F, 303F at 2500'	620 (7")	n/a	0	$552,608.49
TOTAL	**26,314**				**5.5**	**$4,820,606.55** **$183.20/ft**

8 SUMMARY OF PROGRAM EXPENDITURES

Table 2 shows a summary of expenditures and cost share for the San Emidio exploration program from its start through completion on September 30, 2014. Total expenditures for the program were $7,929,301.76. The DOE contribution was $3,772,560.00 (44.84%). US Geothermal, Inc. matching funds totaled $4,156,741.76 (55.15%).

TABLE 2: SAN EMIDIO DOE COST SHARE EXPLORATION PROGRAM
SUMMARY OF EXPENDITURES AND DOE REIMBURSEMENTS THROUGH 9/30/2014

Invoice	DOE Share	US Geo Share	Total
PHASE I			
Through June 2010	$60,101.19	$14,434.36	$74,535.55
July - August 2010	$59,877.33	$14,969.33	$74,846.66
September 2010	$114,172.10	$28,543.03	$142,715.13
October 2010	$185,669.32	$46,417.33	$232,086.65
December 2010	$3,538.10	$0.00	$3,538.10
January - March 2011	$76,772.51	$19,193.13	$95,965.64
Jan 2011	$8,754.94	$2,188.73	$10,943.67
April - June 2011	$9,765.99	$29,453.34	$39,219.33
Total Phase 1	**$518,651.48**	**$155,199.25**	**$673,850.73**
PHASE II			
	DOE Share	US Geo Share	Total
November 2011	$100,071.54	$0.00	$100,071.54
December 2011	$266,325.04	$0.00	$266,325.04
January 2012	$430,045.54	$0.00	$430,045.54
February 2012	$451,901.59	$0.00	$451,901.59
March 2012	$699,166.60	$0.00	$699,166.60
April 2012	$203,279.47	$304,919.20	$508,198.67
May 2012	$112,102.10	$168,153.14	$280,255.24
June - October 2012	$0.00	$104,617.65	$104,617.65
Nov - Dec 2012	$0.00	$56,105.25	$56,105.25
Jan-May 2013	$ 0.00	$82,099.38	$82,099.38
June - September 2013	$197,398.96	$507,597.34	$704,996.30
Oct 2013	$131,534.95	$338,232.73	$469,767.68
Nov-Dec 2013	$29,873.16	$76,816.70	$106,689.87
Jan-Mar 2014	$31,621.78	$81,313.15	$112,934.93
Apr-June 2014	$67,737.46	$174,182.05	$241,919.51
July 2014	$68,482.20	$176,097.08	$244,579.28
Aug 1 to Sept 30, 2014	$464,368.12	$1,931,408.85	$2,395,776.97
Total Phase 2	**$3,253,908.52**	**$4,001,542.51**	**$7,255,451.03**

Final contribution level for Phase 2 Drilling 9/25/14	**44.85%**	**55.15%**	
Total SE DOE Cost Share Expenditures Phase 1+2	**$3,772,560.00**	**$4,156,741.76**	**$7,929,301.76**
Total DOE Award	**$3,772,560.00**		
DOE Funds Remaining 9/30/14	**$0.00**		

9 DISCUSSION OF LESSONS LEARNED

All the geological and geophysical datasets together contributed to well targeting. Target structures were well imaged with the seismic surveys, providing important detail to the 3-D resource and exploration model, while PSInSAR and fault kinematic studies provided information about the orientation and extents of structural controls on the resource. An important aspect of the project included the ability to update models and targets as new data were developed, though this resulted in some delays where exploration plan changes involved Federal land.

Drill costs savings were largely realized by using smaller drilling companies and by drilling the smallest diameter adequate for testing reservoir intersections. In hindsight, even more savings could have been realized with a smaller well in the north (OW-12). Where shallow, very hard formations are present, e.g., at San Emidio, air-hammer drilling is a crucial part of achieving cost-saving rates of penetration.

There was no appreciable difference in the targeting of individual slimhole wells; all wells targeted hypothesized, structurally controlled permeability indicated by multiple datasets. Existing subsurface geologic data were extrapolated outward and guided by gravity, magnetic, and active seismic surveys to refine structural targets. Generally, structures identified by seismic reflection surveys were intercepted very near to where predicted, thus validating the accuracy of the velocity model; however, active-seismic-identified structures were not always hot or permeable.

TABLE 3: SUMMARY OF DRILLING RESULTS

Well	Target	Outcome
OW-6	High TG NW of production	Permeable zones <270F; very low permeability >290F
OW-8	Down dip from production	Little to no permeability but >310F at depth
OW-9	Along strike to S of production	Permeable zones <280F; very low permeability >290F
OW-10	Along strike to S of production	Permeable zones >295F; recompleted, producing >600 gpm at 296F
OW-12	Down dip from shallow 230F	Highest T in shallow outflow; cool at depth; no hot upflow nearby
OW-14	Range-front target S of OW-10	Intersected target; sub-commercial temperature and low permeability
OW-15	Grav, mag, heat flow anomalies	Intersected target; high temperature but low permeability
45A-21	Grav, mag, heat flow anomalies	Intersected target; highest T (321F) recorded in field but low permeability

LAF formation at San Emidio is controlled by lithology and faulting. Rocks must be originally brittle or have become so due to hydrothermal alteration. Those rocks must be located at sufficient depth (~2000'+) and be intersected by faults or dense fractures oriented so as to dilate, or preserve previous dilation, in the current stress regime.

Faults do not host LAFs everywhere along their strike and dip. Cross-cutting faults or small-scale jogs that might be important are not apparent at the resolution of current geological and geophysical data. The subsurface temperature anomaly and horizontal gradient increase to the south-southwest, suggesting that upflow is located in that direction. However, existing production wells heat up almost immediately after shutin (planned plant maintenance) and have distinct entries of higher and lower temperature reservoir fluid suggesting the possibility that multiple upflows exist, one near Section 16 production wells and one located further south. Separate upflow zones might be related to the northeast-trending range-front jog/stepover with upflow zones controlled by the "tips" of the jog/stepover where it intersects ~north-south-trending segments of the main range-front fault system.

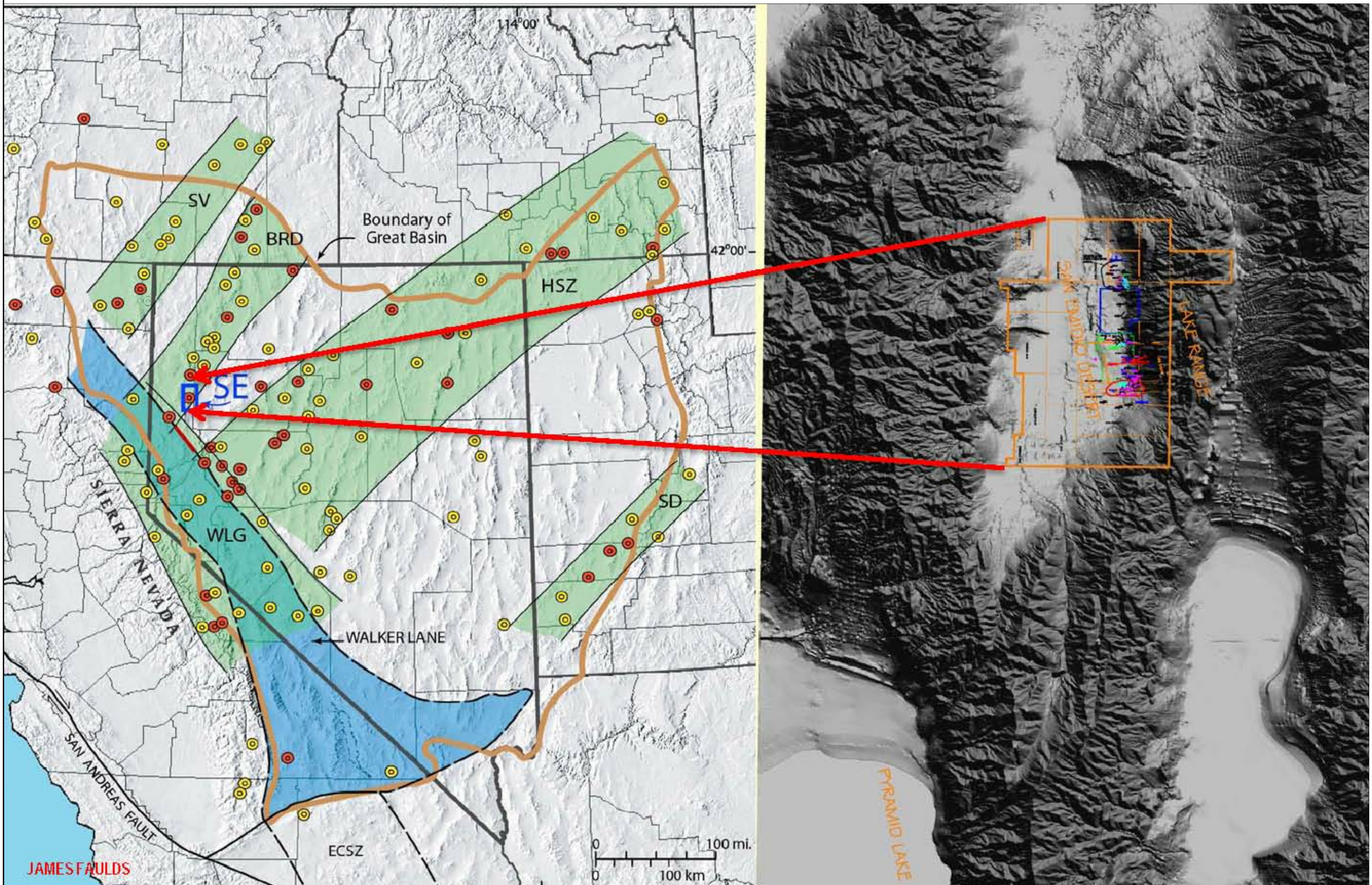
Target faults and lithologies were successfully drill tested; however, only OW-10, and to a lesser extent OW-6 and OW-9 owing to their cooler tempertures, encountered both commercial temperature and permeability. Commercial permeability likely is present to the south based on the highest temperatures measured in the field occurring at ~2300' below surface in 45A-21, south-southwest of OW-10. Future exploration will follow up with focus on the south end of the jog/stepover, where high heat flow is also indicated by shallow 70's era temperature gradient wells.

10 REFERENCES

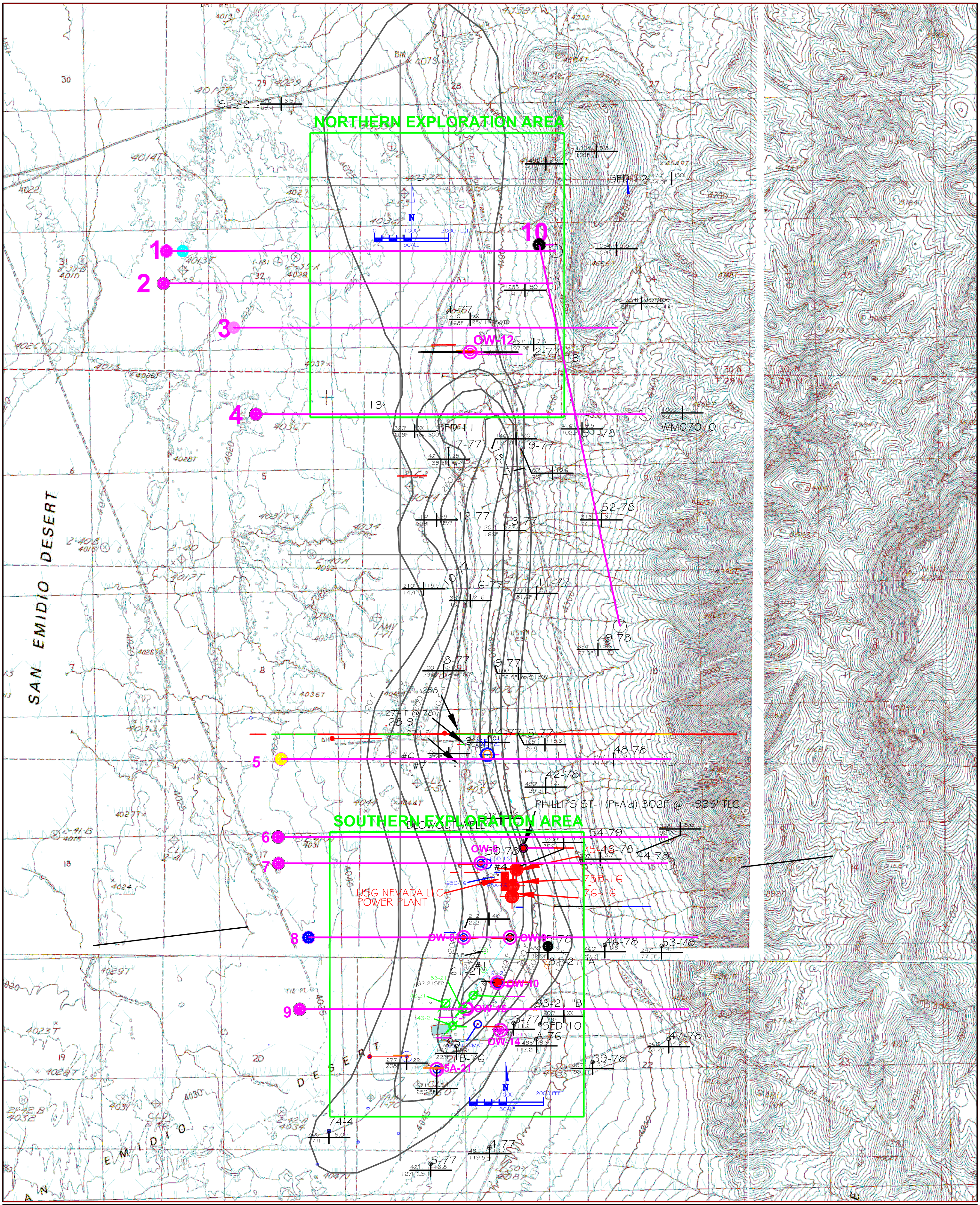
Rhodes, Greg T, 2011, *Structural Controls of the San Emidio Geothermal System, Northwestern Nevada,* Master Thesis, University of Nevada, Reno.

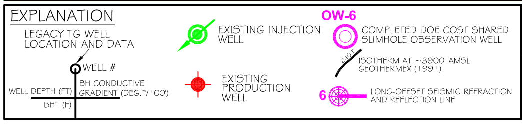
Teplow William, James Faulds, Greg Rhodes, Inga Moeck, Mariana Eneva, Satish Pullamannapallil, 2011, *Finding Large Aperture Fractures in Geothermal Resource Areas Using a Three-Component Long-Offset Surface Seismic Survey, PSInSAR and Kinematic Structural Analysis,* DOE Award No.: DE-EE0002847, Phase 1 Final Report, September 12, 2011.

Lovekin, J. and Brian Acedera, 2013, *Report on Analysis of 62-21 Well Test Data (053221R),* proprietary GeothermEx report prepared for US Geothermal Inc., May 1, 2013.



EXPLANATION	SAN EMIDIO GEOTHERMAL PROJECT		US Geothermal Inc	DATE: 5/8/2013	BY: WM. TEPLOW
US GEOTHERMAL LEASE BOUNDARY	LOCATION MAP			FIGURE 1	





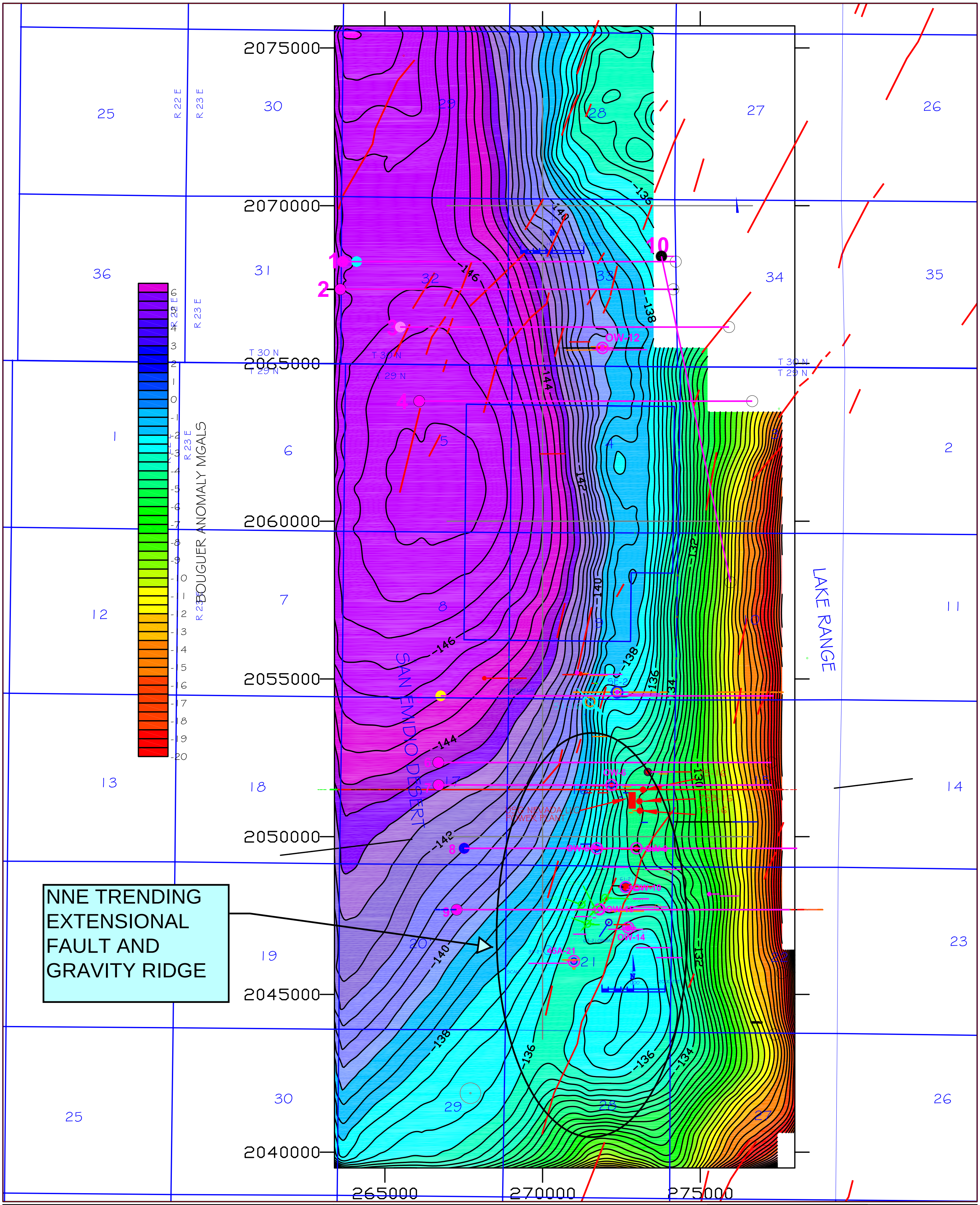
USG NEVADA, LLC.

LOCATION MAP - DOE COST SHARED OBSERVATION WELLS AND SHALLOW THERMAL ANOMALY

US Geothermal Inc

BY: WM. TEPLOW
REV: 4/16/2015

FIGURE 2



EXPLANATION

-136 COMPLETE BOUGUER GRAVITY CONTOUR INTERVAL 0.5 MGALS, US GEOTHERMAL SURVEY, JUNE, 2012)

OW-6 COMPLETED DOE COST SHARED OBSERVATION WELL

6 LONG-OFFSET SEISMIC REFRACTION AND REFLECTION LINE

FAULT SEGMENT WITH MAXIMUM DILATIONAL TENDENCY (RHODES, MOECK, 2011)

EXISTING PRODUCTION WELL

NEVADA STATE PLANE COORDINATES NAD 27 ZONE: NEVADA WEST

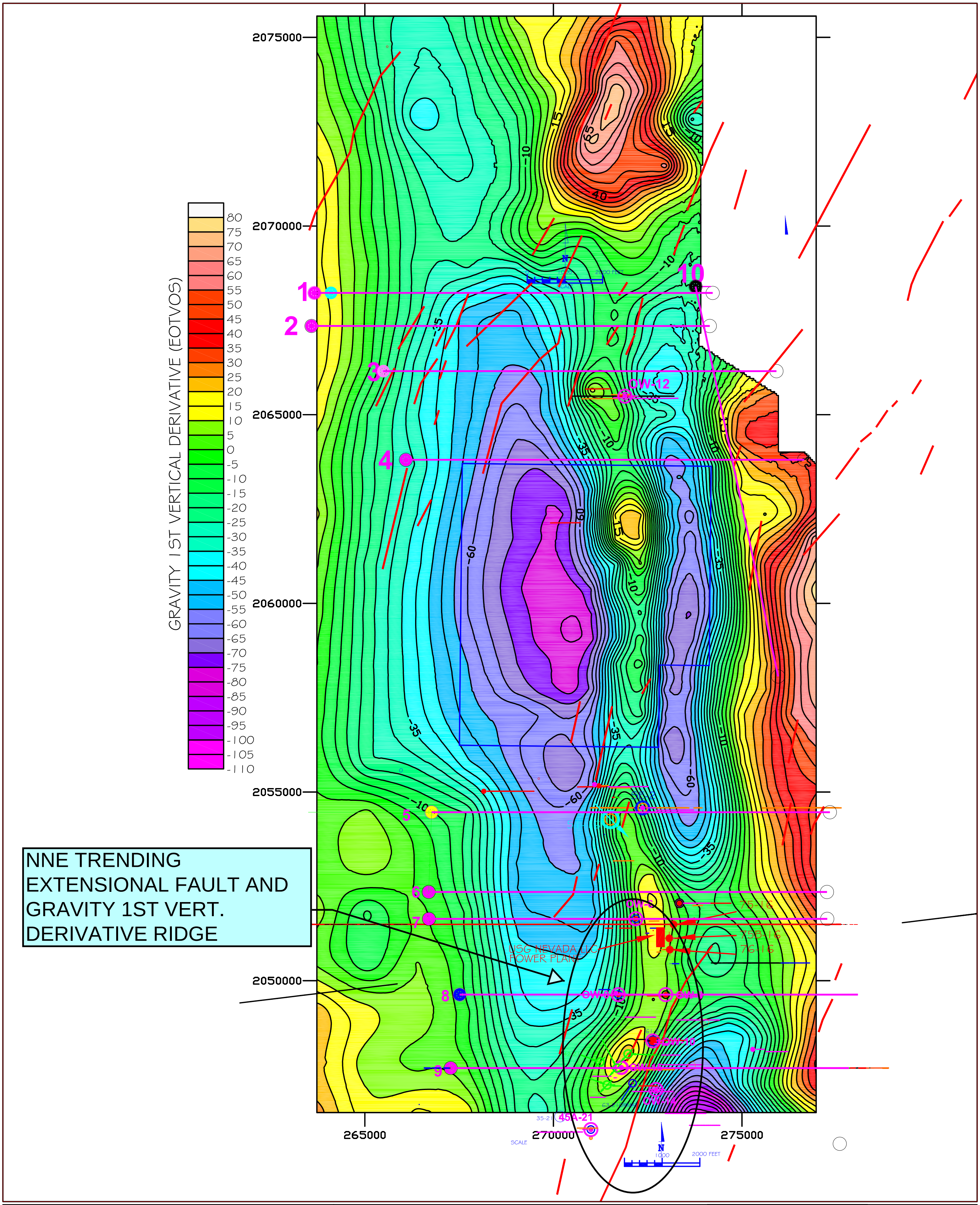
SAN EMIDIO GEOTHERMAL PROJECT

COMPLETE BOUGUER GRAVITY

US Geothermal Inc
CLEAN GREEN RENEWABLE ENERGY

FIGURE 3

BY: WM. TEPLOW
DATE 4/16/2015



EXPLANATION

GRAVITY 1ST VERTICAL DERIVATIVE CONTOUR INTERVAL 5 EOTVOS US GEOTHERMAL SURVEY, JUNE, 2008)

FAULT SEGMENT WITH MAXIMUM DILATIONAL TENDENCY (MOECK, 2011)

EXISTING PRODUCTION WELL

EXISTING INJECTION WELL

7 SEISMIC REFLECTION/REFRACTION PROFILE OCTOBER 2010 SURVEY

SURFACE FAULT TRACE (RHODES, 2011)

NEVADA STATE PLANE COORDINATES NAD 27 ZONE: NEVADA WEST

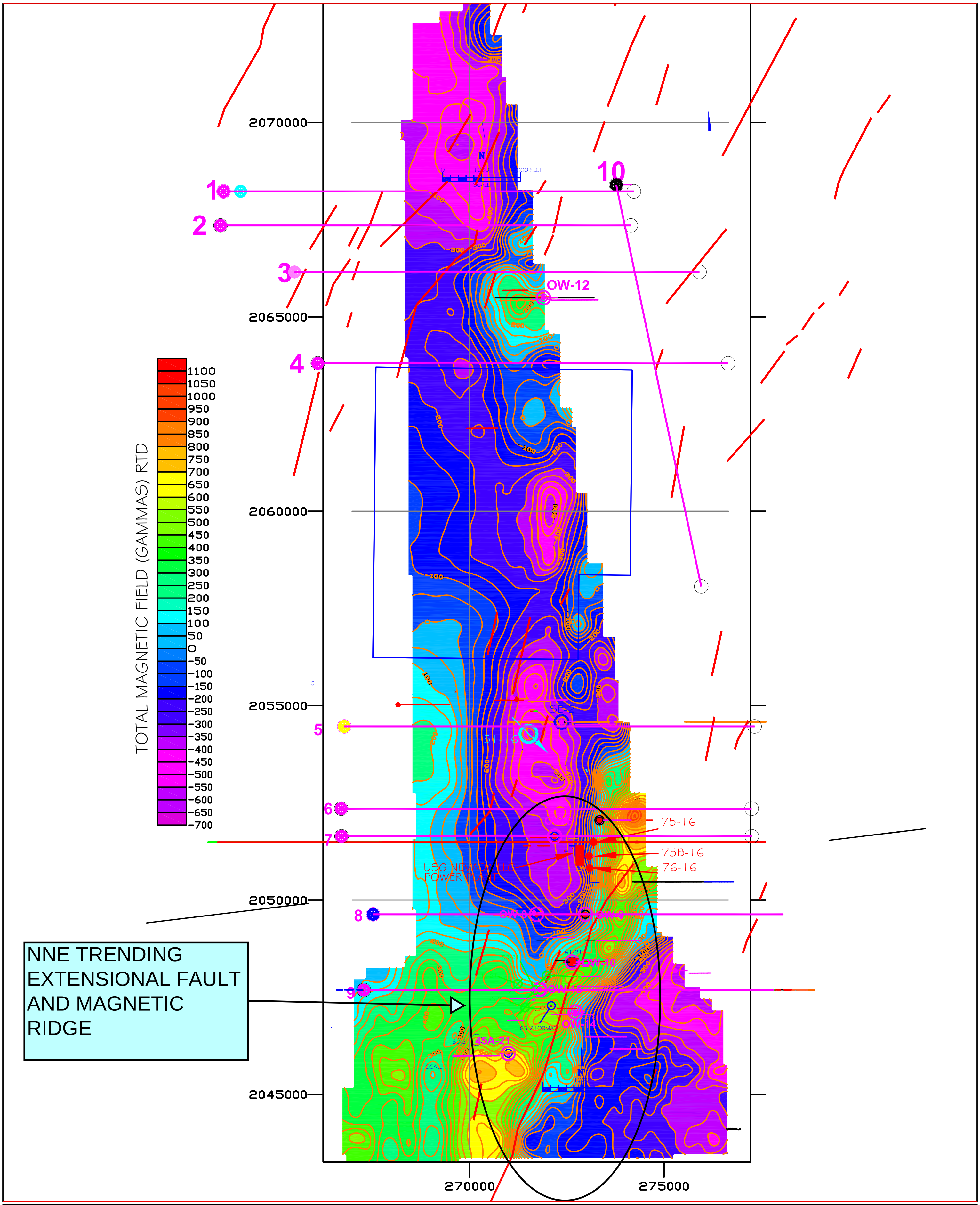
SAN EMIDIO GEOTHERMAL PROJECT

COMPLETE BOUGUER GRAVITY
1st VERTICAL DERIVATIVE

US Geothermal Inc
CLEAN GREEN RENEWABLE ENERGY

FIGURE 4

BY: WM. TEPLOW
DATE 4/16/2015



EXPLANATION

CONTOURS, TOTAL MAGNETIC FIELD ANOMALY (GAMMAS)

OW-6 COMPLETED DOE COST SHARED OBSERVATION WELL

6 LONG-OFFSET SEISMIC REFRACTION AND REFLECTION LINE

FAULT SEGMENT WITH MAXIMUM DILATIONAL TENDENCY (RHODES, MOECK, 2011)

EXISTING PRODUCTION WELL

NEVADA STATE PLANE COORDINATES NAD 27 ZONE: NEVADA WEST

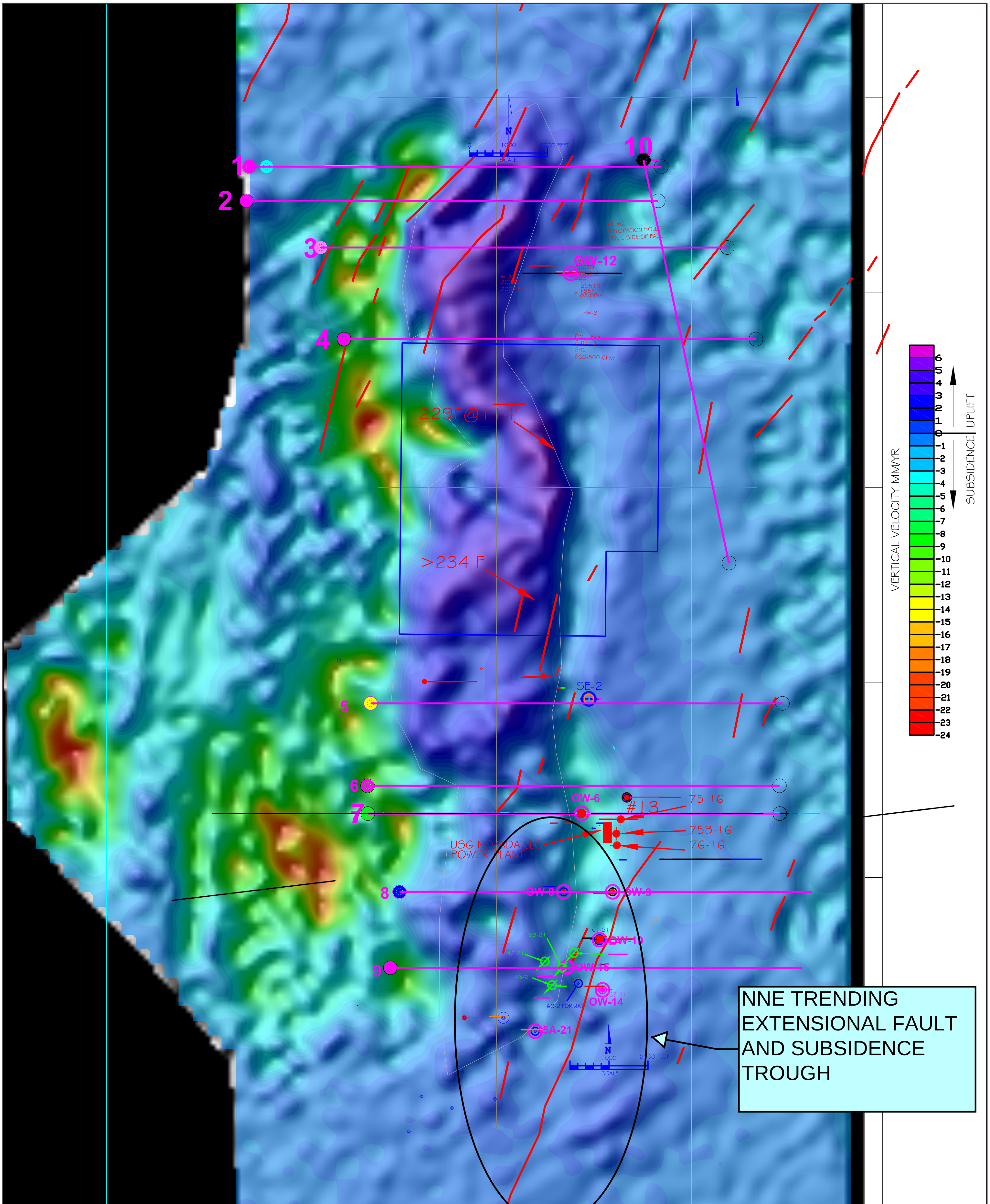
USG NEVADA, LLC.

GROUND MAGNETIC SURVEY
TOTAL FIELD STRENGTH RTD

US Geothermal Inc
CLEAN GREEN RENEWABLE ENERGY

FIGURE 5

BY: WM. TEPLOW
4/17/2015



EXPLANATION

- EXISTING PRODUCTION WELL
- EXISTING INJECTION WELL
- FAULT SEGMENT WITH MAXIMUM DILATIONAL TENDENCY (MOECK, 2011)

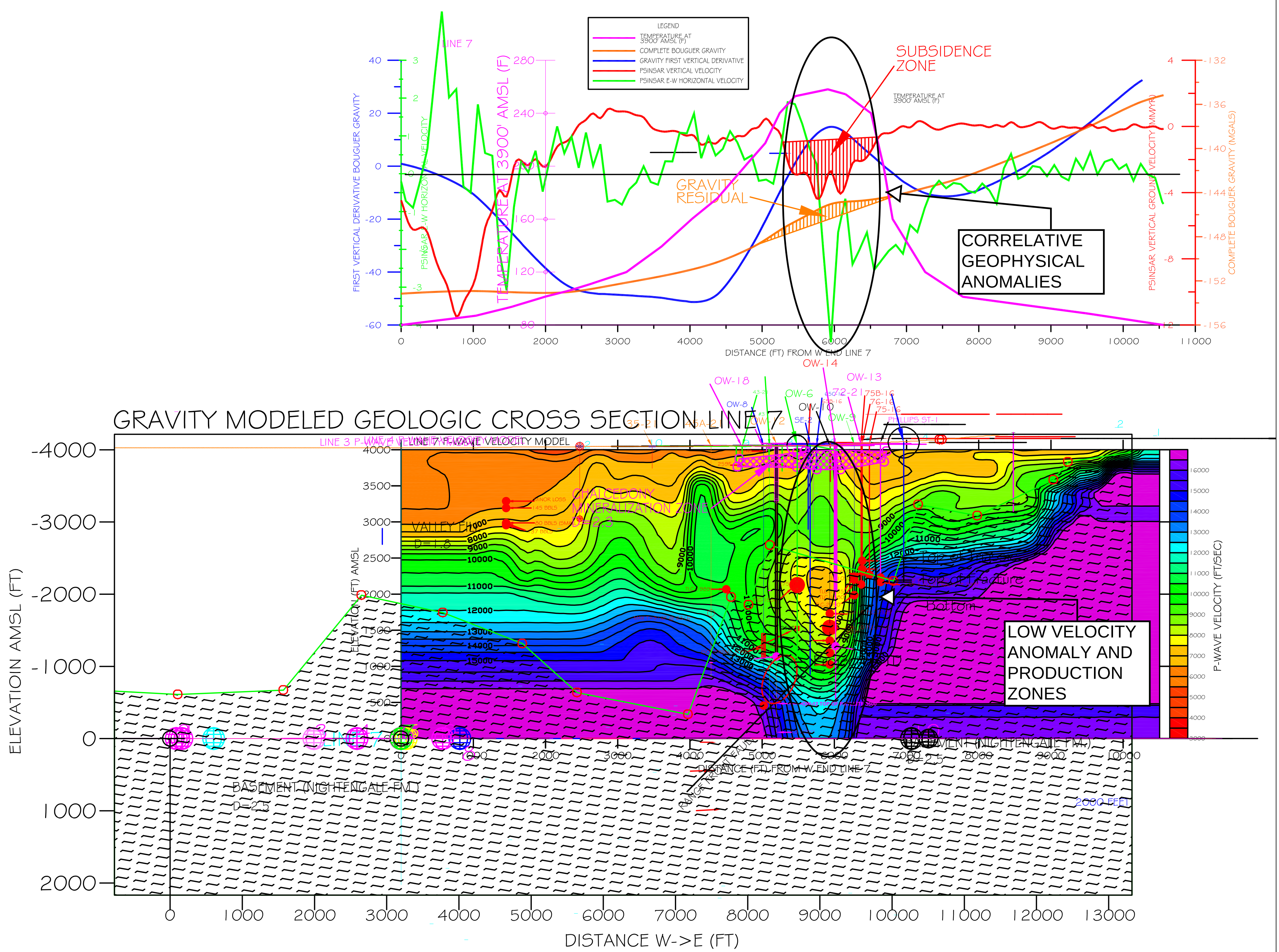
SAN EMIDIO GEOTHERMAL PROJECT

PSINSAR-DERIVED GROUND SURFACE VERTICAL VELOCITY (ENEVA, 2010)

US Geothermal Inc

FIGURE 5A

DATE 7/19/2015



EXPLANATION

LOST CIRCULATION ZONE

SAN EMIDIO GEOTHERMAL PROJECT

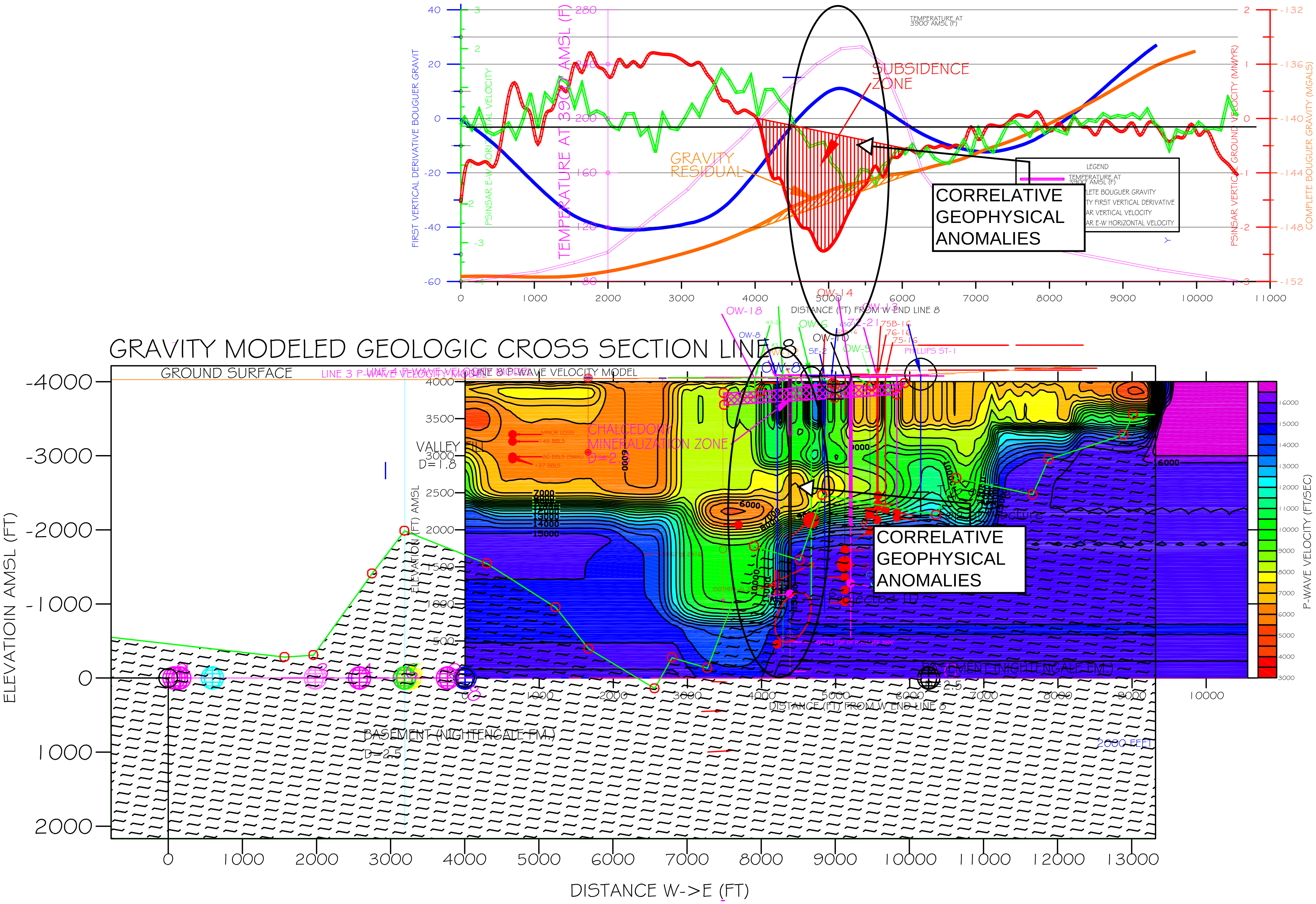
SEISMIC LINE 7 P-WAVE VELOCITY MODEL AND GEOPHYSICAL CORRELATIONS

US Geothermal Inc

DATE: 7/16/2015

BY: WM. TEPLOW

FIGURE 6



EXPLANATION

LOST CIRCULATION ZONE

SAN EMIDIO GEOTHERMAL PROJECT

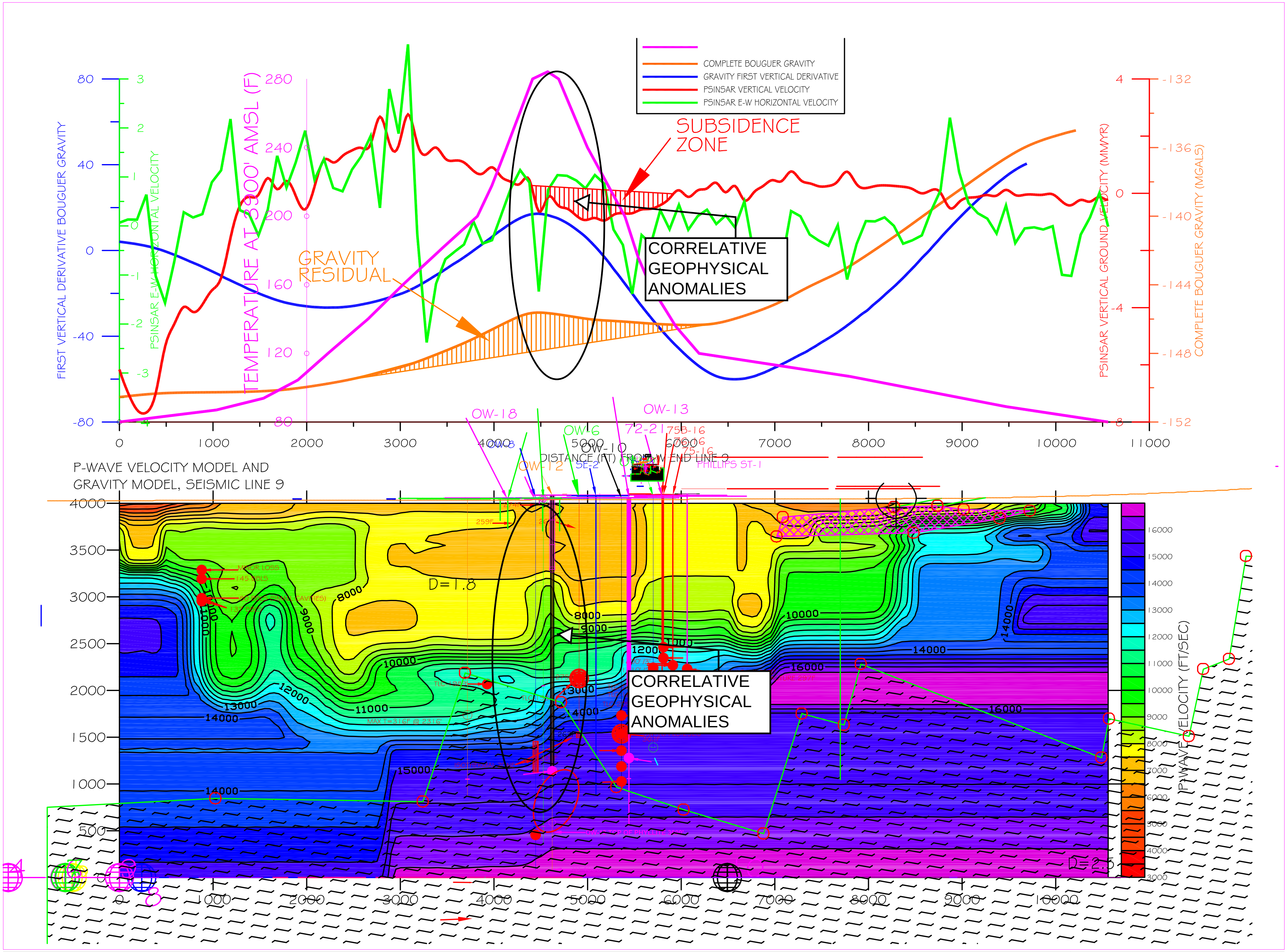
SEISMIC LINE 8 P-WAVE VELOCITY MODEL AND GEOPHYSICAL CORRELATIONS

US Geothermal Inc

DATE: 7/16/2015

BY: WM. TEPLOW

FIGURE 7



EXPLANATION

SAN EMIDIO GEOTHERMAL PROJECT

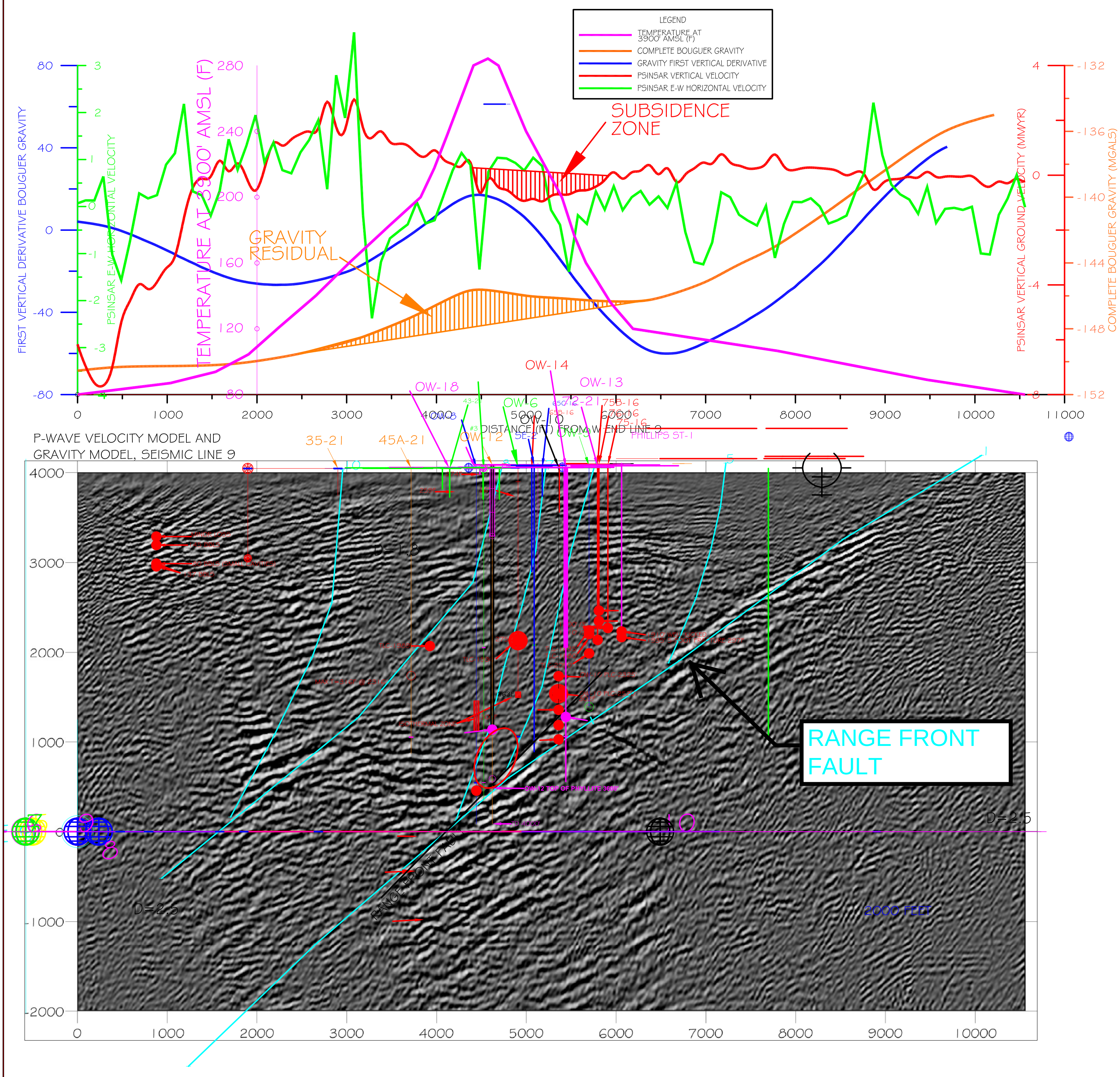
SEISMIC LINE 9 P-WAVE VELOCITY MODEL AND GEOPHYSICAL CORRELATIONS

US Geothermal Inc

DATE: 5/12/2015

BY: WM. TEPLOW

FIGURE 8



EXPLANATION	
	LOST CIRCULATION ZONE
	TOP OF TRIASSIC PHYLLITE (NIGHTINGALE FORMATION)

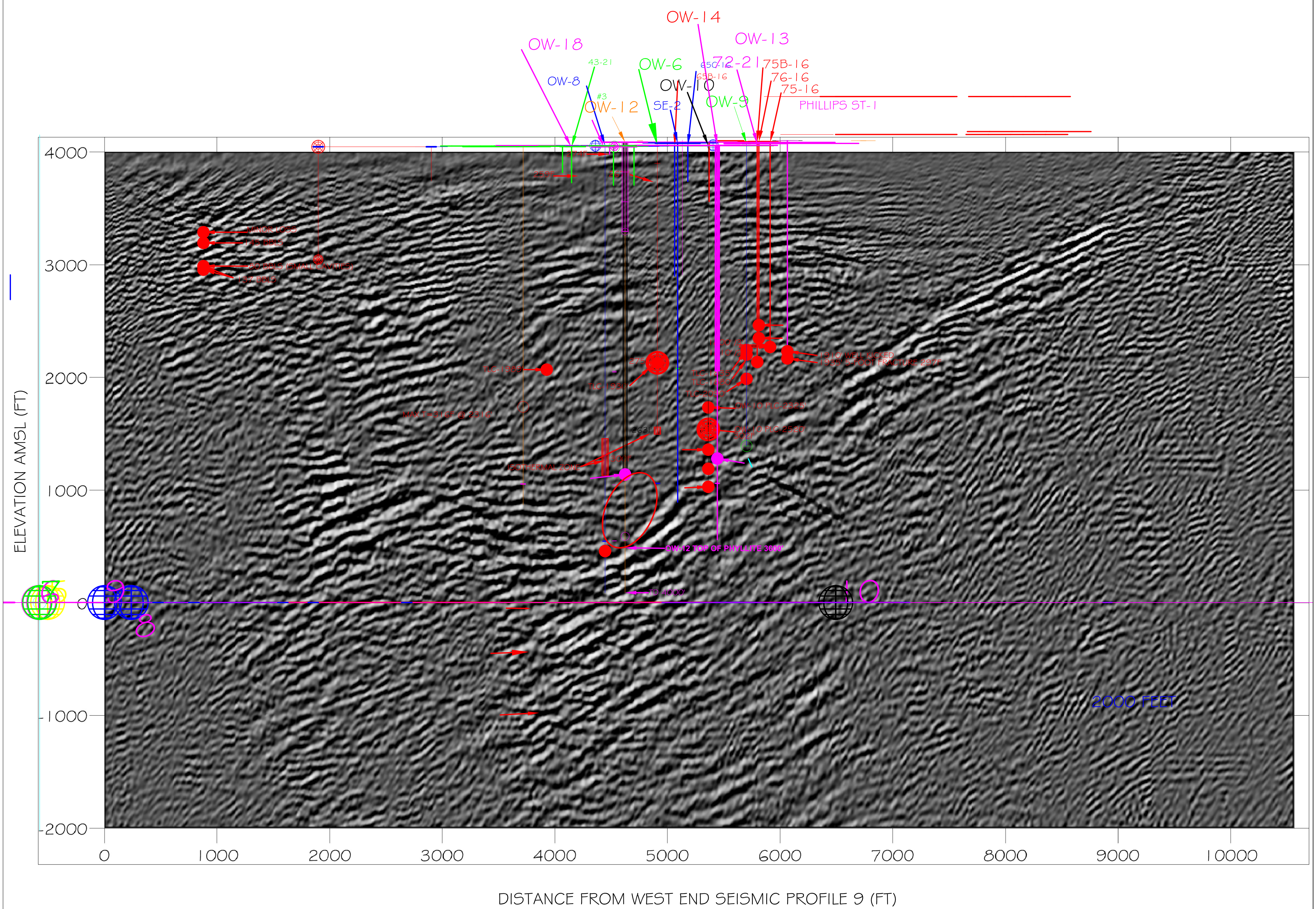
SAN EMIDIO GEOTHERMAL PROJECT

SEISMIC REFLECTION PROFILE 9 AND GEOPHYSICAL PROFILES

US Geothermal Inc
CLEAN GREEN RENEWABLE ENERGY

FIGURE 8A

BY: WM. TEPLOW
DATE 7/28/2015



EXPLANATION

TOP OF TRIASSIC PHYLLITE (NIGHTINGALE FORMATION)

LOST CIRCULATION ZONE

SAN EMIDIO GEOTHERMAL PROJECT

SEISMIC REFLECTION PROFILE 9 DETAIL

US Geothermal Inc

DATE: 7/28/2015

FIGURE 8B

BY: WM. TEPLOW

FIGURE 9: STATIC TEMPERATURE PROFILES-SAN EMIDIO OBSERVATION WELLS

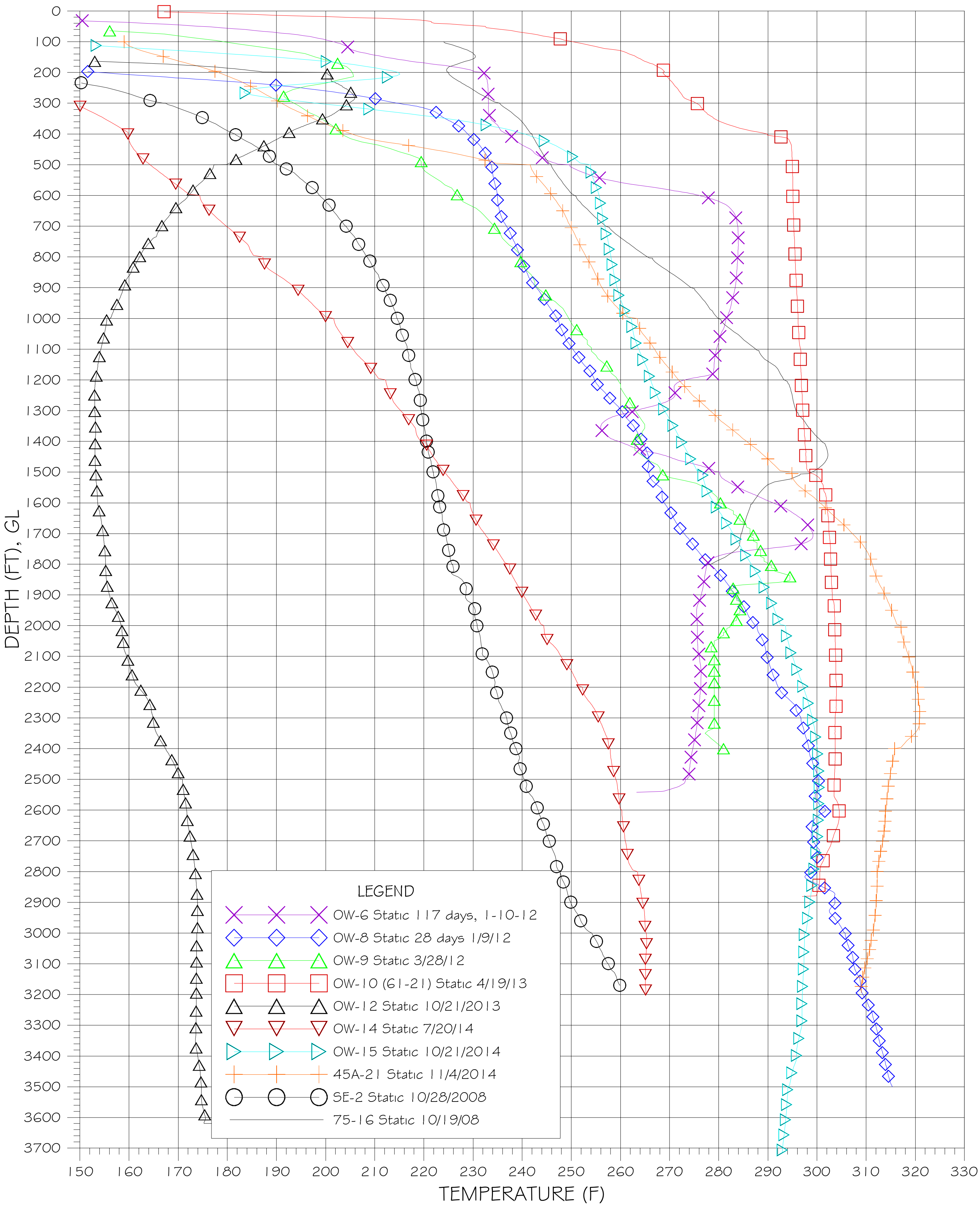
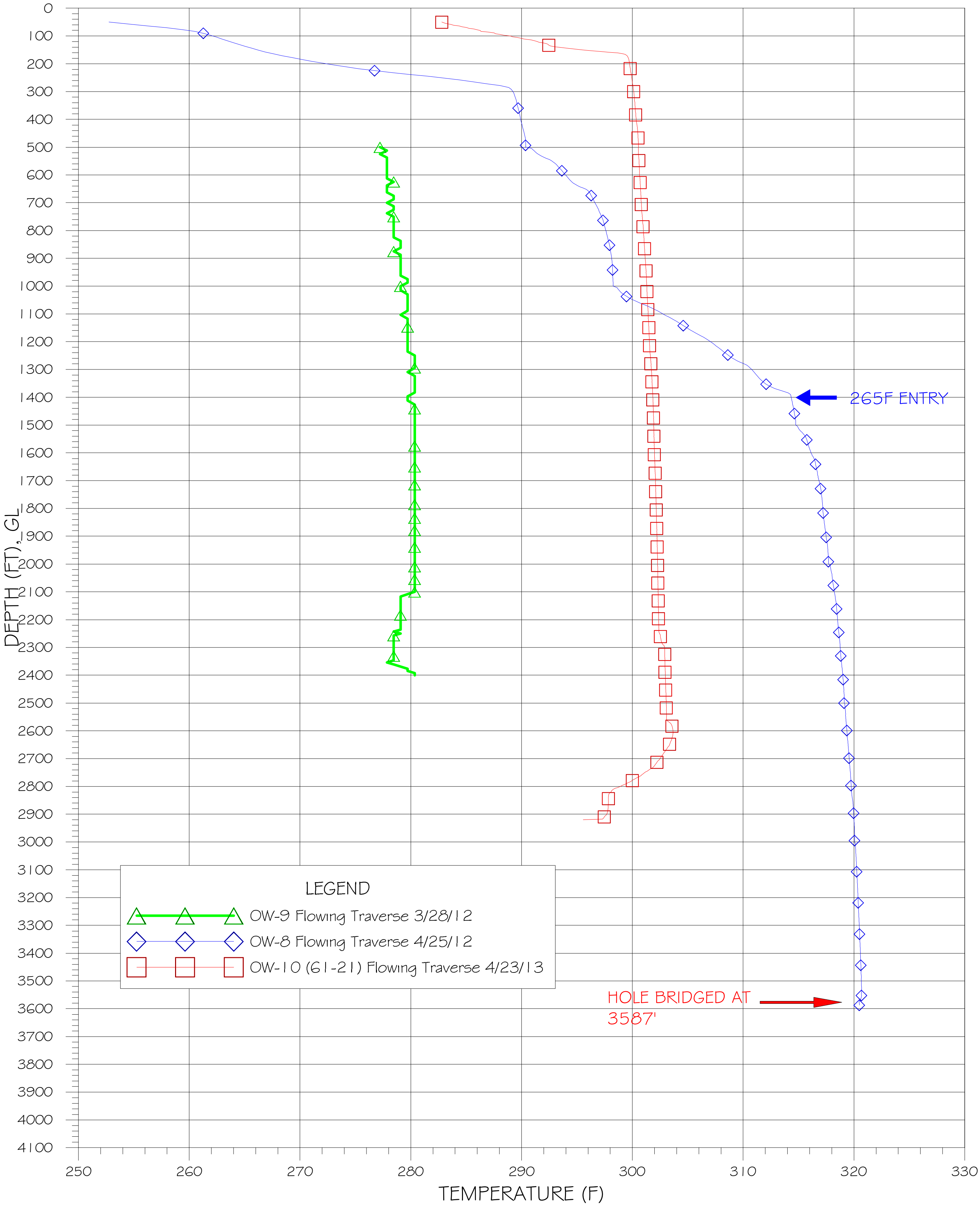
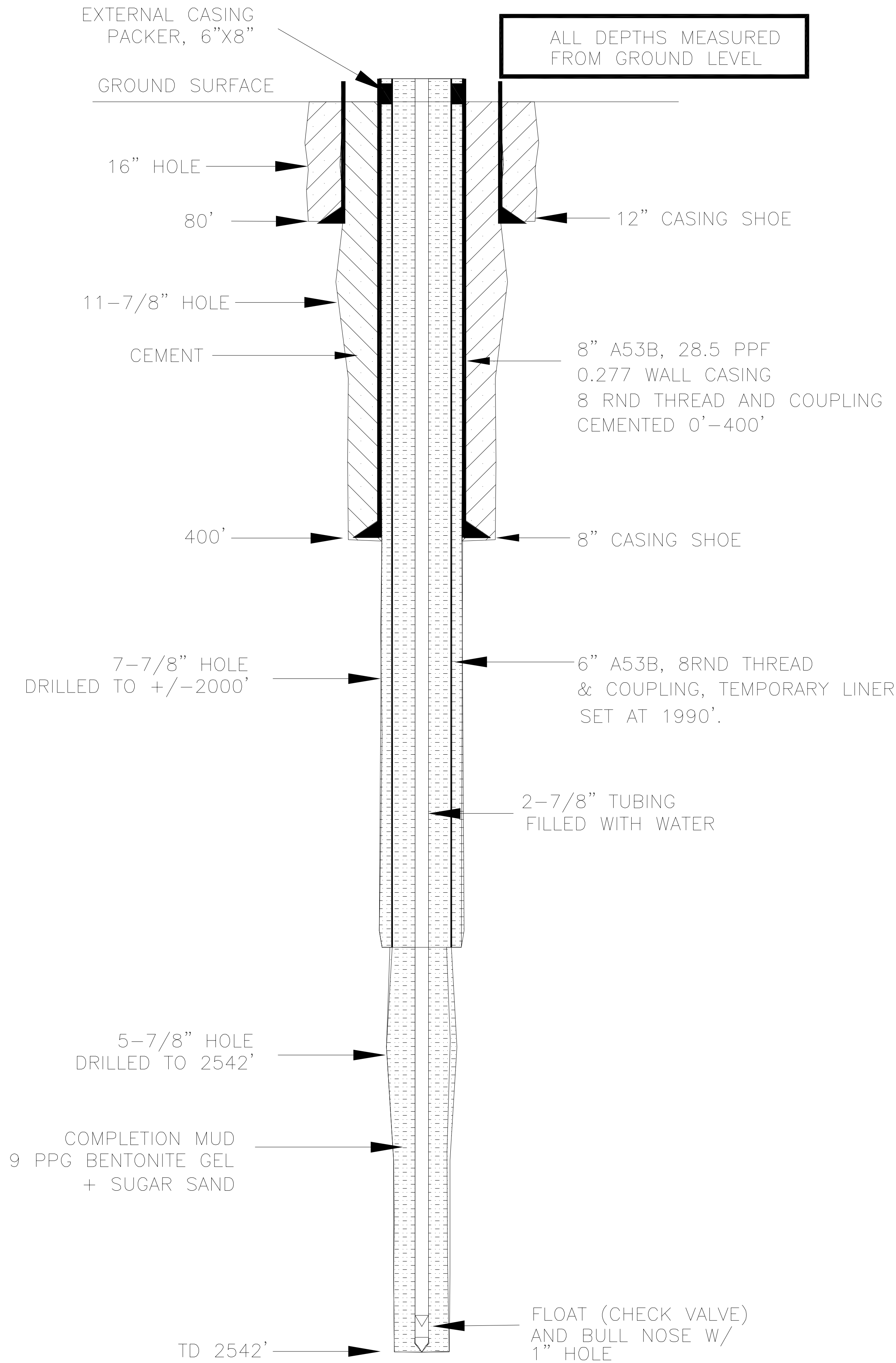


FIGURE 10: FLOWING TEMPERATURE PROFILES, OW-8, 9 AND10





EXPLANATION

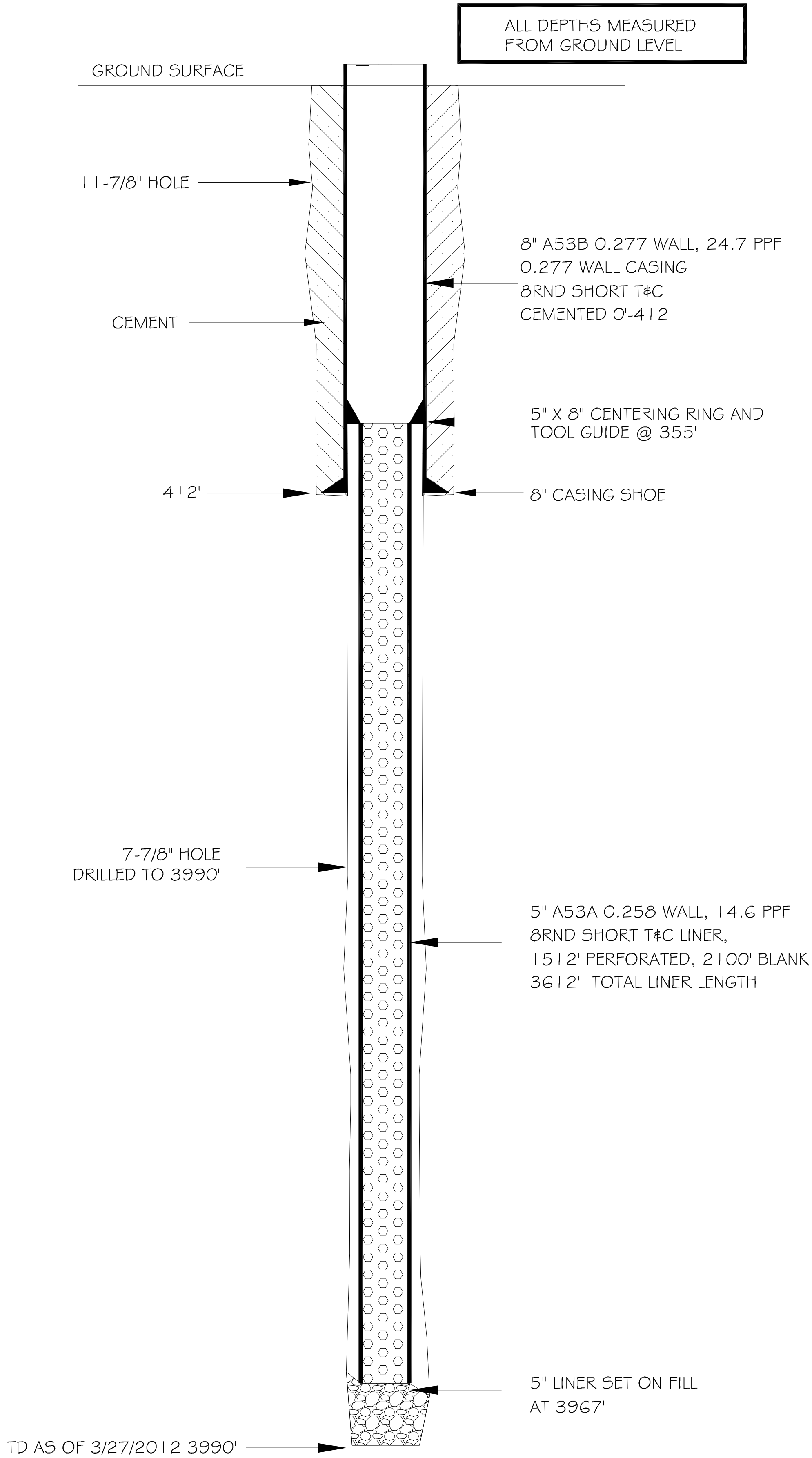
USG NEVADA, LLC.

SAN EMIDIO OBSERVATION WELL OW-6
AS-BUILT CASING SCHEMATIC 9/13/11

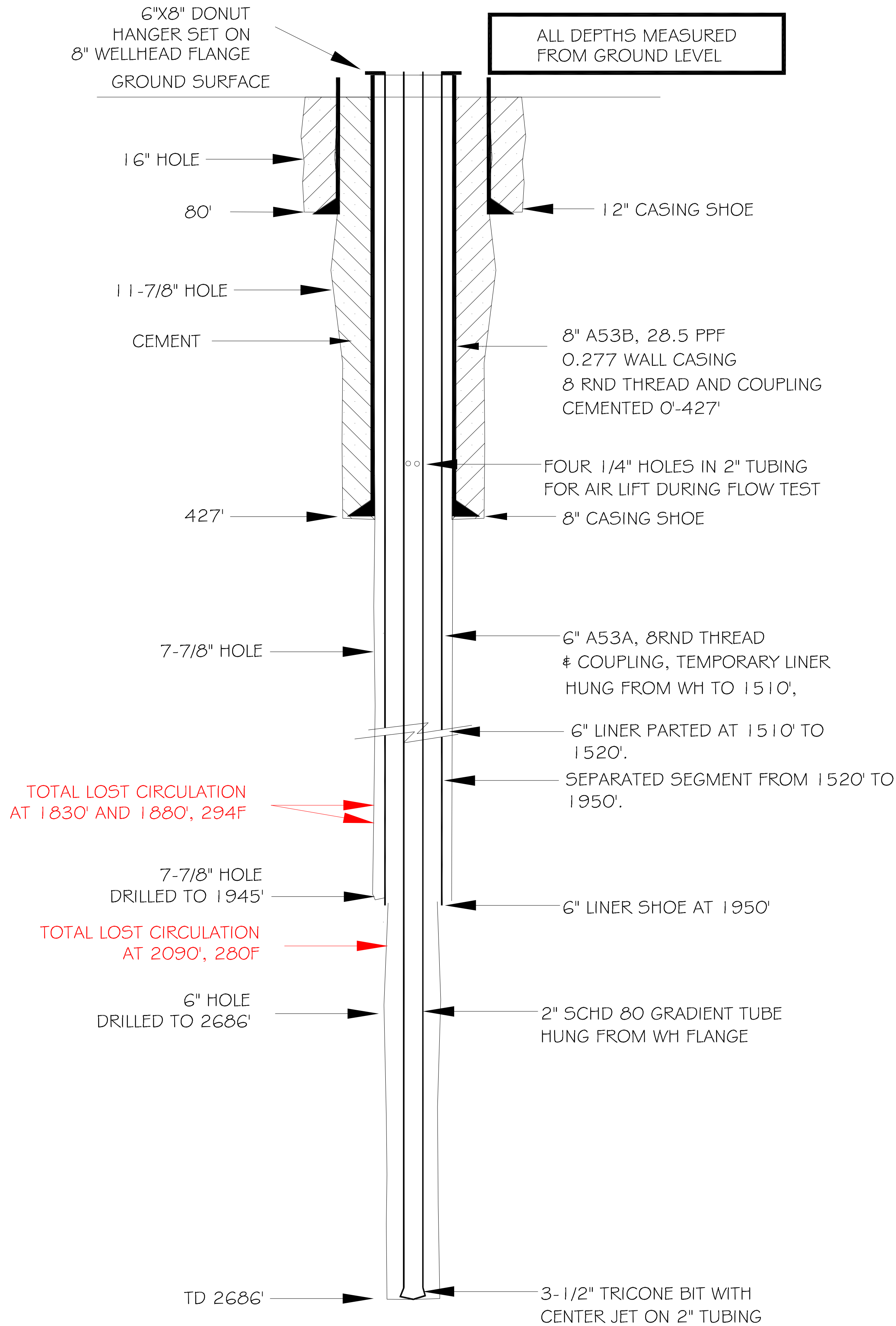
US Geothermal Inc
CLEAN GREEN RENEWABLE ENERGY

FIGURE 11

BY: WM. TEPLOW
DATE 1/11/2012



EXPLANATION	USG NEVADA, LLC. SAN EMIDIO OBSERVATION WELL OW-8 CASING SCHEMATIC AS-BUILT, 4/12/2012	US Geothermal Inc CLEAN GREEN RENEWABLE ENERGY	FIGURE 12 BY: WM. TEPLOW DATE 4/13/2012



EXPLANATION

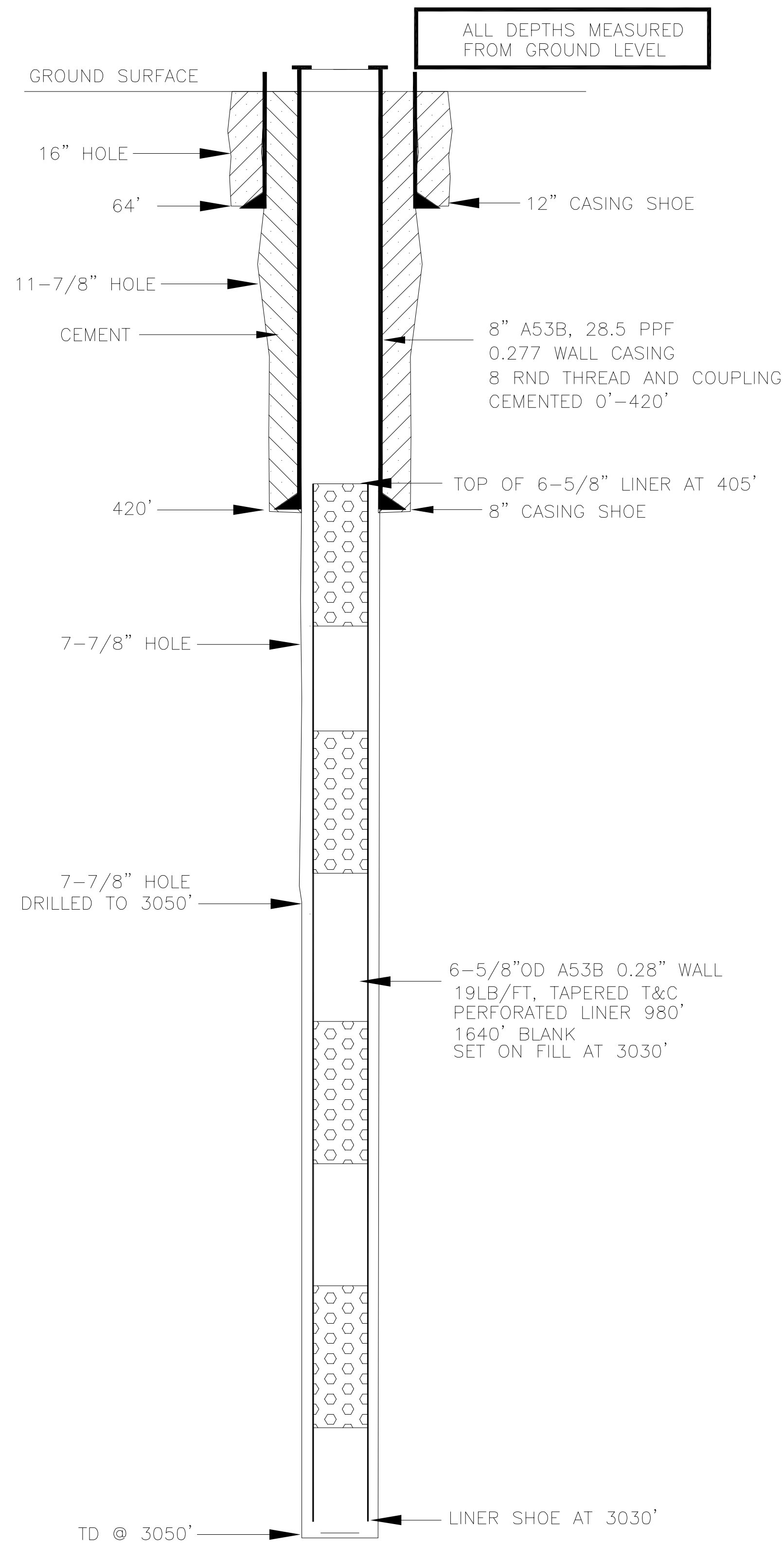
USG NEVADA, LLC.

SAN EMIDIO OBSERVATION WELL OW-9
AS COMPLETED FOR 3/27-2/28 FLOW TEST

US Geothermal Inc
CLEAN GREEN RENEWABLE ENERGY

FIGURE 13

BY: WM. TEPLOW
DATE 2/28/2012



EXPLANATION

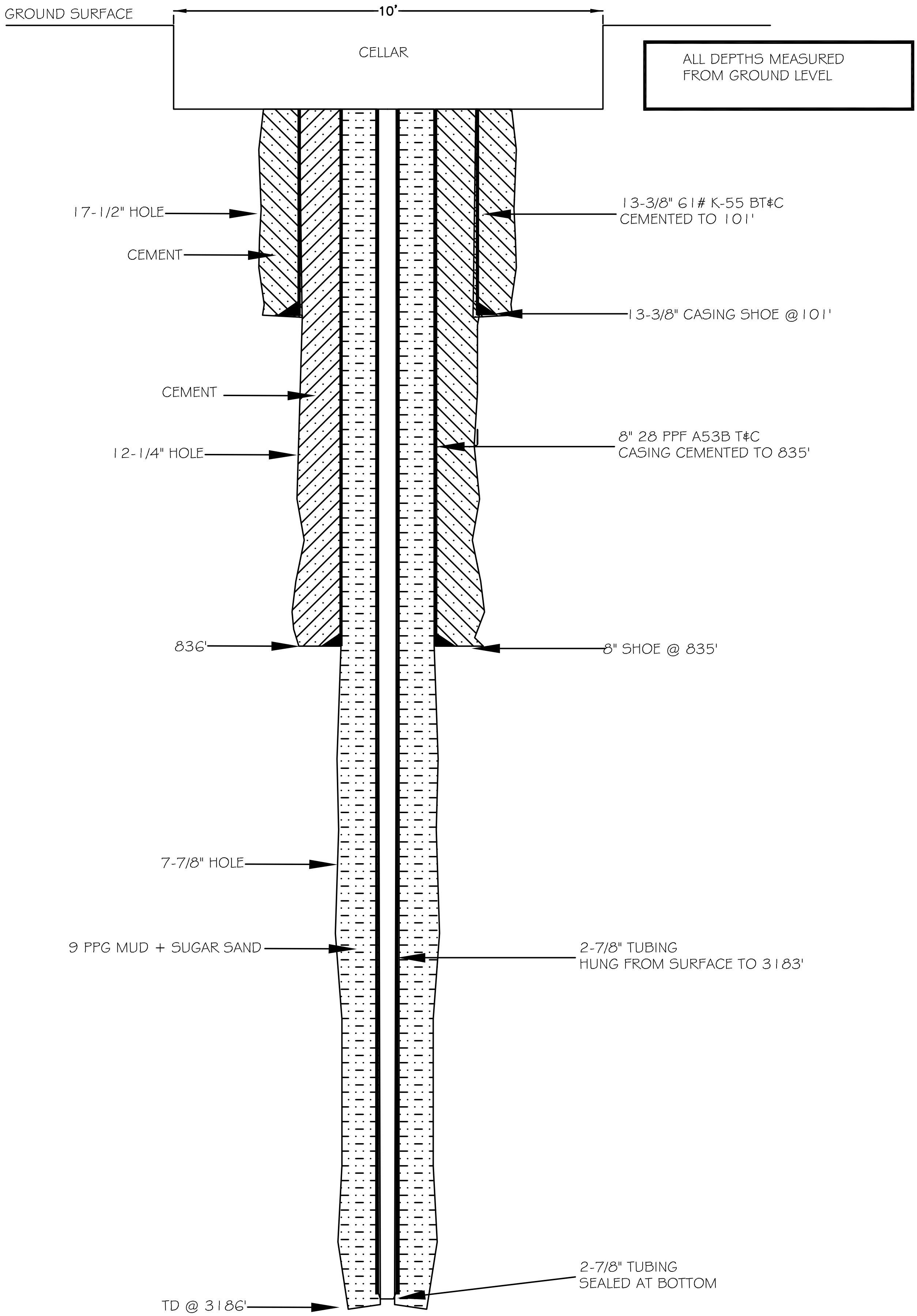
USG NEVADA, LLC.

SAN EMIDIO OBSERVATION WELL 61-21 (OW-10)
AS-BUILT COMPLETION SCHEMATIC

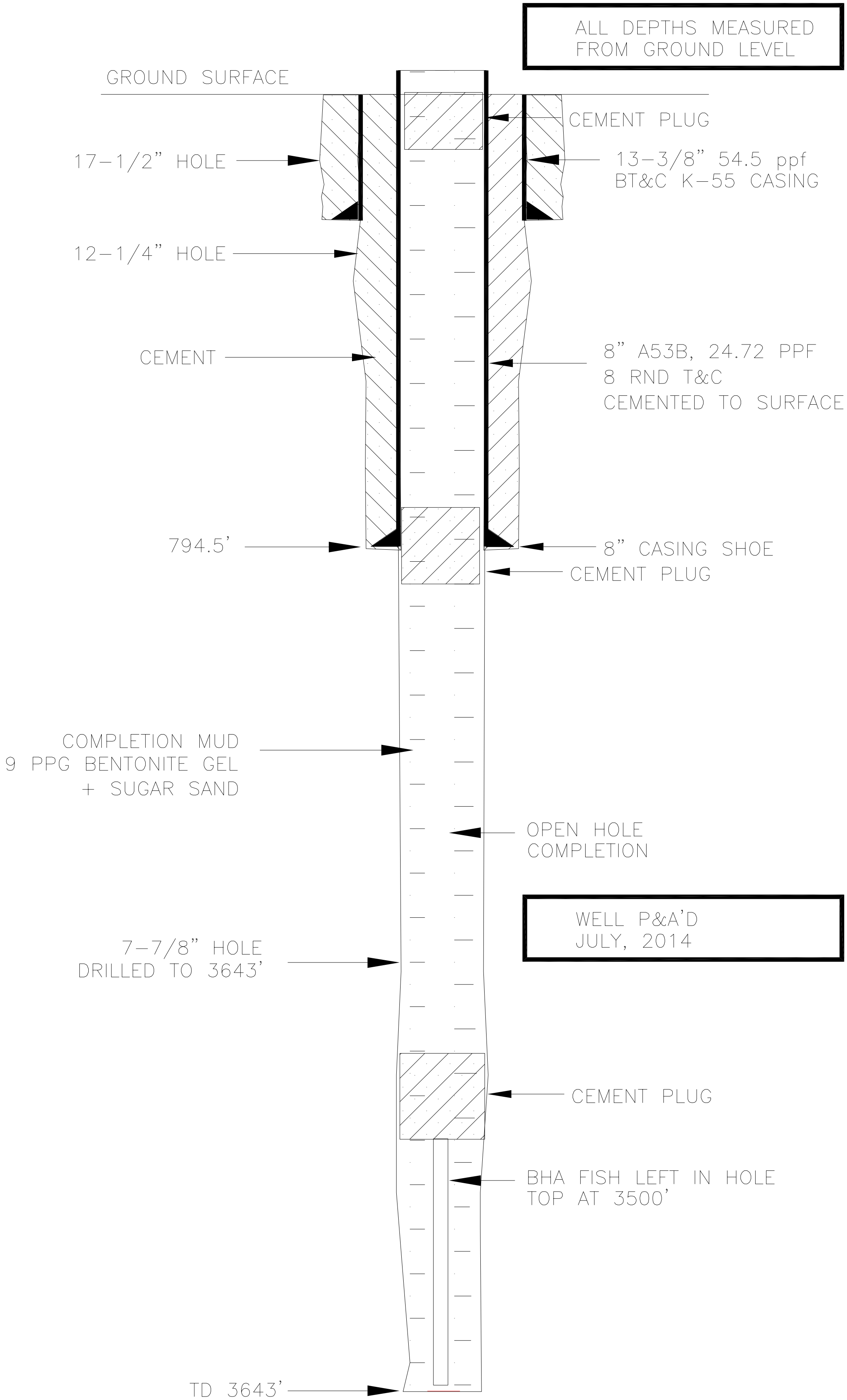
US Geothermal Inc
CLEAN GREEN RENEWABLE ENERGY

FIGURE 14

BY: WM. TEPLOW
DATE 12/4/2014



EXPLANATION	USG NEVADA, LLC. SAN EMIDIO WELL 45A-21 COMPLETION SCHEMATIC AS-BUILT 4/21/2012	US Geothermal Inc CLEAN GREEN RENEWABLE ENERGY	FIGURE 15 BY: WM. TEPLOW DATE 7/9/2012



EXPLANATION

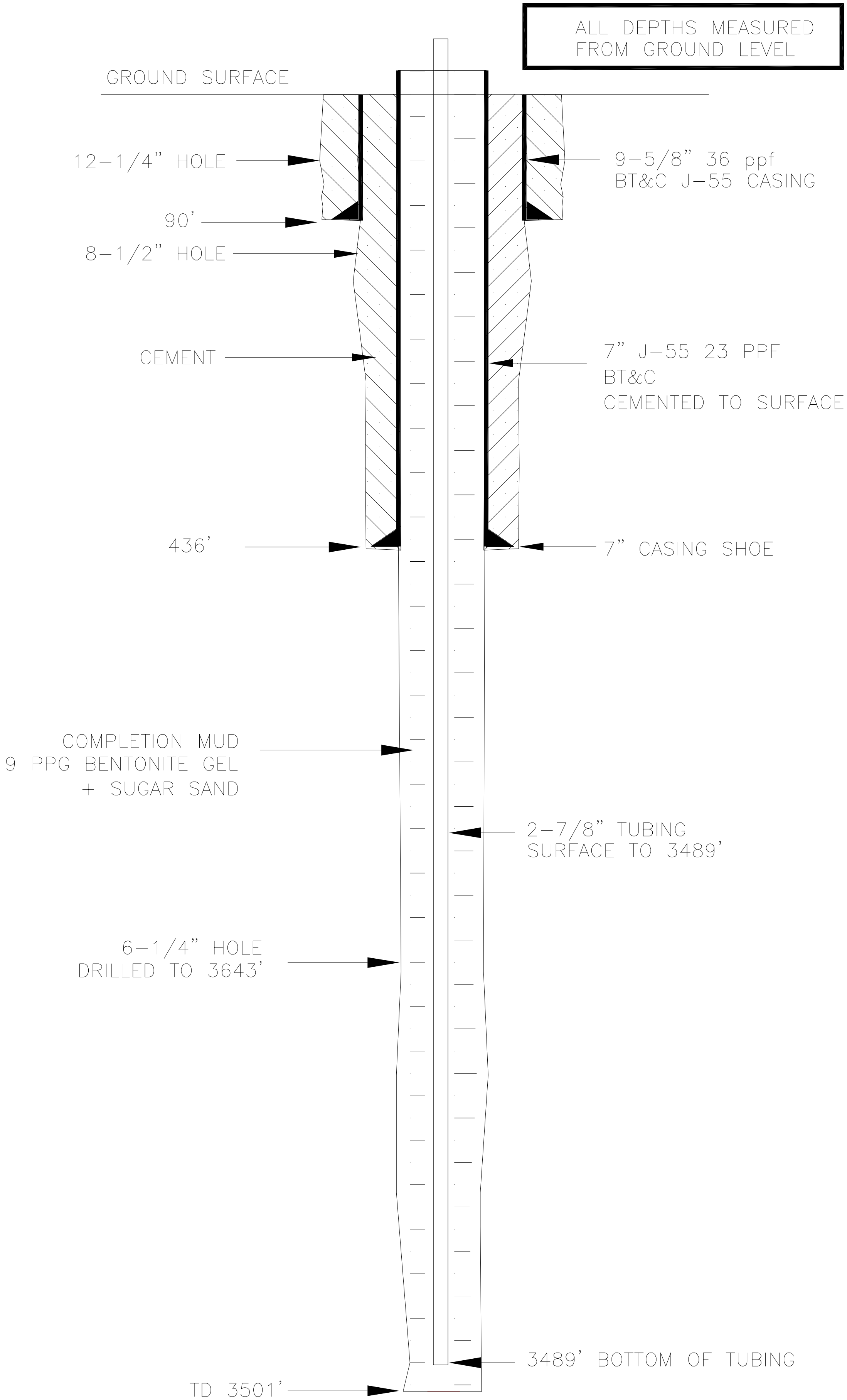
USG NEVADA, LLC.

SAN EMIDIO OBSERVATION WELL OW-12
CASING SCHEMATIC

US Geothermal Inc
CLEAN GREEN RENEWABLE ENERGY

FIGURE 16

BY: WM. TEPLOW
DATE 7/29/2014



EXPLANATION

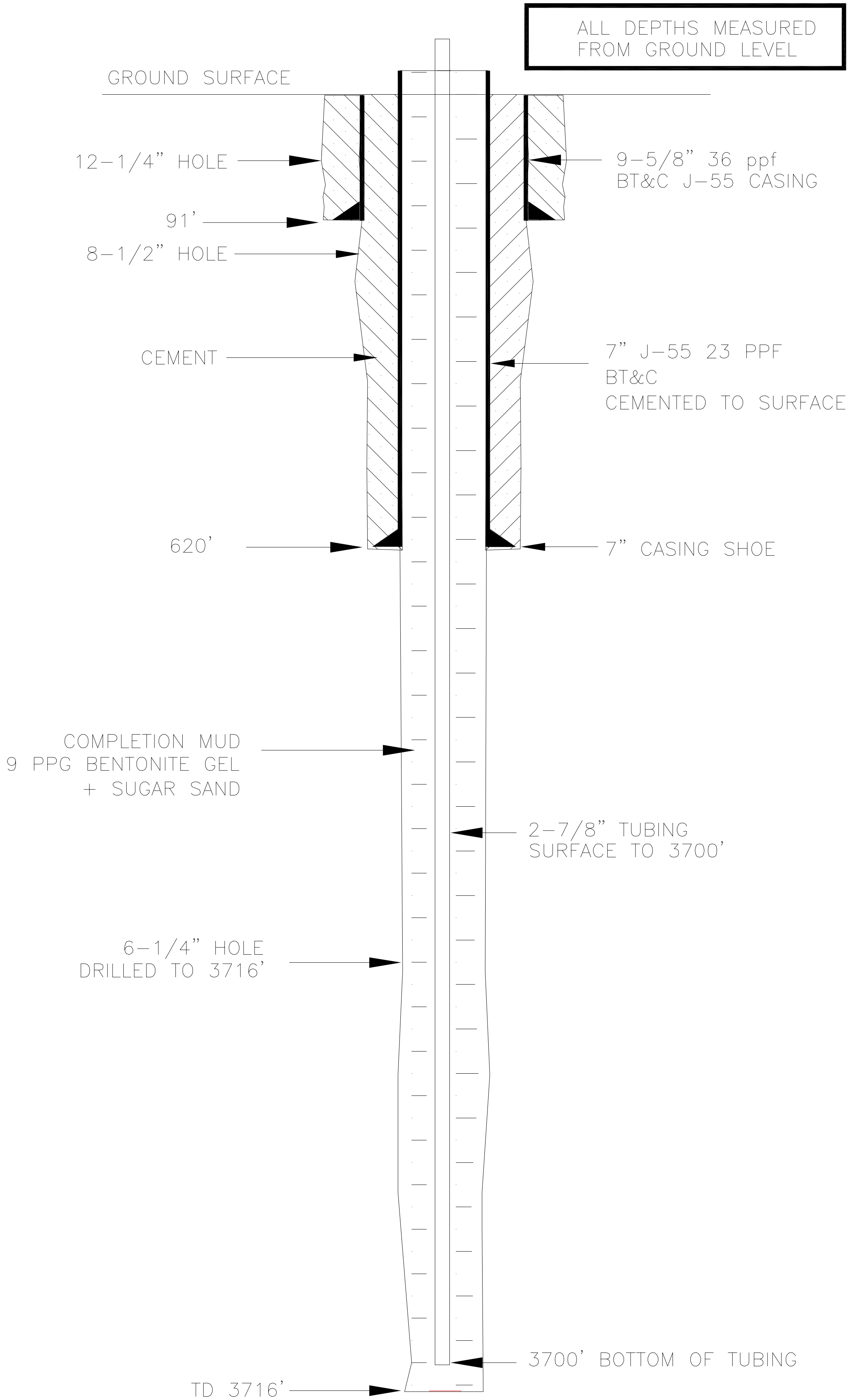
USG NEVADA, LLC.

SAN EMIDIO OBSERVATION WELL OW-14
CASING SCHEMATIC

US Geothermal Inc

FIGURE 17

BY: WM. TEPLOW
DATE 7/29/2014



EXPLANATION

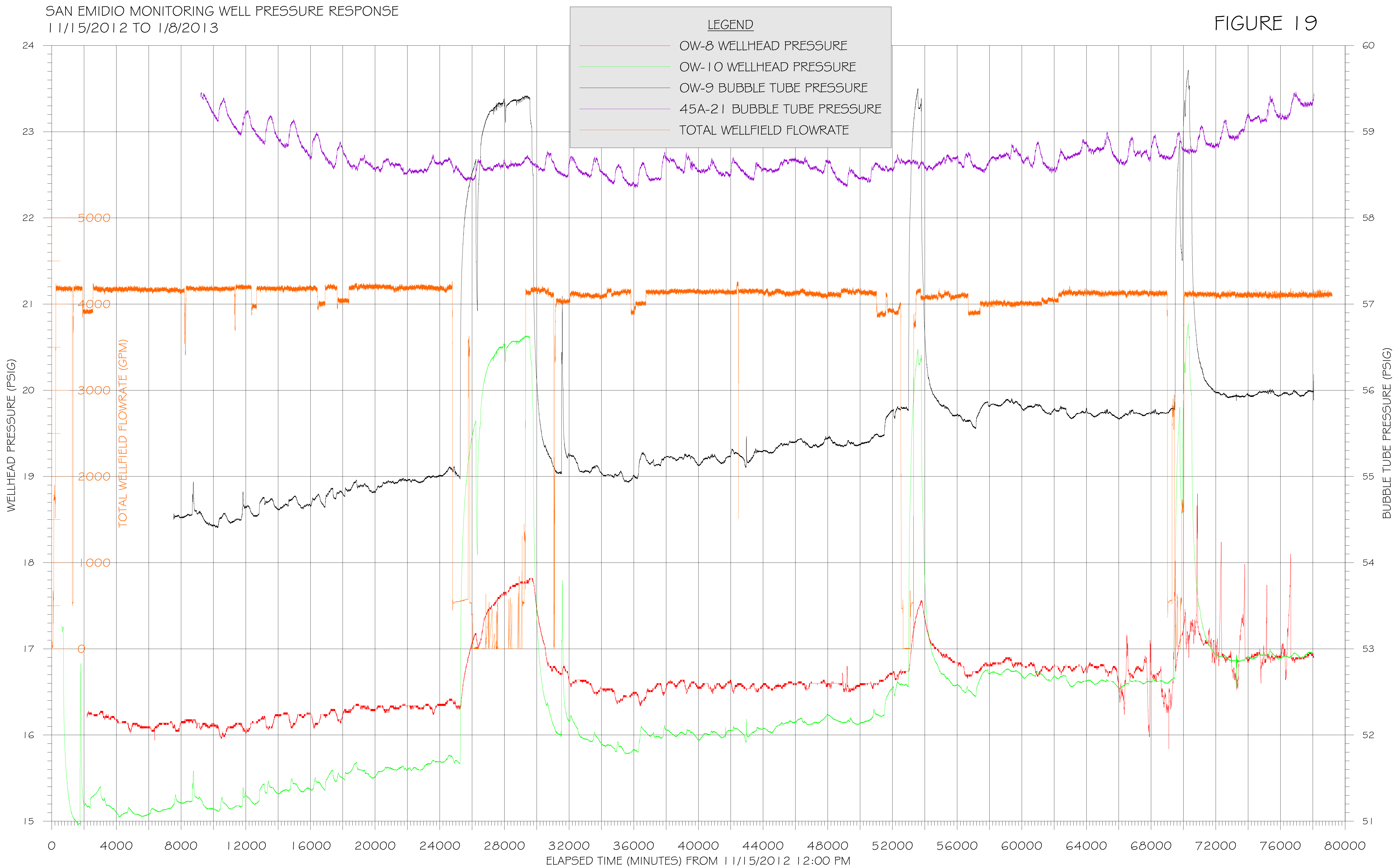
USG NEVADA, LLC.

SAN EMIDIO OBSERVATION WELL OW-15 (53A-21)
AS BUILT CASING SCHEMATIC

US Geothermal Inc

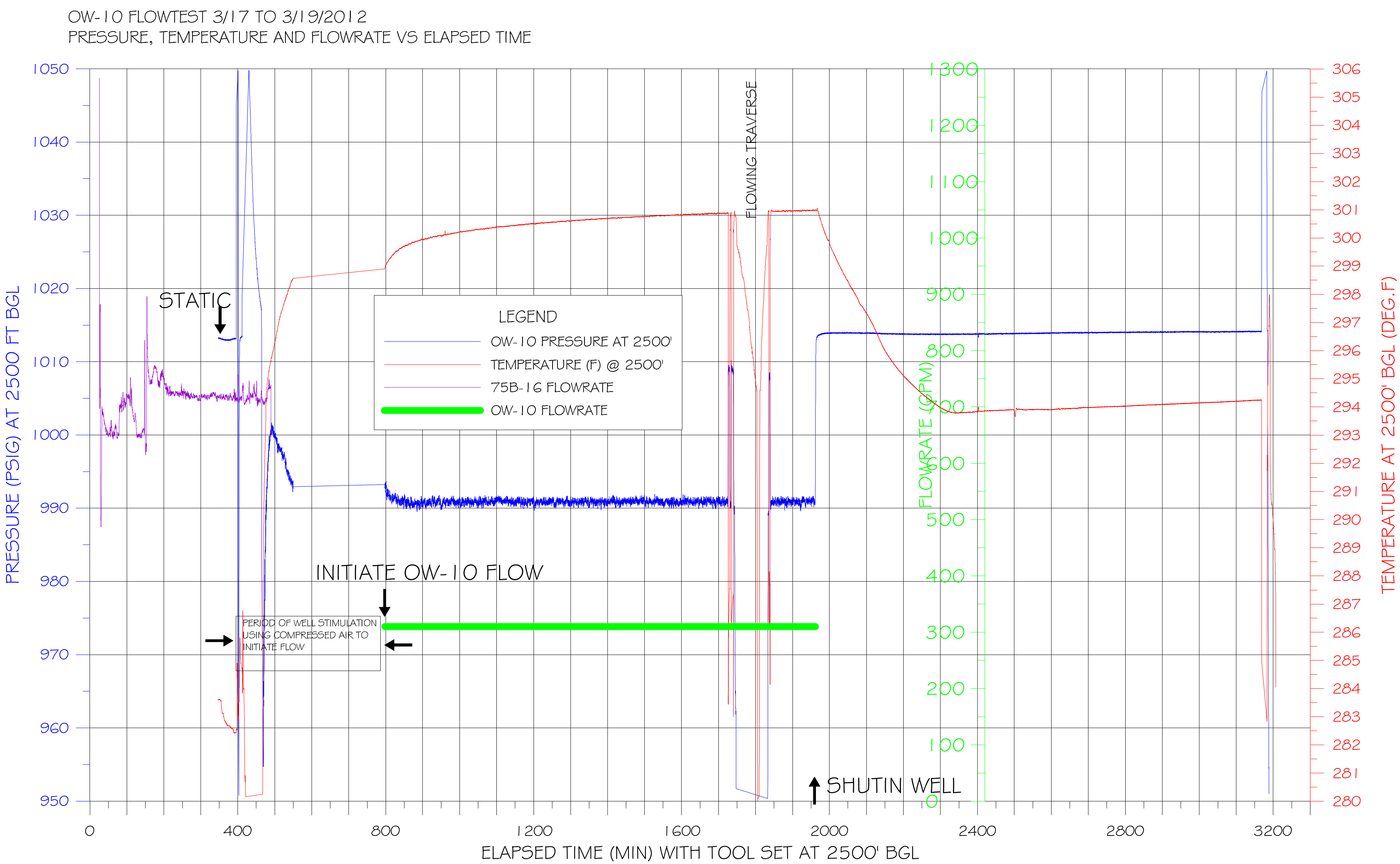
FIGURE 18

BY: WM. TEPLOW
DATE 12/4/2014



SAN EMIDIO MONITORING WELL PRESSURE RESPONSE
11/15/2012 TO 1/8/2013
FIGURE 19
LEGEND
OW-8 WELLHEAD PRESSURE
OW-10 WELLHEAD PRESSURE
OW-9 BUBBLE TUBE PRESSURE
45A-21 BUBBLE TUBE PRESSURE
TOTAL WELLFIELD FLOWRATE
WELLHEAD PRESSURE (PSIG)
TOTAL WELLFIELD FLOWRATE (GPM)
BUBBLE TUBE PRESSURE (PSIG)
ELAPSED TIME (MINUTES) FROM 11/15/2012 12:00 PM
24
23
22
21
20
19
18
17
16
15
5000
4000
3000
2000
1000
0
60
59
58
57
56
55
54
53
52
51
0
4000
8000
12000
16000
20000
24000
28000
32000
36000
40000
44000
48000
52000
56000
60000
64000
68000
72000
76000
80000

FIGURE 20


OW-10 FLOWTEST 3/17 TO 3/19/2012
PRESSURE, TEMPERATURE AND FLOWRATE VS ELAPSED TIME
PRESSURE (PSIG) AT 2500 FT BGL
TEMPERATURE AT 2500' BGL (DEG.F)
FLOWRATE (GPM)
ELAPSED TIME (MIN) WITH TOOL SET AT 2500' BGL
LEGEND
OW-10 PRESSURE AT 2500'
TEMPERATURE (F) @ 2500'
75B-16 FLOWRATE
OW-10 FLOWRATE
STATIC
INITIATE OW-10 FLOW
PERIOD OF WELL STIMULATION USING COMPRESSED AIR TO INITIATE FLOW
FLOWING TRAVERSE
SHUTIN WELL
1050
1040
1030
1020
1010
1000
990
980
970
960
950
0
400
800
1200
1600
2000
2400
2800
3200
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
306
305
304
303
302
301
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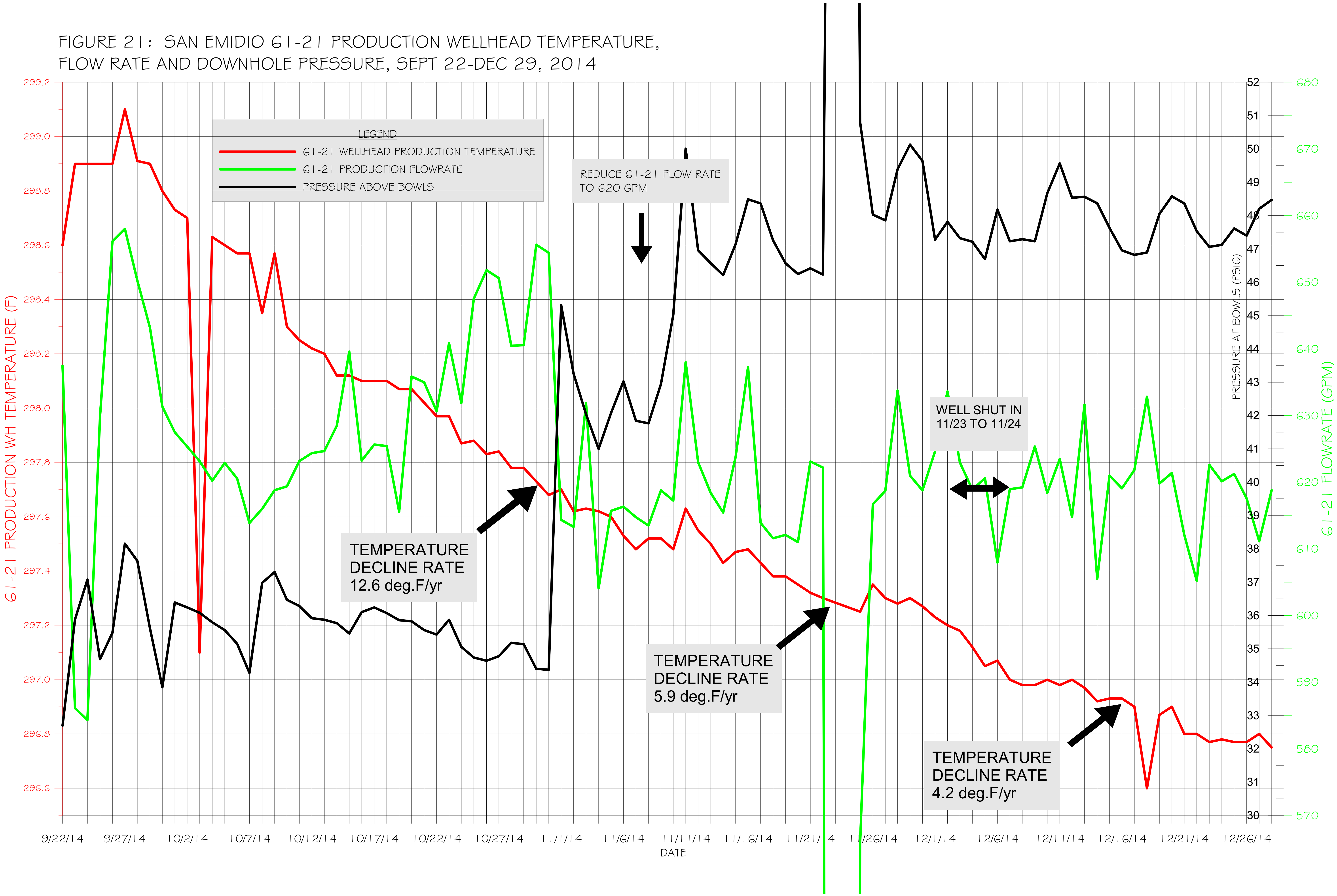
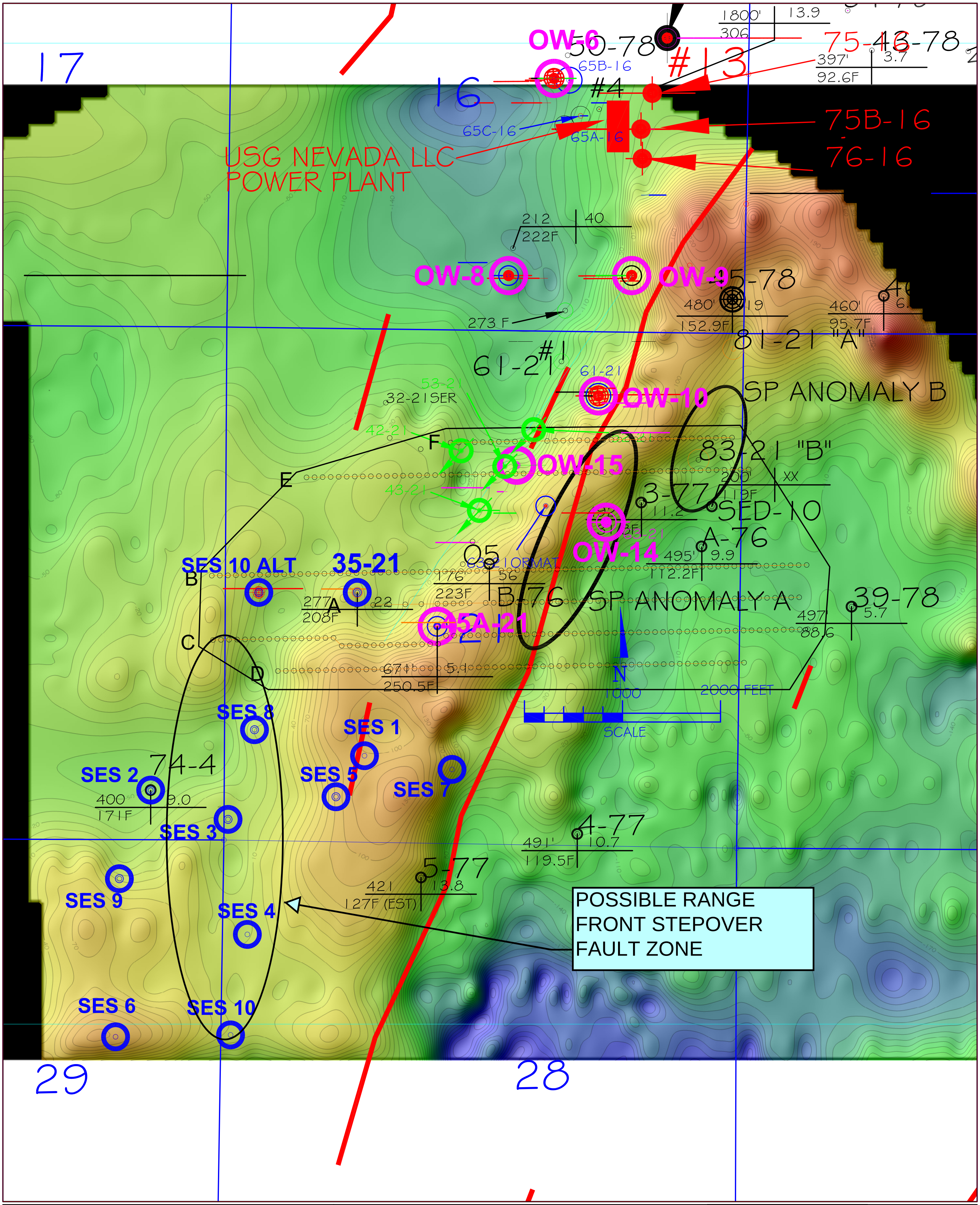
280

FIGURE 21: SAN EMIDIO 61-21 PRODUCTION WELLHEAD TEMPERATURE, FLOW RATE AND DOWNHOLE PRESSURE, SEPT 22-DEC 29, 2014





EXPLANATION

CONTOURS, TOTAL MAGNETIC FIELD ANOMALY (GAMMAS)

SES-5 PROPOSED 1000' TG HOLES

SP PROFILE SHOWING ELECTRODE LOCATIONS

FAULT SEGMENT WITH MAXIMUM DILATIONAL TENDENCY (RHODES, MOECK, 2011)

EXISTING PRODUCTION WELL

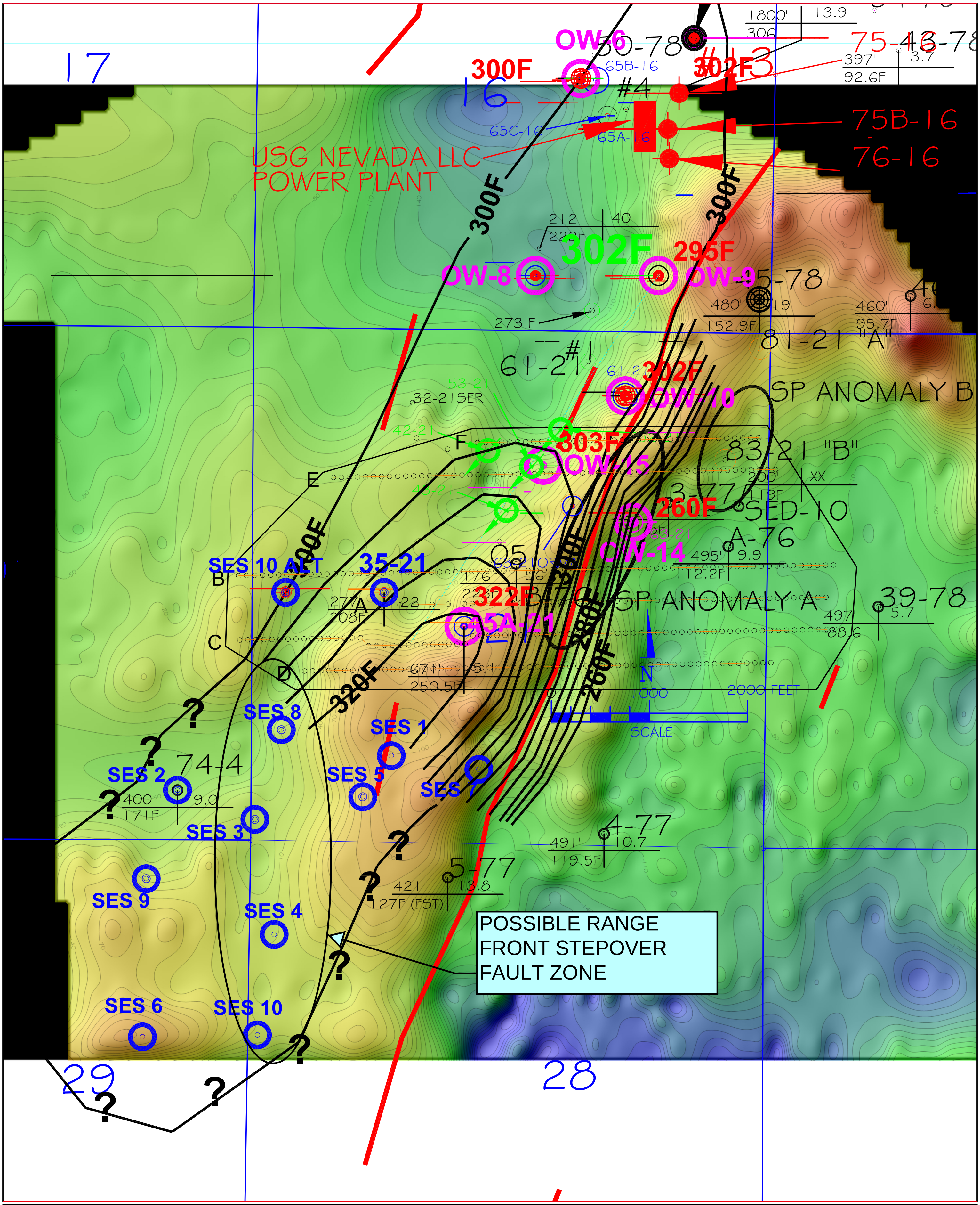
USG NEVADA, LLC.

GROUND MAGNETIC TOTAL FIELD STRENGTH RTD, SP ANOMALIES AND 1000-FT TG HOLE LOCATIONS

US Geothermal Inc

FIGURE 22

BY: WM. TEPLOW
7/28/2015



EXPLANATION

CONTOURS, TOTAL MAGNETIC FIELD ANOMALY (GAMMAS)

TEMPERATURE ISOTHERMS IN TERTIARY BASALT (F)

SES-5 PROPOSED 1000' TG HOLES

SP PROFILE SHOWING ELECTRODE LOCATIONS

FAULT SEGMENT WITH MAXIMUM DILATIONAL TENDENCY (RHODES, MOECK, 2011)

EXISTING PRODUCTION WELL

USG NEVADA, LLC.

GROUND MAGNETIC TOTAL FIELD, SP ANOMALIES, TEMPERATURE IN TERTIARY BASALT AND TG HOLE LOCATIONS

US Geothermal Inc

FIGURE 22A

BY: WM. TEPLOW
7/28/2015

FIGURE 23: SAN EMIDIO SP SMOOTHED PROFILES A-F

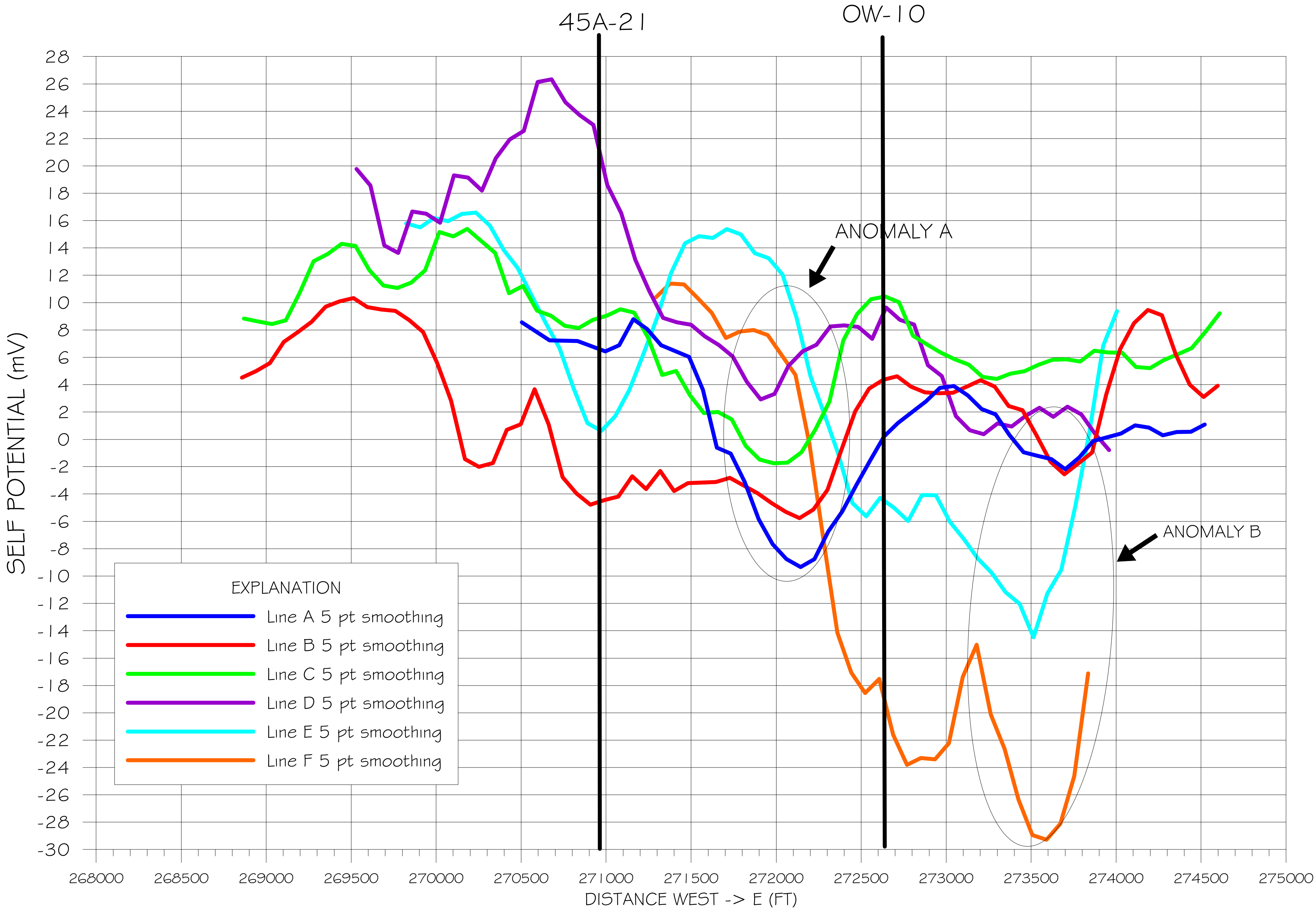
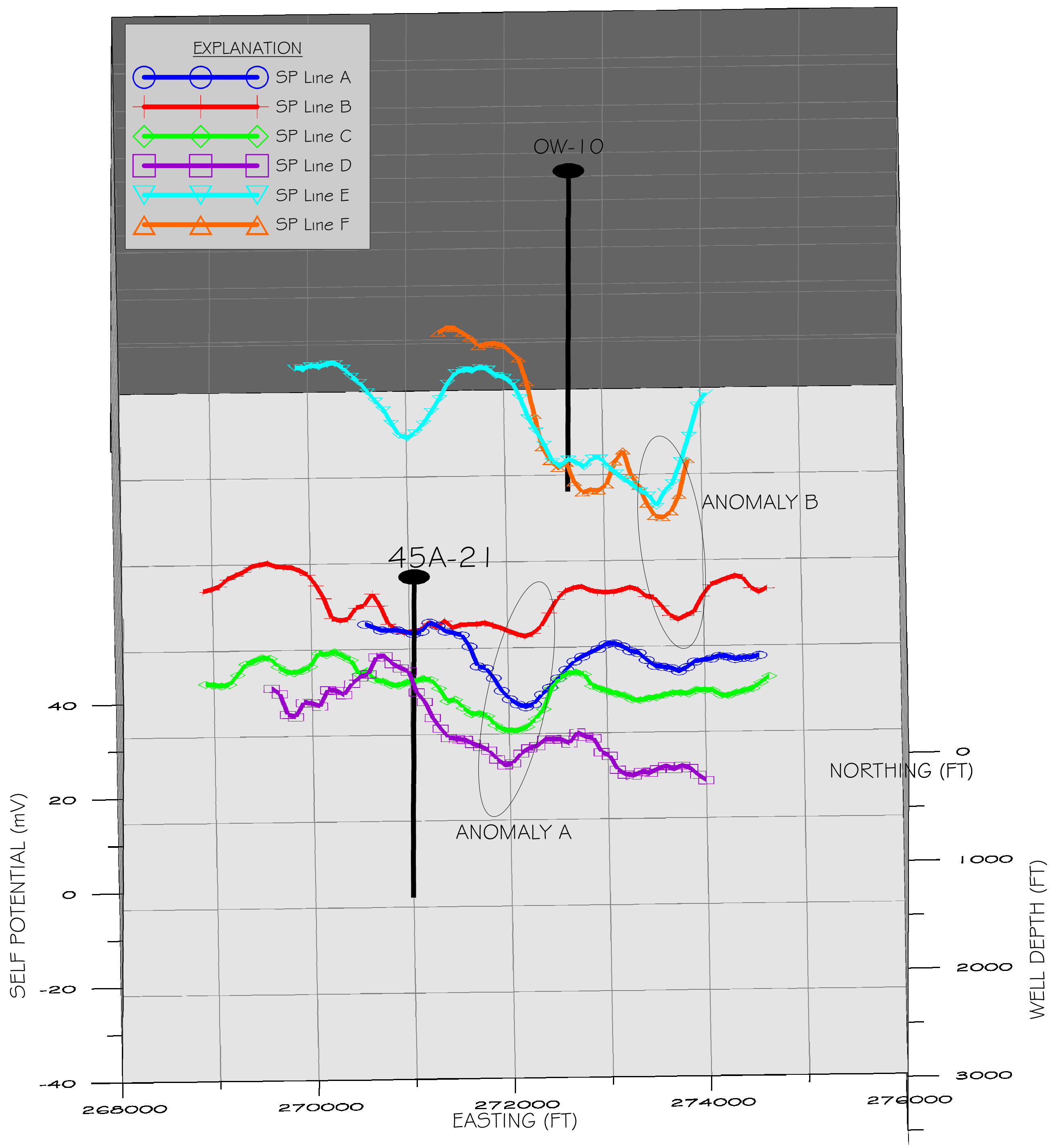
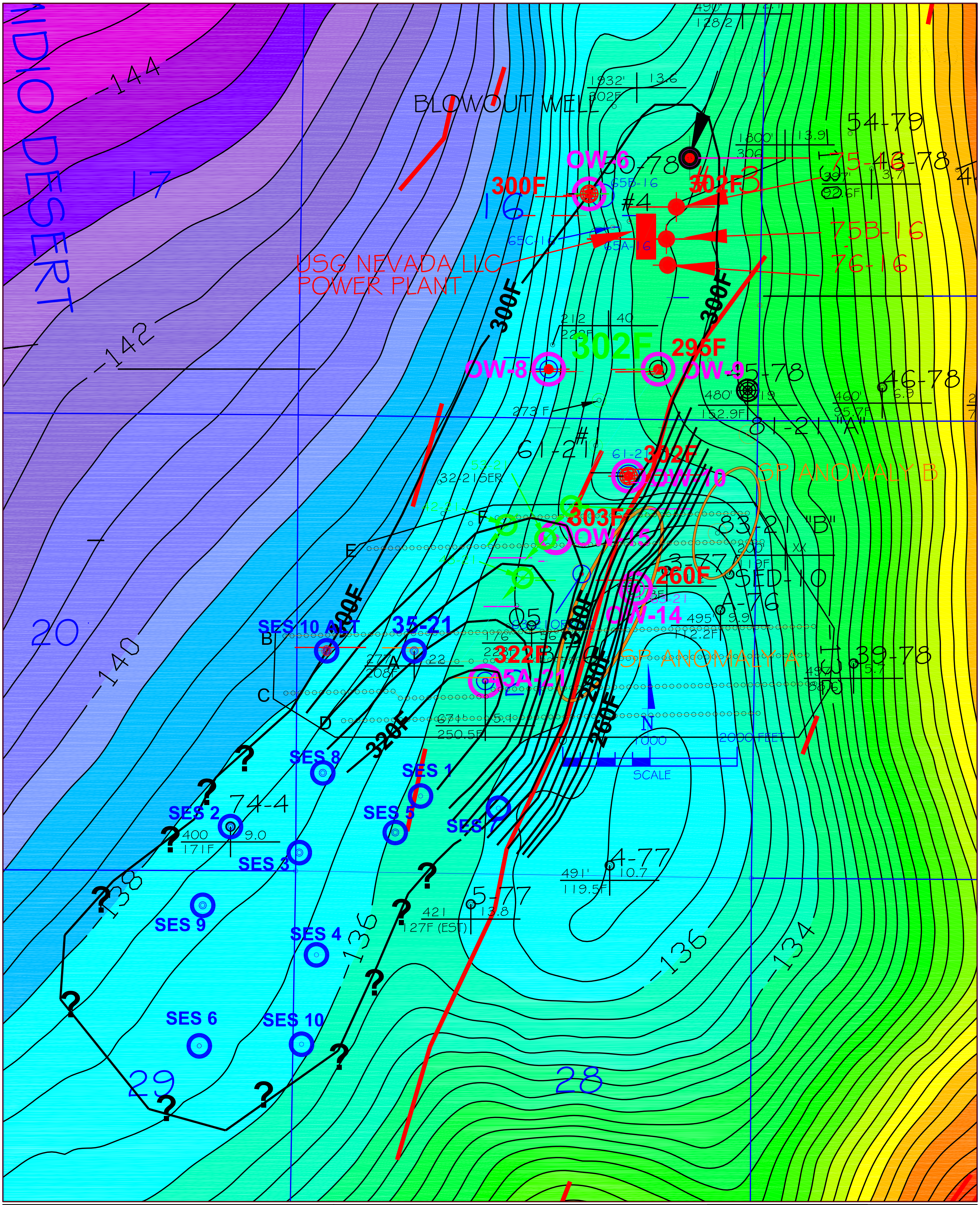


FIGURE 24: 3-D PLOT OF SP LINES A-F, OBLIQUE VIEW LOOKING NORTH





EXPLANATION

- COMPLETE BOUGUER GRAVITY CONTOUR INTERVAL 0.5 MGALS, US GEOTHERMAL SURVEY, JUNE, 2012)
- LEGACY TG WELL — WELL #; WELL DEPTH (FT); BH CONDUCTIVE GRADIENT (DEG.F/100); BHT (F)
- FAULT SEGMENT WITH MAXIMUM DILATIONAL TENDENCY (RHODES, MOECK, 2011)
- SES-5 PROPOSED 1000' TG HOLES
- OW-6 COMPLETED DOE COST SHARED OBSERVATION WELL
- EXISTING PRODUCTION WELL

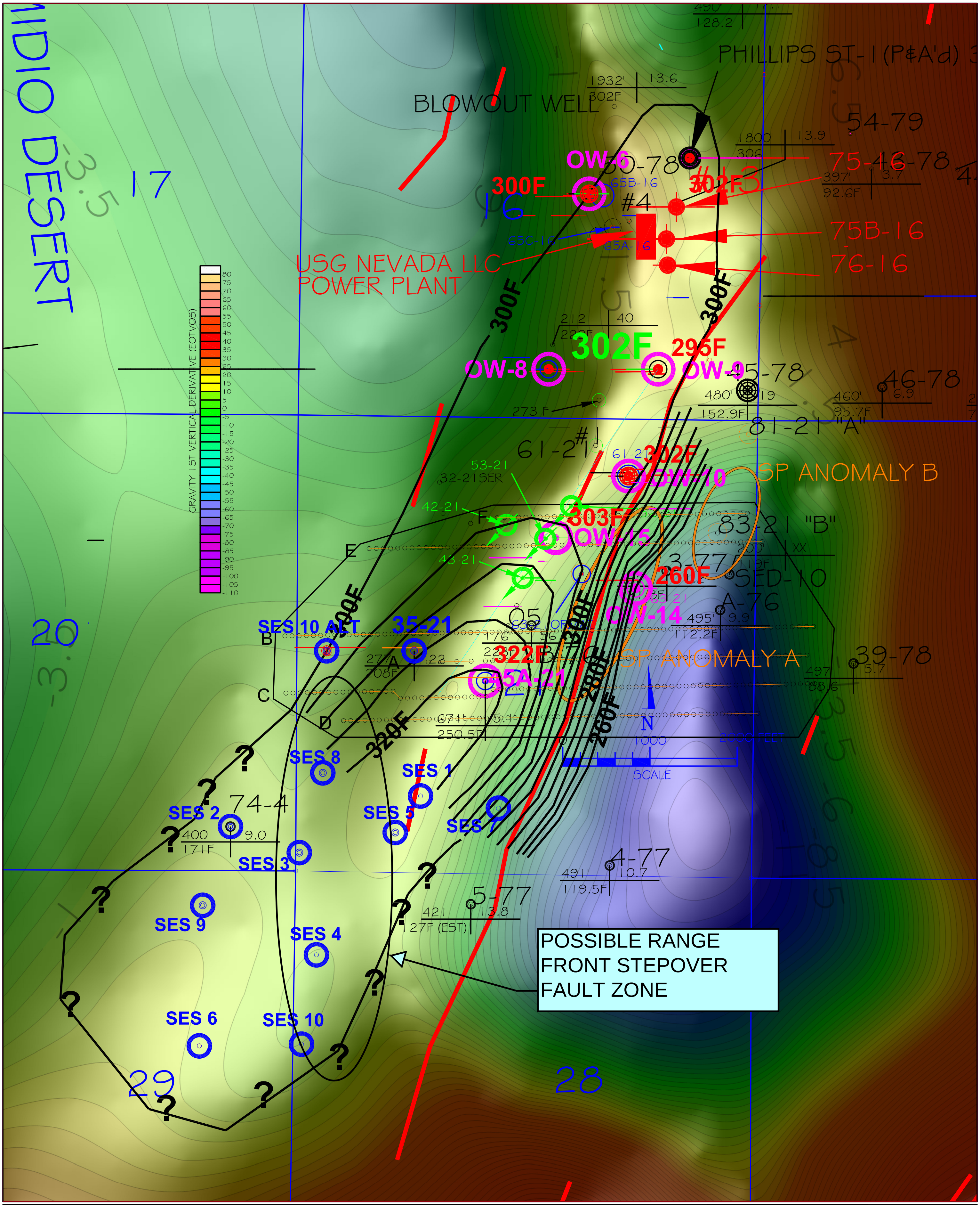
SAN EMIDIO GEOTHERMAL PROJECT

COMPLETE BOUGUER GRAVITY, TEMPERATURE IN TERTIARY BASALT AND TG HOLE LOCATIONS

US Geothermal Inc — CLEAN GREEN RENEWABLE ENERGY

FIGURE 25

BY: WM. TEPLOW
DATE 7/29/2015



EXPLANATION

LEGACY TG WELL — WELL #, BH CONDUCTIVE GRADIENT (DEG.F/100), WELL DEPTH (FT), BHT (F)

COMPLETE BOUGUER GRAVITY CONTOUR INTERVAL 0.5 MGALS, US GEOTHERMAL SURVEY, JUNE, 2012

FAULT SEGMENT WITH MAXIMUM DILATIONAL TENDENCY (RHODES, MOECK, 2011)

EXISTING PRODUCTION WELL

SES-5 PROPOSED 1000' TG HOLES

OW-6 COMPLETED DOE COST SHARED OBSERVATION WELL

GRAVITY FIRST VERTICAL DERIVATIVE CONTOUR INTERVAL 5 EOTVOS, US GEOTHERMAL SURVEY, JUNE, 2008

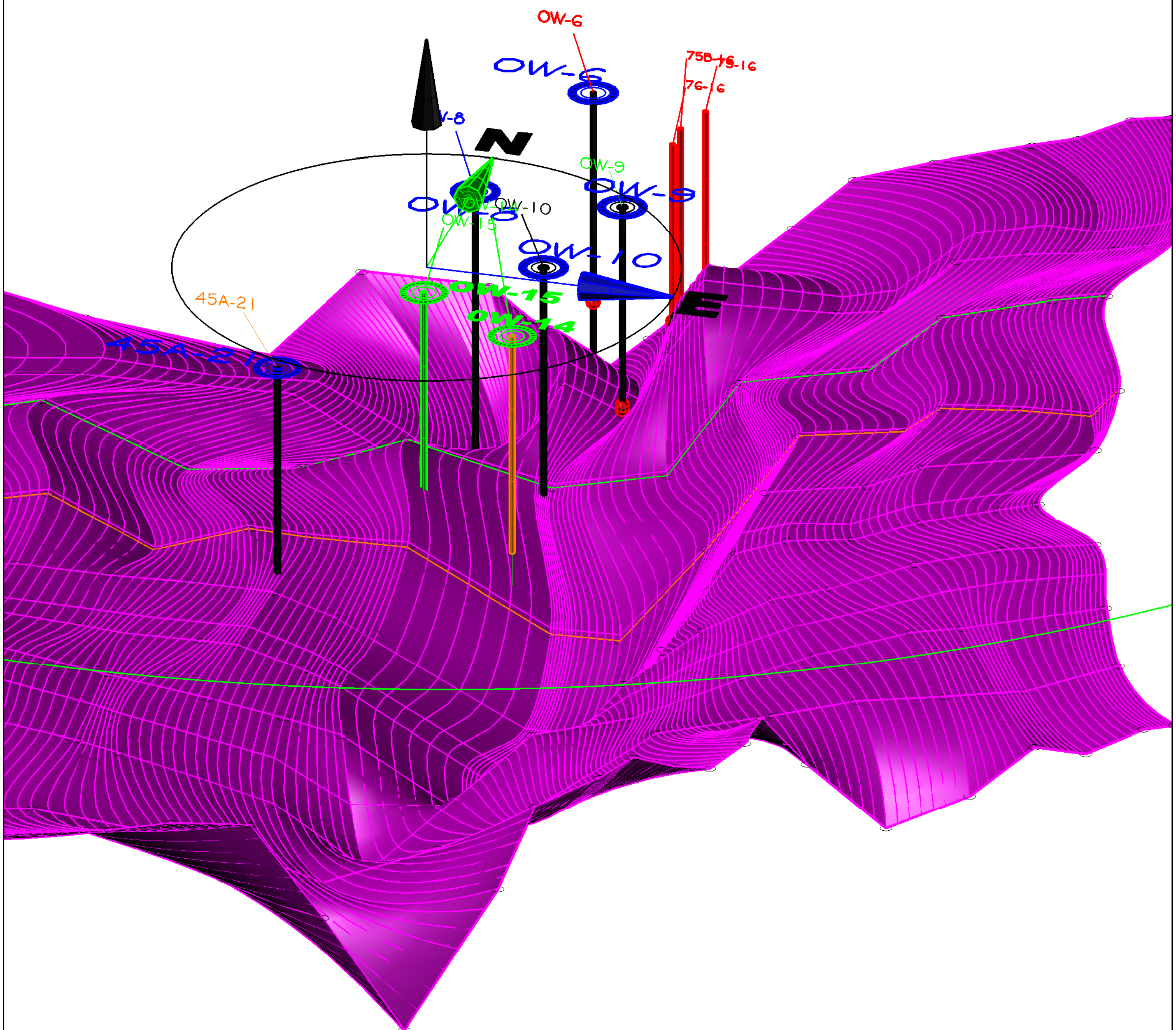
SAN EMIDIO GEOTHERMAL PROJECT

GRAVITY 1st VERTICAL DERIVATIVE, TEMPERATURE IN TERTIARY BASALT AND TG HOLE LOCATIONS

US Geothermal Inc — CLEAN GREEN RENEWABLE ENERGY

FIGURE 25A

BY: WM. TEPLOW
DATE 7/29/2015



EXPLANATION

INJECTION WELL

OW-6 COMPLETED SLIMHOLE OBSERVATION WELL

EXISTING PRODUCTION WELL

USG NEVADA, LLC.

SAN EMIDIO GRAVITY MODEL
BASEMENT SHADED RELIEF

BY: WM. TEPLOW
REV: 11/27/2012

FIGURE 26