Rio Mesa Solar
Final Erosion, Scour, and Sediment Transport Analysis

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I. INTRODUCTION

VTN has prepared an Erosion, Scour, and Sediment Transport Analysis for the proposed ±9,794-acre Rio Mesa Solar (RMS) site. This report describes the methodology and calculations utilized to determine the potential scour of heliostats and other structures within the solar field(s). Portions of this analysis referenced results from the previously submitted *Rio Mesa Solar Overall Existing Condition Hydrologic and Hydraulic Analysis* (*existing condition*) report for the RMS site dated July 2011, prepared by VTN Consulting.

II. DESIGN FLOWS

A. OFFSITE FLOWS

In the referenced RMS *existing condition* analysis, the U.S. Army Corps of Engineers (USACE) HEC-1 software program was utilized to establish storm water runoff values for all tributary offsite basins. Tributary runoff flow values impacting the RMS site are summarized in the referenced *Table 1* shown below. Refer to *Appendix A* for a copy of the referenced *existing condition* basin drainage map.

Table 1: HEC-1 Analysis Runoff Results Summary

Basin / Combination Point	Area (sq.mi.)	24-Hour, 100-Year Q (cfs)
M1	0.76	162
M2	24.30	4,520
M3	0.57	125
M4	2.71	598
M5	0.39	77
M5A	0.17	46
M5B	0.18	49
M6	1.32	316
M7	0.16	35
M8	1.04	265
M9	1.80	439
M10	0.38	85
M11	1.30	300
M12	3.98	954
M13	7.18	1,607
MX	0.01	3
M17	0.67	189
M18	0.12	34
M19	0.11	31
M20	0.49	155
M21	0.17	47
M22	0.07	18
M23	0.18	49
M24	0.66	210
M25	0.15	43
M26	0.53	120
M27	0.22	45

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B. ONSITE FLOWS

The FLO-2D 2-dimensional flood routing program was utilized to generate onsite runoff and to route offsite basin flows through the site in the referenced *Rio Mesa Solar Overall Existing Condition Hydrologic and Hydraulic Analysis*. Cross sections were cut within the FLO-2D model along the eastern boundary of the site to determine the maximum flows discharged from the site. The cross sections report maximum runoff flow rate and volume. Refer to referenced *Figures 7323HYD200* through *7323HYD201* for locations of cross sections included within *Appendix A*.

Table 2: FLO-2D Flood Plain Cross Section Summary

Cross Section	Max Discharge (cfs)	Max. Depth (ft.)
24-Hour, 100-Year		
CS 1	672.15	0.64
CS 2	0	0.10
CS 3	1335.99	1.77
CS 4	0	0.10
CS 5	298.96	0.95
CS 6	6142.51	2.51
CS 7	64.11	0.45
CS 8	787.90	1.07
CS 9	45.35	0.37
CS 10	42.52	0.47
CS 11	443.09	1.79
CS 12	490.93	1.05
CS 13	33.71	0.46

III. SITE INVESTIGATION FOR SCOUR AND EROSION

Several site investigations were conducted to determine the potential for scour and erosion within the RMS site. Based on these site investigations, topographic information, and aerial photography, three main areas were determined to be susceptible to potential erosion and scour within the site. The three areas were classified as Major Flow Corridor areas, Alluvial fan areas, and Head Cut areas. Each area is shown on *Figure 7323HYD402*, *Potential Erosion Areas Exhibit* in *Appendix A*. The following sub-sections A, B, C, and D provide information and conclusion for each potential erosion and scour areas. A more extensive photo documentation of the existing condition washes and onsite and offsite conditions can be found in *the Rio Mesa Solar Overall Existing Condition Hydrologic and Hydraulic Analysis*, by VTN.

A. MAJOR FLOW CORRIDOR AREAS

The site is overlaid with well-defined channels and washes. The majority of the offsite flows are conveyed through the site within these areas. There are two main types of washes located within the site. The first wash types are well defined washes with a single channel that conveys the majority of the flow. These washes are generally located in the western portion of the site (upstream areas) and range from 15-60 ft. wide and 3-6 ft. in depth. The photo below shows a typical single channel wash within the western portion of the site.

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Photo 1: Single Channel Wash

As the washes proceed downstream, they tend to widen and form multiple braided channels. These wash types average 100-800 ft. in width and contain many channels within them averaging 1-3 feet in depth. Flows during storm events may be conveyed in one or several channels depending on the flow magnitude. The photo below provides a view of a typical braided channel within one of the onsite washes.

Photo 2: Braided Channel Wash

A sub-area of the Major Flow Corridors is identified on Figure 7323HYD402 as areas subject to flow breakouts and lateral migration. These areas were determined from a combination of site investigation, aerial photographs, 1-foot topography, and hydraulic analysis. The areas represent potential flow breakout points and channel lateral migration areas out of the determined Major Flow Corridors.

Some of the bank locations along the Major Flow Corridors are nearly vertical. These areas pose a concern to heliostats adjacent to them due to the continued cutting of the banks. The banks show a tendency to be undermined by flows which cause pieces of the bank to break off and fall into the channel. It is recommended that the geotechnical engineer perform bank stability analysis over the vertical sections of the banks to determine an adequate buffer zone between the bank and the heliostats.

B. ALLUVIAL FAN AREAS

Typical alluvial fan formations are located in the northwestern portion of the site. The fans have several well defined washes located within them that more than likely have become preferred flow paths for the majority of storm events. However, due to the ability of flows to take different flow paths in alluvial fan areas, the fan areas were classified as a separate potential erosion area to be evaluated in this report.

The fans contain numerous braided channels that spread laterally throughout. In general, the channels are narrow and shallow (0.5 to 3-ft in depth) excluding the main washes that have cut more permanent flow paths through the fan. A photo of a typical alluvial fan channel is shown below.

Photo 3: Alluvial Fan Channel

C. HEAD CUT AREAS

The Head Cut areas are generally located at the eastern end of the proposed solar fields. The head cut channels are forming in the upstream direction beginning at the banks of well-defined channels. At the eastern portion of the site, a ridge exists that forces the predominately west to east flow direction to the north or south around the ridge. This ridge seems to be causing the concentration of sheet flows from the upstream direction into forming defined channels. From those defined channels, numerous head cut channels are

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forming as sheet flows discharge into the main channel along the western bank. The areas exhibiting these head cut processes have been defined on Figure 7323HYD402 and are labeled as areas 1 through 7.

The Head Cut channels tend to be narrow and well defined with depths between 0.5 and 3-ft. The photo below show an example of a head cut channel located in Area 2 within the southeastern portion of the site.

Photo 4: Typical Head Cut Channel

D. SITE INVESTIGATION CONCLUSIONS

Based on the previous site investigation conducted, the following conclusions were made and incorporated into the erosion and scour analysis conducted for the Rio Mesa site.

- The major offsite flows are routed through the site in well-defined flow corridors that contain multiple channels and well defined channel banks. Most of these areas appear to have been stable for long time periods. However, several channel bends and potential breakout points were observed where flows could laterally migrated out of the present flow corridor.
- Several defined flow corridors contain channels with steep or nearly vertical banks usually coinciding with bends in the channels. These channels typically were located at the western portion of the site. There was evidence of bank failure in these areas where portions of the bank have broken off into the channel. The flows have

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appeared to undercut the banks around the bends which has caused the bank above the flows to break off and fall into the channel.

- There are two well defined alluvial fan formations located at the northwestern portion of the site. Although active alluvial processes are possible in these fans, each fan contains well defined channels that appear to have become preferred flow paths created by past storm events.
- Between the well-defined flow corridors smaller offsite flows and onsite generated flows are conveyed as sheet flows across the site. These areas are mostly flat or contain very shallow gullies that route flows.
- There is an elevated ridge line at the eastern edge of the southern half of the site that extends in the north and south direction. The ridge line causes the predominately west to east flow direction to turn either north or south. The major flow corridors are unaffected by this ridge line however sheet flows are forced to turn north and south at the ridge. This causes the sheet flows to concentrate back into stream flow and appears to be responsible for some head cutting processes that occur upstream of the ridge.

IV. EROSION & SCOUR ANALYSIS FOR HELIOSTATS & STRUCTURES

An erosion and scour analysis was completed to determine potential erosion and scour for the proposed heliostats and structures within the RMS site. Two components of scour were determined for this analysis: general and local scour. The evaluations of both scour components, as well as the findings of the analyses, are discussed in the sections below.

A. GENERAL SCOUR

General scour is defined as the lowering of the streambed related to the passing of a single flood event. For the purposes of this report, the general scour will be interpreted as the scour anticipated during the 100-year flow event. Three different methodologies were implemented in order to compute general scour:

- For areas described in Section III.A –*Major Flow Corridor Areas* of this report, the FLO-2D program sediment transport sub-routine in conjunction with a statistical analysis of the output data was used to compute general scour. The FLO-2D analysis computes scour depths for the overall project area however, the results of the analysis show the greatest scour depths in the areas described in Section III.A-*Major Flow Corridor Areas* of this report.

- For areas described in Section III.B- *Alluvial Fan Areas* of this report, the FEMA Alluvial Fan equations were utilized to compute general scour.

- For areas described in Section III.C- *Head Cut Areas* of this report, a head cut analysis was determined to estimate the head cut potential during the 100-year storm event.

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The results of the three methodologies listed above were examined and compared to each other. The sections below describe in detail the methodologies as well as the results obtained.

1. FLO-2D SCOUR ANALYSIS

The FLO-2D program, in conjunction with the software's sediment transport sub-routine, was utilized to provide estimates of potential general scour throughout the site. The FLO-2D model contains imported hydrographs generated from HEC-1 to simulate the 24 hour 100-year runoff from all offsite drainage basins. The model simulates the onsite runoff from the 24 hour 100-year storm event for the onsite areas through the use of its internal precipitation sub-routine. There are many sediment transport equations that can be utilized within FLO-2D, including the Zeller-Fullerton equation. The Zeller-Fullerton equation is a widely accepted predictor of scour under a wide range of field conditions. Therefore, Zeller-Fullerton was chosen as the equation to execute the sediment transport sub-routine within the FLO-2D analysis.

The soil parameters inputted into the FLO-2D model were provided by the project geotechnical engineer (Ninyo and Moore). It was concluded that the near surface soil makeup within the major flow corridors and braided washes consisted of poorly graded and silty sands. The borings and test pits from several locations throughout the site consisting of sands that are near the surface were utilized to determine an average sediment size fraction. Referenced Ninyo and Moore figures 2 and 3 (Exploratory Excavations), with the above mentioned borings and test pits denoted, are provided in Appendix A. This average sediment size fraction along with the approximated near surface dry density and specific gravity of 110% and 2.66, provided by Ninyo and Moore, was incorporated within the FLO-2D sediment transport sub-routine. The corresponding appurtenant data for the borings and test pits denoted on reference figures 2 and 3 are listed in Table 3 below.

Table 3: FLO-2D Soil Parameter Input Summary

Location	B-2	B-3	B-8	B-10	B-12	B-13	TP-5	TP-11	TP-12	Sand Average Utilized in FLO-2D
Depth	0-1	0-1	3-6	0-5	5-10	0-1	3-5	1-4	1-2	
Soil Type	Sand	Sand	Sand	Sand	Sand	Sand	Sand	Sand	Sand	
	Sediment Diameter (mm)									
D100	50	50	40	10	20	40	10	10	20	27.78
D90	10	20	10	2	6	8	2	2	3	7.00
D80	3	10	8	0.7	2.1	4	6	0.9	0.7	3.93
D70	0.4	7	5	0.4	0.8	2	4	0.43	0.32	2.26
D60	0.3	5	2	0.3	0.41	1	3	0.3	0.2	1.39
D50	0.28	2	1	0.22	0.3	0.7	2	0.2	0.12	0.76
D40	0.2	0.7	0.4	0.2	0.17	0.4	0.12	0.1	0.1	0.27
D30	0.13	0.4	0.23	0.13	0.1	0.3	0.1	0.08	0.07	0.17
D20	0.09	0.3	0.2	0.08	0.06	0.22	0.05			0.11
D10	0.01	0.22	0.05	0.006	0.007	0.2	0.002			0.06

The FLO-2D grid system utilized to conduct this analysis contained 41,896 onsite grid cells (this includes the extents of all 3 solar fields and disturbed area). Of the 41,896 onsite grid cells, 145 cells reported scour depths greater than 1-foot (approximately 0.3%). *Table 4* shown below lists the 71 onsite grid cells within the FLO-2D analysis with the highest scour depth ranked in descending order. These 71 grid cells contain scour depths above the 99th percentile scour depth discussed below and in Section IV.E- Exceedance Probability Analysis for Heliostats, of this report.

Table 4: FLO-2D General Scour Depth Summary (shaded rows indicate cells within NW area – per Figure 7323RIPRAP)

Zeller-Fullerton Equation Scour					
Grid Cell Scour Depth Ranking	Onsite Grid Cell #	Scour Depth (ft.)	Grid Cell Scour Depth Ranking	Onsite Grid Cell #	Scour Depth
1	28968	-6.92	37	29452	-2.14
2	26308	-5.89	38	53293	-2.07
3	27035	-5.51	39	25334	-2.04
4	26550	-5.44	40	44733	-2.02
5	29207	-5.07	41	51100	-2.02
6	26065	-4.65	42	47668	-1.95
7	26792	-4.58	43	50183	-1.93
8	27037	-4.36	44	25578	-1.92
9	27039	-4.3	45	28747	-1.91
10	27038	-4.27	46	29447	-1.82
11	29446	-4.26	47	43802	-1.8
12	25822	-4.07	48	29211	-1.77
13	27036	-3.94	49	34040	-1.77
14	29684	-3.72	50	50120	-1.76
15	3582	-3.54	51	47988	-1.74
16	26551	-3.33	52	52670	-1.74
17	48303	-3.32	53	52040	-1.71
18	28969	-3.07	54	61063	-1.7
19	27282	-3.04	55	27520	-1.66
20	25579	-3.03	56	50119	-1.65
21	44421	-3.03	57	51413	-1.65
22	3427	-2.99	58	3572	-1.64
23	27525	-2.91	59	53292	-1.63
24	29210	-2.9	60	62327	-1.61
25	49803	-2.76	61	3279	-1.58
26	49482	-2.59	62	28990	-1.54
27	28989	-2.49	63	50506	-1.54
28	49804	-2.48	64	62963	-1.54
29	47353	-2.39	65	28985	-1.52
30	29685	-2.35	66	29701	-1.5
31	44736	-2.33	67	29713	-1.5
32	47352	-2.32	68	3425	-1.48
33	47987	-2.31	69	25823	-1.48
34	44734	-2.24	70	53018	-1.48
35	47986	-2.15	71	3426	-1.47
36	51414	-2.15			

The power blocks, heliostat support pylons, and ancillary structures proposed in the RMS site will have drainage facilities designed based on the 100-year flows and scour depths determined in this report. Specifically, the heliostat support pylons will be constructed to account for the scour depths by including additional burial depth during the manufacturing/installation process. Due to the large number of heliostats that are proposed to be installed onsite (±255,000), it would be impractical to design all of the heliostats to the maximum scour depth(s) reported in *Table 4* since these depths are mainly concentrated within a small geographic area of the overall site.

Based on the results of the FLO-2D analysis, a statistical analysis was performed to determine a design general scour depth that is practical from an engineering, statistical, and construction standpoint. Therefore, a 99th percentile general scour depth was calculated from all the onsite grid cells reporting scour depths of 0.01-ft and above. The 99th percentile scour depth (reported below) was based on engineering judgment as the scour depth that balanced the requirement of providing adequate scour protection for the majority of the heliostats while still being feasible from an economic and construction standpoint.

Predicted General Scour Depth: FLO-2D (99th Percentile)
1.46-ft

The FLO-2D results for the general scour analysis are depicted on *Figures 7323SCOUR* and *7323DEP* within *Appendix B*. These figures show both the maximum scour and deposition depths computed by the analysis. At a glance it appears that many of the highest deposition depths and scour depths occur in the same grid cells. However, upon close inspection the majority of the deposition depths within the solar field boundary are in close proximity to but do not occur within the same grid elements as the scour depths. This is not unusual since portions of the stream that are in scour will provide a sediment source that can be deposited in adjacent portions of the stream. Deposition and scour can also occur within the same grid cell at different time periods within a flooding event. The scouring of a grid cell provides larger conveyance areas which produce slower velocities that induce deposition of sediment in high concentrated flows. In general deposition depths are less than 2-ft, however there are a few isolated grid cells located in the northwest solar field area where the deposition depths are between 2 and 3-ft. Note that the final ground surface elevation for some of the grid cells will be reflected by the difference in scour and deposition. This will not have an impact on the general scour analysis due to the difference in time interval occurrence between the scour and deposition. Deposition analysis results may not impact the heliostat pylon design depth, but may be important in the design of other project features within the site.

2. FEMA ALLUVIAL FAN EQUATIONS

In order to determine the general channel scour depth (during the 100-year storm event) within the RMS onsite area subject to alluvial processes, the Federal Emergency

Management Agency (FEMA) channel width and depth alluvial fan equations, as derived in the FAN Publication dated September 1990, were referenced. This analysis determines the potential scour within the Alluvial Fan areas of the site and within the Major Flow Corridor sub-area subject to flow breakouts and lateral migration of washes. The original FEMA equations (A.6 and A.7) for alluvial fan flow assume rectangular channel geometry and are presented as follows:

Depth (d) as a function of discharge:

$$d = 0.07056Q^{\frac{2}{5}}$$

And width, (w) as a function of discharge:

$$w = 9.408Q^{\frac{2}{5}}$$

The channel energy depth, d, is interpreted as the maximum scour depth for alluvial or alluvial-like conditions. By arranging the equations shown above as a width to depth ratio (w/d) denoted as "a" and dividing equals:

$$a = \frac{w}{d} = \frac{9.408\cancel{Q^{\frac{2}{5}}}}{0.07056\cancel{Q^{\frac{2}{5}}}} = 133.3\text{ft/ft}$$

The channel dimensions needed to compute this width to depth ratio were not observed during field visits at the Rio Mesa Solar site. Subsequently, the rectangular channel equations were modified to reflect dimensions representative of the channel hydraulic characteristics that were observed onsite. The modification is performed by referencing Manning's open channel equation, and re-arranging it as a function of flow rate (Q) for both width and depth. In order to modify these equations, the hydraulic properties of 4 reaches located within the alluvial fan zone(s) (washes 60, 0, 80, and 15) were referenced from the HEC-Ras analysis performed for the Existing Condition Hydrology and Hydraulics report. An average of the hydraulic properties (flow width, flow depth, and channel slope) was computed from the HEC-RAS results and a width to depth ratio determined (refer to Appendix C). The FEMA Alluvial Fan equations were then modified to reflect the average hydraulic slope of the fan. With the equations adjusted a width to depth ratio obtained by dividing the FEMA width equation by the depth equation results in a ratio very similar that which was computed directly from the averaged hydraulic results. The equation modification derivation is shown below:

$$Q = \frac{1.49}{n} A R^{\frac{2}{3}} S^{\frac{1}{2}}$$

Where Flow Area, "A"

$$A = wd$$

And Hydraulic Radius, "R"

$$R = \frac{A}{w + 2d}$$

Assuming a shallow flow in rectangular channels, the hydraulic radius can be simplified by ignoring the "2d" term of wetted perimeter

$$R = \frac{A}{w + \cancel{2d}} = \frac{\cancel{w}d}{\cancel{w}} = d$$

Plugging this back into Manning's equation yields:

$$Q = \frac{1.49}{n}(wd)d^{\frac{2}{3}}S^{\frac{1}{2}}$$

Which simplifies to:

$$Q = \frac{1.49}{n}wd^{\frac{5}{3}}S^{\frac{1}{2}}$$

The width to depth ratio, "a", of the representative channels impacting the Rio Mesa Solar site is an average of 111 ft/ft per field investigations and hydraulic analyses completed for the alluvial washes.

$$a = \frac{w}{d} = 111$$

Or

$$w = 111d$$

Or

$$d = \frac{w}{111}$$

Manning's equation in terms of "d", by substituting "a" into equation yields:

$$Q = \frac{1.49}{n}111d^{\frac{8}{3}}S^{\frac{1}{2}}$$

Solving for "d" yields:

$$d = \left[\left(\frac{n}{(1.49)(111)S^{\frac{1}{2}}}\right)Q\right]^{\frac{3}{8}}$$

Plugging average slope, "S", of 0.014 ft/ft, "n" value of 0.035, further simplifies equation to:

$$d = 0.0939Q^{\frac{3}{8}}$$

Likewise, solving the simplified hydraulic radius Manning's equation in terms of width, "w"

$$Q = \frac{1.49}{n}w\left(\frac{w}{111}\right)^{\frac{5}{3}}S^{\frac{1}{2}}$$

Which simplifies to:

$$w = \left[Q\left(\frac{n111^{\frac{5}{3}}}{1.49S^{\frac{1}{2}}}\right)\right]^{\frac{3}{8}}$$

Plugging in average slope, "S", and "n" value of onsite channel yields:

$$w = 10.3516Q^{\frac{3}{8}}$$

The ratio of width to depth, "a", obtained by dividing equations above (w/d) now represent the average channel dimensions observed onsite of 111 ft/ft.

Plugging in the discharge "Q" estimated from tributary apex flow at hydrograph combination point CP1 (referenced from RMS Existing Condition Basin Map *Figure 7323HYD100*) during the 24Hr, Q100 event is 1,406-cfs, which yields a depth of:

$$d = 0.0939(1406)^{\frac{3}{8}} = 1.42ft$$

This is interpreted as the potential general scour for the onsite area subject to alluvial processes. The average parameters utilized in the modification of the FEMA equations are summarized in *Appendix C*.

Predicted General Scour Depth: Alluvial Fan Equations
1.42-ft

B. HEAD CUT AREA

The areas of apparent head cut processes are identified on *Figure 7323HYD402* included in *Appendix A*. The head cut process propagates in the upstream direction by cutting into the existing ground and creating new channels that are approximately equal in depth to the existing channels from which the cutting is taking place. The head cutting process requires a steep grade differential to be present where flows create the large shear stresses required to produce soil failure and cut new portions of channel. The mechanism that is providing the grade difference within the site seems to be where sheet flows are discharging into the downstream channels that are more or less perpendicular to the sheet flow direction. The steep side slopes of these downstream channels are providing the catalyst for the head cut process to begin forming. For the purposes of this design report, the head cutting process has been assumed to occur during the 100-year storm event so that its results can be compared to the other analysis of general scour. In reality the head cut channel formed through the head cut areas of the site most likely occurred over long time periods and multiple storm events. However, as a conservative assumption for the design of the site, it is assumed that the head cutting analysis outlined below occurs during the 100-year design storm for the site.

The head cut potential was determined by creating profile alignments, based on the 1-ft topography, within the head cut areas to determine existing depths of head cut channels. The channel depths were used to compute a weighted average depth throughout the head

cut areas of the site (See *Figures 7323HC – Potential Head Cut Areas and SEC-1* through *SEC-4* within *Appendix D*). To accomplish this, each profile has been divided into 200 ft. reaches. Each 200 ft. reach within a given area has been given an equal assumed area of influence proportional to the number of reaches in that area. The potential head cut depth for each reach has been assumed to act uniformly over its area of influence. The remainder of the solar field that doesn't have a potential for head cutting is included in this calculation with an assumed depth of zero. A weighted average of each head cut depth acting over its assumed area is then used to determine percentile head cut depths over the solar field area. From these weighted averages, a 99th percentile depth was determined in a similar manner as the scour depths from the FLO-2D analysis. This depth was computed to be 1.46 ft.

Predicted Head Cut Depth (99th Percentile)
1.46-ft

C. LOCAL SCOUR

Local scour is defined as the scour in a channel or on a floodplain that is localized at a pier, abutment, utility pole, or other obstruction to flow. For the purposes of this report, the local scour is defined as the scour that occurs around the pylons used to support the proposed heliostat mirrors.

1. FHWA EQUATION

To determine the potential scour depth around the mirror support pylons at the RMS site, the U.S. Department of Transportation Federal Highway Administration (FHWA) Hydraulic Engineering Circular No. 18 (HEC-18) was referenced. Since the shape of the pylons to be installed is a circular cylinder with an average diameter of 0.50-ft, they are assumed to act similar to bridge circular piers during flooding conditions.

$$\frac{y_s}{a} = 2.0\, K_1\, K_2\, K_3\, K_4 \left(\frac{y_1}{a}\right)^{0.35} {Fr_1}^{0.43}$$

Where,

y_s = Calculated scour depth, ft
y_1 = Flow depth directly upstream of pier, ft
K_1 = Correction factor for pier nose shape
K_2 = Correction factor for angle of attack of flow
K_3 = Correction factor for bed condition
K_4 = Correction factor for armoring by bed material size
a = Pier width, ft
V_1 = Mean velocity of flow directly upstream of the pier, ft/s
g = Acceleration of gravity, ft/s^2
Fr = Froude number directly upstream of the pier

The upstream velocity and depth (V_1 and y_1) components of the equation were obtained from the HEC-RAS hydraulic analysis of the channels, based on the worst case scenario (highest values). A K_1 correction factor of 1.0 was based on a circular cylinder pylon shape from referenced *Table 6.1*; a K_2 correction factor based on a 0 degree flow angle attack on the circular pylon; a K_3 correction factor of 1.1 based on no dunes present; and a K_4 correction factor of 1.0 since the onsite geotechnical report indicates a D_{50} < 2 mm at surface samples.

Based on the results of the calculation, the local scour depth (y_s) at the pylon is estimated to be 2-ft. However, due to the maximum depth stipulated in HEC-18 under referenced equation(s) 6.2:

$$y_s \leq 2.4\ x\ pier\ width\ (a) for\ F_r \leq 0.8$$

$$y_s \leq 3.0\ x\ pier\ width\ (a) for\ F_r \geq 0.8$$

The maximum scour depth is reduced to 1.5-ft since the Froude Number (Fr) is within the super-critical flow regime.

The impact of debris accumulation on the pylons was considered in the determination of local scour for the pylons. The most significant factors impacting debris accumulation are the width of the pylon, the spacing between the pylons, and the amount of substantial vegetation that is available from the upstream watershed. The relatively small diameter of the pylons (6 inches) does not provide a significant contact surface to facilitate the accumulation of debris. Also the spacing between the pylons (at least 20 feet in each direction) provides an adequate flow width to allow debris to navigate through the solar field without becoming accumulated on individual pylons or between sets of pylons. Finally, the vegetation source for debris is limited to sparse desert vegetation mostly consisting of small shrubs and bushes. There is not a significant amount of large woody plants and trees that would provide the large debris material that traditionally create debris accumulation problems for bridge piers and other structures. In general it is believed that the spacing between the pylons, the small diameter of the pylons, and the lack of substantial vegetation, provide a reasonable assurance that flow debris will be able to navigate through the solar field pylons without becoming accumulated on individual pylons or between sets of them. Refer to *Appendix E* for calculations and referenced material.

D. TOTAL SCOUR

The strategy for the RMS project is to design the heliostat pylons to withstand the scour depths from the 100-year 24-hour storm. General scour provides the anticipated scour depth for the 100-year 24-hour storm event while local scour provides additional depth specifically related to scour localized around the heliostat pylons. Table 5 below shows the results of all the analyses completed.

Table 5: Total Scour Depth Summary

Analysis	Predicted General Scour Depth (ft.)	Predicted Local Scour Depth (ft.)	Predicted Total Scour Depth (ft.)
General Scour – FLO-2D	1.46	1.5	2.96
General Scour – Alluvial	1.42	1.5	2.92
General Scour - Head Cut	1.46	1.5	2.93

For design purposes, it is recommended that the total scour (general + local) be used. Since the three analyses determined very similar scour depths, the highest scour depth of 1.46 feet is used as the design general scour for the entire solar field. This depth was added to the determined local scour of 1.5 feet to determine the total scour depth for the site of 2.96 feet.

Design Total Scour Depth for Site
2.96-ft

The total scour depth determined is based on the theoretical scour anticipated for one single large storm event (100-year, 24-hour). The solar field will obviously be subjected to numerous small events during the design life of the project regardless of whether the large storm occurs or not. The smaller storm events that produce runoff can have cumulative erosion and scour effects that over time can equal or exceed the total scour depth reported. Due to this, it is recommended that a maintenance program be implemented which entails inspection of the solar fields for signs of scour after storm events that produce noticeable amounts of runoff from the site and tributary offsite area. If the inspection reveals that scour has occurred to heliostat pylons or other ancillary structures within the site, fill material should be imported, placed, and compacted over the eroded areas to restore structure(s) strength and bring such areas back to the previous grade. The fill material and compaction requirements should be specified by a geotechnical engineer to ensure that the material will provide adequate erosion control and resist being washed away during the next storm event.

E. EXCEEDANCE PROBABLILTY ANALYSIS FOR HELIOSTATS

An exceedance analysis was completed to determine the number of heliostats that are potentially subject to the general scour depth of 1.46 as determined in this report. This analysis only applies to the FLO-2D Sediment Transport analysis and Head Cut analysis. The Alluvial analysis computed a general scour depth of 1.42 feet which is below the general scour depth used for design of 1.46 feet. Since the total depth of scour as determined by the alluvial analysis is included in the design general scour, there is no exceedance component to determine for that analysis.

It should also be noted that the general scour processes determined for each of the analyses (FLO-2D, Head Cut, and Alluvial) are assumed to be independent processes. This is due to

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the fundamental differences of the mechanics of each process and the physical difference in location that the processes mainly occur. The head cut process is driven by the ridge area that blocks the sheet flow path and causes the flows to concentrate. These concentrated flows have formed channels roughly parallel to the ridge line. As sheet flows enter these new channels that are roughly perpendicular to the sheet flow direction they eroded the banks of the ridge channel. This eroded bank is the catalyst for formation of the head cut channels propagating in the upstream direction. The FLO-2D analysis is driven mostly by the high flow rates in the Major Flow Corridor areas of the project. These high flow rates create large shear stresses on the bottom of the channels that create the scour and bed mobility that is predicted by the FLO-2D model. The Alluvial analysis is based on the stream power of the apex flows and the ability of that flow to create its own channel in lieu of following the current channel path. As shown on Figure 7323HYD402, the geographical area where these processes occur are spatially separated which provides further evidence of their independence.

1. FLO-2D SEDIMENT TRANSPORT MODEL

The 99th percentile general scour depth represents the scour depth(s) at which 99% of the grid cells (onsite) report equal or less than 1.46-ft. Approximately 71 of the grid cells report higher scour depths greater than the 99th percentile depth. Based on the FLO-2D grid size (75-ft x 75-ft), an estimate of the solar field area subjected to scour depths greater than the 99th percentile depth is presented below:

$$71\ x\ (75ft)^2\ x\ \frac{1ac}{43{,}560ft^2} = 9.17ac$$

The number of *heliostats per acre* proposed at the RMS site is 47.1. For a project permit life of 25 years, the probability of a storm event equal to or exceeding the 100-year event occurring is 0.222 based on the following equation:

$$P = 1 - (1 - \frac{1}{T})^N$$

Where,

P = Probability of T-year storm event being equaled or in any given year.
T = Return period of storm event in years.
N = Design life in years.

Based on the 100-year storm exceedance probability and the solar field area subject to scour depths above the 99th percentile general scour, the number of heliostats subjected to general scour depths exceeding the 99th percentile depth for the permit life of the project was calculated as:

$$9.17ac\ \ x\ 47.1\frac{heliostats}{ac}\ x\ 0.222 = 96\ heliostats$$

2. HEAD CUT ANALYSIS

An analysis of the number of heliostats subject to head cut depths above the determined general scour depth was completed for the head cut area. The historical photos for the site indicated that the head cut channels are propagating at a very slow rate in the upstream direction. The process that appears to be happening at a faster rate is the creation of new head cut channel "fingers" spurring off of the main head cut channels. Therefore, it seems that the head cut area should not extend much further during the permit life of the power plant operation (25 years). However, more head cut channel fingers may be created within the area and may expose more heliostats to risk.

Based on the assumptions above, the number of heliostats within the head cut boundaries that would be subject to head cut depths above the general scour depth for the site was determined. Since the general scour depth for the site was determined to be 1.46 feet by the FLO-2D analysis, 1.46 feet is used in the exceedance calculation for the head cut areas. The Head Cut analysis predicts the number of heliostats that may be subject to head cut depths exceeding 1.46 feet with a permit life of 25-years for the project. For a project permit life of 25 years, the probability of a storm event equal to or exceeding the 100-year event occurring is 0.222. The total head cut area exceeding 1.46 feet was determined to be 53.1 acres. This area was determined by adding all of the area determined to be subject to head cut above 1.46 feet from the weighted area analysis described in Section VI.B – *Head Cut Analysis* of this report. The proposed number of heliostats per acre at the RMS site is 47.1. Therefore, the number of heliostats subject to an exceedance depth above 1.46 feet for the head cut areas was determined to be:

$$53.1\ ac\ \ x\ 47.1\frac{heliostats}{ac}\ x\ 0.222 = 555\ heliostats$$

This value indicates the number of heliostats within the head cut area that would be subject to this exceedence depth if the entire head cut area subject to 1.46 feet or greater head cutting was to evenly cut down to that depth. Due to the apparent slow propagation of the head cut process exhibited at the RMS site, the number of heliostats subject to this exceedance depth in any single storm is most likely a small number. With the maintenance procedures suggested in section IV.D of this report, a majority of the head cutting processes should be able to be mitigated after storm events. All head cut calculations are included in *Appendix D.*

3. TOTAL HELIOSTAT EXCEEDANCE

To determine the total number of heliostats within the solar field estimated to exceed the design general scour depth of 1.46 feet during the 25-year permit life of the project, the number of heliostats from the FLO-2D and Head cut exceedance analyses have be added together.

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Estimated Heliostats Exceeding Design Scour from FLO-2D Analysis	Estimated Heliostats Exceeding Design Scour from Head Cut Analysis	Estimated Total Heliostats Exceeding Design Scour
96	**554**	**650**

This statistical analysis determines the number of heliostats that are predicted to exceed the 99th percentile total scour depth during a 100-year design storm event. This value is only computed to show that there is a certain risk factor that must be accounted for in order to provide a reasonable design general scour depth. This predication is based on numerous conservative assumptions made within the models used for scour analysis including:

- The heliostats are assumed to be evenly distributed throughout the site.
- The FLO-2D analysis assumes that the maximum scour depths reported for each grid cell encompasses the entire grid cells area of over 235 million sq.ft. (41,896 grid cells x 75 feet x 75 feet). The maximum scour depths would most likely be limited to swales or channels cut within portions of the grid cells. This would mean that only some heliostats within the grid cells would be subject to such maximum scour.
- The Head Cut analysis assumes that all areas subject to head cut depths above the design scour depth would cut down uniformly to a depth below the scour depth. In reality, the head cut channels may extend within these areas or form new channels but it would be unlikely that the entire area will be cut down to below the scour depth.

It should also be noted that the local scour depth is added to the general scour depth for the design scour depth for the project. All heliostats within the site will be driven to a depth that accounts for general scour plus local scour. For the purposes of the heliostat exceedance analysis the local scour was not discussed because it is a constant 1.5 feet in all cases and is taken into account fully within the pylon depths. The exceedance analysis only applies to the general scour component which has small portions of the site that exceed the design value.

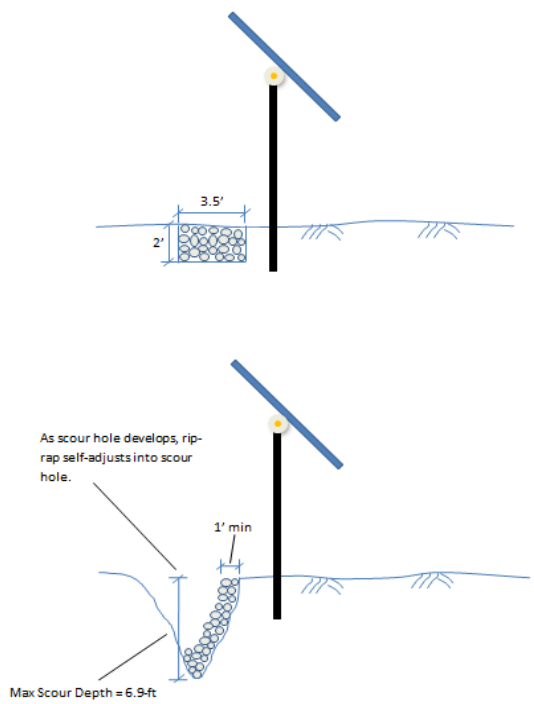
F. NORTHWEST SOLAR FIELD AREA

Examination of the grid cells listed in *Table 4* with the highest scour depth revealed that 27 out of the 71 cells are located in a small area within the northwest portion of the site. *Figure 7323RIPRAP* within *Appendix G* shows the location of this area with respect to the overall site. The 27 out of the 71 grid cells with higher general scour depths than the 99th percentile depth is equivalent to 38% of the site area subjected to scour depth exceedence during the 100-year storm event. The northwest area only makes up 1% of the total area occupied by the solar fields.

To protect the heliostats within this area, an erosion control riprap trench placed upstream of the heliostats is proposed as an alternative. Per the FLO-2D analysis, the highest onsite scour depth reported for this area is 6.9 feet. The trench is designed to include enough

volume of riprap to fill the potential scour hole created at the upstream interface of the riprap and the native soil. As a scour hole develops, the riprap in the trench self-adjusts by falling into the scour hole which stops any potential undermining of the heliostat pylons. A conceptual schematic detail of the riprap trench dimensions and the process is shown below.

Schematic 1: Rip-Rap Protection Trench



If this alternative to protect the heliostats in the northwest areas is utilized, then the exceedance probability analysis in section IV.E.1 can be revised to remove these heliostats from the analysis. With the riprap protection, the number of grid cells area subject to general scour depths above 1.46 is reduced to 44. The number of heliostats subjected to general scour above the 1.46-ft in this scenario becomes:

$$5.68ac \ \ x\ 47.1\frac{heliostats}{ac}\ x\ 0.222 = 60\ heliostats$$

The total number of heliostats exceeding the anticipated scour depth based on the FLO-2D and Head Cut analyses is reduced from 650 to 614.

V. SEDIMENT TRANSPORT ANALYSIS

Sediment transport for the onsite area was determined through the Sediment Transport Sub-routine in FLO-2D. The methodology for the sediment transport analysis is the Zeller-Fullerton equation. The soils information reported in Section IV.A.1- FLO-2D Scour Analysis of this report was used as the basis of the analysis. It should be noted that FLO-2D only computes bed load losses for the sediment transport computations. Source sediment from the offsite areas was supplied to the model based on recommendation from FLO-2D personnel. According to FLO-2D personnel, the preferable method in incorporating sediment supply is to place inflow nodes (referenced HEC-1 hydrographs) upstream of the project boundary where 10 or more elements could be utilized as sacrificial grid elements that would generate a supply to the downstream grid elements. As noted visually on figure 7323SCOUR (FLO-2D SCOUR MAP) this methodology was adhered to within the Rio Mesa Solar project. The existing and developed condition sediment transport results, for the five different storm events, from the FLO-2D analysis are summarized below.

Table 6: Onsite Sediment Load Summary

Storm	Exisiting Condition			Developed Condition			% Change in Sediment Load
	Sediment Load (ac-ft)	Storm water Runoff (ac-ft)	Sediment Concentration (%)	Sediment Load (ac-ft)	Storm water Runoff (ac-ft)	Sediment Concentration (%)	
100-YR	54.72	1296.78	4.22	55.89	1405.26	3.98	2.14
25-YR	22	693.16	3.17	22.35	770.46	2.90	1.59
10-YR	9.78	393.96	2.48	9.89	449.12	2.20	1.12
5-YR	4.19	221.59	1.89	4.21	260.69	1.61	0.48
2-YR	0.72	70.41	1.02	0.72	88.09	0.82	0.00

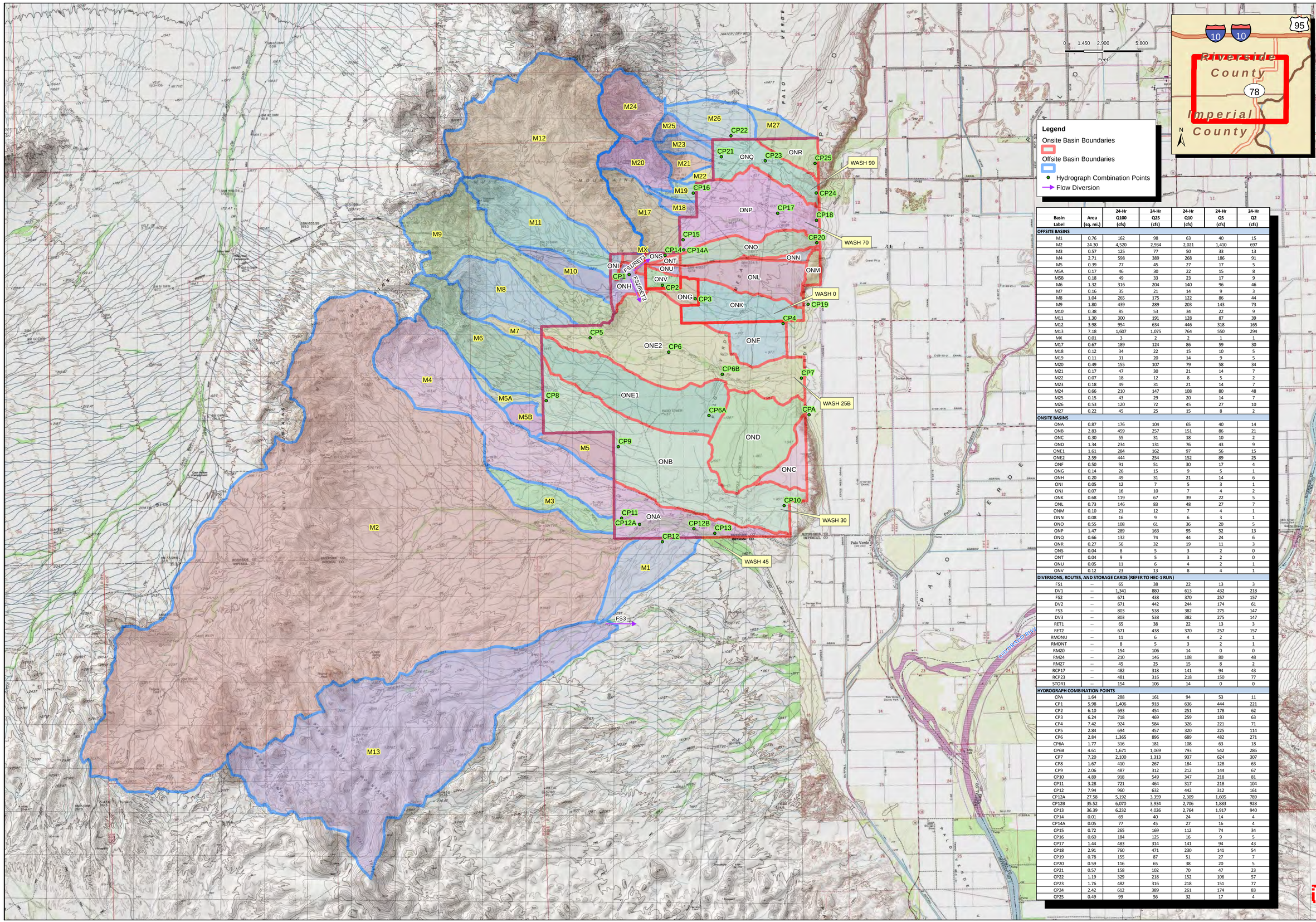
With the increase in runoff between the existing and developed condition storm events due to the higher CN number values representing development, the sediment concentration is reduced. However, as expected with an increase in runoff, the actual sediment load has increased with only a minor impact between 0.00 to 2.14 percent throughout the different storm events. Please refer to *Appendix F* for the FLO-2D summary output for sediment load results.

VI. REFERENCES

1. VTN Consulting: Rio Mesa Solar Overall Existing Condition Hydrologic and Hydraulic Analysis; July 2011.
2. U.S. Department of Transportation Federal Highway Administration (FHWA): Hydraulic Engineering Circular No. 18 (HEC-18); May 2001.
3. Federal Emergency Management Agency (FEMA): FAN – An Alluvial Fan Flooding Computer Program User's Manual; September 1990

APPENDIX A:

Reference Material / Overall Figure



Basin Label	Area (sq. mi.)	24-Hr Q100 (cfs)	24-Hr Q25 (cfs)	24-Hr Q10 (cfs)	24-Hr Q5 (cfs)	24-Hr Q2 (cfs)
OFFSITE BASINS						
M1	0.76	162	98	63	40	15
M2	24.30	4,520	2,934	2,021	1,410	697
M3	0.57	125	77	50	33	13
M4	2.71	598	389	268	186	91
M5	0.39	77	45	27	17	5
M5A	0.17	46	30	22	15	8
M5B	0.18	49	33	23	17	9
M6	1.32	316	204	140	96	46
M7	0.16	35	21	14	9	3
M8	1.04	265	175	122	86	44
M9	1.80	439	289	203	143	73
M10	0.38	85	53	34	22	9
M11	1.30	300	191	128	87	39
M12	3.98	954	634	446	318	165
M13	7.18	1,607	1,075	764	550	294
MX	0.01	3	2	2	1	1
M17	0.67	189	124	86	59	30
M18	0.12	34	22	15	10	5
M19	0.11	31	20	14	9	5
M20	0.49	155	107	79	58	34
M21	0.17	47	30	21	14	7
M22	0.07	18	12	8	5	2
M23	0.18	49	31	21	14	7
M24	0.66	210	147	108	80	48
M25	0.15	43	29	20	14	7
M26	0.53	120	72	45	27	10
M27	0.22	45	25	15	8	2
ONSITE BASINS						
ONA	0.87	176	104	65	40	14
ONB	2.83	459	257	151	86	21
ONC	0.30	55	31	18	10	2
OND	1.34	234	131	76	43	9
ONE1	1.61	284	162	97	56	15
ONE2	2.59	444	254	152	89	25
ONF	0.50	91	51	30	17	4
ONG	0.14	26	15	9	5	1
ONH	0.20	49	31	21	14	6
ONI	0.05	12	7	5	3	1
ONJ	0.07	16	10	7	4	2
ONK	0.68	119	67	39	22	5
ONL	0.73	146	83	48	27	7
ONM	0.10	21	12	7	4	1
ONN	0.08	16	9	6	3	1
ONO	0.55	108	61	36	20	5
ONP	1.47	289	163	95	52	13
ONQ	0.66	132	74	44	24	6
ONR	0.27	56	32	19	11	3
ONS	0.04	8	5	3	2	0
ONT	0.04	9	5	3	2	0
ONU	0.05	11	6	4	2	1
ONV	0.12	23	13	8	4	1
DIVERSIONS, ROUTES, AND STORAGE CARDS (REFER TO HEC-1 RUN)						
FS1	--	65	38	22	13	3
DV1	--	1,341	880	613	432	218
FS2	--	671	438	370	257	157
DV2	--	671	442	244	174	61
FS3	--	803	538	382	275	147
DV3	--	803	538	382	275	147
RET1	--	65	38	22	13	3
RET2	--	671	438	370	257	157
RMONU	--	11	6	4	2	1
RMONT	--	8	5	3	2	1
RM20	--	154	106	14	0	0
RM24	--	210	146	108	80	48
RM27	--	45	25	15	8	2
RCP17	--	482	318	141	94	43
RCP23	--	481	316	218	150	77
STOR1	--	154	106	14	0	0
HYDROGRAPH COMBINATION POINTS						
CPA	1.64	288	161	94	53	11
CP1	5.98	1,406	918	636	444	221
CP2	6.10	693	454	251	178	62
CP3	6.24	718	469	259	183	63
CP4	7.42	924	584	326	221	71
CP5	2.84	694	457	320	225	114
CP6	2.84	1,365	896	689	482	271
CP6A	1.77	316	181	108	63	18
CP6B	4.61	1,671	1,069	793	542	286
CP7	7.20	2,100	1,313	937	624	307
CP8	1.67	410	267	184	128	63
CP9	2.06	487	312	212	144	67
CP10	4.89	918	549	347	218	81
CP11	3.28	721	464	317	218	104
CP12	7.94	960	632	442	312	161
CP12A	27.58	5,192	3,359	2,309	1,605	789
CP12B	35.52	6,070	3,934	2,706	1,883	928
CP13	36.39	6,232	4,026	2,764	1,917	940
CP14	0.01	69	40	24	14	4
CP14A	0.05	77	45	27	16	4
CP15	0.72	265	169	112	74	34
CP16	0.60	184	125	16	9	5
CP17	1.44	483	314	141	94	43
CP18	2.91	760	471	230	141	54
CP19	0.78	155	87	51	27	7
CP20	0.59	116	65	38	20	5
CP21	0.57	158	102	70	47	23
CP22	1.19	329	218	152	106	57
CP23	1.76	482	316	218	151	77
CP24	2.42	612	389	261	174	83
CP25	0.49	99	56	32	17	4

REV.	DATE	BY	REVISION
	7/5/11	RV	Added Q divert arrows per Bechtel comments.
	6/29/11	RV	Rev. hydrology diversion/combining per latest FLO2D flows at x-sections.
	6/11/11	RV	Added additional aug. area offsite/onsite basins per topo. Updated map to 1" = 1,000' from topo. Includes additional parcel per TR 6/10/11.

N W E S

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RIVERSIDE COUNTY, CA

DRAINAGE BASIN EXHIBIT

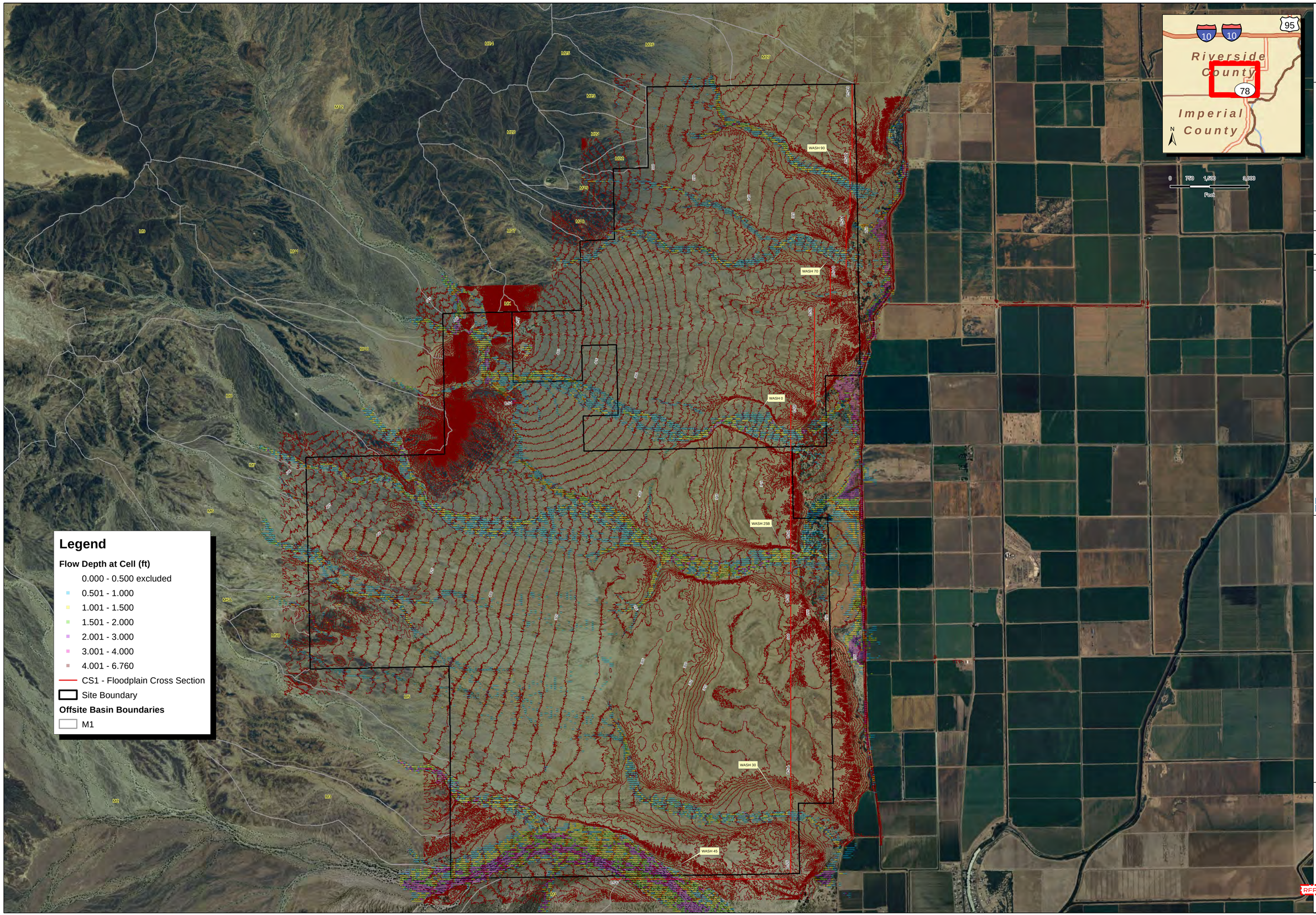
RIO MESA SOLAR

PROJECT NO. 7323
DRAWN BY: RV/LL
DATE 7/5/2011
SCALE 1 " = 3,000 '

REFERENCE MATERIAL

7323HYD100

DATE: 7/5/2011 File: \\vtnnv.com\ds\hydrology\7323-BlythePreliminary Site Investigation\GIS\MXD\7323-BasinExhibit.mxd By: rauh



REV.	DATE	BY	REVISION
	6/16/11	SB	Added augmentation area, replaced CS 7 & 8 and added CS 9-13

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FLO-2D DEPTH MAP
24HR-100YR
EXISTING CONDITION

RIO MESA SOLAR

PROJECT NO: 7323
DRAWN BY: SB
DATE: 6/16/2011
SCALE: 1" = 1,500 '

REFERENCE MATERIAL

7323HYD200

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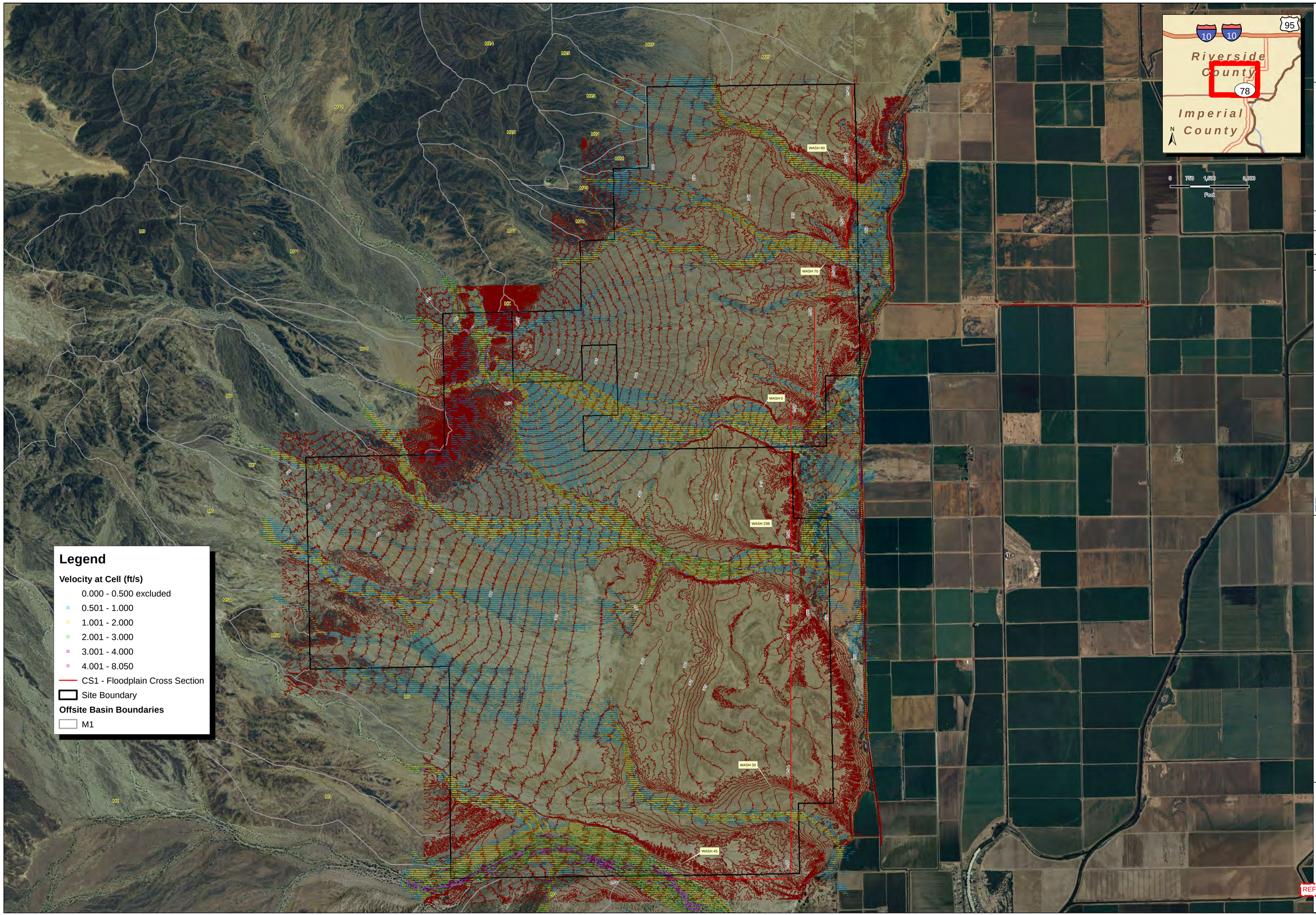

REV.	DATE	BY	REVISION
	6/16/11	SB	Added augmentation area, replaced CS 7 & 8 and added CS 9-13

RIVERSIDE COUNTY, CA

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FLO-2D VELOCITY MAP 24HR-100YR EXISTING CONDITION

RIO MESA SOLAR

PROJECT NO: 7323
DRAWN BY: SB
DATE: 6/16/2011
SCALE: 1 " = 1,500 '

REFERENCE MATERIAL

7323HYD201

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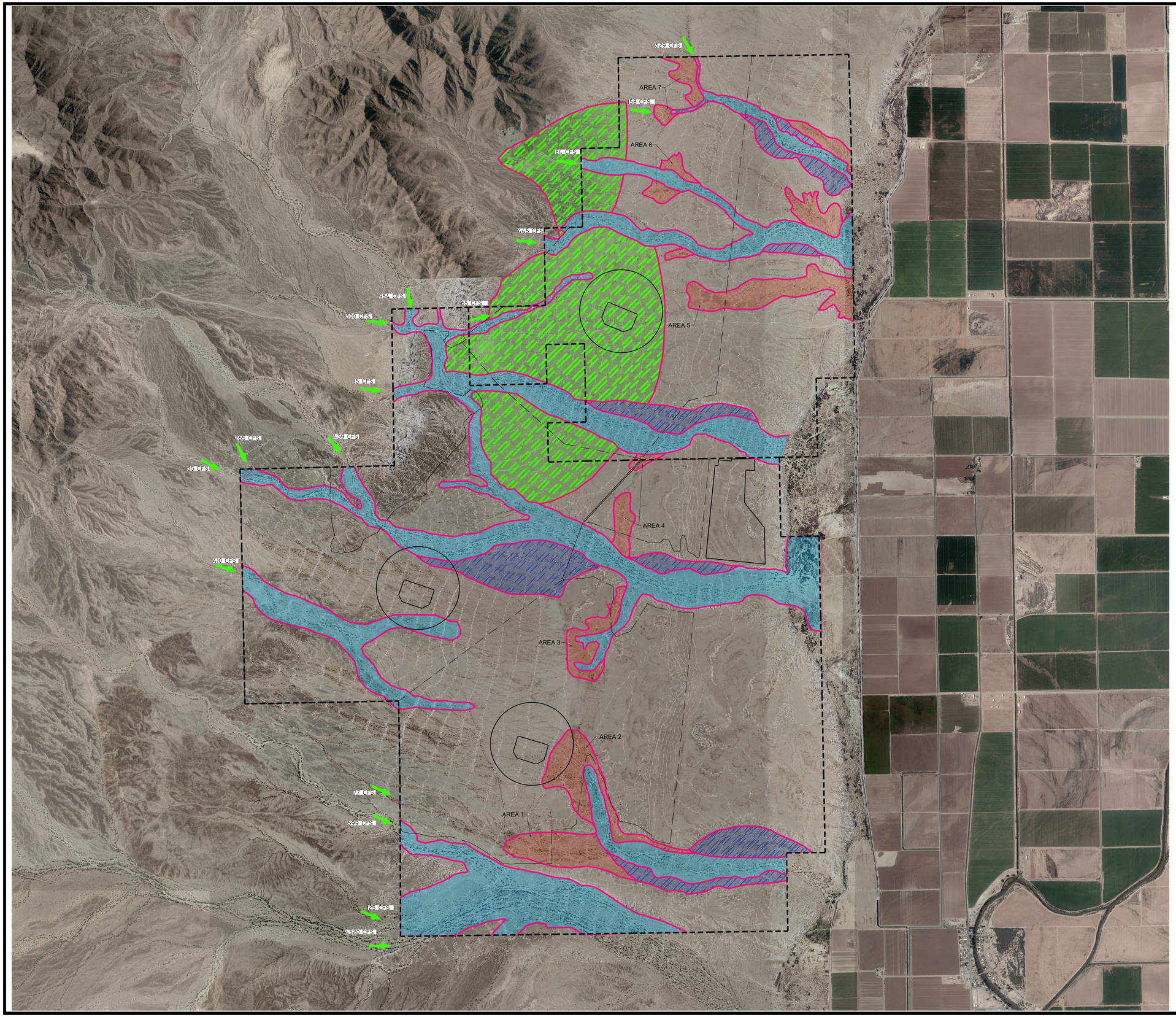

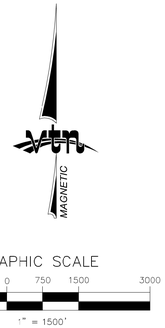

LEGENDS

- SITE BOUNDARY
- 5' CONTOUR
- MAJOR FLOW CORRIDOR AREA: DELINEATIONS BASED ON HISTORICAL PHOTOS AND FIELD EVALUATION. THESE CORRIDORS CONTAIN THE MAJORITY OF THE ONSITE FLOWS AND HAVE SHOWN TO BE RELATIVELY STABLE OVER A PERIOD OF AT LEAST 60 YEARS
- AREA SUBJECT TO FLOW BREAKOUTS AND LATERAL MIGRATION OF WASHES WITHIN THE MAJOR FLOW CORRIDORS WITH LARGE POTENTIAL FOR SCOUR AND EROSION
- ALLUVIAL FAN AREA: AREAS SUBJECT TO ALLUVIAL FAN PROCESSES
- HEADCUT AREA: AREA SUBJECT TO CONCENTRATION OF SHEET FLOWS AND FORMATION OF NEW CHANNELS WHICH SHOW SIGNS OF HEAD CUTTING IN UPSTREAM DIRECTION
- FLOW DIRECTION
- 750 CFS — 24 HR 100 YR FLOW

REV	DATE	BY	REVISION

BRIGHTSOURCE ENERGY

RIO MESA SOLAR

POTENTIAL EROSION AREAS EXHIBIT

2727 SOUTH RAINBOW BOULEVARD
LAS VEGAS, NEVADA 89146-5148
PH. (702) 873-7550 FAX (702) 362-2597 WEB WWW.VTNNV.COM
CONSULTING ENGINEERS ● PLANNERS ● LAND SURVEYORS

DRAWN BY: WT
DESIGNED BY:
CHECKED BY:
PROJECT NO: 7323
SCALE: HORIZ. VERT.

SHEET 7323HYD402 OF SHEETS
DRAWING NO.

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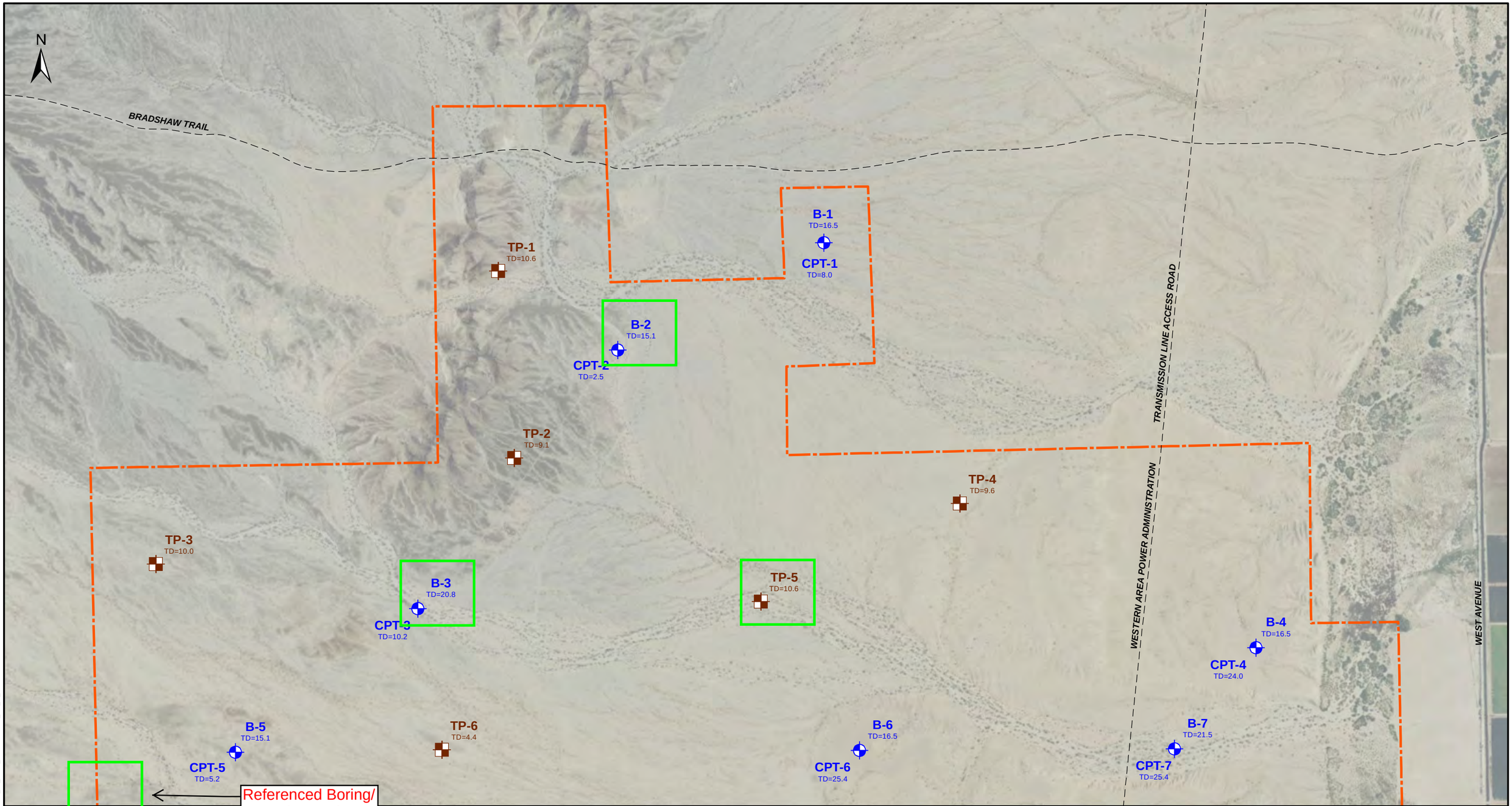


LEGEND

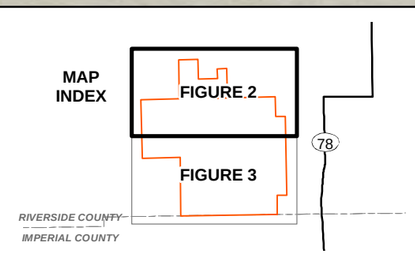
B-16 TD=21.5 / CPT-16 TD=25.4 — BORING / CONE PENETRATION TEST, TD = TOTAL DEPTH IN FEET

TP-15 TD=9.0 — TEST PIT, TD = TOTAL DEPTH IN FEET

UNPAVED ROADWAY

SITE BOUNDARY

MAP INDEX



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NOTE: DIRECTIONS, DIMENSIONS AND LOCATIONS ARE APPROXIMATE

SCALE IN FEET

0 700 1,400 2,800

REFERENCE MATERIAL

Ninyo & Moore		EXPLORATORY EXCAVATIONS	FIGURE
PROJECT NO.	DATE	RIO MESA SOLAR FACILITY BRADSHAW TRAIL AND WEST AVENUE RIVERSIDE COUNTY, CALIFORNIA	2
303256001	6/11		

BSE Document Control Number: 7323HYD400-FINAL-R1

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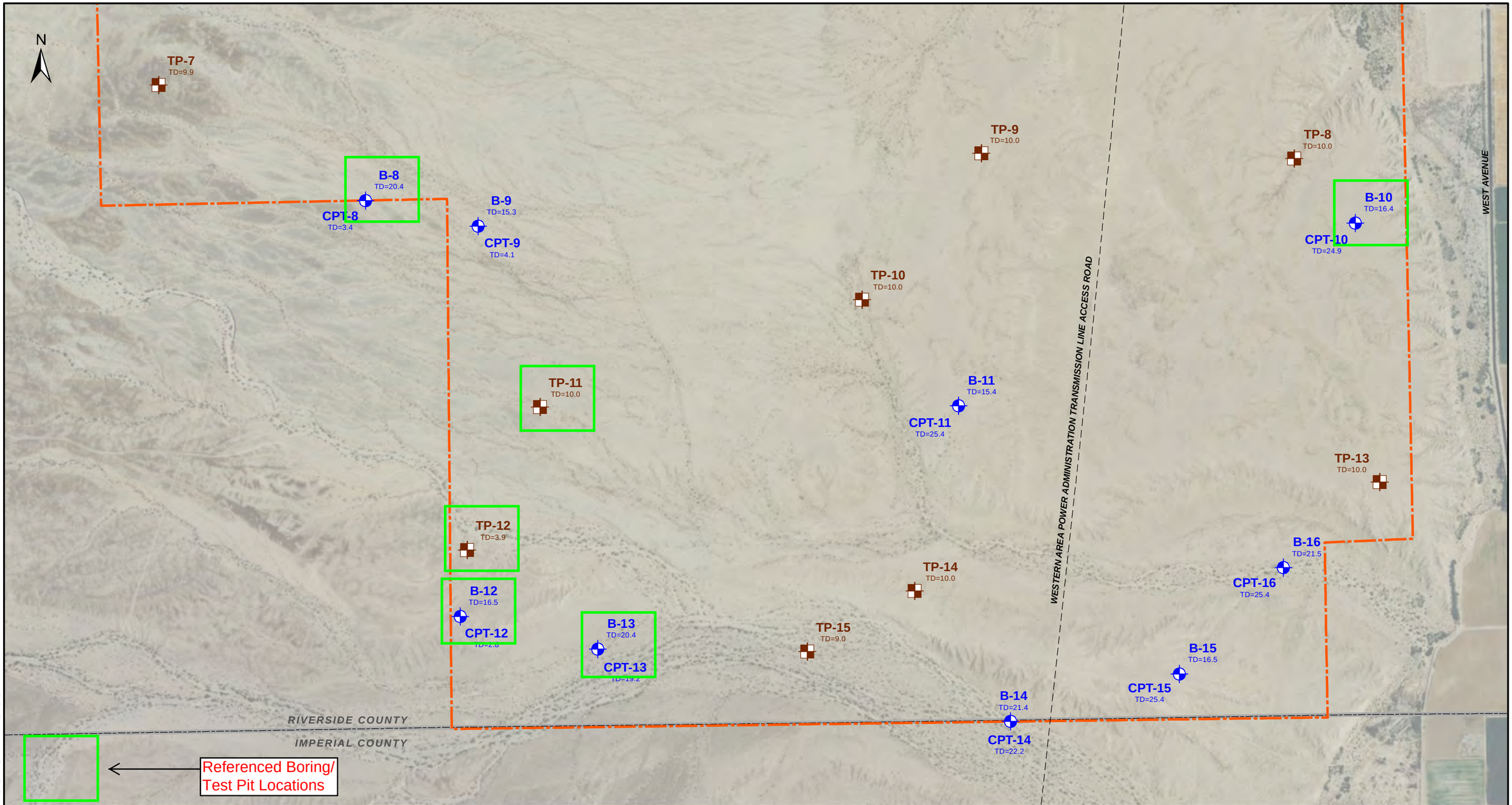

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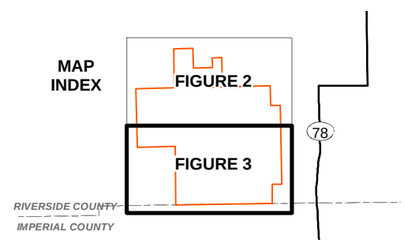
UNPAVED ROADWAY

SITE BOUNDARY

MAP INDEX



NOTE: DIRECTIONS, DIMENSIONS AND LOCATIONS ARE APPROXIMATE

SCALE IN FEET

0 700 1,400 2,800

REFERENCE MATERIAL

Ninyo & Moore

EXPLORATORY EXCAVATIONS

PROJECT NO.	DATE
303256001	6/11

RIO MESA SOLAR FACILITY
BRADSHAW TRAIL AND WEST AVENUE
RIVERSIDE COUNTY, CALIFORNIA

FIGURE 3

BSE Document Control Number: 7323HYD400-FINAL-R1

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APPENDIX B:

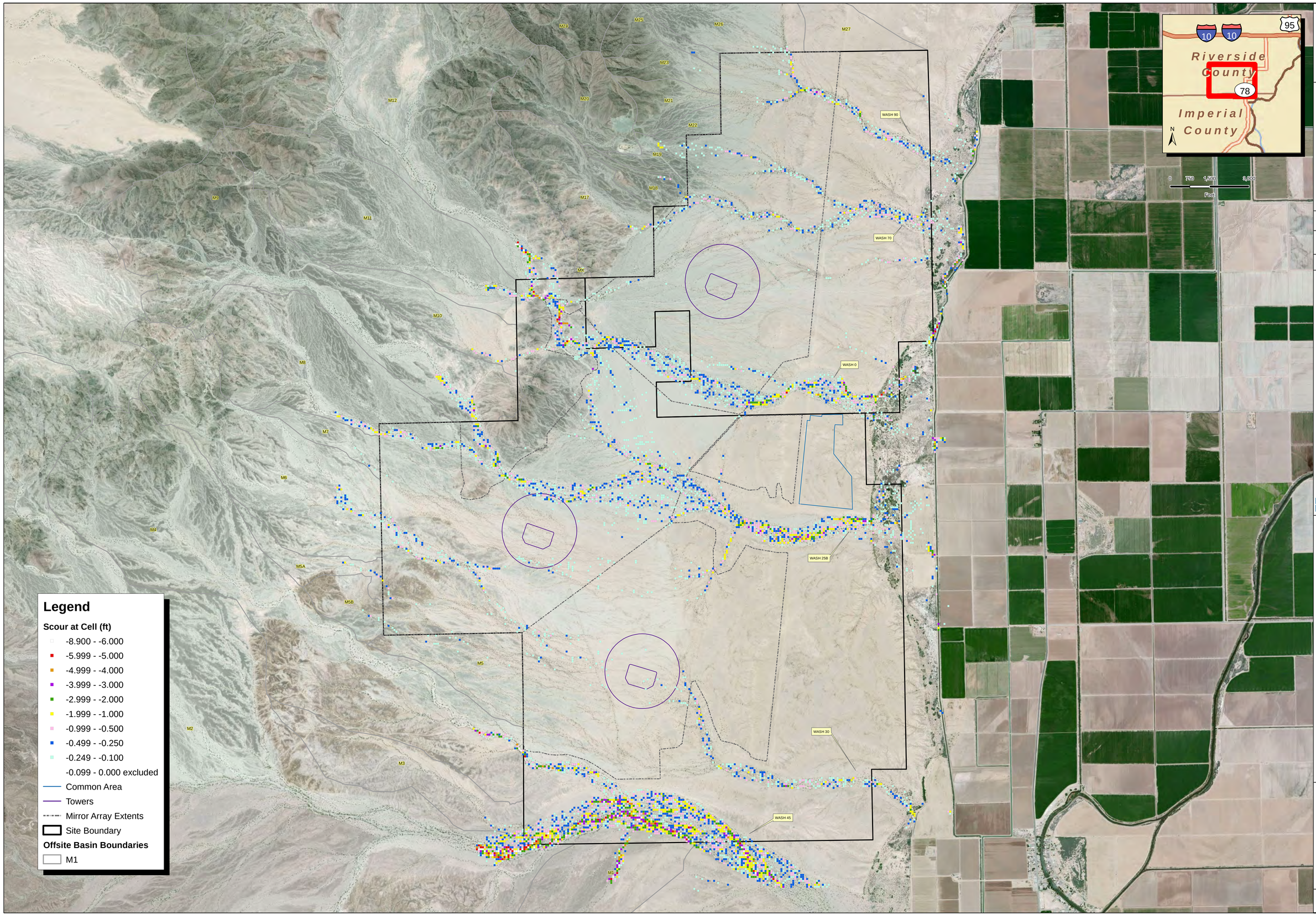
General Scour: FLO-2D Analysis

General Scour: FLO-2D Statistical Analysis Calculations

(Statistics With (-).01-ft to Max Scour Depth Cell Range)

	Range: (-)0.01 to max		Heliostat Ratio = 47.1 Heliostats/acre
	99th Percentile Depth (ft)	Average Depth (ft)	
	-1.46	-0.13	
# Cells Exceeding Percentile Depth =	71		
# of Heliostats with Exceeding Scour Depths =	**431.8**		

# of cells within the "Northwest Area" =		27
# of cells Exceeding Percentile Depth = minus cells within "Northwest Area"	(71-27) =	44
# of Heliostats w/Exceeding Depths = minus cells within "Northwest Area"		267.6



REV.	DATE	BY	REVISION

RIVERSIDE COUNTY, CA

BrightSource

2727 S. Rainbow Boulevard
Las Vegas, NV 89146
Tel (702) 382-2500
Fax (702) 382-2597
www.atmx.com

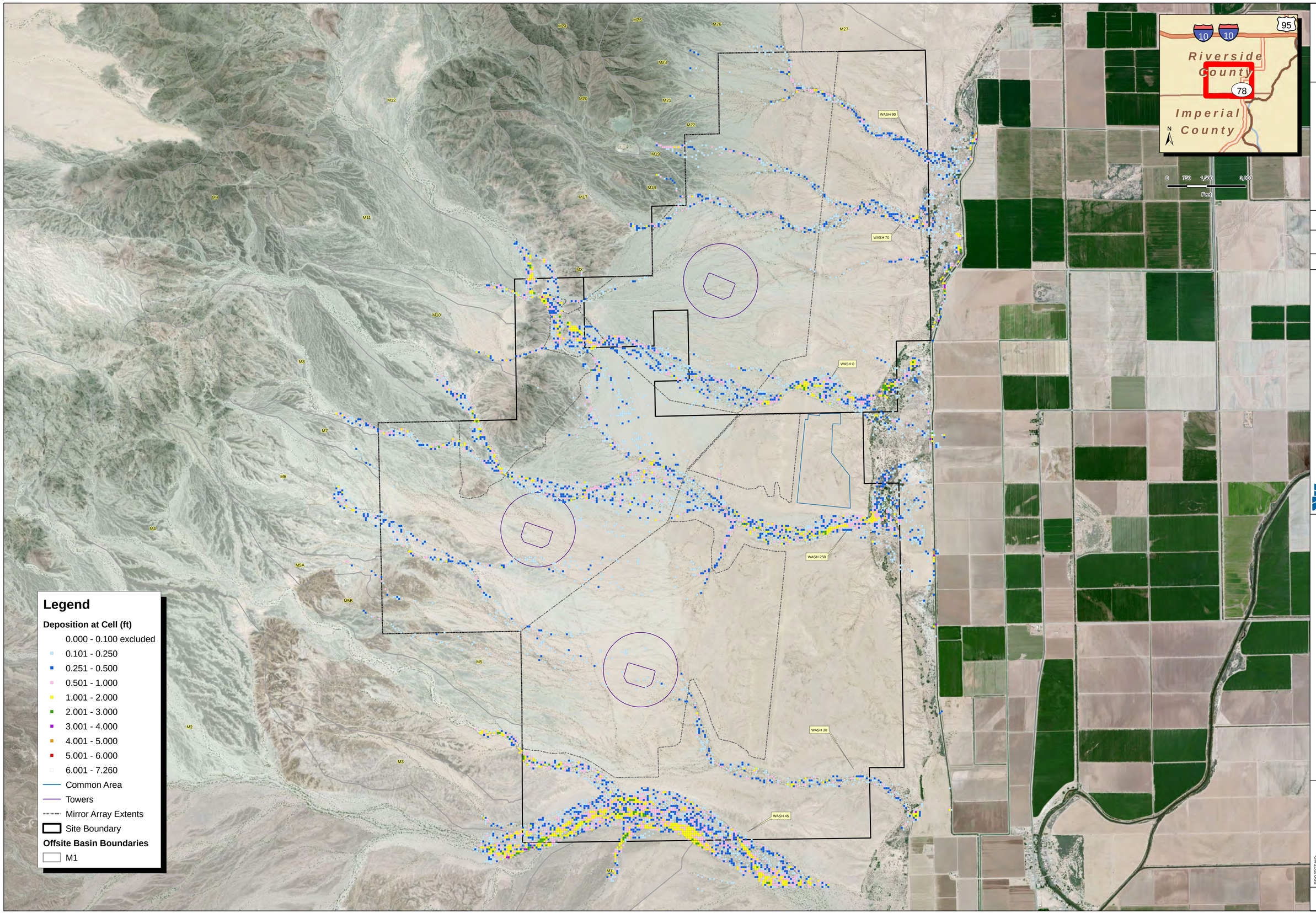
FLO-2D SCOUR MAP
24HR-100YR
ZELLER-FULLERTON METHOD

RIO MESA SOLAR

PROJECT NO: 7323
DRAWN BY: SB
DATE: 8/18/2011
SCALE: 1 " = 1,500 '

SHEET
7323SCOUR

DATE: 11/18/2010; File: \\atmx.com\dfs\gis\data\V7\Arcmd-templates\36x24_revision_block.mxd; By: teresar



REV.	DATE	BY	REVISION

RIVERSIDE COUNTY, CA

BrightSource

2727 S. Rainbow Boulevard
Las Vegas, NV 89146
Tel (702) 382-2500
Fax (702) 382-2597
www.atmx.com

FLO-2D DEPOSITION MAP
24HR-100YR
ZELLER-FULLERTON METHOD

RIO MESA SOLAR

PROJECT NO: 7323

DRAWN BY: SB

DATE: 8/18/2011

SCALE: 1 " = 1,500 '

SHEET
7323DEP

DATE: 11/18/2010; File: \\atmx.com\dfs\gis\data\V7\Arcmd-templates\36x24_revision_block.mxd; By: teresar

BSE Document Control Number: 7323HYD400-FINAL-R1

APPENDIX C:

General Scour: FEMA Alluvial Fan Equations

Average Channel Parameters for Use in FEMA Alluvial Fan Equations

Reach	Flow tributary, Q (cfs)	Froude Number	Slope, "s" (ft/ft)	Flow width, "w" (ft)	Flow depth, "d" (ft)	Width / depth ratio, a (ft/ft)
Wash 60	64	0.65	0.013	62.00	0.88	70
Wash 0C	599	0.70	0.013	308.00	1.62	190
Wash 80	242	0.62	0.010	140.00	1.69	83
Wash 15B	676	0.89	0.019	189.00	1.88	101
Average =		**0.72**	**0.014**	**174.75**	**1.52**	**111**

Apex Flow = 1406 cfs (from hydrograph combination point CP1, existing condition basin map, Figure 7323HYD100)

FEMA Equations Calculations

Erosion Depth

$d = 0.112361 \times Q^{3/8} = 1.70$ ft

$d = 0.077822 \times Q^{3/8} = 1.18$ ft

$d = 0.110851 \times Q^{3/8} = 1.68$ ft

$d = 0.091859 \times Q^{3/8} = 1.39$ ft

$d = 0.093931 \times Q^{3/8} =$ **1.42** ft

FEMA Alluvial Fan Equation obtained from derivation based on averaged parameters

Notes:

1. Channel parameters obtained from HEC-Ras analysis.

APPENDIX D:

General Scour: Head Cutting Areas

RIO MESA SOLAR
HEAD CUT ANALYSIS

99th PERCENTILE HEAD CUT DEPTH

Depth (ft) = **-1.46**

99th Percentile calculation includes 237.4 ac with head cutting occurring (shown below left) and another 5178.3 ac in the solar field area not subject to head cutting.

HEAD CUT PROFILE INFORMATION

SECTION	STA (ft)	CUT (ft)	AREA (ac)
2D	12+00	-3.02	2.89
6A	4+00	-3.01	1.82
4A	14+00	-2.66	2.26
7D	4+00	-2.51	1.49
6B	2+00	-2.12	1.82
2D	10+00	-2.03	2.89
3F	2+00	-2.02	2.57
2C	8+00	-2.01	2.89
2D	14+00	-2.01	2.89
2D	8+00	-2.00	2.89
6A	2+00	-2.00	1.82
6B	4+00	-2.00	1.82
7E	4+00	-2.00	1.49
4A	12+00	-1.97	2.26
2C	10+00	-1.95	2.89
7C	2+00	-1.93	1.49
7F	10+00	-1.89	1.49
7D	2+00	-1.84	1.49
7C	4+00	-1.78	1.49
2B	12+00	-1.65	2.89
6B	10+00	-1.50	1.82
7B	2+00	-1.50	1.49
3E	10+00	-1.49	2.57
6C	2+00	-1.49	1.82
6D	8+00	-1.47	1.82
2B	4+00	-1.40	2.89
3C	6+00	-1.30	2.57
2D	6+00	-1.27	2.89
2B	10+00	-1.26	2.89
3A	6+00	-1.19	2.57
2D	4+00	-1.12	2.89
7A	4+00	-1.12	1.49
7E	2+00	-1.11	1.49
2C	12+00	-1.08	2.89
3F	4+00	-1.07	2.57
2A	2+00	-1.05	2.89
7F	4+00	-1.05	1.49
2B	8+00	-1.04	2.89
2B	14+00	-1.04	2.89
3A	4+00	-1.03	2.57
1A	8+00	-1.02	2.56
2B	6+00	-1.01	2.89
3D	2+00	-1.01	2.57
3E	4+00	-1.01	2.57
3E	6+00	-1.01	2.57
3E	8+00	-1.01	2.57
3F	6+00	-1.01	2.57
5A	6+00	-1.01	2.09
5A	8+00	-1.01	2.09
6B	6+00	-1.01	1.82

Based on comparison of other scour/erosion mechanisms in the watershed, the controlling depth for scour for the project is 1.46 ft.

HELIOSTAT EXCEEDENCE ANALYSIS

Area with headcut exceeding 1.46 ft = 53.10 ac

Ratio = 47.1 Heliostats/acre

Therefore,
the # of units exceeding scour depth = 2501

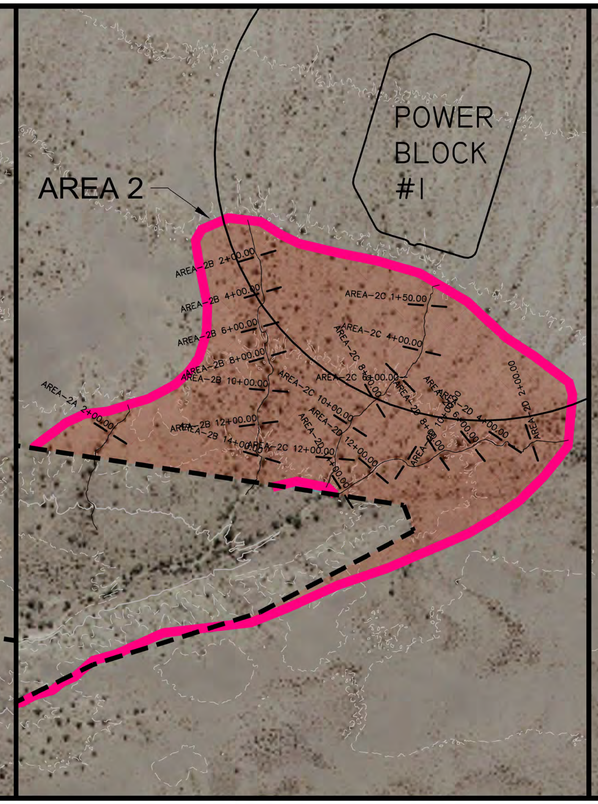
Provided that maintenance is performed following any storm that causes significant erosion/headcutting, the exceedence probability of a 100-year storm over the 25 year permit life of the facility is 22.2%.

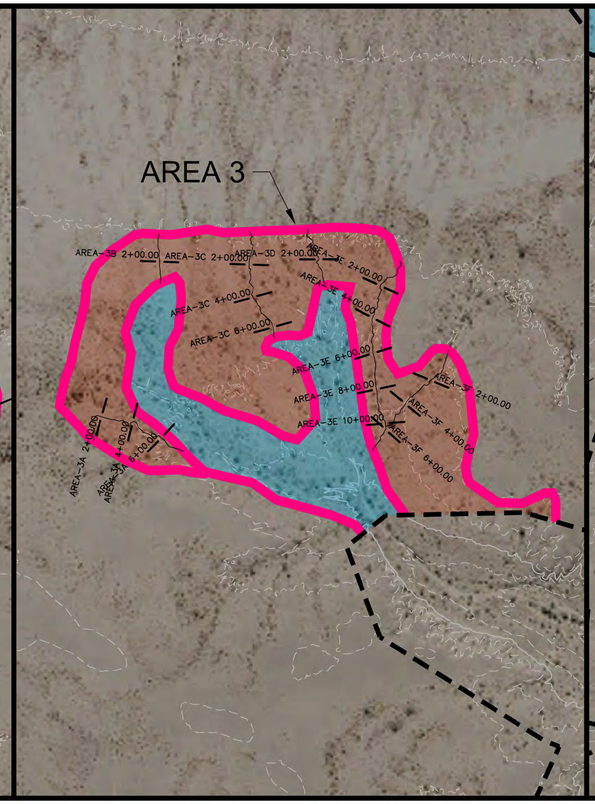
Therefore,
the # of units exceeding scour depth can be taken as:

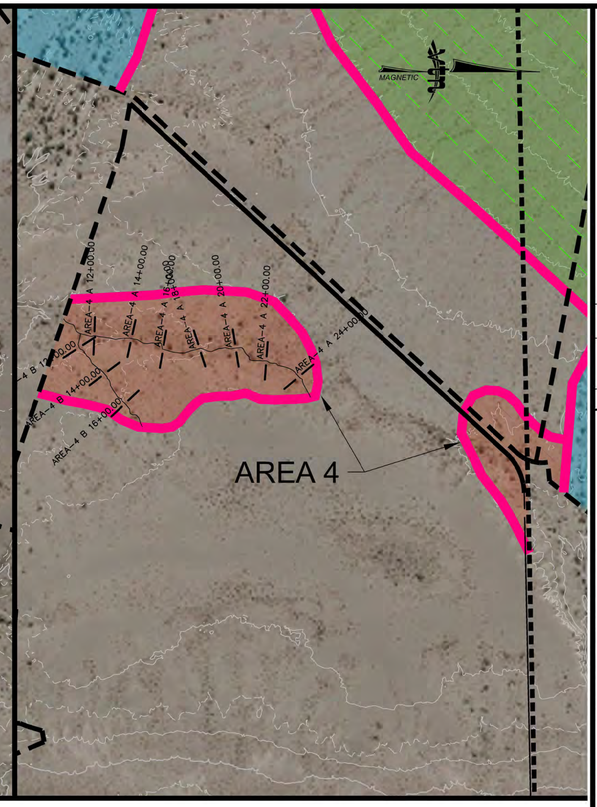
2501 x 0.222 = <u>555 heliostats exceeding scour depth</u>

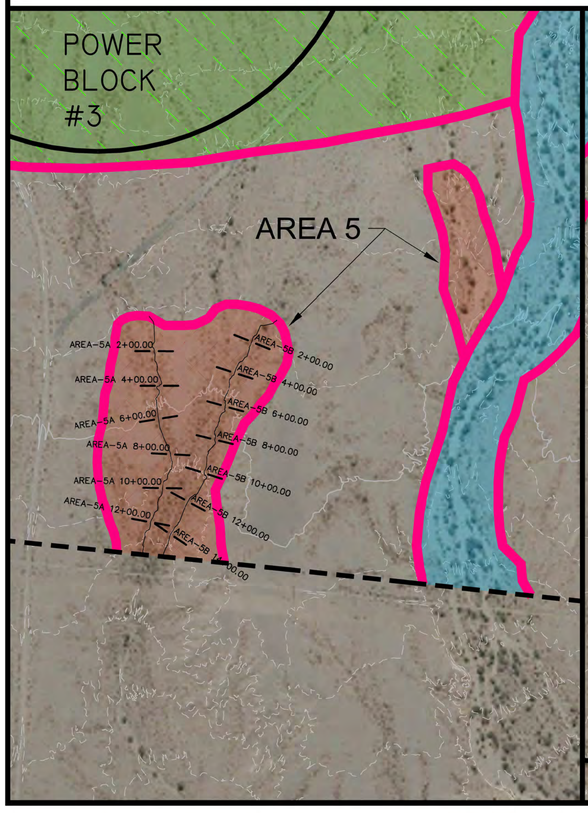
HEAD CUT PROFILE INFORMATION

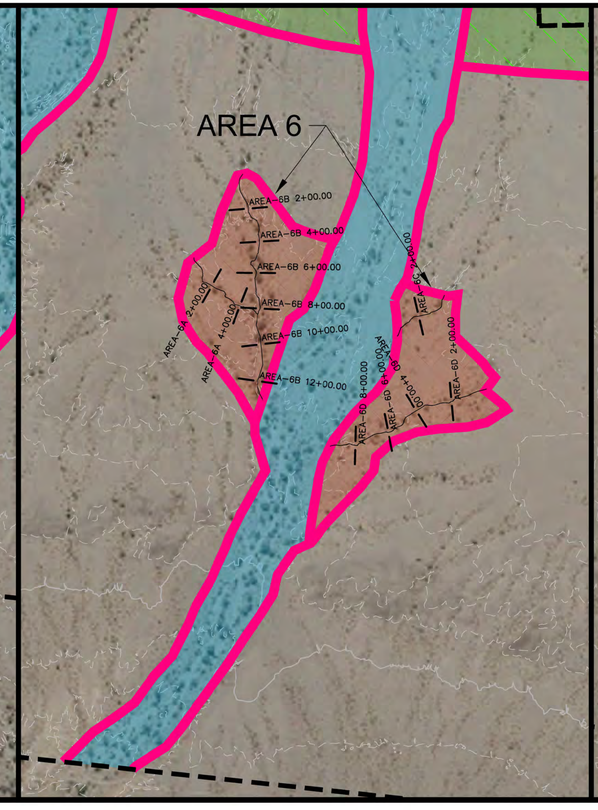
SECTION	STA	CUT	AREA
	(ft)	(ft)	(ac)
6D	6+00	-1.01	1.82
7F	8+00	-1.01	1.49
6B	8+00	-1.00	1.82
7B	4+00	-1.00	1.49
7C	6+00	-1.00	1.49
7F	6+00	-1.00	1.49
5A	10+00	-0.98	2.09
5B	14+00	-0.97	2.09
2B	2+00	-0.90	2.89
6B	12+00	-0.89	1.82
6D	2+00	-0.88	1.82
6D	4+00	-0.88	1.82
7A	2+00	-0.88	1.49
7D	6+00	-0.87	1.49
2D	2+00	-0.86	2.89
4A	24+00	-0.83	2.26
5B	2+00	-0.82	2.09
7G	8+00	-0.81	1.49
7G	4+00	-0.78	1.49
1B	3+50	-0.77	2.56
4B	14+00	-0.77	2.26
3A	2+00	-0.71	2.57
4A	20+00	-0.63	2.26
7G	2+00	-0.58	1.49
7G	6+00	-0.57	1.49
1A	2+00	-0.56	2.56
4A	16+00	-0.56	2.26
5B	4+00	-0.53	2.09
1A	6+00	-0.52	2.56
4A	18+00	-0.50	2.26
1A	14+00	-0.47	2.56
4B	16+00	-0.45	2.26
5B	10+00	-0.45	2.09
2C	6+00	-0.42	2.89
1A	16+00	-0.36	2.56
5B	12+00	-0.33	2.09
7F	2+00	-0.33	1.49
1A	4+00	-0.32	2.56
2C	1+50	-0.30	2.89
3B	2+00	-0.28	2.57
5B	6+00	-0.27	2.09
4A	22+00	-0.25	2.26
4B	12+00	-0.25	2.26
5A	4+00	-0.25	2.09
1B	8+00	-0.24	2.56
2C	4+00	-0.23	2.89
5A	2+00	-0.22	2.09
1B	5+50	-0.21	2.56
5A	12+00	-0.21	2.09
1A	12+00	-0.20	2.56
3C	2+00	-0.18	2.57
1B	1+50	-0.10	2.56
3C	4+00	-0.09	2.57
1A	10+00	-0.05	2.56
5B	8+00	-0.05	2.09
3E	2+00	-0.02	2.57

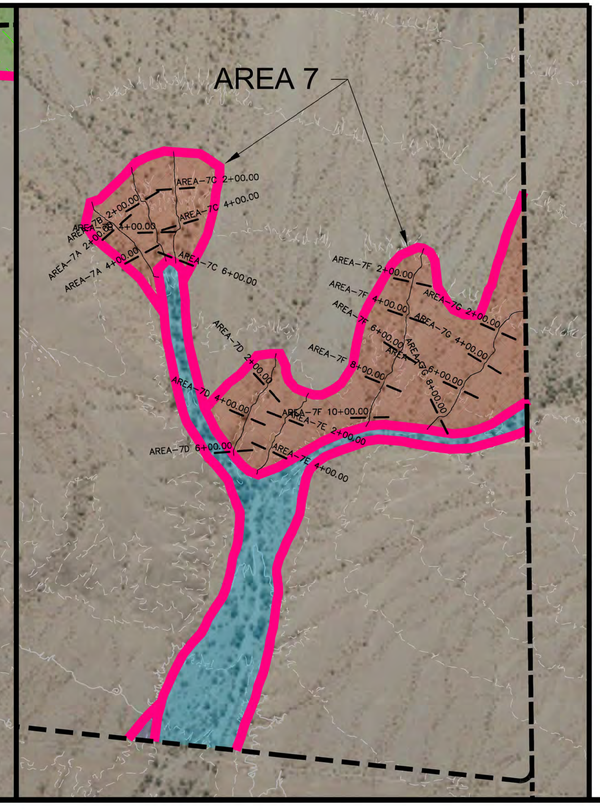












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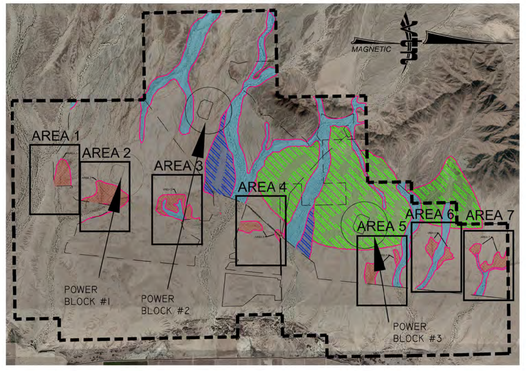

LEGEND

- SITE BOUNDARY
- SOLAR FIELD AREA BOUNDARY
- 5' CONTOUR
- MAJOR FLOW CORRIDOR AREA: DELINEATIONS BASED ON HISTORICAL PHOTOS AND FIELD EVALUATION. THESE CORRIDORS CONTAIN THE MAJORITY OF THE ONSITE FLOWS AND HAVE SHOWN TO BE RELATIVELY STABLE OVER A PERIOD OF AT LEAST 60 YEARS
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- HEADCUT AREA: AREA SUBJECT TO CONCENTRATION OF SHEET FLOWS AND FORMATION OF NEW CHANNELS WHICH SHOW SIGNS OF HEAD CUTTING IN UPSTREAM DIRECTION

NOTE: FLOW AREAS DOWNSTREAM OF SOLAR FIELD BOUNDARY NOT SHOWN.

REV	DATE	BY	REVISION

BRIGHTSOURCE ENERGY

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LAS VEGAS, NEVADA 89146-5148
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RIO MESA SOLAR

POTENTIAL HEAD CUT AREAS EXHIBIT

DRAWN BY: WT
DESIGNED BY:
CHECKED BY:
PROJECT NO: 7323
SCALE: HORIZ. VERT.

SHEET 7323HC OF SHEETS
DRAWING NO.

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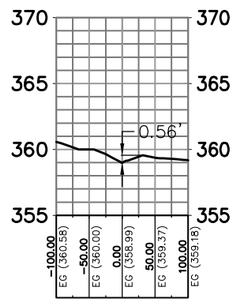

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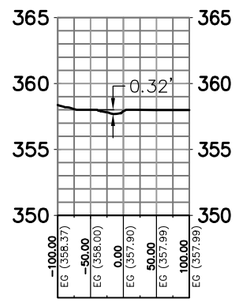

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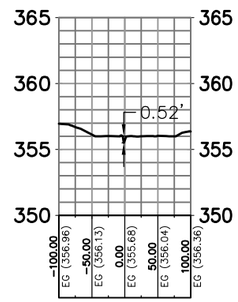

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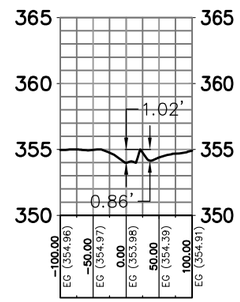

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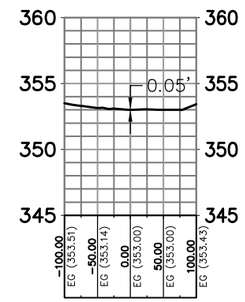

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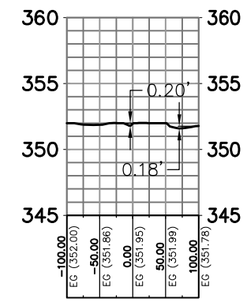

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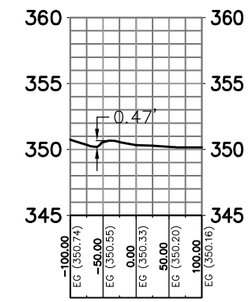

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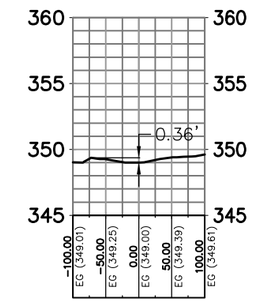

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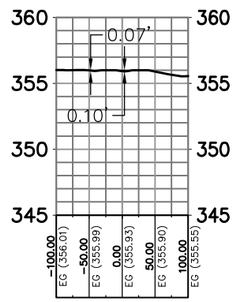

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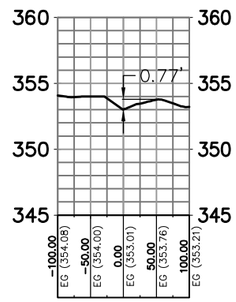

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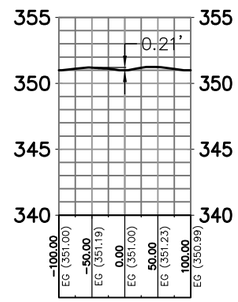

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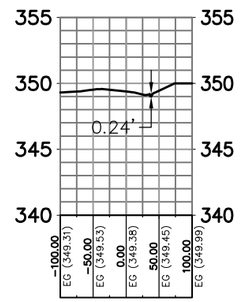
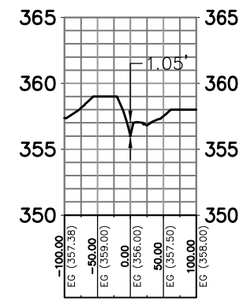
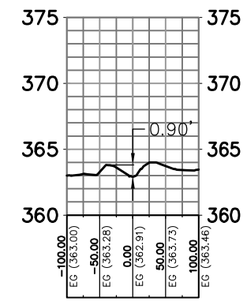


AREA-1B 8+00.00



AREA-2A 2+00.00



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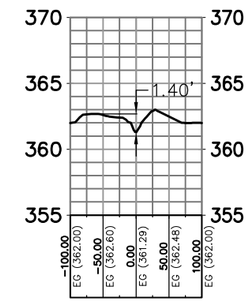
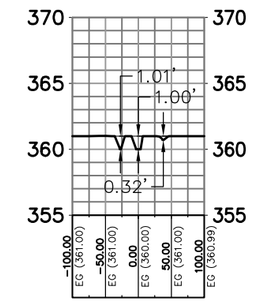


AREA-2B 4+00.00



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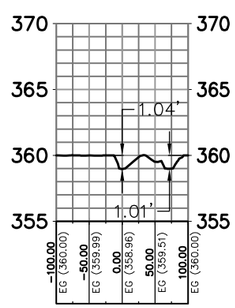

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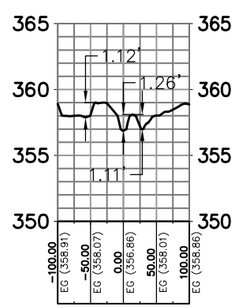
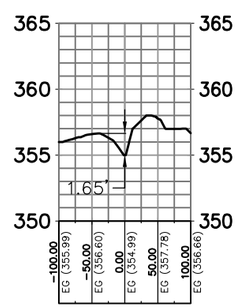


AREA-2B 10+00.00



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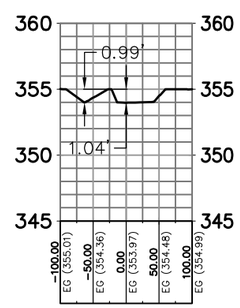

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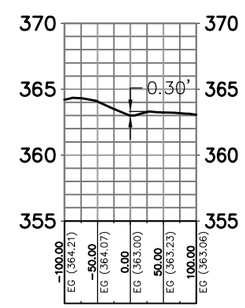
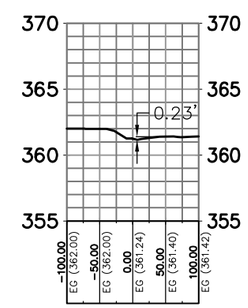
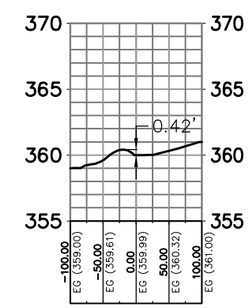


AREA-2C 1+50.00



AREA-2C 4+00.00



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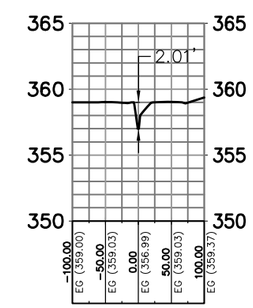

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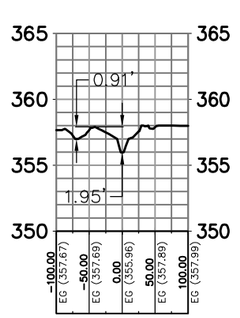

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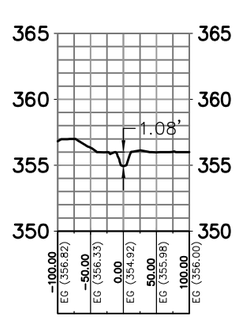
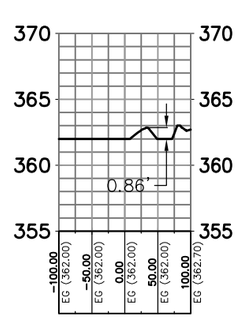
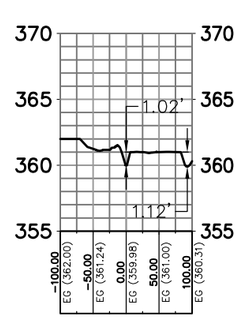


AREA-2C 12+00.00



AREA-2D 2+00.00



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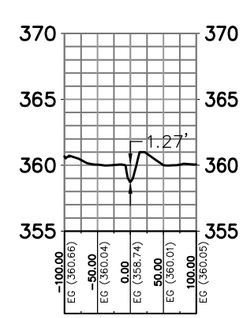

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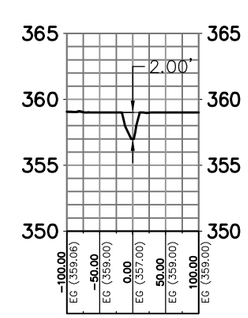

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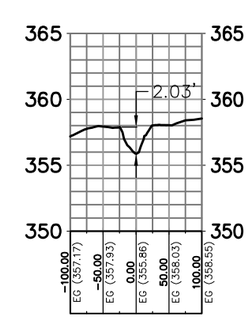

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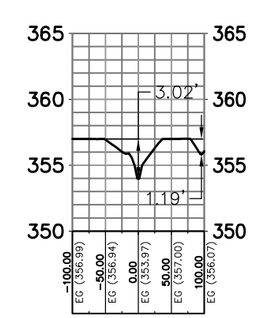

AREA-2D 12+00.00

REV	DATE	BY	REVISION

BRIGHTSOURCE ENERGY

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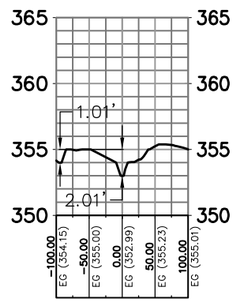
CONSULTING ENGINEERS ● PLANNERS ● LAND SURVEYORS

RIO MESA SOLAR
HEAD CUT CROSS SECTIONS

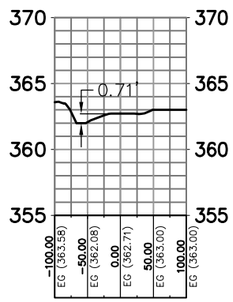
DRAWN BY: WT
DESIGNED BY:
CHECKED BY:
PROJECT NO: 7323
SCALE: HORIZ. VERT.

SHEET **SEC-1** OF SHEETS
DRAWING NO.

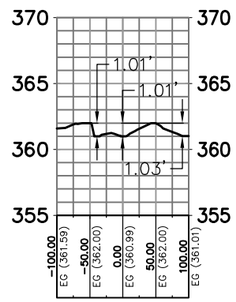
J:\7323-Blythe\Preliminary Site Investigation\Drawing files (dwg)\7323_FLOWPATH-CROSS SECTIONS.dwg (CROSS SECTIONS 1)



AREA–2D 14+00.00



AREA–3A 2+00.00



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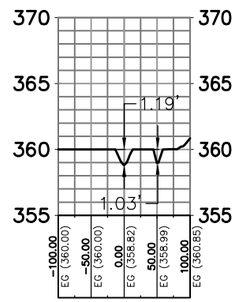

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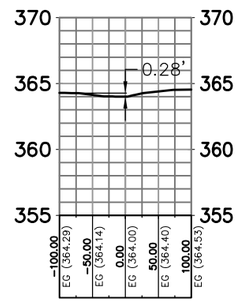

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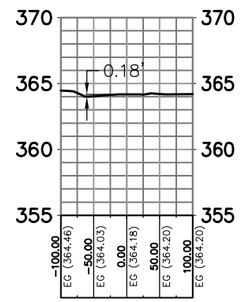
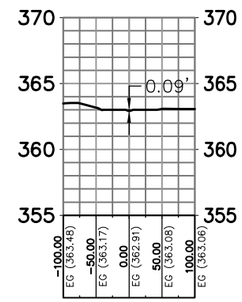


AREA–3C 2+00.00



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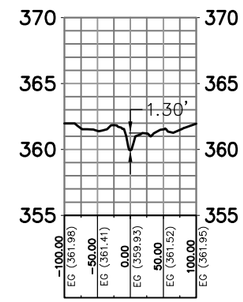

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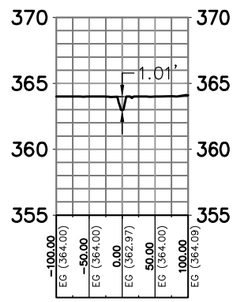

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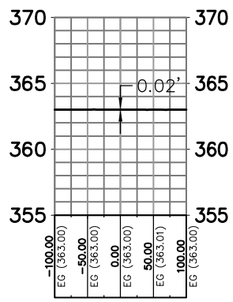
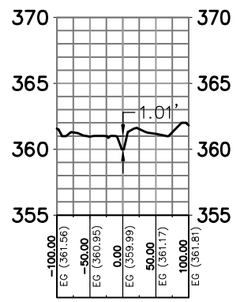
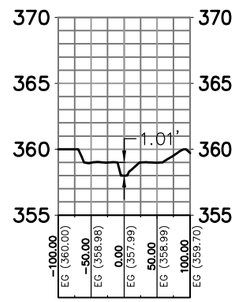


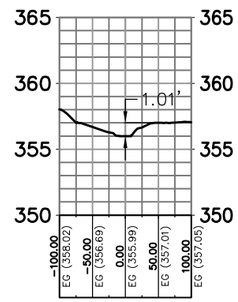
AREA–3E 2+00.00



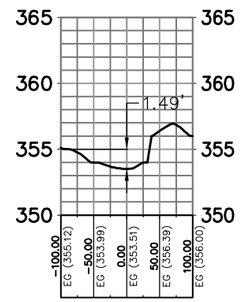
AREA–3E 4+00.00



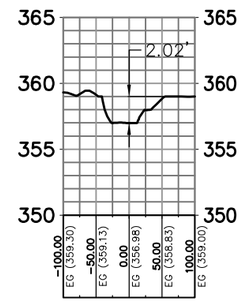
AREA–3E 6+00.00



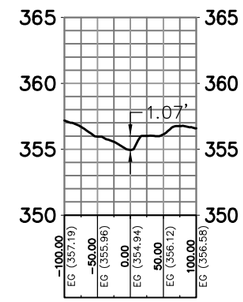
AREA–3E 8+00.00



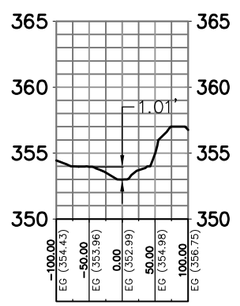
AREA–3E 10+00.00



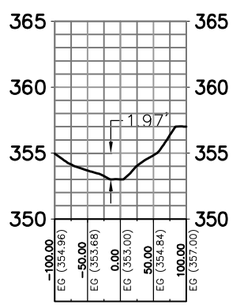
AREA–3F 2+00.00



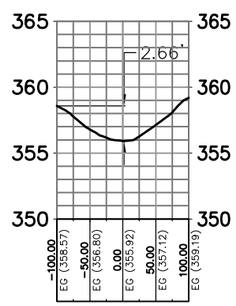
AREA–3F 4+00.00



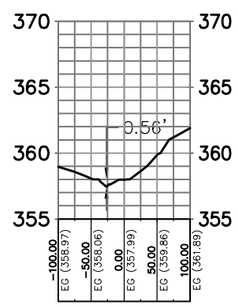
AREA–3F 6+00.00



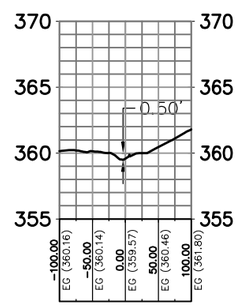
AREA–4 A 12+00.00



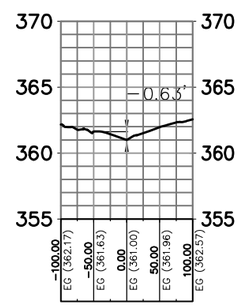
AREA–4 A 14+00.00



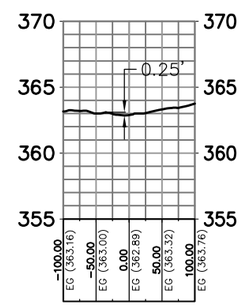
AREA–4 A 16+00.00



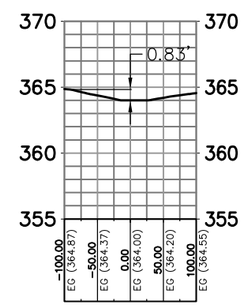
AREA–4 A 18+00.00



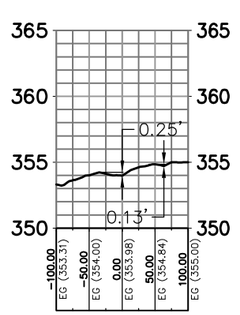
AREA–4 A 20+00.00



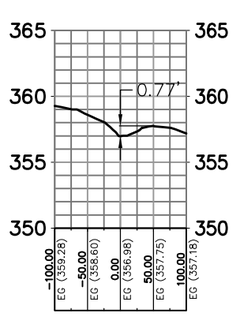
AREA–4 A 22+00.00



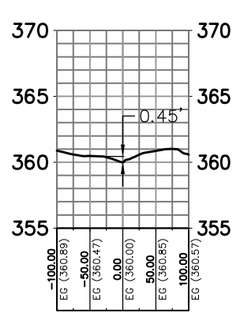
AREA–4 A 24+00.00



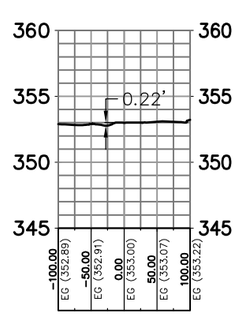
AREA–4 B 12+00.00



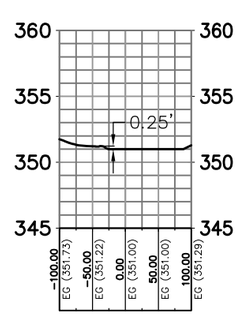
AREA–4 B 14+00.00



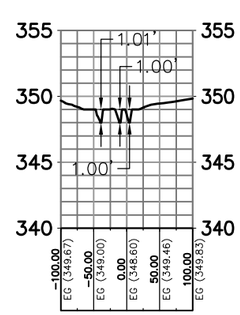
AREA–4 B 16+00.00



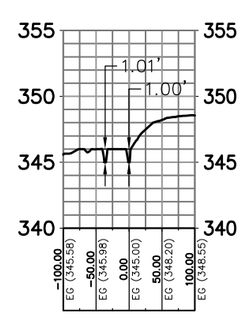
AREA–5A 2+00.00



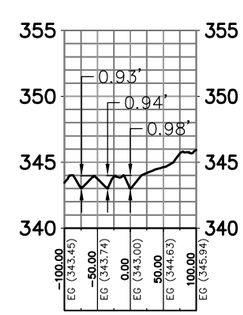
AREA–5A 4+00.00



AREA–5A 6+00.00



AREA–5A 8+00.00



AREA–5A 10+00.00

REV	DATE	BY	REVISION

BRIGHTSOURCE ENERGY

2727 SOUTH RAINBOW BOULEVARD
LAS VEGAS, NEVADA 89146-5148
PH. (702) 873-7550 FAX (702) 362-2597 WEB WWW.VTNINV.COM
CONSULTING ENGINEERS ● PLANNERS ● LAND SURVEYORS

RIO MESA SOLAR
HEAD CUT CROSS SECTIONS

DRAWN BY: WT
DESIGNED BY:
CHECKED BY:
PROJECT NO: 7323
SCALE: HORIZ. VERT.

SHEET **SEC-2** OF SHEETS
DRAWING NO.

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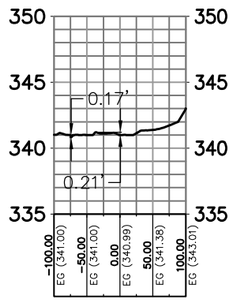

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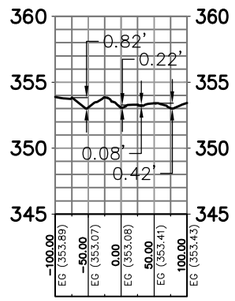

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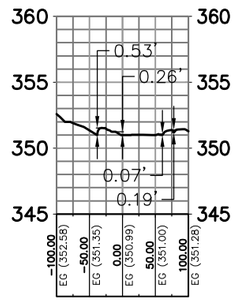

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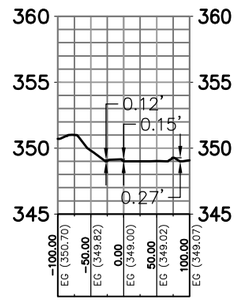

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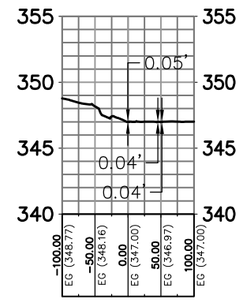

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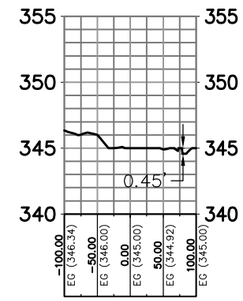

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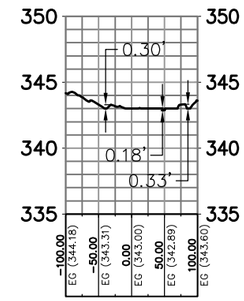

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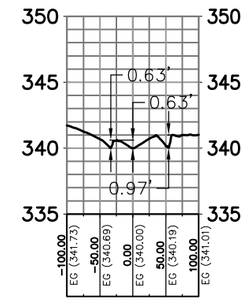

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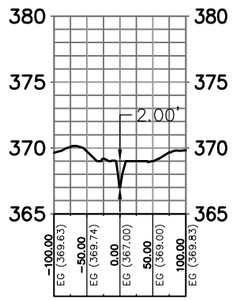

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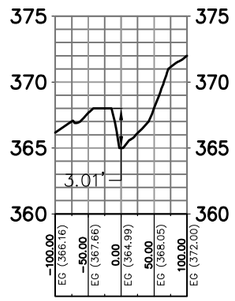

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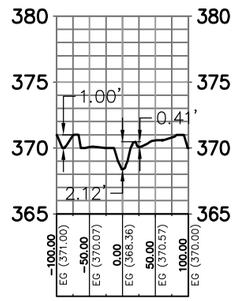

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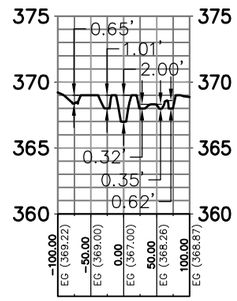

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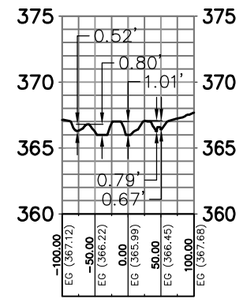

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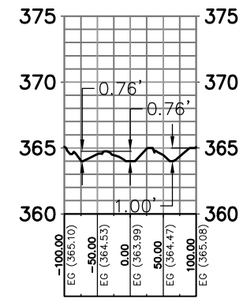

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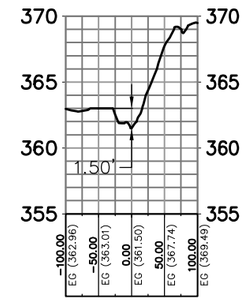

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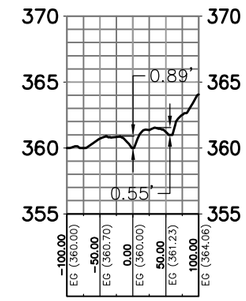

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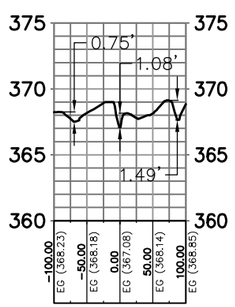

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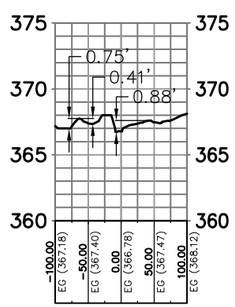

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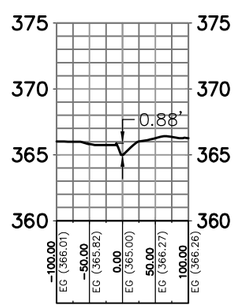

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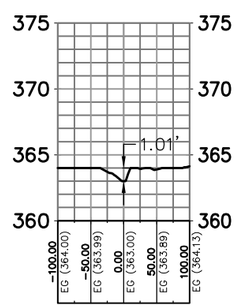

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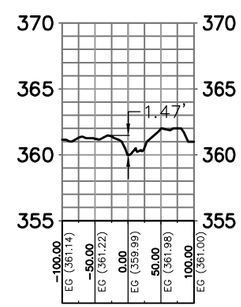

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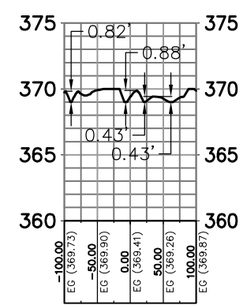

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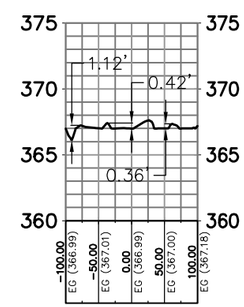

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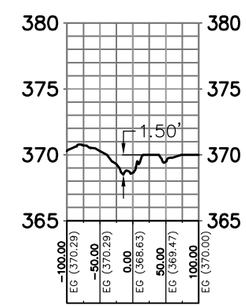

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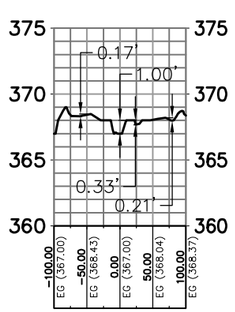

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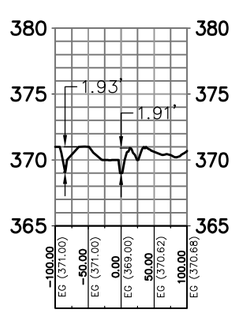

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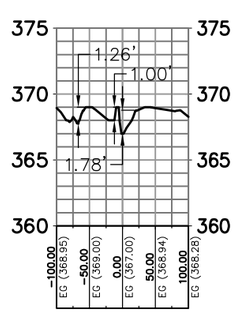

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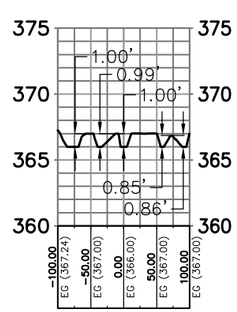

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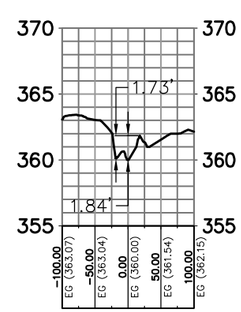

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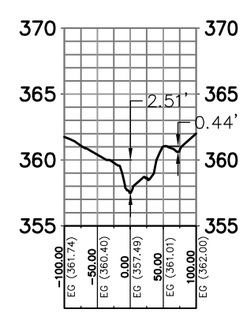

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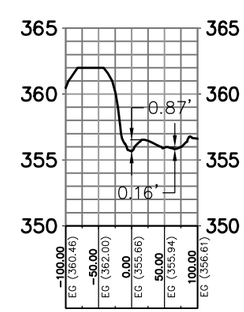

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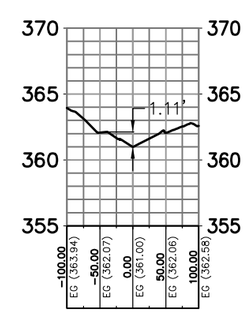

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RIO MESA SOLAR
HEAD CUT CROSS SECTIONS

DRAWN BY: WT
DESIGNED BY:
CHECKED BY:
PROJECT NO: 7323
SCALE:
HORIZ.
VERT.

SHEET **SEC-3** OF SHEETS
DRAWING NO.

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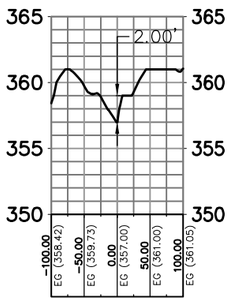

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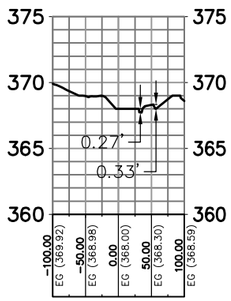

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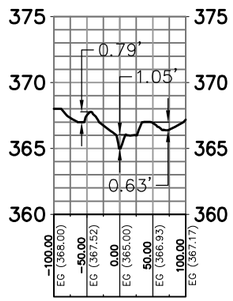

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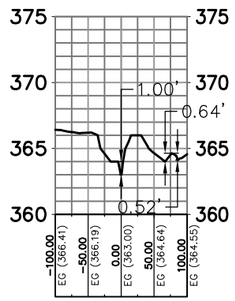

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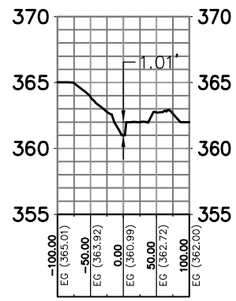

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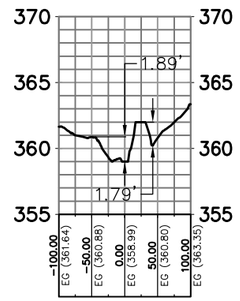

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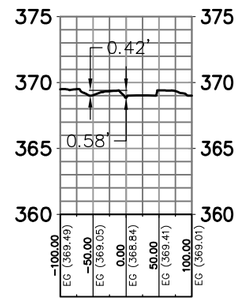

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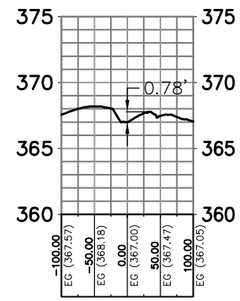

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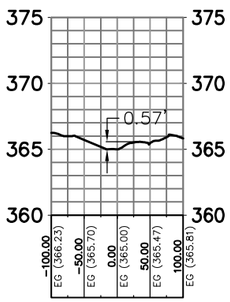

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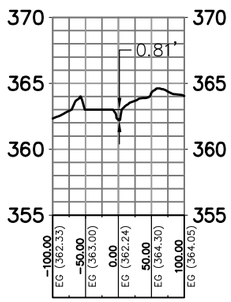

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RIO MESA SOLAR
HEAD CUT CROSS SECTIONS

DRAWN BY: WT
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SHEET
SEC-4
OF SHEETS
DRAWING NO.

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APPENDIX E:

Local Scour: FHWA Equation Calculations

Pylon Local Scour Calculations

DEVELOPMENT: Rio Mesa Solar

CALCULATED BY: RV

Equation :

$$\frac{y_s}{a} = 2.0\, K_1 K_2 K_3 K_4 \left(\frac{y}{a}\right)^{0.35} Fr^{0.43}$$

Flow depth directly upstream of pier, ft.	y =	3.48
Correction factor for pier nose shape	K_1 =	1.00
Correction factor for angle of attack of flow	K_2 =	1.00
Correction factor for bed condition from Table 6.3	K_3 =	1.10
Correction factor for armoring by bed material size from Equation 6.5	K_4 =	1.00
pier width, ft.	a =	0.50
Mean velocity of flow directly upstream of the pier, ft/s	V_1 =	8.81
acceleration of gravity, ft/s^2	g =	32.20
Froude number directly upstream of the pier	Fr =	0.83
Calculated Scour depth, ft.	y_S =	2.00

Maximum scour depth for round nose piers:

If Fr < 0.80, y_s = 2.4 x a (pier width)	y_S =	N/A	
If Fr > 0.80, y_s = 3.0 x a (pier width)	**y_S =**	**1.5**	**ft.**

Notes:

1. Y_s equation (Eq. 6.3) referenced from Federal Highway Administration (FHWA, 2001).
2. Worst case flow depth (y) and velocity (V_1) referenced from onsite Q100, 24-Hour HEC-RAS Analysis.

   worst case depth (y) from Reach 15B, XS = 24+99.29
   worst case velocity (V1) from Reach 15B, XS = 23+51.68
3. Froude number computated from flow depth and veloctiy, Fr = $V_1/[(g \times y)^{0.5}]$

   Fr number reported from HEC-RAS for XS's 24+99.29 & 23+51.68
   is reported as 1.01 & 1.38 respectively, just utilized Fr number eqn.

U.S. Department of Transportation
Federal Highway Administration

Publication No. FHWA NHI 01-001
May 2001

Hydraulic Engineering Circular No. 18

Evaluating Scour At Bridges
Fourth Edition

REFERENCE MATERIAL

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BSE Document Control Number: 7323HYD400-FINAL-R1

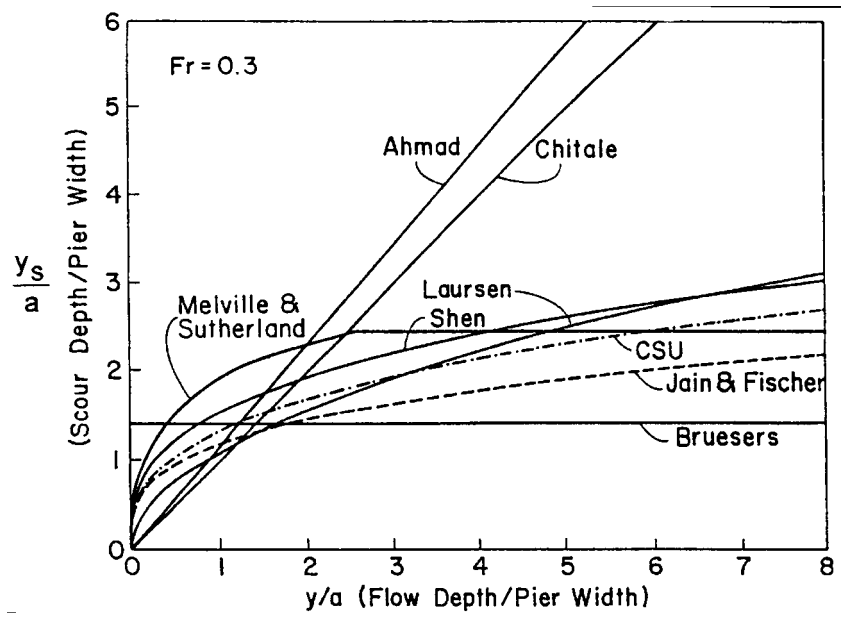

Figure 6.1. Comparison of scour equations for variable depth ratios (y/a) (after Jones).[46]

Mueller[49] compared 22 scour equations using field data collected by the USGS[50]. He concluded that the HEC-18 equation was good for design because it rarely under predicted measured scour depth. However, it frequently over-predicted the observed scour. The data contained 384 field measurements of scour at 56 bridges (Figure 6.2).

From laboratory data, Melville and Sutherland reported 2.4 as an upper limit for the depth of scour to pier width ratio (y_s/a) for cylindrical piers.[28] In these studies, the Froude Number was less than 1.0. Chang[51] also, noted that in all the data he studied, there were no values of the ratio of scour depth to pier width (y_s/a) larger than 2.3. However, values of y_s/a around 3.0 were obtained by Jain and Fischer for chute-and-pool flows with Froude Numbers as high as 1.5.[47] The largest value of y_s/a for antidune flow was 2.5 with a Froude Number of 1.2. These upper limits were derived for circular piers and were uncorrected for pier shape or for skew. Also, pressure flow, ice or debris can increase the ratio.

From the above discussion, the ratio of y_s/a can be as large as 3 at large Froude Numbers. Therefore, it is recommended that the maximum value of the ratio be taken as 2.4 for Froude Numbers less than or equal to 0.8 and 3.0 for larger Froude Numbers. These limiting ratio values apply only to round nose piers which are aligned with the flow.

6.2 LOCAL PIER SCOUR EQUATION

To determine pier scour, an equation based on the CSU equation is recommended for both live-bed and clear-water pier scour.[22] The equation predicts maximum pier scour depths. The equation is:

$$\frac{y_s}{y_1} = 2.0\, K_1\, K_2\, K_3\, K_4 \left(\frac{a}{y_1}\right)^{0.65} Fr_1^{0.43} \qquad (6.1)$$

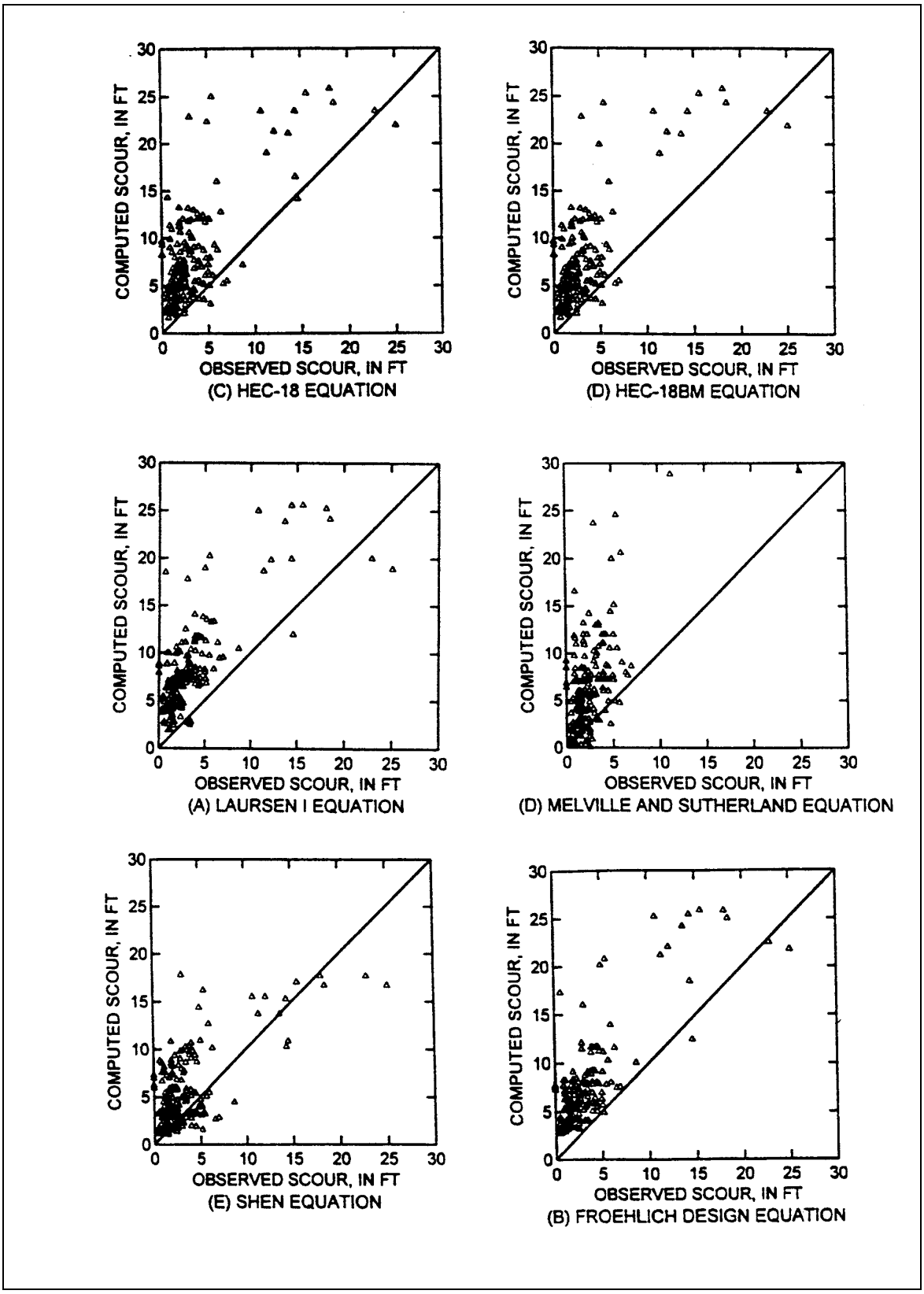

Figure 6.2. Comparison of scour equations with field scour measurements (after Mueller).[49]

As a Rule of Thumb, the maximum scour depth for round nose piers aligned with the flow is:

$y_s \leq 2.4$ times the pier width (a) for $Fr \leq 0.8$ (6.2)
$y_s \leq 3.0$ times the pier width (a) for $Fr > 0.8$

In terms of y_s/a, Equation 6.1 is:

$$\frac{y_s}{a} = 2.0\ K_1\ K_2\ K_3\ K_4 \left(\frac{y_1}{a}\right)^{0.35} Fr_1^{0.43} \qquad (6.3)$$

Referenced Equation

where:

y_s	=	Scour depth, m (ft)
y_1	=	Flow depth directly upstream of the pier, m (ft)
K_1	=	Correction factor for pier nose shape from Figure 6.3 and Table 6.1
K_2	=	Correction factor for angle of attack of flow from Table 6.2 or Equation 6.4
K_3	=	Correction factor for bed condition from Table 6.3
K_4	=	Correction factor for armoring by bed material size from Equation 6.5
a	=	Pier width, m (ft)
L	=	Length of pier, m (ft)
Fr_1	=	Froude Number directly upstream of the pier = $V_1/(gy_1)^{1/2}$
V_1	=	Mean velocity of flow directly upstream of the pier, m/s (ft/s)
g	=	Acceleration of gravity (9.81 m/s^2) (32.2 ft/s^2)

The correction factor, K_2, for angle of attack of the flow, θ, is calculated using the following equation:

$$K_2 = (\text{Cos}\ \theta + L / a\ \text{Sin}\ \theta)^{0.65} \qquad (6.4)$$

If L/a is larger than 12, use L/a = 12 as a maximum in Equation 6.4 and Table 6.2. Table 6.2 illustrates the magnitude of the effect of the angle of attack on local pier scour.

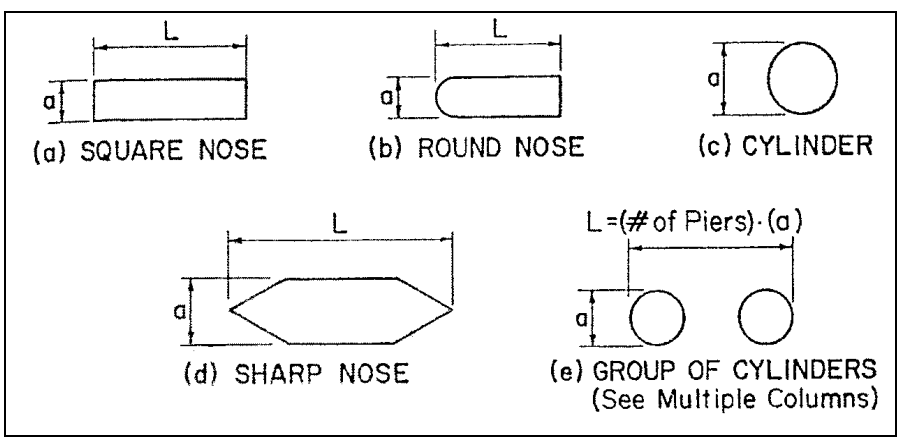

Figure 6.3. Common pier shapes.

Table 6.1. Correction Factor, K_1, for Pier Nose Shape.	
Shape of Pier Nose	K_1
(a) Square nose	1.1
(b) Round nose	1.0
(c) Circular cylinder	1.0
(d) Group of cylinders	1.0
(e) Sharp nose	0.9

Table 6.2. Correction Factor, K_2, for Angle of Attack, θ, of the Flow.			
Angle	L/a=4	L/a=8	L/a=12
0	1.0	1.0	1.0
15	1.5	2.0	2.5
30	2.0	2.75	3.5
45	2.3	3.3	4.3
90	2.5	3.9	5.0
Angle = skew angle of flow L = length of pier, m			

Table 6.3. Increase in Equilibrium Pier Scour Depths, K_3, for Bed Condition.		
Bed Condition	Dune Height m	K_3
Clear-Water Scour	N/A	1.1
Plane bed and Antidune flow	N/A	1.1
Small Dunes	$3 > H \geq 0.6$	1.1
Medium Dunes	$9 > H \geq 3$	1.2 to 1.1
Large Dunes	$H \geq 9$	1.3

Notes:

1. The correction factor K_1 for pier nose shape should be determined using Table 6.1 for angles of attack up to 5 degrees. **For greater angles, K_2 dominates and K_1 should be considered as 1.0**. If L/a is larger than 12, use the values for L/a = 12 as a maximum in Table 6.2 and Equation 6.4.

2. The values of the correction factor K_2 should be applied only when the field conditions are such that the entire length of the pier is subjected to the angle of attack of the flow. Use of this factor will result in a significant over-prediction of scour if (1) a portion of the pier is shielded from the direct impingement of the flow by an abutment or another pier; or (2) an abutment or another pier redirects the flow in a direction parallel to the pier. For such cases, judgment must be exercised to reduce the value of the K_2 factor by selecting the effective length of the pier actually subjected to the angle of attack of the flow. **Equation 6.4 should be used for evaluation and design**. Table 6.2 is intended to illustrate the importance of angle of attack in pier scour computations and to establish a cutoff point for K_2 (i.e., a maximum value of 5.0).

3. The correction factor K_3 results from the fact that for plane-bed conditions, which is typical of most bridge sites for the flood frequencies employed in scour design, the maximum scour may be 10 percent greater than computed with Equation 6.1. In the **unusual** situation where a dune bed configuration **with large dunes** exists at a site during flood flow, the maximum pier scour may be 30 percent greater than the predicted equation value. This may occur on very large rivers, such as the Mississippi. For smaller streams that have a dune bed configuration at flood flow, the dunes will be smaller and the maximum scour may be only 10 to 20 percent larger than equilibrium scour. For antidune bed configuration the maximum scour depth may be 10 percent greater than the computed equilibrium pier scour depth.

4. Piers set close to abutments (for example at the toe of a spill through abutment) must be carefully evaluated for the angle of attack and velocity of the flow coming around the abutment.

The correction factor K_4 decreases scour depths for armoring of the scour hole for bed materials that have a D_{50} equal to or larger than 2.0 mm and D_{95} equal to or larger than 20 mm. The correction factor results from recent research by Molinas and Mueller. Molinas's research for FHWA showed that when the approach velocity (V_1) is less than the critical velocity (V_{c90}) of the D_{90} size of the bed material and there is a gradation in sizes in the bed material, the D_{90} will limit the scour depth.[30, 52] Mueller and Jones[53] developed a K_4 correction coefficient from a study of 384 field measurements of scour at 56 bridges. The equation developed by Jones[54] given in HEC-18 Third Edition should be replaced with the following:

- If $D_{50} < 2$ mm or $D_{95} < 20$ mm, then $K_4 = 1$
- If $D_{50} \geq 2$ mm and $D_{95} \geq 20$ mm

then:

$$K_4 = 0.4\,(V_R)^{0.15} \tag{6.5}$$

where:

$$V_R = \frac{V_1 - V_{icD_{50}}}{V_{cD_{50}} - V_{icD_{95}}} > 0 \tag{6.6}$$

and:

V_{icDx} = approach velocity (m/s or ft/sec) required to initiate scour at the pier for the grain size D_x (m or ft)

$$V_{icD_x} = 0.645 \left(\frac{D_x}{a}\right)^{0.053} V_{cD_x} \tag{6.7}$$

V_{cDx} = critical velocity (m/s or ft/s) for incipient motion for the grain size D_x (m or ft)

$$V_{cD_x} = K_u\, y_1^{1/6}\, D_x^{1/3} \tag{6.8}$$

where:

y_1 = Depth of flow just upstream of the pier, excluding local scour, m (ft)
V_1 = Velocity of the approach flow just upstream of the pier, m/s (ft/s)
D_x = Grain size for which x percent of the bed material is finer, m (ft)
K_u = 6.19 SI Units
K_u = 11.17 English Units

While K_4 provides a good fit with the field data the velocity ratio terms are so formed that if D_{50} is held constant and D_{95} increases, the value of K_4 increases rather than decreases.[53] For field data an increase in D_{95} was always accompanied with an increase in D_{50}. **The minimum value of K_4 is 0.4**.

APPENDIX F:

Sediment Transport: FLO-2D Analysis Output Files

NEGATIVE VOLUME CONSERVATION (ACRE FEET)
INDICATES EXCESS VOLUME (OUTFLOW + STORAGE > INFLOW)

SUMMARY.OUT FILE
CREATED WITH VERSION: 2009.06 BUILD NO. 2009.18.03

SIMULATION TIME (HOURS)	AVERAGE TIMESTEP (SECONDS)	VOLUME CONSERVATION (ACRE FEET)	PERCENT OF INFLOW
0.250	18.028	0.000000	0.000004
0.500	30.000	0.000000	0.000001
0.750	30.000	0.000000	0.000003
1.000	30.000	0.000000	0.000002
1.250	30.000	0.000000	0.000002
1.500	30.000	0.000000	0.000002
1.750	30.000	0.000001	0.000003
2.000	30.000	0.000000	0.000001
2.250	30.000	0.000001	0.000004
2.500	30.000	0.000002	0.000004
2.750	30.000	-0.000001	0.000003
3.000	30.000	0.000002	0.000003
3.250	30.000	-0.000001	0.000002
3.500	30.000	0.000004	0.000005
3.750	30.000	0.000000	0.000000
4.005	27.794	-0.000001	0.000001
4.255	23.042	0.000000	0.000000
4.502	22.292	0.000004	0.000003
4.754	19.702	-0.000005	0.000003
5.005	18.403	0.000006	0.000003
5.252	15.103	0.000006	0.000003
5.500	12.934	0.000003	0.000001
5.751	11.161	-0.000014	0.000005
6.001	9.872	0.000005	0.000002
6.250	8.714	0.000002	0.000001
6.500	8.045	0.000001	0.000000
6.750	7.553	0.000006	0.000002
7.002	6.970	0.000011	0.000003
7.250	6.581	0.000008	0.000002
7.502	6.279	0.000005	0.000001
7.750	5.812	0.000009	0.000002
8.001	5.074	-0.000016	0.000003
8.251	4.684	-0.000029	0.000004
8.501	4.388	-0.000012	0.000002
8.751	3.899	0.000025	0.000003
9.001	3.701	-0.000004	0.000000
9.250	3.636	-0.000026	0.000003
9.500	3.490	-0.000019	0.000002
9.750	3.236	0.000011	0.000001
10.000	3.038	0.000010	0.000001
10.251	3.037	-0.000033	0.000002
10.500	2.311	0.000049	0.000003
10.750	1.302	0.000003	0.000000
11.000	1.339	0.000005	0.000000
11.250	1.357	-0.000055	0.000003
11.500	1.170	-0.000056	0.000003
11.750	1.146	0.000033	0.000001
12.000	1.071	0.000056	0.000002
12.250	1.208	0.000092	0.000003
12.500	1.189	-0.000059	0.000002
12.750	1.180	0.000077	0.000002
13.000	1.171	0.000045	0.000001
13.250	1.194	-0.000008	0.000000
13.500	1.324	0.000116	0.000003
13.750	1.368	0.000122	0.000003
14.000	1.269	0.000093	0.000002
14.250	1.409	-0.000103	0.000002
14.500	0.792	0.000016	0.000000
14.750	1.240	-0.000092	0.000002
15.000	1.237	-0.000183	0.000003
15.250	1.004	-0.000048	0.000001
15.500	1.247	0.000089	0.000001
15.750	1.341	-0.000041	0.000001
16.000	1.006	0.000041	0.000001
16.250	1.160	-0.000040	0.000001
16.500	1.336	-0.000253	0.000004
16.750	1.396	-0.000082	0.000001
17.000	1.262	0.000061	0.000001
17.250	0.994	-0.000194	0.000003
17.500	1.324	-0.000186	0.000003
17.750	1.368	-0.000081	0.000001
18.000	1.387	-0.000129	0.000002
18.250	1.399	-0.000300	0.000004
18.500	1.409	0.000027	0.000000
18.750	1.288	0.000228	0.000003
19.000	1.184	0.000122	0.000002
19.250	1.303	-0.000261	0.000003
19.500	1.417	0.000057	0.000001
19.750	1.189	-0.000227	0.000003
20.000	1.237	-0.000079	0.000001
20.250	1.217	-0.000271	0.000003
20.500	1.142	0.000179	0.000002

20.750	1.282	0.000360	0.000005
21.000	1.376	-0.000014	0.000000
21.250	1.264	0.000340	0.000004
21.500	1.212	0.000253	0.000003
21.750	1.353	-0.000105	0.000001
22.000	1.427	-0.000537	0.000007
22.250	1.448	-0.000138	0.000002
22.500	1.360	-0.000230	0.000003
22.750	1.454	-0.000308	0.000004
23.000	1.515	-0.000462	0.000006
23.250	1.535	-0.000363	0.000004
23.500	1.440	-0.000010	0.000000
23.750	1.352	-0.000179	0.000002
24.000	1.385	0.000023	0.000000
24.250	1.402	-0.000025	0.000000
24.500	1.413	-0.000299	0.000004
24.750	1.422	-0.000499	0.000006
25.000	1.429	0.000211	0.000002
25.250	1.435	-0.000084	0.000001
25.500	1.440	0.000112	0.000001
25.750	1.445	-0.000200	0.000002
26.000	1.449	0.000161	0.000002
26.250	1.453	-0.000226	0.000003
26.500	1.456	-0.000332	0.000004
26.750	1.459	-0.000223	0.000003
27.000	1.462	-0.000041	0.000000
27.250	1.465	-0.000267	0.000003
27.500	1.467	-0.000182	0.000002
27.750	1.470	0.000100	0.000001
28.000	1.472	-0.000205	0.000002
28.250	1.474	0.000204	0.000002
28.500	1.476	0.000027	0.000000
28.750	1.478	-0.000180	0.000002
29.000	1.480	-0.000349	0.000004
29.250	1.481	0.000198	0.000002
29.500	1.483	0.000303	0.000004
29.750	1.484	-0.000316	0.000004
30.000	1.486	-0.000211	0.000002
30.250	1.487	0.000222	0.000003
30.500	1.489	0.000142	0.000002
30.750	1.490	0.000131	0.000002
31.000	1.491	-0.000153	0.000002
31.250	1.493	-0.000234	0.000003
31.500	1.494	-0.000079	0.000001
31.750	1.495	0.000125	0.000001
32.000	1.496	-0.000058	0.000001
32.250	1.497	-0.000226	0.000003
32.500	1.498	-0.000229	0.000003
32.750	1.499	0.000194	0.000002
33.000	1.500	-0.000093	0.000001
33.250	1.501	0.000024	0.000000
33.500	1.502	0.000141	0.000002
33.750	1.503	-0.000372	0.000004
34.000	1.504	0.000218	0.000003
34.250	1.505	-0.000412	0.000005
34.500	1.506	0.000268	0.000003
34.750	1.507	-0.000363	0.000004
35.000	1.508	-0.000048	0.000001
35.250	1.509	-0.000196	0.000002
35.500	1.509	0.000215	0.000002
35.750	1.510	-0.000109	0.000001
36.000	1.511	0.000011	0.000000

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MASS BALANCE INFLOW - OUTFLOW VOLUME

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*** INFLOW (ACRE-FEET) ***

TOTAL POINT RAINFALL: 3.8700 INCHES

	WATER
RAINFALL VOLUME	3498.87
INFLOW HYDROGRAPH	5134.94
INFLOW HYDROGRAPHS + RAINFALL	8633.81

==========

*** OUTFLOW (ACRE-FT) ***

OVERLAND INFILTRATED AND INTERCEPTED WATER 1.91 INCHES

OVERLAND FLOW	WATER

```
WATER LOST TO INFILTRATION & INTERCEPTION         2202.09

FLOODPLAIN STORAGE                                1462.26

FLOODPLAIN OUTFLOW HYDROGRAPH                     4966.74
                                                ---------

FLOODPLAIN OUTFLOW, INFILTRATION & STORAGE        8631.09


          CHANNEL FLOW

CHANNEL STORAGE                                      2.72

CHANNEL OUTFLOW                                      0.00
                                                ---------

CHANNEL OUTFLOW AND STORAGE                          2.72

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                                  *** TOTALS ***


TOTAL OUTFLOW FROM GRID SYSTEM                    4966.74

TOTAL VOLUME OF OUTFLOW AND STORAGE               8633.81

  SURFACE AREA OF INUNDATION REGARDLESS OF THE TIME OF OCCURRENCE:
  (FOR FLOW DEPTHS GREATER THAN THE "TOL" VALUE TYPICALLY 0.1 FT OR 0.03 M)

THE MAXIMUM INUNDATED AREA IS:                       8973.72 ACRES

THE MAXIMUM WETTED FLOODPLAIN AREA IS:               8972.40 ACRES

THE MAXIMUM WETTED CHANNEL AREA IS:                     1.32 ACRES

SEDIMENT TRANSPORT VOLUME CONSERVATION ERROR:                              0.00 CU. FT.    0.000000  PERCENT OF BED
VOLUME

==================================================================================================================
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     COMPUTER RUN TIME IS : 28.54883 HRS

     THIS OUTPUT FILE WAS TERMINATED ON:   8/17/2011  AT:  20:33:41
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SEDCONSERV.OUT
SEDIMENT VOLUME CONSERVATION (CUBIC FT OR M)
NEGATIVE VOLUME INDICATES THAT OUTFLOW + STORAGE EXCEEDS INFLOW

SIMULATION TIME (HRS)	INFLOW	FLOODPLAIN STORAGE	CHANNEL STORAGE	STREET STORAGE	OUTFLOW	CONSERVATION TOTAL	CONSERVATION PERCENT
0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.000000
0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.000000
0.75	0.00	0.00	0.00	0.00	0.00	0.00	0.000000
1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000000
1.25	0.00	0.00	0.00	0.00	0.00	0.00	0.000000
1.50	0.00	0.00	0.00	0.00	0.00	0.00	0.000000
1.75	0.00	0.00	0.00	0.00	0.00	0.00	0.000000
2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000000
2.25	0.00	0.00	0.00	0.00	0.00	0.00	0.000000
2.50	0.00	0.00	0.00	0.00	0.00	0.00	0.000000
2.75	0.00	0.00	0.00	0.00	0.00	0.00	0.000000
3.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000000
3.25	0.00	0.00	0.00	0.00	0.00	0.00	0.000000
3.50	0.00	0.00	0.00	0.00	0.00	0.00	0.000000
3.75	0.00	0.00	0.00	0.00	0.00	0.00	0.000000
4.01	0.00	0.00	0.00	0.00	0.00	0.00	0.000000
4.25	0.00	0.00	0.00	0.00	0.00	0.00	0.000000
4.50	0.00	0.00	0.00	0.00	0.00	0.00	0.000000
4.75	0.00	0.00	0.00	0.00	0.00	0.00	0.000000
5.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000000
5.25	0.00	0.00	0.00	0.00	0.00	0.00	0.000000
5.50	0.00	0.00	0.00	0.00	0.00	0.00	0.000000
5.75	0.00	0.00	0.00	0.00	0.00	0.00	0.000000
6.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000000
6.25	0.00	0.00	0.00	0.00	0.00	0.00	0.000000
6.50	0.00	0.00	0.00	0.00	0.00	0.00	0.000000
6.75	0.00	0.00	0.00	0.00	0.00	0.00	0.000000
7.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000000
7.25	0.00	0.00	0.00	0.00	0.00	0.00	0.000000
7.50	0.00	0.00	0.00	0.00	0.00	0.00	0.000000
7.75	0.00	0.00	0.00	0.00	0.00	0.00	0.000000
8.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000000
8.25	0.00	0.00	0.00	0.00	0.00	0.00	0.000000
8.50	0.00	0.00	0.00	0.00	0.00	0.00	0.000000
8.75	0.00	0.00	0.00	0.00	0.00	0.00	0.000000
9.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000000
9.25	0.00	0.00	0.00	0.00	0.00	0.00	0.000000
9.50	0.00	0.00	0.00	0.00	0.00	0.00	0.000000
9.75	0.00	0.00	0.00	0.00	0.00	0.00	0.000000
10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000000
10.25	0.00	0.00	0.00	0.00	0.00	0.00	0.000000
10.50	0.00	0.00	0.00	0.00	0.00	0.00	0.000000
10.75	0.00	0.00	0.00	0.00	0.00	0.00	0.000000
11.00	0.00	-0.25	0.00	0.00	0.25	0.00	0.000000
11.25	0.00	-57.45	0.00	0.00	57.45	0.00	0.000000
11.50	0.00	-1001.04	0.00	0.00	1001.04	0.00	0.000000
11.75	0.00	-2949.72	0.00	0.00	2949.72	0.00	0.000000
12.00	0.00	-6511.24	38.49	0.00	6472.76	0.00	0.000000
12.25	0.00	-12190.04	58.12	0.00	12131.92	0.00	0.000000
12.50	0.00	-19243.59	-1462.54	0.00	20706.14	0.00	0.000000
12.75	0.00	-29045.78	-4271.89	0.00	33317.67	0.00	0.000000
13.00	0.00	-42417.94	-7403.98	0.00	49821.92	0.00	0.000000
13.25	0.00	-61512.97	-9566.40	0.00	71079.37	0.00	0.000000
13.50	0.00	-86440.28	-11228.75	0.00	97669.03	0.00	0.000000
13.75	0.00	-116915.48	-12479.91	0.00	129395.38	0.00	0.000000
14.00	0.00	-152421.78	-13746.99	0.00	166168.77	0.00	0.000000
14.25	0.00	-193494.17	-14875.75	0.00	208369.92	0.00	0.000000
14.50	0.00	-241280.86	-15278.18	0.00	256559.04	0.00	0.000000
14.75	0.00	-294699.70	-15836.29	0.00	310536.00	0.00	0.000000
15.00	0.00	-353938.61	-17176.57	0.00	371115.18	0.00	0.000000
15.25	0.00	-422210.63	-17176.57	0.00	439387.20	0.00	0.000000
15.50	0.00	-499147.30	-17658.67	0.00	516805.97	0.00	0.000000
15.75	0.00	-587380.44	-17658.67	0.00	605039.11	0.00	0.000000
16.00	0.00	-686033.74	-17658.67	0.00	703692.41	0.00	0.000000
16.25	0.00	-791987.68	-17658.67	0.00	809646.34	0.00	0.000000
16.50	0.00	-900980.44	-18455.39	0.00	919435.82	0.00	0.000000
16.75	0.00	-1010691.54	-18455.39	0.00	1029146.92	0.00	0.000000
17.00	0.00	-1116184.37	-18455.39	0.00	1134639.75	0.00	0.000000
17.25	0.00	-1213917.05	-18455.39	0.00	1232372.43	0.00	0.000000
17.50	0.00	-1302436.14	-18455.39	0.00	1320891.53	0.00	0.000000
17.75	0.00	-1383225.24	-18455.39	0.00	1401680.62	0.00	0.000000
18.00	0.00	-1457720.84	-18455.39	0.00	1476176.22	0.00	0.000000
18.25	0.00	-1526755.01	-18455.39	0.00	1545210.39	0.00	0.000000
18.50	0.00	-1587865.88	-18455.39	0.00	1606321.26	0.00	0.000000
18.75	0.00	-1644419.19	-18455.39	0.00	1662874.57	0.00	0.000000
19.00	0.00	-1695974.51	-18455.39	0.00	1714429.89	0.00	0.000000
19.25	0.00	-1742923.36	-18455.39	0.00	1761378.74	0.00	0.000000
19.50	0.00	-1785516.08	-18455.39	0.00	1803971.46	0.00	0.000000
19.75	0.00	-1824063.82	-18455.39	0.00	1842519.21	0.00	0.000000
20.00	0.00	-1859211.61	-18455.39	0.00	1877667.00	0.00	0.000000
20.25	0.00	-1890958.76	-19187.31	0.00	1910146.07	0.00	0.000000
20.50	0.00	-1920810.77	-19187.31	0.00	1939998.08	0.00	0.000000
20.75	0.00	-1948262.82	-19187.31	0.00	1967450.13	0.00	0.000000
21.00	0.00	-1973595.61	-19187.31	0.00	1992782.92	0.00	0.000000
21.25	0.00	-1996931.53	-19187.31	0.00	2016118.84	0.00	0.000000
21.50	0.00	-2018382.78	-19187.31	0.00	2037570.10	0.00	0.000000
21.75	0.00	-2038118.79	-19187.31	0.00	2057306.10	0.00	0.000000
22.00	0.00	-2056352.61	-19187.31	0.00	2075539.92	0.00	0.000000
22.25	0.00	-2073959.31	-19187.31	0.00	2093146.62	0.00	0.000000
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22.75	0.00	-2106935.95	-19187.31	0.00	2126123.26	0.00	0.000000
23.00	0.00	-2122011.66	-19187.31	0.00	2141198.97	0.00	0.000000
23.25	0.00	-2136329.82	-19187.31	0.00	2155517.13	0.00	0.000000
23.50	0.00	-2150131.64	-19187.31	0.00	2169318.95	0.00	0.000000
23.75	0.00	-2163872.05	-19187.31	0.00	2183059.36	0.00	0.000000
24.00	0.00	-2177368.12	-19187.31	0.00	2196555.43	0.00	0.000000
24.25	0.00	-2190574.72	-19187.31	0.00	2209762.03	0.00	0.000000
24.50	0.00	-2203584.23	-19187.31	0.00	2222771.54	0.00	0.000000
24.75	0.00	-2216464.63	-19187.31	0.00	2235651.94	0.00	0.000000
25.00	0.00	-2229068.12	-19187.31	0.00	2248255.44	0.00	0.000000
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25.75	0.00	-2262794.60	-19187.31	0.00	2281981.91	0.00	0.000000
26.00	0.00	-2272230.22	-19187.31	0.00	2291417.53	0.00	0.000000
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26.50	0.00	-2288492.83	-19187.31	0.00	2307680.14	0.00	0.000000
26.75	0.00	-2295695.96	-19187.31	0.00	2314883.27	0.00	0.000000
27.00	0.00	-2302334.32	-19187.31	0.00	2321521.63	0.00	0.000000
27.25	0.00	-2308425.59	-19187.31	0.00	2327612.90	0.00	0.000000
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27.75	0.00	-2319155.56	-19187.31	0.00	2338342.87	0.00	0.000000
28.00	0.00	-2323858.59	-19187.31	0.00	2343045.90	0.00	0.000000
28.25	0.00	-2328158.47	-19187.31	0.00	2347345.78	0.00	0.000000
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28.75	0.00	-2335662.33	-19187.31	0.00	2354849.64	0.00	0.000000
29.00	0.00	-2338853.36	-19187.31	0.00	2358040.67	0.00	0.000000
29.25	0.00	-2341599.66	-19187.31	0.00	2360786.97	0.00	0.000000
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29.75	0.00	-2346304.71	-19187.31	0.00	2365492.02	0.00	0.000000
30.00	0.00	-2348359.27	-19187.31	0.00	2367546.58	0.00	0.000000
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30.75	0.00	-2353398.44	-19187.31	0.00	2372585.75	0.00	0.000000
31.00	0.00	-2354762.20	-19187.31	0.00	2373949.51	0.00	0.000000
31.25	0.00	-2355985.62	-19187.31	0.00	2375172.93	0.00	0.000000
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31.75	0.00	-2358081.16	-19187.31	0.00	2377268.47	0.00	0.000000
32.00	0.00	-2358960.50	-19187.31	0.00	2378147.81	0.00	0.000000
32.25	0.00	-2359742.60	-19187.31	0.00	2378929.91	0.00	0.000000
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32.75	0.00	-2360872.21	-19187.31	0.00	2380059.52	0.00	0.000000
33.00	0.00	-2361338.30	-19187.31	0.00	2380525.61	0.00	0.000000
33.25	0.00	-2361765.04	-19187.31	0.00	2380952.35	0.00	0.000000
33.50	0.00	-2362161.08	-19187.31	0.00	2381348.39	0.00	0.000000
33.75	0.00	-2362529.56	-19187.31	0.00	2381716.87	0.00	0.000000
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34.25	0.00	-2363164.87	-19187.31	0.00	2382352.18	0.00	0.000000
34.50	0.00	-2363434.20	-19187.31	0.00	2382621.51	0.00	0.000000
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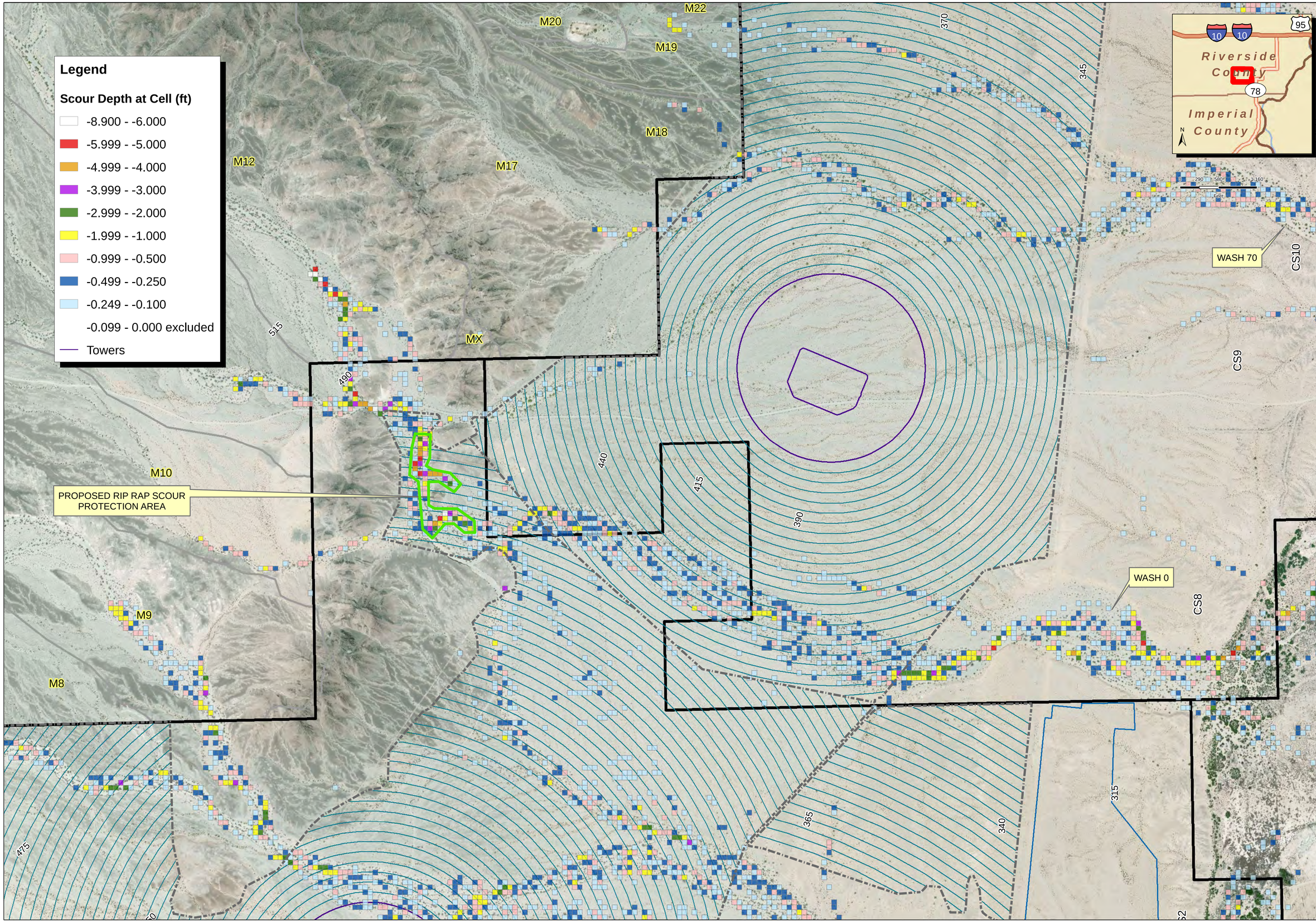
35.25	0.00	-2364071.12	-19187.31	0.00	2383258.43	0.00	0.000000
35.50	0.00	-2364240.89	-19187.31	0.00	2383428.20	0.00	0.000000
35.75	0.00	-2364394.89	-19187.31	0.00	2383582.20	0.00	0.000000
36.00	0.00	-2364537.54	-19187.31	0.00	2383724.85	0.00	0.000000

APPENDIX G:

Northwest Area Alternatives



REV. | DATE | BY | REVISION

RIVERSIDE COUNTY, CA

BrightSource

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Las Vegas, NV 89146
Tel (702) 382-2597
Fax (702) 382-2597
www.vtmx.com

SOLAR FIELD
PROPOSED RIP RAP PROTECTION
EXHIBIT

RIO MESA SOLAR

PROJECT NO: 7323
DRAWN BY: SDB
DATE: 8/24/2011
SCALE: 1" = 600'

SHEET
7323RIPRAP

DATE: 8/24/2011; File: \\vtmx.com\ch\hydrology\7323-Blythe\Preliminary Site Investigation\GIS\MXD\7323-Alternate_Area.mxd; By: rauv

BSE Document Control Number: 7323HYD400-FINAL-R1