Imperial Solar Energy Center West

Appendix H-1

Preliminary CEQA Level Drainage Study

Prepared by Tory R. Walker Engineering, Inc.

October 4, 2010

Imperial Solar Energy Center West

Appendix H1

Preliminary CEQA Level Drainage Study

Prepared by Tory R. Walker Engineering, Inc.

October 4, 2010

PRELIMINARY CEQA LEVEL

DRAINAGE STUDY

for

Imperial Valley West Solar Farm

Imperial County, California

Prepared for:

LightSource Renewables
Development Design Engineering, Inc

June 25, 2010
Revised October 4, 2010

REGISTERED PROFESSIONAL ENGINEER
TORY R WALKER
No. 45005
Exp. 3-31-2012
CIVIL
STATE OF CALIFORNIA

Tory R. Walker, R.C.E. 45005
President

TORY R. WALKER ENGINEERING, INC.
WATER RESOURCES PLANNING & ENGINEERING
973 Vale Terrace Drive, Suite 202, Vista, CA 92084 760.414.9212 www.trwengineering.com

W.O. 166-03

Table of Contents

1. Description and Project Setting

The proposed 1,130 acre Imperial Valley West Solar Farm is located on the north and south sides of Interstate , just east of Dunaway Road in Imperial County, California. This proposed solar farm is located 4.5 miles northwest of the Imperial Valley Substation. It has the potential to interconnect to the Sunrise Powerlink at the CAISO controlled substation. The project is located on disturbed land that was previously farmed. No environmentally sensitive species have been found at the site. The project is bounded by undeveloped BLM land on the north, south, and west and by agricultural land and the Westside Main Canal on the east. The project location is shown in Figure 1.

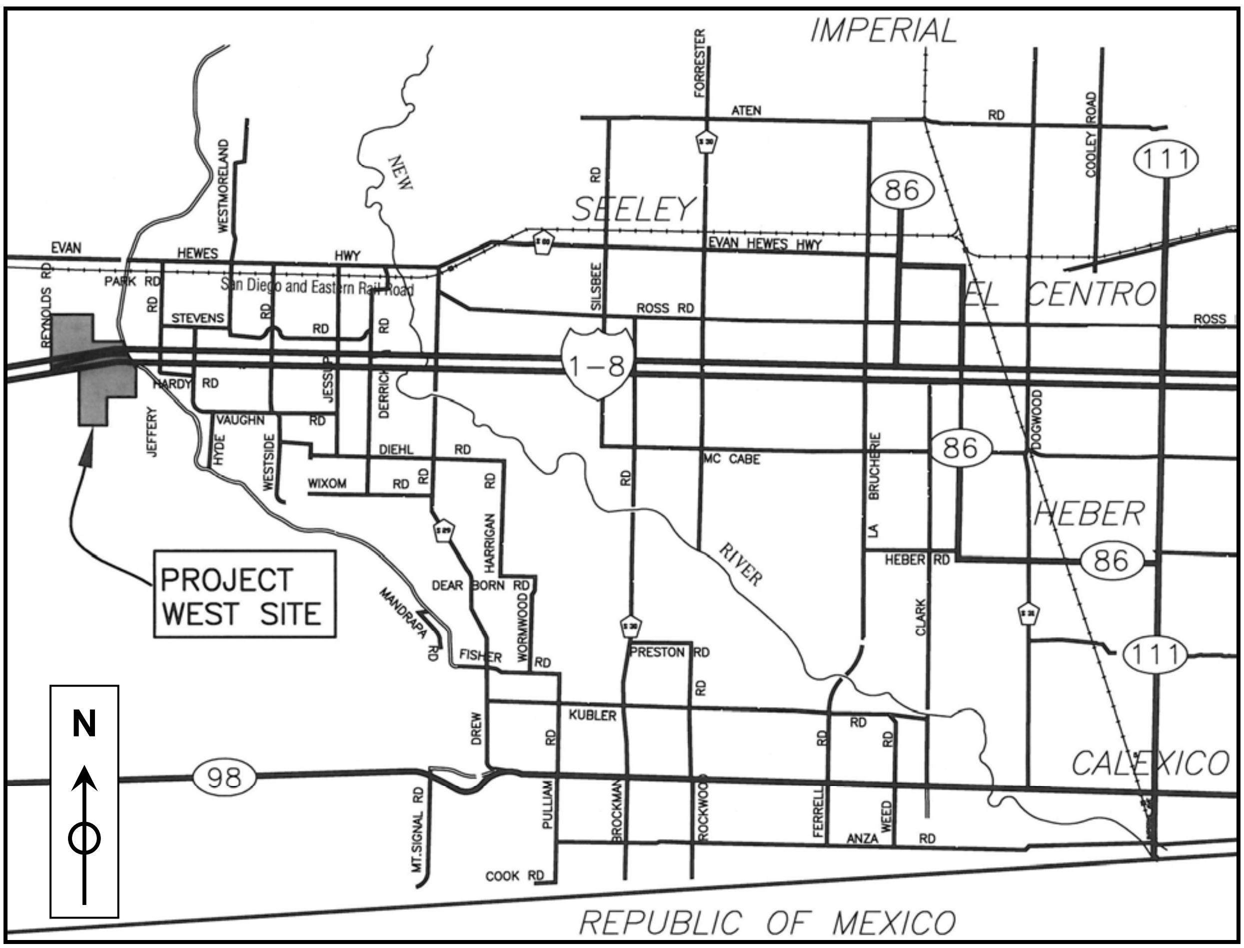


Figure 1. Project Location Map (No Scale)

2. Objectives and Input Parameters

The objectives of this preliminary drainage study are to determine locations where offsite flows enter the site, discharge locations from the site, and compare existing and proposed condition runoff. Preliminary level hydrograph calculations were prepared to estimate runoff peak flow rates and volumes. Detailed calculations of how flow will be routed through the site will be prepared to meet Imperial County criteria for the grading plan submittal. The detailed calculations will likely be prepared using Unit Hydrograph Method calculations, since the drainage design at the site will need to account for peak flow rates and runoff volumes. Unit Hydrograph calculations would likely be prepared using the SCS Method, with inputs developed from the Imperial Irrigation District (IID) Preliminary Drainage Master Plan (Master Plan), Volume 2 of 4 (1995). The input parameters that were used for the preliminary hydrologic calculations are listed below.

Design Storm – Unit Hydrograph calculations were prepared using the SCS Method 24-hour storm and a 100-year return period. The Hydraflow Hydrographs Extension for AutoCAD Civil 3D was used to prepare the calculations.

Land Uses – Existing land use for the onsite areas is grasses in poor condition. Proposed land use will be similar, since the site will be disturbed as little as possible to construct the solar farm. Land underneath the panels will remain pervious and the access roads will also be pervious surfaces. The only proposed impervious areas are the transformer pads within the solar panel blocks and the operations and maintenance facilities. Offsite areas, managed by BLM, were assumed to be open brush in poor condition.

Soil Type – A site-specific soils map was obtained from the NRCS Web Soil Survey. Hydrologic Soil Groups at the site range from A to C. The soils map is attached as Figure 8 in Appendix A.

Runoff Coefficient – In accordance with Figure C-2 from the Master Plan, Curve Numbers were based on land use and soil type.

Precipitation – The rainfall intensity-duration-frequency curve and design precipitation depths were obtained from NOAA Atlas 14. Data from the NOAA website, obtained for the project site's coordinates, are attached.

Time of Concentration – Times of concentration for the preliminary hydrograph analyses were determined using the Kirpich Equation for the onsite and small offsite watersheds. The Corps Lag method was used for the larger Yuha Wash Watershed.

3. Offsite Drainage

There are two locations where offsite flows from the Yuha Desert enter the project site. These locations are breaches through the agricultural berm that defines the western boundary of the property. The breaches are referred to as the north and south breaches on the attached hydrology map (See Figure 3 in Appendix A). The north breach cannot be repaired, since offsite runoff would then pond on the land west of the site. The south breach will be repaired, and flow will be routed south to the offsite wash that parallels the southern border of the project.

Preliminary hydrograph calculations were prepared for the watersheds tributary to the north and south breaches. The peak flow rates at the north and south breaches were calculated to be 112 cfs and 116 cfs, respectively. Calculations are attached in Appendix B.

4. Existing Drainage

Our preliminary review of the existing drainage patterns at the site indicates that offsite and onsite storm runoff ponds in many locations, with any excess gradually flowing east towards the Westside Main Canal. Runoff that enters the north breach flows through an isolated non-wetland water before dissipating on the eastern fields. Runoff that enters the south breach dissipates as sheet flow immediately after entering the site. Runoff will sheet-flow through the site and then return to the Yuha Wash. As mentioned above, the south breach will be repaired and the flow routed south to the Yuha Wash, which is the existing downstream flow path. Runoff entering the north breach will be routed in a channel to a detention basin upstream of the Dixie Drain.

Existing ditches and culverts around the perimeters of the fields also convey runoff, but due to lack of maintenance, many of the existing drainage facilities are plugged or have reduced capacity. A detailed site survey will be made prior to final design to determine the layout of the drainage system and the connections between the onsite system and the IID drains. Runoff that reaches the eastern edge of the parcels south of Interstate 8 will pond onsite and then ultimately drain through a 24-inch culvert to the IID Dixie Drain, which is located east of the Westside Main Canal. The upstream inlet for the culvert is a 60-inch diameter standpipe. Since the fields are not currently being maintained, the tile drains and surface connections to the standpipe may well be plugged with sediment. Tile drain locations can be seen on Figure 9 in Appendix A. The southern portion of the site drains from west to east and discharges to the undeveloped land south of the site.

Runoff on the north side of Interstate 8 also flows towards the eastern property edge. The agricultural ditches and culverts capture the runoff at the field breaks and convey it east and north. The tile drains and a portion of the site drain to a culvert that passes under the Westside Main Canal to the Dixie Drain. Runoff from the remainder of the site flows across the undeveloped areas north of the site to an offsite connection to the Dixie Drain. The discharge points from the property are shown on the attached hydrology maps. The drainage design concept for this project will attempt to replicate the existing conditions.

5. Floodplain Analysis

A portion of the site, south of Interstate 8, is mapped as a Zone A floodplain on FEMA FIRM Panel 060065-1675-C for Imperial County. A Floodplain Exhibit is attached as Figure 5 in Appendix A. The flooding source for this floodplain is the Yuha Wash. There is an existing somewhat degraded agricultural berm that separates the wash from the project site, but site visit evidence indicates that the berm, though not breached, has been overtopped by flood flows. An engineered berm will be constructed on the project-side of the existing berm to protect the site from flood flows in the Yuha Wash.

Our preliminary study of the wash determined that the Yuha Wash watershed area is approximately 31 square miles and the 100-year peak flow rate was calculated to be 5,250 cfs. A watershed map for the Yuha Wash is attached as Figure 4 in Appendix A. The existing berm along the south edge of the site is an agricultural berm most likely constructed from native soil, and probably does not have an impermeable core. A HEC-RAS analysis was performed for the wash using 2-foot interval topography purchased from Intermap. The topography was supplemented with recent site topography where the two data sources overlapped. The HEC-RAS model indicated that the 100-year flows would likely overtop the existing berm at its lowest point. A weir calculation was prepared for the short section of the berm that would be overtopped. This calculation indicated that the flow rate over the berm for a 100-year storm was only 71 cfs. With the relatively flat topography on the project site, this 71 cfs would immediately spread out to a flow depth of less than 1 foot. After the engineered berm is constructed, all of the 100-year runoff in the Yuha Wash will be routed easterly to an existing weir constructed by IID to receive Yuha Wash flows into the Westside Main Canal. There are no residences or structures between the project site and the canal that will be impacted by replacing or reinforcing the berm. The HEC-RAS model indicated no rise as a result of raising the berm along the site. The HEC-RAS results are attached in Appendix B. A no rise certification letter will be submitted to the County.

6. Proposed Improvements

Photovoltaic solar panels will be constructed at the site. The typical layout for the panels is in 2 megawatt blocks, as shown in Figure 2, below. Each block will also contain the necessary inverters and transformers, which will be constructed along the access roads that pass through the site. To minimize the project's impact, the access roads will have pervious gravel surfaces. The site will have a single operations and maintenance facility (See Figure 6 in Appendix A). This facility will be located in the northwest corner of the portion of the development that is south of Interstate 8. A retention basin will be used to contain the runoff from the operations and maintenance facility.

The solar panels will be constructed on posts or beams, and the land beneath the panels will remain pervious. The lower edge of the panels will be approximately 2 feet above the finished ground surface elevation. The solar technology for the site has not been determined, so details about the foundation design and panel dimensions are not available. Regardless of the panel technology selected for the site, there will not be a significant impact on site hydrology. Rain falling on the panels will run off at the drip-line at the lower end of the panels. This runoff will be dispersed as it flows across the pervious areas under the panels.

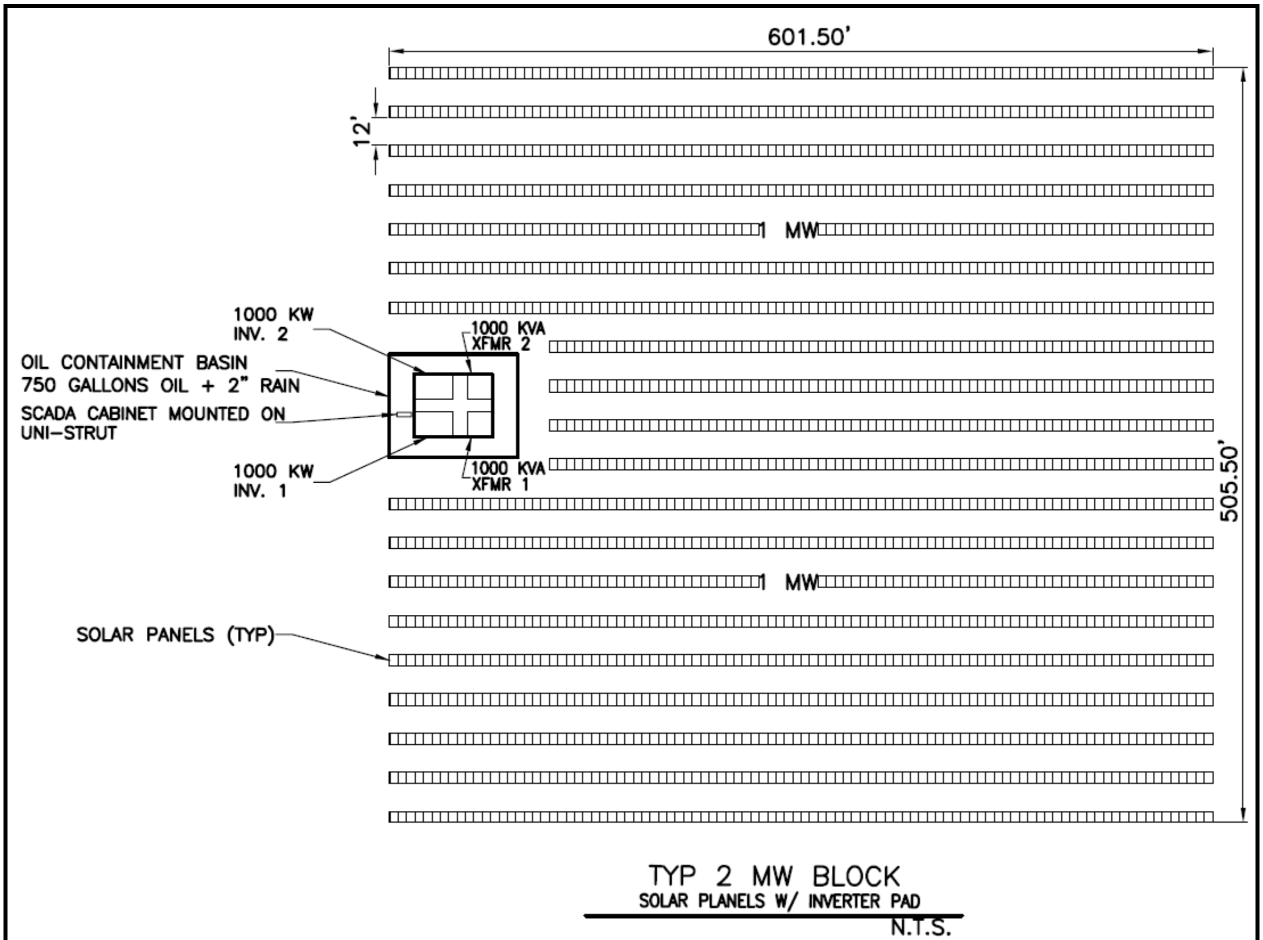


Figure 2. Typical Solar Panel Block

7. Hydrologic Analysis Results

The hydrologic analyses completed for this preliminary submittal included analyzing the major drainage subareas for the solar farm and sizing the retention basin for the operations and maintenance facility. Detailed routing calculations of the onsite and offsite flows will be prepared, as necessary, for the grading plan submittal. For a

tributary area of 0.7 acres, the operations and maintenance facility will need a basin that can store the runoff volume of 7,310 ft^3 from a 3.0 inch storm.
When the grading plans are prepared, a retention volume of approximately 7,310 cubic feet will be provided near the operations and maintenance facility to mitigate for the increase in runoff volume generated by the proposed impervious surfaces. An approximate basin size to obtain this retention volume is 65 feet square with a 2-foot depth.

The solar farm site was divided into 3 major subareas based on common discharge points to the Dixie Drain. The 3 major subareas are divided into 20 minor subareas based on the field breaks. There are 9 minor subareas north of Interstate 8 and 11 minor subareas to the south. The subareas can be seen on the Proposed Condition Hydrology Map that is attached as Figure 6 in Appendix A. The existing field slopes are 0.2% to 0.3% for many of the fields. The flat slopes across the site will be utilized to pond water beneath the solar panels. Hydrograph calculations were prepared for the existing and proposed conditions at the site for each of the major subareas. The 100-year peak flow rates and volumes are compared in Table 1.

Table 1. Summary of Hydrologic Results

Subarea	Area (ac)	Exist Peak (cfs)	Exist Vol (ac-ft)	Prop Peak (cfs)	Prop Vol (ac-ft)	Delta Peak (cfs)	Delta Vol (ac-ft)
W1 to W9	488	379	73.9	383	74.5	4.2	0.6
W10 to W19	537	326	78.9	329	79.5	3.5	0.6
W20	98	62	12.7	63	12.8	0.8	0.1

As can be seen in Table 1, the proposed improvements at the site will result in insignificant increases in peak flow rates and volumes. These increases are a result of the increase in imperviousness at the site from the transformer/inverter pads and the operations facility. The combined impact of these facilities will raise the site imperviousness from 0% to 0.5%. Onsite detention and retention will be used to reduce the flow rates to replicate the existing condition. The total analyzed area of 1,123 acres is less than the project total of 1,130 acres since the area of the Westside Main Canal was not included in the hydrology calculations. The hydrograph calculations are included in Appendix B.

8. Proposed Drainage Infrastructure

The proposed solar panels will have a less than significant impact on peak flow rates and volumes, since the water that drains off of the panels will fall onto the pervious ground surface below the panels. The runoff from the panels will form a drip line along the lower edge of the panels, but then be dispersed as sheet flow as it travels across the flat topography of the site.

In the existing condition, runoff ponds throughout the site and then is drained to the IID drains through culverts and tile drains. There is evidence north and south of Interstate 8 of berms and field breaks being washed out by flood flows. As part of the proposed project, these breaches will be repaired and stabilized to hold runoff at many locations throughout the site. A second step towards replicating the existing condition is that the culvert connections between the site and the IID drains will not be upsized. The peak flow rates leaving the site are limited by the capacity of the existing culverts, assuming that berms are not overtopped allowing runoff to flow directly into the Westside Main Canal.

A third step towards replicating the existing condition is that site grading will be used to provide designated detention basins at the two locations where the site drains through existing culverts to the IID drains. The basin south of I-8, with an estimated capacity of 45 acre-feet, can hold the entire runoff volume of 33 acre feet from the offsite area tributary to the north breach. The additional capacity at this location will be used to attenuate onsite water. The basin volumes have been estimated based on the available space outside of the proposed solar array and with a 50 foot setback from the access road along the Westside Main Canal. The footprints and volumes of the two basins will be revised at final design so that the existing condition runoff is replicated.

A fourth step towards replicating existing condition drainage is a conceptual shallow storage design under some of the solar panels. The solar panels can be designed to accommodate up to 6 inches of ponding. At a typical site slope of 0.35%, a volume of approximately 0.4 ac-ft can be stored under each block of solar panels. For this site, with 122 proposed blocks of panels, the total available storage is 49 ac-ft. Since the field breaks are not being removed, this available storage is in addition to the existing condition storage. An exhibit showing the conceptual detention design is attached as Figure 7 in Appendix A. The purpose of the exhibit is to demonstrate that there is sufficient storage available under the panels so that it will be possible to replicate existing condition peak flow rates. The ultimate detention design will be determined for the grading plan submittal. The small basins under the panels can either infiltrate, based on the results of percolation tests, or drain through risers and tile drains to the discharge points. This design is being proposed to minimize sediment transport out of the site.

Proposed drainage improvements for each of the major subareas are summarized in Table 2. Discharge methods indicated in Table 2 are representative of both existing and proposed conditions. There will be no significant changes to the method or amounts of discharge at any location.

Table 2. Summary of Drainage Improvements

Subarea	Area (ac)	Discharge Method	Recommended Drainage Improvements
W1 to W3	242	Sheet flow to north	Repair and stabilize field breaks. Provide under-panel storage to allow each subarea to drain without overtopping the field breaks.
W4 to W9	245	24-inch culvert to Dixie Drain	Use under-panel storage and a designated basin to allow site to drain through existing culvert to the Dixie Drain without overtopping the road and spilling into the Westside Main Canal.
W10 to W19	537	24-inch culvert to Dixie Drain	Route offsite runoff directly to the detention basin. Use under-panel storage and a designated basin to allow site to drain through existing culvert to the Dixie Drain without overtopping the road and spilling into the Westside Main Canal.
W20	98	Sheet flow to south	Repair berm to prevent offsite flows from reaching site. Minimize grading and use under-panel storage to replicate existing condition storage.

The final determination on the combination of under-panel and designated detention basins will be determined at final engineering. At that point in the design process, the solar panel technology and access road materials will be finalized. Infiltration tests will also be performed to determine the specific infiltration rates at the site. The geotechnical study prepared for the project indicates that most of the site is underlain by sandy soils that are suitable for infiltration.

9. Discussion of CEQA Items

CEQA guidelines include hydrology and water quality items to be addressed. The 2009 California Environmental Equality Act Statues and Guidelines lists these items in Appendix G, sections VIII and XVI. Those items and the anticipated project impact level, are included in Table 3. A brief justification for the findings is also included in the table.

Table 3. CEQA Discussion Items

Item	Would the Project:	Significant Impact?
A (Sec. VIII)	Violate any water quality standards or waste discharge requirements?	No
	Site BMPs will be designed to prevent violation of water quality requirements. See project water quality memo.	
B	Substantially deplete groundwater supplies or interfere substantially with groundwater recharge such that there would be a net deficit in aquifer volume or a lowering of the local groundwater table level?	No
	Site will only have a very minor increase in imperviousness and will not interfere substantially with recharge. Offsite water will be brought in for O&M. Ground water will not be pumped at the site.	
C	Substantially alter the existing drainage pattern of the site or area, including through the alteration of the course of a stream or river, in a manner which would result in substantial erosion or siltation on- or off-site?	No
	Onsite drainage will be designed to replicate the existing condition. Offsite flows will be handled in similar fashion to existing condition.	
D	Substantially alter the existing drainage pattern of the site or area, including through the alteration of the course of a stream or river, or substantially increase the rate or amount of surface runoff in a manner which would result in flooding on- or off-site?	No
	Site will maintain all existing condition points of discharge.	

Item	Would the Project:	Significant Impact?
E	Create or contribute runoff water which would exceed the capacity of existing or planned stormwater drainage systems or provide substantial additional sources of polluted runoff?	No
	Existing condition peak flow rates will be replicated or reduced.	
F	Otherwise substantially degrade water quality?	No
	Site BMPs will be designed to prevent violation of water quality requirements. See project water quality memo.	
G	Place housing within a 100-year flood hazard area as mapped on a federal Flood Hazard Boundary or Flood Insurance Rate Map or other flood hazard delineation map?	No
	Proposed project will not increase floodplain elevations and no housing is located along the flow path between the site and the Westside Main Canal.	
H	Place within a 100-year flood hazard area structures which would impede or redirect flood flows?	No
	The proposed transmission towers and panel supports will not impede flood flows	
I	Expose people or structures to a significant risk of loss, injury or death involving flooding, including flooding as a result of the failure of a levee or dam?	No
	Some small berms will be reinforce or replaced with engineered berms, but none of these would expose people or structures to a significant risk. This project does not have or include any levees or dams.	
J	Inundation by seiche, tsunami, or mudflow?	No
	These items are not a concern at the project site.	
C (Sec. XVI)	Require or result in the construction of new storm water drainage facilities or expansion of existing facilities, the construction of which could cause significant environmental effects?	No
	No offsite facilities are required and the onsite facilities will be constructed on previously disturbed agricultural land	

10. Summary of Findings

This preliminary analysis establishes that onsite and offsite runoff at the Solar West site can be conveyed into existing drainage facilities. There is sufficient detention capacity available on the site to allow the proposed project to replicate existing site drainage conditions. More detailed analyses will be performed at the final engineering stage of the project to the satisfaction of Imperial County, to demonstrate these stated conditions once more.

Appendix A: Figures and Exhibits

3. Offsite and Existing Condition Hydrology Map
4. Yuha Wash Watershed Map
5. Floodplain Exhibit
6. Proposed Condition Hydrology Map
7. Under-panel Detention Concept
8. Soils Map
9. Constraints Map

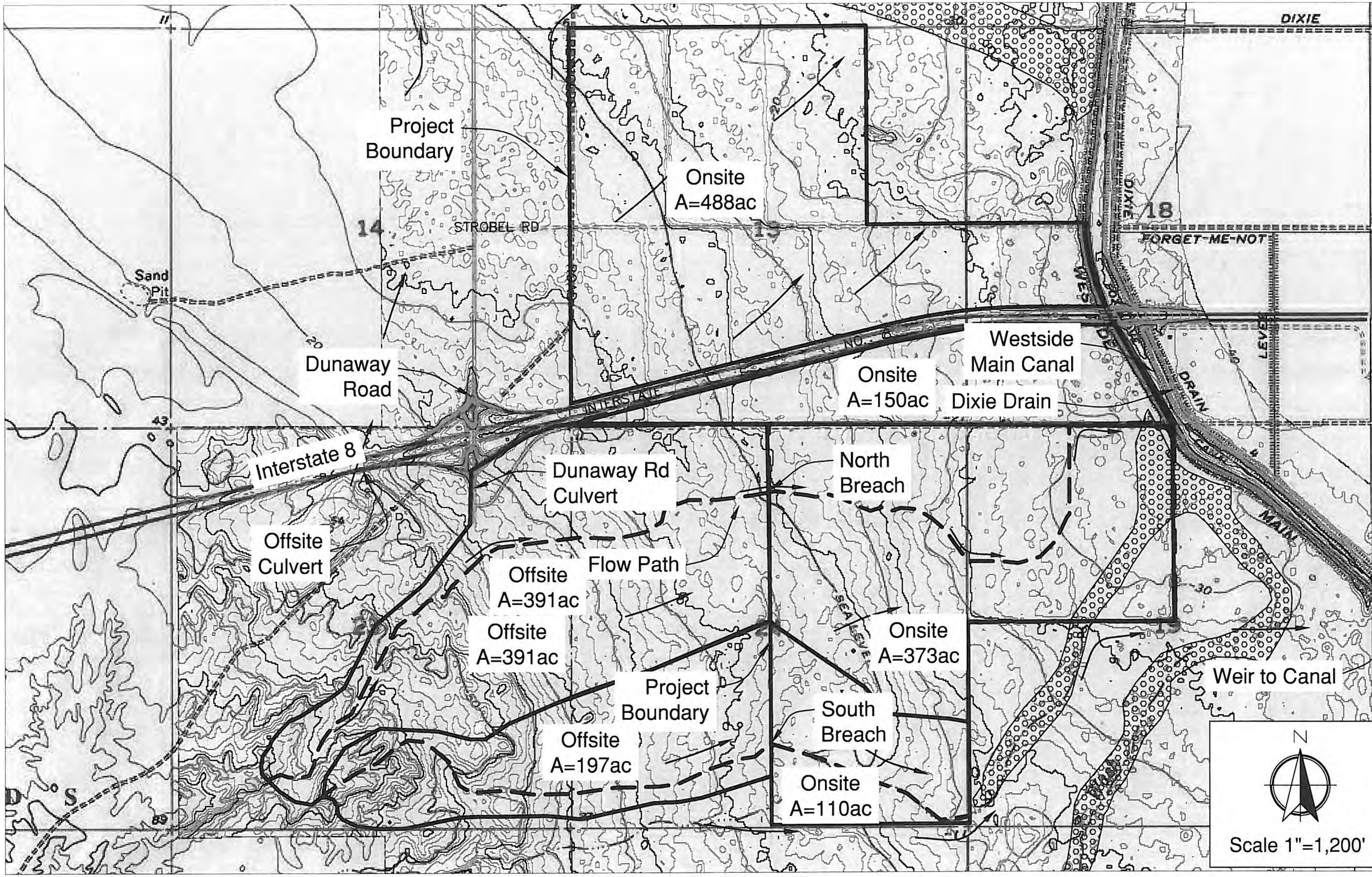


Figure 3: Imperial Valley West Solar Farm - Offsite and Existing Condition Watershed Map

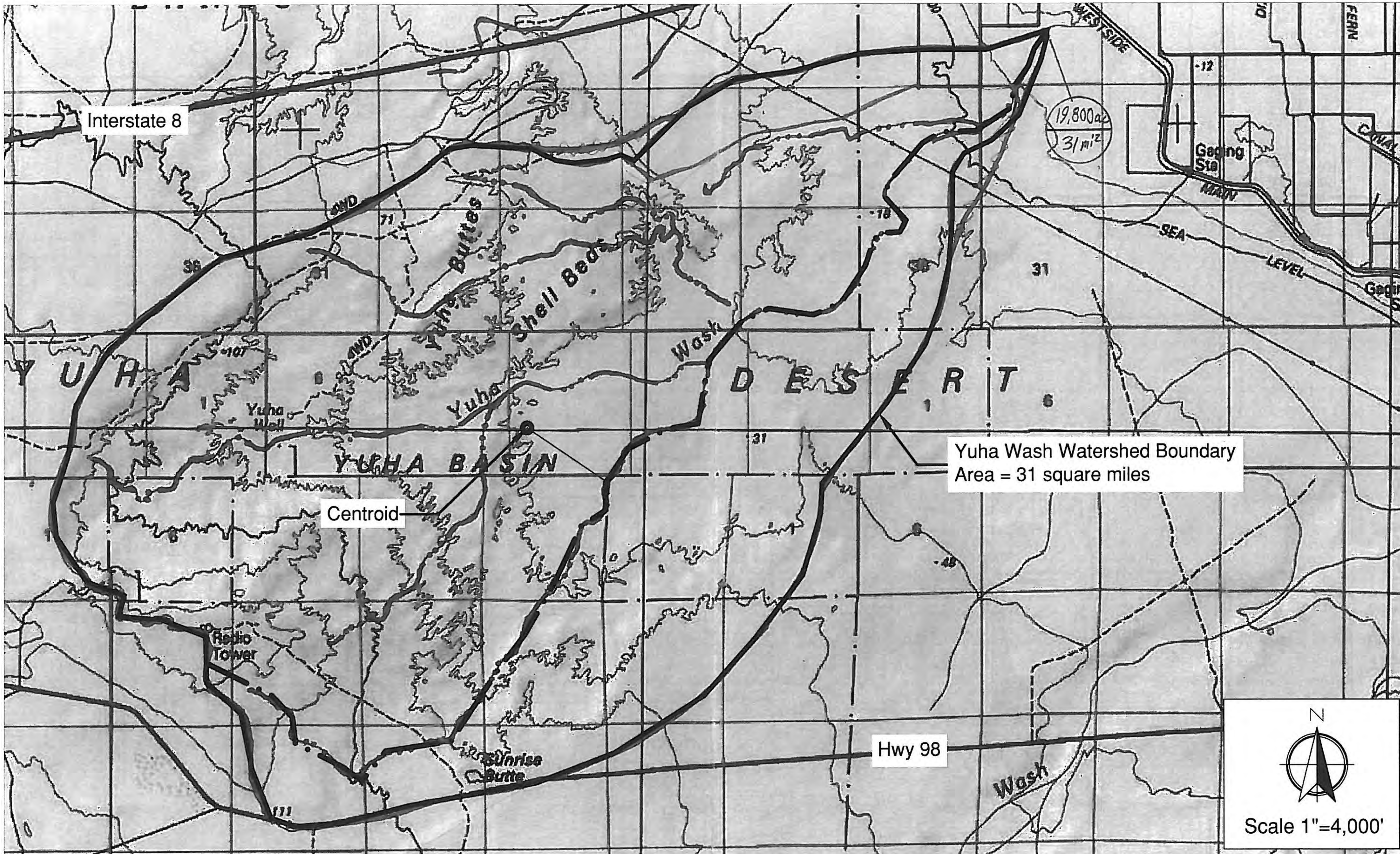


Figure 4: Yuha Wash Watershed Map

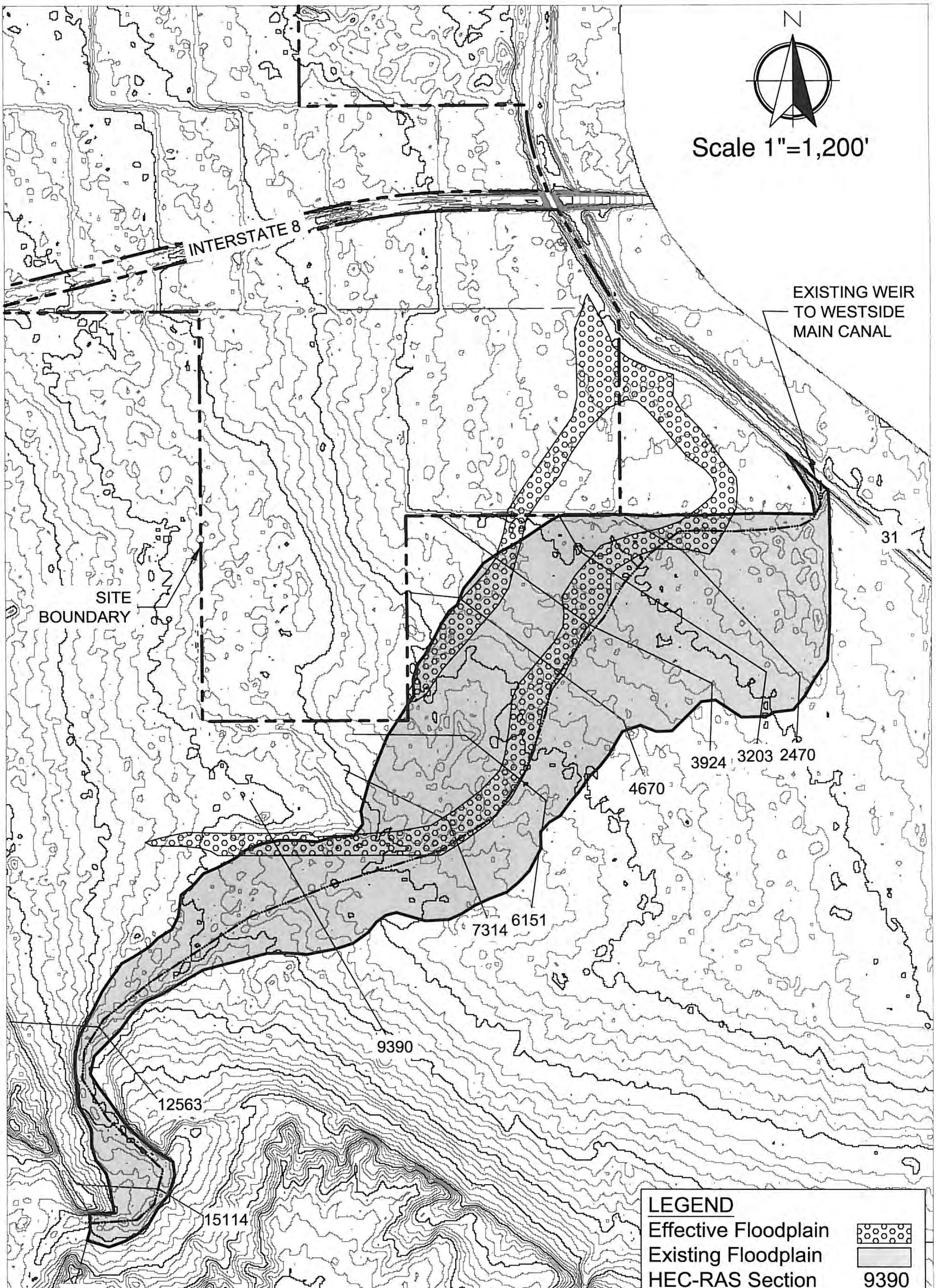


Figure 5: Imperial Valley West Solar Farm - Floodplain Exhibit

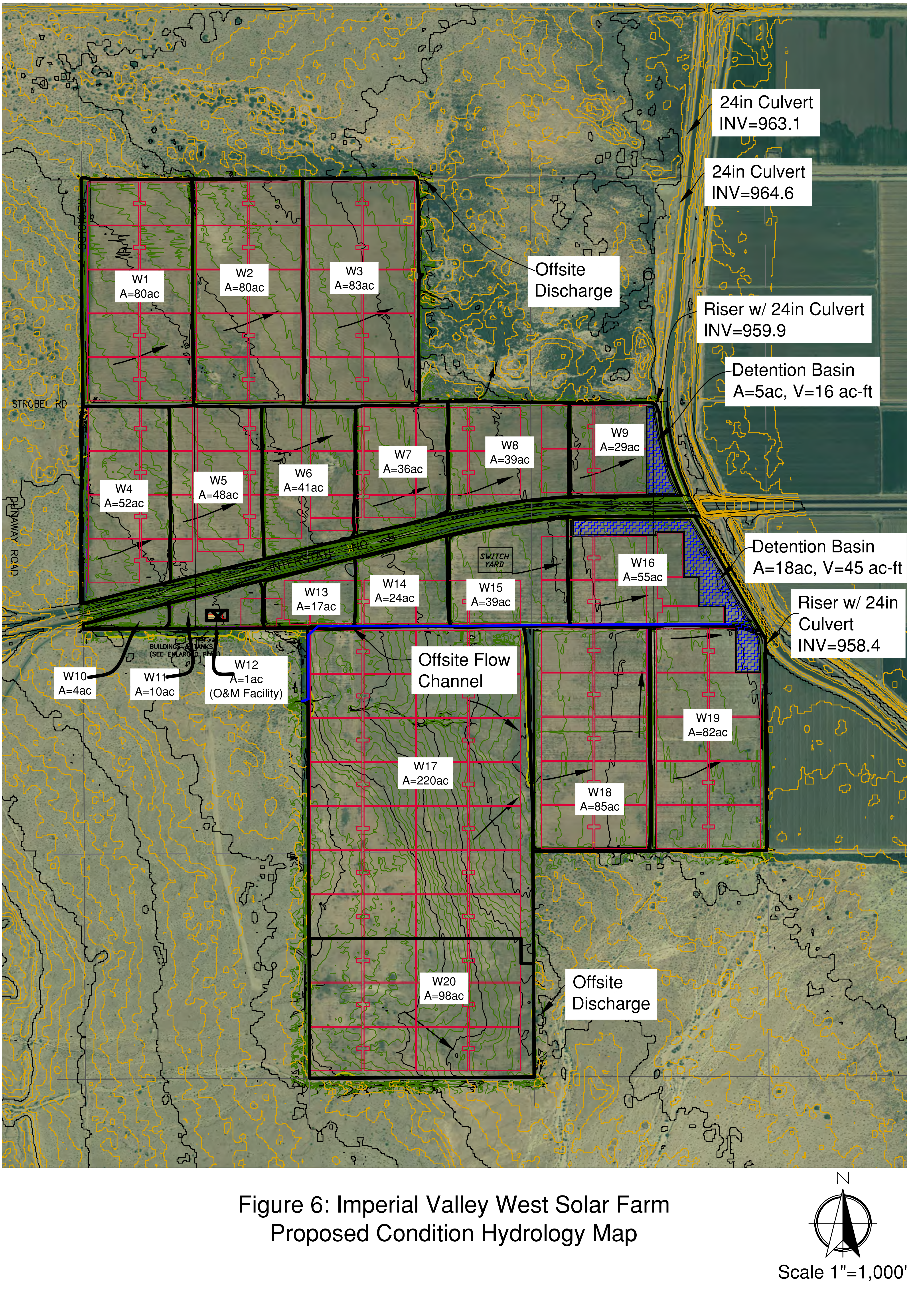


Figure 6: Imperial Valley West Solar Farm
Proposed Condition Hydrology Map

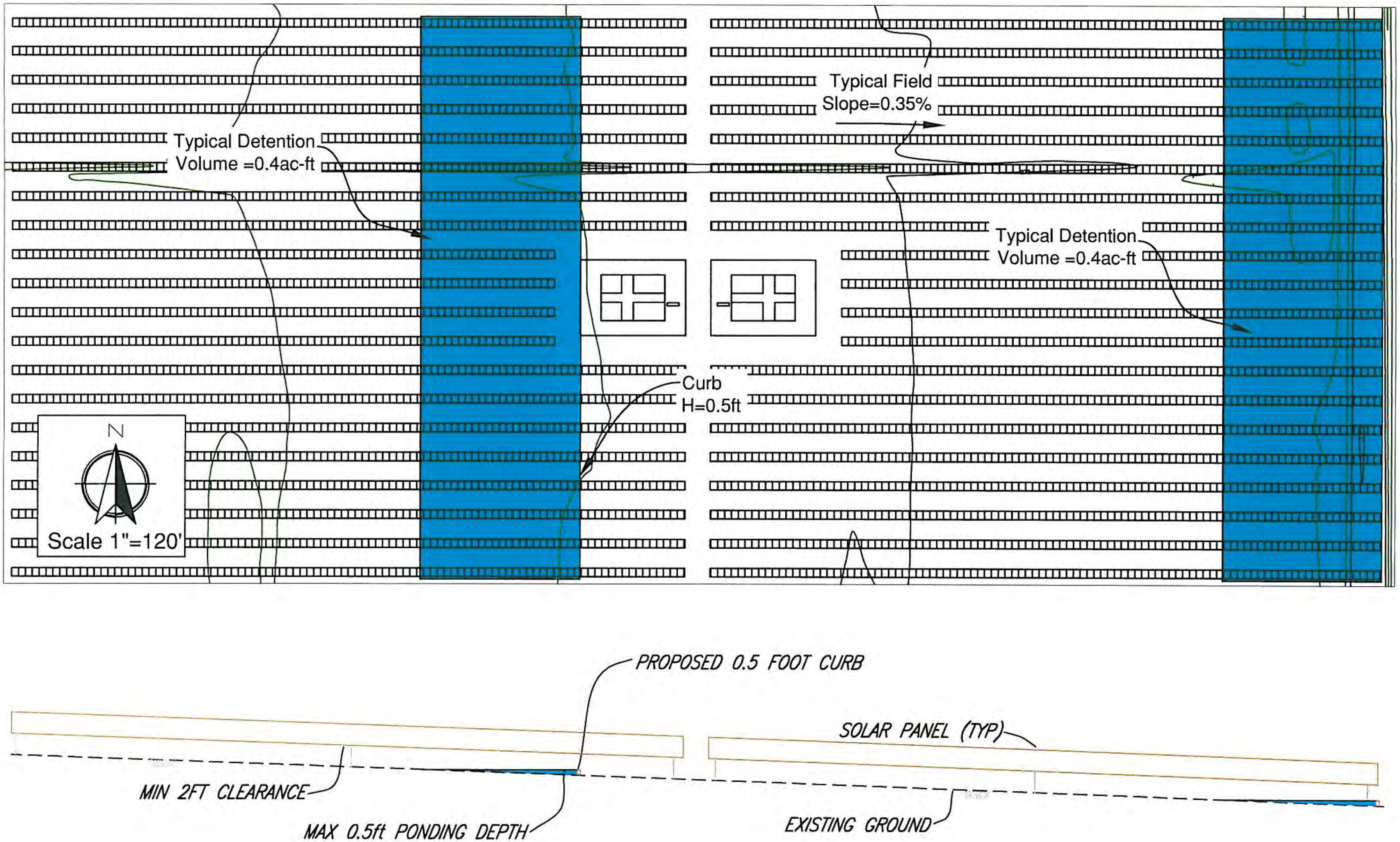
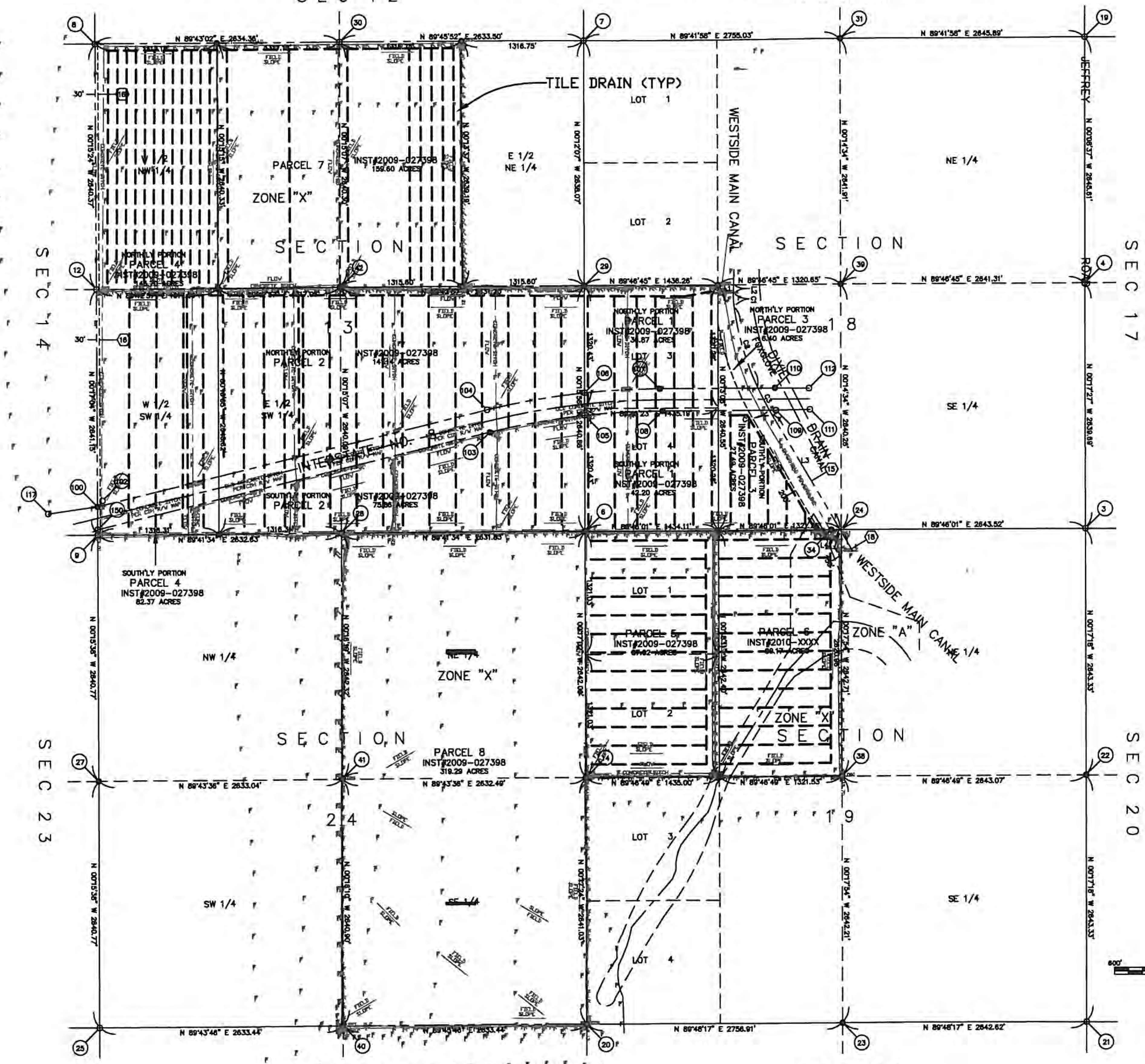


Figure 7: Imperial Valley West Solar Farm - Under-Panel Detention Concept

FIGURE 9 – IMPERIAL VALLEY WEST SOLAR FARM – CONSTRAINTS MAP

PORTIONS OF SECTION 13 & 24, T.16 S., R. 11 E., S.B.M. AND SECTION S 18 & 19, T.16 S.R, 12 E., S.B.M., ALL IN AN UNINCORPORATED AREA OF THE COUNTY OF IMPERIAL, STATE OF CALIFORNIA



SURVEYOR'S MONUMENTATION NOTES:

1. "DIXIE 1934" – FOUND BRASS CAP STAMPED "DIXIE 1934", SET IN TOP OF SQUARE CONCRETE MONUMENT. LOCATED ON SOUTH SIDE OF EVAN HEWES HIGHWAY (FORMERLY HWY 80) APPROXIMATELY 6.3 MILES EAST OF JUNCTION OF EVAN HEWES HIGHWAY AND HASKELL ROAD.

2. "WELLS 1935" -FOUND BRASS CAP STAMPED "WELLS 1935", SET IN BOULDER. LOCATED ALONG EVAN HEWES HIGHWAY (FORMERLY HWY 80) APPROXIMATELY 1.85 MILES EAST OF JUNCTION WITH INTERSTATE NO.8 OVERPASS IN OCOTILLO.

3. SOUTHEAST CORNER SECTION 18, T16S, R12E -FOUND 5/8" DIAMETER IRON PIN REPORTED TO BE SET OVER REDWOOD POST, DOWN 2-1/2', PER IMPERIAL COUNTY SURVEY TIES.

4. EAST 1/4 CORNER SECTION 18, T16S, R12E -FOUND BRASS CAP SET IN TOP OF CONCRETE CYLINDER REPORTED TO BE SET OVER VERY OLD "T" BAR SET IN CONCRETE SET BY STATE TO REPLACE OLD 4"x 4" REDWOOD POST IN CIRCLE OF ROCK, PER IMPERIAL COUNTY SURVEY TIES.

5. INTENTIONALLY OMITTED

6. SOUTHWEST CORNER SECTION 18, T16S, R12E -FOUND 2-1/2" IRON PIPE WITH CDH TAG REPORTED TO BE SET OVER VERY ROTTED MESQUITE POST 2-1/2' LONG WITH BLUE ROCK PER IMPERIAL COUNTY SURVEY TIES.

7. SOUTHWEST CORNER SECTION 7, T16S, R12E -FOUND IRON PIPE WITH BRASS CAP STAMPED IN PART "IMP CO SURV -1982" REPORTED TO BE SET OVER GLO 4"x 4" REDWOOD POST, PER IMPERIAL COUNTY SURVEY TIES.

8. NORTHEAST CORNER SECTION 14, T16S, R11E – FOUND IRON PIPE WITH GLO BRASS CAP, DOWN 0.3', PER IMPERIAL COUNTY SURVEY TIES.

9. SOUTHEAST CORNER SECTION 14, T16S, R11E -FOUND 2-1/2" IRON PIPE WITH CDH TAG, DOWN 0.3', PER IMPERIAL COUNTY SURVEY TIES. NOTE, DID NOT FIND ORIGINAL GLO MONUMENT REPORTEDLY FOUND ON GROUND TO BE SET TO REPLACE CHD IRON PIPE AND TAG PER IMPERIAL COUNTY SURVEY TIES.

10-11. INTENTIONALLY OMITTED

12. EAST 1/4 CORNER SECTION 14, T16S, R11E -FOUND 1" DIAMTER IRON PIPE, TOP BROKEN OFF, WITH METAL STATE GUARD POST ALSO WITH TOP BROKEN OFF AND 0.9' SOUTHEAST OF PIPE. SEARCH FOR TOP PORTION OF REPORTED GLO IRON PIPE WITH BRASS CAP FOUND NOTHING. ACCEPTED AS REMAINS OF SAID CORNER PER IMPERIAL COUNTY SURVEY TIES.

13. EAST 1/4 CORNER SECTION 25, T16S, R11E -FOUND 2" DIAMETER IRON PIPE WITH SDG&E BRASS CAP, STAMPED IN PART "LS 3681 SDGE 1980", PER IMPERIAL COUNTY SURVEY TIES.

14. WEST 1/4 CORNER SECTION 19, T16S, R12E -FOUND DISSINEGRATING REMAINS OF OLD IRON PIPE, DOWN 4', PER IMPERIAL COUNTY SURVEY TIES. SET MONUMENT AS INDICATED, DOWN 0.5', OVER SAME, PER TIES.

15-18. INTENTIONALLY OMITED

19. NORTHWEST CORNER SECTION 17, T16S, R12E -FOUND DISSINEGRATING REMAINS OF OLD IRON PIPE, DOWN 1', PER IMPERIAL COUNTY SURVEY TIES. REPLACED WITH MONUMENT AS INDICATED, DOWN 0.5', PER TIES.

20. SOUTHWEST CORNER SECTION 19, T16S, R12E -SEARCH FOUND NOTHING. SET MONUMENT AS INDICATED.

21. SOUTHEAST CORNER SECTION 19, T16S, R12E -FOUND IMPERIAL IRRIGATION DISTRICT 1-1/2" IRON PIPE SET IN CONCRETE, NO BRASS DISK, PER IMPERIAL COUNTY SURVEY TIES.

22. EAST 1/4 CORNER SECTION 19, T16S, R12E -SEARCH FOUND NOTHING. SET MONUMENT AS INDICATED.

23. SOUTH 1/4 CORNER SECTION 19, T16S, R12E -SEARCH FOUND NOTHING. SET MONUMENT AS INDICATED.

24. NORTH 1/4 CORNER SECTION 19, T16S, R12E -POSITION FALLS IN CANAL. NO SEARCH MADE.

25. NORTHWEST CORNER SECTION 25, T16S, R11E -FOUND IRON PIPE WITH GLO BRASS CAP STAMPED FOR SAID CORNER.

26. INTENTIONALLY OMITTED

27. WEST 1/4 CORNER SECTION 24, T16S, R11E -SEARCH FOUND NOTHING. SET MONUMENT AS INDICATED.

28. NORTH 1/4 CORNER SECTION 24, T16S, R11E -FOUND 2" BRASS CAP SET IN TOP OF CONCRETE CYLINDER, DOWN 4.5', CYLINDER REPORTED TO BE SET IN PLACE OF GLO IRON PIPE, PER COUNTY SURVEY TIES.

29. WEST 1/4 CORNER SECTION 18, T16S, R12E -SEARCH FOUND NOTHING. SET MONUMENT AS INDICATED.

30. NORTH 1/4 SECTION 13, T16S, R11E -FOUND IRON PIPE WITH GLO BRASS CAP STAMPED FOR SAID CORNER.

31. NORTH 1/4 SECTION 18, T16S, R12E -SEARCH FOUND NOTHING. SET MONUMENT AS INDICATED.

32. WEST 1/4 CORNER SECTION 30, T16S, R12E -FOUND 3/4" IRON PIPE, NO TAG. ACCEPTED AS MONUMENT FOUND FOR SAID CORNER PER RS 16-99.

33. SW CORNER SECTION 30, T16S, R12E -FOUND 1-1/4" IRON PIPE, TAG "RCE 19834", PER RS 7-59 AND IMPERIAL COUNTY SURVEY TIES.

34. RP TO NORTH 1/4 CORNER SECTION 19, T16S, R12E -FOUND 1-1/2" IRON PIPE, TAG NOT LEGIBLE, BELIEVED TO BE MONUMENT SET PER PARCEL MAP NO. M-918. ACCEPTED AS RP TO NORTH 1/4 AS INDICATED.

35-37. INTENTIONALLY OMITTED

38. CENTER CORNER SECTION 19, T16S, R12E -SEARCH FOUND NOTHING. SET MONUMENT AS INDICATED.

39. CENTER CORNER SECTION 18, T16S, R12E -SEARCH FOUND NOTHING. SET MONUMENT AS INDICATED.

40. NORTH 1/4 CORNER SECTION 25, T16S, R11E -SEARCH FOUND NOTHING. SET MONUMENT AS INDICATED.

41. CENTER CORNER SECTION 24, T16S, R11E – SEARCH FOUND NOTHING. SET MONUMENT AS INDICATED.

42. CENTER CORNER SECTION 13, T16S, R11E -SEARCH FOUND NOTHING. SET MONUMENT AS INDICATED.

43-99. INTENTIONALLY OMITTED.

100. STATE HIGHWAY R/W MONUMENT - SEARCH FOUND NOTHING. SET MONUMENT AS INDICATED.

101. INTENTIONALLY OMITTED.

102. RP TO STATE HIGHWAY R/W MONUMENT -FOUND 5/8" DIAMETER REBAR WITH PLASTIC CAP "LS 4312", ORIGIN UKNOWN, ACCEPTED AS RP AS INDICATED.

103. STATE HIGHWAY R/W MONUMENT – SEARCH FOUND NOTHING. SET MONUMENT AS INDICATED.

104. STATE HIGHWAY R/W MONUMENT – FOUND 1" DIAMTER IRON PIPE, NO TAG.

105.. STATE HIGHWAY R/W MONUMENT – FOUND 1" DIAMETER IRON PIPE WITH CDH TAG.

106. STATE HIGHWAY R/W MONUMENT – FOUND 1" DIAMETER IRON PIPE WITH CDH TAG.

107. STATE HIGHWAY R/W MONUMENT – SEARCH FOUND NOTHING. SET MONUMENT AS INDICATED.

108. STATE HIGHWAY R/W MONUMENT – SEARCH FOUND NOTHING. SET MONUMENT AS INDICATED.

109. STATE HIGHWAY R/W MONUMENT – FOUND 1" DIAMETER IRON PIPE, NO TAG, DISTURBED.

110. STATE HIGHWAY R/W MONUMENT – SEARCH FOUND NOTHING. SET NOTHING.

111. STATE HIGHWAY R/W MONUMENT – FOUND 1" DIAMETER IRON PIPE, NO TAG, DISTURBED.

112. STATE HIGHWAY R/W MONUMENT – FOUND REMAINS OF 1" DIAMETER IRON PIPE, NO TAG.

113-116. INTENTIONALLY OMITTED.

117. STATE HIGHWAY R/W MONUMENT – FOUND 1" DIAMETER IRON PIPE WITH CDH TAG.

118. STATE HIGHWAY R/W MONUMENT – SEARCH FOUND NOTHING. SET NOTHING.

119-149. INTENTIONALLY OMITTED.

150. STATE HIGHWAY R/W MONUMENT – FOUND REMAIND OF 1" DIAMETER IRON PIPE, NO TAG.

LINE DATA TABLE:

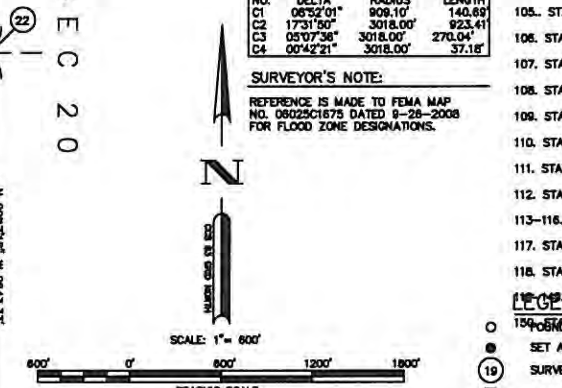
NO.	BEARING	DISTANCE
L1	N89°46'45"E	166.83'
L2	N 01°27'31"E	85.42'
L3	N 30°46'17"W	1460.85'
L4	N 30°46'17"W	25.25'

CURVE DATA TABLE:

NO.	DELTA	RADIUS	LENGTH
C1	08°52'01"	909.10'	140.69'
C2	17°31'50"	3018.00'	923.41'
C3	05°07'36"	3018.00'	270.04'
C4	00°42'21"	3018.00'	37.18'

SURVEYOR'S NOTE:

REFERENCE IS MADE TO FEMA MAP NO. 06025C1675 DATED 9-26-2008 FOR FLOOD ZONE DESIGNATIONS.



LEGEND:

- ○ FOUND SURVEY MONUMENT AS NOTED
- ● SET A 1-1/2" I.D. IRON PIPE W/1" DIA. BRASS TAG STAMPED "G.OLSON LS 7107" PER RECORD OF SURVEY TO BE FILED
- (19) SURVEYOR'S MONUMENTATION NOTE AS DEFINED HEREON
- (15) RECORDED EASEMENTS AS NOTED ON SHEET 1
- —— SURVEY BOUNDARY LINE

BENCH MARK

BRASS CAP STAMPED "DIXIE 1934: SET IN TOP OF SQUARE CONCRETE MONUMENT. LOCATED ON SOUTH SIDE OF EVAN HEWES HIGHWAY (FORMERLY HWY 80) APPROXIMATELY 6.3 MILES EAST OF JUNCTION OF EVAN HEWES HIGHWAY AND HASKELL ROAD.

ELEV= -4.39' (RAW) + 1000.00 = 995.61' (ADJUSTED)

DEVELOPMENT DESIGN & ENGINEERING, INC
PLANNING · CIVIL ENGINEERING LAND SURVEYING PROJECT MANAGEMENT
1065 STATE STREET
EL CENTRO, CA 92243
760-353-8110
FAX (760-352-6408931) 695-7466

CONSTRAINTS MAP
IV WEST SOLAR FARM
COUNTY OF IMPERIAL, CALIFORNIA
DATE: 4-14-2010 BY: G.O.
CLIENT: LIGHTSOURCE RENEWABLES
FILE NAME: 10016IV WEST CON2.DWG
JOB NUMBER: 10016
SHEET 2 OF 2

Appendix B: Supporting Calculations

- Precipitation Data
- SCS Hydrograph Calculations
- HEC-RAS Analysis
- Weir calculation for southern berm
- Channel calculation for north breach flows
- Imperial County General Requirements

Imperial Valley West Solar Farms Precipitation Data
(Location: 32.769 N 115.779 W. Source: NOAA Atlas 14)

Precipitation Frequency Estimates (inches)																		
ARI* (years)	5 min	10 min	15 min	30 min	60 min	120 min	3 hr	6 hr	12 hr	24 hr	48 hr	4 day	7 day	10 day	20 day	30 day	45 day	60 day
1	0.11	0.17	0.20	0.28	0.34	0.44	0.49	0.60	0.69	0.73	0.75	0.76	0.79	0.80	0.87	0.93	1.02	1.06
2	0.14	0.22	0.27	0.37	0.46	0.59	0.66	0.81	0.93	0.99	1.02	1.03	1.06	1.08	1.18	1.27	1.38	1.44
5	0.22	0.34	0.42	0.56	0.70	0.90	0.99	1.19	1.36	1.49	1.53	1.55	1.58	1.61	1.78	1.89	2.05	2.14
10	0.29	0.44	0.54	0.73	0.91	1.16	1.27	1.51	1.70	1.89	1.95	1.96	1.98	2.03	2.24	2.36	2.54	2.66
25	0.40	0.61	0.75	1.01	1.25	1.57	1.70	1.97	2.19	2.45	2.57	2.59	2.62	2.63	2.89	3.01	3.21	3.38
50	0.50	0.76	0.94	1.26	1.56	1.95	2.07	2.35	2.59	2.92	3.09	3.12	3.15	3.18	3.42	3.54	3.72	3.94
100	0.61	0.93	1.16	1.56	1.93	2.37	2.49	2.79	3.02	3.43	3.67	3.71	3.75	3.79	3.99	4.09	4.24	4.52
200	0.75	1.14	1.42	1.91	2.36	2.87	2.97	3.26	3.48	3.98	4.32	4.37	4.41	4.46	4.59	4.68	4.78	5.11
500	0.97	1.47	1.83	2.46	3.04	3.64	3.75	4.00	4.17	4.78	5.29	5.35	5.40	5.46	5.46	5.51	5.56	5.91
1000	1.17	1.77	2.20	2.96	3.66	4.34	4.45	4.70	4.85	5.45	6.12	6.18	6.25	6.31	6.37	6.44	6.50	6.52

Precipitation Depths

Precipitation Intensity Estimates (in/hr)																		
ARI* (years)	5 min	10 min	15 min	30 min	60 min	120 min	3 hr	6 hr	12 hr	24 hr	48 hr	4 day	7 day	10 day	20 day	30 day	45 day	60 day
1	1.30	0.99	0.82	0.55	0.34	0.22	0.16	0.10	0.06	0.03	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00
2	1.74	1.32	1.09	0.74	0.46	0.29	0.22	0.14	0.08	0.04	0.02	0.01	0.01	0.00	0.00	0.00	0.00	0.00
5	2.65	2.02	1.67	1.12	0.70	0.45	0.33	0.20	0.11	0.06	0.03	0.02	0.01	0.01	0.00	0.00	0.00	0.00
10	3.46	2.63	2.18	1.46	0.91	0.58	0.42	0.25	0.14	0.08	0.04	0.02	0.01	0.01	0.00	0.00	0.00	0.00
25	4.78	3.64	3.00	2.02	1.25	0.79	0.57	0.33	0.18	0.10	0.05	0.03	0.02	0.01	0.01	0.00	0.00	0.00
50	5.96	4.54	3.75	2.53	1.56	0.97	0.69	0.39	0.21	0.12	0.06	0.03	0.02	0.01	0.01	0.00	0.00	0.00
100	7.36	5.60	4.63	3.12	1.93	1.19	0.83	0.47	0.25	0.14	0.08	0.04	0.02	0.02	0.01	0.01	0.00	0.00
200	9.00	6.85	5.66	3.81	2.36	1.43	0.99	0.55	0.29	0.17	0.09	0.05	0.03	0.02	0.01	0.01	0.00	0.00
500	11.62	8.84	7.30	4.92	3.04	1.82	1.25	0.67	0.35	0.20	0.11	0.06	0.03	0.02	0.01	0.01	0.01	0.00
1000	13.98	10.64	8.79	5.92	3.66	2.17	1.48	0.78	0.40	0.23	0.13	0.06	0.04	0.03	0.01	0.01	0.01	0.00

Precipitation Intensity

Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2008 by Autodesk, Inc. v6.052

Hyd. No.	Hydrograph type (origin)	Peak flow (cfs)	Time interval (min)	Time to peak (min)	Hyd. volume (acft)	Inflow hyd(s)	Maximum elevation (ft)	Total strge used (acft)	Hydrograph description
1	SCS Runoff	62.23	5	610	12.732	------	------	------	W20-Exist
2	SCS Runoff	62.99	5	610	12.848	------	------	------	W20-Prop
3	SCS Runoff	379.04	5	610	73.901	------	------	------	W1-W9 Exist
4	SCS Runoff	383.15	5	610	74.530	------	------	------	W1-W9 Prop
5	SCS Runoff	325.63	5	625	78.857	------	------	------	W10-W19 Exist
6	SCS Runoff	329.06	5	625	79.528	------	------	------	W10-W19 Proposed
7	SCS Runoff	5242.34	30	750	3282.558	------	------	------	Yuha Wash Offsite
8	SCS Runoff	111.65	10	620	33.397	------	------	------	Offsite-North Breach
9	SCS Runoff	115.62	10	620	27.914	------	------	------	Offsite-South Breach

Onsite-West.gpw	Return Period: 100 Year	Wednesday, Sep 29, 2010

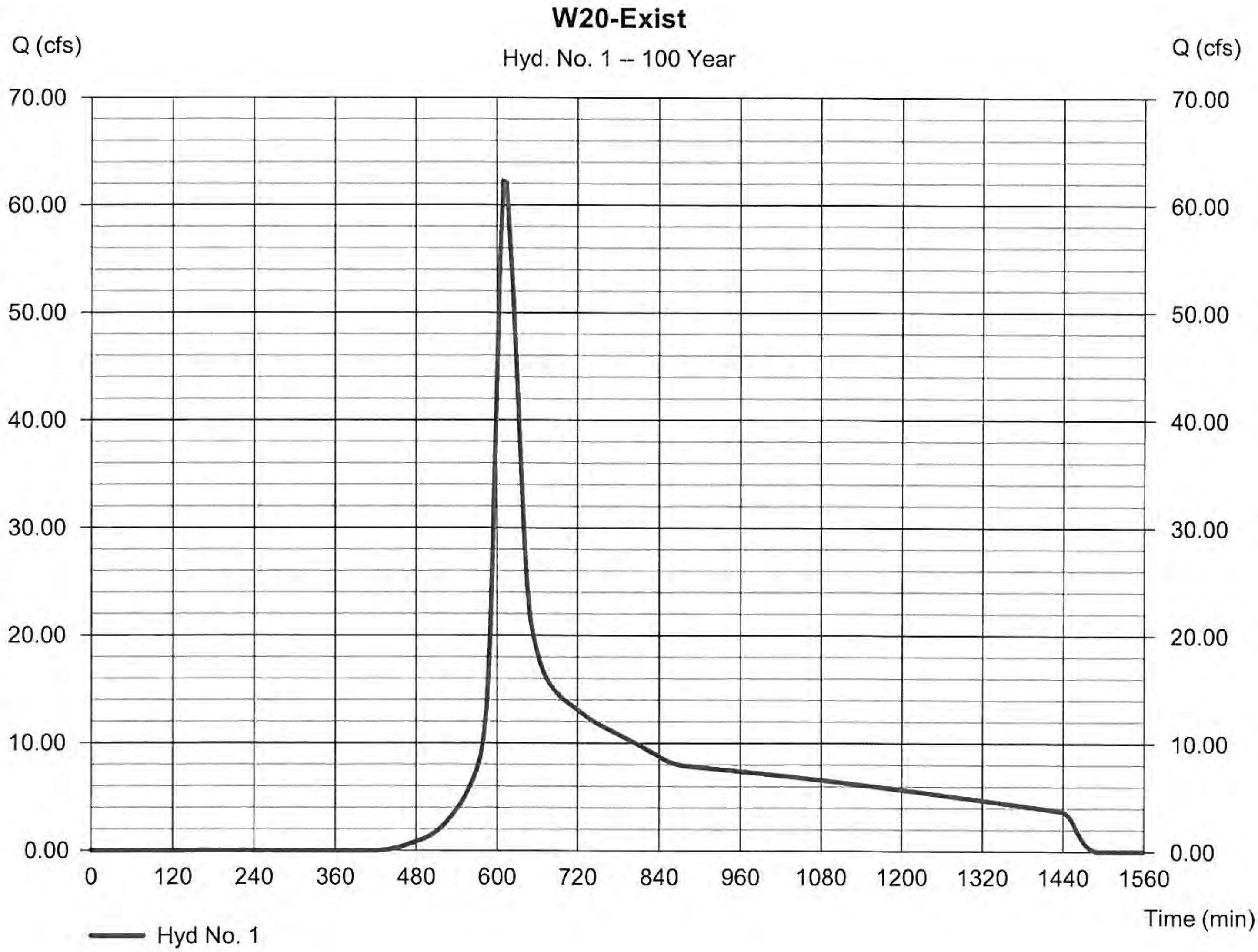
Hydrograph Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2008 by Autodesk, Inc. v6.052 Wednesday, Sep 29, 2010

Hyd. No. 1

W20-Exist

Hydrograph type	= SCS Runoff	Peak discharge	= 62.23 cfs
Storm frequency	= 100 yrs	Time to peak	= 610 min
Time interval	= 5 min	Hyd. volume	= 12.732 acft
Drainage area	= 98.000 ac	Curve number	= 79
Basin Slope	= 0.6 %	Hydraulic length	= 3100 ft
Tc method	= KIRPICH	Time of conc. (Tc)	= 27.64 min
Total precip.	= 3.43 in	Distribution	= Type I
Storm duration	= 24 hrs	Shape factor	= 484



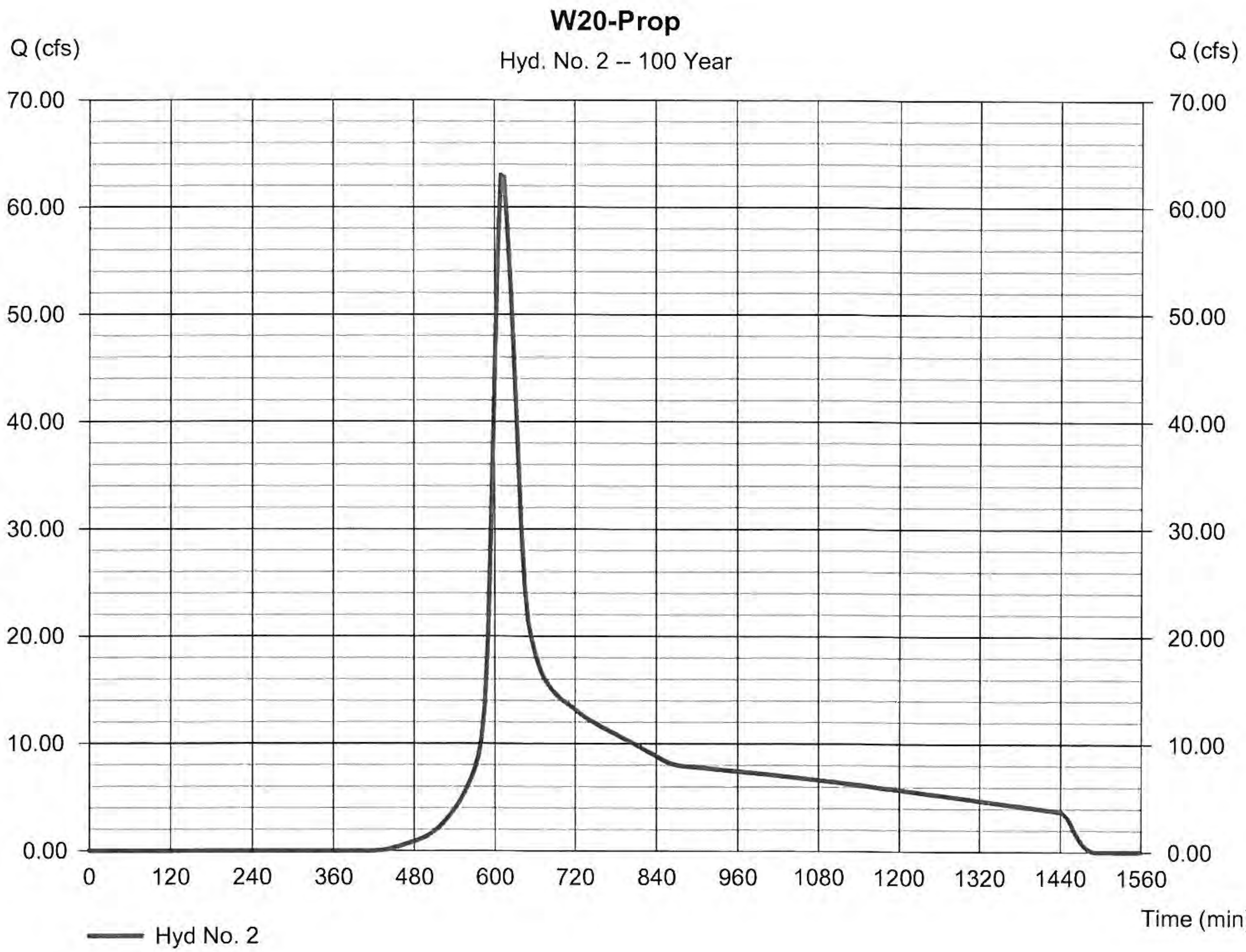
Hydrograph Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2008 by Autodesk, Inc. v6.052 — Wednesday, Sep 29, 2010

Hyd. No. 2

W20-Prop

Hydrograph type	= SCS Runoff	Peak discharge	= 62.99 cfs
Storm frequency	= 100 yrs	Time to peak	= 610 min
Time interval	= 5 min	Hyd. volume	= 12.848 acft
Drainage area	= 98.000 ac	Curve number	= 79.2
Basin Slope	= 0.6 %	Hydraulic length	= 3100 ft
Tc method	= KIRPICH	Time of conc. (Tc)	= 27.64 min
Total precip.	= 3.43 in	Distribution	= Type I
Storm duration	= 24 hrs	Shape factor	= 484



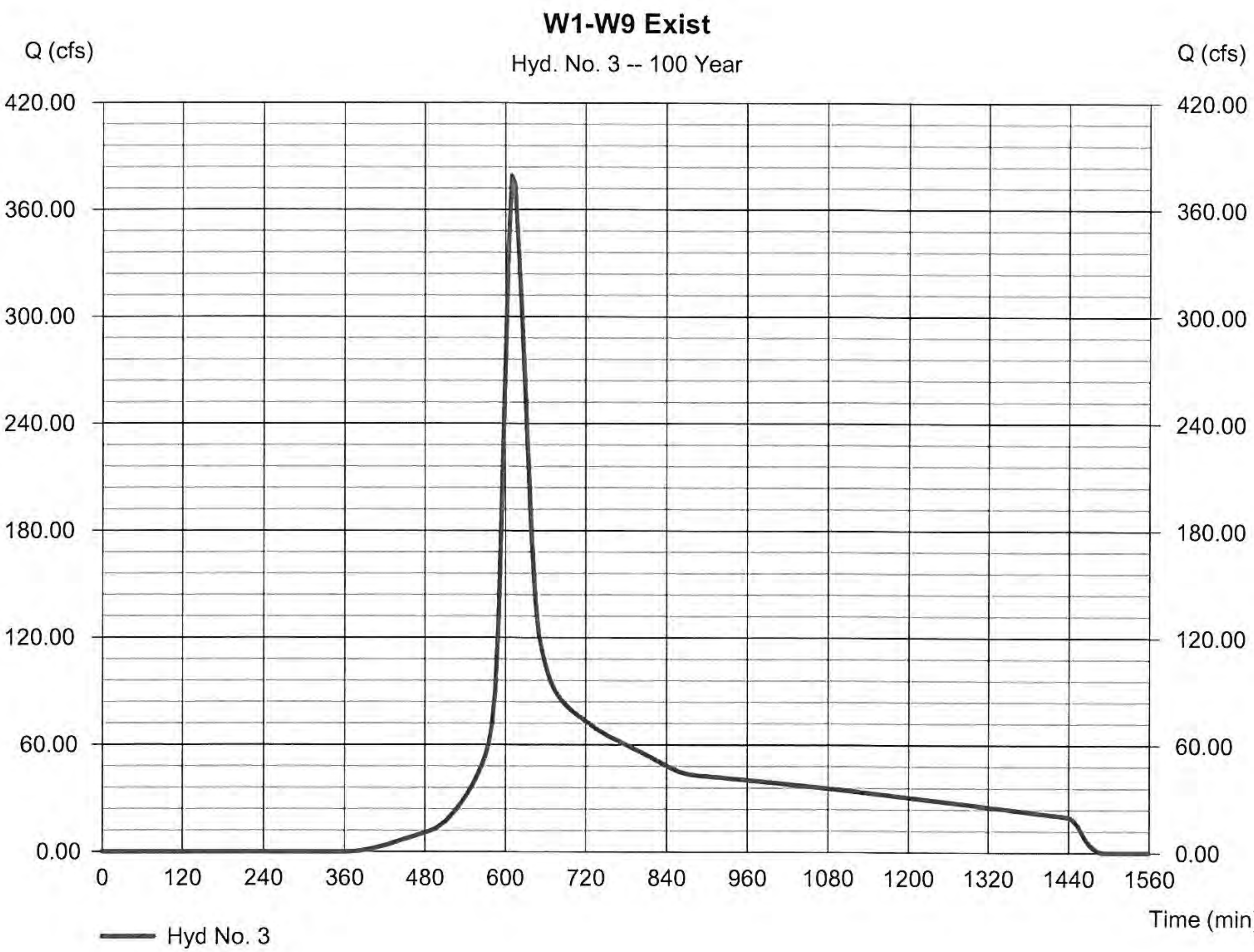
Hydrograph Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2008 by Autodesk, Inc. v6.052 Wednesday, Sep 29, 2010

Hyd. No. 3

W1-W9 Exist

Hydrograph type	= SCS Runoff	Peak discharge	= 379.04 cfs
Storm frequency	= 100 yrs	Time to peak	= 610 min
Time interval	= 5 min	Hyd. volume	= 73.901 acft
Drainage area	= 488.000 ac	Curve number	= 82.5
Basin Slope	= 0.3 %	Hydraulic length	= 2830 ft
Tc method	= KIRPICH	Time of conc. (Tc)	= 32.40 min
Total precip.	= 3.43 in	Distribution	= Type I
Storm duration	= 24 hrs	Shape factor	= 484



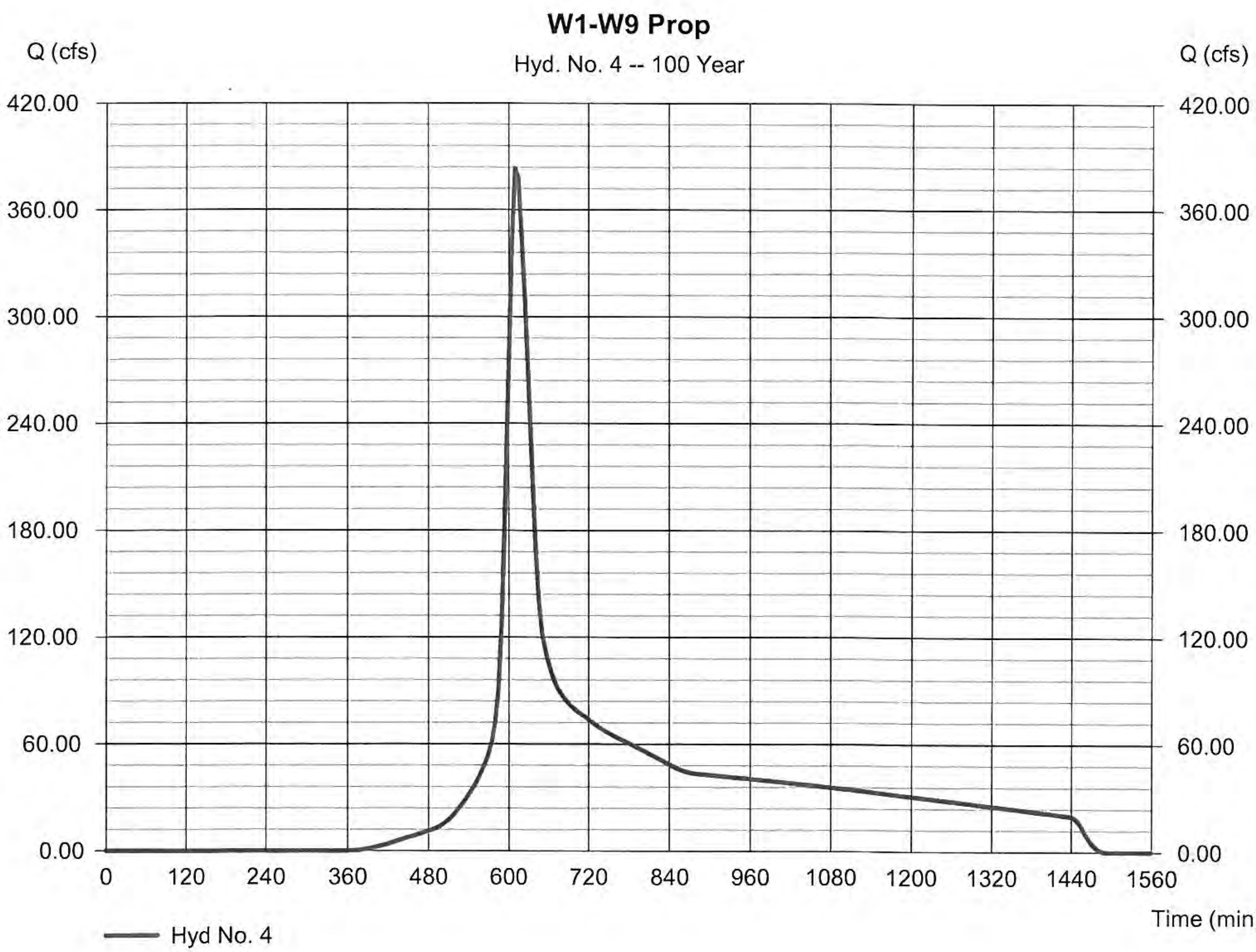
Hydrograph Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2008 by Autodesk, Inc. v6.052 — Wednesday, Sep 29, 2010

Hyd. No. 4

W1-W9 Prop

Hydrograph type	= SCS Runoff	Peak discharge	= 383.15 cfs
Storm frequency	= 100 yrs	Time to peak	= 610 min
Time interval	= 5 min	Hyd. volume	= 74.530 acft
Drainage area	= 488.000 ac	Curve number	= 82.7
Basin Slope	= 0.3 %	Hydraulic length	= 2830 ft
Tc method	= KIRPICH	Time of conc. (Tc)	= 32.40 min
Total precip.	= 3.43 in	Distribution	= Type I
Storm duration	= 24 hrs	Shape factor	= 484



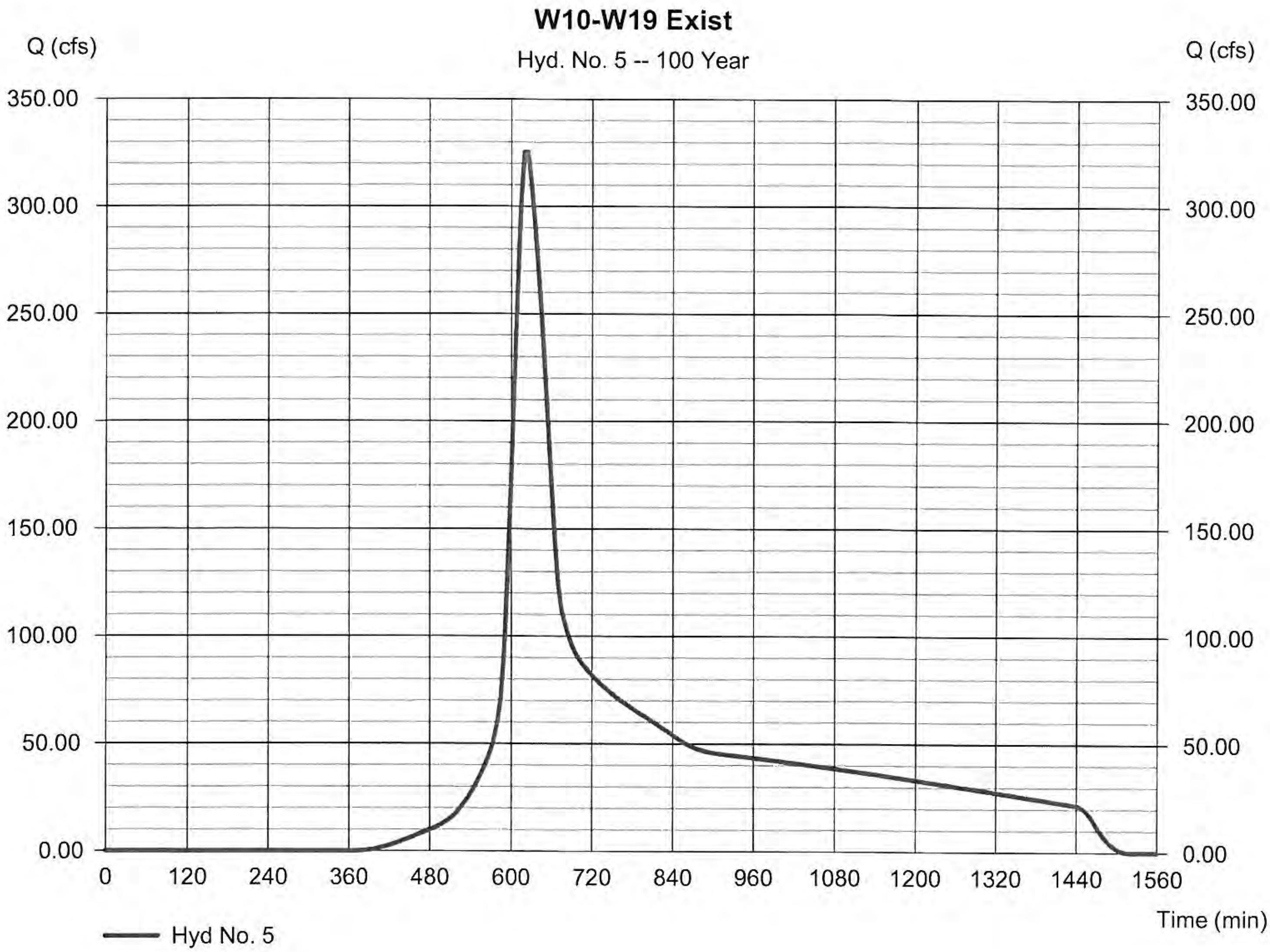
Hydrograph Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2008 by Autodesk, Inc. v6.052 Wednesday, Sep 29, 2010

Hyd. No. 5

W10-W19 Exist

Hydrograph type	= SCS Runoff	Peak discharge	= 325.63 cfs
Storm frequency	= 100 yrs	Time to peak	= 625 min
Time interval	= 5 min	Hyd. volume	= 78.857 acft
Drainage area	= 537.000 ac	Curve number	= 82.5
Basin Slope	= 0.7 %	Hydraulic length	= 5820 ft
Tc method	= KIRPICH	Time of conc. (Tc)	= 42.96 min
Total precip.	= 3.43 in	Distribution	= Type I
Storm duration	= 24 hrs	Shape factor	= 484



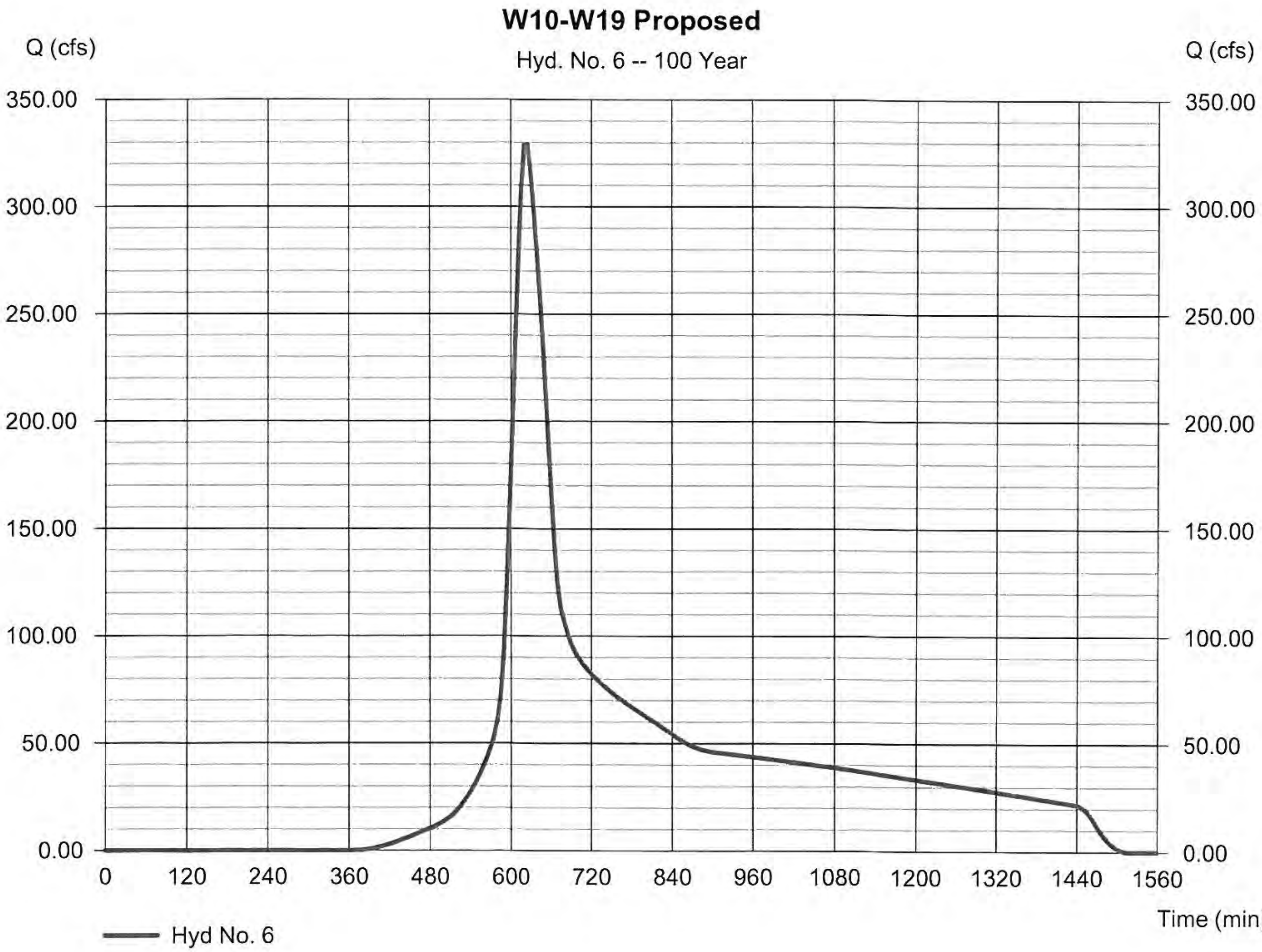
Hydrograph Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2008 by Autodesk, Inc. v6.052 — Wednesday, Sep 29, 2010

Hyd. No. 6

W10-W19 Proposed

Hydrograph type	= SCS Runoff	Peak discharge	= 329.06 cfs
Storm frequency	= 100 yrs	Time to peak	= 625 min
Time interval	= 5 min	Hyd. volume	= 79.528 acft
Drainage area	= 537.000 ac	Curve number	= 82.7
Basin Slope	= 0.7 %	Hydraulic length	= 5820 ft
Tc method	= KIRPICH	Time of conc. (Tc)	= 42.96 min
Total precip.	= 3.43 in	Distribution	= Type I
Storm duration	= 24 hrs	Shape factor	= 484

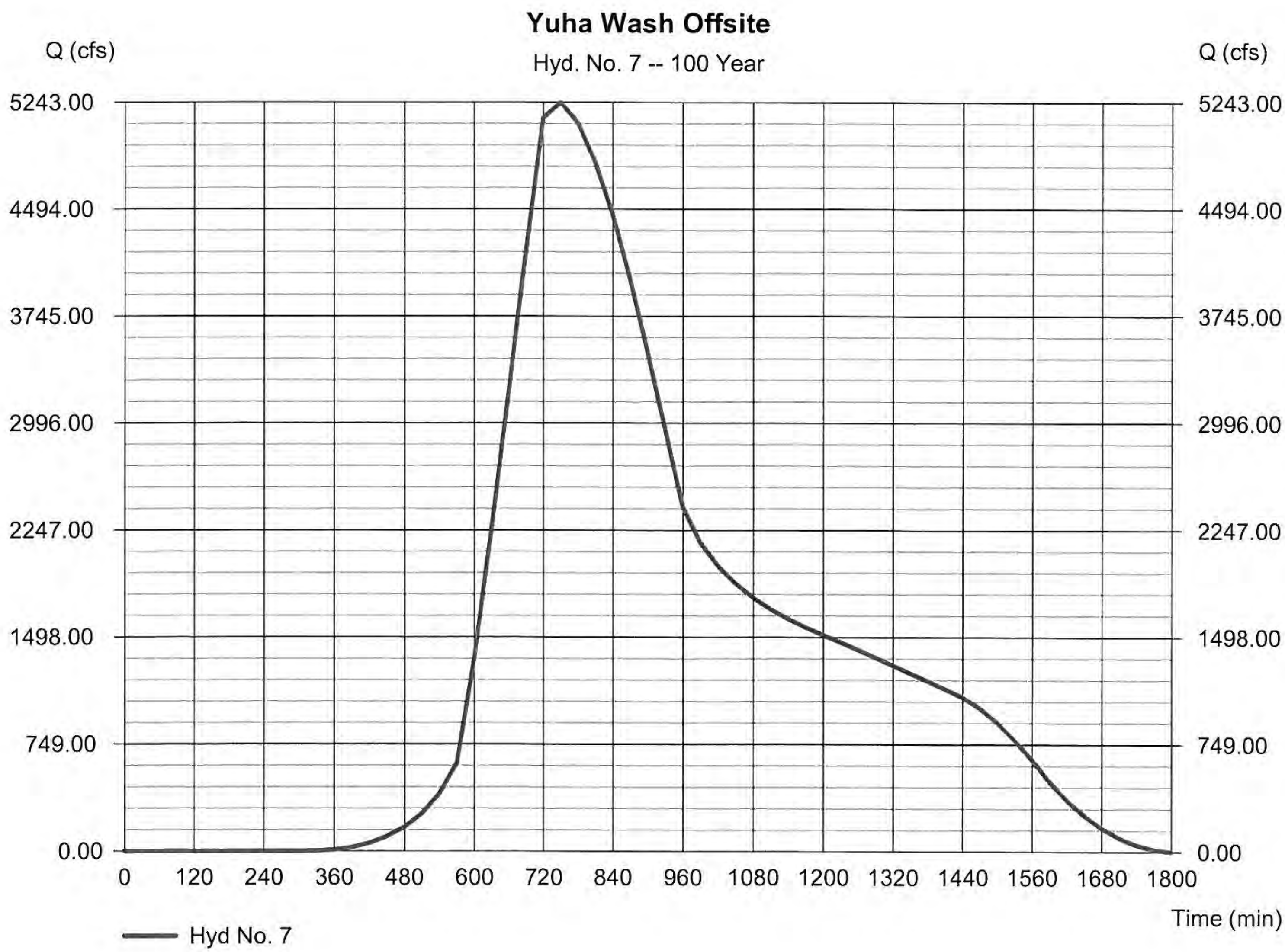


Hydrograph Report

Hyd. No. 7

Yuha Wash Offsite

Hydrograph type	= SCS Runoff	Peak discharge	= 5242.34 cfs
Storm frequency	= 100 yrs	Time to peak	= 750 min
Time interval	= 30 min	Hyd. volume	= 3282.558 acft
Drainage area	= 19840.000 ac	Curve number	= 86
Basin Slope	= 0.6 %	Hydraulic length	= 3100 ft
Tc method	= USER	Time of conc. (Tc)	= 225.00 min
Total precip.	= 3.43 in	Distribution	= Type I
Storm duration	= 24 hrs	Shape factor	= 484



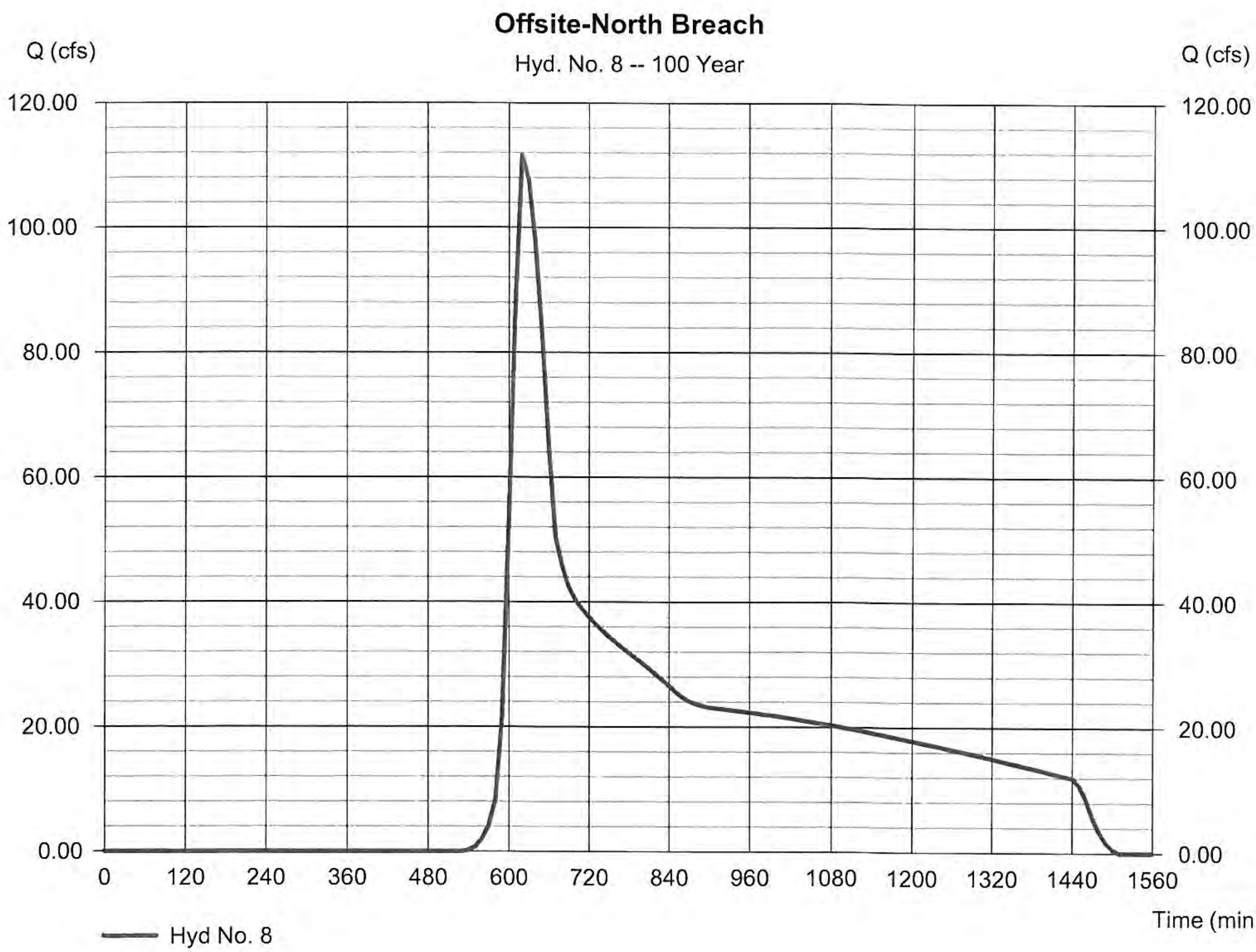
Hydrograph Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2008 by Autodesk, Inc. v6.052 Wednesday, Sep 29, 2010

Hyd. No. 8

Offsite-North Breach

Hydrograph type	= SCS Runoff	Peak discharge	= 111.65 cfs
Storm frequency	= 100 yrs	Time to peak	= 620 min
Time interval	= 10 min	Hyd. volume	= 33.397 acft
Drainage area	= 391.000 ac	Curve number	= 71.1
Basin Slope	= 1.0 %	Hydraulic length	= 8430 ft
Tc method	= KIRPICH	Time of conc. (Tc)	= 49.18 min
Total precip.	= 3.43 in	Distribution	= Type I
Storm duration	= 24 hrs	Shape factor	= 484



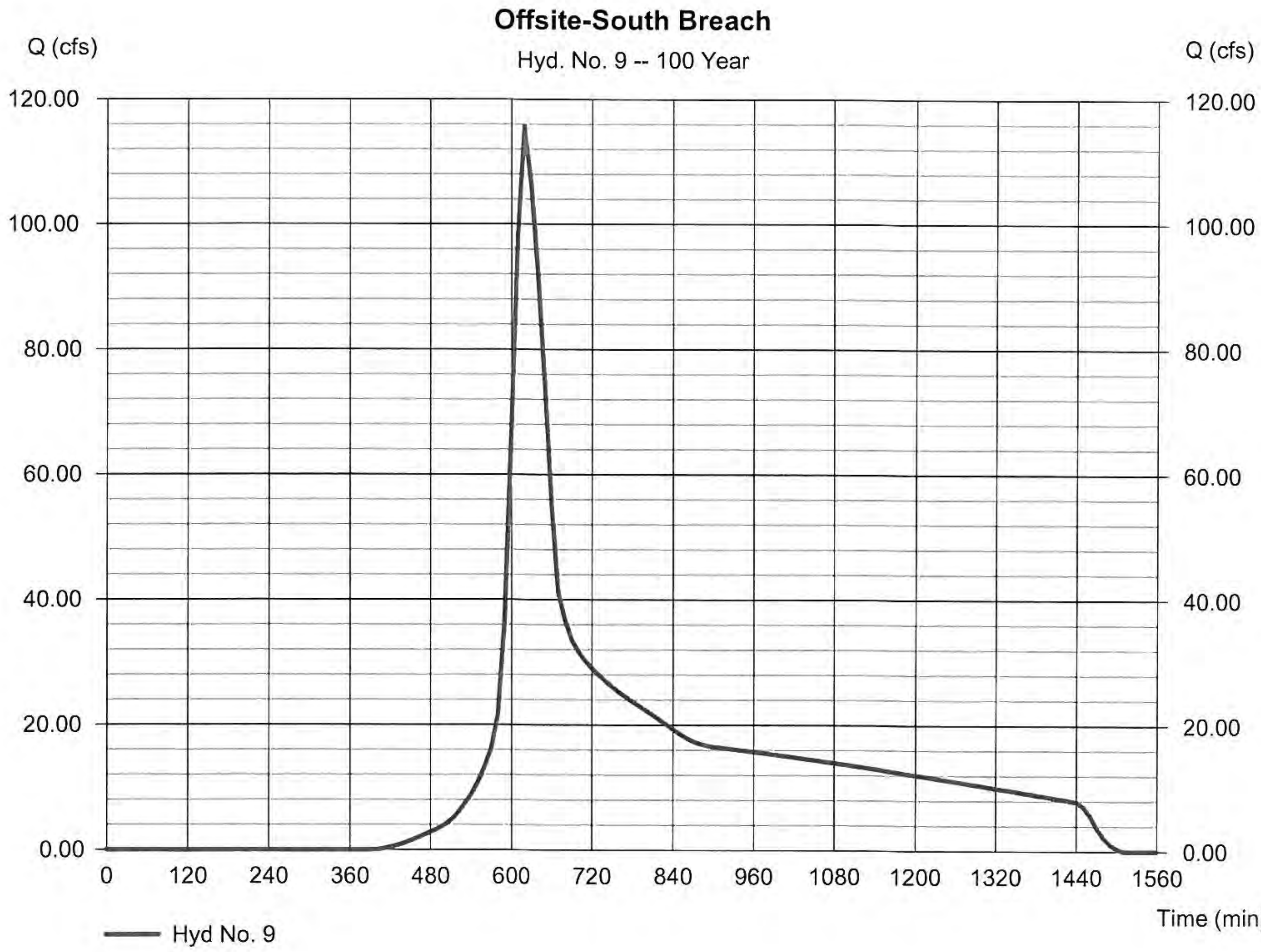
Hydrograph Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2008 by Autodesk, Inc. v6.052 Wednesday, Sep 29, 2010

Hyd. No. 9

Offsite-South Breach

Hydrograph type	= SCS Runoff	Peak discharge	= 115.62 cfs
Storm frequency	= 100 yrs	Time to peak	= 620 min
Time interval	= 10 min	Hyd. volume	= 27.914 acft
Drainage area	= 201.000 ac	Curve number	= 81.2
Basin Slope	= 1.2 %	Hydraulic length	= 6620 ft
Tc method	= KIRPICH	Time of conc. (Tc)	= 37.71 min
Total precip.	= 3.43 in	Distribution	= Type I
Storm duration	= 24 hrs	Shape factor	= 484



TORY R. WALKER ENGINEERING, INC.

Project	Imperial West Solar Farm	**Date**	26-Aug-10	**By**	TJS
Client	LightSource Renewables	**Checked**		**By**	
Subject	Basin Lag Calculations	**Approved**		**By**	

$$T_l = 24 \cdot \bar{n} \cdot \left(\frac{L \cdot L_c}{s^{0.5}} \right)^m$$

Where: T_l = Army Corps of Engineers' Lag Time (hrs)
n = Average Manning's n for watercourse
L = Length of longest watercourse (miles)
L_c = Length along longest watercourse to point opposite centroid (miles)
s = Overall slope of drainage area (feet per mile)
m = Regional constant, equal to 0.38 for San Diego County

Basin Characteristics

Basin	Area (ac)	Area (mi^2)	Upper Elev. (ft)	Lower Elev. (ft)	Length (mi)	Slope (ft/mi)	Length to Centroid (mi)
Yuha	19840	31.0	500	-30	11.00	48	6.00

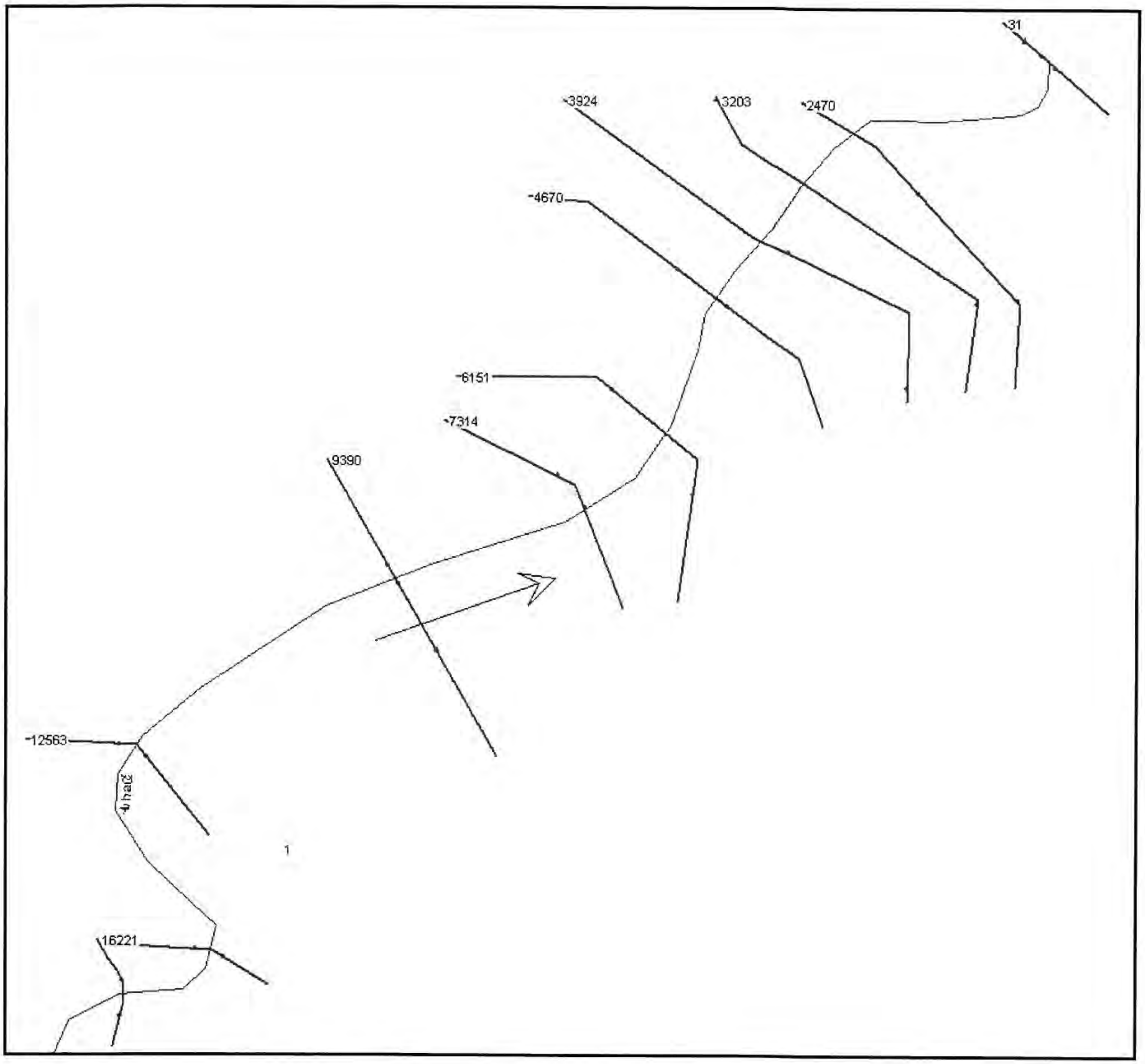
Army Corps Lag Time Calculations

n Value	Lag (min)	Lag (hrs)
0.040	135.6	2.26

Tc calc based on Lag = 0.6 X Tc

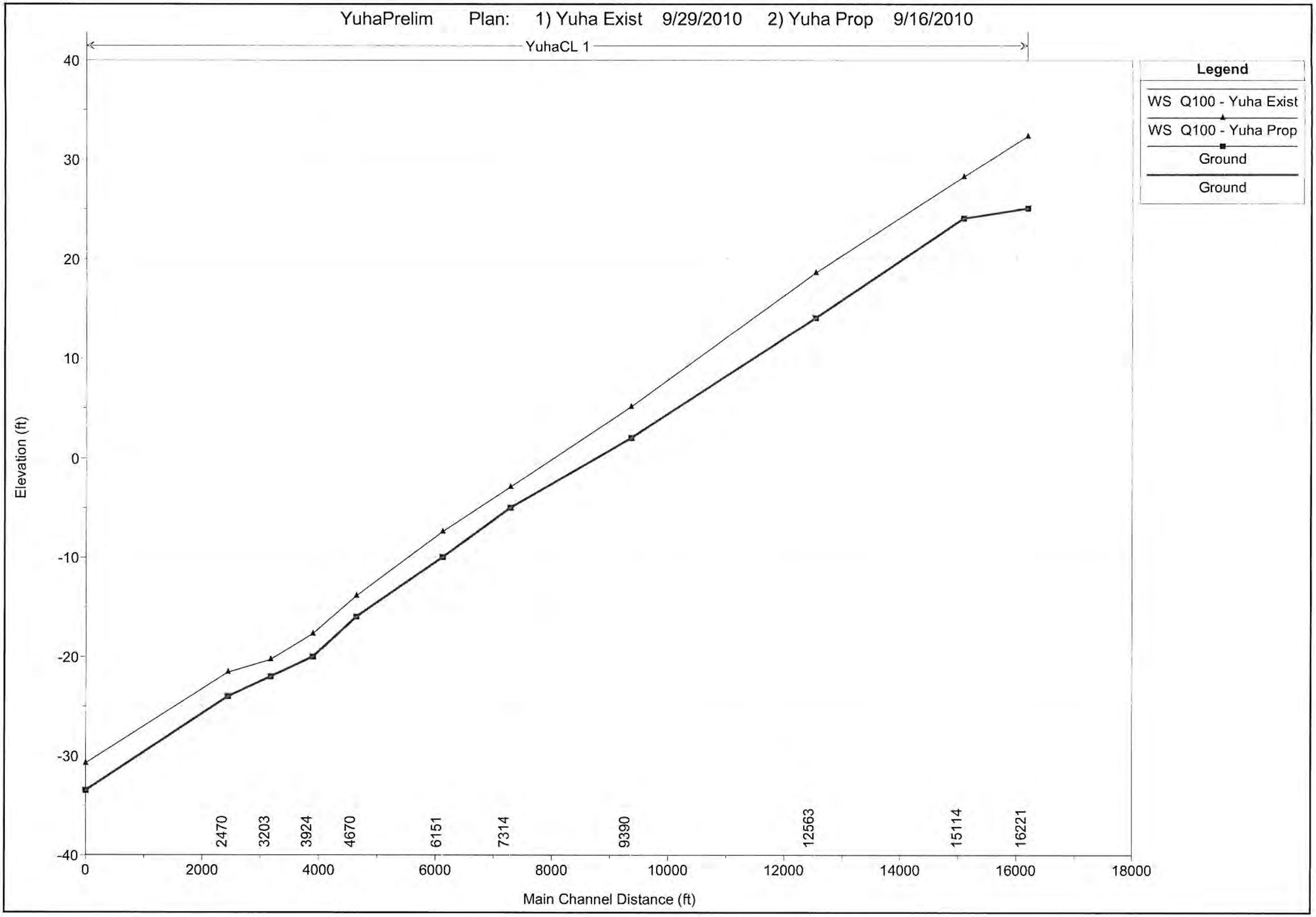
Tc (hrs)	Tc (min)
3.77	226

HEC-RAS Cross-Section Exhibit

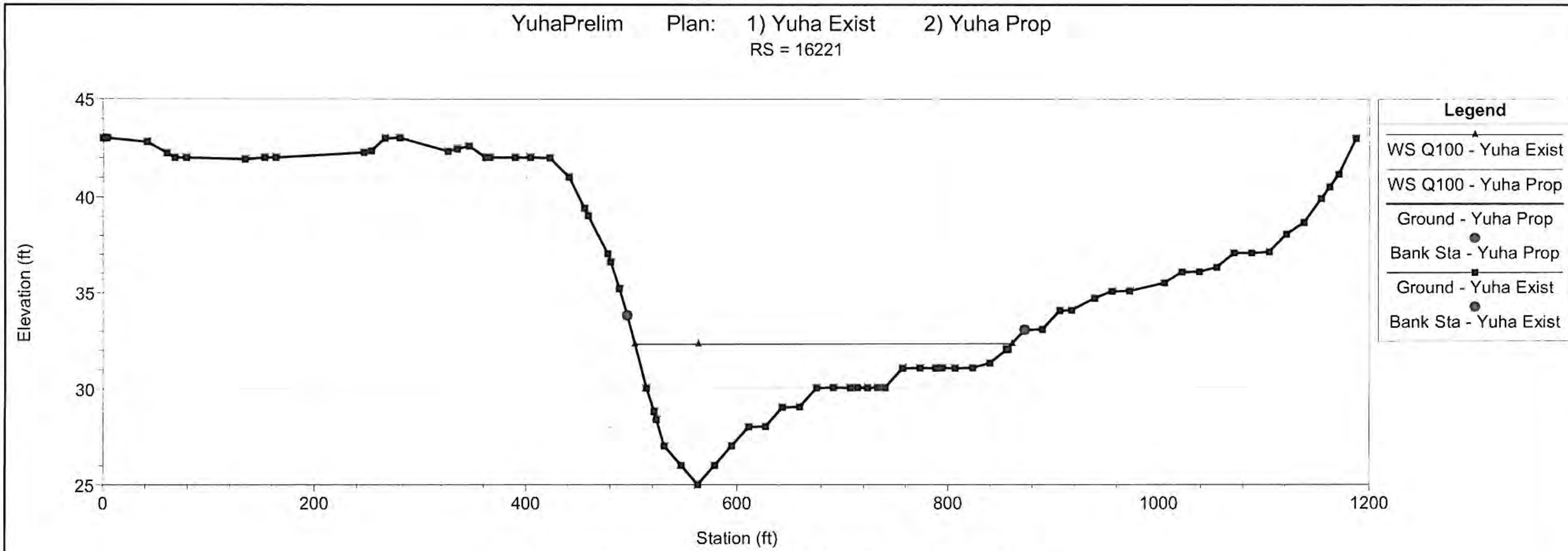


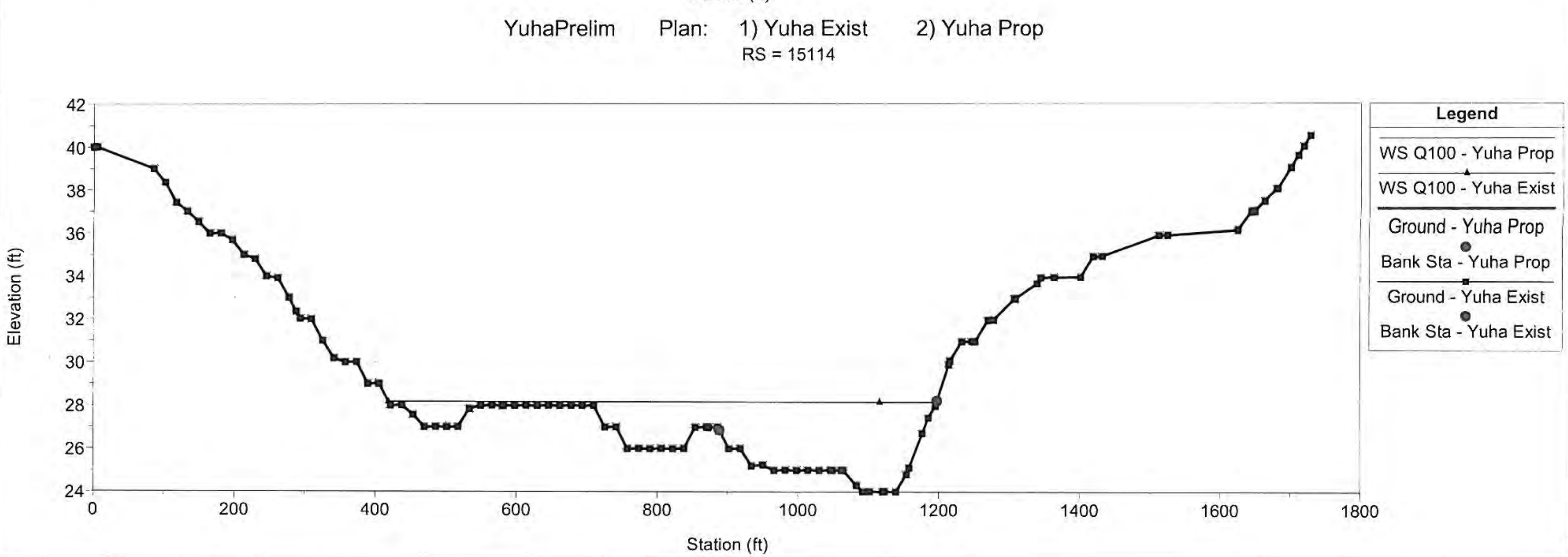
HEC-RAS River: YuhaCL Reach: 1 Profile: Q100

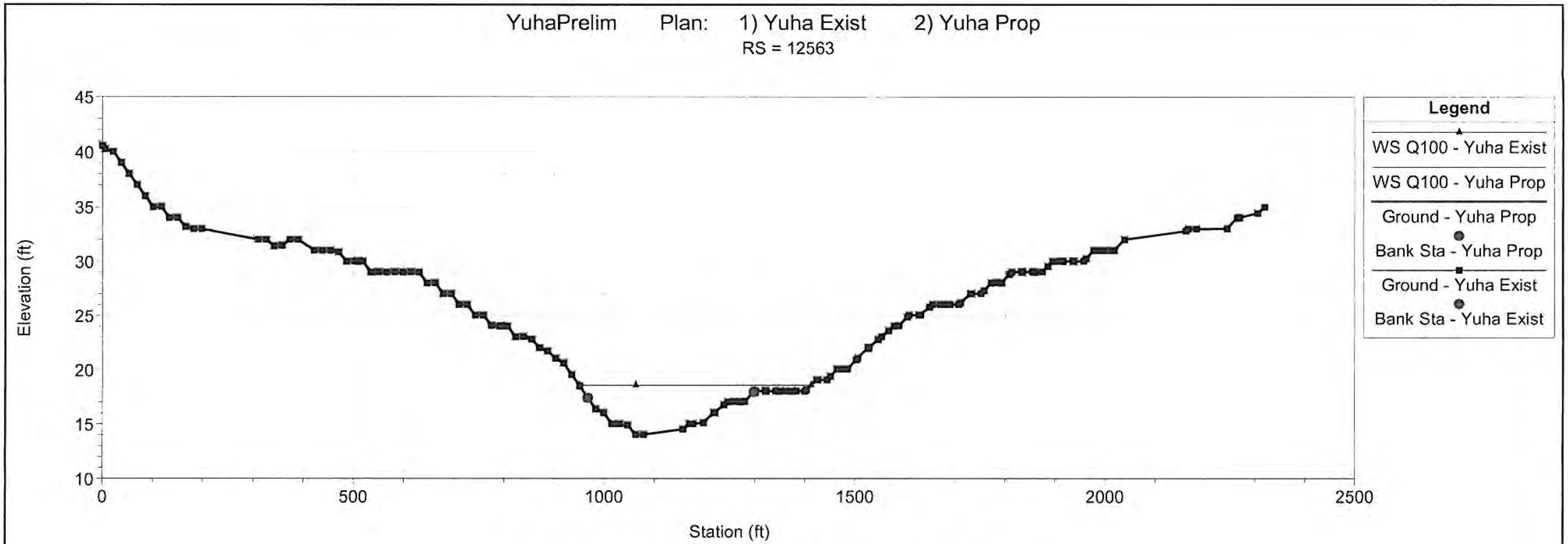
Reach	River Sta	Profile	Plan	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
1	31	Q100	Yuha Exist	5250.00	-33.50	-30.74	-30.74	-29.78	0.014513	8.45	717.82	473.93	0.92
1	31	Q100	Yuha Prop	5250.00	-33.50	-30.74	-30.74	-29.78	0.014513	8.45	717.82	473.93	0.92
1	2470	Q100	Yuha Exist	5250.00	-24.00	-21.56		-21.51	0.001447	1.86	3340.44	3492.61	0.27
1	2470	Q100	Yuha Prop	5250.00	-24.00	-21.56		-21.51	0.001447	1.86	3340.44	3492.61	0.27
1	3203	Q100	Yuha Exist	5250.00	-22.00	-20.28		-20.21	0.002242	2.44	2602.50	2422.98	0.34
1	3203	Q100	Yuha Prop	5250.00	-22.00	-20.27		-20.20	0.002251	2.45	2598.77	2419.95	0.34
1	3924	Q100	Yuha Exist	5250.00	-20.00	-17.69		-17.60	0.006667	2.55	2219.00	3320.19	0.51
1	3924	Q100	Yuha Prop	5250.00	-20.00	-17.69		-17.60	0.006616	2.54	2224.22	3320.33	0.51
1	4670	Q100	Yuha Exist	5250.00	-16.00	-13.90		-13.82	0.003991	2.56	2410.14	2847.89	0.42
1	4670	Q100	Yuha Prop	5250.00	-16.00	-13.90		-13.82	0.004011	2.56	2406.31	2847.22	0.42
1	6151	Q100	Yuha Exist	5250.00	-10.00	-7.42	-7.89	-7.32	0.004854	2.65	2049.07	2161.87	0.46
1	6151	Q100	Yuha Prop	5250.00	-10.00	-7.42	-7.89	-7.32	0.004831	2.64	2052.22	2162.40	0.46
1	7314	Q100	Yuha Exist	5250.00	-5.00	-2.91		-2.81	0.003319	2.69	2213.45	2119.52	0.40
1	7314	Q100	Yuha Prop	5250.00	-5.00	-2.91		-2.81	0.003330	2.69	2211.11	2119.13	0.40
1	9390	Q100	Yuha Exist	5250.00	2.00	5.12	4.62	5.28	0.004591	4.11	1792.36	1968.34	0.50
1	9390	Q100	Yuha Prop	5250.00	2.00	5.12	4.62	5.28	0.004578	4.11	1794.12	1968.59	0.50
1	12563	Q100	Yuha Exist	5250.00	14.00	18.53	17.34	18.91	0.003912	4.97	1104.38	463.17	0.49
1	12563	Q100	Yuha Prop	5250.00	14.00	18.53	17.34	18.91	0.003922	4.97	1103.40	463.09	0.50
1	15114	Q100	Yuha Exist	5250.00	24.00	28.19		28.48	0.003605	4.66	1361.09	778.84	0.47
1	15114	Q100	Yuha Prop	5250.00	24.00	28.19		28.48	0.003598	4.66	1362.04	778.88	0.47
1	16221	Q100	Yuha Exist	5250.00	25.00	32.28		32.65	0.004032	4.90	1072.27	357.80	0.50
1	16221	Q100	Yuha Prop	5250.00	25.00	32.28		32.65	0.004037	4.90	1071.84	357.78	0.50

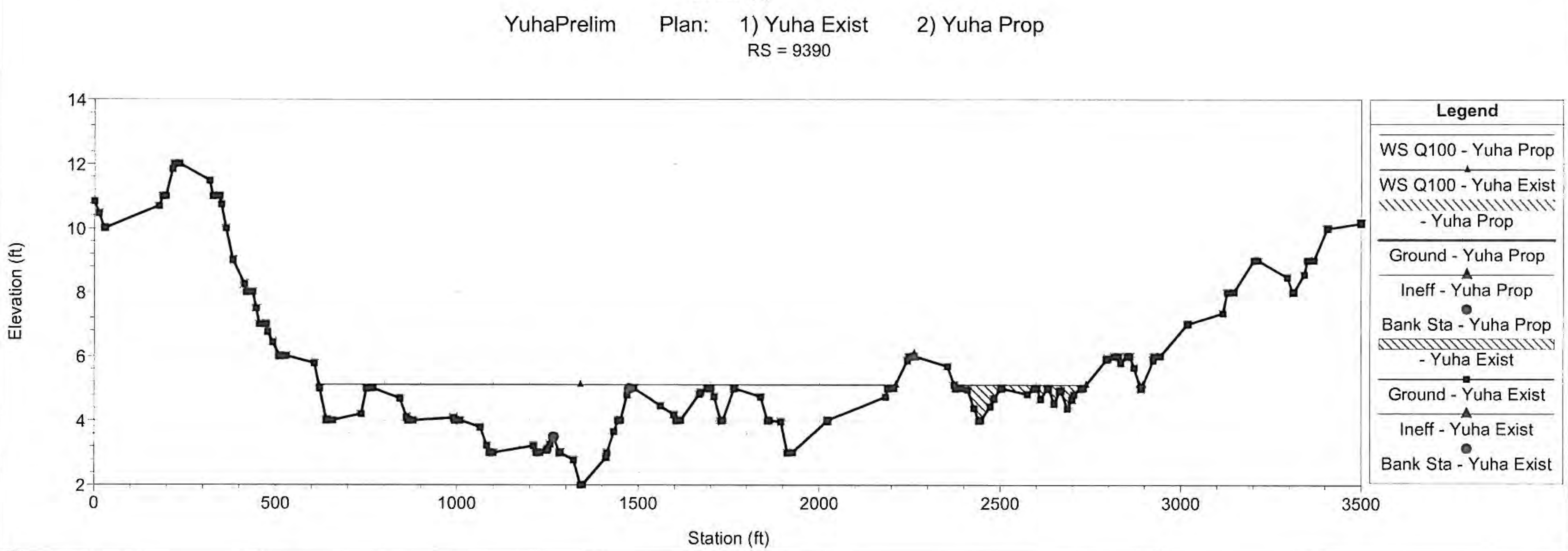


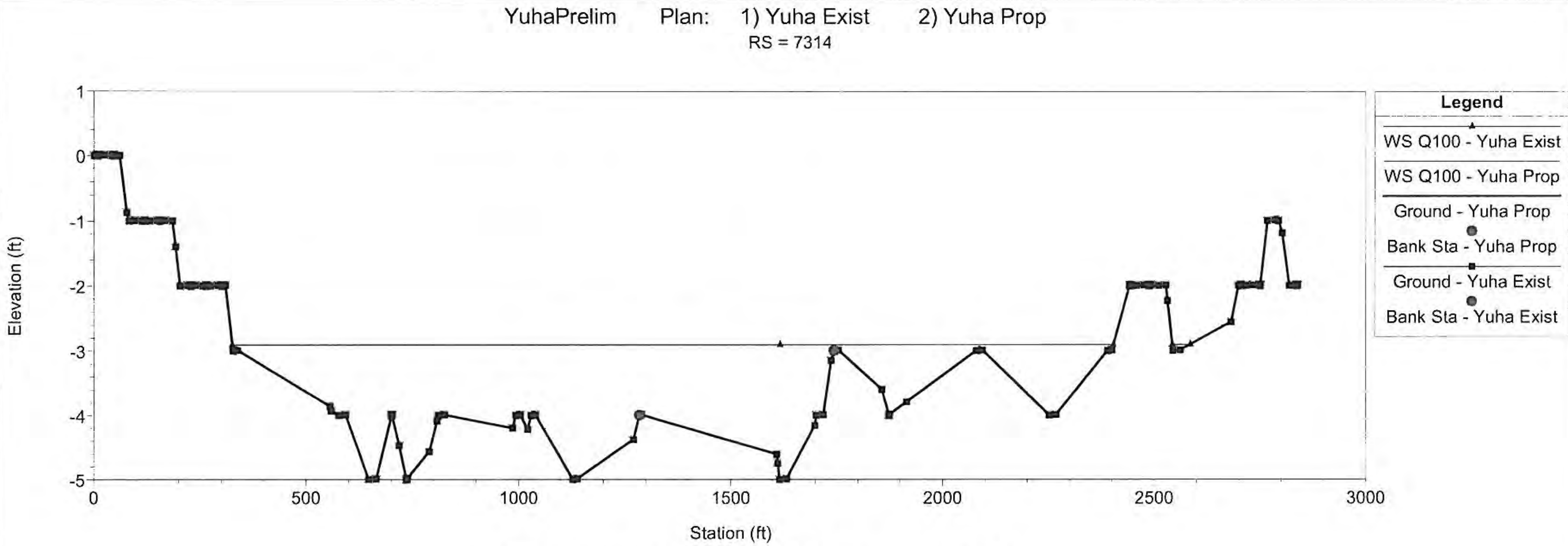
YuhaPrelim Plan: 1) Yuha Exist 9/29/2010 2) Yuha Prop 9/16/2010
YuhaCL 1
Legend
WS Q100 - Yuha Exist
WS Q100 - Yuha Prop
Ground
Ground
Elevation (ft)
40
30
20
10
0
-10
-20
-30
-40
2470
3203
3924
4670
6151
7314
9390
12563
15114
16221
0
2000
4000
6000
8000
10000
12000
14000
16000
18000
Main Channel Distance (ft)

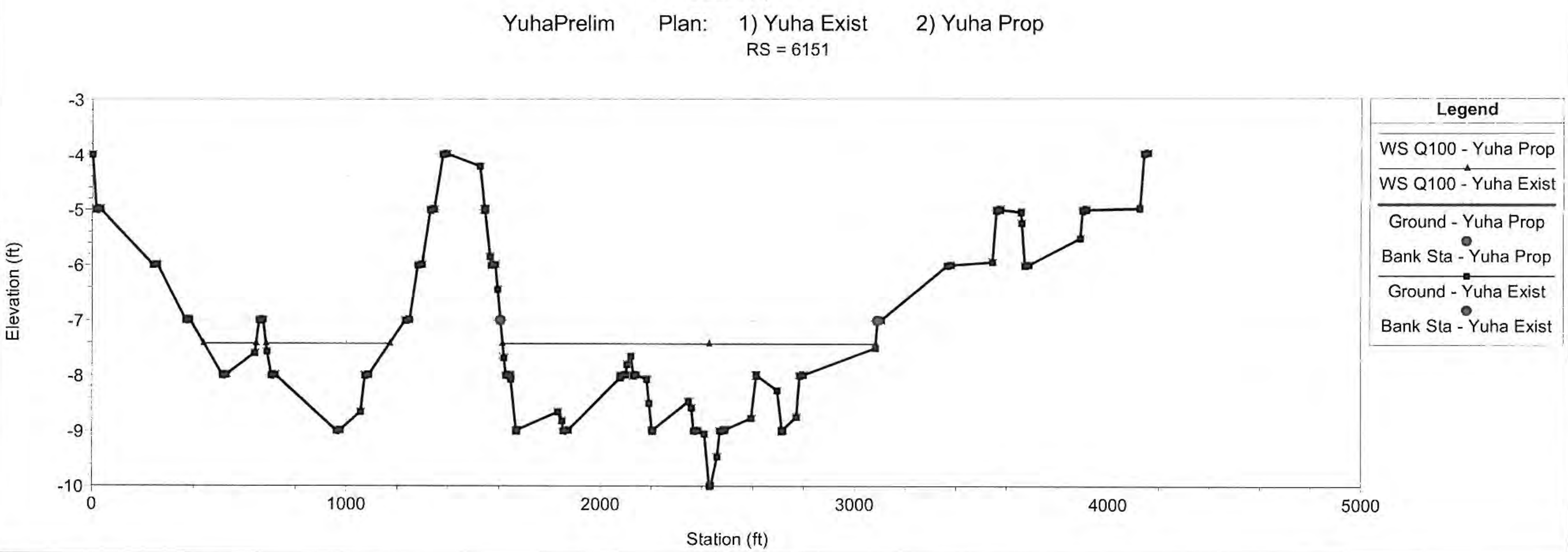

YuhaPrelim Plan: 1) Yuha Exist 2) Yuha Prop
RS = 16221
Legend
WS Q100 - Yuha Exist
WS Q100 - Yuha Prop
Ground - Yuha Prop
Bank Sta - Yuha Prop
Ground - Yuha Exist
Bank Sta - Yuha Exist
Elevation (ft)
Station (ft)
45
40
35
30
25
0
200
400
600
800
1000
1200

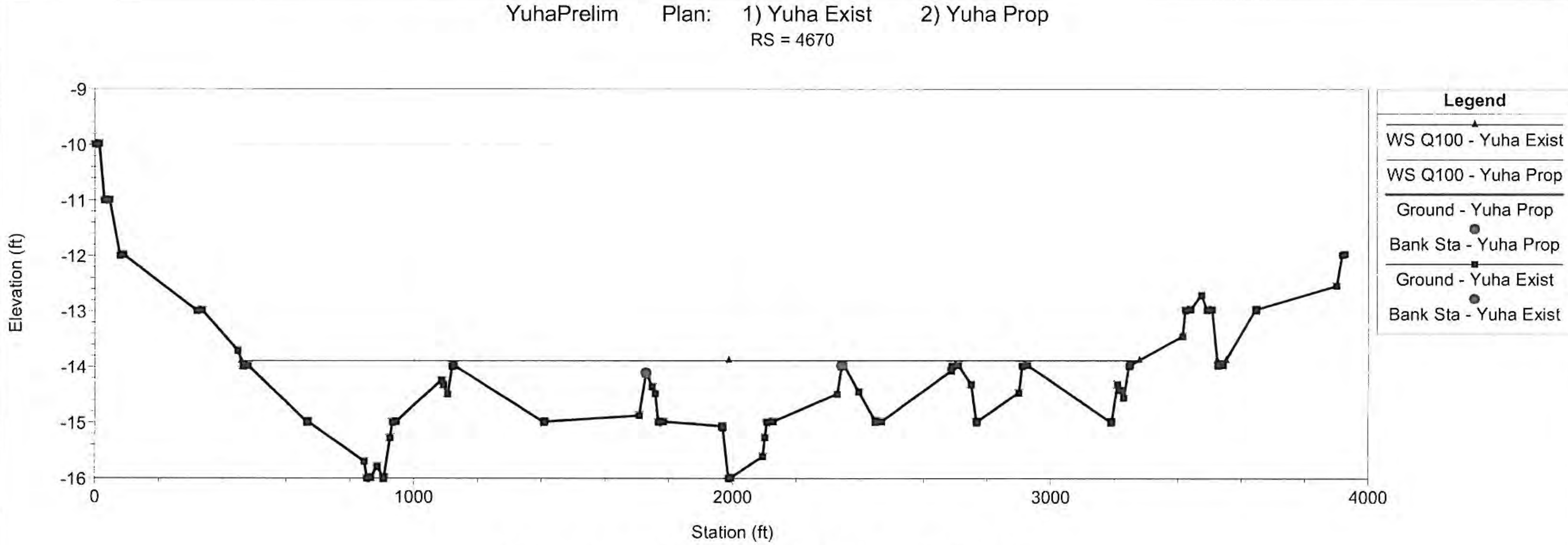

YuhaPrelim Plan: 1) Yuha Exist 2) Yuha Prop
RS = 15114
Legend
WS Q100 - Yuha Prop
WS Q100 - Yuha Exist
Ground - Yuha Prop
Bank Sta - Yuha Prop
Ground - Yuha Exist
Bank Sta - Yuha Exist
Elevation (ft)
Station (ft)
42
40
38
36
34
32
30
28
26
24
0
200
400
600
800
1000
1200
1400
1600
1800

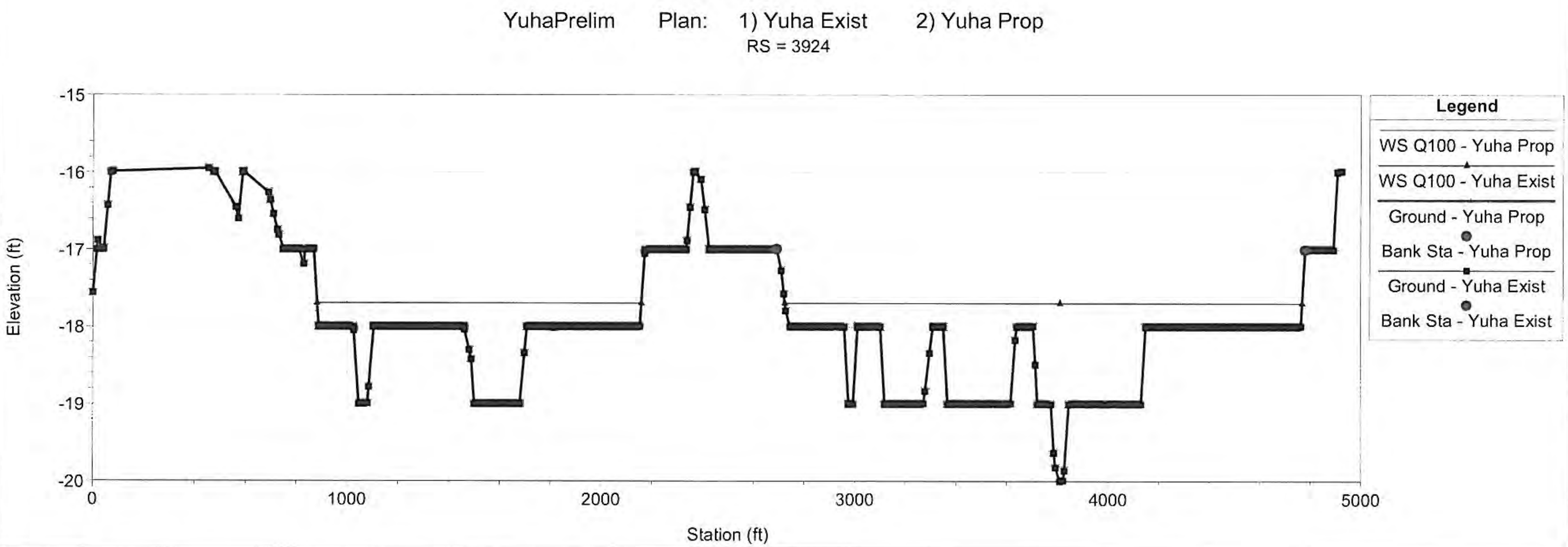

YuhaPrelim Plan: 1) Yuha Exist 2) Yuha Prop
RS = 12563
Elevation (ft)
45
40
35
30
25
20
15
10
0
500
1000
1500
2000
2500
Station (ft)
Legend
WS Q100 - Yuha Exist
WS Q100 - Yuha Prop
Ground - Yuha Prop
Bank Sta - Yuha Prop
Ground - Yuha Exist
Bank Sta - Yuha Exist

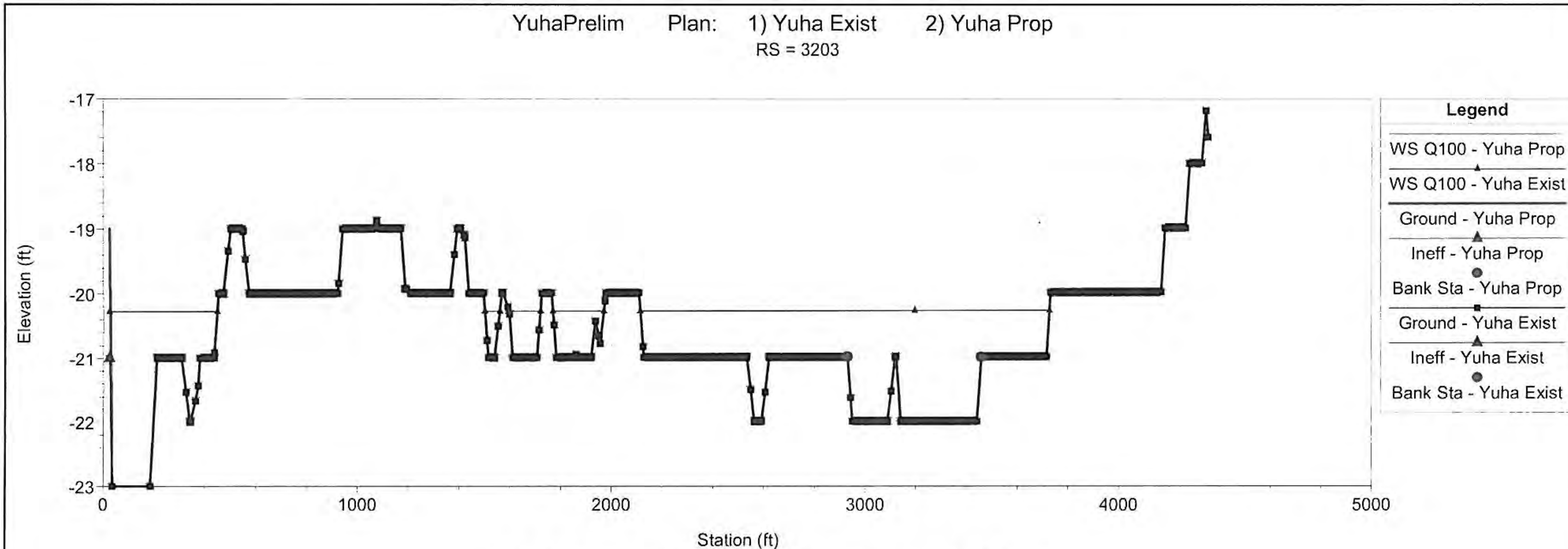

YuhaPrelim Plan: 1) Yuha Exist 2) Yuha Prop
RS = 9390
Elevation (ft)
14
12
10
8
6
4
2
0
500
1000
1500
2000
2500
3000
3500
Station (ft)
Legend
WS Q100 - Yuha Prop
WS Q100 - Yuha Exist
- Yuha Prop
Ground - Yuha Prop
Ineff - Yuha Prop
Bank Sta - Yuha Prop
- Yuha Exist
Ground - Yuha Exist
Ineff - Yuha Exist
Bank Sta - Yuha Exist

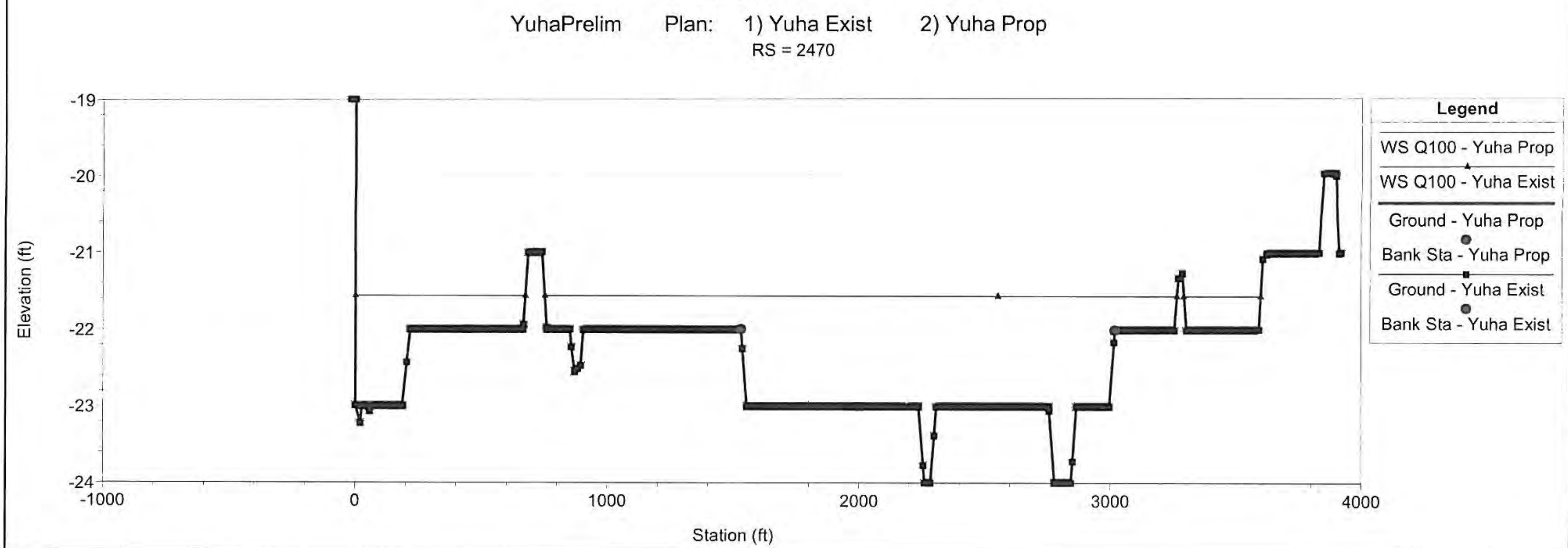

YuhaPrelim Plan: 1) Yuha Exist 2) Yuha Prop
RS = 7314
Legend
WS Q100 - Yuha Exist
WS Q100 - Yuha Prop
Ground - Yuha Prop
Bank Sta - Yuha Prop
Ground - Yuha Exist
Bank Sta - Yuha Exist
Elevation (ft)
Station (ft)
1
0
-1
-2
-3
-4
-5
0
500
1000
1500
2000
2500
3000

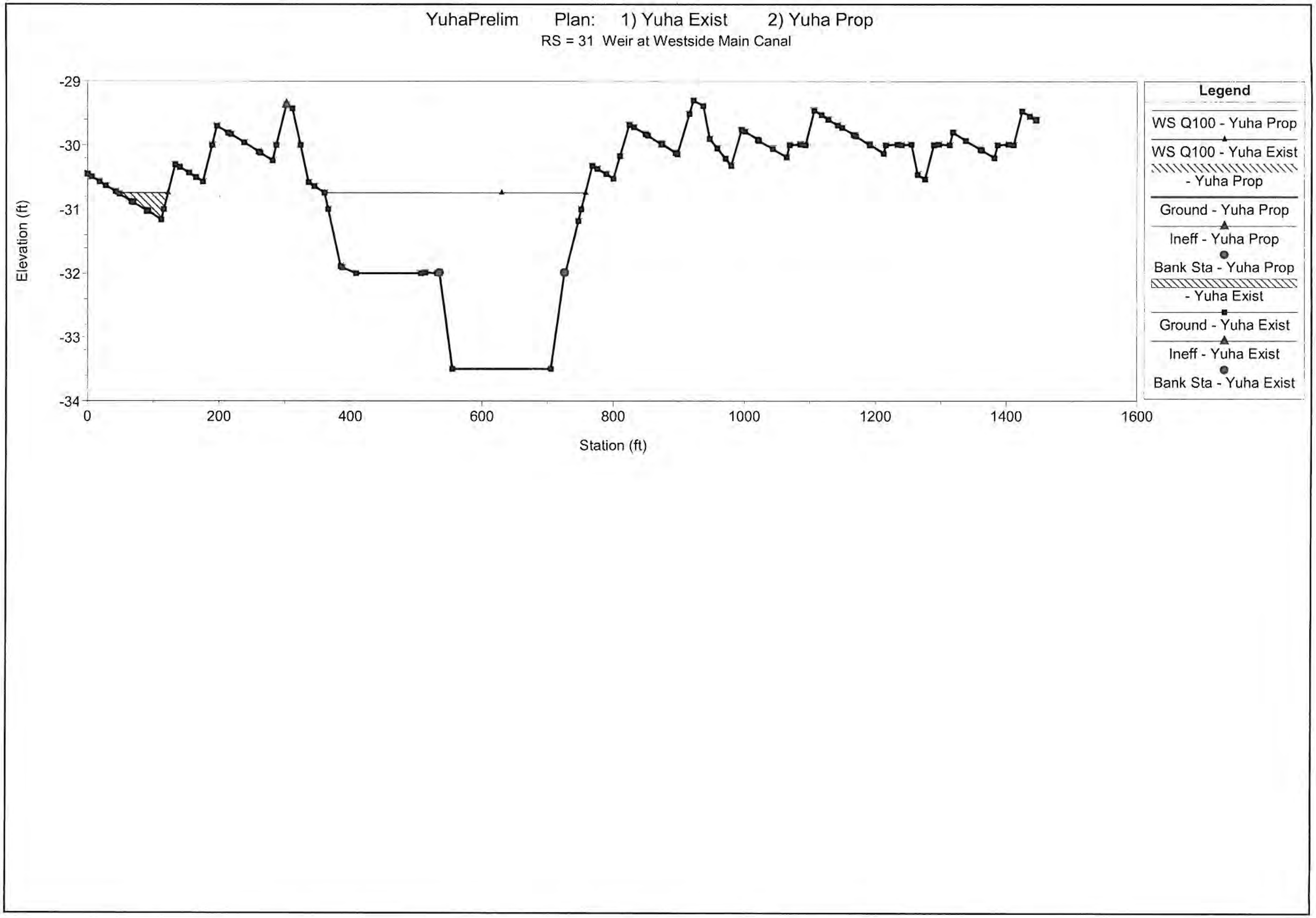

YuhaPrelim Plan: 1) Yuha Exist 2) Yuha Prop
RS = 6151
Legend
WS Q100 - Yuha Prop
WS Q100 - Yuha Exist
Ground - Yuha Prop
Bank Sta - Yuha Prop
Ground - Yuha Exist
Bank Sta - Yuha Exist
Elevation (ft)
Station (ft)
-3
-4
-5
-6
-7
-8
-9
-10
0
1000
2000
3000
4000
5000


YuhaPrelim Plan: 1) Yuha Exist 2) Yuha Prop
RS = 4670
Elevation (ft)
Station (ft)
-9
-10
-11
-12
-13
-14
-15
-16
0
1000
2000
3000
4000
Legend
WS Q100 - Yuha Exist
WS Q100 - Yuha Prop
Ground - Yuha Prop
Bank Sta - Yuha Prop
Ground - Yuha Exist
Bank Sta - Yuha Exist


YuhaPrelim Plan: 1) Yuha Exist 2) Yuha Prop
RS = 3924
Elevation (ft)
Station (ft)
-15
-16
-17
-18
-19
-20
0
1000
2000
3000
4000
5000
Legend
WS Q100 - Yuha Prop
WS Q100 - Yuha Exist
Ground - Yuha Prop
Bank Sta - Yuha Prop
Ground - Yuha Exist
Bank Sta - Yuha Exist


YuhaPrelim Plan: 1) Yuha Exist 2) Yuha Prop
RS = 3203
Elevation (ft)
Station (ft)
-17
-18
-19
-20
-21
-22
-23
0
1000
2000
3000
4000
5000
Legend
WS Q100 - Yuha Prop
WS Q100 - Yuha Exist
Ground - Yuha Prop
Ineff - Yuha Prop
Bank Sta - Yuha Prop
Ground - Yuha Exist
Ineff - Yuha Exist
Bank Sta - Yuha Exist


YuhaPrelim Plan: 1) Yuha Exist 2) Yuha Prop
RS = 2470
Elevation (ft)
Station (ft)
-19
-20
-21
-22
-23
-24
-1000
0
1000
2000
3000
4000
Legend
WS Q100 - Yuha Prop
WS Q100 - Yuha Exist
Ground - Yuha Prop
Bank Sta - Yuha Prop
Ground - Yuha Exist
Bank Sta - Yuha Exist


YuhaPrelim Plan: 1) Yuha Exist 2) Yuha Prop
RS = 31 Weir at Westside Main Canal
Elevation (ft)
-29
-30
-31
-32
-33
-34
0
200
400
600
800
1000
1200
1400
1600
Station (ft)
Legend
WS Q100 - Yuha Prop
WS Q100 - Yuha Exist
- Yuha Prop
Ground - Yuha Prop
Ineff - Yuha Prop
Bank Sta - Yuha Prop
- Yuha Exist
Ground - Yuha Exist
Ineff - Yuha Exist
Bank Sta - Yuha Exist

TORY R. WALKER ENGINEERING, INC.

Project	Imperial West Solar Farm	**Date**	29-Sep-10	**By**	TJS
Client	LightSource Renewables	**Checked**		**By**	
Subject	Ag Berm Overtopping Weir	**Approved**		**By**	

Exist Trapezoidal Weir
Points from Site Topo

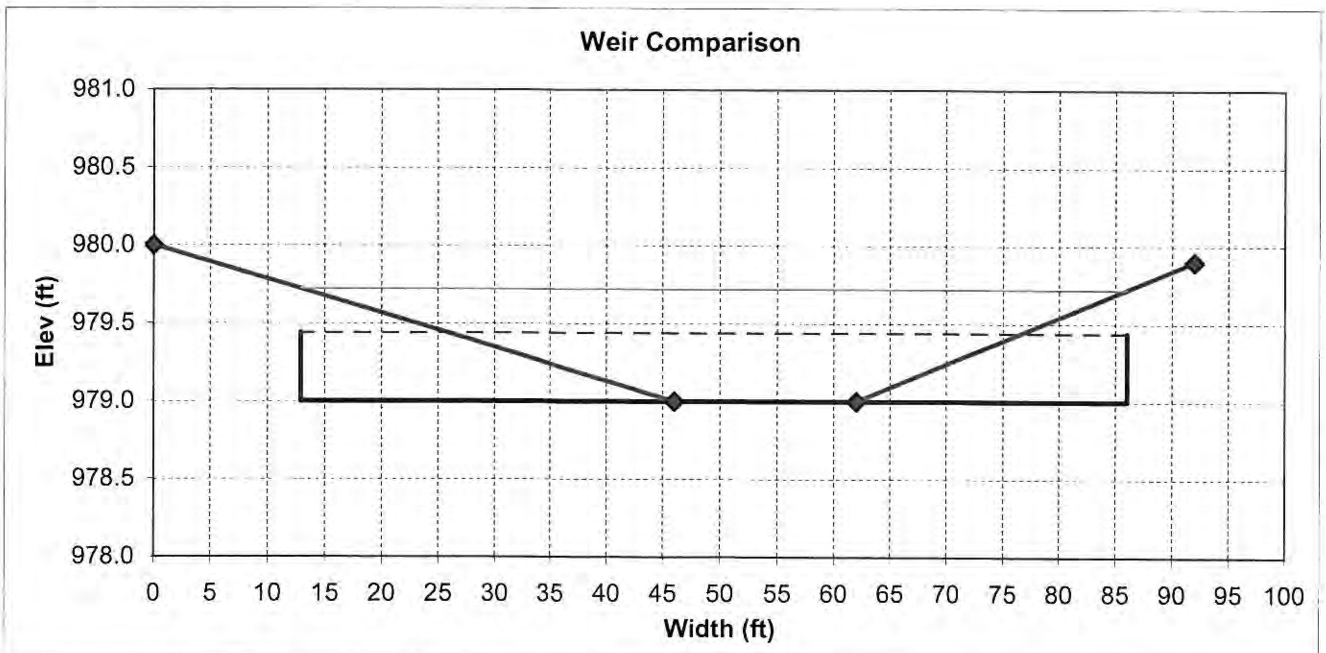
X (ft)	Y (ft)	
0	980	ft
46	979	ft
62	979	ft
92	979.9	ft

Water Surface Intersection Points

Water Elev =	979.72	ft
12.88	979.72	ft
86	979.72	ft
Flow Area =	32.1	ft^2
Left Slope	33.1	:1
Right Slope	24.0	:1
Perimeter	73.1	ft
Hydraulic Radius	0.44	ft
Top Width	73.12	ft
Hyd-Depth	0.44	ft

Rect. Channel with equal area and hydraulic depth

Parameter	Value	Units
Hyd-Depth	0.44	ft
Width	73.12	ft
Perimeter	74.6	ft
Hyd Rad	0.430	ft
Flow Area	32.1	ft^2



Weir Report

Hydraflow Express Extension for AutoCAD® Civil 3D® 2008 by Autodesk, Inc. Wednesday, Sep 29 2010

Approximate Weir for Yuha Wash Overtopping

Rectangular Weir

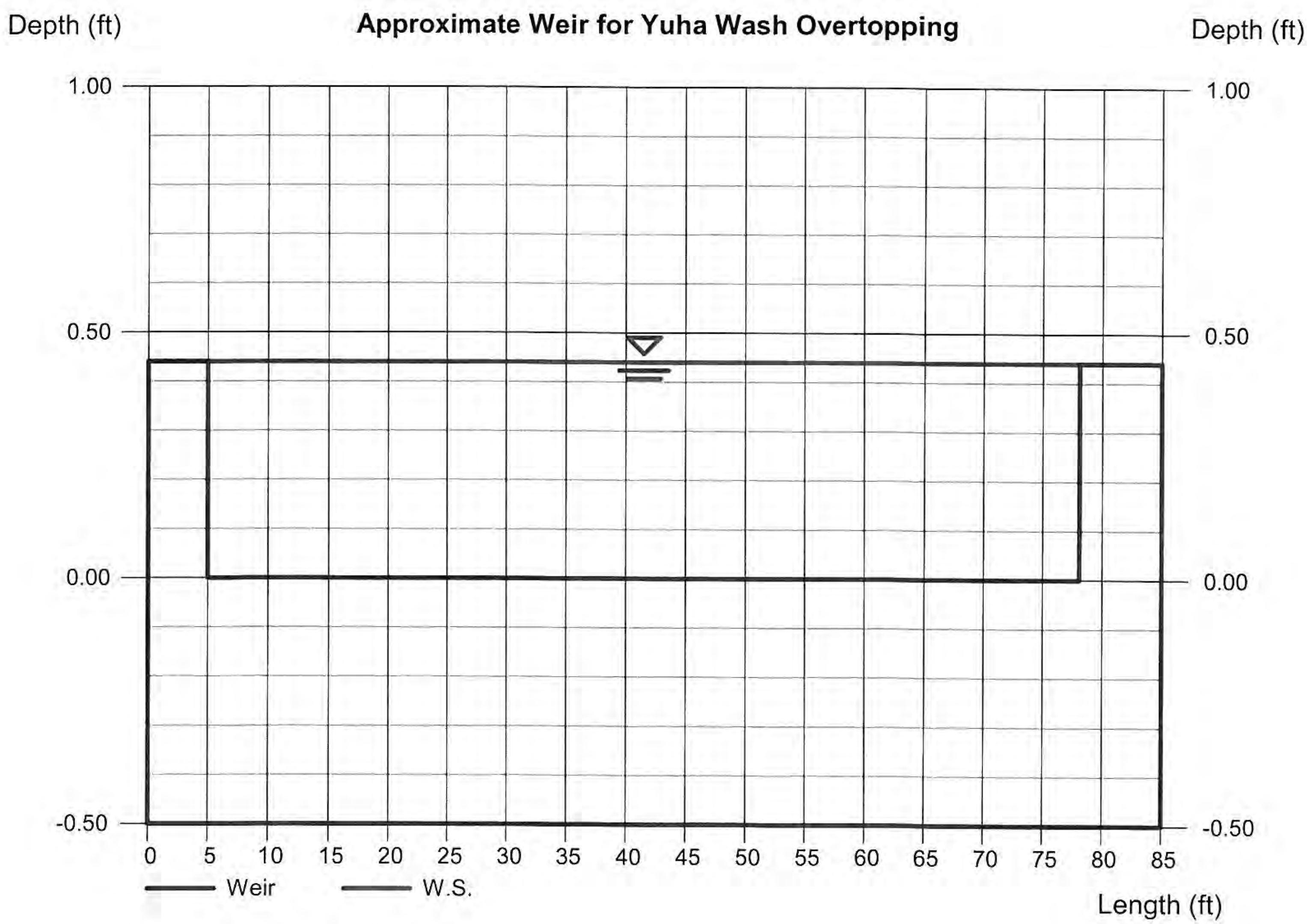
Crest = Sharp
Bottom Length (ft) = 73.12
Total Depth (ft) = 0.44

Calculations

Weir Coeff. Cw = 3.33
Compute by: Known Depth
Known Depth (ft) = 0.44

Highlighted

Depth (ft) = 0.44
Q (cfs) = 71.07
Area (sqft) = 32.17
Velocity (ft/s) = 2.21
Top Width (ft) = 73.12



Channel Report

IV West Perimeter Channel - Offsite Flows

Trapezoidal

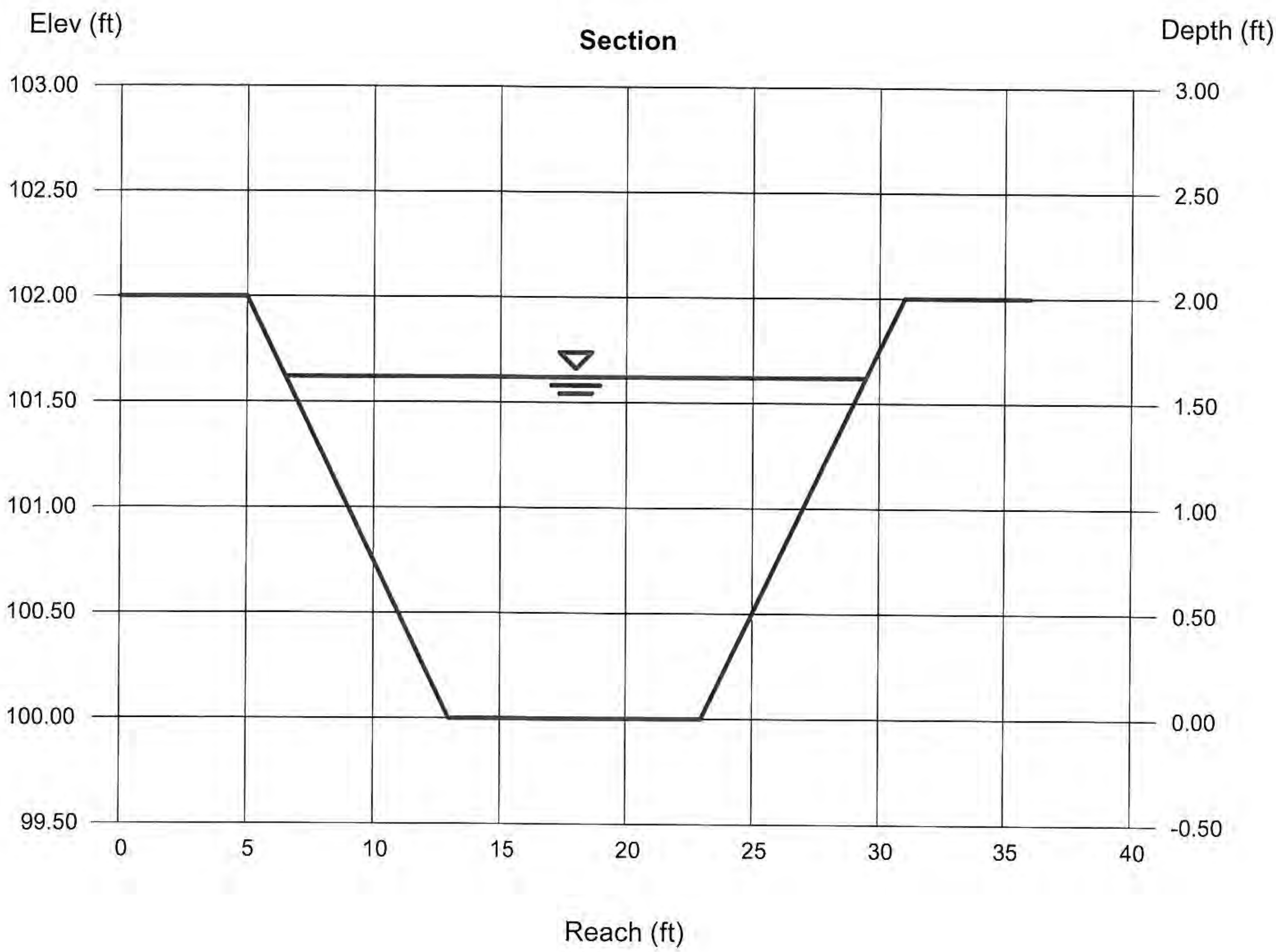
Bottom Width (ft)	= 10.00
Side Slopes (z:1)	= 4.00, 4.00
Total Depth (ft)	= 2.00
Invert Elev (ft)	= 100.00
Slope (%)	= 0.50
N-Value	= 0.030

Calculations

Compute by:	Known Q
Known Q (cfs)	= 102.00

Highlighted

Depth (ft)	= 1.62
Q (cfs)	= 102.00
Area (sqft)	= 26.70
Velocity (ft/s)	= 3.82
Wetted Perim (ft)	= 23.36
Crit Depth, Yc (ft)	= 1.25
Top Width (ft)	= 22.96
EGL (ft)	= 1.85



III A. GENERAL REQUIREMENTS

1. All drainage design and requirements are recommended to be in accordance with the Imperial Irrigation District (IID) "Draft" Hydrology Manual or other recognized source with approval by the County Engineer and based on full development of upstream tributary basins. Another source is the Caltrans I-D-F curves for the Imperial Valley.

2. Public drainage facilities shall be designed to carry the ten-year six-hour storm underground, the 25-year storm between the top of curbs provided two 12' minimum width dry lanes exist and the 100-year frequency storm between the right of way lines with at least one 12' minimum dry lane open to traffic. All culverts shall be designed to accommodate the flow from a 100-year frequency storm.

3. Permanent drainage facilities and right of way, including access, shall be provided from development to point of satisfactory disposal.

4. Retention volume on retention or detention basins should have a total volume capacity for a three (3) inch minimum precipitation covering the entire site with no C reduction factors. Volume can be considered by a combination of basin size and volume considered within parking and/or landscaping areas.

   There is no guarantee that a detention basin outletting to an IID facility or other storm drain system will not back up should the facility be full and unable to accept the project runoff. This provides the safety factor from flooding by ensuring each development can handle a minimum 3-inch precipitation over the project site.

5. Retention basins should empty within 72 hours and no sooner than 24 hours in order to provide mosquito abatement. Draining, evaporation or infiltration, or any combination thereof can accomplish this. If this is not possible then the owner should be made aware of a potential need to address mosquito abatement to the satisfaction of the Environmental Health Services (EHS) Department. Additionally, if it is not possible to empty the basin within 72 hours, the basin should be designed for 5 inches, not 3 inches as mentioned in Item #4 above. This would allow for a saturation condition of the soil due to a 5" storm track. EHS must review and approve all retention basin designs prior to County Public Works approval. Nuisance water must not be allowed to accumulate in retention basins. EHS may require a nuisance water abatement plan if this occurs.

6. The minimum finish floor elevation shall be 12" above top of fronting street curb unless property is below street level and/or 6" above the 100-year frequency storm event or storm track. A local engineering practice is to use a 5" precipitation event as a storm track in the absence of detailed flood information.

   The 100-year frequency storm would be required for detention calculations.

7. Finish pad elevations should be indicated on the plans, which are at or above the 100-year frequency flood elevation identified by the engineer for the parcel. Finish floor elevations should be set at least 6 inches above the 100-year flood elevation.

8. The developer shall submit a drainage study and specifications for improvements of all drainage easements, culverts, drainage structures, and drainage channels to the Department of Public Works for approval. Unless specifically waived herein, required plans and specifications shall provide a drainage system capable of handling and disposing of all surface waters originating within the subdivision and all surface waters that may flow onto the subdivision from adjacent lands. Said drainage system shall include any easements and

structures required by the Department of Public Works or the affected Utility Agency to properly handle the drainage on-site and off-site. The report should detail any vegetation and trash/debris removal as well as address any standing water.

9. Hydrology and hydraulic calculations for determining the storm system design shall be provided to the satisfaction of the Director, Department of Public Works. When appropriate, water surface profiles and adequate field survey cross-section data may also be required.

10. An airtight or screened oil/water separator or equivalent is required prior to permitting onsite lot drainage from entering any street right of way or public storm drain system for all industrial/commercial or multi residential uses. A maximum 6" drain lateral can be used to tie into existing adjacent street curb inlets with some exceptions. Approval from the Director of Public Works is required.

11. The County is implementing a storm water quality program as required by the State Water Resources Control Board, which may modify or add to the requirements and guidelines presented elsewhere in this document.

    This can include ongoing monitoring of water quality of storm drain runoff, implementation of Best Management Practices (BMPs) to reduce storm water quality impacts downstream or along adjacent properties. Attention is directed to the need to reduce any potential of vectors, mosquitos or standing water.

12. A Drainage Report is required for all developments in the County. It shall include a project description, project setting including discussions of existing and proposed conditions, any drainage issues related to the site, summary of the findings or conclusions, offsite hydrology, onsite hydrology, hydraulic calculations and a hydrology map.

13. Specific to small Parcel Map developments:

A. For individual lots, sufficient storage volume must be available on a portion of the proposed parcel to accommodate a three (3) inch precipitation minimum covering the entire area. The resulting storage volume should be accommodated in a single retention basin. However, this office will consider a combination of retention basins and on-lot storage.

B. Remaining portions of the parcel or agricultural parcels that are not being developed should also provide for onsite retention or assurances that the resulting storm runoff does not impact adjacent parcels.

C. Finish pad elevations should be indicated on the plans, which are at or above the 100-year frequency flood elevation identified by the engineer for the parcel. Finish floor elevations should be set at least 6 inches above the 100-year flood elevation.

D. Onsite driveways should be designed and constructed such that they are at least 3 inches above the 100-year frequency flood elevation identified for the parcel.

E. Septic system manhole access, water systems and other associated electrical appurtenances should also have finish elevations indicated on the plans that are at least 6" above the 100 year frequency flood elevation identified for the parcel.

F. Retention basins should empty within 72 hours in order to provide mosquito abatement. This can be accomplished by either draining, evaporation or infiltration, or any combination thereof. If this is not possible, then the owner should be made aware of a potential need to address mosquito abatement to the satisfaction of the Environmental Health Services Department. Additionally, if it is not possible to empty the basin within 72 hours, the basin should be designed for 5 inches, not 3 inches as mentioned in Item #A above. This would allow for a saturation condition of the soil due to a 5' storm track.

Detention Basin Design and Maintenance Guideline Note:

The Imperial County Division of Environmental Health Services Vector Control Program is responsible for vector and mosquito control through a variety of means. Poorly designed and ill-maintained detention basins are capable of breeding large numbers of vectors or mosquitoes and offer excellent harborage for adult mosquitoes from other sources. Because detention basins are often situated in residential neighborhoods and other populated areas, they present a significant health risk and pose a challenging pesticide application situation. The California Health and Safety Codes provide for public nuisance abatement and prevention. EHS has guidelines available and they will review all storm retention basin systems prior to Public Works approval.

III B. HYDROLOGY

1. Off-site, use a blue line or Xerox prints of the subdivision or tract map. Show existing culverts, cross-gutters and drainage courses based on field review. Indicate the direction of flow; clearly delineate each drainage basin showing the area and discharge and the point of concentration.

2. On-site, use the grading plan. If grading is not proposed, then use a 100-scale plan or greater enlargement. Show all proposed and existing drainage facilities and drainage courses. Indicate the direction of flow. Clearly delineate each drainage basin showing the area and discharge and the point of concentration.

3. Use the rational formula Q (flow (cfs)=C I A (area/acreage) for watersheds less than 0.5 square mile unless an alternate method is approved by the County Engineer. For watersheds in excess of 0.5 square mile, the method of analysis shall be approved by the County Engineer prior to submitting calculations.

III C. HYDRAULICS

All facilities that convey drainage must have calculations to support its use. These facilities include streets, culverts, storm drains, channels, catch basins, inlets, etc.

1. Street – provide:

   a) Depth of gutter flow calculation.

   b) Inlet calculations.

   c) Show gutter flow Q, inlet Q, and bypass Q on a plan of the street.

2. Storm drain pipes and open channels – provide:

   a) Hydraulic loss calculations for: entrance, friction, access holes, junctions, bends, angles, reduction and enlargement.

   b) Analyze existing conditions upstream and downstream from proposed system, to be determined by the County Engineer on a case-by-case basis.

c) Calculate critical depth and normal depth for open channel flow conditions.

d) Design for non-silting velocity of 4 feet per second in a two-year frequency storm unless otherwise approved by the County Engineer.

e) All pipes and outlets shall show HGL (hydraulic grade line); velocity and Q value(s) for which the storm drain is designed to discharge.

f) Confluence angles shall be maintained between 45° and 90° from the main upstream flow. Flows shall not oppose main line flows.

III D. INLETS

1. Curb inlets at a sump condition should be designed for two CFS (cubic feet per second) per lineal foot of opening when headwater may rise to the top of curb.

2. Curb inlets on a continuous grade should be designed based on the following equation:

$$Q=0.7\ L\ (a+y) * 3/2$$

Where:
y = depth of flow in approach gutter in feet
a = depth of depression of flow line at inlet in feet
L = length of clear opening in feet (maximum 30 feet)
Q = flow in CFS

3. Grated inlets should be avoided when possible. When necessary, the design should be based on the Bureau of Public Roads Nomographs (now known as the Federal Highway Administration). All grated inlets shall be bicycle proof.

4. All catch basins shall have an access main, a minimum of 24 inches in diameter in the top unless access through the grate section is satisfactory to the County Engineer.

5. Catch basins/curb inlets shall be located so as to eliminate, whenever possible, cross gutters. Catch basins/curb inlets shall not be located within 5 feet of any curb return or driveway.

6. Minimum connector pipes for pubic drainage systems shall be 18 inches.

7. Flow through inlets may be used when pipe size is 24 inches or less and open channel flow characteristics exist.

III E. STORM DRAINS

1. Minimum pipe slopes shall be 0.001 (0.1%) unless otherwise approved by the County Engineer.

2. Minimum storm drain, within public right of way, size shall be 18-inch diameter.

3. Provide cleanouts at 300 feet maximum spacing and at angle points and at breaks in grade greater than 10°. For pipes 48 inches in diameter and larger, a maximum spacing of 500 feet may be used.

4. The material for storm drains in right-of-way shall be rubber gasket reinforced concrete pipe, poly vinyl chloride pipe or HDPE storm drainpipe designed in conformance with Imperial County design criteria.

5. Horizontal and vertical curve design shall conform to manufacturer recommended specifications.

6. The pipe invert elevations, slope, and pipe profile line shall be delineated on the Mylar of the improvement plans.

   The strength classification of any pipe shall be shown on the plans. Minimum strength for RCP shall be Class III in all County streets or future right of way. Minimum strength for depths less than 2 feet, if allowed, shall be Class V or greater.

   PVC pipe, if used, must meet or exceed standards for schedule 40-wall thickness and SDR values. Thirty (30) inches minimum cover depth is required. (See Section II J.)

7. For all drainage designs that are not covered in these standards, other established standard practice criteria can be used as approved by the Director of Public Works.

8. For storm drain discharging into unprotected or natural channel, proper energy dissipation measures shall be installed to prevent damage or erosion.

9. The use of detention basins to even out storm peaks and reduce piping is permitted with substantiating engineering calculations and proper maintenance agreements.

10. Desiltation measures for silt caused by development shall be provided and cleaned regularly and after major rainfall events as required by the County Engineer or his designated representative. Adequate storage capacity shall be maintained at all times.

11. Protection of downstream or adjacent properties from incremental flows (caused by change from an underdeveloped to a developed site) shall be provided. Such flows shall not be concentrated and directed across unprotected adjacent properties unless an easement and storm drains or channels to contain flows are provided.

12. Storm drainpipe under pressure flow for the design storm, i.e., HGL above the soffit of the pipe, shall meet the requirements of ASTM C76, C361, and C443 for water-light joints in the section of pipe calculated to be under pressure.

III F. **DRAINAGE SPECIFICATIONS AND DESIGN STANDARDS**

"To be Added"

Imperial Solar Energy Center West

Appendix H-2

Preliminary Water Quality Report

Prepared by Tory R. Walker Engineering, Inc.

October 4, 2010

PRELIMINARY WATER QUALITY REPORT

For

Imperial Valley West Solar Farm

Prepared For:
LightSource Renewables, LLC
9151 Rehco Road
San Diego, CA 92121
(949) 270-6348

Prepared By:
Tory R. Walker Engineering, Inc.
973 Vale Terrace, Suite 202
Vista, CA 92084
(760)414-9212

4 October 2010

REGISTERED PROFESSIONAL ENGINEER
TORY R WALKER
No. 45005
Exp. 3-31-2012
CIVIL
STATE OF CALIFORNIA

Tory R. Walker, R.C.E. 45005
President

TABLE OF CONTENTS

ATTACHMENTS

LIST OF TABLES AND FIGURES

1.0 INTRODUCTION

The purpose of this Water Quality Report is to address water quality impacts from the proposed Imperial Valley West Solar Farm project. Site design, source control, and treatment control Best Management Practices (BMPs) will be utilized to provide long term solutions to protect storm water quality. This report is subject to revisions as needed to accommodate changes to the project design, or as required by the County and/or Engineer.

1.1 Project Location

The project site is located in Imperial County east of the intersection of Dunaway Road and California Interstate 8. Figure 1.1 (below) illustrates the project location.

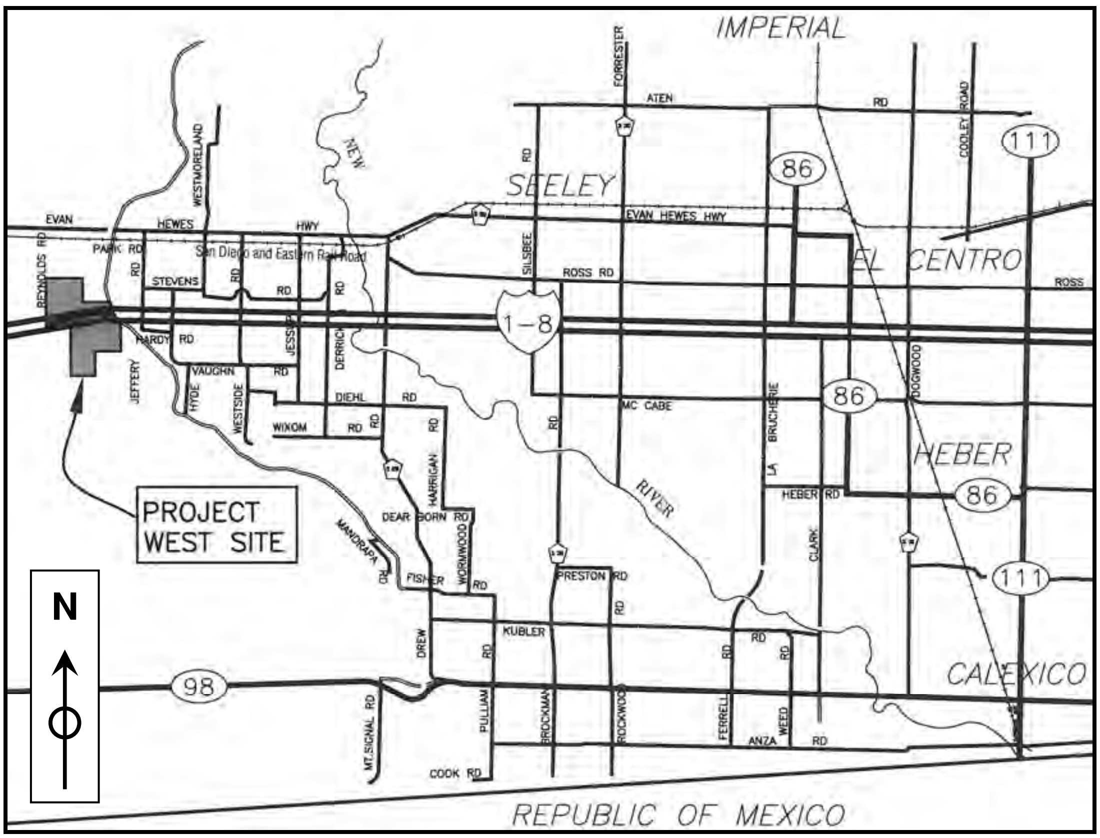


Figure 1.1 Vicinity Map (No Scale)

1.2 Project Description

This project will construct a photovoltaic Solar Energy Farm and will utilize the area bifurcated by California Interstate 8 as shown. Existing runoff, both north and south of I8, flows generally west to east and the majority of the existing drainage patterns will be unchanged. Details can be found in the drainage report titled "Preliminary CEQA Level Drainage Study for Imperial Valley West Solar Farm" dated 4 October 2010 prepared by Tory R. Walker Engineering, Inc.

1.3 Project Size

The project area is approximately 1,130 acres.

1.4 Impervious and Pervious Surface areas

The existing project area is currently abandoned agricultural fields, approximately 0% impervious, and will increase just ½ percent to 0.5% impervious with the proposed construction. The project includes approximately 132 concrete slab pads for the inverter units, a 5,000 ft^2 operations and maintenance building with associated parking lot of approximately 6,850 ft^2, a 5,000 ft^2 water treatment building, and solar panels supported on posts (making a negligible impervious footprint). The project will utilize a gravel surface for the service roads.

2.0 PROJECT SITE ASSESSMENT

This section includes information used to consider the potential water quality and hydrologic impacts from the proposed project. This information is important when considering the appropriate BMPs to reduce identified potential impacts as well as designing source control and treatment control measures to reduce those impacts.

2.1 Land Use and Zoning

Historic Land Use is cropland.

2.2 Existing Topography

The project site area is generally flat, sloping gently from west to east, with elevations ranging from 11 feet above sea level to 31 feet below sea level.

2.3 Existing and Proposed Drainage

The existing site, both north and south of I8, has a watercourse generally running from west to east. The majority of the existing drainage patterns will be untouched by the construction of the project. Runoff in the proposed condition will sheet flow across the site as in the existing condition and be collected by ditches and culverts and routed to the Imperial Irrigation District (IID) drain system. There is an existing onsite system comprised of perforated tile drains that may convey flows to the IID drain system. Detention will be provided on the site so that the proposed drainage replicates the existing condition. The project south of I8 will drain into the Dixie Drain #4 and the project north of I8 will drain into a different location of Dixie Drain #4. Details can be found in the drainage report titled “Preliminary CEQA Level Drainage Study for Imperial Valley West Solar Farm” dated 4 October 2010 prepared by Tory R. Walker Engineering, Inc.

2.4 Watershed, Receiving Waters, and Beneficial Uses

The proposed project is located within the Imperial Hydrologic Unit, Brawley Hydrologic Area, and an undefined Hydrologic Sub-area (Basin Number 723.10). The surface and groundwater receiving waters located in the area and downstream of this project include the Dixie Drain (#4), the Salt Creek Slough, the New River, and the Salton Sea.

From Table 2-3 of the Water Quality Control Plan for the Colorado River Basin Region the Beneficial Uses of the Dixie Drain (#4) and the Salt Creek Slough (both considered part of the IID drains), the New River, and the Salton Sea are as follows.

Table 1

Ground Waters	Hydrologic Unit Basin Number	MUN	AGR	IND	PROC	GWR	FRESH	POW	REC1	REC2	BIOL	WARM	COLD	WILD	RARE	SPWN	AQUA
Imperial Valley Drains	723.10						X		X	X		X		X	X		
New River	723.10			X			X		X	X		X		X	X		
Salton Sea	728.00			X					X	X		X		X	X		X

2.5 303(d) Listed Receiving Waters

The impaired waterbodies listed on the 303(d) list for this Hydrologic Area (728) are the Imperial Valley Drains, the New River, and the Salton Sea. This project does not flow to a drain included on the 303(d) listing of Imperial Valley Drains so no drain listings are provided in this section. The New River is listed for 1,2,4-Trimethylbenzene, Chlordane, Chloroform, Chlorpyrifos, Copper, DDT, Diazinon, Dieldrin, Mercury, meta-par xlyenes, Nutrients, Organic Enrichment/Low Dissolved Oxygen, o-Xylenes, PCBs, p-Cymene, p-Dichlorobenzene/ DCB, Pesticides, Selenium, Toluene, Toxaphene, Toxicity, and Trash. The Salton Sea is listed for Nutrients, Salinity, and Selenium.

The project is approximately: 200 yards to the Dixie Drain (#4), 2 miles to the Salt Creek Slough, 8 miles to the New River, and 40 miles to the Salton Sea.

2.6 Total Maximum Daily Loads (TMDLs)

Table 2

Receiving Water	Hydrologic Unit Basin Number	TMDL	Distance From Project (miles)
Imperial Valley Drain (Dixie Drain #4)	723.10	Sedimentation./Siltation	~200 yards
New River	723.10	Pathogens Sedimentation./Siltation Trash	~ 8

2.7 Soil Type(s) and Conditions

Soil types are classified as hydrologic soil groups A through C. Existing vegetation includes sparse stands of Tamarisk along several of the existing farm roads and native desert species downstream of the north breach. The majority of the remainder is sparsely covered with grasses and shrubs.

3.0 POLLUTANTS OF CONCERN

This section identifies pollutants of concern.

3.1 Project Categories and Features

The project includes concrete slab pads for the inverter units, an operations and maintenance building with associated parking lot and a water treatment building, and solar panels supported on posts (making a negligible impervious footprint). The project will utilize pervious gravel surfaces for the service roads. Project will include a septic system for sanitary sewage disposal.

3.2 Pollutants of Concern

Downstream waters are listed for the following pollutants of concern which are also potential pollutants from this project:

3.2 (a) – Sediments

Soils or other surface materials eroded and then transported or deposited by the action of wind, water, ice, or gravity. Sediments can increase turbidity, clog fish gills, reduce spawning habitat, smother bottom dwelling organisms, and suppress aquatic vegetative growth.

3. 2 (b) – Heavy Metals

Metals are raw material components in non-metal products such as fuels, adhesives, paints, and other coatings. Primary sources of metal pollution in storm water are typically commercially available metals and metal products. Metals of concern include cadmium, chromium, copper, lead, mercury, and zinc. Lead and chromium have been used as corrosion inhibitors in primer coatings and cooling tower systems. Metals occur naturally at low concentrations in soil, and are not toxic at these concentrations. However, at higher concentrations, certain metals can be toxic to aquatic life. Humans can be impacted from contaminated groundwater resources and bioaccumulation of metals in fish and shellfish. Environmental concerns, regarding the potential for release of metals to the environment, have already led to restricted metal usage in certain applications.

3. 2 (c) – Trash & Debris

Examples include paper, plastic, leaves, grass cuttings, and food waste, which may have a significant impact on the recreational value of a water body and aquatic habitat. Excess organic matter can create a high biochemical oxygen demand in a stream and thereby lower its water quality. In areas where stagnant water is present, the presence of excess organic matter can promote septic conditions resulting in the growth of undesirable organisms and the release of odorous and hazardous compounds such as hydrogen sulfide.

3. 2 (d)– Oil & Grease

Characterized as high high-molecular weight organic compounds. Primary sources of oil and grease are petroleum hydrocarbon products, motor products from leaking vehicles, oils, waxes, and high-molecular weight fatty acids. Elevated oil and grease content can decrease the aesthetic value of the water body, as well as the water quality.

3. 2 (e)– Pesticides

Chemical compounds commonly used to control nuisance growth or prevalence of organisms and includes herbicides. Excessive application of a pesticide may result in runoff containing toxic levels of its active component.

3.3 Project Water Quality Analyses

Tributary flows from over 1,130 acres will be attenuated onsite, replicating the pre-project condition. Runoff will be detained in under-panel and designated detention basins.

4.0 BEST MANAGEMENT PRACTICES (BMPs)

Site Design, Source Control, and Treatment Control BMPs will be utilized and are described in the following sections.

4.1 Site Design Strategies and BMPs

Conceptually, there are three strategies for managing runoff from buildings and paving:

1. Optimize the site layout;
2. Use pervious surfaces;
3. Disperse runoff.

This section describes how Site Design strategies have been implemented in the proposed project design.

4.1.1 Optimize the Site Layout

The very nature of the proposed land use optimizes the site layout, thus limiting the development envelope. The majority of the existing drainage will be untouched by the construction.

4.1.2 Use Pervious Surfaces

Service roads will use a pervious gravel surface.

4.1.3 Disperse Runoff

The pervious surfaces will drain to detention areas within the project site.

4.2 Source Control BMPs

It is possible that the following pollutants could be generated at this site: Sediment, Heavy Metals, Trash & Debris, Oil & Grease, and Pesticides.

Based on these anticipated pollutants and operational activities at the site the Source Control BMPs to be installed and/or implemented onsite are summarized below:

- Trash storage
- Integrated Pest Management
- Efficient irrigation and landscape design
- Property owner educational materials regarding source control management

4.3 Treatment Control BMPs

Structural Treatment (treatment control) BMPs are engineered, designed, and constructed to remove pollutants from urban runoff by simple gravity settling of particulate pollutants, filtration, biological uptake, media absorption, or any other physical, biological, or chemical process.

This section discusses the basis for selection and details of the proposed structural treatment BMPs being utilized on this project, as well as methodology used to determine the peak rate of runoff to be treated. Also discussed are targeted pollutants and pollutant removal efficiency information.

The Preliminary CEQA Level Drainage Study for Imperial Valley West Solar Farm" dated 4 October 2010 prepared by Tory R. Walker Engineering, Inc. is the basis for design of the structural treatment BMPs. The SCS Method was used to determine the flows for the existing and proposed conditions. Rainfall data was determined from the NOAA 14 Atlas.

The structural treatment BMPs and drainage facilities can be seen on Figure 2, Site Map (BMP Location Map) located in Attachment 2. Extended Detention Basins were included for both the north and south property areas and the Operations and Maintenance Facility. Under-panel detention is utilized both north and south of I8.

Typical pollutant removal efficiencies of treatment control BMPs are shown in Table 3 below. The column entitled, "Detention Basins" is shaded to reflect the treatment BMP proposed for the site.

Table 3

Pollutant of Concern	***Treatment Control BMP Categories***						
	Biofilters	Detention Basins	Infiltration Basins(2)	Wet Ponds or Wetlands	Drainage Inserts	Filtration(4)	Hydrodynamic Separator Systems(3)
Sediment	M	H	H	H	L	H	M-H
Nutrients	L	M	M	M	L	M-H	L-M
Heavy Metals	M	M	M	H	L	H	L-M
Organic Compounds	U	U	U	U	L	M-H	L-M
Trash & Debris	L	H	U	U	M	H	M-H
Oxygen Demanding Substances	L	M	M	M	L	M-H	L
Bacteria	U	U	H	U	L	M	L
Oil & Grease	M	M	U	U	L	H	L-H
Pesticides	U	U	U	U	L	L-H	L

(1) Copermittees are encouraged to periodically assess the performance characteristics of many of these BMPs to update this table.
(2) Including trenches and porous pavement.
(3) Also known as hydrodynamic devices.
(4) For Proprietary Structural BMPs, not all serve the same function or have the same efficiency.

L (Low): Low removal efficiency (roughly 0-25%)
M (Medium): Medium removal efficiency (roughly 25-75%)
H (High): High removal efficiency (roughly 75-100%)
U: Unknown removal efficiency, applicant must provide evidence supporting use

Sources: *Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters* (1993), *National Stormwater Best Management Practices Database* (2001), and *Guide for BMP Selection in Urban Developed Areas* (2001).

4.3.1 Detention Basins

Detention basins are passive systems whose outlets have been designed to detain the stormwater runoff from a water quality design storm for some minimum time to allow particles and associated pollutants to settle. They can also be used to provide flood control by including additional flood detention storage. They have high removal effectiveness for trash and medium effectiveness for Sediment, nutrients, metals, bacteria, oil and grease, and organics. This project is anticipated to generate sediment similar to the pre-developed condition. It has the potential to generate trash.

5.0 PROJECT PLAN(s) & BMP LOCATION MAP

BMP Location Map is provided in Attachment 2.

6.0 BMP MAINTENANCE

Proper maintenance is required to insure optimum performance of the Detention Basins. Maintenance will be the responsibility of the owner throughout the life of the project. Owner will also instruct any future owner of the maintenance responsibility. The operational and maintenance needs of the proposed detention basins and under-panel detention basins include:

- Periodic sediment removal.
- Monitoring of the basin to ensure it is completely and properly drained.
- Outlet structure cleaning.
- Vegetation management.
- Removal of weeds, tree pruning, leaves, litter, and debris.
- Vegetative stabilization of eroding banks.

Inspection Frequency

The facility will be inspected and inspection visits will be completely documented:

- Once during the rainy season and once between each rainy season at a minimum.
- After every large storm (after every storm monitored or those storms with more than 0.50 inch of precipitation).

Aesthetic and Functional Maintenance

Functional maintenance is important for performance and safety reasons. Aesthetic maintenance is important for public acceptance of storm water facilities.

Aesthetic Maintenance

The following activities will be included in the aesthetic maintenance program:

- Weed Control. Weeds will be removed through mechanical means.

Functional Maintenance

Functional maintenance has two components:

- Preventive maintenance.
- Corrective maintenance.

Preventive Maintenance

Preventive maintenance will be done on a regular basis. Preventive maintenance activities to be instituted at a basin are:

- Trash and Debris. During each inspection and maintenance visit to the site, debris and trash removal will be conducted to reduce the potential for inlet and outlet structures and other components from becoming clogged and inoperable during storm events.
- Sediment Management. Alluvial deposits at the inlet structures may create zones of ponded water. Upon these occurrences these deposits will be graded within the basin in an effort to maintain the functionality of the BMP. Sediment grading will be accomplished by manually raking the deposits.
- Sediment Removal. Surface sediments will be removed when sediment accumulation is greater than 18-inches, or 10 percent of the basin volume, whichever is less. Vegetation removed with any surface sediment excavation activities will be replaced through reseeding.
- Mechanical Components. Regularly scheduled maintenance will be performed on valves, fence gates, locks, and access hatches in accordance with the manufacturers' recommendations. Mechanical components will be operated during each maintenance inspection to assure continued performance.
- Elimination of Mosquito Breeding Habitats. The most effective mosquito control program is one that eliminates potential breeding habitats.

Corrective Maintenance

Corrective maintenance is required on an emergency or non-routine basis to correct problems and to restore the intended operation and safe function of a basin. Corrective maintenance activities include:

- Removal of Debris and Sediment. Sediment, debris, and trash, which threaten the ability of a basin to store or convey water, will be removed immediately and properly disposed of.
- Structural Repairs. Repairs to any structural component of a basin will be made promptly (e.g., within 10 working days). Designers and contractors will conduct repairs where structural damage has occurred.
- Embankment and Slope Repairs. Damage to the embankments and slopes will be repaired quickly (e.g., within 10 working days).
- Erosion Repair. Where a reseeding program has been ineffective, or where other factors have created erosive conditions (i.e., pedestrian traffic, concentrated flow, etc.), corrective steps will be taken to prevent loss of soil and any subsequent danger to the performance of a basin. There are a number of corrective actions than can be taken. These include erosion control blankets, riprap, sodding, or reduced flow through the area. Design engineers will be consulted to address erosion problems if the solution is not evident.
- Fence Repair. Timely repair of fences (e.g., within 10 working days) will be done to maintain the security of the site.
- Elimination of Trees and Woody Vegetation. Woody vegetation will be removed from embankments.
- Elimination of Animal Burrows. Animal burrows will be filled and steps taken to remove the animals if burrowing problems continue to occur (filling and compacting). If the problem persists, vector control specialists will be consulted regarding removal steps. This consulting is

necessary as the threat of rabies in some areas may necessitate the animals being destroyed rather than relocated.

- General Facility Maintenance. In addition to the above elements of corrective maintenance, general corrective maintenance will address the overall facility and its associated components. If corrective maintenance is being done to one component, other components will be inspected to see if maintenance is needed.

Maintenance Frequency

Maintenance indicators, described above, will determine the schedule of maintenance activities to be implemented at the basin. These basins should not require a rigorous maintenance schedule, once the landscaping is established. The inspection frequency and regular preventative maintenance will indicate when corrective maintenance is necessary.

The detention basins must be inspected at least once during the rainy season and at least once between each rainy season. These basins must be maintained so that they continue to function as designed. All inspections and maintenance activities will be documented for submittal to the County of Imperial and the Regional Water Quality Control Board if requested.

ATTACHMENTS

ATTACHMENT 1

Colorado River Basin 303(d) List

2006 CWA SECTION 303(d) LIST OF WATER QUALITY LIMITED SEGMENTS REQUIRING TMDLS

COLORADO RIVER BASIN REGIONAL WATER QUALITY CONTROL BOARD

USEPA APPROVAL DATE: JUNE 28, 2007

REGION	TYPE	NAME	CALWATER WATERSHED	POLLUTANT/STRESSOR	POTENTIAL SOURCES	ESTIMATED SIZE AFFECTED	PROPOSED TMDL COMPLETION
7	R	Alamo River	72310000				
				Chlorpyrifos		57 Miles	2019
					Source Unknown		
				DDT		57 Miles	2019
					Source Unknown		
				Dieldrin		57 Miles	2019
					Source Unknown		
				PCBs (Polychlorinated biphenyls)		57 Miles	2019
					Source Unknown		
				Selenium		57 Miles	2003
				Selenium originates from Upper Basin Portion of Colorado River. Elevated fish tissue levels. For 2006, selenium was moved by USEPA from the being addressed list back to the 303(d) list pending completion and USEPA approval of a TMDL.			
					Agricultural Return Flows		
				Toxaphene		57 Miles	2019
					Source Unknown		
7	R	Coachella Valley Storm Water Channel	71947000				
				Pathogens		24 Miles	2006
				This listing for pathogens only applies to a 17 mile area of the Coachella Valley Storm Water Channel from Dillion Road to the Salton Sea.			
					Source Unknown		
				Toxaphene		24 Miles	2019
				This listing for toxaphene only applies to a 2 mile area of the Coachella Valley Storm Water Channel from Lincoln Street to the Salton Sea.			
					Source Unknown		
7	R	Colorado River (Imperial Reservoir to California-Mexico Border)	72700000				
				Selenium		11 Miles	2019
					Source Unknown		

2006 CWA SECTION 303(d) LIST OF WATER QUALITY LIMITED SEGMENTS REQUIRING TMDLS

COLORADO RIVER BASIN REGIONAL WATER QUALITY CONTROL BOARD

USEPA APPROVAL DATE: JUNE 28, 2007

REGION	TYPE	NAME	CALWATER WATERSHED	POLLUTANT/STRESSOR	POTENTIAL SOURCES	ESTIMATED SIZE AFFECTED	PROPOSED TMDL COMPLETION
7	R	**Imperial Valley Drains**	72310000				
				DDT *The listing for DDT only applies to the Barbara Worth Drain, Peach Drain, and Rice Drain areas of the Imperial Valley drains.*	**Source Unknown**	1225 Miles	2019
				Dieldrin *The listing for dieldrin only applies to the Barbara Worth Drain and Fig Drain areas of the Imperial Valley drains.*	**Source Unknown**	1225 Miles	2019
				Endosulfan *The listing for endosulfan only applies to the Peach Drain area of the Imperial Valley drains.*	**Source Unknown**	1225 Miles	2019
				PCBs (Polychlorinated biphenyls) *The listing for PCBs only applies to the Central Drain area of the Imperial Valley drains, from Meloland Road to the outlet into the Alamo River.*	**Source Unknown**	1225 Miles	2019
				Selenium *Selenium originates from Upper Basin Portion of Colorado River. Elevated fish tissue levels.*	**Agricultural Return Flows**	1225 Miles	2019
				Toxaphene *This listing for toxaphene only applies to the Barbara Worth Drain, Peach Drain, and Rice Drain of the Imperial Valley drains.*	**Source Unknown**	1225 Miles	2019
7	R	**New River (Imperial County)**	72800000				
				1,2,4-Trimethylbenzene	**Industrial Point Sources** **Out-of-state source**	66 Miles	2006
				Chlordane	**Source Unknown**	66 Miles	2019
				Chloroform	**Industrial Point Sources** **Out-of-state source**	66 Miles	2006
				Chlorpyrifos	**Source Unknown**	66 Miles	2019

REGION	TYPE	NAME	CALWATER WATERSHED	POLLUTANT/STRESSOR	POTENTIAL SOURCES	ESTIMATED SIZE AFFECTED	PROPOSED TMDL COMPLETION
				Copper *This listing was made by USEPA for 2006.*		66 Miles	2019
					Source Unknown		
				DDT		66 Miles	2019
					Source Unknown		
				Diazinon		66 Miles	2019
					Source Unknown		
				Dieldrin		66 Miles	2019
					Source Unknown		
				Mercury		66 Miles	2019
					Source Unknown		
				meta-para xylenes		66 Miles	2006
					Industrial Point Sources		
					Out-of-state source		
				Nutrients *Regional Board proposes to establish TMDL in cooperation with U.S. EPA and Mexico.*		66 Miles	2006
					Major Municipal Point Source-dry and/or wet weather discharge		
					Agricultural Return Flows		
					Out-of-state source		
				Organic Enrichment/Low Dissolved Oxygen		66 Miles	2006
					Wastewater		
					Inappropriate Waste Disposal/Wildcat Dumping		
					Out-of-state source		
					Unknown point source		
				o-Xylenes		66 Miles	2006
					Industrial Point Sources		
					Out-of-state source		

REGION	TYPE	NAME	CALWATER WATERSHED	POLLUTANT/STRESSOR	POTENTIAL SOURCES	ESTIMATED SIZE AFFECTED	PROPOSED TMDL COMPLETION
				PCBs (Polychlorinated biphenyls)		66 Miles	2019
					Source Unknown		
				p-Cymene		66 Miles	2006
					Industrial Point Sources		
					Out-of-state source		
				p-Dichlorobenzene/DCB		66 Miles	2006
					Industrial Point Sources		
					Out-of-state source		
				Pesticides		66 Miles	2019
					Agricultural Return Flows		
					Out-of-state source		
				Selenium		66 Miles	2019
					Source Unknown		
				Toluene		66 Miles	2006
					Industrial Point Sources		
					Out-of-state source		
				Toxaphene		66 Miles	2019
					Source Unknown		
				Toxicity		66 Miles	2019
					Source Unknown		
				Trash		66 Miles	2006
					Out-of-state source		
7	R	Palo Verde Outfall Drain and Lagoon	71540000				
				DDT		19 Miles	2019
					Source Unknown		

2006 CWA SECTION 303(d) LIST OF WATER QUALITY LIMITED SEGMENTS REQUIRING TMDLS

COLORADO RIVER BASIN REGIONAL WATER QUALITY CONTROL BOARD

USEPA APPROVAL DATE: JUNE 28, 2007

REGION	TYPE	NAME	CALWATER WATERSHED	POLLUTANT/STRESSOR	POTENTIAL SOURCES	ESTIMATED SIZE AFFECTED	PROPOSED TMDL COMPLETION
				Pathogens *This listing was made by USEPA for 2006.*	Source Unknown	19 Miles	2019
7	S	Salton Sea	72800000				
				Nutrients	Major Industrial Point Source Agricultural Return Flows Out-of-state source	233340 Acres	2006
				Salinity *TMDL development will not be effective in addressing this problem, which will require an engineering solution with federal, local, and state cooperation.*	Agricultural Return Flows Out-of-state source Point Source	233340 Acres	2019
				Selenium	Agricultural Return Flows	233340 Acres	2019

REGION	TYPE	NAME	CALWATER WATERSHED	POLLUTANT/STRESSOR	POTENTIAL SOURCES	ESTIMATED SIZE AFFECTED	PROPOSED TMDL COMPLETION

ABBREVIATIONS

REGIONAL WATER QUALITY CONTROL BOARDS

1	North Coast
2	San Francisco Bay
3	Central Coast
4	Los Angeles
5	Central Valley
6	Lahontan
7	Colorado River Basin
8	Santa Ana
9	San Diego

WATER BODY TYPE

B =	Bays and Harbors
C =	Coastal Shorelines/Beaches
E =	Estuaries
L =	Lakes/Reserviors
R =	Rivers and Streams
S =	Saline Lakes
T =	Wetlands, Tidal
W=	Wetlands, Freshwater

CALWATER WATERSHED

"Calwater Watershed" is the State Water Resources Control Board hydrological subunit area or an even smaller area delineation.

GROUP A PESTICIDES OR CHEM A

aldrin, dieldrin, chlordane, endrin, heptachlor, heptachlor epoxide, hexachlorocyclohexane (including lindane), endosulfan, and toxaphene

ATTACHMENT 2

Site Map (BMP Location Map)

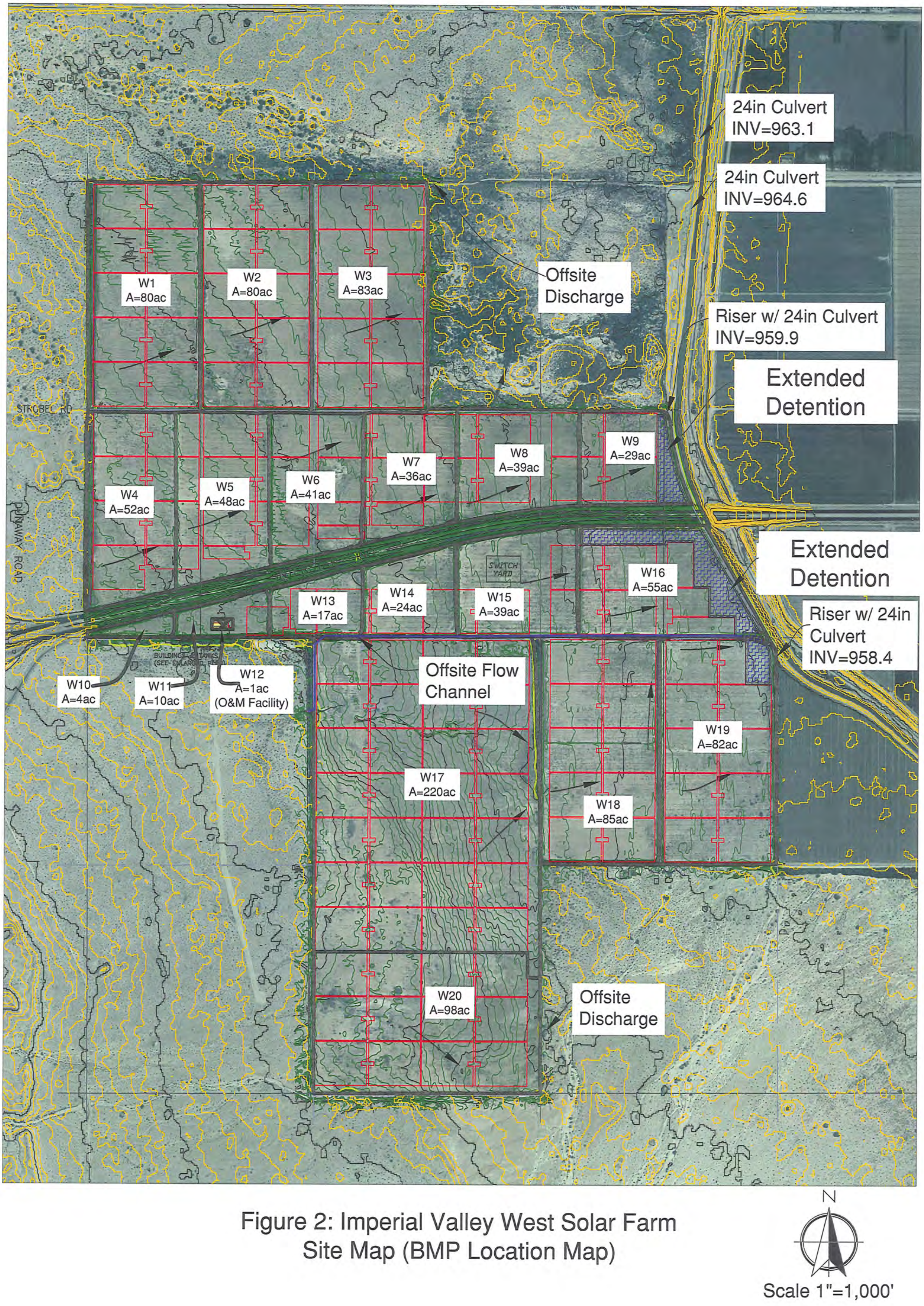


Figure 2: Imperial Valley West Solar Farm
Site Map (BMP Location Map)

ATTACHMENT 3

BMP Datasheets

Extended Detention Basin TC-22

Design Considerations

- Tributary Area
- Area Required
- Hydraulic Head

Description

Dry extended detention ponds (a.k.a. dry ponds, extended detention basins, detention ponds, extended detention ponds) are basins whose outlets have been designed to detain the stormwater runoff from a water quality design storm for some minimum time (e.g., 48 hours) to allow particles and associated pollutants to settle. Unlike wet ponds, these facilities do not have a large permanent pool. They can also be used to provide flood control by including additional flood detention storage.

California Experience

Caltrans constructed and monitored 5 extended detention basins in southern California with design drain times of 72 hours. Four of the basins were earthen, less costly and had substantially better load reduction because of infiltration that occurred, than the concrete basin. The Caltrans study reaffirmed the flexibility and performance of this conventional technology. The small headloss and few siting constraints suggest that these devices are one of the most applicable technologies for stormwater treatment.

Advantages

- Due to the simplicity of design, extended detention basins are relatively easy and inexpensive to construct and operate.
- Extended detention basins can provide substantial capture of sediment and the toxics fraction associated with particulates.
- Widespread application with sufficient capture volume can provide significant control of channel erosion and enlargement caused by changes to flow frequency

Targeted Constituents

☑	Sediment	▲
☑	Nutrients	●
☑	Trash	■
☑	Metals	▲
☑	Bacteria	▲
☑	Oil and Grease	▲
☑	Organics	▲

Legend ***(Removal Effectiveness)***

● Low ■ High

▲ Medium

CASQA
CALIFORNIA STORMWATER QUALITY ASSOCIATION

relationships resulting from the increase of impervious cover in a watershed.

Limitations

- Limitation of the diameter of the orifice may not allow use of extended detention in watersheds of less than 5 acres (would require an orifice with a diameter of less than 0.5 inches that would be prone to clogging).

- Dry extended detention ponds have only moderate pollutant removal when compared to some other structural stormwater practices, and they are relatively ineffective at removing soluble pollutants.

- Although wet ponds can increase property values, dry ponds can actually detract from the value of a home due to the adverse aesthetics of dry, bare areas and inlet and outlet structures.

Design and Sizing Guidelines

- Capture volume determined by local requirements or sized to treat 85% of the annual runoff volume.

- Outlet designed to discharge the capture volume over a period of hours.

- Length to width ratio of at least 1.5:1 where feasible.

- Basin depths optimally range from 2 to 5 feet.

- Include energy dissipation in the inlet design to reduce resuspension of accumulated sediment.

- A maintenance ramp and perimeter access should be included in the design to facilitate access to the basin for maintenance activities and for vector surveillance and control.

- Use a draw down time of 48 hours in most areas of California. Draw down times in excess of 48 hours may result in vector breeding, and should be used only after coordination with local vector control authorities. Draw down times of less than 48 hours should be limited to BMP drainage areas with coarse soils that readily settle and to watersheds where warming may be determined to downstream fisheries.

Construction/Inspection Considerations

- Inspect facility after first large to storm to determine whether the desired residence time has been achieved.

- When constructed with small tributary area, orifice sizing is critical and inspection should verify that flow through additional openings such as bolt holes does not occur.

Performance

One objective of stormwater management practices can be to reduce the flood hazard associated with large storm events by reducing the peak flow associated with these storms. Dry extended detention basins can easily be designed for flood control, and this is actually the primary purpose of most detention ponds.

Dry extended detention basins provide moderate pollutant removal, provided that the recommended design features are incorporated. Although they can be effective at removing some pollutants through settling, they are less effective at removing soluble pollutants because of the absence of a permanent pool. Several studies are available on the effectiveness of dry extended detention ponds including one recently concluded by Caltrans (2002).

The load reduction is greater than the concentration reduction because of the substantial infiltration that occurs. Although the infiltration of stormwater is clearly beneficial to surface receiving waters, there is the potential for groundwater contamination. Previous research on the effects of incidental infiltration on groundwater quality indicated that the risk of contamination is minimal.

There were substantial differences in the amount of infiltration that were observed in the earthen basins during the Caltrans study. On average, approximately 40 percent of the runoff entering the unlined basins infiltrated and was not discharged. The percentage ranged from a high of about 60 percent to a low of only about 8 percent for the different facilities. Climatic conditions and local water table elevation are likely the principal causes of this difference. The least infiltration occurred at a site located on the coast where humidity is higher and the basin invert is within a few meters of sea level. Conversely, the most infiltration occurred at a facility located well inland in Los Angeles County where the climate is much warmer and the humidity is less, resulting in lower soil moisture content in the basin floor at the beginning of storms.

Vegetated detention basins appear to have greater pollutant removal than concrete basins. In the Caltrans study, the concrete basin exported sediment and associated pollutants during a number of storms. Export was not as common in the earthen basins, where the vegetation appeared to help stabilize the retained sediment.

Siting Criteria

Dry extended detention ponds are among the most widely applicable stormwater management practices and are especially useful in retrofit situations where their low hydraulic head requirements allow them to be sited within the constraints of the existing storm drain system. In addition, many communities have detention basins designed for flood control. It is possible to modify these facilities to incorporate features that provide water quality treatment and/or channel protection. Although dry extended detention ponds can be applied rather broadly, designers need to ensure that they are feasible at the site in question. This section provides basic guidelines for siting dry extended detention ponds.

In general, dry extended detention ponds should be used on sites with a minimum area of 5 acres. With this size catchment area, the orifice size can be on the order of 0.5 inches. On smaller sites, it can be challenging to provide channel or water quality control because the orifice diameter at the outlet needed to control relatively small storms becomes very small and thus prone to clogging. In addition, it is generally more cost-effective to control larger drainage areas due to the economies of scale.

Extended detention basins can be used with almost all soils and geology, with minor design adjustments for regions of rapidly percolating soils such as sand. In these areas, extended detention ponds may need an impermeable liner to prevent ground water contamination.

The base of the extended detention facility should not intersect the water table. A permanently wet bottom may become a mosquito breeding ground. Research in Southwest Florida (Santana et al., 1994) demonstrated that intermittently flooded systems, such as dry extended detention ponds, produce more mosquitoes than other pond systems, particularly when the facilities remained wet for more than 3 days following heavy rainfall.

A study in Prince George's County, Maryland, found that stormwater management practices can increase stream temperatures (Galli, 1990). Overall, dry extended detention ponds increased temperature by about 5°F. In cold water streams, dry ponds should be designed to detain stormwater for a relatively short time (i.e., 24 hours) to minimize the amount of warming that occurs in the basin.

Additional Design Guidelines

In order to enhance the effectiveness of extended detention basins, the dimensions of the basin must be sized appropriately. Merely providing the required storage volume will not ensure maximum constituent removal. By effectively configuring the basin, the designer will create a long flow path, promote the establishment of low velocities, and avoid having stagnant areas of the basin. To promote settling and to attain an appealing environment, the design of the basin should consider the length to width ratio, cross-sectional areas, basin slopes and pond configuration, and aesthetics (Young et al., 1996).

Energy dissipation structures should be included for the basin inlet to prevent resuspension of accumulated sediment. The use of stilling basins for this purpose should be avoided because the standing water provides a breeding area for mosquitoes.

Extended detention facilities should be sized to completely capture the water quality volume. A micropool is often recommended for inclusion in the design and one is shown in the schematic diagram. These small permanent pools greatly increase the potential for mosquito breeding and complicate maintenance activities; consequently, they are not recommended for use in California.

A large aspect ratio may improve the performance of detention basins; consequently, the outlets should be placed to maximize the flowpath through the facility. The ratio of flowpath length to width from the inlet to the outlet should be at least 1.5:1 (L:W) where feasible. Basin depths optimally range from 2 to 5 feet.

The facility's drawdown time should be regulated by an orifice or weir. In general, the outflow structure should have a trash rack or other acceptable means of preventing clogging at the entrance to the outflow pipes. The outlet design implemented by Caltrans in the facilities constructed in San Diego County used an outlet riser with orifices

Figure 1
Example of Extended Detention Outlet Structure

sized to discharge the water quality volume, and the riser overflow height was set to the design storm elevation. A stainless steel screen was placed around the outlet riser to ensure that the orifices would not become clogged with debris. Sites either used a separate riser or broad crested weir for overflow of runoff for the 25 and greater year storms. A picture of a typical outlet is presented in Figure 1.

The outflow structure should be sized to allow for complete drawdown of the water quality volume in 72 hours. No more than 50% of the water quality volume should drain from the facility within the first 24 hours. The outflow structure can be fitted with a valve so that discharge from the basin can be halted in case of an accidental spill in the watershed.

Summary of Design Recommendations

(1) Facility Sizing - The required water quality volume is determined by local regulations or the basin should be sized to capture and treat 85% of the annual runoff volume. See Section 5.5.1 of the handbook for a discussion of volume-based design.

Basin Configuration – A high aspect ratio may improve the performance of detention basins; consequently, the outlets should be placed to maximize the flowpath through the facility. The ratio of flowpath length to width from the inlet to the outlet should be at least 1.5:1 (L:W). The flowpath length is defined as the distance from the inlet to the outlet as measured at the surface. The width is defined as the mean width of the basin. Basin depths optimally range from 2 to 5 feet. The basin may include a sediment forebay to provide the opportunity for larger particles to settle out.

A micropool should not be incorporated in the design because of vector concerns. For online facilities, the principal and emergency spillways must be sized to provide 1.0 foot of freeboard during the 25-year event and to safely pass the flow from 100-year storm.

(2) Pond Side Slopes - Side slopes of the pond should be 3:1 (H:V) or flatter for grass stabilized slopes. Slopes steeper than 3:1 (H:V) must be stabilized with an appropriate slope stabilization practice.

(3) Basin Lining – Basins must be constructed to prevent possible contamination of groundwater below the facility.

(4) Basin Inlet – Energy dissipation is required at the basin inlet to reduce resuspension of accumulated sediment and to reduce the tendency for short-circuiting.

(5) Outflow Structure - The facility's drawdown time should be regulated by a gate valve or orifice plate. In general, the outflow structure should have a trash rack or other acceptable means of preventing clogging at the entrance to the outflow pipes.

The outflow structure should be sized to allow for complete drawdown of the water quality volume in 72 hours. No more than 50% of the water quality volume should drain from the facility within the first 24 hours. The outflow structure should be fitted with a valve so that discharge from the basin can be halted in case of an accidental spill in the watershed. This same valve also can be used to regulate the rate of discharge from the basin.

The discharge through a control orifice is calculated from:

$$Q = CA(2gH-H_o)^{0.5}$$

where: Q = discharge (ft^3/s)
C = orifice coefficient
A = area of the orifice (ft^2)
g = gravitational constant (32.2)
H = water surface elevation (ft)
H_o= orifice elevation (ft)

Recommended values for C are 0.66 for thin materials and 0.80 when the material is thicker than the orifice diameter. This equation can be implemented in spreadsheet form with the pond stage/volume relationship to calculate drain time. To do this, use the initial height of the water above the orifice for the water quality volume. Calculate the discharge and assume that it remains constant for approximately 10 minutes. Based on that discharge, estimate the total discharge during that interval and the new elevation based on the stage volume relationship. Continue to iterate until H is approximately equal to H_o. When using multiple orifices the discharge from each is summed.

(6) Splitter Box - When the pond is designed as an offline facility, a splitter structure is used to isolate the water quality volume. The splitter box, or other flow diverting approach, should be designed to convey the 25-year storm event while providing at least 1.0 foot of freeboard along pond side slopes.

(7) Erosion Protection at the Outfall - For online facilities, special consideration should be given to the facility's outfall location. Flared pipe end sections that discharge at or near the stream invert are preferred. The channel immediately below the pond outfall should be modified to conform to natural dimensions, and lined with large stone riprap placed over filter cloth. Energy dissipation may be required to reduce flow velocities from the primary spillway to non-erosive velocities.

(8) Safety Considerations - Safety is provided either by fencing of the facility or by managing the contours of the pond to eliminate dropoffs and other hazards. Earthen side slopes should not exceed 3:1 (H:V) and should terminate on a flat safety bench area. Landscaping can be used to impede access to the facility. The primary spillway opening must not permit access by small children. Outfall pipes above 48 inches in diameter should be fenced.

Maintenance

Routine maintenance activity is often thought to consist mostly of sediment and trash and debris removal; however, these activities often constitute only a small fraction of the maintenance hours. During a recent study by Caltrans, 72 hours of maintenance was performed annually, but only a little over 7 hours was spent on sediment and trash removal. The largest recurring activity was vegetation management, routine mowing. The largest absolute number of hours was associated with vector control because of mosquito breeding that occurred in the stilling basins (example of standing water to be avoided) installed as energy dissipaters. In most cases, basic housekeeping practices such as removal of debris accumulations and vegetation management to ensure that the basin dewaters completely in 48-72 hours is sufficient to prevent creating mosquito and other vector habitats.

Consequently, maintenance costs should be estimated based primarily on the mowing frequency and the time required. Mowing should be done at least annually to avoid establishment of woody vegetation, but may need to be performed much more frequently if aesthetics are an important consideration.

Typical activities and frequencies include:

- Schedule semiannual inspection for the beginning and end of the wet season for standing water, slope stability, sediment accumulation, trash and debris, and presence of burrows.
- Remove accumulated trash and debris in the basin and around the riser pipe during the semiannual inspections. The frequency of this activity may be altered to meet specific site conditions.
- Trim vegetation at the beginning and end of the wet season and inspect monthly to prevent establishment of woody vegetation and for aesthetic and vector reasons.
- Remove accumulated sediment and regrade about every 10 years or when the accumulated sediment volume exceeds 10 percent of the basin volume. Inspect the basin each year for accumulated sediment volume.

Cost

Construction Cost

The construction costs associated with extended detention basins vary considerably. One recent study evaluated the cost of all pond systems (Brown and Schueler, 1997). Adjusting for inflation, the cost of dry extended detention ponds can be estimated with the equation:

$$C = 12.4V^{0.760}$$

where: C = Construction, design, and permitting cost, and
V = Volume (ft^3).

Using this equation, typical construction costs are:

$ 41,600 for a 1 acre-foot pond

$ 239,000 for a 10 acre-foot pond

$ 1,380,000 for a 100 acre-foot pond

Interestingly, these costs are generally slightly higher than the predicted cost of wet ponds (according to Brown and Schueler, 1997) on a cost per total volume basis, which highlights the difficulty of developing reasonably accurate construction estimates. In addition, a typical facility constructed by Caltrans cost about $160,000 with a capture volume of only 0.3 ac-ft.

An economic concern associated with dry ponds is that they might detract slightly from the value of adjacent properties. One study found that dry ponds can actually detract from the perceived value of homes adjacent to a dry pond by between 3 and 10 percent (Emmerling-Dinovo, 1995).

Maintenance Cost

For ponds, the annual cost of routine maintenance is typically estimated at about 3 to 5 percent of the construction cost (EPA website). Alternatively, a community can estimate the cost of the maintenance activities outlined in the maintenance section. Table 1 presents the maintenance costs estimated by Caltrans based on their experience with five basins located in southern California. Again, it should be emphasized that the vast majority of hours are related to vegetation management (mowing).

Table 1 Estimated Average Annual Maintenance Effort

Activity	Labor Hours	Equipment & Material ($)	Cost
Inspections	4	7	183
Maintenance	49	126	2282
Vector Control	0	0	0
Administration	3	0	132
Materials	-	535	535
Total	**56**	**$668**	**$3,132**

References and Sources of Additional Information

Brown, W., and T. Schueler. 1997. *The Economics of Stormwater BMPs in the Mid-Atlantic Region*. Prepared for Chesapeake Research Consortium. Edgewater, MD. Center for Watershed Protection. Ellicott City, MD.

Denver Urban Drainage and Flood Control District. 1992. *Urban Storm Drainage Criteria Manual—Volume 3: Best Management Practices*. Denver, CO.

Emmerling-Dinovo, C. 1995. Stormwater Detention Basins and Residential Locational Decisions. *Water Resources Bulletin 31(3)*: 515–521

Galli, J. 1990. *Thermal Impacts Associated with Urbanization and Stormwater Management Best Management Practices*. Metropolitan Washington Council of Governments. Prepared for Maryland Department of the Environment, Baltimore, MD.

GKY, 1989, *Outlet Hydraulics of Extended Detention Facilities* for the Northern Virginia Planning District Commission.

MacRae, C. 1996. Experience from Morphological Research on Canadian Streams: Is Control of the Two-Year Frequency Runoff Event the Best Basis for Stream Channel Protection? In *Effects of Watershed Development and Management on Aquatic Ecosystems*. American Society of Civil Engineers. Edited by L. Roesner. Snowbird, UT. pp. 144–162.

Maryland Dept of the Environment, 2000, Maryland Stormwater Design Manual: Volumes 1 & 2, prepared by MDE and Center for Watershed Protection. http://www.mde.state.md.us/environment/wma/stormwatermanual/index.html

Metzger, M. E., D. F. Messer, C. L. Beitia, C. M. Myers, and V. L. Kramer. 2002. The Dark Side Of Stormwater Runoff Management: Disease Vectors Associated With Structural BMPs. Stormwater 3(2): 24-39.

Santana, F., J. Wood, R. Parsons, and S. Chamberlain. 1994. Control of Mosquito Breeding in Permitted Stormwater Systems. Prepared for Southwest Florida Water Management District, Brooksville, FL.

Schueler, T. 1997. Influence of Ground Water on Performance of Stormwater Ponds in Florida. *Watershed Protection Techniques* 2(4):525–528.

Watershed Management Institute (WMI). 1997. *Operation, Maintenance, and Management of Stormwater Management Systems*. Prepared for U.S. Environmental Protection Agency, Office of Water. Washington, DC.

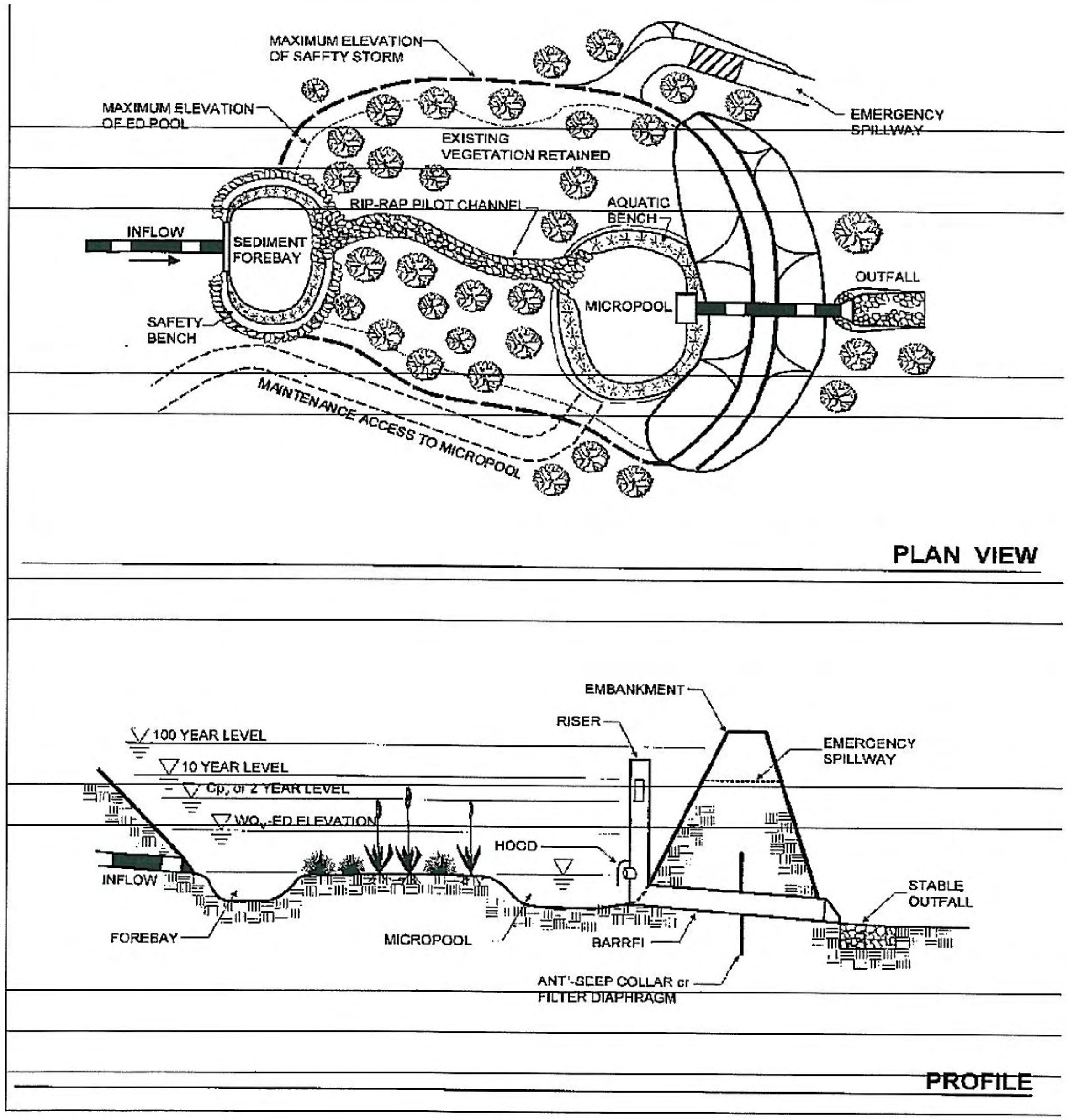
Young, G.K., et al., 1996, *Evaluation and Management of Highway Runoff Water Quality*, Publication No. FHWA-PD-96-032, U.S. Department of Transportation, Federal Highway Administration, Office of Environment and Planning.

Information Resources

Center for Watershed Protection (CWP), Environmental Quality Resources, and Loiederman Associates. 1997. *Maryland Stormwater Design Manual*. Draft. Prepared for Maryland Department of the Environment, Baltimore, MD.

Center for Watershed Protection (CWP). 1997. *Stormwater BMP Design Supplement for Cold Climates*. Prepared for U.S. Environmental Protection Agency, Office of Wetlands, Oceans and Watersheds. Washington, DC.

U.S. Environmental Protection Agency (USEPA). 1993. *Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters*. EPA-840-B-92-002. U.S. Environmental Protection Agency, Office of Water, Washington, DC.



Schematic of an Extended Detention Basin (MDE, 2000)