APPENDIX I

DRAINAGE MASTER PLAN, EXECUTIVE SUMMARY MEMORANDUM OF THE DRAINAGE MASTER PLAN, AND THE WATER QUALITY ASSESSMENT

Drainage Master Plan

La Entrada Specific Plan Development:

DRAINAGE MASTER PLAN

City of Coachella and County of Riverside, California

Final Report

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Table of Contents

1 Introduction 1-1
1.1 Project overview 1-1
1.2 Project description and location 1-1
1.3 Study goals and objectives 1-1
1.4 Report format 1-2

2 Geomorphic Watershed Assessment 2-1
2.1 Project site and immediate surroundings 2-1
2.1.1 Description 2-1
2.1.2 Review of project-related geologic studies 2-1
2.2 Geomorphic watershed assessment of the upper piedmont 2-2
2.2.1 Description 2-2
2.2.2 Methodology 2-2
2.2.3 Results 2-2

3 Regional Hydrology 3-1
3.1 Synthetic Unit Hydrograph Method 3-1
3.1.1 Infiltration characteristics 3-2
3.1.2 Frequency-duration precipitation depths 3-7
3.1.3 Synthetic unit hydrograph development 3-11
3.1.4 Effective rainfall 3-11
3.2 Verification of drainage boundaries on the upper piedmont 3-11
3.2.1 Geomorphology 3-12
3.2.2 Model development and analysis 3-12
3.3 Revised hydrologic method 3-23
3.3.1 Eastside Dike original design hydrology 3-23
3.3.2 Eastside Dike original design hydrology duplicate effective model 3-24
3.3.3 Green-Ampt equivalent duplicate effective model 3-25
3.3.4 Adopted model parameters and assumptions 3-25
3.4 Debris yield 3-30
3.5 Flood hydrograph development results 3-35
3.5.1 Baseline Conditions 3-35
3.5.2 Project Conditions 3-35
3.5.3 Regional Channel Design Discharges 3-62
3.6 Project-related hydrologic impacts 3-63
3.6.1 Flood conveyance 3-63
3.6.2 Eastside Dike Impacts 3-63
3.7 Conclusions and recommendations 3-65

4 Local Hydrology 4-1
4.1 Water Quality Assessment 4-2
4.2 Development Phasing 4-3

5 References 5-1

Figures

Figure 1-1. Regional location map 1-3
Figure 1-2. Project location map 1-3
Figure 1-3. Project land use map 1-5
Figure 2-1. Aerial photograph showing the five areas of interest (red) 2-3
Figure 2-2. Aerial photograph of Area #1 showing active and inactive portions of the piedmont. 2-4
Figure 2-3. Aerial photograph of Area #2 showing active and inactive portions of the piedmont. 2-5
Figure 2-4. Aerial photograph of Areas #3/4 showing active and inactive portions of the piedmont. 2-6
Figure 2-5. Aerial photograph of Area #5 showing only inactive portions of the piedmont. 2-7
Figure 3-1. Eastside Dike and Project watershed (subbasins 1A, 1B, and 7A not shown) 3-2
Figure 3-2. NRCS Detailed Soils – Coachella Valley Area Soil Survey 3-3
Figure 3-3. NRCS U.S. Generalized Soil Map 3-4
Figure 3-4. Composite of NRCS detailed and U.S. generalized soils 3-4
Figure 3-5. NA14 10-percent annual chance 3-hour precipitation depth isohyetals 3-8
Figure 3-6. NA14 10-percent annual chance 6-hour precipitation depth isohyetals 3-9
Figure 3-7. NA14 1-percent annual chance 3-hour precipitation depth isohyetals 3-9
Figure 3-8. NA14 1-percent annual chance 6-hour precipitation depth isohyetals 3-10
Figure 3-9. NA14 1-percent annual chance 24-hour precipitation depth isohyetals 3-10
Figure 3-10. Models A, B, and C - Individual I-10 crossing drainages 3-13
Figure 3-11. Model ABC - Combined I-10 crossing drainages 3-14
Figure 3-12. Model A - Echo Gulch upper drainage 3-14
Figure 3-13. Model XA - Echo Gulch upper drainage and fringe area to the northwest 3-15
Figure 3-14. Model ABC flood velocities 3-21
Figure 3-15. Flood velocities along assumed boundary where intermingling of flows occurs 3-21
Figure 3-16. Adopted upper piedmont drainage boundaries 3-22
Figure 3-17. Plate 3 – Topography (Slater et al, 1950) with Area "D" identified with a red boundary 3-27
Figure 3-18. Plate 18 – Generalized Surface Geology (Slater et al, 1950) with Area "D" identified with a red boundary 3-28
Figure 3-19. Baseline regional hydrology map – upstream Project boundary subbasins 3-37
Figure 3-20. Baseline regional hydroiogy map – Eastside Dike subbasins 3-39
Figure 3-21. Project regional hydrology map – upstream Project boundary subbasins 3-41
Figure 3-22. Project regional hydrology map – Eastside Dike subbasins 3-43
Figure 3-23. Project watershed composite NRCS soil map 3-45
Figure 3-24. Baseline 1-percent annual chance 24-hour maximum water surface elevations 3-67
Figure 3-25. Project with crossings 1-percent annual chance 24-hour maximum water surface elevations 3-69
Figure 3-26. Baseline SPF maximum water surface elevations 3-71
Figure 3-27. Project with crossings SPF maximum water surface elevations 3-73
Figure 3-28. Baseline 1-percent annual chance 24-hour maximum water surface elevation impacts 3-75
Figure 3-29. Project no crossings maximum water surface elevation impacts 3-77
Figure 3-30. Project with crossings SPF maximum water surface elevation impacts 3-79
Figure 3-31. Comparison of water surface elevation profiles along the Eastside Dike 3-81
Figure 3-32. Baseline 1-percent annual chance 24-hour maximum flow velocities 3-83
Figure 3-33. Project with crossings 1-percent annual chance 24-hour maximum flow velocities 3-85
Figure 3-34. Baseline SPF maximum flow velocities 3-87
Figure 3-35. Project with crossings SPF maximum flow velocities 3-89
Figure 3-36. Project 1-percent annual chance 24-hour maximum flow velocity impacts 3-91
Figure 3-37. Project with crossings SPF maximum flow velocity impacts 3-93
Figure 4-1. Project storm drain facilities layout 4-6

Tables

Table 3-1. Hydrologic soil group distribution for myoma – carsitas – carrizo (s991) 3-5
Table 3-2. Hydrologic soil groups for rock outcrop-nillito-beeline-badland (s995) 3-5
Table 3-3. Hydrologic soil group distribution for rock outcrop – lithic torriorthents (s1130) 3-6
Table 3-4. Lower drainage AMCI II soil loss rate comparison – NRCS CVA survey area soils 3-6
Table 3-5. Lower drainage AMC II soil loss rate comparison – NRCS U.S. generalized soils 3-7
Table 3-6. Adopted natural pervious AMC II soil loss rate characteristics 3-7
Table 3-7. Echo Gulch subbasin AMC II loss rate determination 3-18
Table 3-8. Smoky Gulch subbasin AMC II loss rate determination 3-18
Table 3-9. Sunny Gulch subbasin AMC II loss rate determination 3-18
Table 3-10. Effective rainfall parameters based on AMC II 3-19
Table 3-11. Unit hydrograph parameters 3-19
Table 3-12. 1-percent annual chance 6-hour flood hydrograph development results 3-19
Table 3-13. Summary of FLO-2D peak flow rates and peak flow rate ratios at Interstate 10 3-20
Table 3-14. Model ABC distribution of flood depths 3-20
Table 3-15. Comparison of SPF models 3-29
Table 3-16. Adopted saturated hydraulic conductivity values 3-30
Table 3-17. Adopted Green-Ampt infiltration parameters 3-30
Table 3-18. A-T factor breakdown for each subbasin 3-33
Table 3-19. Los Angeles District Debris Method (Table D-1; USACE, 2002) A-T factor guidelines 3-34
Table 3-20. Baseline soil distribution – upstream Project boundary subbasins 3-47
Table 3-21. Baseline soil distribution – Eastside Dike subbasins 3-47
Table 3-22. Baseline loss rates – upstream Project boundary subbasins 3-48
Table 3-23. Baseline loss rates – Eastside Dike subbasins 3-48
Table 3-24. Baseline short-duration rainfall 3-49
Table 3-25. Baseline 24-hour rainfall – Eastside Dike subbasins 3-49
Table 3-26. Baseline lag basin factor determination – upstream Project boundary subbasins 3-50
Table 3-27. Baseline lag basin factor determination – Eastside Dike subbasins 3-50
Table 3-28. Baseline unit hydrograph lag parameters – upstream Project boundary subbasins 3-51
Table 3-29. Baseline unit hydrograph lag parameters – Eastside Dike subbasins 3-51
Table 3-30. Baseline short-duration flood hydrograph results 3-52
Table 3-31. Baseline 24-hour flood hydrograph results – Eastside Dike subbasins 3-52
Table 3-32. Baseline short-duration debris yield and bulking analysis results 3-53
Table 3-33. Baseline 24-hour 1-percent annual chance debris yield analysis results 3-54
Table 3-34. Baseline SPF hydrologic and debris yield analysis results 3-54
Table 3-35. Project soil distribution – upstream Project boundary subbasins 3-55
Table 3-36. Project soil distribution – Eastside Dike subbasins 3-55
Table 3-37. Project landuse distribution – Eastside Dike subbasins 3-55
Table 3-38. Project loss rates – upstream Project boundary subbasins 3-56
Table 3-39. Project loss rates – Eastside Dike subbasins 3-56
Table 3-40. Project short-duration rainfall – Eastside Dike subbasins 3-57
Table 3-41. Project 24-hour rainfall – Eastside Dike subbasins 3-57
Table 3-42. Project lag basin factor determination – upstream Project boundary subbasins 3-58
Table 3-43. Project lag basin factor determination – Eastside Dike subbasins 3-58
Table 3-44. Project unit hydrograph lag parameters – upstream Project boundary subbasins 3-59
Table 3-45. Project unit hydrograph lag parameters – Eastside Dike subbasins 3-59
Table 3-46. Project short-duration flood hydrograph results 3-60
Table 3-47. Project 24-hour flood hydrograph data – Eastside Dike subbasins 3-60

Table 3-48. Project short-duration debris yield and bulking analysis results 3-61
Table 3-49. Project 24-hour 1-percent annual chance debris yield – Eastside Dike subbasins 3-62
Table 3-50. Project SPF hydrologic and debris yield analysis results 3-62
Table 3-51. Comparison of Baseline and Project conditions short-duration events 3-63
Table 3-52. Comparison of Baseline and Project conditions maximum water surface elevations 3-65
Table 4-1. Assigned land use percent imperviousness...4-4
Table 4-2. Rational Method computed local peak flow rates 4-5

Exhibits

Exhibit 1. La Entrada Onsite Project Conditions Hydrology Map

Exhibit 2. Geotechnical Commentary on Potential for Certification of Portions of the Eastside Dike Adjacent to the La Entrada Project, City of Coachella, Riverside County, California Letter

Technical Appendix

DVD in sleeve on inside back cover

HEC-1 input and output files

FLO-2D input and output files

Excel spreadsheet – unit hydrograph development worksheets

Excel spreadsheet – representative slope analysis worksheets

Excel spreadsheet – Green-Ampt infiltration worksheets

Excel spreadsheet – lag basin factor worksheets

Excel spreadsheet – debris analysis worksheet

AES Rational Method input and output files

ArcGIS files

1 INTRODUCTION

1.1 Project overview

The La Entrada Specific Plan is a 2,200 acre master planned community in the eastern portion of the City of Coachella and unincorporated Riverside County, California. The Specific Plan area is comprised of a series of northeast-southwest trending ridges and canyons that drain towards the lower elevations of the Coachella Valley to the south and west. Bounded by the Interstate 10 freeway to the north and the Coachella Branch of the All American Canal to the west, the La Entrada Specific Plan is surrounded to the north and east by undeveloped land, sparsely developed agricultural land to the south, and existing agricultural land to the west.

The purpose of the Drainage Master Plan is to determine the projects' impacts to existing hydrology, floodplains, and drainage features, and identify appropriate flood control and local drainage facilities necessary for the development of the project site. The Master Plan addresses both local and regional impacts, flood hazard mitigation requirements, and design features. This Master Plan is based on the requirements of the Coachella Valley Water District (CVWD), County of Riverside, and the City of Coachella. See Figure 1-1 for a Regional Location Map and Figure 1-2 for a Project Location Map.

1.2 Project description and location

The proposed La Entrada Specific Plan is based on a comprehensive update of the previously approved 1989 McNaughton Specific Plan, which allows up to 8,000 residential dwelling units. The proposed La Entrada Specific Plan includes an additional 588 acres of new land within the Specific Plan area. As proposed, the new Specific Plan would allow up to a maximum of approximately 7,800 residential dwelling units within the 2,200 acre area, varying from Very Low Density (2.0 du/ac), Low Density (4.5 du/ac), Medium Density (8.0 du/ac), to High Density (20.0 du/ac) uses. In addition, the Plan proposes the development of Mixed Use areas that allow commercial retail and higher density residential uses; up to four elementary school sites, approximately 263 acres of parks, 553 acres of open space, and public/ community facilities. Development of the proposed uses would occur in a series of phases and be coordinated closely with the construction/ extension of the regional roadway network over the All American Canal and a new proposed interchange along the I-10 freeway. At buildout, it is anticipated that the La Entrada Specific Plan area could increase the population of the City by as much as 21,000 new residents. The land use map for the La Entrada Specific Plan is shown in Figure 1-3.

1.3 Study goals and objectives

The purpose of this study is to provide a detailed watershed assessment including regional and local hydrology, flood hazard analysis, hydraulics, and sedimentation to develop a drainage master plan for the La Entrada project site. The overall goal of this study is to provide the appropriate level of flood protection for the public, non-CVWD stormwater facilities, and impacted CVWD stormwater facilities that are consistent with the guidelines and requirements instituted by the City of Coachella, Coachella Valley Water District, and the Bureau of Reclamation (Coachella Canal).

The primary objectives of this study include the following:

- Develop baseline and project-based regional hydrology to establish peak flow rates and flood volumes for use in the conceptual design of combined onsite/offsite flood conveyances, which extend through the proposed development
- Develop project-based hydrology for use in the conceptual design of local onsite storm conveyance and retention facilities
- Identify and propose mitigation for any potentially significant development-related adverse flood hazard impacts, including the Coachella Canal and levee system

- Identify hydraulic, sedimentation, and erosion issues/design constraints associated with the major flood conveyances, which extend through the proposed development.
- Formulate the conceptual design of local and regional storm facilities

The project included the preparation of detailed technical studies for the on- and off-site watershed areas leading to the identification of flood hazards and mitigation measures for the site development. The technical studies included:

- Geomorphic assessment of the project site and tributary watershed
- Regional hydrology, hydraulics, and sedimentation analysis for the off-site watersheds
- Eastside Dike flood routing and impact analysis
- Local hydrology analysis and preliminary pipe sizing

The intended use of the master plan is to; identify flood hazards at the La Entrada Specific Plan development site; develop a regional approach to mitigate the flood hazards; identify local drainage facility requirements; and evaluate development related impacts to existing facilities such as the Eastside Dike along the Coachella Canal.

1.4 Report format

The chapters of the report are set out to complete the primary objectives of this drainage master plan and include the detailed discussion and technical analysis used for the study. The report includes the methodologies, technical approaches, assumptions, design parameters, and summaries of results used for the development of the analyses, and identification of flood protection requirements and mitigation measures. The detailed technical calculations including spreadsheets and computer input/output files are included on a DVD attached to the back cover of the report.

Submittal and Approval Process

The report is being submitted in 3 phases to facilitate the review and approval of the document. Each succeeding phase will expand on the previous submittal. The 3 phases include:

1. Regional Baseline Hydrology
2. Local and Regional Project Condition Hydrology
3. Final Report including impact analysis and mitigation

This document is a resubmittal of the ***3rd phase*** *submittal which includes the regional and local hydrology and draft final report including the determination of project-related increased runoff volume impacts and mitigation.*

Figure 1-1. Regional location map

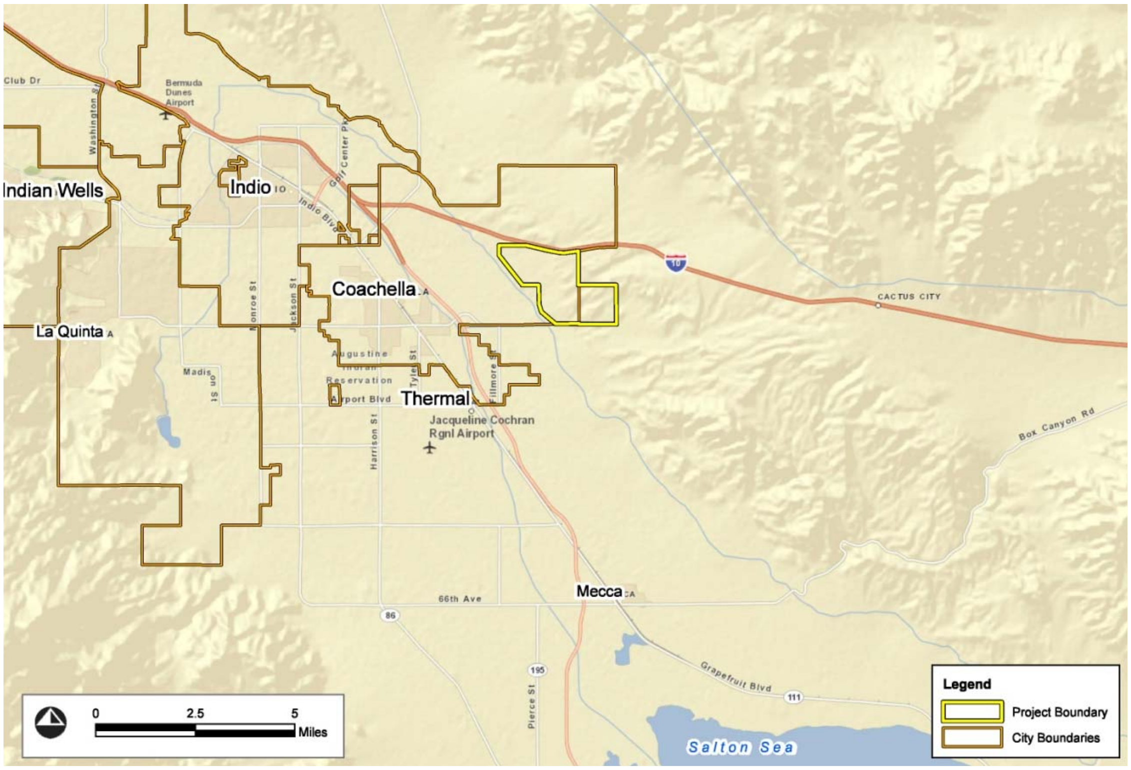

Figure 1-2. Project location map

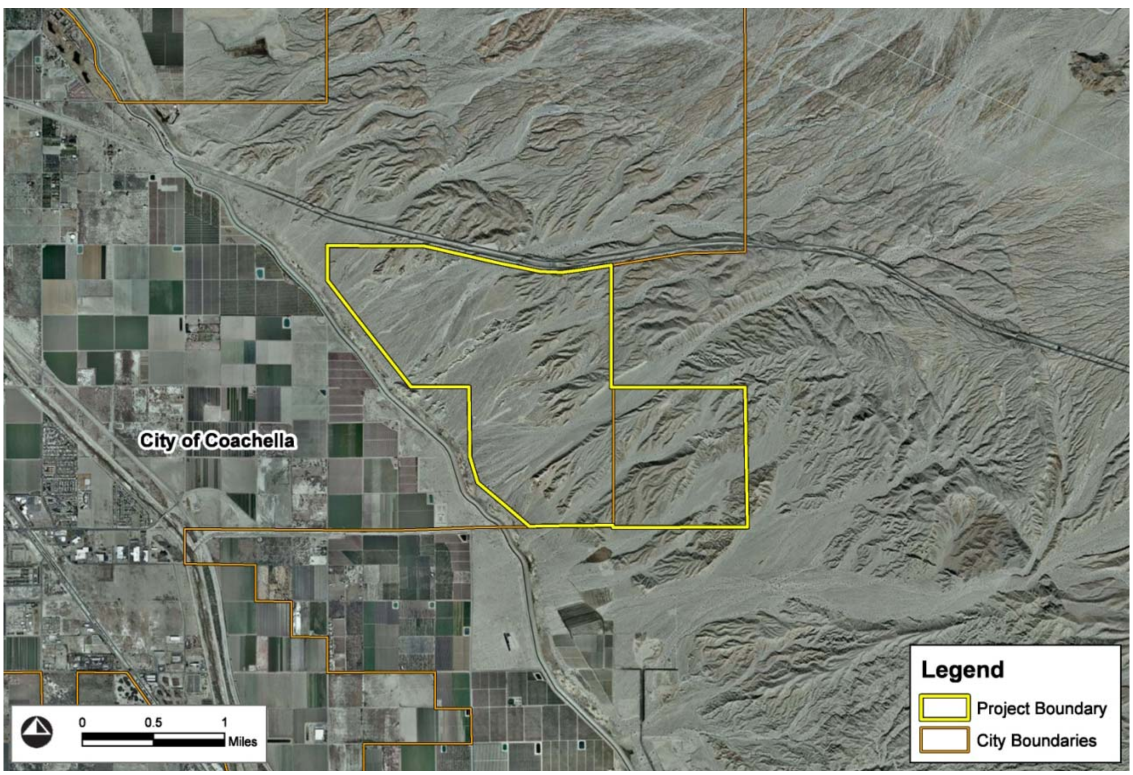

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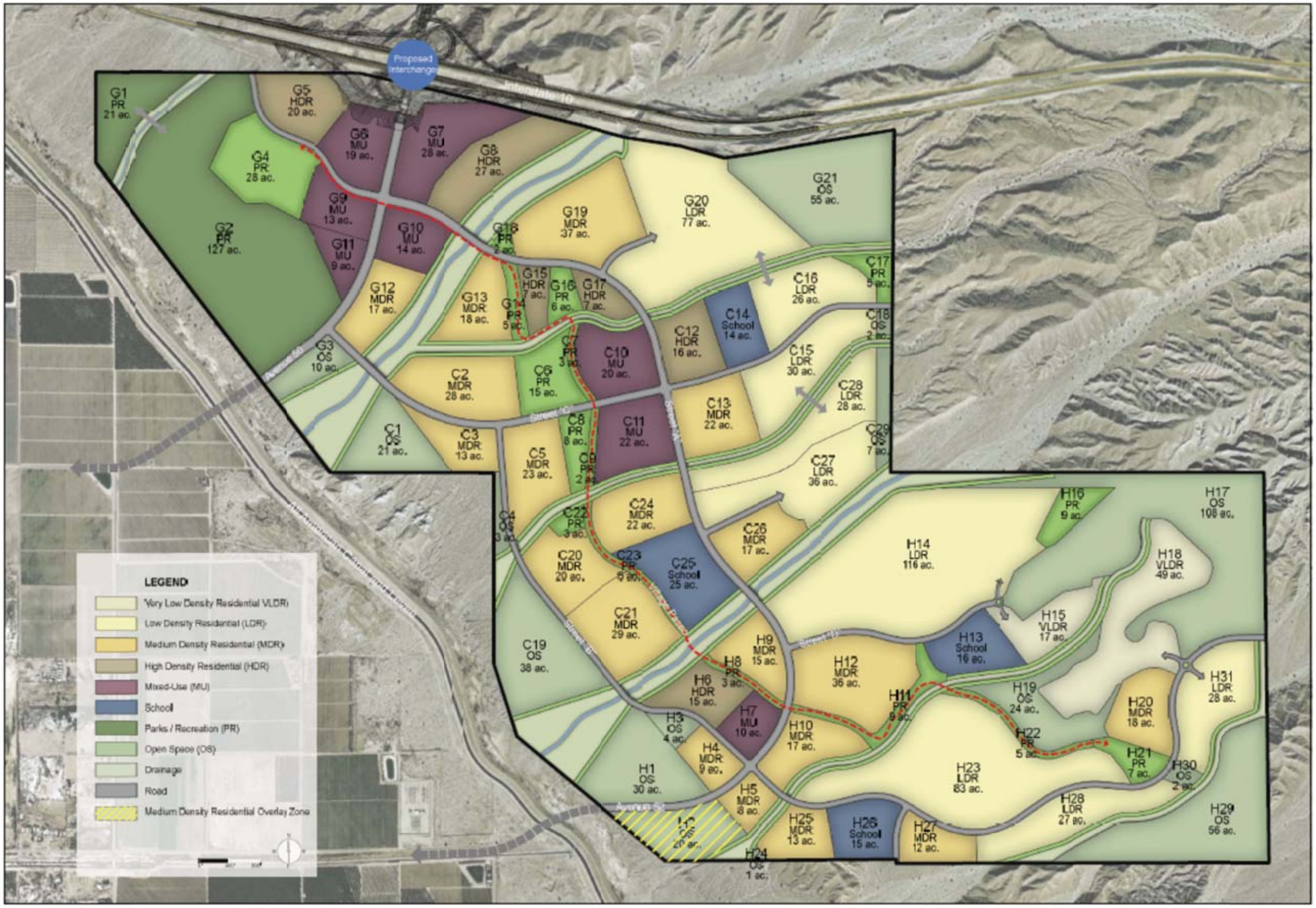
Figure 1-3. Project land use map



Note: Planning Area acreages have been rounded.

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2 GEOMORPHIC WATERSHED ASSESSMENT

The geomorphic assessments presented herein were conducted by JE Fuller/Hydrology & Geomorphology, Inc., 8400 South Kyrene Road, Suite 201, Tempe, Arizona. As part of the assessment, geology information in the report titled "Geotechnical Input for Preparation of Environmental Impact Report, Lomas del Sol Project, Coachella, Riverside County, California" (Petra, 2005) was reviewed.

2.1 Project site and immediate surroundings

The field assessment was conducted on December 29, 2011.

2.1.1 Description

The proposed La Entrada Community Development (Project) Site is located on a piedmont bajada composed of steep-sloped active and relict alluvial fans. In the upper piedmont, the active alluvial fan areas consist of wide, highly braided floodplains confined shallow canyons formed by topographically higher, relict fan deposits with some volcanic bedrock units. In the lower piedmont, the active fan areas consist of a series of overlapping, low relief, surfaces that comprise a broad bajada that spans the entire project limits. The active fans do not have a strongly defined fan shape, but there is ample evidence of the potential for flow path uncertainty, avulsion, and high rates of sediment transport. There is some surface differentiation within the active portions of the upper piedmont braided flow corridors, but all of the younger surfaces within the shallow canyon floors could be considered potentially flood-prone or at risk of lateral erosion, unless more detailed modeling is completed to justify a different conclusion. Similarly, any surface differentiation between late to mid-Holocene units (Qf1-Qf3) on the lower piedmont is of limited utility from a floodplain and drainage engineering perspective.

2.1.2 Review of project-related geologic studies

Based on field observations, the Petra Geologic Report appears to adequately characterize the site geomorphology for the purposes of flood hazard assessment. A Stage 1 and Stage 2 alluvial fan delineation could readily be prepared from the information derived from the Petra Geologic Report. However, given that the proposed development will significantly alter the existing alluvial fan and riverine floodplains on the site, there is no reason to delineate a baseline floodplain.

Key observations from the Petra Report include the following:

- The modern sedimentation rate is 1 foot per 1,000 years. This translates to an average aggradation rate of 0.1 feet/100 years, or 0.001 feet/year. Given this rate of long-term aggradation and the lack of potential for debris flows, it may be concluded that the alluvial fans on the Project site are fluvial fans. Therefore, the primary avulsion mechanisms will be stream capture (piracy), and gradual channel fill combined with overbank flow concentration.
- No evidence of debris flows was reported at the site. Watershed conditions and the distance from the mountain watershed make runout of debris flows past the I-10 corridor highly improbable.
- The Qf1 and Qf2 surfaces mapped by Petra may be considered to be active alluvial fans.
- The Qf3 surface was determined to be > 3,000 years old, but was included in the surfaces for which the modern sedimentation rate applies. Based on my field observations, I would include the Qf3 surface as subject to alluvial fan flooding, unless FLO2D modeling definitively indicates that the surface cannot be inundated.

2.2 Geomorphic watershed assessment of the upper piedmont

2.2.1 Description

A geomorphic analysis was conducted to identify regional watershed boundaries on the upper piedmont for use in developing offsite flow rates for design of the La Entrada Project.

The La Entrada Project is located on a piedmont bajada composed of steep-sloped active and relict alluvial fans. The bajada extends from the San Bernardino Mountains, across the western extension of the Mecca Hills to the floor of the Coachella Valley. After leaving the front range of eastern San Bernardino Mountains, the off-site watersheds that drain to the La Entrada Project cross a series of active and inactive alluvial fans on the upper piedmont near the mountain front. Further downstream, the piedmont becomes confined in shallow canyons formed by topographically higher, relict fan deposits with some volcanic bedrock units before entering the La Entrada project limits. The active fans in the upper piedmont do not have a strongly defined fan shape, but there is some evidence of the potential for flow path uncertainty and relatively high rates of sediment transport. This geomorphic analysis is intended to help evaluate the effects of potential flow path uncertainty on watershed delineation and peak flow estimates.

2.2.2 Methodology

The geomorphic analysis was based on aerial photographic interpretation, evaluation of topographic, geologic and soils maps, and field observations. Surficial characteristics such as development of desert varnish, desert pavement, weathering of surface rock, color, channel pattern, drainage network development, channel incision, topographic relief, and vegetative suites were examined to identify active and relict fluvial processes. These surficial characteristics are indicative of surface age, which in turn is indicative of the flood and erosional history of the surface. That is, old surfaces become "old" by not being subject to flood inundation or to widespread erosion and sediment deposition. Using this methodology, active and inactive areas on the piedmont were readily distinguished. Active areas are subject to potential flow path uncertainty. For inactive areas, flow path uncertainty can be set aside.

2.2.3 Results

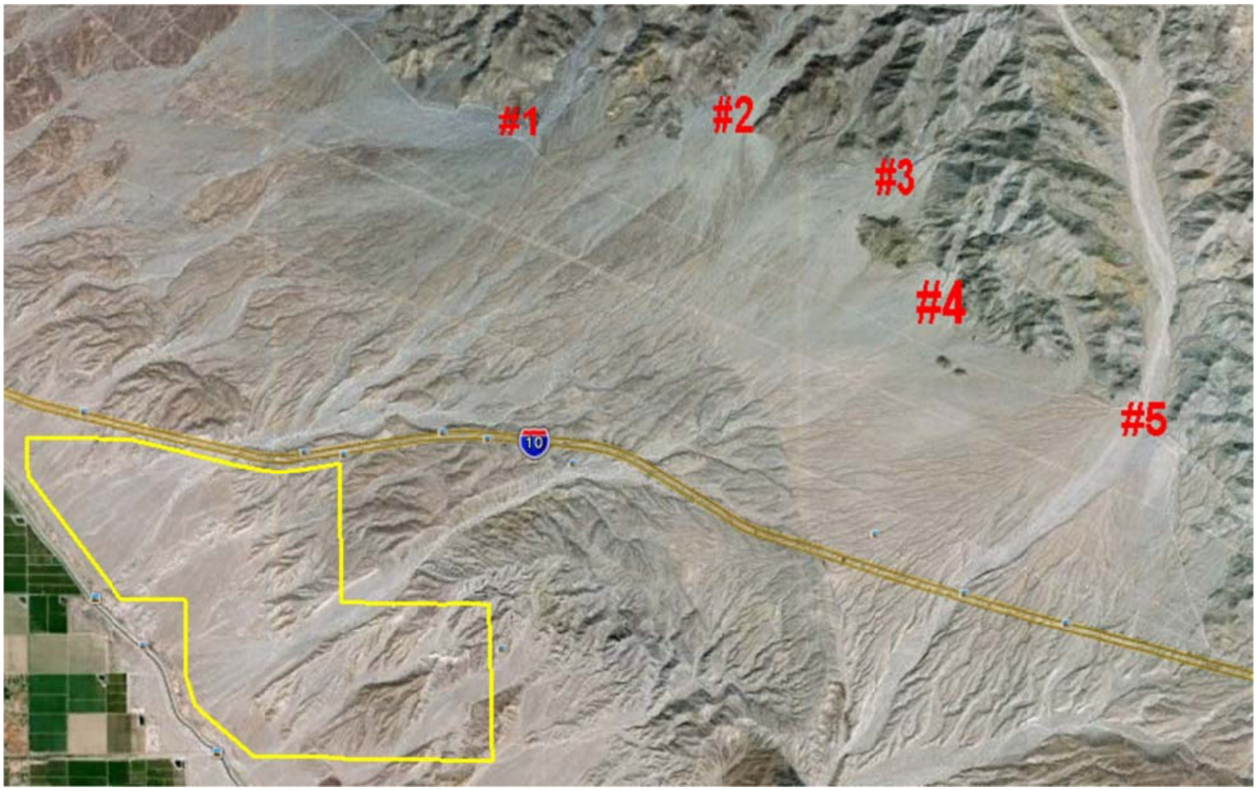
The study area was divided into five areas of interest, as indicated in Figure 2-1. The five areas of interest correspond to the five most significant watersheds draining onto the San Bernardino Mountain Piedmont toward the La Entrada Project.

The following general findings apply to the entire study area:

- None of the areas have large mountain watersheds, reach high elevations or have dense vegetative cover vulnerable to wildfire impacts.
- The active alluvial fans in the study area are subject only to fluvial processes. None of the alluvial fans are at risk of debris flows downstream of the mountain front.
- The active alluvial fan areas are limited in extent. The active portions of the piedmont are located adjacent the mountain front and do not extend downstream to the I-10 corridor. Secondary active apexes are located on some portions of the piedmont within the La Entrada Project limits downstream of I-10.
- Large portions of the piedmont are inactive or are subject to shallow sheet flooding.
- The active alluvial fan areas are bounded by topographically higher, geomorphically older surfaces.
- Evidence of Stage III carbonate (> 100,000 yrs.) was observed in cuts into the older, higher surfaces.
- The piedmont has been dominated by erosional/transport processes in recent geologic time, and has very limited areas of net aggradation. Within engineering time scales, net aggradation will be minimal, as will the effect of sedimentation aggradation on drainage boundaries.

- No evidence of significant long-term scour was observed in the 1-10 bridge crossings where the natural canyon width was significantly narrowed by bridge construction, suggesting that the channel corridors in the study area may not be sensitive to man-made width changes.
- The channel morphology on the fan surface suggests that infiltration is an important process on the inundated portions of the active and inactive fan surface.
- Given the limited deposition on the bajada upstream of the project, and the dominance of erosion processes on the piedmont, the expected impact of such changes on the hydrology and sediment inflow to the project will be minimal and well within the normal range of error of estimate.

Figure 2-1. Aerial photograph showing the five areas of interest (red)



Note: Project boundary is indicated in yellow

Specific findings related to Area #1 (Figure 2-2*).* Area #1 is the westernmost of the piedmont drainage systems considered in this analysis. The following conclusions were drawn from the geomorphic analysis:

- The active alluvial fan area trends due west after leaving the mountain front and does not impact the hydrology at the La Entrada Project.
- There is a well-defined topographic rise that directs flow to the west in the vicinity of the dirt road shown in Figure 2.
- If runoff enters the area labeled as "Possible Overflow" it occurs only during rare large floods and consists of shallow sheet flooding or stable distributary flow.
- There is very limited potential for runoff from Area #1 to intermingle with or break over and reach runoff from Area #2. Any flow intermingling outside of the active fan areas consists of shallow sheet flooding over watershed divides or flow between stable distributaries, not subject to avulsions connected to the fan apex.
- Initial field evidence indicates that the surfaces are much older (no recent overtopping) than they appear on the aerials.

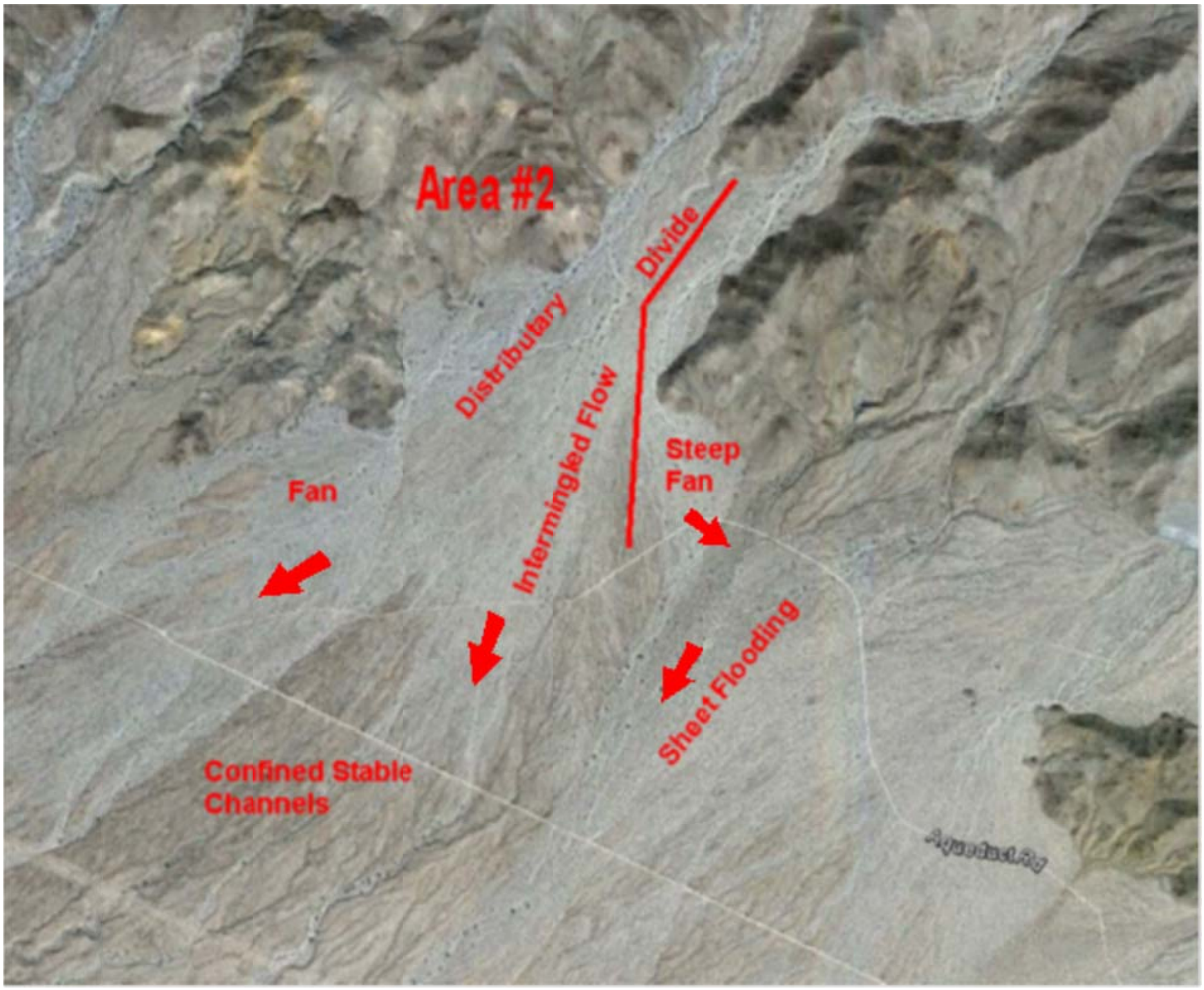
Figure 2-2. Aerial photograph of Area #1 showing active and inactive portions of the piedmont.

Note: red arrow indicates the dominant flow direction.

Specific findings related to Area #2 (Figure 2-3). Area #2 is the westernmost of the piedmont drainage systems that impacts the La Entrada Project. The following conclusions were drawn from the geomorphic analysis:

- Area #2 consists of two coalescing fans with an intermediate area that may accept flow from both sources.
- The active alluvial fan area is located primarily within the embayment upstream of the mountain front, but in places extends downstream to the Aqueduct Road. Below the Aqueduct Road, the piedmont consists of inactive alluvial fan surface, stable distributary flow areas, and sheet flooding areas.
- The western portion of the active alluvial fan area consists of fine textured surfaces with many low islands of older surfaces, indicating very slow net aggradation and rare avulsions. It is more likely to be a stable distributary or sheet flooding area.
- All of the flow bifurcations in the active alluvial fan area rejoin before crossing the I-10 corridor and entering the La Entrada Project. Any flow intermingling outside of the active fan areas consists of shallow sheet flooding over watershed divides or flow between stable distributaries, not subject to avulsions connected to the fan apex.

Figure 2-3. Aerial photograph of Area #2 showing active and inactive portions of the piedmont.

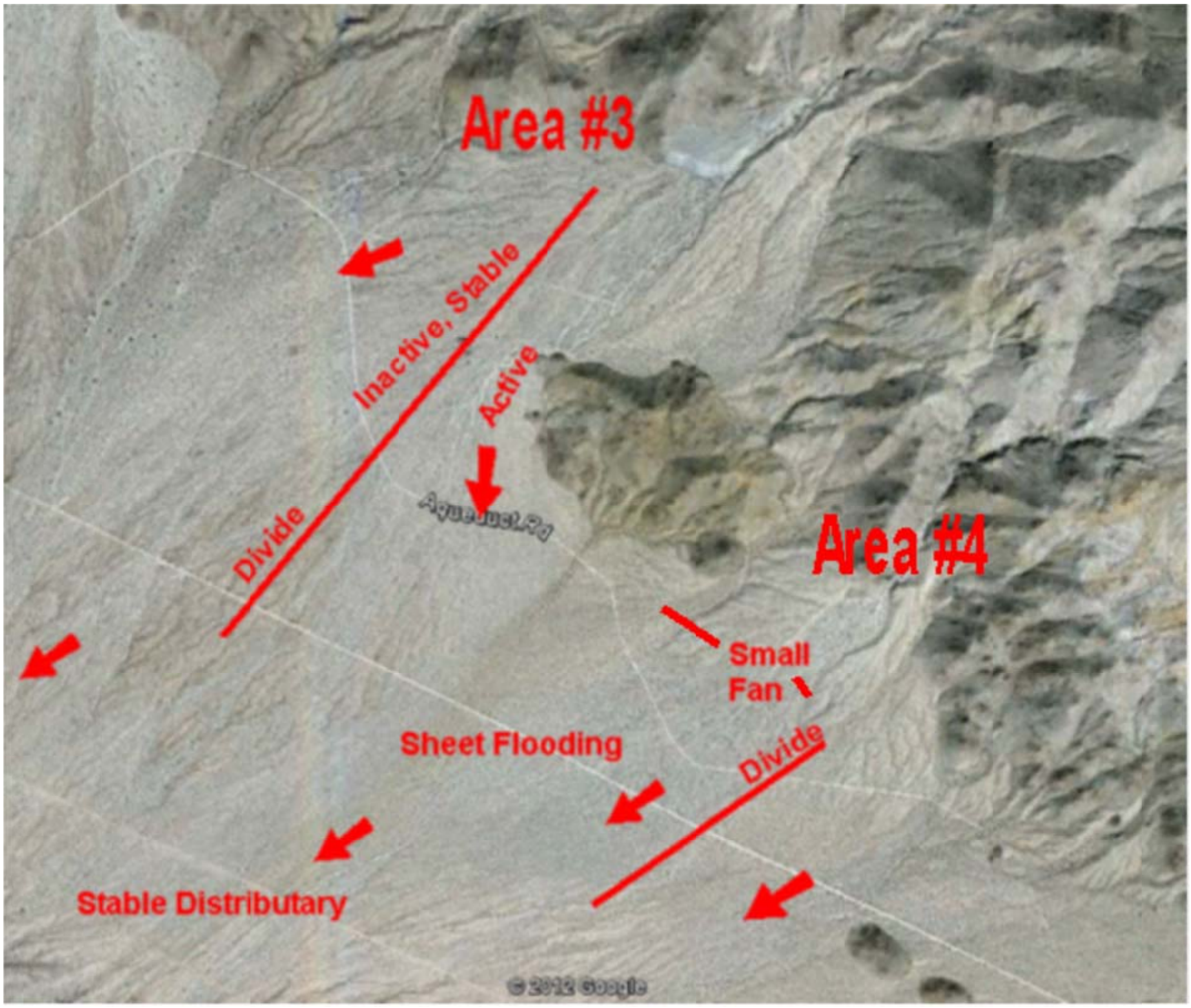


Note: red arrow indicates the dominant flow direction.

Specific findings related to Area #3 and Area #4 (Figure 2-4). Areas #3 and #4 have some potential for flow intermingling along their divide. Area #3 drains primary to the westernmost crossing of I-10 upstream of La Entrada. Area #4 drains primarily toward the south. The following conclusions were drawn from the geomorphic analysis:

- There is a very small, steep active alluvial fan in Area #3 near point of the prominent inselberg. Runoff on this fan drains toward the fosse that separates Area #3 and #4. Upon reaching the fosse, runoff is conveyed primarily as sheet flooding.
- The active alluvial fan areas do not extend past the Aqueduct Road.
- The remainder of this area is subject to sheet flooding or stable distributary flooding areas.
- Area #4 is not an active alluvial fan. It is possible that some of the sheet flooding in the mid-piedmont portion of Area #4 intermingles with sheet flooding from Area #3.

Figure 2-4. Aerial photograph of Areas #3/4 showing active and inactive portions of the piedmont.



Note: red arrow indicates the dominant flow direction.

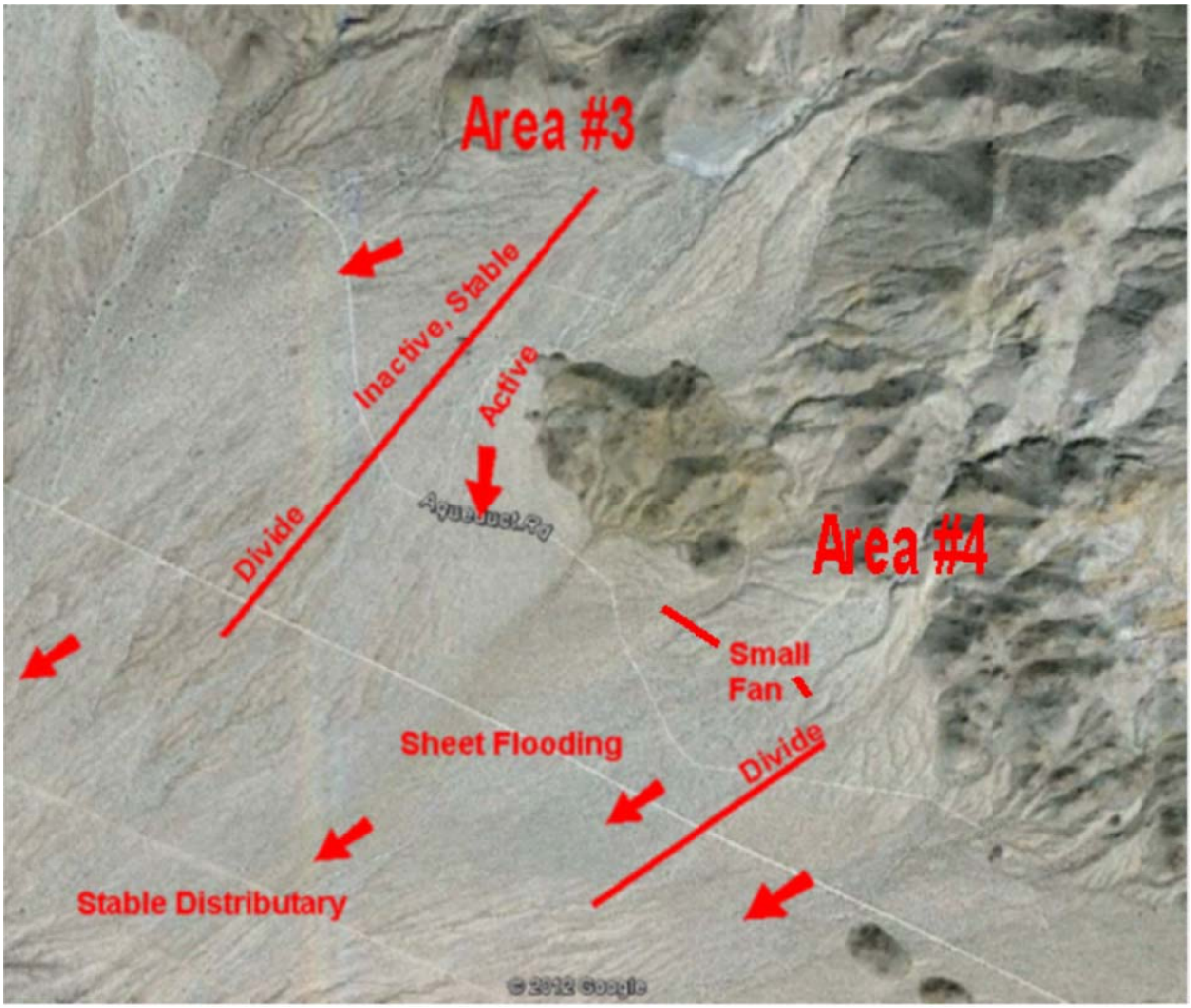
Discussion of flow intermingling between Area #3 and Area #4. If flow from Area #3 and #4 intermingle, they have the potential to affect peak discharge estimates at the Smoky Gulch (west) and Sunny Gulch (east) crossings of the I-10 corridor, as well as the areas downstream within La Entrada. From a geomorphic perspective, the drainage from the Area #3 fan flows directly at the fosse, before turning to the southwest and flowing along the "divide" with Area #4. It appears that most of the runoff from Area #3 tends to ultimately flow toward the Smoky crossing, with a small amount possibly breaking over the "divide" toward the Sunny crossing. Similarly, the westernmost drainage in Area #4 crosses it's upper piedmont, and drains obliquely toward the #3/#4 fosse before turning to the southwest and flowing along the "divide." All of the other drainage basins from Area #4 do not flow toward the fosse, and appear to have no potential of reaching, let alone for overflowing, the divide into the Smoky watershed. Therefore, the only subwatersheds that might contribute runoff to either the Smoky or Sunny crossings are those that flow directly at the fosse.

The fosse is not located on the active fans – by definition it defines the toes or lateral margins of those landforms. Therefore, the question of whether runoff crosses the "divide" after reaching the fosse, is not a question of channel avulsion on an active alluvial fan, it is a question of flow distribution in a shallow sheet flooding area.

Specific findings related to Area #5 (Figure 2-5). Area #5 is the easternmost of the piedmont drainage systems considered in this analysis. The following conclusions were drawn from the geomorphic analysis:

- Area #5 is not an active alluvial fan.
- No runoff from Area #5 breaks toward La Entrada, and hasn't for 100,000's of years.
- No runoff breaks into Area #5 from the west. The inactive fan is an effective divide.

Figure 2-5. Aerial photograph of Area #5 showing only inactive portions of the piedmont.



Note: red arrow indicates the dominant flow direction.

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3 REGIONAL HYDROLOGY

The regional hydrology for the proposed La Entrada Specific Planning Area (Project) watershed was developed for the Baseline (existing) and Project conditions, focusing on the 10 major subbasins (Figure 3-1), which lie tributary to the northerly segment of Coachella Canal Dike No. 1 (Eastside Dike). Floodwaters temporarily impounded by the Eastside Dike are discharged to the Whitewater River (Coachella Valley Storm Drain Channel) via Wasteway No. 2 which is located along the southerly side of Avenue 52. Wasteway No. 2 includes a triple 6' x 6' reinforced concrete box underneath the Coachella Canal connecting to a reinforced concrete rectangular channel of similar basewidth.

The Project watershed is approximately 50.6 square miles, based on a 5-meter digital terrain model developed from interferometric synthetic aperture radar (IFSAR) data (Intermap Technologies, 2005). There are seven subbasins, which intersect the Project (1, 2, 3, 4, 5, 6, and 7). Subbasins 3, 6, and 7 are associated with the three Interstate 10 (I-10) bridge crossings, identified as Echo Gulch (Subbasin 3), Smoky Gulch (Subbasin 6), and Sunny Gulch (Subbasin 7). These subbasins obviously extend beyond the I-10 corridor onto the upper piedmont and terminate at the headwaters of the Little San Bernardino Mountains. The headwaters of Subbasins 1, 2, 4, and 5 terminate at the I-10 corridor.The remaining subbasins (1A, 1B, and 7A) flank the Project boundaries without intersection. Subbasin 1A represents Thermal Canyon, the predominant drainage tributary to Wasteway No. 2 accounting for roughly 20 square miles.

The regional hydrology was developed to determine impacts and subsequent mitigation requirements related to flood conveyance through the Project and the temporary impoundment of floodwaters along the Eastside Dike.

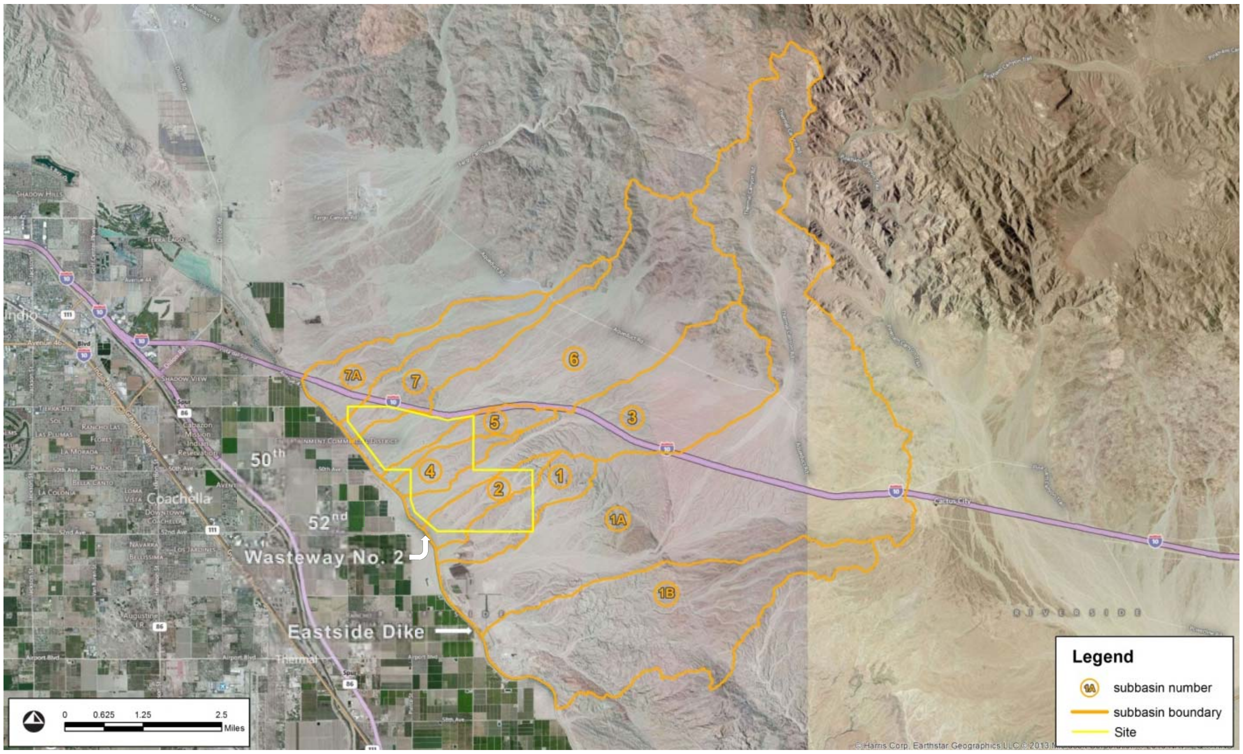
Baseline and Project conditions short-duration (3- and 6-hour events) 10- and 1-percent annual chance flood hydrographs were developed as part of the evaluation of those regional flood conveyances, which intersect the Project (Subbasins 1, 2, 3, 4, 5, 6, and 7). Flood hydrograph results were produced at upstream Project boundaries, confluences, and along the Eastside Dike.

Baseline and Project conditions 1-percent annual 24-hour duration and Standard Project Flood (SPF) flood hydrographs were developed for all regional subbasins extending down to the Eastside Dike as part of the evaluation of temporary impoundment impacts along the Eastside Dike.

3.1 Synthetic Unit Hydrograph Method

The Synthetic Unit Hydrograph Method (SUHM) described in the Riverside County Hydrology Manual (RCHM; RCFCWCD, 1978) was used to develop flood hydrographs for each subbasin delineated within the Project Watershed. The SUHM is statistically based, assuming the watershed discharge is related to the total volume of runoff. The time factors affecting the shape of the SUHM are dominant. The watershed storm rainfall-runoff relationships are characterized by watershed area, slope, and shape factors. The SUHM is used to estimate the time distribution of watershed runoff in drainage basins where stream gauge information is not available. In Riverside County, the SUHM is normally used to evaluate single area drainage basins in excess of 300 acres.

Figure 3-1. Eastside Dike and Project watershed (subbasins 1A, 1B, and 7A not shown)



3.1.1 Infiltration characteristics

The infiltration method prescribed in the RCHM was applied in the development of the 1-percent annual chance 3-hour AMC II flood hydrographs used in the performance of the drainage boundary analysis (see Section 3.2). This method was later superseded for all subsequent regional hydrologic analysis (see Section 3.3)

The low loss fraction was assigned a value of 0.9 for all subbasins under all conditions, which is consistent with Riverside County practices for regionally-based hydrology studies. For 24-hour duration events, the minimum loss rate (F_{min}) was assumed equal to 50 percent of the maximum loss rate as suggested by the RCHM.

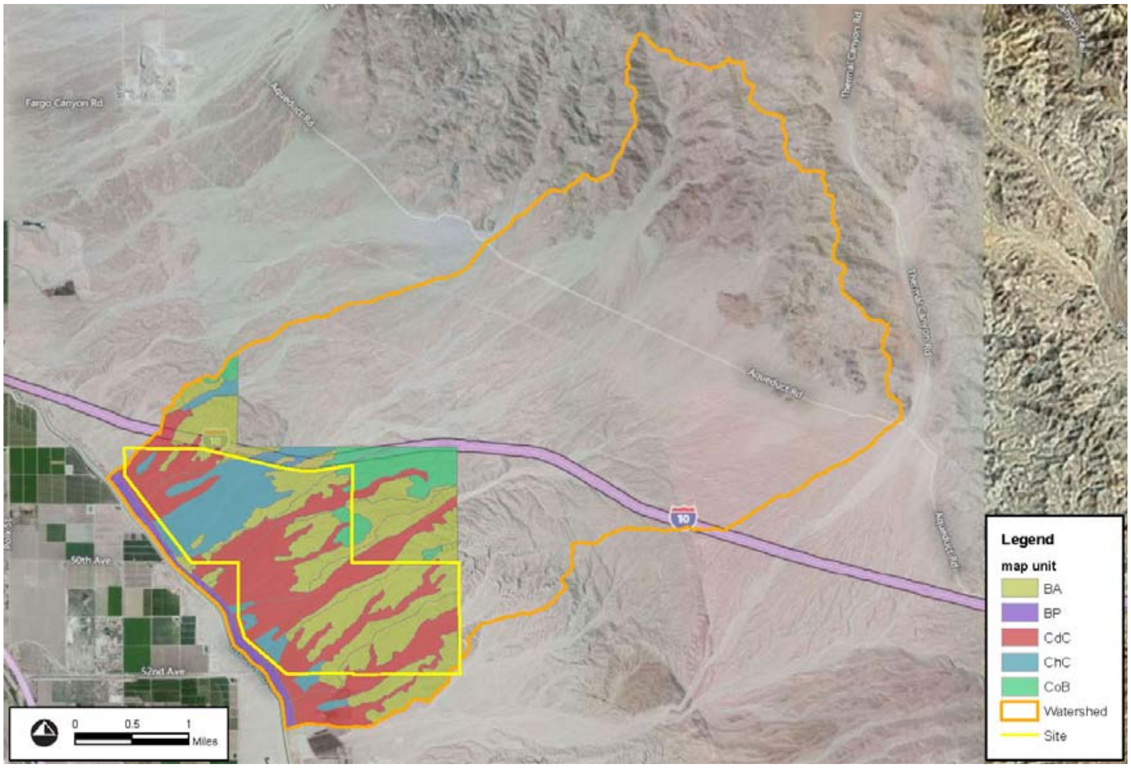
The infiltration method described in the RCHM is SCS-based, relying on the classification of soils into four hydrologic groups: (1) Group A-soils, which are composed primarily of sand, loamy sand, or sandy loam soil textures, have low runoff potential due to high infiltration rates with water transmission rates in excess of 0.30 in/h for bare soil conditions; (2) Group B-soils, which are mostly represented by silt loam or loam soil texture, have low to moderate runoff potential with water transmission rates ranging from 0.30 to 0.15 in/h for bare soil conditions, (3) Group C-soils, which are predominantly characterized by sand clay loam or similar composite soil texture, have moderate to high runoff potential with water transmission rates ranging from 0.15 to 0.05 in/h for bare soil conditions, and (4) Group D-soils, which are composed of clay loam, silty clay loam, sandy clay, silty clay, or clay soil texture, have high runoff potential with water transmission rates not exceeding 0.05 in/h for bare soil conditions.

In Riverside County, the Natural Resources Conservation Service (NRCS) detailed soil survey maps are typically used to determine the distribution of hydrologic soil groups within the drainage basin of interest. Unfortunately, the only detailed soil map with any coverage in the Project Watershed is the Coachella Valley Area Soil Survey (NRCS, 1978), which encompasses about 10 percent of the Project Watershed (Figure 3-2); therefore, as a recourse, the NRCS U.S Generalized Soils Map was considered for supplementing soil information for the remainder of the Project watershed (Figure 3-3). The composite soil map is shown in Figure 3-4.

The NRCS U.S. Generalized Soils Map is coarser in that it combines two or more detailed soil map units into one generalized soil map unit. To test the consistency between the two soil map sources, composite infiltration characteristics were computed based on each source and compared for the same coverage area within the Project Watershed. There are three generalized soil map units located in the Project Watershed (Figure 3-3): (1) myoma – carsitas – carrizo [map unit s991], (2) rock outcrop – nillito – beeline – badland [map unit s995], and (3) rock outcrop – lithic torriorthents [map unit s1130]. The composite distribution of hydrologic soil groups for each of these map units was determined based on the breakdown of detailed map units, which form each generalized map unit. The results of this composition analysis are presented in Table 3-1 (s991), Table 3-2 (s995), and Table 3-3 (s1130).

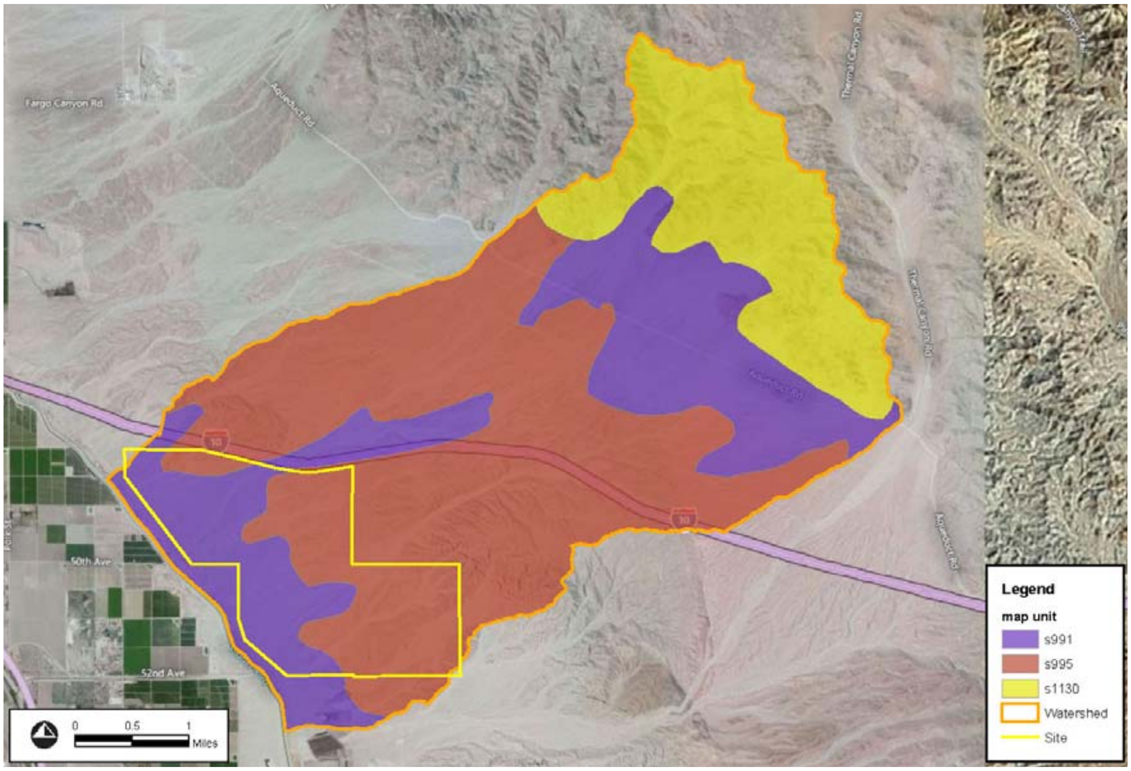
The composite RCHM pervious loss rate (F_p) as well as the saturated hydraulic conductivity (XKSAT) and percent imperviousness (RTIMP) were computed based on the NRCS Coachella Valley Area detailed soils information (Table 3-4) and NRCS U.S. generalized soils data (Table 3-5). The evaluated infiltration characteristics are effectively the same for both datasets; therefore, the U.S. Generalized Soils Map is adopted as a soil map source for use in the development of the regional and local hydrology associated with the Project watershed. A list of Project-adopted detailed and generalized soil map units and their infiltration characteristics was compiled as shown in Table 3-6. The XKSAT values were determined based on data published by Rawls et al (1983), Saxton and Rawls (2006), and the Flood Control District of Maricopa County (2009).

Figure 3-2. NRCS Detailed Soils – Coachella Valley Area Soil Survey



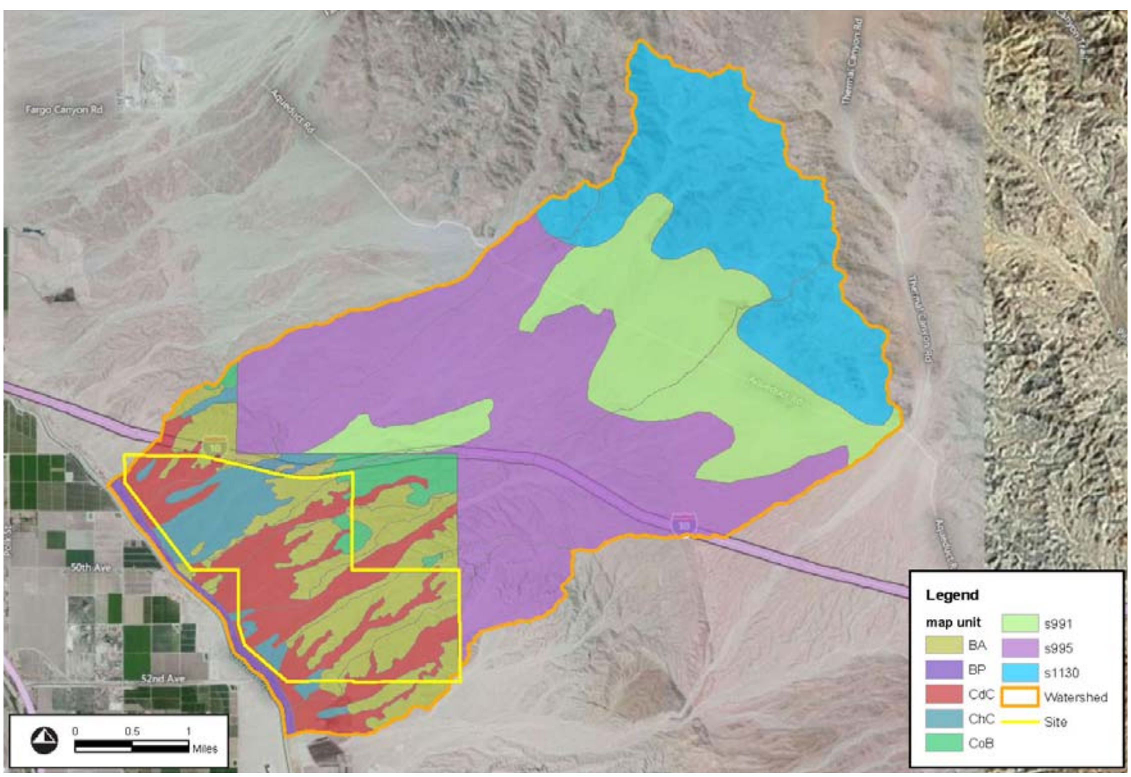
Note: subbasins 1A, 1B, and 7A are not shown

Figure 3-3. NRCS U.S. Generalized Soil Map



Note: subbasins 1A, 1B, and 7A are not shown

Figure 3-4. Composite of NRCS detailed and U.S. generalized soils



Note: subbasins 1A, 1B, and 7A are not shown

Table 3-1. Hydrologic soil group distribution for myoma – carsitas – carrizo (s991)

U.S. Generalized Map Unit: myoma-carsitas-carrizo {s991}					
composition		hydrologic soil group			
map unit	percent	A	B	C	D
carsitas	12	12			
riverwash	1	1			
carrizo	10	10			
carsitas	29	29			
myoma	18	18			
myoma	12	12			
myoma	1	1			
carsitas	15	15			
carsitas	2	2			
total:	100	100	0	0	0

Table 3-2. Hydrologic soil groups for rock outcrop-nillito-beeline-badland (s995)

U.S. Generalized Map Unit: rock outcrop-rillito-beeline-badland {s995}					
composition		hydrologic soil group			
map unit	percent	A	B	C	D
chuckawalla	2		2		
carsitas	3	3			
badland	46				46
rillito	10		10		
aco	2		2		
carrizo	2	2			
beeline	20				20
rock outcrop	10				10
lithic torriorthents	5		5		
total:	100	5	19	0	76

Table 3-3. Hydrologic soil group distribution for rock outcrop – lithic torriorthents (s1130)

U.S. Generalized Map Unit: rock outcrop-lithic torriorthents {s1130}					
composition		hydrologic soil group			
map unit	percent	A	B	C	D
lithic torriorthents	9		9		
lithic torriorthents	15		15		
calvista	5		5		
hi vista	2			2	
hi vista	1			1	
tecopa	2				2
tecopa	1				1
trigger	1		1		
rock outcrop	55				55
rubble land	3				3
cajon	1	1			
knob hill	1		1		
bitter	1				1
calvista	2				2
arizo	1	1			
total:	100	2	31	3	64

Table 3-4. Lower drainage AMCI II soil loss rate comparison – NRCS CVA survey area soils

NRCS survey area	MUSYM	drainage area {acres}	XKSAT {in/hr}	RTIMP {%}	hydrologic soil group				F_p* {in/hr}
					A	B	C	D	
CA680	BA	1,347	0.155	0.0	0	0	0	100	0.120
CA680	BP	174	0.000	0.0	0	0	0	100	0.120
CA680	CdC	1,246	0.890	0.0	100	0	0	0	0.440
CA680	ChC	474	0.840	0.0	100	0	0	0	0.440
CA680	CoB	290	0.056	0.0	0	0	0	100	0.120
		3,530	0.490	0.0	49	0	0	51	0.276

*based on desert shrub, poor cover: CN equal to 63, 77, 85, and 88 for hydrologic soil groups A, B, C,and D, respectively

Table 3-5. Lower drainage AMC II soil loss rate comparison – NRCS U.S. generalized soils

NRCS survey area	MUSYM	drainage area {acres}	XKSAT {in/hr}	RTIMP {%}	hydrologic soil group				F_p* {in/hr}
					A	B	C	D	
US	s991	1,478	0.990	0.0	100	0	0	0	0.440
US	s995	2,052	0.101	10.0	5	19	0	76	0.166
US	s1130	0	0.342	55.0	2	31	3	64	0.178
		3,530	0.496	5.8	45	11	0	44	0.281

*based on desert shrub, poor cover: CN equal to 63, 77, 85, and 88 for hydrologic soil groups A, B, C,and D, respectively

Table 3-6. Adopted natural pervious AMC II soil loss rate characteristics

NRCS survey area	MUSYM	hydrologic soil group				F_p* {in/h}
		A	B	C	D	
US	s991	100	0	0	0	0.440
US	s995	5	19	0	76	0.166
US	s1130	2	31	3	64	0.178
CA680	BA	0	0	0	100	0.120
CA680	BP	0	0	0	100	0.120
CA680	CdC	100	0	0	0	0.440
CA680	ChC	100	0	0	0	0.440
CA680	CoB	0	0	0	100	0.120
CA680	GP	100	0	0	0	0.440
CA680	Is	0	100	0	0	0.280
CA680	MaB	100	0	0	0	0.440

*based on desert shrub, poor cover: CN 63, 77, 85, and 88 for hydrologic soil groups A, B, C,and D, respectively

3.1.2 Frequency-duration precipitation depths

The 3-, 6-, and 24-hour storm patterns shown on RCHM Plate E-5.9 were used in conjunction with the 10- and 1-percent annual chance area-weighted average maximum point precipitation depths determined from NOAA Atlas 14 (NA14; NWS, 2011). The frequency-duration precipitation depth isohyetals (represented in inches) used to develop the model rainfall parameters are presented in the following figures:

- Figure 3-5: 10-percent annual chance 3-hour precipitation depth isohyetals
- Figure 3-6: 10-percent annual chance 6-hour precipitation depth isohyetals
- Figure 3-7: 1-percent annual chance 3-hour precipitation depth isohyetals
- Figure 3-8: 1-percent annual chance 6-hour precipitation depth isohyetals
- Figure 3-9: 1-percent annual chance 24-hour precipitation depth isohyetals

The 24-hour precipitation depths were reduced to account for the variability in the hydrologic processes across the entire Project watershed (50.6 square miles) using the appropriate depth-areal reduction curve from Plate E-5.8 (RCHM; RCFCWCD, 1978).

The short-duration events were only applied to the individual regional conveyances, which intersect the Project. The subbasins corresponding to these regional conveyances (1, 2, 3, 4, 5, 6, and 7) exhibit tributary drainages less than 10 square miles and therefore, do not warrant a reduction in precipitation depth.

The Standard Project Flood (SPF) was analyzed based on the Indio Storm of September 24, 1939, which produced a total precipitation depth of 6.45 inches in 6 hours. This value was reduced using the depth-areal reduction curve developed by the USACE for this same event. The curve was taken from the USACE report titled "Imperial Valley Standard Project Summer Thunderstorm Instructions for Computation of Rainfall" (USACE, 1972). This version of the chart was also used in the Draft "Without Project" Hydrology Report, Thousand Palms Area, Whitewater River Basin Riverside and San Bernardino Counties, California (Bechtel, 1997). An orographic transposition factor of 1.0 was identified for use in the Whitewater basin (USACE, 1972). Based on a combined tributary drainage of 50.6 square miles, which approximately represents the watershed tributary to Wasteway No. 2, the depth-areal reduction factor is 0.78. This factor reduces the depth down to 5.03 inches. This reduced depth was assumed for all subbasins analyzed for the SPF. The 6-hour storm pattern shown on RCHM Plate E-5.9 is based on the Indio Storm of September 24, 1939 and therefore, was used to analyze the SPF.

Figure 3-5. NA14 10-percent annual chance 3-hour precipitation depth isohyetals

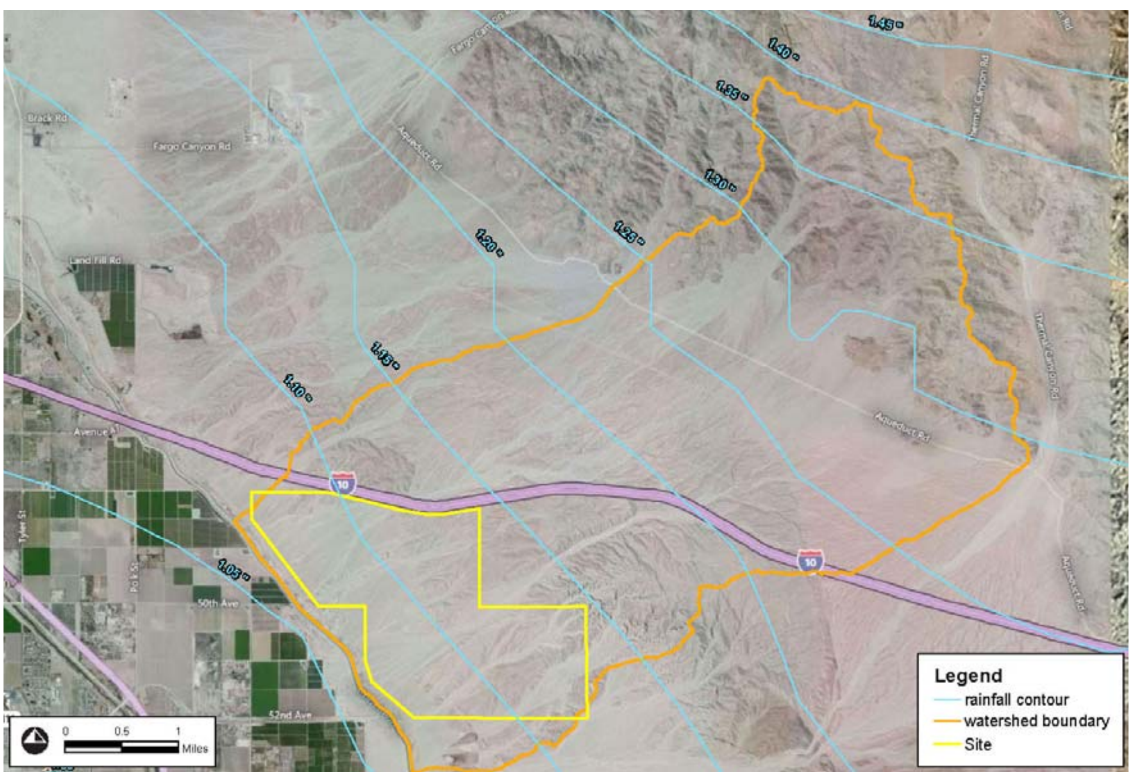


Figure 3-6. NA14 10-percent annual chance 6-hour precipitation depth isohyetals

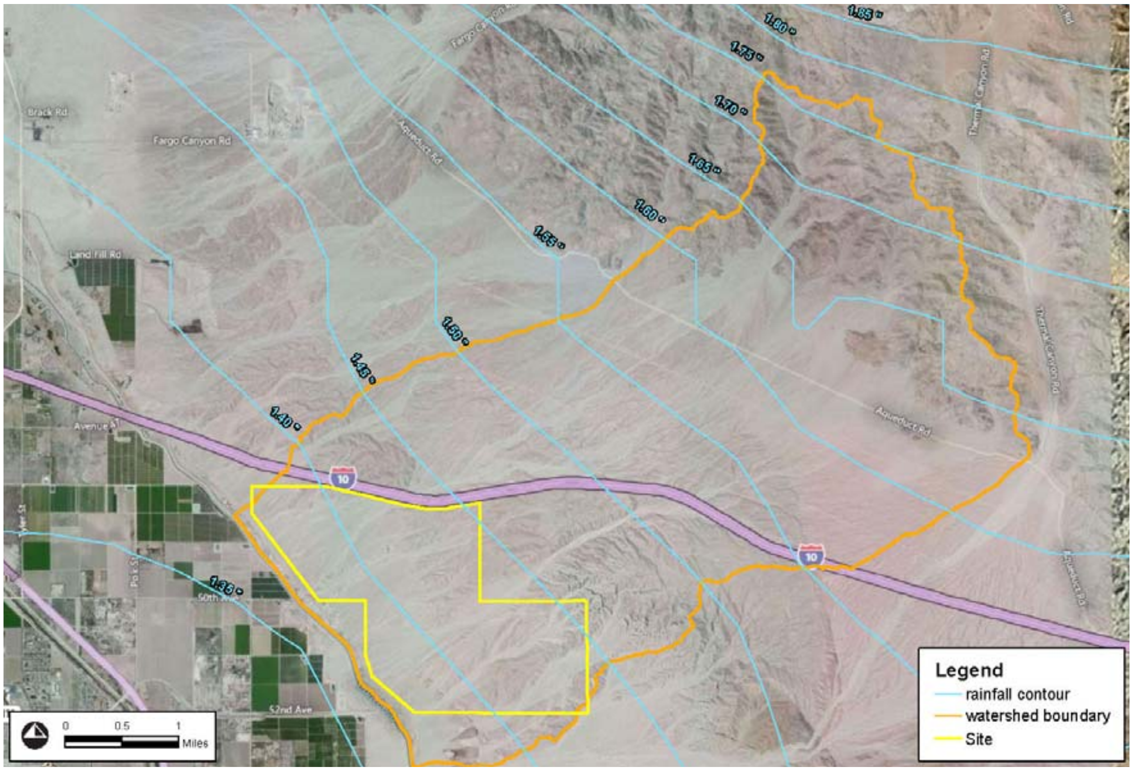


Figure 3-7. NA14 1-percent annual chance 3-hour precipitation depth isohyetals

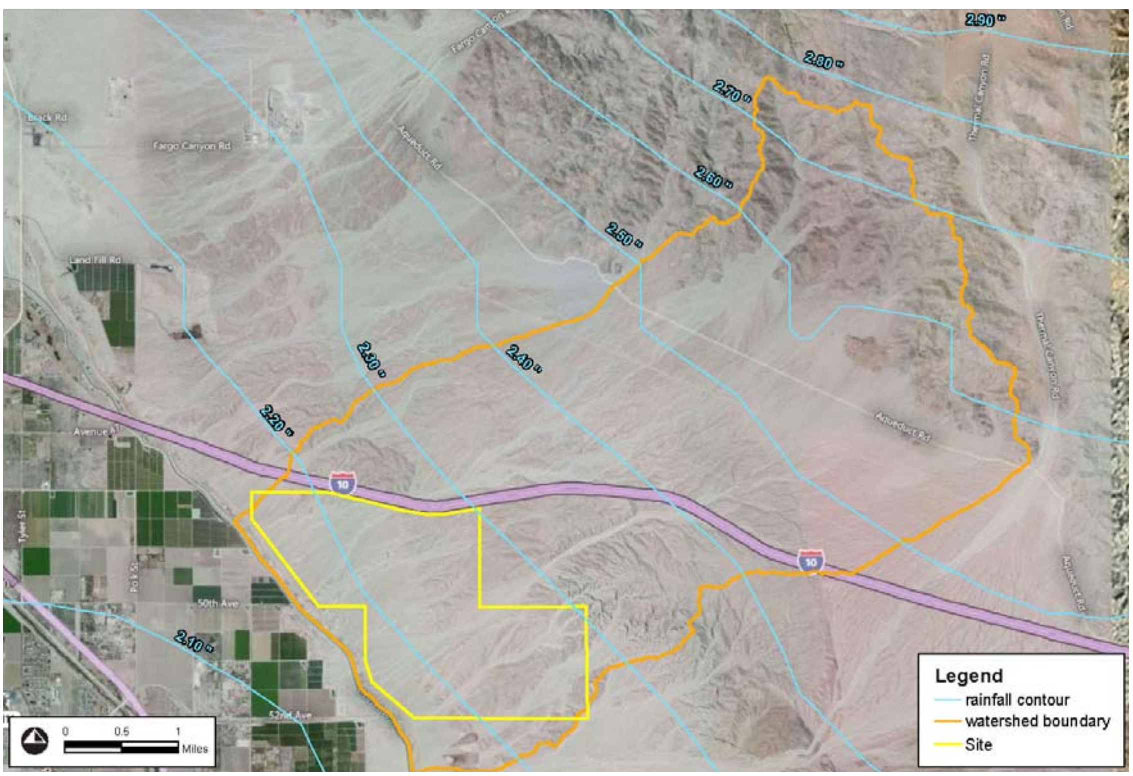


Figure 3-8. NA14 1-percent annual chance 6-hour precipitation depth isohyetals

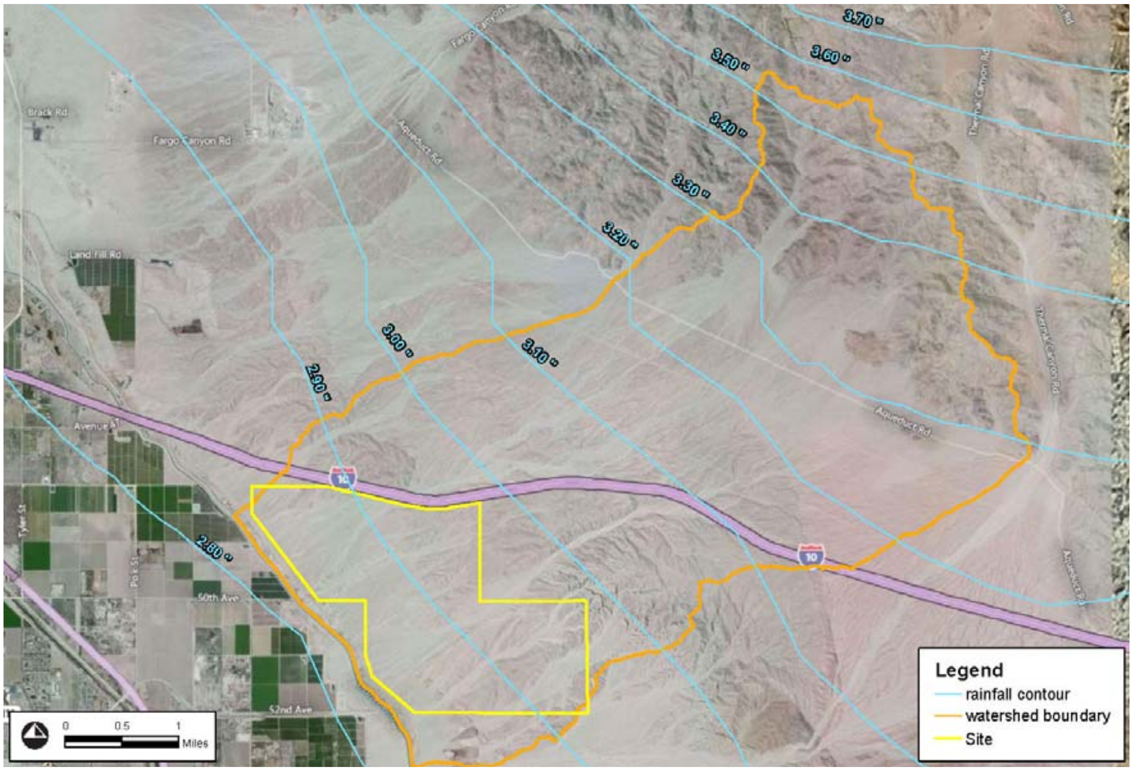
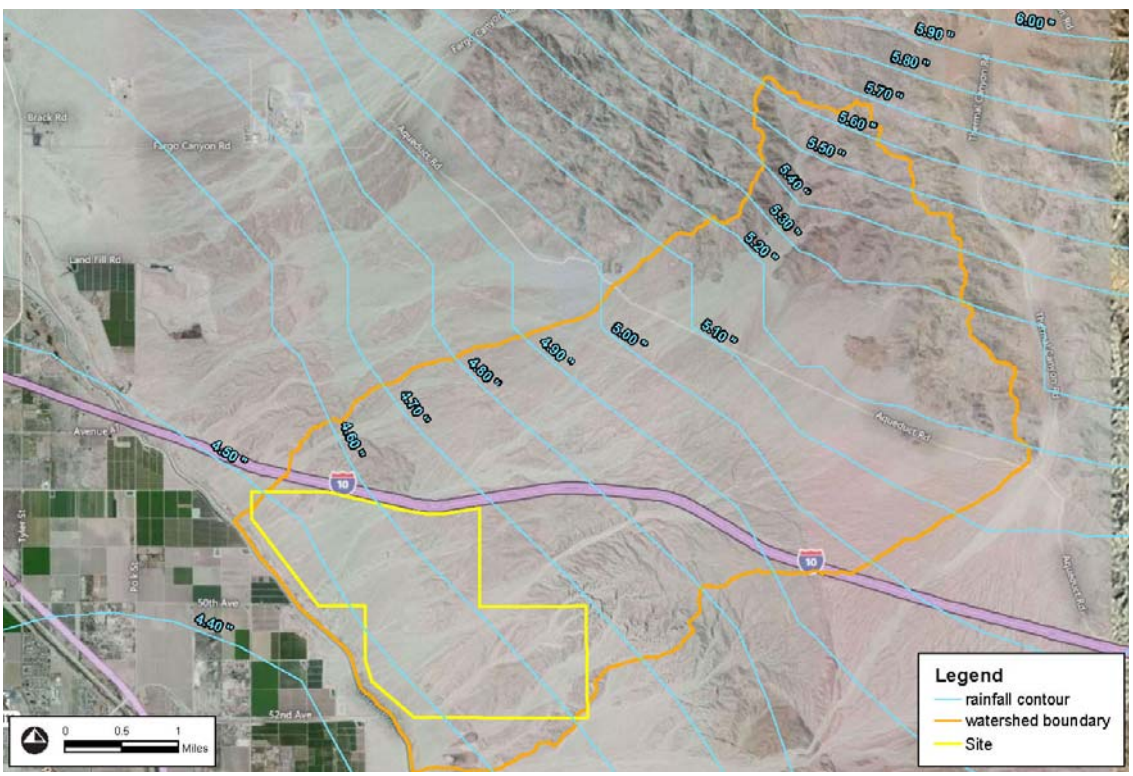


Figure 3-9. NA14 1-percent annual chance 24-hour precipitation depth isohyetals



3.1.3 Synthetic unit hydrograph development

A spreadsheet was used to compute the unit hydrograph parameters for each flood hydrograph developed. The unit hydrograph lag parameters were determined as described below:

Watercourse lengths. The length of the longest watercourse (L) and the length along the longest watercourse from downstream to a line that intersects the area centroid and longest watercourse and is perpendicular to the longest watercourse (LCA) were computed for each delineated subbasin using Intermap data.

Representative slope. The representative slope of the longest watercourse (S) was determined for each analyzed subbasin by balancing the area above and below a constant slope (representative slope) formed between the longitudinal profile (determined from topographic data) and the constant slope.

Basin factor. A composite basin factor (N) for natural conditions was determined for each delineated subbasin within the Project Watershed based on a general correlation observed between the landforms and soil map units within the Project Watershed. A basin factor of 0.03 was assumed for A-, B-, and C-grouped soils and a basin factor of 0.05 was assumed for D-type soils. This is a conservative assumption given that more than 90 percent of the watershed will likely experience shallow flooding less than 0.5 feet in depth. Shallow flooding n-values typically range from 0.05 to 0.3 (USACE, 1997), influenced by gradient, uniformity of the terrain, soil texture, and vegetation. The presence of vegetation can either raise or lower the hydraulic roughness of the terrain depending on the physical nature of the vegetation, which may lend towards either the concentration (lower n-value) or diffusion (higher n-value) of floodwaters. Changes in landuse and/or the nature of conveyance were incorporated into the weighting of the composite basin factor for those subbasins affected under Project Conditions based on the specific types of changes incurred.

S-graph. The Whitewater S-graph was assumed to represent the runoff response of the Project Watershed. It is the adopted desert S-graph for Riverside County. The Whitewater S-graph was developed by the USACE, Los Angeles District by averaging the S-graphs constructed for nine gauged watersheds located in southern California.

3.1.4 Effective rainfall

The effective rainfall and associated pattern were determined external to HEC-1 using a spreadsheet due to the inability of HEC-1 to directly apply the constant and variable loss rate methods described in the RCHM.

3.2 Verification of drainage boundaries on the upper piedmont

Three subbasins tributary to the Project (Subbasins 3, 6, and 7 as referenced in Figure 3-1) extend north beyond the I-10 corridor onto the upper piedmont and eventually terminate upstream at their headwaters in the Little San Bernardino Mountains. The major I-10 corridor bridges located within the Project watershed are identified by Caltrans as Sunny Gulch, Smoky Gulch, and Echo Gulch. These bridges correlate to Subbasins 3, 6, and 7, respectively. Subbasins 3, 6, and 7, in conjunction with the other local subbasins, were initially delineated using a 5-meter digital terrain model developed from interferometric synthetic aperture radar (IFSAR) data (Intermap Technologies, 2005).

On the upper piedmont, the subbasin boundaries were defined along shallow divides. Where shallow divides appeared nonexistent, boundaries were generally aligned perpendicular to the topographic contours. If two subbasins intersected along a fosse, the shared boundary was defined along the flow line created by the fosse.

To address the uncertainty associated with boundary placement on the upper piedmont, a process was developed and implemented to analyze their influence as it relates to the distribution of runoff volume and development of peak flow rates downstream. This process involved the following steps:

- A geomorphic watershed assessment was performed to determine the potential for event-based flow conditions to change along the exterior and interior subbasin boundaries on the upper piedmont.
- A series of two-dimensional flood routing models were developed using FLO-2D® to analyze the influence the placement of the subbasin boundaries has on the distribution of runoff volume and the development of peak flow rates at the I-10 corridor crossings within the Project watershed.
- Single-node flood hydrograph models were developed using HEC-1 to evaluate the assigned FLO-2D rainfall-runoff parameters using the aggregate runoff volume produced from all three subbasins.

3.2.1 Geomorphology

As part of the evaluation of the subbasin boundaries on the upper piedmont, a watershed geomorphic assessment was conducted and presented in Section 2.2. This assessment concluded with the following points:

- None of the areas have large mountain watersheds, reach high elevations or have dense vegetative cover vulnerable to wildfire impacts.
- The active alluvial fans in the study area are subject only to fluvial processes. None of the alluvial fans are at risk of debris flows downstream of the mountain front.
- The active alluvial fan areas are limited in extent. The active portions of the piedmont are located adjacent the mountain front and do not extend downstream to the I-10 corridor.
- Large portions of the piedmont are inactive or are subject to shallow sheet flooding.
- The active alluvial fan areas are bounded by topographically higher, geomorphically older surfaces.
- Evidence of Stage III carbonate (> 100,000 years) was observed in cuts into the older, higher surfaces.
- The piedmont has been dominated by erosional/transport processes in recent geologic time, and has very limited areas of net aggradation; within engineering time scales, net aggradation will be minimal, as will the effect of sedimentation aggradation on drainage boundaries.

Based on these points, the event-based flow conditions along the subbasin boundaries on the upper piedmont are not expected to change over engineering time. The Project watershed exterior boundary along the southeast limits of the Sunny Gulch subbasin is not subject to significant lateral flow.

3.2.2 Model development and analysis

A series of two-dimensional flood routing models were developed using FLO-2D to evaluate the placement of boundaries on the upper piedmont and their influence as it relates to the distribution of runoff and the development of peak flow rates downstream.

A base model was constructed in association with each of the three major I-10 corridor bridges (Sunny Gulch, Smoky Gulch, and Echo Gulch). For the purpose of this analysis, the subbasins (drainages) tributary to these three crossings are referred to by the same name (i.e., Echo Gulch subbasin, Smoky Gulch subbasin, and Sunny Gulch subbasin). These individual base models are identified as Model A (Echo Gulch subbasin), Model B (Smoky Gulch subbasin), and Model C (Sunny Gulch subbasin).

A composite base model identified as Model ABC was defined by merging the three individual base models (Models A, B, and C). This combined base model in conjunction with the three individual base models were used to analyze the boundary shared between the Echo Gulch drainage and Smoky Gulch drainage as well as between the Smoky Gulch drainage and Sunny Gulch drainage.

Another base model was defined, identified as Model XA, which expands Model A (Echo Gulch subbasin) to include the adjacent exterior drainage along the north boundary of the Echo Gulch subbasin.

This combined base model (Model XA) in conjunction with the base model representing the Echo Gulch subbasin (Model A) were used to analyze the Project watershed exterior boundary.

The model domain boundaries, which correspond to the subbasin boundaries on the upper piedmont, are depicted in the following figures:

- Figure 3-10: Echo Gulch drainage (A), Smoky Gulch drainage (B), and Sunny Gulch drainage (C) tributary to the I-10 corridor.
- Figure 3-11: ABC represents the combined model domains of A, B, and C (no interior drainage boundaries).
- Figure 3-12: Echo Gulch drainage (A) tributary to the I-10 corridor with the adjacent exterior drainage along the north boundary individually depicted as well
- Figure 3-13: XA represents the domain of A combined with the adjacent exterior drainage along the north boundary

Figure 3-10. Models A, B, and C - Individual I-10 crossing drainages

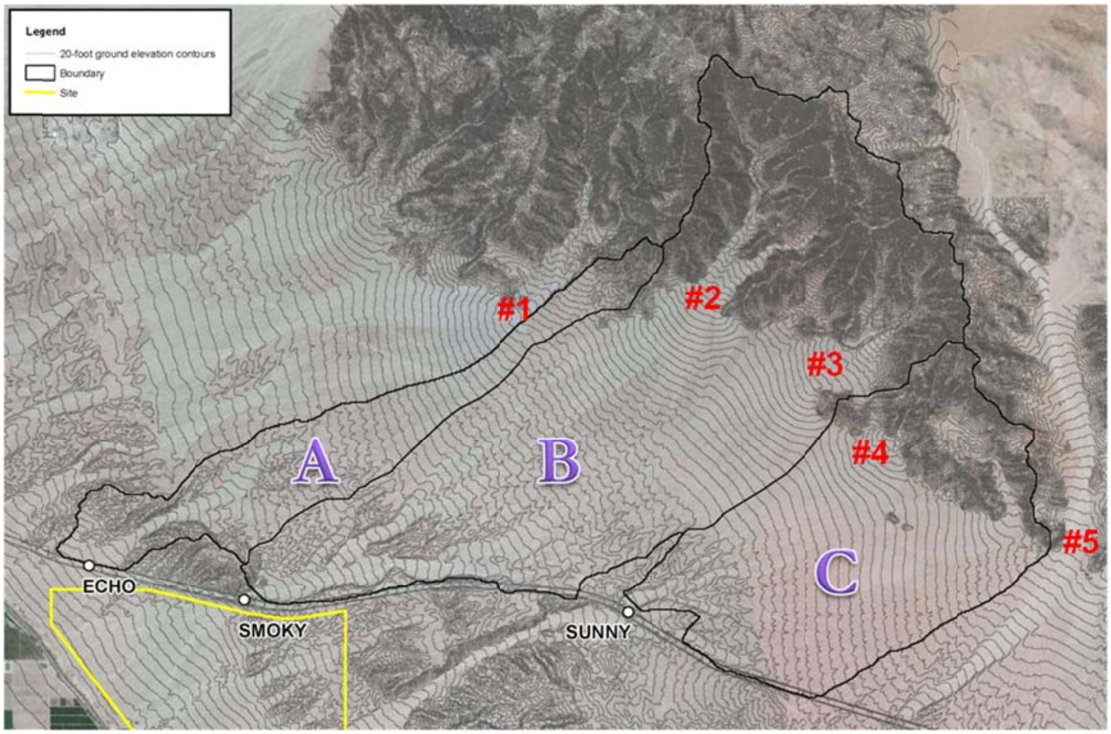


Figure 3-11. Model ABC - Combined I-10 crossing drainages

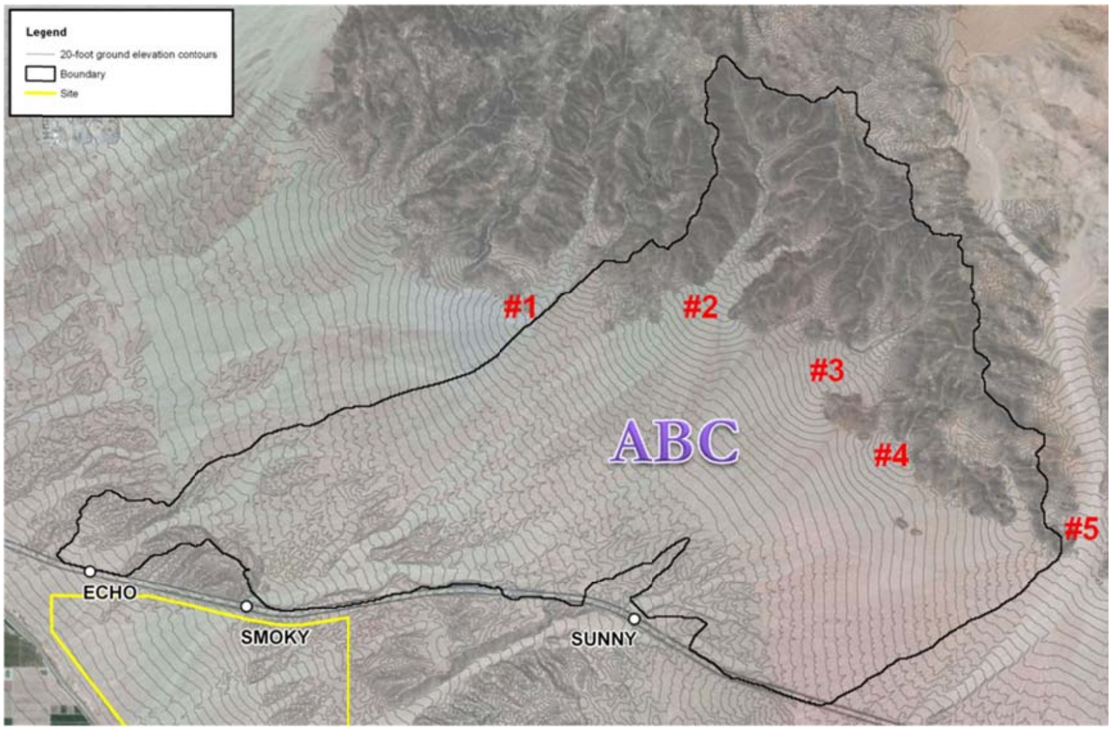


Figure 3-12. Model A - Echo Gulch upper drainage

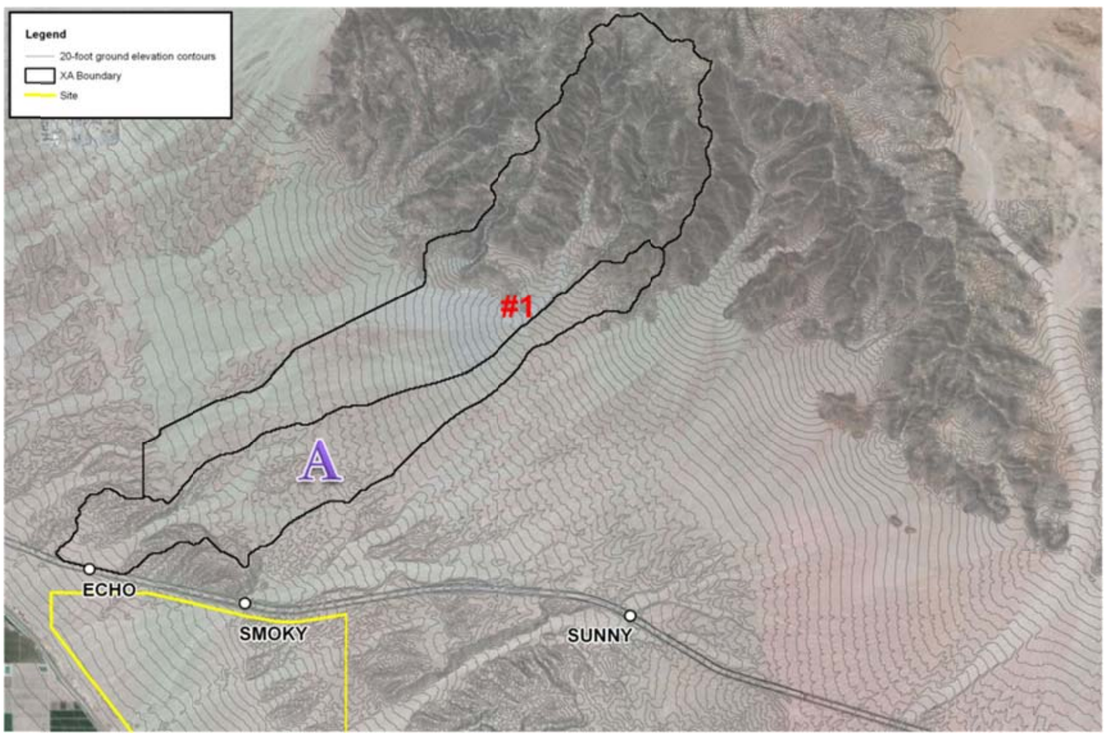
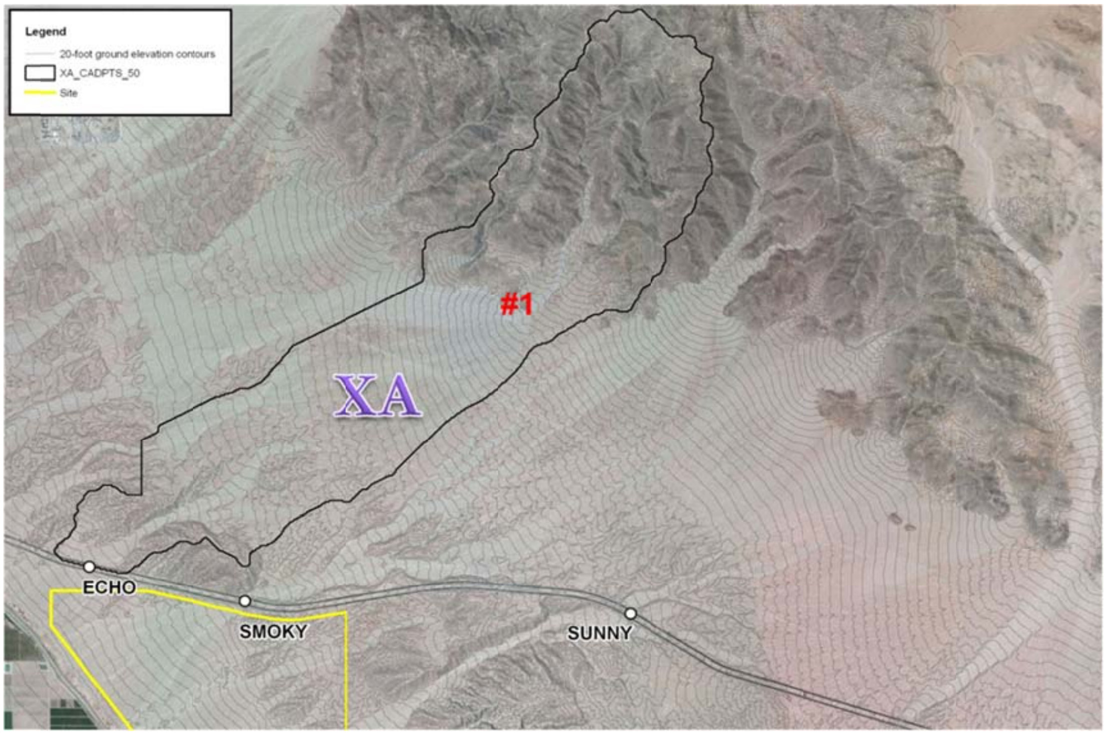


Figure 3-13. Model XA - Echo Gulch upper drainage and fringe area to the northwest



3.2.2.1 Flood hydrograph development using HEC-1

A single-node HEC-1 model was developed for each individual drainage (Echo Gulch, Smoky Gulch, and Sunny Gulch) based on the boundaries defined in their FLO-2D model counterparts (Models A, B, and C) to determine the aggregate runoff volume at the I-10 corridor to determine the appropriate constant precipitation depth to apply in FLO-2D for a 6-hour duration event.

The Green-Ampt infiltration method was applied directly in the FLO-2D models, which also accounts for transmission losses. The SCS-based infiltration method typically applied in Riverside County does not consider transmission losses. Consequently, the aggregate runoff volume at the I-10 corridor is expected to be different between the two methods. To compensate for this difference, a range of precipitation depths were applied in FLO-2D to determine, which assumed value produces an aggregate runoff volume that is comparable to the aggregate runoff volume computed using conventional methodology through the application of HEC-1.

The loss rate calculations are presented in the following tables:

- Table 3-7: Echo Gulch subbasin
- Table 3-8: Smoky Gulch subbasin
- Table 3-9: Sunny Gulch subbasin

The effective rainfall and unit hydrograph parameters are shown in Table 3-10 and Table 3-11, respectively. The 1-percent annual chance 6-hour duration flood hydrograph development results are presented in Table 3-12. The aggregate runoff volume tributary to the I-10 corridor is 1,238 acre-feet.

3.2.2.2 Two-dimensional flood routing model development using FLO-2D®

The two-dimensional flood routing model, FLO-2D®, was used to develop the following models:

- Models A (Echo Gulch drainage), B (Smoky Gulch drainage), and C (Sunny Gulch drainage) with no outflow permitted along their lateral boundaries. The only outflow nodes defined are those located just upstream of the I-10 corridor corresponding to the major bridge and culvert crossings within the Project watershed.
- Model ABC (a composite of Models, A, B, and C), which allows floodwaters to move freely between the shared boundaries (interior boundaries of the composite domain) as a result of their elimination through the process of combining the individual models.
- Model XA (a composite of Model A and the adjacent exterior drainage along the north boundary), which allows floodwaters to move freely across the shared lateral exterior boundary.

The following FLO-2D components were defined as described for each model:

Grid definition. Each model domain is comprised of 50' x 50' grid elements. The elevation for each grid element was interpolated from a 5-meter digital terrain model (DTM) developed from IFSAR data (Intermap Technologies, 2005).

Precipitation. The 6-hour storm pattern (RCHM, Plate E-5.9) was applied to the following precipitation depths of 1.57 (10-percent annual chance event), 2.00, 2.50, 3.18 (1-percent annual chance event), 3.50, 4.00, and 4.50 inches.

Hydraulic roughness. The flood-wave progression was controlled by limiting the Froude number to a maximum value of 0.95, thereby precluding the occurrence of supercritical flow, which is not expected to occur on the upper piedmont. A general roughness coefficient of 0.045 was assumed to represent the overland flow resistance. For shallow flow depths, the roughness coefficient typically ranges between 0.100 and 0.250. A roughness coefficient of 0.100 was assumed for shallow flow conditions to limit the resistance during shallow flooding.

Hydraulic structures. There are no identifiable major hydraulic facilities or structures located within the model domains. Any influence related to anthropogenic features or disturbances such as transportation- and utility-related alignments located within the modeled domain were not specifically defined other than what might be captured by the 5-meter IFSAR DTM (Intermap Technologies, 2005).

Boundary conditions. Outflow nodes were defined just upstream of the locations corresponding to the major bridge and culvert crossings along the I-10 corridor within the Project watershed (Echo Gulch Bridge, Smoky Gulch Bridge, Sunny Gulch Bridge, and the culvert just east of Sunny Gulch Bridge).

Infiltration. The Green-Ampt infiltration relationships were used to account for precipitation losses in lieu of the County standard. The physical soil parameters, which form the relationship for determining infiltration, are saturated hydraulic conductivity (XKSAT), wetting front capillary suction (PSIF), and volumetric soil moisture deficit (DTHETA). These parameters were estimated by relating the soil composition of the watershed based on Natural Resources Conservation Service (NRCS) soils mapping to average infiltration characteristics associated with soil texture classes for bare ground conditions (Rawls et al., 1983; Rawls and Brakensiek, 1983) assuming antecedent moisture conditions are near field capacity, which is consistent with the conditions immediately following a significant precipitation event. Each NRCS soil map unit is characterized by descriptive and numerical information such as (1) a representative profile, (2) engineering and physical properties, and (3) formation, morphology, and classification. This information was used in part to form the correlation between the soil composition and average infiltration characteristics. The Green-Ampt infiltration characteristics were determined based on the most restrictive soil layer with respect to infiltration. The land use definition intersected with the NRCS soils information was assumed to be entirely natural open space with effectively no impervious areas. The initial abstraction was assumed constant throughout the watershed at 0.15 inches applied by assigning a value of 0.0125 feet to the threshold for flood routing (TOL). Typical values for initial abstraction include 0.35 inches for flat-sloped desert and rangeland, 0.15 inches for Sonoran Desert hill slopes, 0.25 inches for mountains with vegetated surfaces, 0.20 inches for residential/commercial lawn and turf, 0.05 inches for pavement, and 0.50 inches for tilled fields and irrigated pasture.

3.2.2.3 Analysis summary

The developed FLO-2D models were each simulated for a 24-hour period. A maximum value of 0.25 was assigned to the numerical stability coefficient, which directly controls the maximum time step for full dynamic wave routing. Volume conservation was confirmed at each 0.1-hour time interval over the entire duration of the simulation. The maximum flood velocities on the upper piedmont as simulated by Model ABC are presented in Figure 3-14. A closer view of the maximum flood velocities along the shared boundary is shown in Figure 3-15.

Comparative analysis of FLO-2D and HEC-1. The 1-percent annual chance 6-hour duration aggregate runoff volume determined using HEC-1 is 1,238 acre-feet, the combined runoff volume from the Echo Gulch, Smoky Gulch, and Sunny Gulch drainages. The 1-percent annual chance 6-hour duration aggregate runoff volume computed using FLO-2D® is 1,069 acre-feet based on an domain- averaged precipitation depth of 4.00 inches and 1,336 acre-feet based on a domain-average precipitation depth of 4.50 inches. The FLO-2D aggregate runoff volume based on 4.50 inches exceeds the HEC-1 aggregate runoff volume by about 8 percent; therefore, the FLO-2D model simulations based on 4.50 inches are considered reasonable enough for evaluating the shared drainage boundaries as it relates to the behavior of the 1-percent annual chance 6-hour event.

Comparative summary of individual and combined FLO-2D model results. The computed outflows from Models A, B, and C were compared to the computed outflows from Model ABC at the I-10 corridor crossings associated with Echo Gulch, Smoky Gulch, and Sunny Gulch to quantify the significance of lateral flow as it translates to the peak flow rate and flood volume at these locations. Similarly, the computed outflow from Model A was compared to the computed outflow from Model XA at the I-10 corridor crossing associated with Echo Gulch. The computed outflow peak flow rates and their ratios between Model comparisons are presented in Table 3-13. Note that a peak flow rate ratio that is greater than unity (1) indicates that the compared individual model is underestimating the contribution of lateral flow to the outflow conditions as a result of boundary placement; and if a peak flow rate ratio is less than unity (1) then the compared individual model is overestimating the contribution of lateral flow to the outflow conditions. A comparative analysis between the results of individual models versus the composite models is presented in Table 3-13. The percent distribution across different ranges of flood depths for Model ABC is shown in Table 3-14.

3.2.2.4 Conclusions

Geomorphic-based changes are not expected to alter the event-based flow conditions along the exterior and interior subbasin boundaries on the upper piedmont within the Project watershed. The placement of the exterior and interior subbasin boundaries on the upper piedmont are considered reasonable for the purpose of developing the hydrology for the Project based on field observations in conjunction with the analytical testing performed herein. As a result of lateral flows moving across the current placement of boundaries, the peak flow rate for the Echo Gulch subbasin is overestimated by 5 percent, the peak flow rate for the Smoky Gulch subbasin is overestimated by 2 percent, and the peak flow rate for the Sunny Gulch subbasin is underestimated by about 6 percent based on the weighted average value between the bridge (Sunny_1) and culvert (Sunny_2) as shown in Table 3-13. The outflow associated with the Echo Gulch subbasin was not influenced by lateral flows across the exterior lateral boundary. As a general note, the amount and direction of lateral flow across a shared boundary varies with precipitation; and the lateral flow across a shared boundary between two subbasins does not necessarily influence the downstream outflow of either drainage.

Table 3-7. Echo Gulch subbasin AMC II loss rate determination

NRCS survey area	MUSYM	drainage area {acres}	XKSAT {in/hr}	RTIMP {%}	hydrologic soil group				F_p* {in/hr}
					A	B	C	D	
US	s995	816	0.101	10.0	5	19	0	76	0.166
US	s1130	103	0.342	55.0	2	31	3	64	0.178
CA680	BA	137	0.155	0.0	0	0	0	100	0.120
CA680	CdC	56	0.890	0.0	100	0	0	0	0.440
CA680	ChC	27	0.840	0.0	100	0	0	0	0.440
CA680	CoB	20	0.056	0.0	0	0	0	100	0.120
		1,159	0.181	11.9	11	16	0	73	0.181

*based on desert shrub, poor cover: CN equal to 63, 77, 85, and 88 for hydrologic soil groups A, B, C,and D, respectively

Table 3-8. Smoky Gulch subbasin AMC II loss rate determination

NRCS survey area	MUSYM	drainage area {acres}	XKSAT {in/hr}	RTIMP {%}	hydrologic soil group				F_p* {in/hr}
					A	B	C	D	
US	s991	1,437	0.990	0.0	100	0	0	0	0.440
US	s995	1,618	0.101	10.0	5	19	0	76	0.166
US	s1130	1,720	0.342	55.0	2	31	3	64	0.178
CA680	BA	8	0.155	0.0	0	0	0	100	0.120
CA680	ChC	23	0.840	0.0	100	0	0	0	0.440
CA680	CoB	21	0.056	0.0	0	0	0	100	0.120
		4,827	0.499	22.9	33	17	1	49	0.253

*based on desert shrub, poor cover: CN equal to 63, 77, 85, and 88 for hydrologic soil groups A, B, C,and D, respectively

Table 3-9. Sunny Gulch subbasin AMC II loss rate determination

NRCS survey area	MUSYM	drainage area {acres}	XKSAT {in/hr}	RTIMP {%}	hydrologic soil group				F_p* {in/hr}
					A	B	C	D	
US	s991	879	0.990	0.0	100	0	0	0	0.440
US	s995	837	0.101	10.0	5	19	0	76	0.166
US	s1130	676	0.342	55.0	2	31	3	64	0.178
		2,393	0.542	19.0	39	15	1	45	0.270

*based on desert shrub, poor cover: CN equal to 63, 77, 85, and 88 for hydrologic soil groups A, B, C,and D, respectively

Table 3-10. Effective rainfall parameters based on AMC II

subbasin	F {in/h}	low loss fraction	1-percent annual chance precipitation {6-hour duration}				
			P {inches}	DAR factor	P_{DAR} {inches}	P_{loss} {inches}	P_{excess} {inches}
Echo Gulch	0.181	0.9	3.04	0.997	3.03	1.07	1.96
Smoky Gulch	0.253	0.9	3.26	0.986	3.21	1.46	1.75
Sunny Gulch	0.270	0.9	3.25	0.993	3.23	1.55	1.68

Table 3-11. Unit hydrograph parameters

subbasion	BA {sq mi}	L {miles}	LCA {miles}	S {ft/mi}	basin faction N	s-graph	lag {hours}
Echo Gulch	1.81	5.03	2.80	250.3	0.042	Whitewater	0.96
Smoky Gulch	7.63	5.83	3.99	304.6	0.038	Whitewater	1.02
Sunny Gulch	3.78	3.29	1.94	281.9	0.039	Whitewater	0.65

Table 3-12. 1-percent annual chance 6-hour flood hydrograph development results

subbasin	BA {sq mi}	Q_p {cfs}	$Q_{m,24}$ {cfs}	runoff volume {ac-ft}
Echo Gulch	1.81	919	144	189
Smoky Gulch	7.63	3,709	541	711
Sunny Gulch	3.78	2,248	257	338

Table 3-13. Summary of FLO-2D peak flow rates and peak flow rate ratios at Interstate 10

parameter	I-10 crossing	FLO-2D model	6-hour precipitation depth {inches}						
			1.57	2.00	2.50	3.18	3.50	4.00	4.50
peak flow rate {cfs}	Echo	ABC	212	398	593	919	1062	1292	1531
	Smoky	ABC	343	756	1252	2105	2536	3245	4310
	Sunny_1	ABC	191	280	401	648	995	1562	2157
	Sunny_2	ABC	113	177	240	332	367	450	520
	Echo	XA	210	401	593	960	1114	1357	1609
	Echo	A	212	401	593	960	1114	1357	1609
	Smoky	B	327	735	1192	2033	2443	3289	4381
	Sunny_1	C	189	285	400	603	889	1420	2007
	Sunny_2	C	113	173	239	328	366	450	517
peak flow rate ratio	Echo	XA : A	0.99	1.00	1.00	1.00	1.00	1.00	1.00
	Echo	ABC : A	1.00	0.99	1.00	0.96	0.95	0.95	0.95
	Smoky	ABC : B	1.05	1.03	1.05	1.04	1.04	0.99	0.98
	Sunny_1	ABC : C	1.01	0.98	1.00	1.07	1.12	1.10	1.07
	Sunny_2	ABC : C	0.99	1.02	1.00	1.01	1.00	1.00	1.01

Table 3-14. Model ABC distribution of flood depths

depth range {feet}	P_6 = 3.18 inches {percent}		P_6 = 4.50 inches {percent}	
	incremental	accumulative	incremental	accumulative
0 ≤ depth < 0.1	67.57	67.57	59.83	59.83
0.1 ≤ depth < 0.25	21.32	88.89	23.89	83.72
0.25 ≤ depth < 0.5	7.41	96.29	9.21	92.93
0.5 ≤ depth < 1	2.87	99.16	4.77	97.71
1 ≤ depth < 1.5	0.62	99.78	1.65	99.36
1.5 ≤ depth < 2	0.13	99.91	0.44	99.79
2 ≤ depth < 2.5	0.05	99.96	0.12	99.91
2.5 ≤ depth < 3	0.02	99.97	0.04	99.95
3 ≤ depth < 4	0.02	99.99	0.03	99.98
4 ≤ depth < 5	0.00	100.00	0.01	99.99
5 ≤ depth < 7	0.00	100.00	0.00	100.00
7 ≤ depth < 9	0.00	100.00	0.00	100.00
9 ≤ depth < 12	0.00	100.00	0.00	100.00

Figure 3-14. Model ABC flood velocities

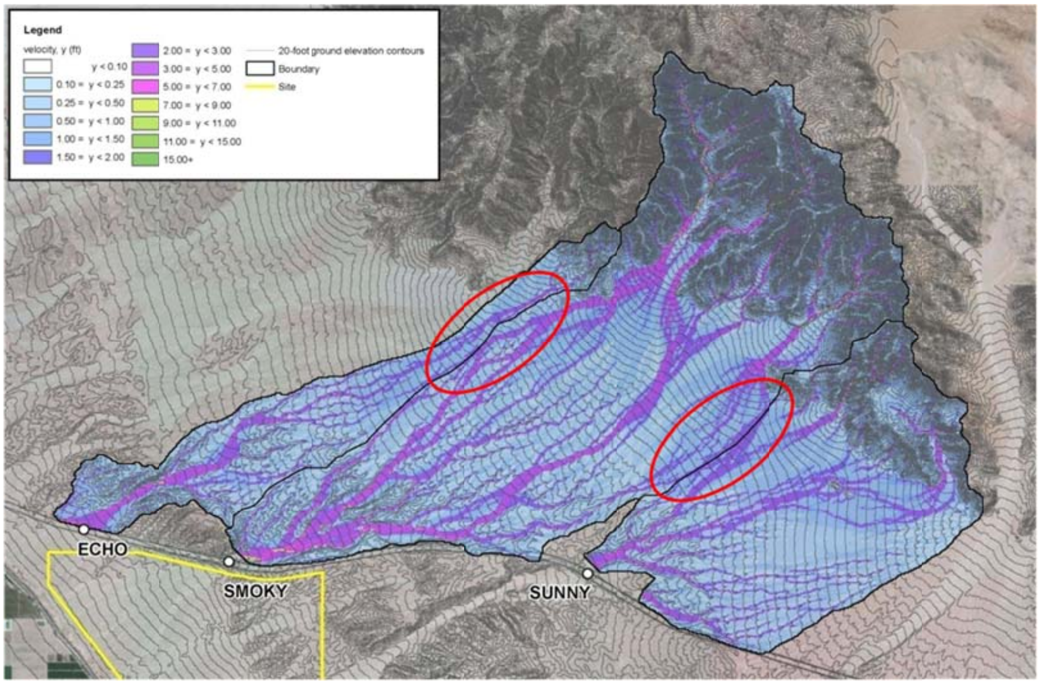
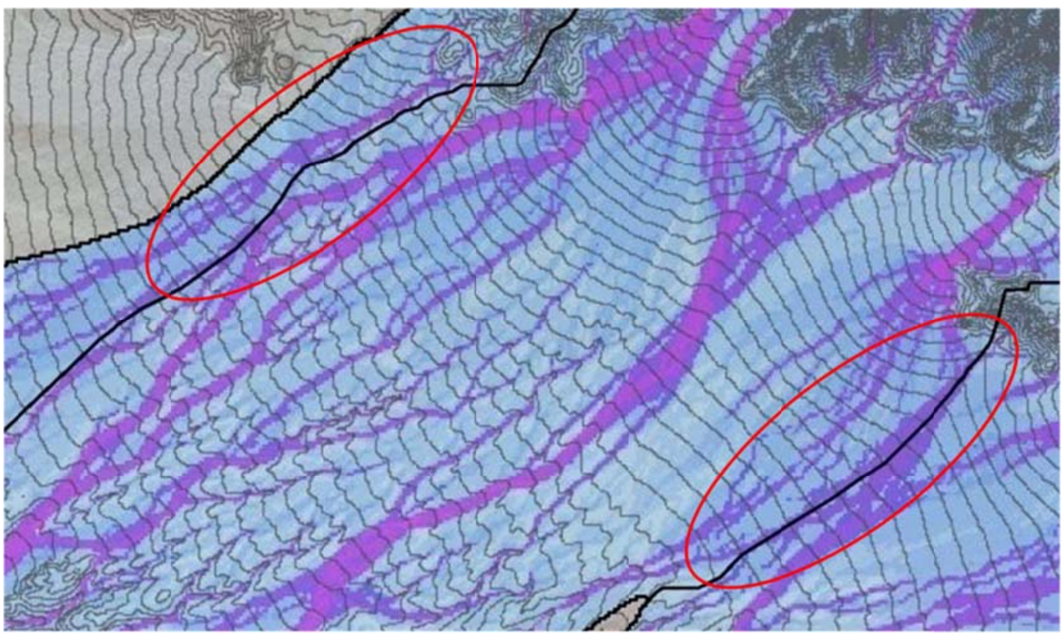
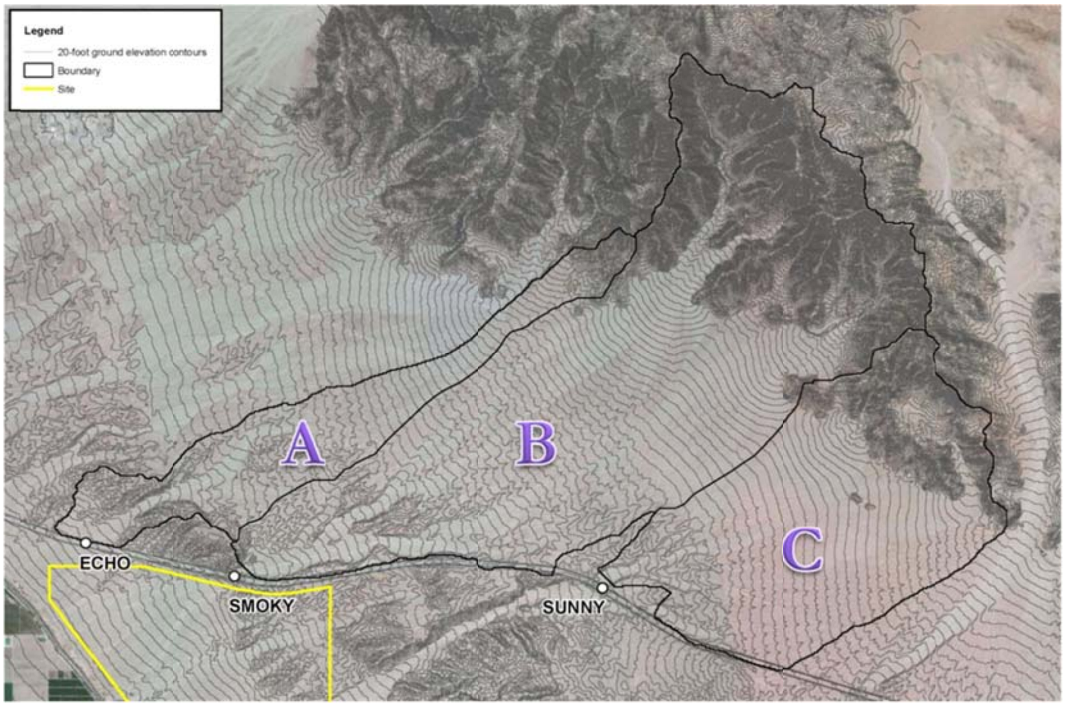


Figure 3-15. Flood velocities along assumed boundary where intermingling of flows occurs



The Project-adopted drainage boundaries north of the I-10 corridor are as shown in Figure 3-16, where "A" corresponds to the Echo Gulch drainage and the upper portion of Project subbasin 7, "B" corresponds to the Smoky Gulch drainage and the upper portion of Project subbasin 6, and "C" corresponds to the Sunny Gulch drainage and upper portion of Project subbasin 3.

Figure 3-16. Adopted upper piedmont drainage boundaries



3.3 Revised hydrologic method

Revisions to the standard hydrologic method previously implemented herein were devised to account for the unique nature of the hydrologic regime in the Coachella Valley relative to the region of Riverside County west of the San Jacinto Range as well as resolve the known flaws associated with the standard precipitation loss rate mechanism and assumptions typically employed within Riverside County, In particular, precipitation losses based on the RCHM do not account for the higher permeability of the sandy soils often found on the piedmont-like surfaces, which encompass a large part of the Coachella Valley.

The Green-Ampt infiltration method was selected in lieu of the standard loss rate method prescribed in the RCHM to account for the higher permeability exhibited by sandy soils. The most notable standard use of the Green-Ampt method in a semiarid or arid region is in Maricopa County under the administration of the Flood Control District of Maricopa County (FCDMC, 2009).

The physical-based soil parameters, which form the Green-Ampt relationships for determining infiltration, are saturated hydraulic conductivity (XKSAT), wetting front capillary suction (PSIF), and volumetric soil moisture deficit (DTHETA). These parameters were estimated by relating the soil composition of the watershed based on the Natural Resources Conservation Service (NRCS) spatial soil database to average infiltration characteristics associated with soil texture classes for bare ground conditions determined from exhaustive research and testing under the umbrella of the National Soils Laboratory (Rawls et al., 1983; Rawls and Brakensiek, 1983; USACE, 1997; Saxton and Rawls, 2006; and FCDMC, 2009) assuming antecedent moisture conditions are near field capacity, which is consistent with the conditions immediately following a significant precipitation event (similar to AMC II).

Each NRCS soil map unit is characterized by descriptive and numerical information such as (1) a representative profile, (2) engineering and physical properties, and (3) formation, morphology, and classification. This information was used in part to form the correlation between the soil composition and average infiltration characteristics.

The Green-Ampt infiltration characteristics for each soil map unit were determined based on the most restrictive soil horizon with respect to infiltration and assuming the average infiltration characteristics associated with soil texture classes for bare ground conditions are representative within in the subject watershed, regardless of land use.

The basis for this proposed change to the hydrologic method was developed through its correlation with the Eastside Dike original design hydrology (Slater et al, 1950). The development of this basis involved the following steps:

- Identification of the Eastside Dike original design hydrology approach, methods, parameters, and assumptions
- Development of a duplicate effective hydrologic model, which reproduces the same peak flow rate and runoff volume reported by Slater et al (1950)
- Development of a Green-Ampt equivalent duplicate effective hydrologic model

3.3.1 Eastside Dike original design hydrology

The original design hydrology developed for the Eastside Dike (Slater et al, 1950) identifies four (4) watershed areas (A, B, C, and D) that are tributary to the Eastside Dike. Area “D” represents the watershed that encompasses the La Entrada Specific Planning Area and also defines the approximate drainage that lies tributary to Wasteway No. 2 (Figure 3-17). The original design hydrology for Area “D” as reported by Slater et al (1950) is summarized as follows:

- **Tributary drainage**. Area “D” represents the watershed that includes the La Entrada Specific Planning Area, encompassing 51.8 square miles, and the approximate drainage that lies tributary to Wasteway No. 2

- **Precipitation**. The SPF precipitation is based on the Avalon Storm of October 21, 1941, which produced 5.53 inches of rainfall in 3.25 hours; a depth-areal reduction factor was applied to account for the inherent variability in the hydrologic processes; assuming a tributary drainage of 51.8 square miles, a depth-areal reduction factor of 0.75 was estimated from depth-areal reduction curve for the Avalon Storm of October 21, 1941 (Plate 15; Slater et al, 1950); this factor reduced the precipitation depth from 5.53 inches down to 4.13 inches
- **Storm pattern**. The SPF storm pattern is based on a regionally derived 3-hour mass curve (Plate 17; Slater et al, 1950)
- **Precipitation losses**. The precipitation losses are based on a constant loss rate with no mention of initial abstraction; a constant loss rate of 1.0 inches per hour was assumed for alluvial surfaces and a constant loss rate of 0.2 inches per hour was assumed for non-alluvial surfaces; although not reported by Slater et al (1950), an area-weighted constant loss rate of 0.7 inches per hour was approximated herein based on the graphical distribution of alluvial and non-alluvial surfaces shown in Figure 3-18 (Plate 13; Slater et al, 1950)
- **Synthetic unit hydrograph**. The synthetic unit hydrograph was developed using the USACE lag equation in conjunction with the Whitewater S-graph (Plate 14; Slater et al, 1950); lag parameters were not identified by Slater et al (1950)
- **Flood hydrograph**. The results of the flood hydrograph development produced a peak discharge of 21,000 cfs and a flood volume of 6,350 acre-feet; these results do not reflect the influence of transmission losses and debris bulking

3.3.2 Eastside Dike original design hydrology duplicate effective model

A model representative of the original SPF design hydrology for Area “D” was developed using HEC-1 (USACE, 1998) based on the hydrologic information reported by Slater et al (1950) as described above (see Section 3.3.1):

- **Tributary drainage**. Area “D” represents the watershed that includes the La Entrada Specific Planning Area, encompassing 51.8 square miles, and the approximate drainage that lies tributary to Wasteway No. 2
- **Precipitation**. The SPF precipitation is based on the Avalon Storm of October 21, 1941, which produced 5.53 inches of rainfall in 3.25 hours; a depth-areal reduction factor was applied to account for the inherent variability in the hydrologic processes; assuming a tributary drainage of 51.8 square miles, a depth-areal reduction factor of 0.75 was estimated from depth-areal reduction curve for the Avalon Storm of October 21, 1941 (Plate 15; Slater et al, 1950); this factor reduced the precipitation depth from 5.53 inches down to 4.13 inches
- **Storm pattern**. The SPF storm pattern is based on a regionally derived 3-hour mass curve (Plate 17; Slater et al, 1950)
- **Precipitation losses**. The precipitation losses are based on a constant loss rate approach with no initial abstraction; the constant loss rate was adjusted to 0.725 inches per hour (compared to 0.7 inches per hour, which was previously estimated graphically) as part of correlating the model results to the original design hydrology (Slater et al, 1950)
- **Unit hydrograph**. The synthetic unit hydrograph was developed using the USACE lag equation based on its application to Thermal Canyon, which is the predominant drainage within Area “D”, in conjunction with the Whitewater S-graph; the lag basin factor (n) was adjusted to a value of 0.078 as part of correlating the model results to the original SPF design hydrology (Slater et al, 1950)
- **Model results**. As indicated above, the constant loss rate and basin factor were adjusted to values of 0.725 inches per hour and 0.078, respectively, to correlate the model results to the original SPF design hydrology (Slater et al, 1950); the computed peak discharge and runoff volume are 21,000 cfs and 6,349 acre-feet, respectively; these results do not reflect the influence of transmission losses and debris bulking

3.3.3 Green-Ampt equivalent duplicate effective model

The duplicate effective model of the original SPF design hydrology for Area "D" was revised to account for precipitation losses based on the Green-Ampt infiltration relationships:

- **Tributary drainage**. Area "D" represents the watershed that includes the La Entrada Specific Planning Area, encompassing 51.8 square miles, and the approximate drainage that lies tributary to Wasteway No. 2
- **Precipitation**. The SPF precipitation is based on the Avalon Storm of October 21, 1941, which produced 5.53 inches of rainfall in 3.25 hours; a depth-areal reduction factor was applied to account for the inherent variability in the hydrologic processes; assuming a tributary drainage of 51.8 square miles, a depth-areal reduction factor of 0.75 was estimated from depth-areal reduction curve for the Avalon Storm of October 21, 1941 (Plate 15; Slater et al, 1950); this factor reduced the precipitation depth from 5.53 inches down to 4.13 inches
- **Storm pattern**. The SPF storm pattern is based on a regionally derived 3-hour mass curve (Plate 17; Slater et al, 1950)
- **Precipitation losses**. The precipitation losses were based on the Green-Ampt infiltration relationships; an imperviousness (RTIMP) of 16.3 percent was determined for Area "D" based on NRCS soils mapping; the saturated hydraulic conductivity (XKSAT) was determined through the integration of NRCS spatial soil data with average XKSAT values determined for various soil texture classes (Rawls et al, 1983); The maximum XKSAT threshold for any soil texture class was adjusted to a value of 1.17 inches per hour as part of correlating the model results to the original design hydrology (Slater et al, 1950); this maximum XKSAT threshold only limits sand and loamy sand, which have reported average XKSAT values of 4.64 and 1.20 inches per hour, respectively (Rawls et al, 1983); the average XKSAT value for Area "D" is 0.377 inches per hour based on a maximum XKSAT threshold of 1.17 inches per hour; the resultant maximum XKSAT threshold of 1.17 inches per hour closely approximates the maximum XKSAT threshold adopted by FCDMC (2009), which applies a value of 1.20 inches per hour; the soil moisture deficit (DTHETA) and wetting suction front (PSIF) were treated as functions of XKSAT (FCDMC, 2009); the initial abstraction was assumed to be zero
- **Unit hydrograph**. The synthetic unit hydrograph was developed using the USACE lag equation based on its application to Thermal Canyon, which is the predominant drainage within Area "D", in conjunction with the Whitewater S-graph; the lag basin factor (n) was adjusted to a value of 0.070 as part of correlating the model results to the original SPF design hydrology (Slater et al, 1950)
- **Model results**. As indicated above, the maximum XKSAT threshold for Area "D" was adjusted to a value of 1.17 inches per hour, which produced an average XKSAT value of 0.377 inches per hour; in addition, the lag basin factor was adjusted to a value of 0.070; these adjustments were performed to correlate the model results to the original design hydrology (Slater et al, 1950); the computed peak discharge and runoff volume are 21,000 cfs and 6,346 acre-feet, respectively; these results do not reflect the influence of transmission losses and debris bulking

3.3.4 Adopted model parameters and assumptions

The duplicate effective models (constant loss and Green-Ampt equivalent) correlated quite well with the original design hydrology (Slater et al, 1950) as summarized in Table 3-15; and therefore, the Green-Ampt infiltration method was adopted for the development of the regional hydrology.

An initial abstraction (IA) of 0.15 inches was used based on a typical value for the Sonoran Desert (FCDMC, 2009); saturated hydraulic conductivity (XKSAT) values were determined by intersecting NRCS soils mapping with average XKSAT values determined for various soil texture classes (Rawls et al, 1983) except sand; the sand soil texture class was limited to an XKSAT value of 1.20 inches per hour, which is consistent with Maricopa County guidelines (FCDMC, 2009) while closely approximating the previously correlated value of 1.17 inches per hour; the volumetric moisture deficit (DTHETA) and wetting front suction (PSIF) are treated as functions of XKSAT (FCDMC, 2009); the adopted saturated hydraulic conductivity values for the standard soil texture classes are listed in Table 3-16; the adopted Green-Ampt infiltration parameters for each map unit within the watershed are presented in Table 3-17.

The basin factors used in the development of the synthetic unit hydrograph lag times will remain conservative, ranging between 0.030 and 0.050, inclusive, relative to the correlated value of 0.070 determined as part of the development of the Green-Ampt equivalent duplicate effective model. The application of smaller basin factors will result in shorter lag times and subsequently, produce flood hydrographs with higher peak flow rates and flood volumes.

Figure 3-17. Plate 3 – Topography (Slater et al, 1950) with Area "D" identified with a red boundary

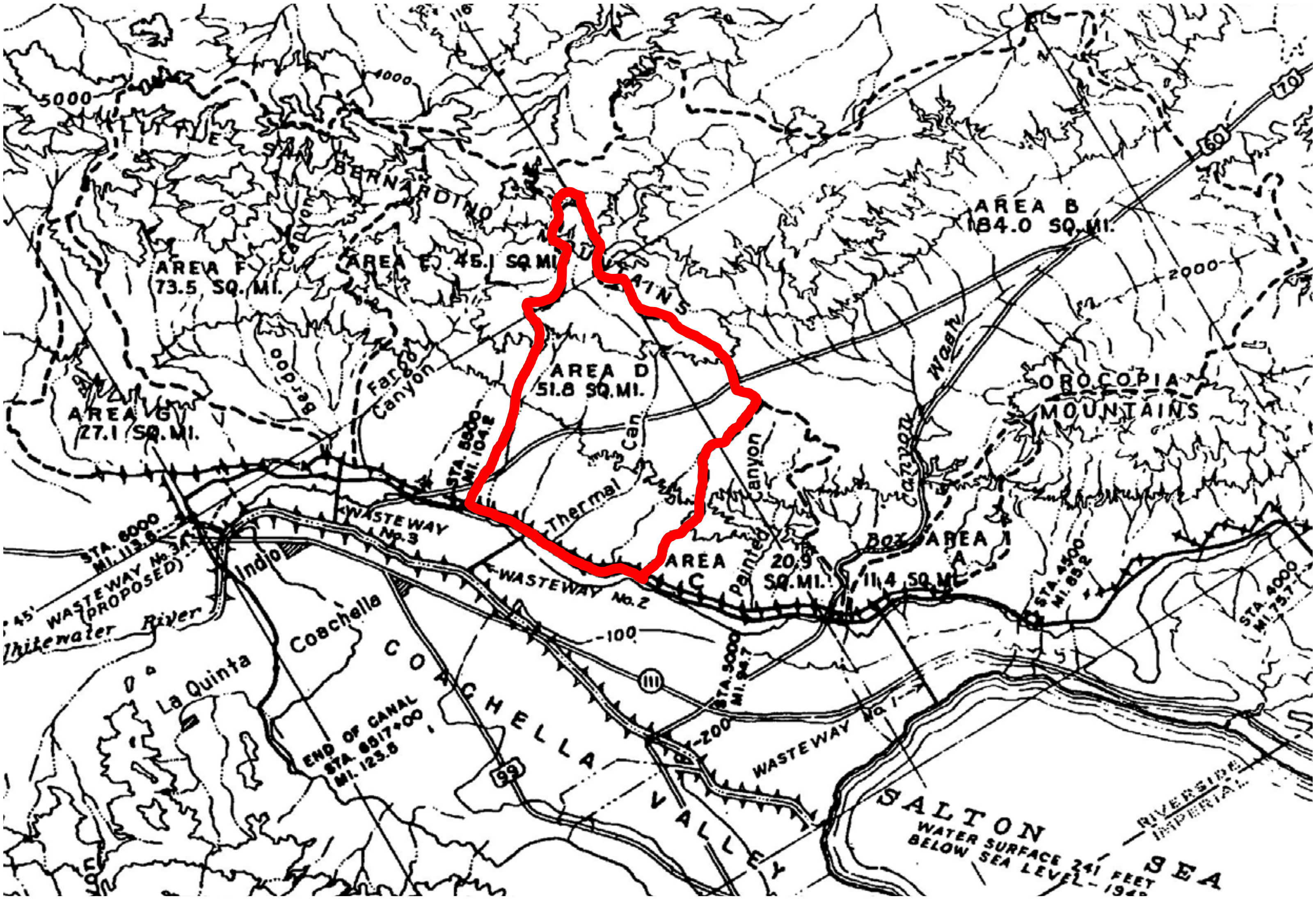


Figure 3-18. Plate 18 – Generalized Surface Geology (Slater et al, 1950) with Area "D" identified with a red boundary

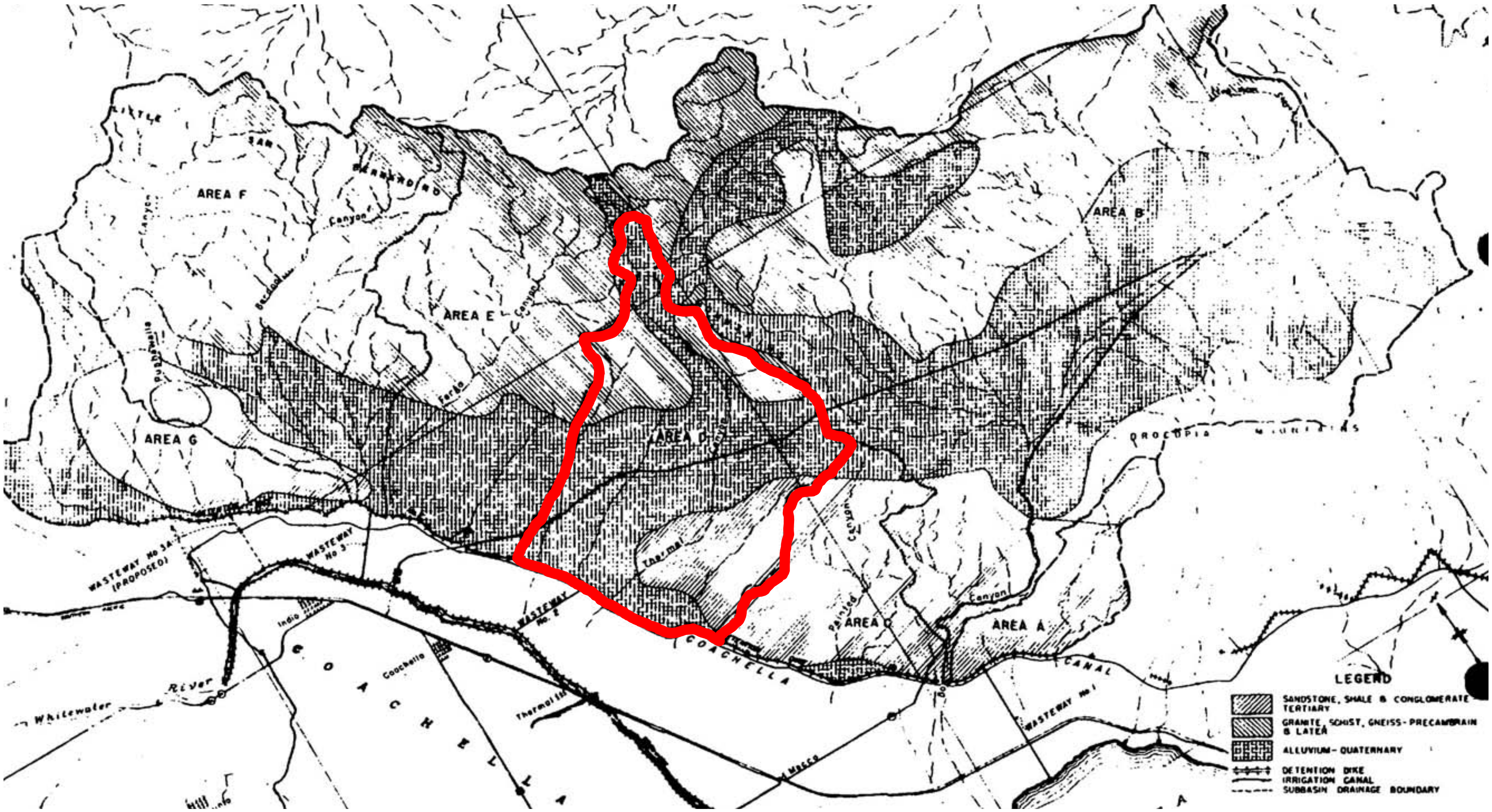


Table 3-15. Comparison of SPF models

hydrology study	storm event	infiltration methodology	Q_p {cfs}	runoff volume {ac-ft}	IA {inches}	RTIMP {%}	CONSTL {in/h}	XKSAT {in/h} weighted average	XKSAT {in/h} maximum for sand	lag basin factor
Slater et al, 1950 Area "D" {51.8 sq mi}	Avalon October 21, 1941 5.53 in; 3.25 hours	constant {alluvium = 1.0 in/h; non-alluvium = 0.2 in/h}	21,000	6,350	-	-	~ 0.7	-	-	-
Slater et al, 1950 Area "D" duplicate model {51.8 sq mi}			21,000	6,349	-	-	0.725	-	-	0.078
		Green-Ampt {DTHETA and PSIF functions of XKSAT}	21,000	6,346	-	16.3	-	0.377	1.17	0.070
			20,895	6,305	-	16.3	-	0.385	1.20	0.070
			12,258	3,613	-	16.3	-	1.289	4.64	0.070
			19,812	5,980	0.15	16.3	-	0.385	1.20	0.070
La Entrada baseline condtions 10 subbasins {50.6 sq mi}	Indio September 24, 1939 6.45 in; 6 hours		19,417	6,650	0.15	16.3		0.385	1.20	0.070
			*	6,754	0.15	16.3	-	0.385	1.20	*
	1-percent annual chance 24 hours		*	2,615	0.15	16.3	-	0.385	1.20	*

*values computed for the 10 subbasins, which form Area "D"

Table 3-16. Adopted saturated hydraulic conductivity values

soil texture class	saturated hydraulic conductivity			
	Rawls et al, 1983		FCDMC, 2009	adopted
	{cm/h}	{in/h}	{in/h}	{in/h}
sand	11.78	4.64	1.20	1.20
loamy sand	2.99	1.18	1.20	1.18
sandy loam	1.09	0.43	0.40	0.43
loam	0.34	0.13	0.25	0.13
silt loam	0.65	0.26	0.15	0.26
silt	-	-	0.10	0.10
sandy clay loam	0.15	0.06	0.06	0.06
clay loam	0.10	0.04	0.04	0.04
silty clay loam	0.10	0.04	0.04	0.04
sandy clay	0.06	0.02	0.02	0.02
silty clay	0.05	0.02	0.02	0.02
clay	0.03	0.01	0.01	0.01

Table 3-17. Adopted Green-Ampt infiltration parameters

NRCS		drainage area						
soil survey	map unit	{acres}	{sq mi}	IA {inches}	DTHETA	PSIF {inches}	XKSAT {in/h}	RTIMP {%}
CA680	BA	2,370	3.70	0.15	0.250	5.928	0.155	0.0
	BP	388	0.61	0.15	0.050	12.493	0.000	0.0
	CdC	2,234	3.49	0.15	0.285	2.809	0.890	0.0
	ChC	996	1.56	0.15	0.283	2.881	0.840	0.0
	CoB	456	0.71	0.15	0.150	8.569	0.056	0.0
	GP	23	0.04	0.15	0.250	5.638	0.175	0.0
	Is	10	0.02	0.15	0.250	4.972	0.238	0.0
	MaB	0	0.00	0.15	0.296	2.554	1.105	0.0
US	s991	6,870	10.73	0.15	0.291	2.679	0.990	0.0
	s995	11,585	18.10	0.15	0.152	6.971	0.101	10.0
	s1130	7,464	11.66	0.15	0.250	4.268	0.342	55.0

3.4 Debris yield

The USACE Los Angeles District Debris Method (USACE, 2002) consists of a set of predictive equations expressing the single event unit debris yield of a watershed as a function of physiographic, hydrologic, and meteorologic parameters. These predictive equations were developed by multiple regression analyses of single event debris data observed in the San Gabriel Ranges of southern California.

As defined in this method, the “total debris yield” is the total debris outflow from a watershed measurable at a specific concentration point for a specified event. It may include clay, silt, sand, gravel, boulders, tree stumps, and other organic materials. The “debris production” is the gross erosion within a watershed while the “debris yield” is the quantity of debris actually delivered to a concentration point of interest. The entire debris production of the watershed may not necessarily reach its outlet because it is stored temporarily within the watershed due to the lack of transporting capacity of the conveyance system.

Predictive equations. There are five empirical equations that were derived on the basis of watershed size ranging from 0.1 to 200 square miles. The multiple regression analyses indicated that the unit debris yield (DY) for a watershed is highly correlated with the following basin parameters: relief ratio (RR) analogous to watershed slope, drainage area (A), unit peak flow (Q) or 1-hour precipitation (P), and the non-dimensional fire factor (FF).

Equation 2 is usually applied to drainages 3 to 10 square miles in area. Equation 1, which is a function of precipitation rather than runoff, is used for basins 0.1 to 3; however, if frequency discharge information is available, Equation 2 may be used for areas less than 3 square miles (USACE, 2002).

Equation 2 was applied herein to the drainages of interest less than 3 square miles in size since frequency discharge information was available; thus, Equation 2 was applied to every subbasin except subbasin 1A.

Equation 3 is used to compute the debris yield for drainages ranging in area from 10 to 25 square miles. Equation 3 was applied to subbasin 1A (Thermal Canyon), which is a little more than 20 square miles.

Equation 2: $\log(DY) = 0.85\log(Q) + 0.53\log(RR) + 0.04\log(A) + 0.22\,(FF)$

Equation 3: $\log(DY) = 0.88\log(Q) + 0.48\log(RR) + 0.06\log(A) + 0.20\,(FF)$

where

DY = unit debris yield (yd^3/mi^2),

RR = relief ratio (feet/mile),

A = drainage area (acres),

FF = non-dimensional fire factor, and

Q = unit peak flow (cfs/mi^2)

Limitations. The general limitations related to the applications of the USACE Los Angeles District Debris Method in the prediction of debris yield are as follows: (1) geographic constraints, (2) drainage area constraints, (3) topographic constraints, (4) frequency constraints, and (5) input constraints. The frequency and input constraints pertain to small events less than 20-percent annual chance and low runoff or precipitation. Since the recurrence interval in this study is 100-year, only the geographic, drainage area and topographic constraints remain. This method is intended to be used for the estimation of debris yield mainly from coastal-draining mountainous watersheds located in southern California. Since the predictive equations were derived from data observed in the San Gabriel Range, the use of these equations for watershed conditions different from those of the San Gabriel Range must be specifically addressed. The method is applicable only to watersheds with areas ranging from 0.1 to 200 square miles and with a high proportion of their total area in steep, mountainous terrain. The use of this method to compute debris yields for watersheds in mild-sloped valley areas with a high percentage of piedmonts and alluvial fans or valley fill areas may result in estimates that are higher than actual yield. If the sediment transport capacity is less than the statistical debris method results, the sediment transport capacity governs the debris yield.

Adjustment-Transposition (A-T) factor. The use of predictive equations developed from data pertaining to watersheds, which historically demonstrate extremely high unit yields will result in overestimates of debris yields when applied to areas with less erosional activity. Recognizing this limitation, and the importance of uncertain geomorphic and geologic parameters, the USACE Los Angeles District developed an Adjustment-Transposition (A-T) factor.

Since there are no debris or sediment records available for the Project or nearby watersheds, the USACE Los Angeles District suggests using Technique 4 (USACE, 2002) to estimate the A-T factor. Technique 4, describes a method to determine the Adjustment-Transposition factor based on four basin parameters: (1) parent material or surficial geology, (2) soils, (3) channel morphology, and (4) hillslope geomorphology. A numerical factor ranging from 0.05 to 0.25 is assigned to each of these parameters according to the characteristics of each of these parameters. Guidelines were developed (Table D-1; USACE, 2002) to aid in the selection of these values. The guidelines are also shown in Table 3-19. The A-T factor is equal to the sum of the individually assigned numerical values for the four the A-T subfactor groups.

Observations that formed the basis for the A-T factor selection are summarized below and in Table 3-18 based on segmenting Project watershed into three generalized groupings of similar characteristics: (1) mildy-sloped alluvial surfaces – 34 percent of the watershed, (2) Little San Bernardino Mountains – 23 percent of the watershed, and (3) badlands, well-developed piedmont surfaces, and the Mecca Hills – 43 percent of the watershed. The resultant A-T factors estimated for the subbasins ranged in value from 0.32 to 0.47; however, an A-T factor value of 0.5 was conservatively applied to each subbasin.

Similarly, an A-T Factor of 0.5 was also assumed for the *"Without Project" Hydrology Report, Thousand Palms Area, Whitewater River Basin, Riverside and San Bernardino Counties, California* (Bechtel, 1997), which has terrain characteristics (parent material, soils, channel morphology, and hillslope morphology) that are similar to the Project watershed.

Parent material. The influence of folding, faulting, and fracturing on sediment production and delivery was considered most severe in the Little San Bernardino Mountains, moderate in the badlands and Mecca Hills, and minor on the milder sloped alluvial surfaces. Weathering is sporadic, primarily a function of chemical, thermal, and wind processes, and the highly episodic nature of high intensity rainfall. Overall, the parent materials do not exhibit a significant rate of weathering under present environmental conditions.

Soils. The influence of cohesion and clay colloids was considered limited on the mildy sloped alluvial surfaces, moderate in the Little San Bernardino Mountains, and most significant in the badlands and Mecca Hills. The soil profile was viewed as being most developed in the badlands and Mecca Hills, moderately developed in areas of the Little San Bernardino, and minimally developed on the mildy sloped alluvial surfaces.

Channel morphology. Bedrock exposures and bank erosion are expected to some contribution in portions of subbasin 3 and very limited influence in the remaining subbasins. Vegetation is generally scarce throughout and there is no significant evidence of headcutting observed in the watershed. Bed and bank materials are generally non-cohesive on the mildy-sloped alluvial surfaces, partially cohesive in portions of the Little San Bernardino Mountains, and most significant in the badlands and Mecca Hills.

Hillslope morphology. This subfactor group has little influence on the production and delivery of sediment and debris within the watershed. There is no significant evidence of active rilling, gulling, and mass movement. There are minimal eroding deposits in the confined channel reaches on the south side of Interstate 10.

Due to the low risk of wildfires occurring in this region due to sparse vegetation, the Fire Factor (FF) used in the analysis of each subbasin was assigned a minimum value of 3.0 based on fire factor (Tables A-1 and A-2; USACE, 2002).

Table 3-18. A-T factor breakdown for each subbasin

subfactor group	group parameter	subbasin									
		1A	1B	1	2	3	4	5	6	7	7A
parent material	folding	0.15	0.15	0.10	0.10	0.15	0.10	0.10	0.15	0.15	0.10
	faulting	0.15	0.15	0.10	0.10	0.15	0.10	0.10	0.15	0.15	0.10
	fracturing	0.15	0.15	0.10	0.10	0.15	0.10	0.10	0.15	0.15	0.10
	weathering	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
	A-T subfactor	0.13	0.13	0.09	0.09	0.13	0.09	0.09	0.13	0.13	0.09
soils	cohesion	0.10	0.05	0.10	0.15	0.10	0.15	0.20	0.10	0.10	0.15
	profile	0.10	0.05	0.10	0.15	0.10	0.15	0.20	0.10	0.10	0.15
	cover	0.10	0.05	0.10	0.15	0.10	0.15	0.20	0.10	0.10	0.15
	clay colloids	0.10	0.05	0.10	0.15	0.10	0.15	0.20	0.10	0.10	0.15
	A-T subfactor	0.10	0.05	0.10	0.15	0.10	0.15	0.20	0.10	0.10	0.15
channel morphology	bedrock exposures	0.10	0.05	0.05	0.05	0.10	0.05	0.05	0.10	0.05	0.05
	bank erosion	0.05	0.05	0.05	0.05	0.10	0.05	0.05	0.05	0.05	0.05
	bed and bank materials	0.10	0.05	0.10	0.15	0.10	0.15	0.20	0.10	0.10	0.15
	vegetation	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
	headcutting	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
	A-T subfactor	0.11	0.09	0.10	0.11	0.12	0.11	0.12	0.11	0.10	0.11
hillslope erosion	rills and gullies	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
	mass movement	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
	debris deposits	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
	A-T subfactor	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
A-T factor		0.39	0.32	0.34	0.40	0.40	0.40	0.46	0.39	0.38	0.40

The Baseline conditions debris yield analysis results are presented in Table 3-32 (short-duration 10- and 1-percent annual chance events), Table 3-33 (1-percent annual chance 24-hour event), and Table 3-34 (SPF). The Project conditions debris yield analysis results are presented in Table 3-48 (short-duration 10- and 1-percent annual chance events), Table 3-49 (1-percent annual chance 24-hour event), and Table 3-50 (SPF).

Table 3-19. Los Angeles District Debris Method (Table D-1; USACE, 2002) A-T factor guidelines

subfactor group	group parameter	A-T subfactor				
		0.25	0.20	0.15	0.10	0.05
parent material	folding	severe		moderate		minor
	faulting	severe		moderate		minor
	fracturing	severe		moderate		minor
	weathering	severe		moderate		minor
soils	cohesion	non-cohesive		partly cohesive		highly cohesive
	profile	minimum soil profile		some soil profile		well-developed soil profile
	cover	much bare soil in evidence		some bare soil in evidence		little bare soil in evidence
	clay colloids	few clay colloids		some clay colloids		many clay colloids
channel morphology	bedrock exposures	few segments in bedrock		some segments in bedrock		many segments in bedrock
	bank erosion	> 30% of banks eroding		10 - 30% of banks eroding		< 10% of banks erodings
	bed and bank materials	non-cohesive bed and banks		partly cohesive bed and banks		mildy cohesive bed and banks
	vegetation	poorly vegetated		some vegetation		much vegetation
	headcutting	many headcuts		few headcuts		no headcutting
hillslope erosion	rills and gullies	many and active		some signs		few signs
	mass movement	many scars evident		few signs evident		no signs evident
	debris deposits	many eroding deposits		some eroding deposits		few eroding deposits

3.5 Flood hydrograph development results

The regional flood hydrographs were developed for the Baseline and Project conditions to facilitate the determination of hydrologic impacts and the evaluation of their mitigation as well as establish hydrologic planning-level design parameters for the proposed La Entrada Development Specific Planning Area.

The Baseline and Project conditions short-duration 10- and 1-percent annual chance flood hydrographs were developed for the regional flood conveyances, which intersect the Project (1, 2, 3, 4, 5, 6, and 7). The results are intended to support the future evaluation of hydraulics, sedimentation, and erosion issues/constraints, and the subsequent design of proposed flood conveyance facilities.

The Baseline and Project conditions 1-percent annual chance 24-hour and SPF flood hydrographs were developed for subbasins all subbasins tributary to Wasteway No. 2 (1A, 1B, 1, 2, 3, 4, 5, 6, 7, and 7A) to be used in the determination of Project-related increases in temporary impoundment along the Eastside Dike.

As part of the flood hydrograph model development, infiltration characteristics and synthetic unit hydrographs were developed for each subbasin. The Baseline conditions regional hydrology maps are presented in Figure 3-19 (upstream property boundary subbasins) and Figure 3-20 (Eastside Dike subbasins). The project conditions regional hydrology maps are shown in Figure 3-21 (upstream property boundary subbasins) and Figure 3-22 (Eastside Dike subbasins).

3.5.1 Baseline Conditions

The hydrologic characteristics defined for the Baseline conditions are as follows:

Soil and land use. The distribution of soils within the Project watershed is presented in Table 3-20 (single-node subbasins tributary to the U/S property boundary) and Table 3-21 (Eastside Dike subbasins). Refer to Table 3-17 for a breakdown of the hydrologic soil type distribution for each NRCS soil map unit. For simplicity, the Baseline conditions watershed is assumed to be undeveloped, comprised of areas lightly covered by desert shrub throughout.

Precipitation. The short duration (3- and 6-hour) 10- and 1-percent annual chance precipitation depths are shown in Table 3-24 (upstream property boundary and Eastside Dike subbasins). The 24-hour duration frequency precipitation depths for the Eastside Dike subbasins are shown in Table 3-25.

Infiltration. The subbasin Green-Ampt infiltration characteristics are summarized in Table 3-22 (upstream property boundary subbasins) and Table 3-23 (Eastside Dike subbasins). The detailed loss rate calculation worksheets are included in the Technical Appendix.

Unit hydrograph. The basin factor determination and lag parameters are presented in Table 3-26 and Table 3-27, respectively, for the upstream property boundary subbasins; and Table 3-28 and Table 3-29, respectively, for the Eastside Dike subbasins. The lag times were used in conjunction with the Whitewater S-graph to develop the synthetic unit hydrographs for each subbasin.

Flood hydrograph and debris yield analysis results. The short duration (3- and 6-hour) 10- and 1-percent annual chance flood hydrograph peak flow rates and runoff volumes are presented Table 3-30. The 1-percent annual chance 24-hour peak flow rates and runoff volumes are shown in Table 3-31. The debris yield analysis results are listed in Table 3-33 (24-hour duration 1-percent annual chance event) and Table 3-32 (short duration 10- and 1-percent annual chance events). The SPF hydrologic and debris yield analysis results are presented in Table 3-34.

3.5.2 Project Conditions

The hydrologic characteristics defined for the Project conditions are as follows:

Soil and land use. The distribution of soils within the Project watershed is presented in Table 3-35 (upstream Project boundary subbasins) and Table 3-36 (Eastside Dike subbasins). Refer to Table 3-17 for a breakdown of the hydrologic soil type distribution for each NRCS soil map unit. The distribution of land uses within the Project watershed is presented in Table 3-37.

Infiltration. The Green-Ampt infiltration characteristics are listed in Table 3-38 (upstream Project boundary subbasins) and Table 3-39 (Eastside Dike subbasins).

Precipitation. The 3- and 6-hour (short duration) 10- and 1-percent annual chance precipitation depths are shown in Table 3-40 (upstream property boundary subbasins). The precipication data for the upstream Project boundary subbasins is the same for both sets of conditions (i.e., Baseline and Project), despite minor variations in acreage and drainage divides. The 24-hour duration frequency precipitation depths for the Eastside subbasins are shown in Table 3-41.

Unit hydrograph. The basin factor determination and lag parameters are presented in Table 3-42 and Table 3-43, respectively, for the upstream Project boundary conditions; and Table 3-44 and Table 3-45, respectively, for the Eastside Dike subbasins. The lag times were used in conjunction with the Whitewater S-graph to develop the unit hydrographs for each subbasin.

Flood hydrograph and debris yield analysis. The 3- and 6-hour (short duration) 10- and 1-percent annual chance flood hydrograph peak flow rates and runoff volumes are presented Table 3-46. The 1-percent annual chance 24-hour peak flow rates and runoff volumes are shown in Table 3-47. The debris yield analysis results are listed in Table 3-49 (24-hour duration 1-percent annual chance event) and Table 3-48 (short duration 10- and 1-percent annual chance events). The SPF results are shown in Table 3-50.

Figure 3-19. Baseline regional hydrology map – upstream Project boundary subbasins

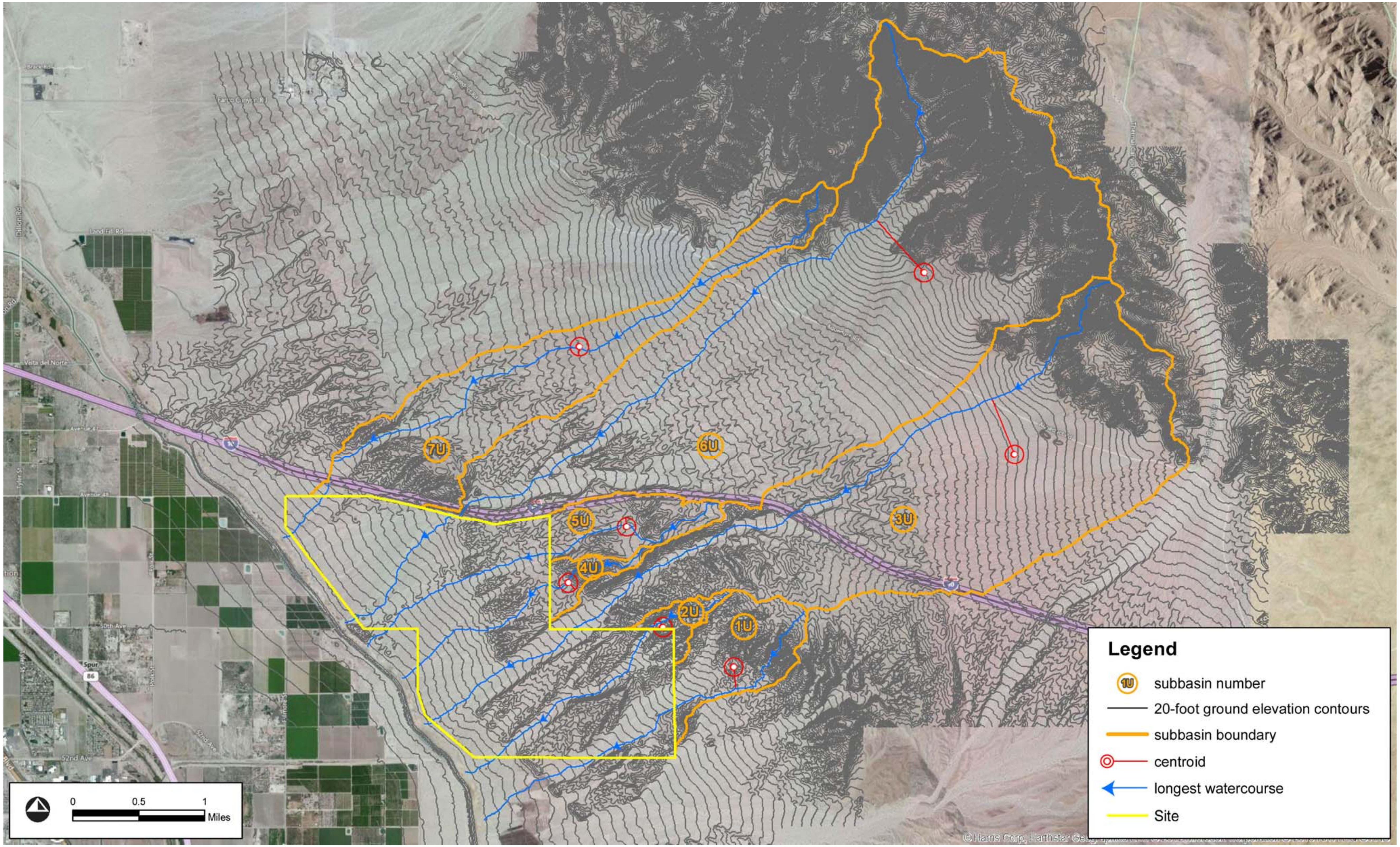


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Figure 3-20. Baseline regional hydroiogy map – Eastside Dike subbasins

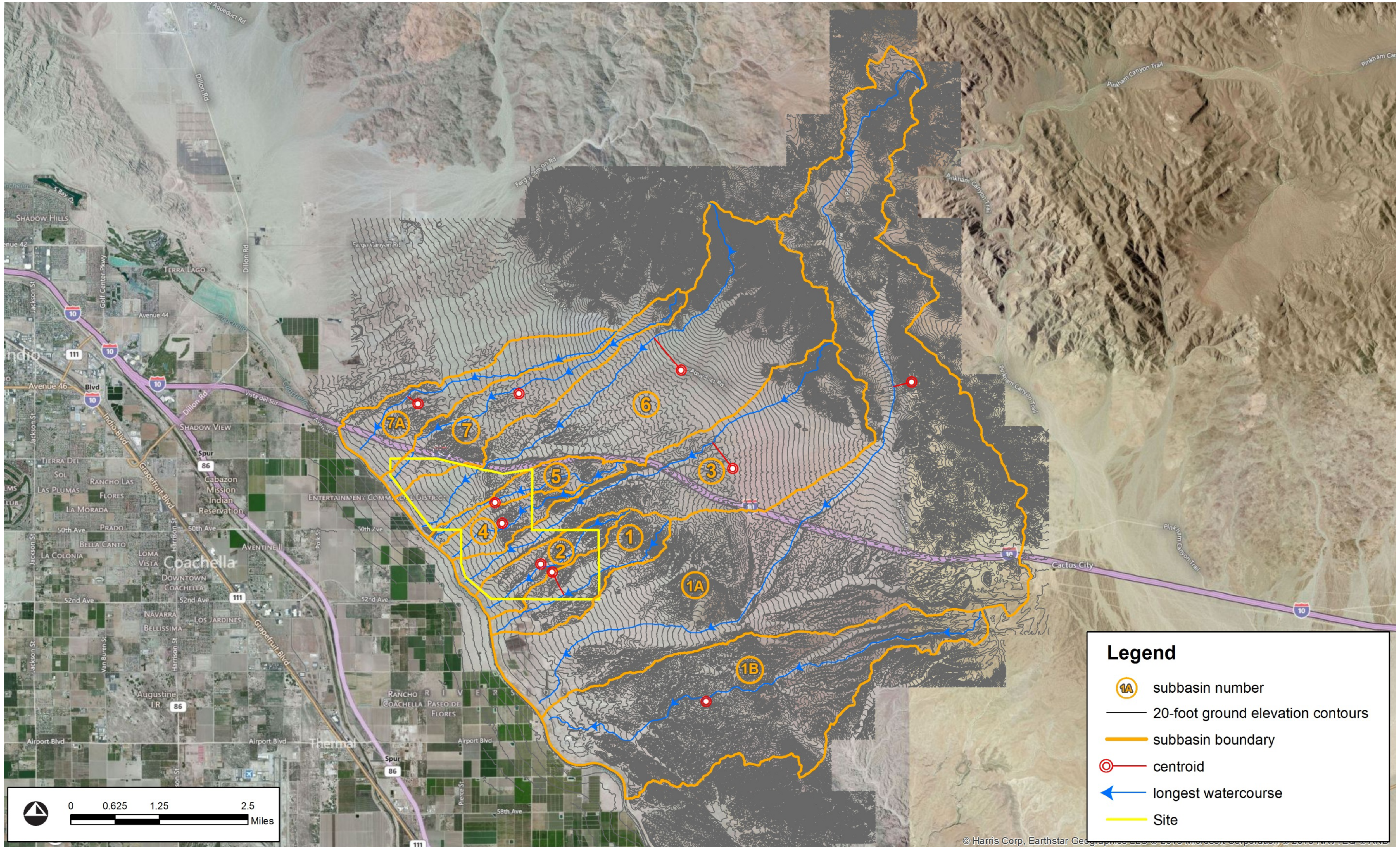

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Figure 3-21. Project regional hydrology map – upstream Project boundary subbasins

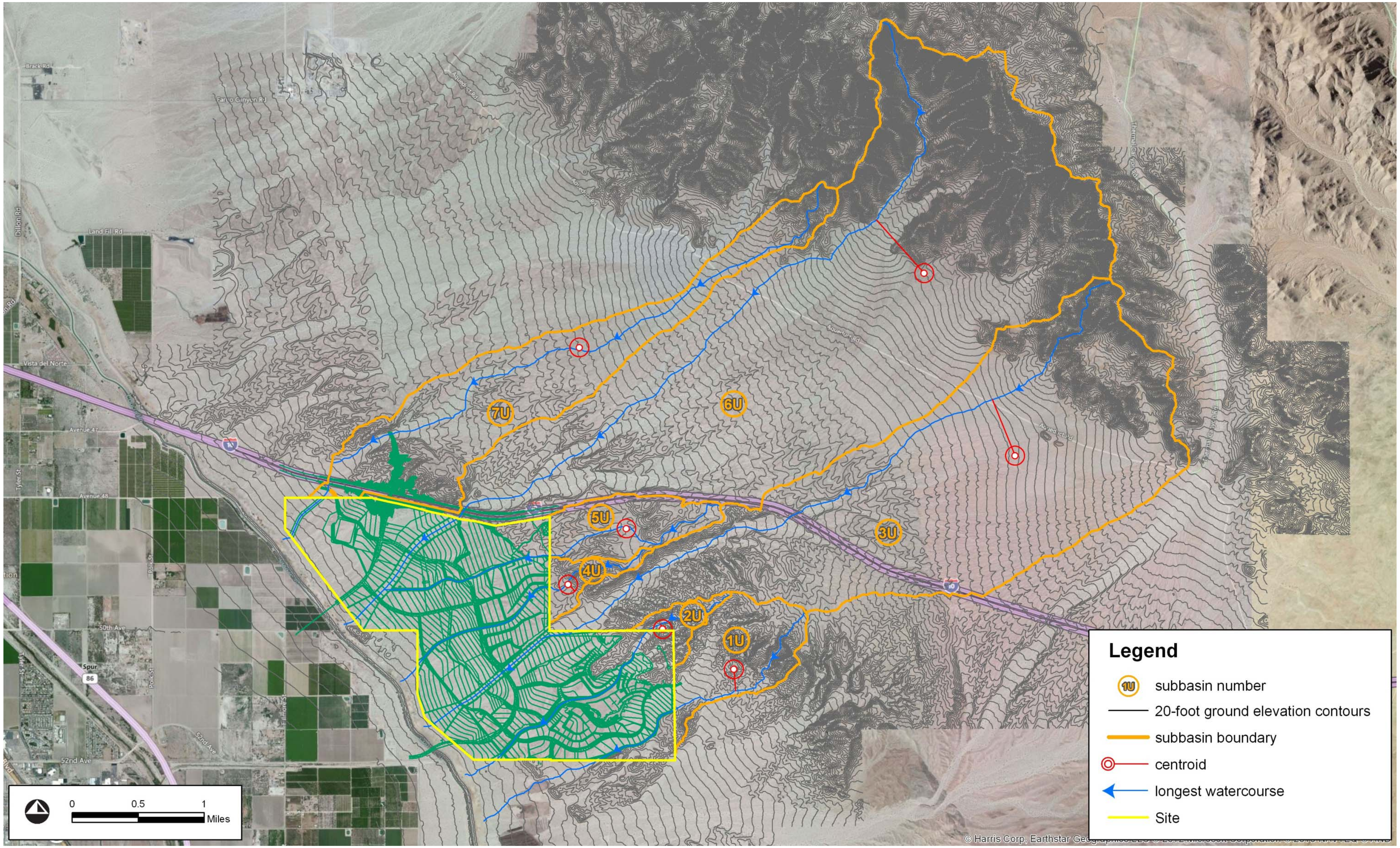

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Figure 3-22. Project regional hydrology map – Eastside Dike subbasins

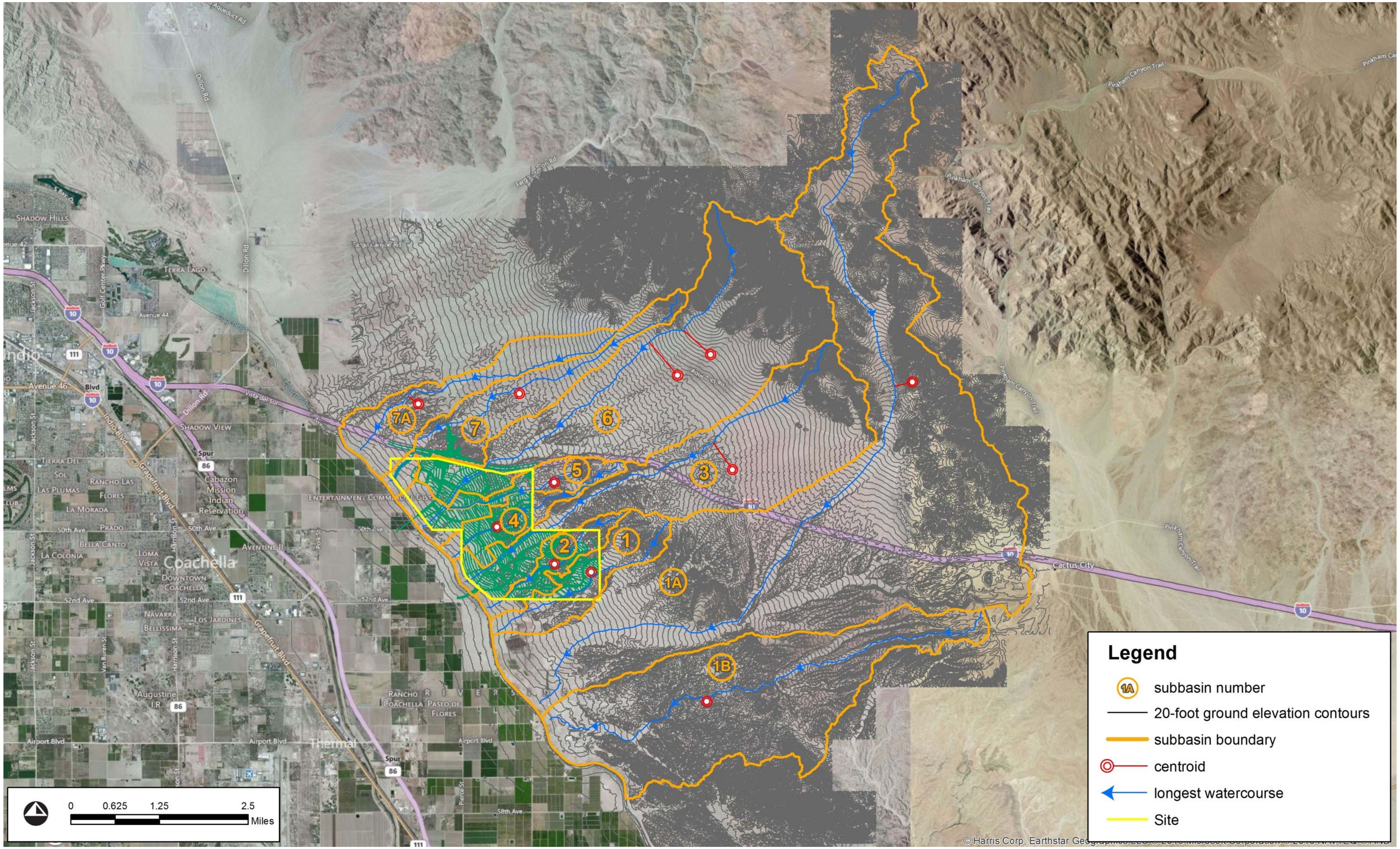

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Figure 3-23. Project watershed composite NRCS soil map

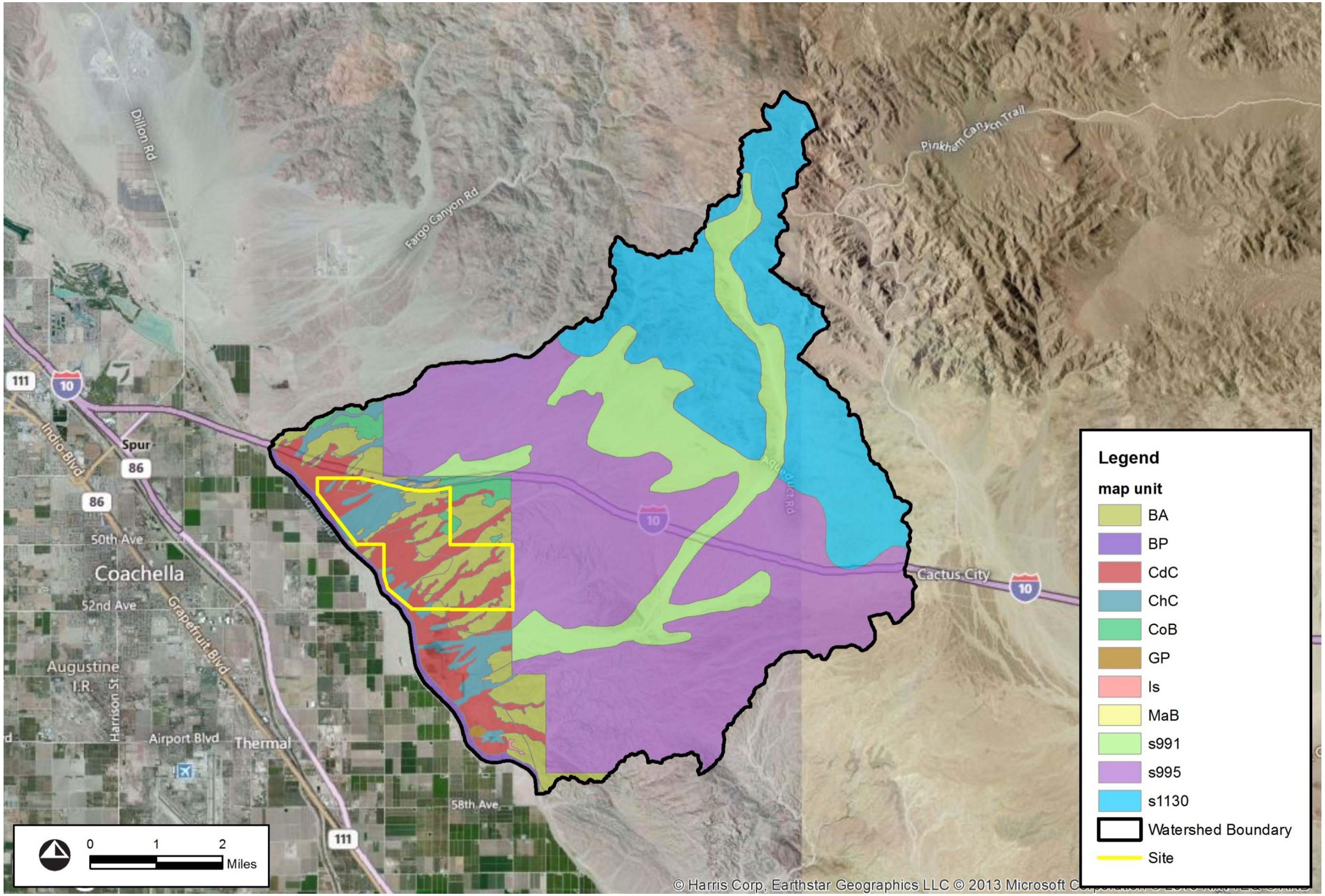

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Table 3-20. Baseline soil distribution – upstream Project boundary subbasins

subbasin	soil distribution in *acres*											
	NRCS CA680								NRCS US			total
	BA	BP	CdC	ChC	CoB	GP	Is	MaB	s991	s995	s1130	
1U	0	0	0	0	0	0	0	0	0	402	0	402
2U	18	0	1	0	4	0	0	0	0	61	0	83
3U	134	0	80	0	4	0	0	0	878	1,561	677	3,334
4U	76	0	0	0	23	0	0	0	0	0	0	99
5U	42	0	28	0	177	0	0	0	3	54	0	305
6U	29	0	0	38	32	0	0	0	1,443	1,635	1,728	4,906
7U	176	0	45	32	19	0	0	0	0	872	102	1,246
total	476	0	154	70	260	0	0	0	2,324	4,585	2,507	10,376

Table 3-21. Baseline soil distribution – Eastside Dike subbasins

subbasin	soil distribution in *acres*											
	NRCS CA680								NRCS US			total
	BA	BP	CdC	ChC	CoB	GP	Is	MaB	s991	s995	s1130	
1A	174	86	345	351	0	0	0	0	4,531	2,577	4,957	13,020
1B	519	103	293	32	0	23	10	0	15	3,914	0	4,909
1	296	13	273	12	0	0	0	0	0	405	0	998
2	327	23	180	34	4	0	0	0	0	61	0	630
3	190	31	269	30	4	0	0	0	878	1,561	677	3,641
4	208	11	242	3	46	0	0	0	0	0	0	511
5	104	8	157	0	186	0	0	0	3	54	0	512
6	142	34	77	376	34	0	0	0	1,443	1,635	1,728	5,469
7	197	23	172	40	19	0	0	0	0	872	102	1,426
7A	213	55	225	116	162	0	0	0	0	507	0	1,279
total	2,370	388	2,234	996	456	23	10	0	6,870	11,585	7,464	32,395

Table 3-22. Baseline loss rates – upstream Project boundary subbasins

subbasin	drainage area {acres}	drainage area {sq mi}	IA {inches}	DTHETA	PSIF {inches}	XKSAT {in/h}	RTIMP {%}
1U	402	0.6	0.15	0.152	6.971	0.101	10.0
2U	83	0.1	0.15	0.183	6.598	0.117	7.3
3U	3,334	5.2	0.15	0.253	3.863	0.430	15.8
4U	99	0.2	0.15	0.215	6.288	0.133	0.0
5U	305	0.5	0.15	0.250	5.780	0.165	1.8
6U	4,906	7.7	0.15	0.259	3.630	0.496	22.7
7U	1,246	1.9	0.15	0.250	5.677	0.172	11.5

Table 3-23. Baseline loss rates – Eastside Dike subbasins

subbasin	drainage area {acres}	drainage area {sq mi}	IA {inches}	DTHETA	PSIF {inches}	XKSAT {in/h}	RTIMP {%}
1A	13,020	20.3	0.15	0.253	3.859	0.431	22.9
1B	4,909	7.7	0.15	0.250	5.776	0.165	8.0
1	998	1.6	0.15	0.250	4.223	0.350	4.1
2	630	1.0	0.15	0.250	4.015	0.394	1.0
3	3,641	5.7	0.15	0.255	3.778	0.453	14.5
4	512	0.8	0.15	0.259	3.635	0.495	0.0
5	512	0.8	0.15	0.250	4.265	0.342	1.1
6	5,469	8.5	0.15	0.261	3.566	0.517	20.4
7	1,426	2.2	0.15	0.250	4.916	0.245	10.1
7A	1,279	2.0	0.15	0.250	4.423	0.314	4.0
composite	32,395	50.6	0.15	0.250	4.054	0.385	16.3

Table 3-24. Baseline short-duration rainfall

subbasin	storm event duration {hours}	*n*-percent annual chance average maximum point rainfall depth {inches}			
		upstream property boundary subbasins		Eastside Dike subbasins	
		$n = 10$	$n = 1$	$n = 10$	$n = 1$
1	3	1.16	2.33	1.12	2.26
	6	1.47	3.01	1.43	2.94
2	3	1.16	2.33	1.11	2.24
	6	1.47	3.01	1.42	2.91
3	3	1.25	2.50	1.24	2.47
	6	1.58	3.20	1.57	3.18
4	3	1.14	2.29	1.11	2.24
	6	1.45	2.97	1.42	2.91
5	3	1.16	2.33	1.14	2.29
	6	1.47	3.01	1.45	2.96
6	3	1.27	2.54	1.25	2.51
	6	1.61	3.26	1.59	3.23
7	3	1.17	2.36	1.16	2.33
	6	1.49	3.04	1.48	3.01

Table 3-25. Baseline 24-hour rainfall – Eastside Dike subbasins

subbasin	drainage area {sq mi}	24-hour DAR factor	*n*-percent annual chance average maximum point rainfall depth {inches}			
			unadjusted		DAR	
			$n = 50$	$n = 1$	$n = 50$	$n = 1$
1A	50.6	0.950	1.32	5.15	1.25	4.89
1B	50.6	0.950	1.20	4.71	1.14	4.47
1	50.6	0.950	1.17	4.63	1.11	4.40
2	50.6	0.950	1.16	4.58	1.10	4.35
3	50.6	0.950	1.28	5.00	1.22	4.75
4	50.6	0.950	1.16	4.58	1.10	4.35
5	50.6	0.950	1.18	4.67	1.12	4.44
6	50.6	0.950	1.30	5.08	1.24	4.83
7	50.6	0.950	1.21	4.75	1.15	4.51
7A	50.6	0.950	1.19	4.66	1.13	4.43

Table 3-26. Baseline lag basin factor determination – upstream Project boundary subbasins

subbasin	area {acres}	hydrologic soil group {%}				basin factor
		A	B	C	D	
1U	402	5	19	0	76	0.041
2U	83	4	14	0	82	0.042
3U	3334	31	15	1	53	0.038
4U	99	0	0	0	100	0.045
5U	305	11	3	0	86	0.043
6U	4906	33	17	1	49	0.037
7U	1246	10	16	0	74	0.041

Table 3-27. Baseline lag basin factor determination – Eastside Dike subbasins

subbasin	area {acres}	hydrologic soil group {%}				basin factor
		A	B	C	D	
1A	13020	28	18	1	53	0.038
1B	4909	11	15	0	73	0.041
1	998	31	8	0	62	0.039
2	630	35	2	0	64	0.040
3	3641	35	14	1	51	0.038
4	511	48	0	0	52	0.038
5	512	32	2	0	66	0.040
6	5469	37	15	1	47	0.037
7	1426	18	14	0	68	0.040
7A	1279	29	8	0	64	0.040

Table 3-28. Baseline unit hydrograph lag parameters – upstream Project boundary subbasins

subbasin	BA {sq mi}	L {miles}	LCA {miles}	S {ft/mi}	basin factor N	lag {hours}
1U	0.628	1.502	0.519	366.9	0.041	0.29
2U	0.130	0.981	0.314	441.3	0.042	0.20
3U	5.209	5.332	3.838	267.9	0.038	0.99
4U	0.155	0.983	0.163	345.5	0.045	0.18
5U	0.477	1.597	0.650	263.3	0.043	0.36
6U	7.666	5.959	4.120	305.9	0.037	1.01
7U	1.947	5.057	2.504	253.2	0.041	0.90

Table 3-29. Baseline unit hydrograph lag parameters – Eastside Dike subbasins

subbasin	BA {sq mi}	L {miles}	LCA {miles}	S {ft/mi}	basin factor N	lag {hours}
1	1.560	3.264	1.125	251.9	0.039	0.54
2	0.984	2.669	1.000	283.2	0.040	0.48
3	5.688	6.739	4.245	269.0	0.038	1.13
4	0.799	2.425	0.881	298.3	0.038	0.41
5	0.800	3.251	1.076	279.2	0.040	0.53
6	8.546	7.268	4.508	279.5	0.037	1.15
7	2.228	5.511	2.492	257.7	0.040	0.90

Table 3-30. Baseline short-duration flood hydrograph results

subbasin	duration {hours}	10-percent annual chance storm event				1-percent annual chance storm event			
		U/S PL		Eastside Dike		U/S PL		Eastside Dike	
		Q_p {cfs}	runoff volume {ac-ft}	Q_p {cfs}	runoff volume {ac-ft}	Q_p {cfs}	runoff volume {ac-ft}	Q_p {cfs}	runoff volume {ac-ft}
1	3	218	13	79	6	565	48	704	53
	6	189	16	81	8	490	57	643	61
2	3	46	2	23	1	126	9	424	27
	6	41	3	28	2	111	11	391	30
3	3	396	64	350	62	1,963	254	1,852	256
	6	355	78	319	76	1,815	292	1,740	295
4	3	48	2	1	0	147	9	324	18
	6	43	2	6	0	128	11	276	17
5	3	88	5	40	2	337	25	366	26
	6	83	5	39	2	309	30	333	30
6	3	704	125	630	121	2,958	413	2,878	425
	6	636	157	576	153	2,719	483	2,633	490
7	3	249	29	211	25	924	118	930	111
	6	235	33	194	29	882	141	893	133

Table 3-31. Baseline 24-hour flood hydrograph results – Eastside Dike subbasins

subbasin	area {acres}	*n*-percent chance annual event			
		n = 50		*n* = 1	
		Q_p {cfs}	runoff volume {ac-ft}	Q_p {cfs}	runoff volume {ac-ft}
1A	13,020	366	311	1,648	1,253
1B	4,909	48	37	1,118	472
1	998	5	4	81	19
2	630	1	1	21	3
3	3,641	70	54	313	214
4	511	0	0	0	0
5	512	1	1	40	5
6	5,469	149	115	579	449
7	1,426	19	14	258	101
7A	1,279	17	14	241	99
total	32,395	--	551	--	2,615

Table 3-32. Baseline short-duration debris yield and bulking analysis results

subbasin	CP	total area {acres}	natural area {acres}	slope {ft/mi}	10-percent annual chance storm event					1-percent annual chance storm event				
					Q_p {cfs}	runoff volume {ac-ft}	debris yield {ac-ft}	bulking factor	$Q_{p,bulked}$ {cfs}	Q_p {cfs}	runoff volume {ac-ft}	debris yield {ac-ft}	bulking factor	$Q_{p,bulked}$ {cfs}
1	U/S PL	402	402	367	218	13	4	1.29	281	567	48	8	1.18	666
	Eastside Dike	998	998	252	81	8	2	1.20	97	704	53	10	1.19	835
2	U/S PL	83	83	441	46	2	1	1.41	65	126	9	2	1.21	153
	Eastside Dike	630	630	283	28	2	1	1.31	37	424	27	6	1.23	522
3	U/S PL	3,334	3,334	268	396	64	8	1.12	445	1,963	254	31	1.12	2,199
	Eastside Dike	3,641	3,641	269	350	62	7	1.12	391	1,852	256	30	1.12	2,067
4	U/S PL	99	99	346	48	2	1	1.38	66	147	9	2	1.22	179
	Eastside Dike	511	511	298	6	0	0	1.34	8	324	18	5	1.27	412
5	U/S PL	305	305	263	88	5	1	1.27	112	337	25	4	1.17	395
	Eastside Dike	512	512	279	40	2	1	1.40	56	366	26	5	1.20	440
6	U/S PL	4,906	4,906	306	704	125	15	1.12	787	2,958	413	50	1.12	3,316
	Eastside Dike	5,469	5,469	279	630	121	13	1.11	698	2,878	425	48	1.11	3,200
7	U/S PL	1,246	1,246	253	249	29	4	1.15	286	924	118	13	1.11	1,026
	Eastside Dike	1,426	1,426	258	211	25	4	1.15	243	930	111	14	1.12	1,043

Table 3-33. Baseline 24-hour 1-percent annual chance debris yield analysis results

subbasin	total area {acres}	natural area {acres}	slope {ft/mi}	Q_p {cfs}	runoff volume {ac-ft}	debris yield {ac-ft}	bulked volume {ac-ft}	bulking factor	$Q_{p,bulked}$ {cfs}
1A	13,020	13,020	243.0	1,648	1,253	30	1,283	1.02	1,687
1B	4,909	4,909	217.5	1,118	472	18	490	1.04	1,161
1	998	998	252	81	19	2	21	1.08	88
2	630	630	283	21	3	0	3	1.16	24
3	3,641	3,641	269	313	214	7	221	1.03	323
4	511	511	298	0	0	0	0	1.00	0
5	512	512	279	40	5	1	6	1.16	46
6	5,469	5,469	279	579	449	12	461	1.03	595
7	1,426	1,426	258	258	101	5	106	1.04	270
7A	1,279	1,279	234.7	241	99	4	103	1.04	251
total	32,395	32,395	--	--	2,615	78	2,693	--	--

Table 3-34. Baseline SPF hydrologic and debris yield analysis results

subbasin	total area {acres}	natural area {acres}	slope {ft/mi}	Q_p {cfs}	runoff volume {ac-ft}	debris yield {ac-ft}	bulked volume {ac-ft}	bulking factor	$Q_{p,bulked}$ {cfs}
1A	13,020	13,020	243.0	10,587	2,786	152	2,938	1.05	11,165
1B	4,909	4,909	217.5	6,039	1,221	77	1,298	1.06	6,418
1	998	998	252	1,489	182	19	201	1.10	1,641
2	630	630	283	955	103	12	115	1.12	1,070
3	3,641	3,641	269	3,706	682	53	735	1.08	3,997
4	511	511	298	754	71	10	81	1.00	754
5	512	512	279	766	91	10	101	1.11	849
6	5,469	5,469	279	5,470	1,052	82	1,134	1.08	5,897
7	1,426	1,426	258	1,850	321	24	345	1.08	1,990
7A	1,279	1,279	234.7	1,858	245	23	268	1.09	2,030
total	32,395	32,395	--	--	6,754	462	7,216	--	--

Table 3-35. Project soil distribution – upstream Project boundary subbasins

subbasin	soil distribution in *acres*											
	NRCS CA680								NRCS US			total
	BA	BP	CdC	ChC	CoB	GP	Is	MaB	s991	s995	s1130	
1U	0	0	0	0	0	0	0	0	0	402	0	402
2U	18	0	1	0	4	0	0	0	0	61	0	83
3U	134	0	80	0	4	0	0	0	878	1,561	677	3,334
4U	78	0	0	0	23	0	0	0	0	0	0	101
5U	41	0	28	0	177	0	0	0	3	54	0	303
6U	37	0	3	38	32	0	0	0	1,443	1,635	1,728	4,916
7U	168	0	42	32	19	0	0	0	0	872	102	1,236
total	476	0	154	70	260	0	0	0	2,324	4,585	2,507	10,376

Table 3-36. Project soil distribution – Eastside Dike subbasins

subbasin	soil distribution in *acres*											
	NRCS CA680								NRCS US			total
	BA	BP	CdC	ChC	CoB	GP	Is	MaB	s991	s995	s1130	
1	251	13	266	12	0	0	0	0	0	405	0	946
2	282	23	132	21	4	0	0	0	0	61	0	524
3	273	31	322	46	4	0	0	0	878	1,561	677	3,792
4	217	11	250	1	47	0	0	0	0	0	0	525
5	95	0	64	36	186	0	0	0	3	54	0	439
6C	130	0	83	216	34	0	0	0	1,443	1,635	1,728	5,270
5+6	268	43	285	376	220	0	0	0	1,446	1,689	1,728	6,055
7	172	23	117	40	19	0	0	0	0	872	102	1,345
total	1,464	143	1,371	496	294	0	0	0	2,324	4,587	2,507	13,187

Table 3-37. Project landuse distribution – Eastside Dike subbasins

subbasin	landuse distribution in *acres*											
	DR	HDR	LDR	MDR	MU	NAT	OS	PR	RD	SCH	VLDR	total
1	11	0	74	30	0	707	78	16	13	0	17	946
2	12	0	96	15	0	171	100	32	15	30	52	524
3	57	15	84	102	10	3,378	96	25	22	3	0	3,792
4	11	10	117	121	22	153	12	38	22	20	0	525
5	11	20	19	18	0	298	43	21	2	8	0	439
6C	35	46	58	47	79	4,898	21	29	26	29	0	5,270
5+6	73	66	77	112	99	5,300	96	150	45	36	0	6,055
7	8	0	0	0	0	1,256	0	72	0	9	0	1,345
total	172	91	448	380	131	10,965	383	332	116	99	69	13,187

Table 3-38. Project loss rates – upstream Project boundary subbasins

subbasin	drainage area		IA	DTHETA	PSIF	XKSAT	RTIMP
	{acres}	{sq mi}	{inches}		{inches}	{in/h}	{%}
1U	402	0.6	0.15	0.152	6.971	0.101	10.0
2U	83	0.1	0.15	0.183	6.598	0.117	7.3
3U	3,334	5.2	0.15	0.253	3.863	0.430	15.8
4U	101	0.2	0.15	0.215	6.281	0.133	0.0
5U	303	0.5	0.15	0.250	5.786	0.164	1.8
6U	4,909	7.7	0.15	0.259	3.629	0.497	22.7
7U	1,235	1.9	0.15	0.250	5.704	0.170	11.6

Table 3-39. Project loss rates – Eastside Dike subbasins

subbasin	drainage area		IA	DTHETA	PSIF	XKSAT	RTIMP
	{acres}	{sq mi}	{inches}		{inches}	{in/h}	{%}
1A	13,020	20.3	0.15	0.253	3.859	0.431	22.9
1B	4,909	7.7	0.15	0.250	5.776	0.165	8.0
1	946	1.5	0.15	0.250	4.275	0.340	9.7
2	524	0.8	0.15	0.250	4.487	0.304	15.1
3	3,792	5.9	0.15	0.255	3.779	0.453	16.8
4	525	0.8	0.15	0.256	3.761	0.458	27.0
5	439	0.7	0.15	0.250	4.856	0.252	8.6
6C	5,270	8.2	0.15	0.260	3.615	0.501	24.4
5 + 6	6,055	9.5	0.15	0.258	3.657	0.488	22.9
7	1,345	2.1	0.15	0.250	5.241	0.210	11.7
7A	1,279	2.0	0.15	0.250	4.423	0.314	4.0
composite	32,395	50.6	0.15	0.250	4.081	0.379	18.3

Table 3-40. Project short-duration rainfall – Eastside Dike subbasins

subbasin	storm event duration {hours}	*n*-percent annual chance average maximum point rainfall depth {inches}	
		n = 10	*n* = 1
1	3	1.12	2.26
	6	1.44	2.94
2	3	1.11	2.25
	6	1.42	2.92
3	3	1.23	2.47
	6	1.56	3.17
4	3	1.11	2.23
	6	1.42	2.91
5*	3	1.14	2.30
	6	1.46	2.98
6C*	3	1.26	2.53
	6	1.60	3.24
5 + 6	3	1.24	2.49
	6	1.58	3.20
7	3	1.16	2.34
	6	1.48	3.02

*Subbasins tributary to the confluence of Channels 5 and 6

Table 3-41. Project 24-hour rainfall – Eastside Dike subbasins

subbasin	drainage area {sq mi}	24-hour DAR factor	*n*-percent annual chance average maximum point rainfall depth {inches}			
			unadjusted		DAR	
			n = 50	*n* = 1	*n* = 50	*n* = 1
1	50.6	0.950	1.17	4.63	1.11	4.40
2	50.6	0.950	1.16	4.60	1.10	4.37
3	50.6	0.950	1.27	4.99	1.21	4.74
4	50.6	0.950	1.16	4.58	1.10	4.35
5 + 6	50.6	0.950	1.29	5.05	1.23	4.80
7	50.6	0.950	1.21	4.76	1.15	4.52

Table 3-42. Project lag basin factor determination – upstream Project boundary subbasins

subbasin	area {acres}	hydrologic soil group {%}				basin factor
		A	B	C	D	
1	402	5	19	0	76	0.041
2	83	4	14	0	82	0.042
3	3334	31	15	1	53	0.038
4	101	0	0	0	100	0.045
5	303	11	3	0	86	0.043
6	4909	33	17	1	49	0.037
7	1235	10	16	0	74	0.041

Table 3-43. Project lag basin factor determination – Eastside Dike subbasins

subbasin	area {acres}	hydrologic soil group {%}				RTIMP	basin factor
		A	B	C	D		
1	946	31	8	0	60	5.4	0.037
2	524	30	2	0	68	14.0	0.031
3	3792	35	13	1	51	2.8	0.036
4	525	48	0	0	52	27.0	0.027
5	439	24	2	0	73	7.4	0.038
6C	5270	35	16	1	48	3.3	0.036
5 + 6	6055	37	14	1	48	4.5	0.036
7	1345	15	15	0	70	1.1	0.040

Table 3-44. Project unit hydrograph lag parameters – upstream Project boundary subbasins

subbasin	BA {sq mi}	L {miles}	LCA {miles}	S {ft/mi}	basin factor N	lag {hours}
1U	0.628	1.502	0.519	366.9	0.041	0.29
2U	0.130	0.981	0.314	441.3	0.042	0.20
3U	5.209	5.332	3.838	267.9	0.038	0.99
4U	0.158	0.983	0.163	343.9	0.045	0.18
5U	0.473	1.597	0.650	263.3	0.043	0.36
6U	7.670	6.001	4.163	304.2	0.037	1.02
7U	1.930	5.057	2.504	253.2	0.041	0.90

Table 3-45. Project unit hydrograph lag parameters – Eastside Dike subbasins

subbasin	BA {sq mi}	L {miles}	LCA {miles}	S {ft/mi}	basin factor N	lag {hours}
1	1.478	3.263	1.659	251.8	0.037	0.59
2	0.818	2.644	1.172	287.0	0.031	0.39
3	5.925	6.703	4.209	271.5	0.036	1.06
4	0.821	2.369	0.771	308.0	0.027	0.27
5*	0.686	2.914	1.662	276.6	0.038	0.57
6C*	8.234	6.449	3.933	323.6	0.036	0.98
5 + 6	9.461	6.857	3.954	313.1	0.036	1.02
7	2.102	5.512	2.493	257.6	0.040	0.91

*Subbasins tributary to the confluence of Channels 5 and 6

Table 3-46. Project short-duration flood hydrograph results

subbasin	duration {hours}	10-percent annual chance storm event				1-percent annual chance storm event			
		U/S PL		Eastside Dike		U/S PL		Eastside Dike	
		Q_p {cfs}	runoff volume {ac-ft}	Q_p {cfs}	runoff volume {ac-ft}	Q_p {cfs}	runoff volume {ac-ft}	Q_p {cfs}	runoff volume {ac-ft}
1	3	218	13	103	11	565	48	670	58
	6	189	16	103	14	490	57	622	69
2	3	46	2	101	9	126	9	490	38
	6	41	3	92	11	111	11	443	46
3	3	396	64	419	72	1,963	254	2,097	280
	6	355	78	381	90	1,815	292	1,911	324
4	3	49	2	49	2	150	9	536	40
	6	44	2	105	17	131	11	461	49
5*	3	88	5	77	7	336	25	361	31
	6	83	5	73	8	307	30	331	38
6*	3	702	125	798	141	2,952	413	3,284	454
	6	632	157	724	178	2,705	483	2,970	531
5 + 6	3	--	--	836	151	--	--	3,560	499
	6	--	--	765	191	--	--	3,271	585
7	3	249	29	233	28	919	117	936	116
	6	235	33	218	32	877	140	896	139

*These subbasins only extend down to the confluence of Channels 5 and 6

Table 3-47. Project 24-hour flood hydrograph data – Eastside Dike subbasins

subbasin	total area {acres}	*n*-percent chance annual event			
		n = 50		*n* = 1	
		Q_p {cfs}	runoff volume {ac-ft}	Q_p {cfs}	runoff volume {ac-ft}
1	946	12	8	106	39
2	524	11	7	92	34
3	3,792	84	64	375	257
4	525	20	13	80	51
5 + 6	6,055	188	142	745	556
7	1,345	20	16	295	119
total	13,187	--	250	--	1,056

Table 3-48. Project short-duration debris yield and bulking analysis results

subbasin	CP	total area {acres}	natural area {acres}	slope {ft/mi}	10-percent annual chance storm event Q_p {cfs}	runoff volume {ac-ft}	debris yield {ac-ft}	bulking factor	$Q_{p,bulked}$ {cfs}	1-percent annual chance storm event Q_p {cfs}	runoff volume {ac-ft}	debris yield {ac-ft}	bulking factor	$Q_{p,bulked}$ {cfs}
1	U/S PL	402	402	366.9	218	13	4	1.29	281	565	48	8	1.17	664
	Eastside Dike	946	796	251.8	103	11	2	1.14	118	670	58	8	1.13	760
2	U/S PL	83	83	441.3	46	2	1	1.41	65	126	9	2	1.21	153
	Eastside Dike	524	301	287.0	101	9	1	1.11	112	490	38	4	1.10	540
3	U/S PL	3,334	3,334	267.9	396	64	8	1.12	445	1,963	254	31	1.12	2,199
	Eastside Dike	3,792	3,533	271.5	419	72	8	1.11	465	2,097	280	31	1.11	2,329
4	U/S PL	101	101	343.9	49	2	1	1.39	68	150	9	2	1.22	184
	Eastside Dike	525	176	308.0	105	17	1	1.04	109	536	40	2	1.06	569
5*	U/S PL	303	303	263.3	88	5	1	1.27	112	336	25	4	1.17	394
	6C	439	352	276.6	77	7	1	1.15	89	361	31	4	1.13	407
6*	U/S PL	4,909	4,909	304.2	702	125	15	1.12	785	2,952	413	50	1.12	3,308
	6C	5,270	4,955	323.6	798	141	16	1.11	889	3,284	454	54	1.12	3,671
5 + 6	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	Eastside Dike	6,055	5,469	313.1	836	151	16	1.11	926	3,560	499	56	1.11	3,956
7	U/S PL	1,236	1,236	253.2	249	29	4	1.15	285	919	117	13	1.11	1,020
	Eastside Dike	1,345	1,264	257.6	233	28	4	1.14	265	936	116	13	1.11	1,038

*These subbasins only extend down to the confluence of Channels 5 and 6 alternatively referred to as Concentration Point (CP) 6C

Table 3-49. Project 24-hour 1-percent annual chance debris yield – Eastside Dike subbasins

subbasin	total area {acres}	natural area {acres}	slope {ft/mi}	Q_p {cfs}	runoff volume {ac-ft}	debris yield {ac-ft}	bulked volume {ac-ft}	bulking factor	$Q_{p,bulked}$ {cfs}
1	946	796	251.8	106	39	2	41	1.04	110
2	524	301	287.0	92	34	1	35	1.03	95
3	3,792	3,533	271.5	375	257	7	264	1.03	385
4	525	176	308.0	80	51	0	51	1.00	80
5 + 6	6,055	5,469	313.1	745	556	15	571	1.03	765
7	1,345	1,264	257.6	295	119	5	124	1.04	307
total	13,187	11,539	--	--	1,056	30	1,086	--	--

Table 3-50. Project SPF hydrologic and debris yield analysis results

subbasin	total area {acres}	natural area {ac-ft}	slope {ft/mi}	Q_p {cfs}	runoff volume {ac-ft}	debris yield {ac-ft}	bulked volume {ac-ft}	bulking factor	$Q_{p,bulked}$ {cfs}
1	946	796	251.8	1,392	188	15	203	1.08	1,500
2	524	301	287.0	940	115	7	122	1.06	995
3	3,792	3,533	271.5	4,045	734	54	788	1.07	4,344
4	525	176	308.0	1,009	116	4	120	1.00	1,009
5 + 6	6,055	5,469	313.1	6,667	1,237	95	1,332	1.08	7,177
7	1,345	1,264	257.6	1,797	322	22	344	1.07	1,919
total	13,187	11,539	--	--	2,712	196	2,908	--	--

3.5.3 Regional Channel Design Discharges

The peak flow discharges used for the design of the regional channel drainage systems should use the 1% annual chance short-duration bulked flow rates shown in Table 3-48. These peak flow rates were developed using the RCFCWCD 3- and 6-hour storm patterns. Uncertainty in the actual storm pattern, and rainfall-runoff modeling using different patterns such as the USACE hypothetical storm pattern can result in variations in the design peak flow rates. The hydraulic design of the channel systems should evaluate the impacts of various flow rates and consider the use of a risk and uncertainty analysis for the final design.

3.6 Project-related hydrologic impacts

The project-related increases in peak flow rate and flood volume were determined based on the change in hydrologic environment between the Baseline Conditions and Project Conditions.

3.6.1 Flood conveyance

The short-duration storm events were used to determine the project-related increases in peak flow rate as shown in Table 3-51.

Table 3-51. Comparison of Baseline and Project conditions short-duration events

channel	CP	10-percent annual chance storm event			1-percent annual chance storm event		
		baseline $Q_{p,bulked}$ {cfs}	project $Q_{p,bulked}$ {cfs}	ΔQ {cfs}	baseline $Q_{p,bulked}$ {cfs}	project $Q_{p,bulked}$ {cfs}	ΔQ {cfs}
1	U/S PL	281	281	0	666	664	-3
	Eastside Dike	97	118	21	835	760	-75
2	U/S PL	65	65	0	153	153	0
	Eastside Dike	37	112	76	522	540	18
3	U/S PL	445	445	0	2,199	2,199	0
	Eastside Dike	391	465	74	2,067	2,329	263
4	U/S PL	66	68	2	179	184	4
	Eastside Dike	8	109	101	412	569	157
5	U/S PL	112	112	0	395	394	-1
	6C*	--	89	--	--	407	--
	Eastside Dike	56	--	--	440	--	--
6	U/S PL	787	785	-3	3,316	3,308	-8
	6C*	--	889	--	--	3,671	--
	Eastside Dike	698	926	228	3,200	3,956	756
7	U/S PL	286	285	0	1,026	1,020	-5
	Eastside Dike	243	265	22	1,043	1,038	-6

*Concentration Point (CP) 6C represents the confluence location of Channels 5 and 6

3.6.2 Eastside Dike Impacts

Ordinance 1234.1, adopted March 25, 2013, states that levees shall be designed with a minimum of 4 feet of freeboard from the levee crest elevation to the 100-year flood water surface elevation and a minimum of one foot of freeboard as measured from the levee crest elevation to the SPF water surface elevation.

The 1-percent annual chance 24-hour storm and SPF events were used to determine the baseline and project freeboard along the Eastside Dike.

The 1-percent annual chance 24-hour storm event experienced an increased storm water runoff volume (bulked) of 269 acre-feet based on the data shown in Table 3-33 and Table 3-49 (Subbasins 1-7). The SPF event experienced an increase of 196 acre-feet based on the data listed in Table 3-34 and Table 3-50 (Subbasins 1-7). Note that Subasins 1A, 1B, and 7A in Tables 3-33 and 3-34 are outside of the development area and are not used for the comparison of storm water runoff volumes.

The freeboard impacts related to the increase in runoff volume (bulked) was analyzed to evaluate the effects of the La Entrada Specific Plan development on the Eastside Dike. For each event (1-percent annual chance 24-hour storm and SPF) and condition (Baseline and Project), a flood routing analysis was performed using FLO-2D to simulate the conveyance and dispersion of floodwaters along the Eastside Dike and subsequently, determined the water surface elevation (WSE) profile and maximum flow velocities.

The FLO-2D model definition includes the following:

- Domain consisting of 64,021 grid elements
- 50' x 50' grid element size
- Grid element elevations were interpolated from Intermap data
- 0.045 floodplain n-value
- 0.95 limiting Froude number
- 0.100 shallow n-value
- No infiltration (transmission losses)
- Wasteway No. 2 defined as a floodplain-to-floodplain culvert (inlet control)
- Inflow hydrographs were defined for each of the significant drainage tributaries previously analyzed (1A, 1B, 1, 2, 3, 4, 5, 6, 7, and 7A). The inflow locations are consistent between the baseline and project conditions. Inflow hydrographs were depth proportioned across one to several lateral grid elements based on a common water surface elevation across the applicable grid elements. Inflow hydrographs were bulked based on the estimated debris yield. The inflow hydrographs were developed based on the entire tributary of each drainage down to the Eastside Dike
- The domain boundary was defined along the top of the Eastside Dike to serve as a levee of infinite height except at the Wasteway No. 2 inlet where levee components were defined along the top of the Eastside Dike to prevent overtopping; this is the only area where the domain was extended to the west of the Eastside Dike to allow Wasteway No. 2 to discharge downstream
- A simplified approach was used to represent the proposed channels aligned through the La Entrada Specific Plan. These channels were not formally defined within FLO-2D; instead, levees were defined to represent the banks of each channel to confine flow to within each proposed channel footprint; the baseline ground elevations within each proposed channel footprint were applied, which are generally consistent with the proposed grading

The emulation of the proposed channels was considered important in the evaluation of impacts because the concentration of floodwaters and improved hydraulic efficiency in the project condition relative to the baseline conditions are expected to influence the flood-related impacts along the Eastside Dike.

The maximum WSE along the Eastside Dike between the Avenue 50 and 52 crossings is generally higher than the WSE north of the Avenue 50 crossing and south of the Avenue 52 crossing as a result of the energy potential required to disperse the floodwaters to these outside areas.

Table 3-52. Comparison of Baseline and Project conditions maximum water surface elevations

statistic	1-percent annual chance 24-hour storm event			Standard Project Flood (SPF) -Indio Storm of September 24, 1939-				
	baseline	project		baseline	project -no crossings-		project	
	WSE {feet}	WSE {feet}	ΔWSE {feet}	WSE {feet}	WSE {feet}	ΔWSE {feet}	WSE {feet}	ΔWSE {feet}
maximum	55.11	56.03	1.75	65.15	65.82	0.69	67.01	1.88
average	53.25	54.51	1.23	64.08	64.55	0.47	65.28	1.18
minimum	51.66	52.45	0.51	63.62	64.07	0.22	64.13	0.31

The average top of levee elevation along the Project segment of the Eastside Dike is 71 feet. The original SPF design water surface elevation is 66.24 feet (64.0 feet based on NGVD29; Slater et al, 1950). The Project-based SPF maximum water surface elevation is 67.01 feet, which occurs within the Channel 6 outfall inundation area just south of the Avenue 50 crossing.

The project SPF flood hazard exceeds the original design SPF water surface elevation for 0.4 miles of the 2.2 mile-segment of the Eastside Dike, which fronts the project, extending southward beginning on the southside of the Avenue 50 crossing. This impact is largely attributed to the concentration of floodwaters delivered by Channel 6.

The resultant maximum water surface elevation contours are presented in Figure 3-24 (Baseline 1-percent annual chance 24-hour storm event), Figure 3-25 (Project 1-percent annual chance 24-hour storm event), Figure 3-26 (Baseline SPF), and Figure 3-27 (Project w/crossings SPF). The Project-related change to the maximum water surface elevations are shown in Figure 3-28 (Project w/crossings 1-percent annual chance 24-hour storm event), Figure 3-29 (Project no crossings SPF), and Figure 3-30 (Project w/crossings SPF).

A profile comparison of maximum water surface elevations and the top of the Eastside Dike is depicted in Figure 3-31. The top of dike elevations shown in parentheses on the figure are based on the aerial topographic mapping prepared for the Lomas Del Sol development in 2004 and are based on the North American Vertical Datum (NAVD88).

The resultant maximum flow velocities tributary to and along the Eastside Dike are depicted in Figures 3-32 through 3-35. The figures are provided for the 1-percent annual chance 24-hour and the SPF events for the baseline and project conditions. The velocities shown on the exhibits are the maximum peak velocities that occur over the entire duration of the storm event and are not necessarily associated with the peak discharge. The maximum peak flow velocities were evaluated to assess the impacts from the Project development including channelization of the major drainage courses. The Project-related changes to the maximum flow velocities are shown in Figures 3-36 and 3-37.

3.7 Conclusions and recommendations

This study identified a limited degree of Project-related flood hazard impacts along the Eastside Dike with respect to its original SPF design hydrology (Slater et al, 1950) and the baseline condition analysis. There are several mitigating factors to consider related to these impacts:

- At least 4 feet of freeboard is maintained along the Eastside Dike, which exceeds the SPF minimum freeboard requirement of one foot adopted by CVWD
- The Project WSE only exceeds the Eastside Dike original SPF design WSE (66.24 feet) for a 0.4-mile segment of the Eastside Dike
- The maximum project WSE (67.01 feet) is limited to a localized area near the outfall of Channel 6
- For all conditions, the WSE is highest near the outfall of Channel 6, which is by far the largest source of runoff among those channels intersecting the La Entrada Specific Planning Area; this is important to note since the original SPF design WSE is assumed constant for the entire alignment of the Eastside Dike; if un-level pooling was considered in the determination of the original Eastside Dike SPF design WSE, its differential with respect to the Project WSE would likely be far less significant and potentially negligible.
- Transmission losses were not considered for this study, but were included in the original SPF design hydrology. If considered in this study it would lower the Project WSE and thus, further limit the Project-related flood hazard impacts.
- Velocities along the dike are generally at 5 feet per second or less, and the impacts as a result of the project are isolated to the channel outlets and are approximately 1.5 feet per second or less.

The most important point to reiterate is that at least 4 feet of freeboard is maintained along the Eastside Dike as it relates to the SPF, which far exceeds the SPF one-foot freeboard requirement as stated in Ordinance 1234.1, adopted March 25, 2013. The analysis of the 1-percent annual chance event demonstrates that a minimum of about 15 feet of freeboard is maintained, which overwhelmingly satisfies the 100-year 4-foot freeboard requirement identified in Ordinance 1234.1 as well. This fulfillment of the freeboard requirements combined with the other mitigating factors listed above supports the recommendation to preclude the mitigation of volume impacts associated with the project development. The regional channels will be properly designed to convey 100-year peak flows based on the Project Conditions.

The Eastside Dike has not been certified by CVWD or accredited by the Federal Emergency Management Agency (FEMA) as to providing flood protection for the 1-percent annual chance storm event. Levee certification requires additional analyses beyond the ability to contain the 1-percent annual chance storm event with the appropriate freeboard. These other analyses include a detailed geotechnical evaluation of the levee for factors such as stability and seepage during a storm event. To assess the potential for the dike to be certified, and to evaluate the impacts associated with the change in maximum water surface elevations as a result of the Project, a preliminary qualitative geotechnical assessment of the Eastside Dike was prepared by PETRA Geotechnical, Inc. The assessment was based on existing available data. The results of the assessment are summarized in a letter report titled “Geotechnical Commentary on Potential for Certification of Portions of the Eastside Dike Adjacent to the La Entrada Project, City of Coachella, Riverside County, California,” dated May 29, 2013 (PETRA, 2013). The letter is included as Exhibit 2, and summarized below.

The limited data available indicates that the Dike is primarily granular (sandy) material. It is not clear if this material is fine or coarse grained. The nearby geologic materials likely used to construct the Dike consist of clays, silts and fine to coarse sands. Without mitigation, ponding of water on the order of an additional 2 to 3 feet above the maximum flood stage is anticipated to account for the development of the La Entrada Site. The additional potential height of the water ponded against the Dike is not expected to greatly impact the results of the seepage analysis, but will be analyzed in detail as part of the levee certification process. Based on the above findings, it is likely that the Eastside Dike in the area of the La Entrada Project can be certified under USACE Guidelines and FEMA requirements with additional geotechnical investigation to document the existing condition and provide recommendations for improvement if needed.

Figure 3-24. Baseline 1-percent annual chance 24-hour maximum water surface elevations

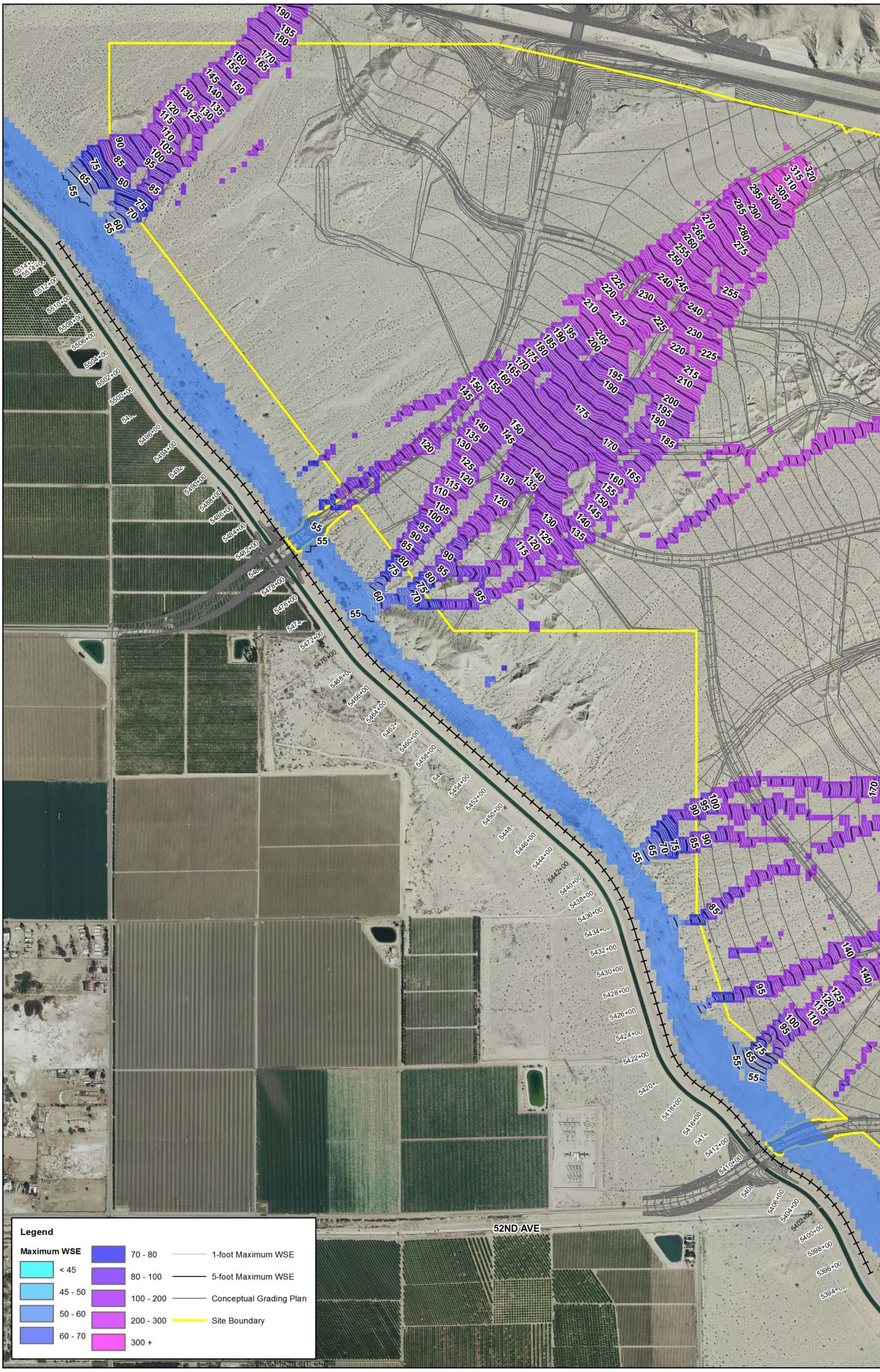

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Figure 3-25. Project with crossings 1-percent annual chance 24-hour maximum water surface elevations

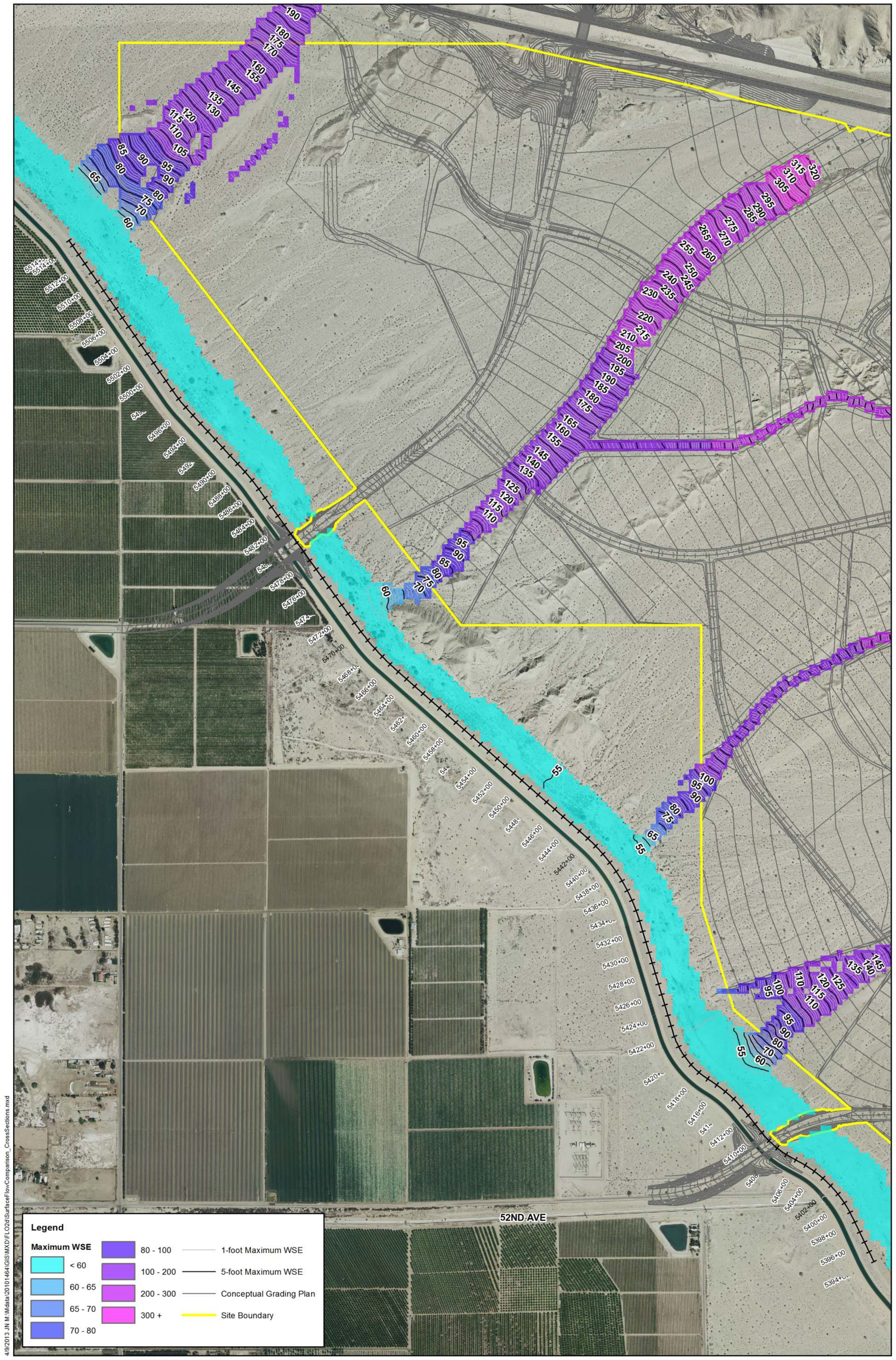

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Figure 3-26. Baseline SPF maximum water surface elevations

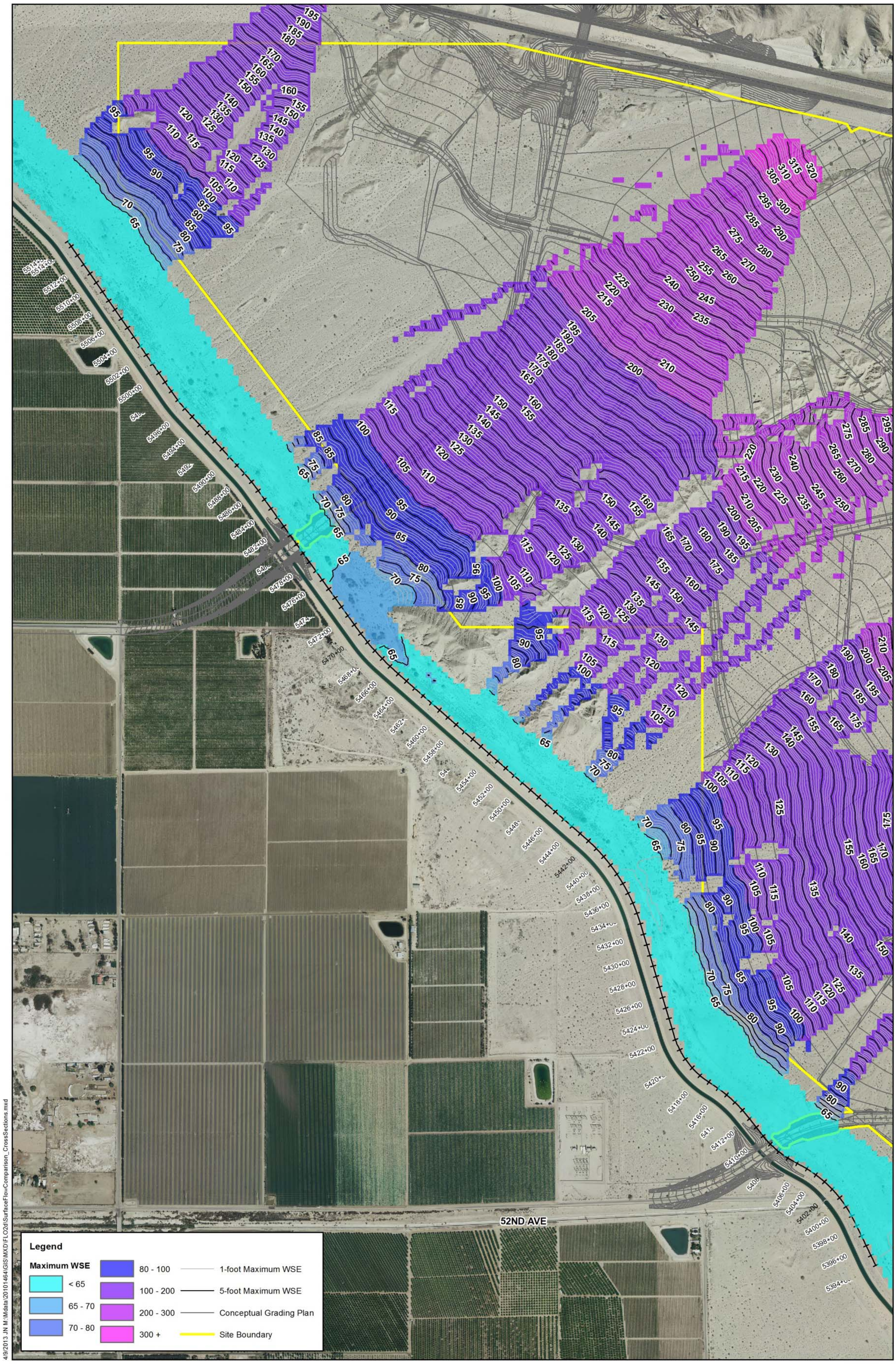

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Figure 3-27. Project with crossings SPF maximum water surface elevations

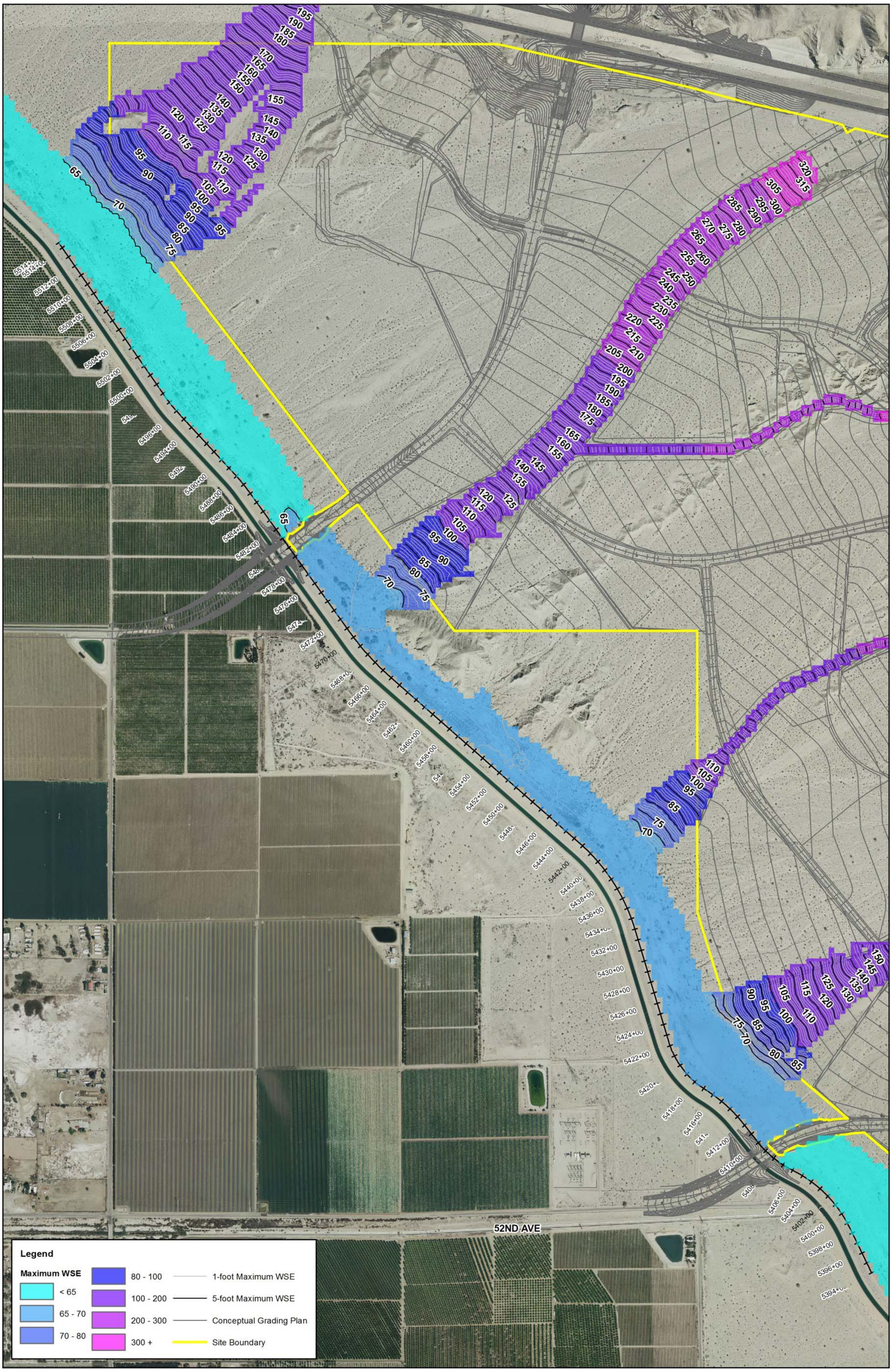

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Figure 3-28. Baseline 1-percent annual chance 24-hour maximum water surface elevation impacts

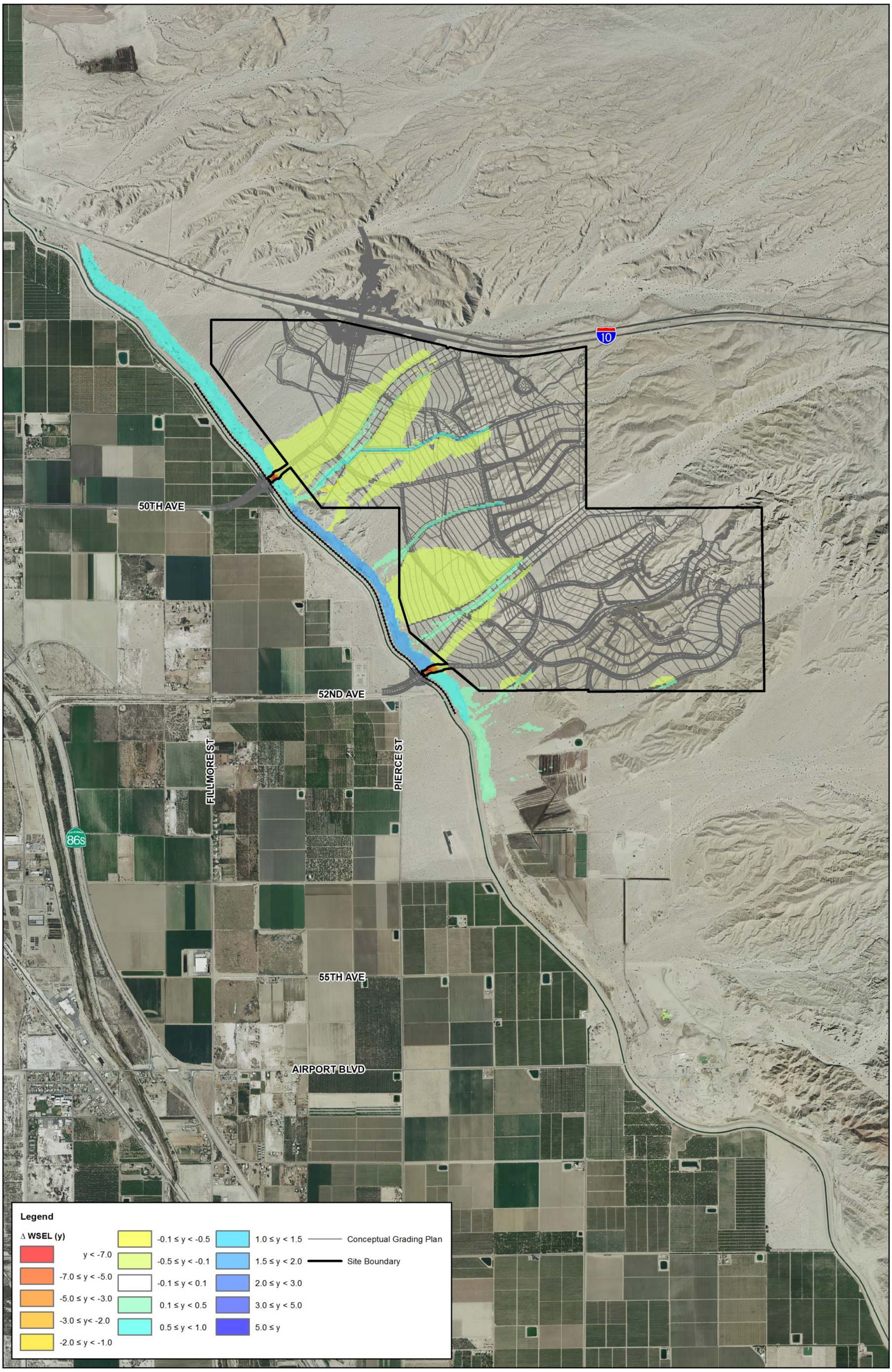

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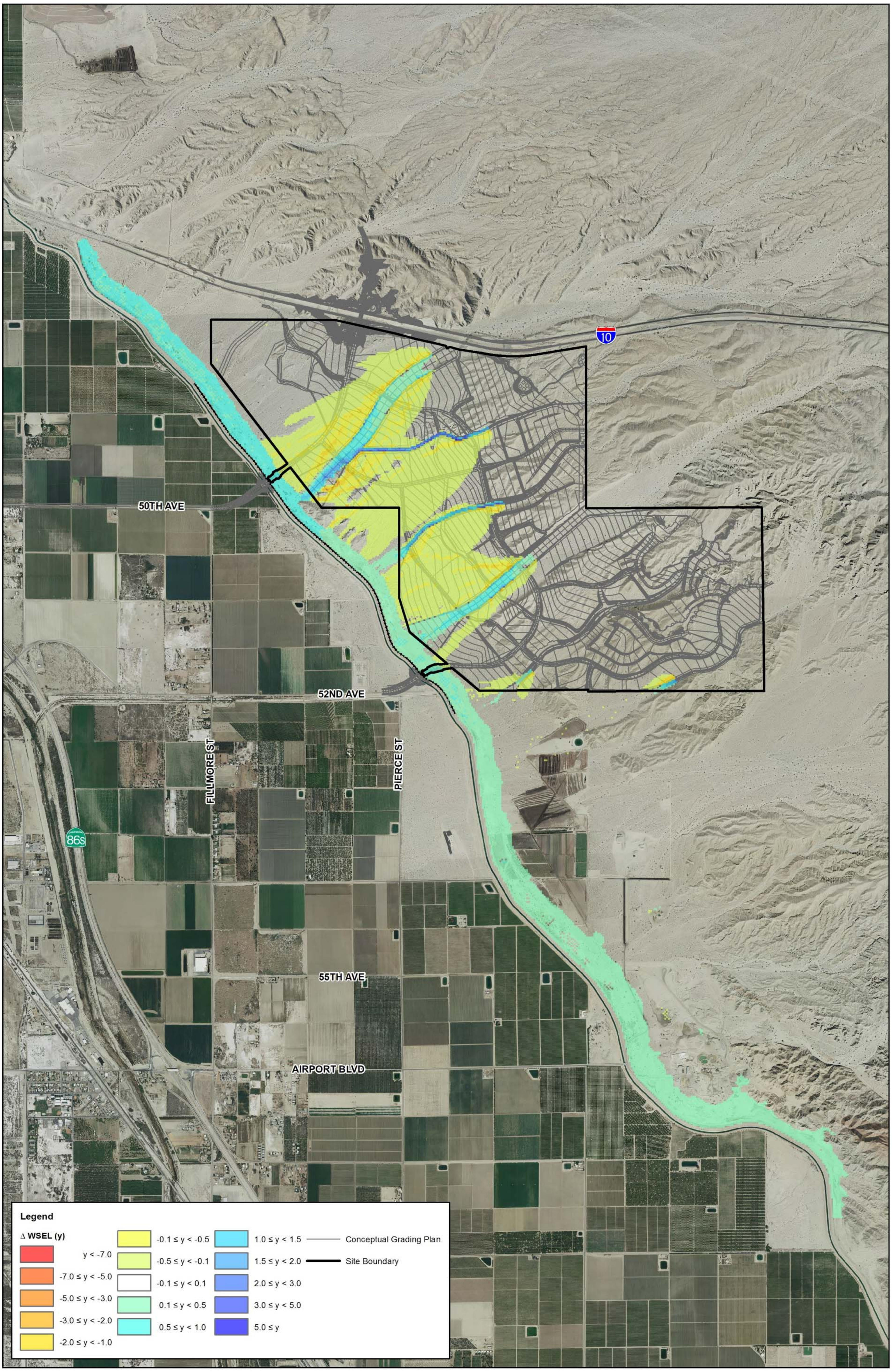
Figure 3-29. Project no crossings maximum water surface elevation impacts



4/9/2013 JN M:\Mdata\10101464\GIS\MXD\FLO2d\SurfaceFlowComparison_CrossSections.mxd

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Figure 3-30. Project with crossings SPF maximum water surface elevation impacts

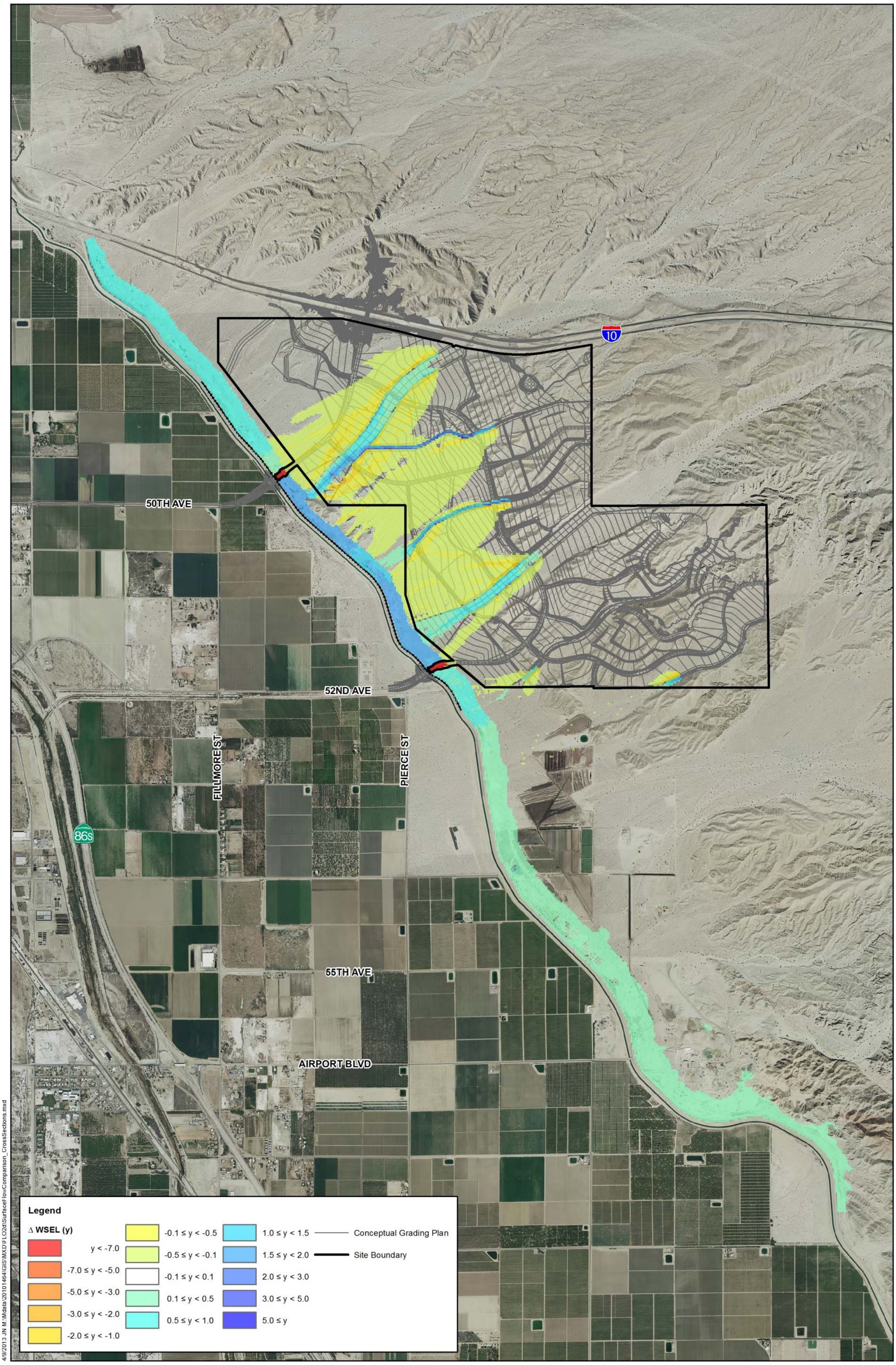

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Figure 3-31. Comparison of water surface elevation profiles along the Eastside Dike

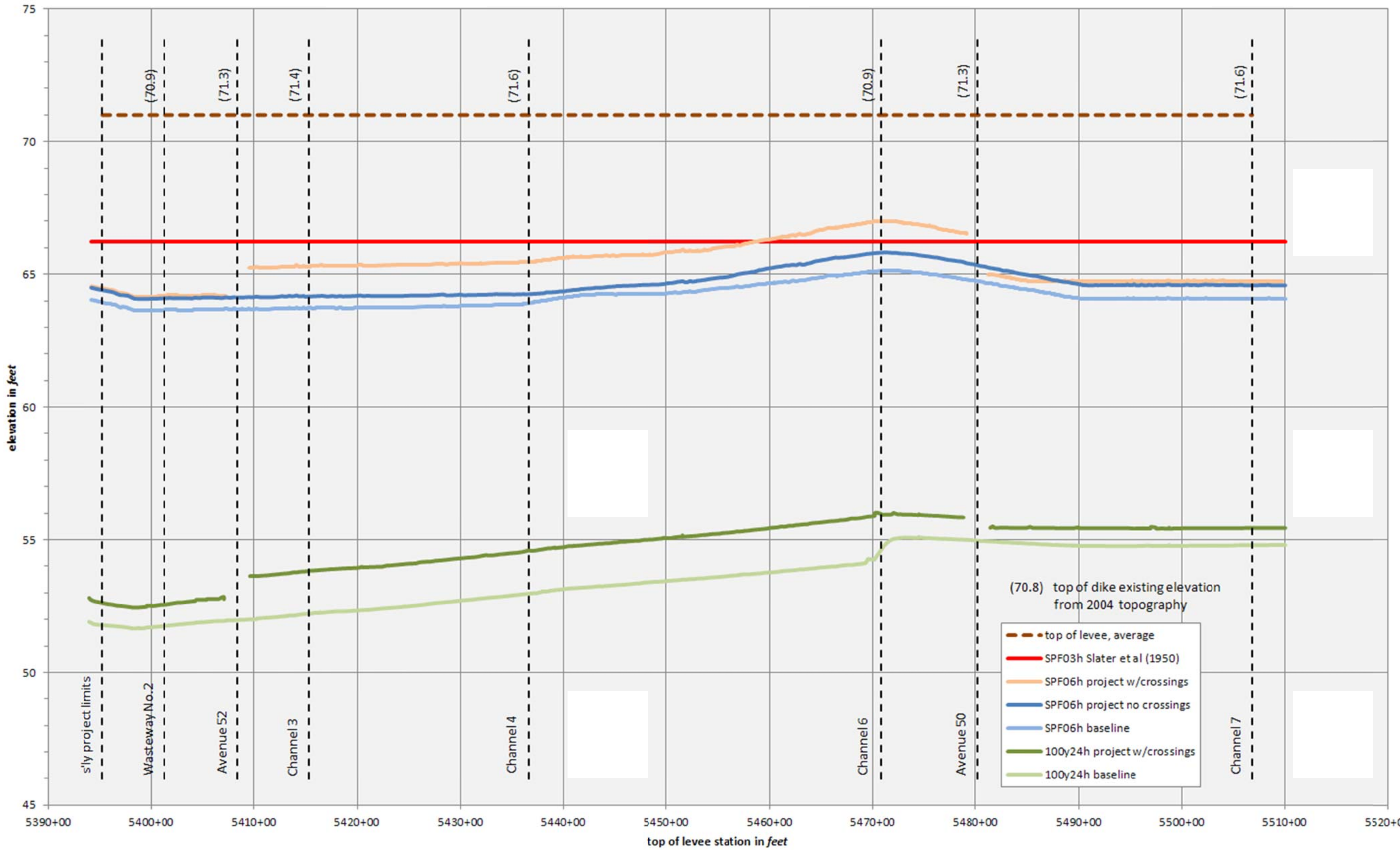

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Figure 3-32. Baseline 1-percent annual chance 24-hour maximum flow velocities

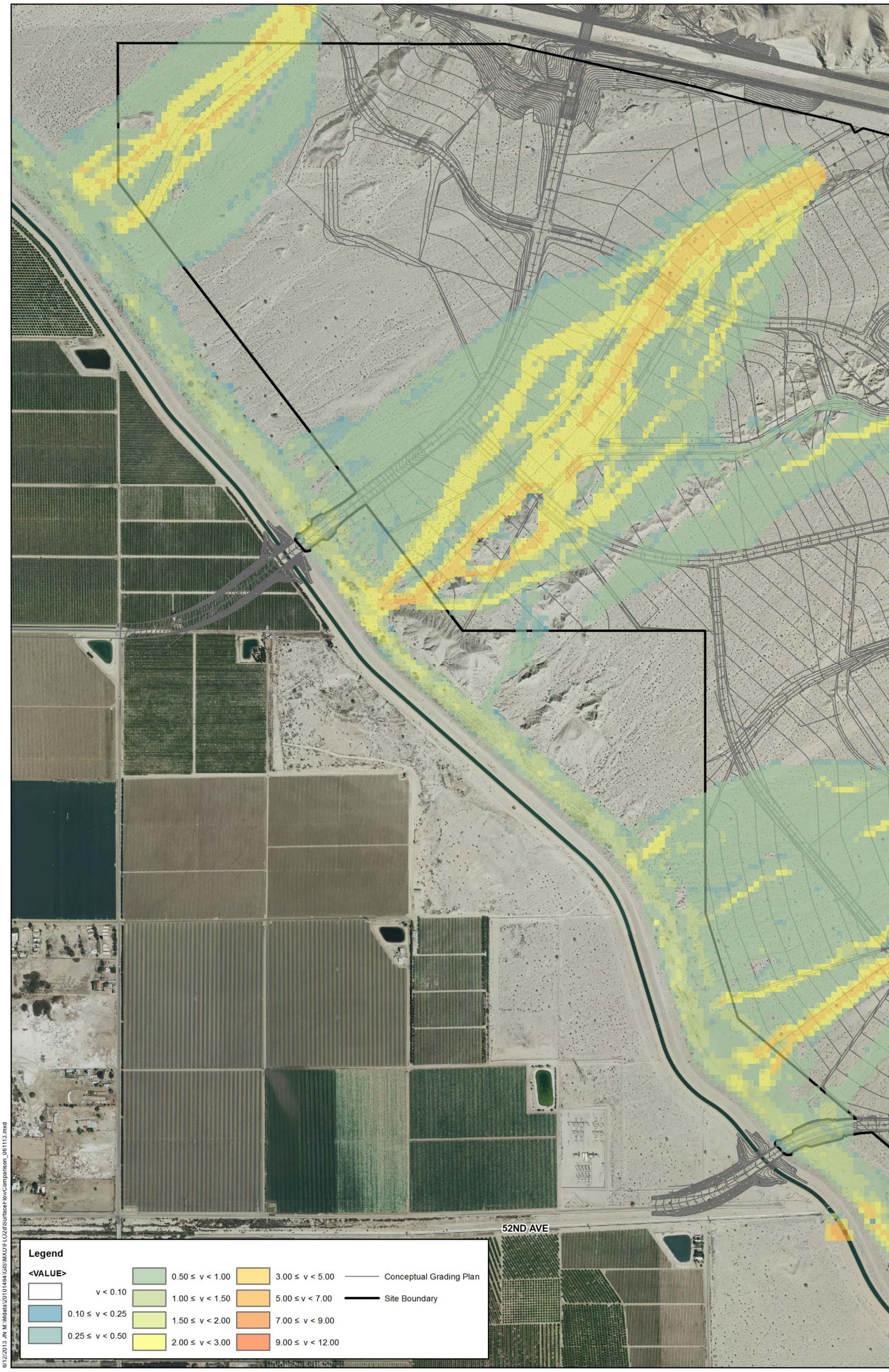

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Figure 3-33. Project with crossings 1-percent annual chance 24-hour maximum flow velocities

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Figure 3-34. Baseline SPF maximum flow velocities

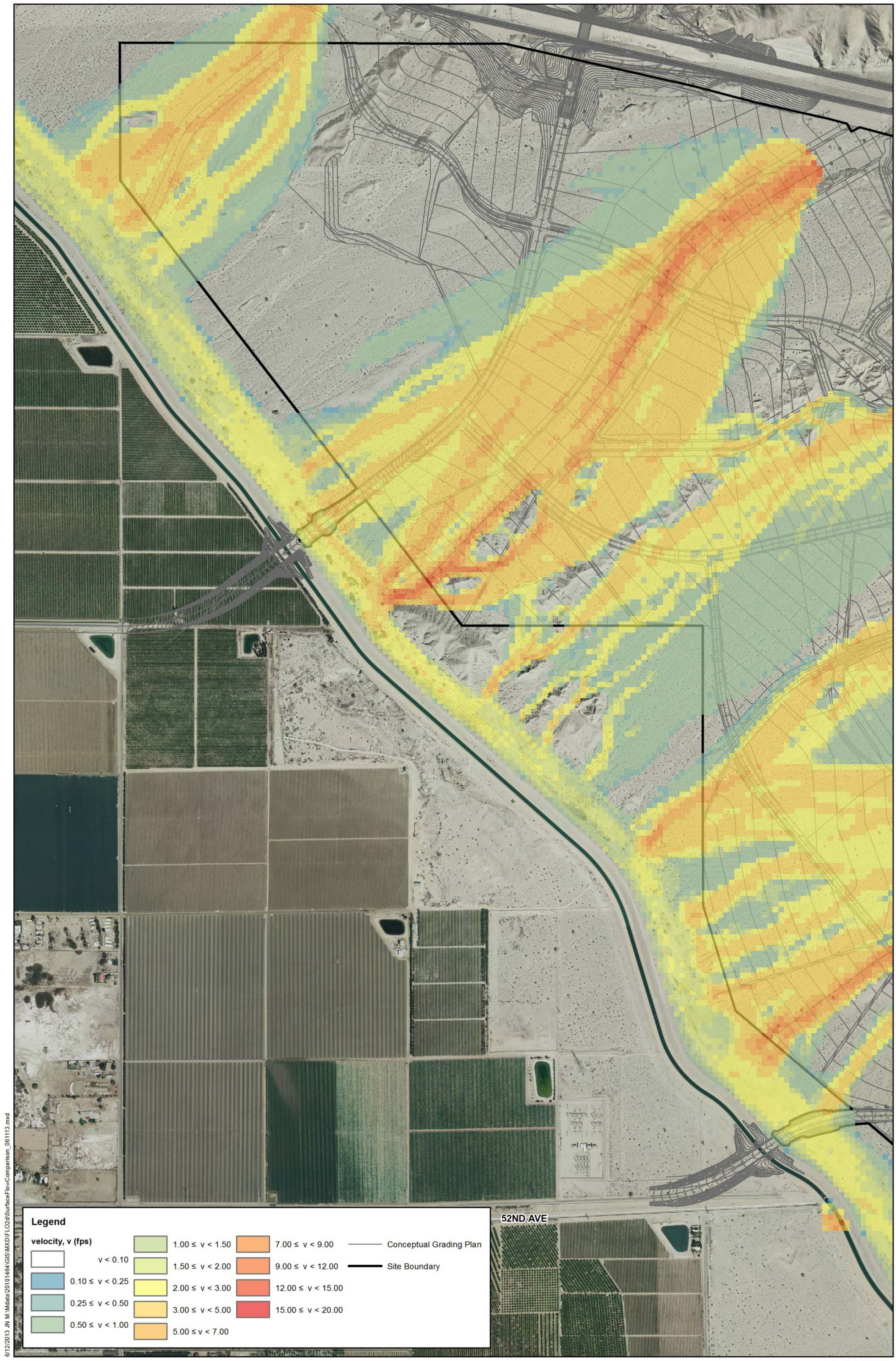

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Figure 3-35. Project with crossings SPF maximum flow velocities

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Figure 3-36. Project 1-percent annual chance 24-hour maximum flow velocity impacts

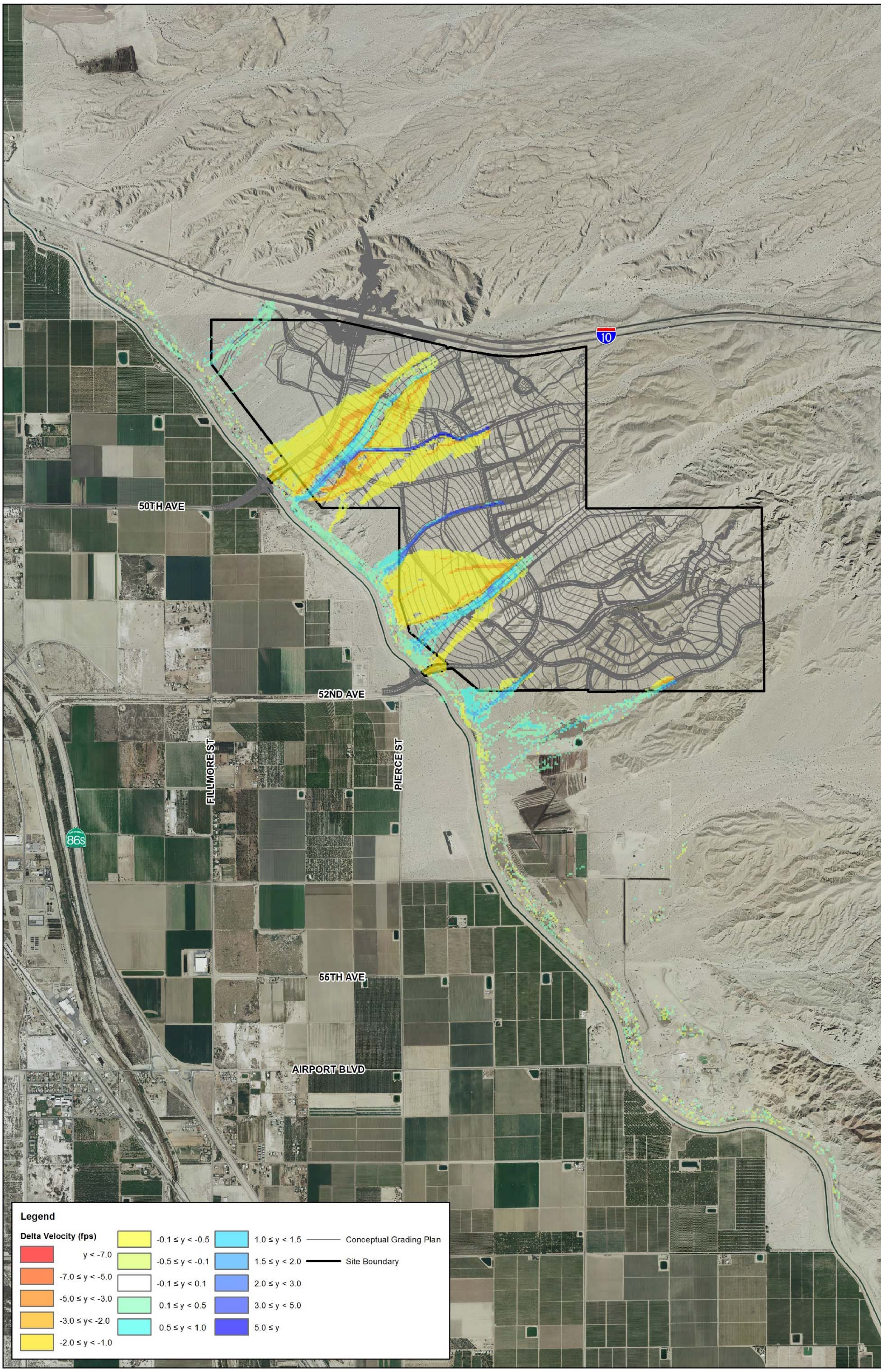

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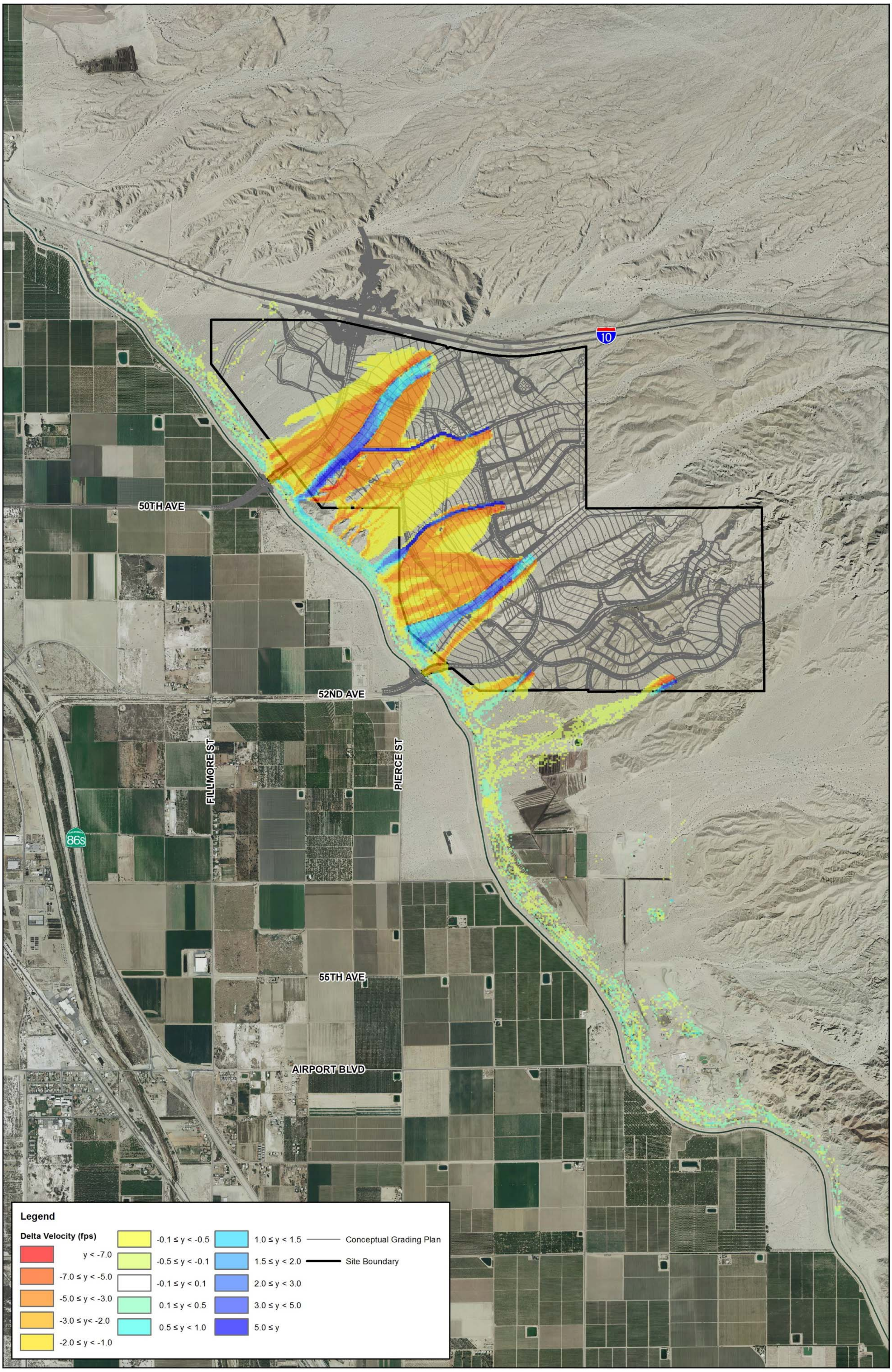
Figure 3-37. Project with crossings SPF maximum flow velocity impacts



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4 LOCAL HYDROLOGY

The onsite hydrology analysis for the La Entrada project utilized the Riverside County Flood Control and Water Conservation District (RCFC&WCD) Hydrology Manual as a basis for calculating flowrates to each of the regional channels. Because all onsite subwatersheds are less than 640 acres, the Rational Method was used to calculate flowrates.

The Rational Method is an empirical computational procedure for developing a peak runoff/ discharge for storms of specified recurrence intervals in small watersheds. The Rational Method is used to compute peak flow rates for watersheds less than 640 acres. The formula is:

$$Q = CIA$$

where:

Q = Peak runoff rate, in cfs.
C = Runoff coefficient, proportion of rainfall that runs off the surface
I = Average rainfall intensity corresponding to the time of concentration for the area, in in/hr.
A = Drainage area, in acres

The basic assumption for the Rational Method is that the precipitation rate is constant and uniform over the entire watershed for a time duration such that runoff could travel from the most remote point in the watershed to the concentration point; after which time the rate of runoff does not increase. This is the time defined as the “time of concentration (T_c).” The method is based on the assumption that the peak flow rate is directly proportional to drainage area, rainfall intensity, and a runoff coefficient “C,” which is related to land use and soil type.

The 10-, and 100-year hydrologic analysis has been performed based on the proposed grading plan, and using the procedures outlined in the RCFC&WCD Hydrology Manual, dated April 2004.

The hydrologic calculations were performed using a computer program developed by Advanced Engineering Software (AES, 2011) for the RCFCD&WCD Rational Method. The 10-, and 100-year design discharges at intermediate points were computed by generating a hydrologic "link-node" model which divides the area into drainage subareas, each tributary to a concentration point or hydrologic "node" point determined by the existing terrain or proposed street layout.

The following assumptions/guidelines were applied for use of the Rational Method:

1. The Rational Method hydrology includes the effects of infiltration caused by soil surface characteristics. The soils map from the RCFC&WCD Hydrology Manual indicates that the study area consists of primarily soil type "B". Hydrologic soil ratings are based on a scale of A through D, where D is the least pervious, providing the greatest runoff.

2. The type of vegetation or ground cover and percentage of impervious surfaces affects the infiltration rate. The runoff coefficients specified for various land uses in the Hydrology Manual (Plate D-5.6) were used to represent the hydrologic sub areas.

3. The Kirpich formula was used to determine the times of concentration (Tc) for initial upstream subareas. Initial subareas were drawn to be less than 10 acres in size and less than 1,000 feet in length per County guidelines.

4. Pipe travel times were computed based on preliminary pipe sizes; with a minimum pipe size of 18-inches for the mainline storm drain system. Local drainage areas are sized with smaller pipe sizes to convey flows to the mainline storm drain system.

The AES RATSCx Computer Program allows for the development of Rational Method models based on the Riverside County hydrology standard. The onsite land use was determined using the latest land planning and is shown in Figure 1-3. The percent imperviousness for various land use designations that can be used in the Rational Method analysis are indicated on Plate D-5.6 in the RCFC&WCD Hydrology Manual. The available land use designations in the hydrology manual are different then the La Entrada land use designations in the specific plan. Therefore, the specific plan designations were translated to the closest designation in the hydrology manual for use in the Rational Method calculations. Table 4-1 identifies the specific plan land use (column 1) and the closest designation in the hydrology manual (column 2). The percent impervious for the hydrology manual designation is shown in column 3.

The onsite soils data is consistent with the baseline conditions regional hydrology analysis (see Section 3). Average rainfall data for each subarea from NOAA Atlas 14 was used in accordance with the baseline conditions regional hydrology analysis as presented in Section 3. Onsite conveyances were assumed to be a combination of street and pipe flow with assumed drainage patterns because the interior street alignments are not available at this time.

To be consistent with the regional analysis, the local hydrology drainages are divided into 7 regional channels. The local hydrology was calculated for both the 10- and 1-percent annul chance (10- and 100-year) storm events. The local hydrology map is shown in Exhibit 1 (map pocket, inside back cover). The drainage subareas were based on a combination of baseline topography and proposed mass grading as shown on the local hydrology map (Exhibit 1). Local drainage subareas varied from 10 to 243 acres. The local hydrology analyses are included in the Electronic Technical Appendix as .res files (text files) and PDF files. A summary of the local hydrology results for each conveyance are presented in Table 4-2. Peak flow rates for the 10-percent annual chance (10-year) storm event ranged from 14 cfs to 245 cfs.

The local hydrology was used to estimate onsite storm drain sizes using the 10-year storm peak flow rates and normal depth analysis assuming that the storm drain is not flowing at full capacity. The onsite storm drains range in size from 18 inches to 54 as reported in the results of the Rational Method analysis. The storm drain pipe layout and facility sizing is shown on Figure 4-1.

4.1 Water Quality Assessment

Water quality assessment for the project site was prepared under a separate report. The report titled, *"La Entrada Specific Plan Development Water Quality Assessment Report"* (RBF, 2012) was prepared to evaluate potential impacts of the project on adjacent water resources and their beneficial uses, and identify best management practices (BMPs) to mitigate project impacts and comply with the regulatory permits.

The project area is located within the City of Coachella and the unincorporated area of the County of Riverside. It is covered by the urban Municipal Separate Storm Sewer System (MS4) National Pollutant Discharge Elimination System (NPDES) permitted area (NPDES Order R7-2008-0001, NPDES Number CAS617002), which was issued to the Riverside County Flood Control and Water Conservation District, the County of Riverside, and 10 incorporated cities (collectively called "permittees"). The City of

Coachella and the County of Riverside are copermittees under this permit, and developed the Whitewater River Region Stormwater Management Plan (SWMP) that describes activities, programs, procedures, financial responsibilities, and practices the permittees use to protect water quality by reducing or eliminating pollutants discharged from storm drainage systems they own or operate, including the selection and implementation of Best Management Practices (BMPs). All guidelines and procedures outlined in the SWMP, including the post-development Water Quality Management Plan (WQMP) requirements, will be adhered to during all phases of the project, as currently written or subsequent future regulations. All parties working on the project, or in the project area, will be required to implement pollution prevention, treatment controls, and construction BMPs consistent with the requirements outlined in the SWMP.

The project's runoff drains to the embankment wall of the All American Canal (Eastside Dike), where it pools, disperses, and is potentially discharged to the Coachella Valley Stormwater Channel/Whitewater River via Wasteway No. 2, a concrete-lined channel approximately 2.2 miles long. Wasteway Number 2 confluences with the Coachella Valley Stormwater Channel below the Avenue 52 Bridge approximate 7.5 miles downstream from the Indio Boulevard Bridge and just over 11 miles upstream from the Salton Sea. The frequency peak flow rates are constant along this channel reach of the Coachella Valley Stormwater Channel, which implies that Wasteway No. 2 is not a significant tributary to the Coachella Valley Stormwater Channel. The regional hydrologic analysis indicates that the project will result in a slight increase in runoff volume as a result of the increase in impervious area proposed within the project site. The project area is a small percentage of the Whitewater River watershed (0.002 percent) and is unlikely to have a regional hydromodification effect. Based on the data available, the project is not expected to cause a hydrologic condition of concern to downstream channels.

The City of Coachella requires that development projects incorporate Best Management Practices (BMPs) into their design to address anticipated pollutants. Selection, design, and implementation of BMPs will be based on the Riverside County Whitewater River Region Stormwater Quality Best Management Practice Design Handbook guidance (Exhibit 3 in *Whitewater River Region Water Quality Management Plan for Urban Runoff*, January 2011), or equivalent. BMPs will be considered for implementation where feasible, and may include Site Design BMPs, Source Control BMPs (such as Non-Structural BMPs and Structural BMPs), and Treatment Control BMPs. The selection, sizing, and location of BMPs will be determined in future design phases. Conceptual locations for water quality features are identified on the project storm drain facilities layout map (Figure 4-1). All runoff from the site development will be treated prior to discharge to a regional channel or off-site facility.

4.2 Development Phasing

The La Entrada Specific Plan may be constructed in phases based on market demand and available infrastructure improvements. Phases may occur concurrently provided the associated infrastructure is also completed. The Specific Plan identified 5 anticipated development phases.

The drainage improvements will also need to be constructed in phases with the associated development. The regional channels and storm drain systems identified in each of the phases should be constructed with the other infrastructure within that phase. Interim facilities will be required with a phased construction. The regional channels will require the construction of interim dikes to capture flow on the natural drainage areas and safely convey the flood waters to the channel systems. The dikes should be designed for a 100-year storm event (similar to the channel systems) based on the calculated regional hydrology flow rates. The final configuration for the interim facilities will depend on the phased grading and should be determined in future design stages.

Table 4-1. Assigned land use percent imperviousness

specific plan landuse	hydrology manual land use breakdown	percent imperviousness
drainage (DR)	undeveloped	0
high density residential (HDR)	condominium (67%) and single family residential 1/4-acre lots (33%)	60
low density residential (LDR)	single family residential: 1/2-acre lots (50%) and 1-acre lots (50%)	30
medium density residential (MDR)	single family residential 1/2-acre lots	40
mixed use (MU)	commercial (50%) and apartment (50%)	85
natural (NAT)	undeveloped	0
open space (OS)	undeveloped	0
parks and recreation (PR)	single family residential 1-acre lots (75%) and undeveloped (25%)	15
road (RD)	commercial	90
school (SCH)	single family residential 1/4-acre lots	50
very low density residential (VLDR)	single family residential 1-acre lots	20

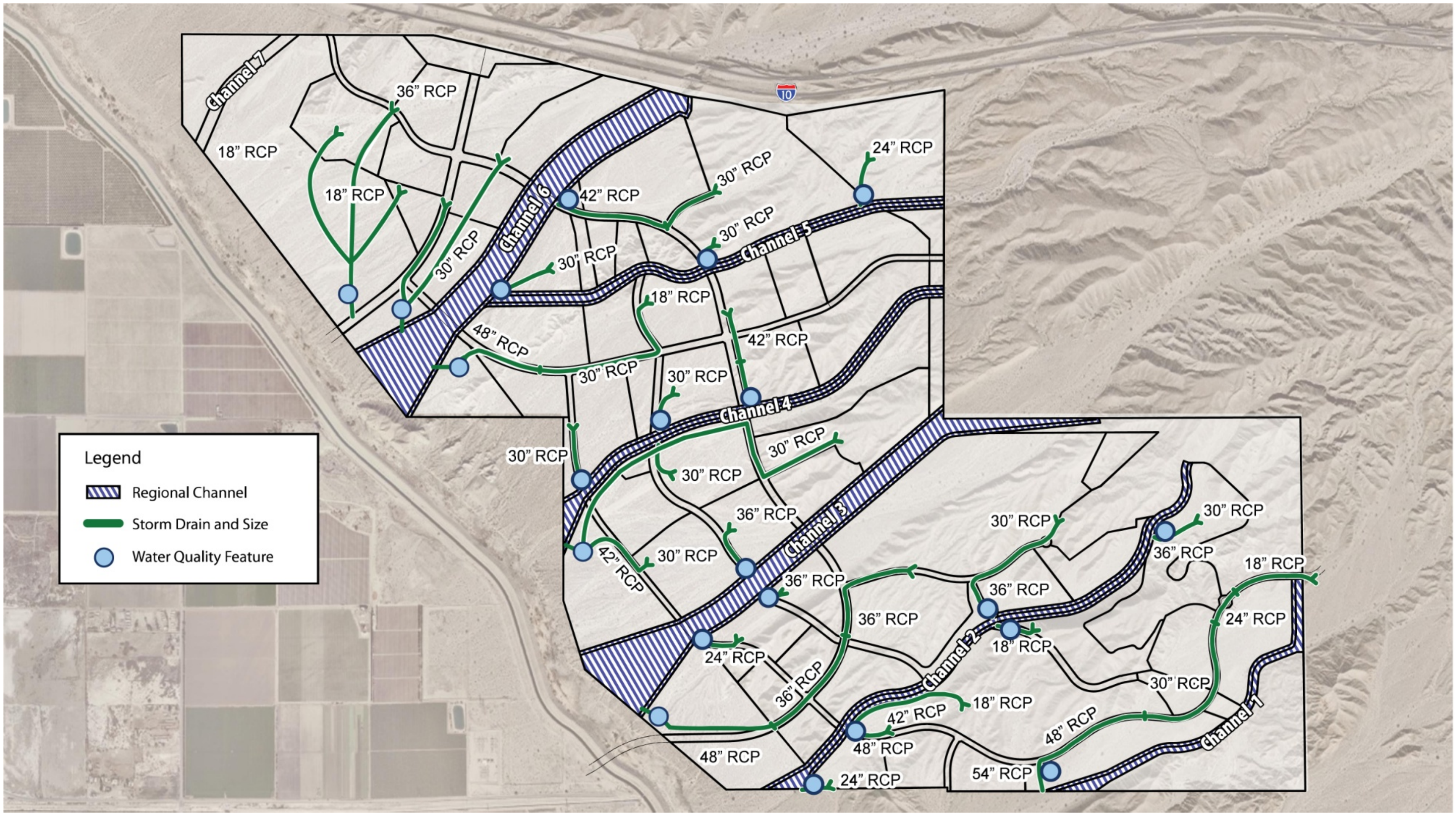
Note: The land use breakdown in column 2 is the available land use (or combination of land uses) from the RCFC&WCD Hydrology Manual (Plate D-5.6) that best represent the specific plan land uses (column 1).

Table 4-2. Rational Method computed local peak flow rates

subbasin	subarea	acreage	node	*n*-percent annual chance peak flow rate (cfs) n = 10	n = 1
1	X	195.5	625	245	527
2	T	88.6	495	75	173
	U	152.1	520	140	310
	V	98.0	565	107	224
	W	18.4	585	19	42
3	L	152.6	315	126	281
	M	58.7	315	51	114
	P	87.5	435	75	165
	Q	81.2	410	76	173
	R	18.6	410	25	50
	S*	243.0	450	197	438
4	K	133.3	249	138	293
	N	27.3	282	41	83
	O	37.4	319	33	75
5	G	32.1	208	26	60
	H	42.2	215	45	96
	I	53.3	226	50	110
6	B	169.4	120	162	359
	D	10.4	164	14	28
	E	109.2	164	133	275
	F	190.7	188	116	274
	J	115.1	236	124	272
7	A	101.2	145	63	163

*includes subbarea "P"

Figure 4-1. Project storm drain facilities layout



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5 REFERENCES

AES, 2011, *RATSCx Computer Program*, Advanced Engineering Software (AES).

Bechtel, 2003, *Flood Insurance Study for the Oasis Area of Coachella Valley*, prepared for the Coachella Valley Water District, Coachella, Californai.

Bechtel, 1997, *"Without Project" Hydrology Report, Thousand Palms Area, Whitewater Basin, Riverside and San Bernardino Counties, California*, prepared for the U. S. Army Corps of Engineers, Los Angeles District.

CVWD, 2010, *Development Design Manual*, Coachella Valley Water District (CVWD), Coachella, California, March 19.

FEMA, 2008, *Flood Insurance Study, Riverside County, California, and Incorporated Areas*, 06065CV001A, Federal Emergency Management Agency, Effective August 28, 2008.

FEMA, 2003, *Guidelines and Specifications for Flood Hazard Mapping Partners*, Appendix G: Guidance for Alluvial Fan Flooding Analyses and Mapping, Federal Emergency Management Agency, April.

FCDMC, 2009, *Drainage Design Manual for Maricopa County, Arizona*, Flood Control District of Maricopa County.

James, W.P., J. Warinner, and M. Reedy, 1992, *Application of the Green-Ampt infiltration equation to watershed modeling*, Water Resources Bulletin, AWRA, 28(3), pp. 623-634

Hromadka II, T.V., R.H. McCuen, and C.C. Yen, 1987, Computational Hydrology in Flood Control Design and Planning, Lighthouse Publications, Mission Viejo, CA.

MCFCD, 1995, *Maricopa County Drainage Design Manual: Hydrology*, Maricopa County Flood Control District (MCFCD), Arizona.

Miller, J.F., R.H. Frederick, and R.J. Tracey, 1973. NOAA Atlas 2, Precipitation-Frequency Atlas of the Western United States, Volume IX-California, National Weather Service, Silver Spring, MD.

NOAA, 2011, NOAA Atlas 14 Precipitation-Frequency Atlas of the United States, Volume 6: California, Version 2, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, Silver Springs, MD, June.

NRCS, 2008, *Soil Survey Geographic (SSURGO) Database for Riverside County, Coachella Valley Area, California*, CA680, Natural Resources Conservation Service, Fort Worth, Texas.

NRCS, 2006, *Soil Survey Geographic (SSURGO) Digital General Soil Map of United States*, Natural Resources Conservation Service, Fort Worth, Texas.

O'Brien, J.S., 2012. *FLO-2D PRO Computer Program*, Nutrioso, AZ.

O'Brien, J.S., 2007. *FLO-2D Computer Program*, Version 2007.10, Nutrioso, AZ.

PETRA, 2013, *Geotechnical Commentary on Potential for Certification of Portions of the Eastside Dike Adjacent to the La Entrada Project, City of Coachella, Riverside County, California,"* letter addressed to Mr. Terry Manley, Lightstone Acquisitions, LLC, from PETRA Geotechnical, Inc. dated May 29, 2013.

PETRA, 2005, *Geotechnical Input for Preparation of Environmental Impact Report, Lomas del Sol Project, Coachella, Riverside County, California*, December 20.

Rawls, W.J. and D.L Brakensiek, 1983, *A procedure to predict Green and Ampt infiltration parameters*, Proceedings of the American Society of Agricultural Engineers Conference on Advances in Infiltration, Chicago, Illinois, Pages 102-112.

Rawls, W.J., D.L. Brakensiek, and N. Miller, 1983, *Green-Ampt infiltration parameters from soils data*, ASCE, Journal of Hydraulic Engineering, Volume 109, Number 1, Pages 62-71.

RBF, 2012, *La Entrada Specific Plan Development Water Quality Assessment Report,* RBF Consulting (RBF), September.

RCFCWCD, 1978, *Hydrology Manual*, Riverside County Flood Control and Water Conservation District (RCFCWCD), Riverside County, April.

SCS, 1980. *Soil Survey of Riverside County, California, Coachella Valley Area*, Soil Conservation Service (SCS), United States Department of Agriculture in cooperation with University of California Experiment Station.

Slater, William R., Howard G. Curtis, and Paul A. Oliver, 1950. *Flood Control Works of the All-American Canal, Coachella Branch, Boulder Canyon Project*, presented at the Joint Summer Convention of the American Society of Civil Engineers and the Engineering Institute of Canada, Toronto, Ontario, July 1950.USACE, 1998, *HEC-1 Flood Hydrograph Package,* Version 4.1, Hydrologic Engineering Center, U.S. Army Corps of Engineers (USACE), Davis, California, June.

USACE, 1994, Flood-Runoff Analysis, EM 1110-2-1417, U.S. Army Corps of Engineers (USACE), Washington D.C., August 31.

USACE, 1972. *Imperial Valley Standard Project Summer Thunderstorm Instructions for Computation of Rainfall.* Los Angeles District.

USACE, 1962. *Improved procedure for determining drainage area lag values*, Los Angeles District.

VA Consulting, Inc., 2006, *Preliminary hydrology report for Lomas del Sol, City of Coachella, California,* May 20.

Zehr, R.M. and V.A. Myers, 1984, *Depth-area ratios in the semi-arid southwest United States*, Technical Memorandum NWS HYDRO-40, Office of Hydrology, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, Silver Springs, MD, August.

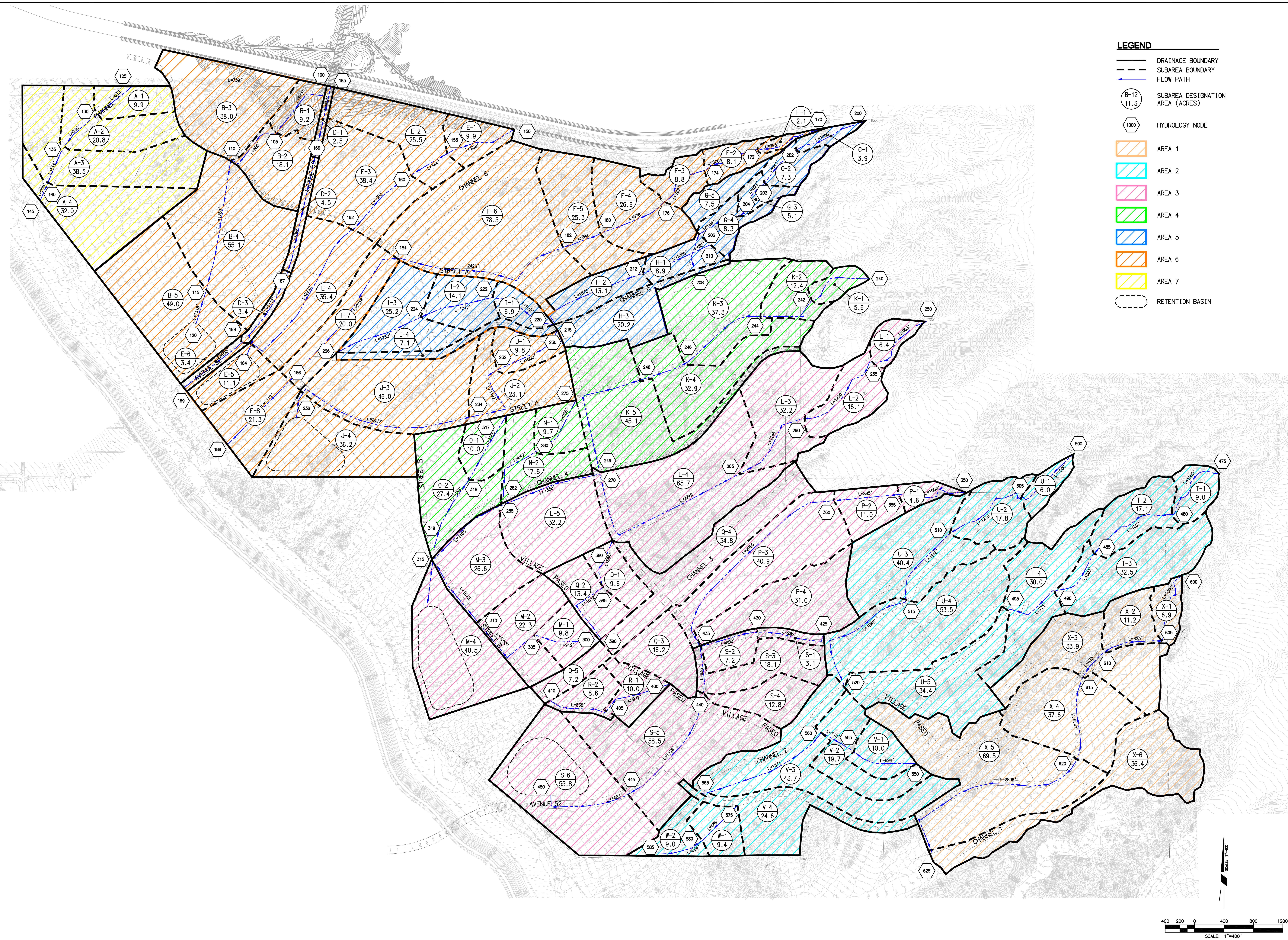

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EXHIBIT 1
LA ENTRADA ONSITE
PROJECT CONDITIONS HYDROLOGY MAP

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DESERT REGION

42-240 Green Way, Suite E
Palm Desert, California 92211
T: 760-340-5303 F: 760-340-5096

Exhibit 2

PETRA

past + present + future
it's in our science

Engineers, Geologists
Environmental Scientists

May 29, 2013
J.N. 11-376

Mr. Terry Manley
LIGHTSTONE ACQUISITIONS, LLC
3708 Happy Lane
Las Vegas, NV 89120

Subject: **Geotechnical Commentary on Potential for Certification of Portions of the Eastside Dike Adjacent to the La Entrada Project, City of Coachella, Riverside County, California.**

Reference: Hushmand Associates and Petra Geotechnical, 2006, Foundation Report, Avenue 50 and Avenue 52 Bridges Over All American Canal, City of Coachella, Riverside County, California; prepared for Fiesta Development, dated May 3rd.

Dear Mr. Manley:

Based on discussions with Mr. John McCarthy at RBF Consulting, Petra Geotechnical, Inc. **(**Petra) conducted an evaluation of the potential for Levee Certification of the Eastside Dike (Dike) where it lies adjacent to the La Entrada Project. This evaluation consisted of review of a previous investigation for the Avenue 50 and 52 Canal/Dike crossings conducted for the Lomas Del Sol Project (now known as the La Entrada Project).

In May 2006, Hushmand and Associates, Inc. (HAI), in partnership with Petra, conducted a geotechnical investigation to make recommendation for bridge foundations for the extension of Avenue 50 and 52 across the Coachella Branch of the All-American Canal and the Dike to access the Lomas Del Sol Project (reference). The report was prepared for Fiesta Development.

SUMMARY OF PREVIOUS WORK

To provide geotechnical recommendations for the then proposed bridge structures, an investigation consisting of Cone Penetration Testing (CPT) and hollow-stem auger drilling was undertaken (Reference). Drilling was not conducted through the Dike, but CPT Soundings were. CPT's, designated as PPT-5 and PPT-5a, were advanced through the Dike at the Avenue 50 crossing, and a CPT, designated as PPT-4, and was advance thought the Dike at the Avenue 52 Crossing.

PPT 5 encountered refusal to advancement at a depth of 31.3 feet below ground surface (bgs) and it appears that another sounding (PPT-5a) was attempted near that location. PPT-5a, although not designated as refusal in the referenced report, was not advance below 30.8 feet bgs indicating that refusal also encountered at that location. We estimate that this depth correlates with the bottom of the fill placed to create the Dike.

CPT sounding PPT-4 (Avenue 52 Crossing) was advanced to 60.2 bgs. We estimate this depth is approximately 30 feet below the fill placed to create the Dike.

Hollow-stem auger borings were drilled, sampled and logged at the toe of the dike at each crossing to depths of 70 feet bgs at the western toe and about 101 feet bgs at the eastern toe. CPT sounding were also advanced at each crossing (~30 bgs at the western toe and 40 to 50 feet bgs at the eastern toe).

Groundwater was not encountered at any of the exploratory borings.

FINDINGS AND CONCLUSIONS

Review of the CPT sounding results and boring logs indicate that the soils placed to construct the Dike and the native material below are at a competent state for their intended use.

The limited data available indicates that the Dike is primarily granular (sandy) material. It is not clear if this material is fine or coarse grained. The nearby geologic materials likely used to construct the Dike consist of clays, silts and fine to coarse sands. We understand that ponding of water on the order of an additional 2 to 3 above the flood stage is anticipated to account for the elimination of retention basins at the La Entrada Site. The additional potential height of the water ponded against the Dike is not expected to greatly impact the results of the seepage analysis but will be analyzed as part of the levee certification.

Based on the above findings, it is our professional opinion and engineering judgment that it is likely that the Eastside Dike in the area of the La Entrada Project can be certified under Army Corp of Engineers Guidelines with additional geotechnical investigation to document the existing condition and provide recommendations for improvement if needed.

Respectfully submitted,
PETRA GEOTECHNICAL, INC.

Alan Pace, CEG
Senior Associate Geologist
Vice President

Dr. Siamak Jafroudi, GE 2024
Senior Principal Engineer
President

Executive Summary Memorandum of the Drainage Master Plan

RBF CONSULTING
A Baker Company

Executive Summary Memorandum
La Entrada Specific Plan Development:
Drainage Master Plan
City of Coachella and County of Riverside, California

E.1 Project Overview

The La Entrada Specific Plan is a 2,200 acre master planned community in the eastern portion of the City of Coachella and unincorporated Riverside County, California. The Specific Plan area is comprised of a series of northeast-southwest trending ridges and canyons that drain towards the lower elevations of the Coachella Valley to the south and west. Bounded by the Interstate 10 freeway to the north and the Coachella Branch of the All American Canal to the west, the La Entrada Specific Plan is surrounded to the north and east by undeveloped land, sparsely developed agricultural land to the south, and existing agricultural land to the west.

The purpose of the Drainage Master Plan is to determine the projects' impacts to existing hydrology, floodplains, and drainage features, and identify appropriate flood control and local drainage facilities necessary for the development of the project site. The Master Plan addresses both local and regional impacts, flood hazard mitigation requirements, and design features. The master plan is being developed in conjunction with, and in support of the La Entrada Specific Plan. This Master Plan is based on the requirements the Coachella Valley Water District (CVWD), County of Riverside, and the City of Coachella.

The overall goal of this study is to provide a detailed watershed assessment including regional and local hydrology, flood hazard analysis, hydraulics, and sedimentation to develop a drainage master plan that is consistent with the guidelines and requirements instituted by the City of Coachella, Coachella Valley Water District, and the Bureau of Reclamation (Coachella Canal).

The primary objectives of this study include the following:

- Develop baseline and project-based regional hydrology to establish peak flow rates and flood volumes for use in the conceptual design of combined onsite/offsite flood conveyances, which extend through the proposed development
- Develop project-based onsite hydrology for use in the conceptual design of local onsite storm conveyance and retention facilities
- Identify and propose mitigation for any potentially significant development-related adverse flood hazard impacts, including the Coachella Canal and levee system
- Identify hydraulic, sedimentation, and erosion issues/design constraints associated with the major flood conveyances, which extend through the proposed development.
- Formulate the conceptual layout and design of local and regional storm facilities

The intended use of the master plan is to; identify flood hazards at the La Entrada Specific Plan development site; develop a regional approach to mitigate the flood hazards; identify local drainage facility requirements; and mitigate development related impacts to existing facilities such as the Eastside Dike along the Coachella Canal.

E.2 Technical Studies

The project included the preparation of detailed technical studies for the on- and off-site watershed areas leading to the identification of flood hazards and mitigation measures for the site development. The technical studies included:

- Geomorphic assessment of the project site and tributary watershed
- Regional hydrology analysis for the off-site watersheds
- Eastside Dike flood routing and impact analysis
- Local hydrology analysis and preliminary pipe sizing

A summary of the technical studies and the results from those studies are outlined below.

E.2.1 Geomorphic Assessment

A geomorphic analysis was conducted to identify regional watershed boundaries on the upper piedmont for use in developing offsite flow rates for design of the La Entrada Specific Plan.

The La Entrada Specific Plan is located on a piedmont bajada composed of steep-sloped active and relict alluvial fans. The bajada extends from the San Bernardino Mountains, across the western extension of the Mecca Hills to the floor of the Coachella Valley. After leaving the front range of eastern San Bernardino Mountains, the off-site watersheds that drain to the La Entrada site cross a series of active and inactive alluvial fans on the upper piedmont near the mountain front. Further downstream, the piedmont becomes confined in shallow canyons formed by topographically higher, relict fan deposits with some volcanic bedrock units before entering the La Entrada project limits. The active fans in the upper piedmont do not have a strongly defined fan shape, but there is some evidence of the potential for flow path uncertainty and relatively high rates of sediment transport. This geomorphic analysis is intended to help evaluate the effects of potential flow path uncertainty on watershed delineation and peak flow estimates.

The geomorphic analysis was based on aerial photographic interpretation, evaluation of topographic, geologic and soils maps, and field observations. Five areas of interest in the upper watershed were evaluated corresponding to the most significant watersheds draining onto the San Bernardino Mountain Piedmont toward the La Entrada Project. The results of the geomorphic assessment were used to delineate the watershed boundaries on the upper piedmont north of the I-10 freeway. The watershed boundaries were then used as part of the regional hydrology analysis.

E.2.2 Regional Hydrology

The regional hydrology for the proposed La Entrada Specific Plan watershed was developed for the Baseline (existing) and Project conditions, focusing on the 10 major subbasins, which lie tributary to the northerly segment of Coachella Canal Dike No. 1 (Eastside Dike). Seven (7) of the watersheds directly impact the project site. Floodwaters impounded by the Eastside Dike are eventually discharged to the Whitewater River (Coachella Valley Storm Drain Channel) via Wasteway No. 2, a triple 6’ x 6’ reinforced concrete box underneath the Coachella Canal connecting to a reinforced concrete rectangular channel of similar base width. The total watershed area tributary to Wasteway No. 2 is approximately 50.6 square miles.

The regional hydrology was developed to determine design flow rates, impacts and subsequent mitigation requirements related to flood conveyance through the Project and the temporary impoundment of floodwaters along the Eastside Dike. The regional hydrology analysis was prepared for the 10- and 1-percent annual chance (10- and 100-year) and Standard Project Flood (SPF) storm events. The analysis is completed using the Synthetic Unit Hydrograph Method (SUHM) described in the Riverside County Hydrology Manual (RCHM; RCFCWCD, 1978), and in accordance with CVWD standards and criteria.

Revisions to the standard hydrologic methodology in the RCHM were devised to account for the unique nature of the hydrologic regime in the Coachella Valley and the watershed areas tributary to the La Entrada Specific Plan site. In particular, precipitation losses based on the RCHM do not account for the higher permeability of the sandy soils often found on the piedmont-like surfaces, which encompass a large part of the tributary watershed. The Green-Ampt infiltration method was selected in lieu of the standard loss rate method prescribed in the RCHM to account for the higher permeability exhibited by sandy soils. The application and technical approach for the analysis was coordinated with CVWD throughout the development of the regional hydrology analysis.

The regional hydrology analysis for the 10- and 1-percent annual chance storm events were prepared to determine design discharges to each of the seven (7) regional watercourses through the project site. The analysis was prepared for the baseline (existing) and project conditions and identified flow rates at the upstream (U/S PL) and downstream (Eastside Dike) project limits. The results of the analysis are summarized in Table E-1. The project condition ($Q_{p,\ bulked}$) flow rates are intended to be used for the design of the regional channel systems through the La Entrada Specific Plan site.

Table E-1. Comparison of Baseline and Project conditions

		10-percent annual chance storm event			1-percent annual chance storm event		
channel	CP	baseline $Q_{p,bulked}$ {cfs}	project $Q_{p,bulked}$ {cfs}	ΔQ {cfs}	baseline $Q_{p,bulked}$ {cfs}	project $Q_{p,bulked}$ {cfs}	ΔQ {cfs}
1	U/S PL	281	281	0	666	664	-3
	Eastside Dike	97	118	21	835	760	-75
2	U/S PL	65	65	0	153	153	0
	Eastside Dike	37	112	76	522	540	18
3	U/S PL	445	445	0	2,199	2,199	0
	Eastside Dike	391	465	74	2,067	2,329	263
4	U/S PL	66	68	2	179	184	4
	Eastside Dike	8	109	101	412	569	157
5	U/S PL	112	112	0	395	394	-1
	6C*	--	89	--	--	407	--
	Eastside Dike	56	--	--	440	--	--
6	U/S PL	787	785	-3	3,316	3,308	-8
	6C*	--	889	--	--	3,671	--
	Eastside Dike	698	926	228	3,200	3,956	756
7	U/S PL	286	285	0	1,026	1,020	-5
	Eastside Dike	243	265	22	1,043	1,038	-6

*Concentration Point (CP) 6C represents the confluence location of Channels 5 and 6

Six (6) regional channel systems are proposed for the site development. The 7th water course is located in an open space area and no channel improvements are proposed. Final sizes for the channel systems including base width and depth will be determined in conjunction with future phases of the project design and entitlement. The preliminary layout and widths included in the specific plan were developed to limit encroachment into the active flow path areas where possible. The channels are envisioned to maintain a shallow-wide flow conveyance with flow depths averaging approximately 3-feet. The channels were aligned to follow the primary active flow paths and work with the land use and conceptual grading plans.

E.2.3 Eastside Dike Analysis and Impacts

The Eastside Dike is an earthen levee system constructed along the north side of the Coachella Channel. Regional and local runoff from the project and north of the project will flow through the seven onsite regional channels and follow their historic course to the Eastside Dike at the southwestern edge of the project site. The runoff generally ponds along the dike and is eventually discharged to the Coachella Valley Stormwater Channel via Wasteway No. 2. The impacts to the Eastside Dike associated with the site development were assessed for the 1-percent annual chance (24-hour duration) and SPF storm events. The baseline and project conditions were evaluated to assess the project related impacts to the runoff and ponding along the dike.

The results of the regional hydrology analysis indicate that the 1-percent annual chance 24-hour storm event experienced an increased storm water runoff volume of 269 acre-feet based on the La Entrada Specific Plan development. The SPF event experienced an increase of 196 acre-feet. The freeboard impacts related to the increase in runoff volume was analyzed to evaluate the effects of the La Entrada Specific Plan development on the Eastside Dike.

A flood routing analysis was performed using the FLO-2D® computer program to simulate the conveyance and dispersion of floodwaters along the Eastside Dike and subsequently determine the water surface elevation (WSE) profiles along the dike for the baseline and project conditions. The results of the analysis are summarized in Table E-2.

Table E-2. Comparison of Baseline and Project conditions maximum water surface elevations

	1-percent annual chance 24-hour storm event			Standard Project Flood (SPF) -Indio Storm of September 24, 1939-				
	baseline	project		baseline	project -no crossings-		project	
statistic	WSE {feet}	WSE {feet}	ΔWSE {feet}	WSE {feet}	WSE {feet}	ΔWSE {feet}	WSE {feet}	ΔWSE {feet}
maximum	55.11	56.03	1.75	65.15	65.82	0.69	67.01	1.88
average	53.25	54.51	1.23	64.08	64.55	0.47	65.28	1.18
minimum	51.66	52.45	0.51	63.62	64.07	0.22	64.13	0.31

The average top of levee elevation along the Project segment of the Eastside Dike is 71 feet. The original SPF design water surface elevation is 66.24 feet (64.0 feet based on NGVD29; Slater et al, 1950). The Project-based SPF maximum water surface elevation is 67.01 feet, which occurs near the Channel 6 outfall inundation area just south of the Avenue 50 crossing.

This study identified a limited degree of Project-related flood hazard impacts along the Eastside Dike with respect to its original SPF design hydrology and the baseline condition analysis. The project SPF flood hazard exceeds the original design SPF water surface elevation for 0.4 miles of the 2.2 mile-segment of the Eastside Dike which fronts the project site. This impact is largely attributed to the concentration of floodwaters delivered by Channel 6. The project SPF flood hazard exceeds the baseline condition by an average of 1.18 feet. The results of the analysis indicate that at least 4 feet of freeboard is maintained along the Eastside Dike as it relates to the SPF, which far exceeds the SPF plus one-foot freeboard requirement as stated in CVWD Ordinance 1234.1, adopted March 25, 2013. The analysis of the 1-percent annual chance event demonstrates that a minimum of about 15 feet of freeboard is maintained, which overwhelmingly satisfies the 100-year plus 4-foot freeboard requirement identified in Ordinance.

Mitigation of project related impacts to the storm water runoff volume would require the construction of storm water retention basins on the project site. To adequately capture the increased volume, the basins would typically be located at the downstream (southern) boundary of the project site. Basins at this location would be only 400 to 600 feet upstream of the Eastside Dike, and only a couple hundred feet from the water that would be ponding along the dike during a large scale storm event. Based on these site specific conditions, the implementation of storm water retention basins on-site would provide a redundant function that is currently provided by the Eastside Dike. Therefore, on-site storm water retention basins are not proposed to mitigate the increased storm water runoff volume as a result of the site development. The fulfillment of the freeboard requirements along the dike supports the recommendation to preclude the mitigation of volume impacts associated with the project development. The regional channels will be properly designed to convey 100-year peak flows based on the Project Conditions.

E.2.4 Local Hydrology

A separate local hydrology analysis was prepared for the onsite Specific Plan areas. The onsite hydrology analysis for the project utilized the RCHM as a basis for calculating flowrates to each of the backbone storm drain systems associated with the proposed development. Because all onsite subwatersheds are less than 640 acres, the Rational Method was used to calculate flowrates for the layout and sizing of the local drainage systems. The hydrology analysis was prepared for the 10- and 1-percent annual chance (10- & 100-year) storm events. To be consistent with the regional analysis, the local hydrology drainages are divided into 7 regional channels. The drainage subareas were based on the proposed mass grading for the Specific Plan, and developed to approximate the existing drainage patterns. The local hydrology was used to identify and layout the necessary storm drain systems to support the La Entrada Specific Plan development, and to estimate the onsite storm drain pipe sizes using the 10-year storm peak flow rates. A normal depth hydraulic analysis was prepared to determine the approximate sizes for the local storm drain facilities. The onsite storm drain pipes range in size from 18 inches to 54 inches in diameter.

The City of Coachella Code of Ordinances Section 13.16.110 requires that all new developments identified as a priority project under the newly implemented NPDES permit to retain 100% of the storm water runoff from the 100-year 24-hour duration event. The purpose is to prevent deterioration of the water quality and comply with the requirements of the permit (No. CAS617002). As indicated in the assessment of impacts to the Eastside Dike, on-site retention to mitigate for the increase in runoff as a result of the project development is not necessary. On-site retention to capture and store the 100-year runoff would be redundant to what is already provided at the Eastside Dike, and would result in environmental impacts (due to the basin construction) which exceed the water quality benefits. Water quality features to meet the requirements of the NPDES permit are identified in the separate water quality assessment report.

While on-site retention basins for increased storm water volume are not proposed for the implementation of the La Entrada Specific Plan, it is recognized that the determination of the basin requirements will need approvals from numerous agencies. To accommodate the uncertainty in the final approvals, storm water basins are included in the specific plan documents. Elimination of the basins will not impact the land use plan as the locations of the basins are in Open Space (OS) areas. Elimination of the basins would allow these areas to be kept in a more natural condition.

E.2.4.1 Water Quality Assessment

Water quality assessment for the project site was prepared under a separate report. The report titled, *"La Entrada Specific Plan Development Water Quality Assessment Report"* was prepared to evaluate potential impacts of the project on adjacent water resources and their beneficial uses, and identify best management practices (BMPs) to mitigate project impacts and comply with the regulatory permits.

The project area is located within the City of Coachella and the unincorporated area of the County of Riverside. It is covered by the urban Municipal Separate Storm Sewer System (MS4) National Pollutant Discharge Elimination System (NPDES) permitted area (NPDES Order R7-2008-0001, NPDES Number CAS617002), which was issued to the Riverside County Flood Control and Water Conservation District, the County of Riverside, and 10 incorporated cities (collectively called "permittees"). The City of Coachella and the County of Riverside are copermittees under this permit, and developed the Whitewater River Region Stormwater Management Plan (SWMP) that describes activities, programs, procedures, financial responsibilities, and practices the permittees use to protect water quality by reducing or eliminating pollutants discharged from storm drainage systems they own or operate, including the selection and implementation of Best Management Practices (BMPs). All guidelines and procedures outlined in the SWMP, including the post-development Water Quality Management Plan (WQMP) requirements, will be adhered to during all phases of the project, as currently written or subsequent future regulations. All parties working on the project, or in the project area, will be required to implement pollution prevention, treatment controls, and construction BMPs consistent with the requirements outlined in the SWMP.

The project's runoff drains to the embankment wall of the All American Canal (Eastside Dike), where it pools, disperses, and is potentially discharged to the Coachella Valley Stormwater Channel/Whitewater River via Wasteway No. 2, a concrete-lined channel approximately 2.2 miles long. Wasteway Number 2 confluences with the Coachella Valley Stormwater Channel below the Avenue 52 Bridge approximate 7.5 miles downstream from the Indio Boulevard Bridge and just over 11 miles upstream from the Salton Sea. The frequency peak flow rates are constant along this channel reach of the Coachella Valley Stormwater Channel, which implies that Wasteway No. 2 is not a significant tributary to the Coachella Valley Stormwater Channel. The regional hydrologic analysis indicates that the project will result in a slight increase in runoff volume as a result of the increase in impervious area proposed within the project site. The project area is a small percentage of the Whitewater River watershed (0.002 percent) and is unlikely to have a regional hydromodification effect. Based on the data available, the project is not expected to cause a hydrologic condition of concern to downstream channels.

The City of Coachella requires that development projects incorporate Best Management Practices (BMPs) into their design to address anticipated pollutants. Selection, design, and implementation of BMPs will be based on the Riverside County Whitewater River Region Stormwater Quality Best Management Practice

Design Handbook guidance (Exhibit 3 in *Whitewater River Region Water Quality Management Plan for Urban Runoff*, January 2011), or equivalent. BMPs will be considered for implementation where feasible, and may include Site Design BMPs, Source Control BMPs (such as Non-Structural BMPs and Structural BMPs), and Treatment Control BMPs. The selection, sizing, and location of BMPs will be determined in future design phases. Conceptual locations for water quality features are identified on the project storm drain facilities layout map. All runoff from the site development will be treated prior to discharge to a regional channel or off-site facility.

E.3 Development Phasing

The La Entrada Specific Plan may be constructed in phases based on market demand and available infrastructure improvements. Phases may occur concurrently provided the associated infrastructure is also completed. The Specific Plan identified 5 anticipated development phases.

The drainage improvements will also need to be constructed in phases with the associated development. The regional channels and storm drain systems identified in each of the phases should be constructed with the other infrastructure within that phase. Interim facilities will be required with a phased construction. The regional channels will require the construction of interim dikes to capture flow on the natural drainage areas and safely convey the flood waters to the channel systems. The dikes should be designed for a 100-year storm event (similar to the channel systems) based on the calculated regional hydrology flow rates.

The final configuration for the interim facilities will depend on the phased grading and should be determined in future design stages. A preliminary drainage infrastructure phasing plan has been developed for the specific plan. In general, the downstream reaches of the channel systems will be constructed first and extended upstream in future phases. Interim dikes will need to be eliminated and reconstructed above the subsequent phases as development occurs.

E.4 Summary and Conclusions

The Drainage Master Plan was prepared to identify a general framework for the storm water management infrastructure to meet the drainage and flood protection requirements for the La Entrada Specific Plan Development. The master plan is a planning level document to understand and mitigate the impacts associated with the project development and identify infrastructure requirements. The facility sizes indicated are not intended for final design, but to assist in the planning effort to ensure that adequate backbone infrastructure is provided with the proposed development.

Regional hydrology has been prepared to identify and mitigate flood hazards, and to identify regional channel requirements. The regional hydrology flow rates should be used for the final design of the channel improvements. Local hydrology has been prepared based on the conceptual grading plan to determine flow patterns and local storm drain system requirements. The local hydrology is subject to change pending more detailed planning area design. The general drainage patterns should be maintained to avoid impacts to the channel systems and the downstream facilities such as the Eastside Dike.

On-site retention basins are not recommended as part of the drainage master plan. They are redundant based on the function of the existing conditions with the ponding along the Eastside Dike. The elimination of the basins is anticipated to require the approvals of numerous agencies, and are therefore included in the specific plan documents. Agreements and approvals should be discussed with the appropriate agencies to eliminate the basins in future design stages. Elimination of the basins would preserve dedicated open space areas in a natural condition.

Water Quality Assessment

La Entrada Specific Plan Development
Draft Water Quality Assessment Report

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September 2012

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Table of Contents

Executive Summary iii
1 Introduction 1
1.1 Project Description 1
2 Environmental Setting 5
2.1 Regional and Local Hydrology 5
2.2 Floodplains 9
2.3 Precipitation and Climate 9
2.4 Groundwater Hydrology 9
2.5 Soil Erosion Potential 9
2.6 Surrounding Land Uses 9
2.7 Topography 10
3 Regulatory Setting 13
3.1 Clean Water Act 13
3.2 Porter-Cologne Water Quality Act 13
3.3 State Water Resources Control Board and Regional Water Quality Control Board 14
3.3.1 Beneficial Uses and Water Quality Objectives 14
3.3.2 NPDES Program 17
3.3.3 Riverside County Water Quality Management Plan 17
3.3.4 Construction Activity Permitting 17
4 Water Quality Assessment 19
4.1 Receiving Surface Water Bodies 19
4.2 Water Quality Objectives 19
4.3 Anticipated Pollutants 21
4.4 Hydrologic Conditions of Concern 23
5 Mitigation Measures 24
6 References 28
Appendix A: Water Quality Objectives for Inland Surface Waters A-1

List of Figures

Figure 1: Regional Vicinity Map 3
Figure 2: Local Vicinity Map 4
Figure 3: Whitewater River Watershed Map 7
Figure 4: Topography Map 11

List of Tables

Table 1: Beneficial Uses of Downstream Water Bodies 16
Table 2: Summary of Impaired Water Bodies 19
Table 3: Numeric Objectives for the Salton Sea 20
Table 4: Potential Pollutants Generated by Land Use Type 22

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Executive Summary

The La Entrada Specific Plan Development (project) is based on a comprehensive update of the previously approved 1989 McNaughton Specific Plan, which allows up to 8,000 residential dwelling units (du). The proposed project includes an additional 588 acres of new land within the project area. As proposed, the project would allow up to a maximum of approximately 7,800 residential dwelling units within the 2,200 acre area, varying from Very Low Density (2.0 du/ac), Low Density (4.5 du/ac), Medium Density (8.0 du/ac), and High Density (20.0 du/ac) uses. In addition, the project proposes the development of Mixed Use areas that allow commercial retail and higher density residential uses; up to four elementary school sites, approximately 263 acres of parks, 357 acres of open space, and public/community facilities. The development of the proposed uses will occur in a series of phases and coordinated closely with the construction/ extension of the regional roadway network over the All American Canal (Eastside Dike) and a new proposed interchange along the I-10 freeway. At buildout, it is anticipated that the project area could increase the population of the City of Coachella by 21,000 new residents.

The project's runoff drains to the embankment wall of the All American Canal (Eastside Dike), where it pools, disperses, and is potentially discharged to the Coachella Valley Stormwater Channel/Whitewater River via Wasteway Number 2, which confluences with the Coachella Valley Stormwater Channel/Whitewater River, and flows into the Salton Sea. Wasteway 2 is not listed on the 303(d) List of impairments nor have Total Maximum Daily Loads (TMDLs), or limits on the amount of pollutants that can be discharged, been established. The Coachella Valley Stormwater Channel/Whitewater River is listed as impaired on the 2010 303(d) List for DDT, Dieldrin, PCBs and Toxaphene. There also is a TMDL for pathogens established. The Salton Sea is listed as impaired on the 2010 303(d) List for Arsenic, Chlorpyrifos, DDT, Enterococcus, Nutrients, Salinity and Selenium but no TMDLs have been established. Downstream impairments will be taken into consideration during the design of Best Management Practices (BMPs) while the project is designed.

During construction of the project, a Stormwater Pollution Prevention Plan (SWPPP) will be prepared and implemented. The SWPPP identifies specific BMPs that will be implemented during the project's construction to meet the technology requirements and to retain sediment, as stipulated in the National Pollutant Discharge Elimination System (NPDES) Construction General Permit (CGP) and the Whitewater River Region NPDES Permit.

Based on the project's conceptual land use plan, it is anticipated that the proposed land use types will result in an increase in impervious area within the project limits. This report assesses the potential impacts that the project may have on the water quality of nearby receiving water bodies. It evaluates the future development of the project and how it addresses water quality standards, how it complies with current NPDES permit compliance for new development in the Whitewater River Watershed of Riverside County, and how it complies with the Construction General Permit. In addition, Site Design BMPs, Source Control BMPs, and Treatment Control BMPs that will address the anticipated post-construction priority pollutants from the project will be considered for feasibility to mitigate the impacts from the project on downstream waterbodies. The project area, as compared to the watershed size, is relatively insignificant. However, based on the data available, it cannot be determined whether or not the project will cause a hydrologic condition of concern to downstream channels. It is recommended that additional studies and analysis are conducted to identify options to mitigate for the increase in flow.

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1 Introduction

The La Entrada Specific Plan Development (project) is a 2,200 acre master planned community in the eastern portion of the City of Coachella (City) and unincorporated Riverside County, California. The approximately 588 acres in unincorporated Riverside County are within the City's General Plan planning area. This area would not be subject to the Specific Plan until it is annexed by the City. The project area has a series of northeast-southwest trending ridges and canyons that drain toward the lower elevations of the Coachella Valley, to the south and west. The Interstate 10 freeway lies to the north and the Coachella Branch of the All American Canal (Eastside Dike) lies to the west of the project. The project is surrounded to the north and east by undeveloped land, sparsely developed agricultural land to the south, and existing agricultural land to the west.

This report evaluates the potential impacts of the project on adjacent water resources and their beneficial uses. It will examine the existing surface and ground water resources, assess the potential effects the project may have on them, and support the project's Environmental Impact Report. This technical report describes the detailed analysis to evaluate all physical and regulatory aspects of the project, including:

- Environmental setting;
- Regulatory setting; and
- Water quality assessment.

1.1 Project Description

The proposed project is based on a comprehensive update of the previously approved 1989 McNaughton Specific Plan, which allows up to 8,000 residential dwelling units (du). The proposed project includes an additional 588 acres of new land within the project area. As proposed, the project would allow up to a maximum of approximately 7,800 residential dwelling units within the 2,200 acre area, varying from Very Low Density (2.0 du/ac), Low Density (4.5 du/ac), Medium Density (8.0 du/ac), and High Density (20.0 du/ac) uses. In addition, the project proposes the development of Mixed Use areas that allow commercial retail and higher density residential uses; up to four elementary school sites, approximately 263 acres of parks, 357 acres of open space, and public/community facilities. The development of the proposed uses will occur in a series of phases and coordinated closely with the construction/extension of the regional roadway network over the All American Canal (Eastside Dike) and a new proposed interchange along the I-10 freeway. At buildout, it is anticipated that the project area could increase the population of the City by 21,000 new residents. Figure 1 and Figure 2 demonstrate the regional and local vicinities, respectively, of the proposed project.

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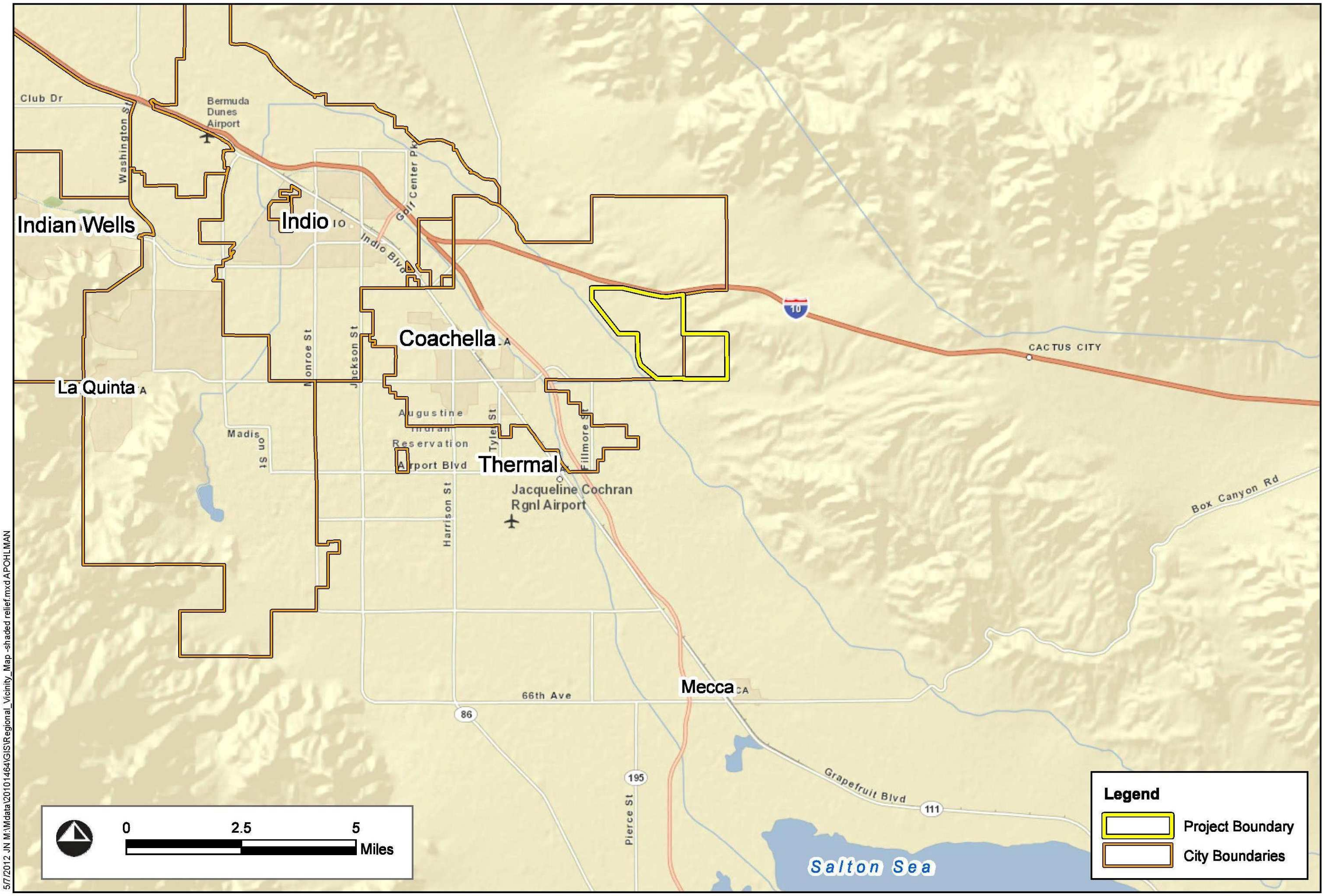
Figure 1: Regional Vicinity Map



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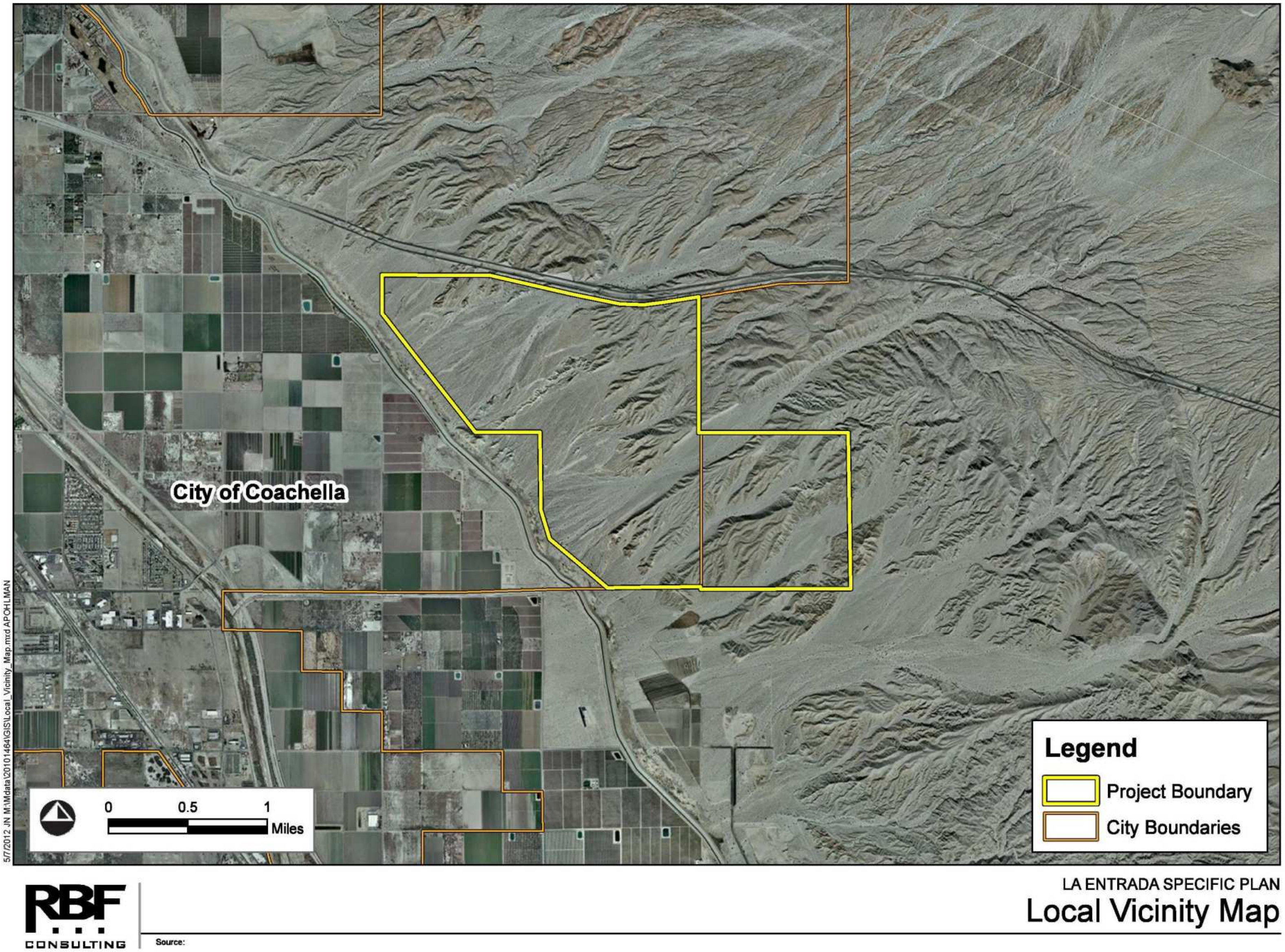
RBF CONSULTING

Source:

LA ENTRADA SPECIFIC PLAN
Regional Vicinity Map

Figure 2: Local Vicinity Map



2 Environmental Setting

The project is located in the southeastern Coachella Valley, with the San Bernardino Mountains to the north and east of the project, and the Mecca Hills to the southeast. Surface water from the area generally flows southwest toward the All American Canal (Eastside Dike).

2.1 Regional and Local Hydrology

The project is situated in the Whitewater River Watershed, which is approximately 1,500 square miles and conveys runoff to the Salton Sea in southern Riverside County. The Whitewater River's headwaters lie in the San Bernardino Mountains in San Bernardino County, north of Riverside County. Several mountain ranges form the Coachella Valley, such as the San Jacinto Mountains, the Santa Rosa Mountains, the Chocolate Mountains, the Mecca Hills, the Cottonwood Mountains, and the Orocopia Mountains. Runoff from these mountains drains through a network of surface streams and collects on the Coachella Valley floor and flows southeast via the Whitewater River toward the Salton Sea. The Salton Sea is a lake that has no outlet and does not discharge to the ocean.

Runoff from the existing topography within the project boundary drains to six existing washes within the project boundary and collects near the embankment wall of the All American Canal (Eastside Dike). A portion of the drainage from the project may potentially discharge to Wasteway Number 2 via a drainage structure under the All American Canal (Eastside Dike), which then confluences with the Whitewater River. The current project plan indicates that the existing washes will continue to operate after construction of the project. The Whitewater River discharges to the Salton Sea approximately 13 miles southeast of the project.

The Whitewater River Watershed has water bodies within it that have Total Maximum Daily Loads (TMDL) approved by the Colorado River Basin Regional Water Quality Control Board (Colorado River Basin RWQCB) and are listed on the 2010 California 303(d) List of Water Quality Limited Segments. These water bodies include the Coachella Valley Stormwater Channel/Whitewater River and the Salton Sea, and are further discussed in Section 4.2. Figure 3 shows the project and its location in the watershed.

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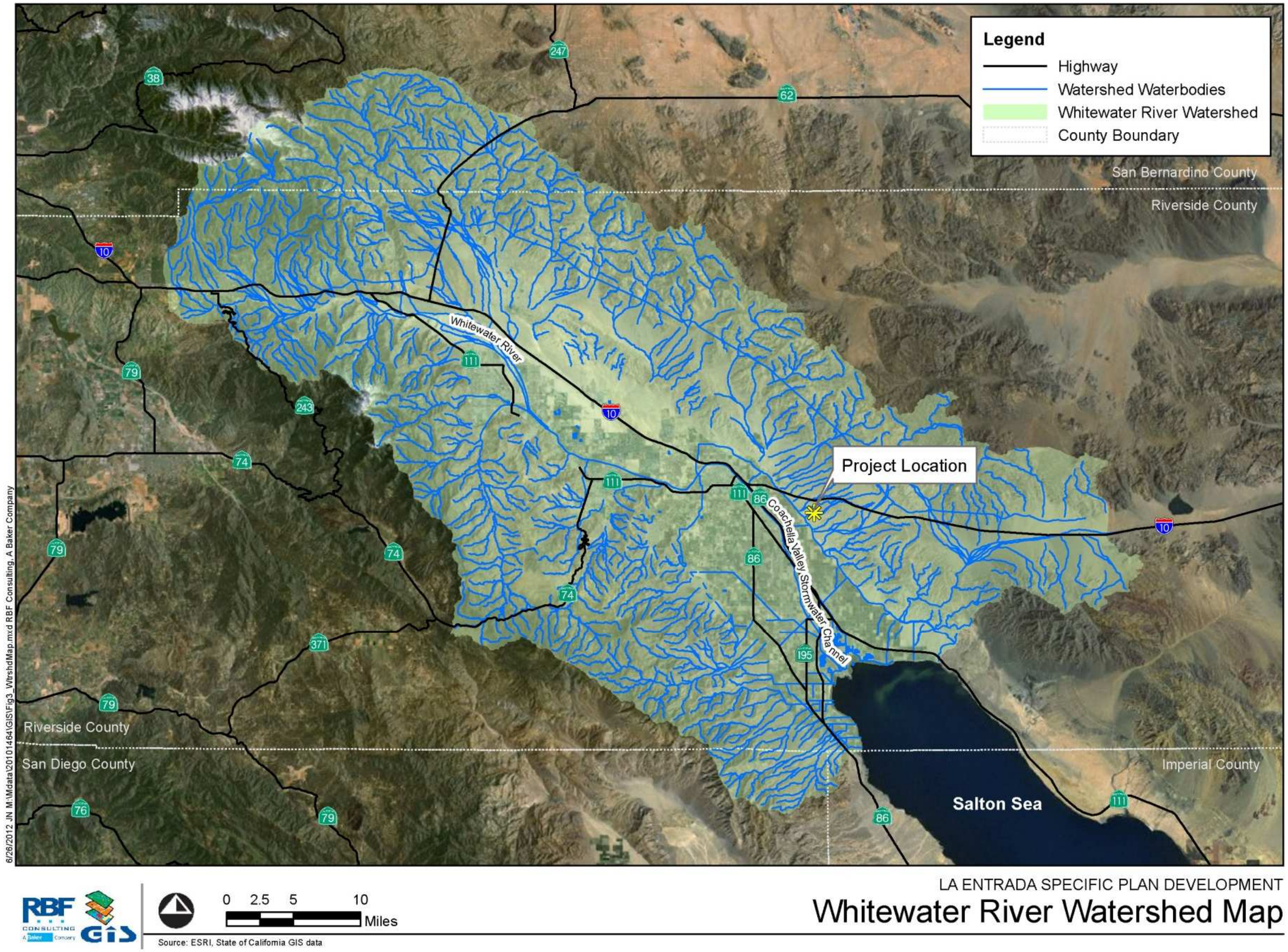
Figure 3: Whitewater River Watershed Map



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2.2 Floodplains

This site is located in areas designated as Zone D and X. The Zone D designation corresponds to areas with possible but undetermined flood hazards. The Zone X designation corresponds to areas of 0.2 percent annual chance flood, areas of one percent annual chance flood with average depths of less than one foot or with drainage areas less than one square mile, and areas protected by levees from one percent annual chance flood. No base flood elevations or depths are shown within the project boundary (Flood Insurance Rate Map Number 06065C2300G, August 28, 2008).

2.3 Precipitation and Climate

Typically, the climate for the area is characterized by long summers with intense thunderstorms, and brief, rainy winters. The annual average rainfall in the City of Indio, which is located near the City of Coachella, is three inches[1].

2.4 Groundwater Hydrology

The California Department of Water Resources Water Data Library was reviewed to determine if groundwater data was available within the project boundary or in the vicinity. Several wells are located northwest of the project, but the data is inaccessible to the public. However, the California Department of Water Resources developed an inventory of groundwater basins throughout the state, entitled *California's Groundwater Bulletin 118*, and updated the document in 2003. It characterizes the quality of groundwater in the Desert Hot Springs Subbasin of the Coachella Valley Groundwater Basin as high in total dissolved solids concentrations of sodium sulfate.

2.5 Soil Erosion Potential

The Soil Erodibility Factor (K factor) represents:

- The susceptibility of soil or surface material to erosion
- The transportability of the sediment
- The amount and rate of runoff given a particular rainfall input, as measured under a standard condition.

The K factor for the site is 0.08 according to the Natural Resources Conservation Service (NRCS) soil survey data, which is available in Appendix C. Generally, this equates to a low to moderate potential for erosion within the project area characterized by particles resistant to detachment.

2.6 Surrounding Land Uses

The land surrounding the project collects along the embankment wall of the All American Canal (Eastside Dike) just as runoff from the project area does, and includes four types of land uses:

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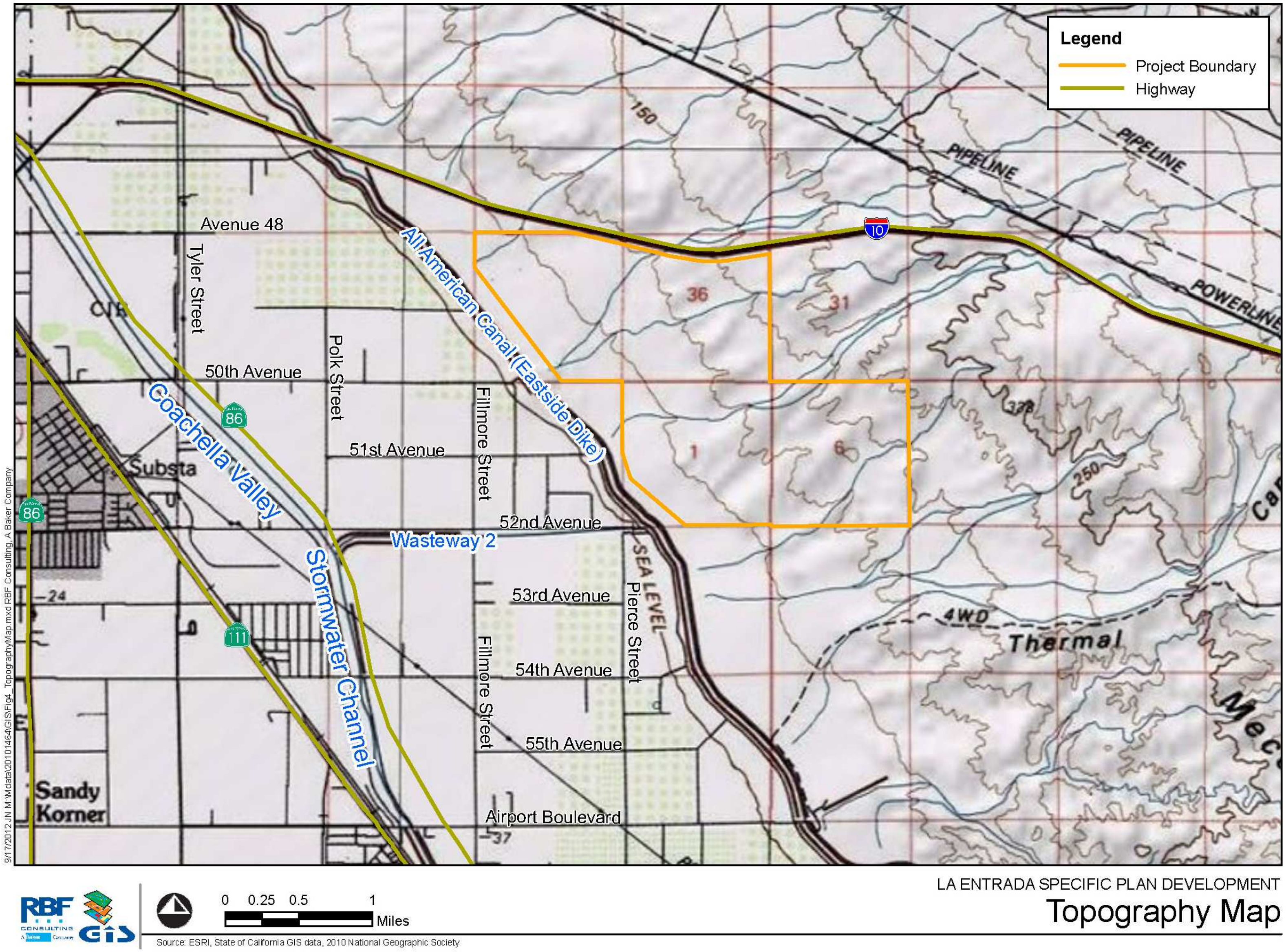
[1] Riverside County Flood Control and Water Conservation District, Rainfall Summary Report, posted at http://rcflood.org/Data/Rainfall_Summary_Report.pdf .

- Entertainment Commercial – land designated for commercial uses with an emphasis on entertainment;
- Open Space – vacant land that does not contain man-made impervious surfaces;
- Low Density Residential – single-family detached residences on large parcels of ½ to 1 acre, and limited agriculture and animal keeping is permitted, however, intensive animal keeping is discouraged;
- Very Low Density Residential – single-family detached residences on large parcels of 1 to 2 acres, and limited agriculture and animal keeping is permitted, however, intensive animal keeping is discouraged; and,
- Light Industrial – industrial and related uses including warehousing/distribution, assembly and light manufacturing, repair facilities, and supporting retail uses.

2.7 Topography

The existing topography within the proposed Project slopes from the northeast, at approximately 640 feet, to the southwest, at approximately 50 feet. The total change in existing topography is approximately 590 feet. Figure 4 is a topography map of the proposed Project.

Figure 4: Topography Map



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3 Regulatory Setting

The Environmental Protection Agency (EPA) and the State Water Resources Control Board (SWRCB), in accordance with the CWA and its amendments, sets regional water quality standards. The Colorado River Basin RWQCB administers the regional and local implementation of the NPDES program, which regulates the discharge of contaminants into waterways and extends permitting for point- and non-point source discharges. Point source discharges are discharges generated by runoff from specific sources such as an auto repair shop, and non-point source discharges are, by contrast, from many diffuse sources such as a mixed use residential development. During construction of the project, the state's current Construction General Permit requires measures to protect water quality during construction activities for construction sites of an acre or more. It should be noted that the U.S. Army Corps of Engineers (USACE) also has specific regulatory responsibilities associated with water quality, under the CWA, which are described in the following section.

3.1 Clean Water Act

The CWA, as amended by the Water Quality Act of 1987, is the federal legislation governing water quality, which was enacted "to restore and maintain the chemical, physical, and biological integrity of the nation's waters." Important sections of the CWA include:

- Sections 303 and 304 – provide for water quality standards, criteria, and guidelines;
- Section 401 – requires an applicant for any project that proposes an activity that may result in a discharge to waters of the United States to obtain certification from the state that the discharge will comply with other provisions of the act;
- Section 402 – establishes the NPDES system, a permitting system for the discharge of any pollutant (except for dredge or fill material) into waters of the United States. This permitting program is administered by the California State Water Resources Control Board and its Regional Boards; and
- Section 404 – establishes a permit program for the discharge of dredge or fill material into waters of the United States. This permit program is administered by the USCOE.

Coordination with the respective agencies is ongoing to obtain the necessary permits for the project. The project will be required to comply with permit conditions during all phases of the project.

3.2 Porter-Cologne Water Quality Act

California's Porter-Cologne Water Quality Act is the basis for water quality regulation within the state. The act requires a "Report of Waste Discharge" for any discharge of waste (liquid, solid, or otherwise) to land or surface waters that may impair a beneficial use of the water body. The project does not require a waste discharge permit, because any potential construction waste discharge that may impair a beneficial use of surface water will not be discharged to any land or surface waters. Stormwater discharges are expected to comply with and are regulated by the Riverside County Municipal Stormwater permit in the Whitewater River Watershed.

3.3 State Water Resources Control Board and Regional Water Quality Control Board

The SWRCB administers water rights, water pollution control, and water quality functions throughout the state, while the RWQCBs conduct planning, permitting, and enforcement activities. The project area lies within the jurisdiction of the Colorado River Basin RWQCB (Region 7). The *Water Quality Control Plan, Colorado River Basin – Region 7* (Basin Plan) includes water quality standards to protect beneficial uses including maintaining aquatic ecosystems and the resources those systems provide to society. The Basin Plan also requires projects that drain to the Whitewater River Watershed to address any identified impairments in the river itself, or its tributaries.

3.3.1 Beneficial Uses and Water Quality Objectives

The Colorado River Basin RWQCB is responsible for the protection of beneficial uses of water resources within its jurisdiction and uses planning, permitting, and enforcement authorities to meet this responsibility. Every water body within the jurisdiction of the Colorado River Basin RWQCB is designated a set of beneficial uses that are protected by appropriate water quality objectives. The Basin Plan describes the beneficial uses as the following:

- Municipal and Domestic Supply (MUN) – Uses of water for community, military, or individual water supply systems including, but not limited to, drinking water supply.
- Agriculture Supply (AGR) – Uses of water for farming, horticulture, or ranching including, but not limited to, irrigation, stock watering, or support of vegetation for range grazing.
- Aquaculture (AQUA) – Uses of water for aquaculture or mariculture operations including, but not limited to, propagation, cultivation, maintenance, or harvesting of aquatic plants and animals for human consumption or bait purposes.
- Freshwater Replenishment (FRSH) – Uses of water for natural or artificial maintenance of surface water quantity or quality (e.g., salinity).
- Industrial Service Supply (IND) – Uses of water for industrial activities that do not depend primarily on water quality, including, but not limited to, mining, cooling water supply, hydraulic conveyance, gravel washing, fire protection, or oil well re-pressurization.
- Water Contact Recreation (REC-1) – Uses of water for recreational activities involving body contact with water where ingestion of water is reasonably possible. These uses include, but are not limited to, swimming, wading, water-skiing, skin and scuba diving, surfing, whitewater activities, fishing, and use of natural hot springs.
- Non-Contact Water Recreation (REC 2) – Uses of water for recreational activities involving proximity to water, but not normally involving body contact with water where ingestion of water is reasonably possible. These uses include, but are not limited to, picnicking, sunbathing, hiking, beachcombing, camping, boating, tide pool and marine life study, hunting, sightseeing, and aesthetic enjoyment in conjunction with the above activities.

- Warm Freshwater Habitat (WARM) – Uses of water that support warm water ecosystems including, but not limited to, preservation or enhancement of aquatic habitats, vegetation, fish, or wildlife, including invertebrates.
- Wildlife Habitat (WILD) – Uses of water that support terrestrial ecosystems including, but not limited to, the preservation and enhancement of terrestrial habitats, vegetation, wildlife (e.g., mammals, birds, reptiles, amphibians, invertebrates), or wildlife water and food sources.
- Preservation of Rare, Threatened, or Endangered Species (RARE) – Uses of water that support habitats necessary, at least in part, for the survival and successful maintenance of plant or animal species established under state or federal law as rare, threatened, or endangered.

Table 1 indicates the beneficial uses designated in the Basin Plan for the inland surface water bodies downstream of the project and the ground waters in the project's vicinity.

Table 1: Beneficial Uses of Downstream Water Bodies

Name	MUN	AGR	AQUA	FRSH	IND	REC I	REC II	WARM	WILD	RARE
Surface Water Beneficial Uses										
Wasteway 2	-	-	-	-	-	-	-	-	-	-
Coachella Valley Storm Water Channel	-	-	-	✓	-	✓	✓	✓	✓	✓
Salton Sea	-	-	✓	-	✓	✓	✓	✓	✓	✓
Ground Water Beneficial Uses										
Coachella hydrologic subunit	✓	✓	-	-	✓	-	-	-	-	-

3.3.2 NPDES Program

The project area is located within the incorporated area of the City of Coachella and the unincorporated area of the County of Riverside. It is covered by the urban Municipal Separate Storm Sewer System (MS4) National Pollutant Discharge Elimination System (NPDES) permitted area (NPDES Order R7-2008-0001, NPDES Number CAS617002), which was issued to the Riverside County Flood Control and Water Conservation District, the County of Riverside, and 10 incorporated cities (collectively called "permittees"). The City of Coachella and the County of Riverside are copermittees under this permit, and developed the Whitewater River Region Stormwater Management Plan (SWMP) that describes activities, programs, procedures, financial responsibilities, and practices the permittees use to protect water quality by reducing or eliminating pollutants discharged from storm drainage systems they own or operate, including the selection and implementation of Best Management Practices (BMPs). All guidelines and procedures outlined in the SWMP, including the post-development Water Quality Management Plan (WQMP) requirements, will be adhered to during all phases of the project, as currently written or subsequent future regulations. All parties working on the project, or in the project area, will be required to implement pollution prevention, treatment controls, and construction BMPs consistent with the requirements outlined in the SWMP.

3.3.3 Riverside County Water Quality Management Plan

Riverside County has a WQMP template for projects within the Whitewater River Watershed and guidance that identifies BMP design guidelines and criteria. The WQMP outlines recommended BMPs which must be incorporated into design plans for a project of this size, particularly because it will likely include the following Priority Development Project categories:

- Single-family hillside residences that create 10,000 square feet or more of impervious area where the natural slope is 25% or greater;
- Commercial and industrial developments of 100,000 square feet or more; and,
- Home subdivisions with 10 or more housing units.

The specific BMPs that may be considered for the project and evaluated for feasibility when it is designed are listed in Section 5 of this report.

3.3.4 Construction Activity Permitting

When construction of the project occurs, it will result in a disturbance of soil that will require compliance with the NPDES General Permit, *Waste Discharge Requirements for Discharges of Stormwater Runoff Associated with Construction Activities* (Order Number 2009-0009-DWQ, NPDES Number CAS000002), or subsequent permit. By law, all stormwater discharges associated with construction activity where clearing, grading, and excavation results in a soil disturbance of at least one acre of total land area must comply with the provisions of this NPDES Permit, or subsequent permit, and develop and implement an effective Stormwater Pollution Prevention Plan (SWPPP). The permit requires:

- Electronic submittal of the Permit Registration Documents (PRD) to the SWRCB at least 30 days before the start of construction, which includes submittal of a Notice of Intent (NOI), risk assessment, site map, Stormwater Pollution Prevention Plan (SWPPP), annual fee, and a signed certification statement;

- Preparation and implementation of a SWPPP; and,
- Electronic submittal of a Notice of Termination (NOT) to the SWRCB upon completion of construction and stabilization of the site.

Based on the project's location and what water body it drains to, a risk level will be assigned to the project indicating the level of monitoring that will be required during construction. At this phase of planning for the project, it is anticipated that areas of the project will be developed during various phases and by different entities. As each area is developed, coverage under the Construction General Permit will need to be obtained by each entity for each development area. Based on the information available, it is anticipated that the development areas within the project boundary will either be Risk Level 1 or 2 projects. Risk Level 1 projects require that minimum BMPs are installed and visual monitoring is conducted, and Risk Level 2 projects require that stormwater samples are collected during storm events in addition to installing minimum BMPs and conducting visual monitoring.

4 Water Quality Assessment

The Water Quality Assessment analyzed the project's affect on water quality and whether it will meet the applicable water quality standards of downstream surface receiving waters. This section reports the findings of this review, and identifies the following:

- Receiving surface water bodies and their impairments;
- The water quality objectives to maintain the beneficial uses the water body has been designated for by the RWQCB;
- The anticipated pollutants generated by the project; and
- The hydrologic conditions of concern.

4.1 Receiving Surface Water Bodies

As previously mentioned, runoff from the project drains to the embankment wall of the All American Canal (Eastside Dike) where it pools, disperses, and is potentially discharged to the Coachella Valley Stormwater Channel/Whitewater River via Wasteway Number 2. Section 303(d) of the CWA and EPA water quality planning and management regulations, lists waters that do not meet, or are not expected to meet, water quality standards, even after technology-based or other required controls are in place. These water bodies are considered water quality-limited and are reported by states in their 303(d) List. The Coachella Valley Stormwater Channel/Whitewater River is 303(d) listed for the pollutants in Table 2 and TMDLs have not been established for the Whitewater River water bodies.

Table 2: Summary of Impaired Water Bodies

Water Body Name	303 (d) List Constituents	TMDL Constituents
Wasteway 2	-	-
Coachella Valley Stormwater Channel/ Whitewater River	DDT (Dichlorodiphenyltrichloroethane) Dieldrin PCBs (Polychlorinated biphenyls) Toxaphene	Pathogens
Salton Sea	Arsenic Chlorpyrifos DDT (Dichlorodiphenyltrichloroethane) Enterococcus Nutrients Salinity Selenium	-

4.2 Water Quality Objectives

The Porter-Cologne Water Quality Control Act defines water quality objectives as "...the limits or levels of water quality constituents or characteristics which are established for reasonable protection of beneficial uses of water or the prevention of nuisance within a specific area."

There are two forms of water quality objectives:

- Narrative objectives present a general description of water quality that must be attained through pollutant control measures and watershed management. They also serve as the basis for the development of detailed numeric objectives. Narrative objectives apply to all water bodies and they are listed in Appendix A.
- Numeric objectives typically describe pollutant concentrations, physical and chemical conditions of the water, and toxicity of the water to aquatic organisms. Places where numeric limits are specified represent the maximum levels that will allow the beneficial use to continue unimpaired. In other cases, an objective may prohibit the discharge of specific substances, tolerate natural or "background" levels of certain substances or characteristics (but not increases over those values), or may express a limit, in terms of not impacting other beneficial uses. An adverse effect or impact on a beneficial use occurs where there is an actual or threatened loss or impairment of that beneficial use. No numeric objectives have been established for Wasteway 2, or the Coachella Valley Stormwater Channel/Whitewater River. The numeric objectives in Table 3 have been established for the Salton Sea.

Table 3: Numeric Objectives for the Salton Sea

Constituent	Numeric Water Quality Objective
Total Dissolved Solids (Salinity)	The total dissolved solids concentration of the Salton Sea in 1992 was approximately 44,000 mg/l. The water quality objective for Salton Sea is to reduce the present level of salinity, and stabilize it at 35,000 mg/l unless it can be demonstrated that a different level of salinity is optimal for the sustenance of the Sea's wild and aquatic life (California Department of Fish and Game is attempting to make this determination). However, the achievement of this water quality objective shall be accomplished without adversely affecting the primary purpose of the Sea which is to receive and store agricultural drainage, seepage, and storm waters. Also, because of economic considerations, 35,000 mg/l may not be realistically achievable. In such case, any reduction in salinity which still allows for survival of the sea's aquatic life shall be deemed an acceptable alternative or interim objective. Because of the difficulty and predicted costliness of achieving salinity stabilization of Salton Sea, it is unreasonable for the Regional Board to assume responsibility for implementation of this objective. That responsibility must be shared jointly by all of the agencies which have direct influence on the sea's fate. Additionally, there must be considerable public support for achieving this objective, without which it is unlikely that the necessary funding for Salton Sea salinity control will ever be realized.

Constituent	Numeric Water Quality Objective
Selenium	The beneficial use of the Salton Sea for recreation has been impaired due to elevated levels of selenium in tissues of resident wildlife and aquatic life (See page 4-10 [of the Basin Plan] for a more detailed discussion of this). The following objectives apply to all surface waters that are tributaries to the Salton Sea: a. A four day average value of selenium shall not exceed .005 mg/L; b. A one hour average value of selenium shall not exceed .02 mg/L. These numeric limits are based on the United States Environmental Protection Agency's National Ambient Water Quality Criteria.

4.3 Anticipated Pollutants

When the project is ultimately developed per the conceptual land use plan, the residential, mixed use (commercial retail and high density residential), schools, parks/recreation, and open space development will replace the existing vacant land and open space in phases. Typical pollutants that are generated by project category are summarized in Table 4. The project's conceptual land use categories are anticipated to generate the following pollutants:

- Sediment/Turbidity
- Nutrients
- Organic Compounds
- Trash and Debris
- Oxygen Demanding Substances
- Bacteria and Viruses
- Oil and Grease
- Pesticides
- Metals

Table 4: Potential Pollutants Generated by Land Use Type[2]

Type of Development (Land Use)	Sediment/ Turbidity	Nutrients	Organic Compounds	Trash and Debris	Oxygen Demanding Substances	Bacteria and Viruses	Oil and Grease	Pesticides	Metals
Detached Residential Development	P	P	N	P	P	P	P	P	N
Attached Residential Development	P	P	N	P	P(1)	P	P(2)	P	N
Commercial/Industrial Development	P(1)	P(1)	P(5)	P	P(1)	P(3)	P	P(1)	P
Automotive Repair Shops	N	N	P(4,5)	P	N	N	P	N	P
Restaurants	N	N	N	P	P	P	P	N	N
Hillside Development	P	P	N	P	P	P	P	P	N
Parking Lots	P(1)	P(1)	P(4)	P	P(1)	P(6)	P	P(1)	P

Abbreviations:
P = Potential
N = Not potential

Notes:
(1) A potential pollutant if landscaping or open area exists on the project site.
(2) A potential pollutant if the project includes uncovered parking areas.
(3) A potential pollutant if land use involves animal waste.
(4) Specifically, petroleum hydrocarbons.
(5) Specifically, solvents.
(6) Bacterial indicators are routinely detected in pavement runoff.

[2] Riverside County NPDES/Municipal Stormwater Management Program, *Whitewater River Region Water Quality Management Plan for Urban Runoff*, Exhibit 2, *Potential Pollutants Generated by Land Use Type* table, January 2011.

4.4 Hydrologic Conditions of Concern

The project's runoff drains to the embankment wall of the All American Canal (Eastside Dike), where it pools, disperses, and is potentially discharged to the Coachella Valley Stormwater Channel/Whitewater River via Wasteway Number 2, a concrete-lined channel approximately 2.2 miles long. Wasteway Number 2 confluences with the Coachella Valley Stormwater Channel below the Avenue 52 Bridge approximate 7.5 miles downstream from the Indio Boulevard Bridge and just over 11 miles upstream from the Salton Sea. The frequency peak flow rates are constant along this channel reach of the Coachella Valley Stormwater Channel, which implies that Wasteway Number 2 is not a significant tributary to the Coachella Valley Stormwater Channel. The 1- and 10-percent annual chance peak flow rates along this channel reach are 43,000 cfs and 8,500 cfs, respectively (U.S. Department of Homeland Security, August 2008). The tributary drainage area increases from 1,073 square miles at Indio Boulevard to 1,600 square miles at the Salton Sea (U.S. Department of Homeland Security, August 2008 and U.S. Geological Survey, June 2000).

Based on the limited information available when this report was prepared, the hydrologic analysis indicates that the project will result in a slight increase in runoff volume as a result of the increase in impervious area proposed within the project site (RBF Consulting, September 2012). Although the project area is a small percentage of the Whitewater River watershed (0.002 percent) and is unlikely to have a regional hydromodification effect, additional studies, such as along the interior of the All American Canal (Eastside Dike) embankment to ensure that the project will not cause erosion. Based on the data available, the project is not expected to cause a hydrologic condition of concern to downstream channels.

5 Mitigation Measures

This section discusses the procedures and practices that will be applied to reduce the potential environment effects to water quality identified during the Water Quality Assessment analysis by implementing the project. Since this project is still in the preliminary development phase, the specific details of the development areas are unknown at this time. However, when the project is ultimately constructed and maintained after construction, it is anticipated that construction activities and the installation of new impervious surfaces will impact downstream water bodies. The construction of the project and the increase in runoff associated with the increase in impervious area will potentially cause or contribute to an alteration of water quality and the beneficial uses of downstream water bodies.

The City of Coachella requires that development projects incorporate Best Management Practices (BMPs) into their design to address anticipated pollutants. Selection, design, and implementation of BMPs will be based on the Riverside County Whitewater River Region Stormwater Quality Best Management Practice Design Handbook guidance (Exhibit 3 in *Whitewater River Region Water Quality Management Plan for Urban Runoff*, January 2011), or equivalent. BMPs will be considered for implementation where feasible, and may include Site Design BMPs, Source Control BMPs (such as Non-Structural BMPs and Structural BMPs), and Treatment Control BMPs. The following BMPs will be considered where feasible during the project's design phase:

<u>Site Design BMPs</u>

- Minimize Urban Runoff, Minimize Impervious Footprint, and Conserve Natural Areas, and
- Minimize Directly Connected Impervious Area

<u>Source Control Non-Structural BMPs</u>

- Education/Training for Property Owners, Operators, Tenants, Occupants, or Employees
- Activity Restrictions
- Irrigation System and Landscape Maintenance
- Common Area Litter Control
- Street Sweeping Private Streets and Parking Lots
- Drainage Facility Inspection and Maintenance

<u>Source Control Structural BMPs</u>

- Storm Drain Inlet Stenciling and Signage
- Landscape and Irrigation System Design

- Protection of Slopes and Channels
- Provide Community Car Wash Racks and Wash Water Controls for Food Preparation Areas
- Proper Design and Maintenance of:
    - Fueling Areas
    - Air/Water Supply Area Drainage
    - Trash Storage Areas
    - Loading Docks
    - Maintenance Bays
    - Vehicle and Equipment Wash Areas
    - Outdoor Material Storage Areas
    - Outdoor Work Areas or Processing Areas

<u>Treatment Control BMPs</u>

- Biofilters (includes grass swales, grass strips, wetland vegetation swales, and bioretention)
- Detention Basins (includes extended/dry detention basins with grass lining and extended/dry detention basins with impervious lining)
- Infiltration BMPs (includes infiltration basins, infiltration trenches, and porous pavements)
- Wet Ponds or Wetlands (includes permanent pool wet ponds and constructed wetlands)
- Filtration Systems (includes sand filters and media filters)
- Water Quality Inlets
- Hydrodynamic Separator Systems (also known as hydrodynamic devices, baffle boxes, swirl concentrators, or cyclone separators)
- Manufactured or Proprietary Devices (includes proprietary stormwater treatment devices as listed in the California Stormwater Quality Association [CASQA] Stormwater Best Management Practices Handbooks, other stormwater treatment BMPs not specifically listed in the WQMP guidance, or newly developed/emerging stormwater treatment technologies)

To determine what BMPs to select, the project type, the anticipated project activities, and the anticipated pollutants will be considered. In addition, the pollutants that a water body is listed for on the Colorado River Basin RWQCB's 303(d) priority list, or if a Total Maximum Daily Load has been developed, are also considered. The land use categories in the conceptual land use plan for this project are anticipated to generate pollutants such as:

- Sediment/Turbidity
- Nutrients
- Organic Compounds
- Trash and Debris
- Oxygen Demanding Substances
- Bacteria and Viruses
- Oil and Grease
- Pesticides
- Metals

During the design of the project, the following Treatment Control BMPs will be evaluated for feasibility, location, and appropriately sized:

- Infiltration BMPs;
- Wet Ponds or Wetlands;
- Filtration Systems;
- Biofilters;
- Detention Basins;
- Filtration Systems;
- Water Quality Inlets;
- Hydrodynamic Separator Systems; and
- Manufactured or Propietary Devices.

Therefore, compliance with the standard requirements of the Whitewater River Region SWMP for potential short-term (during construction) and long-term (post-construction/ maintenance) impacts (listed below in Measures WQ-1, WQ-2, and WQ-3) is required.

WQ-1 The project will comply with the provisions of the Whitewater River Watershed MS4 NPDES Permit (Order Number R7-2008-0001, NPDES Number CAS617002) and the *NPDES General Permit, Waste Discharge Requirements (WDRs) for Discharges of Storm Water Runoff Associated with Construction Activities* (Order Number 2009-0009-DWQ, NPDES Number CAS000002) and any subsequent permit in effect at the time of construction.

WQ-2 A Stormwater Pollution Prevention Plan (SWPPP) shall be prepared and implemented to address all construction-related activities, equipment, and materials that have the potential to impact water quality. The SWPPP shall identify the sources of pollutants that may affect the quality of stormwater and include construction site BMPs to control pollutants such as sediment control, catch basin inlet protection, construction materials management and non-stormwater BMPs. All construction site BMPs shall follow the latest edition of the *2003 California Stormwater Best Management Practice Handbook, Construction* (CASQA, 2010) and the *Storm Water Quality Handbooks: Construction Site Best Management Practices (BMPs) Manual* (Caltrans, 2003) to control and minimize the impacts of construction related activities, material and pollutants on the watershed. These include, but are not limited to temporary sediment control, temporary soil stabilization, scheduling, waste management, materials handling, and other non-stormwater BMPs.

WQ-3 The Best Management Practices (BMPs) approved by Riverside County will be implemented to the Maximum Extent Practicable (MEP) consistent with the requirements of the *Waste Discharge Requirements for Discharges from the Municipal Separate Storm Sewer System within the Whitewater River Watershed Riverside County Flood Control and Water Conservation District, County of Riverside, Coachella Valley Water District, and Incorporated Cities of Riverside County within the Whitewater River Basin* (Order Number R7-2008-0001, NPDES Number CAS617002) and any subsequent permits. BMPs will be considered for implementation where feasible, and may include Site Design BMPs, Source Control BMPs (such as Non-Structural BMPs and Structural BMPs), and Treatment Control BMPs.

6 References

California Department of Water Resources, *California's Groundwater Bulletin 118, Coachella Valley Groundwater Basin, Desert Hot Springs Subbasin*, (Groundwater Basin Number 7-21.03), 2003, updated February 27, 2004.

California State Water Resources Control Board, *2010 Integrated Report (Clean Water Act Section 303(d) List/305(b) Report) – Statewide*, April 2010.

California Stormwater Quality Association, *California Stormwater Best Management Practices Handbooks*, 2003 and 2010 (Construction only).

California Regional Water Quality Control Board, Colorado River Basin Region, National Pollutant Discharge Elimination System (NPDES) Order No. R7-2008-0001, Permit No. CAS617002, *Waste Discharge Requirements for Discharges from the Municipal Separate Storm Sewer System (MS4) within the Whitewater River Watershed, Riverside County Flood Control and Water Conservation District (Owner/Operator), County of Riverside (Owner/Operator), Coachella Valley Water District (Owner/Operator), and Incorporated Cities of Riverside County within the Whitewater River Basin (Owners/Operators)*, May 21, 2008.

California Regional Water Quality Control Board, Colorado River Basin Region, *Water Quality Control Plan, Colorado River Basin – Region 7*, adopted June 2006.

County of Riverside Transportation and Land Management Agency, *County of Riverside Eastern Coachella Valley Area Plan*, October 2003.

RBF Consulting, A Company of Michael Baker Corporation, *La Entrada Specific Plan Development: Drainage Master Plan, City of Coachella and County of Riverside, California, Draft Report, Regional and Local Hydrology*, September 11, 2012.

Riverside County Flood Control and Water Conservation District, Rainfall Summary Report, for Period Ending 10:00 AM, June 4, 2012.

Riverside County Flood Control and Water Conservation District, *Riverside County Whitewater River Region Stormwater Quality Best Management Practice Design Handbook*, June 2009.

Riverside County Flood Control and Water Conservation District, County of Riverside, Coachella Valley Water District, Cities of Banning, Cathedral City, Coachella, Desert Hot Springs, Indian Wells, Indio, La Quinta, Palm Desert, Palm Springs, and Rancho Mirage, *Whitewater River Region Stormwater Management Plan*, June 2009, Revised January 2011.

Riverside County Flood Control and Water Conservation District, County of Riverside, Coachella Valley Water District, Cities of Banning, Cathedral City, Coachella, Desert Hot Springs, Indian Wells, Indio, La Quinta, Palm Desert, Palm Springs, and Rancho Mirage, *Whitewater River Region Stormwater Management Plan, Appendix H – Whitewater River Region Water Quality Management Plan for Urban Runoff*, June 2009, Revised January 2011.

State Water Resources Control Board, *National Pollutant Discharge Elimination System (NPDES) General Permit for Storm Water Discharges Associated with Construction and Land Disturbance Activities* (Order Number 2009-0009-DWQ, NPDES Number CAS000002), September 2, 2009.

U.S. Department of Homeland Security, Federal Emergency Management Agency, Flood Insurance Rate Maps, Map Number 06065C2300G, August 28, 2008.

U.S. Department of Homeland Security, *Flood Insurance Study, Riverside County, California and Incorporated Areas*, Volume 1 of 4, Flood Insurance Study Number 06065CV001A, Effective August 28, 2008.

U.S. Geological Survey, 1999 California Hydrologic Data Report, Station 10259300 Whitewater River at Indio, California, [http://ca.water.usgs.gov/data/waterdata/99/10259300.html], last modified June 14, 2000.

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Appendix A: Water Quality Objectives for General Surface Waters[3]

Aesthetic Qualities

All waters shall be free from substances attributable to wastewater of domestic or industrial origin or other discharges which adversely affect beneficial uses not limited to:

- Settling to form objectionable deposits;
- Floating as debris, scum, grease, oil, wax, or other matter that may cause nuisances; and
- Producing objectionable color, odor, taste, or turbidity.

Tainting Substances

Water shall be free of unnatural materials which individually or in combination produce undesirable flavors in the edible portions of aquatic organisms.

Toxicity

All waters shall be maintained free of toxic substances in concentrations which are toxic to, or which produce detrimental physiological responses in human, plant, animal, or indigenous aquatic life. Compliance with this objective will be determined by use of indicator organisms, analyses of species diversity, population density, growth anomalies, 96-hour bioassay or bioassays of appropriate duration or other appropriate methods as specified by the Regional Board. Effluent limits based upon bioassays of effluent will be prescribed where appropriate, additional numerical receiving water objectives for specific toxicants will be established as sufficient data become available, and source control of toxic substances will be encouraged.

The survival of aquatic life in surface waters subjected to a waste discharge or other controllable water quality factors, shall not be less than that for the same water body in areas unaffected by the waste discharge, or other control water which is consistent with the requirements for "experimental water" as described in Standards Methods for the Examination of Water and Wastewater, 18th Edition. As a minimum, compliance with this objective as stated in the previous sentence shall be evaluated with a 96-hour bioassay.

As described in Chapter 6 (of the Basin Plan), the Regional Board will conduct toxic monitoring of the appropriate surface waters to gather baseline data as time and resources allow.

Temperature

The natural receiving water temperature of surface waters shall not be altered by discharges of waste unless it can be demonstrated to the satisfaction of the Regional Board that such alteration in temperature does not adversely affect beneficial uses.

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[3] *Water Quality Control Plan, Los Angeles Region, Basin Plan for the Coastal Watersheds of Los Angeles and Ventura Counties*, California Regional Water Quality Control Board Los Angeles Region, June 13, 1994.

pH

Since the regional waters are somewhat alkaline, pH shall range from 6.0-9.0. Discharges shall not cause any changes in pH detrimental to beneficial water uses.

Dissolved Oxygen

The dissolved oxygen concentration shall not be reduced below the following minimum levels at any time:

Waters designated:

WARM ....5.0 mg/l

COLD... 8.0 mg/l

WARM and COLD........................8.0 mg/l

Suspended Solids and Settleable Solids

Discharges of wastes or wastewater shall not contain suspended or settleable solids in concentrations which increase the turbidity of receiving waters, unless it can be demonstrated to the satisfaction of the Regional Board that such alteration in turbidity does not adversely affect beneficial uses.

Total Dissolved Solids

Discharges of wastes or wastewater shall not increase the total dissolved solids content of receiving waters, unless it can be demonstrated to the satisfaction of the Regional Board that such an increase in total dissolved solids does not adversely affect beneficial uses of receiving waters.

Additionally, any discharge, excepting discharges from agricultural sources, shall not cause concentration of total dissolved solids (TDS) in surface waters to exceed the following limits:

	TDS (mg/L)	
	Annual Ave.	Maximum
New River	4000	4500
Alamo River	4000	4500
Imperial Valley Drains	4000	4500
Coachella Valley Drains	2000	2500
Palo Verde Valley Drains	2000	2500

Bacteria

In waters designated for water contact recreation (REC I) or noncontact water recreation (REC II), the following bacterial objectives apply. Although the objectives are expressed as fecal coliforms, E. coli, and enterococci bacteria, they address pathogenic microorganisms in general[4] (e.g., bacteria, viruses, and fungi).

Based on a statistically sufficient number of samples (generally not less than five samples equally spaced over a 30-day period), the geometric mean of the indicated bacterial densities should not exceed one or the other of the following:

	REC I	REC II
E. coli	126 per 100 mL	630 per 100 mL
enterococci	33 per 100 mL	165 per 100 mL

nor shall any sample exceed the following maximum allowables:

	REC I	REC II
E. coli	400 per 100 mL	2,000 per 100 mL
enterococci	100 per 100 mL	500 per 100 mL

except that for the Colorado River, the following maximum allowables shall apply:

	REC I	REC II
E. coli	235 per 100 mL	1,175 per 100 mL
enterococci	61 per 100 mL	305 per 100 mL

In addition to the objectives above, in waters designated for water contact recreation (REC I), the fecal coliform concentration based on a minimum of not less than five samples for any 30-day period, shall not exceed a log mean of 200 MPN per 100 mL, nor shall more than ten percent of total samples during any 30-day period exceed 400 MPN per 100 mL.

Biostimulatory Substances

Waters shall not contain biostimulatory substances in concentrations that promote aquatic growths to the extent that such growths cause nuisance or adversely affect beneficial uses. Nitrate and phosphate limitations will be placed on industrial discharges to New and Alamo Rivers and irrigation basins on a case-by-case basis, taking into consideration the beneficial uses of these streams.

Sediment

The suspended sediment load and suspended sediment discharge rate to surface waters shall not be altered in such a manner as to cause nuisance or adversely affect beneficial uses.

Turbidity

Waters shall be free of changes in turbidity that cause nuisance or adversely affect beneficial uses.

[4] Fecal coliforms and E. coli bacteria are being used as the indicator microorganisms in the Region until better and similarly practical tests become readily available in the region to more specifically target pathogens.

Radioactivity

Radionuclides shall not be present in waters in concentrations which are deleterious to human, plant, animal or aquatic life or that result in the accumulation of radionuclides in the food web to an extent which presents a hazard to human, plant, animal or aquatic life. Waters designated for use as domestic or municipal supply (MUN) shall not contain concentrations of radionuclides in excess of the limits specified in the California Code of Regulations, Title 22, Chapter 15, Article 5, Section 64443, as listed below:

Constituent	Maximum Contaminant Level, pci/L
Combined Radium-226 and Radium-228	5
Gross Alpha particle activity (including Radium-226 but excluding Radon and Uranium)	15
Tritium	20,000
Strontium-90	8
Gross Beta particle activity	50
Uranium	20

Chemical Constituents

No individual chemical or combination of chemicals shall be present in concentrations that adversely affect beneficial uses. There shall be no increase in hazardous chemical concentrations found in bottom sediments or aquatic life. Waters designated for use as domestic or municipal supply (MUN) shall not contain concentrations of chemical constituents in excess of the limits specified below:

Maximum Contaminant Levels (MCLs) for Organic and Inorganic Chemicals

Inorganic Chemical Constituents:	MCL, mg/L
Arsenic	0.05
Barium	1.0
Cadmium	0.010
Chromium	0.05
Lead	0.005
Mercury	0.002
Nitrate (as Nitrogen)	10.0
Selenium	0.01
Silver	0.05

Maximum Contaminant Levels (MCLs) for Organic and Inorganic Chemicals

Organic Chemical Constituents:	MCL, mg/L
(a) Chlorinated Hydrocarbons	
Endrin	0.002
Lindane	0.004
Methoxychlor	0.1
Toxaphene	0.005
(b) Chlorophenoxys	
2,4-D	0.1
2,4,5-TP Silvex	0.01

Limiting Concentrations of Fluoride

Annual Average of Maximum Daily Air Temperature — Fluoride Concentrations mg/L

Degrees Fahrenheit	Degrees Celsius	Lower	Optimum	Upper	MCL
below 53.8	below 12.1	0.9	1.2	1.7	2.4
53.8 to 58.3	12.1 to 14.6	0.8	1.1	1.5	2.2
58.4 to 63.8	14.7 to 17.6	0.8	1.0	1.3	2.0
63.9 to 70.6	17.7 to 21.4	0.7	0.9	1.2	1.8
70.7 to 79.2	21.5 to 26.2	0.7	0.8	1.0	1.6
79.3 to 90.5	26.3 to 32.5	0.6	0.7	0.8	1.4

Pesticide Wastes

The discharge of pesticidal wastes from pesticide manufacturing processing or cleaning operations to any surface water is prohibited.

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