Pacific Advanced Civil Engineering, Inc., "Newhall Ranch River Fluvial Study Phase 2" (January 2008)

Newhall Ranch

River Fluvial Study

PHASE 2

SANTA CLARA RIVER

Prepared for:

NEWHALL LAND
A LENNAR/LNR COMPANY

Prepared by:

PACE
Advanced Water Engineering

JANUARY 2008
(August 2007) - Revised
(July 2006) - Revised
Job #8197E

PACIFIC ADVANCED CIVIL ENGINEERING, INC.

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August 24, 2007

Ben Willardson
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(626) 458-6117

Re: Responses to the Newhall Ranch Santa Clara River Study – Phase 2A Review of Tributary Sediment Yield Impact to River **#8197E**

Dear Mr. Willardson:

Pacific Advanced Civil Engineering, Inc. (PACE) is pleased to provide the following responses to the LADPW review comments regarding the above referenced project. The responses from PACE are as follows:

General Comments

1. *The models for existing hydrology appear to be developed properly. The hydrology models for the proposed condition are sectioned into pieces and do not appear to provide flow data at the outlet where sediment transport is being modeled. The hydrologic models for the proposed condition must be revised to provide flow data and hydrographs at the downstream outlet. Flows for existing and proposed conditions must be calculated and used in SAM.*

PACE RESPONSE:
The hydrology modeling has been revised and hydrologic modeling in the present draft is conducted using only Los Angeles County Flood Control District Modified Rational Method.

2. *All of the sections in the report describe 100-yr floodplains. Were these calculated using HEC-1 and HEC-RAS models? Why are different hydrologic models being used, MODRAT vs. HEC-1? Please use consistent models for all watersheds for both the existing and proposed conditions.*

PACE RESPONSE:
Please see response to Comment 1.

3. *Flow rates in the SAM models are inconsistent with the hydrology studies. The flow rates used for the existing conditions SAM models should match the single event output from the existing conditions hydrologic models. The flow in the proposed condition SAM models should match proposed condition hydrologic model flows. SAM should be used to calculate sediment transport for the peak flow, the mean flow, 0.5 times the mean flow, and a flow between the mean and the peak. This requires analyzing the hydrographs from the hydrologic models.*

PACE RESPONSE:
The hydrographs used in SAM numerical modeling in the present draft employ output from the MODRAT hydrology simulations as discussed in Comment 1, above. The hydrographs for the respective models are entered into the SAM.YLD component of the sediment transport model.

4. *There are two processes being termed "yield" in the report. Watersheds produce sediment through erosion processes. Sediment yield describes how much sediment a watershed produces. The second process, the change in transport potential within a stream, is not "yield". The stream will carry what is provided to it, up to the stream transport potential. If the characteristics of the stream change, the stream will have a different transport potential. Changes between proposed and existing conditions only dictate how much sediment can be transported. If the supply is sufficient, the difference indicates changes to the downstream river system sediment supply. If the supply is insufficient, the channel will try to make up the difference by eroding channel bed and banks.*

   For example, the sediment yield for the Potrero watershed is estimated at 237,473 and 104,506 tons/event for the existing and proposed conditions respectively. Based on the submitted SAM models, the channel transport potential changes from 17,484 to 49,792 tons/day for the existing and proposed conditions, respectively. In this case, the yield to the river appears to increase by 32,308 tons/day since the watershed yield is still sufficient to meet the transport capacity. However, if a debris basin is involved, it may be possible that only the smaller fraction of the sediment may stay in the system. This would result in degradation of the stream system and a much smaller sediment delivery to the river system. This type of discussion and analysis needs to be provided in order to quantify changes to the river system supply. More information is needed on why yields are changing and how it will affect the sediment delivery to the river. How much of the watershed will be developed? Is a debris basin being proposed? Do water quality basins capture sediment? Is the transport potential higher or lower than the yield? All of these things impact sediment delivery to the river system, which is what this report needs to evaluate.

PACE RESPONSE:
There are two types of yield addressed in this report; watershed yield and stream yield. Watershed yield is calculated using procedures such as MUSLE, ACOE (Tatum) and LAC method, and is an estimate of sediment production of a watershed during a hypothetical design storm. Stream yield is an estimate of the sediment transported through a section of channel during a hypothetical design event, and is the sum of the area under the sediment hydrograph. Stream yield is measured in the present study using SAM.YLD, which applies a hydrograph from MODRAT to the SAM.SED model output. The wording in the text has been updated to clarify the type of yield being discussed in a given section.

5. *Maps showing general regions of development within each watershed, along with proposed debris basins and water quality ponds, would help to understand the changes for proposed conditions. These maps can be integrated into the sections on the watersheds.*

PACE RESPONSE:
The figures have been updated to show proposed conditions.

6. *More information and detail is needed in the yield calculations. The electronic versions of the spreadsheets must be provided, or equations and step-by-step calculations must be shown. Subareas and delineations used for developed areas and debris control areas must be named the same as the information provided in the maps requested in comment #5.*

PACE RESPONSE:
The electronic versions of the MUSLE and ACOE (TATUM) spreadsheets are included in Appendix Chapter 3. The MODRAT models are also included in the appendix.

7. *Why is only the LS factor in the MUSLE method changed? This only accounts for length and slope differences, which in most cases should be minor. What about changes to the cropping factor (C) and erosion control (P)? Please provide a description of each variable and how it is modified to reflect development of the watershed.*

PACE RESPONSE:
The MUSLE method was originally intended to estimate sediment production of a watershed, or watershed yield, where agricultural activities are presently in practice. Cropping and erosion control factors specifically refer to types of agricultural practices related to harvesting of crops. Cropping does not appear to have an analog in land development. In the present draft, the erosion control factor to represent the change in imperviousness between the existing and proposed conditions is used. The application of the revised methodology is discussed in Chapter 4.

8. *Do the proposed hydraulic conditions in the SAM model reflect the "restoration" techniques discussed in the last presentation by Newhall and PACE?*

PACE RESPONSE:
The present study addresses issues associated with the establishment of the top and toe of soil cement bank protection for Santa Clara River below the Landmark Project site. The restoration techniques used in the tributary channels will be discussed in future Drainage Concept Reports. The conditions modeled in the SAM models represent a starting point for the future reports.

9. *The flow rates used in the ACOE method appear to be incorrect for the existing conditions. Taking the flow rate from the hydrologic model, divided by the area, provides flows of approximately 1 cfs/acre. This translates to 640 cfs/sq. mi. These values are not reflected in the calculations. Numbers for the proposed condition were not compared since the hydrologic models for the proposed conditions do not appear to be complete.*

PACE RESPONSE:
The hydrologic modeling in the present draft has been revised; please see response to Comment 1. The values of discharge are taken directly from the MODRAT models, divided by the watershed area, and entered into the ACOE (Tatum) calculation spreadsheets. Please see Chapter 4 and Appendix Chapter 4.

10. *The ACOE method indicates that for use of the method outside of the San Gabriel Mountains, rates should be modified using the A-T method. The current study uses the same A-T factor for all subareas. Based on the LADPW debris production zones, the erosion rate is not the same in the 4 tributaries. More detailed calculations and documentation for the development of the A-T factor are needed.*

    Four methods are suggested in the ACOE manual. Method 1 is most preferable and Method 4 is the least preferable. The current study appears to use the tables from Method 4 to develop an A-T factor. However, there is not enough supporting documentation to show that a thorough field investigation and comparison were made between the Newhall Land areas and the San Gabriel Mountains. It is felt that this method should only be used as a check since other methods can be used in the Newhall Land area.

    Method 3 allows use of nearby debris basins to calculate yields and appropriate A-T values. Method 3 could be developed for the Newhall Ranch area. Method 2 requires periodic on-site debris measurements. However, the LADPW Sedimentation Manual has curves that relate erosion rates in the Santa Clara River watershed to erosion rates in the San Gabriel Mountains. These curves could be used as substitutes for actual debris measurements in a method very similar to Method 2.

More detailed documentation and calculations for proposed and existing conditions need to be provided for the ACOE sediment yield method. In order to make the results truly comparable with the LADPW methodology, a fire factor related to watershed recovery of 5 years with a probability of exceedence of 0.02 should also be used for the existing condition. The current study uses a fire factor of approximately 3 for both proposed and existing conditions. Unless a detailed study can be shown for this area, LADPW feels that this fire factor value is much too low for the area for existing conditions. Based on Figures A-1 and A-2 in the ACOE manual, this value should be between 4.0 and 4.5.

PACE RESPONSE:
As discussed with LAC personnel (B. Willardson, July 7, 2007) the method used in the present draft provides more conservative results than changing the A-T factor based on methods one through three. Because the present method is more conservative, another method was not used.

11. *The data in the tables for sediment yield and tributary yield potential should all be in the same units. Tons/day and tons/event should be fairly comparable terms for the LADPW and ACOE methods. The final delivery to the river should also be expressed in tons/day for comparison to SAM models of the Santa Clara River.*

PACE RESPONSE:
The units have been adjusted in the text and tables to be consistent between methodologies.

Page Specific Concerns to be Addressed

12. *Page iii, paragraph 1, the MUSLE method is based on agricultural erosion of topsoil and is not a "yield" based method. Yield based methods are more appropriate for sediment transport since they usually deal with the heavier portion of the sediment which is trapped by debris control structures. It is good for comparison purposes, but was not developed specifically for use within the Southern California environment.*

PACE RESPONSE:
MULSE is included as a basis of comparison of values for watershed yield. It is also included because it is a well known technique, carefully considered in the literature.

13. *Page iii, paragraph 1, the LADPW method was developed based on "yields" to debris basins and dams using much of the same data used for the Army Corps of Engineers method.*

PACE RESPONSE:
The text has been updated to reflect this comment.

14. *Page v, paragraph 2, more discussion is needed on the differences between the Length-Slope factor (LS) used in the current report versus the Simons, Li, and Associates report.*

PACE RESPONSE:
The length-slope factor is a function of slope length and bed slope and is computed using the Wischmeier and Smith (1965) equation. The SLA study uses super-watersheds that are comprised of several of the watersheds considered in the present report. For example, in the present study Grande (~3.4 mi^2) and Chiquito (~4.8 mi^2) watersheds are studied separately, where as in the SLA study the individual watersheds are parts of a larger watershed (~19.0 mi^2) and studied as a whole. Because of the dissimilarity in watersheds studied, differences in the slopes and slope length are observed, changing the LS values. The report has been updated to reflect this response.

15. *Page v, paragraph 2, the differences in the soil erodibility factor (K), cropping factor (C), and erosion control factor (P) used in the current report versus the Simons, Li, and Associates report need to be explained further.*

PACE RESPONSE:
In the present study K factor values are taken from USDA texture tables for sediment samples described in Phase 1, while in the SLA study USGS soil maps were used to determine K values. SLA also used a combined cropping factor/erosion control factor after USDA (1980). The combined factor followed Wischmeier (1975) but does not appear to be based on on-site analysis. The present study utilized aerial photography and site visits to arrive at estimates of C after USDA (1980). The erosion control factor, P, is used in the manner described in Chapter 4. The text of the report has been updated to reflect this comment.

16. *Page vi, paragraph 2, the "yield' from SAM is actually transport potential. See general comment 3. The transport potential will increase based on channel design. However, the yield from the watershed only changes when land use changes.*

PACE RESPONSE:
As noted in response to Comment 3, there are two types of yield discussed in this report. SAM models produce estimates of transport potential from the SAM.SED module and values of stream yield from the SAM.YLD module. Hydrographs from the tributaries for the SAM.YLD module are taken from MODRAT models of the tributary watersheds. Please see response to Comment 3.

17. *Page vi, paragraph 3, the largest flow measured at the Old Road Bridge over the Santa Clara River was 31,800 cfs. The largest flow at the County Line gage just below the project area was 68,000 cfs based on USGS data. This information is also found in the draft Newhall Ranch Specific Plan in the Hydromodification section.*

PACE RESPONSE:
The report has been revised to reflect these values.

18. *Page 1, paragraph 1, discussion in this paragraph indicates that the purpose of this report is to evaluate impacts to the river from single storm events, long-term fluvial operations, and to determine the top and toe of levees on the Santa Clara River. The Phase 2A study only evaluates changes for a single hypothetical event. If yields and delivery to the river change significantly for this event, more analysis on the long-term effects of changes may be necessary to assess the changes to effective sediment transport flows and effects on the river.*

PACE RESPONSE:
The present study considers watershed yield and stream yield differences for the four main tributaries to Santa Clara River within Newhall Ranch below the Landmark Project site. The study also considers the changes to yield based on the complete removal of sediment from tributary discharges during the CAP and peak observed (31,800 cfs) events. Please see Chapter 7.

19. *Page 3, paragraph 2, this paragraph discusses the Santa Clara River within the Newhall Ranch property boundaries. The construction of Castaic Dam should be included in this discussion, along with the effects it had on sediment delivery, changes to flow in the river, etc…*

PACE RESPONSE:
The text has been updated to reflect this comment.

20. *Figure 2.1, The figure shows gaps in watershed delineations between neighboring watersheds. The watersheds should share a boundary.*

    PACE RESPONSE:
    Figure 2.1 has been revised to eliminate the gaps between watershed boundaries.

21. *Page 7, paragraph 1, this paragraph indicates that the average slope of San Martinez Grande Canyon watercourse is 0.059. The slope of the watercourse within the Newhall Ranch property boundary is 0.022. Does this indicate a depositional area and how will this be addressed? How will changes to the depositional area effect sediment delivery to the river?*

    PACE RESPONSE:
    The fact that the upper watershed is steeper than the lower watershed does not necessarily indicate that the upper watershed is erosional, while the lower watershed is depositional. This concept is supported by the fact that both the upper and lower slopes are hydraulically steep. It is likely that the lower watershed is observing less degradation than the upper portions, as would be expected in similar watershed settings. The present study examines the impact on the River by the limiting, lower reaches of the tributaries with SAM modeling in Chapter 6. Design issues associated with sediment control on the tributary will be addressed in a separate, future drainage concept report.

22. *Page 8, paragraph 2, This paragraph indicates that there is a wide section in the middle of Long Canyon watershed that will result in delivering more runoff in a shorter time frame. However, the watershed appears to be fairly uniform in width for the entire length of the watercourse. Please revise or add more discussion.*

    PACE RESPONSE:
    The text has been revised to reflect this comment.

23. *Page 9, paragraph 1, this paragraph references a 500 ft upstream area of the watershed with a less defined active channel and much wider canyon floor, reflecting a depositional area. Please indicate this area and how it affects the sediment yield.*

    PACE RESPONSE:
    As noted in response to Comment 21, it is likely that the lower watershed is observing less degradation than the upper portions, as would be expected in similar watershed settings. The present study examines the impact on the River by the limiting, lower reaches of the tributaries with SAM modeling in Chapter 6. Design issues associated with sediment control on the tributary will be addressed in a separate, future drainage concept report.

24. *Page 12, paragraph 2, this paragraph references the 1991 manual, not the 2006 Hydrology Manual.*

    PACE RESPONSE:
    The text has been revised to reflect this comment.

25. *Page 13, paragraph 2, this paragraph references MORA runs using a fire factor of 1. Based on the 2006 Hydrology Manual, a fire factor should be 0.34 used.*

    PACE RESPONSE:
    The present draft no longer employs MORA, instead using MODRAT. Please see response to Comment 1

26. *Page 13, paragraph 3, MORA does not accept soil values above 199.*

PACE RESPONSE:
Please see response to Comment #25.

27. *Page 13, paragraph 9, indicates that debris basins were used to reduce burned and bulked flow rates for proposed conditions. The burned flow rate should still be applied, but not the bulked. The idea is that the sediment settles, but due to reduced vegetation, and hydrophobic soil conditions, the amount of runoff increases over the unburned condition.*

PACE RESPONSE:
The text has been revised to reflect this comment.

28. *Page 13, paragraph 9, debris basins indicated in this paragraph should be shown on the maps along with the assumed debris capacities.*

PACE RESPONSE:
The text has been revised to reflect this comment.

29. *Page 14, paragraph 2, there is a statement that the HEC-1 program includes procedures that are more physically based and representative of actual surface runoff processes. However, the sentence does not complete the thought about what HEC-1 is more representative than in determining runoff processes.*

PACE RESPONSE:
Please see response to Comment #25.

30. *Page 14, paragraph 5, the synthetic storm used for the analysis was based on sources other than Los Angeles County's design storm. Please indicate how this will influence runoff calculated by the HEC-1 program. HEC-1 was only used for one of the existing and proposed hydrologic models. Consistent methods should be used for all subareas.*

PACE RESPONSE:
Please see response to Comment #25.

31. *Page 15, paragraph 3, discussion is provided about averaging overland flow lengths from the headwaters of each watershed. Please provide the details of the averaging procedure for each watershed in an appendix. This should include the number of overland flow paths that were averaged, the lengths, and the average overland flow length for the watershed. However, this is again related to the HEC-1 model, which was only used for Potrero Canyon.*

PACE RESPONSE:
Please see response to Comment #25.

32. *Page 16 and 17, paragraphs 1 and 2, respectively suggest that a summary table of kinematic wave parameters for the subareas within Potrero Canyon will be provided. The table is not in the report.*

    PACE RESPONSE:
    Please see response to Comment #25.

33. *Page 19, paragraph 4, this paragraph indicates that the A-T table from the ACOE (Tatum) method will be provided in the Appendix Chapter 4. The table is not in the appendix. See comment 10 for more discussion on the information needed for the A-T factor.*

    PACE RESPONSE:
    Please see response to comment #10.

34. *Page 20, paragraph 2, the results section discusses a slight increase in yield for the Grande watershed, indicating that more sediment is being produced after development. This normally only occurs when land uses change from natural conditions to less environmentally friendly practices. Conversion of farmland to residential and commercial uses should reduce sediment yield since pavement and grass cover sediments that were previously more exposed to surface runoff and erosion processes. Please explain how the yield will increase when the production area is decreasing.*

    PACE RESPONSE:
    In the present draft, no increases in watershed yield are expected. Please see Chapter 4.

35. *Page 21, Table 4.1 shows negative changes in yield. See comment 34.*

    PACE RESPONSE:
    Please see response to Comment 34.

36. *Page 22, paragraph 2, reference to the SLA sub-watershed size uses acres instead of square miles.*

    PACE RESPONSE:
    The text has been updated to reflect this comment.

37. *Page 23, paragraph 1, the references to the Los Angeles County methods should be updated to reference the 2006 Hydrology Manual and the reformatted Sedimentation Manual, which have now been separated into two different manuals.*

    PACE RESPONSE:
    The text has been updated to reflect this comment.

38. *Page 23, paragraph 2, the discussion on differences between the SLA and PACE study indicate that changes were made to the LADPW burning and bulking methodologies after the SLA study. This is not true. The methodologies were not changed and this should not be a factor in the differences.*

    PACE RESPONSE:
    The text has been updated to reflect this comment.

39. *Page 24, paragraph 3, the existing and proposed cropping (C) and erosion control factor (P) should be altered for existing and proposed conditions in the MUSLE method. More discussion of these factors for each subarea should be added for the existing and proposed conditions in each subarea. The spreadsheets in Appendix 5 should include information similar to the ACOE spreadsheet calculations regarding factors, ranges, limitations, etc.*

    PACE RESPONSE:
    The text has been updated to reflect this comment.

40. *Page 24, paragraph 4, comparison of flow volumes on a cfs/acre or cfs/square mile should be provided for a true comparison of differences.*

    PACE RESPONSE:
    SLA did not comment on the acreage used to determine these values. It can be assumed that the full 19 to 20 mi^2 was used, but that is not clear from the SLA text. Because no clarity exists on this issue, the values have not been updated.

41. *Page 24, paragraph 4, the LADPW burning and bulking methodologies were not modified after the SLA study.*

    PACE RESPONSE:
    The text has been updated to reflect this comment.

42. *Page 29, paragraph 2, this paragraph uses yield versus transport potential. See comment 4.*

    PACE RESPONSE:
    Please see response to Comment 4.

43. *Page 30, Table 6.2, the existing and proposed sediment yield does not match information from the SAM models based on existing or proposed hydraulics and the design event. Please investigate the differences. The results provided in the table are misleading and incomplete. Changes in transport potential do not indicate changes to yield to the river. They work in conjunction with changes to yield to impact sediment delivery. The full analysis should provide final information on the changes to sediment delivery. See comment 4.*

    PACE RESPONSE:
    Table 6.2 was revised to match information from the revised SAM models. Please see response to Comment 4.

44. *Page 32, Table 6.4, the Q_s provided in the third column appears to be approximately the flow value in cubic feet per second, not changes to delivery in tons/event.*

    PACE RESPONSE:
    The third column of table 6.4 corresponds to changes to delivery in tons/event. Please see revise table headings.

45. Page 33, paragraph 1, Why are different hydrology models used? See comment 2.

PACE RESPONSE:
Please see response to Comment 1.

46. Page 33, paragraph 4, this paragraph uses yield in place of transport potential. See comment 4.

PACE RESPONSE:
Please see response to Comment 4.

47. Page 34, paragraph 3, this paragraph needs to be rephrased. Using different study areas does not change the physical parameters used, but results in a refinement of input for modeling purposes.

PACE RESPONSE:
The text has been updated to reflect this comment.

If you have any questions regarding the above responses, please do not hesitate to contact us at (714) 481-7300.

Sincerely,

PACIFIC ADVANCED CIVIL ENGINEERING, INC.

David A. Jaffe, PhD, PE
Project Manager

DAJ/mr

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River Fluvial Study – Phase 2

Newhall Ranch
Santa Clara River

January 2008

Prepared For Submittal to:

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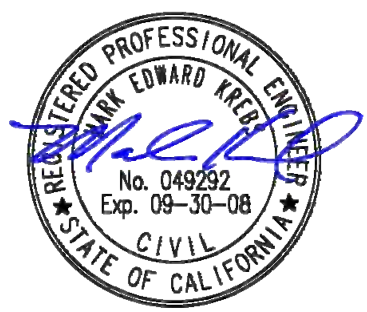

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#8197E

Table of Contents

Executive Summary

This technical investigation provides a detailed and focused evaluation of the fluvial characteristics and long-term stability of the Santa Clara River for the reach including all of Newhall Land's proposed Newhall Ranch and Phase 2 development below the proposed Landmark Village. The River study reach is located from upstream of Chiquito and Long Canyon Creeks on the east and to a point directly downstream of the Ventura County/Los Angeles County line. This reach includes the Newhall Ranch Specific Plan and the proposed Entrada project. The first phase of the Newhall Ranch Specific Plan (Landmark Village) is bounded by the River on the south, State Highway 126 on the north, Castaic Creek on the east, and Grande Canyon on the west. The primary objective of this report is to develop the technical engineering analysis to assess river bed impacts from potential modifications of fluvial operation from proposed development west of and including the Long and Chiquito Canyon Creek confluences, including the Newhall Ranch Specific Plan.

The 1,634 square mile Santa Clara River watershed contains Newhall Ranch. **Approximately 12,000 acres of Santa Clara River or only one percent of the watershed area is located within the Newhall Ranch property boundary, with the majority being upstream or offsite.** The 4.8 square mile (3,053 acre) Chiquito Canyon watershed is a tributary to the northern bank of the Santa Clara River within the Newhall Ranch. Approximately 490 acres of Chiquito Canyon or only 16% of the watershed area is located within the Newhall Ranch property boundary, with the majority being upstream or offsite. The 4.6 square mile (2,938 acre) Potrero Canyon watershed is a tributary to the southern bank of the Santa Clara River within the Newhall Ranch. The 4.6 square mile (2,938 acre) Potrero Canyon watershed is a tributary to the southern bank of the Santa Clara River within the Newhall Ranch. The 1.5 square mile (982 acre) Long Canyon watershed is a tributary to the southern bank of the Santa Clara River within the Newhall Ranch. Approximately 450 acres of Long Canyon or 50% of the watershed area is located within the Newhall Ranch property boundary, with the majority being upstream or offsite. The 3.3 square mile (2,111 acre) San Martinez Grande Canyon watershed is a tributary to the northern bank of the Santa Clara River within the Newhall Ranch. Approximately 200 acres of San Martinez Grande Canyon, or only 10% of the watershed area, is located within the Newhall Ranch property boundary, with the majority being upstream or offsite.

The LA County approved WMS/MODRAT hydrology model is utilized to perform all rainfall-runoff analysis and transformation of rainfall excess into surface runoff. The WMS/MODRAT hydrology model calculates the 50-year frequency design storm, which is based on rainfall with a 2% probability of being equaled or exceeded in any given year. The 50-year frequency design storm occurs over a period of four days, with the maximum rainfall falling on the fourth day. This hydrology model was adopted for this study to provide the precipitation-runoff modeling since this is the accepted method and approved for use by Los Angeles County. The program's hydrologic procedures transform the physical characteristics of the watershed into a "link-node" model in which the hydrologic process occurs at a calculation node and these processes within the watershed are linked together by hydraulic connections.

Three different methods were used to calculate watershed sediment production: MUSLE, ACOE(Tatum), and MODRAT. The different methods were chosen for their use of data in, near, or within an environment similar to that found within the present Santa Clara River study reach. The MUSLE method is a modification of the Universal Loss Equation developed to predict watershed sediment yields for single storm events in a given watershed. The modification entails a runoff factor instead of a rainfall energy factor. The MUSLE equation is applicable to ephemeral stream of the desert southwest since the equation uses runoff from individual storms, which is the primary mode of sediment delivery in the region. The Los Angeles District of the Army Corps of Engineers developed the ACOE(Tatum) method to estimate the quantity of debris caught by some structure at some location within a watershed during a single discrete event. The method is intended to be used in coastal-draining, mountainous watersheds in southern California between 0.1 and 200 square miles in area and for storms with return periods greater than 5-year return periods. The data for the ACOE method was originally collected in southern California from both ACOE and other sources. The MODRAT hydrology model uses Los Angeles County Department of Public Works Sedimentation Manual methodology to estimate sediment production based on debris production areas. A debris production area (DPA) is defined as a zone that yields similar volumes of sediment under similar conditions. The LADPW method was developed based on "yields" to debris basins and dams using much of the same data used for the Army Corps of Engineers method.

Debris production was calculated for each of the four tributary watersheds for both the existing and proposed conditions. The proposed conditions utilize the most recent plans at the time of writing, and any revisions to the proposed condition are not expected to alter debris production. The results of the calculations based on the Capital rainfall for each tributary by each method for both the existing and proposed condition are presented in Table 4.1. Of the three calculation methods, the MUSLE method predicted the smallest total debris production for every tributary while the LA County method predicted the highest debris production for every tributary. On the north bank tributaries of Grande and Chiquito the average change in debris production between the existing and proposed conditions is a 5.2% and 4.4% decrease, respectively, while the maximum is 10.6% decrease (MUSLE method) and 7.1% decrease (LA County method), respectively. **The primary limiting factor to the change in north bank watersheds debris production is the relatively small size of the proposed development on each of the northern watersheds. For the tributaries on the River's south bank of Long and Potrero, the larger change in debris production is a function of the extent of development of the south bank watersheds.** For tributaries on the south bank of the River the average change in debris production between the existing and proposed conditions is a 32.3% and 32.2% decrease, respectively, while the maximum is 67.0% and 63.6% decrease (MUSLE method), respectively. **These results are summarized in Table 4.1.**

Table 4.1: Existing and Proposed Conditions Debris Production Yield by Watershed for the Capital Event [1]

Tributary	Debris Yield (tons/event) Existing	Debris Yield (tons/event) Proposed	Δ (tons/event)	Δ (%)
MUSLE				
Chiquito	6,047	5,801	-246	-4.1
Long	17,704	5,836	-11,868	-67.0
Grande	32,191	28,791	-3,400	-10.6
Potrero	15,725	5,720	-10,005	-63.6
ACOE(Tatum)				
Chiquito	84,128	82,494	-1,634	-1.9
Long	35,136	31,850	-3,286	-9.4
Grande	104,408	103,131	-1,277	-1.2
Potrero	91,204	81,116	-10,088	-11.1
LA County				
Chiquito	282,342	262,197	-20,145	-7.1
Long	79,417	63,105	-16,312	-20.5
Grande	209,251	201,348	-7,903	-3.8
Potrero	360,951	282,229	-78,722	-21.8
Average				Δ (%) [2]
Chiquito	124,172	116,831	-7,342	-4.4
Long	44,086	33,597	-10,489	-32.3
Grande	115,283	111,090	-4,193	-5.2
Potrero	155,960	123,022	-32,938	-32.2

1: All calculations have been converted to tons/event.

2: Average of percentage change from all three methods

In May of 1998, Simons, Li & Associates (SLA) submitted to Los Angeles County Department of Public Works (LACDPW) the *Quantitative Analysis and Mathematical modeling of the Existing Condition of the Santa Clara River Basin, Third Interim Report*. The report covered several areas including hydrologic analysis, hydraulic analysis, sediment watershed yield analysis, and bed sediment analysis. The most relevant to this study is the watershed sediment yield analysis which included the LA County method, the MUSLE method, and the ACOE(Tatum) method. Of the three methods discussed in the report, the authors found that the most representative equation for determining the production of sediment was the LA County equation. **The SLA study has two sub-watersheds that overlap with the watersheds in the present study: the Hasley Canyon group covering the north bank watersheds of Chiquito and Grande watersheds, plus additional area; and the Potrero Canyon group cover the south bank watersheds of Long and Potrero, plus additional area. The SLA sub-watersheds cover an area of 20.0 and 19.0 mi^2, respectively for the Hasley and Potrero groups.**

PACE prepared the approved *Newhall Ranch River Fluvial Study Phase 1 Final Draft* (March 2006). The technical study provides an evaluation of the existing and proposed fluvial characteristics and long-term stability of Santa Clara River between Interstate 5 and an area generally west of the Los Angeles/Ventura County line near the Newhall Ranch Specific Plan. The study was conducted because proposed development along the River within the study area has the potential to modify the fluvial mechanics of the River. The proposed buried soil cement bank protection on both the north and south banks of the River is intended to provide long-term erosion protection from lateral migration of the bank and flood protection for the adjacent proposed development areas. The analysis of the Phase 1 study evaluates impacts from build-out of Newhall Ranch from (1) fluvial modifications of the river bed from single hypothetical storm events, and (2) changes in the floodplain fluvial operation over the long-term.
Several differences exist between the present and SLA values used to calculate watershed sediment yield using the ACOE (Tatum) method. First, the SLA report uses watershed groups with areas of 19 to 20 mi^2, while the present study considers only the watersheds in which proposed development will occur, and with a total area of approximately 6 to 8 mi^2. In the SLA study, slopes are generally higher than in the present study: 264 to 349 ft/mi and 163 to 312 ft/mi, respectively. This difference is due primarily to the difference in area whereby the larger slopes occur in the larger watershed groups. Based on SLA Table 4.7 it appears that the study based runoff on rainfall while the present study utilizes peak runoff. Peak runoff was chosen in the present because the ACOE manual indicates that runoff should be used for watersheds greater than 1920 Ac.

Several differences exist between the PACE and SLA values used to calculate watershed sediment yield. As noted above, the SLA and present studies use different study areas. The studies also use differing soil erodibility factor, K, values. The SLA study uses a K value of K=0.43 while the present study uses a value of 0.10. The SLA value was based on estimation of the soils present in the watershed using soil survey data, and the present study based the K value on soil samples presented in Phase 1. The reason for the difference between the two values likely arises from the extent of data considered. In the present study K factor values are taken from USDA texture tables for sediment samples described in Phase 1, while in the SLA study USGS soil maps were used to determine K values. The SLA study considers more upland area possessing a higher percentage of fine particles with the present study focused on single watersheds adjacent to a river valley with more coarse particles. Different methods were used in the respective studies to calculate the slope length factor, LS. SLA also used a combined cropping factor/erosion control factor after USDA (1980). The combined factor followed Wischmeier (1975) but does not appear to be based on on-site analysis. The present study utilized aerial photography and site visits to arrive at estimates of C after USDA (1980). The erosion control factor, P, is used in the manner described in Chapter 4. The values of runoff volume presented in the present study, taken from the hydrologic analysis, described above, are 399 and 370 ac-ft for the north-bank watersheds and 145 and 586 ac-ft for the south bank watersheds. Values in the SLA study for the 50-year peak discharge are approximately 18,625 and 15,825 cfs for the north and south watershed groups, respectively, while values in the present study are approximately 3,195 and 3,080 cfs and 1,135 and 3,340 cfs for the north- and south-bank watersheds. The difference in the two studies can be attributed to the differences in watershed size.

The primary difference in debris production using the LAC method between the SLA and present studies is a function of the areas used in the calculations. In the SLA study the debris production rate (DPR) is calculated, while in the present study the DPR is read from tables in within GIS layers stored in the MODRAT model. This difference leads to very small differences in DPR between the two studies. There is also some difference in debris production area (DPA) acreages. In the SLA study one hundred percent of both the north- and south-bank watershed groups are DPA 5. In the present study, all of the north-bank watersheds are DPA 5 and DPA 9, and the south-bank watersheds are a combination of DPA 3, 5, 8 and 9. The resultant debris production in cubic yards per square mile is 23,000 and 24,000 cubic yards per square mile for SLA north- and south-bank watershed groups, respectively, and approximately 27,246 and 32,949 cubic yards per square mile for the present study north- and south-bank watersheds, respectively. **The differences between the SLA and the present study are show in Table 5.1.**

Table 5.1: Comparison of SLA and Present Study Debris Production (existing condition)

Drainage	Area (MI^2)	Debris Production (yd^3/mi^2)		
		MUSLE	ACOE(Tatum)	LAC
Hasley	19.9	**11,469**	**36,750**	**23,000**
Potrero	19.0	**51,919**	**32,250**	**24,000**
Drainage	Area (MI^2)	Debris Production (yd^3/mi^2)		
		MUSLE*	ACOE(Tatum)	LAC
Chiquito	4.8	566	7,868	26,407
Grande	3.3	4,379	14,204	28,467
Combined	8.1	**2,119**	**10,449**	**27,246**
Long	1.5	5,299	10,516	23,769
Potrero	4.5	1,569	9,099	36,010
Combined	6.0	**2,501**	**9,453**	**32,949**

*Assumes soil densiity of 165 lb/ft^3

Tributary sediment transport and delivery was estimated in this study using the US Army Corps of Engineers (ACOE) SAM steady-state numerical model. Here, SAM was employed to provide a calculation of sediment delivery for tributary subreaches confluencing with Santa Clara River. The SAM Sediment Hydraulic Package is an integrated system of programs developed through the Flood Damage Reduction and Stream Restoration Research Program to aid in the analyses associated with designing, operating, and maintaining flood control channels and stream restoration projects. SAM combines the hydraulic information and the bed material gradation information to compute the sediment transport capacity and stream yield in a given channel or floodplain hydraulic cross-section for a given discharge at a single point in time. A number of sediment transport functions are available for this analysis and SAM has the ability to assist in selecting the most appropriate sediment transport equation. For each tributary sediment potential and stream yield modeling was conducted for both the existing and proposed condition at the downstream, limiting subreach. For SAM modeling sediment data was provided by Seward Engineering Geology, hydraulic data was taken from HEC-RAS models of the tributaries, and the hydrographs used were taken from the hydrologic modeling presented in Chapter 2. Modeling shows that the stream yields of all the tributaries increase in the proposed condition by approximately 10 to 49 percent at the limiting (downstream) section. The increase in stream yield is a result in the greater efficiency of the channel in the proposed conditions. Similarly, the greater efficiency of River sections in the proposed condition increases stream sediment yield by approximately 1.4 to 2.3 percent, depending on tributary, except at the Potrero confluence where a decrease in stream sediment yield of approximately 9 percent is expected.

A comparison of the stream sediment yield in the River with the change in sediment yield from the tributaries for the tributary Capitol event and either the Capitol or the Peak Observed event on the River (31,800 cfs, winter 1968-1969, Old Road Bridge) was made. (The largest flow at the County Line gage just below the project area was 68,000 cfs based on USGS data. This data is not utilized in the study because County Line is significantly downstream of the project reach.) The Peak Observed event was chosen as a basis for comparison since there is a lower probability of the Capitol event on both the tributaries and River simultaneously than a Capitol event on the tributaries coincident with a sub-Capitol extreme event on the River. **The results show that for coincident Capitol events the tributary stream sediment yield only constitutes between approximately 0.1 and 0.3 percent of the transport of one River subreach, depending on tributary. In addition, during the Peak Observed event the tributary stream sediment yield constitutes between approximately 0.6 and 1.1 percent of the River stream yield on one River subreach, again depending on tributary.**

A comparison of modeling results illustrate that the total sediment stream yield from the tributaries relatively represents between approximately 0.9 and 1.2 percent of the River sediment stream yield on one River subreach during the River Capitol event, depending on tributary. In the case that *no* sediment is delivered to the River from the tributaries during coincident Capitol events, the tributaries represent less than 2 percent of the stream sediment yield of the River. During the Peak Observed event on the River, the stream sediment yield from the tributaries to the River represents between approximately 4.1 and 5.9 percent of the River stream yield on one River subreach, depending on tributary. Likewise these numbers represent the relative changes to the River were *all* the sediment yielded by the tributary delivered to the River. **These results are show in Tables 6.3 and 6.4.**

Table 6.3: Comparison of River Stream Yield with Change in Tributary Stream Yield Resulting from Watershed Development During a Tributary Capitol Event (Tons/Event)

Capital Event			
Subreach	Q_s - River	$\Delta Q_{s\text{-}}$ Creek	Δ%
Chiquito Confluence	174,434	202	**0.12**
Long Confluence	174,434	282	**0.16**
Grande Confluence	183,265	536	**0.29**
Potrero Confluence	207,302	370	**0.18**
Peak Observed Event (31,800 cfs)			
Subreach	Q_s - River	$\Delta Q_{s\text{-}}$ Creek	Δ%
Chiquito Confluence	36,804	202	**0.55**
Long Confluence	36,804	282	**0.77**
Grande Confluence	49,933	536	**1.07**
Potrero Confluence	51,371	370	**0.72**

1. Positive means there is an increase from existing to proposed

Table 6.4: Comparisonof River Yield with No Tributary Yield Resulting from Watershed Development (Tons/Event)			
Tributary with No Delivery - Capitol in River			
Subreach	Q_s - River	$Q_{s\text{ -}}$ Creek	Δ%
Chiquito Confluence	174,434	2,182	**1.25**
Long Confluence	174,434	1,517	**0.87**
Grande Confluence	183,265	1,623	**0.89**
Potrero Confluence	207,302	2,364	**1.14**
Tributary w/ No Delivery - Peak Observed in River (31,800 cfs)			
Subreach	Q_s - River	$Q_{s\text{ -}}$ Creek	Δ%
Chiquito Confluence	36,804	2,182	**5.93**
Long Confluence	36,804	1,517	**4.12**
Grande Confluence	49,933	1,623	**3.25**
Potrero Confluence	51,371	2,364	**4.60**

1. Positive means there is an increase from existing to proposed

In Phase 1 of this study, SAM numerical modeling was used to estimate the change in bed elevation. Bed change was determined by calculating the difference between subreach upstream and downstream sediment potential transport for the Q_{CAP} discharge. The difference in transport potential, ΔTP, between subreach inflow and outflow was converted to general adjustment, GA. To estimate how the proposed changes in sediment delivery from the tributaries impact the fluvial mechanics of the River the general adjustment equation was modified to consider the change in tributary sediment delivery given that none of the sediment produced on the watershed reaches the River confluence. The results for the proposed condition potential where both the tributaries and the River are flowing at the Q_{CAP} discharge show that the grade change ranges from -1.5 to 2.1 feet where the highest degradation occurs in Subreach SRE3 and the greatest aggradation occurs in Subreach SRE2. **A comparison between the grade change for the Phase 1 (no reduction in tributary sediment inflow) and Phase 2 (present study with reduction in tributary sediment inflow) potential bed stability shows that influence of the tributary's sediment delivery considered is minimal relative to local river bed grade change. That is, in the worst case whereby all the sediment presently contributed to the River by the tributaries is prohibited in reaching the River, no grade change in the vicinity of the tributary confluences is expected because the relative contribution of tributary sediment is small with respect to the sediment transport potential of the River at the considered subreach confluences.**

A comparison of the proposed condition where the tributaries are flowing at the Q_{CAP} discharge and the River is flowing at the peak observed discharge (Q=31,800 cfs) finds that the potential grade change ranges from -0.3 to 0.4 feet where the highest degradation occurs in Subreach SRD3 and the greatest aggradation occurs in Subreach SRE2. It is important to note that the potential general adjustment in this scenario is very small relative to the potential general adjustment that occurs during the Q_{CAP} scenario. **Comparing the grade change for the Phase 1 (no reduction in tributary sediment inflow) and Phase 2 (present study with reduction in tributary sediment inflow) potential bed stability for the Q_{CAP}-Q_{31800} scenario shows that influence of the tributary's sediment delivery considered is**

minimal relative to local river bed grade change. That is, in the worst case whereby all the sediment presently contributed to the River by the tributaries is prohibited in reaching the River, no grade change in the vicinity of the tributary confluences is expected because the relative contribution of tributary sediment is small with respect to the sediment transport potential of the River at the considered subreach confluences.

The same comparison was made with tributary stream yield replacing potential transport in the calculations. The results show that the sediment yield grade change ranges from -0.3 to 0.5 feet where the highest degradation occurs in Subreach SRD3 and the greatest aggradation occurs in Subreach SRE2. The results show that influence of the tributary's sediment delivery considered is minimal relative to local river bed yield grade change. The results also show that the yield grade change ranges from -0.1 to 0.1 feet. It is important to note that the yield general adjustment in this scenario is very small relative to the yield general adjustment that occurs during the QCAP scenario. The yield results show that influence of the tributary's sediment delivery considered is minimal relative to local river bed grade change. **The results of the yield-based analysis are similar to those for the potential-based analysis: that influence of the tributary's sediment delivery considered is minimal relative to local river bed yield grade change. These results are shown in tables 7.2, 7.4, 7.6 and 7.8.**

Table 7.2: Phase 2 Santa Clara River SAM Phase 1 vs Phase 2 Conditions Potential Bed Stability - Q_{CAP}

Subreach	US Sta	Phase 1 Proposed Conditions Grade Change (ft)	Phase 2 Proposed Conditions Grade Change (ft)	Phase 1/Phase 2 Delta (ft)	Result
SRC4	24795	0.2	0.2	**0.0**	**NO CHANGE**
SRD1	22195	-0.2	-0.2	**0.0**	**NO CHANGE**
SRD2	19855	1.4	1.4	**0.0**	**NO CHANGE**
SRD3	17510	-1.3	-1.3	**0.0**	**NO CHANGE**
SRE1	15125	-0.4	-0.4	**0.0**	**NO CHANGE**
SRE2	13030	2.1	2.1	**0.0**	**NO CHANGE**
SRE3	11015	-1.5	-1.5	**0.0**	**NO CHANGE**

Table 7.4: Phase 2 Santa Clara River SAM Phase 1 vs Phase 2 Conditions Potential Bed Stability - Q_{31800}

Subreach	US Sta	Phase 1 Proposed Conditions Grade Change (ft)	Phase 2 Proposed Conditions Grade Change (ft)	Phase 1/Phase 2 Delta (ft)	Result
SRC4	24795	0.0	0.0	**0.0**	**NO CHANGE**
SRD1	22195	0.1	0.1	**0.0**	**NO CHANGE**
SRD2	19855	0.1	0.1	**0.0**	**NO CHANGE**
SRD3	17510	-0.3	-0.3	**0.0**	**NO CHANGE**
SRE1	15125	-0.1	-0.1	**0.0**	**NO CHANGE**
SRE2	13030	0.4	0.4	**0.0**	**NO CHANGE**
SRE3	11015	-0.2	-0.2	**0.0**	**NO CHANGE**

Table 7.6: Phase 2 Santa Clara River SAM Phase 1 vs Phase 2 Conditions Yield Bed Stability - Q_{Burn}					
Subreach	**US Sta**	**Phase 1 Proposed Conditions Grade Change (ft)**	**Phase 2 Proposed Conditions Grade Change (ft)**	**Phase 1/Phase 2 Delta (ft)**	**Result**
SRC4	24795	0.0	0.1	**0.1**	**CHANGE**
SRD1	22195	0.1	0.0	**-0.1**	**CHANGE**
SRD2	19855	0.1	0.3	**0.2**	**CHANGE**
SRD3	17510	-0.2	-0.3	**-0.1**	**CHANGE**
SRE1	15125	-0.1	-0.1	**0.0**	**NO CHANGE**
SRE2	13030	0.3	0.5	**0.2**	**CHANGE**
SRE3	11015	-0.1	-0.3	**-0.2**	**CHANGE**

Table 7.8: Phase 2 Santa Clara River SAM Phase 1 vs Phase 2 Conditions Yield Bed Stability - Q_{31800}					
Subreach	**US Sta**	**Phase 1 Proposed Conditions Grade Change (ft)**	**Phase 2 Proposed Conditions Grade Change (ft)**	**Phase 1/Phase 2 Delta (ft)**	**Result**
SRC4	24795	0.1	0.0	**-0.1**	**CHANGE**
SRD1	22195	0.1	0.0	**-0.1**	**CHANGE**
SRD2	19855	-0.1	0.0	**0.1**	**CHANGE**
SRD3	17510	0.1	0.0	**-0.1**	**CHANGE**
SRE1	15125	-0.1	0.0	**0.1**	**CHANGE**
SRE2	13030	0.0	0.0	**0.0**	**NO CHANGE**
SRE3	11015	0.1	0.0	**-0.1**	**CHANGE**

Because the findings of the present study suggest that the impacts of development on the four watersheds considered within will be insignificant with respect to the fluvial mechanics of Santa Clara River, PACE recommends that the top and toe elevations calculated in Phase 1 of this study be approved for final design. These values are presented here in Table 7.1.

Several possible reasons exist to explain the discrepancy between the SAM stream yield and MORA watershed yield calculations. It could be expected that aggradation would occur when watershed yield exceeded stream yield, or conversely, that degradation would occur when stream yield exceeded watershed yield. In the case of Newhall Ranch Canyons fans or delta-type features are present at the confluence with Santa Clara River. To some extent, as yet uncharacterized, the shape and extent of the fan is mediated by large discharges within the River. The Creek as a whole, however, is not aggrading as suggested by the difference in watershed and stream yields presented above. **Two of the explanations are the lack of fines in the SAM model and location of debris basin data within the watershed.**

Additional discussion of the nature of the study watershed's stream and watershed yield is included in a memorandum by Phillip Williams & Associates, included in Appendix Chapter 7.

1 Introduction

The following technical investigation provides a detailed and focused evaluation of the fluvial characteristics and long-term stability of the Santa Clara River for the reach including all of Newhall Land's proposed Newhall Ranch and Phase 2 development below the proposed Landmark Village. The River study reach is located from upstream of Chiquito and Long Canyon Creeks on the east and to a point directly downstream of the Ventura County/Los Angeles County line (Figure 1.1). This reach includes the Newhall Ranch Specific Plan and the proposed Entrada project. The first phase of the Newhall Ranch Specific Plan (Landmark Village) is bounded by the River on the south, State Highway 126 on the north, Castaic Creek on the east, and Grande Canyon on the west (Figure 1.1). The Santa Clara River fluvial system extends from Acton, California in the east to the Pacific Ocean, the River's natural terminus, in the west. Adjacent development along the River within the study reach has the potential to modify the fluvial response of the watershed through changes in the runoff and reduction in the sediment supply from the developed areas. The proposed buried soil cement bank protection on both the north and south banks of the River within the study reach is intended to provide long-term erosion protection from lateral migration of the bank and flood protection for the adjacent proposed development areas. These modifications to the river system have the potential to modify the fluvial operation of the floodplain and cause changes to the stream mechanics. The intent of this analysis is to evaluate these impacts from (1) fluvial modifications of the river bed from single hypothetical storm events, (2) changes in the floodplain fluvial operation over the long-term; and, (3) to determine the top and toe of the proposed bank protection.

1.1 Study Objectives

The primary objective of this report is to develop the technical engineering analysis to assess river bed impacts from potential modifications of fluvial operation from proposed development west of and including the Long and Chiquito Canyon Creek confluences, including the Newhall Ranch Specific Plan. The intent is to provide a comprehensive assessment of hydro-modification-related bed adjustment. This report provides technical analysis for (1) tributary hydrology, (2) watershed sediment production, (3) sediment transport and delivery, (4) total soil cement bank protection toe-down design. The objectives of the fluvial assessment for the proposed development project include the following:

1. Quantify the volume of sediment runoff from each of the tributary watersheds.

2. Estimate the limiting (downstream) transport potential and stream yield for each of the tributary watersheds.

3. Compare the quantity of sediment produced to that delivered to the River from each tributary watershed.

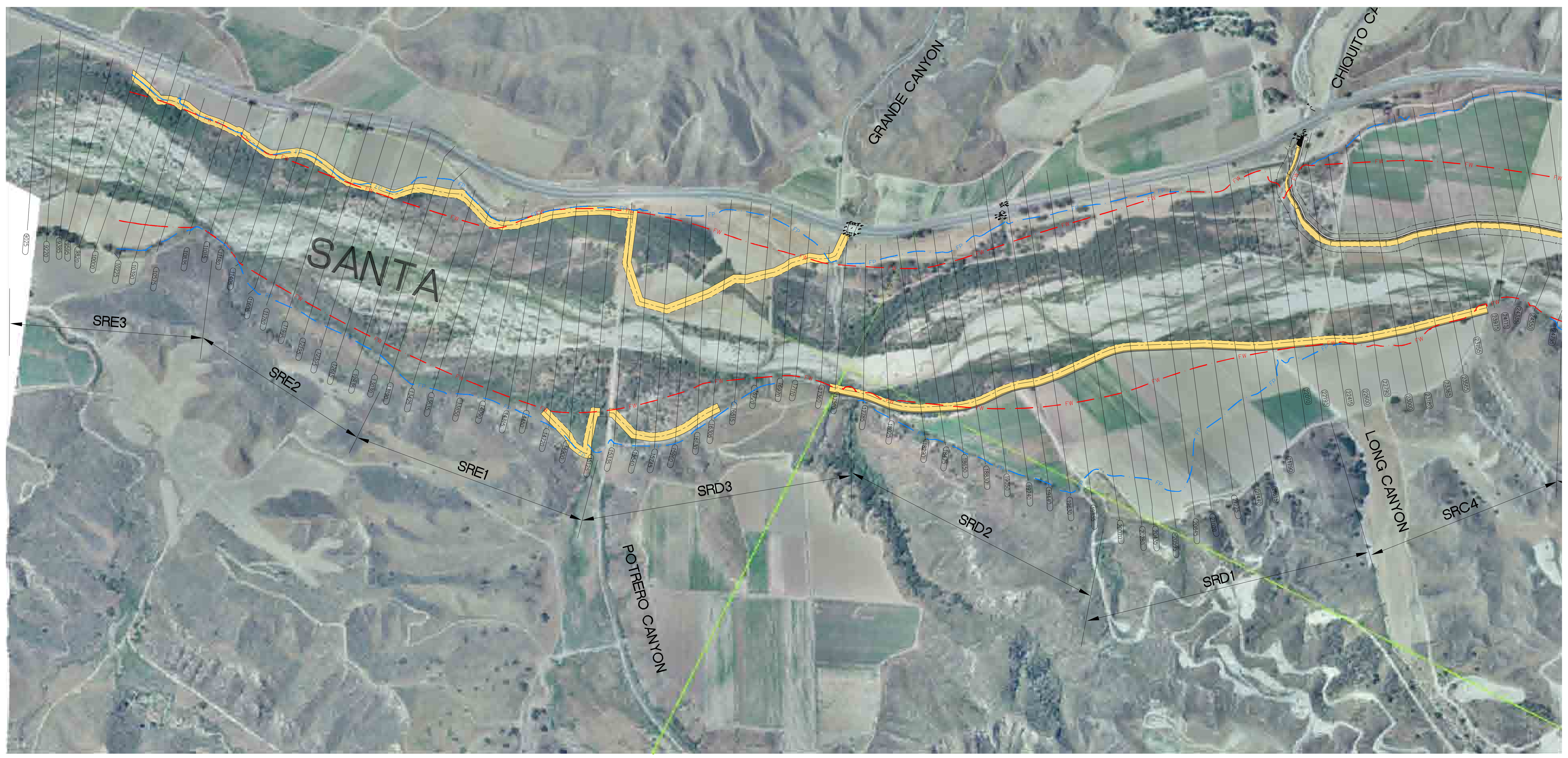
4. Determine if and the extent to which changes to the tributary watersheds will alter sediment transport potential, watershed yield and delivery.

5. Predict river bed response to the extremes in changes in sediment transport, potential, and stream yield.

6. Calculate toe-down depths and freeboard height for proposed bank protection.

   A variety of engineering analysis and tasks were associated with both the different aspects of the watershed hydrology and floodplain hydraulics. A technical framework was developed to guide the analysis of the system. These major task areas of study reflected the various objectives of the study and included the following:

   a. Tributary hydrology and MORA numerical modeling.



LEGEND

LA COUNTY FLOODPLAIN BOUNDARY (SCANNED FROM LADPW ML MAPS DATED AUG 6, 1985

LA COUNTY FLOODWAY BOUNDARY (SCANNED FROM LADPW ML MAPS DATED AUG 6, 1985

SRA4 — FLUVIAL ANALYSIS SUB REACH

NEWHALL RANCH SPECIFIC PLAN BOUNDARY LINE

PROPOSED BANK PROTECTION (PER NRMP & NEWHALL RANCH SPECIFIC PLAN)

46195 — HEC-RAS MODEL CROSS SECTION

NORTH

400 200 0 400 800

NEWHALL RANCH

FIGURE 1.1

PACE
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FOUNTAIN VALLEY, CA 92708
PH (714) 481-7300 FAX (714) 481-7299

P:\7104E\Engineering\GlobalExhibits\7104E-Fluvial Study-FIG1.1.dwg - Tab: EX COND AERIAL By: enarvaez on Feb. 25, 2008 at 10:52 am
Dimscale = 1; LTscale = 0.5; PSltscale = 1; Acad Ver. = 17.1s (LMS Tech); Visretain = 1

b. Baseline HEC-RAS hydraulic model – Prepare tributary models in HEC-RAS based on the 1999 digital geometry and flowrates from hydrology models. Evaluation based on single storm event and steady flow conditions.

c. HEC-2 model creation – Conversion of HEC model formats for use in SAM and HEC-6 modeling.

d. Watershed sediment production estimation – Calculations of watershed sediment production based on MUSLE, ACOE(Tatum) and Los Angeles County methodologies.

e. SAM.SED numerical modeling.

f. SAM.YLD numerical modeling.

g. Estimation of all-or-none sediment delivery impacts – Compare the impacts to Santa Clara River if sediment delivery is increased to one hundred percent of sediment produced in a tributary; compare the impacts to Santa Clara River if sediment delivery is reduced to zero percent of sediment produced in a tributary.

h. Comparison of results with results from previous studies.

2 River and Tributary Descriptions

2.1 Santa Clara River

The 1,634 square mile Santa Clara River watershed contains Newhall Ranch. Approximately 12,000 acres of Santa Clara River or only one percent of the watershed area is located within the Newhall Ranch property boundary, with the majority being upstream or offsite. The distance from the upper headwaters to the project is more than 40 miles with an average overall slope of 0.007. The major natural main stem drainage course within the watershed has an average slope in the lower reaches of the watershed through the Newhall Ranch property of approximately 0.007. The majority of the Santa Clara River watershed is characterized by both rugged and steeply developed foothills that have numerous smaller tributary canyons that dissect the watershed, connecting to the narrow alluvial valley associated with the main stem River. A majority of the watershed consists of the rugged foothill topography with the remainder being the narrow valley floor. The topography for the watershed varies from a maximum elevation of over 5000 in the headwaters to a low elevation of approximately sea level at the ocean. Generally, the soils in the watershed in the vicinity of the Project are characterized as silty clay loams from both the Castaic and Saugus formations. Also, the soils within the Santa Clara River watershed can be predominately classified as being in hydrologic soil group C with exception of areas adjacent to the main stem River that are type A and group B. The associated vegetative cover within the watershed varies, but primarily consists of native grasses, chaparral, scrub oak, and sage brush. There are no major flood control improvements or dams within the project vicinity, other than several road culvert/bridge crossings such as the Interstate 5, which would influence the watershed response to rainfall events.

The Newhall Ranch reach and vicinity along Santa Clara River extends approximately 47,000 feet downstream from Interstate 5 to the Ventura/Los Angeles County Line. The geomorphology of the active bed reflects a more highly variable and sinuous alignment that reflects the influence of the physical and topographic features. There is also a great variation of the active channel geometry (i.e. width and depth) along this relatively short reach of channel. The active portion of the River is more deeply incised below the canyon valley floor. The floodplain is generally entirely contained within the active banks and there is little overbank flow. The changes in River geometry and form may indicate influences from the upper watershed that affect the sediment delivery. The changes in channel geometry are also reflected in coincidental variations of the streambed slope. The slope variations are generally higher in the contractions of the channel geometry and flatter in the expansion areas, upstream and downstream. The average streambed slope of the channel indicated by the topographic data is approximately 0.007. The running average slope ranges from 0.5 in the contractions to 0.0009 for the expansions. The upstream half of the study reach has a less defined active channel and a much wider canyon floor that reflects depositional area and increased floodplain vegetation within this zone. The only manmade structure that influences the hydraulic operation are the roadway bridge crossings for Interstate 5 and Old Road. A dam is located on upper Castaic Creek that limits the discharge of water and sediment from the Creek into the River. A detailed discussion of the influence of the dam can be found in “Castaic Creek Fluvial Study Phase 1 Final Draft January, 2006” (approved LACDPW April 18, 2006). Detailed hydraulic modeling of the existing floodplain was performed and indicated that approximately 44% of the Project reach of the Santa Clara River floodplain was hydraulically “steep” (Froude numbers greater than a value of 1.0) during a Capital flood event, while the remainder of the channel, primarily the lower portion of the study reach, was hydraulically a ”mild” channel. The hydraulics also indicated at several locations the influence of the contraction in the channel geometry which controlled the hydraulics upstream and downstream of these locations. The hydraulic characteristics of the 100-year floodplain generated by the hydraulic modeling indicates that (1) the average depth is approximately 9 feet, ranging from approximately 4 feet to 18 feet, (2) the average velocity is approximately 12 fps, ranging from approximately 5 fps to 25 fps, and the width of the floodplain water surface averages 1070 feet, ranging from approximately 250 feet to 2300 feet consistent with the various channel constrictions. Higher velocities generally occur within the contracted and incised portions of the floodplain and lower velocities within expansion areas and flatter longitudinal streambed slopes. Along the fringes of the floodplain lower velocities occur while the higher velocities are in the deeper portions of a channel section.

TITLE
WATERSHED BOUNDARIES

JOB
NEWHALL RANCH
LOS ANGELES COUNTY
CA

SCALE	1"= 3500'
DESIGNED	T.H.
DRAWING	R.S.
CHECKED	M.K.
DATE	1/24/06
JOB NO.	7904-E

PACE
PACIFIC ADVANCED CIVIL ENGINEERING
17520 NEWHOPE STREET, SUITE 200
FOUNTAIN VALLEY, CA 92708
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FIGURE
2.1

2.2 Chiquito Canyon Creek

The 4.8 square mile (3,053 acre) Chiquito Canyon watershed is a tributary to the northern bank of the Santa Clara River within the Newhall Ranch. Approximately 490 acres of Chiquito Canyon or only 16% of the watershed area is located within the Newhall Ranch property boundary, with the majority being upstream or offsite. The Creek in the headwaters flows in a general west to east direction while the remaining lower portion of the Creek flows in a north to south direction, similar in alignment to Grande Canyon and joining the Santa Clara River floodplain valley. The overall watershed boundary develops a shape such that a larger portion of the drainage area is tributary in the upstream portion watershed, with a maximum width of 8,300 feet, and tapers down towards the mouth of the canyon, with an average width of 2,800 feet. The distance from the upper headwaters to the canyon mouth is approximately 28,318 feet with an average overall slope of 0.031. The major natural main stem drainage course within the watershed has an average slope in the lower reaches of the watershed through the Newhall Ranch property of approximately 0.025. The majority of the Chiquito Canyon watershed is characterized by both rugged and steeply developed foothills that have numerous smaller tributary canyons that dissect the watershed, connecting to the narrow alluvial valley associated with the main stem creek. Approximately 90% or more of the watershed consists of the rugged foothill topography with the remainder being the narrow valley floor. The topography for the watershed varies from a maximum elevation of 1800 in the headwaters to a low elevation of 925 near the mouth of the canyon at the Santa Clara River valley. Generally, the soils in the watershed are characterized as silty clay loams from both the Castaic and Saugus formations. Also, the soils within the Chiquito Canyon watershed can be predominately classified as being in hydrologic soil group C with exception of areas adjacent to the main stem creek that are group A and group B in the lower reaches. The associated vegetative cover within the watershed varies, but primarily consists of native grasses, chaparral, scrub oak, and sage brush.

The lower Chiquito Canyon creek extends approximately 8,200 feet upstream from the canyon mouth at the Santa Clara River valley to the Newhall Ranch boundary. The geomorphology of the active creek reflects a more highly variable and sinuous alignment that reflects the influence of the physical and topographic features. The floodplain is generally entirely contained within the active creek banks and there is little overbank flow. The changes in channel geometry are reflected in coincidental variations of the streambed slope. The slope variations are generally higher in the contractions of the channel geometry and flatter in the expansion areas, upstream and downstream. Detailed hydraulic modeling of the existing floodplain was performed and indicated that a major portion of the Chiquito Canyon floodplain was hydraulically “steep” (Froude numbers greater than a value of 1.0. The hydraulic characteristics of the 100-year floodplain generated by the hydraulic modeling indicates that (1) the average depth is approximately 3.8 feet, ranging from 9.5 feet to 1.6 feet, (2) the average velocity is approximately 11.9 fps, ranging form 22 fps to 5 fps, and the width of the floodplain water surface averages 194 feet, ranging from 549 feet to 36 feet consistent with the various channel constrictions. Higher velocities generally occur within the contracted and incised portions of the floodplain and lower velocities within expansion areas and flatter longitudinal streambed slopes. Along the fringes of the floodplain lower velocities occur while the higher velocities are in the deeper portions of a channel section.

2.3 Potrero Canyon Creek

The 4.6 square mile (2,938 acre) Potrero Canyon watershed is a tributary to the southern bank of the Santa Clara River within the Newhall Ranch. The Creek flows in a general west to east direction, similar in alignment to Long Canyon and joining the Santa Clara River floodplain valley. The overall watershed boundary has a fairly uniform width, with an upstream maximum width of approximately 8,600 and a minimum of 5,400 feet downstream. A significant portion of this wide region is in the south-western section near the upstream end of the creek. The shape of the watershed is important since that influences when runoff reaches the outlet. Although the watershed is relatively long, the greater width throughout the central portion of the watershed will result in a higher amount of runoff during a shorter period of time, increasing the peak discharges observed at the outlet. The distance from the upper headwaters to the canyon mouth is approximately 24,139 feet with an average overall slope of 0.033. The major natural main stem drainage course within the watershed has an average slope in the lower reaches of the watershed through the Newhall Ranch property of approximately 0.024. The majority of the Potrero Canyon watershed is characterized by both rugged and steeply developed foothills that have numerous

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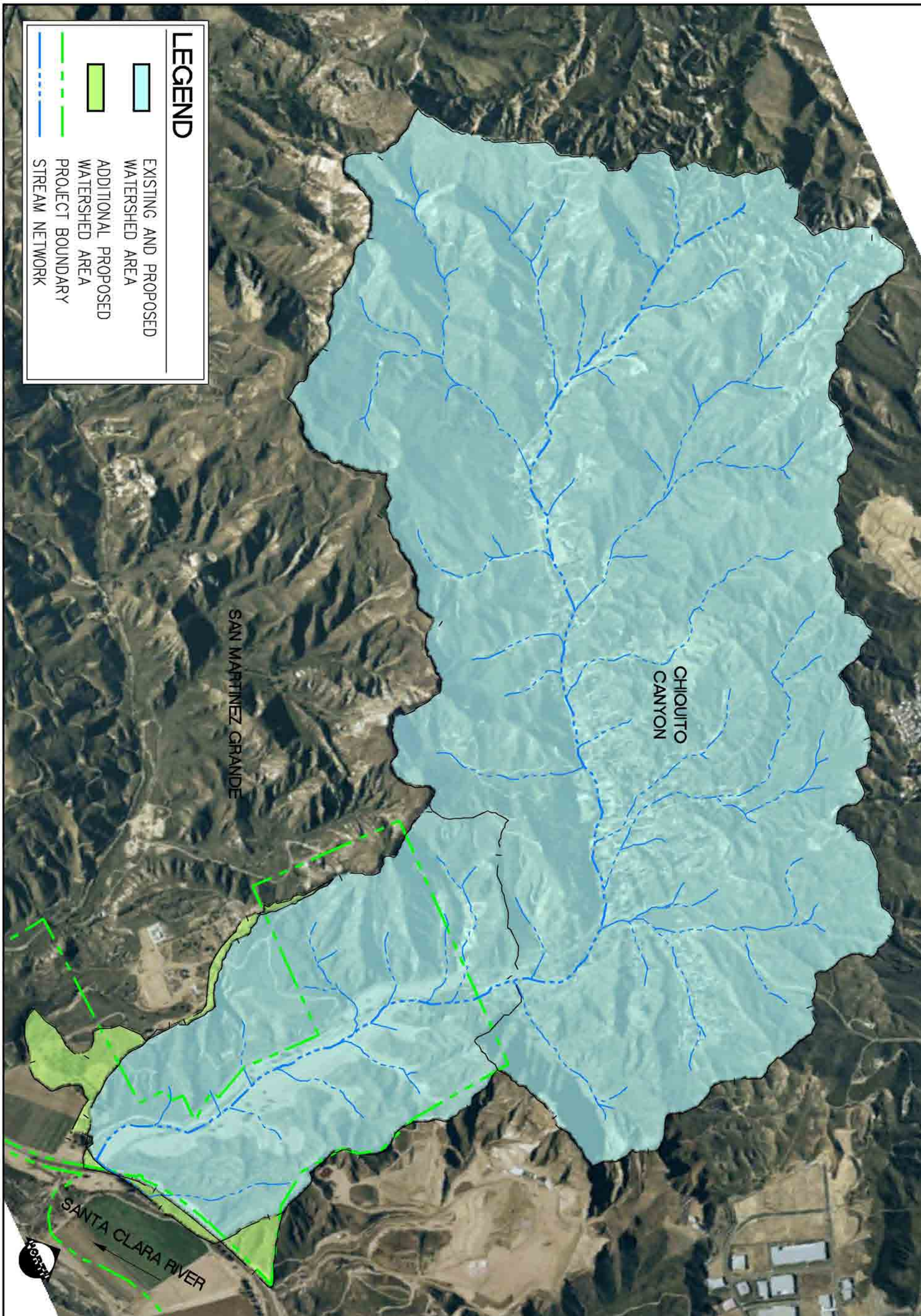

FIGURE				JOB	TITLE
2.2	PACE PACIFIC ADVANCED CIVIL ENGINEERING 17520 NEWHOPE STREET, SUITE 200 FOUNTAIN VALLEY, CA 92708 PH (714) 481-7300 FAX (714) 481-7299	SCALE	NTS	NEWHALL RANCH	CHIQUITO CANYON EXISTING & PROPOSED OVERALL WATERSHED BOUNDARIES
		DESIGNED	JJD		
		DRAWN	GA		
		CHECKED	JJD		
		DATE	JULY 2007		
		JOB NO.	8197-E	LOS ANGELES CO. CA	

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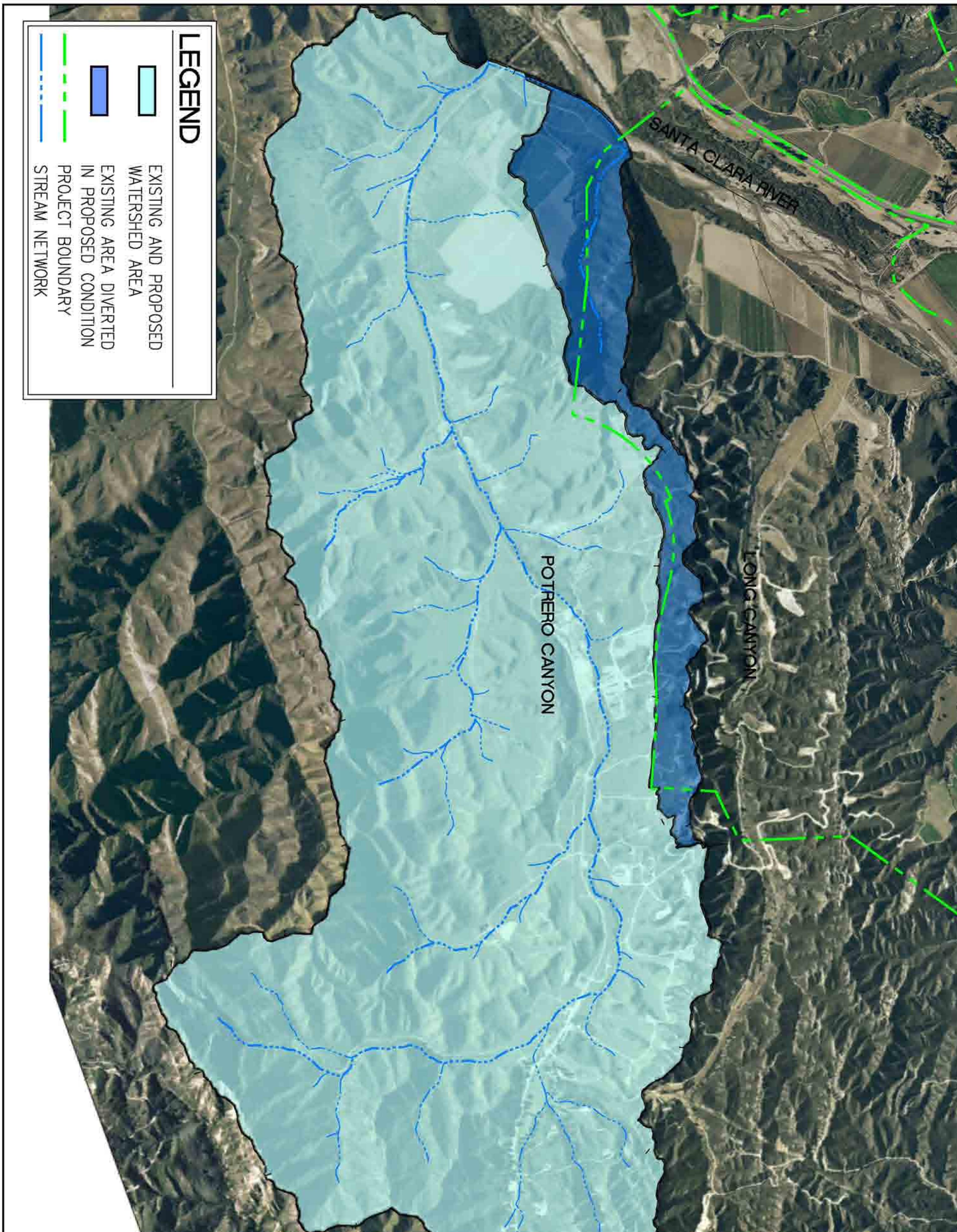

FIGURE 2.3	PACE PACIFIC ADVANCED CIVIL ENGINEERING 17520 NEWHOPE STREET, SUITE 200 FOUNTAIN VALLEY, CA 92708 PH (714) 481-7300 FAX (714) 481-7299	SCALE NTS DESIGNED JJD DRAWN GA CHECKED JJD DATE JULY 2007 JOB NO. 8197-E	JOB NEWHALL RANCH LOS ANGELES CO. CA

TITLE
POTRERO CANYON EXISTING & PROPOSED OVERALL WATERSHED BOUNDARIES

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smaller tributary canyons that dissect the watershed, connecting to the narrow alluvial valley associated with the main stem creek. Approximately 90% of the watershed consists of the rugged foothill topography with the remainder being the narrow valley floor. The topography for the watershed varies from a maximum elevation of 1675 in the headwaters to a low elevation of 870 near the mouth of the canyon at the Santa Clara River valley. Generally, the soils in the watershed are characterized as silty clay loams from both the Castaic and Saugus formations. Also, the soils within the Potrero Canyon watershed can be predominately classified as being in hydrologic soil group C with exception of areas adjacent to the main stem creek that are group A and group B in the lower reaches. The associated vegetative cover within the watershed varies, but primarily consists of native grasses, chaparral, scrub oak, and sage brush. There are no major flood control improvements or dams within the watershed, other than several road culvert/bridge crossings such as the SR 126, that would influence the watershed response to rainfall events. Detailed hydrologic modeling has been performed to evaluate the baseline existing watershed conditions and the results of the peak discharges are discussed in the Section on Hydrology.

The lower Potrero Canyon creek extends approximately 18,270 feet upstream from the canyon mouth at the Santa Clara River valley to the Newhall Ranch boundary. The geomorphology of the active creek reflects a more highly variable and sinuous alignment that reflects the influence of the physical and topographic features. There is also a steady variation of the active channel geometry (i.e. width and depth) along this relatively short reach of channel, with the active portion of the creek being more deeply incised below the canyon valley floor. The floodplain is generally entirely contained within the active Creek banks and there is little overbank flow. The changes in channel geometry are reflected in coincidental variations of the streambed slope. The slope variations are generally higher in the contractions of the channel geometry and flatter in the expansion areas, upstream and downstream. The average streambed slope of the channel indicated by the topographic data is approximately 0.024. The average slopes ranges from 0.055 in the contraction to 0.011. The upstream 500 feet has a less defined active channel and a much wider canyon floor that reflects depositional area, also the increased floodplain vegetation within this zone. Detailed hydraulic modeling of the existing floodplain was performed and indicated that approximately 40% of the lower reach of the Potrero Canyon floodplain was hydraulically “steep” (Froude numbers greater than a value of 1.0) while the remainder of the canyon, primarily the upper portion to the Newhall Ranch boundary was hydraulically a ”mild” channel. The hydraulics also indicated at several locations the influence of the contraction in the channel geometry which controlled the hydraulics upstream and downstream of these locations. The characteristics of the 100-year floodplain generated by the hydraulic modeling indicate that, (1) the average depth is approximately 3.1 feet, ranging from 6.6 feet to 0.7 feet, (2) the average velocity is approximately 5.9 fps, ranging form 11.2 fps to 2.2 fps, and the width of the floodplain water surface averages 330 feet, ranging from 950 feet to 50 feet consistent with the various channel constrictions. Higher velocities generally occur within the contracted and incised portions of the floodplain and lower velocities within expansion areas and flatter longitudinal streambed slopes. Along the fringes of the floodplain lower velocities occur while the higher velocities are in the deeper portions of a channel section.

2.4 San Martinez Grande Canyon Creek

The 3.3 square mile (2,111 acre) San Martinez Grande Canyon watershed is a tributary to the northern bank of the Santa Clara River within the Newhall Ranch. Approximately 200 acres of San Martinez Grande Canyon, or only 10% of the watershed area, is located within the Newhall Ranch property boundary, with the majority being upstream or offsite. The Creek in the headwaters flows in a general west to east direction while the remaining lower portion of the Creek flows in a north to south direction, similar in alignment to Chiquito Canyon and joining the Santa Clara River floodplain valley. The shape of develops creates a dog-leg type appearance. The overall watershed boundary develops a shape such that a larger portion of the drainage area is tributary in the mid portion watershed since the width of the watershed narrows in either the upstream and downstream tails of the watershed while the central portion of the watershed widens to approximately 6,800 feet in width. The shape of the watershed is important since that influences when runoff reaches the outlet. The distance from the upper headwaters to the canyon mouth is approximately 20,000 feet with an average overall slope of 0.059. The major natural main stem drainage course within the watershed has an average slope in the lower reaches of the watershed through the Newhall Ranch property of approximately 0.022. The majority of the San Martinez

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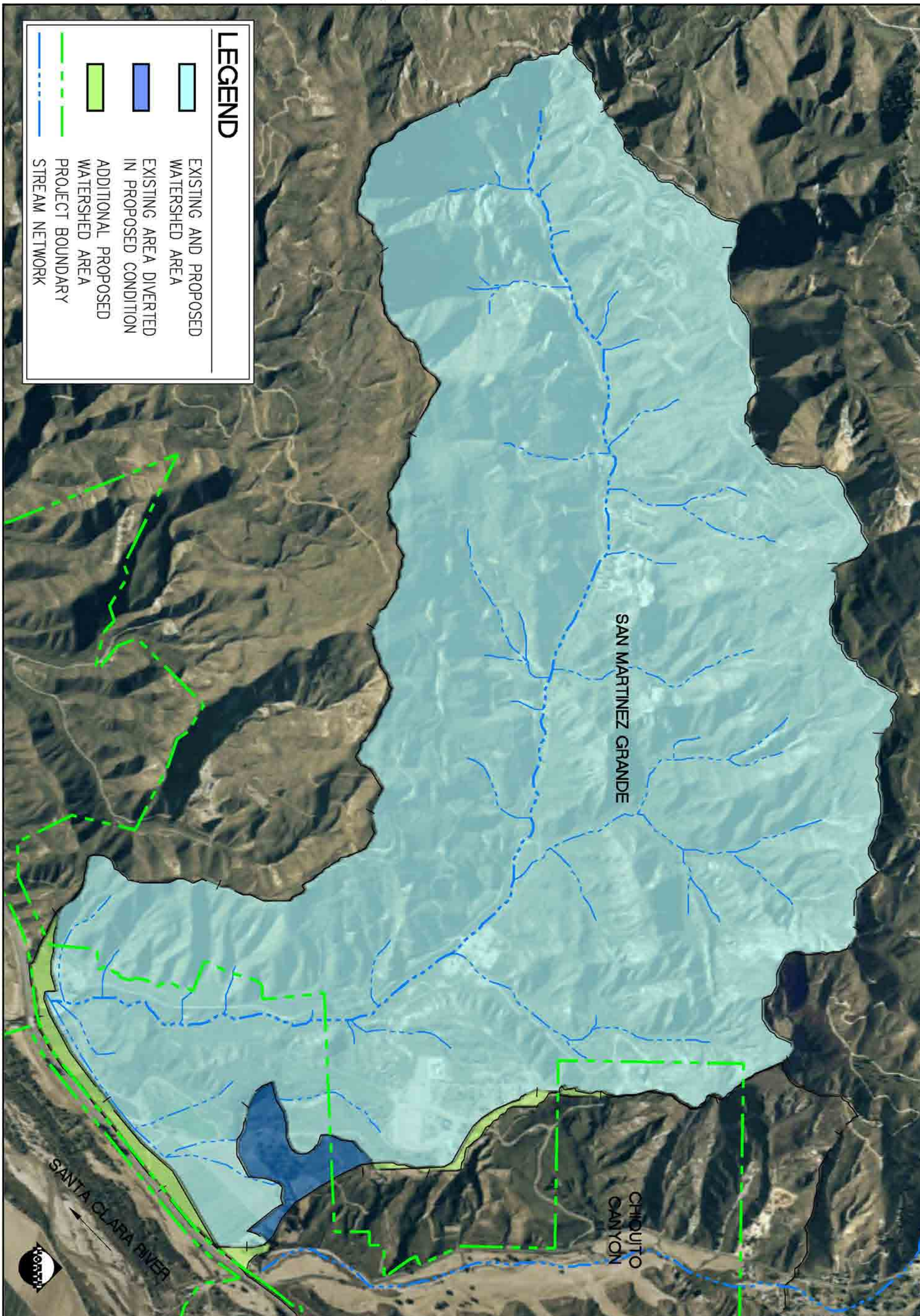

FIGURE 2.4	PACE PACIFIC ADVANCED CIVIL ENGINEERING 17520 NEWHOPE STREET, SUITE 200 FOUNTAIN VALLEY, CA 92708 PH (714) 481-7300 FAX (714) 481-7299	SCALE NTS DESIGNED JJD DRAWN GA CHECKED JJD DATE JULY 2007 JOB NO. 8197-E	JOB NEWHALL RANCH LOS ANGELES CO. CA

TITLE
SAN MARTINEZ GRANDE
EXISTING & PROPOSED
OVERALL WATERSHED
BOUNDARIES

P:\8197E\Engineering\8197-XX (Castaic Creek Sections)\exhibits\8197-E-FIG-24B-PR-HOMESTEAD CENTRAL.dwg - Tab: Layout1 - by enarvaez on 08/14/07 at

Grande Canyon watershed is characterized by both rugged and steeply developed foothills that have numerous smaller tributary canyons that dissect the watershed, connecting to the narrow alluvial valley associated with the main stem creek. Approximately 90% or more of the watershed consists of the rugged foothill topography with the remainder being the narrow valley floor. The topography for the watershed varies from a maximum elevation of 2062 in the headwaters to a low elevation of 890 near the mouth of the canyon at the Santa Clara River valley. Generally, the soils in the watershed are characterized as silty clay loams from both the Castaic and Saugus formations. Also, the soils within the San Martinez Grande Canyon watershed can be predominately classified as being in hydrologic soil group C with exception of areas adjacent to the main stem creek that are group A and group B in the lower reaches. The associated vegetative cover within the watershed varies, but primarily consists of native grasses, chaparral, scrub oak, and sagebrush. There are no major flood control improvements or dams within the watershed, other than several road culvert/bridge crossings such as the SR 126 that would influence the watershed response to rainfall events.

The lower San Martinez Grande Canyon creek extends approximately 4,800 feet upstream from the canyon mouth at the Santa Clara River valley to the Newhall Ranch boundary. The geomorphology of the active Creek reflects a more highly variable and sinuous alignment that reflects the influence of the physical and topographic features. There is also a much greater variation of the active channel geometry (i.e. width and depth) along this relatively short reach of channel. The active portion of the Creek is more deeply incised below the canyon valley floor. The floodplain is generally entirely contained within the active creek banks and there is little overbank flow. The changes in channel geometry are reflected in coincidental variations of the streambed slope. The slope variations are generally higher in the contractions of the channel geometry and flatter in the expansion areas, upstream and downstream. The average streambed slope of the channel indicated by the topographic data is approximately 0.022. The average slopes ranges from 0.08 in the contraction to 0.005. The upstream 500 feet has a less defined active channel and a much wider canyon floor that reflects depositional area, also the increased floodplain vegetation within this zone. The only manmade structure that influences the hydraulic operation is the roadway culvert crossing for SR 126, but this appears to have sufficient hydraulic capacity with minimal effects to the floodplain. Detailed hydraulic modeling of the existing floodplain was performed and indicated that approximately 50% of the lower reach of the San Martinez Grande Canyon floodplain was hydraulically “steep” (Froude numbers greater than a value of 1.0) while the remainder of the canyon, primarily the upper portion to the Newhall Ranch boundary was hydraulically a ”mild” channel. The hydraulic characteristics of the 100-year floodplain generated by the hydraulic modeling indicates that (1) the average depth is approximately 6.4 feet, ranging from 15 feet to 2.9 feet, (2) the average velocity is approximately 8.9 fps, ranging form 19 fps to 2.2 fps, and the width of the floodplain water surface averages 110 feet, ranging from 220 feet to 42 feet consistent with the various channel constrictions. Higher velocities generally occur within the contracted and incised portions of the floodplain and lower velocities within expansion areas and flatter longitudinal streambed slopes. Along the fringes of the floodplain lower velocities occur while the higher velocities are in the deeper portions of a channel section.

2.5 Long Canyon Creek

The 1.5 square mile (982 acre) Long Canyon watershed is a tributary to the southern bank of the Santa Clara River within the Newhall Ranch. Approximately 450 acres of Long Canyon or 50% of the watershed area is located within the Newhall Ranch property boundary, with the majority being upstream or offsite. The creek in the headwaters flows in a general west to east. The watershed boundary has a shape that is rather uniform in width throughout the mid-section at approximately 2,500 ft. The boundary then gradually widens at both the upstream and downstream ends to approximately 3,750 ft. The shape of the watershed is important since that influences when runoff reaches the outlet. The distance from the upper headwaters to the canyon mouth is approximately 18,350 feet with an average overall slope of 0.052. The major natural main stem drainage course within the watershed has an average slope in the lower reaches of the watershed through the Newhall Ranch property of approximately 0.11. The majority of the Long Canyon watershed is characterized by both rugged and steeply developed foothills that have numerous smaller tributary canyons that dissect the watershed, connecting to the narrow alluvial valley associated with the main stem creek. Approximately 85% or more of the watershed consists of the rugged foothill topography with the remainder being the narrow valley floor. The topography for the watershed varies from a maximum elevation of 2600 ft in the headwaters to a low elevation of 930 ft near the mouth of the canyon at the Santa Clara River valley. Generally, the soils in the watershed are characterized as silty clay loams from both the Castaic and Saugus formations. Also, the soils within the Long Canyon watershed can be predominately classified as being in hydrologic soil group C with exception of areas adjacent to the main stem creek that are group A and group B in the lower reaches. The associated vegetative cover within the watershed varies, but primarily consists of native grasses, chaparral, scrub oak, and sage brush. There are no major flood control improvements or dams within the watershed.

The lower Long Canyon Creek extends approximately 8,350 feet upstream from the canyon mouth at the Santa Clara River valley to the Newhall Ranch boundary. The geomorphology of the active creek reflects a more highly variable and sinuous alignment that reflects the influence of the physical and topographic features. There is also a much greater variation of the active channel geometry (i.e. width and depth) along this relatively short reach of channel. The active portion of the Creek is more deeply incised below the canyon valley floor then flattens and widens near the Creek outlet. The floodplain is generally entirely contained within the active creek banks and there is little overbank flow. The changes in Creek geometry and form may indicate influences from the upper watershed that affect the sediment delivery. The changes in channel geometry are also reflected in coincidental variations of the streambed slope. The slope variations are generally higher in the contractions of the channel geometry and flatter in the expansion areas, upstream and downstream. The average streambed slope of the channel indicated by the topographic data is approximately 0.052. The average slopes ranges from 0.1 in the contraction to 0.05. The upstream 500 feet has a less defined active channel and a much wider canyon floor that reflects depositional area, also the increased floodplain vegetation within this zone. Detailed hydraulic modeling of the existing floodplain was performed and indicated that approximately 80% of the lower reach of the Long Canyon floodplain was hydraulically "steep" (Froude numbers greater than a value of 1.0) while the remainder of the canyon, primarily the upper portion to the Newhall Ranch boundary was hydraulically a "mild" channel. The hydraulics also indicated at several locations the influence of the contraction in the channel geometry which controlled the hydraulics upstream and downstream of these locations. The hydraulic characteristics of the 100-year floodplain generated by the hydraulic modeling indicates that (1) the average depth is approximately 2.4 feet, ranging from 6.5 feet to 0.7 feet, (2) the average velocity is approximately 7.8 fps, ranging form 17 fps to 3.5 fps, and the width of the floodplain water surface averages 140 feet, ranging from 420 feet to 30 feet consistent with the various channel constrictions. Higher velocities generally occur within the contracted and incised portions of the floodplain and lower velocities within expansion areas and flatter longitudinal streambed slopes. Along the fringes of the floodplain lower velocities occur while the higher velocities are in the deeper portions of a channel section.

3 River and Tributary Hydrology

3.1 Methodology

The LA County approved WMS/MODRAT hydrology model was utilized as the modeling program to perform all rainfall-runoff analysis and transformation of rainfall excess into surface runoff for the project area. The hydrology models are included in Appendix Chapter 3.

3.1.1 Link Node Hydrology Models

The WMS/MODRAT hydrology model calculates the 50-year frequency design storm, which is based on rainfall with a 2% probability of being equaled or exceeded in any given year. The 50-year frequency design storm occurs over a period of four days, with the maximum rainfall falling on the fourth day. This hydrology model was adopted for this study to provide the precipitation-runoff modeling since this is the accepted method and approved for use by Los Angeles County. The program's hydrologic procedures transform the physical characteristics of the watershed into a "link-node" model in which the hydrologic process occurs at a calculation node and these processes within the watershed are linked together by hydraulic connections.

The parameters of this model are developed from physical characteristics of the watersheds, and equations of motion are used to simulate the movement of water through the system. Parameters such as catchment length and area, roughness, slope and channel geometry are used to define the flow of water conceptually over watershed surfaces, into stream channels, and through the channel network of the watershed. This method is particularly useful to study the effects of urbanization since these can be directly measured or accounted for by changing the measurable physical parameters of slope, catchment length, surface roughness, and others. The surface features of the basin are represented with two basic types of elements: (1) overland flow, and (2) channel flow. One or two overland-flow elements are combined with one or two channel-flow elements to represent the processes occurring within a sub-watershed. Three additional elements specific to each subarea within the watershed are required for modeling and include precipitation, land use, and soil type. All of these parameters are used to determine time of concentration of each subarea. Lastly, routing type is specified in the model to route runoff through a natural channel, street flow, or pipe flow. These parameters are the basic building block for determining the 50-year frequency design storm for each watershed. The entire watershed is modeled by linking the various sub-basins together in a network.

3.2 Watershed Parameters

3.2.1 Watershed and Subarea Delineation

The main framework watershed delineation is the first step to modeling the hydrology for a given area of interest. The physical topographic features and ridgelines were used to establish the major regional watershed boundaries for each of the four watersheds. The regional watershed boundaries were then subdivided into sub-basins to facilitate the modeling process and establish appropriate delineation of the interior watershed area. Located at specific collection points in the watershed, the sub-basins generally corresponded to smaller individual drainage systems based on the drainage patterns. The sub-basins were located based on the smaller tributary stream systems, confluences or streams, drainage area size, and anticipated development or ownerships. The sub-basin delineation also allows studying the local land-use changes within the regional watershed but analyzed on a local sub-basin level. The sub-basin areas are typically 40 acres each in size with a maximum of an additional 20%, for a total maximum of 48 acres or less as a modeling requirement.

The sub-watersheds and junctions were numbered sequentially from upstream to downstream in the WMS/MODRAT hydrology model. The WMS/MODRAT program using a digital elevation model (DEM) first determined all major watershed and sub-basin delineations. This DEM is an elevated topographic model that the WMS/MODRAT program uses to delineate sub-basins and calculate area, length, and slope of sub-basins. The delineated sub-basins are then manually adjusted and fine-tuned where necessary.

3.2.2 Hydrometeorlogic Characteristics

The GIS based rainfall isohyetal shapefile for all of Los Angeles County was downloaded from the Los Angeles County Department of Public Works (LACDPW) website (http://ladpw.org/wrd/publication/). The GIS 50-year, 24-hour rainfall layer was incorporated in the WMS/MODRAT program where the rainfall for each sub-basin was electronically calculated. The GIS rainfall layer contains isohyetal lines and values from Los Angeles County that correspond with the Newhall Ranch project area. Sub-basin rainfall depths for the 50-year storm event vary from 5.6 inches to 7.1 inches throughout the project area.

3.2.3 Geology

The GIS based soil type shapefile for all of Los Angeles County was downloaded from the Los Angeles County Department of Public Works (LACDPW) website (http://ladpw.org/wrd/publication/). The GIS soil type layer was incorporated in the WMS/MODRAT program where a predominant hydrologic soil group is determined for each sub-basin within the 4 watersheds. Each sub-basin is given individual soil types with values ranging from 1-180. An area-weighting technique was applied to the sub-basins that had multiple soil types crossing through it. There are three main soil types in the Newhall Ranch project site: 20, 91, and 97.

3.2.4 Landuse/Vegetation

Hydrologic classification of soils have been developed by the US Soil Conservation Service (formerly the SCS and now the NRCS) and mapping of soils types is available indicating the relative amount of infiltration potential from the soils. The general defined classification of soils includes four types, ranging from type “A”, which is very permeable, representing more of a sandy soil, to a type “D” which is more impermeable representing clayey type systems. Generally, the soils in the Newhall Ranch watershed are characterized as silty clay loams from both the Castaic and Saugus formations. The soil mapping overlay of the watershed boundary indicates that the soils within the all six of the watersheds can be predominately classified as being in hydrologic soil group C (higher runoff potential) with exception of areas adjacent to the main stem creek of Chiquito Canyon and parts of Grapevine Mesa that are Type B.

The existing GIS landuse shapefile for all of Los Angeles County was downloaded from the Los Angeles County Department of Public Works (LACDPW) website (http://ladpw.org/wrd/publication/) and incorporated into the WMS/MODRAT program. For the existing (regional) condition models, the WMS/MODRAT grogram determines an impervious percentage for each sub-basin from the landuse shapefile. For the proposed condition models, the proposed GIS landuse shapefile for the proposed project, obtained from the project planner, Hunsaker & Associates, was merged with the existing landuse shapefile to make a composite proposed land use layer. Each land use polygon was given a distinct proportion impervious value. However, the land use boundaries rarely corresponded with the sub-watershed boundaries. For each sub-watershed, an area-weighted proportion impervious value was calculated electronically in the WMS/MODRAT model. Percent impervious values for a given land use are taken from Los Angeles County Department of Public Works Water Resources Division, June 2002 (LACDPW, 2002) Appendix E. Results are listed in the individual WMS/MODRAT output files.

3.2.5 MORA Routing

The MORA/LAR04 model is a lumped parameter model that takes raw data from each subarea, computes the runoff, and then routes the runoff from one subarea to the next. All of the previously described parameters affect the amount of cumulative runoff routed through each subarea. The model has the ability to route hydrographs downstream through the drainage network while taking into account timing issues associated with land use and soil type.

3.2.6 *MORA Burning and Bulking*

The LACDPW Addendum to the Hydrology Manual requires that a certain portion of the watershed be considered burned for hydrologic calculations. Burning a watershed increases the peak discharge values and storage volumes. Each major watershed in LA County has been designated a “fire factor,” or the percentage of the watershed that should be considered burned for hydrologic calculations. A fire factor of 1 was used for all existing and proposed condition simulations for each of the five watersheds. A fire factor of 1 indicates that the entire watershed is burned.

In the MORA\LAR04 model, values for the burned sub-watersheds are given a value 200 more than non-burned watersheds. For example, if a sub-watershed has a primary soil number of 20, a value of 220 is inserted into MORA\LAR04 to signify that it will be burned.

LACDPW requirements for bulking watersheds are specified in Section 3C-1 of the LACDPW Sedimentation Manual. In the case of the four tributary watersheds, equation 3.12 is used to bulk a partially developed watershed in multiple Debris Production Area (DPA) zones. There is no function in the MORA\LAR04 program that allows the user to bulk a given watershed or sub-watershed. The model allows the user to calculate burned watershed values, and then equation 3.12 in LACDPWHSM is applied to calculate burned and bulked flow rates.

The methodology used to calculate the existing conditions burned and bulked flow rates is as follows:

1. The 50-year clear water flow event was simulated in WMS. See Appendix Chapter 3 for 50- year MORA\LAR04 output.
2. The 50-year burned flow event was calculated by adding 200 to the soil values for all sub-basins. Because the existing condition assumes a pre-developed condition, the entire watershed was burned for each of the four tributary watersheds.
3. Equation 3.12 for bulking was then used to calculate burned and bulked flows. Discharge values calculated in step 2 were used in equation 3.12. The four tributary watersheds contain large channels so the burned and bulked flow rates were calculated at the main nodes in the creek channels.

3.2.7 *Time of Concentration Calculator*

The time of concentration, Tc, is electronically calculated in the WMS/MODRAT modeling program. The modeler draws in longest path lengths for each sub-basin. The model then calculates the length of longest path and corresponding slope. In conjunction with these parameters, the model considers imperviousness, soil type and rainfall depth, and then calculates a time of concentration. Time of concentration values varies with the above-mentioned parameters therefore; Tc is calculated separately for clear water and burned conditions simulations.

3.2.8 *Debris Volume Calculations*

The WMS/MODRAT program also calculates debris production volumes using the burned flow rates and the DPA Zone factors. Debris volume is an electronic calculation that the model performs using this data.

3.3 General Discussion of Results

The hydrologic modeling reflects conservative estimates of the watershed response associated with a single hypothetical rainfall event and it is not intended to reproduce historical storm events or historical time series. The watershed models illustrate that the influence of development to changes of the peak discharge is more dramatic on the smaller storm events while it has less of an influence on the larger storm events because of the larger contribution of the upstream watershed.

The watershed models do not take into account the effect from hydrologic mitigation measures that may be installed within the proposed development areas which may include flood control detention basins or storm water quality detention basins. The hydrologic modeling is intended to estimate the maximum potential change in flowrate and runoff response from the watershed affecting the floodplain areas. Modeling results are summarized in Table 3.1. For detailed model output tables for the six watersheds, see Appendix Chapter 3.

Table 3.1: Newhall Ranch Phase 2 Tributary MODRAT Results Summary

Tributary/Parameter	Chiquito		Grande		Long		Potrero	
	Existing	Proposed	Existing	Proposed	Existing	Proposed	Existing	Proposed
Outlet Node	173 A	252 A	130 A	185 AO	53 A	166 AD	173 A	173 A
Area (ac)	3048	3135	2134	2274	989	1149	2857	2857
Q_{burned} (cfs)	3181	3217	2964	3022	1125	1119	3255	3293
Burn Runoff Vol. (ac-ft)	397	467	367	400	142	212	583	685
Q_{cap} (cfs)	4195	4145	3921	3908	1450	1305	4445	4166
Debris Vol (cu yd)	126,753	117,709	93,940	90,392	35,653	28,330	162,043	126,702
DPA Zones	5, 9	5, 9	5, 9	5, 9	5, 8, 9	5, 8, 9	3, 5, 8, 9	3, 5, 8, 9

4 Watershed Sediment Production

4.1 Methods

Three different methods were use to calculate watershed sediment production. It is important to examine the results of different methodologies because each methodology incorporates distinct assumptions about the relative importance of different watershed parameters. The result of these assumptions is varying quantities of sediment production depending on the extent to which the assumptions in the calculation methodologies match the behavior of the sediment generating mechanisms naturally occurring within the watershed. The different methods were chosen for their use of data inside, near or within an environment similar to that found within the present Santa Clara River study reach.

4.2 MUSLE

The MUSLE method is a modification of the Universal Loss Equation developed to predict sediment watershed yields for single storm events in a given watershed. The modification entails a runoff factor instead of a rainfall energy factor. The MUSLE equation is applicable to ephemeral stream of the desert southwest since the equation uses runoff from individual storms, which is the primary mode of sediment delivery in the region.

The MUSLE equation is given by:

$$YIELD = \alpha (Vq)^{\beta} KLCP$$

where K is the soil erodibility factor from UDSA soil texture, L is a topographic factor, C is a cover factor taken from the SCS Agriculture Handbook 537, P=1 is an erosion control factor, V is the runoff volume for a given storm, q is the is the storm peak discharge rate, and $\alpha=95$ and $\beta=0.56$ are calibration coefficients. The cropping factor, C, is not adjusted between the existing and proposed conditions because there is not a comparable procedure in land development. The erosion control factor is used in the proposed condition to reduce the area of land contributing runoff as a decimal percent of the impervious area greater than 15% impervious. The topographic factor is calculated as:

$$L = \left(\frac{\lambda}{72.6} \right)^{n} (0.065 + 0.0454S + 0.0065S^{2})$$

where λ is the slope length, S is the percent slope and n is the slope exponent given as:

$$S \le 0.03 \rightarrow n = 0.3$$
$$S = 0.04 \rightarrow n = 0.4$$
$$S \ge 0.05 \rightarrow n = 0.5$$

The MUSLE method was originally developed to calculate soil loss for Albuquerque, New Mexico, however, because the area and climate in and around Albuquerque and Los Angeles County, California are similar the values predicted using the MUSLE method are expected to be comparable predictors of sediment production in this study.

4.3 ACOE (TATUM)

The Los Angeles District of the Army Corps of Engineers developed the ACOE (Tatum) method to estimate the quantity of debris caught by some structure at some location within a watershed during a single discrete event. The method is intended to be used in coastal-draining, mountainous watersheds in Southern California between 0.1 and 200 square miles in area and for storms with return periods greater than 5-year return periods. The data for the ACOE method was originally collected in Southern California from both ACOE and other sources. Multiple linear regression analysis and logarithmic transformation was used to develop the coefficients in the debris yield equation.

The primary variables of analysis for the ACOE(Tatum) method are precipitation, runoff (as volume per area), drainage area, stream length, relief ratio (as watershed slope), recent burning of the watershed and channel slope. The debris yield equation has the general form:

$$LOG(YIELD) = AT(C_1 LOG(RATE) + C_2 LOG(RR) + C_3 LOG(A) + C_4 FF)$$

where YIELD is the unit debris watershed yield, RATE is either the precipitation or the discharge depending on watershed size, RR is the relief ratio, A is the watershed area and FF is the fire factor. The coefficients C_1 through C_4 are coefficients which vary with the size of the watershed and AT is an adjustment factor designed to address debris yield relative to the ACOE original study area. ACOE(Tatum) calculations for this study can be found in Appendix Chapter 4.

4.4 Los Angeles County

The Los Angeles County Department of Public Works Sedimentation Manual estimates sediment production based on debris production areas. A debris production area (DPA) is defined as a zone that yields similar volumes of sediment under similar conditions. By way of comparison, DPA Zone 1, San Gabriel Mountains (the same debris production area for which the ACOE(Tatum) method uses an AT factor of 1) the Los Angeles County method produces 120,000 cubic yards per square mile of sediment. This value of production would correspond in the ACOE(Tatum) method approximately to a watershed of 10 acres, a relief ratio of 20, a fire factor of 3.65, and a discharge of 992.

In general, debris production is the product of the DPR and the area being studied. By extension, the debris production multiple watersheds with a common confluence is the sum of the products of DPR and area. For multiple watersheds with multiple DPR zones and development debris production takes the general form (Debris Manual equation 3.5g):

$$YIELD = \sum \left[DPR_{i(A)}(A_i - A_{d_i})\left(\frac{A_i - A_{d_i}}{A}\right) + DPR_{i(A_i - A_{d_i})}(A_i - A_{d_i})\left(\frac{(A - A_i) + A_{d_i}}{A}\right)\right]$$

where $DPR_{i(Ai)}$ is the debris production rate for drainage area A_i in DPA zone i, A_i is the drainage area including development, and A_{di} is the developed area drainage area. This equation is applied to each tributary watershed in this study for the proposed condition to determine debris production and is part of the MODRAT model described above.

4.5 Results

Debris production was calculated for each of the four tributary watersheds for both the existing and proposed conditions. The proposed conditions utilize the most recent plans at the time of writing, and any revisions to the proposed condition are not expected to alter debris production. Hydrology for the calculations is discussed in Chapter 3, above. The results of the calculations based on the Capital rainfall for each tributary by each method for both the existing and proposed condition are presented in Table 4.1. The raw data for the calculations is presented in Appendix Chapter 4. Of the three calculation methods, the MUSLE method predicted the smallest total debris production for every tributary while the LA County method predicted the highest debris production for every tributary. Table 4.1 shows that on the north bank tributaries of Grande and Chiquito the average change in debris production between the existing and proposed conditions is a 5.2% and 4.4% decrease, respectively, while the maximum is 10.6% decrease (MUSLE method) and 7.1% decrease (LA County method), respectively. The primary limiting factor to the change in debris production is the relatively small size of the proposed development on each of the northern watersheds. For the tributaries on the River's south bank (e.g. Long and Potrero), the larger change in debris production is a function of the extent of development of the south bank watersheds. Table 4.1 shows that for tributaries on the south bank of the River the average change in debris production between the existing and proposed conditions is a 32.3% and 32.2% decrease, respectively, while the maximum (MUSLE method) is 67.0% and 63.6% decrease, respectively.

Table 4.1: Existing and Proposed Conditions Debris Production Yield by Watershed for the Capital Event [1]

Tributary	Debris Yield (tons/event) Existing	Debris Yield (tons/event) Proposed	Δ (tons/event)	Δ (%)
MUSLE				
Chiquito	6,047	5,801	-246	-4.1
Long	17,704	5,836	-11,868	-67.0
Grande	32,191	28,791	-3,400	-10.6
Potrero	15,725	5,720	-10,005	-63.6
ACOE(Tatum)				
Chiquito	84,128	82,494	-1,634	-1.9
Long	35,136	31,850	-3,286	-9.4
Grande	104,408	103,131	-1,277	-1.2
Potrero	91,204	81,116	-10,088	-11.1
LA County				
Chiquito	282,342	262,197	-20,145	-7.1
Long	79,417	63,105	-16,312	-20.5
Grande	209,251	201,348	-7,903	-3.8
Potrero	360,951	282,229	-78,722	-21.8
Average				Δ (%) [2]
Chiquito	124,172	116,831	-7,342	-4.4
Long	44,086	33,597	-10,489	-32.3
Grande	115,283	111,090	-4,193	-5.2
Potrero	155,960	123,022	-32,938	-32.2

1: All calculations have been converted to tons/event.

2: Average of percentage change from all three methods

5 Comparison with Previous Work

5.1 SLA's Fluvial Study of the Santa Clara River and Its Tributaries Interim Report

In May of 1998, Simons, Li & Associates (SLA) submitted to Los Angeles County Department of Public Works (LACDPW) the Quantitative Analysis and Mathematical modeling of *The Existing Condition of the Santa Clara River Basin, Third Interim Report.* The report covered several areas including hydrologic analysis, hydraulic analysis, sediment yield analysis, and bed sediment analysis. The most relevant to this study is the watershed sediment yield analysis which included the LA County method, the MUSLE method and the ACOE(Tatum) method. Of the three methods discussed in the report, the authors found that the most representative equation for determining the production of sediment was the LA County equation.

To conduct the study, the Santa Clara River watershed upstream of Los Angeles County line was divided into 28 sub-areas with hydrology for each sub-area provided by the County. Because the areas of study were so large, a modified version of the County method was used. The SLA report recommends modifying the debris potential areas 3, 5, 8 and 9 to reflect certain physical characteristics of the sub-watersheds. The SLA study has two sub-watersheds that overlap with the watersheds in the present study: the Hasley Canyon group covering the north bank watersheds of Chiquito and Grande watersheds, plus additional area; and the Potrero Canyon group cover the south bank watersheds of Long and Potrero, plus additional area. The SLA sub-watersheds cover an area of 19.9 and 19.0 acres, respectively for the Hasley and Potrero groups.

Four methods were used to determine sediment debris production including the Los Angeles County method, a modified LAC method, the ACOE(Tatum) method, and MUSLE method. The LAC method predicted a debris production of 23,000 and 24,000 yd^3/mi^2 for the Hasley and Potrero groups, respectively, the MUSLE method predicted debris production of approximately 11,500 and 52,000 yd^3/mi^2, respectively, and the Tatum method predicted a debris production of 36,705 and 32,250 yd^3/mi^2, respectively. The watershed sediment yield from the SLA study is given as approximately 15,200 and 14,000 yd^3/mi^2, respectively.

5.2 PACE's Newhall Ranch River Fluvial Study Phase 1 Final Draft

PACE prepared the approved *Newhall Ranch River Fluvial Study Phase 1 Final Draft* (March 2006). The technical study provides an evaluation of the existing and proposed fluvial characteristics and long-term stability of Santa Clara River between Interstate 5 and an area generally west of the Los Angeles/Ventura County line near the Newhall Ranch Specific Plan. The study was conducted because proposed development along the River within the study area has the potential to modify the fluvial mechanics of the River. The proposed buried soil cement bank protection on both the north and south banks of the River is intended to provide long-term erosion protection from lateral migration of the bank and flood protection for the adjacent proposed development areas. The analysis of the Phase 1 study evaluates impacts from build-out of Newhall Ranch from (1) fluvial modifications of the river bed from single hypothetical storm events, and (2) changes in the floodplain fluvial operation over the long-term.

In the Phase 1 study general adjustment, long-term adjustment, and other scour were summed to determine total potential bed adjustment following LACH&SM methodology (2006 draft and formatting). For cross-sections where SAM modeling predicts aggradation, the general adjustment contribution to total bed adjustment is not included for degradation calculations. The existing condition is predicted to have a combined bed adjustment of approximately -6.9 to -19.7 feet for the outside of curved reaches and -6.2 to -15.4 feet for the inside of curved and straight reaches. Calculations in the proposed condition predict that the combined bed adjustment ranges from approximately -6.7 to -26.2 feet for both the outside of curved reaches and for the inside of curved and straight reaches. Freeboard elevation in the Phase 1 study was calculated based on LACH&SM Chapter 5A-3, and includes LACFCDDM calculations. The freeboard for the River ranges from approximately 2.5 to 5.2 feet for both outside of curved and straight or inside of curved reaches in the proposed condition. Maximum total toe-down, total freeboard, toe-down elevation and freeboard elevation are presented in the report. The report was approved by LACDPW horizontal and vertical position of the bank protection upstream of the Chiquito and Long confluences to the River and for horizontal position of the bank protection downstream.

5.3 Results

5.3.1 Differences in ACOE(Tatum) method results

Several differences exist between the present and SLA values used to calculate watershed sediment yield using the ACOE(Tatum) method. First, the SLA report uses watershed groups with areas of 19 to 20 mi^2, while the present study considers only the watersheds in which proposed development will occur, and with a total area of approximately 6 to 8 mi^2. In the SLA study, slopes are generally higher than in the present study: 264 to 349 ft/mi and 163 to 312 ft/mi, respectively. This difference is due primarily to the difference in area whereby the larger slopes occur in the larger watershed groups. The SLA study notes that a fire factor of 2.5 was used, although a factor of 3.13 is used in the present study. This difference will increase the watershed sediment yield in the present study relative to the SLA study where all other factors are equal. The present study utilizes an adjustment-transposition factor following the guidelines outlined in the ACOE manual; this factor does not appear to be utilized in the SLA study. Finally, based on SLA Table 4.7 it appears that the study based runoff on rainfall while the present study utilizes peak runoff. Peak runoff was chosen in the present because the ACOE manual indicates that runoff should be used for watersheds greater than 1920 Ac. The watershed sediment yield based on the ACOE (Tatum) method for each of the watersheds considered in the present study is summarized in Table 5.1.

5.3.2 Differences in MUSLE method results

Like the ACOE(Tatum) calculation methodology, several differences exist between the PACE and SLA values used to calculate watershed sediment yield. As noted above, the SLA and present studies use different study areas. The studies also use differing soil erodibility factor, and K values. The SLA study uses a K value of K=0.43 while the present study uses a value of 0.10. The SLA value was based on estimation of the soils present in the watershed using soil survey data, and the present study based the K value on soil samples presented in Phase 1. The K=0.43 value is more indicative of silty loam soil types. In contrast, the K=0.10 represents a coarse sand or a loamy sand with gravel. The reason for the difference between the two values likely arises from the extent of data considered. The SLA study considers more upland area possessing a higher percentage of fine particles with the present study focused on single watersheds adjacent to a river valley with more coarse particles. In the present study K factor values are taken from USDA texture tables for sediment samples described in Phase 1, while in the SLA study USGS soil maps were used to determine K values.

Different methods were used in the respective studies to calculate the slope length factor, LS: The SLA study used Williams and Berndt without comment, while the present study used Wischmeier and Smith, as directed in the AMAFCA manual. The results of this difference do not appear to be large for the north bank watersheds (6.0 vs. 1.6 to 9.3 for the SLA and the present study, respectively), however, for south bank watersheds a large disparity exists (22.1 vs. 1.6 to 7.6 for the SLA and the present study, respectively). The length-slope factor is a function of slope length and bed slope. The SLA study uses super-watersheds that are comprised of several of the watersheds considered in the present report. For example, in the present study Grande (~3.4 mi^2) and Chiquito (~4.8 mi^2) watersheds are studied separately, where as in the SLA study the individual watersheds are parts of a larger watershed (~19.0 mi^2) and studied as a whole. Because of the dissimilarity in watersheds studied, differences in the slopes and slope length are observed, changing the LS values.

The SLA study reports the product of the cropping (C) and erosion control (P) factors as CP=0.1. The present study uses cropping value of C=0.13 (40% cover with tall weeds) and an erosion control value of P=1.0 (no control). The product of these two values is CP=0.13, similar to the value reported by SLA.

SLA used a combined cropping factor/erosion control factor after USDA (1980). The combined factor followed Wischmeier (1975) but does not appear to be based on on-site analysis. The present study utilized aerial photography and site visits to arrive at estimates of C after USDA (1980). The erosion control factor, P, is used in the manner described in Chapter 4, above.

Values reported in the SLA study for the north and south watershed groups for runoff volume are approximately 1840 and 2890 ac-ft, respectively. The values of runoff volume presented in the present study, taken from the hydrologic analysis, described above, are 641 and 464 ac-ft for the north-bank watersheds and 214 and 393 ac-ft for the south bank watersheds. Values in the SLA study for the 50-year peak discharge are approximately 18,625 and 15,825 cfs for the north and south watershed groups, respectively, while values in the present study are approximately 4065 and 2845 cfs and 1630 and 3310 cfs for the north- and south-bank watersheds. The difference in the two studies can be attributed to the differences in watershed size.

The watershed sediment yield based on the MUSLE method for each of the watersheds considered in the present study is summarized in Table 5.1.

5.3.3 Differences in Los Angeles County method results

The primary difference in debris production using the LAC method between the SLA and present studies is a function of the areas used in the calculations. In the SLA study, the debris production rate (DPR) is calculated, while in the present study the DPR is read from tables in the LAC Sedimentation Manual (reformatted 2006). This difference leads to very small differences in DPR between the two studies. There is also some difference in debris production area (DPA) acreages. In the SLA study, one hundred percent of both the north- and south-bank watershed groups are DPA 5. In the present study, all of the north-bank watersheds are DPA 5, but the south-bank watersheds are a combination of DPA 3, 5, 8 and 9. The resultant debris production in cubic yards is 457,700 (23,000 yd^3/mi^2) and 456,000 (24,000 yd^3/mi^2) for SLA north- and south-bank watershed groups, respectively, and approximately 126,754 and 93,941 (or 27,246 yd^3/mi^2), and approximately 35,654 and 162,045 cubic yards (or 32,949 yd^3/mi^2) for the present study north- and south-bank watersheds, respectively. The watershed sediment yield based on the Los Angeles County method for each of the watersheds considered in the present study is summarized in Table 5.1.

Table 5.1: Comparison of SLA and Present Study Debris Production (existing condition)

Drainage	Area (MI^2)	Debris Production (yd^3/mi^2)		
		MUSLE	ACOE(Tatum)	LAC
Hasley	19.9	**11,469**	**36,750**	**23,000**
Potrero	19.0	**51,919**	**32,250**	**24,000**

Drainage	Area (MI^2)	Debris Production (yd^3/mi^2)		
		MUSLE*	ACOE(Tatum)	LAC
Chiquito	4.8	566	7,868	26,407
Grande	3.3	4,379	14,204	28,467
Combined	8.1	**2,119**	**10,449**	**27,246**
Long	1.5	5,299	10,516	23,769
Potrero	4.5	1,569	9,099	36,010
Combined	6.0	**2,501**	**9,453**	**32,949**

*Assumes soil densiity of 165 lb/ft^3

6 Sediment Transport and Delivery

6.1 Methods

Tributary sediment transport and delivery was estimated in this study using the US Army Corps of Engineers (ACOE) SAM steady-state numerical model. Here, SAM was employed to provide a calculation of sediment delivery for tributary subreaches confluencing with Santa Clara River. The SAM Sediment Hydraulic Package is an integrated system of programs developed through the Flood Damage Reduction and Stream Restoration Research Program to aid in the analyses associated with designing, operating, and maintaining flood control channels and stream restoration projects. SAM combines the hydraulic information and the bed material gradation information to compute the sediment transport capacity and stream yield in a given channel or floodplain hydraulic cross-section for a given discharge at a single point in time. A number of sediment transport functions are available for this analysis and SAM has the ability to assist in selecting the most appropriate sediment transport equation.

The three primary fluvial components of SAM are SAM.HYD, SAM.SED and SAM.AID. SAM.HYD provides a steady state, normal-depth, one-dimensional representation of channel hydraulics. The SAM.SED module combines the hydraulic parameters with the bed material gradation curve to compute bed material discharge rating curves by size classification. The SAM.AID module provides the user with recommended sediment transport equations based on the best matches between hydraulic parameters and grain size distribution of the study reach with parameters from widely accepted and published research.

The SAM numerical model is built upon hydraulic and fluvial components. The hydraulic components include representations of river bed characteristics that are input into an analytical procedure. The fluvial component includes representation of bed gradation as percent finer statistics and a selection of up to twenty sediment transport equations. SAM's hydraulic component will accept either average reach parameters or cross-section data imported from HEC-2/HEC-6 models. Hydraulic modeling is based on a uniform flow equation where discharge is the dependent variable such that,

$$Q = f(D, n, W, z, S)$$

where Q is discharge in cfs, D is flow depth in feet, n is the Manning's number, W is bottom width in feet, z is the channel side slope, and S is the energy slope. The bottom width is representative of the total moveable bed width of the channel and Manning's number is a composite value. Normal depth is calculated using Manning's equation, and effective values of width and depth are calculated following normal depth calculations. In cases where HEC-2 cross-sections are used for modeling, as in this study, the effective depth and width are calculated from the cross-section data based on the channel hydraulics.

The fluvial component is based on sediment transport functions to calculate the bed portion of the sediment discharge-rating curve.

The sediment transport equations are of the form,

$$GS_i=f(V, D, S_e, B_e, d_e, \rho_s, G_{sf}, d_s, i_b, \rho_f, T)$$

where GS_i is the transport rate for sediment size class i; the hydraulic terms $V, D, S_e,$ and $B_e,$ are the average velocity, effective flow depth, energy slope, and effective flow width, respectively; the sediment particle parameters d_e, ρ_s, and G_{sf} are the effective particle size, particle density, and grain size shape factor, respectively; the sediment mixture properties, d_s and i_b are the geometric mean particle size of sediment class i and fraction of class i in the bed, respectively; and the fluid properties ρ_f, and T, the water density and temperature, respectively. Twenty well known, published, peer-reviewed transport equations are available including Ackers-White, Colby, Laursen-Copeland, Laursen–Madden, MPM, Toffaleti, Yang, Van Rijn and others. Once the data assembly is complete, the SAM.SED module can be used to create a sediment discharge-rating curve based on grain size distribution. The reader is referred to the SAM user's documentation for further reference.

It is important to note that the SAM model is a zero-dimensional computational package that is only based on a single cross-section at a particular point in time. As such, SAM simulations can only represent a reach average during a steady state discharge. Because SAM applies sediment transport to a point, no variability in size distribution in either space or time is calculated. With these limitations in mind, in this study SAM is intended to provide a first approximation to sediment transport to which other more sensitive calculations can be compared.

6.1.1 SAM Transport Potential

Representation of sediment grain size distribution in SAM takes the form of percent finer data obtained from sieve analysis of channel sediment grab samples. At each sampling location, multiple samples are collected and analyzed, and the average data is input into the model. Sediment transport equations used in all SAM modeling were chosen with the assistance of the Army Corps' SAM.AID subroutine. The SAM.AID subroutine determines the most representative transport function based on the hydraulic parameters and percent finer data for each subreach by comparing model data with the results of 20 peer-reviewed and widely acknowledged sediment transport studies. This case-by-case transport equation selection is more likely to provide a robust representation of channel sediment transport than choosing an individual transport equation for all reaches.

Application of different transport functions to an individual channel reach may provide significantly differing model output. This is because the parameters of a given study from which the function is derived, vary greatly. To accomplish the task of guiding the user in selecting an appropriate transport function, SAM.AID assumes that the function that best represents sediment transport in a gauged stream would also best represent transport in an ungauged stream with similar sediment and hydraulic characteristics. SAM.AID begins by comparing study parameters (V, D, S_e, B_e, D_{50}) with parameters in the transport function database. Comparison begins by determining if D_{50} falls within one of the ranges identified in the database. Once the initial matches have been made in the database, the three best-matched sediment transport functions for the study reach are listed along with the parameters that matched the data set.

Once the best transport equation matches have been determined by SAM.AID, the most representative equations are run in SAM.SED for each subreach. Yang (Yang, 1984) and MPM (Meyer-Peter and Muller, 1948) equations are added to all simulations where they are not explicitly matched by SAM.AID so that there is a continuity of comparison between subreaches. Following SAM.SED computations, sediment transport potential for each subreach can be estimated by reviewing the calculations from each equation and analyzing the results. The raw data is presented in Appendix Chapter 3.

The MPM equation was found to be the representative transport equation for tributary and river confluence subreaches for the existing and proposed conditions.

6.1.2 SAM Yield

The SAM.YLD module calculates the stream yield passing a section during a specific period as defined by a hydrograph or duration curve. The hydrograph can range in duration from a specific event to a year or more. Calculations are based on the flow-duration sediment-discharge rating curve method. Hydrographs are taken from MODRAT model output in the case of the tributaries and as an SCS type hydrograph for the River.

6.1.3 SAM Model Assembly

Hydraulic representation of a channel bed is accomplished in several distinct steps. First, the HEC-RAS numerical model is thinned to no more than 100 stations per cross-section using HEC-RAS's cross-section points filter. HEC-RAS is a rigid boundary hydraulic model, which assumes the channel bed does not fluctuate. HEC-RAS executes a one-dimensional solution of the energy equation, where energy losses are evaluated by friction through Manning's equation and contraction/expansion based on the coefficient and change in velocity head. The channel cross-section data is first obtained from existing topography for the project site. A Manning's coefficient is then applied to the study reach and a discharge selected for analysis. In this study a Manning's value of n=0.035 us used based on site visits and aerial photography. Boundary conditions for the design Capitol discharge are entered to initiate hydraulic calculations based on "mixed" flow. Second, the HEC-RAS geometry is converted to HEC-2 format using the Army Corps RAS2UNET software. Like HEC-RAS, HEC-2 is a one-dimensional rigid boundary hydraulic model. Next, the HEC-2 model deck is arranged to run in subcritical mode and all features, such as ineffective flow areas and levees, are added. Once the HEC-2 model is complete, it is re-imported into HEC-RAS and compared to the original model. Any cross-sectional differences between the RAS and 2 models are resolved. Once the original and re-imported models match, the HEC-2 model is run to produce the Army Corps' T95 binary hydraulic simulation output file. Next, the T95 file is then read directly into SAM using the SAM model's M95 subroutine using the reach length option.

6.2 Results

For each tributary, sediment potential and stream yield modeling was conducted for both the existing and proposed condition at the downstream, limiting subreach. Table 6.1 shows the downstream subreach extents. Seward Engineering Geology (as presented in Phase 1) provided sediment data for SAM modeling. Hydraulic data was taken from HEC-RAS models of the tributaries (as presented in Phase 1), and the hydrographs used were taken from the hydrologic modeling presented in Chapter 2.

Table 6.1: River* and Tributary SAM Modeling Subreach Section Boundaries

Channel	Bounding Sections		River Subreach
	Existing	Proposed	
Chiquito	1560-1000	1708-1007	-
Chiquito Confluence*	22195-20070		D1
Long	1100-1000	1900-1200	-
Long Confluence*	22195-20070		D1
Grande	1050-1000	900	-
Grande Confluence*	17510-15335		D3
Potrero	1000		-
Potrero Confluence*	15125-13190		E1

Table 6.2 compares the existing and proposed conditions stream sediment yields for the various tributaries as well as the tributary confluences with the River. The table shows that the stream yields of all the tributaries increase in the proposed condition by approximately 10 to 49 percent at the limiting (downstream) section. The increase in stream yield is a result in the greater efficiency of the channel in the proposed conditions. Similarly, the greater efficiency of River sections in the proposed condition increases stream sediment yield by approximately 1.4 to 2.3 percent, depending on tributary, except at the Potrero confluence where a decrease in stream sediment yield of approximately 9 percent is expected.

Table 6.2: Existing and Proposed Conditions Sediment Yield (SAM.yld) by Channel for The Q_{burn} Discharge (Ton)				
Tributary Sediment Transport Yield				
Tributary	Sediment Yield (tons/event) Existing	Sediment Yield (tons/event) Proposed	Δ (tons)	Δ (%)[1]
Chiquito	1,980	2,182	202	**10.20**
Long	1,235	1,517	282	**22.83**
Grande	1,087	1,623	536	**49.31**
Portrero	1,994	2,364	370	**18.56**
River Sediment Transport Yield				
Tributary	Sediment Yield (tons/event) Existing	Sediment Yield (tons/event) Proposed	Δ (tons)	Δ (%)
Chiquito Confluence	172,027	174,434	2,407	**1.40**
Long Confluence	172,027	174,434	2,407	**1.40**
Grande Confluence	179,143	183,265	4,122	**2.30**
Potrero Confluence	228,107	207,302	-20,805	**-9.12**

1. Positive means there is an increase from existing to proposed

To determine the fluvial impacts to the River resulting from development of the tributary watersheds a comparison between the proposed River stream sediment yield and the change in tributary stream sediment yield is examined at the River confluence locations. Table 6.3 compares the stream sediment yield in the River with the change in stream sediment yield from the tributaries for the tributary Capitol event and either the Capitol or Peak Observed event on the River (31,800 cfs, winter 1968-1969). The Peak Observed event was chosen as a basis for comparison since there is a lower probability of the Capitol event on both the tributaries and River simultaneously than a Capitol event on the tributaries coincident with a sub-Capitol extreme event on the River. The table shows that for coincident Capitol events that the tributary stream sediment yield only constitutes between approximately 0.1 and 0.3 percent of the transport of one River subreach, depending on tributary. The table also shows that during the Peak Observed event on the River that the tributary stream sediment yield constitutes between approximately 0.6 and 1.1 percent of the River stream yield on one River subreach, depending on tributary.

Table 6.3: Comparison of River Stream Yield with Change in Tributary Stream Yield Resulting from Watershed Development During a Tributary Capitol Event (Tons/Event)			
Capital Event			
Subreach	Q_s - River	$\Delta Q_{s\,-}$ Creek	Δ%
Chiquito Confluence	174,434	202	**0.12**
Long Confluence	174,434	282	**0.16**
Grande Confluence	183,265	536	**0.29**
Potrero Confluence	207,302	370	**0.18**
Peak Observed Event (31,800 cfs)			
Subreach	Q_s - River	$\Delta Q_{s\,-}$ Creek	Δ%
Chiquito Confluence	36,804	202	**0.55**
Long Confluence	36,804	282	**0.77**
Grande Confluence	49,933	536	**1.07**
Potrero Confluence	51,371	370	**0.72**

1. Positive means there is an increase from existing to proposed

To examine the relative contribution of each tributary's stream yield to the River stream yield, the Capitol tributary stream sediment yield is compared to the River stream sediment yield during the Capitol and Peak Observed events for the proposed condition. Table 6.4 shows that the total stream sediment yield from the tributaries relatively represents between approximately 0.9 and 1.2 percent of the River stream sediment yield on one River subreach during the River Capitol event, depending on tributary. In the case that *no* sediment is delivered to the River from the tributaries during coincident Capitol events, the tributaries represent less than 2 percent of the stream sediment yield of the River. During the Peak Observed event on the River, the stream sediment yield from the tributaries to the river represents between approximately 0.6 and 1.1 percent of the River stream yield on one River subreach, depending on tributary. Likewise these numbers represent the relative changes to the River were *all* the stream sediment yielded by the tributary delivered to the River. The results are shown graphically in Appendix Chapter 6.

Table 6.4: Comparisonof River Yield with No Tributary Yield Resulting from Watershed Development (Tons/Event)			
Tributary with No Delivery - Capitol in River			
Subreach	Q_s - River	$Q_{s\,-}$ Creek	Δ%
Chiquito Confluence	174,434	2,182	**1.25**
Long Confluence	174,434	1,517	**0.87**
Grande Confluence	183,265	1,623	**0.89**
Potrero Confluence	207,302	2,364	**1.14**
Tributary w/ No Delivery - Peak Observed in River (31,800 cfs)			
Subreach	Q_s - River	$Q_{s\,-}$ Creek	Δ%
Chiquito Confluence	36,804	2,182	**5.93**
Long Confluence	36,804	1,517	**4.12**
Grande Confluence	49,933	1,623	**3.25**
Potrero Confluence	51,371	2,364	**4.60**

1. Positive means there is an increase from existing to proposed

7 Summary and Recommendations

7.1 Summary

The MODRAT numerical model was used to determine the hydrology of the tributary watersheds within the study area. The model was run for both the existing and proposed conditions. The model is based on the LACFCD hydrology manual.

Three different methods were use to calculate watershed sediment production: MUSLE, ACOE(Tatum), and Los Angeles County. Debris production was calculated for each of the four tributary watersheds for both the existing and proposed conditions. Of the three calculation methods, the MUSLE method predicted the smallest total debris production for every tributary while the LA County method predicted the highest debris production for every tributary. On the north bank tributaries of Grande and Chiquito the average change in debris production between the existing and proposed conditions is a 5.2% and 4.4% decrease, respectively, while the maximum is 10.6% decrease (MUSLE method) and 7.1% decrease (LA County method), respectively. The primary limiting factor to the change in debris production on north-bank watersheds is the relatively small size of the proposed development, while for the tributaries on the River's south bank the larger change is debris production is a function of the extent of development of the watersheds. For tributaries on the south bank of the River, Long and Potrero, the average change in debris production between the existing and proposed conditions is a 32.3% and 32.2% decrease, respectively, while the maximum is 67.0% and 63.6% decrease (MUSLE method), respectively.

Tributary sediment transport and delivery was estimated in this study using the US Army Corps of Engineers (ACOE) SAM steady-state numerical model. Here, SAM was employed to provide a calculation of sediment delivery for tributary subreaches confluencing with Santa Clara River.

For each tributary sediment transport potential and stream yield modeling was conducted for both the existing and proposed condition at the downstream, limiting subreach. Modeling predicts that the stream yields of all the tributaries increase in the proposed condition by approximately 10 to 49 percent at the limiting (downstream) section. The increase in stream yield is a result in the greater efficiency of the channel in the proposed conditions. Similarly, the greater efficiency of River sections in the proposed condition increases sediment stream yield by approximately 1.4 to 2.3 percent, depending on tributary, except at the Potrero confluence where a decrease in stream sediment yield of approximately 9 percent is expected.

To determine the fluvial impacts to the River resulting from development of the tributary watersheds, a comparison between the proposed River stream sediment yield and the change in tributary stream sediment yield is examined at the River confluence locations. For coincident Capitol events, tributary stream sediment yield only constitutes between approximately 0.1 and 0.3 percent of the stream sediment yield of one River subreach, depending on tributary. During the Peak Observed event on the River, the stream sediment yield constitutes between approximately 0.6 and 1.1 percent of the River stream yield on one River subreach, depending on tributary.

To examine the relative contribution of each tributary's stream yield to the River stream yield, the Capitol tributary stream sediment yield is compared to the River stream sediment yield during the Capitol and Peak Observed events for the proposed condition. Modeling shows that the total stream sediment yield from the tributaries relatively represents between approximately 0.9 and 1.2 percent of the River stream sediment yield on one River subreach during the River Capitol event, depending on tributary. In the case that *no* sediment is delivered to the River from the tributaries during coincident Capitol events, the tributaries represent less than 2 percent of the stream sediment yield of one River subreach. During the Peak Observed event on the River, the stream sediment yield from the tributaries to the River represents between approximately 3.2 and 5.9 percent of the River stream yield on one River subreach, depending on tributary. Likewise these numbers represent the relative changes to the River were *all* the sediment yielded by the tributary delivered to the River.

Several differences exist between the present study's parameter values and the previous SLA study parameter values used to calculate watershed sediment yield. The SLA report uses watershed groups with areas of 19 to 20 mi^2, while the present study considers only the watersheds in which proposed development will occur, and with a total area of approximately 6 to 8 mi^2. This difference in area impacts study slopes, land use ratios, soil parameter ratios, and other parameter ratios in the calculation methods. Additionally, since the SLA study was completed, Los Angeles County has modified the manner in which the Capital discharge is computed. Some of difference in discharge and subsequently watershed sediment yield between the two studies can be attributed to these ratios.

7.2 Recommendations

In Phase 1 of this study, SAM numerical modeling was used to estimate the change in bed elevation. Bed change was determined by calculating the difference between subreach upstream and downstream sediment potential transport for the Q_{CAP} discharge. The difference in transport potential, ΔTP, between subreach inflow and outflow was converted to general adjustment, GA, as:

$$GA = \frac{\Delta TP}{\rho bRL} day$$

where ρ is the sediment density taken as 165.36 lb/ft^3, *b* is channel width in feet, ***day*** denotes one day's time (for the 24 hour hydrograph), and *RL* is reach length in feet. To estimate how the proposed changes in sediment delivery from the tributaries impact the fluvial mechanics of the River the general adjustment equation was modified to take the form:

$$GA = \frac{TP_{IN} - \Delta TP_{TRIBUTARY} - TP_{OUT}}{\rho bRL} day$$

where TP_{IN} is the transport potential flowing into a subreach, TP_{OUT} is the transport potential flowing out of a subreach, and $\Delta TP_{TRIBUTARY}$ is the change in tributary sediment delivery given that none of the sediment produced on the watershed reaches the River confluence.

The results for the proposed condition where both the tributaries and the River are flowing at the Q_{CAP} discharge are shown in Table 7.1. The table shows that the transport potential grade change ranges from -1.5 to 2.1 feet where the highest degradation occurs in Subreach SRE3 and the greatest aggradation occurs in Subreach SRE2. Table 7.2 compares the grade change for the Phase 1 (no reduction in tributary sediment inflow) and Phase 2 (present study with reduction in tributary sediment inflow) potential bed stability. The table shows that influence of the tributary's sediment delivery considered is minimal relative to local river bed potential grade change. That is, in the worst case whereby all the sediment presently contributed to the River by the tributaries is prohibited in reaching the River, no potential grade change in the vicinity of the tributary confluences is expected because the relative contribution of tributary sediment is small with respect to the sediment transport potential of the River at the considered subreach confluences.

Table 7.1: Phase 2 Santa Clara River Proposed Conditions General Adjustment Potential Bed Stability - Q_{CAP} River Transport Potential VS. Tributary Yield										
Subreach	US Sta	DS Sta	Trans Eq	Potential** Transport (ton)	Trib Inflow Yld. (ton)	Potential - Inflow	Top Width (ft)	Depth (ft)	A/D	Grade Change (ft)
SRC4	24795	22415	MPM	603,656	0	603,656	860.1	0.2	**AGGRADE**	**0.2**
SRD1*	22195	20070	MPM	661,922	3,699	658,223	1,511.4	0.2	**DEGRADE**	**-0.2**
SRD2	19855	17785	MPM	319,200	0	319,200	1,431.8	1.4	**AGGRADE**	**1.4**
SRD3	17510	15335	MPM	620,768	1,623	619,145	1,274.3	1.3	**DEGRADE**	**-1.3**
SRE1	15125	13190	MPM	731,941	2,364	729,577	1,588.9	0.4	**DEGRADE**	**-0.4**
SRE2	13030	11180	MPM	291,031	0	291,031	1,375.5	2.1	**AGGRADE**	**2.1**
SRE3	11015	9025	MPM	636,713	0	636,713	1,399.3	1.5	**DEGRADE**	**-1.5**

* Chiquito and Long Canyon Creeks confluence into the same subreach

** Q Cap

*** Q Burn

Table 7.2: Phase 2 Santa Clara River SAM Phase 1 vs Phase 2 Conditions Potential Bed Stability - Q_{CAP}					
Subreach	**US Sta**	**Phase 1 Proposed Conditions Grade Change (ft)**	**Phase 2 Proposed Conditions Grade Change (ft)**	**Phase 1/Phase 2 Delta (ft)**	**Result**
SRC4	24795	0.2	0.2	**0.0**	**NO CHANGE**
SRD1	22195	-0.2	-0.2	**0.0**	**NO CHANGE**
SRD2	19855	1.4	1.4	**0.0**	**NO CHANGE**
SRD3	17510	-1.3	-1.3	**0.0**	**NO CHANGE**
SRE1	15125	-0.4	-0.4	**0.0**	**NO CHANGE**
SRE2	13030	2.1	2.1	**0.0**	**NO CHANGE**
SRE3	11015	-1.5	-1.5	**0.0**	**NO CHANGE**

The results for the proposed condition where the tributaries are flowing at the Q_{CAP} discharge and the River is flowing at the peak observed discharge (Q=31,800 cfs) are shown in Table 7.3. The table shows that the potential grade change ranges from -0.3 to 0.4 feet where the highest degradation occurs in Subreach SRD3 and the greatest aggradation occurs in Subreach SRE2. It is important to note that the potential general adjustment in this scenario is very small relative to the potential general adjustment that occurs during the Q_{CAP} scenario. Table 7.4 compares the grade change for the Phase 1 (no reduction in tributary sediment inflow) and Phase 2 (present study with reduction in tributary sediment inflow) potential bed stability for the Q_{CAP}-Q_{31800} scenario. The table shows that influence of the tributary's sediment delivery considered is minimal relative to local river bed grade change. That is, in the worst case whereby all the sediment presently contributed to the River by the tributaries is prohibited in reaching the River, no grade change in the vicinity of the tributary confluences is expected because the relative contribution of tributary sediment is small with respect to the sediment transport potential of the River at the considered subreach confluences.

Table 7.3: Phase 2 Santa Clara River Proposed Conditions General Adjustment Potential Bed Stability - Q_{31800} River Transport Potential VS Tributary Creek Yield										
Subreach	US Sta	DS Sta	Trans Eq	Potential** Transport (ton)	Trib Inflow (ton)**	Potential - Inflow	Top Width (ft)	Depth (ft)	A/D	Grade Change (ft)
SRC4	24795	22415	MPM	161,304	0	161,304	705.5	0.0	**AGGRADE**	**0.0**
SRD1*	22195	20070	MPM	139,888	3,699	136,189	832.4	0.1	**AGGRADE**	**0.1**
SRD2	19855	17785	MPM	119,715	0	119,715	1,023.9	0.1	**AGGRADE**	**0.1**
SRD3	17510	15335	MPM	169,432	1,623	167,809	1,076.4	0.3	**DEGRADE**	**-0.3**
SRE1	15125	13190	MPM	181,691	2,364	179,327	1,484.5	0.1	**DEGRADE**	**-0.1**
SRE2	13030	11180	MPM	121,496	0	121,496	1,071.8	0.4	**AGGRADE**	**0.4**
SRE3	11015	9025	MPM	148,010	0	148,010	1,060.7	0.2	**DEGRADE**	**-0.2**

*: Chiquito and Long Canyon Creeks confluence into the same subreach

** Q Peak

*** Q Burn

Table 7.4: Phase 2 Santa Clara River SAM Phase 1 vs Phase 2 Conditions Potential Bed Stability - Q_{31800}					
Subreach	**US Sta**	**Phase 1 Proposed Conditions Grade Change (ft)**	**Phase 2 Proposed Conditions Grade Change (ft)**	**Phase 1/Phase 2 Delta (ft)**	**Result**
SRC4	24795	0.0	0.0	**0.0**	**NO CHANGE**
SRD1	22195	0.1	0.1	**0.0**	**NO CHANGE**
SRD2	19855	0.1	0.1	**0.0**	**NO CHANGE**
SRD3	17510	-0.3	-0.3	**0.0**	**NO CHANGE**
SRE1	15125	-0.1	-0.1	**0.0**	**NO CHANGE**
SRE2	13030	0.4	0.4	**0.0**	**NO CHANGE**
SRE3	11015	-0.2	-0.2	**0.0**	**NO CHANGE**

The same comparison was made with tributary stream yield replacing potential transport in the calculations. The results for the proposed condition where both the tributaries and the River are flowing at the Q_{CAP} discharge are shown in Table 7.5. The table shows that the stream yield grade change ranges from -0.3 to 0.5 feet where the highest degradation occurs in Subreach SRD3 and the greatest aggradation occurs in Subreach SRE2. Table 7.6 compares the yield grade change for the Phase 1 (no reduction in tributary sediment inflow) and Phase 2 (present study with reduction in tributary sediment inflow) yield bed stability. The table shows that influence of the tributary's stream sediment yield considered is minimal relative to local river bed stream yield grade change.

Table 7.5: Phase 2 Santa Clara River Proposed Conditions Yield Bed Stability - Qburn River VS Creek Yield										
Subreach	US Sta	DS Sta	Trans Eq	Yield (ton)	Trib Inflow (ton)	Yield - Inflow	Top Width (ft)	Depth (ft)	A/D	Grade Change (ft)
SRC4	24795	22415	MPM	176,022	0	176,022	860.1	0.1	**AGGRADE**	**0.1**
SRD1*	22195	20070	MPM	174,434	3,699	170,735	1,511.4	0.0	**AGGRADE**	**0.0**
SRD2	19855	17785	MPM	112,540	0	112,540	1,431.8	0.3	**AGGRADE**	**0.3**
SRD3	17510	15335	MPM	183,265	1,623	181,642	1,274.3	0.3	**DEGRADE**	**-0.3**
SRE1	15125	13190	MPM	207,302	2,364	204,938	1,588.9	0.1	**DEGRADE**	**-0.1**
SRE2	13030	11180	MPM	110,603	0	110,603	1,375.5	0.5	**AGGRADE**	**0.5**
SRE3	11015	9025	MPM	175,157	0	175,157	1,399.4	0.3	**DEGRADE**	**-0.3**

*: Chiquito and Long Canyon Creeks confluence into the same subreach

Table 7.6: Phase 2 Santa Clara River SAM Phase 1 vs Phase 2 Conditions Yield Bed Stability - Q_{Burn}					
Subreach	**US Sta**	**Phase 1 Proposed Conditions Grade Change (ft)**	**Phase 2 Proposed Conditions Grade Change (ft)**	**Phase 1/Phase 2 Delta (ft)**	**Result**
SRC4	24795	0.0	0.1	**0.1**	**CHANGE**
SRD1	22195	0.1	0.0	**-0.1**	**CHANGE**
SRD2	19855	0.1	0.3	**0.2**	**CHANGE**
SRD3	17510	-0.2	-0.3	**-0.1**	**CHANGE**
SRE1	15125	-0.1	-0.1	**0.0**	**NO CHANGE**
SRE2	13030	0.3	0.5	**0.2**	**CHANGE**
SRE3	11015	-0.1	-0.3	**-0.2**	**CHANGE**

The results for the proposed condition where the tributaries are flowing at the Q_{CAP} discharge and the River is flowing at the peak observed discharge (Q=31,800 cfs) are shown in Table 7.7. The table shows that there is no change in stream yield grade. It is important to note that the stream yield general adjustment in this scenario is very small relative to the stream yield general adjustment that occurs during the Q_{CAP} scenario. Table 7.8 compares the grade change for the Phase 1 (no reduction in tributary sediment inflow) and Phase 2 (present study with reduction in tributary sediment inflow) yield bed stability for the Q_{CAP}-Q_{31800} scenario. The table shows that influence of the tributary's sediment delivery considered is minimal relative to local river bed grade change. The results of the stream yield-based analysis are similar to those for the potential-based analysis: that influence of the tributary's sediment delivery considered is minimal relative to local river bed stream yield grade change.

Table 7.7: Phase 2 Santa Clara River Proposed Conditions Yield Bed Stability - Q_{31800} River yield VS Creek Yield										
	US Sta	DS Sta	Trans Eq	Yield (ton)	Trib Inflow (ton)	Yield - Inflow	Top Width (ft)	Depth (ft)	A/D	Grade Change (ft)
SRC4	24795	22415	MPM	43,989	0	43,989	860.1	0.0	**AGGRADE**	**0.0**
SRD1*	22195	20070	MPM	36,804	3,699	33,105	1,511.4	0.0	**AGGRADE**	**0.0**
SRD2	19855	17785	MPM	42,154	0	42,154	1,431.8	0.0	**DEGRADE**	**0.0**
SRD3	17510	15335	MPM	49,933	1,623	48,310	1,274.3	0.0	**DEGRADE**	**0.0**
SRE1	15125	13190	MPM	51,371	2,364	49,007	1,588.9	0.0	**DEGRADE**	**0.0**
SRE2	13030	11180	MPM	46,105	0	46,105	1,375.5	0.0	**AGGRADE**	**0.0**
SRE3	11015	9025	MPM	40,660	0	40,660	1,399.4	0.0	**AGGRADE**	**0.0**

*: Chiquito and Long Canyon Creeks confluence into the same subreach

Table 7.8: Phase 2 Santa Clara River SAM Phase 1 vs Phase 2 Conditions Yield Bed Stability - Q_{31800}					
Subreach	**US Sta**	**Phase 1 Proposed Conditions Grade Change (ft)**	**Phase 2 Proposed Conditions Grade Change (ft)**	**Phase 1/Phase 2 Delta (ft)**	**Result**
SRC4	24795	0.1	0.0	**-0.1**	**CHANGE**
SRD1	22195	0.1	0.0	**-0.1**	**CHANGE**
SRD2	19855	-0.1	0.0	**0.1**	**CHANGE**
SRD3	17510	0.1	0.0	**-0.1**	**CHANGE**
SRE1	15125	-0.1	0.0	**0.1**	**CHANGE**
SRE2	13030	0.0	0.0	**0.0**	**NO CHANGE**
SRE3	11015	0.1	0.0	**-0.1**	**CHANGE**

Because the findings of the present study suggest that the impacts of development on the four watersheds considered within will be small but measurable with respect to the fluvial mechanics of Santa Clara River, PACE recommends that the top and toe elevations calculated in Phase 1 of this study be approved for final design. The values for top and toe are presented here in Table 7.9.

Table 7.9: Phase 1 & Phase 2 Toe Down and Freeboard Adjustment (Feet)					
Subreach	US Sta	Toe[1]		Freeboard[2]	
		Δ Curved / Outside	Δ Straight/ Inside	Δ Curved / Outside	Δ Curved / Outside
SRC4	24795	-0.1	-0.1	0.1	0.1
SRD1*	22195	-	-	-	-
SRD2	19855	-	-	0.1	0.1
SRD3	17510	-	-	-	-
SRE1	15125	-0.1	-0.1	-	-
SRE2	13030	-	-	0.2	0.2
SRE3	11015	-	-	-	-

1 Only Station 22790, and 15125

2 All Station in Subreach

7.3 A Note Concerning Differences between Calculated Tributary and Stream Yields

Several possible reasons exist to explain the discrepancy between the SAM stream yield and MORA watershed yield calculations. It could be expected that aggradation would occur when watershed yield exceeded stream yield, or conversely, that degradation would occur when stream yield exceeded watershed yield. In the case of Newhall Ranch Canyons fans or delta-type features are present at the confluence with Santa Clara River. To some extent, as yet uncharacterized, the shape and extent of the fan is mediated by large discharges within the River. The Creek as a whole, however, is not aggrading as suggested by the difference in watershed and stream yields presented above. Two of the explanations are the lack of fines in the SAM model and location of debris basin data within the watershed.

The study used to develop the LAC method for watershed yield relied on measurements based on debris basins. These debris basins have the potential to catch all particle sizes ranging from silts and clays to large cobbles and even larger particles. Some portion of the sediment trapped in the basins will be fine material, which is generally transported as wash load. The SAM numerical model excludes the fine materials smaller than 0.075 mm (sieve #200) from calculation. Heretofore, the focus of fluvial analysis on Santa Clara River and its tributaries has dealt with particles greater than 0.075 mm. The fine sediments ($\phi < 0.075$ mm) not considered by SAM, but measured in the sediment basins used to calibrate the LAC method, may account for the difference between stream and watershed yield calculations.

The location of sediment basins within a watershed may be significant for determining the rate of sediment delivery into a sediment basin. Not all sediment basins within the same watershed will have the same sediment yield. The sediment yield is strongly a function of local bed slope, sub-watershed ground cover, sub-watershed soil type, local valley width, and other locally varying watershed factors. The tributary watersheds located within Newhall Ranch have steep sub-watersheds upstream, and flatter sub-watersheds at the River confluence, for example. In the present study SAM numerical modeling is focused on the downstream, transport-limiting stream subreaches located near the River confluence, while watershed modeling occurs over the entire tributary watershed area. This difference may account for some of the watershed and stream yield discrepancy.

Additional discussion of the nature of the study watershed’s stream and watershed yield is included in a memorandum by Phillip Williams & Associates, included in Appendix Chapter 7.

8 References

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Simons, Li & Associates (November 1990) Fluvial Study of Santa Clara River and the Tributaries.

US Army Corps of Engineers (ACOE) (September 2002) SAM Hydraulic Design Package For Channels.

US Geological Survey (USGS) (August 1979) Sediment Discharge in the Santa Clara River Basin, Ventura and Los Angeles Counties, California. Water Resource Investigations 79-78.

Table 7.1: Santa Clara River Summary of Maximum Proposed Toe-down & Freeboard (ft)											
			Outside Curved Reach		Straight-Inside Curved Reach			Outside Curved Reach		Straight-Inside Curved Reach	
Subreach	HEC-RAS Section	Z_{99} [2]	Maximum Total Degradation [3]	Proposed Toe-down Elevation [1,4]	Maximum Total Degradation [3]	Proposed Toe-down Elevation [1,4]	WSE	Maximum Total Freeboard [3]	Proposed Top of Levee Elevation [1]	Maximum Total Freeboard [3]	Proposed Top of Levee Elevation [1]
SRA1	46195	1035.0	14.0	1021.0	14.0	1021.0	1063.1	3.1	1066.3	3.1	1066.3
	46020	1032.0	14.0	1018.0	14.0	1018.0	1062.0	3.0	1065.0	3.0	1065.0
	45545	1030.0	14.0	1016.0	14.0	1016.0	1057.9	3.4	1061.3	3.4	1061.3
	45030	1025.0	14.0	1011.0	14.0	1011.0	1054.2	3.0	1057.3	3.0	1057.3
	44585	1022.0	14.0	1008.0	14.0	1008.0	1050.6	3.2	1053.8	3.2	1053.8
	44210	1020.0	14.0	1006.0	14.0	1006.0	1047.8	2.9	1050.8	2.9	1050.8
SRA2	43820	1018.0	15.4	1002.6	15.4	1002.6	1042.1	3.9	1046.0	3.9	1046.0
	43610	1017.0	17.0	1000.0	17.0	1000.0	1038.3	4.0	1042.2	4.0	1042.2
	43410	1016.0	15.8	1000.2	15.8	1000.2	1035.8	3.6	1039.4	3.6	1039.4
	43200	1014.0	16.3	997.7	16.3	997.7	1033.2	3.5	1036.7	3.5	1036.7
	42975	1012.0	15.5	996.5	15.5	996.5	1031.0	2.9	1033.8	2.7	1033.7
	42815	1011.0	15.5	995.5	15.5	995.5	1029.7	2.5	1032.2	2.5	1032.2
	42590	1010.0	21.0	989.0	14.7	995.3	1028.4	2.5	1030.9	2.5	1030.9
	42430	1008.0	21.0	987.0	15.3	992.7	1027.5	2.5	1030.0	2.5	1030.0
	42215	1006.0	21.0	985.0	14.7	991.3	1026.7	2.5	1029.2	2.5	1029.2
	41940	1005.0	15.0	990.0	11.9	993.1	1025.6	2.5	1028.1	2.5	1028.1
	41730	1004.0	15.0	989.0	12.0	992.0	1024.6	2.5	1027.1	2.5	1027.1
	41460	1002.0	15.0	987.0	11.9	990.1	1023.2	2.5	1025.7	2.5	1025.7
SRA3	41280	1001.0	12.5	988.5	12.5	988.5	1021.8	2.5	1024.3	2.5	1024.3
	41080	1000.0	14.0	986.0	14.0	986.0	1020.5	2.5	1023.0	2.5	1023.0
	40825	999.5	21.0	978.5	14.0	985.5	1019.3	2.5	1021.8	2.5	1021.8
	40585	998.0	18.0	980.0	12.5	985.5	1018.3	2.5	1020.8	2.5	1020.8
	40335	996.0	15.0	981.0	10.0	986.0	1017.4	2.5	1019.9	2.5	1019.9
	40130	995.0	15.0	980.0	10.0	985.0	1016.6	2.5	1019.1	2.5	1019.1
	39945	994.0	15.0	979.0	10.0	984.0	1015.9	2.5	1018.4	2.5	1018.4
	39755	994.0	12.5	981.5	12.5	981.5	1014.6	2.5	1017.1	2.5	1017.1
	39605	993.0	14.0	979.0	14.0	979.0	1013.7	2.5	1016.2	2.5	1016.2
	39310	992.0	18.0	974.0	12.5	979.5	1012.2	2.5	1014.7	2.5	1014.7
	39100	990.0	14.0	976.0	14.0	976.0	1011.1	2.5	1013.6	2.5	1013.6
	38925	989.5	10.0	979.5	10.0	979.5	1010.3	2.5	1012.8	2.5	1012.8
SRA4	38710	988.0	10.0	978.0	10.0	978.0	1009.2	2.5	1011.7	2.5	1011.7
	38475	986.0	12.5	973.5	12.5	973.5	1007.0	2.6	1009.5	2.6	1009.5
	38300	985.5	14.0	971.5	14.0	971.5	1005.8	2.5	1008.3	2.5	1008.3
	38065	984.0	10.0	974.0	10.0	974.0	1004.1	2.5	1006.6	2.5	1006.6
	37810	983.0	14.0	969.0	14.0	969.0	1001.4	2.8	1004.2	2.8	1004.2
	37655	982.0	14.0	968.0	14.0	968.0	999.9	2.6	1002.5	2.6	1002.5
	37390	981.0	14.0	967.0	14.0	967.0	998.5	2.5	1001.0	2.5	1001.0
	37135	980.0	12.5	967.5	12.5	967.5	996.8	2.5	999.3	2.5	999.3
	36930	978.0	14.0	964.0	14.0	964.0	995.7	2.5	998.2	2.5	998.2
	36735	977.0	12.5	964.5	12.5	964.5	994.6	2.5	997.1	2.5	997.1
	36515	975.0	15.0	960.0	10.0	965.0	993.6	2.5	996.1	2.5	996.1
	36265	974.0	15.0	959.0	10.0	964.0	992.3	2.5	994.8	2.5	994.8
SRB1	36080	973.0	22.9	950.1	22.0	951.0	990.6	2.5	993.1	2.5	993.1
	35845	971.0	15.0	956.0	10.0	961.0	989.1	2.5	991.6	2.5	991.6
	35725	970.0	15.0	955.0	10.0	960.0	988.3	2.5	990.8	2.5	990.8
	35515	969.0	18.0	951.0	12.5	956.5	986.9	2.5	989.4	2.5	989.4
	35245	968.0	18.0	950.0	12.5	955.5	985.0	2.5	987.5	2.5	987.5
	35040	967.0	21.0	946.0	14.0	953.0	983.6	2.5	986.1	2.5	986.1
	34860	966.0	21.0	945.0	14.0	952.0	982.3	2.5	984.8	2.5	984.8
	34720	965.5	21.0	944.5	14.0	951.5	981.3	2.5	983.8	2.5	983.8
	34495	964.0	18.0	946.0	12.5	951.5	979.7	2.5	982.2	2.5	982.2
	34310	963.0	18.0	945.0	12.5	950.5	978.4	2.5	980.9	2.5	980.9
	34090	962.0	18.0	944.0	12.5	949.5	977.0	2.5	979.5	2.5	979.5
SRB2	33880	960.0	18.0	942.0	12.5	947.5	975.7	2.5	978.2	2.5	978.2
	33710	959.0	18.0	941.0	12.5	946.5	974.6	2.5	977.1	2.5	977.1
	33500	958.0	18.0	940.0	12.5	945.5	973.3	2.5	975.8	2.5	975.8
	33310	957.0	18.0	939.0	12.5	944.5	972.3	2.5	974.8	2.5	974.8
	33115	956.0	15.0	941.0	10.0	946.0	971.4	2.5	973.9	2.5	973.9
	32795	954.0	15.0	939.0	10.0	944.0	969.7	2.5	972.2	2.5	972.2
	32605	952.0	15.0	937.0	10.0	942.0	968.7	2.5	971.2	2.5	971.2
SRC1	32265	950.0	18.0	932.0	12.5	937.5	967.2	2.5	969.7	2.5	969.7
	31875	949.0	15.0	934.0	10.0	939.0	965.6	2.5	968.1	2.5	968.1
	31585	946.0	15.0	931.0	10.0	936.0	964.7	2.5	967.2	2.5	967.2
	31360	944.0	15.0	929.0	10.0	934.0	963.9	2.5	966.4	2.5	966.4
	31060	942.0	12.0	930.0	8.0	934.0	963.2	2.5	965.7	2.5	965.7
	30720	940.0	12.0	928.0	8.0	932.0	962.5	2.5	965.0	2.5	965.0
	30445	938.0	12.0	926.0	8.0	930.0	962.1	2.5	964.6	2.5	964.6
	30095	936.0	12.0	924.0	8.0	928.0	961.5	2.5	964.0	2.5	964.0
	29815	935.0	12.0	923.0	8.0	927.0	960.8	2.5	963.3	2.5	963.3
	29565	934.0	12.0	922.0	8.0	926.0	960.3	2.5	962.8	2.5	962.8
	29385	933.0	12.0	921.0	8.0	925.0	959.6	2.5	962.1	2.5	962.1
SRC2	29140	932.0	12.0	920.0	9.1	922.9	958.4	2.5	960.9	2.5	960.9
	28895	930.0	21.0	909.0	14.0	916.0	953.8	4.8	958.6	4.7	958.5
	28695	928.0	15.0	913.0	15.0	913.0	952.9	2.5	955.4	2.5	955.4
	28500	927.5	14.7	912.8	14.7	912.8	950.5	3.1	953.5	2.9	953.4
	28280	926.0	21.0	905.0	14.0	912.0	949.8	2.5	952.3	2.5	952.3
	28080	925.0	15.0	910.0	10.0	915.0	949.1	2.5	951.6	2.5	951.6
	27925	924.0	10.3	913.7	10.3	913.7	948.1	2.5	950.6	2.5	950.6
	27725	923.0	14.0	909.0	14.0	909.0	946.1	2.9	949.0	2.9	949.0
	27545	922.0	15.0	907.0	15.0	907.0	944.3	3.1	947.4	3.1	947.4
	27335	921.0	14.1	906.9	14.1	906.9	943.0	2.7	945.7	2.6	945.6
	27155	920.5	14.0	906.5	14.0	906.5	941.5	2.9	944.4	2.8	944.2
SRC3	26990	920.0	21.0	899.0	14.0	906.0	940.4	2.5	942.9	2.5	942.9
	26780	918.0	21.0	897.0	14.0	904.0	939.3	2.5	941.8	2.5	941.8
	26575	917.0	21.0	896.0	14.0	903.0	938.5	2.5	941.0	2.5	941.0
	26355	916.0	18.0	898.0	12.5	903.5	937.6	2.5	940.1	2.5	940.1
	26170	915.0	18.0	897.0	12.5	902.5	936.9	2.5	939.4	2.5	939.4
	25965	914.0	21.0	893.0	14.0	900.0	936.2	2.5	938.7	2.5	938.7
	25785	913.5	21.0	892.5	14.0	899.5	935.5	2.5	938.0	2.5	938.0
	25600	912.5	21.0	891.5	14.0	898.5	934.8	2.5	937.3	2.5	937.3
	25425	911.0	21.0	890.0	14.0	897.0	934.1	2.5	936.6	2.5	936.6
	25215	910.0	15.0	895.0	10.0	900.0	933.3	2.5	935.8	2.5	935.8
	25000	909.0	15.0	894.0	10.0	899.0	932.5	2.5	935.0	2.5	935.0
SRC4	24795	908.0	15.0	893.0	10.0	898.0	931.5	3.7	935.2	3.4	934.9
	24550	906.0	18.0	888.0	12.5	893.5	930.1	3.4	933.4	3.2	933.2
	24335	905.0	21.0	884.0	14.0	891.0	928.5	3.7	932.2	3.4	931.9
	24115	904.0	21.0	883.0	14.0	890.0	927.0	3.8	930.8	3.5	930.5
	23975	903.5	21.0	882.5	14.0	889.5	926.1	3.6	929.7	3.4	929.5
	23755	902.0	21.0	881.0	14.0	888.0	924.7	3.6	928.4	3.4	928.1
	23565	900.0	21.0	879.0	14.0	886.0	923.6	3.5	927.1	3.3	926.9
	23365	900.0	21.0	879.0	14.0	886.0	922.4	3.5	925.9	3.3	925.7
	23180	899.0	21.0	878.0	14.0	885.0	921.5	3.6	925.0	3.3	924.8
	23000	898.0	21.0	877.0	14.0	884.0	920.0	3.6	923.6	3.3	923.4
	22790	897.5	26.8	870.7	23.0	874.5	917.5	3.9	921.4	3.6	921.1
	22600	896.0	21.0	875.0	14.0	882.0	915.8	3.8	919.6	3.5	919.3
	22415	895.5	21.0	874.5	14.0	881.5	914.4	3.5	918.0	3.3	917.7

1 - Phase 1 Analysis, see end note

2 - Minimum 1999 Bed Elevation

3 - Toe-down and Freeboard based on max of LA County Hydrology & Sedimentation Manual (with SAM general aggradation) and LA County Design Manual, as per Hydrology & Sedimentation Manual

4 - Values at bridges are approxmiate. Final design of levee at bridge locations will include detailed bridge analysis

Table 7.1: Santa Clara River Summary of Proposed Toe-down & Freeboard (ft) continued											
			Outside Curved Reach		Straight-Inside Curved Reach			Outside Curved Reach		Straight-Inside Curved Reach	
Subreach	HEC-RAS Section	Z_{99} [2]	Maximum Total Degradation [3]	Proposed Toe-down Elevation [1,4]	Maximum Total Degradation [3]	Proposed Toe-down Elevation [1,4]	WSE	Maximum Total Freeboard [3]	Proposed Top of Levee Elevation [1]	Maximum Total Freeboard [3]	Proposed Top of Levee Elevation [1]
SRD1	22195	894.0	15.0	879.0	10.0	884.0	913.1	2.5	915.6	2.5	915.6
	22010	892.0	18.0	874.0	12.5	879.5	911.4	3.0	914.3	2.7	914.0
	21790	891.5	21.0	870.5	14.0	877.5	909.9	2.8	912.7	2.5	912.4
	21615	892.0	21.0	871.0	14.0	878.0	908.9	2.5	911.4	2.5	911.4
	21440	890.0	18.0	872.0	12.5	877.5	907.8	2.6	910.4	2.5	910.3
	21225	888.0	21.0	867.0	14.0	874.0	906.7	2.5	909.2	2.5	909.2
	21020	887.0	21.0	866.0	14.0	873.0	905.6	2.5	908.1	2.5	908.1
	20845	886.0	18.0	868.0	12.5	873.5	904.7	2.5	907.2	2.5	907.2
	20595	885.0	15.0	870.0	10.0	875.0	903.6	2.5	906.1	2.5	906.1
	20435	884.0	15.0	869.0	10.0	874.0	902.8	2.5	905.4	2.5	905.3
	20280	883.7	18.0	865.7	12.5	871.2	901.8	2.6	904.4	2.5	904.3
	20070	882.0	21.0	861.0	14.0	868.0	900.6	2.6	903.2	2.5	903.1
SRD2	19855	880.5	21.0	859.5	14.0	866.5	899.6	3.4	903.0	3.2	902.8
	19630	880.0	21.0	859.0	14.0	866.0	898.6	3.4	902.0	3.1	901.8
	19440	878.0	15.0	863.0	10.0	868.0	897.9	3.3	901.1	3.1	901.0
	19240	877.5	18.0	859.5	12.5	865.0	896.9	3.3	900.2	3.2	900.0
	19050	876.0	21.0	855.0	14.0	862.0	896.2	3.1	899.3	3.0	899.2
	18830	874.0	15.0	859.0	10.0	864.0	895.4	3.1	898.5	3.0	898.4
	18650	873.5	15.0	858.5	10.0	863.5	894.7	3.1	897.8	3.0	897.7
	18475	872.0	13.6	858.4	8.0	864.0	894.3	2.9	897.2	2.9	897.1
	18290	871.5	14.1	857.4	8.0	863.5	893.6	3.0	896.6	2.9	896.5
	18025	870.0	8.0	862.0	8.0	862.0	892.9	2.9	895.7	2.9	895.7
	17785	868.0	8.0	860.0	8.0	860.0	892.0	3.0	895.0	3.0	895.0
SRD3	17510	868.0	10.0	858.0	10.0	858.0	890.4	2.5	892.9	2.5	892.9
	17360	868.0	12.5	855.5	12.5	855.5	888.3	2.7	890.9	2.7	890.9
	17110	864.0	14.0	850.0	14.0	850.0	885.5	2.6	888.1	2.6	888.1
	16970	863.7	14.0	849.7	14.0	849.7	884.0	2.6	886.5	2.6	886.5
	16720	863.5	14.0	849.5	14.0	849.5	882.3	2.5	884.8	2.5	884.8
	16515	862.0	14.0	848.0	14.0	848.0	881.2	2.5	883.7	2.5	883.7
	16305	860.0	10.0	850.0	10.0	850.0	880.4	2.5	882.9	2.5	882.9
	16130	860.0	12.5	847.5	12.5	847.5	879.4	2.5	881.9	2.5	881.9
	15960	859.0	12.5	846.5	12.5	846.5	878.6	2.5	881.1	2.5	881.1
	15745	858.0	10.0	848.0	10.0	848.0	877.6	2.5	880.1	2.5	880.1
	15540	857.5	10.0	847.5	10.0	847.5	876.7	2.5	879.2	2.5	879.2
	15335	856.0	12.5	843.5	12.5	843.5	874.8	2.5	877.3	2.5	877.3
SRE1	15125	854.0	26.1	827.9	26.1	827.9	872.0	2.5	874.5	2.5	874.5
	14900	853.0	14.0	839.0	14.0	839.0	869.7	2.5	872.2	2.5	872.2
	14720	852.0	21.0	831.0	14.0	838.0	868.4	2.5	870.9	2.5	870.9
	14480	850.5	21.0	829.5	14.0	836.5	866.9	2.5	869.4	2.5	869.4
	14315	850.0	15.0	835.0	10.0	840.0	866.0	2.5	868.5	2.5	868.5
	14090	850.0	15.0	835.0	10.0	840.0	864.8	2.5	867.3	2.5	867.3
	13850	848.0	15.0	833.0	10.0	838.0	863.6	2.5	866.1	2.5	866.1
	13635	846.0	18.0	828.0	12.5	833.5	862.5	2.5	865.0	2.5	865.0
	13425	845.0	21.0	824.0	14.0	831.0	861.8	2.5	864.3	2.5	864.3
	13190	844.0	15.0	829.0	10.0	834.0	861.1	2.5	863.6	2.5	863.6
SRE2	13030	843.0	15.0	828.0	10.0	833.0	860.6	3.6	864.3	3.6	864.2
	12835	842.0	10.0	832.0	10.0	832.0	860.0	3.6	863.7	3.6	863.6
	12615	841.0	10.0	831.0	10.0	831.0	859.3	3.7	863.0	3.7	863.0
	12395	840.0	10.0	830.0	10.0	830.0	858.7	3.7	862.4	3.7	862.4
	12195	839.0	10.0	829.0	10.0	829.0	858.1	3.7	861.7	3.7	861.7
	11995	837.0	10.0	827.0	10.0	827.0	857.3	3.8	861.1	3.8	861.1
	11780	836.0	10.0	826.0	10.0	826.0	856.6	3.8	860.4	3.8	860.4
	11605	835.5	10.0	825.5	10.0	825.5	855.8	3.9	859.7	3.9	859.7
	11405	834.0	10.0	824.0	10.0	824.0	854.6	4.1	858.7	4.1	858.7
	11180	833.0	12.5	820.5	12.5	820.5	852.7	4.6	857.3	4.6	857.3
SRE3	11015	831.5	14.0	817.5	14.0	817.5	850.2	5.2	855.5	5.2	855.5
	10835	831.0	14.0	817.0	14.0	817.0	848.1	5.1	853.2	5.1	853.2
	10575	830.0	14.0	816.0	14.0	816.0	846.1	4.2	850.3	4.2	850.3
	10390	828.0	14.0	814.0	14.0	814.0	845.1	4.1	849.2	4.1	849.2
	10225	827.5	12.5	815.0	12.5	815.0	844.1	4.0	848.1	4.0	848.1
	10000	826.0	10.0	816.0	10.0	816.0	842.6	4.0	846.5	4.0	846.5
	9820	824.0	14.0	810.0	14.0	810.0	841.4	3.9	845.3	3.9	845.3
	9595	823.8	10.0	813.8	10.0	813.8	839.9	4.0	843.8	3.9	843.8
	9385	823.0	18.0	805.0	12.5	810.5	838.6	3.8	842.4	3.8	842.4
	9220	822.0	18.0	804.0	12.5	809.5	837.6	3.8	841.4	3.7	841.3
	9025	821.0	18.0	803.0	12.5	808.5	836.6	3.8	840.4	3.8	840.4

1 - Phase 1 Analysis, see end note

2 - Minimum 1999 Bed Elevation

3 - Toe-down and Freeboard based on max of LA County Hydrology & Sedimentation Manual (with SAM general aggradation) and LA County Design Manual, as per Hydrology & Sedimentation Manual

4 - Values at bridges are approxmiate. Final design of levee at bridge locations will include detailed bridge analysis

ACOE (TATUM) DEBRIS YIELD: CHIQUITO CANYON CREEK EXISTING Q_{CAP}

P (IN)=	0.00	CP/CQ=	0.85
RR (FT/MI)=	163.68	CRR=	0.53
A (AC)=	3048.00	CA/Q=	0.04
FF=	3.13	CFF=	0.22
Q (FT^3/S/MI^2)=	880.84		
A-T (SEE SHEET A-T)=	0.39		
DY (YD^3/MI^2)=	12,329		
DY (AC FT)=	36		
DY (TON/MI^2)=	17,665		
DY (TON)=	84,128		

VARIABLES:

ENTER PARAMETERS IN RED

YELLOW BACKGROUNDS ARE CALCULATED

CONVERSIONS USED:

1 MI^2 = 639.997 AC; 1 AC = 1.5625E-3 MI^2

1 TON = 907184.74 G; 1 YD^3 = 764554.86 CM^3

DENSITY (G/CM^3)= 1.7

DY= DEBRIS YIELD
P=MAXIMUM 1-HR PRECIP
RR=RELIEF RATIO
A=DRAINAGE AREA
FF=FIRE FACTOR; FF=3 IN DESERTS; SEE SHEET "FF"
Q=PEAK RUNOFF
A-T=ADJUSTMENT-TRANSPOSITION FACTOR; SEE SHEET "AT"

CALCULATIONS FOR DEBRIS YIELD BASED ON ACOE - LA DISTRICT (TATUM) DEBRIS METHOD MANUAL (FEB 2000) "LOS ANGELES DISTRICT METHOD FOR PREDICTION OF DEBRIS YIELD," SECTION 5.3 P. 15. ENTER THE REQUIRED VARIABLES WITH THE REQUIRED UNITS AND THE SHEET WILL CALCULATE THE DEBRIS YIELD USING THE APPROPRIATE COEFFICIENTS. DEBRIS YIELD IN TONS ASSUMES A DENSITY OF 1.7G/CM^3. THE SHEET IS SET UP TO CALCULATE YIELD FOR WATERSHEDS LESS THAN 3 MI^2 USING Q IN LIEU OF P ASSUMING THE REGRESSION FOR SMALL WATERSHEDS IS VALID. ONLY ENTER P FOR WATERSHEDS LESS THAN 3 MI^2 AND WHEN NOT USING Q. DO NOT USE Q AND P IN THE SAME CALCULATION. PLEASE SEE TABLES FOR FIRE FACTOR AND A-T FACTORS. SOIL DENSITY GENERALLY RANGES FROM 1.2 G/CM^3 FOR CLAY SOILS TO 1.7 G/CM^3 FOR SAND SOILS. PARTICLE DENSITY IS APPROXIMATELY 2.65 G/CM^3.

4061.64	3068.3	847.1954
1626.47	989.1	1052.412
2842.13	2139	850.3802
3309	2938	720.8169
4070.88	2866.6	908.8688
784	4737	105.9236
2937.53	1968.8	954.9061
1363	850	1026.259

BY DAVID A. JAFFE, PHD, PE
PACIFIC ADVANCED CIVIL ENGINEERING, INC (PACE)
AUGUST, 2007

PACIFIC ADVANCED CIVIL ENGINEERING, INC.

ACOE (TATUM) DEBRIS YIELD: CHIQUITO CANYON CREEK PROPOSED Q_{CAP}

P (IN)=	0.00	CP/CQ=	0.85
RR (FT/MI)=	163.68	CRR=	0.53
A (AC)=	2900.00	CA/Q=	0.04
FF=	3.13	CFF=	0.22
Q (FT^3/S/MI^2)=	914.80		
A-T (SEE SHEET A-T)=	0.39		
DY (YD^3/MI^2)=	12,707		
DY (AC FT)=	36		
DY (TON/MI^2)=	18,205		
DY (TON)=	82,494		

VARIABLES:
ENTER PARAMETERS IN RED
YELLOW BACKGROUNDS ARE CALCULATED

CONVERSIONS USED:
1 MI^2 = 639.997 AC; 1 AC = 1.5625E-3 MI^2
1 TON = 907184.74 G; 1 YD^3 = 764554.86 CM^3
DENSITY (G/CM^3)= 1.7

DY= DEBRIS YIELD
P=MAXIMUM 1-HR PRECIP
RR=RELIEF RATIO
A=DRAINAGE AREA
FF=FIRE FACTOR; FF=3 IN DESERTS; SEE SHEET "FF"
Q=PEAK RUNOFF
A-T=ADJUSTMENT-TRANSPOSITION FACTOR; SEE SHEET "AT"

CALCULATIONS FOR DEBRIS YIELD BASED ON ACOE - LA DISTRICT (TATUM) DEBRIS METHOD MANUAL (FEB 2000) "LOS ANGELES DISTRICT METHOD FOR PREDICTION OF DEBRIS YIELD," SECTION 5.3 P. 15. ENTER THE REQUIRED VARIABLES WITH THE REQUIRED UNITS AND THE SHEET WILL CALCULATE THE DEBRIS YIELD USING THE APPROPRIATE COEFFICIENTS. DEBRIS YIELD IN TONS ASSUMES A DENSITY OF 1.7G/CM^3. THE SHEET IS SET UP TO CALCULATE YIELD FOR WATERSHEDS LESS THAN 3 MI^2 USING Q IN LIEU OF P ASSUMING THE REGRESSION FOR SMALL WATERSHEDS IS VALID. ONLY ENTER P FOR WATERSHEDS LESS THAN 3 MI^2 AND WHEN NOT USING Q. DO NOT USE Q AND P IN THE SAME CALCULATION. PLEASE SEE TABLES FOR FIRE FACTOR AND A-T FACTORS. SOIL DENSITY GENERALLY RANGES FROM 1.2 G/CM^3 FOR CLAY SOILS TO 1.7 G/CM^3 FOR SAND SOILS. PARTICLE DENSITY IS APPROXIMATELY 2.65 G/CM^3.

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ACOE (TATUM) DEBRIS YIELD: GRANDE CANYON CREEK EXISTING Q_{CAP}

P (IN)=	0.00	CP/CQ=	0.85
RR (FT/MI)=	311.54	CRR=	0.53
A (AC)=	2134.00	CA/Q=	0.04
FF=	3.13	CFF=	0.22
Q (FT^3/S/MI^2)=	1175.93		
A-T (SEE SHEET A-T)=	0.39		
DY (YD^3/MI^2)=	21,855		
DY (AC FT)=	45		
DY (TON/MI^2)=	31,312		
DY (TON)=	104,408		

VARIABLES:

ENTER PARAMETERS IN RED

YELLOW BACKGROUNDS ARE CALCULATED

CONVERSIONS USED:

1 MI^2 = 639.997 AC; 1 AC = 1.5625E-3 MI^2

1 TON = 907184.74 G; 1 YD^3 = 764554.86 CM^3

DENSITY (G/CM^3)= 1.7

DY= DEBRIS YIELD
P=MAXIMUM 1-HR PRECIP
RR=RELIEF RATIO
A=DRAINAGE AREA
FF=FIRE FACTOR; FF=3 IN DESERTS; SEE SHEET "FF"
Q=PEAK RUNOFF
A-T=ADJUSTMENT-TRANSPOSITION FACTOR; SEE SHEET "AT"

CALCULATIONS FOR DEBRIS YIELD BASED ON ACOE - LA DISTRICT (TATUM) DEBRIS METHOD MANUAL (FEB 2000) "LOS ANGELES DISTRICT METHOD FOR PREDICTION OF DEBRIS YIELD," SECTION 5.3 P. 15. ENTER THE REQUIRED VARIABLES WITH THE REQUIRED UNITS AND THE SHEET WILL CALCULATE THE DEBRIS YIELD USING THE APPROPRIATE COEFFICIENTS. DEBRIS YIELD IN TONS ASSUMES A DENSITY OF 1.7G/CM^3. THE SHEET IS SET UP TO CALCULATE YIELD FOR WATERSHEDS LESS THAN 3 MI^2 USING Q IN LIEU OF P ASSUMING THE REGRESSION FOR SMALL WATERSHEDS IS VALID. ONLY ENTER P FOR WATERSHEDS LESS THAN 3 MI^2 AND WHEN NOT USING Q. DO NOT USE Q AND P IN THE SAME CALCULATION. PLEASE SEE TABLES FOR FIRE FACTOR AND A-T FACTORS. SOIL DENSITY GENERALLY RANGES FROM 1.2 G/CM^3 FOR CLAY SOILS TO 1.7 G/CM^3 FOR SAND SOILS. PARTICLE DENSITY IS APPROXIMATELY 2.65 G/CM^3.

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ACOE (TATUM) DEBRIS YIELD: GRANDE CANYON CREEK PROPOSED Q_{CAP}

P (IN)=	0.00	CP/CQ=	0.85
RR (FT/MI)=	311.54	CRR=	0.53
A (AC)=	2030.00	CA/Q=	0.04
FF=	3.13	CFF=	0.22
Q (FT^3/S/MI^2)=	1232.10		
A-T (SEE SHEET A-T)=	0.39		
DY (YD^3/MI^2)=	22,694		
DY (AC FT)=	45		
DY (TON/MI^2)=	32,514		
DY (TON)=	103,131		

VARIABLES:
ENTER PARAMETERS IN RED
YELLOW BACKGROUNDS ARE CALCULATED

CONVERSIONS USED:
1 MI^2 = 639.997 AC; 1 AC = 1.5625E-3 MI^2
1 TON = 907184.74 G; 1 YD^3 = 764554.86 CM^3
DENSITY (G/CM^3)= 1.7

DY= DEBRIS YIELD
P=MAXIMUM 1-HR PRECIP
RR=RELIEF RATIO
A=DRAINAGE AREA
FF=FIRE FACTOR; FF=3 IN DESERTS; SEE SHEET "FF"
Q=PEAK RUNOFF
A-T=ADJUSTMENT-TRANSPOSITION FACTOR; SEE SHEET "AT"

CALCULATIONS FOR DEBRIS YIELD BASED ON ACOE - LA DISTRICT (TATUM) DEBRIS METHOD MANUAL (FEB 2000) "LOS ANGELES DISTRICT METHOD FOR PREDICTION OF DEBRIS YIELD," SECTION 5.3 P. 15. ENTER THE REQUIRED VARIABLES WITH THE REQUIRED UNITS AND THE SHEET WILL CALCULATE THE DEBRIS YIELD USING THE APPROPRIATE COEFFICIENTS. DEBRIS YIELD IN TONS ASSUMES A DENSITY OF 1.7G/CM^3. THE SHEET IS SET UP TO CALCULATE YIELD FOR WATERSHEDS LESS THAN 3 MI^2 USING Q IN LIEU OF P ASSUMING THE REGRESSION FOR SMALL WATERSHEDS IS VALID. ONLY ENTER P FOR WATERSHEDS LESS THAN 3 MI^2 AND WHEN NOT USING Q. DO NOT USE Q AND P IN THE SAME CALCULATION. PLEASE SEE TABLES FOR FIRE FACTOR AND A-T FACTORS. SOIL DENSITY GENERALLY RANGES FROM 1.2 G/CM^3 FOR CLAY SOILS TO 1.7 G/CM^3 FOR SAND SOILS. PARTICLE DENSITY IS APPROXIMATELY 2.65 G/CM^3.

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AUGUST, 2007

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ACOE (TATUM) DEBRIS YIELD: LONG CANYON CREEK EXISTING Q_{CAP}

P (IN)=	0.00	CP/CQ=	0.85
RR (FT/MI)=	274.56	CRR=	0.53
A (AC)=	989.00	CA/Q=	0.04
FF=	3.07	CFF=	0.22
Q (FT^3/S/MI^2)=	938.30		
A-T (SEE SHEET A-T)=	0.39		
DY (YD^3/MI^2)=	15,870		
DY (AC FT)=	15		
DY (TON/MI^2)=	22,737		
DY (TON)=	35,136		

VARIABLES:

ENTER PARAMETERS IN RED

YELLOW BACKGROUNDS ARE CALCULATED

CONVERSIONS USED:

1 MI^2 = 639.997 AC; 1 AC = 1.5625E-3 MI^2

1 TON = 907184.74 G; 1 YD^3 = 764554.86 CM^3

DENSITY (G/CM^3)= 1.7

DY= DEBRIS YIELD
P=MAXIMUM 1-HR PRECIP
RR=RELIEF RATIO
A=DRAINAGE AREA
FF=FIRE FACTOR; FF=3 IN DESERTS; SEE SHEET "FF"
Q=PEAK RUNOFF
A-T=ADJUSTMENT-TRANSPOSITION FACTOR; SEE SHEET "AT"

CALCULATIONS FOR DEBRIS YIELD BASED ON ACOE - LA DISTRICT (TATUM) DEBRIS METHOD MANUAL (FEB 2000) "LOS ANGELES DISTRICT METHOD FOR PREDICTION OF DEBRIS YIELD," SECTION 5.3 P. 15. ENTER THE REQUIRED VARIABLES WITH THE REQUIRED UNITS AND THE SHEET WILL CALCULATE THE DEBRIS YIELD USING THE APPROPRIATE COEFFICIENTS. DEBRIS YIELD IN TONS ASSUMES A DENSITY OF 1.7G/CM^3. THE SHEET IS SET UP TO CALCULATE YIELD FOR WATERSHEDS LESS THAN 3 MI^2 USING Q IN LIEU OF P ASSUMING THE REGRESSION FOR SMALL WATERSHEDS IS VALID. ONLY ENTER P FOR WATERSHEDS LESS THAN 3 MI^2 AND WHEN NOT USING Q. DO NOT USE Q AND P IN THE SAME CALCULATION. PLEASE SEE TABLES FOR FIRE FACTOR AND A-T FACTORS. SOIL DENSITY GENERALLY RANGES FROM 1.2 G/CM^3 FOR CLAY SOILS TO 1.7 G/CM^3 FOR SAND SOILS. PARTICLE DENSITY IS APPROXIMATELY 2.65 G/CM^3.

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AUGUST, 2007

PACE
PACIFIC ADVANCED
CIVIL ENGINEERING, INC.

ACOE (TATUM) DEBRIS YIELD: LONG CANYON CREEK PROPOSED Q_{CAP}

P (IN)=	0.00	CP/CQ=	0.85
RR (FT/MI)=	274.56	CRR=	0.53
A (AC)=	945.00	CA/Q=	0.04
FF=	3.07	CFF=	0.22
Q (FT^3/S/MI^2)=	883.80		
A-T (SEE SHEET A-T)=	0.39		
DY (YD^3/MI^2)=	15,056		
DY (AC FT)=	14		
DY (TON/MI^2)=	21,570		
DY (TON)=	31,850		

VARIABLES:
ENTER PARAMETERS IN RED
YELLOW BACKGROUNDS ARE CALCULATED

CONVERSIONS USED:
1 MI^2 = 639.997 AC; 1 AC = 1.5625E-3 MI^2
1 TON = 907184.74 G; 1 YD^3 = 764554.86 CM^3
DENSITY (G/CM^3)= 1.7

DY= DEBRIS YIELD
P=MAXIMUM 1-HR PRECIP
RR=RELIEF RATIO
A=DRAINAGE AREA
FF=FIRE FACTOR; FF=3 IN DESERTS; SEE SHEET "FF"
Q=PEAK RUNOFF
A-T=ADJUSTMENT-TRANSPOSITION FACTOR; SEE SHEET "AT"

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PACIFIC ADVANCED CIVIL ENGINEERING, INC (PACE)
AUGUST, 2007

PACE
PACIFIC ADVANCED CIVIL ENGINEERING, INC.

ACOE (TATUM) DEBRIS YIELD: POTRERO CANYON CREEK EXISTING Q_{CAP}

P (IN)x100=	0.00	CP/CQ=	0.85
RR (FT/MI)=	174.24	CRR=	0.53
A (AC)=	2857.00	CA/Q=	0.04
FF=	3.13	CFF=	0.22
Q (FT^3/S/MI^2)=	995.70		
A-T (SEE SHEET A-T)=	0.39		
DY (YD^3/MI^2)=	14,260		
DY (AC FT)=	39		
DY (TON/MI^2)=	20,431		
DY (TON)=	91,204		

VARIABLES:

ENTER PARAMETERS IN RED

YELLOW BACKGROUNDS ARE CALCULATED

CONVERSIONS USED:

1 MI^2 = 639.997 AC; 1 AC = 1.5625E-3 MI^2

1 TON = 907184.74 G; 1 YD^3 = 764554.86 CM^3

DENSITY (G/CM^3)= 1.7

DY= DEBRIS YIELD
P=MAXIMUM 1-HR PRECIP x100
RR=RELIEF RATIO
A=DRAINAGE AREA
FF=FIRE FACTOR; FF=3 IN DESERTS; SEE SHEET "FF"
Q=PEAK RUNOFF
A-T=ADJUSTMENT-TRANSPOSITION FACTOR; SEE SHEET "AT"

CALCULATIONS FOR DEBRIS YIELD BASED ON ACOE - LA DISTRICT (TATUM) DEBRIS METHOD MANUAL (FEB 2000) "LOS ANGELES DISTRICT METHOD FOR PREDICTION OF DEBRIS YIELD," SECTION 5.3 P. 15. ENTER THE REQUIRED VARIABLES WITH THE REQUIRED UNITS AND THE SHEET WILL CALCULATE THE DEBRIS YIELD USING THE APPROPRIATE COEFFICIENTS. DEBRIS YIELD IN TONS ASSUMES A DENSITY OF 1.7G/CM^3. THE SHEET IS SET UP TO CALCULATE YIELD FOR WATERSHEDS LESS THAN 3 MI^2 USING Q IN LIEU OF P ASSUMING THE REGRESSION FOR SMALL WATERSHEDS IS VALID. ONLY ENTER P FOR WATERSHEDS LESS THAN 3 MI^2 AND WHEN NOT USING Q. DO NOT USE Q AND P IN THE SAME CALCULATION. PLEASE SEE TABLES FOR FIRE FACTOR AND A-T FACTORS. SOIL DENSITY GENERALLY RANGES FROM 1.2 G/CM^3 FOR CLAY SOILS TO 1.7 G/CM^3 FOR SAND SOILS. PARTICLE DENSITY IS APPROXIMATELY 2.65 G/CM^3.

BY DAVID A. JAFFE, PHD, PE
PACIFIC ADVANCED CIVIL ENGINEERING, INC (PACE)
MARCH, 2006

PACE
PACIFIC ADVANCED CIVIL ENGINEERING, INC.

ACOE (TATUM) DEBRIS YIELD: POTRERO CANYON CREEK PROPOSED Q_{CAP}

P (IN)x100=	0.00	CP/CQ=	0.85
RR (FT/MI)=	174.24	CRR=	0.53
A (AC)=	2060.00	CA/Q=	0.04
FF=	3.13	CFF=	0.22
Q (FT^3/S/MI^2)=	1294.30		
A-T (SEE SHEET A-T)=	0.39		
DY (YD^3/MI^2)=	17,590		
DY (AC FT)=	35		
DY (TON/MI^2)=	25,201		
DY (TON)=	81,116		

VARIABLES:

ENTER PARAMETERS IN RED

YELLOW BACKGROUNDS ARE CALCULATED

CONVERSIONS USED:

1 MI^2 = 639.997 AC; 1 AC = 1.5625E-3 MI^2

1 TON = 907184.74 G; 1 YD^3 = 764554.86 CM^3

DENSITY (G/CM^3)= 1.7

DY= DEBRIS YIELD
P=MAXIMUM 1-HR PRECIP x100
RR=RELIEF RATIO
A=DRAINAGE AREA
FF=FIRE FACTOR; FF=3 IN DESERTS; SEE SHEET "FF"
Q=PEAK RUNOFF
A-T=ADJUSTMENT-TRANSPOSITION FACTOR; SEE SHEET "AT"

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AUGUST, 2007

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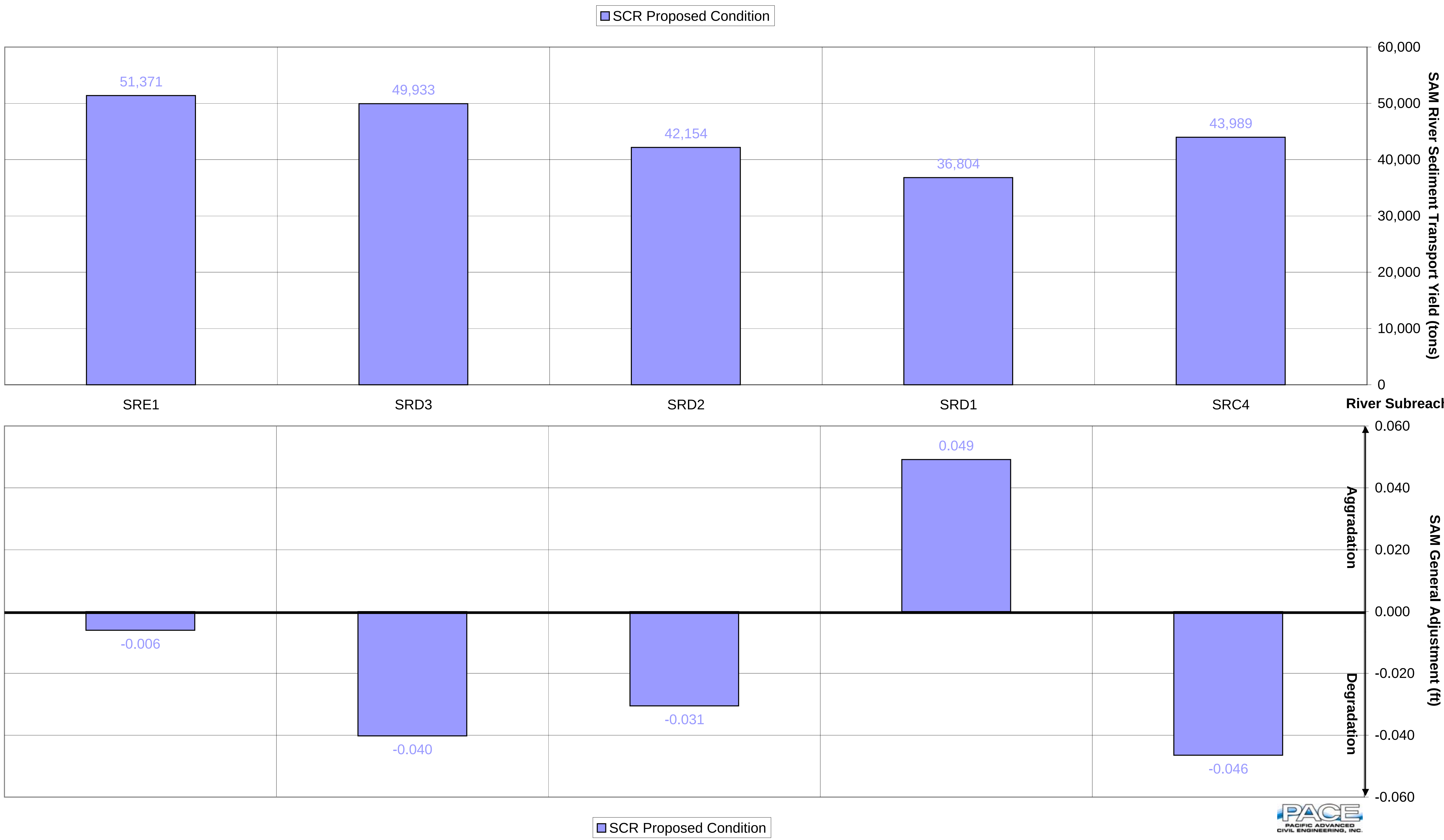
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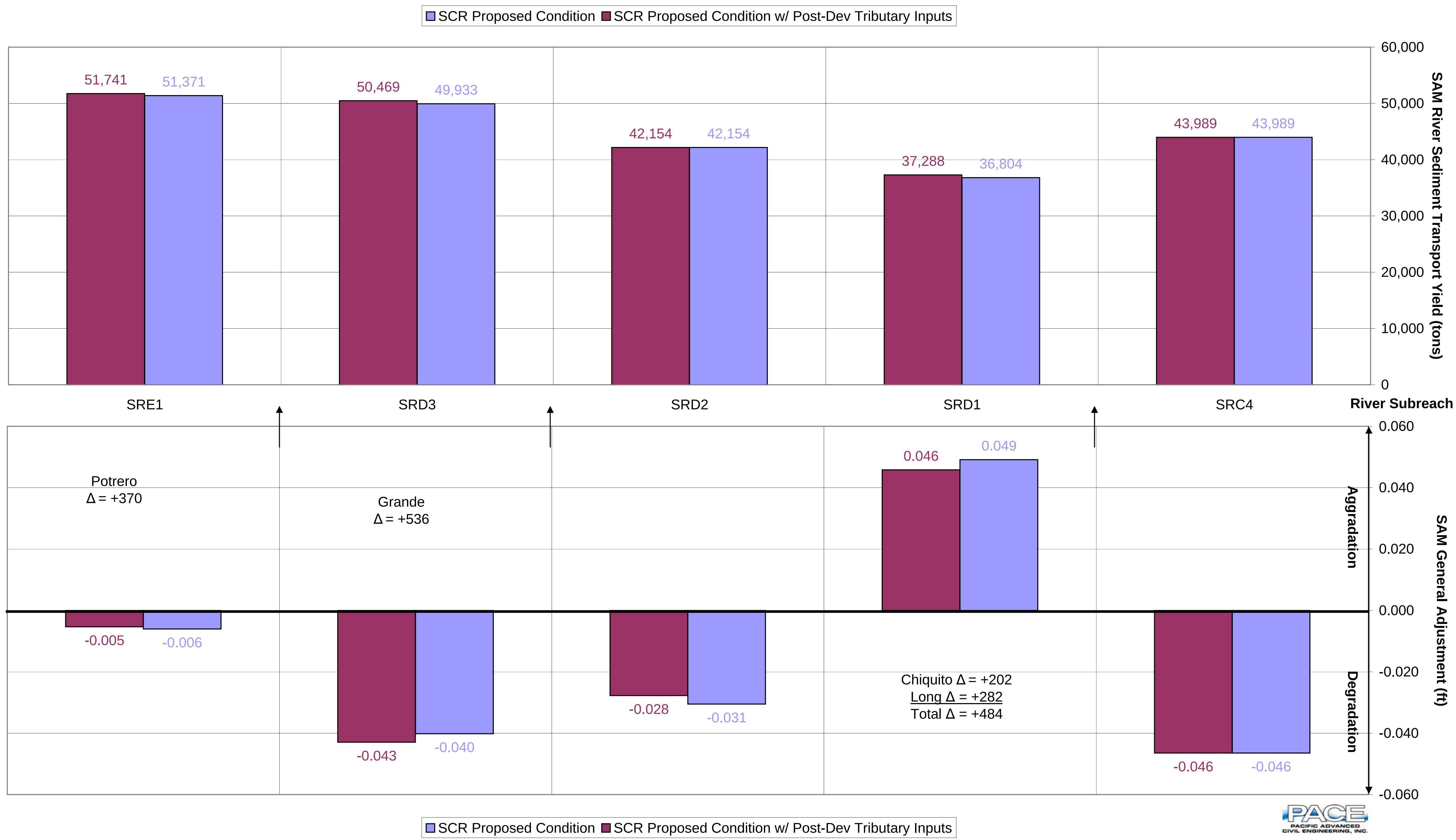
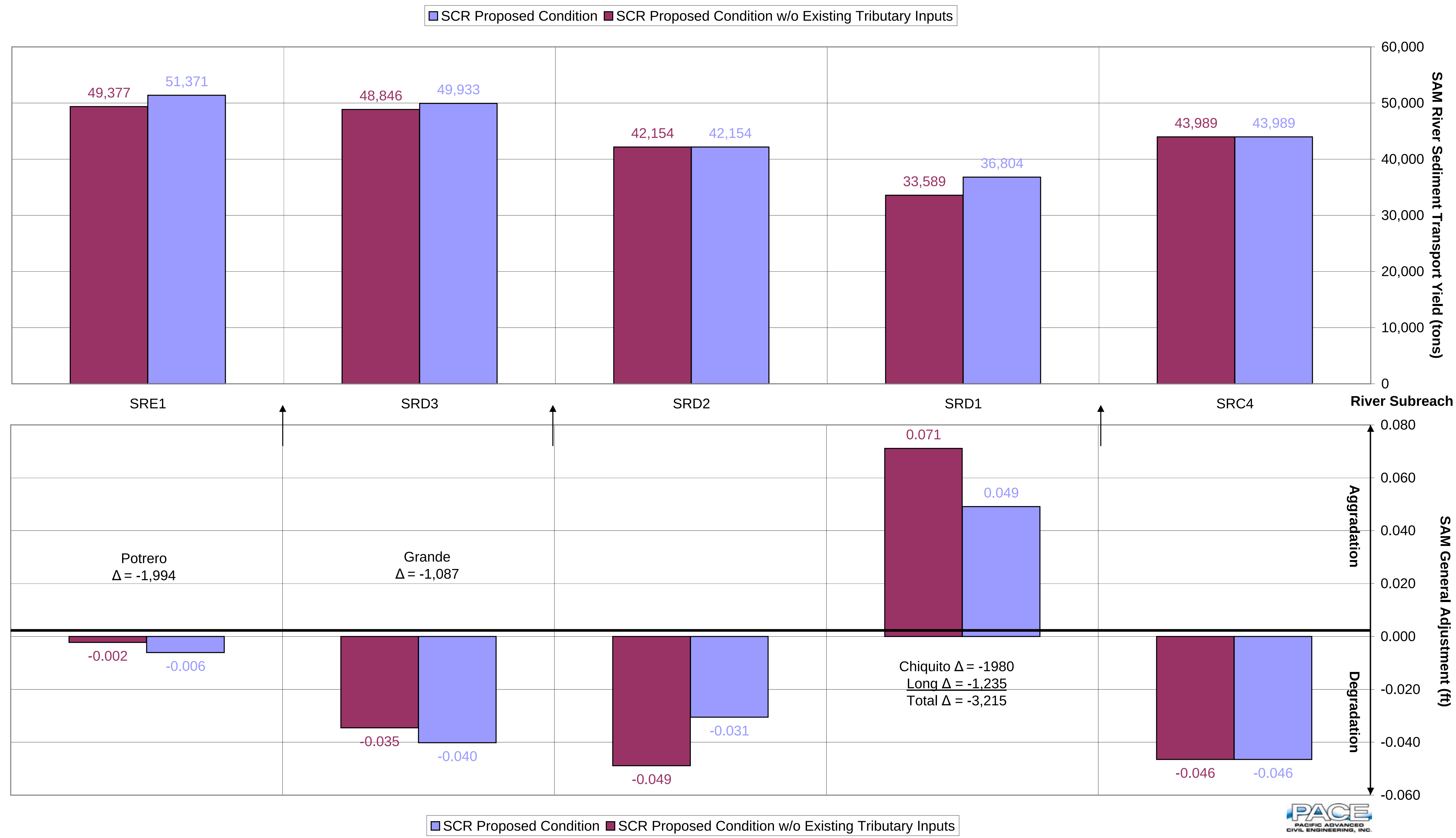
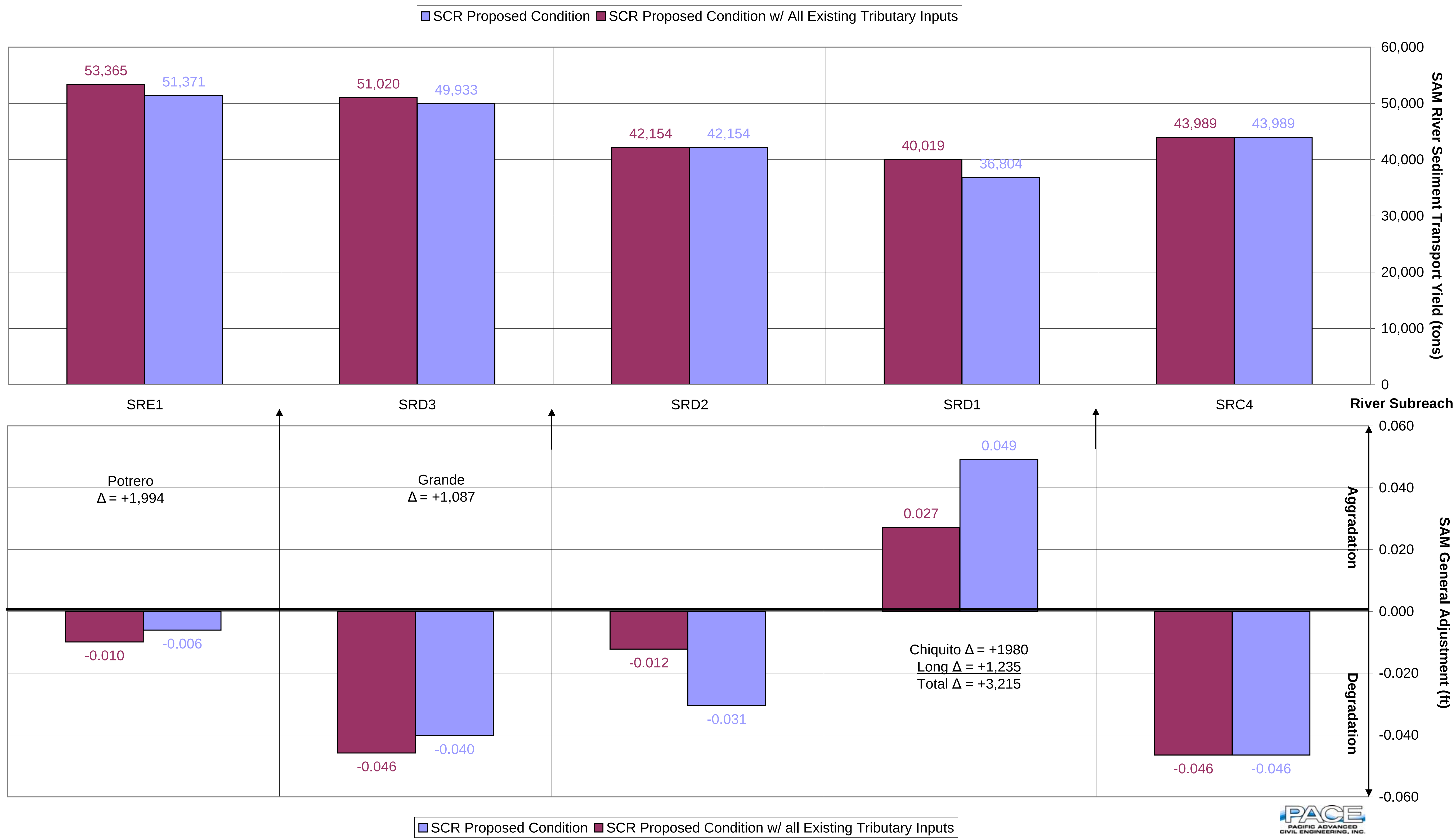
51,371
49,933
42,154
36,804
43,989
60,000
50,000
40,000
30,000
20,000
10,000
0
SAM River Sediment Transport Yield (tons)
SRE1
SRD3
SRD2
SRD1
SRC4
River Subreach
0.060
0.040
0.020
0.000
-0.020
-0.040
-0.060
Aggradation
Degradation
SAM General Adjustment (ft)
0.049
-0.006
-0.040
-0.031
-0.046
SCR Proposed Condition
PACE
PACIFIC ADVANCED CIVIL ENGINEERING, INC.



SCR Proposed Condition
SCR Proposed Condition w/ Post-Dev Tributary Inputs
SAM River Sediment Transport Yield (tons)
60,000
50,000
40,000
30,000
20,000
10,000
0
51,741
51,371
50,469
49,933
42,154
42,154
37,288
36,804
43,989
43,989
SRE1
SRD3
SRD2
SRD1
SRC4
River Subreach
Potrero
Δ = +370
Grande
Δ = +536
Chiquito Δ = +202
Long Δ = +282
Total Δ = +484
0.046
0.049
-0.005
-0.006
-0.043
-0.040
-0.028
-0.031
-0.046
-0.046
0.060
0.040
0.020
0.000
-0.020
-0.040
-0.060
Aggradation
Degradation
SAM General Adjustment (ft)
SCR Proposed Condition
SCR Proposed Condition w/ Post-Dev Tributary Inputs


SCR Proposed Condition
SCR Proposed Condition w/o Existing Tributary Inputs
49,377
51,371
48,846
49,933
42,154
42,154
33,589
36,804
43,989
43,989
60,000
50,000
40,000
30,000
20,000
10,000
0
SAM River Sediment Transport Yield (tons)
SRE1
SRD3
SRD2
SRD1
SRC4
River Subreach
0.080
0.060
0.040
0.020
0.000
-0.020
-0.040
-0.060
Aggradation
Degradation
SAM General Adjustment (ft)
Potrero
Δ = -1,994
Grande
Δ = -1,087
Chiquito Δ = -1980
Long Δ = -1,235
Total Δ = -3,215
0.071
0.049
-0.002
-0.006
-0.035
-0.040
-0.049
-0.031
-0.046
-0.046
SCR Proposed Condition
SCR Proposed Condition w/o Existing Tributary Inputs
PACE
PACIFIC ADVANCED CIVIL ENGINEERING, INC.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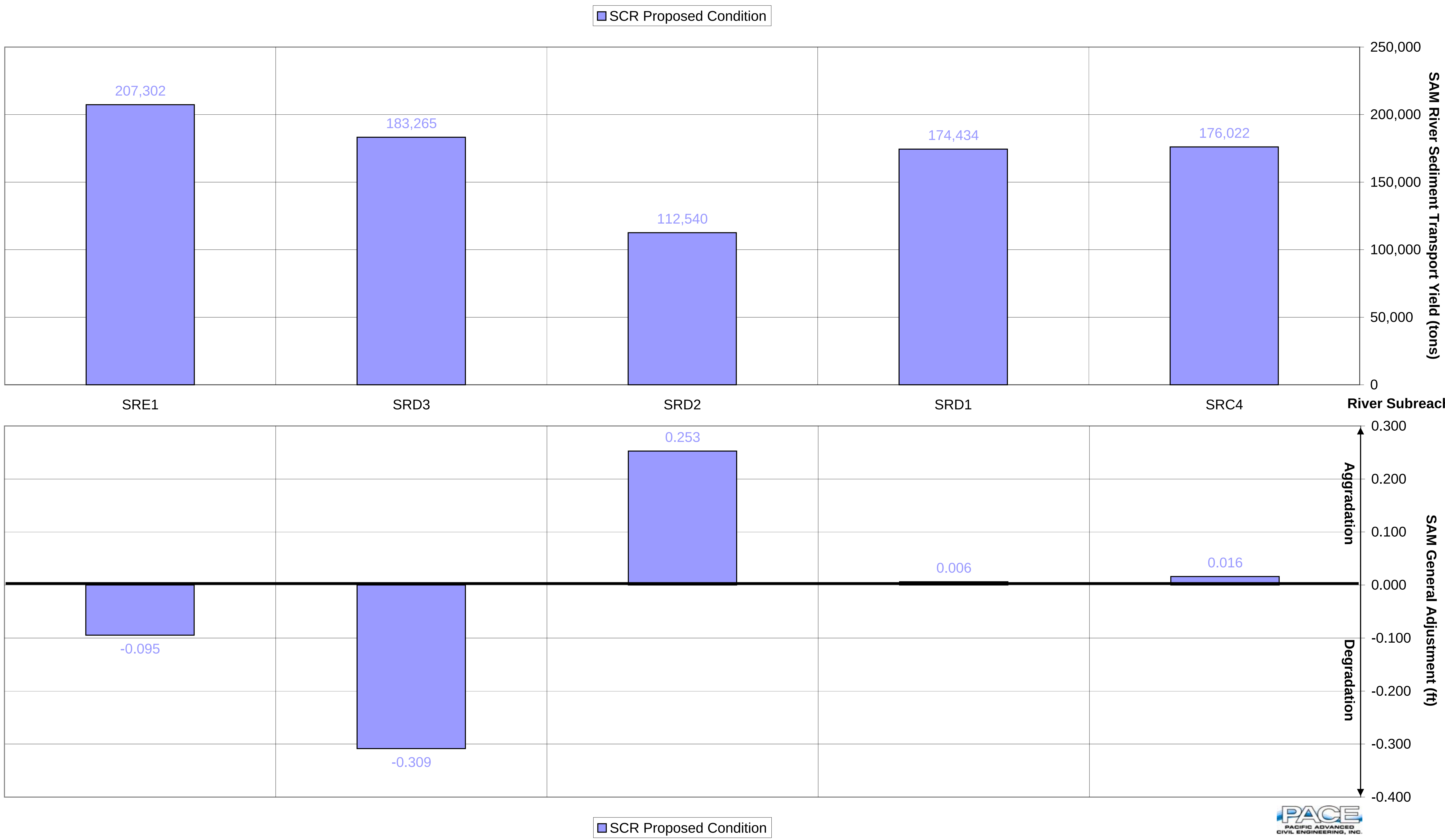
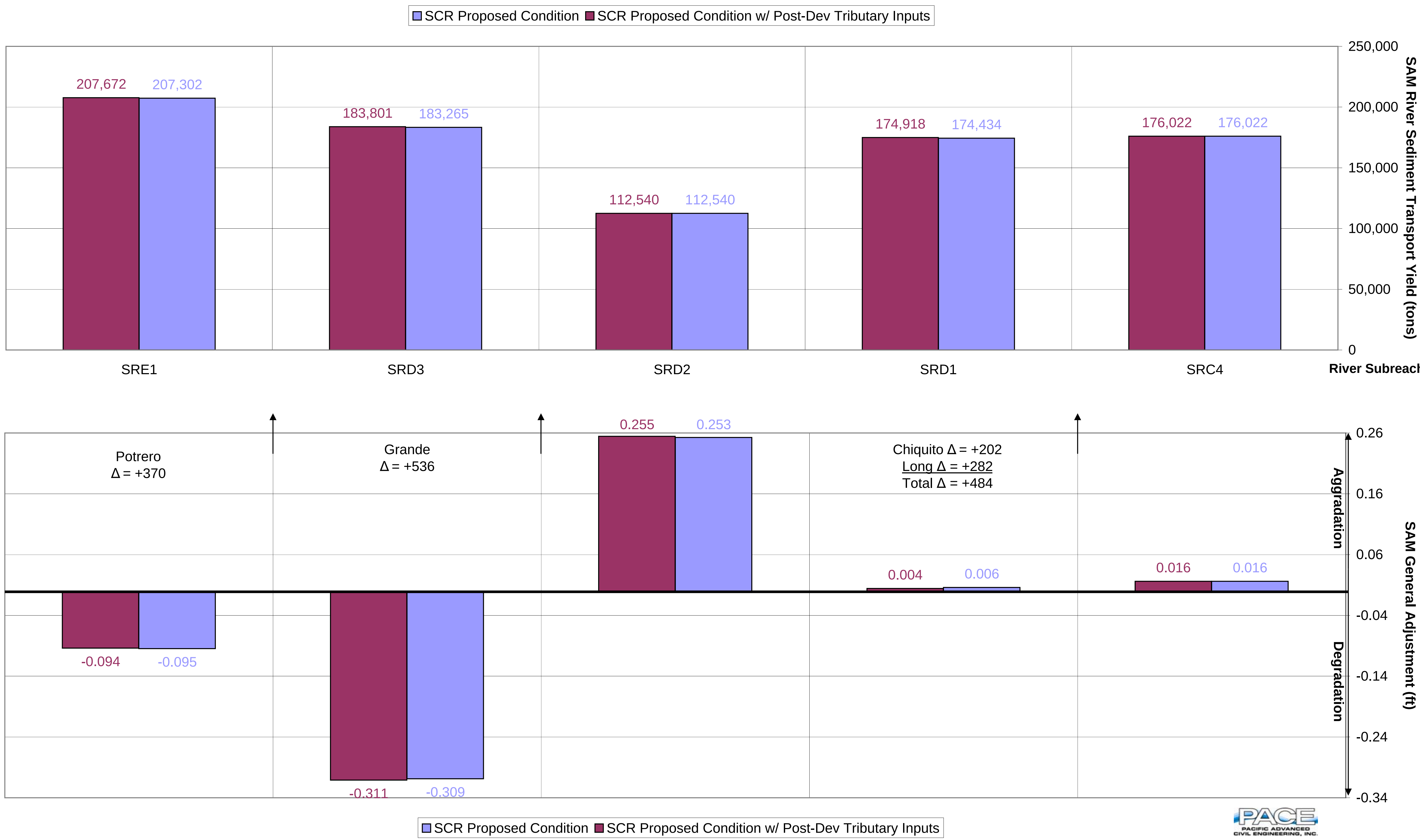
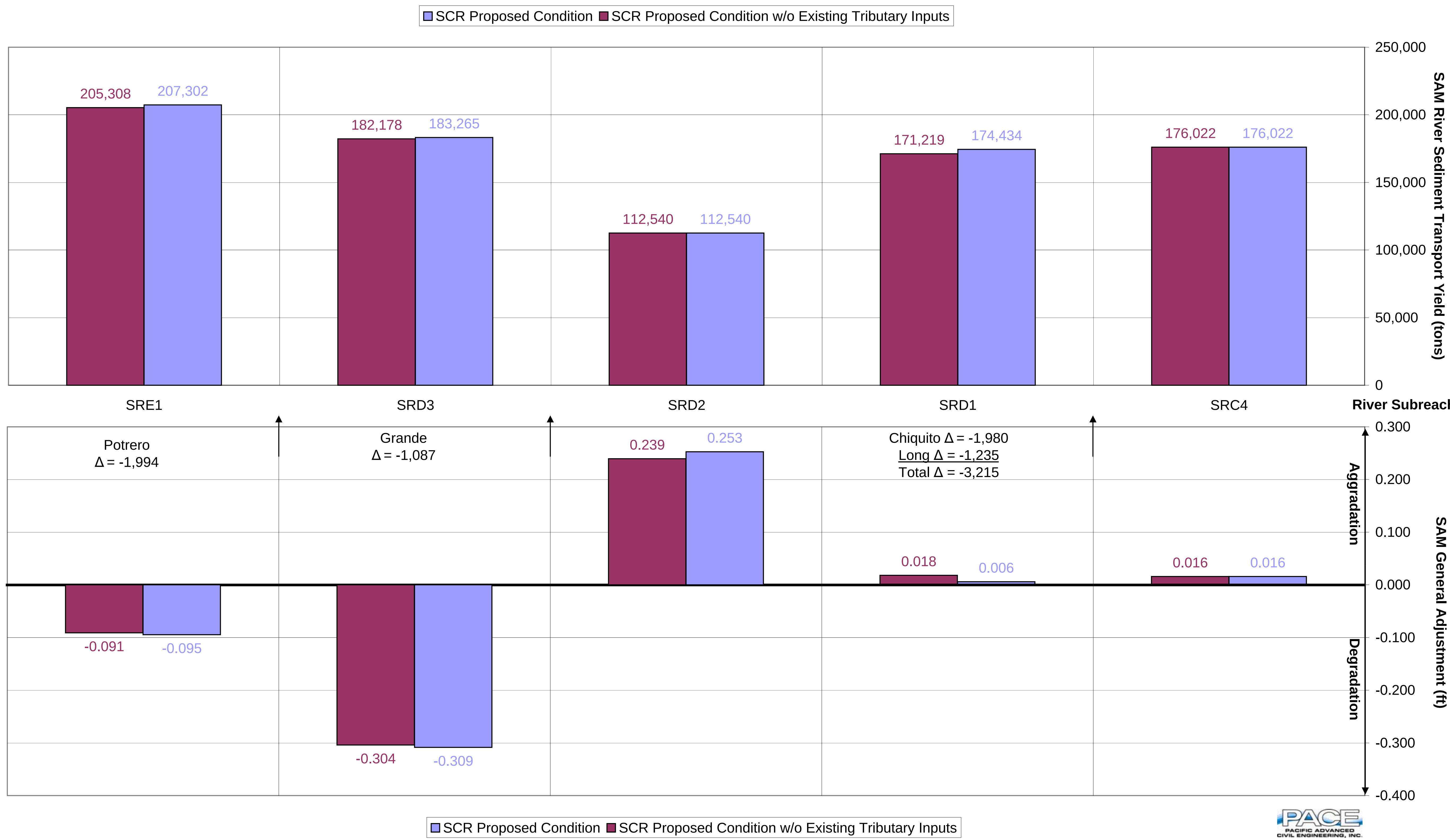
SCR Proposed Condition w/ All Existing Tributary Inputs
53,365
51,371
51,020
49,933
42,154
42,154
40,019
36,804
43,989
43,989
60,000
50,000
40,000
30,000
20,000
10,000
0
SAM River Sediment Transport Yield (tons)
SRE1
SRD3
SRD2
SRD1
SRC4
River Subreach
Potrero
Δ = +1,994
Grande
Δ = +1,087
0.049
0.027
-0.010
-0.006
-0.046
-0.040
-0.012
-0.031
Chiquito Δ = +1980
Long Δ = +1,235
Total Δ = +3,215
-0.046
-0.046
Aggradation
Degradation
0.060
0.040
0.020
0.000
-0.020
-0.040
-0.060
SAM General Adjustment (ft)
SCR Proposed Condition
SCR Proposed Condition w/ all Existing Tributary Inputs
PACE
PACIFIC ADVANCED CIVIL ENGINEERING, INC.


SCR Proposed Condition
207,302
183,265
112,540
174,434
176,022
250,000
200,000
150,000
100,000
50,000
0
SAM River Sediment Transport Yield (tons)
SRE1
SRD3
SRD2
SRD1
SRC4
River Subreach
0.253
0.006
0.016
-0.095
-0.309
0.300
0.200
0.100
0.000
-0.100
-0.200
-0.300
-0.400
Aggradation
Degradation
SAM General Adjustment (ft)
SCR Proposed Condition



SCR Proposed Condition
SCR Proposed Condition w/ Post-Dev Tributary Inputs
207,672
207,302
183,801
183,265
112,540
112,540
174,918
174,434
176,022
176,022
250,000
200,000
150,000
100,000
50,000
0
SAM River Sediment Transport Yield (tons)
SRE1
SRD3
SRD2
SRD1
SRC4
River Subreach
Potrero
Δ = +370
Grande
Δ = +536
Chiquito Δ = +202
Long Δ = +282
Total Δ = +484
0.255
0.253
0.004
0.006
0.016
0.016
-0.094
-0.095
-0.311
-0.309
0.26
0.16
0.06
-0.04
-0.14
-0.24
-0.34
Aggradation
Degradation
SAM General Adjustment (ft)
SCR Proposed Condition
SCR Proposed Condition w/ Post-Dev Tributary Inputs
PACE
PACIFIC ADVANCED CIVIL ENGINEERING, INC.


SCR Proposed Condition
SCR Proposed Condition w/o Existing Tributary Inputs
250,000
200,000
150,000
100,000
50,000
0
SAM River Sediment Transport Yield (tons)
205,308
207,302
182,178
183,265
112,540
112,540
171,219
174,434
176,022
176,022
SRE1
SRD3
SRD2
SRD1
SRC4
River Subreach
Potrero
Δ = -1,994
Grande
Δ = -1,087
Chiquito Δ = -1,980
Long Δ = -1,235
Total Δ = -3,215
0.239
0.253
0.018
0.006
0.016
0.016
-0.091
-0.095
-0.304
-0.309
Aggradation
Degradation
0.300
0.200
0.100
0.000
-0.100
-0.200
-0.300
-0.400
SAM General Adjustment (ft)
SCR Proposed Condition
SCR Proposed Condition w/o Existing Tributary Inputs
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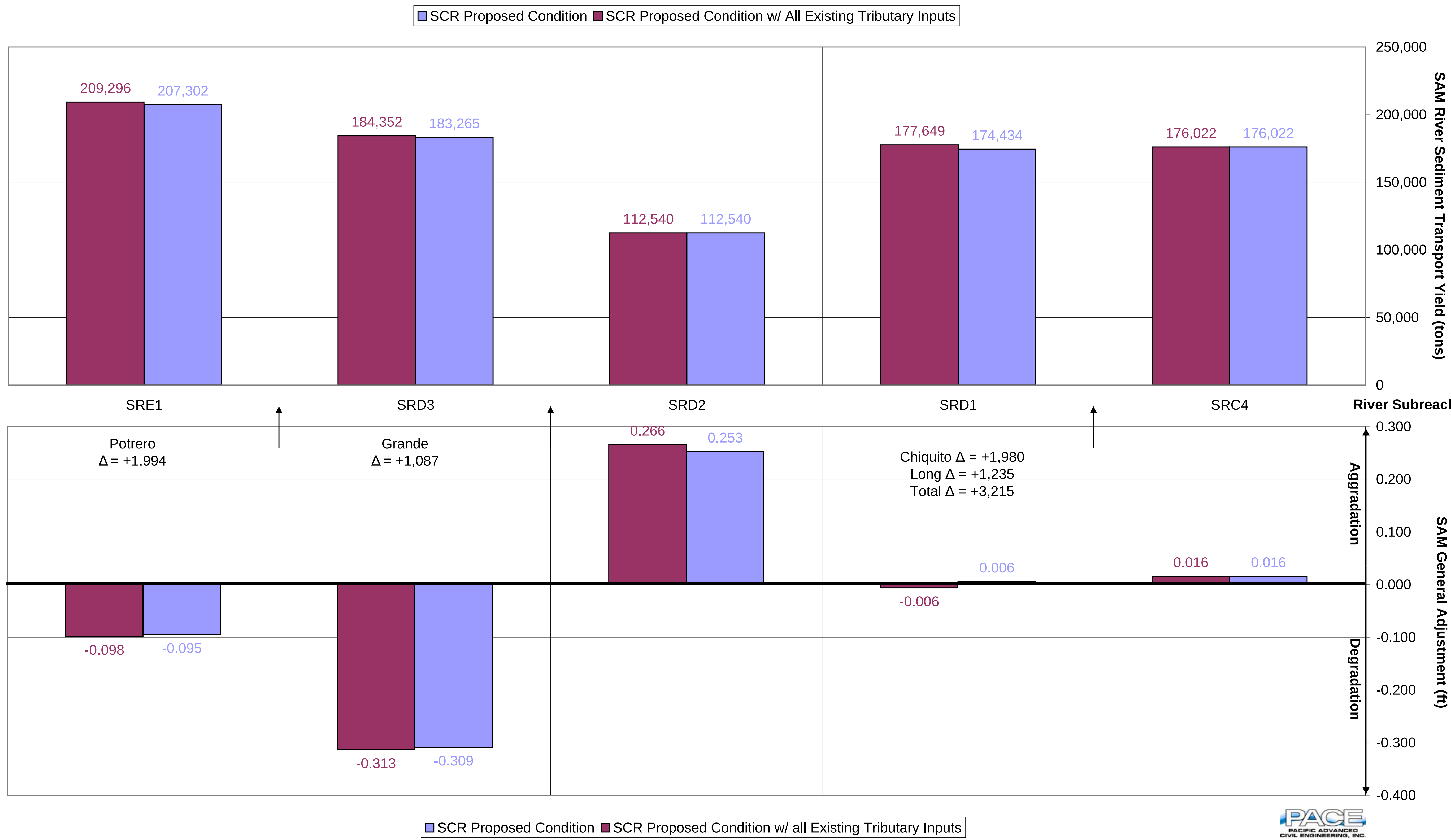
SCR Proposed Condition
SCR Proposed Condition w/ All Existing Tributary Inputs
209,296
207,302
184,352
183,265
112,540
112,540
177,649
174,434
176,022
176,022
250,000
200,000
150,000
100,000
50,000
0
SAM River Sediment Transport Yield (tons)
SRE1
SRD3
SRD2
SRD1
SRC4
River Subreach
Potrero
Δ = +1,994
Grande
Δ = +1,087
Chiquito Δ = +1,980
Long Δ = +1,235
Total Δ = +3,215
0.266
0.253
0.016
0.016
0.006
-0.006
-0.098
-0.095
-0.313
-0.309
0.300
0.200
0.100
0.000
-0.100
-0.200
-0.300
-0.400
Aggradation
Degradation
SAM General Adjustment (ft)
SCR Proposed Condition
SCR Proposed Condition w/ all Existing Tributary Inputs
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MEMORANDUM

Date:	January 14, 2008
To:	Corey Harpole[1], Matt Carpenter[1], Mark Krebbs[2] and David Jaffey[2]
Organization:	[1]Newhall Land, [2]PACE
From:	Setenay Bozkurt and Andrew Collison
PWA Project #:	1820
PWA Project Name:	Newhall Ranch
Subject:	A review of sediment yield and sediment transport estimates in the Newhall Ranch tributary watersheds
Copy(ies) To:	File

Analytical studies performed by PACE have highlighted the discrepancy between estimated watershed sediment yield and estimated channel sediment transport capacity in the Newhall Ranch tributaries, with a surplus of sediment yield over transport capacity. This raises the potential need for sediment management to prevent channel aggradation and loss of flood capacity. To develop a better understanding of the tributaries PWA reviewed PACE's analysis as reported in the River Fluvial Study Phase 2 (August 2007) and the revised summary table provided via e-mail by David Jaffe (December 2007). We compared their modeled estimates for existing conditions with other estimates based on field measurement of sediment in similar environments. We supplemented PACE's data with other studies and estimates that were carried out either in Los Angeles County or in watersheds with similar physical characteristics.

PACE used three different methods to calculate hillslope sediment yields: MUSLE, ACoE (Tatum), and the LA County Method. The hillslope sediment yield estimates were performed for the Capital Event (Q_{cap}) and are summarized in Table 1 below (originally reported in PACE [2007], pages 14 and 17, revised in December 2007).

Table 1 – Existing Conditions Hillslope Sediment Yield for the Q_{cap}

Location	Area	MUSLE		Tatum Method		LA County Method	
	(mi^2)	(yd^3/mi^2) 1	($tons/mi^2$) 2	(yd^3/mi^2) 1	($tons/mi^2$) 2	(yd^3/mi^2) 1	($tons/mi^2$) 2
Chiquito	4.8	880	1,279	12,248	17,802	41,105	59,746
Long	1.5	8,248	11,988	16,369	23,792	36,998	53,777
Grande	3.3	6,817	9,909	22,110	32,137	44,311	64,406
Potrero	4.5	2,442	3,549	14,163	20,586	56,053	81,473

PACE (2007) report also included the results of a study prepared by Simons, Li and Associates (SLA) (1998) for the LACDPW titled the Quantitative Analysis and Mathematical Modeling of the Existing Condition of the Santa Clara River Basin, Third Interim Report. This study was carried out for adjacent watersheds and for a similar discharge. Table 2 presents the unit sediment yield estimates by the PACE and SLA studies.

Table 2 - Comparison of SLA and PACE Studies for Existing Conditions

SLA (1998)				
Location	**Area (mi^2)**	**Debris Production (yd^3/mi^2)**		
		MUSLE	**Tatum**	**LA County**
Hasley	19.9	11,469	36,750	23,000
Potrero	19.0	51,919	32,250	24,000
PACE (2007)				
Location	**Area (mi^2)**	**Debris Production (yd^3/mi^2)**		
		MUSLE	**Tatum**	**LA County**
Chiquito	4.8	880	12,248	41,105
Grande	3.3	6,817	22,110	44,311
Combined	*8.1*	*3,299*	*16,266*	*42,411*
Long	1.5	8,248	16,369	36,998
Potrero	4.5	2,442	14,163	56,053
Combined	*6.0*	*3,893*	*14,715*	*51,289*

The unit sediment yield estimates are dissimilar between the two studies because of differences in watershed area and some parameter values selected (e.g. the SLA study aggregated the PACE watersheds within a much larger watershed area, and so reflects different locations).

The unit sediment yield estimates using the LA County method as reported in the Phase 2 Study were revised by PACE in December 2007. The revised estimates by PACE are approximately 42,000 and 51,000 for the north and south bank watersheds, respectively. These estimates are approximately 2 times larger than the SLA estimates, and therefore, the differences between the two studies are not considered to be significant given the spatial area differences, changes in soil types and uncertainties involved in estimating sediment yield using empirical methods.

In summary, we conclude the following for sediment yield estimates:

- LA County method is the most representative equation for determining sediment production in the Newhall Ranch watersheds (based on comparison to other studies);
- Debris production rates for the Newhall Ranch watersheds would range from 30,000 to 50,000 $tons/mi^2$ (or 20,000 to 35,000 yd^3/mi^2) under the Q_{cap} or events of comparable magnitude such as the 50-year event; and

- Based on debris basin monitoring data in the Santa Clara Basin and the Los Angeles County, as well as data from San Gabriel Mountains, average annual sediment yield in the region is approximately 10,000 tons/mi^2.

PACE (2007) study also estimated tributary channel sediment transport capacity using the ACoE SAM steady-state model. The results are presented in Table 3 below.

Table 3 –Channel Sediment Yield Estimates for the Q_{burn}

	Hillslope Sediment Yield Estimates (tons/event)	**SAM Sediment Transport (tons/event)**
Chiquito	6,000 – 285,000	1,980
Long	18,000 – 83,000	1,235
Grande	33,000 – 215,400	1,087
Potrero	16,000 – 374,000	1,994

As Table 3 indicates, hillslope sediment yield estimates are significantly higher than channel transport capacities and yields (ranging from three times as much to three orders of magnitude as much). This discrepancy can partly be explained by four factors:

1. Hillslope sediment models estimate the total amount of sediment produced in the watershed and includes both the coarse and fine materials. However, channel transport capacity estimates only take into account the coarse load. In Newhall Ranch watersheds, soils are silty clay loams where the fine materials constitute a large percentage of the soils (approximately 90% given that all watersheds are primarily underlain by Castaic soils). Therefore, in order to compare hillslope sediment yield estimates to channel sediment transport estimates, approximately 10% (depending on the watershed) of the hillslope yields should be considered.
2. Sediment yield calculations are biased towards the steep headwater areas of watersheds (where most sediment is produced, and where sediment trapping basins are generally located). The sediment transport capacity calculations are performed in the flatter downstream portions of the tributaries. In the south side tributaries these headwaters are included within the project area and sediment generate here may have an impact downstream. However, in the north side tributaries much of the sediment generated in the headwaters is likely to deposit in the flatter channel and floodplain reaches upstream of the Newhall Ranch project area.
3. Watershed storage and channel storage partially accounts for the discrepancy between hillslope sediment yield versus channel sediment transport estimates. Typically, there is a lag time between when a sediment particle is mobilized from a hillslope and when it reaches the channel. Not all sediment that is eroded from the hillslopes reaches the channel during the same event. Sediment can be stored in fans, landslides, terraces, or behind or beneath vegetation. In addition, some of the sediment that reaches the channel during a large event can be stored within the channel to be transported downstream during a subsequent flood. Sediment is stored on the bed, bars, or behind coarse material or vegetation in the channels. It is possible that sediment generated during larger floods is stored temporarily in the channel and eroded during smaller events.

4. Natural processes are inherently very complex and difficult to model. Any attempt to mimic nature to estimate rates of processes is bound to have significant errors without actual measurements. All the models used to estimate sediment yield and transport incorporate many assumptions, ignore many details that may be important, and have considerable uncertainties and error margins. Therefore, all the above estimates should be viewed as rough estimates to obtain a representative rate that is at best within an order of magnitude of actual rates.

Summary

PACE’s estimated values for sediment production are within the range of observed sediment accumulation rates for similar settings. The apparent discrepancy between sediment production and sediment transport capacity in the Newhall Ranch watersheds is potentially up to an order of magnitude smaller than initially appears based on sediment size fraction, and in the case of the north side tributaries the true sediment yield entering the project area may undergo a further significant reduction due to upstream storage. Notwithstanding these observations, field evidence from the Newhall ranch tributaries supports the case that some sediment is accumulating in the floodplain and channel (i.e. sediment yield has exceeded transport capacity for some time prior to our fieldwork). For example, sediment is accumulating under the Highway 126 Bridge, representing long term sediment accumulation. In the case of the south side tributaries the developed condition will greatly reduce sediment delivery and a sediment surplus is highly unlikely to occur (indeed, we anticipate sediment-limited conditions in these watersheds). In the north side tributaries the proposed development is much smaller as a percentage of the watershed, and the potential for continued sediment accumulation can not be excluded.

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