DRAFT

HYDROLOGY AND DRAINAGE STUDY

MOUNT RUBIDOUX PARK

Riverside, California

Prepared for:

City of Riverside
3900 Main Street
Riverside, CA 92522

Prepared by:

AMEC
121 Innovation Drive, Suite 200
Irvine, California 92617-3094
(949) 642-0245

May 12, 2014

Project No. IR13164470

DRAFT

TABLE OF CONTENTS

Page

1.0 INTRODUCTION 1
- 1.1 PURPOSE AND OBJECTIVES 1
- 1.2 SCOPE OF WORK 1
- 1.3 METHODOLOGY 2

2.0 BACKGROUND INFORMATION 2
- 2.1 SITE LOCATION 2
- 2.2 RECENT HISTORY OF UPROAD REPAIRS 2
- 2.3 RECENT STORM EVENTS 3
- 2.4 SITE RECONNAISSANCE 3

3.0 HYDROLOGY 4
- 3.1 PRECIPITATION 4
- 3.2 INFILTRATION 5
  - 3.2.1 Hydrologic Soil Group 6
  - 3.2.2 Soil Cover and Vegetation Type 6
  - 3.2.3 Antecedent Moisture Conditions 6
- 3.3 ESTIMATION OF STORM RUNOFF PEAK DISCHARGE 7

4.0 DRAINAGE ANALYSIS 8
- 4.1 SITE INFRASTRUCTURE 8
- 4.2 NATURAL DRAINAGE FEATURES 8
- 4.3 UPROAD HYDRAULICS 9
- 4.4 HYDRAULICS DISCUSSION 9
- 4.5 DEPOSITION OF SOIL ON THE UPROAD 11

5.0 RECOMMENDATIONS 12
- 5.1 ALTERNATIVES 12
  - 5.1.1 Alternative 1 - Install Storm Drain System Along the Alignment of the Uproad 12
  - 5.1.2 Alternative 2 - No Action 14
  - 5.1. 3 Alternative 3 – Install New AC Berm 14
  - 5.1.4 Alternative 4 - Remove the AC Berms and Install Erosion Control Measures 15
- 5.2 RECOMMENDATIONS 16

6.0 REFERENCES 16

TABLES

Table 1 Uproad Tributary Sub-Areas
Table 2 Storm Runoff Peak Flow Rates for 2-Year Storm
Table 3 Storm Runoff Peak Flow Rates for 5-Year Storm
Table 4 Storm Runoff Peak Flow Rates for 10-Year Storm
Table 5 Storm Runoff Peak Flow Rates for 25-Year Storm

TABLE OF CONTENTS
(Continued)

DRAFT

Table 6	Storm Runoff Peak Flow Rates for 50-Year Storm
Table 7	Storm Runoff Peak Flow Rates for 100-Year Storm
Table 8	Uproad Hydraulic Analysis for 2-Year Storm
Table 9	Uproad Hydraulic Analysis for 5-Year Storm
Table 10	Uproad Hydraulic Analysis for 10-Year Storm
Table 11	Uproad Hydraulic Analysis for 25-Year Storm
Table 12	Uproad Hydraulic Analysis for 50-Year Storm
Table 13	Uproad Hydraulic Analysis for 100-Year Storm
Table 14	Results of Uproad Hydraulic Analysis
Table 15	Conceptual Construction Cost Estimates for Alternatives

FIGURES

Figure 1	Site Vicinity Map
Figure 2	Hydrology Map
Figure 3	Watershed Schematic
Figure 4	Cross Section A
Figure 5	Cross Section B
Figure 6	Cross Section C
Figure 7	Cross Section D
Figure 8	Cross Section E
Figure 9	Cross Section F
Figure 10	Cross Section G
Figure 11	Cross Section H
Figure 12	Cross Section I
Figure 13	Cross Section J
Figure 14	Cross Section K
Figure 15	Cross Section L
Figure 16	Cross Section M
Figure 17	Cross Section N
Figure 18	Cross Section O
Figure 19	Cross Section P
Figure 20	Cross Section Q
Figure 21	Cross Section R
Figure 22	Cross Section S
Figure 23	Cross Section T
Figure 24	Cross Section U
Figure 25	Cross Section V
Figure 26	Cross Section W
Figure 27	Cross Section X
Figure 28	Cross Section Y
Figure 29	Cross Section Z
Figure 30	Cross Section AA
Figure 31	Cross Section BB
Figure 32	Cross Section CC
Figure 33	Cross Section DD

TABLE OF CONTENTS
(Continued)

DRAFT

Figure 34 Cross Section EE

APPENDIXES

Appendix A Mount Rubidoux Park Hydrologic Parameters
Appendix B Maximum Capacity Uproad Hydraulic Analysis – FlowMaster Output
Appendix C 2-Year Storm Uproad Hydraulic Analysis – FlowMaster Output
Appendix D 5-Year Storm Uproad Hydraulic Analysis – FlowMaster Output
Appendix E 10-Year Storm Uproad Hydraulic Analysis – FlowMaster Output
Appendix F 25-Year Storm Uproad Hydraulic Analysis – FlowMaster Output
Appendix G 50-Year Storm Uproad Hydraulic Analysis – FlowMaster Output
Appendix H 100-Year Storm Uproad Hydraulic Analysis – FlowMaster Output

HYDROLOGY AND DRAINAGE STUDY
Mount Rubidoux Park
Riverside, California

1.0 INTRODUCTION

AMEC Environment & Infrastructure, Inc. (AMEC), has prepared this report on behalf of the City of Riverside (City) to describe the methods and findings of a hydrology and drainage study of a portion of a pedestrian pathway referred to as the "Uproad" at Mount Rubidoux Park, Riverside, California (the site). The following sections of this report present the purpose and scope of the study, describe general background information associated with the site, discuss hydrology and drainage characteristics and analysis, and present alternatives and recommendations for potential improvements.

1.1 PURPOSE AND OBJECTIVES

The purpose of this study was to assess hydrology and drainage conditions at the site. Specific objectives were to:

- identify, describe, and analyze hydrologic and hydraulic conditions of the Uproad;
- evaluate whether recent road resurfacing, erosion measures, and repairs completed in 2009 and 2011 have exacerbated the existing surface flow from storm events on the side of the hill adjacent to Miramonte Place; and
- recommend potential improvements if feasible and necessary.

1.2 SCOPE OF WORK

The scope of work for this study consisted of:

- visiting the site to observe drainage features and recent roadway improvements;
- performing a land survey of a portion of the Uproad to obtain data for existing site features and topography;
- conducting a hydrologic analysis to estimate peak storm runoff;
- conducting a hydraulic analysis to estimate the conveyance capacity of the Uproad;
- proposing recommendations for drainage improvements at the site if feasible and necessary; and
- preparing this report.

1.3 METHODOLOGY

Hydrologic and hydraulic calculations were performed in accordance with the Riverside County Flood Control and Water Conservation District (the District) Hydrology Manual (RCHM; Riverside County, 1978). Calculations were completed for the 2, 5, 10, 25, 50, and 100-year recurrence interval storms for existing conditions at the Uproad.

Peak storm flow was calculated using the Rational Method described in the RCHM. Areas contributing to storm flow were based on City furnished engineering drawings of the site that AMEC verified and modified based on data from the land survey. The intensity-duration-frequency relationship used was calculated with the regression equations and parameters contained in the RCHM (Appendix A).

The hydraulics of street flow was modeled as an irregular channel using the FlowMaster (Bentley, 2008) software package. The cross section perpendicular to the alignment of the Uproad is not uniform and is not well represented by the typical symmetrical street sections.

2.0 BACKGROUND INFORMATION

This section provides information on the site location, relevant site history, and current site information based on a recent site reconnaissance.

2.1 SITE LOCATION

Mount Rubidoux is an isolated granite hill and designated landmark located on the western boundary of Riverside, California. The hill is a City park referred to as Mount Rubidoux Park (park). The Santa Ana River runs along the base of the western face of Mount Rubidoux and Mission Inn Avenue is the northern boundary of the park. An entrance to the park and the beginning of the Uproad is located at the intersection of 9th Street and Mt. Rubidoux Drive. Figure 1 shows Mount Rubidoux Park and its vicinity.

2.2 RECENT HISTORY OF UPROAD REPAIRS

In 2009, the City approved engineering plans and performed construction to repair two portions of an asphalt concrete (AC) paved pedestrian path at the park referred to as the Uproad and Downroad (Rick Engineering, 2009). The engineering plans included the following repairs to the Uproad within the area of this study:

- placement of one inch of AC pavement over existing pavement and application of fog seal from Station 27+50 to 32+00 and from Station 36+50 to 40+75 (stationing is approximate); and

- construction of a two-foot wide AC swale, removal of existing AC pavement and placement of four inches of AC pavement over existing sub-grade, and application of fog seal from Station 32+00 to 36+50 and from Station 40+75 to 43+60.

A multiple-day storm event occurred at the site during December 16 through December 22, 2010. The storm runoff caused significant damage including "erosion that undermined the road, mudslides and trail washouts, and fallen boulders" (City, 2011). The City Council approved emergency repairs for the site in 2011. The City approved plans in 2011 to address emergency road repairs at the site that included:

- construction of 6-inch rolled AC berms along the downhill edge of the Uproad at select locations; and

- construction of gabion basket overside drains at select locations (Rick Engineering, 2011).

The gabion basket overside drains were located in discontinuities or gaps in the proposed AC berms and appear to be designed to transmit runoff from the roadway and natural drainage features back to the natural drainage features down-slope of the roadway. The rolled AC berms were installed to prevent over the slope drainage that caused erosion on the steep hillsides (Hilltop Geotechnical, 2011).

2.3 RECENT STORM EVENTS

On August 29, 2013, a storm event occurred at the site and nearby areas. A summer thunderstorm delivered 2.2 inches of rainfall over a period of approximately two and half hours. Hillside erosion occurred at the site depositing soil and debris along the road, particularly in the canyon area near station 24+10 and station 32+25. The runoff from the storm caused damage to several properties on Miramonte Place located at the eastern toe of Mount Rubidoux.

2.4 SITE RECONNAISSANCE

AMEC performed a site visit on November 5, 2013 to observe drainage infrastructure and site conditions visible from the City's property at Mount Rubidoux. AMEC made visual observations of topography at Mount Rubidoux to determine tributary areas that likely would contribute to the residential properties that sustained damage from the runoff associated with the August storm. The Uproad was cleared of debris and soils at the time of the site visit.

While at the site, AMEC staff noted repairs and infrastructure shown on the 2009 and 2011 road repair plans. At locations where the road crossed a larger, natural drainage feature like a

canyon where runoff is concentrated, the asphalt berms were discontinuous, generally consistent with the 2011 emergency repair construction plans. However, the repairs did not include a rock filled gabion basket at the discontinuity as required by the detail in the plans. Instead, an asphalt apron leading to a slope reinforced with a combination of riprap and shotcrete was constructed at the berm discontinuity.

AMEC returned to the site on November 22, 2013 to observe a forecasted storm event. The storm event resulted in a total rainfall of 0.05 inches recorded at the University of California, Riverside (U.C. Riverside, 2014). AMEC observed negligible runoff for this storm event. The prior day's storm event on November 21, 2013 resulted in 1.01 inches of rainfall recorded at University of California, Riverside. AMEC noticed soil and debris deposited at certain locations on the road on November 22, presumably from runoff from the prior day's storm event.

A land survey was completed in March 2014 to retrieve spatial and topographic data for the Uproad corridor. Data from the survey were used to create cross sections necessary for hydraulic analysis of the Uproad and to obtain a better understanding of the drainage infrastructure and dimensions. The survey was limited in scope and focused on the area in proximity to the recent damage from the August 2013 storm. Therefore, the upper tributary sub-areas 1 through 8, shown on Figure 2, were not a part of the Uproad topographic survey.

3.0 HYDROLOGY

Hydrologic analysis and results of peak runoff calculations for the site are summarized here.

3.1 PRECIPITATION

The RCHM describes the three types of storms which can occur over Riverside County as general winter storms, general summer storms, and high intensity thunderstorms. Of the three types of storms, "most precipitation results from the general winter storms which occur in the late fall or winter months and may have durations of several days" (RCHM, 1978).

Although most precipitation in the area results from general winter storms, the RCHM states:

> "thunderstorms can occur at any time of the year causing extremely high rates of precipitation for relatively short durations. Thunderstorms can occur either during general storms, or as an isolated phenomena, but are most common from July through September when moist unstable air subject to convective lifting may cover the Southern California area" (1978).

The storm event that occurred in August 2013 appears to be an isolated thunderstorm and falls within the period of the year when these events are most common. The City provided a preliminary precipitation assessment conducted by a meteorologist for the storm event on August 29, 2013. Data for the storm event is as follows:

> "On 8.29.13, the City received approximately 2.2" of rain during the hours of 2:30 p.m. to 4:56 p.m. However, "most" of the rain fell between 2:46 p.m. and 4:16 p.m. Between 3:13 p.m. and 3:49 p.m., the rain was falling at a rate of 1.5" to 2.0" per hour."

In the area of Mount Rubidoux, the point precipitation for the 100-year 1-hour storm is 1.06 inches of rainfall. Based on the data for the August storm, for 36 minutes, the period of time between 3:13 p.m. and 3:49 p.m., rain fell at a rate of 1.5 to 2.0 inches per hour. The amount of rain that fell within those 36 minutes ranges from 0.9 to 1.2 inches of rain. Considering the rain that fell within the remaining 24 minutes (before or after this 36 minute period), the magnitude of the August storm event is in the range of the 100-year precipitation as described in the RCHM.

For this hydrologic analysis, estimation of peak runoff from the tributary areas is required to determine the conveyance capacity of the existing drainage infrastructure. Because peak runoff is estimated by the Rational Method, the isohyetal maps of point precipitation for the 1-hour storm contained within the RCHM were used to develop the intensity-frequency-duration curves necessary for the calculations. Although the 1-hour map is used for this analysis, the storm is assumed to be the more common general winter storm and not the less common thunderstorm. The 1-hour duration map was developed by the District using information and equations from the National Oceanic and Atmospheric Administration Atlas 2, Precipitation-Frequency Atlas of the Western United States, Volume XI-California published in 1973. The 2-year and 100-year 1-hour precipitation depths for Mount Rubidoux are 0.52 inches and 1.06 inches respectively as shown on Plates D-4.3 and D-4.4 of the RCHM. Determination of rainfall depth for the intervening return periods was accomplished by the method described in the RCHM and documented in Appendix A.

3.2 INFILTRATION

Infiltration is the process of rainfall entering into pervious areas including soils and forest litter. For the RCHM, infiltration is expressed as the rate in inches per hour that precipitation enters the soil surface and is stored in the pore space. Haan et al. states the rate of infiltration is dependent on "soil physical properties, vegetative cover, antecedent soil water conditions, rainfall intensity, and the slope of the infiltrating surface" (1994). The percent of impervious area is accounted for in the runoff coefficient that characterizes infiltration. The Uproad was the primary impervious surface and composed 5% of the tributary area. In the following

sections, the factors affecting infiltration for hydrologic studies within Riverside County are discussed.

3.2.1 Hydrologic Soil Group

The Natural Resource Conservation Service (NRCS, formerly the Soil Conservation Service) and the US Forest Service have mapped the soils in many areas of Riverside County based on the soil's infiltration capabilities as classified by the NRCS. The NRCS categorized soils into four hydrologic soil groups according to their minimum infiltration rate. The four hydrologic soil groups consist of:

- Group A – soils having high rates of infiltration (greater than 0.3 inches/hour);
- Group B – soils having moderate rates of infiltration (0.15 – 0.3 inches/hour);
- Group C – soils having low rates of infiltration (0.05 – 0.15 inches/hour); and
- Group D – soils having very low rates of infiltration (0 - 0.05 inches/hour).

On plate C-1.15 of the RCHM, soil at Mount Rubidoux has been placed in the Group C hydrologic soil group, meaning the soils have a moderately fine to fine texture, have a slow rate of water transmission, and have a medium to high potential to produce runoff.

3.2.2 Soil Cover and Vegetation Type

The type of vegetation, or soil cover, as well as the quality and density of that soil cover within the watershed have a major impact on the infiltration capacity of a given soil (RCHM, 1978). The District uses the system developed by the NRCS to consider and account for soil cover.

The natural vegetation on the mountain is classified as coastal sage scrub, a vegetation type found at relatively dry sites in lowland California and characterized by sub-woody shrubs that are deciduous during the long summer dry season (Friends of Mount Rubidoux, 2014). The Open Brush cover type described in the RCHM most closely matched the vegetation at the site (Plate C-2 in Appendix A). Because the storm event used for this study is a general winter storm occurring during the winter as opposed to the drier summer conditions, the quality of the soil cover was considered to be in Fair condition. Fair cover quality is described as moderate cover with 50 percent to 75 percent of the ground surface protected.

3.2.3 Antecedent Moisture Conditions

The RCHM defines antecedent moisture conditions (AMC) as the relative wetness of a watershed just prior to a runoff producing storm event. If a storm event was preceded by a

separate, significant storm event that increased the water content of the soil, less storage is available within the soil pore space. This is accounted for through the AMC as follows:

- AMC I – Lowest runoff potential. The watershed soils are dry enough to allow satisfactory grading or cultivation to take place.
- AMC II – Moderate runoff potential, an intermediate condition.
- AMC III – Highest runoff potential. The soil is practically saturated from antecedent rains.

For the purposes of design hydrology, the RCHM requires using AMC II for hydrologic analysis of the 10-year and 100-year storms. AMC II was the condition considered for the analysis.

3.3 ESTIMATION OF STORM RUNOFF PEAK DISCHARGE

Peak storm runoff generated from tributary areas was estimated using the Rational Method described in the RCHM. The Rational Method estimates peak discharge in cubic feet per second (cfs) based on the product of:

- C, runoff coefficient that accounts for infiltration and its related factors as well as the proportion of pervious to impervious area;
- I, intensity of rainfall in inches per hour (in/hr); and
- A, tributary area in acres.

Using the elevation contours provided on the 2011 Mount Rubidoux Uproad Repair plans and the Uproad survey data, tributary areas for the Uproad were delineated as shown on Figure 2. The first bridge encountered on the Uproad marked the divide between the upper Uproad and the lower Uproad, the area this analysis considers. Because the area just upstream of the bridge as well as the bridge itself do not have berms on both sides of the roadway to contain runoff collected and conveyed from the upper Uproad, runoff has the ability to flow off the bridge to the natural drainage feature underneath the bridge. The tributary area totaling 25.4 acres was divided into 34 sub-areas (summarized in Table 1) to facilitate the Rational Method analysis and more accurately determine the time of concentration. The ordering of the sub-areas is sequential and a schematic of the watershed is shown in Figure 3. The point of concentration, the location where the tributary area discharges runoff, was identified as the end of the Uproad at its intersection with 9th Street.

In order to determine the time of concentration, travel time was calculated for each sub-area and summed. The time of concentration for the initial sub-area was determined from the nomograph in the RCHM shown on Plate D-3. The travel time through sub-area 2 was

determined from the RCHM's Plate D-6.3 for natural mountain channels. For sub-areas 3 through 34, travel time was determined by modeling the Uproad as an open channel using the Bentley FlowMaster software.

Tables 2 through 7 summarize the calculations for the Rational Method analysis for the Uproad tributary area. The 2-year storm would produce approximately 22.7 cfs of runoff assuming all flow reaches the point of concentration. The 5-year, 10-year, 25-year, 50-year, and 100-year storms would produce 31.1 cfs, 36.1 cfs, 43.5 cfs, 49.7 cfs, and 55.2 cfs, respectively.

4.0 DRAINAGE ANALYSIS

The drainage analysis and the results of hydraulic calculations for the site are summarized here.

4.1 SITE INFRASTRUCTURE

Mount Rubidoux Park is a largely undeveloped urban open space park. The primary infrastructure at the site is the roadway. The Uproad is approximately ten feet wide but widens to sixteen feet at the site entrance at 9th Street. The road is composed of AC pavement and generally the width of the road slopes downward towards the ascending slope of the hillside, creating a depression where runoff can accumulate and flow along the uphill side of the roadway (for an example, see Figure 4). The Uproad, in the area of this study, does not have culverts to convey water underneath the roadway; therefore, runoff flowing in natural drainage features that intersect with the Uproad flows directly onto the Uproad. If the Uproad was initially constructed using culverts, the natural drainage features connected by the culverts would more closely resemble the natural drainage patterns prior to construction of the Uproad.

As part of the road repairs completed in 2011, asphalt berms were constructed in selected locations to prevent over the slope drainage. The locations of the asphalt berms are shown on Figure 2. Small discontinuities in the asphalt berm were included in the design at locations of natural drainage features. From the field reconnaissance, asphalt aprons leading to a slope reinforced with a combination of riprap and shotcrete was constructed at the berm discontinuities to provide erosion control for the slope.

4.2 NATURAL DRAINAGE FEATURES

Natural drainage features were identified primarily from topographic contour lines and some of the larger channels were observed during the field reconnaissance. These natural drainage features are locations where runoff has concentrated and incised channels through shearing forces produced by the channelized flow.

The natural drainage feature located in sub-area 12 and 22, whose location is approximately shown on Figure 2, is situated in the center of a steep canyon where runoff concentrates. After the August 2013 storm event, the deposition of soil on the roadway at the location where the Uproad intersects this natural drainage feature demonstrated the preferred flow path was directly down the canyon and over the roadway for this storm event.

4.3 UPROAD HYDRAULICS

To determine the conveyance capacity of the Uproad, representative cross sections of the roadway were plotted and analyzed. Each roadway cross section was modeled in the Bentley FlowMaster software to calculate the maximum flow capacity of the roadway operating as an open channel. The maximum flow capacity was determined to occur when the water surface elevation reached the highest elevation within the roadway; runoff would flow within the roadway without spilling outside of the roadway. Figures 4 through 34 represent cross sections A through EE and visually illustrate the results of the analysis. The data input and results of the model output for each cross section are contained within Appendix B.

Through the Ration Method hydrologic analysis, peak flowrates for storm runoff were determined for the 2-year, 5-year, 10-year, 25-year, 50-year, and 100-year return periods. The flowrate for any sub-area is the accumulation of runoff in that particular sub-area plus the aggregation of runoff from each of the sub-areas upstream of that sub-area. For example, runoff at the end of sub-area 5 is the sum of flow from sub-area 5 plus each preceding sub-area (sub-areas 1 through 4). The peak flowrates for each sub-area for each storm was modeled for each corresponding cross section. The results of the hydraulic analysis for the 2-year storm are summarized in Table 8. The results of the hydraulic analysis for the 5-year, 10-year, 25-year, 50-year, and 100-year storms are summarized in Tables 9 through 13, respectively. The results of the open channel hydraulic analysis for each storm event are contained in Appendixes C through H.

4.4 HYDRAULICS DISCUSSION

The maximum conveyance capacity of each of the cross sections was compared to the calculated storm runoff expected at each cross section. The results of the comparison are summarized in Table 14. For the 2-year storm, 21 of the 31 cross sections of the Uproad have the capacity to convey the runoff generated by the storm. For the sections that do not have the capacity to convey the runoff, flow essentially spills out of the roadway, likely draining over the adjacent slope. This runoff will then flow directly down the hill to a natural drainage feature or potentially is picked up by the road below, if applicable. For the 10-year storm, the number of cross sections of the Uproad capable of conveying the runoff is 16 of the 31. For the 100-year storm, the number is reduced to 12 cross sections.

The Uproad does not have the capability to convey the full flow from the upper sub-areas at certain cross sections; therefore, the hydraulic model is approximate because it does not quantify and account for the lost flow in the cross sections that follow.

Noting the maximum discharges for each cross section (Table 14), the range for the Uproad can be seen to vary from 1.9 cfs to 215.7 cfs. A range in conveyance capacity of the roadway would be acceptable if the capacity steadily increased as one moved downstream; the roadway at the bottom of the watershed would require a higher conveyance capacity because flow accumulates as one moves downstream. The conveyance capacity of the Uproad varies considerably between nearby cross sections: Section C can convey 215.7 cfs while just downstream at Section D the capacity is 11.4 cfs. There is little consistency in the conveyance capacity of the Uproad.

Another demonstration of the variability in conveyance capacity between cross sections in close proximity begins with Section BB. Section BB (Figure 31) is capable of conveying the 100-year storm flow. Section N (Figure 17), approximately 25 feet downstream of Section BB, is not able to convey the 2-year storm flow without spilling outside of the roadway. Section O (Figure 18), approximately 110 feet downstream of Section N, is capable of conveying the 100-year storm flow.

The canyon in sub-area 12 is an area that has been observed to flow outside or over the roadway. Section D is representative of the Uproad geometry in the vicinity of the canyon and is not capable of conveying the flow for a 2-year or larger storm. The AC pavement of the roadway in this area was replaced in 2009 and an AC berm was constructed in 2011. One of the primary deficiencies of this cross section is that the roadway is sloped towards the descending slope of the hillside and the AC berm is the only element that provides this area of the Uproad some ability to convey water (Figure 7). Therefore, if the AC berm was not constructed, most runoff that flows to this section would spill off the roadway and over the downhill slope.

One of the objectives of this study was to analyze the construction of the AC berm along sections of the Uproad adjacent to the residential properties along Miramonte Place. For Section P, shown in Figure 19, the construction of the AC berm appears to not have a substantial impact on the cross section's ability to convey storm runoff; the 100-year storm water surface just reaches the elevation of the bottom of the AC berm. For Sections L, Q, and AA, the berm markedly improves the conveyance capacity; the 2-year storm runoff would exceed each of these cross sections if the AC berm were not constructed (see Figures 15, 20, and 30). By comparing the Section Q and Section CC shown on Figures 20 and 32, the impact of the AC berm is apparent. Section Q contains a berm and Section CC does not.

Section Q can convey the 100-year storm runoff whereas Section CC, 50 feet downstream, cannot convey the 2-year storm runoff.

The construction of the AC berm generally provides protection to the properties that are shielded by the AC berm. The AC berms provide protection by changing the drainage patterns. Runoff that would have flowed onto a property prior to construction of the AC berm is now redirected downstream. This runoff has the potential to exacerbate conditions for properties downstream. Although it is possible to identify the properties that are protected by the AC berm, it is difficult to readily identify the properties where conditions are exacerbated by the construction of the AC berm. There are stretches of the Uproad that do not have an AC berm but are capable of conveying the 100-year storm runoff. There are also stretches of the Uproad that have very little conveyance capacity. If a property in one of the areas with little conveyance capacity is downstream of a property protected by an AC berm, the damage from the runoff would be incremental and not all due to flow redirected by the AC berm because the property had deficient protection before the construction of the AC berm.

The discontinuity in the AC berm located at Section M adds complexity to the analysis. Runoff flowing along the roadway has momentum and therefore will not simply redirect itself to flow out of the discontinuity. The short discontinuity in the AC berm acts as a side weir where the flow in the roadway will continue along the roadway due to momentum but some water that is higher in elevation than the bottom of the discontinuity will spill out of the gap in the AC berm. If the discontinuity located at Section M were downstream of a natural drainage feature that crosses the road, the situation would be different. Flow from the natural drainage feature at the center of the canyon would be in line with the opening and flow immediately out of the discontinuity. As it stands, the discontinuity is not downstream of the natural drainage feature in the canyon and is actually higher in elevation. Quantifying the amount of flow through a side weir is a complex analysis. But considering the surrounding AC berm both upstream and downstream of this particular discontinuity, the overall protection afforded by the berms is greater than if the berms were not constructed.

4.5 DEPOSITION OF SOIL ON THE UPROAD

Soil is eroded from the hillsides and is transported and deposited on the Uproad. The deposition of the soil on the Uproad is highly dynamic depending on the varying intensity of the precipitation and resulting runoff. Soil deposited on the Uproad was observed in sub-area 12 after the storm event in August and November 2013. The soil deposited in the roadway blanketed the roadway and the AC berm and appeared to have the potential to act as a dam preventing some runoff from continuing past the deposited soil forcing that runoff over the downhill slope. The deposition of soil on the Uproad has the potential to redirect runoff and adds uncertainty to the flow patterns during storm events.

5.0 RECOMMENDATIONS

The alternatives for addressing drainage at the site and recommendations are summarized here.

5.1 ALTERNATIVES

Drainage infrastructure, consisting primarily of the AC berm, provides uneven and varying levels of protection from storm runoff along the alignment of the Uproad adjacent to the residencies on Miramonte Place. In addition to the intermittent nature of the drainage infrastructure, the roadway cross section changes along the alignment of the Uproad adding variability to its conveyance capacity.

Three strategies have been evaluated for the City to manage the drainage at Mount Rubidoux Park. The first strategy is to provide an even and consistent level of drainage control along the Uproad. This option would require reaching a consensus on the quantity of flow that the drainage infrastructure would handle followed by construction to install traditional drainage infrastructure. Alternative 1, described in the following section, addresses this strategy.

The second strategy is to continue to provide partial drainage control, as the existing drainage infrastructure does, and address damage caused by runoff and erosion as it arises. Alternatives 2 and 3 describe scenarios that would provide partial drainage control.

The third strategy is to limit drainage control to what is provided by the roadway without the AC berm and restore drainage patterns to those prior to construction of the AC berm. The AC berm installed in 2011 appears to be used solely for erosion control for the slope but has had the unintended consequence of providing partial drainage control. Slope and erosion control measures would be constructed in erosion prone areas within the tributary area and along the Uproad. The erosion control measures, made of porous materials such as riprap and rock filled gabion baskets, would have less influence on drainage patterns than the AC berms. Alternative 4 in Section 5.1.4 describes this scenario.

The cost estimates developed for these alternatives are based on a conceptual design and should be considered order-of-magnitude estimates. A more detailed design may reveal higher costs unaccounted for in the conceptual design or may reveal efficiencies leading to lower costs.

5.1.1 Alternative 1 - Install Storm Drain System Along the Alignment of the Uproad

Alternative 1 involves the construction of a storm drain system comprised of catch basins, storm drains, and manholes to collect and convey the storm runoff. This alternative considers full drainage control for the Uproad up to a predetermined storm event. The alignment of the

storm drain for this alternative follows the Uproad down the hill, then proceeds southeast on Ninth Street where the storm drain would connect to the existing storm drain located on Cedar Street. The alignment was selected in order to stay within the park's boundary. The storm drains' route is circuitous and changes direction numerous times in order to stay within the roadway; this alignment is not ideal for storm drain hydraulics as gradual changes in direction of flow are preferred. Another possible variation of this option that was not developed would involve constructing a storm drain system that goes directly down the face of Mount Rubidoux at the location of the largest canyon. This would entail crossing the Uproad and traversing a residential property until reaching Miramonte Place. The storm drain would go southwest on Miramonte Place, then turn southeast on Fourteenth Street eventually joining the existing storm drain located on Pine Street. The more direct alignment would require acquisition of a storm drain easement on residential property.

The effectiveness of this alternative depends on the ability to collect and convey the storm runoff accumulated at the point of concentration to a storm drain downstream. The closest storm drain is located at the intersection of 9th Street and Cedar Street. The available capacity in this storm drain is currently not known but may be available from the City of Riverside Public Works Department. To facilitate collection of runoff, minor grading and the use of local depressions around the catch basins would be necessary. Erosion control measures in the vicinity of the catch basins would be used to reduce the amount of sediment transported and deposited within the storm drain. Despite the inclusion of erosion control measures, long term maintenance would be required to remove accumulated sediment within the catch basins and storm drain that would reduce the flow capacity.

This alternative could be implemented with standard construction materials and methods. Implementation of this alternative is contingent upon the availability of capacity in the existing storm drain on Cedar Street. Constructing a storm drain system would require extensive excavation and trenching in the Uproad. A geotechnical investigation would be necessary to assess the subsurface conditions and to determine the feasibility of construction in proximity to slopes susceptible to erosion.

A conceptual cost estimate was developed for Alternative 1 and is summarized in Table 15. The conceptual storm drain system associated with this cost estimate was sized to convey the peak runoff from the 10-year storm. Alternative 1 requires the installation of 5526 linear feet of reinforced concrete pipe, 31 manholes, and 26 catch basins. The estimated capital construction cost to implement Alternative 1 is approximately $1,705,500.

5.1.2 Alternative 2 - No Action

A “no action” alternative would leave the site and existing drainage system in place with no alterations. The existing drainage improvements were installed as part of the 2009 and 2011 road repairs and consist primarily of AC berms and swales. The existing drainage improvements provide partial drainage control at the site, presumably focused on slope protection in the areas that were damaged by soil erosion after the December 2010 storm.

The effectiveness of the current drainage improvements was discussed in previous sections. At locations on the Uproad shielded by an AC berm, drainage control was improved. At locations on the Uproad not having an AC berm, drainage control was not improved. This alternative is partially effective in controlling drainage and providing erosion control.

Implementation of this alternative requires no additional action. There are no construction costs associated with this alternative.

5.1. 3 Alternative 3 – Install New AC Berm

Alternative 3 involves the construction of a new AC berm along the Uproad behind the residencies located at 4165 and 4143 Miramonte Place. The berm would match the height and width of the existing berm and would span the 120-foot gap between the two existing berms. The new berm would provide drainage control for these residencies, one of which sustained damage from the August 2013 storm. The changes associated with this alternative are focused on providing drainage control for a property that appears to have been impacted by the partial drainage control provided by the drainage improvements constructed in 2011.

This alternative is effective in providing drainage control for properties at 4165 and 4143 Miramonte Place but reroutes runoff flowing onto said properties downstream, potentially resulting in flow entering other properties downstream. However, immediately following the existing berm, there is a rock- lined swale located at Station 18+65 that allows roadway overflow to enter the residential property located at 4085 Miramonte Place and presumably onto the roadway. Although this swale appears to have the ability to direct some runoff off the roadway, the capacity of the swale is not known. It is unclear what capacity the City can rely on the drainage swale or if the City can improve the capacity of the swale. Alternative 3 provides drainage control for the adjacent residential properties but the drainage pattern of the rerouted flow is uncertain.

Alternative 3 can be implemented with standard construction materials and methods in a short timeframe. The scope of the construction involves installation of 120 feet of AC berm estimated to have a capital construction cost of $41,250. Table 15 summarizes the construction cost for the drainage improvement.

5.1.4 Alternative 4 - Remove the AC Berms and Install Erosion Control Measures

For Alternative 4, all of the AC berms along the Uproad adjacent to the residencies on Miramonte Place would be removed. Consequently, removing the AC berms would reduce drainage control. This alternative would attempt to reestablish the drainage patterns that existed prior to the construction of the AC berms. Assuming the AC berms were installed for erosion control, other measures protecting against erosion would be placed along the shoulder of the roadway as well as in the canyon and around natural drainage features. These measures would help to reduce erosion while decreasing the overall effects of altering the drainage pattern. The design would utilize a combination of riprap, gabion baskets, and other measures that would allow flow through and around the additions. Introduction of native vegetation may be an option to aid in erosion control if it is acceptable and does not require long-term irrigation.

The AC berms redirected flow as well as concentrated flow. The removal of the AC berms would allow runoff to disburse to a wider area and not concentrate and be released at sections of the Uproad where the roadway has a lower conveyance capacity. The effectiveness of this alternative relies on the implicit notion that the flow patterns prior to the construction of the AC berm were acceptable. Also, the erosion control measures used would need to be roughly as effective at providing protection as the AC berm where it was successful at providing drainage control. Erosion control measures would need to be thorough and widespread, not just located at the location of the AC berm to be removed. If erosion occurs in the upper portion of the tributary area and is transported and deposited along the lower portion of the Uproad, the deposited soil may reduce the ability of runoff to flow through the erosion control measures and may result in the runoff being redirected. Long-term inspection, maintenance, and periodic replacement of the erosion control measures will be required, especially after large storm events.

This alternative could be implemented with standard construction materials and methods. The challenge to implementation of this alternative is determining the correct locations and extent of the erosion control measures necessary and simultaneously considering the impacts on the natural landscape and habitat within the park.

Alternative 4 includes the removal of 655 linear feet of AC berm, installation of gabion baskets totaling 4269 square yards, and placement of rip rap covering 1856 square yards of land. The estimated capital construction cost to implement Alternative 4 is approximately $664,100 and summarized in Table 15.

5.2 RECOMMENDATIONS

The alternatives provided for drainage improvement at the site are not ideal. The preferred method of dealing with drainage is during the planning stage of land development. The development of the residencies along Miramonte Place would have benefitted from drainage infrastructure that would have allowed drainage to flow directly downhill from Mount Rubidoux. Also, the inclusion of culverts under the Uproad during initial construction would have retained more of the natural drainage patterns at the site.

Implementing Alternative 1 will require extensive construction along the Uproad and limit access to the park. Construction activities will extend outside of the site and the available capacity of the storm drain on Cedar Street is currently not known. The costs for Alternative 1 are high relative to the other alternatives.

Alternatives 2 and 3 require little to no construction but provide only partial drainage control. Results similar to those experienced after the August 2013 storm event can be expected for large storm events in the future.

Alternative 4 minimizes drainage control in an effort to restore drainage patterns prior to the emergency road repairs conducted in 2009 and 2011. The viability of the alternative relies on the notion that drainage patterns prior to the emergency road repair were acceptable.

It is recommended that the City review its available resources and determine acceptable risks associated with the alternatives. A long-term, comprehensive approach for dealing with drainage at Mount Rubidoux is recommended.

6.0 REFERENCES

City of Riverside, Parks, Recreation & Community Services Department, 2011, City Council Memorandum - Subject: Mt. Rubidoux Trail/Roadway – Resolution Declaring the Roadway Stabilization and Repairs an Urgent Necessity for Preservation of Life, Health and Property; Authorization for Emergency Work – Supplemental Appropriation.

Friends of Mt. Rubidoux, 2014, Natural Resources – Plants, available at http://www.mt-rubidoux.org/

Haan, C.T., Barfield, B.J., and Hayes, J.C., 1994, Design Hydrology and Sedimentology for Small Catchments, Academic Press.

Hilltop Geotechnical, Inc., 2011, Report of Mount Rubidoux Park Emergency Road Repair, Riverside, California, January 12.

Rick Engineering Company, 2011, Mount Rubidoux Emergency Road Repairs 2011 (Engineering Plans)

Rick Engineering Company, 2009, Mount Rubidoux Road Repair (Engineering Plans)

Riverside County Flood Control and Water Conservation District, 1978, Hydrology Manual

University of California, Riverside (U.C. Riverside), 2014, University of California Cooperative Extension – Riverside County, U.C. Riverside, Riverside – Daily Totals for November; available at http://ceriverside.ucanr.edu/about/weather_667/?weather=monthlyinfo&station=44&month=11

TABLES

DRAFT

TABLE 1
UPROAD TRIBUTARY SUB-AREAS
Hydrology and Drainage Study - Mount Rubidoux Park
Riverside, California

Area I.D.	Area (feet^2)	Area (acres)	Upper Station	Lower Station	Centerline Distance (feet)	Upper Elevation (feet)	Lower Elevation (feet)	Δ Elevation (feet)	Assigned Cross Section
1	16,291	0.37			255.0	1270	1152	118	Initial Subarea
2	19,943	0.46			207.0	1152	1048.62	103.38	Mountain Channel
3	26,746	0.61	4294.41	4200.00	94.4	1048.62	1045.29	3.33	A
4	31,324	0.72	4200.00	4078.19	121.8	1045.29	1040.99	4.3	A
5	34,909	0.80	4078.19	4032.75	45.4	1040.99	1039.39	1.6	A
6	62,952	1.45	4032.75	3993.77	39.0	1039.39	1038.02	1.37	A
7	39,611	0.91	3993.77	3769.90	223.9	1038.02	1030.12	7.9	A
8	19,794	0.45	3769.90	3735.49	34.4	1030.12	1028.9	1.22	A
9	35,103	0.81	3735.49	3466.17	269.3	1028.9	1019.71	9.19	A
10	51,925	1.19	3466.17	3436.79	29.4	1019.71	1018.77	0.94	B
11	22,071	0.51	3436.79	3271.70	165.1	1018.77	1011.46	7.31	C
12	174,103	4.00	3271.70	3210.53	61.2	1011.46	1009.52	1.94	D
13	13,881	0.32	3210.53	3108.64	101.9	1009.52	1005.66	3.86	E
14	25,400	0.58	3108.64	3063.18	45.5	1005.66	1002.81	2.85	F
15	42,807	0.98	3063.18	3011.35	51.8	1002.81	1000.58	2.23	G
16	13,739	0.32	3011.35	2938.26	73.1	1000.58	997.9	2.68	H
17	35,101	0.81	2938.26	2879.51	58.8	997.9	996.31	1.59	I
18	21,589	0.50	2879.51	2777.89	101.6	996.31	990.97	5.34	J
19	2,242	0.05	2777.89	2700.00	77.9	990.97	988.21	2.76	K
20	2,422	0.06	2700.00	2611.43	88.6	988.21	982.77	5.44	L
21	5,908	0.14	2611.43	2467.53	143.9	982.77	978.01	4.76	M
22	10,934	0.25	2467.53	2335.83	131.7	978.01	973.3	4.71	N
23	9,304	0.21	2335.83	2227.05	108.8	973.3	969.27	4.03	O
24	9,954	0.23	2227.05	2123.36	103.7	969.27	964.66	4.61	P
25	15,074	0.35	2123.36	1992.92	130.4	964.66	958.54	6.12	Q
26	18,339	0.42	1992.92	1834.23	158.7	958.54	951.76	6.78	R
27	13,271	0.30	1834.23	1772.55	61.7	951.76	948.17	3.59	S
28	39,251	0.90	1772.55	1628.50	144.1	948.17	943.01	5.16	T
29	92,345	2.12	1628.50	1433.53	195.0	943.01	934.18	8.83	U
30	37,227	0.85	1433.53	1057.06	376.5	934.18	918.16	16.02	V
31	49,407	1.13	1057.06	747.74	309.3	918.16	906.38	11.78	W
32	36,940	0.85	747.74	590.89	156.9	906.38	903.17	3.21	X
33	22,114	0.51	590.89	438.31	152.6	903.17	899.91	3.26	Y
34	54,361	1.25	438.31	31.43	406.9	899.91	896.14	3.77	Z
Total		**25.40**							

TABLE 2
STORM RUNOFF PEAK FLOW RATES FOR 2-YEAR STORM
RATIONAL METHOD CALCULATIONS[1]
Hydrology and Drainage Study - Mount Rubidoux Park
Riverside, California

Sub-Area	Soil Group[2]	Cover Type[3]	Area (feet^2)	Area (acres)	Impervious Area (ft^2)	Percent Impervious	Rainfall Intensity[4] (in/hour)	Runoff Index[5]	Runoff Coefficient[6]	Δ Flow Rate (cfs)	Σ Flow Rate (cfs)	Upper Elevation (ft)	Lower Elevation (ft)	Length of Sub-Area (feet)	Slope (ft/ft)	Section	Velocity[7] (ft/s)	Δ Time of Concentration[8] (minutes)	Σ Time of Concentration (minutes)
1	C	Open Brush	16,291	0.37	0	0%	1.88	77	0.73	0.51		1270	1152	255				5.75	5.75
2	C	Open Brush	19,943	0.46	828	4%	1.74	77	0.73	0.58	0.51	1152	1048.62	207.0	0.499	Nat. Mtn. Chan.[9]	3.9	0.88	6.63
3	C	Open Brush	26,746	0.61	836	3%	1.68	77	0.73	0.75	1.10	1048.62	1045.29	94.4	0.035	Section A	3.46	0.45	7.09
4	C	Open Brush	31,324	0.72	1061	3%	1.61	77	0.73	0.85	1.85	1045.29	1040.99	121.8	0.035	Section A	3.78	0.54	7.63
5	C	Open Brush	34,909	0.80	425	1%	1.59	77	0.70	0.89	2.69	1040.99	1039.39	45.4	0.035	Section A	4.08	0.19	7.81
6	C	Open Brush	62,952	1.45	346	1%	1.57	77	0.70	1.59	3.58	1039.39	1038.02	39.0	0.035	Section A	4.32	0.15	7.96
7	C	Open Brush	39,611	0.91	1831	5%	1.50	77	0.71	0.97	5.18	1038.02	1030.12	223.9	0.035	Section A	4.85	0.77	8.73
8	C	Open Brush	19,794	0.45	289	1%	1.48	77	0.70	0.47	6.14	1030.12	1028.9	34.4	0.035	Section A	5.19	0.11	8.84
9	C	Open Brush	35,103	0.81	2790	8%	1.41	77	0.71	0.81	6.61	1028.9	1019.71	269.3	0.034	Section A	5.29	0.85	9.69
10	C	Open Brush	51,925	1.19	296	1%	1.40	77	0.69	1.16	7.42	1019.71	1018.77	29.4	0.032	Section B	5.48	0.09	9.78
11	C	Open Brush	22,071	0.51	1650	7%	1.37	77	0.69	0.48	8.58	1018.77	1011.46	165.1	0.044	Section C	5.51	0.50	10.28
12	C	Open Brush	174,103	4.00	697	0.4%	1.35	77	0.68	3.66	9.05	1011.46	1009.52	61.2	0.032	Section D	3.84	0.27	10.55
13	C	Open Brush	13,881	0.32	968	7%	1.33	77	0.69	0.29	12.72	1009.52	1005.66	101.9	0.038	Section E	5.25	0.32	10.87
14	C	Open Brush	25,400	0.58	422	2%	1.32	77	0.68	0.52	13.01	1005.66	1002.81	45.5	0.063	Section F	7.21	0.11	10.97
15	C	Open Brush	42,807	0.98	499	1%	1.31	77	0.67	0.86	13.53	1002.81	1000.58	51.8	0.043	Section G	5.45	0.16	11.13
16	C	Open Brush	13,739	0.32	710	5%	1.29	77	0.68	0.28	14.39	1000.58	997.9	73.1	0.037	Section H	5.43	0.22	11.36
17	C	Open Brush	35,101	0.81	599	2%	1.28	77	0.67	0.69	14.67	997.9	996.31	58.8	0.027	Section I	4.7	0.21	11.56
18	C	Open Brush	21,589	0.50	1555	7%	1.26	77	0.68	0.43	15.36	996.31	990.97	101.6	0.053	Section J	5.91	0.29	11.85
19	C	Open Brush	2,242	0.05	1027	46%	1.25	77	0.77	0.05	15.79	990.97	988.21	77.9	0.035	Section K	6.94	0.19	12.04
20	C	Open Brush	2,422	0.06	940	39%	1.24	77	0.76	0.05	15.84	988.21	982.77	88.6	0.061	Section L	7.57	0.20	12.23
21	C	Open Brush	5,908	0.14	1390	24%	1.22	77	0.73	0.12	15.89	982.77	978.01	143.9	0.033	Section M	6.21	0.39	12.62
22	C	Open Brush	10,934	0.25	1337	12%	1.20	77	0.68	0.20	16.01	978.01	973.3	131.7	0.036	Section N	5.13	0.43	13.05
23	C	Open Brush	9,304	0.21	1101	12%	1.18	77	0.68	0.17	16.21	973.3	969.27	108.8	0.037	Section O	5.45	0.33	13.38
24	C	Open Brush	9,954	0.23	1025	10%	1.17	77	0.68	0.18	16.38	969.27	964.66	103.7	0.044	Section P	5.91	0.29	13.67
25	C	Open Brush	15,074	0.35	1308	9%	1.15	77	0.67	0.27	16.57	964.66	958.54	130.4	0.047	Section Q	7.08	0.31	13.98
26	C	Open Brush	18,339	0.42	1587	9%	1.13	77	0.67	0.32	16.83	958.54	951.76	158.7	0.043	Section R	6.32	0.42	14.40
27	C	Open Brush	13,271	0.30	699	5%	1.13	77	0.67	0.23	17.15	951.76	948.17	61.7	0.058	Section S	6.94	0.15	14.55
28	C	Open Brush	39,251	0.90	1468	4%	1.11	77	0.67	0.67	17.38	948.17	943.01	144.1	0.036	Section T	5.55	0.43	14.98
29	C	Open Brush	92,345	2.12	7839	8%	1.09	77	0.67	1.55	18.05	943.01	934.18	195.0	0.045	Section U	6.89	0.47	15.45
30	C	Open Brush	37,227	0.85	4245	11%	1.06	77	0.67	0.61	19.61	934.18	918.16	376.5	0.043	Section V	6.97	0.90	16.35
31	C	Open Brush	49,407	1.13	3608	7%	1.03	77	0.65	0.76	20.21	918.16	906.38	309.3	0.038	Section W	7.45	0.69	17.04
32	C	Open Brush	36,940	0.85	1686	5%	1.02	77	0.65	0.56	20.97	906.38	903.17	156.9	0.020	Section X	6.27	0.42	17.46
33	C	Open Brush	22,114	0.51	1681	8%	1.00	77	0.66	0.34	21.54	903.17	899.91	152.6	0.021	Section Y	4.48	0.57	18.03
34	C	Open Brush	54,361	1.25	6014	11%	0.95	77	0.66	0.78	21.87	899.91	896.14	406.9	0.009	Section Z	3.75	1.81	19.84
Total			**1,106,379**	**25.40**	**52,757**	**5%**					**22.7**								

Notes:
1. Riverside County Flood Control and Water Conservation District Hydrology Manual, April 1978
2. Plate C-1.15, RCFC&WCD 1978
3. Plate C-2, RCFC&WCD 1978
4. Plate D-4.3, 4.4, 4.5, 4.6, 4.7, and regression line equations, RCFC&WCD 1978
5. Plate D-5.5, RCFC&WCD 1978
6. Plate D-5.7 (10 of 12) - Since table exists for even numbered values, use value of 76, RCFC&WCD 1978
7. Plate D-6.3 for Natural Mountain Channel, Use Bentley FlowMaster Software for Street Sections, RCFC&WCD 1978
8. Plate D-3 for Initial Sub-Area, RCFC&WCD 1978
9. Assume flowrate, Q = 1 cfs, the minimum value on Plate D-6.3.

TABLE 3
STORM RUNOFF PEAK FLOW RATES FOR 5-YEAR STORM
RATIONAL METHOD CALCULATIONS[1]
Hydrology and Drainage Study - Mount Rubidoux Park
Riverside, California

Sub-Area	Soil Group[2]	Cover Type[3]	Area (feet^2)	Area (acres)	Impervious Area (ft^2)	Percent Impervious	Rainfall Intensity[4] (in/hour)	Runoff Index[5]	Runoff Coefficient[6]	Δ Flow Rate (cfs)	Σ Flow Rate (cfs)	Upper Elevation (ft)	Lower Elevation (ft)	Length of Sub-Area (feet)	Slope (ft/ft)	Section	Velocity[7] (ft/s)	Δ Time of Concentration[8] (minutes)	Σ Time of Concentration (minutes)
1	C	Open Brush	16,291	0.37	0	0%	2.39	77	0.76	0.68		1270	1152	255				5.75	5.75
2	C	Open Brush	19,943	0.46	828	4%	2.22	77	0.76	0.77	0.68	1152	1048.62	207.0	0.499	Nat. Mtn. Chan.	3.9	0.88	6.63
3	C	Open Brush	26,746	0.61	836	3%	2.14	77	0.76	1.00	1.45	1048.62	1045.29	94.4	0.035	Section A	3.61	0.44	7.07
4	C	Open Brush	31,324	0.72	1061	3%	2.06	77	0.75	1.11	2.45	1045.29	1040.99	121.8	0.035	Section A	4.01	0.51	7.58
5	C	Open Brush	34,909	0.80	425	1%	2.04	77	0.74	1.21	3.56	1040.99	1039.39	45.4	0.035	Section A	4.32	0.18	7.75
6	C	Open Brush	62,952	1.45	346	1%	2.02	77	0.74	2.16	4.77	1039.39	1038.02	39.0	0.035	Section A	4.7	0.14	7.89
7	C	Open Brush	39,611	0.91	1831	5%	1.93	77	0.74	1.30	6.93	1038.02	1030.12	223.9	0.035	Section A	5.43	0.69	8.58
8	C	Open Brush	19,794	0.45	289	1%	1.92	77	0.73	0.64	8.23	1030.12	1028.9	34.4	0.035	Section A	5.8	0.10	8.68
9	C	Open Brush	35,103	0.81	2790	8%	1.83	77	0.75	1.11	8.86	1028.9	1019.71	269.3	0.034	Section A	5.92	0.76	9.43
10	C	Open Brush	51,925	1.19	296	1%	1.82	77	0.73	1.59	9.97	1019.71	1018.77	29.4	0.032	Section B	5.86	0.08	9.52
11	C	Open Brush	22,071	0.51	1650	7%	1.77	77	0.73	0.66	11.56	1018.77	1011.46	165.1	0.044	Section C	5.51	0.50	10.02
12	C	Open Brush	174,103	4.00	697	0.4%	1.75	77	0.72	5.04	12.21	1011.46	1009.52	61.2	0.032	Section D	4.26	0.24	10.26
13	C	Open Brush	13,881	0.32	968	7%	1.72	77	0.73	0.40	17.25	1009.52	1005.66	101.9	0.038	Section E	5.88	0.29	10.55
14	C	Open Brush	25,400	0.58	422	2%	1.72	77	0.72	0.72	17.65	1005.66	1002.81	45.5	0.063	Section F	8.06	0.09	10.64
15	C	Open Brush	42,807	0.98	499	1%	1.70	77	0.72	1.21	18.37	1002.81	1000.58	51.8	0.043	Section G	5.96	0.14	10.78
16	C	Open Brush	13,739	0.32	710	5%	1.69	77	0.73	0.39	19.58	1000.58	997.9	73.1	0.037	Section H	6.05	0.20	10.99
17	C	Open Brush	35,101	0.81	599	2%	1.67	77	0.71	0.96	19.96	997.9	996.31	58.8	0.027	Section I	5.15	0.19	11.18
18	C	Open Brush	21,589	0.50	1555	7%	1.65	77	0.72	0.59	20.92	996.31	990.97	101.6	0.053	Section J	6.67	0.25	11.43
19	C	Open Brush	2,242	0.05	1027	46%	1.64	77	0.80	0.07	21.51	990.97	988.21	77.9	0.035	Section K	7.78	0.17	11.60
20	C	Open Brush	2,422	0.06	940	39%	1.62	77	0.79	0.07	21.58	988.21	982.77	88.6	0.061	Section L	8.47	0.17	11.77
21	C	Open Brush	5,908	0.14	1390	24%	1.60	77	0.76	0.16	21.65	982.77	978.01	143.9	0.033	Section M	6.94	0.35	12.12
22	C	Open Brush	10,934	0.25	1337	12%	1.57	77	0.73	0.29	21.81	978.01	973.3	131.7	0.036	Section N	5.79	0.38	12.50
23	C	Open Brush	9,304	0.21	1101	12%	1.55	77	0.72	0.24	22.10	973.3	969.27	108.8	0.037	Section O	6.05	0.30	12.80
24	C	Open Brush	9,954	0.23	1025	10%	1.54	77	0.72	0.25	22.34	969.27	964.66	103.7	0.044	Section P	6.53	0.26	13.06
25	C	Open Brush	15,074	0.35	1308	9%	1.52	77	0.72	0.38	22.59	964.66	958.54	130.4	0.047	Section Q	7.96	0.27	13.33
26	C	Open Brush	18,339	0.42	1587	9%	1.50	77	0.72	0.45	22.97	958.54	951.76	158.7	0.043	Section R	7.13	0.37	13.70
27	C	Open Brush	13,271	0.30	699	5%	1.49	77	0.71	0.32	23.43	951.76	948.17	61.7	0.058	Section S	7.83	0.13	13.84
28	C	Open Brush	39,251	0.90	1468	4%	1.47	77	0.71	0.94	23.75	948.17	943.01	144.1	0.036	Section T	6.26	0.38	14.22
29	C	Open Brush	92,345	2.12	7839	8%	1.44	77	0.71	2.17	24.69	943.01	934.18	195.0	0.045	Section U	7.77	0.42	14.64
30	C	Open Brush	37,227	0.85	4245	11%	1.40	77	0.71	0.85	26.86	934.18	918.16	376.5	0.043	Section V	7.09	0.88	15.52
31	C	Open Brush	49,407	1.13	3608	7%	1.37	77	0.69	1.07	27.71	918.16	906.38	309.3	0.038	Section W	8.37	0.62	16.14
32	C	Open Brush	36,940	0.85	1686	5%	1.35	77	0.69	0.79	28.78	906.38	903.17	156.9	0.020	Section X	6.99	0.37	16.51
33	C	Open Brush	22,114	0.51	1681	8%	1.33	77	0.70	0.47	29.57	903.17	899.91	152.6	0.021	Section Y	5.03	0.51	17.02
34	C	Open Brush	54,361	1.25	6014	11%	1.27	77	0.69	1.09	30.05	899.91	896.14	406.9	0.009	Section Z	4.17	1.63	18.64
Total			**1,106,379**	**25.40**	**52,757**	**5%**					**31.1**								

Notes:
1. Riverside County Flood Control and Water Conservation District Hydrology Manual, April 1978
2. Plate C-1.15, RCFC&WCD 1978
3. Plate C-2, RCFC&WCD 1978
4. Plate D-4.3, 4.4, 4.5, 4.6, 4.7, and regression line equations, RCFC&WCD 1978
5. Plate D-5.5, RCFC&WCD 1978
6. Plate D-5.7 (10 of 12) - Since table exists for even numbered values, use value of 76, RCFC&WCD 1978
7. Plate D-6.3 for Natural Mountain Channel, Use Bentley FlowMaster Software for Street Sections, RCFC&WCD 1978
8. Plate D-3 for Initial Sub-Area, RCFC&WCD 1978
9. Assume flowrate, Q = 1 cfs, the minimum value on Plate D-6.3.

TABLE 4
STORM RUNOFF PEAK FLOW RATES FOR 10-YEAR STORM
RATIONAL METHOD CALCULATIONS[1]
Hydrology and Drainage Study - Mount Rubidoux Park
Riverside, California

Sub-Area	Soil Group[2]	Cover Type[3]	Area (feet^2)	Area (acres)	Impervious Area (ft^2)	Percent Impervious	Rainfall Intensity[4] (in/hour)	Runoff Index[5]	Runoff Coefficient[6]	Δ Flow Rate (cfs)	Σ Flow Rate (cfs)	Upper Elevation (ft)	Lower Elevation (ft)	Length of Sub-Area (feet)	Slope (ft/ft)	Section	Velocity[7] (ft/s)	Δ Time of Concentration[8] (minutes)	Σ Time of Concentration (minutes)
1	C	Open Brush	16,291	0.37	0	0%	2.69	77	0.78	0.79		1270	1152	255				5.75	5.75
2	C	Open Brush	19,943	0.46	828	4%	2.49	77	0.78	0.89	0.79	1152	1048.62	207.0	0.499	Nat. Mtn. Chan.	3.9	0.88	6.63
3	C	Open Brush	26,746	0.61	836	3%	2.41	77	0.78	1.15	1.67	1048.62	1045.29	94.4	0.035	Section A	3.71	0.42	7.06
4	C	Open Brush	31,324	0.72	1061	3%	2.32	77	0.77	1.28	2.83	1045.29	1040.99	121.8	0.035	Section A	4.11	0.49	7.55
5	C	Open Brush	34,909	0.80	425	1%	2.29	77	0.76	1.40	4.11	1040.99	1039.39	45.4	0.035	Section A	4.46	0.17	7.72
6	C	Open Brush	62,952	1.45	346	1%	2.27	77	0.76	2.49	5.51	1039.39	1038.02	39.0	0.035	Section A	4.97	0.13	7.85
7	C	Open Brush	39,611	0.91	1831	5%	2.17	77	0.76	1.50	8.00	1038.02	1030.12	223.9	0.035	Section A	5.75	0.65	8.50
8	C	Open Brush	19,794	0.45	289	1%	2.16	77	0.75	0.74	9.50	1030.12	1028.9	34.4	0.035	Section A	6.13	0.09	8.60
9	C	Open Brush	35,103	0.81	2790	8%	2.07	77	0.76	1.27	10.24	1028.9	1019.71	269.3	0.034	Section A	6.26	0.72	9.31
10	C	Open Brush	51,925	1.19	296	1%	2.06	77	0.74	1.82	11.51	1019.71	1018.77	29.4	0.032	Section B	5.97	0.08	9.39
11	C	Open Brush	22,071	0.51	1650	7%	2.00	77	0.75	0.76	13.32	1018.77	1011.46	165.1	0.044	Section C	5.66	0.49	9.88
12	C	Open Brush	174,103	4.00	697	0.4%	1.98	77	0.74	5.85	14.09	1011.46	1009.52	61.2	0.032	Section D	4.47	0.23	10.11
13	C	Open Brush	13,881	0.32	968	7%	1.95	77	0.75	0.47	19.94	1009.52	1005.66	101.9	0.038	Section E	6.22	0.27	10.38
14	C	Open Brush	25,400	0.58	422	2%	1.94	77	0.74	0.84	20.40	1005.66	1002.81	45.5	0.063	Section F	8.52	0.09	10.47
15	C	Open Brush	42,807	0.98	499	1%	1.93	77	0.73	1.38	21.24	1002.81	1000.58	51.8	0.043	Section G	6.29	0.14	10.61
16	C	Open Brush	13,739	0.32	710	5%	1.91	77	0.74	0.45	22.63	1000.58	997.9	73.1	0.037	Section H	6.37	0.19	10.80
17	C	Open Brush	35,101	0.81	599	2%	1.89	77	0.73	1.11	23.07	997.9	996.31	58.8	0.027	Section I	5.44	0.18	10.98
18	C	Open Brush	21,589	0.50	1555	7%	1.87	77	0.74	0.69	24.18	996.31	990.97	101.6	0.053	Section J	7.06	0.24	11.22
19	C	Open Brush	2,242	0.05	1027	46%	1.86	77	0.80	0.08	24.87	990.97	988.21	77.9	0.035	Section K	8.19	0.16	11.38
20	C	Open Brush	2,422	0.06	940	39%	1.84	77	0.80	0.08	24.95	988.21	982.77	88.6	0.061	Section L	8.92	0.17	11.54
21	C	Open Brush	5,908	0.14	1390	24%	1.81	77	0.77	0.19	25.03	982.77	978.01	143.9	0.033	Section M	7.34	0.33	11.87
22	C	Open Brush	10,934	0.25	1337	12%	1.78	77	0.74	0.33	25.22	978.01	973.3	131.7	0.036	Section N	6.13	0.36	12.23
23	C	Open Brush	9,304	0.21	1101	12%	1.76	77	0.74	0.28	25.55	973.3	969.27	108.8	0.037	Section O	6.34	0.29	12.51
24	C	Open Brush	9,954	0.23	1025	10%	1.74	77	0.74	0.29	25.83	969.27	964.66	103.7	0.044	Section P	6.85	0.25	12.77
25	C	Open Brush	15,074	0.35	1308	9%	1.72	77	0.74	0.44	26.12	964.66	958.54	130.4	0.047	Section Q	8.39	0.26	13.03
26	C	Open Brush	18,339	0.42	1587	9%	1.70	77	0.74	0.53	26.56	958.54	951.76	158.7	0.043	Section R	7.54	0.35	13.38
27	C	Open Brush	13,271	0.30	699	5%	1.69	77	0.73	0.38	27.09	951.76	948.17	61.7	0.058	Section S	8.28	0.12	13.50
28	C	Open Brush	39,251	0.90	1468	4%	1.67	77	0.72	1.08	27.47	948.17	943.01	144.1	0.036	Section T	6.63	0.36	13.86
29	C	Open Brush	92,345	2.12	7839	8%	1.64	77	0.73	2.54	28.55	943.01	934.18	195.0	0.045	Section U	8.19	0.40	14.26
30	C	Open Brush	37,227	0.85	4245	11%	1.59	77	0.73	0.99	31.09	934.18	918.16	376.5	0.043	Section V	7.41	0.85	15.11
31	C	Open Brush	49,407	1.13	3608	7%	1.56	77	0.72	1.27	32.08	918.16	906.38	309.3	0.038	Section W	8.84	0.58	15.69
32	C	Open Brush	36,940	0.85	1686	5%	1.54	77	0.71	0.93	33.35	906.38	903.17	156.9	0.020	Section X	7.35	0.36	16.04
33	C	Open Brush	22,114	0.51	1681	8%	1.51	77	0.72	0.55	34.28	903.17	899.91	152.6	0.021	Section Y	5.31	0.48	16.52
34	C	Open Brush	54,361	1.25	6014	11%	1.44	77	0.71	1.28	34.83	899.91	896.14	406.9	0.009	Section Z	4.4	1.54	18.07
Total			**1,106,379**	**25.40**	**52,757**	**5%**					**36.1**								

Notes:
1. Riverside County Flood Control and Water Conservation District Hydrology Manual, April 1978
2. Plate C-1.15, RCFC&WCD 1978
3. Plate C-2, RCFC&WCD 1978
4. Plate D-4.3, 4.4, 4.5, 4.6, 4.7, and regression line equations, RCFC&WCD 1978
5. Plate D-5.5, RCFC&WCD 1978
6. Plate D-5.7 (10 of 12) - Since table exists for even numbered values, use value of 76, RCFC&WCD 1978
7. Plate D-6.3 for Natural Mountain Channel, Use Bentley FlowMaster Software for Street Sections, RCFC&WCD 1978
8. Plate D-3 for Initial Sub-Area, RCFC&WCD 1978
9. Assume flowrate, Q = 1 cfs, the minimum value on Plate D-6.3.

TABLE 5
STORM RUNOFF PEAK FLOW RATES FOR 25-YEAR STORM
RATIONAL METHOD CALCULATIONS[1]
Hydrology and Drainage Study - Mount Rubidoux Park
Riverside, California

Sub-Area	Soil Group[2]	Cover Type[3]	Area (feet[2])	Area (acres)	Impervious Area (ft[2])	Percent Impervious	Rainfall Intensity[4] (in/hour)	Runoff Index[5]	Runoff Coefficient[6]	Δ Flow Rate (cfs)	Σ Flow Rate (cfs)	Upper Elevation (ft)	Lower Elevation (ft)	Length of Sub-Area (feet)	Slope (ft/ft)	Section	Velocity[7] (ft/s)	Δ Time of Concentration[8] (minutes)	Σ Time of Concentration (minutes)
1	C	Open Brush	16,291	0.37	0	0%	3.12	77	0.79	0.92		1270	1152	255				5.75	5.75
2	C	Open Brush	19,943	0.46	828	4%	2.88	77	0.79	1.04	0.92	1152	1048.62	207.0	0.499	Nat. Mtn. Chan.	3.9	0.88	6.63
3	C	Open Brush	26,746	0.61	836	3%	2.79	77	0.79	1.35	1.96	1048.62	1045.29	94.4	0.035	Section A	3.82	0.41	7.05
4	C	Open Brush	31,324	0.72	1061	3%	2.69	77	0.78	1.51	3.32	1045.29	1040.99	121.8	0.035	Section A	4.25	0.48	7.52
5	C	Open Brush	34,909	0.80	425	1%	2.66	77	0.78	1.66	4.83	1040.99	1039.39	45.4	0.035	Section A	4.72	0.16	7.68
6	C	Open Brush	62,952	1.45	346	1%	2.64	77	0.78	2.97	6.49	1039.39	1038.02	39.0	0.035	Section A	5.3	0.12	7.81
7	C	Open Brush	39,611	0.91	1831	5%	2.53	77	0.78	1.80	9.47	1038.02	1030.12	223.9	0.035	Section A	6.12	0.61	8.42
8	C	Open Brush	19,794	0.45	289	1%	2.52	77	0.77	0.88	11.26	1030.12	1028.9	34.4	0.035	Section A	6.55	0.09	8.50
9	C	Open Brush	35,103	0.81	2790	8%	2.42	77	0.78	1.52	12.14	1028.9	1019.71	269.3	0.034	Section A	6.68	0.67	9.18
10	C	Open Brush	51,925	1.19	296	1%	2.41	77	0.77	2.21	13.66	1019.71	1018.77	29.4	0.032	Section B	6.35	0.08	9.25
11	C	Open Brush	22,071	0.51	1650	7%	2.34	77	0.77	0.91	15.87	1018.77	1011.46	165.1	0.044	Section C	6.04	0.46	9.71
12	C	Open Brush	174,103	4.00	697	0.4%	2.32	77	0.76	7.04	16.79	1011.46	1009.52	61.2	0.032	Section D	4.74	0.22	9.92
13	C	Open Brush	13,881	0.32	968	7%	2.29	77	0.77	0.56	23.82	1009.52	1005.66	101.9	0.038	Section E	6.66	0.25	10.18
14	C	Open Brush	25,400	0.58	422	2%	2.27	77	0.76	1.01	24.38	1005.66	1002.81	45.5	0.063	Section F	9.13	0.08	10.26
15	C	Open Brush	42,807	0.98	499	1%	2.26	77	0.76	1.69	25.39	1002.81	1000.58	51.8	0.043	Section G	6.71	0.13	10.39
16	C	Open Brush	13,739	0.32	710	5%	2.24	77	0.76	0.54	27.08	1000.58	997.9	73.1	0.037	Section H	6.77	0.18	10.57
17	C	Open Brush	35,101	0.81	599	2%	2.22	77	0.75	1.34	27.62	997.9	996.31	58.8	0.027	Section I	5.82	0.17	10.74
18	C	Open Brush	21,589	0.50	1555	7%	2.19	77	0.76	0.83	28.96	996.31	990.97	101.6	0.053	Section J	7.58	0.22	10.96
19	C	Open Brush	2,242	0.05	1027	46%	2.18	77	0.82	0.09	29.79	990.97	988.21	77.9	0.035	Section K	8.59	0.15	11.11
20	C	Open Brush	2,422	0.06	940	39%	2.16	77	0.81	0.10	29.88	988.21	982.77	88.6	0.061	Section L	9.51	0.16	11.27
21	C	Open Brush	5,908	0.14	1390	24%	2.13	77	0.79	0.23	29.97	982.77	978.01	143.9	0.033	Section M	7.87	0.30	11.57
22	C	Open Brush	10,934	0.25	1337	12%	2.10	77	0.76	0.40	30.20	978.01	973.3	131.7	0.036	Section N	6.57	0.33	11.91
23	C	Open Brush	9,304	0.21	1101	12%	2.07	77	0.76	0.34	30.60	973.3	969.27	108.8	0.037	Section O	6.72	0.27	12.18
24	C	Open Brush	9,954	0.23	1025	10%	2.05	77	0.76	0.36	30.94	969.27	964.66	103.7	0.044	Section P	7.25	0.24	12.42
25	C	Open Brush	15,074	0.35	1308	9%	2.03	77	0.76	0.53	31.30	964.66	958.54	130.4	0.047	Section Q	8.97	0.24	12.66
26	C	Open Brush	18,339	0.42	1587	9%	2.00	77	0.76	0.64	31.83	958.54	951.76	158.7	0.043	Section R	8.08	0.33	12.99
27	C	Open Brush	13,271	0.30	699	5%	1.99	77	0.75	0.46	32.47	951.76	948.17	61.7	0.058	Section S	8.87	0.12	13.10
28	C	Open Brush	39,251	0.90	1468	4%	1.97	77	0.75	1.33	32.93	948.17	943.01	144.1	0.036	Section T	7.12	0.34	13.44
29	C	Open Brush	92,345	2.12	7839	8%	1.94	77	0.76	3.12	34.25	943.01	934.18	195.0	0.045	Section U	8.77	0.37	13.81
30	C	Open Brush	37,227	0.85	4245	11%	1.88	77	0.75	1.20	37.37	934.18	918.16	376.5	0.043	Section V	7.87	0.80	14.61
31	C	Open Brush	49,407	1.13	3608	7%	1.84	77	0.74	1.55	38.58	918.16	906.38	309.3	0.038	Section W	9.45	0.55	15.15
32	C	Open Brush	36,940	0.85	1686	5%	1.82	77	0.74	1.14	40.12	906.38	903.17	156.9	0.020	Section X	7.83	0.33	15.49
33	C	Open Brush	22,114	0.51	1681	8%	1.79	77	0.74	0.67	41.26	903.17	899.91	152.6	0.021	Section Y	5.67	0.45	15.93
34	C	Open Brush	54,361	1.25	6014	11%	1.71	77	0.74	1.58	41.94	899.91	896.14	406.9	0.009	Section Z	4.71	1.44	17.37
Total			**1,106,379**	**25.40**	**52,757**	**5%**					**43.5**								

Notes:
1. Riverside County Flood Control and Water Conservation District Hydrology Manual, April 1978
2. Plate C-1.15, RCFC&WCD 1978
3. Plate C-2, RCFC&WCD 1978
4. Plate D-4.3, 4.4, 4.5, 4.6, 4.7, and regression line equations, RCFC&WCD 1978
5. Plate D-5.5, RCFC&WCD 1978
6. Plate D-5.7 (10 of 12) - Since table exists for even numbered values, use value of 76, RCFC&WCD 1978
7. Plate D-6.3 for Natural Mountain Channel, Use Bentley FlowMaster Software for Street Sections, RCFC&WCD 1978
8. Plate D-3 for Initial Sub-Area, RCFC&WCD 1978
9. Assume flowrate, Q = 1 cfs, the minimum value on Plate D-6.3.

TABLE 6
STORM RUNOFF PEAK FLOW RATES FOR 50-YEAR STORM
RATIONAL METHOD CALCULATIONS[1]
Hydrology and Drainage Study - Mount Rubidoux Park
Riverside, California

Sub-Area	Soil Group[2]	Cover Type[3]	Area (feet^2)	Area (acres)	Impervious Area (ft^2)	Percent Impervious	Rainfall Intensity[4] (in/hour)	Runoff Index[5]	Runoff Coefficient[6]	Δ Flow Rate (cfs)	Σ Flow Rate (cfs)	Upper Elevation (ft)	Lower Elevation (ft)	Length of Sub-Area (feet)	Slope (ft/ft)	Section	Velocity[7] (ft/s)	Δ Time of Concentration[8] (minutes)	Σ Time of Concentration (minutes)
1	C	Open Brush	16,291	0.37	0	0%	3.48	77	0.80	1.04		1270	1152	255				5.75	5.75
2	C	Open Brush	19,943	0.46	828	4%	3.22	77	0.80	1.18	1.04	1152	1048.62	207.0	0.499	Nat. Mtn. Chan.	3.9	0.88	6.63
3	C	Open Brush	26,746	0.61	836	3%	3.12	77	0.80	1.53	2.22	1048.62	1045.29	94.4	0.035	Section A	3.92	0.40	7.04
4	C	Open Brush	31,324	0.72	1061	3%	3.01	77	0.79	1.71	3.75	1045.29	1040.99	121.8	0.035	Section A	4.37	0.46	7.50
5	C	Open Brush	34,909	0.80	425	1%	2.98	77	0.79	1.89	5.46	1040.99	1039.39	45.4	0.035	Section A	4.95	0.15	7.65
6	C	Open Brush	62,952	1.45	346	1%	2.95	77	0.79	3.37	7.34	1039.39	1038.02	39.0	0.035	Section A	5.55	0.12	7.77
7	C	Open Brush	39,611	0.91	1831	5%	2.84	77	0.79	2.04	10.72	1038.02	1030.12	223.9	0.035	Section A	6.43	0.58	8.35
8	C	Open Brush	19,794	0.45	289	1%	2.82	77	0.78	1.00	12.76	1030.12	1028.9	34.4	0.035	Section A	6.87	0.08	8.43
9	C	Open Brush	35,103	0.81	2790	8%	2.71	77	0.79	1.73	13.76	1028.9	1019.71	269.3	0.034	Section A	7.01	0.64	9.07
10	C	Open Brush	51,925	1.19	296	1%	2.70	77	0.78	2.51	15.49	1019.71	1018.77	29.4	0.032	Section B	6.63	0.07	9.15
11	C	Open Brush	22,071	0.51	1650	7%	2.64	77	0.78	1.04	18.00	1018.77	1011.46	165.1	0.044	Section C	6.34	0.43	9.58
12	C	Open Brush	174,103	4.00	697	0.4%	2.61	77	0.77	8.02	19.04	1011.46	1009.52	61.2	0.032	Section D	4.94	0.21	9.79
13	C	Open Brush	13,881	0.32	968	7%	2.57	77	0.78	0.64	27.06	1009.52	1005.66	101.9	0.038	Section E	7	0.24	10.03
14	C	Open Brush	25,400	0.58	422	2%	2.56	77	0.77	1.15	27.70	1005.66	1002.81	45.5	0.063	Section F	9.6	0.08	10.11
15	C	Open Brush	42,807	0.98	499	1%	2.54	77	0.77	1.92	28.85	1002.81	1000.58	51.8	0.043	Section G	7.05	0.12	10.23
16	C	Open Brush	13,739	0.32	710	5%	2.52	77	0.78	0.62	30.77	1000.58	997.9	73.1	0.037	Section H	7.07	0.17	10.41
17	C	Open Brush	35,101	0.81	599	2%	2.50	77	0.77	1.55	31.39	997.9	996.31	58.8	0.027	Section I	6.09	0.16	10.57
18	C	Open Brush	21,589	0.50	1555	7%	2.47	77	0.78	0.96	32.95	996.31	990.97	101.6	0.053	Section J	7.97	0.21	10.78
19	C	Open Brush	2,242	0.05	1027	46%	2.46	77	0.83	0.10	33.90	990.97	988.21	77.9	0.035	Section K	8.89	0.15	10.92
20	C	Open Brush	2,422	0.06	940	39%	2.44	77	0.82	0.11	34.01	988.21	982.77	88.6	0.061	Section L	9.94	0.15	11.07
21	C	Open Brush	5,908	0.14	1390	24%	2.40	77	0.80	0.26	34.12	982.77	978.01	143.9	0.033	Section M	8.28	0.29	11.36
22	C	Open Brush	10,934	0.25	1337	12%	2.37	77	0.78	0.46	34.38	978.01	973.3	131.7	0.036	Section N	6.91	0.32	11.68
23	C	Open Brush	9,304	0.21	1101	12%	2.34	77	0.77	0.38	34.84	973.3	969.27	108.8	0.037	Section O	7	0.26	11.94
24	C	Open Brush	9,954	0.23	1025	10%	2.32	77	0.77	0.41	35.23	969.27	964.66	103.7	0.044	Section P	7.56	0.23	12.17
25	C	Open Brush	15,074	0.35	1308	9%	2.29	77	0.77	0.61	35.63	964.66	958.54	130.4	0.047	Section Q	9.39	0.23	12.40
26	C	Open Brush	18,339	0.42	1587	9%	2.26	77	0.77	0.73	36.25	958.54	951.76	158.7	0.043	Section R	8.49	0.31	12.71
27	C	Open Brush	13,271	0.30	699	5%	2.25	77	0.77	0.53	36.98	951.76	948.17	61.7	0.058	Section S	9.32	0.11	12.82
28	C	Open Brush	39,251	0.90	1468	4%	2.22	77	0.76	1.52	37.51	948.17	943.01	144.1	0.036	Section T	7.48	0.32	13.14
29	C	Open Brush	92,345	2.12	7839	8%	2.19	77	0.77	3.57	39.03	943.01	934.18	195.0	0.045	Section U	9.21	0.35	13.50
30	C	Open Brush	37,227	0.85	4245	11%	2.13	77	0.77	1.40	42.60	934.18	918.16	376.5	0.043	Section V	8.2	0.77	14.26
31	C	Open Brush	49,407	1.13	3608	7%	2.08	77	0.76	1.80	44.00	918.16	906.38	309.3	0.038	Section W	9.91	0.52	14.78
32	C	Open Brush	36,940	0.85	1686	5%	2.06	77	0.75	1.31	45.80	906.38	903.17	156.9	0.020	Section X	8.2	0.32	15.10
33	C	Open Brush	22,114	0.51	1681	8%	2.03	77	0.76	0.78	47.11	903.17	899.91	152.6	0.021	Section Y	5.95	0.43	15.53
34	C	Open Brush	54,361	1.25	6014	11%	1.94	77	0.76	1.84	47.89	899.91	896.14	406.9	0.009	Section Z	4.94	1.37	16.90
Total			**1,106,379**	**25.40**	**52,757**	**5%**					**49.7**								

Notes:
1. Riverside County Flood Control and Water Conservation District Hydrology Manual, April 1978
2. Plate C-1.15, RCFC&WCD 1978
3. Plate C-2, RCFC&WCD 1978
4. Plate D-4.3, 4.4, 4.5, 4.6, 4.7, and regression line equations, RCFC&WCD 1978
5. Plate D-5.5, RCFC&WCD 1978
6. Plate D-5.7 (10 of 12) - Since table exists for even numbered values, use value of 76, RCFC&WCD 1978
7. Plate D-6.3 for Natural Mountain Channel, Use Bentley FlowMaster Software for Street Sections, RCFC&WCD 1978
8. Plate D-3 for Initial Sub-Area, RCFC&WCD 1978
9. Assume flowrate, Q = 1 cfs, the minimum value on Plate D-6.3.

TABLE 7
STORM RUNOFF PEAK FLOW RATES FOR 100 YEAR STORM
RATIONAL METHOD CALCULATIONS[1]
Hydrology and Drainage Study - Mount Rubidoux Park
Riverside, California

Sub-Area	Soil Group[2]	Cover Type[3]	Area (feet[2])	Area (acres)	Impervious Area (ft[2])	Percent Impervious	Rainfall Intensity[4] (in/hour)	Runoff Index[5]	Runoff Coefficient[6]	Δ Flow Rate (cfs)	Σ Flow Rate (cfs)	Upper Elevation (ft)	Lower Elevation (ft)	Length of Sub-Area (feet)	Slope (ft/ft)	Section	Velocity[7] (ft/s)	Δ Time of Concentration[8] (minutes)	Σ Time of Concentration (minutes)
1	C	Open Brush	16,291	0.37	0	0%	3.78	77	0.80	1.13		1270	1152	255				5.75	5.75
2	C	Open Brush	19,943	0.46	828	4%	3.51	77	0.81	1.30	1.13	1152	1048.62	207.0	0.499	Nat. Mtn. Chan.	4	0.86	6.61
3	C	Open Brush	26,746	0.61	836	3%	3.40	77	0.81	1.69	2.43	1048.62	1045.29	94.4	0.035	Section A	4.01	0.39	7.00
4	C	Open Brush	31,324	0.72	1061	3%	3.29	77	0.80	1.89	4.12	1045.29	1040.99	121.8	0.035	Section A	4.46	0.46	7.46
5	C	Open Brush	34,909	0.80	425	1%	3.25	77	0.80	2.09	6.01	1040.99	1039.39	45.4	0.035	Section A	5.14	0.15	7.61
6	C	Open Brush	62,952	1.45	346	1%	3.23	77	0.80	3.73	8.10	1039.39	1038.02	39.0	0.035	Section A	5.76	0.11	7.72
7	C	Open Brush	39,611	0.91	1831	5%	3.11	77	0.79	2.23	11.83	1038.02	1030.12	223.9	0.035	Section A	6.67	0.56	8.28
8	C	Open Brush	19,794	0.45	289	1%	3.09	77	0.79	1.11	14.06	1030.12	1028.9	34.4	0.035	Section A	7.13	0.08	8.36
9	C	Open Brush	35,103	0.81	2790	8%	2.97	77	0.80	1.92	15.17	1028.9	1019.71	269.3	0.034	Section A	7.27	0.62	8.98
10	C	Open Brush	51,925	1.19	296	1%	2.96	77	0.79	2.79	17.09	1019.71	1018.77	29.4	0.032	Section B	6.86	0.07	9.05
11	C	Open Brush	22,071	0.51	1650	7%	2.89	77	0.79	1.16	19.88	1018.77	1011.46	165.1	0.044	Section C	6.55	0.42	9.47
12	C	Open Brush	174,103	4.00	697	0.4%	2.86	77	0.78	8.91	21.03	1011.46	1009.52	61.2	0.032	Section D	5.1	0.20	9.67
13	C	Open Brush	13,881	0.32	968	7%	2.82	77	0.78	0.70	29.94	1009.52	1005.66	101.9	0.038	Section E	7.27	0.23	9.90
14	C	Open Brush	25,400	0.58	422	2%	2.81	77	0.78	1.28	30.64	1005.66	1002.81	45.5	0.063	Section F	9.98	0.08	9.98
15	C	Open Brush	42,807	0.98	499	1%	2.79	77	0.78	2.14	31.92	1002.81	1000.58	51.8	0.043	Section G	7.34	0.12	10.10
16	C	Open Brush	13,739	0.32	710	5%	2.77	77	0.79	0.69	34.06	1000.58	997.9	73.1	0.037	Section H	7.32	0.17	10.26
17	C	Open Brush	35,101	0.81	599	2%	2.74	77	0.78	1.73	34.75	997.9	996.31	58.8	0.027	Section I	6.34	0.15	10.42
18	C	Open Brush	21,589	0.50	1555	7%	2.72	77	0.78	1.05	36.47	996.31	990.97	101.6	0.053	Section J	8.28	0.20	10.62
19	C	Open Brush	2,242	0.05	1027	46%	2.70	77	0.84	0.12	37.52	990.97	988.21	77.9	0.035	Section K	9.17	0.14	10.76
20	C	Open Brush	2,422	0.06	940	39%	2.68	77	0.82	0.12	37.64	988.21	982.77	88.6	0.061	Section L	10.3	0.14	10.91
21	C	Open Brush	5,908	0.14	1390	24%	2.64	77	0.81	0.29	37.76	982.77	978.01	143.9	0.033	Section M	8.6	0.28	11.19
22	C	Open Brush	10,934	0.25	1337	12%	2.60	77	0.78	0.51	38.05	978.01	973.3	131.7	0.036	Section N	7.18	0.31	11.49
23	C	Open Brush	9,304	0.21	1101	12%	2.57	77	0.78	0.43	38.56	973.3	969.27	108.8	0.037	Section O	7.23	0.25	11.74
24	C	Open Brush	9,954	0.23	1025	10%	2.55	77	0.78	0.45	38.99	969.27	964.66	103.7	0.044	Section P	7.86	0.22	11.96
25	C	Open Brush	15,074	0.35	1308	9%	2.52	77	0.78	0.68	39.44	964.66	958.54	130.4	0.047	Section Q	9.75	0.22	12.18
26	C	Open Brush	18,339	0.42	1587	9%	2.49	77	0.78	0.82	40.13	958.54	951.76	158.7	0.043	Section R	8.83	0.30	12.48
27	C	Open Brush	13,271	0.30	699	5%	2.48	77	0.78	0.59	40.94	951.76	948.17	61.7	0.058	Section S	9.67	0.11	12.59
28	C	Open Brush	39,251	0.90	1468	4%	2.45	77	0.78	1.72	41.53	948.17	943.01	144.1	0.036	Section T	7.78	0.31	12.90
29	C	Open Brush	92,345	2.12	7839	8%	2.41	77	0.78	3.99	43.25	943.01	934.18	195.0	0.045	Section U	9.56	0.34	13.24
30	C	Open Brush	37,227	0.85	4245	11%	2.34	77	0.77	1.54	47.24	934.18	918.16	376.5	0.043	Section V	8.48	0.74	13.98
31	C	Open Brush	49,407	1.13	3608	7%	2.30	77	0.77	2.01	48.78	918.16	906.38	309.3	0.038	Section W	10.28	0.50	14.48
32	C	Open Brush	36,940	0.85	1686	5%	2.27	77	0.77	1.48	50.78	906.38	903.17	156.9	0.020	Section X	8.5	0.31	14.79
33	C	Open Brush	22,114	0.51	1681	8%	2.24	77	0.77	0.87	52.27	903.17	899.91	152.6	0.021	Section Y	6.17	0.41	15.20
34	C	Open Brush	54,361	1.25	6014	11%	2.14	77	0.77	2.06	53.14	899.91	896.14	406.9	0.009	Section Z	5.13	1.32	16.52
Total			**1,106,379**	**25.40**	**52,757**	**5%**					**55.2**								

Notes:
1. Riverside County Flood Control and Water Conservation District Hydrology Manual, April 1978
2. Plate C-1.15, RCFC&WCD 1978
3. Plate C-2, RCFC&WCD 1978
4. Plate D-4.3, 4.4, 4.5, 4.6, 4.7, and regression line equations, RCFC&WCD 1978
5. Plate D-5.5, RCFC&WCD 1978
6. Plate D-5.7 (10 of 12) - Since table exists for even numbered values, use value of 76, RCFC&WCD 1978
7. Plate D-6.3 for Natural Mountain Channel, Use Bentley FlowMaster Software for Street Sections, RCFC&WCD 1978
8. Plate D-3 for Initial Sub-Area, RCFC&WCD 1978
9. Assume flowrate, Q = 1 cfs, the minimum value on Plate D-6.3.

TABLE 8
UPROAD HYDRAULIC ANALYSIS FOR 2-YEAR STORM
OPEN CHANNEL FLOW CALCULATIONS[1]
Hydrology and Drainage Study - Mount Rubidoux Park
Riverside, California

Label	Solve For	Friction Method	Roughness Coefficient	Channel Slope (ft/ft)	Water Surface Elevation (ft)	Elevation Range	Discharge (ft^3/s)	Flow Area (ft^2)	Top Width (ft)	Normal Depth (ft)	Critical Depth (ft)	Velocity (ft/s)	Froude Number	Flow Type
Sub-Area 9 - Section A	Normal Depth	Manning Formula	0.013	0.034	1020.94	1020.69 to 1025.96 ft	6.6	1.25	9.88	0.25	0.37	5.3	2.62	Supercritical
Sub-Area 10 - Section B	Normal Depth	Manning Formula	0.014	0.032	1019.00	1018.77 to 1024.46 ft	7.4	1.35	8.81	0.23	0.36	5.5	2.46	Supercritical
Sub-Area 11 - Section C	Normal Depth	Manning Formula	0.017	0.044	1012.52	1011.90 to 1016.00 ft	8.6	1.56	9.40	0.62	0.75	5.5	2.39	Supercritical
Sub-Area 12 - Section D	Normal Depth	Manning Formula	0.015	0.032	1009.60	1009.20 to 1009.85 ft	9.1	1.90	14.12	0.40	0.50	4.8	2.29	Supercritical
Sub-Area 13 - Section E	Normal Depth	Manning Formula	0.015	0.038	1005.82	1005.46 to 1012.00 ft	12.7	1.95	10.06	0.36	0.54	6.5	2.62	Supercritical
Sub-Area 14 - Section F	Normal Depth	Manning Formula	0.014	0.063	1004.19	1003.89 to 1007.00 ft	13.0	1.81	12.24	0.30	0.48	7.2	3.31	Supercritical
Sub-Area 15 - Section G	Normal Depth	Manning Formula	0.017	0.043	1001.70	1001.27 to 1006.00 ft	13.5	2.48	15.47	0.43	0.55	5.5	2.40	Supercritical
Sub-Area 16 - Section H	Normal Depth	Manning Formula	0.016	0.037	999.00	998.66 to 1003.00 ft	14.4	2.65	15.39	0.34	0.48	5.4	2.31	Supercritical
Sub-Area 17 - Section I	Normal Depth	Manning Formula	0.017	0.027	997.02	996.31 to 1000.00 ft	14.7	3.12	16.61	0.71	0.81	4.7	1.91	Supercritical
Sub-Area 18 - Section J	Normal Depth	Manning Formula	0.015	0.053	995.34	994.90 to 1000.00 ft	15.4	2.60	18.68	0.44	0.58	5.9	2.80	Supercritical
Sub-Area 19 - Section K	Normal Depth	Manning Formula	0.014	0.035	988.17	987.85 to 995.00 ft	15.8	2.28	11.38	0.32	0.51	6.9	2.73	Supercritical
Sub-Area 20 - Section L	Normal Depth	Manning Formula	0.015	0.061	983.87	983.29 to 992.00 ft	15.8	2.09	11.48	0.58	0.79	7.6	3.12	Supercritical
Sub-Area 21 - Section M	Normal Depth	Manning Formula	0.014	0.033	978.13	977.74 to 985.00 ft	15.9	2.56	13.85	0.39	0.55	6.2	2.55	Supercritical
Sub-Area 22 - Section N	Normal Depth	Manning Formula	0.015	0.036	973.37	972.56 to 977.51 ft	16.0	2.65	13.22	0.81	0.97	6.1	2.38	Supercritical
Sub-Area 23 - Section O	Normal Depth	Manning Formula	0.016	0.037	969.35	968.84 to 973.78 ft	16.2	2.97	16.88	0.51	0.64	5.5	2.29	Supercritical
Sub-Area 24 - Section P	Normal Depth	Manning Formula	0.017	0.044	965.61	965.10 to 970.00 ft	16.4	2.77	14.57	0.51	0.66	5.9	2.39	Supercritical
Sub-Area 25 - Section Q	Normal Depth	Manning Formula	0.015	0.047	960.95	960.44 to 962.00 ft	16.6	2.34	12.03	0.51	0.71	7.1	2.83	Supercritical
Sub-Area 26 - Section R	Normal Depth	Manning Formula	0.016	0.043	951.84	951.45 to 954.85 ft	16.8	2.66	14.46	0.39	0.55	6.3	2.60	Supercritical
Sub-Area 27 - Section S	Normal Depth	Manning Formula	0.015	0.058	949.25	948.76 to 951.00 ft	17.2	2.47	15.31	0.49	0.67	6.9	3.05	Supercritical
Sub-Area 28 - Section T	Normal Depth	Manning Formula	0.016	0.036	943.03	942.63 to 946.45 ft	17.4	3.13	16.92	0.40	0.54	5.6	2.27	Supercritical
Sub-Area 29 - Section U	Normal Depth	Manning Formula	0.015	0.045	934.22	933.69 to 937.77 ft	18.1	2.62	14.44	0.53	0.72	6.9	2.85	Supercritical
Sub-Area 30 - Section V	Normal Depth	Manning Formula	0.016	0.043	919.46	918.84 to 921.25 ft	19.6	2.81	13.28	0.62	0.81	7.0	2.67	Supercritical
Sub-Area 31 - Section W	Normal Depth	Manning Formula	0.016	0.038	906.84	906.31 to 908.24 ft	20.2	2.71	9.58	0.53	0.77	7.5	2.47	Supercritical
Sub-Area 32 - Section X	Normal Depth	Manning Formula	0.014	0.020	903.43	903.02 to 906.00 ft	21.0	3.34	12.15	0.41	0.59	6.3	2.11	Supercritical
Sub-Area 33 - Section Y	Normal Depth	Manning Formula	0.016	0.021	901.40	901.09 to 902.00 ft	21.5	4.17	17.53	0.31	0.44	5.2	1.87	Supercritical
Sub-Area 34 - Section Z	Normal Depth	Manning Formula	0.015	0.009	896.14	895.75 to 900.00 ft	21.9	5.83	22.47	0.39	0.45	3.8	1.30	Supercritical
Section AA	Normal Depth	Manning Formula	0.015	0.036	976.21	975.88 to 978.00 ft	15.9	2.54	13.76	0.33	0.49	6.2	2.56	Supercritical
Section BB	Normal Depth	Manning Formula	0.016	0.036	974.48	973.84 to 977.00 ft	15.9	2.78	14.88	0.64	0.79	5.7	2.33	Supercritical
Section CC	Normal Depth	Manning Formula	0.015	0.047	958.66	958.23 to 964.50 ft	16.6	2.28	10.92	0.43	0.64	7.3	2.80	Supercritical
Section EE	Normal Depth	Manning Formula	0.014	0.047	954.75	954.28 to 959.26 ft	16.6	2.26	12.42	0.47	0.67	7.3	3.03	Supercritical
Section DD	Normal Depth	Manning Formula	0.016	0.047	957.48	957.05 to 962.83 ft	16.6	2.60	14.87	0.43	0.60	6.4	2.69	Supercritical

Notes:
1. Bentley FlowMaster V8i Software Output

TABLE 9
UPROAD HYDRAULIC ANALYSIS FOR 5-YEAR STORM
OPEN CHANNEL FLOW CALCULATIONS[1]
Hydrology and Drainage Study - Mount Rubidoux Park
Riverside, California

Label	Solve For	Friction Method	Roughness Coefficient	Channel Slope (ft/ft)	Water Surface Elevation (ft)	Elevation Range	Discharge (ft^3/s)	Flow Area (ft^2)	Top Width (ft)	Normal Depth (ft)	Critical Depth (ft)	Velocity (ft/s)	Froude Number	Flow Type
Sub-Area 9 - Section A	Normal Depth	Manning Formula	0.013	0.034	1020.97	1020.69 to 1025.96 ft	8.9	1.50	9.95	0.28	0.42	5.9	2.69	Supercritical
Sub-Area 10 - Section B	Normal Depth	Manning Formula	0.014	0.032	1019.04	1018.77 to 1024.46 ft	10.0	1.70	9.88	0.27	0.42	5.9	2.49	Supercritical
Sub-Area 11 - Section C	Normal Depth	Manning Formula	0.016	0.044	1012.57	1011.90 to 1016.00 ft	11.6	2.10	13.72	0.67	0.79	5.5	2.48	Supercritical
Sub-Area 12 - Section D	Normal Depth	Manning Formula	0.015	0.032	1009.63	1009.20 to 1009.85 ft	12.2	2.35	14.96	0.43	0.55	5.2	2.31	Supercritical
Sub-Area 13 - Section E	Normal Depth	Manning Formula	0.015	0.038	1005.87	1005.46 to 1012.00 ft	17.3	2.40	10.86	0.41	0.61	7.2	2.69	Supercritical
Sub-Area 14 - Section F	Normal Depth	Manning Formula	0.014	0.063	1004.22	1003.89 to 1007.00 ft	17.7	2.19	12.56	0.33	0.55	8.1	3.40	Supercritical
Sub-Area 15 - Section G	Normal Depth	Manning Formula	0.016	0.043	1001.74	1001.27 to 1006.00 ft	18.4	3.08	16.96	0.47	0.62	6.0	2.47	Supercritical
Sub-Area 16 - Section H	Normal Depth	Manning Formula	0.016	0.037	999.04	998.66 to 1003.00 ft	19.6	3.24	15.79	0.38	0.54	6.1	2.36	Supercritical
Sub-Area 17 - Section I	Normal Depth	Manning Formula	0.017	0.027	997.06	996.31 to 1000.00 ft	20.0	3.88	18.39	0.75	0.87	5.2	1.98	Supercritical
Sub-Area 18 - Section J	Normal Depth	Manning Formula	0.015	0.053	995.37	994.90 to 1000.00 ft	20.9	3.13	18.73	0.47	0.64	6.7	2.88	Supercritical
Sub-Area 19 - Section K	Normal Depth	Manning Formula	0.014	0.035	988.21	987.85 to 995.00 ft	21.5	2.77	11.55	0.36	0.60	7.8	2.80	Supercritical
Sub-Area 20 - Section L	Normal Depth	Manning Formula	0.015	0.061	983.91	983.29 to 992.00 ft	21.6	2.55	11.72	0.62	0.87	8.5	3.20	Supercritical
Sub-Area 21 - Section M	Normal Depth	Manning Formula	0.014	0.033	978.17	977.74 to 985.00 ft	21.7	3.12	14.22	0.43	0.63	6.9	2.61	Supercritical
Sub-Area 22 - Section N	Normal Depth	Manning Formula	0.015	0.036	973.41	972.56 to 977.51 ft	21.8	3.20	13.26	0.85	1.05	6.8	2.44	Supercritical
Sub-Area 23 - Section O	Normal Depth	Manning Formula	0.016	0.037	969.39	968.84 to 973.78 ft	22.1	3.66	17.53	0.55	0.70	6.1	2.33	Supercritical
Sub-Area 24 - Section P	Normal Depth	Manning Formula	0.017	0.044	965.65	965.10 to 970.00 ft	22.3	3.42	15.70	0.55	0.73	6.5	2.47	Supercritical
Sub-Area 25 - Section Q	Normal Depth	Manning Formula	0.015	0.047	960.99	960.44 to 962.00 ft	22.6	2.84	12.17	0.55	0.80	8.0	2.90	Supercritical
Sub-Area 26 - Section R	Normal Depth	Manning Formula	0.016	0.043	951.88	951.45 to 954.85 ft	23.0	3.22	14.51	0.43	0.63	7.1	2.67	Supercritical
Sub-Area 27 - Section S	Normal Depth	Manning Formula	0.015	0.058	949.28	948.76 to 951.00 ft	23.4	2.99	15.41	0.52	0.74	7.8	3.13	Supercritical
Sub-Area 28 - Section T	Normal Depth	Manning Formula	0.016	0.036	943.07	942.63 to 946.45 ft	23.8	3.79	16.95	0.44	0.61	6.3	2.34	Supercritical
Sub-Area 29 - Section U	Normal Depth	Manning Formula	0.015	0.045	934.26	933.69 to 937.77 ft	24.7	3.18	14.59	0.57	0.80	7.8	2.93	Supercritical
Sub-Area 30 - Section V	Normal Depth	Manning Formula	0.015	0.043	919.53	918.84 to 921.25 ft	26.9	3.79	17.87	0.69	0.89	7.1	2.72	Supercritical
Sub-Area 31 - Section W	Normal Depth	Manning Formula	0.016	0.038	906.90	906.31 to 908.24 ft	27.7	3.31	9.70	0.59	0.89	8.4	2.53	Supercritical
Sub-Area 32 - Section X	Normal Depth	Manning Formula	0.014	0.020	903.49	903.02 to 906.00 ft	28.8	4.12	12.46	0.47	0.69	7.0	2.14	Supercritical
Sub-Area 33 - Section Y	Normal Depth	Manning Formula	0.016	0.021	901.46	901.09 to 902.00 ft	29.6	5.08	17.80	0.37	0.53	5.8	1.92	Supercritical
Sub-Area 34 - Section Z	Normal Depth	Manning Formula	0.015	0.009	896.20	895.75 to 900.00 ft	30.1	7.21	23.26	0.45	0.52	4.2	1.32	Supercritical
Section AA	Normal Depth	Manning Formula	0.015	0.036	976.25	975.88 to 978.00 ft	21.7	3.09	13.98	0.37	0.57	7.0	2.62	Supercritical
Section BB	Normal Depth	Manning Formula	0.016	0.036	974.53	973.84 to 977.00 ft	21.7	3.43	15.57	0.69	0.86	6.3	2.37	Supercritical
Section CC	Normal Depth	Manning Formula	0.015	0.047	958.70	958.23 to 964.50 ft	22.6	2.76	10.98	0.47	0.73	8.2	2.88	Supercritical
Section DD	Normal Depth	Manning Formula	0.016	0.047	957.52	957.05 to 962.83 ft	22.6	3.15	15.01	0.47	0.68	7.2	2.76	Supercritical
Section EE	Normal Depth	Manning Formula	0.014	0.047	954.79	954.28 to 959.26 ft	22.6	2.75	12.59	0.51	0.76	8.2	3.11	Supercritical

Notes:
1. Bentley FlowMaster V8i Software Output

TABLE 10
UPROAD HYDRAULIC ANALYSIS FOR 10-YEAR STORM
OPEN CHANNEL FLOW CALCULATIONS[1]
Hydrology and Drainage Study - Mount Rubidoux Park
Riverside, California

Label	Solve For	Friction Method	Roughness Coefficient	Channel Slope (ft/ft)	Water Surface Elevation (ft)	Elevation Range	Discharge (ft^3/s)	Flow Area (ft^2)	Top Width (ft)	Normal Depth (ft)	Critical Depth (ft)	Velocity (ft/s)	Froude Number	Flow Type
Sub-Area 9 - Section A	Normal Depth	Manning Formula	0.013	0.034	1020.98	1020.69 to 1025.96 ft	10.2	1.64	9.99	0.29	0.45	6.3	2.73	Supercritical
Sub-Area 10 - Section B	Normal Depth	Manning Formula	0.014	0.032	1019.06	1018.77 to 1024.46 ft	11.5	1.93	10.85	0.29	0.45	6.0	2.50	Supercritical
Sub-Area 11 - Section C	Normal Depth	Manning Formula	0.016	0.044	1012.59	1011.90 to 1016.00 ft	13.3	2.35	15.04	0.69	0.82	5.7	2.52	Supercritical
Sub-Area 12 - Section D	Normal Depth	Manning Formula	0.015	0.032	1009.64	1009.20 to 1009.85 ft	14.1	2.60	15.26	0.44	0.58	5.4	2.32	Supercritical
Sub-Area 13 - Section E	Normal Depth	Manning Formula	0.015	0.038	1005.89	1005.46 to 1012.00 ft	19.9	2.63	10.93	0.43	0.66	7.6	2.73	Supercritical
Sub-Area 14 - Section F	Normal Depth	Manning Formula	0.014	0.063	1004.24	1003.89 to 1007.00 ft	20.4	2.39	12.58	0.35	0.59	8.5	3.44	Supercritical
Sub-Area 15 - Section G	Normal Depth	Manning Formula	0.016	0.043	1001.75	1001.27 to 1006.00 ft	21.2	3.38	17.10	0.48	0.65	6.3	2.50	Supercritical
Sub-Area 16 - Section H	Normal Depth	Manning Formula	0.016	0.037	999.06	998.66 to 1003.00 ft	22.6	3.55	16.00	0.40	0.58	6.4	2.38	Supercritical
Sub-Area 17 - Section I	Normal Depth	Manning Formula	0.017	0.027	997.08	996.31 to 1000.00 ft	23.1	4.24	18.48	0.77	0.91	5.4	2.00	Supercritical
Sub-Area 18 - Section J	Normal Depth	Manning Formula	0.015	0.053	995.38	994.90 to 1000.00 ft	24.2	3.42	18.75	0.48	0.67	7.1	2.91	Supercritical
Sub-Area 19 - Section K	Normal Depth	Manning Formula	0.014	0.035	988.23	987.85 to 995.00 ft	24.9	3.04	11.66	0.38	0.64	8.2	2.83	Supercritical
Sub-Area 20 - Section L	Normal Depth	Manning Formula	0.015	0.061	983.93	983.29 to 992.00 ft	25.0	2.80	11.84	0.64	0.92	8.9	3.24	Supercritical
Sub-Area 21 - Section M	Normal Depth	Manning Formula	0.014	0.033	978.19	977.74 to 985.00 ft	25.0	3.41	14.24	0.45	0.67	7.3	2.65	Supercritical
Sub-Area 22 - Section N	Normal Depth	Manning Formula	0.015	0.036	973.43	972.56 to 977.51 ft	25.2	3.50	13.27	0.87	1.09	7.2	2.47	Supercritical
Sub-Area 23 - Section O	Normal Depth	Manning Formula	0.017	0.037	969.41	968.84 to 973.78 ft	25.6	4.03	17.87	0.57	0.74	6.3	2.35	Supercritical
Sub-Area 24 - Section P	Normal Depth	Manning Formula	0.017	0.044	965.67	965.10 to 970.00 ft	25.8	3.77	16.28	0.57	0.77	6.9	2.51	Supercritical
Sub-Area 25 - Section Q	Normal Depth	Manning Formula	0.015	0.047	961.01	960.44 to 962.00 ft	26.1	3.11	12.24	0.57	0.84	8.4	2.93	Supercritical
Sub-Area 26 - Section R	Normal Depth	Manning Formula	0.016	0.043	951.90	951.45 to 954.85 ft	26.6	3.52	14.53	0.45	0.68	7.5	2.70	Supercritical
Sub-Area 27 - Section S	Normal Depth	Manning Formula	0.015	0.058	949.30	948.76 to 951.00 ft	27.1	3.27	15.47	0.54	0.79	8.3	3.17	Supercritical
Sub-Area 28 - Section T	Normal Depth	Manning Formula	0.016	0.036	943.09	942.63 to 946.45 ft	27.5	4.15	16.97	0.46	0.65	6.6	2.36	Supercritical
Sub-Area 29 - Section U	Normal Depth	Manning Formula	0.015	0.045	934.28	933.69 to 937.77 ft	28.6	3.48	14.66	0.59	0.85	8.2	2.96	Supercritical
Sub-Area 30 - Section V	Normal Depth	Manning Formula	0.015	0.043	919.55	918.84 to 921.25 ft	31.1	4.19	18.38	0.71	0.93	7.4	2.74	Supercritical
Sub-Area 31 - Section W	Normal Depth	Manning Formula	0.016	0.038	906.93	906.31 to 908.24 ft	32.1	3.63	9.76	0.62	0.95	8.8	2.55	Supercritical
Sub-Area 32 - Section X	Normal Depth	Manning Formula	0.014	0.020	903.53	903.02 to 906.00 ft	33.4	4.54	12.62	0.51	0.75	7.4	2.16	Supercritical
Sub-Area 33 - Section Y	Normal Depth	Manning Formula	0.016	0.021	901.48	901.09 to 902.00 ft	34.3	5.58	17.96	0.39	0.57	6.1	1.94	Supercritical
Sub-Area 34 - Section Z	Normal Depth	Manning Formula	0.015	0.009	896.23	895.75 to 900.00 ft	34.8	7.91	23.41	0.48	0.56	4.4	1.34	Supercritical
Section AA	Normal Depth	Manning Formula	0.015	0.036	976.27	975.88 to 978.00 ft	25.0	3.39	14.10	0.39	0.61	7.4	2.65	Supercritical
Section BB	Normal Depth	Manning Formula	0.016	0.036	974.55	973.84 to 977.00 ft	25.0	3.80	15.94	0.71	0.90	6.6	2.38	Supercritical
Section CC	Normal Depth	Manning Formula	0.015	0.047	958.73	958.23 to 964.50 ft	26.1	3.02	11.01	0.50	0.78	8.7	2.91	Supercritical
Section DD	Normal Depth	Manning Formula	0.016	0.047	957.54	957.05 to 962.83 ft	26.1	3.45	15.08	0.49	0.72	7.6	2.79	Supercritical
Section EE	Normal Depth	Manning Formula	0.014	0.047	954.81	954.28 to 959.26 ft	26.1	3.00	12.68	0.53	0.80	8.7	3.15	Supercritical

Notes:
1. Bentley FlowMaster V8i Software Output

TABLE 11
UPROAD HYDRAULIC ANALYSIS FOR 25-YEAR STORM
OPEN CHANNEL FLOW CALCULATIONS[1]
Hydrology and Drainage Study - Mount Rubidoux Park
Riverside, California

Label	Solve For	Friction Method	Roughness Coefficient	Channel Slope (ft/ft)	Water Surface Elevation (ft)	Elevation Range	Discharge (ft^3/s)	Flow Area (ft^2)	Top Width (ft)	Normal Depth (ft)	Critical Depth (ft)	Velocity (ft/s)	Froude Number	Flow Type
Sub-Area 9 - Section A	Normal Depth	Manning Formula	0.013	0.034	1021.00	1020.69 to 1025.96 ft	12.1	1.82	10.04	0.31	0.49	6.7	2.77	Supercritical
Sub-Area 10 - Section B	Normal Depth	Manning Formula	0.014	0.032	1019.08	1018.77 to 1024.46 ft	13.7	2.15	10.97	0.31	0.48	6.4	2.53	Supercritical
Sub-Area 11 - Section C	Normal Depth	Manning Formula	0.016	0.044	1012.60	1011.90 to 1016.00 ft	15.9	2.63	15.19	0.70	0.86	6.0	2.56	Supercritical
Sub-Area 12 - Section D	Normal Depth	Manning Formula	0.015	0.032	1009.67	1009.20 to 1009.85 ft	16.8	2.94	15.67	0.47	0.61	5.7	2.33	Supercritical
Sub-Area 13 - Section E	Normal Depth	Manning Formula	0.015	0.038	1005.92	1005.46 to 1012.00 ft	23.8	2.94	11.02	0.46	0.72	8.1	2.77	Supercritical
Sub-Area 14 - Section F	Normal Depth	Manning Formula	0.014	0.063	1004.26	1003.89 to 1007.00 ft	24.4	2.67	12.60	0.37	0.65	9.1	3.50	Supercritical
Sub-Area 15 - Section G	Normal Depth	Manning Formula	0.017	0.043	1001.78	1001.27 to 1006.00 ft	25.4	3.78	17.30	0.51	0.69	6.7	2.53	Supercritical
Sub-Area 16 - Section H	Normal Depth	Manning Formula	0.016	0.037	999.09	998.66 to 1003.00 ft	27.1	4.00	16.30	0.43	0.63	6.8	2.41	Supercritical
Sub-Area 17 - Section I	Normal Depth	Manning Formula	0.017	0.027	997.11	996.31 to 1000.00 ft	27.6	4.75	18.60	0.80	0.96	5.8	2.03	Supercritical
Sub-Area 18 - Section J	Normal Depth	Manning Formula	0.015	0.053	995.40	994.90 to 1000.00 ft	29.0	3.82	18.78	0.50	0.72	7.6	2.96	Supercritical
Sub-Area 19 - Section K	Normal Depth	Manning Formula	0.014	0.035	988.27	987.85 to 995.00 ft	29.8	3.47	12.05	0.42	0.71	8.6	2.83	Supercritical
Sub-Area 20 - Section L	Normal Depth	Manning Formula	0.016	0.061	983.96	983.29 to 992.00 ft	29.9	3.14	12.02	0.67	0.98	9.5	3.28	Supercritical
Sub-Area 21 - Section M	Normal Depth	Manning Formula	0.014	0.033	978.22	977.74 to 985.00 ft	30.0	3.81	14.26	0.48	0.73	7.9	2.69	Supercritical
Sub-Area 22 - Section N	Normal Depth	Manning Formula	0.015	0.036	973.46	972.56 to 977.51 ft	30.2	3.91	13.30	0.90	1.15	7.7	2.51	Supercritical
Sub-Area 23 - Section O	Normal Depth	Manning Formula	0.017	0.037	969.44	968.84 to 973.78 ft	30.6	4.55	18.34	0.60	0.79	6.7	2.38	Supercritical
Sub-Area 24 - Section P	Normal Depth	Manning Formula	0.017	0.044	965.70	965.10 to 970.00 ft	30.9	4.27	17.07	0.60	0.82	7.3	2.55	Supercritical
Sub-Area 25 - Section Q	Normal Depth	Manning Formula	0.015	0.047	961.05	960.44 to 962.00 ft	31.3	3.49	12.35	0.61	0.91	9.0	2.97	Supercritical
Sub-Area 26 - Section R	Normal Depth	Manning Formula	0.016	0.043	951.93	951.45 to 954.85 ft	31.8	3.94	14.57	0.48	0.74	8.1	2.74	Supercritical
Sub-Area 27 - Section S	Normal Depth	Manning Formula	0.015	0.058	949.33	948.76 to 951.00 ft	32.5	3.66	15.55	0.57	0.84	8.9	3.22	Supercritical
Sub-Area 28 - Section T	Normal Depth	Manning Formula	0.016	0.036	943.12	942.63 to 946.45 ft	32.9	4.63	16.99	0.49	0.71	7.1	2.40	Supercritical
Sub-Area 29 - Section U	Normal Depth	Manning Formula	0.015	0.045	934.31	933.69 to 937.77 ft	34.3	3.90	14.77	0.62	0.91	8.8	3.01	Supercritical
Sub-Area 30 - Section V	Normal Depth	Manning Formula	0.016	0.043	919.58	918.84 to 921.25 ft	37.4	4.75	18.80	0.74	0.98	7.9	2.76	Supercritical
Sub-Area 31 - Section W	Normal Depth	Manning Formula	0.017	0.038	906.98	906.31 to 908.24 ft	38.6	4.08	9.85	0.67	1.04	9.5	2.59	Supercritical
Sub-Area 32 - Section X	Normal Depth	Manning Formula	0.014	0.020	903.57	903.02 to 906.00 ft	40.1	5.13	12.80	0.55	0.83	7.8	2.18	Supercritical
Sub-Area 33 - Section Y	Normal Depth	Manning Formula	0.016	0.021	901.52	901.09 to 902.00 ft	41.3	6.28	18.18	0.43	0.63	6.6	1.97	Supercritical
Sub-Area 34 - Section Z	Normal Depth	Manning Formula	0.016	0.009	896.28	895.75 to 900.00 ft	41.9	8.91	23.64	0.53	0.61	4.7	1.35	Supercritical
Section AA	Normal Depth	Manning Formula	0.015	0.036	976.30	975.88 to 978.00 ft	30.0	3.81	14.26	0.42	0.67	7.9	2.69	Supercritical
Section BB	Normal Depth	Manning Formula	0.016	0.036	974.58	973.84 to 977.00 ft	30.0	4.31	16.45	0.74	0.95	7.0	2.40	Supercritical
Section CC	Normal Depth	Manning Formula	0.015	0.047	958.76	958.23 to 964.50 ft	31.3	3.38	11.06	0.53	0.86	9.3	2.95	Supercritical
Section DD	Normal Depth	Manning Formula	0.016	0.047	957.57	957.05 to 962.83 ft	31.3	3.87	15.19	0.52	0.78	8.1	2.83	Supercritical
Section EE	Normal Depth	Manning Formula	0.016	0.047	957.57	957.05 to 962.83 ft	31.3	3.87	15.19	0.52	0.78	8.1	2.83	Supercritical

Notes:
1. Bentley FlowMaster V8i Software Output

TABLE 12
UPROAD HYDRAULIC ANALYSIS FOR 50-YEAR STORM
OPEN CHANNEL FLOW CALCULATIONS[1]
Hydrology and Drainage Study - Mount Rubidoux Park
Riverside, California

Label	Solve For	Friction Method	Roughness Coefficient	Channel Slope (ft/ft)	Water Surface Elevation (ft)	Elevation Range	Discharge (ft^3/s)	Flow Area (ft^2)	Top Width (ft)	Normal Depth (ft)	Critical Depth (ft)	Velocity (ft/s)	Froude Number	Flow Type
Sub-Area 9 - Section A	Normal Depth	Manning Formula	0.013	0.034	1021.01	1020.69 to 1025.96 ft	13.8	1.96	10.09	0.32	0.52	7.0	2.80	Supercritical
Sub-Area 10 - Section B	Normal Depth	Manning Formula	0.014	0.032	1019.10	1018.77 to 1024.46 ft	15.5	2.34	11.07	0.33	0.52	6.6	2.55	Supercritical
Sub-Area 11 - Section C	Normal Depth	Manning Formula	0.016	0.044	1012.62	1011.90 to 1016.00 ft	18.0	2.85	15.30	0.72	0.89	6.3	2.58	Supercritical
Sub-Area 12 - Section D	Normal Depth	Manning Formula	0.015	0.032	1009.68	1009.20 to 1009.85 ft	19.0	3.21	15.99	0.48	0.64	5.9	2.34	Supercritical
Sub-Area 13 - Section E	Normal Depth	Manning Formula	0.015	0.038	1005.94	1005.46 to 1012.00 ft	27.1	3.18	11.08	0.48	0.76	8.5	2.80	Supercritical
Sub-Area 14 - Section F	Normal Depth	Manning Formula	0.014	0.063	1004.28	1003.89 to 1007.00 ft	27.7	2.88	12.62	0.39	0.69	9.6	3.54	Supercritical
Sub-Area 15 - Section G	Normal Depth	Manning Formula	0.017	0.043	1001.79	1001.27 to 1006.00 ft	28.9	4.09	17.34	0.52	0.73	7.1	2.56	Supercritical
Sub-Area 16 - Section H	Normal Depth	Manning Formula	0.016	0.037	999.11	998.66 to 1003.00 ft	30.8	4.35	16.53	0.45	0.67	7.1	2.43	Supercritical
Sub-Area 17 - Section I	Normal Depth	Manning Formula	0.017	0.027	997.13	996.31 to 1000.00 ft	31.3	5.13	18.69	0.82	0.99	6.1	2.05	Supercritical
Sub-Area 18 - Section J	Normal Depth	Manning Formula	0.015	0.053	995.42	994.90 to 1000.00 ft	33.0	4.13	18.80	0.52	0.76	8.0	3.00	Supercritical
Sub-Area 19 - Section K	Normal Depth	Manning Formula	0.014	0.035	988.30	987.85 to 995.00 ft	33.9	3.81	12.36	0.45	0.76	8.9	2.82	Supercritical
Sub-Area 20 - Section L	Normal Depth	Manning Formula	0.016	0.061	983.98	983.29 to 992.00 ft	34.0	3.42	12.16	0.69	1.03	9.9	3.30	Supercritical
Sub-Area 21 - Section M	Normal Depth	Manning Formula	0.014	0.033	978.24	977.74 to 985.00 ft	34.1	4.12	14.28	0.50	0.77	8.3	2.71	Supercritical
Sub-Area 22 - Section N	Normal Depth	Manning Formula	0.015	0.036	973.49	972.56 to 977.51 ft	34.4	4.23	13.32	0.93	1.20	8.1	2.54	Supercritical
Sub-Area 23 - Section O	Normal Depth	Manning Formula	0.017	0.037	969.46	968.84 to 973.78 ft	34.8	4.98	18.71	0.62	0.83	7.0	2.39	Supercritical
Sub-Area 24 - Section P	Normal Depth	Manning Formula	0.017	0.044	965.72	965.10 to 970.00 ft	35.2	4.66	17.57	0.62	0.86	7.6	2.59	Supercritical
Sub-Area 25 - Section Q	Normal Depth	Manning Formula	0.015	0.047	961.07	960.44 to 962.00 ft	35.6	3.79	12.43	0.63	0.96	9.4	3.00	Supercritical
Sub-Area 26 - Section R	Normal Depth	Manning Formula	0.016	0.043	951.95	951.45 to 954.85 ft	36.3	4.27	14.60	0.50	0.79	8.5	2.77	Supercritical
Sub-Area 27 - Section S	Normal Depth	Manning Formula	0.015	0.058	949.35	948.76 to 951.00 ft	37.0	3.97	15.61	0.59	0.89	9.3	3.26	Supercritical
Sub-Area 28 - Section T	Normal Depth	Manning Formula	0.016	0.036	943.15	942.63 to 946.45 ft	37.5	5.01	17.01	0.52	0.75	7.5	2.43	Supercritical
Sub-Area 29 - Section U	Normal Depth	Manning Formula	0.015	0.045	934.33	933.69 to 937.77 ft	39.0	4.24	14.85	0.64	0.96	9.2	3.04	Supercritical
Sub-Area 30 - Section V	Normal Depth	Manning Formula	0.016	0.043	919.60	918.84 to 921.25 ft	42.6	5.19	19.13	0.76	1.03	8.2	2.78	Supercritical
Sub-Area 31 - Section W	Normal Depth	Manning Formula	0.017	0.038	907.02	906.31 to 908.24 ft	44.0	4.44	9.92	0.71	1.11	9.9	2.61	Supercritical
Sub-Area 32 - Section X	Normal Depth	Manning Formula	0.014	0.020	903.61	903.02 to 906.00 ft	45.8	5.58	12.90	0.59	0.89	8.2	2.20	Supercritical
Sub-Area 33 - Section Y	Normal Depth	Manning Formula	0.016	0.021	901.55	901.09 to 902.00 ft	47.1	6.84	18.36	0.46	0.68	6.9	1.99	Supercritical
Sub-Area 34 - Section Z	Normal Depth	Manning Formula	0.016	0.009	896.31	895.75 to 900.00 ft	47.9	9.69	23.81	0.56	0.66	4.9	1.36	Supercritical
Section AA	Normal Depth	Manning Formula	0.015	0.036	976.32	975.88 to 978.00 ft	34.1	4.14	14.38	0.44	0.72	8.2	2.71	Supercritical
Section BB	Normal Depth	Manning Formula	0.016	0.036	974.61	973.84 to 977.00 ft	34.1	4.72	16.84	0.77	0.99	7.2	2.41	Supercritical
Section CC	Normal Depth	Manning Formula	0.015	0.047	958.79	958.23 to 964.50 ft	35.6	3.67	11.10	0.56	0.91	9.7	2.97	Supercritical
Section DD	Normal Depth	Manning Formula	0.016	0.047	957.59	957.05 to 962.83 ft	35.6	4.20	15.27	0.54	0.82	8.5	2.85	Supercritical
Section EE	Normal Depth	Manning Formula	0.014	0.047	954.86	954.28 to 959.26 ft	35.6	3.66	12.89	0.58	0.92	9.8	3.23	Supercritical

Notes:
1. Bentley FlowMaster V8i Software Output

TABLE 13
UPROAD HYDRAULIC ANALYSIS FOR 100-YEAR STORM
OPEN CHANNEL FLOW CALCULATIONS[1]
Hydrology and Drainage Study - Mount Rubidoux Park
Riverside, California

Label	Solve For	Friction Method	Roughness Coefficient	Channel Slope (ft/ft)	Water Surface Elevation (ft)	Elevation Range	Discharge (ft^3/s)	Flow Area (ft^2)	Top Width (ft)	Normal Depth (ft)	Critical Depth (ft)	Velocity (ft/s)	Froude Number	Flow Type
Sub-Area 9 - Section A	Normal Depth	Manning Formula	0.013	0.034	1021.02	1020.69 to 1025.96 ft	15.2	2.09	10.12	0.33	0.54	7.3	2.82	Supercritical
Sub-Area 10 - Section B	Normal Depth	Manning Formula	0.014	0.032	1019.11	1018.77 to 1024.46 ft	17.1	2.49	11.15	0.34	0.54	6.9	2.56	Supercritical
Sub-Area 11 - Section C	Normal Depth	Manning Formula	0.016	0.044	1012.63	1011.90 to 1016.00 ft	19.9	3.04	15.40	0.73	0.91	6.6	2.60	Supercritical
Sub-Area 12 - Section D	Normal Depth	Manning Formula	0.015	0.032	1009.70	1009.20 to 1009.85 ft	21.0	3.44	16.26	0.50	0.66	6.1	2.34	Supercritical
Sub-Area 13 - Section E	Normal Depth	Manning Formula	0.015	0.038	1005.96	1005.46 to 1012.00 ft	29.9	3.39	11.09	0.50	0.80	8.8	2.82	Supercritical
Sub-Area 14 - Section F	Normal Depth	Manning Formula	0.014	0.063	1004.29	1003.89 to 1007.00 ft	30.6	3.07	12.63	0.40	0.73	10.0	3.57	Supercritical
Sub-Area 15 - Section G	Normal Depth	Manning Formula	0.017	0.043	1001.81	1001.27 to 1006.00 ft	31.9	4.35	17.35	0.54	0.76	7.3	2.58	Supercritical
Sub-Area 16 - Section H	Normal Depth	Manning Formula	0.016	0.037	999.13	998.66 to 1003.00 ft	34.1	4.65	16.72	0.47	0.70	7.3	2.45	Supercritical
Sub-Area 17 - Section I	Normal Depth	Manning Formula	0.017	0.027	997.15	996.31 to 1000.00 ft	34.8	5.49	18.77	0.84	1.02	6.3	2.07	Supercritical
Sub-Area 18 - Section J	Normal Depth	Manning Formula	0.015	0.053	995.44	994.90 to 1000.00 ft	36.5	4.41	18.82	0.54	0.79	8.3	3.02	Supercritical
Sub-Area 19 - Section K	Normal Depth	Manning Formula	0.014	0.035	988.32	987.85 to 995.00 ft	37.5	4.09	12.51	0.47	0.80	9.2	2.83	Supercritical
Sub-Area 20 - Section L	Normal Depth	Manning Formula	0.016	0.061	984.00	983.29 to 992.00 ft	37.6	3.65	12.27	0.71	1.07	10.3	3.33	Supercritical
Sub-Area 21 - Section M	Normal Depth	Manning Formula	0.014	0.033	978.26	977.74 to 985.00 ft	37.8	4.39	14.29	0.52	0.81	8.6	2.73	Supercritical
Sub-Area 22 - Section N	Normal Depth	Manning Formula	0.015	0.036	973.51	972.56 to 977.51 ft	38.1	4.51	13.33	0.95	1.24	8.4	2.56	Supercritical
Sub-Area 23 - Section O	Normal Depth	Manning Formula	0.017	0.037	969.48	968.84 to 973.78 ft	38.6	5.33	19.02	0.64	0.86	7.2	2.41	Supercritical
Sub-Area 24 - Section P	Normal Depth	Manning Formula	0.017	0.044	965.74	965.10 to 970.00 ft	39.0	4.96	17.64	0.64	0.90	7.9	2.61	Supercritical
Sub-Area 25 - Section Q	Normal Depth	Manning Formula	0.015	0.047	961.09	960.44 to 962.00 ft	39.4	4.04	12.49	0.65	1.01	9.8	3.02	Supercritical
Sub-Area 26 - Section R	Normal Depth	Manning Formula	0.016	0.043	951.97	951.45 to 954.85 ft	40.1	4.55	14.62	0.52	0.83	8.8	2.79	Supercritical
Sub-Area 27 - Section S	Normal Depth	Manning Formula	0.015	0.058	949.36	948.76 to 951.00 ft	40.9	4.23	15.66	0.60	0.93	9.7	3.28	Supercritical
Sub-Area 28 - Section T	Normal Depth	Manning Formula	0.016	0.036	943.16	942.63 to 946.45 ft	41.5	5.34	17.02	0.53	0.79	7.8	2.45	Supercritical
Sub-Area 29 - Section U	Normal Depth	Manning Formula	0.015	0.045	934.35	933.69 to 937.77 ft	43.3	4.52	14.92	0.66	1.00	9.6	3.06	Supercritical
Sub-Area 30 - Section V	Normal Depth	Manning Formula	0.016	0.043	919.62	918.84 to 921.25 ft	47.2	5.57	19.40	0.78	1.07	8.5	2.79	Supercritical
Sub-Area 31 - Section W	Normal Depth	Manning Formula	0.017	0.038	907.05	906.31 to 908.24 ft	48.8	4.74	9.98	0.74	1.17	10.3	2.63	Supercritical
Sub-Area 32 - Section X	Normal Depth	Manning Formula	0.014	0.020	903.64	903.02 to 906.00 ft	50.8	5.97	12.99	0.62	0.94	8.5	2.21	Supercritical
Sub-Area 33 - Section Y	Normal Depth	Manning Formula	0.016	0.021	901.58	901.09 to 902.00 ft	52.3	7.31	18.50	0.49	0.73	7.2	2.01	Supercritical
Sub-Area 34 - Section Z	Normal Depth	Manning Formula	0.016	0.009	896.34	895.75 to 900.00 ft	53.1	10.36	23.96	0.59	0.69	5.1	1.38	Supercritical
Section AA	Normal Depth	Manning Formula	0.015	0.036	976.34	975.88 to 978.00 ft	37.8	4.42	14.49	0.46	0.76	8.5	2.73	Supercritical
Section BB	Normal Depth	Manning Formula	0.016	0.036	974.63	973.84 to 977.00 ft	37.8	5.07	17.17	0.79	1.02	7.5	2.42	Supercritical
Section CC	Normal Depth	Manning Formula	0.015	0.047	958.81	958.23 to 964.50 ft	39.4	3.92	11.13	0.58	0.96	10.1	2.99	Supercritical
Section DD	Normal Depth	Manning Formula	0.016	0.047	957.61	957.05 to 962.83 ft	39.4	4.48	15.33	0.56	0.86	8.8	2.87	Supercritical
Section EE	Normal Depth	Manning Formula	0.014	0.047	954.88	954.28 to 959.26 ft	39.4	3.89	12.91	0.60	0.96	10.1	3.25	Supercritical

Notes:
1. Bentley FlowMaster V8i Software Output

TABLE 14
RESULTS OF UPROAD HYDRAULIC ANALYSIS
OPEN CHANNEL FLOW CALCULATIONS[1]
Hydrology and Drainage Study - Mount Rubidoux Park
Riverside, California

Cross Section	Sub-Area	Maximum Discharge for Section (cfs)	2-Year Runoff Discharge (cfs)	Result for 2-Year Storm[A]	5-Year Runoff Discharge (cfs)	Result for 5-Year Storm	10-Year Runoff Discharge (cfs)	Result for 10-Year Storm	25-Year Runoff Discharge (cfs)	Result for 25-Year Storm	50-Year Runoff Discharge (cfs)	Result for 50-Year Storm	100-Year Runoff Discharge (cfs)	Result for 100-Year Storm
Section A	9	4.2	6.6	Exceeded	8.9	Exceeded	10.2	Exceeded	12.1	Exceeded	13.8	Exceeded	15.2	Exceeded
Section B	10	11.5	7.4	Within	10.0	Within	11.5	Exceeded	13.7	Exceeded	15.5	Exceeded	17.1	Exceeded
Section C[B]	11	215.7	8.6	Within	11.6	Within	13.3	Within	15.9	Within	18.0	Within	19.9	Within
Section D	12	11.4	9.1	Within	12.2	Exceeded	14.1	Exceeded	16.8	Exceeded	19.0	Exceeded	21.0	Exceeded
Section E	13	25.9	12.7	Within	17.3	Within	19.9	Within	23.8	Within	27.1	Exceeded	29.9	Exceeded
Section F	14	17.4	13.0	Within	17.7	Exceeded	20.4	Exceeded	24.4	Exceeded	27.7	Exceeded	30.6	Exceeded
Section G[B]	15	26.0	13.5	Within	18.4	Within	21.2	Within	25.4	Within	28.9	Exceeded	31.9	Exceeded
Section H[B]	16	66.4	14.4	Within	19.6	Within	22.6	Within	27.1	Within	30.8	Within	34.1	Within
Section I[B]	17	13.3	14.7	Exceeded	20.0	Exceeded	23.1	Exceeded	27.6	Exceeded	31.3	Exceeded	34.8	Exceeded
Section J	18	3.9	15.4	Exceeded	20.9	Exceeded	24.2	Exceeded	29.0	Exceeded	33.0	Exceeded	36.5	Exceeded
Section K	19	35.8	15.8	Within	21.5	Within	24.9	Within	29.8	Within	33.9	Within	37.5	Exceeded
Section L	20	70.6	15.8	Within	21.6	Within	25.0	Within	29.9	Within	34.0	Within	37.6	Within
Section M	21	20.3	15.9	Within	21.7	Exceeded	25.0	Exceeded	30.0	Exceeded	34.1	Exceeded	37.8	Exceeded
Section N[B]	22	6.8	16.0	Exceeded	21.8	Exceeded	25.2	Exceeded	30.2	Exceeded	34.4	Exceeded	38.1	Exceeded
Section O[B,C]	23	39.1	16.2	Within	22.1	Within	25.6	Within	30.6	Within	34.8	Within	38.6	Within
Section P[B]	24	54.8	16.4	Within	22.3	Within	25.8	Within	30.9	Within	35.2	Within	39.0	Within
Section Q	25	82.6	16.6	Within	22.6	Within	26.1	Within	31.3	Within	35.6	Within	39.4	Within
Section R[B]	26	12.6	16.8	Exceeded	23.0	Exceeded	26.6	Exceeded	31.8	Exceeded	36.3	Exceeded	40.1	Exceeded
Section S[B]	27	67.2	17.2	Within	23.4	Within	27.1	Within	32.5	Within	37.0	Within	40.9	Within
Section T	28	2.0	17.4	Exceeded	23.8	Exceeded	27.5	Exceeded	32.9	Exceeded	37.5	Exceeded	41.5	Exceeded
Section U	29	42.5	18.1	Within	24.7	Within	28.6	Within	34.3	Within	39.0	Within	43.3	Exceeded
Section V[B,C]	30	49.2	19.6	Within	26.9	Within	31.1	Within	37.4	Within	42.6	Within	47.2	Within
Section W	31	10.2	20.2	Exceeded	27.7	Exceeded	32.1	Exceeded	38.6	Exceeded	44.0	Exceeded	48.8	Exceeded
Section X	32	25.6	21.0	Within	28.8	Exceeded	33.4	Exceeded	40.1	Exceeded	45.8	Exceeded	50.8	Exceeded
Section Y[C]	33	80.2	21.5	Within	29.6	Within	34.3	Within	41.3	Within	47.1	Within	52.3	Within
Section Z[C]	34	119.4	21.9	Within	30.1	Within	34.8	Within	41.9	Within	47.9	Within	53.1	Within
Section AA	22	41.1	15.9	Within	21.7	Within	25.0	Within	30.0	Within	34.1	Within	37.8	Within
Section BB	22	38.4	15.9	Within	21.7	Within	25.0	Within	30.0	Within	34.1	Within	37.8	Within
Section CC	26	1.9	16.6	Exceeded	22.6	Exceeded	26.1	Exceeded	31.3	Exceeded	35.6	Exceeded	39.4	Exceeded
Section DD	26	6.0	16.6	Exceeded	22.6	Exceeded	26.1	Exceeded	31.3	Exceeded	35.6	Exceeded	39.4	Exceeded
Section EE	26	34.9	16.6	Within	22.6	Within	26.1	Within	31.3	Within	35.6	Exceeded	39.4	Exceeded

Notes:
A. Within - Amount of runoff is within calculated capacity of roadway channel cross section.
Exceeded - The calculated capacity of the roadway channel cross section is exceeded by the amount of runoff.
B. Multiple depressions within channel (road) cross section. Flow can occur on both sides of the road.
C. Topographic survey did not fully describe the capacity of the channel section.

DRAFT

TABLE 15
CONCEPTUAL CONSTRUCTION COST ESTIMATES FOR ALTERNATIVES
Hydrology and Drainage Study - Mount Rubidoux Park
Riverside, California

Alternative 1 - Install Storm Drain System Along the Alignment of the Uproad

Item No.	Description	Estimated Quantity	Unit	Item Total
1	Mobilization			$112,700
2	Construction Survey and Staking	2	DAY	$2,500
3	Saw Cutting for Ninth Street excavation	2720	LF	$9,200
4	Trenching for Storm Drain	5526	LF	$89,000
5	Excavation for Manholes	343	CY	$9,600
6	Excavation for Catch basins	148	CY	$4,200
7	Fine Grading for Local Depression for Catchbasins	26	EA	$5,200
8	Shoring System, Trench Safety System	1	LS	$5,000
9	Bedding Material	292	CY	$14,600
10	Reinforced Concrete Pipe			$478,200
	18" diameter RCP	1040	LF	
	24" diameter RCP	2352	LF	
	30" diameter RCP	2134	LF	
11	Manholes,	31	EA	$124,000
12	Catch Basins	26	EA	$65,000
13	Backfill Material CLSM	2559	CY	$192,000
14	Aggregate Base Material for Road	371	CY	$22,300
15	Asphalt Concrete	2531	SY	$50,900
16	Connect to Existing Storm Drain	1	EA	$25,000
17	Traffic Control	30	DAY	$30,000
18	Dispose of Excavated Material	1	LS	$85,100
19	Permanent Erosion Control Around Catch Basins	26	EA	$13,000
20	Construction Storm Water Protection	1	LS	$27,000
21	Contingency (25% of total)			$341,000
	Alternative 1 Total			***$1,705,500***

Alternative 2 - No Action

Item No.	Description	Estimated Quantity	Unit	Item Total
0	No Construction			$0
	Alternative 2 Total			***$0***

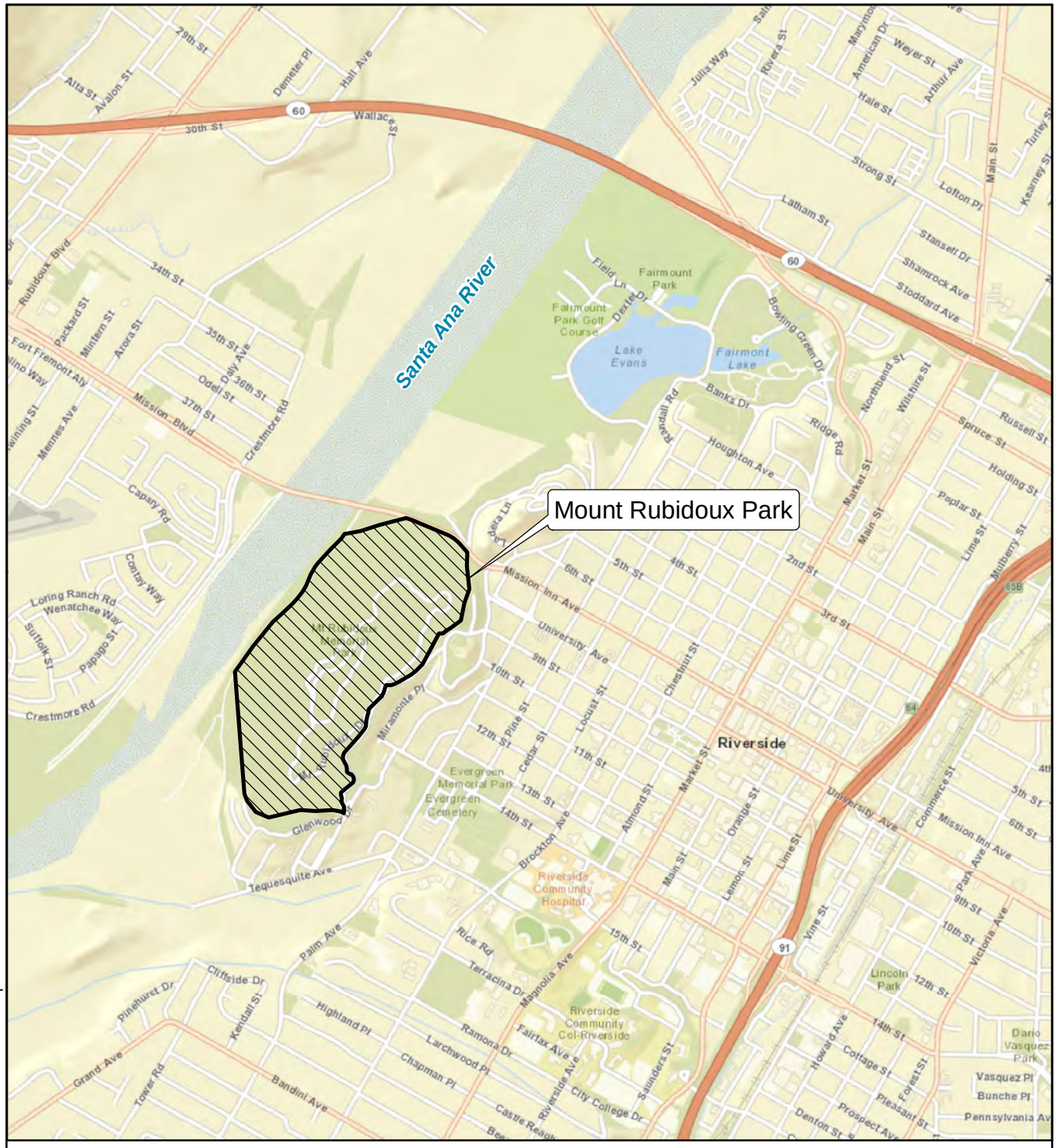
Alternative 3 - Install New AC Berm

Item No.	Description	Estimated Quantity	Unit	Item Total
1	Mobilization	1	LS	$3,000
2	Construct New Asphalt Berm	120	LF	$30,000
3	Contingency (25% of total)			$8,250
	Alternative 3 Total			***$41,250***

Alternative 4 - Remove the AC Berms and Install Erosion Control Measures

Item No.	Description	Estimated Quantity	Unit	Item Total
1	Mobilization	1	LS	$25,300
2	Remove Asphalt Berm	655	LF	$22,600
3	Erosion Control - Gabion Baskets	4269	SY	$285,800
4	Erosion Control - Rip Rap	1856	SY	$197,600
5	Contingency (25% of total)			$132,800
	Alternative 4 Total			***$664,100***

FIGURES



DRAFT

Basemap modified from aerial photograph provided by ESRI and DigitalGlobe (Microsoft) dated 2012.

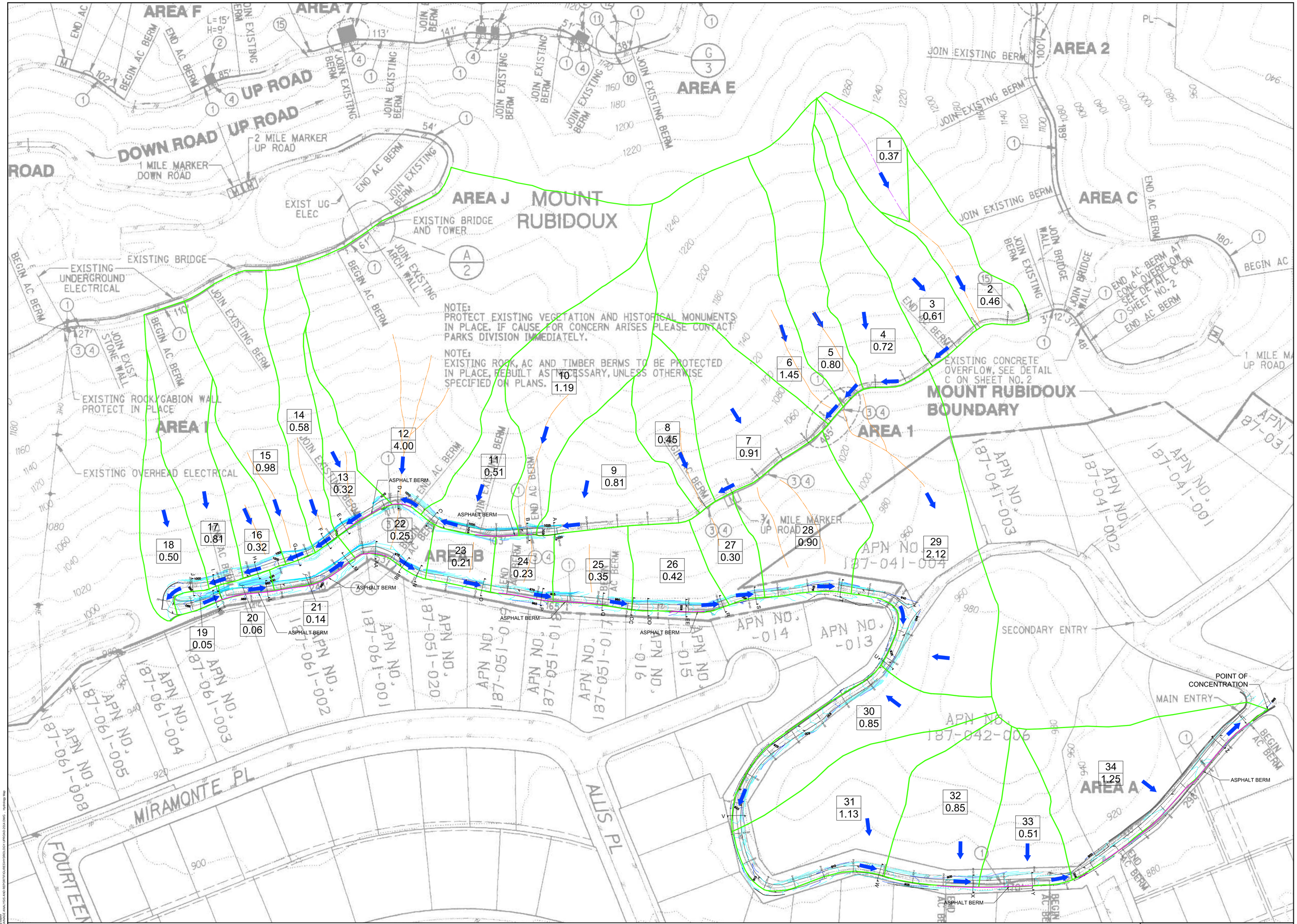
0 1,000 2,000

Approximate Scale in Feet

SITE VICINITY MAP
Hydrology and Drainage Study
Mount Rubidoux Park
Riverside, California

By: pah	Date: 04/23/2014	Project No. IR13164470
amec		Figure 1

Path: K:\IR13164470 - Mt Rubidoux\Drawings\esri\Site Location Map.mxd



EXPLANATION

33 / 0.51 — SUB-AREA IDENTIFICATION AREA IN ACRES

GENERAL DIRECTION OF RUNOFF FOR 2-YEAR STORM

SUB-AREA BOUNDARY

R — UPROAD CROSS SECTION

ELEVATION CONTOUR

ASPHALT BERM

POTENTIAL LOCATION OF NATURAL DRAINAGE CHANNEL

50 25 0 50
Approximate Scale in Feet

Basemap modified from Sheet 4 of 4 Mt. Rubidoux Emergency Road Repairs 2011 Construction Plans prepared by Rick Engineering Company.

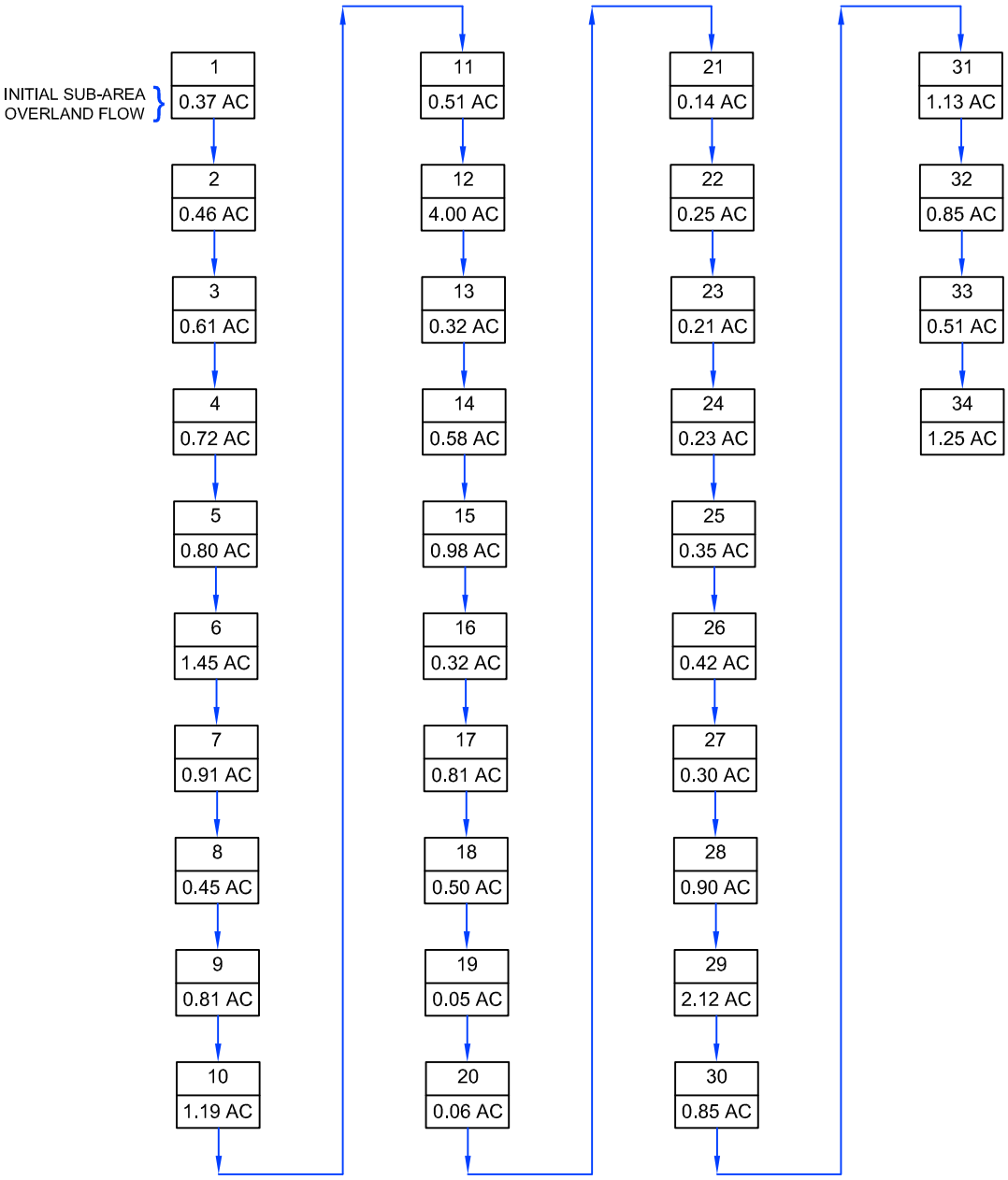
DRAFT

HYDROLOGY MAP
Hydrology and Drainage Study
Mount Rubidoux Park, Riverside, California

By: DLS	Date: 04/24/14	Project No. IR13164470
amec		Figure 2

Plot Date: 4/24/2014 5:45:31 PM Plotted By: dorothy.sadler
Drawing: J:\CIVIL\IR13164470 Mt Rubidoux Park\ANALYSIS AND REPORTS\FIGURES\HYDROLOGY UPROAD 2014.DWG - Hydrology Map

WATERSHED SCHEMATIC FOR RATIONAL METHOD ANALYSIS



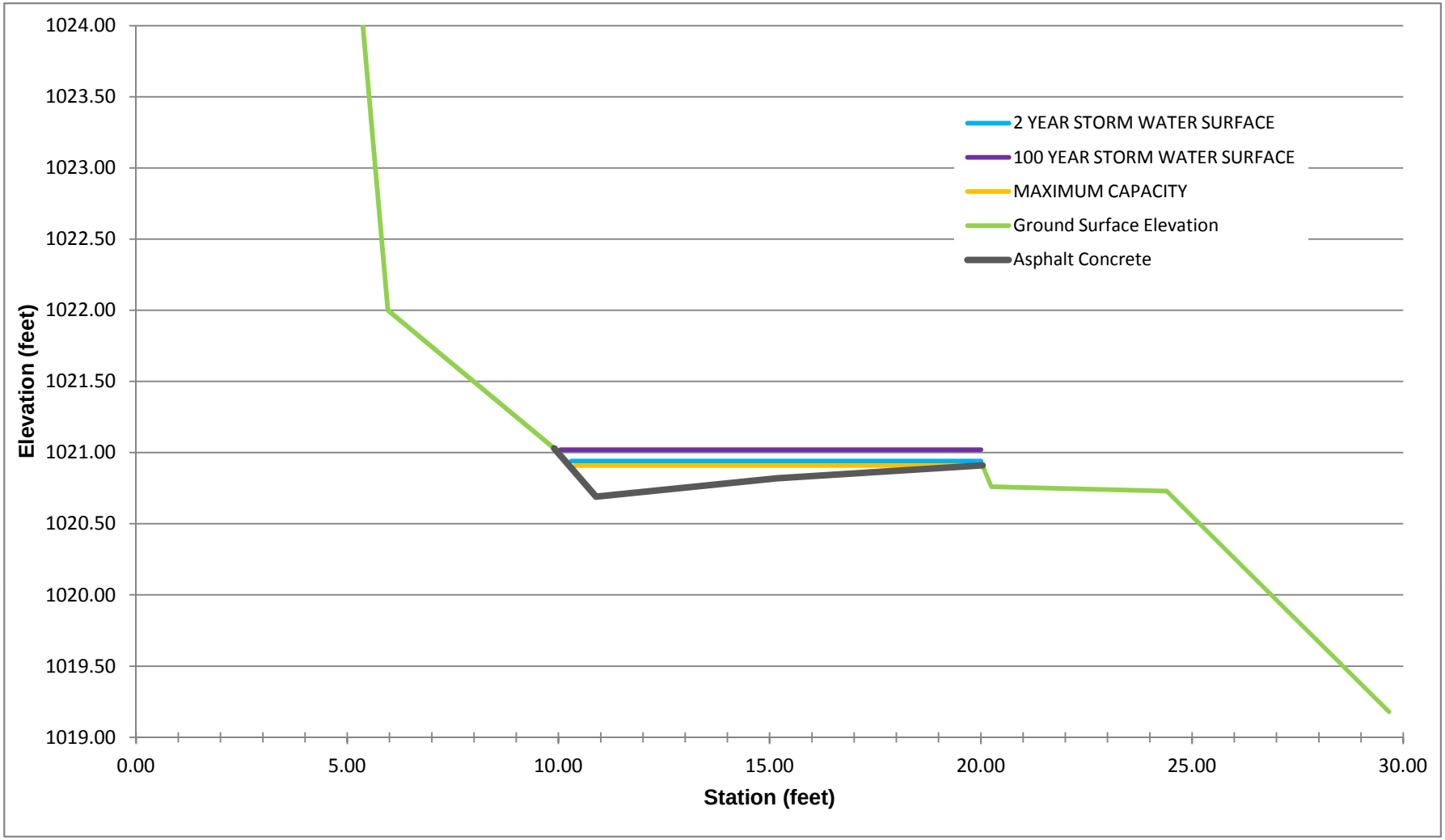
WATERSHED SCHEMATIC
Hydrology and Hydraulic Analysis
Mount Rubidoux Park, Riverside, California

By: DLS	Date: 04/22/14	Project No.	IR13164470
amec		Figure	3

DRAFT

Plot Date: 4/23/2014 10:09:44 AM, Plotted by: daney.saylor
Drawing Path: K:\IR13164470 - MT RUBIDOUX\DRAINAGE ANALYSIS AND REPORT\FIGURES\WATERSHEDSCHEMATIC.DWG , A Size (P)

P:\164470\Docs\Hydrology and Drainage Study\Draft Report\Figures\Figures 4-34_Uproad Sections Figure 4

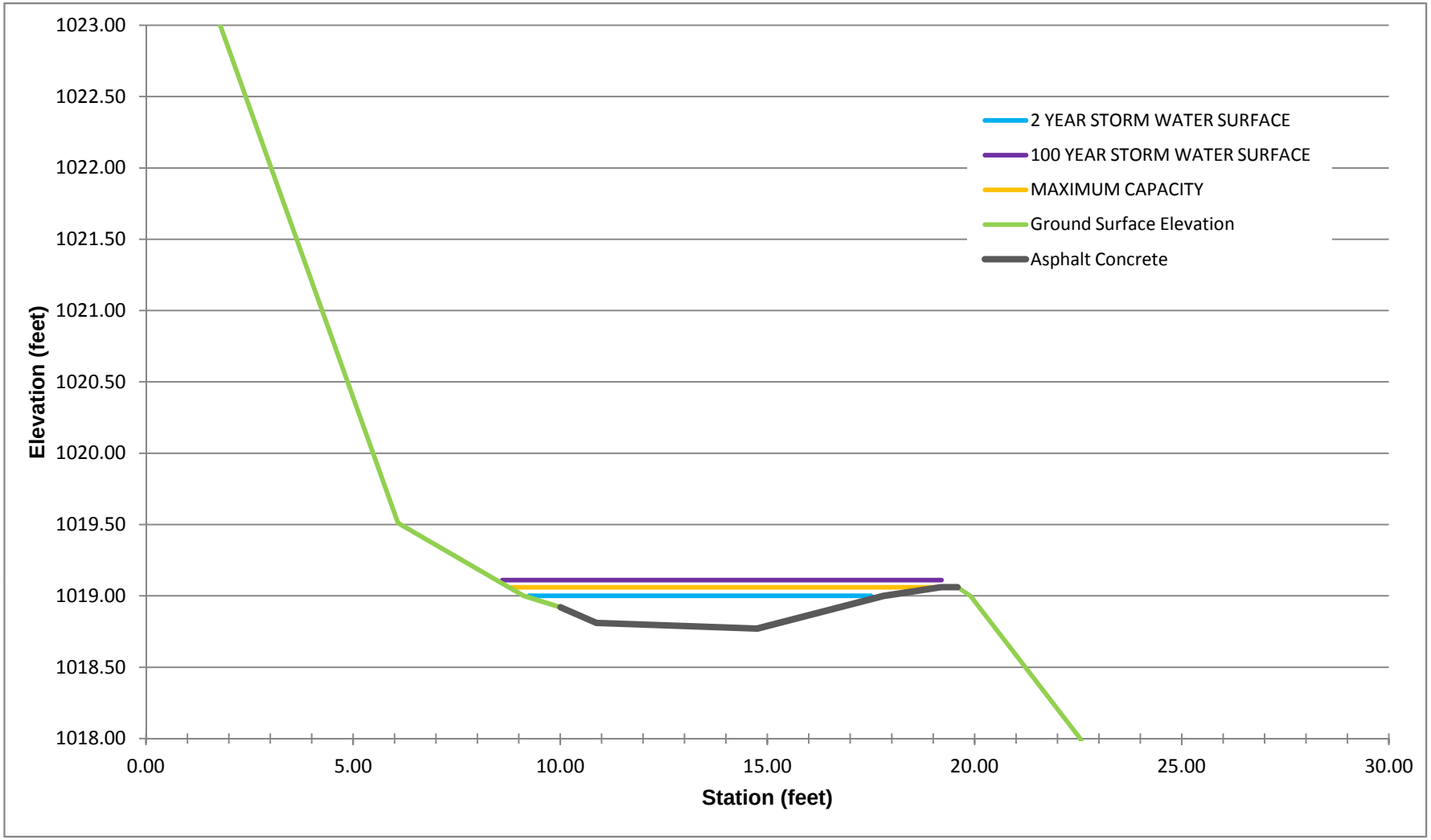


DRAFT

Cross Section A
Mount Rubidoux - Uproad
Hydrology and Drainage Study
Riverside, California

By: dls	Date: 04/18/14	Project No.: IR131164470
amec		Figure 4

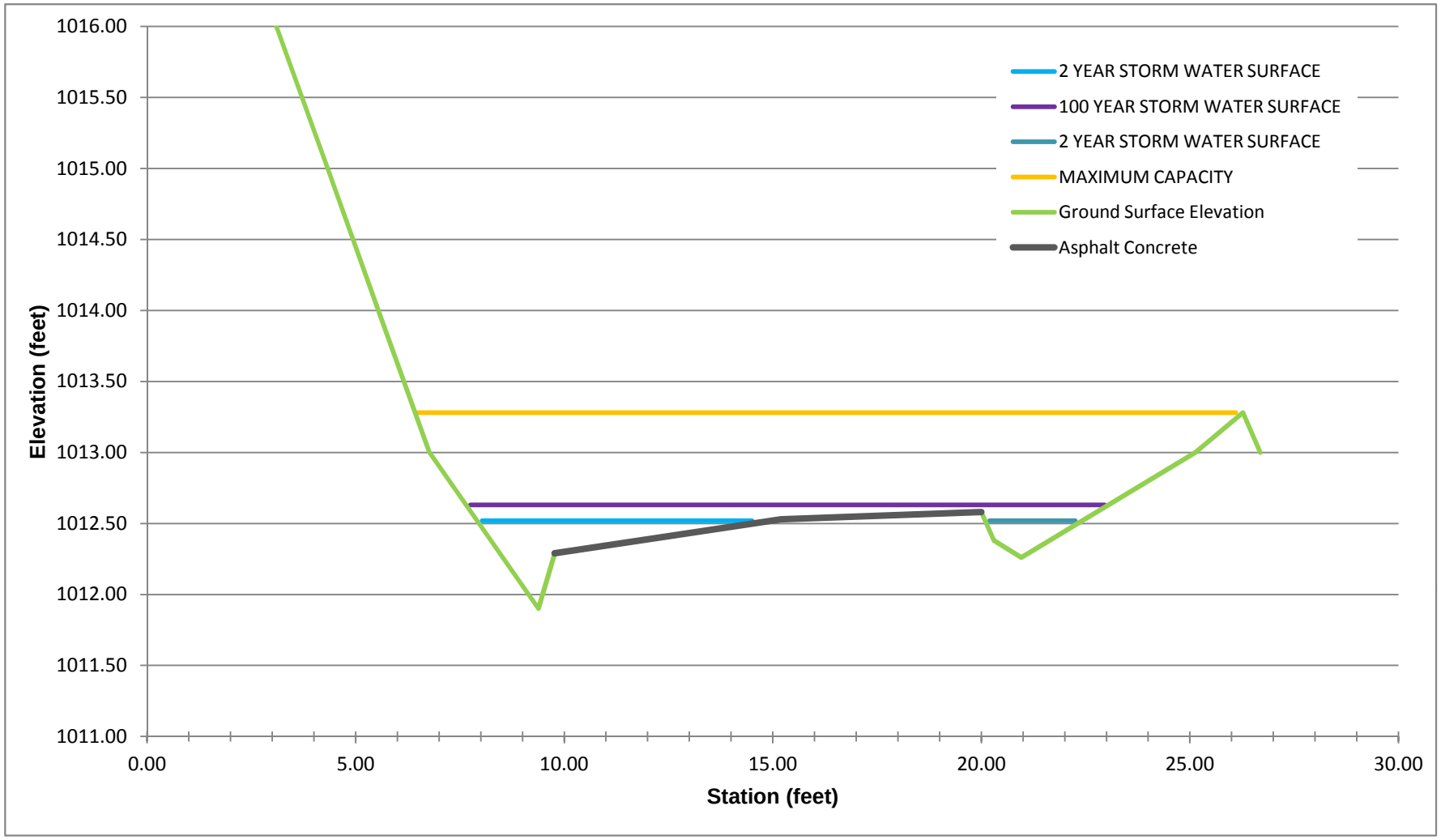
P:\164470\Docs\Hydrology and Drainage Study\Draft Report\Figures\Figures 4-34_Uproad Sections Figure 5



DRAFT

Cross Section B
Mount Rubidoux - Uproad
Hydrology and Drainage Study
Riverside, California

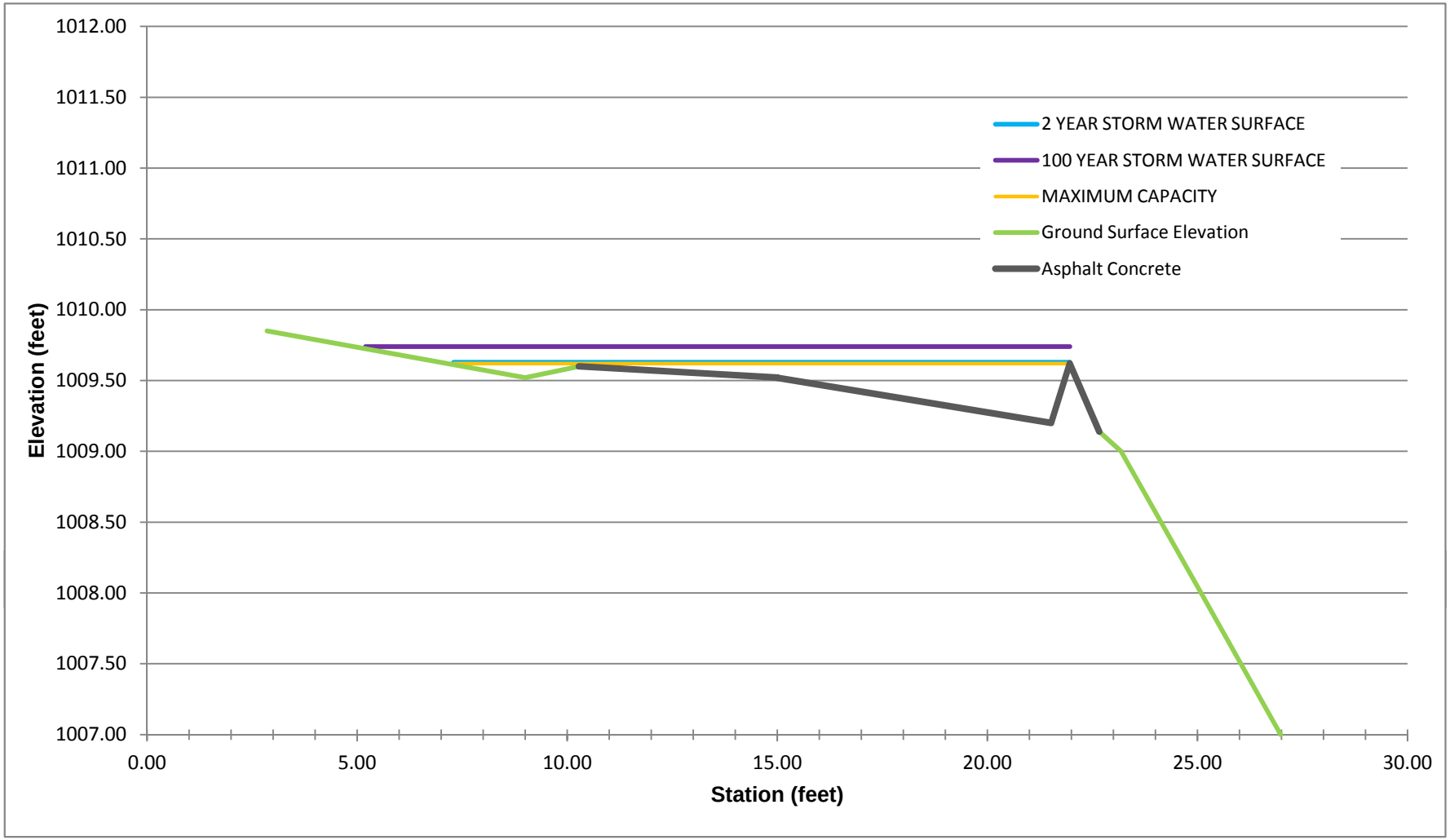
By: dls	Date: 04/18/14	Project No.: IR131164470
amec		Figure **5**



DRAFT

Cross Section C
Mount Rubidoux - Uproad
Hydrology and Drainage Study
Riverside, California

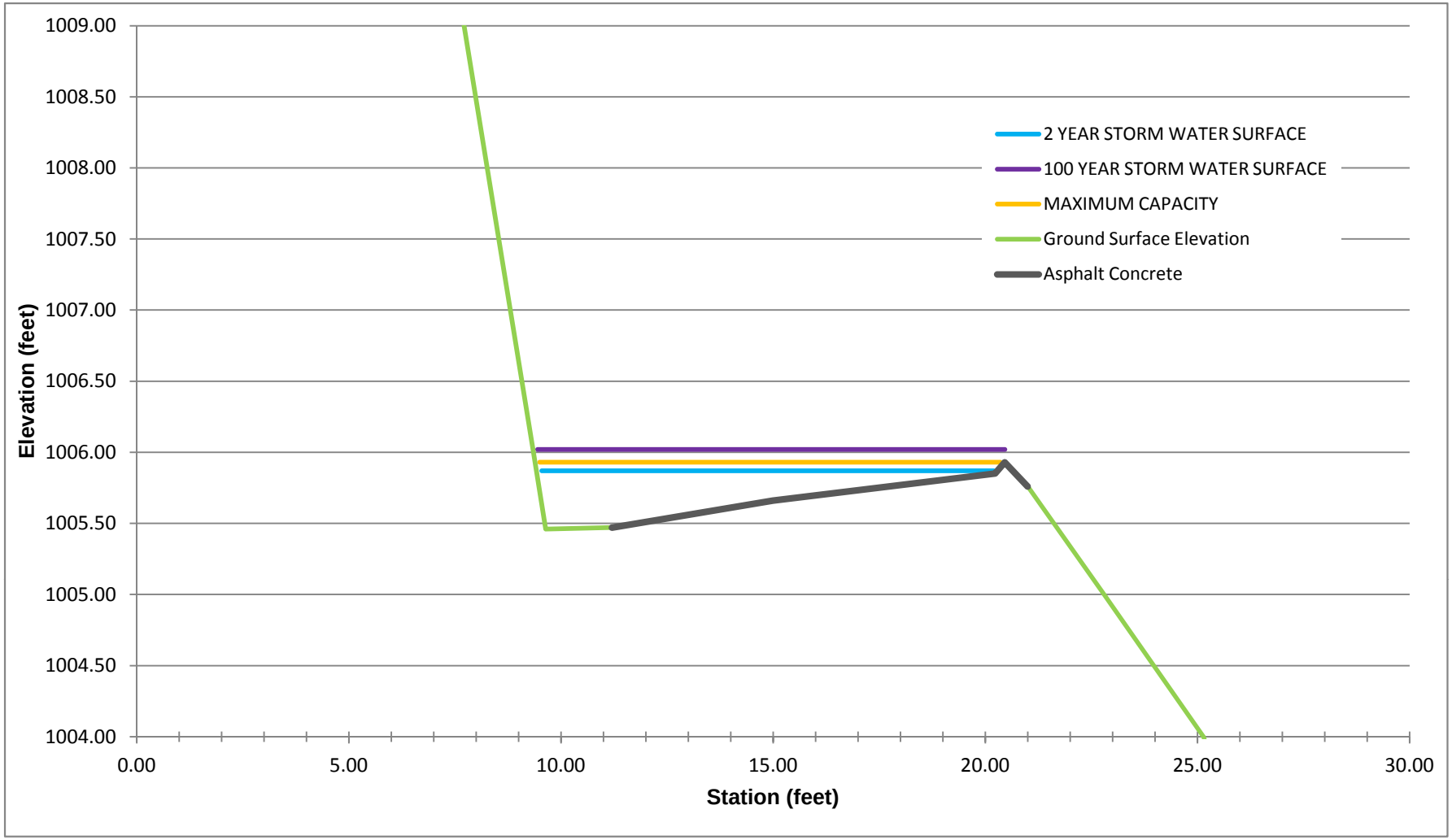
By: dls	Date: 04/18/14	Project No.: IR131164470
amec		Figure 6



DRAFT

Cross Section D
Mount Rubidoux - Uproad
Hydrology and Drainage Study
Riverside, California

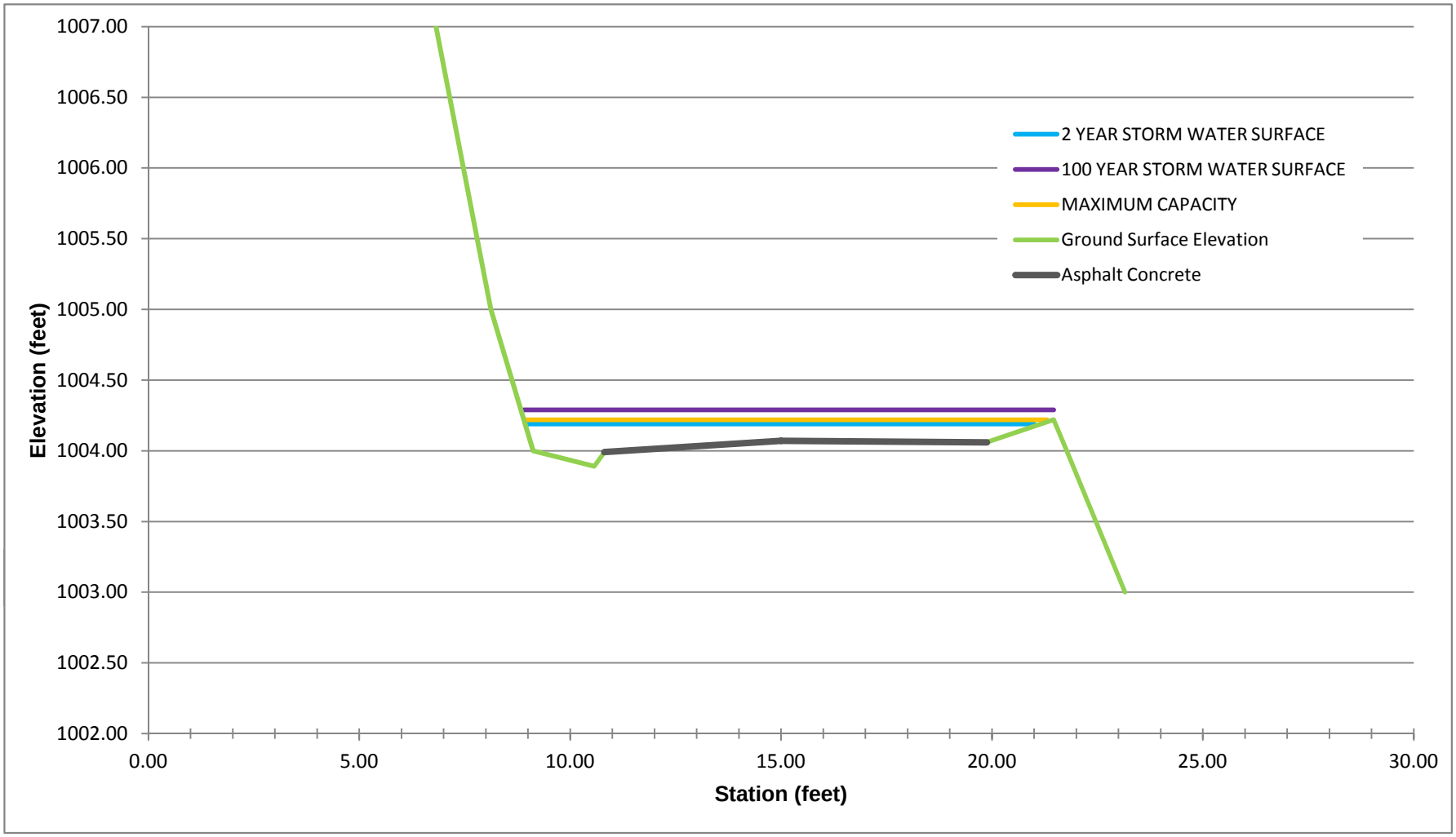
By: dls	Date: 04/18/14	Project No.: IR131164470
amec		Figure 7



DRAFT

Cross Section E
Mount Rubidoux - Uproad
Hydrology and Drainage Study
Riverside, California

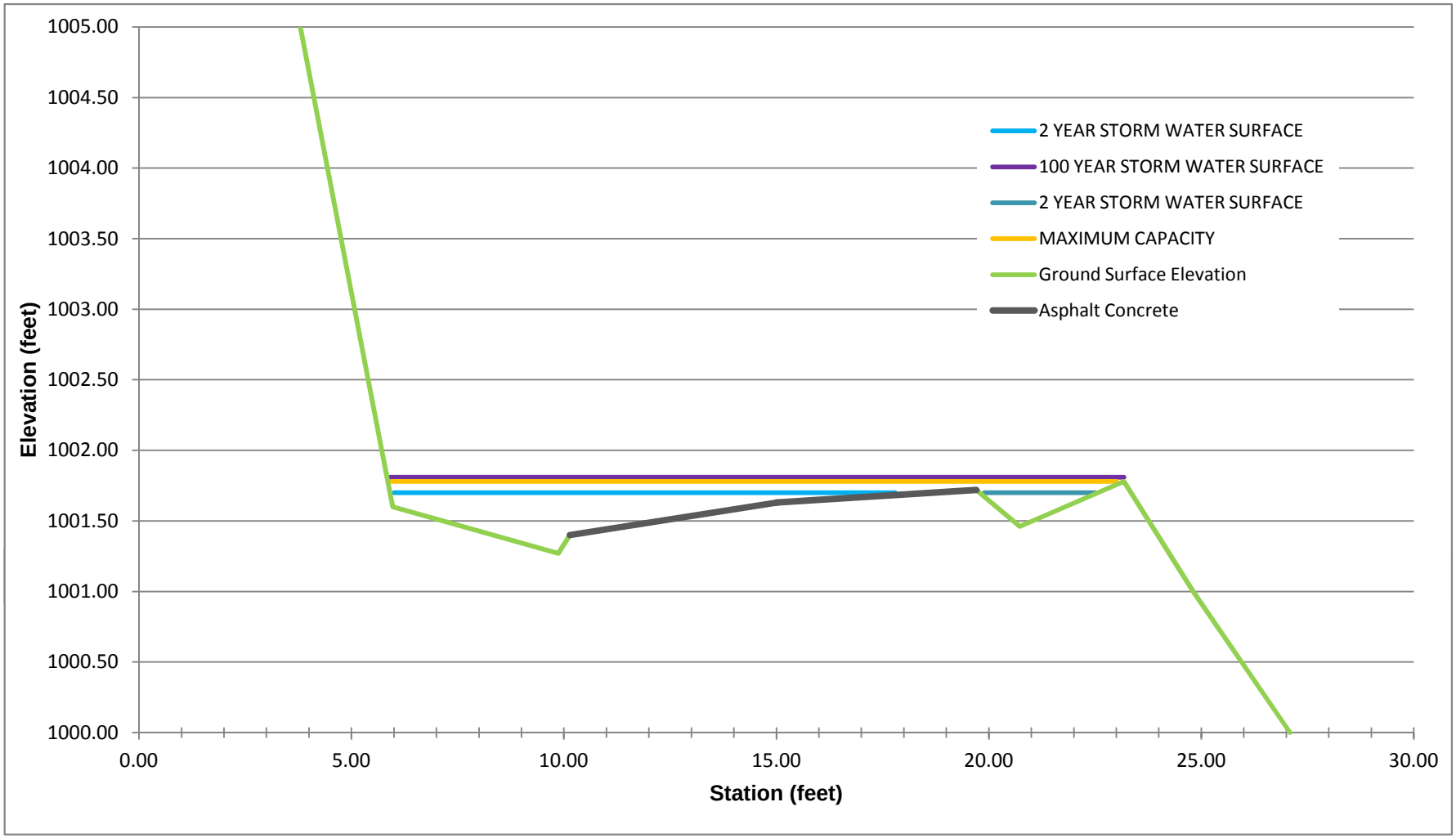
By: dls	Date: 04/18/14	Project No.: IR131164470
amec		Figure **8**



DRAFT

Cross Section F
Mount Rubidoux - Uproad
Hydrology and Drainage Study
Riverside, California

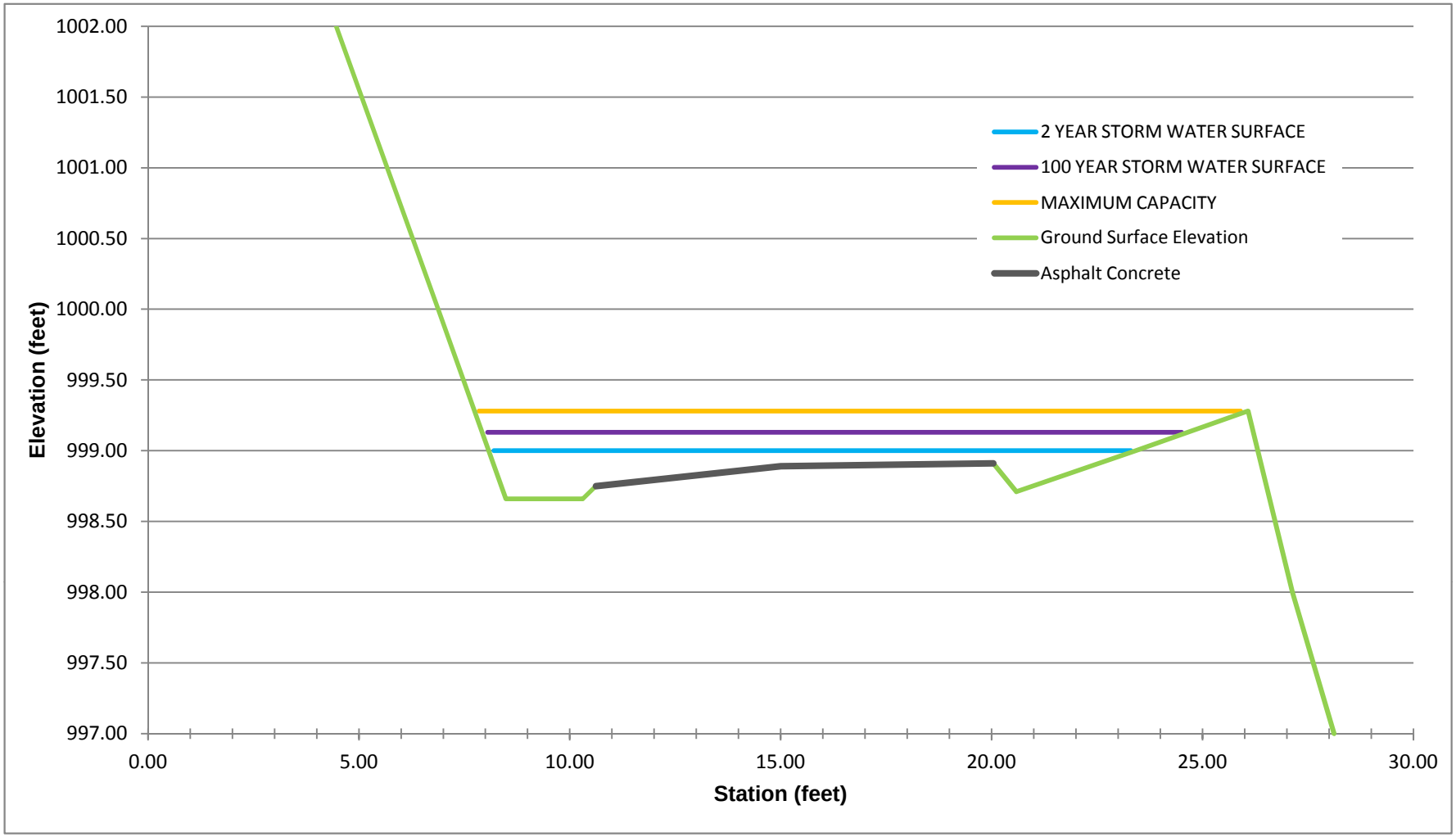
By: dls	Date: 04/18/14	Project No.: IR131164470
amec		Figure 9



DRAFT

Cross Section G
Mount Rubidoux - Uproad
Hydrology and Drainage Study
Riverside, California

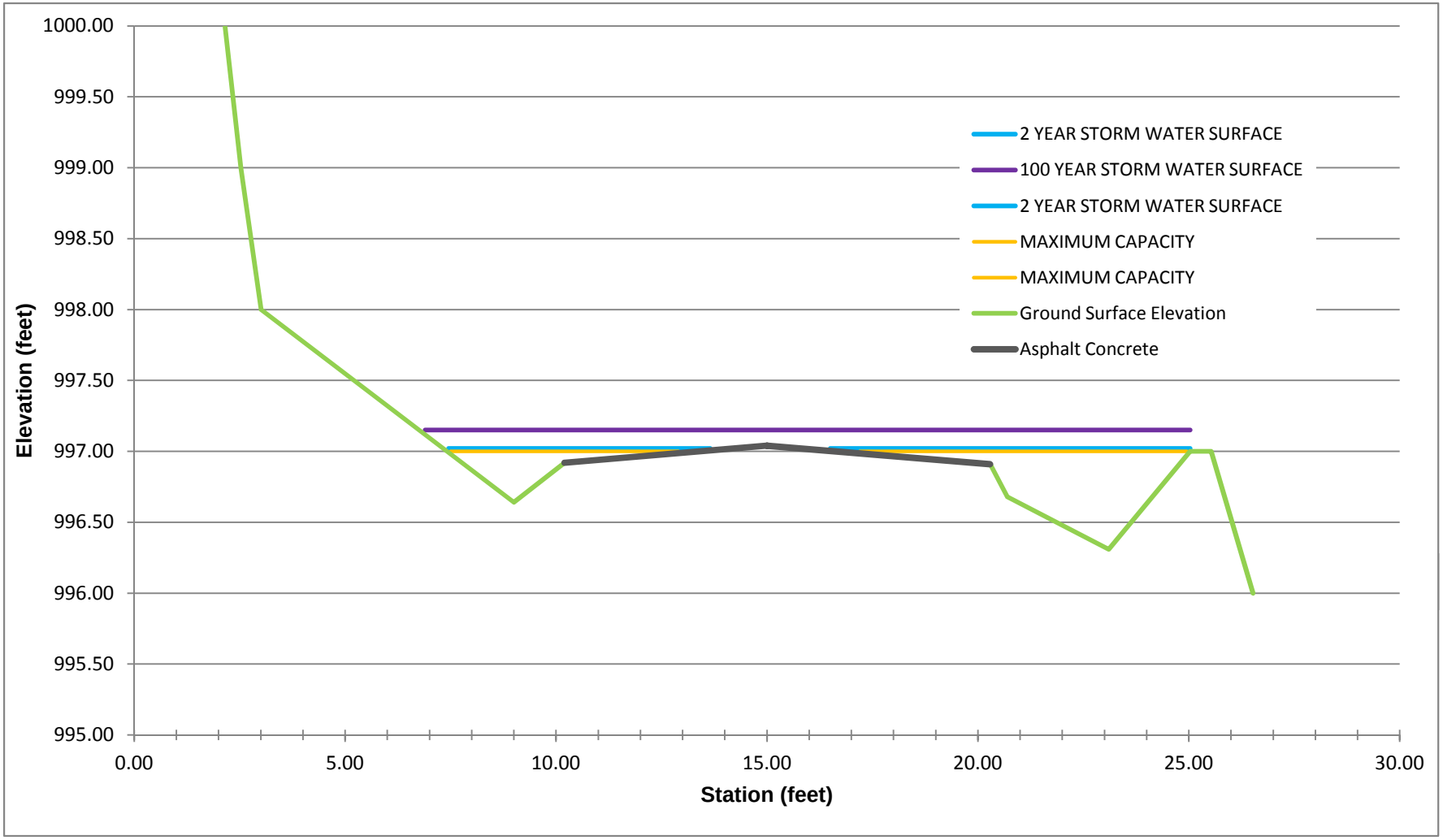
By: dls	Date: 04/18/14	Project No.: IR131164470
amec		Figure **10**



DRAFT

Cross Section H
Mount Rubidoux - Uproad
Hydrology and Drainage Study
Riverside, California

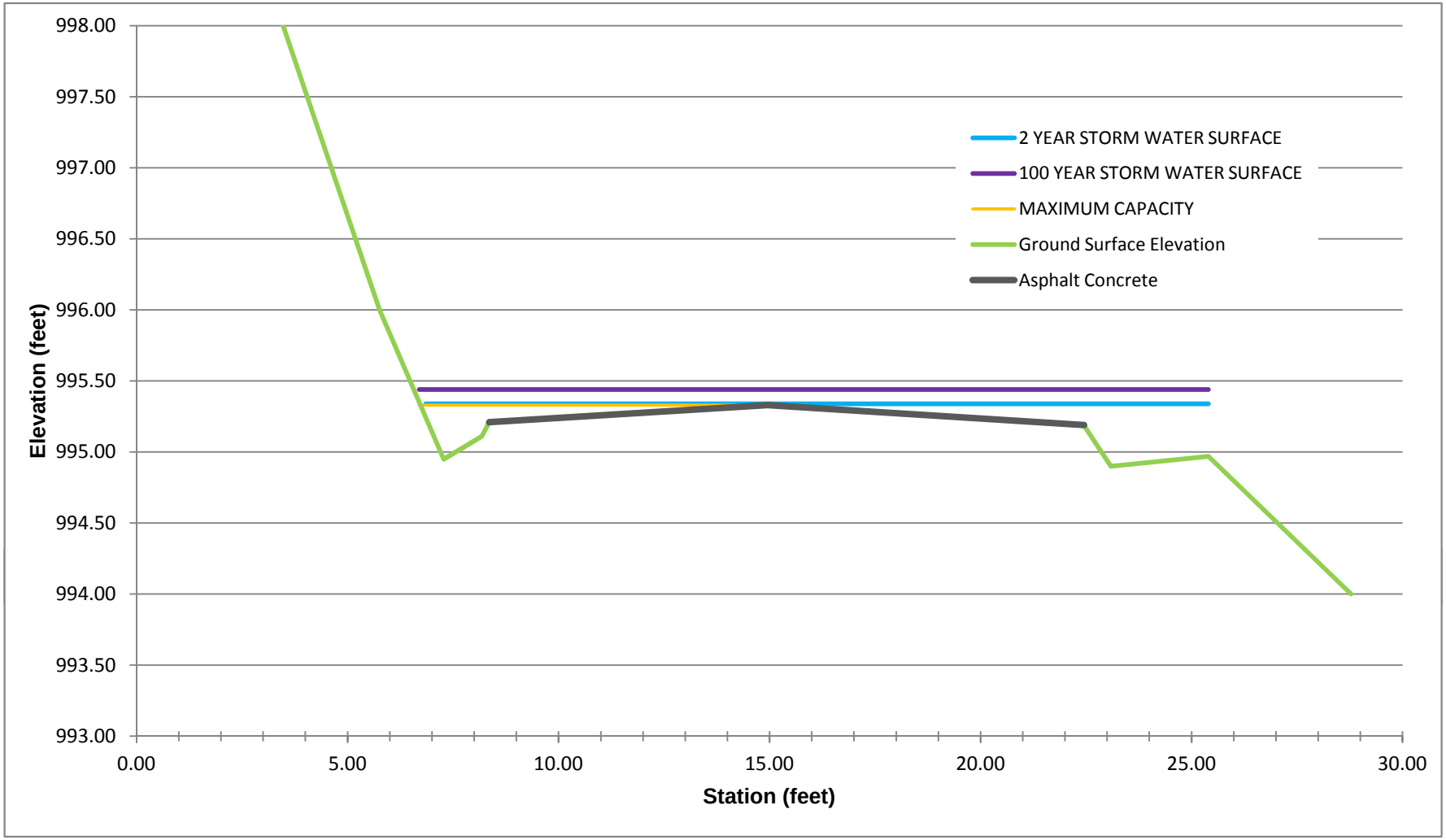
By: dls	Date: 04/18/14	Project No.: IR131164470
amec		Figure **11**



DRAFT

Cross Section I
Mount Rubidoux - Uproad
Hydrology and Drainage Study
Riverside, California

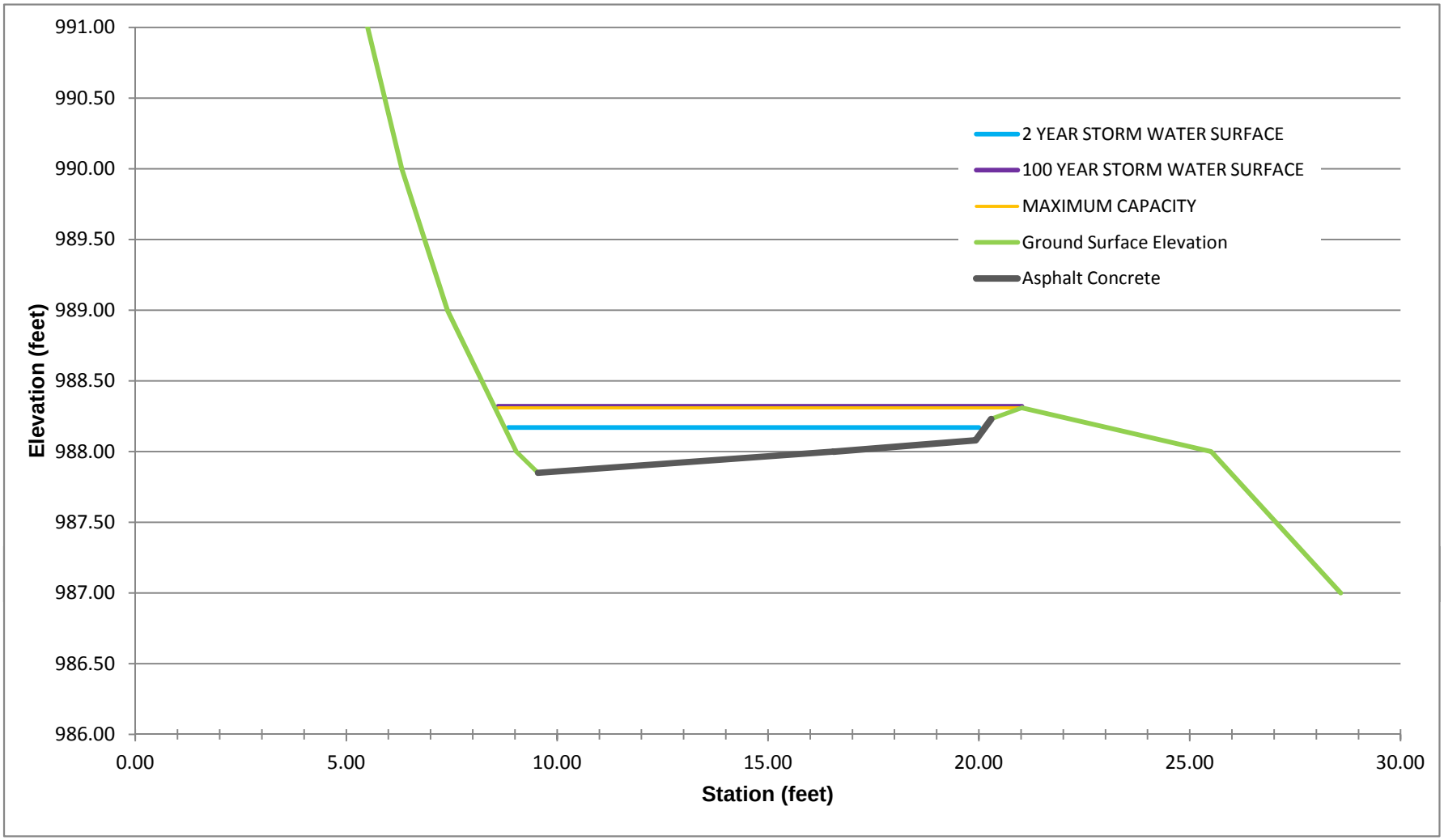
By: dls	Date: 04/21/14	Project No.: IR131164470
amec		Figure **12**



DRAFT

Cross Section J
Mount Rubidoux - Uproad
Hydrology and Drainage Study
Riverside, California

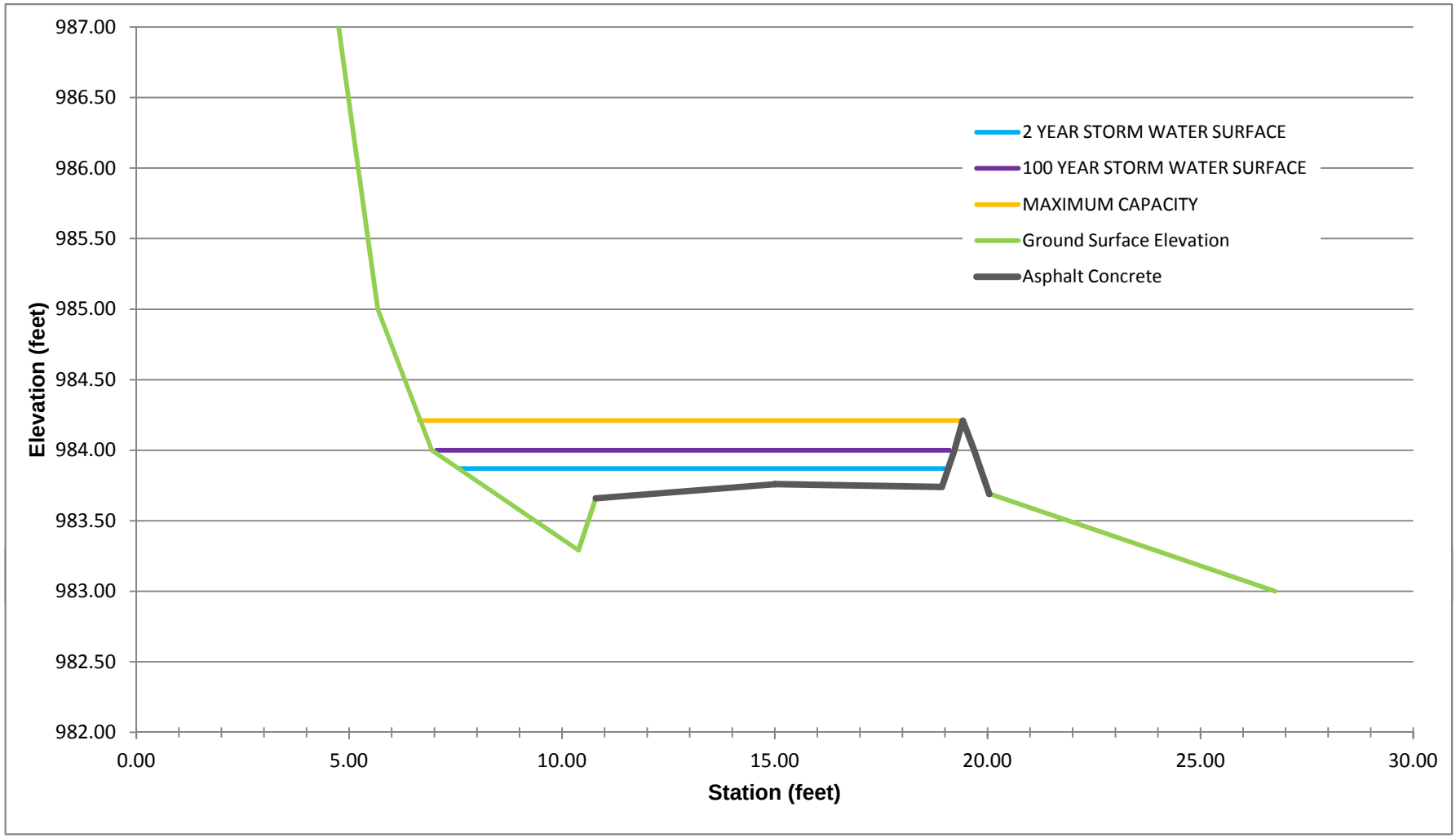
By: dls	Date: 04/21/14	Project No.: IR131164470
amec		Figure **13**



DRAFT

Cross Section K
Mount Rubidoux - Uproad
Hydrology and Drainage Study
Riverside, California

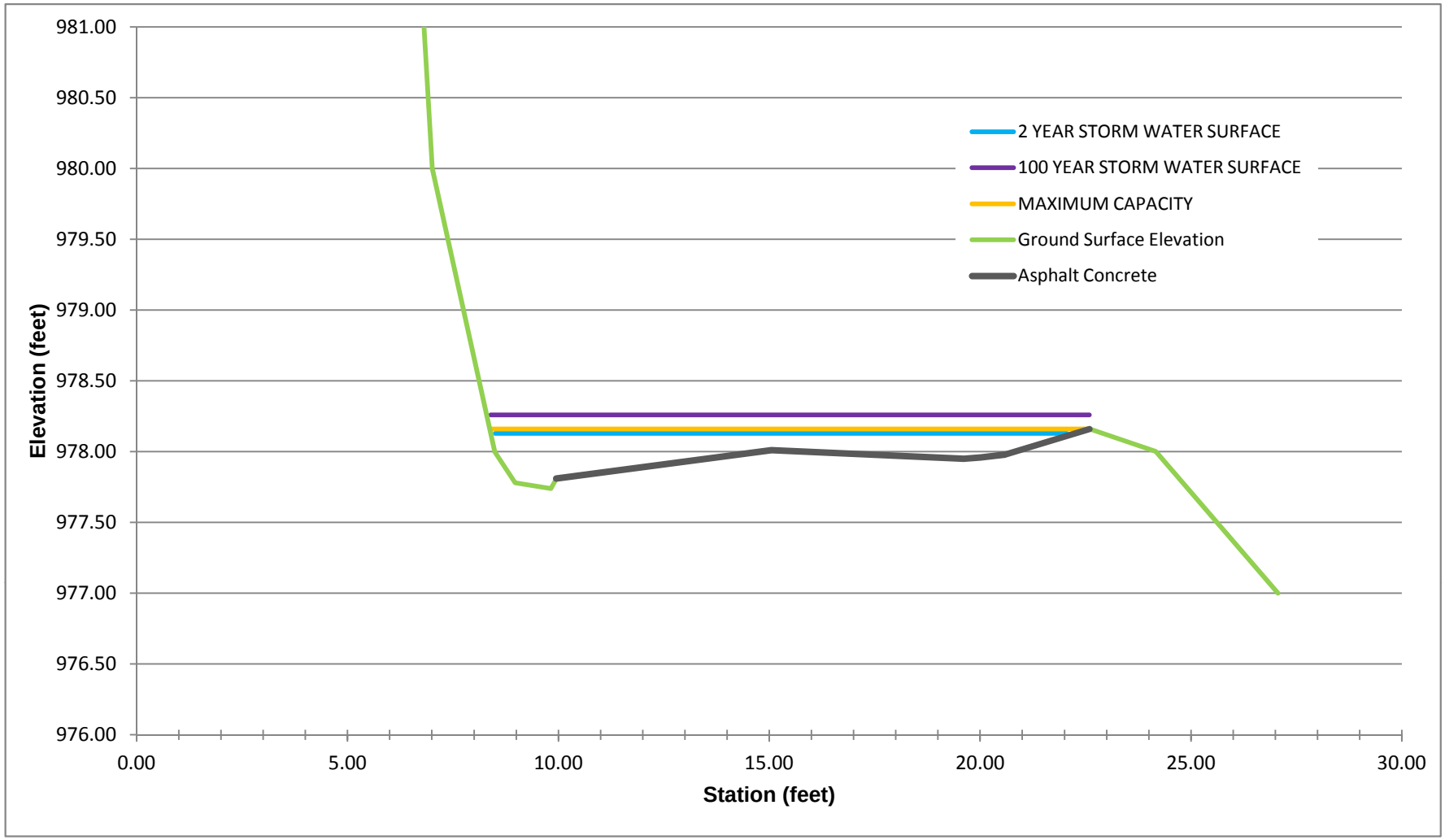
By: dls	Date: 04/21/14	Project No.: IR131164470
amec		Figure **14**



DRAFT

Cross Section L
Mount Rubidoux - Uproad
Hydrology and Drainage Study
Riverside, California

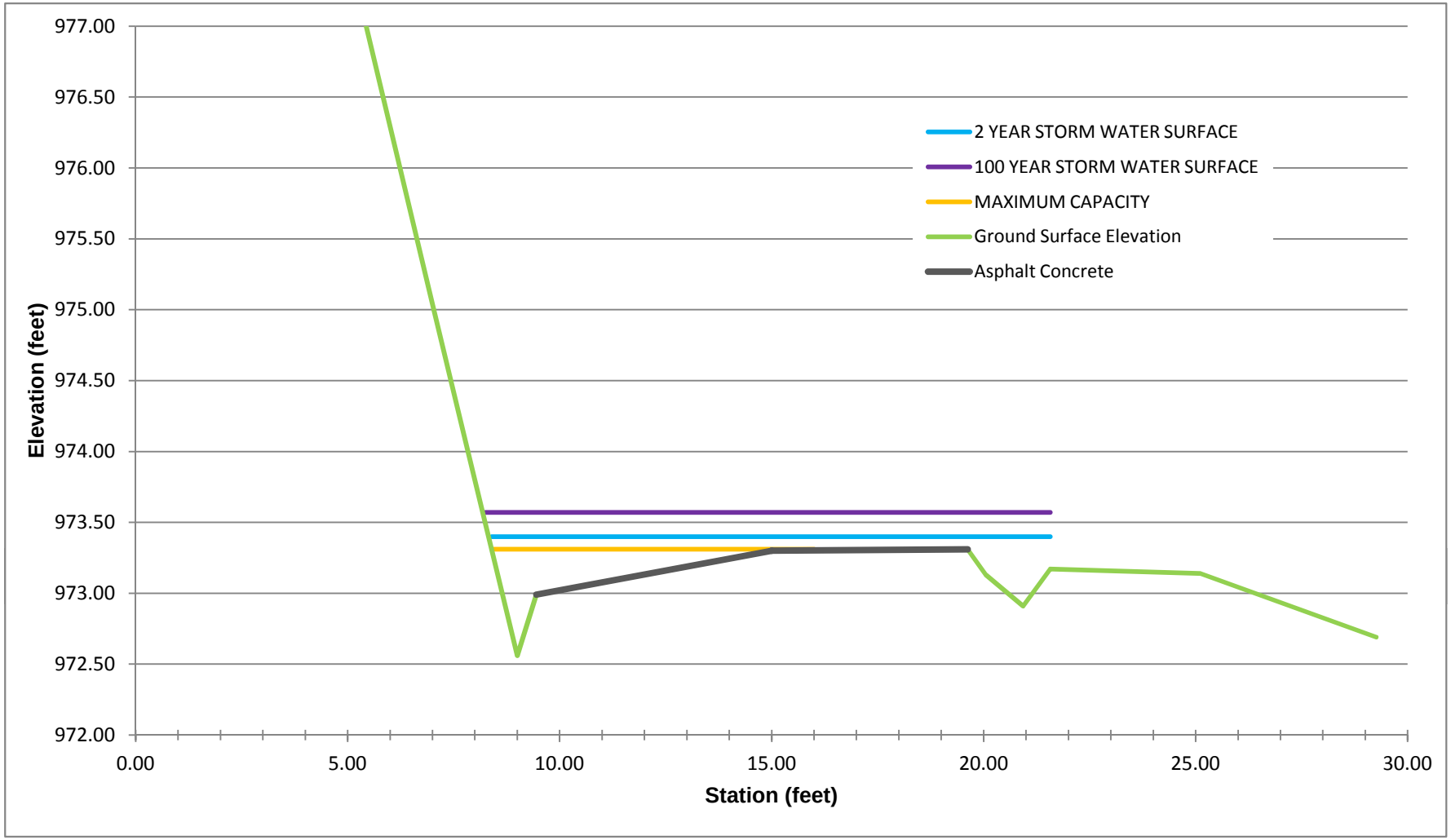
By: dls	Date: 04/21/14	Project No.: IR131164470
amec		Figure **15**



DRAFT

Cross Section M
Mount Rubidoux - Uproad
Hydrology and Drainage Study
Riverside, California

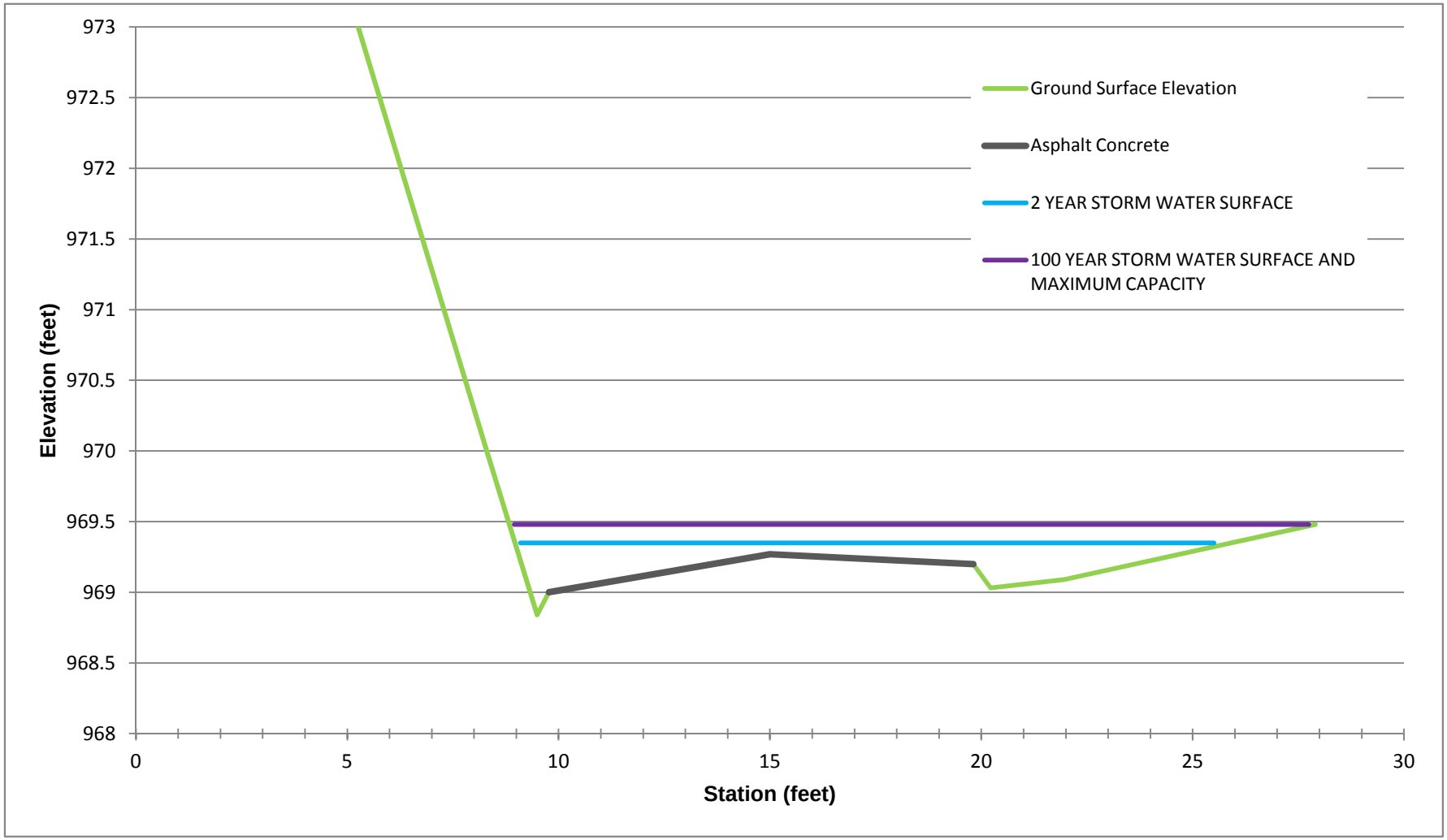
By: dls	Date: 04/21/14	Project No.: IR131164470
amec		Figure **16**



DRAFT

Cross Section N
Mount Rubidoux - Uproad
Hydrology and Drainage Study
Riverside, California

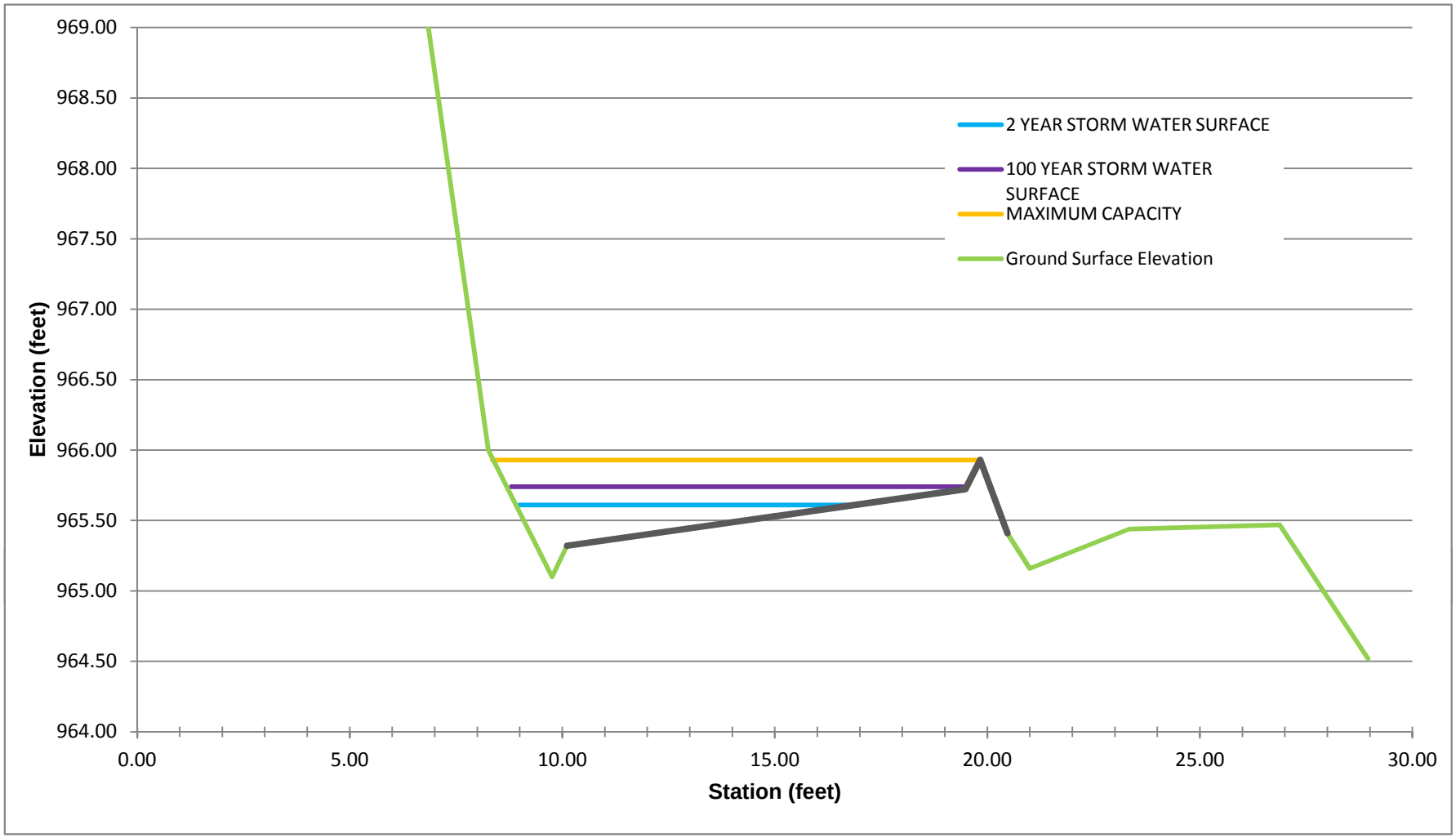
By: dls	Date: 04/21/14	Project No.: IR131164470
amec		Figure 17



DRAFT

Cross Section O
Mount Rubidoux - Uproad
Hydrology and Drainage Study
Riverside, California

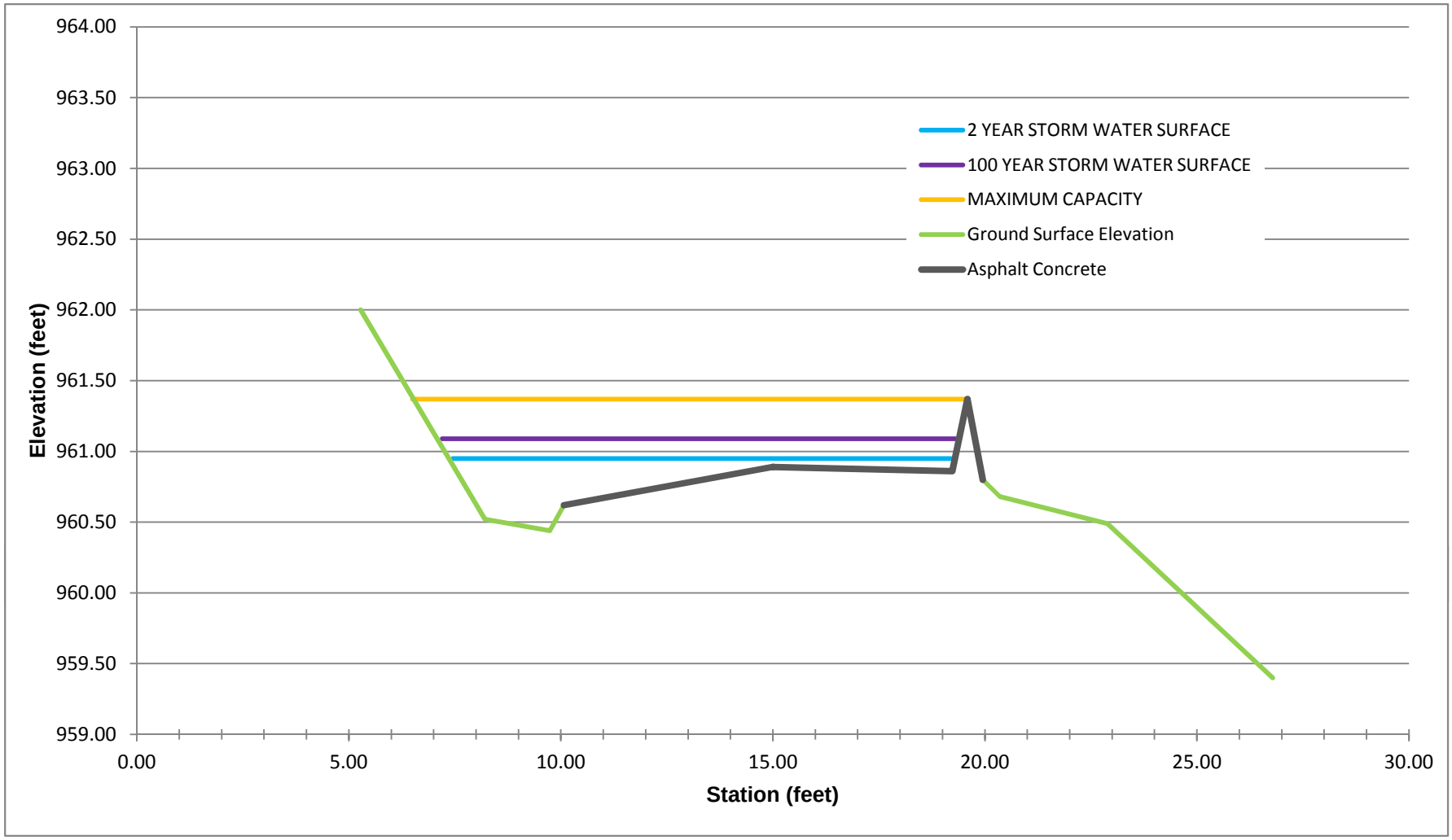
By: dls	Date: 04/21/14	Project No.: IR131164470
amec		Figure **18**



DRAFT

Cross Section P
Mount Rubidoux - Uproad
Hydrology and Drainage Study
Riverside, California

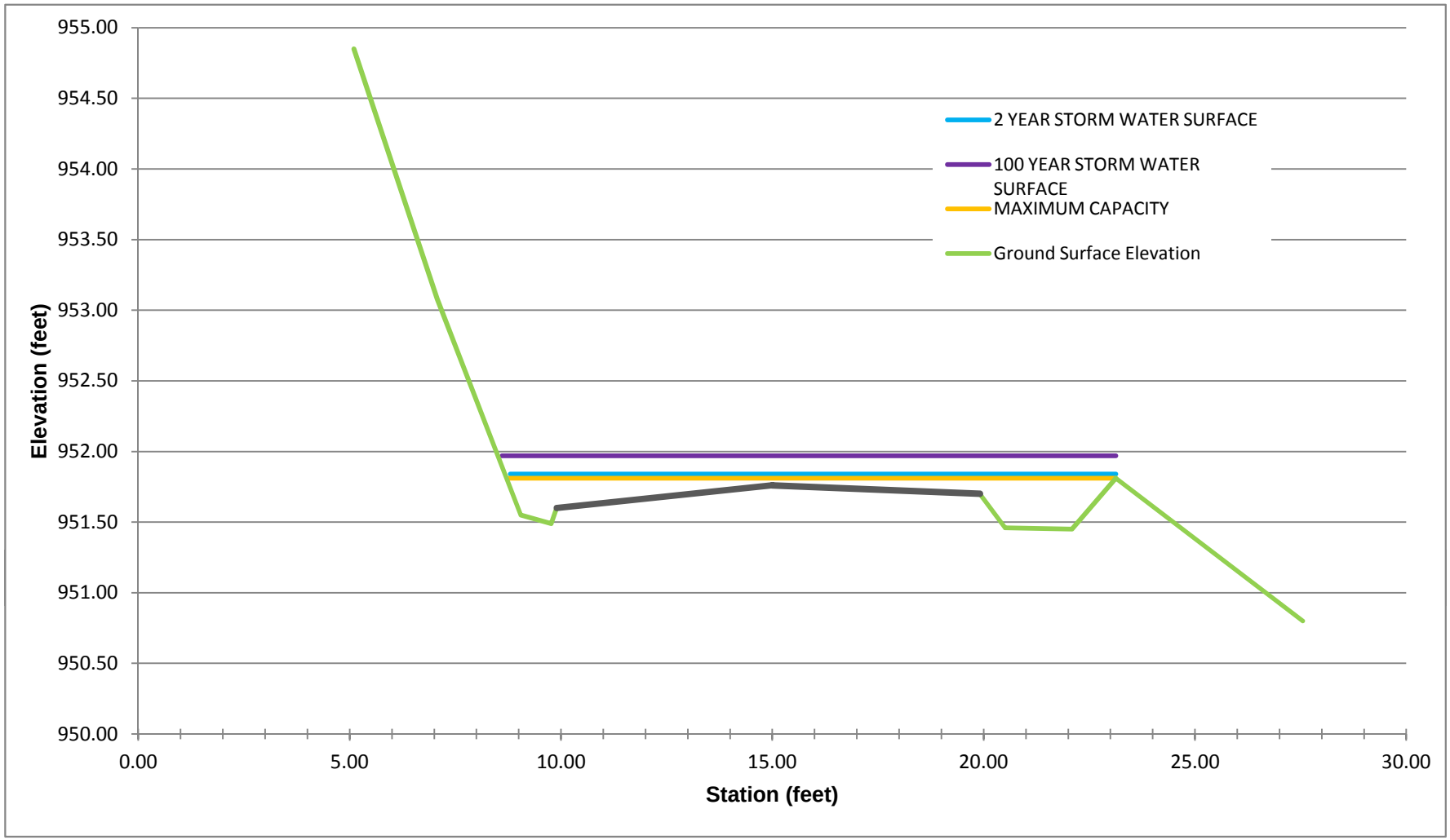
By: dls	Date: 04/21/14	Project No.: IR131164470
amec		Figure 19



DRAFT

Cross Section Q
Mount Rubidoux - Uproad
Hydrology and Drainage Study
Riverside, California

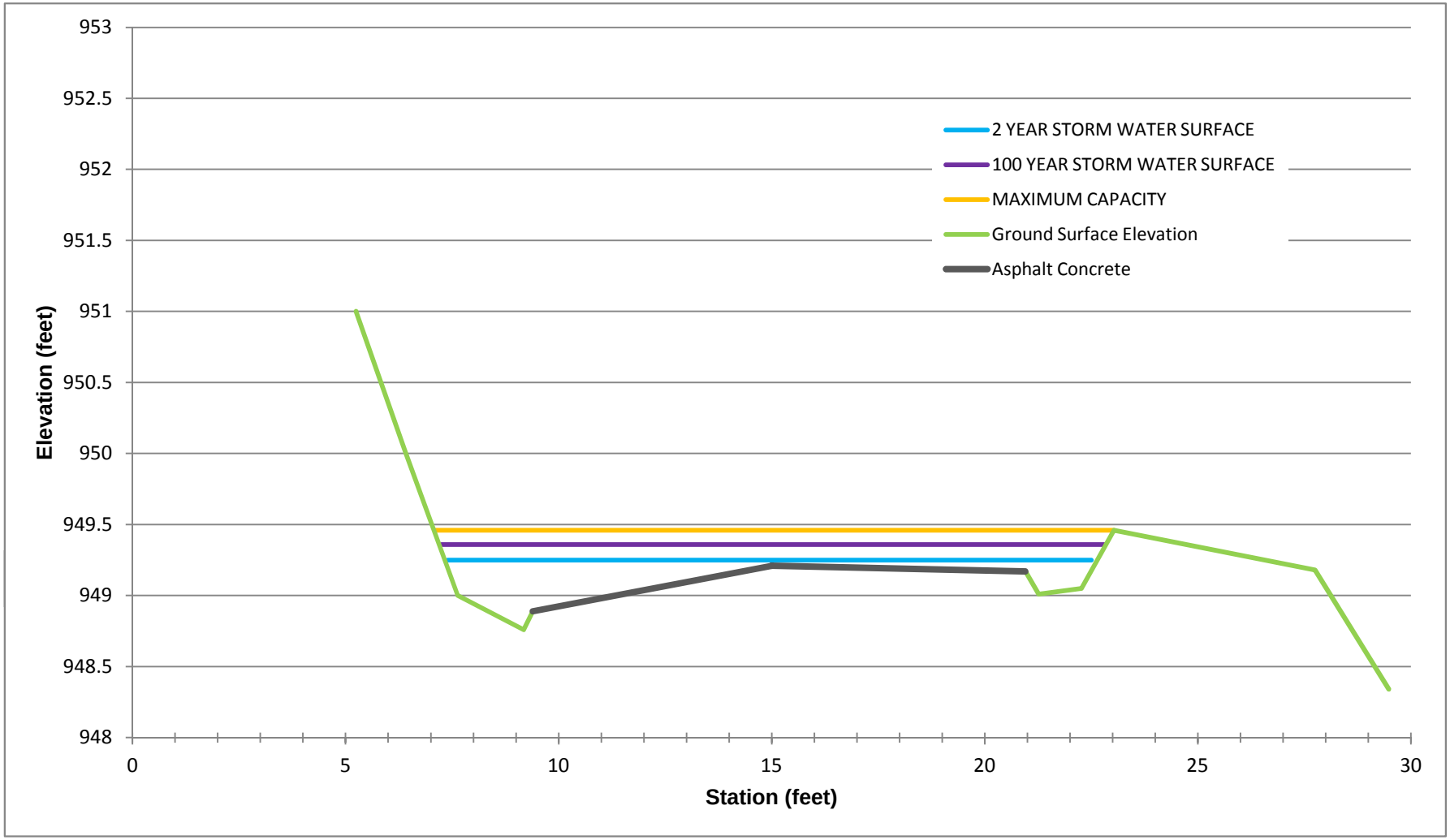
By: dls	Date: 04/21/14	Project No.: IR131164470
amec		Figure **20**



DRAFT

Cross Section R
Mount Rubidoux - Uproad
Hydrology and Drainage Study
Riverside, California

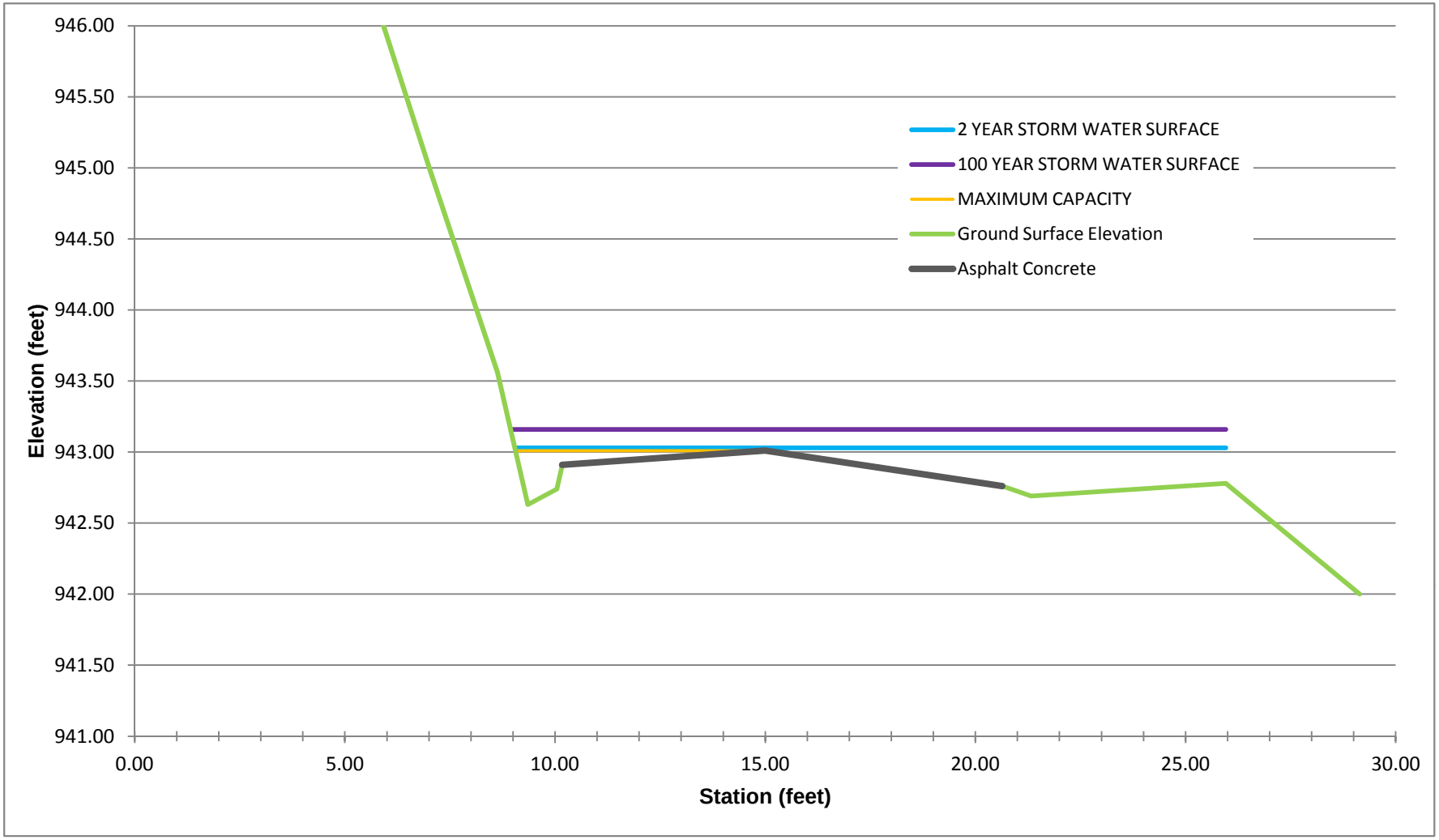
By: dls	Date: 04/21/14	Project No.: IR131164470
amec		Figure 21



DRAFT

Cross Section S
Mount Rubidoux - Uproad
Hydrology and Drainage Study
Riverside, California

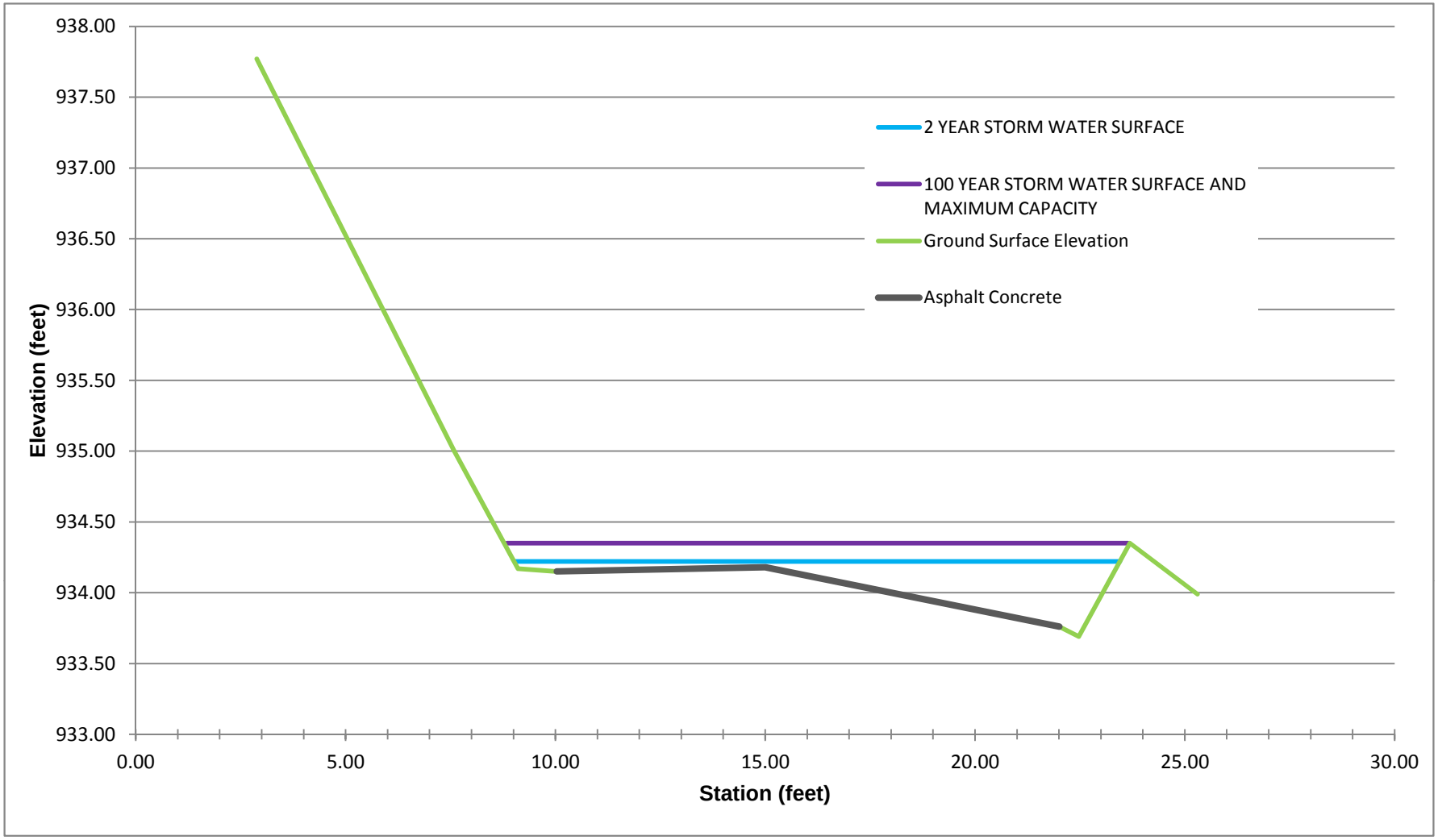
By: dls	Date: 04/21/14	Project No.: IR131164470
amec		Figure **22**



DRAFT

Cross Section T
Mount Rubidoux - Uproad
Hydrology and Drainage Study
Riverside, California

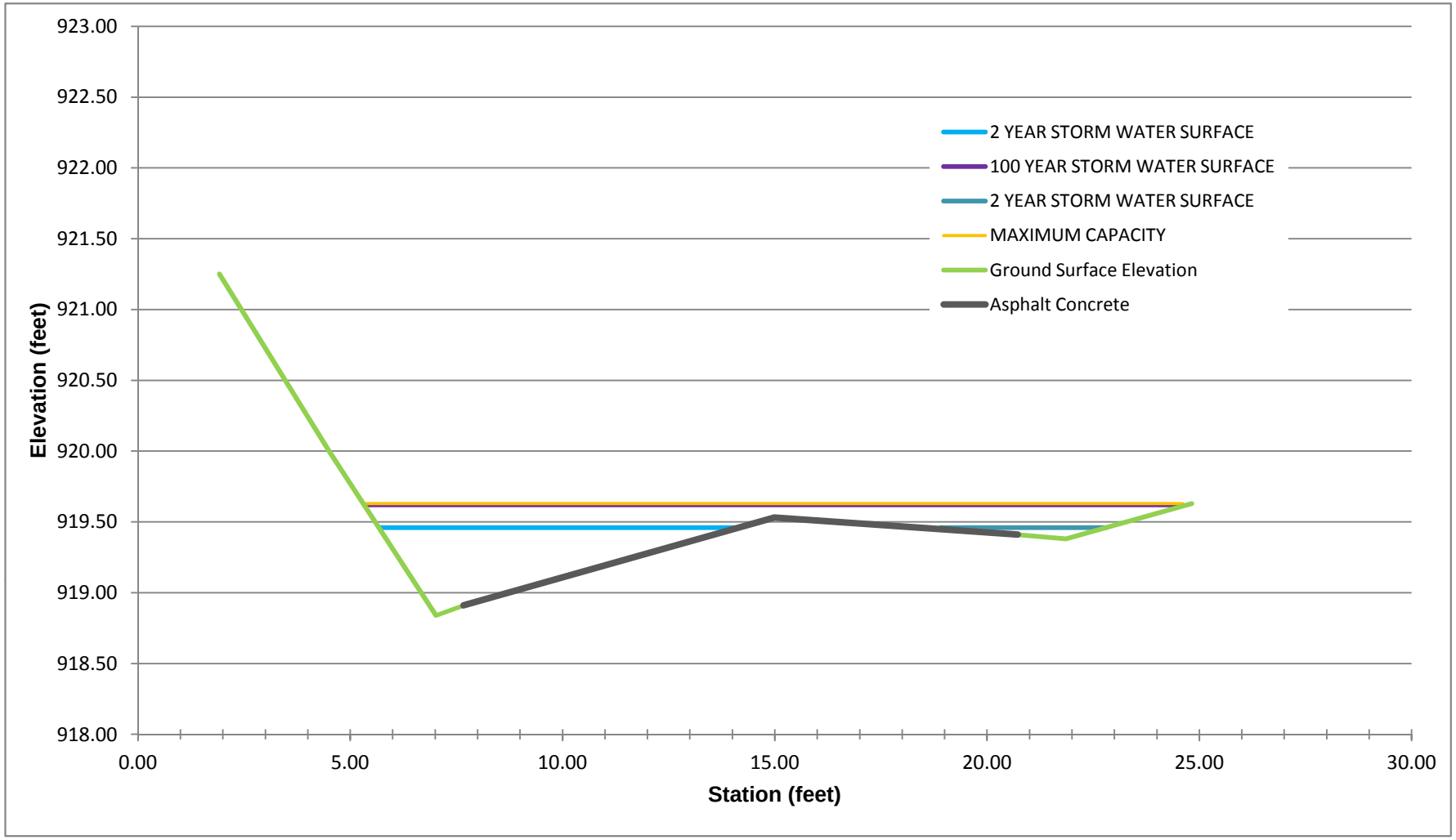
By: dls	Date: 04/21/14	Project No.: IR131164470
amec		Figure **23**



DRAFT

Cross Section U
Mount Rubidoux - Uproad
Hydrology and Drainage Study
Riverside, California

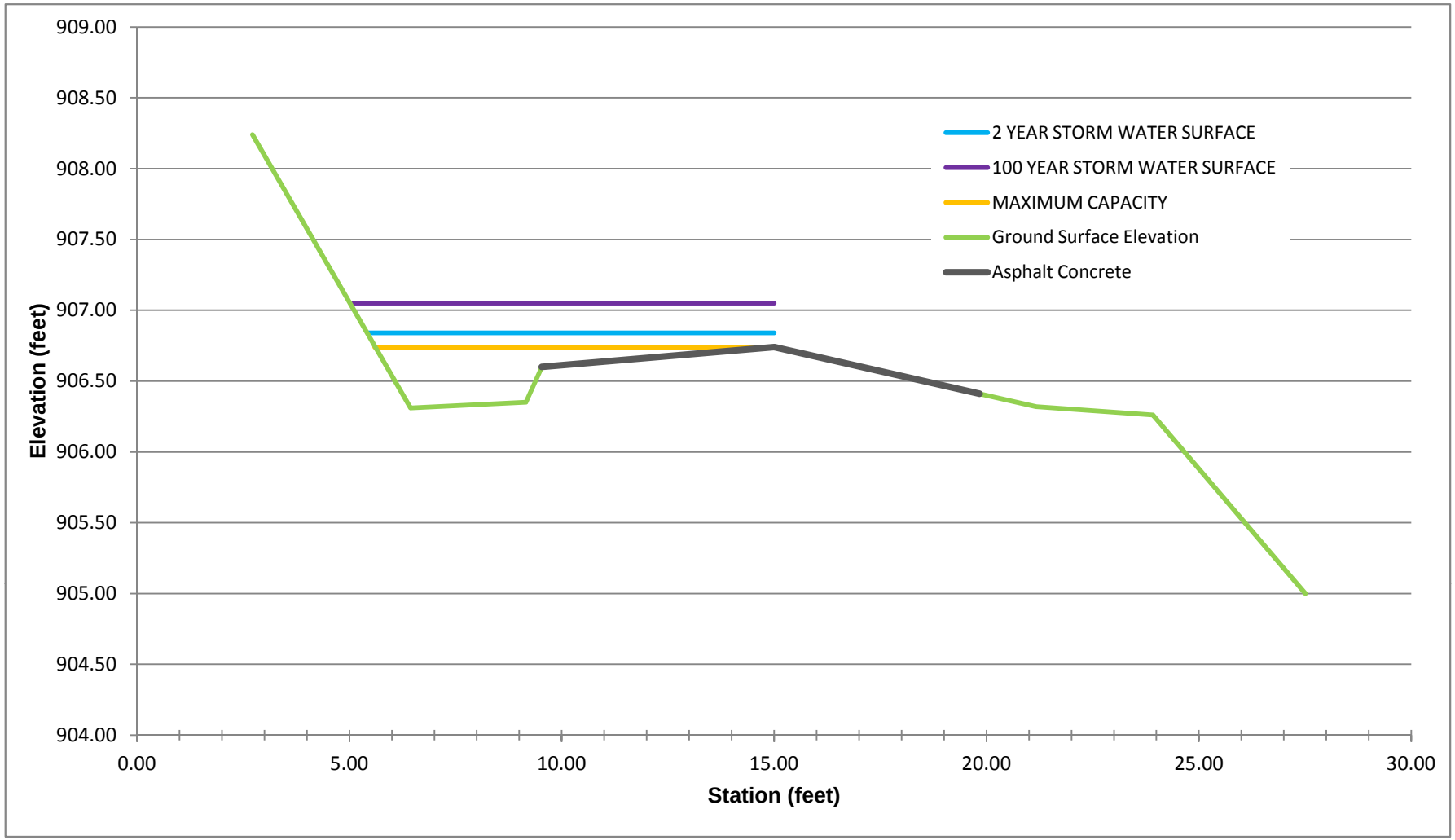
By: dls	Date: 04/21/14	Project No.: IR131164470
amec		Figure **24**



DRAFT

Cross Section V
Mount Rubidoux - Uproad
Hydrology and Drainage Study
Riverside, California

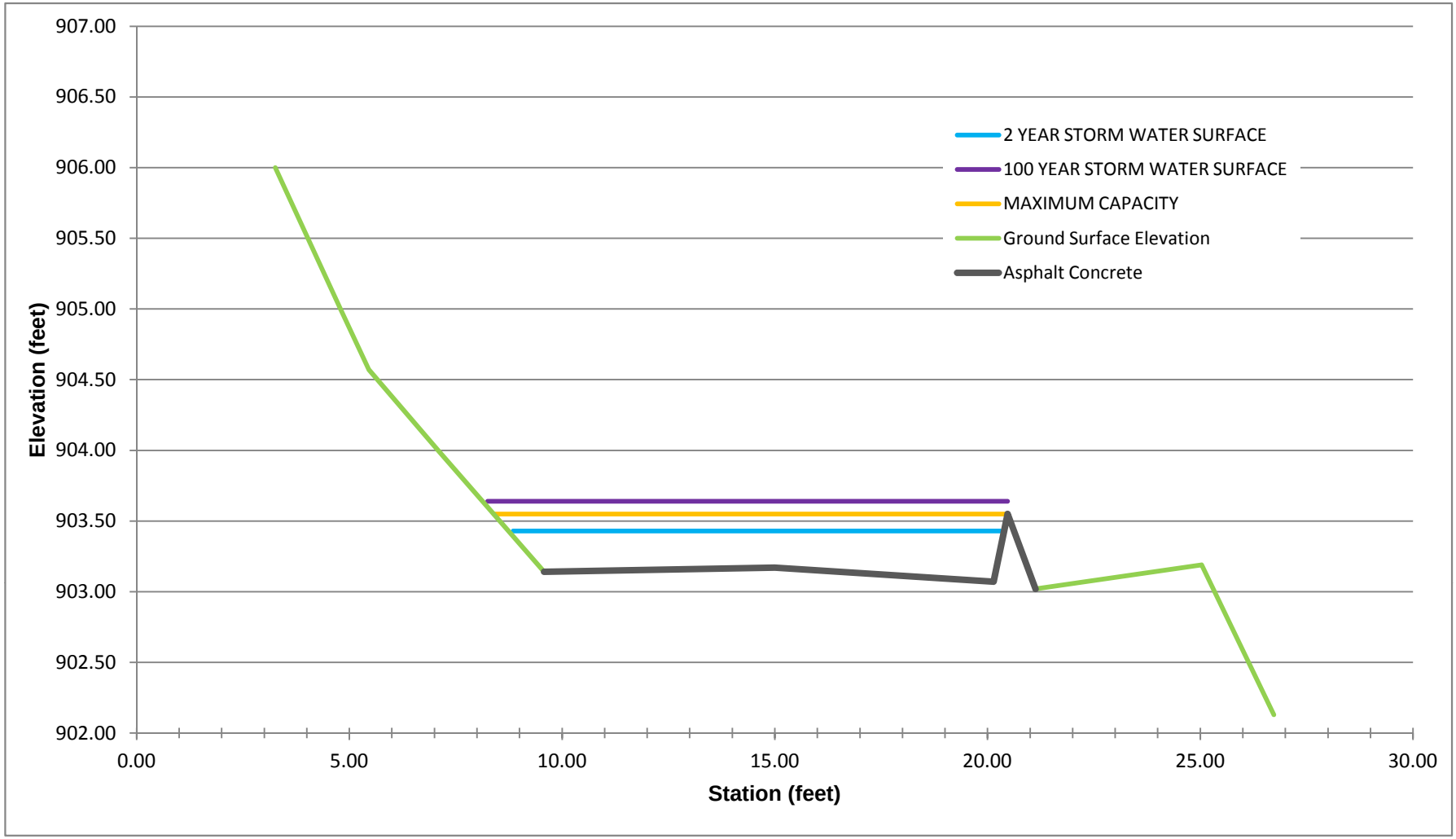
By: dls	Date: 04/21/14	Project No.: IR131164470
amec		Figure 25



DRAFT

Cross Section W
Mount Rubidoux - Uproad
Hydrology and Drainage Study
Riverside, California

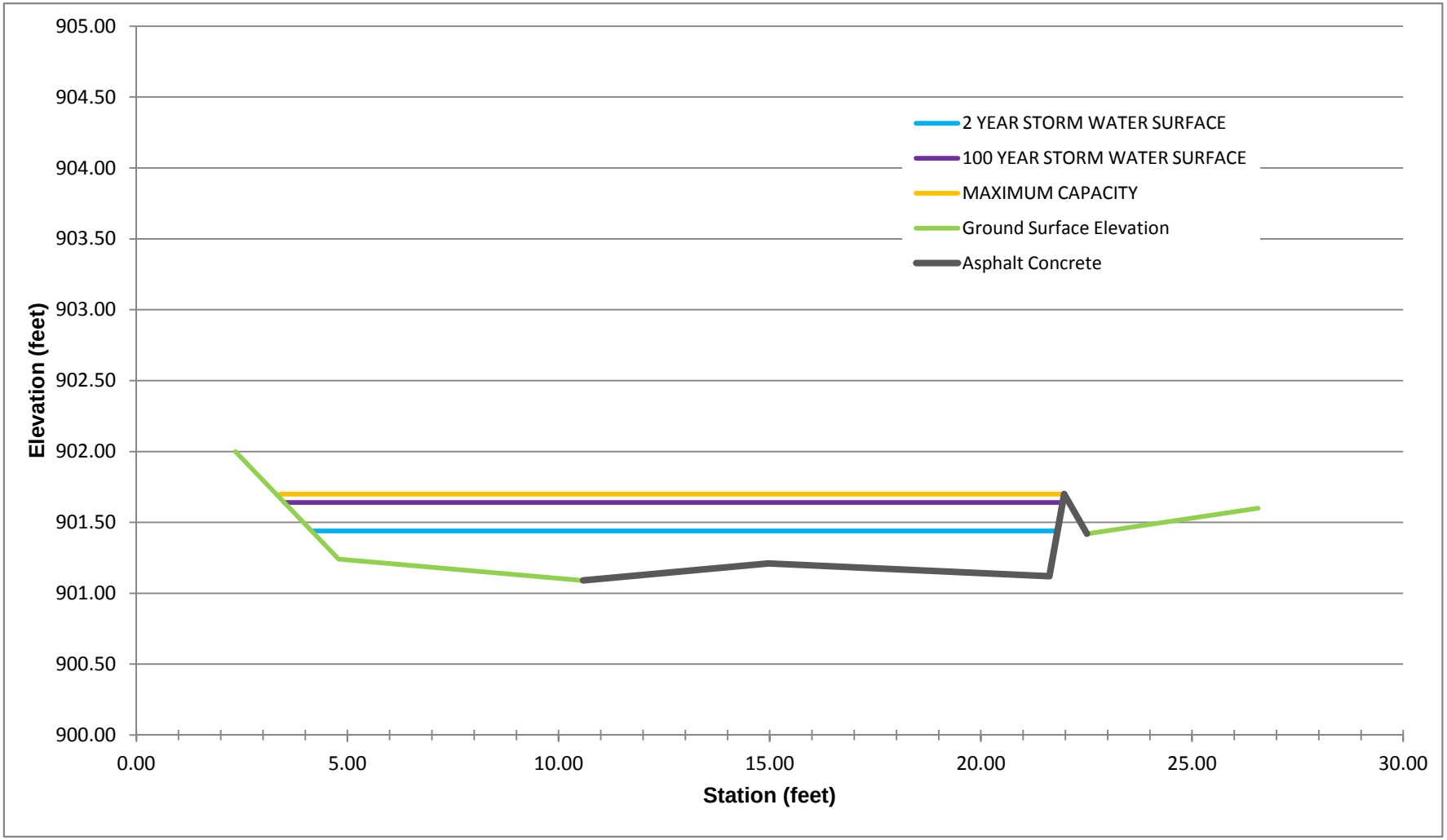
By: dls	Date: 04/21/14	Project No.: IR131164470
amec		Figure **26**



DRAFT

Cross Section X
Mount Rubidoux - Uproad
Hydrology and Drainage Study
Riverside, California

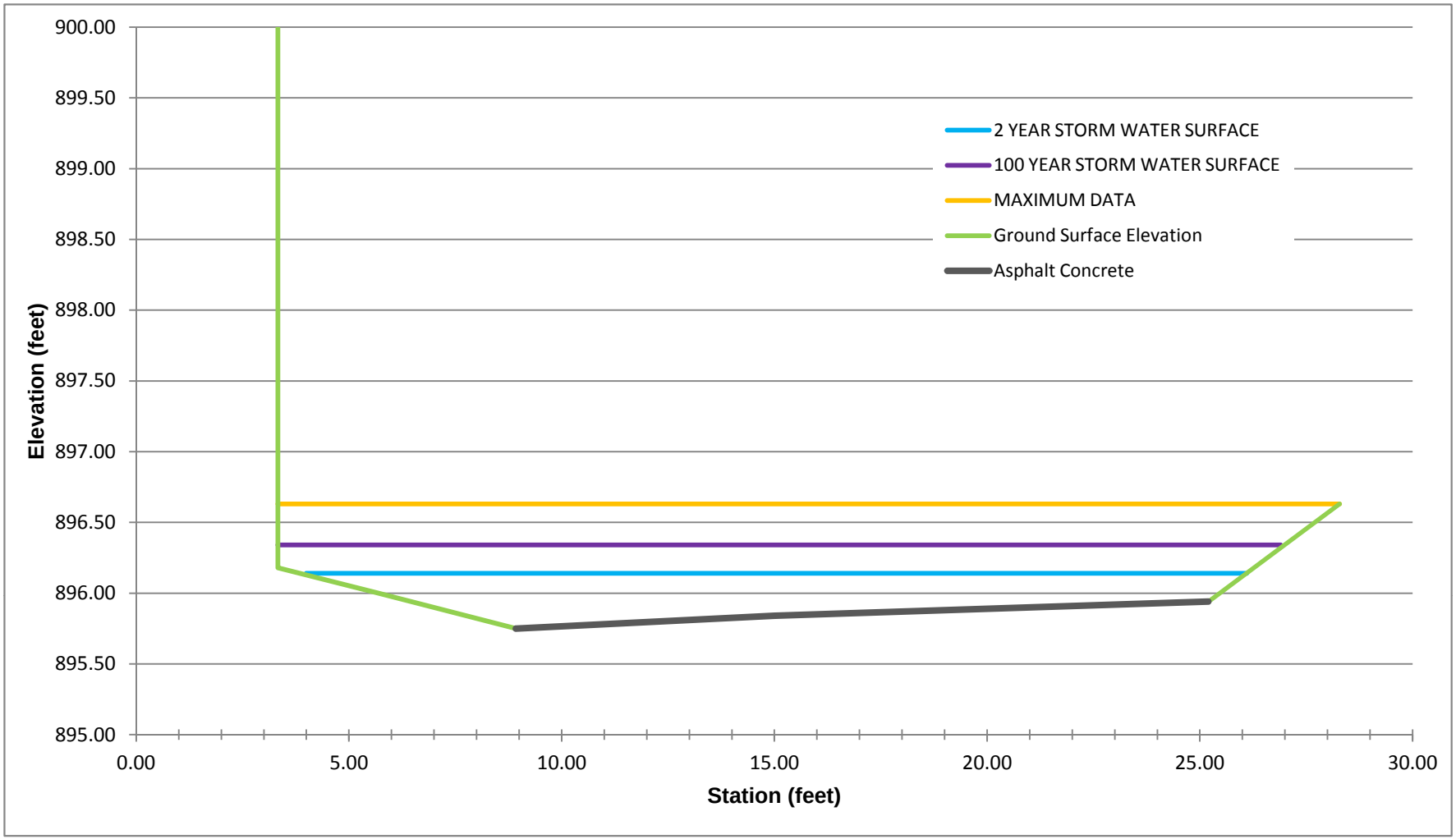
By: dls	Date: 04/21/14	Project No.: IR131164470
amec		Figure 27



DRAFT

Cross Section Y
Mount Rubidoux - Uproad
Hydrology and Drainage Study
Riverside, California

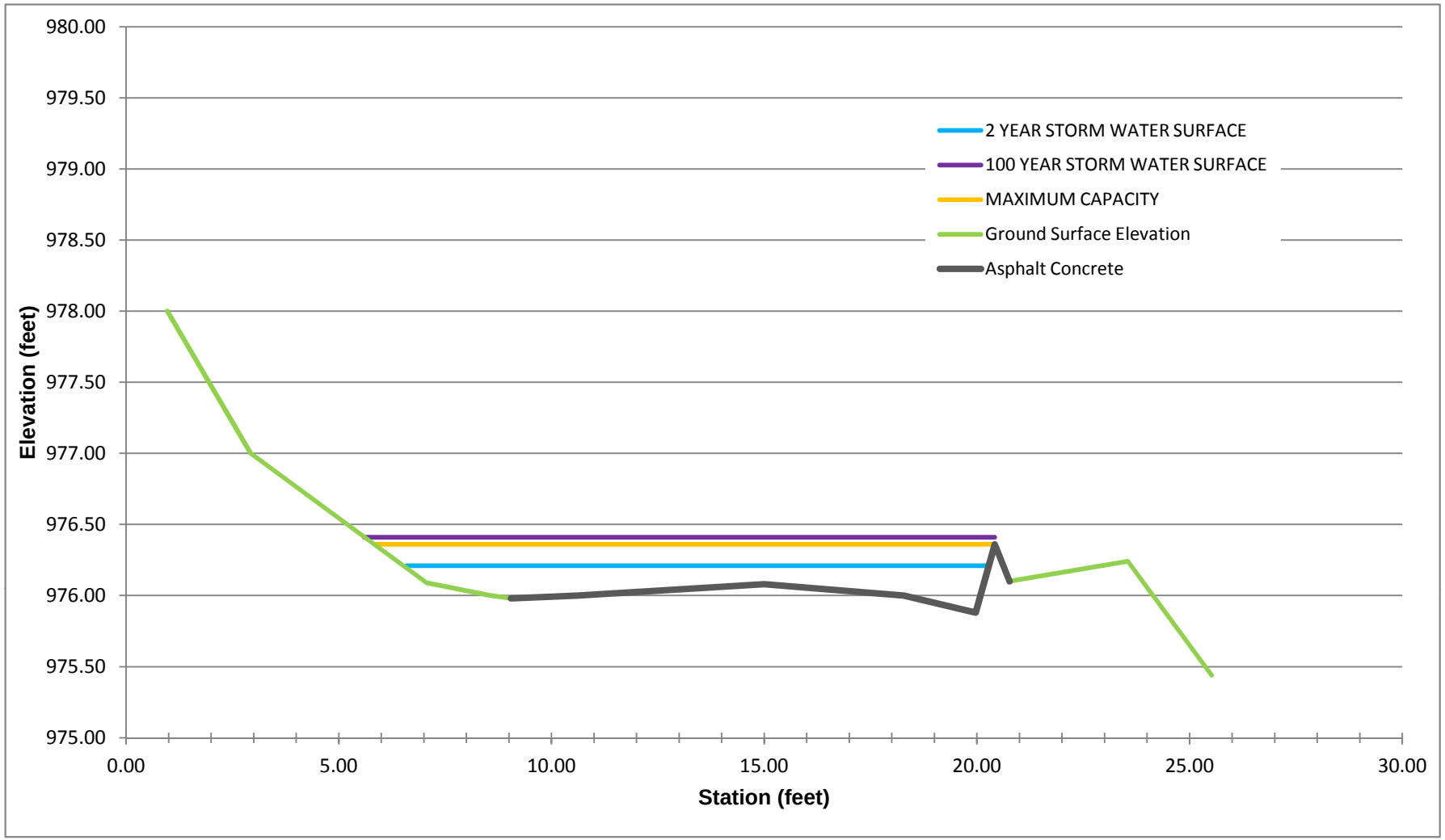
By: dls	Date: 04/21/14	Project No.: IR131164470
amec		Figure **28**



DRAFT

Cross Section Z
Mount Rubidoux - Uproad
Hydrology and Drainage Study
Riverside, California

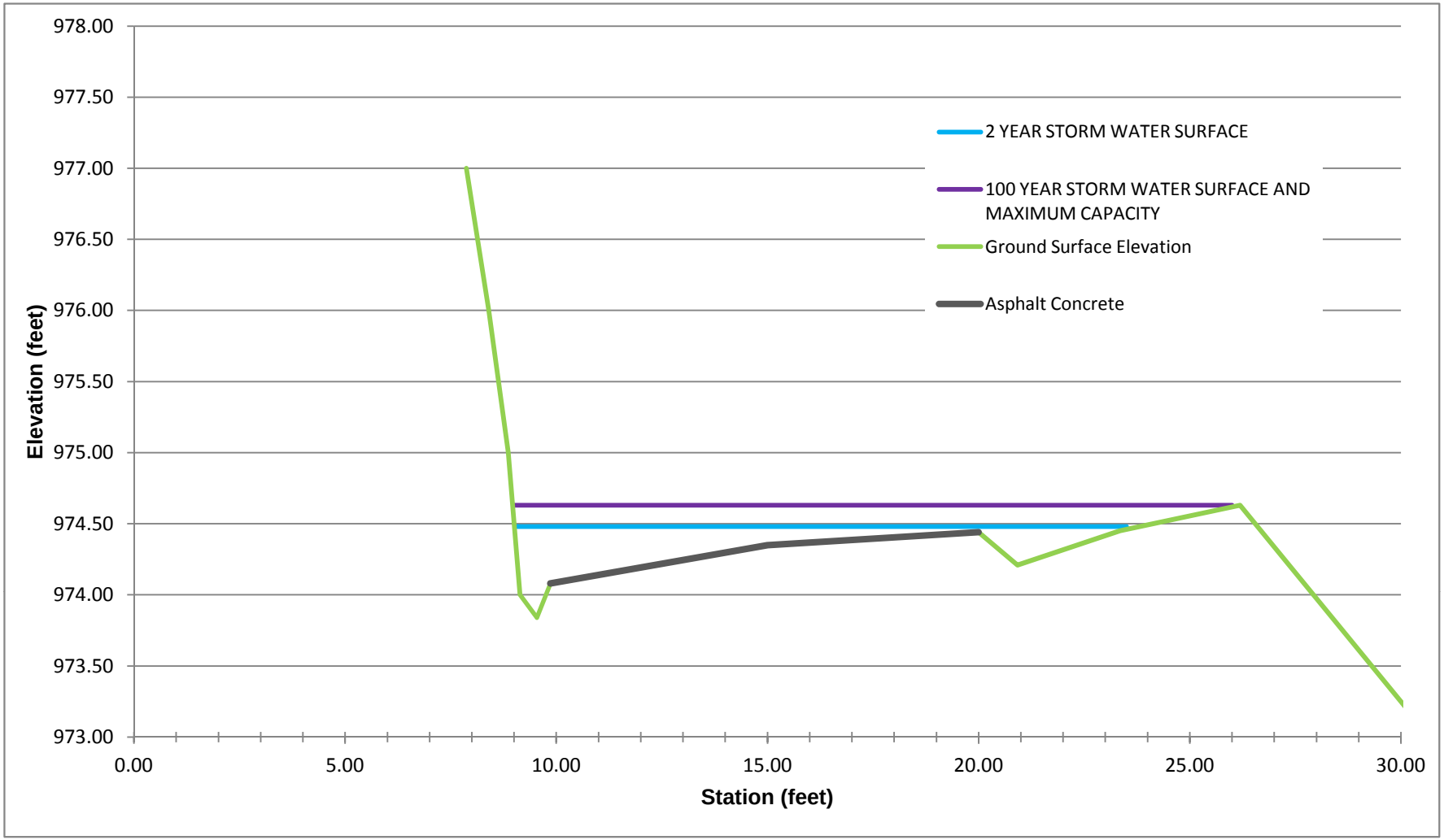
By: dls	Date: 04/21/14	Project No.: IR131164470
amec		Figure 29



DRAFT

Cross Section AA
Mount Rubidoux - Uproad
Hydrology and Drainage Study
Riverside, California

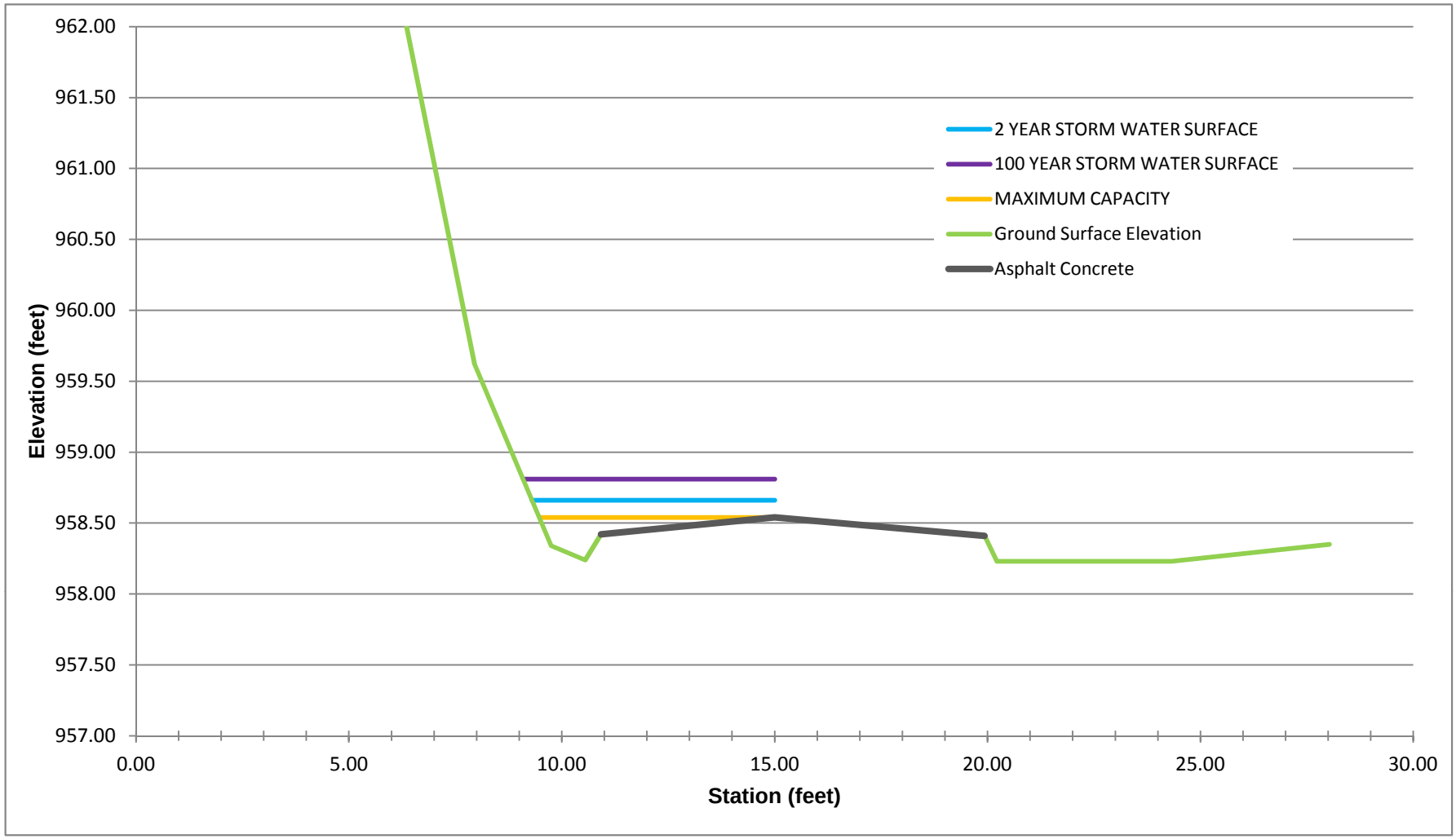
By: dls	Date: 04/21/14	Project No.: IR131164470
amec		Figure **30**



DRAFT

Cross Section BB
Mount Rubidoux - Uproad
Hydrology and Drainage Study
Riverside, California

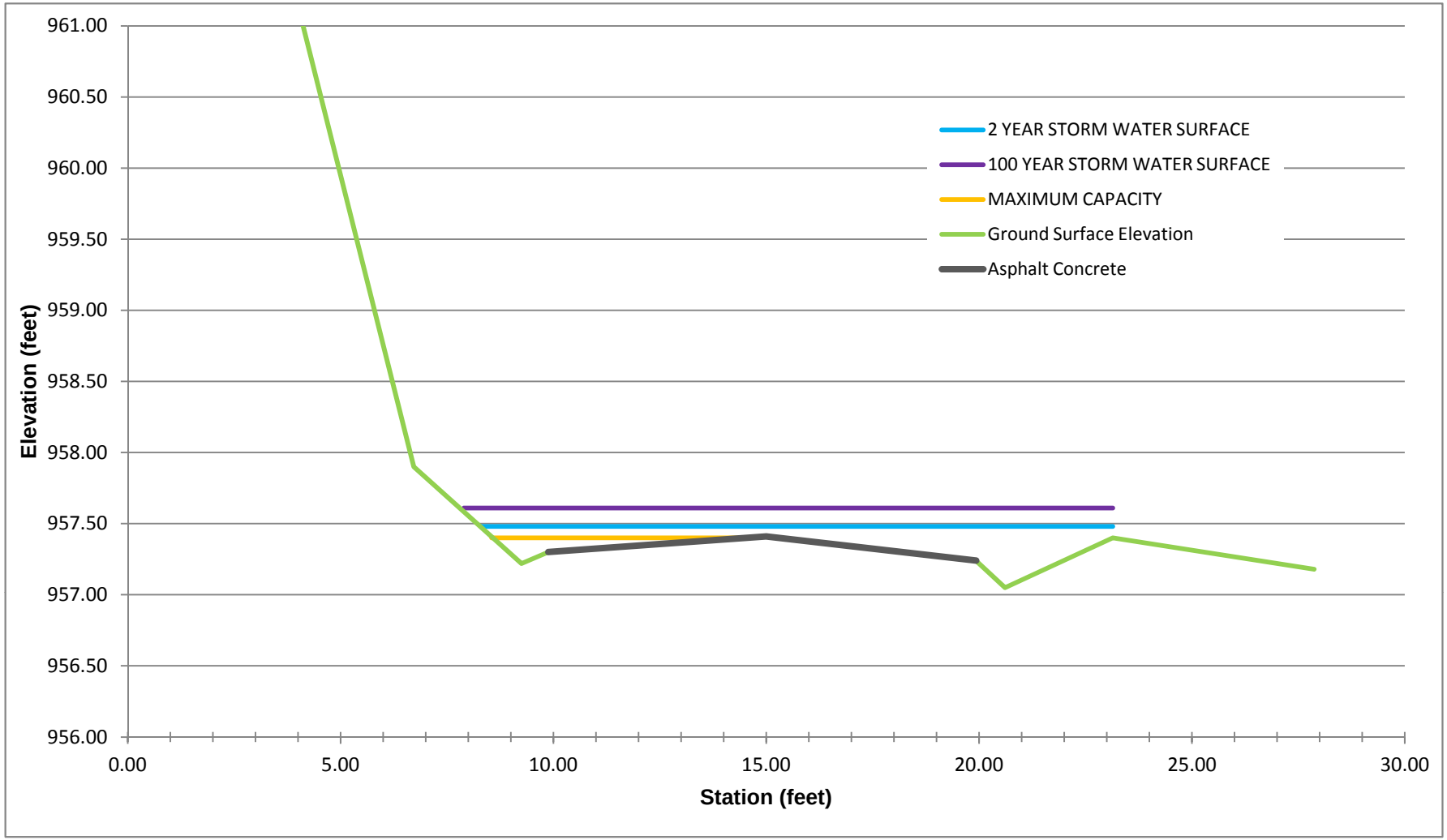
By: dls	Date: 04/21/14	Project No.: IR131164470
amec		Figure **31**



DRAFT

Cross Section CC
Mount Rubidoux - Uproad
Hydrology and Drainage Study
Riverside, California

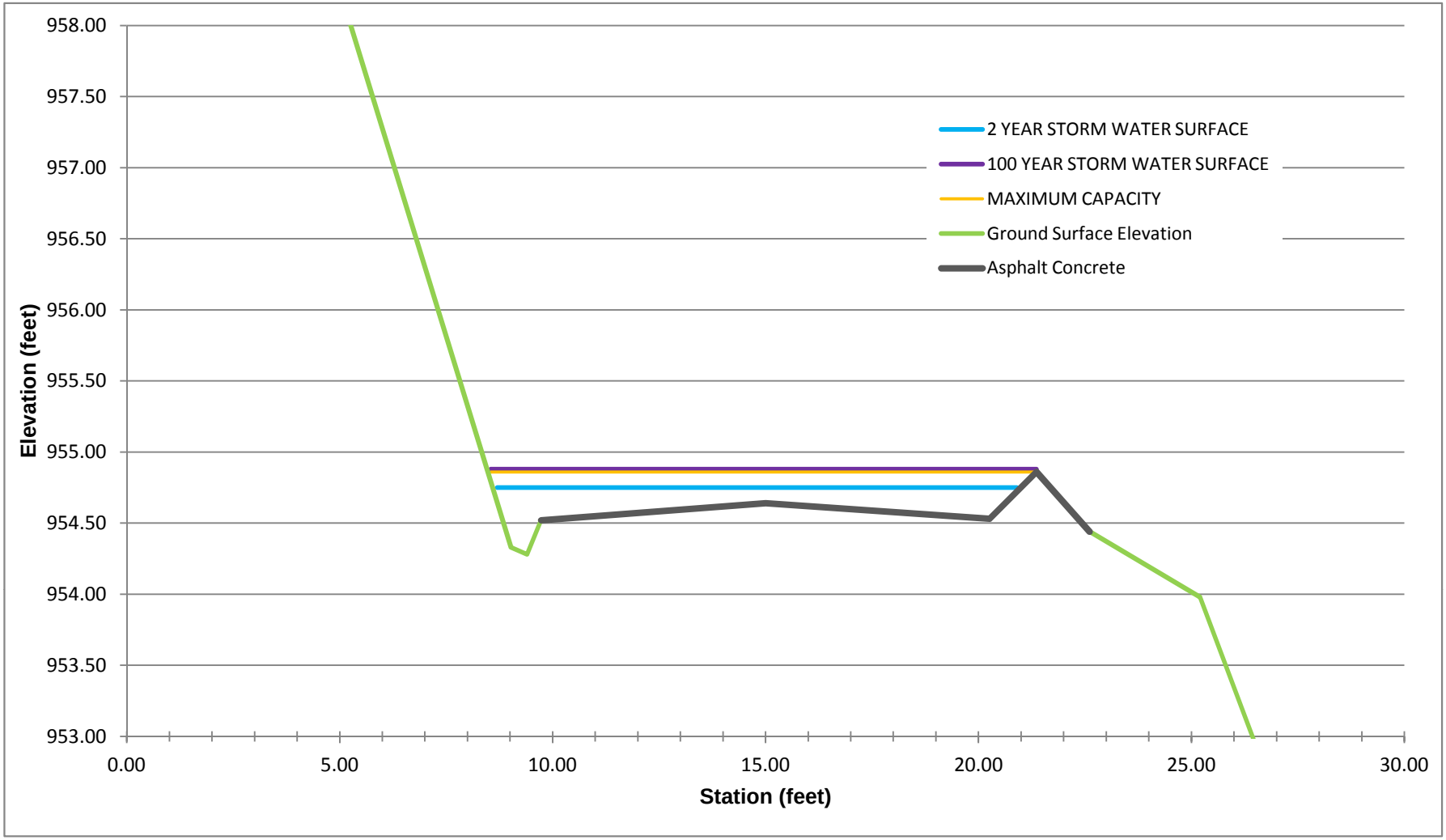
By: dls	Date: 04/21/14	Project No.: IR131164470
amec		Figure **32**



DRAFT

Cross Section DD
Mount Rubidoux - Uproad
Hydrology and Drainage Study
Riverside, California

By: dls	Date: 04/21/14	Project No.: IR131164470
amec		Figure 33



DRAFT

Cross Section EE
Mount Rubidoux - Uproad
Hydrology and Drainage Study
Riverside, California

By: dls	Date: 04/21/14	Project No.: IR131164470
amec		Figure **34**