PRELIMINARY DRAINAGE STUDY
TO
DETERMINED PEAK PRE AND POST DEVELOPMENT Q_S

CHURCH OF THE WOODS

RIM FOREST, CA

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Table of Contents

Water Quality Management Plan
Proposed Permanent Drainage Improvements

Appendix "A" – Hydrologic Soils Map

Appendix "B" – Isohyetals

Appendix "C" – NOAA Point Precipitation

Appendix "D" – Proposed Site Plan & Preliminary Grading Plan

Appendix "E" – Developed Impervious Area Map

Appendix "F" – Rational Method Total Drainage Area Calculations

Appendix "F-1" – Rational Method Hydraulic Calculations Total Drainage Area (100-Year Storm Event) and Proposed Project Area Undeveloped (100-Year Storm Event) and Map

Appendix "F-2" – Rational Method Hydraulic Calculations Total Drainage Area (100-Year Storm Event) and Proposed Project Area Developed (100-Year Storm Event) and Map

Appendix "G" – Rational Method Onsite Calculations

Appendix "G-1" – Rational Method Hydraulic Calculations Proposed Project Area Undeveloped (100-Year Storm Event) and Map

Appendix "G-2" – Rational Method Hydraulic Calculations Proposed Project Area Developed (100-Year Storm Event) and Map

Appendix "H" – Capacity Calculations

Appendix "I" – Previously Approved Water Quality Management Plan

Site Description

The site consists of 36.98 acres on the north side of State Hwy 18 in the northwest ¼ of Section 29 T 2 N, R 3 W. The site is located on the easterly edge of the area known as Rim Forest in the Lake Arrowhead area of San Bernardino County.

The site is bounded on the south by State Highway 18; on the west by an existing subdivision known as the Arrowview Tract (Tract No. 2015) consisting of 4,000 ± S. F. Residential lots; on the north and east by vacant land owned by the U. S. Forest Service. State Highway 18 on the south boundary is a paved, two lane highway. Daley Canyon Road, an existing two-lane road, cuts across the northeast corner of the site.

The site itself is a typical wooded mountain site. Since the original report was prepared, dead tree removal has occurred primarily in the area of the site proposed for development. There is an existing natural drainage course running diagonally through the site from the southwest corner to the northeast corner. There is an existing 8" sewer main located in the natural drainage course. This sewer is part of the Lake Arrowhead Community Services District's Wastewater Collection System.

There are no existing drainage or storm drain improvements located on the site.

Proposed Project

The proposed project consists of a church, athletic field, and appurtenant facilities. A proposed Site Plan is included as Appendix "A" of this report. The proposed facilities are located generally in the south and northwest areas of the site.

The total site consists of approximately 36.98 acres. Approximately 6.5 acres will be impervious area, buildings, parking lots, sidewalk and paved assembly areas. Approximately 7.1 acres will be landscaped areas, sodded recreation areas, water quality basin and landscaped slopes. Approximately 23.3 acres will be retained in its natural state.

The proposed project will require a fill in the natural drainage course in the southwest corner of the site. This fill will require the construction of approximately 750' of storm drain. This storm drain is shown on the site plan.

The development of this project will not alter the existing drainage patterns of the offsite watershed.

The development of this project will redirect approximately 5 acres of area that currently drains onto the property easterly of the site, to the west of its current flow path and into the projects storm drain system. The project storm drain system discharges into the natural drainage course at approximately the center of the property.

In the natural state, this 5 acres drains onto the property to the east between this site and Daley Canyon Road. The flows then run northerly on Daley Canyon Road and are discharged into the natural drainage course in the vicinity of the northeast corner of the site.

In summary, all the redirected flows return to the same drainage course by the time that they reach the northeast corner of the property.

Hydrology Study

The hydrology study consists of a rational analysis of the off site areas contributing to the site and the project area based on a 100 year storm event. Isohyetal rainfall information was used for the project due to the project site not being located in an arid region.

The study was performed using the "San Bernardino County Rational Hydrology Program (Hydrology Manual date – August 1986) Civilcadd / Civildesign Engineering Software (C) 1989-2005 versions 7.1". A field review of the existing drainage and road improvements, within the contributing drainage area was conducted to determine, as accurately as possible, the flow paths within the areas.

The rational method hydrology calculations are included as Appendix "F" and Appendix "G" of this report

Existing Water Sheds

Offsite

The offsite watershed areas that contribute runoff to the site generally located to the west of the site. These watershed areas are shown on the maps labeled "Drainage Map Undeveloped" and "Drainage Map Developed" contained in Appendix "F" of this report.

Generally, the total watershed area consists of some vacant forested land, some existing mountain residential area and some commercial development.

The southerly offsite watershed is broken down into 8 sub areas for the purpose of the Rational Hydrology Calculations.

These sub areas are identified by Node Numbers as required by the computer program. For example, the most westerly area runs from Node Number 1 to Node Number 2 and consists of 8.5 acres.

The project area is included in this analysis so that the project impact is shown as it relates to the overall watershed.

A discussion of each offsite watershed sub area is as follows:

Offsite / Onsite Undeveloped

Subarea Node 15-16

The subarea consists of 3.9 acres. This area is shown as an initial area in the Rational Method Calculations. The area is undeveloped and consists of average ground cover. The Soil group designation for this area is "D". The elevation at the top (Node No. 15) of the area is 6,020 feet above sea level and the elevation at the bottom of the subarea (Node No. 16) is 5,850 feet above sea level. The length of the flow path within the subarea is 700 feet.

The calculated 100-year "Q" at Node No. 16 is 21.40 C.F.S.

The drainage ways within the subarea are unnamed.

Subarea Node 16-17

The subarea consists of 8.9 acres. The area is undeveloped and consists of average ground cover. The Soil group designation for this area is "D". The elevation at the top of the subarea (Node No. 16) is 5,850 feet above sea level and the elevation at the bottom of the subarea (Node No. 17) is 5,635 feet above sea level. The length of the flow path within the subarea is 1,200 feet.

The calculated 100-year "Q" at Node No. 17 is 60.55 C.F.S. at Highway 18.

The drainage ways within the subarea are unnamed.

Subarea Node 17-4

Node 17-4 is not a subarea, but, instead, it is a flow path that conveys water along the highway. As such, this section does not have an area associated with it, and is modeled as channel flow for the water that falls on the south facing slopes. It is a flow path of 1,650 feet east down Highway 18 to a confluence with Node No. 4. The elevation at the top of the subarea (Node No. 17) is 5,635 feet above sea level and the elevation at the bottom of the subarea (Node No. 4) is 5,600 feet above sea level.

Subarea Node 1-2

The area consists of 8.5 acres. This area is shown as an initial area in the Rational Method Calculations; the area is undeveloped and consists of average ground cover. The Soil group designation for this area is "D". The elevation at the top of the subarea (Node No. 1) is 6,040 feet above sea level and the elevation at the bottom of the subarea (Node No. 2) is 5,920 feet above sea level. The length of the flow path within the subarea is 900 feet.

The calculated 100-year "Q" at Node No. 2 is 39.89 C.F.S.

The drainage ways within the subarea are unnamed.

Subarea Node 2-3

The area consists of 19.0 acres. Approximately 10 acres of this subarea is within Tract No. 2015, the Arrowhead View Tract, a review of the San Bernardino County Assessor's records indicate that Tract No. 2015, which was recorded in 1929, consists of lots varying in size from 2,600 SF to 8,000 SF in area. The homes that have been constructed within this Tract have been constructed on the larger lots or combinations of the smaller lots. The homes themselves range in size from a small of 400 +/- SF to a large of 2,500 +/- SF with most falling within the 900 SF to 1,100 SF range. Consequently, we used a development classification of 2 dwelling units per acre for the purpose of the Rational Method Calculations due to the spread out nature of the houses as well as many of the lots being undeveloped. For the remaining 9 acres a soil classification of undeveloped with average cover was used. A weighted average was found in order to characterize the subarea as a whole.

The Soil group designation for this area is "D". The elevation at the top of the subarea (Node No. 2) is 5,920 feet above sea level and the elevation at the bottom of the subarea (Node No. 3) is 5,790 feet above sea level. The length of the flow path within the subarea is 900 feet.

The calculated 100-year "Q" at Node No. 3 is 121.05 C.F.S.

The drainage ways within the subarea are unnamed.

Subarea Node 3-4

The area consists of 32.0 acres. Approximately 15.3 acres of this subarea is within Tract No. 2015 (see discussions above about the character of this area). Approximately 6.4 acres consist of relatively low-density commercial development. Weighing the commercial portion of this subarea, we used a development classification of 3-4 dwelling units per acre for the purpose of the Rational Method Calculations.

The Soil group designation for this area is "D". The elevation at the top of the subarea (Node No. 3) is 5,790 feet above sea level and the elevation at the bottom of the subarea (Node No. 4) is 5,600 feet above sea level. The length of the flow path within the subarea is 1,500 feet.

The calculated 100-year "Q" at Node No. 4 is 242.15 C.F.S.

Node No. 4 is located on the west property line of the proposed project. At this point the flows will be confluenced with previously mentioned Node No. 4. The 100-year

confluence "Q" will be 301.15 C.F.S. The flows will then be picked up in a reinforced concrete storm drainpipe and conveyed approximately 1/2 of the way through the project.

The drainage ways within the subarea are unnamed.

Subarea Node 4-5

The area consists of 12.3 acres. Approximately 1.7 acres of this subarea is within Tract No. 2015 (see discussion in offsite Subarea 2-3 about the character of this area) but drains onto the subject parcel. The remaining 10.6 acres is undeveloped. With few developed houses located in this subarea an undeveloped average ground cover classification was used.

The Soil group designation for this area is "D". The elevation at the top of the subarea (Node No. 4) is 5,600 feet above sea level and the elevation at the bottom of the subarea (Node No. 5) is 5,560 feet above sea level. The length of the flow path within the subarea is 750 feet.

The calculated 100-year "Q" at Node No. 5 is 324.84 C.F.S.

The drainage way within the subarea is the head water of Little Bear Creek.

Subarea Node 5-6

The area consists of 14.8 acres. This area is undeveloped and consists of average ground cover. The Soil group designation for this area is "D".

The elevation at the top of the subarea (Node No. 5) is 5,560 feet above sea level and the elevation at the bottom of the subarea (Node No. 6) is 5,440 feet above sea level. The length of the flow path within the subarea is 980 feet.

The calculated 100-year "Q" at Node No. 6 is 367.23 C.F.S.

The drainage way within the subarea is the head water of Little Bear Creek.

Node No. 6 is a confluence point with other onsite and offsite areas.

Subarea Node 7-8

The area consists of 6.1 acres. This area is undeveloped and consists of average ground cover. The Soil group designation for this area is "D".

The elevation at the top of the subarea (Node No. 7) is 5,662 feet above sea level and the elevation at the bottom of the subarea (Node No. 8) is 5,560 feet above sea level. The length of the flow path within the subarea is 700 feet.

The calculated 100-year "Q" at Node No. 8 is 31.13 C.F.S.

The drainage ways within the subarea are unnamed.

Subarea Node 8-6

The area consists of 4.2 acres. This area is undeveloped and consists of average ground cover. The Soil group designation for this area is "D".

The elevation at the top of the subarea (Node No. 8) is 5,560 feet above sea level and the elevation at the bottom of the subarea (Node No. 6) is 5,440 feet above sea level. The length of the flow path within the subarea is 750 feet.

The calculated 100-year "Q" at Node No. 6 is 49.87 C.F.S.

The drainage ways within the subarea are unnamed.

Node No. 6 is a confluence point with other onsite and offsite areas.

Subarea Node 9-10

The area consists of 10.0 acres. Approximately 8.8 acres of this subarea is undeveloped. Approximately 1.2 acres of this subarea is within Tract No. 2015 (see discussions above about the character of this area). This subarea is shown as an initial area in the Rational Method Calculations.

Weighing the areas within this subarea, we used a development classification of Residential 2.5 dwelling units per acre for the purpose of the Rational Method Calculations.

The Soil group designation for this area is "D". The elevation at the top of the subarea (Node No. 9) is 5,974 feet above sea level and the elevation at the bottom of the subarea (Node No. 10) is 5,720 feet above sea level. The length of the flow path within the subarea is 800 feet.

The calculated 100-year "Q" at Node No. 10 is 70.58 C.F.S.

The drainage ways within the subarea are unnamed.

Subarea Node 10-11

The area consists of 20.8 acres. Approximately 7.6 acres of this subarea is undeveloped. Approximately 13.2 acres of this subarea is within Tract No. 2015 (see discussions above about the character of this area).

Weighing the areas within this subarea, we used a development classification of Residential 2.5 dwelling units per acre for the purpose of the Rational Method Calculations.

The Soil group designation for this area is "D". The elevation at the top of the subarea (Node No. 10) is 5,720 feet above sea level and the elevation at the bottom of the subarea (Node No. 11) is 5,588 feet above sea level. The length of the flow path within the subarea is 1,300 feet.

The calculated 100-year "Q" at Node No. 11 is 187.45 C.F.S.

The drainage ways within the subarea are unnamed.

Subarea Node 11-6

The area consists of 3.3 acres. The area is undeveloped and consists of average ground cover. The Soil group designation for this area is "D". The elevation at the top of the subarea (Node No. 11) is 5,588 feet above sea level and the elevation at the bottom of the subarea (Node No. 6) is 5,440 feet above sea level. The length of the flow path within the subarea is 700 feet.

The calculated 100-year "Q" at Node No. 6 is 198.06 C.F.S.

The subarea Node 11-6 is the final confluence area for Node 6. The total undeveloped Q100 at Node No. 6 is 550.15 C.F.S.

The drainage ways within the subarea are unnamed.

Node No. 11 is located at the point where the natural drainage course intersects the north boundary of the proposed project.

The natural drainage channels within the undeveloped offsite drainage areas are not highly eroded.

The natural drainage channels within the developed or semi developed offsite drainage areas consist of roadside swales and pipes that are maintained by the San Bernardino County Transportation Department. These swales are not highly eroded.

Offsite / Onsite Developed

Subarea Node 15-16

The subarea consists of 3.9 acres. This area is shown as an initial area in the Rational Method Calculations. The area is undeveloped and consists of average ground cover. The Soil group designation for this area is "D". The elevation at the top of the subarea (Node No. 15) is 6,020 feet above sea level and the elevation at the bottom of the subarea (Node No. 16) is 5,850 feet above sea level. The length of the flow path within the subarea is 700 feet.

The calculated 100-year "Q" at Node No. 16 is 21.40 C.F.S.

The drainage ways within the subarea are unnamed.

Subarea Node 16-17

The subarea consists of 8.9 acres. The area is undeveloped and consists of average ground cover. The Soil group designation for this area is "D". The elevation at the top of the subarea (Node No. 16) is 5,850 feet above sea level and the elevation at the bottom of the subarea (Node No. 17) is 5,635 feet above sea level. The length of the flow path within the subarea is 1,200 feet.

The calculated 100-year "Q" at Node No. 17 is 60.55 C.F.S. at Highway 18.

The drainage ways within the subarea are unnamed.

Subarea Node 17-4

Node 17-4 is not a subarea, but, instead, it is a flow path that conveys water along the highway. As such, this section does not have an area associated with it, and is modeled as channel flow for the water that falls on the south facing slopes. It is a flow path of 1,650 feet east down Highway 18 to a confluence with Node No. 4. The elevation at the top of the subarea (Node No. 17) is 5,635 feet above sea level and the elevation at the bottom of the subarea (Node No. 4) is 5,600 feet above sea level.

Subarea Node 1-2

The area consists of 8.5 acres. This area is shown as an initial area in the Rational Method Calculations; the area is undeveloped and consists of average ground cover. The Soil group designation for this area is "D". The elevation at the top of the subarea (Node No. 1) is 6,040 feet above sea level and the elevation at the bottom of the subarea (Node No. 2) is 5,920 feet above sea level. The length of the flow path within the subarea is 900 feet.

The calculated 100-year "Q" at Node No. 2 is 39.89 C.F.S.

The drainage ways within the subarea are unnamed.

Subarea Node 2-3

The area consists of 19.0 acres. Approximately 10 acres of this subarea is within Tract No. 2015, the Arrowhead View Tract, a review of the San Bernardino County Assessor's records indicate that Tract No. 2015, which was recorded in 1929, consists of lots varying in size from 2,600 SF to 8,000 SF in area. The homes that have been constructed within this Tract have been constructed on the larger lots or combinations of the smaller lots. The homes themselves range in size from a small of 400 +/- SF to a large of 2,500 +/- SF with most falling within the 900 SF to 1,100 SF range. Consequently, we used a development classification of 2 dwelling units per acre for the purpose of the Rational Method Calculations due to the spread out nature of the houses as well as many of the lots being undeveloped. For the remaining 9 acres a soil classification of undeveloped with average cover was used. A weighted average was found in order to characterize the subarea as a whole.

The Soil group designation for this area is "D". The elevation at the top of the subarea (Node No. 2) is 5,920 feet above sea level and the elevation at the bottom of the subarea (Node No. 3) is 5,790 feet above sea level. The length of the flow path within the subarea is 900 feet.

The calculated 100-year "Q" at Node No. 3 is 121.05 C.F.S.

The drainage ways within the subarea are unnamed.

Subarea Node 3-4

The area consists of 32.0 acres. Approximately 15.3 acres of this subarea is within Tract No. 2015 (see discussions above about the character of this area). Approximately 6.4 acres consist of relatively low-density commercial development. Weighing the commercial portion of this subarea, we used a development classification of 3-4 dwelling units per acre for the purpose of the Rational Method Calculations.

The Soil group designation for this area is "D". The elevation at the top of the subarea (Node No. 3) is 5,790 feet above sea level and the elevation at the bottom of the subarea (Node No. 4) is 5,600 feet above sea level. The length of the flow path within the subarea is 1,500 feet.

The calculated 100-year "Q" at Node No. 4 is 242.15 C.F.S.

Node No. 4 is located on the west property line of the proposed project. At this point the flows will be confluenced with previously mentioned Node No. 17. The 100-year

confluence "Q" will be 301.15 C.F.S. The flows will then be picked up in a reinforced concrete storm drainpipe and conveyed approximately 1/2 of the way through the project.

The drainage ways within the subarea are unnamed.

Subarea Node 4-12

The area consists of 14.1 acres approximately 1.7 acres of this subarea is within Tract No. 2015 (see discussion in offsite subarea 2-3 about the character of this area) but drains onto the subject parcel. The remaining 12.4 acres is our developed portion of the subject parcel. This value is larger than the sum of the areas developed drainage map due to the inclusion of the area within the right-of-way that drains towards the state highway. A user commercial SCS number was used with a 50% pervious factor for this subarea. The proposed impervious area for this development can be found in Appendix "D".

The Soil group designation for this area is "D". The elevation at the top of the subarea (Node No. 4) is 5,600 feet above sea level and the elevation at the bottom of the subarea (Node No. 12) is 5,560 feet above sea level. The length of the flow path within the subarea is 750 feet.

The calculated 100-year "Q" at Node No. 12 is 341.76 C.F.S.

A storm drain will be installed across this subarea.

Subarea Node 12-6

The area consists of 15.3 acres. The area is undeveloped and consists of average ground cover. The Soil group designation for this area is "D".

The elevation at the top of the subarea (Node No. 12) is 5,560 feet above sea level and the elevation at the bottom of the subarea (Node No. 6) is 5,440 feet above sea level. The length of the flow path within the subarea is 980 feet.

The calculated 100-year "Q" at Node No. 6 is 386.57 C.F.S.

Node No. 6 is a confluence point with other onsite and offsite areas.

The drainage way within the subarea is Little Bear Creek.

Subarea Node 13-14

The area consists of 2.9 acres. The area is undeveloped and consists of average ground cover. The Soil group designation for this area is "D".

The elevation at the top of the subarea (Node No. 13) is 5,602 feet above sea level and the elevation at the bottom of the subarea (Node No. 14) is 5,560 feet above sea level. The length of the flow path within the subarea is 700 feet.

The calculated 100-year "Q" at Node No. 14 is 13.05 C.F.S.

The drainage ways within the subarea are unnamed.

Subarea Node 14-6

The subarea consists of 4.4 acres. The area is undeveloped and consists of average ground cover. The Soil group designation for this area is "D".

The elevation at the top of the subarea (Node No. 14) is 5,560 feet above sea level and the elevation at the bottom of the subarea (Node No. 6) is 5,440 feet above sea level. The length of the flow path within the subarea is 750 feet.

The calculated 100-year "Q" at Node No. 6 is 31.20 C.F.S.

Node No. 6 is a confluence point with other onsite and offsite areas.

The drainage ways within the subarea are unnamed.

Subarea Node 9-10

The area consists of 10.0 acres. Approximately 8.8 acres of this subarea is undeveloped. Approximately 1.2 acres of this subarea is within Tract No. 2015 (see discussions above about the character of this area). This subarea is shown as an initial area in the Rational Method Calculations.

Weighing the areas within this subarea, we used a development classification of 2.5 dwelling units per acre for the purpose of the Rational Method Calculations.

The Soil group designation for this area is "D". The elevation at the top of the subarea (Node No. 9) is 5,974 feet above sea level and the elevation at the bottom of the subarea (Node No. 10) is 5,720 feet above sea level. The length of the flow path within the subarea is 800 feet.

The calculated 100-year "Q" at Node No. 10 is 70.58 C.F.S.

The drainage ways within the subarea are unnamed.

Subarea Node 10-11

The area consists of 20.8 acres. Approximately 7.6 acres of this subarea is undeveloped. Approximately 13.2 acres of this subarea is within Tract No. 2015 (see discussions above about the character of this area).

Weighing the areas within this subarea, we used a development classification of 2.5 dwelling units per acre for the purpose of the Rational Method Calculations.

The Soil group designation for this area is "D". The elevation at the top of the subarea (Node No. 10) is 5,720 feet above sea level and the elevation at the bottom of the subarea (Node No. 11) is 5,588 feet above sea level. The length of the flow path within the subarea is 1,300 feet.

The calculated 100-year "Q" at Node No. 11 is 187.45 C.F.S.

The drainage ways within the subarea are unnamed.

Subarea Node 11-6

The area consists of 3.3 acres. The area is undeveloped and consists of average ground cover. The Soil group designation for this area is "D". The elevation at the top of the subarea (Node No. 11) is 5,588 feet above sea level and the elevation at the bottom of the subarea (Node No. 6) is 5,440 feet above sea level. The length of the flow path within the subarea is 700 feet.

The calculated 100-year "Q" at Node No. 6 is 198.06 C.F.S.

The subarea Node 11-6 is the final confluence area for Node 6. The total developed Q100 at Node No. 6 is 551.39 C.F.S.

The drainage ways within the subarea are unnamed.

Node No. 11 is located at the point where the natural drainage course intersects the north boundary of the proposed project.

The natural drainage channels within the undeveloped offsite drainage areas are not highly eroded.

The natural drainage channels within the developed or semi developed offsite drainage areas consist of roadside swales and pipes that are maintained by the San Bernardino County Transportation Department. These swales are not highly eroded.

Onsite

The onsite water shed area of the project was analyzed separately so that the project impact is shown as it relates to the discharge into the overall watershed.

A discussion of each onsite watershed area is as follows:

Project Onsite Undeveloped

Subarea Node 1-2

The subarea consists of 7.94 acres. This area is shown as an initial area in the Rational Method Calculations. The area is undeveloped and consists of average ground cover. The Soil group designation for this area is "D". The elevation at the top (Node No. 1) of the area is 5,663 feet above mean sea level and the elevation at the bottom of the subarea (Node No. 2) is 5,590 feet above mean sea level. The length of the flow path within the subarea is 365 feet.

The calculated 100-year "Q" at Node No. 2 is 50.97 C.F.S.

The drainage ways within the subarea are unnamed.

Subarea Node 3-2

The subarea consists of 3.5 acres. This area is shown as an initial area in the Rational Method Calculations. The area is undeveloped and consists of average ground cover. The Soil group designation for this area is "D". The elevation at the top (Node No. 3) of the area is 5,636 feet above mean sea level and the elevation at the bottom of the subarea (Node No. 2) is 5,590 feet above mean sea level. The length of the flow path within the subarea is 490 feet.

The calculated 100-year "Q" at Node No. 2 is 18.62 C.F.S.

The drainage ways within the subarea are unnamed.

The Subarea Node 3-2 is the final confluence area for Node No. 2. The total undeveloped Q_{100} at Node No. 2 is 68.18 C.F.S.

Project Onsite Developed

Subarea Node 1-2

The subarea consists of 6.38 acres. This area is shown as an initial area in the Rational Method Calculations. The area is developed and consists of buildings, parking and landscaping. The effective runoff coefficient used for this area is 0.898. The Soil group designation for this area is "D". The elevation at the top (Node No. 1) of the area is 5,634.9 feet above mean sea level and the elevation at the bottom of the subarea (Node No. 2) is 5,618.0 feet above mean sea level. The length of the flow path within the subarea is 880 feet.

The calculated 100-year "Q" at Node No. 1 is 41.9 C.F.S.

The drainage ways within the subarea are generally within the parking lots.

Subarea Node 2-3

The subarea consists of 1.56 acres. The area is developed and consists of parking lots and the water quality basin. The effective runoff coefficient used for this area is 0.884. The Soil group designation for this area is "D". The elevation at the top (Node No. 2) of the area is 5,618.0 feet above mean sea level and the elevation at the bottom of the subarea (Node No. 3) is 5,606.0 feet above mean sea level. The length of the flow path within the subarea is 530 feet.

The total calculated 100-year "Q" at Node No. 3 is 46.8 C.F.S.

The drainage ways within the subarea are generally within the parking lots.

Subarea Node 4-3

The subarea consists of 3.51 acres. This area is shown as an initial area in the Rational Method Calculations. The area is developed and consists of buildings, parking and landscaping. The effective runoff coefficient used for this area is 0.884. The Soil group designation for this area is "D". The elevation at the top (Node No. 4) of the area is 5636.0 feet above mean sea level and the elevation at the bottom of the subarea (Node No. 3) is 5,606.0 feet above mean sea level. The length of the flow path within the subarea is 515 feet.

The calculated 100-year "Q" at Node No. 3 is 23.07 C.F.S.

The drainage ways within the subarea are generally within the parking lots.

The Subarea Node 4-3 is the final confluence area for Node No. 3. The total developed Q_{100} at Node No. 3 is 67.46 C.F.S.

Summary

	Total Offsite & Project Area Q_{100}	Project Area Q_{100}
Undeveloped	550.15 C.F.S.	68.18 C.F.S.
Developed	551.39 C.F.S.	67.46 C.F.S.

When comparing the resulting flow values for the total project area and onsite studies, it is important to note the differences in the studies. When looking at the onsite flows, it can be seen that the developed flow actually decreases due to the flattening of the project area. Decreasing the slopes at the top of the drainage area caused the time of concentration to decrease enough to outweigh the effects of having increased impervious area.

When looking at the drainage study the focuses on the total drainage area however, it can be seen that for the subarea dealing with the project area (subarea 4-5 for undeveloped and 4-12 for developed) that the flow for these regions is larger in the developed than undeveloped. This difference between studies is caused by the change to the drainage areas by the altering of the topography.

The study that looks at the total drainage area takes into account the changes to the drainage areas caused by the project site. This is why subarea 4-5 of the undeveloped study is 1.8 acres smaller than subarea 4-12 of the developed study. Conversely, in the onsite drainage study, both the developed and undeveloped scenarios have the same total acreage. The total increased area caused by the flattening of the slopes at the top of the project site was used for both the developed and undeveloped condition to show how the total affected area of the site will behave before and after development. The decreased flow value from the onsite study shows that the project development is not increasing the amount of runoff by any significant amount.

Water Quality Management Plan

Appendix "I" of this report contains the previously approved Water Quality Management Report dated May 2, 2011.

Proposed Permanent Drainage Improvements

Major offsite flows enter the site at two locations. One location is on the north side of the highway at the southwest corner of the site. The other location is on the north boundary approximately 350' east of the northwest corner.

The flows entering the site at the southwest corner will be intercepted by a storm drain pipe. This pipe will continue through the fill area in the southwest portion of the site.

The pipe will consist of a 60" reinforced concrete pipe and will be approximately 750 feet in length. See Capacity calculations included in Appendix "H" of this report.

The 60" storm drain proposed by this project is adequate to convey the flows generated by a 100-year storm event over the drainage area found on the developed drainage map within this report. San Bernardino County Flood Control is also planning a project to be built on 10 acres at the northwest corner of this site. For their project, Flood Control is proposing a 72" storm drain to be built in place of this projects 60" pipe. Flood Control's project proposes to divert more water through this storm drain than currently drains to the area, resulting in an increased drainage area, and, thus, a larger pipe. The drainage study found within this report supports a standalone design that does not rely on the improvements provided by San Bernardino County Flood Control's project. The 60" and 72" pipes are the same storm drain, and though this study is not dependent on Flood Control, coordination between the two projects has taken place. In all likelihood, the storm drain will be constructed as a 72" storm drain.

The flows entering the site on the north boundary line will be left in their natural condition and discharged into the natural drainage course within the site.

The storm drain improvements also include energy dissipaters at the outlet of the 60" RCP and the concrete lined channel. The dimensions of these energy dissipaters are shown on the Site Plan included in Appendix "D" of this report.

The water quality management BMP's proposed for the project consists of depressed landscape areas and storm drain filters.

Initial "First Flush" flows from most of the parking and driveway areas will be directed to "grassy swales" within the landscape areas. These grassy swales are shown on Appendix "D" of this report.

Additionally, Fossil Filters will be installed in the storm drain inlet to the 60" reinforced concrete pipe.

All of the proposed developed area, along with a portion of offsite area east of Bear Springs Road, drains to the storm drain.

The athletic fields, in addition to the landscape areas will act as infiltration beds to mitigate the increased runoff due to the impervious area. As such, no drainage outlets will be needed for these areas. Overall, this project will consist of 50% pervious and 50% impervious area.

With proper maintenance of the landscape irrigation on site, there should be essentially no nuisance water exiting the site.

The increased storm water issue has been addressed by calculating the 100-year "Q" prior to the development and after the proposed development for the same area.

The drainage area within the developed portion of the site consists of steep mountainous slopes, prior to the grading of the project. The grading of the site will create flatter areas where the steep slopes previously existed. This will change the nature of the storm water runoff by increasing the Time of Concentration, which decreases the average intensity for any given storm event.

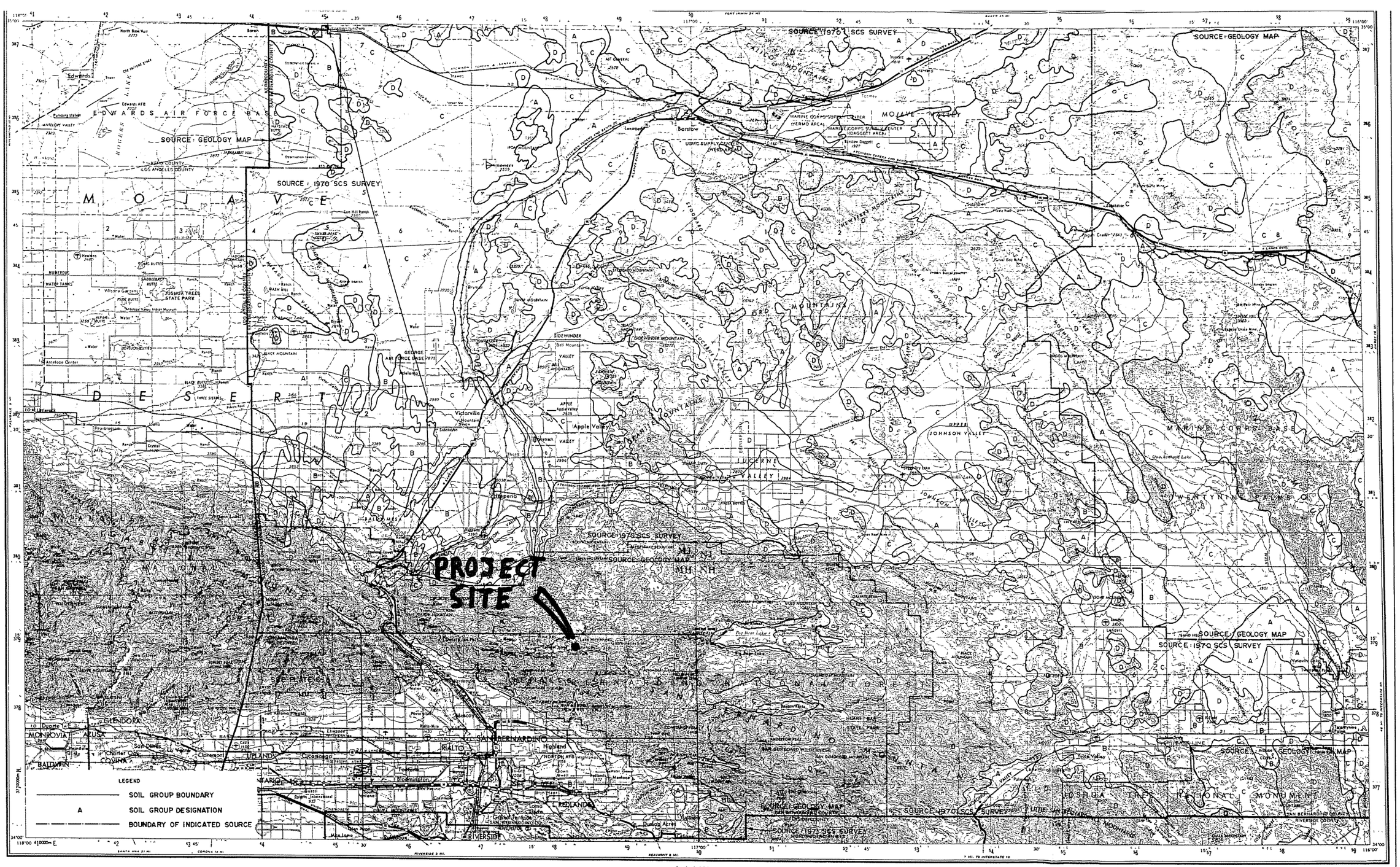
The results of the Rational Method Calculations for the 100-year storm runoff from the site before development and after development are as follows:

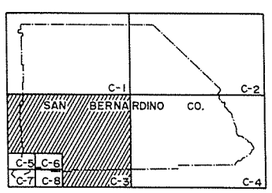
Node No.	Q Undeveloped	Q Developed
6	550.15 cfs	551.39

In summary, according to the Rational Method Calculations, the proposed project does not significantly increase the storm water runoff from the site.

APPENDIX "A"

HYDROLOGIC SOILS MAP





INDEX MAP

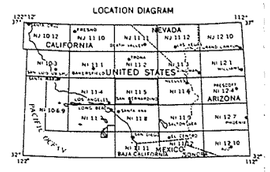
Scale 1:250,000

CONTOUR INTERVAL 200 FEET
WITH SUPPLEMENTARY CONTOURS AT 100 FOOT INTERVALS
TRANSVERSE MERCATOR PROJECTION
BLACK NUMBERED LINES INDICATE THE 10,000 METER UNIVERSAL TRANSVERSE MERCATOR GRID, ZONE 11
1965 MAGNETIC DECLINATION FROM TRUE NORTH VARIES FROM 15½° (260 MILS) EASTERLY FOR THE CENTER OF THE WEST EDGE TO 15° (270 MILS) EASTERLY FOR THE CENTER OF THE EAST EDGE

BASE MAP REPRODUCED FROM U.S.G.S. "SAN BERNARDINO" TOPOGRAPHIC MAP

SCALE REDUCED BY 1/2

LOCATION DIAGRAM



SAN BERNARDINO COUNTY
HYDROLOGY MANUAL

HYDROLOGIC SOILS GROUP MAP FOR SOUTHCENTRAL AREA

FIGURE C-II

APPENDIX "B"

ISOHYETALS

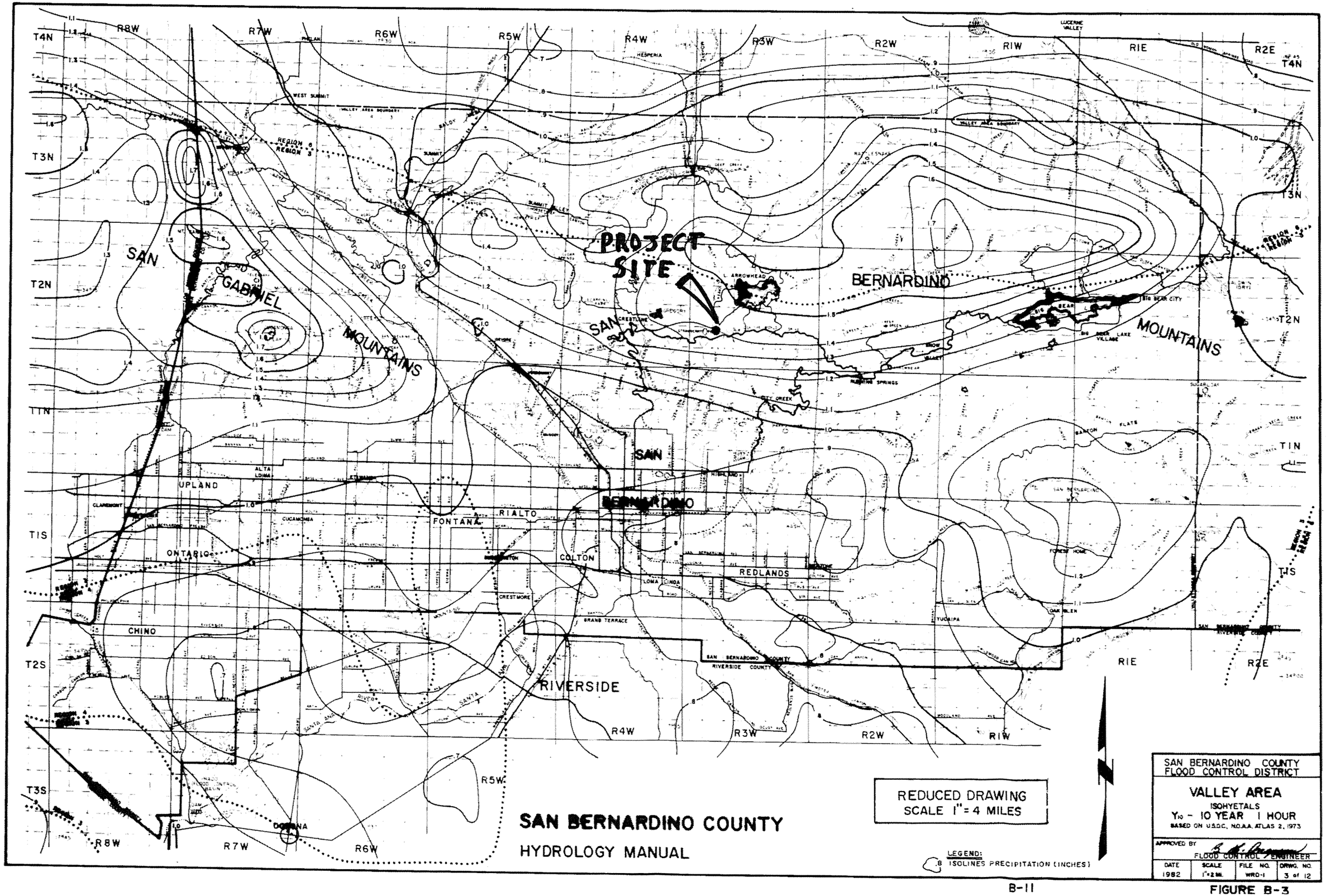
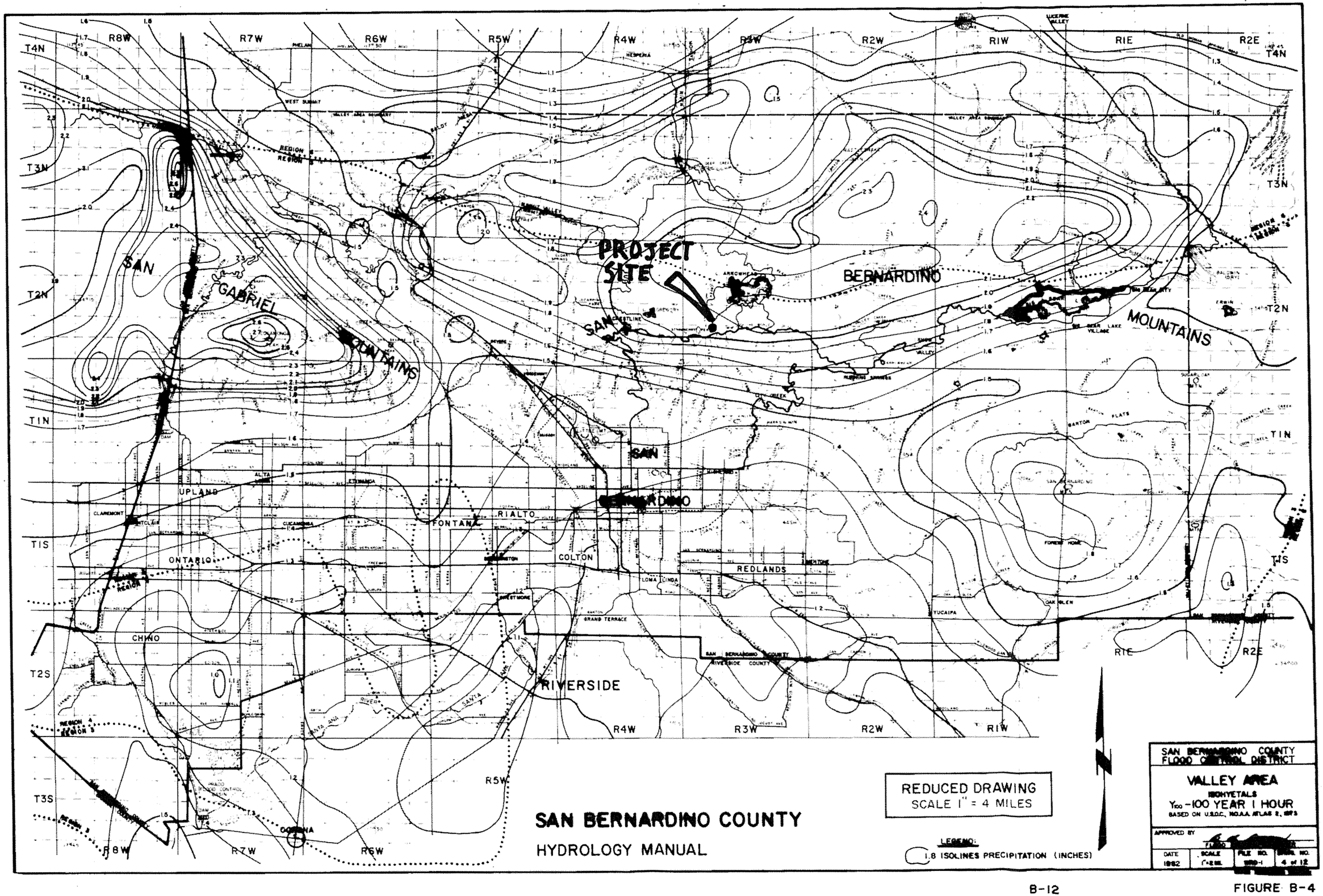

PROJECT SITE
SAN GABRIEL MOUNTAINS
SAN BERNARDINO MOUNTAINS
SAN BERNARDINO
RIVERSIDE
UPLAND
ONTARIO
CHINO
FONTANA
RIALTO
COLTON
REDLANDS
LOMA LINDA
GRAND TERRACE
CRESTMORE
YUCAIPA
CRESTLINE
L. ARROWHEAD
BIG BEAR CITY
BIG BEAR LAKE VILLAGE
RUNNING SPRINGS
SNOW VALLEY
HESPERIA
WEST SUMMIT
SUMMIT
SUMMIT VALLEY
ALTA LOMA
CUCAMONGA
CLAREMONT
DEVORE
SAN BERNARDINO COUNTY
RIVERSIDE COUNTY
REGION 6
REGION 3
T4N
T3N
T2N
T1N
T1S
T2S
T3S
R8W
R7W
R6W
R5W
R4W
R3W
R2W
R1W
R1E
R2E
SAN BERNARDINO COUNTY
HYDROLOGY MANUAL
REDUCED DRAWING
SCALE 1" = 4 MILES
LEGEND:
.8 ISOLINES PRECIPITATION (INCHES)
SAN BERNARDINO COUNTY
FLOOD CONTROL DISTRICT
VALLEY AREA
ISOHYETALS
Y10 - 10 YEAR 1 HOUR
BASED ON U.S.D.C., N.O.A.A. ATLAS 2, 1973
APPROVED BY
FLOOD CONTROL ENGINEER
DATE 1982
SCALE 1"=2 MI.
FILE NO. WRD-1
DRWG. NO. 3 of 12

FIGURE B-3



SAN BERNARDINO COUNTY

HYDROLOGY MANUAL

REDUCED DRAWING
SCALE 1" = 4 MILES

LEGEND:
1.8 ISOLINES PRECIPITATION (INCHES)

SAN BERNARDINO COUNTY
FLOOD CONTROL DISTRICT

VALLEY AREA
ISOHYETALS
Y_{100} - 100 YEAR 1 HOUR
BASED ON U.S.D.C., NOAA ATLAS 2, 1973

APPROVED BY

DATE	SCALE	FILE NO.	DRWG. NO.
1982	1"=2 MI.	SBD-1	4 of 12

FIGURE B-4

APPENDIX "C"

NOAA POINT PRECIPITATION

NOAA Atlas 14, Volume 6, Version 2
Location name: Twin Peaks, California, USA*
Latitude: 34.2304°, Longitude: -117.2185°
Elevation: 5648.87 ft**
* source: ESRI Maps
** source: USGS

POINT PRECIPITATION FREQUENCY ESTIMATES

Sanja Perica, Sarah Dietz, Sarah Heim, Lillian Hiner, Kazungu Maitaria, Deborah Martin, Sandra Pavlovic, Ishani Roy, Carl Trypaluk, Dale Unruh, Fenglin Yan, Michael Yekta, Tan Zhao, Geoffrey Bonnin, Daniel Brewer, Li-Chuan Chen, Tye Parzybok, John Yarchoan

NOAA, National Weather Service, Silver Spring, Maryland

PF_tabular | PF_graphical | Maps_&_aerials

PF tabular

PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches)[1]

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	0.221 (0.184-0.269)	0.289 (0.239-0.352)	0.382 (0.316-0.467)	0.462 (0.378-0.569)	0.576 (0.456-0.734)	0.668 (0.518-0.870)	0.767 (0.580-1.02)	0.874 (0.643-1.20)	1.03 (0.725-1.47)	1.15 (0.786-1.71)
10-min	0.317 (0.263-0.386)	0.414 (0.343-0.505)	0.548 (0.452-0.669)	0.662 (0.542-0.816)	0.825 (0.654-1.05)	0.958 (0.743-1.25)	1.10 (0.832-1.47)	1.25 (0.921-1.72)	1.47 (1.04-2.11)	1.65 (1.13-2.45)
15-min	0.383 (0.318-0.467)	0.501 (0.415-0.610)	0.662 (0.547-0.809)	0.800 (0.656-0.986)	0.998 (0.791-1.27)	1.16 (0.899-1.51)	1.33 (1.01-1.78)	1.52 (1.11-2.08)	1.78 (1.26-2.55)	2.00 (1.36-2.97)
30-min	0.555 (0.460-0.675)	0.724 (0.600-0.883)	0.958 (0.792-1.17)	1.16 (0.949-1.43)	1.44 (1.14-1.84)	1.68 (1.30-2.18)	1.92 (1.46-2.57)	2.19 (1.61-3.01)	2.58 (1.82-3.69)	2.89 (1.97-4.29)
60-min	0.782 (0.649-0.952)	1.02 (0.847-1.25)	1.35 (1.12-1.65)	1.63 (1.34-2.01)	2.04 (1.61-2.60)	2.36 (1.83-3.08)	2.71 (2.05-3.62)	3.09 (2.27-4.24)	3.63 (2.56-5.20)	4.08 (2.78-6.05)
2-hr	1.16 (0.960-1.41)	1.48 (1.23-1.81)	1.93 (1.60-2.36)	2.32 (1.90-2.86)	2.87 (2.27-3.66)	3.32 (2.58-4.33)	3.80 (2.88-5.08)	4.33 (3.18-5.94)	5.08 (3.58-7.28)	5.71 (3.89-8.46)
3-hr	1.47 (1.22-1.79)	1.87 (1.55-2.28)	2.42 (2.00-2.96)	2.90 (2.37-3.57)	3.58 (2.83-4.56)	4.13 (3.20-5.38)	4.72 (3.57-6.30)	5.36 (3.95-7.37)	6.29 (4.44-9.01)	7.06 (4.81-10.5)
6-hr	2.18 (1.81-2.65)	2.76 (2.29-3.36)	3.56 (2.94-4.35)	4.25 (3.48-5.24)	5.23 (4.14-6.67)	6.03 (4.68-7.86)	6.89 (5.21-9.19)	7.81 (5.75-10.7)	9.14 (6.45-13.1)	10.2 (6.98-15.2)
12-hr	3.09 (2.56-3.76)	4.02 (3.33-4.90)	5.29 (4.38-6.47)	6.38 (5.23-7.86)	7.91 (6.27-10.1)	9.14 (7.09-11.9)	10.4 (7.90-13.9)	11.8 (8.71-16.3)	13.8 (9.76-19.8)	15.5 (10.5-22.9)
24-hr	4.54 (4.02-5.22)	6.14 (5.43-7.08)	8.32 (7.34-9.62)	10.2 (8.90-11.8)	12.8 (10.8-15.4)	14.9 (12.3-18.3)	17.1 (13.8-21.5)	19.4 (15.3-25.2)	22.8 (17.2-30.7)	25.5 (18.6-35.6)
2-day	5.88 (5.21-6.77)	8.05 (7.12-9.28)	11.1 (9.76-12.8)	13.7 (12.0-15.9)	17.4 (14.8-21.0)	20.5 (17.0-25.2)	23.8 (19.3-30.0)	27.4 (21.6-35.5)	32.7 (24.7-44.1)	37.1 (27.1-51.7)
3-day	6.57 (5.82-7.56)	9.03 (7.99-10.4)	12.5 (11.0-14.5)	15.5 (13.6-18.1)	20.0 (16.9-24.1)	23.7 (19.7-29.1)	27.7 (22.5-34.9)	32.2 (25.3-41.6)	38.7 (29.3-52.2)	44.2 (32.3-61.7)
4-day	7.15 (6.34-8.24)	9.88 (8.74-11.4)	13.7 (12.1-15.9)	17.1 (15.0-19.9)	22.1 (18.7-26.6)	26.2 (21.8-32.3)	30.8 (24.9-38.8)	35.8 (28.2-46.4)	43.3 (32.7-58.4)	49.6 (36.3-69.2)
7-day	8.27 (7.33-9.53)	11.4 (10.1-13.2)	15.9 (14.0-18.4)	19.8 (17.4-23.1)	25.6 (21.7-30.9)	30.5 (25.3-37.5)	35.8 (29.0-45.1)	41.7 (32.9-54.0)	50.4 (38.2-68.0)	57.8 (42.3-80.7)
10-day	8.99 (7.96-10.4)	12.4 (11.0-14.3)	17.3 (15.3-20.0)	21.6 (18.9-25.2)	27.9 (23.7-33.6)	33.2 (27.6-40.8)	39.0 (31.6-49.1)	45.4 (35.8-58.8)	54.8 (41.5-74.0)	62.8 (45.9-87.7)
20-day	10.8 (9.53-12.4)	15.0 (13.3-17.3)	21.0 (18.6-24.3)	26.3 (23.0-30.6)	33.9 (28.8-40.9)	40.3 (33.4-49.5)	47.2 (38.2-59.4)	54.8 (43.2-70.9)	66.0 (49.9-89.0)	75.4 (55.1-105)
30-day	12.6 (11.2-14.5)	17.7 (15.6-20.4)	24.7 (21.8-28.5)	30.8 (26.9-35.9)	39.6 (33.6-47.7)	46.9 (38.9-57.7)	54.8 (44.4-69.0)	63.4 (50.0-82.1)	76.0 (57.5-103)	86.6 (63.4-121)
45-day	15.0 (13.3-17.3)	20.9 (18.5-24.1)	29.0 (25.6-33.6)	36.0 (31.5-42.0)	46.0 (39.0-55.4)	54.2 (45.0-66.6)	63.0 (51.0-79.3)	72.6 (57.2-93.9)	86.5 (65.4-117)	98.1 (71.7-137)
60-day	17.8 (15.8-20.5)	24.4 (21.6-28.2)	33.5 (29.6-38.8)	41.3 (36.2-48.1)	52.4 (44.4-63.1)	61.4 (50.9-75.4)	70.9 (57.5-89.3)	81.3 (64.1-105)	96.3 (72.9-130)	109 (79.5-152)

[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

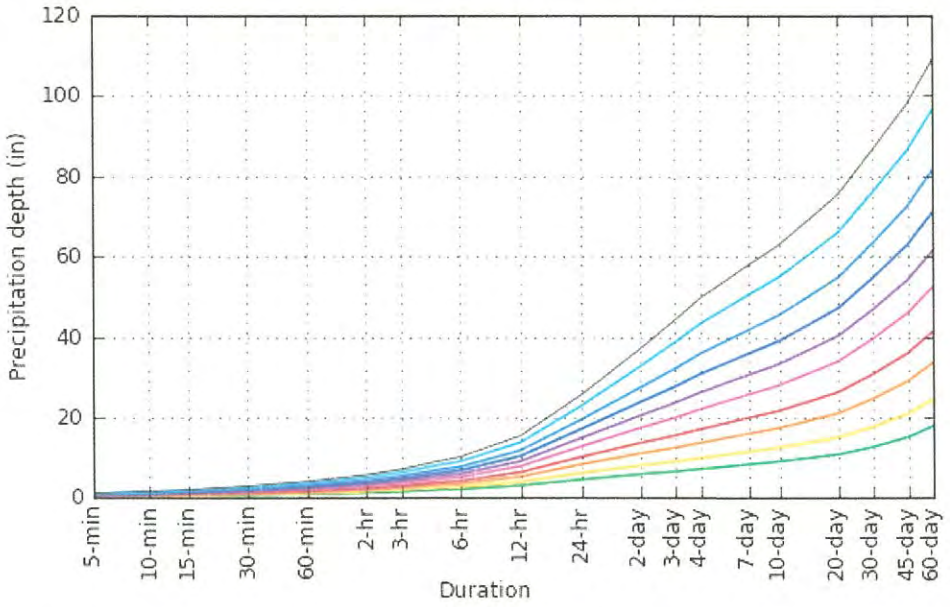
Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.

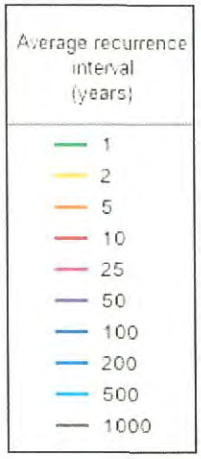
Please refer to NOAA Atlas 14 document for more information.

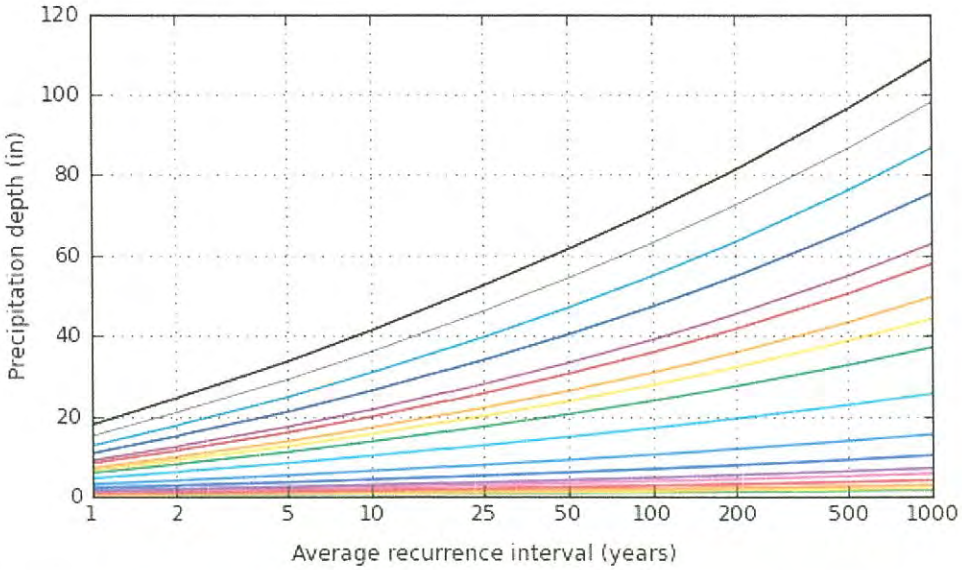
Back to Top

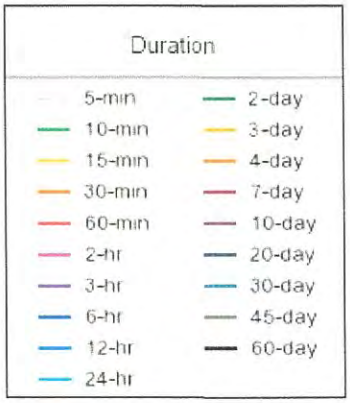
PF graphical

PDS-based depth-duration-frequency (DDF) curves
Latitude: 34.2304°, Longitude: -117.2185°









NOAA Atlas 14, Volume 6, Version 2

Created (GMT): Fri Apr 20 15:10:22 2018

Back to Top

Maps & aerials

Small scale terrain

Large scale terrain

Large scale map

Large scale aerial

Back to Top

US Department of Commerce
National Oceanic and Atmospheric Administration
National Weather Service
National Water Center
1325 East West Highway
Silver Spring, MD 20910
Questions?: HDSC.Questions@noaa.gov

Disclaimer

APPENDIX "D"

PROPOSED SITE PLAN &
PRELIMINARY GRADING PLAN

CHURCH OF THE WOODS

CONDITIONAL USE PERMIT
SITE PLAN &
PRELIMINARY GRADING

Scale: 1" = 50'

0 25 50 100 150

NOTES:

1. RECORD OWNER: CHURCH OF THE WOODS, A CALIFORNIA CORPORATION; P.O. BOX 2000; LAKE ARROWHEAD, CA; 92352; 909-337-5483.
2. PUBLIC UTILITIES ARE AS FOLLOWS:
   A) WATER: CRESTLINE LAKE ARROWHEAD WATER AGENCY; P.O. BOX 3880; CRESTLINE, CA. 92325; 909-338-1775
   B) SEWER: LAKE ARROWHEAD COMMUNITY SERVICES DIST; P. O. BOX 789; LAKE ARROWHEAD, CA 92352; 909-337-8555
   C) NATURAL GAS: SO. CAL. GAS CO.; P. O. BOX 6226; SAN BERNARDINO, CA; 909-889-9711
   D) ELECTRIC: SO. CAL. EDISON CO.; P. O. BOX 96; RIM FOREST, CA; 92378; 909-337-2564
   E) TELEPHONE: VERIZON; 1500 CRAFTON AVE.; MENTONE, CA; 92359; 909-793-7441
   F) CABLE TV: FALCON CABLE; P. O. BOX 9; RIM FOREST, CA; 92378; 909-336-2457
3. THE CURRENT AND PROPOSED GENERAL PLAN USE DISTRICT IS LA/IC.
4. ENTRY SIGNS WILL BE SUBMITTED FOR REVIEW AT A LATER DATE.
5. ALL PARKING AREAS WILL BE SURFACED WITH ASPHALT. THE MINIMUM PARKING SPACE WILL BE 9'x19' TYPICAL.
6. TREES TO BE REMOVED ARE DISCUSSED IN THE FORESTERS REPORT PREPARED BY JOHN HATCHER DATED 3-25-03.

PROJECT SUMMARY:

BUILDINGS

PHASE 1
YOUTH CENTER GYMATORIUM.

FIRST FLOOR	18,305 SF
SECOND FLOOR	8,579 SF
SNACK BAR	480 SF
TOTAL SF:	27,364 SF

PHASE 2
ASSEMBLY BUILDING - CHILDREN'S MINISTRY

FIRST FLOOR	27,254 SF
SECOND FLOOR	13,783 SF
TOTAL =	41,037 SF

MAINTENANCE BUILDING & CARETAKERS RESIDENCE

FIRST FLOOR	750 SF
SECOND FLOOR	750 SF
TOTAL SF=	1,500 SF
TOTAL PH 2=	42,537 SF

PROJECT SUMMARY

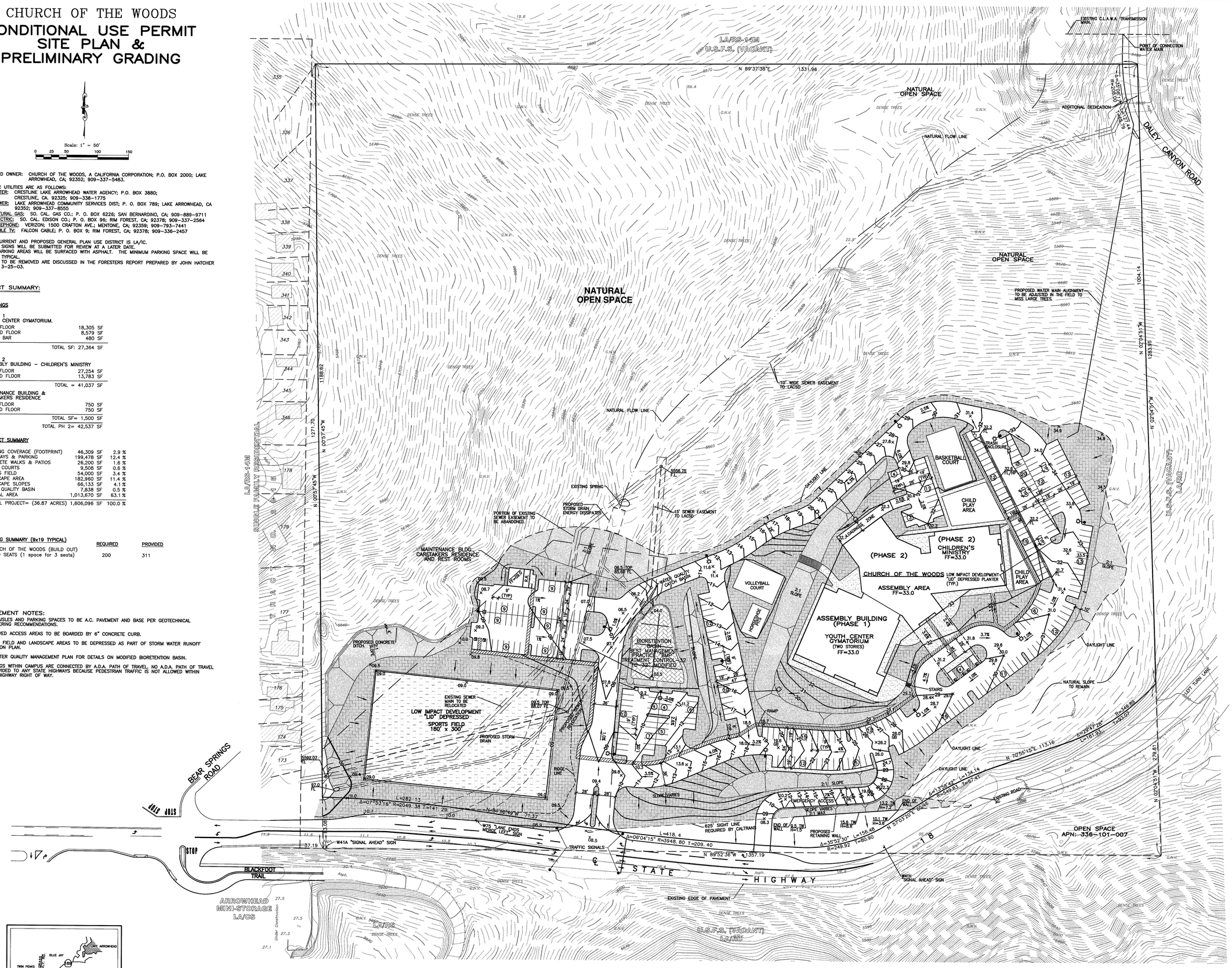
BUILDING COVERAGE (FOOTPRINT)	46,309 SF	2.9 %
DRIVEWAYS & PARKING	199,478 SF	12.4 %
CONCRETE WALKS & PATIOS	26,200 SF	1.6 %
SPORT COURTS	9,508 SF	0.6 %
SPORTS FIELD	54,000 SF	3.4 %
LANDSCAPE AREA	182,960 SF	11.4 %
LANDSCAPE SLOPES	66,133 SF	4.1 %
WATER QUALITY BASIN	7,838 SF	0.5 %
NATURAL AREA	1,013,670 SF	63.1 %
TOTAL PROJECT= (36.87 ACRES)	1,606,096 SF	100.0 %

PARKING SUMMARY (9x19 TYPICAL)

	REQUIRED	PROVIDED
CHURCH OF THE WOODS (BUILD OUT) 600 SEATS (1 space for 3 seats)	200	311

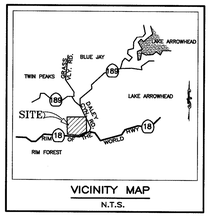
IMPROVEMENT NOTES:

1. DRIVE AISLES AND PARKING SPACES TO BE A.C. PAVEMENT AND BASE PER GEOTECHNICAL ENGINEERING RECOMMENDATIONS.
2. ALL PAVED ACCESS AREAS TO BE BOARDED BY 6" CONCRETE CURB.
3. SPORTS FIELD AND LANDSCAPE AREAS TO BE DEPRESSED AS PART OF STORM WATER RUNOFF MITIGATION PLAN.
4. SEE WATER QUALITY MANAGEMENT PLAN FOR DETAILS ON MODIFIED BIORETENTION BASIN.
5. BUILDINGS WITHIN CAMPUS ARE CONNECTED BY A.D.A. PATH OF TRAVEL. NO A.D.A. PATH OF TRAVEL IS PROVIDED TO ANY STATE HIGHWAYS BECAUSE PEDESTRIAN TRAFFIC IS NOT ALLOWED WITHIN STATE HIGHWAY RIGHT OF WAY.



LEGEND:

- INDICATES PLAY FIELD
- INDICATES ORNAMENTAL LANDSCAPE
- INDICATES SLOPE
- INDICATES CONCRETE WALKWAY
- INDICATES A.D.A. PATH OF TRAVEL
- INDICATES DIRECTION OF FLOW
- FF INDICATES FINISH FLOOR
- 29.8 INDICATES FINISH GRADE
- INDICATES EXISTING CONTOURS
- 00 INDICATES PROPOSED CONTOURS
- INDICATES LIGHT POLE



VICINITY MAP
N.T.S.

LEGAL DESCRIPTION:
THE SE 1/4; NW 1/4; SECTION 29 T2N; R3W; S.B.M. COUNTY OF SAN BERNARDINO STATE OF CALIFORNIA.

APN: 336-101-06
CUP FOR 42,537 SF CHURCH FACILITIES

APPLICANT/ OWNERS: CHURCH OF THE WOODS
P.O. BOX 2000, LAKE ARROWHEAD CA, 92352.
PHONE: 909-337-5483.

PREPARED BY:
W.J. McKEEVER, INC.
CIVIL ENGINEERING
900 E. WASHINGTON STREET, SUITE 208
COLTON, CALIFORNIA 92324
PH.: (909) 825-8048
FAX: (909) 825-8639

REVISIONS
4-23-13
3-14-17
3-28-17
4/14/17

W.J. McKEEVER, R.C.E. 22502 — DATE 4/14/17

REGISTERED PROFESSIONAL ENGINEER — WILLIAM J. McKEEVER — No. 22502 Exp. 12-31-17 — CIVIL — STATE OF CALIFORNIA

PLOT DATE: 4/14/17

APPENDIX "E"

DEVELOPED IMPERVIOUS AREA MAP

CHURCH OF THE WOODS

DRAINAGE MAP
DEVELOPED
IMPERVIOUS AREA MAP

VICINITY MAP
N.T.S.

0 40 80 160 240 320
SCALE: 1 INCH = 80 FEET

SEAL–ENGINEER

REGISTERED PROFESSIONAL ENGINEER
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PREPARED BY: WILLIAM J. McKEEVER
R.C.E. NO. 22502
DATE: 4/24/18

DRAINAGE MAP
DEVELOPED

CHURCH OF THE WOODS
APN: 336-101-06

LAKE ARROWHEAD

SHEET NO. 1
OF 1 SHEETS

PLOT DATE: 4/23/18

APPENDIX "F"

RATIONAL METHOD
TOTAL DRAINAGE AREA
CALCULATIONS

APPENDIX "F-1"

RATIONAL METHOD HYDRAULIC CALCULATIONS TOTAL DRAINAGE AREA (100-YEAR STORM EVENT) AND PROPOSED PROJECT AREA UNDEVELOPED (100-YEAR STORM EVENT) AND MAP

San Bernardino County Rational Hydrology Program

(Hydrology Manual Date - August 1986)

CIVILCADD/CIVILDESIGN Engineering Software, (c) 1989-2005 Version 7.1
Rational Hydrology Study Date: 04/20/18

Program License Serial Number 6222

Church of the Woods
Rim Forest
100 Year 1 Hour
Undeveloped

********* Hydrology Study Control Information **********

Rational hydrology study storm event year is 100.0
10 Year storm 1 hour rainfall = 1.400(In.)
100 Year storm 1 hour rainfall = 2.100(In.)
Computed rainfall intensity:
Storm year = 100.00 1 hour rainfall = 2.100 (In.)
Slope used for rainfall intensity curve b = 0.7000
Soil antecedent moisture condition (AMC) = 3

++
Process from Point/Station 15.000 to Point/Station 16.000
**** INITIAL AREA EVALUATION ****

UNDEVELOPED (average cover) subarea
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
SCS curve number for soil(AMC 2) = 84.00
Adjusted SCS curve number for AMC 3 = 96.40
Pervious ratio(Ap) = 1.0000 Max loss rate(Fm)= 0.071(In/Hr)
Initial subarea data:
Initial area flow distance = 700.000(Ft.)
Top (of initial area) elevation = 6020.000(Ft.)
Bottom (of initial area) elevation = 5850.000(Ft.)
Difference in elevation = 170.000(Ft.)
Slope = 0.24286 s(%)= 24.29
TC = k(0.706)*[(length^3)/(elevation change)]^0.2
Initial area time of concentration = 12.876 min.
Rainfall intensity = 6.167(In/Hr) for a 100.0 year storm
Effective runoff coefficient used for area (Q=KCIA) is C = 0.890
Subarea runoff = 21.397(CFS)
Total initial stream area = 3.900(Ac.)
Pervious area fraction = 1.000
Initial area Fm value = 0.071(In/Hr)

++
Process from Point/Station 16.000 to Point/Station 17.000

```
**** IRREGULAR CHANNEL FLOW TRAVEL TIME ****
------------------------------------------------------------------------
Estimated mean flow rate at midpoint of channel =      0.000(CFS)
Depth of flow =   0.554(Ft.), Average velocity =   6.678(Ft/s)
      ******* Irregular Channel Data ***********
------------------------------------------------------------------------
Information entered for subchannel number 1 :
Point number      'X' coordinate     'Y' coordinate
      1              0.00              1.00
      2             20.00              0.00
      3             40.00              1.00
Manning's 'N' friction factor =   0.040
------------------------------------------------------------------------
Sub-Channel flow  =     41.019(CFS)
  '     '    flow top width =     22.167(Ft.)
  '     '    velocity=    6.678(Ft/s)
  '     '    area =      6.142(Sq.Ft)
  '     '    Froude number =     2.236

Upstream point elevation =  5850.000(Ft.)
Downstream point elevation =  5635.000(Ft.)
Flow length =  1200.000(Ft.)
Travel time  =    2.99 min.
Time of concentration =   15.87 min.
Depth of flow =   0.554(Ft.)
Average velocity =   6.678(Ft/s)
Total irregular channel flow =    41.019(CFS)
Irregular channel normal depth above invert elev. =   0.554(Ft.)
Average velocity of channel(s) =   6.678(Ft/s)
 Adding area flow to channel
UNDEVELOPED (average cover) subarea
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
SCS curve number for soil(AMC 2)  = 84.00
Adjusted SCS curve number for AMC 3 = 96.40
Pervious ratio(Ap) = 1.0000     Max loss rate(Fm)=     0.071(In/Hr)
Rainfall intensity =      5.327(In/Hr) for a   100.0 year storm
Effective runoff coefficient used for area,(total area with modified
rational method)(Q=KCIA) is C = 0.888
Subarea runoff =     39.155(CFS) for    8.900(Ac.)
Total runoff =     60.553(CFS)
Effective area this stream =       12.80(Ac.)
Total Study Area (Main Stream No. 1) =       12.80(Ac.)
Area averaged Fm value =    0.071(In/Hr)
Depth of flow =   0.641(Ft.), Average velocity =   7.361(Ft/s)


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station       17.000 to Point/Station        4.000
**** IRREGULAR CHANNEL FLOW TRAVEL TIME ****
------------------------------------------------------------------------
Depth of flow =   1.095(Ft.), Average velocity =   5.087(Ft/s)
!!Warning: Water is above left or right bank elevations
      ******* Irregular Channel Data ***********
------------------------------------------------------------------------
Information entered for subchannel number 1 :
Point number      'X' coordinate     'Y' coordinate
      1              0.00              1.00
```

```
      2             10.00              0.00
      3             20.00              1.00
Manning's 'N' friction factor =   0.030
-----------------------------------------------------------------
Sub-Channel flow  =     60.553(CFS)
   '      '    flow top width =     20.000(Ft.)
   '      '    velocity=    5.087(Ft/s)
   '      '    area =     11.903(Sq.Ft)
   '      '    Froude number =     1.162

Upstream point elevation =  5635.000(Ft.)
Downstream point elevation =  5600.000(Ft.)
Flow length =  1650.000(Ft.)
Travel time  =    5.41 min.
Time of concentration =   21.28 min.
Depth of flow =   1.095(Ft.)
Average velocity =   5.087(Ft/s)
Total irregular channel flow =    60.553(CFS)
Irregular channel normal depth above invert elev. =   1.095(Ft.)
Average velocity of channel(s) =   5.087(Ft/s)
!!Warning: Water is above left or right bank elevations


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Process from Point/Station       17.000 to Point/Station        4.000
**** CONFLUENCE OF MINOR STREAMS ****
________________________________________________________________________
Along Main Stream number: 1 in normal stream number 1
Stream flow area =     12.800(Ac.)
Runoff from this stream =     60.553(CFS)
Time of concentration =   21.28 min.
Rainfall intensity =     4.339(In/Hr)
Area averaged loss rate (Fm) =    0.0710(In/Hr)
Area averaged Pervious ratio (Ap) = 1.0000


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station        1.000 to Point/Station        2.000
**** INITIAL AREA EVALUATION ****
________________________________________________________________________
UNDEVELOPED (average cover) subarea
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
SCS curve number for soil(AMC 2)  = 84.00
Adjusted SCS curve number for AMC 3 = 96.40
Pervious ratio(Ap) = 1.0000     Max loss rate(Fm)=     0.071(In/Hr)
Initial subarea data:
Initial area flow distance =   900.000(Ft.)
Top (of initial area) elevation =  6040.000(Ft.)
Bottom (of initial area) elevation =  5920.000(Ft.)
Difference in elevation =   120.000(Ft.)
Slope =    0.13333  s(%)=      13.33
TC = k(0.706)*[(length^3)/(elevation change)]^0.2
Initial area time of concentration =   16.051 min.
Rainfall intensity =      5.285(In/Hr) for a   100.0 year storm
Effective runoff coefficient used for area (Q=KCIA) is C = 0.888
Subarea runoff =     39.889(CFS)
Total initial stream area =      8.500(Ac.)
```

```
Pervious area fraction = 1.000
Initial area Fm value =    0.071(In/Hr)


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station        2.000 to Point/Station        3.000
**** IRREGULAR CHANNEL FLOW TRAVEL TIME ****
------------------------------------------------------------------------
Estimated mean flow rate at midpoint of channel =      0.000(CFS)
Depth of flow =   1.369(Ft.), Average velocity =  10.745(Ft/s)
      ******* Irregular Channel Data ***********
------------------------------------------------------------------------
Information entered for subchannel number 1 :
Point number      'X' coordinate     'Y' coordinate
      1              0.00              10.00
      2             40.00               0.00
      3             80.00              10.00
Manning's 'N' friction factor =   0.040
------------------------------------------------------------------------
Sub-Channel flow  =     80.503(CFS)
  '     '    flow top width =     10.949(Ft.)
  '     '    velocity=   10.745(Ft/s)
  '     '    area =      7.492(Sq.Ft)
  '     '    Froude number =     2.289

Upstream point elevation =  5920.000(Ft.)
Downstream point elevation =  5790.000(Ft.)
Flow length =   900.000(Ft.)
Travel time  =    1.40 min.
Time of concentration =   17.45 min.
Depth of flow =   1.369(Ft.)
Average velocity =  10.745(Ft/s)
Total irregular channel flow =    80.503(CFS)
Irregular channel normal depth above invert elev. =   1.369(Ft.)
Average velocity of channel(s) =  10.745(Ft/s)
 Adding area flow to channel
Soil classification AP and SCS  values input by user
USER INPUT of soil data for subarea
SCS curve number for soil(AMC 2)  = 79.30
Adjusted SCS curve number for AMC 3 = 93.58
Pervious ratio(Ap) = 0.8400     Max loss rate(Fm)=     0.105(In/Hr)
Rainfall intensity =      4.986(In/Hr) for a   100.0 year storm
Effective runoff coefficient used for area,(total area with modified
rational method)(Q=KCIA) is C = 0.883
Subarea runoff =     81.161(CFS) for   19.000(Ac.)
Total runoff =    121.050(CFS)
Effective area this stream =       27.50(Ac.)
Total Study Area (Main Stream No. 1) =       40.30(Ac.)
Area averaged Fm value =    0.095(In/Hr)
Depth of flow =   1.595(Ft.), Average velocity =  11.898(Ft/s)


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station        3.000 to Point/Station        4.000
**** IRREGULAR CHANNEL FLOW TRAVEL TIME ****
------------------------------------------------------------------------
Estimated mean flow rate at midpoint of channel =      0.000(CFS)
Depth of flow =   1.903(Ft.), Average velocity =  12.536(Ft/s)
      ******* Irregular Channel Data ***********
------------------------------------------------------------------------
```

```
Information entered for subchannel number 1 :
Point number      'X' coordinate     'Y' coordinate
      1              0.00              10.00
      2             40.00               0.00
      3             80.00              10.00
Manning's 'N' friction factor =   0.040
-----------------------------------------------------------------
Sub-Channel flow  =    181.643(CFS)
  '      '    flow top width =     15.226(Ft.)
  '      '    velocity=   12.536(Ft/s)
  '      '    area =     14.490(Sq.Ft)
  '      '    Froude number =     2.265

Upstream point elevation =  5790.000(Ft.)
Downstream point elevation =  5600.000(Ft.)
Flow length =  1500.000(Ft.)
Travel time  =    1.99 min.
Time of concentration =   19.44 min.
Depth of flow =   1.903(Ft.)
Average velocity =  12.536(Ft/s)
Total irregular channel flow =   181.643(CFS)
Irregular channel normal depth above invert elev. =   1.903(Ft.)
Average velocity of channel(s) =  12.536(Ft/s)
 Adding area flow to channel
RESIDENTIAL(3 - 4 dwl/acre)
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
SCS curve number for soil(AMC 2)  = 75.00
Adjusted SCS curve number for AMC 3 = 91.00
Pervious ratio(Ap) = 0.6000     Max loss rate(Fm)=     0.104(In/Hr)
Rainfall intensity =      4.622(In/Hr) for a   100.0 year storm
Effective runoff coefficient used for area,(total area with modified
rational method)(Q=KCIA) is C = 0.881
Subarea runoff =    121.102(CFS) for   32.000(Ac.)
Total runoff =    242.152(CFS)
Effective area this stream =       59.50(Ac.)
Total Study Area (Main Stream No. 1) =       72.30(Ac.)
Area averaged Fm value =    0.100(In/Hr)
Depth of flow =   2.120(Ft.), Average velocity =  13.470(Ft/s)


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station        3.000 to Point/Station        4.000
**** CONFLUENCE OF MINOR STREAMS ****
_________________________________________________________________________
Along Main Stream number: 1 in normal stream number 2
Stream flow area =     59.500(Ac.)
Runoff from this stream =    242.152(CFS)
Time of concentration =   19.44 min.
Rainfall intensity =     4.622(In/Hr)
Area averaged loss rate (Fm) =    0.0998(In/Hr)
Area averaged Pervious ratio (Ap) = 0.7338
Summary of stream data:

Stream Flow rate    Area     TC      Fm       Rainfall Intensity
 No.     (CFS)    (Ac.)       (min)  (In/Hr)      (In/Hr)
```

```
1     60.55    12.800     21.28    0.071      4.339
2    242.15    59.500     19.44    0.100      4.622
Qmax(1) =
         1.000 *    1.000 *    60.553) +
         0.937 *    1.000 *   242.152) + =     287.565
Qmax(2) =
         1.066 *    0.914 *    60.553) +
         1.000 *    1.000 *   242.152) + =     301.149

Total of 2 streams to confluence:
Flow rates before confluence point:
      60.553     242.152
Maximum flow rates at confluence using above data:
      287.565      301.149
Area of streams before confluence:
       12.800       59.500
Effective area values after confluence:
       72.300       71.196
Results of confluence:
Total flow rate =    301.149(CFS)
Time of concentration =    19.442 min.
Effective stream area after confluence =     71.196(Ac.)
Study area average Pervious fraction(Ap) =  0.781
Study area average soil loss rate(Fm) =    0.095(In/Hr)
Study area total (this main stream) =      72.30(Ac.)


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Process from Point/Station        4.000 to Point/Station        5.000
**** IRREGULAR CHANNEL FLOW TRAVEL TIME ****
------------------------------------------------------------------------
Estimated mean flow rate at midpoint of channel =      0.000(CFS)
Depth of flow =   2.348(Ft.), Average velocity =   9.461(Ft/s)
      ******* Irregular Channel Data ***********
------------------------------------------------------------------
Information entered for subchannel number 1 :
Point number      'X' coordinate     'Y' coordinate
      1              0.00              10.00
      2             55.00               0.00
      3            120.00              10.00
Manning's 'N' friction factor =   0.040
------------------------------------------------------------------
Sub-Channel flow  =    313.021(CFS)
  '      '    flow top width =     28.179(Ft.)
  '      '    velocity=    9.461(Ft/s)
  '      '    area =     33.085(Sq.Ft)
  '      '    Froude number =     1.539

Upstream point elevation =  5600.000(Ft.)
Downstream point elevation =  5560.000(Ft.)
Flow length =   750.000(Ft.)
Travel time  =    1.32 min.
Time of concentration =   20.76 min.
Depth of flow =   2.348(Ft.)
Average velocity =   9.461(Ft/s)
Total irregular channel flow =   313.021(CFS)
Irregular channel normal depth above invert elev. =   2.348(Ft.)
Average velocity of channel(s) =   9.461(Ft/s)
 Adding area flow to channel
UNDEVELOPED (average cover) subarea
```

```
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
SCS curve number for soil(AMC 2)  = 84.00
Adjusted SCS curve number for AMC 3 = 96.40
Pervious ratio(Ap) = 1.0000     Max loss rate(Fm)=     0.071(In/Hr)
Rainfall intensity =      4.414(In/Hr) for a   100.0 year storm
Effective runoff coefficient used for area,(total area with modified
rational method)(Q=KCIA) is C = 0.881
Subarea runoff =     23.687(CFS) for   12.300(Ac.)
Total runoff =    324.835(CFS)
Effective area this stream =       83.50(Ac.)
Total Study Area (Main Stream No. 1) =       84.60(Ac.)
Area averaged Fm value =    0.091(In/Hr)
Depth of flow =   2.381(Ft.), Average velocity =   9.549(Ft/s)


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Process from Point/Station        5.000 to Point/Station        6.000
**** IRREGULAR CHANNEL FLOW TRAVEL TIME ****
________________________________________________________________________
Estimated mean flow rate at midpoint of channel =      0.000(CFS)
Depth of flow =   2.086(Ft.), Average velocity =  13.249(Ft/s)
      ******* Irregular Channel Data ***********
------------------------------------------------------------------
Information entered for subchannel number 1 :
Point number      'X' coordinate     'Y' coordinate
      1              0.00             10.00
      2             55.00              0.00
      3            120.00             10.00
Manning's 'N' friction factor =   0.040
------------------------------------------------------------------
Sub-Channel flow  =    346.064(CFS)
  '     '    flow top width =     25.037(Ft.)
  '     '    velocity=   13.249(Ft/s)
  '     '    area =     26.119(Sq.Ft)
  '     '    Froude number =     2.286

Upstream point elevation =  5560.000(Ft.)
Downstream point elevation =  5440.000(Ft.)
Flow length =   980.000(Ft.)
Travel time  =    1.23 min.
Time of concentration =   22.00 min.
Depth of flow =   2.086(Ft.)
Average velocity =  13.249(Ft/s)
Total irregular channel flow =   346.064(CFS)
Irregular channel normal depth above invert elev. =   2.086(Ft.)
Average velocity of channel(s) =  13.249(Ft/s)
 Adding area flow to channel
UNDEVELOPED (average cover) subarea
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
SCS curve number for soil(AMC 2)  = 84.00
Adjusted SCS curve number for AMC 3 = 96.40
Pervious ratio(Ap) = 1.0000     Max loss rate(Fm)=     0.071(In/Hr)
Rainfall intensity =      4.239(In/Hr) for a   100.0 year storm
Effective runoff coefficient used for area,(total area with modified
```

```
rational method)(Q=KCIA) is C = 0.881
Subarea runoff =     42.396(CFS) for   14.800(Ac.)
Total runoff =    367.231(CFS)
Effective area this stream =       98.30(Ac.)
Total Study Area (Main Stream No. 1) =       99.40(Ac.)
Area averaged Fm value =    0.088(In/Hr)
Depth of flow =   2.133(Ft.), Average velocity =  13.447(Ft/s)


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Process from Point/Station        5.000 to Point/Station        6.000
**** CONFLUENCE OF MINOR STREAMS ****
------------------------------------------------------------------------
Along Main Stream number: 1 in normal stream number 1
Stream flow area =     98.296(Ac.)
Runoff from this stream =    367.231(CFS)
Time of concentration =   22.00 min.
Rainfall intensity =     4.239(In/Hr)
Area averaged loss rate (Fm) =    0.0882(In/Hr)
Area averaged Pervious ratio (Ap) = 0.8413


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Process from Point/Station        7.000 to Point/Station        8.000
**** INITIAL AREA EVALUATION ****
------------------------------------------------------------------------
UNDEVELOPED (average cover) subarea
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
SCS curve number for soil(AMC 2)  = 84.00
Adjusted SCS curve number for AMC 3 = 96.40
Pervious ratio(Ap) = 1.0000     Max loss rate(Fm)=     0.071(In/Hr)
Initial subarea data:
Initial area flow distance =   700.000(Ft.)
Top (of initial area) elevation =  5662.000(Ft.)
Bottom (of initial area) elevation =  5560.000(Ft.)
Difference in elevation =   102.000(Ft.)
Slope =    0.14571  s(%)=      14.57
TC = k(0.706)*[(length^3)/(elevation change)]^0.2
Initial area time of concentration =   14.261 min.
Rainfall intensity =      5.741(In/Hr) for a   100.0 year storm
Effective runoff coefficient used for area (Q=KCIA) is C = 0.889
Subarea runoff =     31.131(CFS)
Total initial stream area =        6.100(Ac.)
Pervious area fraction = 1.000
Initial area Fm value =    0.071(In/Hr)


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station        8.000 to Point/Station        6.000
**** IRREGULAR CHANNEL FLOW TRAVEL TIME ****
------------------------------------------------------------------------
Estimated mean flow rate at midpoint of channel =      0.000(CFS)
Depth of flow =   1.889(Ft.), Average velocity =  11.356(Ft/s)
      ******* Irregular Channel Data ***********
------------------------------------------------------------------
Information entered for subchannel number 1 :
Point number      'X' coordinate     'Y' coordinate
```

```
      1              0.00              5.00
      2              5.00              0.00
      3             10.00              5.00
Manning's 'N' friction factor =   0.040
-----------------------------------------------------------------
Sub-Channel flow  =     40.542(CFS)
   '      '    flow top width =      3.779(Ft.)
   '      '    velocity=   11.356(Ft/s)
   '      '    area =      3.570(Sq.Ft)
   '      '    Froude number =     2.059

Upstream point elevation =  5560.000(Ft.)
Downstream point elevation =  5440.000(Ft.)
Flow length =   750.000(Ft.)
Travel time  =    1.10 min.
Time of concentration =   15.36 min.
Depth of flow =   1.889(Ft.)
Average velocity =  11.356(Ft/s)
Total irregular channel flow =    40.542(CFS)
Irregular channel normal depth above invert elev. =   1.889(Ft.)
Average velocity of channel(s) =  11.356(Ft/s)
 Adding area flow to channel
UNDEVELOPED (average cover) subarea
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
SCS curve number for soil(AMC 2)  = 84.00
Adjusted SCS curve number for AMC 3 = 96.40
Pervious ratio(Ap) = 1.0000     Max loss rate(Fm)=     0.071(In/Hr)
Rainfall intensity =      5.450(In/Hr) for a   100.0 year storm
Effective runoff coefficient used for area,(total area with modified
rational method)(Q=KCIA) is C = 0.888
Subarea runoff =     18.735(CFS) for    4.200(Ac.)
Total runoff =     49.866(CFS)
Effective area this stream =       10.30(Ac.)
Total Study Area (Main Stream No. 1) =      109.70(Ac.)
Area averaged Fm value =    0.071(In/Hr)
Depth of flow =   2.042(Ft.), Average velocity =  11.959(Ft/s)


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station        8.000 to Point/Station        6.000
**** CONFLUENCE OF MINOR STREAMS ****
_________________________________________________________________________
Along Main Stream number: 1 in normal stream number 2
Stream flow area =     10.300(Ac.)
Runoff from this stream =     49.866(CFS)
Time of concentration =   15.36 min.
Rainfall intensity =     5.450(In/Hr)
Area averaged loss rate (Fm) =    0.0710(In/Hr)
Area averaged Pervious ratio (Ap) = 1.0000


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station        9.000 to Point/Station       10.000
**** INITIAL AREA EVALUATION ****
_________________________________________________________________________
RESIDENTIAL(2.5 acre lot)
Decimal fraction soil group A = 0.000
```

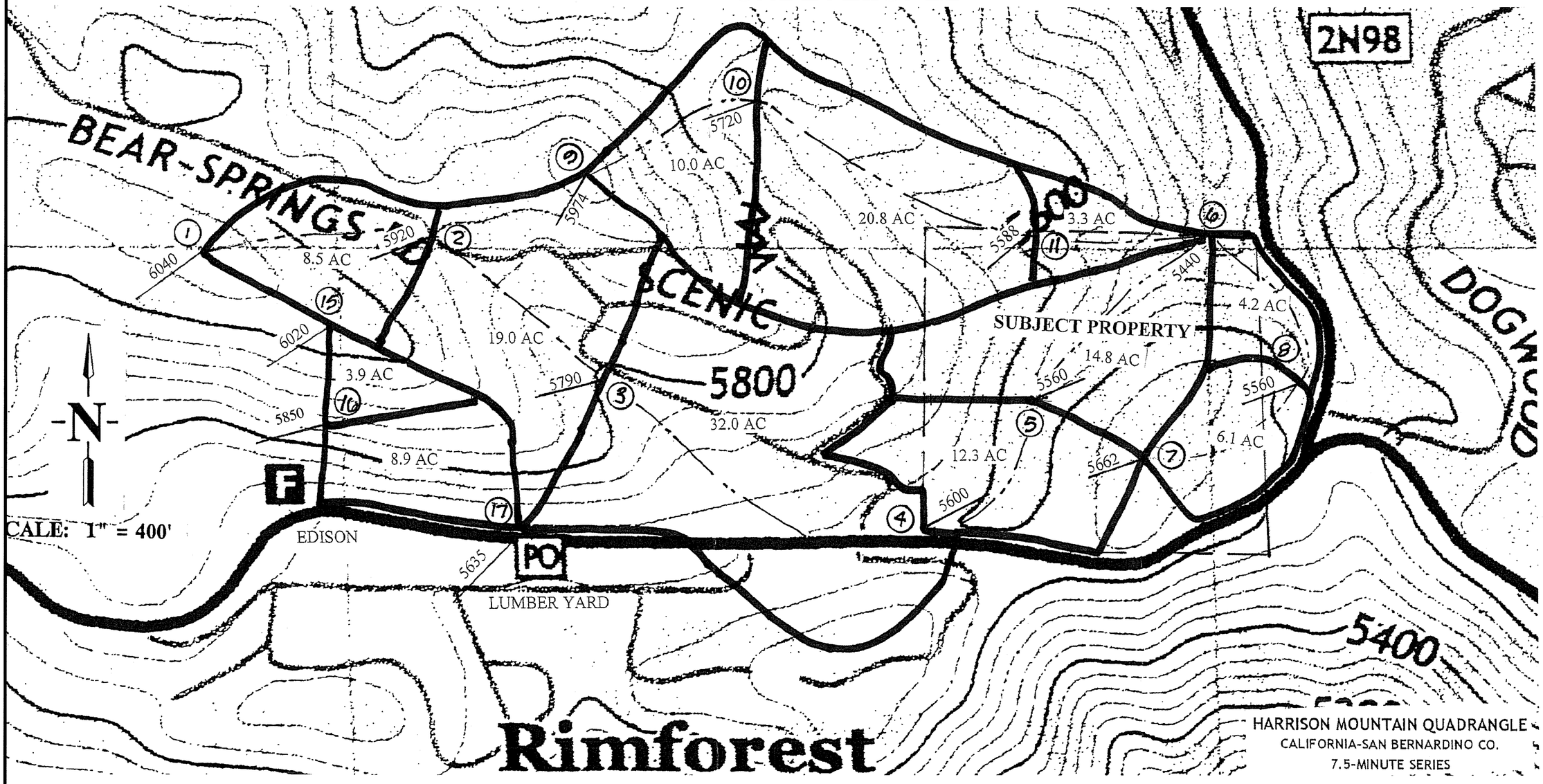
```
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
SCS curve number for soil(AMC 2)  = 75.00
Adjusted SCS curve number for AMC 3 = 91.00
Pervious ratio(Ap) = 0.9000     Max loss rate(Fm)=     0.156(In/Hr)
Initial subarea data:
Initial area flow distance =   800.000(Ft.)
Top (of initial area) elevation =  5974.000(Ft.)
Bottom (of initial area) elevation =  5720.000(Ft.)
Difference in elevation =   254.000(Ft.)
Slope =    0.31750  s(%)=      31.75
TC = k(0.487)*[(length^3)/(elevation change)]^0.2
Initial area time of concentration =    8.880 min.
Rainfall intensity =      7.999(In/Hr) for a   100.0 year storm
Effective runoff coefficient used for area (Q=KCIA) is C = 0.882
Subarea runoff =     70.583(CFS)
Total initial stream area =       10.000(Ac.)
Pervious area fraction = 0.900
Initial area Fm value =    0.156(In/Hr)


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station       10.000 to Point/Station       11.000
**** IRREGULAR CHANNEL FLOW TRAVEL TIME ****
------------------------------------------------------------------------
Estimated mean flow rate at midpoint of channel =      0.000(CFS)
Depth of flow =   1.745(Ft.), Average velocity =  10.593(Ft/s)
      ******* Irregular Channel Data ***********
------------------------------------------------------------------
Information entered for subchannel number 1 :
Point number      'X' coordinate     'Y' coordinate
      1              0.00              10.00
      2             40.00               0.00
      3             80.00              10.00
Manning's 'N' friction factor =   0.040
------------------------------------------------------------------
Sub-Channel flow  =    129.051(CFS)
  '     '    flow top width =     13.961(Ft.)
  '     '    velocity=   10.593(Ft/s)
  '     '    area =     12.182(Sq.Ft)
  '     '    Froude number =     1.998

Upstream point elevation =  5720.000(Ft.)
Downstream point elevation =  5588.000(Ft.)
Flow length =  1300.000(Ft.)
Travel time  =    2.05 min.
Time of concentration =   10.93 min.
Depth of flow =   1.745(Ft.)
Average velocity =  10.593(Ft/s)
Total irregular channel flow =   129.051(CFS)
Irregular channel normal depth above invert elev. =   1.745(Ft.)
Average velocity of channel(s) =  10.593(Ft/s)
 Adding area flow to channel
RESIDENTIAL(2.5 acre lot)
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
SCS curve number for soil(AMC 2)  = 75.00
```

```
Adjusted SCS curve number for AMC 3 = 91.00
Pervious ratio(Ap) = 0.9000     Max loss rate(Fm)=     0.156(In/Hr)
Rainfall intensity =      6.919(In/Hr) for a   100.0 year storm
Effective runoff coefficient used for area,(total area with modified
rational method)(Q=KCIA) is C = 0.880
Subarea runoff =    116.865(CFS) for   20.800(Ac.)
Total runoff =    187.448(CFS)
Effective area this stream =       30.80(Ac.)
Total Study Area (Main Stream No. 1) =      140.50(Ac.)
Area averaged Fm value =    0.156(In/Hr)
Depth of flow =   2.007(Ft.), Average velocity =  11.630(Ft/s)


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station       11.000 to Point/Station        6.000
**** IRREGULAR CHANNEL FLOW TRAVEL TIME ****
------------------------------------------------------------------------
Estimated mean flow rate at midpoint of channel =      0.000(CFS)
Depth of flow =   1.768(Ft.), Average velocity =  15.419(Ft/s)
      ******* Irregular Channel Data ***********
------------------------------------------------------------------
Information entered for subchannel number 1 :
Point number      'X' coordinate     'Y' coordinate
      1              0.00             10.00
      2             40.00              0.00
      3             80.00             10.00
Manning's 'N' friction factor =   0.040
------------------------------------------------------------------
Sub-Channel flow  =    192.794(CFS)
  '     '    flow top width =     14.144(Ft.)
  '     '    velocity=   15.419(Ft/s)
  '     '    area =     12.503(Sq.Ft)
  '     '    Froude number =     2.890

Upstream point elevation =  5588.000(Ft.)
Downstream point elevation =  5440.000(Ft.)
Flow length =   700.000(Ft.)
Travel time  =    0.76 min.
Time of concentration =   11.68 min.
Depth of flow =   1.768(Ft.)
Average velocity =  15.419(Ft/s)
Total irregular channel flow =   192.794(CFS)
Irregular channel normal depth above invert elev. =   1.768(Ft.)
Average velocity of channel(s) =  15.419(Ft/s)
 Adding area flow to channel
UNDEVELOPED (average cover) subarea
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
SCS curve number for soil(AMC 2)  = 84.00
Adjusted SCS curve number for AMC 3 = 96.40
Pervious ratio(Ap) = 1.0000     Max loss rate(Fm)=     0.071(In/Hr)
Rainfall intensity =      6.602(In/Hr) for a   100.0 year storm
Effective runoff coefficient used for area,(total area with modified
rational method)(Q=KCIA) is C = 0.880
Subarea runoff =     10.614(CFS) for    3.300(Ac.)
Total runoff =    198.063(CFS)
Effective area this stream =       34.10(Ac.)
Total Study Area (Main Stream No. 1) =      143.80(Ac.)
```

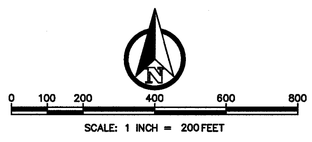
```
Area averaged Fm value =    0.148(In/Hr)
Depth of flow =   1.786(Ft.), Average velocity =  15.524(Ft/s)


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station       11.000 to Point/Station        6.000
**** CONFLUENCE OF MINOR STREAMS ****
________________________________________________________________________
Along Main Stream number: 1 in normal stream number 3
Stream flow area =     34.100(Ac.)
Runoff from this stream =    198.063(CFS)
Time of concentration =   11.68 min.
Rainfall intensity =     6.602(In/Hr)
Area averaged loss rate (Fm) =    0.1482(In/Hr)
Area averaged Pervious ratio (Ap) = 0.9097
Summary of stream data:

Stream Flow rate    Area     TC      Fm       Rainfall Intensity
 No.    (CFS)    (Ac.)       (min) (In/Hr)      (In/Hr)


1    367.23    98.296     22.00    0.088       4.239
2     49.87    10.300     15.36    0.071       5.450
3    198.06    34.100     11.68    0.148       6.602
Qmax(1) =
         1.000 *    1.000 *   367.231) +
         0.775 *    1.000 *    49.866) +
         0.634 *    1.000 *   198.063) + =     531.427
Qmax(2) =
         1.292 *    0.698 *   367.231) +
         1.000 *    1.000 *    49.866) +
         0.822 *    1.000 *   198.063) + =     543.884
Qmax(3) =
         1.569 *    0.531 *   367.231) +
         1.214 *    0.760 *    49.866) +
         1.000 *    1.000 *   198.063) + =     550.145

Total of 3 streams to confluence:
Flow rates before confluence point:
     367.231      49.866     198.063
Maximum flow rates at confluence using above data:
      531.427      543.884      550.145
Area of streams before confluence:
       98.296       10.300       34.100
Effective area values after confluence:
      142.696      113.049       94.138
Results of confluence:
Total flow rate =    550.145(CFS)
Time of concentration =    11.682 min.
Effective stream area after confluence =     94.138(Ac.)
Study area average Pervious fraction(Ap) =  0.869
Study area average soil loss rate(Fm) =    0.101(In/Hr)
Study area total (this main stream) =     142.70(Ac.)
End of computations, Total Study Area =          143.80 (Ac.)
The following figures may
be used for a unit hydrograph study of the same area.
Note: These figures do not consider reduced effective area
effects caused by confluences in the rational equation.

Area averaged pervious area fraction(Ap) = 0.868
```

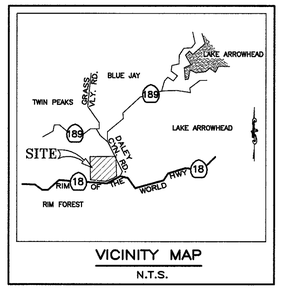
Area averaged SCS curve number = 79.4

DRAINAGE MAP
UNDEVELOPED



Upstream Node	Downstream Node	CN (AMC II)	Ap
15	16	84	1.00
16	17	84	1.00
17	4	N/A	N/A
1	2	84	1.00
2	3	79.3	0.84
3	4	75	0.60
4	12	75	0.50
12	6	84	1.00
13	14	84	1.00
14	6	84	1.00
9	10	75	0.90
10	11	75	0.90
11	6	84	1.00





VICINITY MAP
N.T.S.

REGISTERED PROFESSIONAL ENGINEER
WILLIAM J. McKEEVER
No. 22502
Exp. 12-31-19
CIVIL
STATE OF CALIFORNIA

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WILLIAM J. McKEEVER, R.C.E. 22502 — DATE 4/24/18

APPENDIX "F-2"

RATIONAL METHOD HYDRAULIC CALCULATIONS TOTAL DRAINAGE AREA (100-YEAR STORM EVENT) AND PROPOSED PROJECT AREA DEVELOPED (100-YEAR STORM EVENT) AND MAP

San Bernardino County Rational Hydrology Program

(Hydrology Manual Date - August 1986)

CIVILCADD/CIVILDESIGN Engineering Software, (c) 1989-2005 Version 7.1
Rational Hydrology Study Date: 04/20/18

Program License Serial Number 6222

Church of the Woods
Rim Forest
100 Year 1 Hour
Developed

********* Hydrology Study Control Information **********

Rational hydrology study storm event year is 100.0
10 Year storm 1 hour rainfall = 1.400(In.)
100 Year storm 1 hour rainfall = 2.100(In.)
Computed rainfall intensity:
Storm year = 100.00 1 hour rainfall = 2.100 (In.)
Slope used for rainfall intensity curve b = 0.7000
Soil antecedent moisture condition (AMC) = 3

++
Process from Point/Station 15.000 to Point/Station 16.000
**** INITIAL AREA EVALUATION ****

UNDEVELOPED (average cover) subarea
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
SCS curve number for soil(AMC 2) = 84.00
Adjusted SCS curve number for AMC 3 = 96.40
Pervious ratio(Ap) = 1.0000 Max loss rate(Fm)= 0.071(In/Hr)
Initial subarea data:
Initial area flow distance = 700.000(Ft.)
Top (of initial area) elevation = 6020.000(Ft.)
Bottom (of initial area) elevation = 5850.000(Ft.)
Difference in elevation = 170.000(Ft.)
Slope = 0.24286 s(%)= 24.29
TC = k(0.706)*[(length^3)/(elevation change)]^0.2
Initial area time of concentration = 12.876 min.
Rainfall intensity = 6.167(In/Hr) for a 100.0 year storm
Effective runoff coefficient used for area (Q=KCIA) is C = 0.890
Subarea runoff = 21.397(CFS)
Total initial stream area = 3.900(Ac.)
Pervious area fraction = 1.000
Initial area Fm value = 0.071(In/Hr)

++
Process from Point/Station 16.000 to Point/Station 17.000

```
**** IRREGULAR CHANNEL FLOW TRAVEL TIME ****
------------------------------------------------------------------------
Estimated mean flow rate at midpoint of channel =      0.000(CFS)
Depth of flow =   0.554(Ft.), Average velocity =   6.678(Ft/s)
      ******* Irregular Channel Data ***********
------------------------------------------------------------------------
Information entered for subchannel number 1 :
Point number      'X' coordinate     'Y' coordinate
      1              0.00              1.00
      2             20.00              0.00
      3             40.00              1.00
Manning's 'N' friction factor =   0.040
------------------------------------------------------------------------
Sub-Channel flow  =     41.019(CFS)
  '      '    flow top width =     22.167(Ft.)
  '      '    velocity=    6.678(Ft/s)
  '      '    area =      6.142(Sq.Ft)
  '      '    Froude number =     2.236

Upstream point elevation =  5850.000(Ft.)
Downstream point elevation =  5635.000(Ft.)
Flow length =  1200.000(Ft.)
Travel time  =    2.99 min.
Time of concentration =   15.87 min.
Depth of flow =   0.554(Ft.)
Average velocity =   6.678(Ft/s)
Total irregular channel flow =    41.019(CFS)
Irregular channel normal depth above invert elev. =   0.554(Ft.)
Average velocity of channel(s) =   6.678(Ft/s)
 Adding area flow to channel
UNDEVELOPED (average cover) subarea
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
SCS curve number for soil(AMC 2)  = 84.00
Adjusted SCS curve number for AMC 3 = 96.40
Pervious ratio(Ap) = 1.0000     Max loss rate(Fm)=     0.071(In/Hr)
Rainfall intensity =      5.327(In/Hr) for a   100.0 year storm
Effective runoff coefficient used for area,(total area with modified
rational method)(Q=KCIA) is C = 0.888
Subarea runoff =     39.155(CFS) for    8.900(Ac.)
Total runoff =     60.553(CFS)
Effective area this stream =       12.80(Ac.)
Total Study Area (Main Stream No. 1) =       12.80(Ac.)
Area averaged Fm value =    0.071(In/Hr)
Depth of flow =   0.641(Ft.), Average velocity =   7.361(Ft/s)


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station       17.000 to Point/Station        4.000
**** IRREGULAR CHANNEL FLOW TRAVEL TIME ****
------------------------------------------------------------------------
Depth of flow =   1.095(Ft.), Average velocity =   5.087(Ft/s)
!!Warning: Water is above left or right bank elevations
      ******* Irregular Channel Data ***********
------------------------------------------------------------------------
Information entered for subchannel number 1 :
Point number      'X' coordinate     'Y' coordinate
      1              0.00              1.00
```

```
      2             10.00              0.00
      3             20.00              1.00
Manning's 'N' friction factor =   0.030
-----------------------------------------------------------------
Sub-Channel flow  =     60.553(CFS)
   '      '    flow top width =     20.000(Ft.)
   '      '    velocity=    5.087(Ft/s)
   '      '    area =     11.903(Sq.Ft)
   '      '    Froude number =     1.162

Upstream point elevation =  5635.000(Ft.)
Downstream point elevation =  5600.000(Ft.)
Flow length =  1650.000(Ft.)
Travel time  =    5.41 min.
Time of concentration =   21.28 min.
Depth of flow =   1.095(Ft.)
Average velocity =   5.087(Ft/s)
Total irregular channel flow =    60.553(CFS)
Irregular channel normal depth above invert elev. =   1.095(Ft.)
Average velocity of channel(s) =   5.087(Ft/s)
!!Warning: Water is above left or right bank elevations


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station       17.000 to Point/Station        4.000
**** CONFLUENCE OF MINOR STREAMS ****
------------------------------------------------------------------------
Along Main Stream number: 1 in normal stream number 1
Stream flow area =     12.800(Ac.)
Runoff from this stream =     60.553(CFS)
Time of concentration =   21.28 min.
Rainfall intensity =     4.339(In/Hr)
Area averaged loss rate (Fm) =    0.0710(In/Hr)
Area averaged Pervious ratio (Ap) = 1.0000


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station        1.000 to Point/Station        2.000
**** INITIAL AREA EVALUATION ****
------------------------------------------------------------------------
UNDEVELOPED (average cover) subarea
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
SCS curve number for soil(AMC 2)  = 84.00
Adjusted SCS curve number for AMC 3 = 96.40
Pervious ratio(Ap) = 1.0000     Max loss rate(Fm)=     0.071(In/Hr)
Initial subarea data:
Initial area flow distance =   900.000(Ft.)
Top (of initial area) elevation =  6040.000(Ft.)
Bottom (of initial area) elevation =  5920.000(Ft.)
Difference in elevation =   120.000(Ft.)
Slope =    0.13333  s(%)=      13.33
TC = k(0.706)*[(length^3)/(elevation change)]^0.2
Initial area time of concentration =   16.051 min.
Rainfall intensity =      5.285(In/Hr) for a   100.0 year storm
Effective runoff coefficient used for area (Q=KCIA) is C = 0.888
Subarea runoff =     39.889(CFS)
Total initial stream area =        8.500(Ac.)
```

```
Pervious area fraction = 1.000
Initial area Fm value =    0.071(In/Hr)


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station        2.000 to Point/Station        3.000
**** IRREGULAR CHANNEL FLOW TRAVEL TIME ****
------------------------------------------------------------------------
Estimated mean flow rate at midpoint of channel =      0.000(CFS)
Depth of flow =   1.369(Ft.), Average velocity =  10.745(Ft/s)
      ******* Irregular Channel Data ***********
------------------------------------------------------------------------
Information entered for subchannel number 1 :
Point number      'X' coordinate     'Y' coordinate
      1              0.00              10.00
      2             40.00               0.00
      3             80.00              10.00
Manning's 'N' friction factor =   0.040
------------------------------------------------------------------------
Sub-Channel flow  =     80.503(CFS)
  '     '    flow top width =     10.949(Ft.)
  '     '    velocity=   10.745(Ft/s)
  '     '    area =      7.492(Sq.Ft)
  '     '    Froude number =     2.289

Upstream point elevation =  5920.000(Ft.)
Downstream point elevation =  5790.000(Ft.)
Flow length =   900.000(Ft.)
Travel time  =    1.40 min.
Time of concentration =   17.45 min.
Depth of flow =   1.369(Ft.)
Average velocity =  10.745(Ft/s)
Total irregular channel flow =    80.503(CFS)
Irregular channel normal depth above invert elev. =   1.369(Ft.)
Average velocity of channel(s) =  10.745(Ft/s)
 Adding area flow to channel
Soil classification AP and SCS  values input by user
USER INPUT of soil data for subarea
SCS curve number for soil(AMC 2)  = 79.30
Adjusted SCS curve number for AMC 3 = 93.58
Pervious ratio(Ap) = 0.8400     Max loss rate(Fm)=     0.105(In/Hr)
Rainfall intensity =      4.986(In/Hr) for a   100.0 year storm
Effective runoff coefficient used for area,(total area with modified
rational method)(Q=KCIA) is C = 0.883
Subarea runoff =     81.161(CFS) for   19.000(Ac.)
Total runoff =    121.050(CFS)
Effective area this stream =       27.50(Ac.)
Total Study Area (Main Stream No. 1) =       40.30(Ac.)
Area averaged Fm value =    0.095(In/Hr)
Depth of flow =   1.595(Ft.), Average velocity =  11.898(Ft/s)


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station        3.000 to Point/Station        4.000
**** IRREGULAR CHANNEL FLOW TRAVEL TIME ****
------------------------------------------------------------------------
Estimated mean flow rate at midpoint of channel =      0.000(CFS)
Depth of flow =   1.903(Ft.), Average velocity =  12.536(Ft/s)
      ******* Irregular Channel Data ***********
------------------------------------------------------------------------
```

```
Information entered for subchannel number 1 :
Point number      'X' coordinate     'Y' coordinate
      1              0.00              10.00
      2             40.00               0.00
      3             80.00              10.00
Manning's 'N' friction factor =   0.040
-----------------------------------------------------------------
Sub-Channel flow  =    181.643(CFS)
   '      '    flow top width =     15.226(Ft.)
   '      '    velocity=   12.536(Ft/s)
   '      '    area =     14.490(Sq.Ft)
   '      '    Froude number =     2.265

Upstream point elevation =  5790.000(Ft.)
Downstream point elevation =  5600.000(Ft.)
Flow length =  1500.000(Ft.)
Travel time  =    1.99 min.
Time of concentration =   19.44 min.
Depth of flow =   1.903(Ft.)
Average velocity =  12.536(Ft/s)
Total irregular channel flow =   181.643(CFS)
Irregular channel normal depth above invert elev. =   1.903(Ft.)
Average velocity of channel(s) =  12.536(Ft/s)
 Adding area flow to channel
RESIDENTIAL(3 - 4 dwl/acre)
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
SCS curve number for soil(AMC 2)  = 75.00
Adjusted SCS curve number for AMC 3 = 91.00
Pervious ratio(Ap) = 0.6000     Max loss rate(Fm)=     0.104(In/Hr)
Rainfall intensity =      4.622(In/Hr) for a   100.0 year storm
Effective runoff coefficient used for area,(total area with modified
rational method)(Q=KCIA) is C = 0.881
Subarea runoff =    121.102(CFS) for   32.000(Ac.)
Total runoff =    242.152(CFS)
Effective area this stream =       59.50(Ac.)
Total Study Area (Main Stream No. 1) =       72.30(Ac.)
Area averaged Fm value =    0.100(In/Hr)
Depth of flow =   2.120(Ft.), Average velocity =  13.470(Ft/s)


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station        3.000 to Point/Station        4.000
**** CONFLUENCE OF MINOR STREAMS ****
_________________________________________________________________________
Along Main Stream number: 1 in normal stream number 2
Stream flow area =     59.500(Ac.)
Runoff from this stream =    242.152(CFS)
Time of concentration =   19.44 min.
Rainfall intensity =     4.622(In/Hr)
Area averaged loss rate (Fm) =    0.0998(In/Hr)
Area averaged Pervious ratio (Ap) = 0.7338
Summary of stream data:

Stream Flow rate    Area     TC      Fm       Rainfall Intensity
 No.    (CFS)    (Ac.)       (min) (In/Hr)      (In/Hr)
```

```
1     60.55    12.800     21.28    0.071       4.339
2    242.15    59.500     19.44    0.100       4.622
Qmax(1) =
         1.000 *    1.000 *    60.553) +
         0.937 *    1.000 *   242.152) + =     287.565
Qmax(2) =
         1.066 *    0.914 *    60.553) +
         1.000 *    1.000 *   242.152) + =     301.149

Total of 2 streams to confluence:
Flow rates before confluence point:
      60.553     242.152
Maximum flow rates at confluence using above data:
      287.565      301.149
Area of streams before confluence:
       12.800       59.500
Effective area values after confluence:
       72.300       71.196
Results of confluence:
Total flow rate =    301.149(CFS)
Time of concentration =    19.442 min.
Effective stream area after confluence =     71.196(Ac.)
Study area average Pervious fraction(Ap) =  0.781
Study area average soil loss rate(Fm) =    0.095(In/Hr)
Study area total (this main stream) =      72.30(Ac.)


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station        4.000 to Point/Station       12.000
**** PIPEFLOW TRAVEL TIME (Program estimated size) ****
------------------------------------------------------------------------
Upstream point/station elevation =  5600.000(Ft.)
Downstream point/station elevation =  5560.000(Ft.)
Pipe length  =   750.00(Ft.)   Manning's N = 0.015
No. of pipes = 1  Required pipe flow  =   301.149(CFS)
Nearest computed pipe diameter  =     51.00(In.)
Calculated individual pipe flow  =   301.149(CFS)
Normal flow depth in pipe =   37.50(In.)
Flow top width inside pipe =   45.00(In.)
Critical depth could not be calculated.
Pipe flow velocity =     26.92(Ft/s)
Travel time through pipe =    0.46 min.
Time of concentration (TC) =    19.91 min.


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station        4.000 to Point/Station       12.000
**** SUBAREA FLOW ADDITION ****
------------------------------------------------------------------------
Soil classification AP and SCS  values input by user
USER INPUT of soil data for subarea
SCS curve number for soil(AMC 2)  = 75.00
Adjusted SCS curve number for AMC 3 = 91.00
Pervious ratio(Ap) = 0.5000     Max loss rate(Fm)=     0.087(In/Hr)
Time of concentration =    19.91 min.
Rainfall intensity =    4.546(In/Hr) for a   100.0 year storm
Effective runoff coefficient used for area,(total area with modified
rational method)(Q=KCIA) is C = 0.882
Subarea runoff =     40.667(CFS) for   14.100(Ac.)
Total runoff =    341.815(CFS)
```

```
Effective area this stream =       85.30(Ac.)
Total Study Area (Main Stream No. 1) =       86.40(Ac.)
Area averaged Fm value =    0.093(In/Hr)


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station       12.000 to Point/Station        6.000
**** IRREGULAR CHANNEL FLOW TRAVEL TIME ****
________________________________________________________________________
Estimated mean flow rate at midpoint of channel =      0.000(CFS)
Depth of flow =   2.127(Ft.), Average velocity =  13.420(Ft/s)
      ******* Irregular Channel Data ***********
------------------------------------------------------------------
Information entered for subchannel number 1 :
Point number      'X' coordinate     'Y' coordinate
      1              0.00              10.00
      2             55.00               0.00
      3            120.00              10.00
Manning's 'N' friction factor =   0.040
------------------------------------------------------------------
Sub-Channel flow  =    364.228(CFS)
  '     '    flow top width =     25.522(Ft.)
  '     '    velocity=   13.420(Ft/s)
  '     '    area =     27.141(Sq.Ft)
  '     '    Froude number =     2.293

Upstream point elevation =  5560.000(Ft.)
Downstream point elevation =  5440.000(Ft.)
Flow length =   980.000(Ft.)
Travel time  =    1.22 min.
Time of concentration =   21.12 min.
Depth of flow =   2.127(Ft.)
Average velocity =  13.420(Ft/s)
Total irregular channel flow =   364.227(CFS)
Irregular channel normal depth above invert elev. =   2.127(Ft.)
Average velocity of channel(s) =  13.420(Ft/s)
 Adding area flow to channel
UNDEVELOPED (average cover) subarea
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
SCS curve number for soil(AMC 2)  = 84.00
Adjusted SCS curve number for AMC 3 = 96.40
Pervious ratio(Ap) = 1.0000     Max loss rate(Fm)=     0.071(In/Hr)
Rainfall intensity =      4.361(In/Hr) for a   100.0 year storm
Effective runoff coefficient used for area,(total area with modified
rational method)(Q=KCIA) is C = 0.881
Subarea runoff =     44.758(CFS) for   15.270(Ac.)
Total runoff =    386.573(CFS)
Effective area this stream =      100.57(Ac.)
Total Study Area (Main Stream No. 1) =      101.67(Ac.)
Area averaged Fm value =    0.090(In/Hr)
Depth of flow =   2.175(Ft.), Average velocity =  13.621(Ft/s)


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station       12.000 to Point/Station        6.000
**** CONFLUENCE OF MINOR STREAMS ****
________________________________________________________________________
```

```
Along Main Stream number: 1 in normal stream number 1
Stream flow area =    100.566(Ac.)
Runoff from this stream =    386.573(CFS)
Time of concentration =   21.12 min.
Rainfall intensity =     4.361(In/Hr)
Area averaged loss rate (Fm) =    0.0900(In/Hr)
Area averaged Pervious ratio (Ap) = 0.7748


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station       13.000 to Point/Station       14.000
**** INITIAL AREA EVALUATION ****
----------------------------------------------------------------------
UNDEVELOPED (average cover) subarea
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
SCS curve number for soil(AMC 2)  = 84.00
Adjusted SCS curve number for AMC 3 = 96.40
Pervious ratio(Ap) = 1.0000     Max loss rate(Fm)=     0.071(In/Hr)
Initial subarea data:
Initial area flow distance =   700.000(Ft.)
Top (of initial area) elevation =  5602.000(Ft.)
Bottom (of initial area) elevation =  5560.000(Ft.)
Difference in elevation =    42.000(Ft.)
Slope =    0.06000  s(%)=       6.00
TC = k(0.706)*[(length^3)/(elevation change)]^0.2
Initial area time of concentration =   17.030 min.
Rainfall intensity =      5.071(In/Hr) for a   100.0 year storm
Effective runoff coefficient used for area (Q=KCIA) is C = 0.887
Subarea runoff =     13.049(CFS)
Total initial stream area =        2.900(Ac.)
Pervious area fraction = 1.000
Initial area Fm value =    0.071(In/Hr)


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station       14.000 to Point/Station        6.000
**** IRREGULAR CHANNEL FLOW TRAVEL TIME ****
----------------------------------------------------------------------
Estimated mean flow rate at midpoint of channel =      0.000(CFS)
Depth of flow =   1.506(Ft.), Average velocity =   9.763(Ft/s)
      ******* Irregular Channel Data ***********
----------------------------------------------------------------------
Information entered for subchannel number 1 :
Point number      'X' coordinate     'Y' coordinate
      1              0.00              5.00
      2              5.00              0.00
      3             10.00              5.00
Manning's 'N' friction factor =   0.040
----------------------------------------------------------------------
Sub-Channel flow  =     22.152(CFS)
  '     '    flow top width =      3.013(Ft.)
  '     '    velocity=    9.763(Ft/s)
  '     '    area =      2.269(Sq.Ft)
  '     '    Froude number =     1.983

Upstream point elevation =  5560.000(Ft.)
Downstream point elevation =  5440.000(Ft.)
```

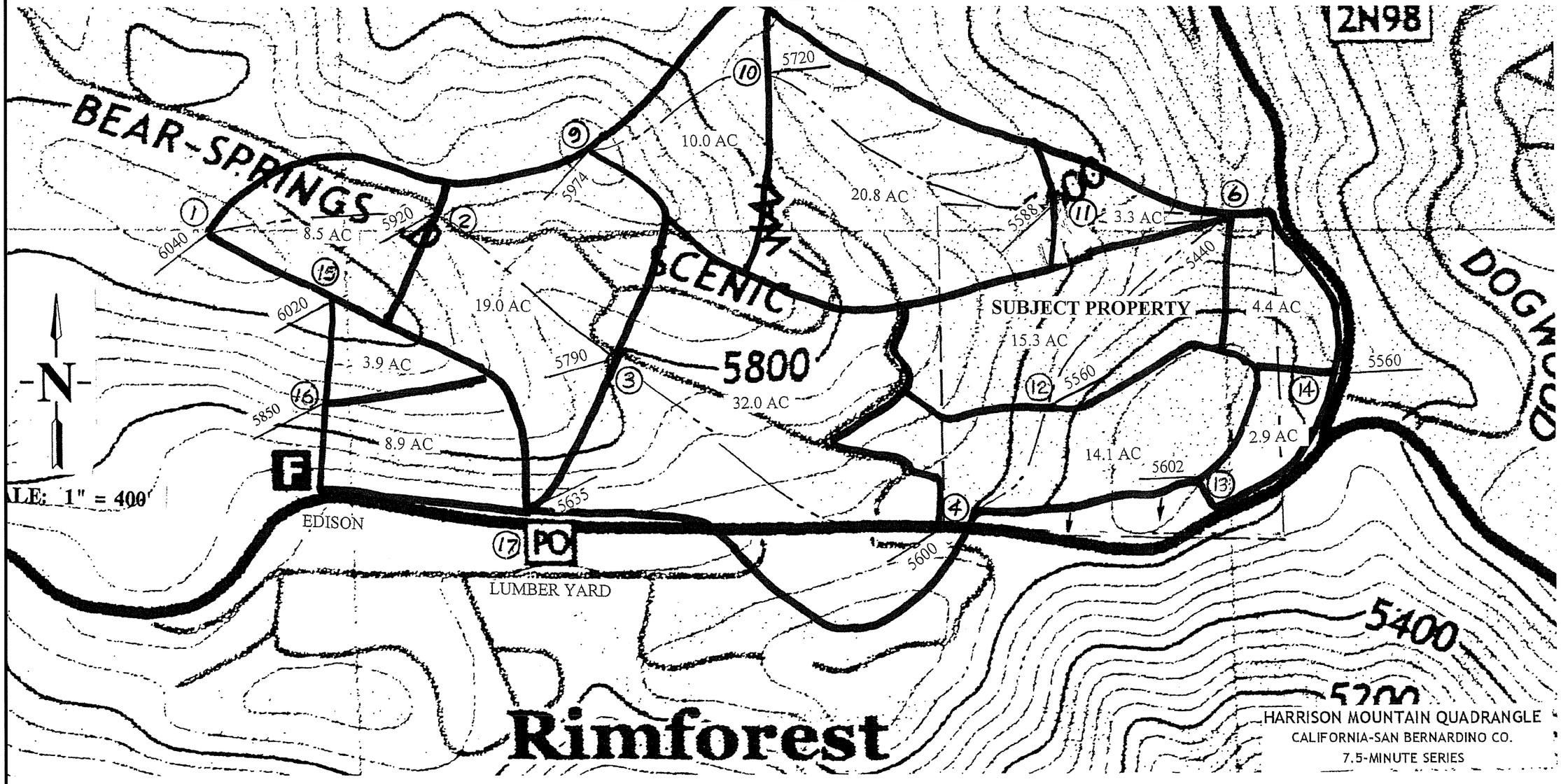
```
Flow length =   750.000(Ft.)
Travel time  =    1.28 min.
Time of concentration =   18.31 min.
Depth of flow =   1.506(Ft.)
Average velocity =   9.763(Ft/s)
Total irregular channel flow =    22.152(CFS)
Irregular channel normal depth above invert elev. =   1.506(Ft.)
Average velocity of channel(s) =   9.763(Ft/s)
 Adding area flow to channel
UNDEVELOPED (average cover) subarea
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
SCS curve number for soil(AMC 2)  = 84.00
Adjusted SCS curve number for AMC 3 = 96.40
Pervious ratio(Ap) = 1.0000     Max loss rate(Fm)=     0.071(In/Hr)
Rainfall intensity =      4.820(In/Hr) for a   100.0 year storm
Effective runoff coefficient used for area,(total area with modified
rational method)(Q=KCIA) is C = 0.887
Subarea runoff =     18.151(CFS) for    4.400(Ac.)
Total runoff =     31.200(CFS)
Effective area this stream =        7.30(Ac.)
Total Study Area (Main Stream No. 1) =      108.97(Ac.)
Area averaged Fm value =    0.071(In/Hr)
Depth of flow =   1.713(Ft.), Average velocity =  10.636(Ft/s)


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station       14.000 to Point/Station        6.000
**** CONFLUENCE OF MINOR STREAMS ****
------------------------------------------------------------------------
Along Main Stream number: 1 in normal stream number 2
Stream flow area =      7.300(Ac.)
Runoff from this stream =     31.200(CFS)
Time of concentration =   18.31 min.
Rainfall intensity =     4.820(In/Hr)
Area averaged loss rate (Fm) =    0.0710(In/Hr)
Area averaged Pervious ratio (Ap) = 1.0000


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station        9.000 to Point/Station       10.000
**** INITIAL AREA EVALUATION ****
------------------------------------------------------------------------
RESIDENTIAL(2.5 acre lot)
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
SCS curve number for soil(AMC 2)  = 75.00
Adjusted SCS curve number for AMC 3 = 91.00
Pervious ratio(Ap) = 0.9000     Max loss rate(Fm)=     0.156(In/Hr)
Initial subarea data:
Initial area flow distance =   800.000(Ft.)
Top (of initial area) elevation =  5974.000(Ft.)
Bottom (of initial area) elevation =  5720.000(Ft.)
Difference in elevation =   254.000(Ft.)
Slope =    0.31750  s(%)=      31.75
TC = k(0.487)*[(length^3)/(elevation change)]^0.2
```

```
Initial area time of concentration =    8.880 min.
Rainfall intensity =      7.999(In/Hr) for a   100.0 year storm
Effective runoff coefficient used for area (Q=KCIA) is C = 0.882
Subarea runoff =     70.583(CFS)
Total initial stream area =       10.000(Ac.)
Pervious area fraction = 0.900
Initial area Fm value =    0.156(In/Hr)


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station       10.000 to Point/Station       11.000
**** IRREGULAR CHANNEL FLOW TRAVEL TIME ****
________________________________________________________________________
Estimated mean flow rate at midpoint of channel =      0.000(CFS)
Depth of flow =   1.745(Ft.), Average velocity =  10.593(Ft/s)
      ******* Irregular Channel Data ***********
------------------------------------------------------------------
Information entered for subchannel number 1 :
Point number      'X' coordinate     'Y' coordinate
      1              0.00              10.00
      2             40.00               0.00
      3             80.00              10.00
Manning's 'N' friction factor =   0.040
------------------------------------------------------------------
Sub-Channel flow  =    129.051(CFS)
  '     '    flow top width =     13.961(Ft.)
  '     '    velocity=   10.593(Ft/s)
  '     '    area =     12.182(Sq.Ft)
  '     '    Froude number =     1.998

Upstream point elevation =  5720.000(Ft.)
Downstream point elevation =  5588.000(Ft.)
Flow length =  1300.000(Ft.)
Travel time  =    2.05 min.
Time of concentration =   10.93 min.
Depth of flow =   1.745(Ft.)
Average velocity =  10.593(Ft/s)
Total irregular channel flow =   129.051(CFS)
Irregular channel normal depth above invert elev. =   1.745(Ft.)
Average velocity of channel(s) =  10.593(Ft/s)
 Adding area flow to channel
RESIDENTIAL(2.5 acre lot)
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
SCS curve number for soil(AMC 2)  = 75.00
Adjusted SCS curve number for AMC 3 = 91.00
Pervious ratio(Ap) = 0.9000     Max loss rate(Fm)=     0.156(In/Hr)
Rainfall intensity =      6.919(In/Hr) for a   100.0 year storm
Effective runoff coefficient used for area,(total area with modified
rational method)(Q=KCIA) is C = 0.880
Subarea runoff =    116.865(CFS) for   20.800(Ac.)
Total runoff =    187.448(CFS)
Effective area this stream =       30.80(Ac.)
Total Study Area (Main Stream No. 1) =      139.77(Ac.)
Area averaged Fm value =    0.156(In/Hr)
Depth of flow =   2.007(Ft.), Average velocity =  11.630(Ft/s)
```

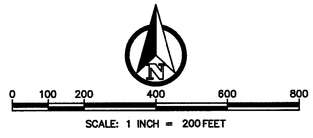
```
++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station       11.000 to Point/Station        6.000
**** IRREGULAR CHANNEL FLOW TRAVEL TIME ****
------------------------------------------------------------------------
Estimated mean flow rate at midpoint of channel =      0.000(CFS)
Depth of flow =   1.768(Ft.), Average velocity =  15.419(Ft/s)
      ******* Irregular Channel Data ***********
------------------------------------------------------------------------
Information entered for subchannel number 1 :
Point number      'X' coordinate     'Y' coordinate
      1              0.00              10.00
      2             40.00               0.00
      3             80.00              10.00
Manning's 'N' friction factor =   0.040
------------------------------------------------------------------------
Sub-Channel flow  =    192.794(CFS)
  '     '   flow top width =     14.144(Ft.)
  '     '   velocity=   15.419(Ft/s)
  '     '   area =     12.503(Sq.Ft)
  '     '   Froude number =     2.890

Upstream point elevation =  5588.000(Ft.)
Downstream point elevation =  5440.000(Ft.)
Flow length =   700.000(Ft.)
Travel time  =    0.76 min.
Time of concentration =   11.68 min.
Depth of flow =   1.768(Ft.)
Average velocity =  15.419(Ft/s)
Total irregular channel flow =   192.794(CFS)
Irregular channel normal depth above invert elev. =   1.768(Ft.)
Average velocity of channel(s) =  15.419(Ft/s)
 Adding area flow to channel
UNDEVELOPED (average cover) subarea
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
SCS curve number for soil(AMC 2)  = 84.00
Adjusted SCS curve number for AMC 3 = 96.40
Pervious ratio(Ap) = 1.0000     Max loss rate(Fm)=     0.071(In/Hr)
Rainfall intensity =      6.602(In/Hr) for a   100.0 year storm
Effective runoff coefficient used for area,(total area with modified
rational method)(Q=KCIA) is C = 0.880
Subarea runoff =     10.614(CFS) for    3.300(Ac.)
Total runoff =    198.063(CFS)
Effective area this stream =       34.10(Ac.)
Total Study Area (Main Stream No. 1) =      143.07(Ac.)
Area averaged Fm value =    0.148(In/Hr)
Depth of flow =   1.786(Ft.), Average velocity =  15.524(Ft/s)


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station       11.000 to Point/Station        6.000
**** CONFLUENCE OF MINOR STREAMS ****
------------------------------------------------------------------------
Along Main Stream number: 1 in normal stream number 3
Stream flow area =     34.100(Ac.)
Runoff from this stream =    198.063(CFS)
Time of concentration =   11.68 min.
Rainfall intensity =     6.602(In/Hr)
```

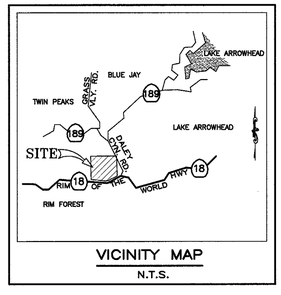
```
Area averaged loss rate (Fm) =    0.1482(In/Hr)
Area averaged Pervious ratio (Ap) = 0.9097
Summary of stream data:

Stream Flow rate    Area     TC      Fm       Rainfall Intensity
 No.    (CFS)    (Ac.)       (min) (In/Hr)      (In/Hr)


1    386.57   100.566     21.12    0.090      4.361
2     31.20     7.300     18.31    0.071      4.820
3    198.06    34.100     11.68    0.148      6.602
Qmax(1) =
         1.000 *    1.000 *   386.573) +
         0.903 *    1.000 *    31.200) +
         0.653 *    1.000 *   198.063) + =     544.054
Qmax(2) =
         1.107 *    0.867 *   386.573) +
         1.000 *    1.000 *    31.200) +
         0.724 *    1.000 *   198.063) + =     545.670
Qmax(3) =
         1.525 *    0.553 *   386.573) +
         1.375 *    0.638 *    31.200) +
         1.000 *    1.000 *   198.063) + =     551.391

Total of 3 streams to confluence:
Flow rates before confluence point:
     386.573      31.200     198.063
Maximum flow rates at confluence using above data:
      544.054      545.670      551.391
Area of streams before confluence:
      100.566        7.300       34.100
Effective area values after confluence:
      141.966      128.575       94.375
Results of confluence:
Total flow rate =    551.391(CFS)
Time of concentration =    11.682 min.
Effective stream area after confluence =     94.375(Ac.)
Study area average Pervious fraction(Ap) =  0.819
Study area average soil loss rate(Fm) =    0.103(In/Hr)
Study area total (this main stream) =     141.97(Ac.)
End of computations, Total Study Area =          143.07 (Ac.)
The following figures may
be used for a unit hydrograph study of the same area.
Note: These figures do not consider reduced effective area
effects caused by confluences in the rational equation.

Area averaged pervious area fraction(Ap) = 0.818
Area averaged SCS curve number =  78.5
```

DRAINAGE MAP
DEVELOPED



Upstream Node	Downstream Node	CN (AMC II)	Ap
15	16	84	1.00
16	17	84	1.00
17	4	N/A	N/A
1	2	84	1.00
2	3	79.3	0.84
3	4	75	0.60
4	12	75	0.50
12	6	84	1.00
13	14	84	1.00
14	6	84	1.00
9	10	75	0.90
10	11	75	0.90
11	6	84	1.00





VICINITY MAP
N.T.S.

REGISTERED PROFESSIONAL ENGINEER
WILLIAM J. McKEEVER
No. 22502
Exp. 12-31-19
CIVIL
STATE OF CALIFORNIA

W.J. McKEEVER, INC.
CIVIL ENGINEERING
900 E. WASHINGTON STREET, SUITE 208
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PH.: (909) 825-8048
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WILLIAM J. McKEEVER, R.C.E. 22502 — DATE 4/24/19

APPENDIX "G"

RATIONAL METHOD ONSITE CALCULATIONS

APPENDIX "G-1"

RATIONAL METHOD HYDRAULIC CALCULATIONS PROPOSED PROJECT AREA UNDEVELOPED (100-YEAR STORM EVENT) AND MAP

San Bernardino County Rational Hydrology Program

(Hydrology Manual Date - August 1986)

CIVILCADD/CIVILDESIGN Engineering Software, (c) 1989-2005 Version 7.1
Rational Hydrology Study Date: 04/18/17

Church of the Woods
Rim Forest
100 Year 1 Hour
On-Site Undeveloped

Program License Serial Number 6222

********* Hydrology Study Control Information **********

Rational hydrology study storm event year is 100.0
10 Year storm 1 hour rainfall = 1.400(In.)
100 Year storm 1 hour rainfall = 2.100(In.)
Computed rainfall intensity:
Storm year = 100.00 1 hour rainfall = 2.100 (In.)
Slope used for rainfall intensity curve b = 0.7000
Soil antecedent moisture condition (AMC) = 3

++
Process from Point/Station 1.000 to Point/Station 2.000
**** INITIAL AREA EVALUATION ****

UNDEVELOPED (average cover) subarea
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
SCS curve number for soil(AMC 2) = 84.00
Adjusted SCS curve number for AMC 3 = 96.40
Pervious ratio(Ap) = 1.0000 Max loss rate(Fm)= 0.071(In/Hr)
Initial subarea data:
Initial area flow distance = 365.000(Ft.)
Top (of initial area) elevation = 5663.100(Ft.)
Bottom (of initial area) elevation = 5590.000(Ft.)
Difference in elevation = 73.100(Ft.)
Slope = 0.20027 s(%)= 20.03
TC = k(0.706)*[(length^3)/(elevation change)]^0.2
Initial area time of concentration = 10.313 min.
Rainfall intensity = 7.204(In/Hr) for a 100.0 year storm
Effective runoff coefficient used for area (Q=KCIA) is C = 0.891
Subarea runoff = 50.969(CFS)
Total initial stream area = 7.940(Ac.)
Pervious area fraction = 1.000
Initial area Fm value = 0.071(In/Hr)

-++
Process from Point/Station 1.000 to Point/Station 2.000

**** CONFLUENCE OF MINOR STREAMS ****

Along Main Stream number: 1 in normal stream number 1
Stream flow area = 7.940(Ac.)
Runoff from this stream = 50.969(CFS)
Time of concentration = 10.31 min.
Rainfall intensity = 7.204(In/Hr)
Area averaged loss rate (Fm) = 0.0710(In/Hr)
Area averaged Pervious ratio (Ap) = 1.0000

++
Process from Point/Station 3.000 to Point/Station 2.000
**** INITIAL AREA EVALUATION ****

UNDEVELOPED (average cover) subarea
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
SCS curve number for soil(AMC 2) = 84.00
Adjusted SCS curve number for AMC 3 = 96.40
Pervious ratio(Ap) = 1.0000 Max loss rate(Fm)= 0.071(In/Hr)
Initial subarea data:
Initial area flow distance = 490.000(Ft.)
Top (of initial area) elevation = 5636.000(Ft.)
Bottom (of initial area) elevation = 5590.000(Ft.)
Difference in elevation = 46.000(Ft.)
Slope = 0.09388 s(%)= 9.39
TC = k(0.706)*[(length^3)/(elevation change)]^0.2
Initial area time of concentration = 13.501 min.
Rainfall intensity = 5.966(In/Hr) for a 100.0 year storm
Effective runoff coefficient used for area (Q=KCIA) is C = 0.889
Subarea runoff = 18.622(CFS)
Total initial stream area = 3.510(Ac.)
Pervious area fraction = 1.000
Initial area Fm value = 0.071(In/Hr)

++
Process from Point/Station 3.000 to Point/Station 2.000
**** CONFLUENCE OF MINOR STREAMS ****

Along Main Stream number: 1 in normal stream number 2
Stream flow area = 3.510(Ac.)
Runoff from this stream = 18.622(CFS)
Time of concentration = 13.50 min.
Rainfall intensity = 5.966(In/Hr)
Area averaged loss rate (Fm) = 0.0710(In/Hr)
Area averaged Pervious ratio (Ap) = 1.0000
Summary of stream data:

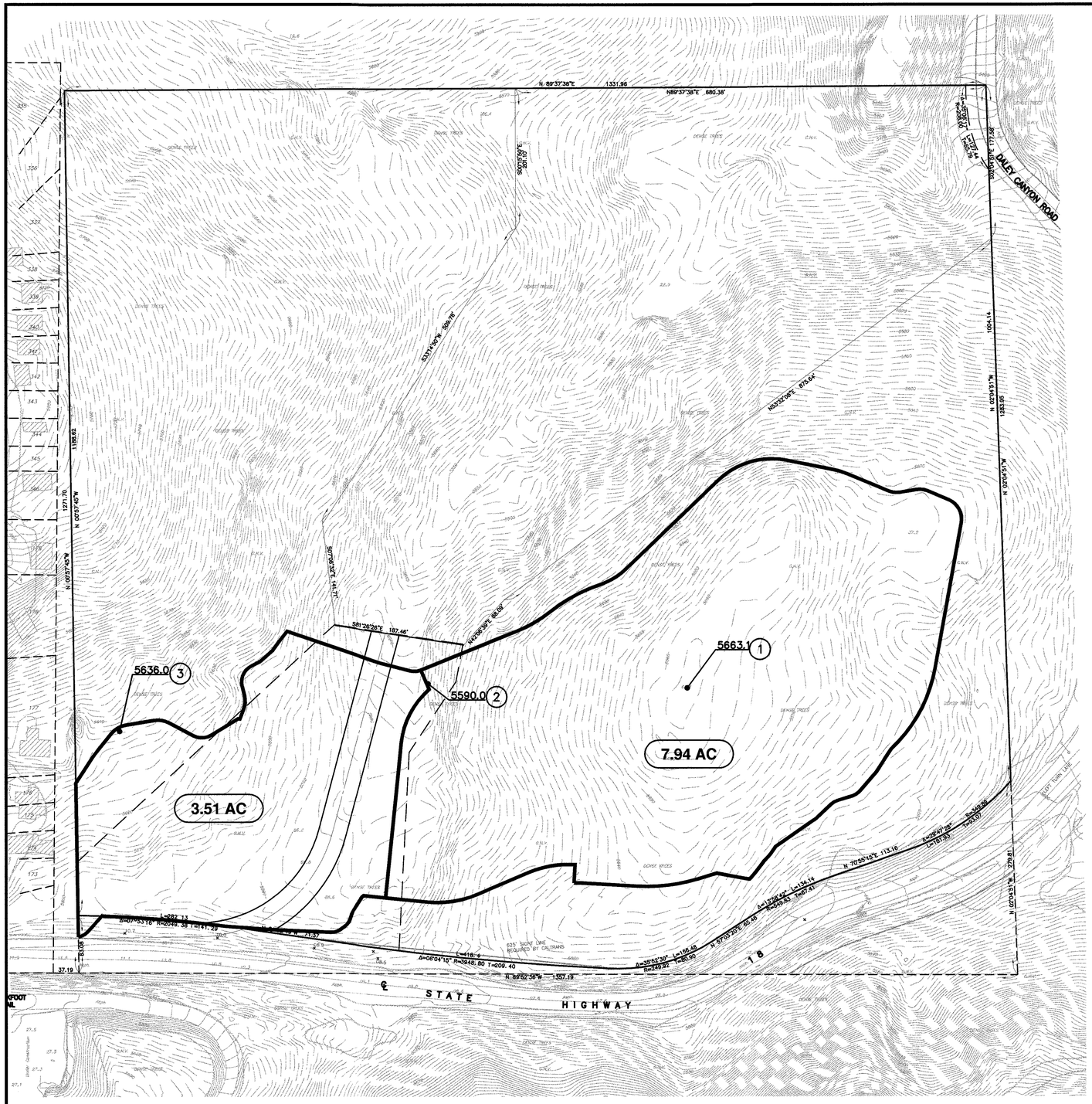
Stream No.	Flow rate (CFS)	Area (Ac.)	TC (min)	Fm (In/Hr)	Rainfall Intensity (In/Hr)
1	50.97	7.940	10.31	0.071	7.204
2	18.62	3.510	13.50	0.071	5.966

Qmax(1) =
1.000 * 1.000 * 50.969) +

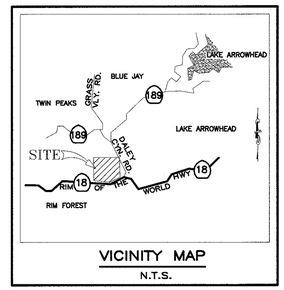
```
         1.210 *    0.764 *    18.622) + =      68.181
Qmax(2) =
         0.826 *    1.000 *    50.969) +
         1.000 *    1.000 *    18.622) + =      60.745

Total of 2 streams to confluence:
Flow rates before confluence point:
      50.969      18.622
Maximum flow rates at confluence using above data:
       68.181       60.745
Area of streams before confluence:
        7.940        3.510
Effective area values after confluence:
       10.621       11.450
Results of confluence:
Total flow rate =     68.181(CFS)
Time of concentration =    10.313 min.
Effective stream area after confluence =     10.621(Ac.)
Study area average Pervious fraction(Ap) =  1.000
Study area average soil loss rate(Fm) =    0.071(In/Hr)
Study area total (this main stream) =      11.45(Ac.)
End of computations, Total Study Area =           11.45 (Ac.)
The following figures may
be used for a unit hydrograph study of the same area.
Note: These figures do not consider reduced effective area
effects caused by confluences in the rational equation.

Area averaged pervious area fraction(Ap) = 1.000
Area averaged SCS curve number =  84.0
```

CHURCH OF THE WOODS

DRAINAGE MAP
UNDEVELOPED



Upstream Node	Downstream Node	CN (AMC II)	Ap
1	2	84	1.00
3	2	84	1.00



VICINITY MAP
N.T.S.

0 40 80 160 240 320
SCALE: 1 INCH = 80 FEET

SEAL–ENGINEER

REGISTERED PROFESSIONAL ENGINEER
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PREPARED BY: WILLIAM J. McKEEVER
R.C.E. NO. 22502
DATE: 4/24/18

DRAINAGE MAP
UNDEVELOPED

CHURCH OF THE WOODS
APN: 336-101-06

LAKE ARROWHEAD

SHEET NO. 1
OF 1 SHEETS

PLOT DATE: 4/20/18

APPENDIX "G-2"

RATIONAL METHOD HYDRAULIC CALCULATIONS PROPOSED PROJECT AREA DEVELOPED (100-YEAR STORM EVENT) AND MAP

San Bernardino County Rational Hydrology Program

(Hydrology Manual Date - August 1986)

CIVILCADD/CIVILDESIGN Engineering Software, (c) 1989-2005 Version 7.1
Rational Hydrology Study Date: 04/18/17

Church of the Woods
Rim Forest
100 Year 1 Hour
On-Site Developed

Program License Serial Number 6222

********* Hydrology Study Control Information **********

Rational hydrology study storm event year is 100.0
10 Year storm 1 hour rainfall = 1.400(In.)
100 Year storm 1 hour rainfall = 2.100(In.)
Computed rainfall intensity:
Storm year = 100.00 1 hour rainfall = 2.100 (In.)
Slope used for rainfall intensity curve b = 0.7000
Soil antecedent moisture condition (AMC) = 3

++
Process from Point/Station 1.000 to Point/Station 2.000
**** INITIAL AREA EVALUATION ****

COMMERCIAL subarea type
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
SCS curve number for soil(AMC 2) = 75.00
Adjusted SCS curve number for AMC 3 = 91.00
Pervious ratio(Ap) = 0.1000 Max loss rate(Fm)= 0.017(In/Hr)
Initial subarea data:
Initial area flow distance = 880.000(Ft.)
Top (of initial area) elevation = 5634.900(Ft.)
Bottom (of initial area) elevation = 5618.000(Ft.)
Difference in elevation = 16.900(Ft.)
Slope = 0.01920 s(%)= 1.92
TC = k(0.304)*[(length^3)/(elevation change)]^0.2
Initial area time of concentration = 10.092 min.
Rainfall intensity = 7.314(In/Hr) for a 100.0 year storm
Effective runoff coefficient used for area (Q=KCIA) is C = 0.898
Subarea runoff = 41.895(CFS)
Total initial stream area = 6.380(Ac.)
Pervious area fraction = 0.100
Initial area Fm value = 0.017(In/Hr)

++
Process from Point/Station 2.000 to Point/Station 3.000

```
**** STREET FLOW TRAVEL TIME + SUBAREA FLOW ADDITION ****
------------------------------------------------------------------------
Top of street segment elevation =  5618.000(Ft.)
End of street segment elevation =  5606.000(Ft.)
Length of street segment  =   530.000(Ft.)
Height of curb above gutter flowline  =    6.0(In.)
Width of half street (curb to crown)  =  18.000(Ft.)
Distance from crown to crossfall grade break  =  16.000(Ft.)
Slope from gutter to grade break (v/hz) =   0.080
Slope from grade break to crown (v/hz)  =   0.020
Street flow is on [2] side(s) of the street
Distance from curb to property line  =  10.000(Ft.)
Slope from curb to property line (v/hz) =   0.020
Gutter width =   2.000(Ft.)
Gutter hike from flowline =  2.000(In.)
 Manning's N in gutter =  0.0150
 Manning's N from gutter to grade break =  0.0150
 Manning's N from grade break to crown =  0.0150
Estimated mean flow rate at midpoint of street =     44.436(CFS)
Depth of flow =   0.533(Ft.), Average velocity =   5.260(Ft/s)
Warning: depth of flow exceeds top of curb
Note:  depth of flow exceeds top of street crown.
Distance that curb overflow reaches into property =    1.64(Ft.)
Streetflow hydraulics at midpoint of street travel:
Halfstreet flow width =  18.000(Ft.)
Flow velocity =   5.26(Ft/s)
Travel time =    1.68 min.     TC =   11.77  min.
 Adding area flow to street
COMMERCIAL subarea type
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
SCS curve number for soil(AMC 2)  = 75.00
Adjusted SCS curve number for AMC 3 = 91.00
Pervious ratio(Ap) = 0.1000     Max loss rate(Fm)=     0.017(In/Hr)
Rainfall intensity =      6.567(In/Hr) for a   100.0 year storm
Effective runoff coefficient used for area,(total area with modified
rational method)(Q=KCIA) is C = 0.898
Subarea runoff =      4.906(CFS) for    1.560(Ac.)
Total runoff =     46.801(CFS)
Effective area this stream =        7.94(Ac.)
Total Study Area (Main Stream No. 1) =        7.94(Ac.)
Area averaged Fm value =    0.017(In/Hr)
Street flow at end of street =     46.801(CFS)
Half street flow at end of street =     23.400(CFS)
Depth of flow =   0.541(Ft.), Average velocity =   5.325(Ft/s)
Warning: depth of flow exceeds top of curb
Note:  depth of flow exceeds top of street crown.
Distance that curb overflow reaches into property =    2.07(Ft.)
Flow width (from curb towards crown)=  18.000(Ft.)


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station        2.000 to Point/Station        3.000
**** CONFLUENCE OF MINOR STREAMS ****
------------------------------------------------------------------------
Along Main Stream number: 1 in normal stream number 1
Stream flow area =      7.940(Ac.)
Runoff from this stream =     46.801(CFS)
```

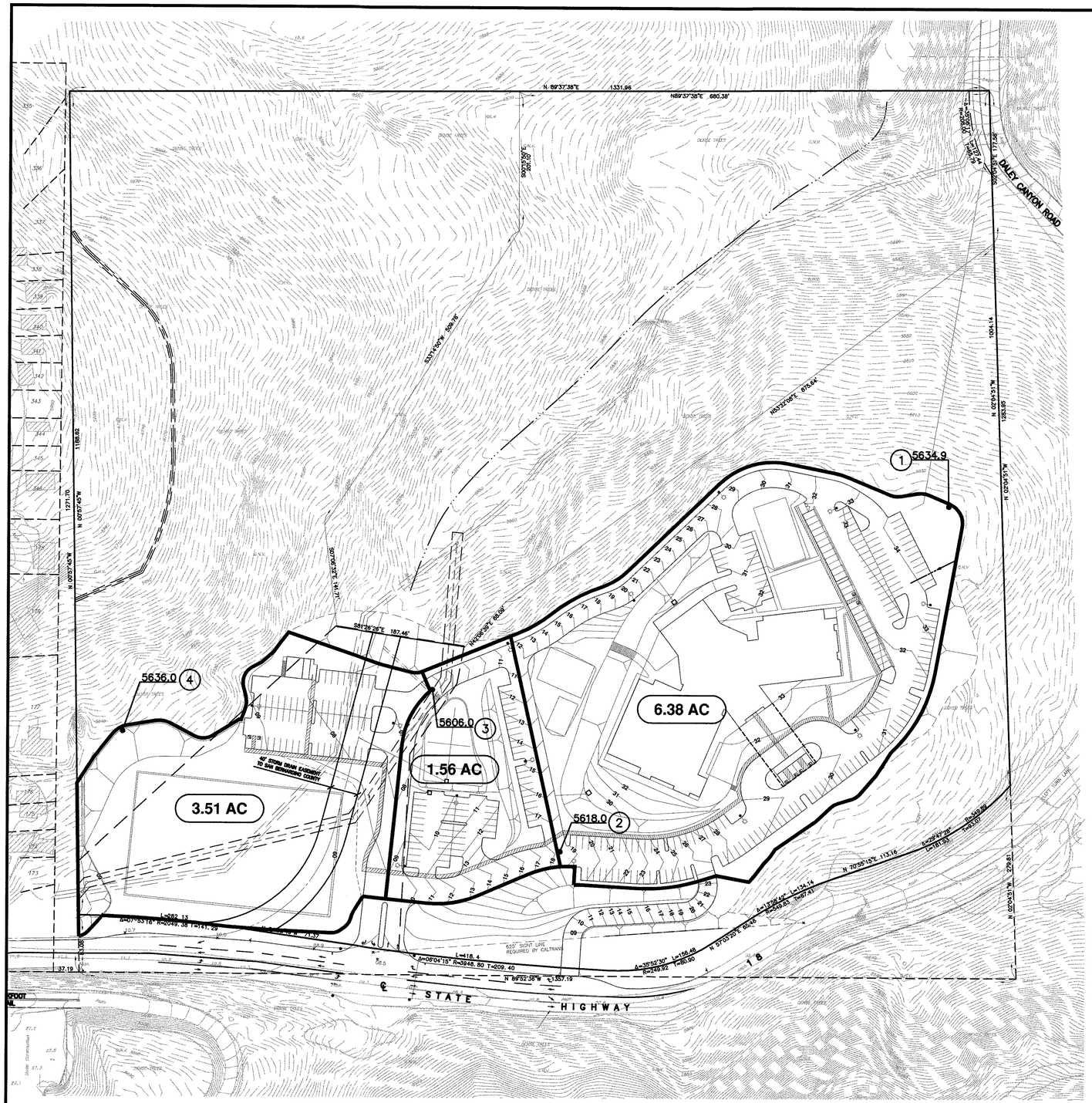
```
Time of concentration =   11.77 min.
Rainfall intensity =     6.567(In/Hr)
Area averaged loss rate (Fm) =    0.0174(In/Hr)
Area averaged Pervious ratio (Ap) = 0.1000


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station        4.000 to Point/Station        3.000
**** INITIAL AREA EVALUATION ****
------------------------------------------------------------------------------
Soil classification AP and SCS  values input by user
USER INPUT of soil data for subarea
SCS curve number for soil(AMC 2)  = 75.00
Adjusted SCS curve number for AMC 3 = 91.00
Pervious ratio(Ap) = 0.7500     Max loss rate(Fm)=     0.130(In/Hr)
Initial subarea data:
Initial area flow distance =   515.000(Ft.)
Top (of initial area) elevation =  5636.000(Ft.)
Bottom (of initial area) elevation =  5606.000(Ft.)
Difference in elevation =    30.000(Ft.)
Slope =    0.05825  s(%)=       5.83
TC = k(0.459)*[(length^3)/(elevation change)]^0.2
Initial area time of concentration =    9.860 min.
Rainfall intensity =      7.434(In/Hr) for a   100.0 year storm
Effective runoff coefficient used for area (Q=KCIA) is C = 0.884
Subarea runoff =     23.071(CFS)
Total initial stream area =        3.510(Ac.)
Pervious area fraction = 0.750
Initial area Fm value =    0.130(In/Hr)


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Process from Point/Station        4.000 to Point/Station        3.000
**** CONFLUENCE OF MINOR STREAMS ****
------------------------------------------------------------------------------
Along Main Stream number: 1 in normal stream number 2
Stream flow area =      3.510(Ac.)
Runoff from this stream =     23.071(CFS)
Time of concentration =    9.86 min.
Rainfall intensity =     7.434(In/Hr)
Area averaged loss rate (Fm) =    0.1303(In/Hr)
Area averaged Pervious ratio (Ap) = 0.7500
Summary of stream data:

Stream Flow rate    Area     TC      Fm       Rainfall Intensity
 No.     (CFS)    (Ac.)       (min) (In/Hr)      (In/Hr)


1     46.80     7.940     11.77    0.017      6.567
2     23.07     3.510      9.86    0.130      7.434
Qmax(1) =
         1.000 *    1.000 *    46.801) +
         0.881 *    1.000 *    23.071) + =      67.133
Qmax(2) =
         1.132 *    0.838 *    46.801) +
         1.000 *    1.000 *    23.071) + =      67.463

Total of 2 streams to confluence:
Flow rates before confluence point:
      46.801      23.071
```

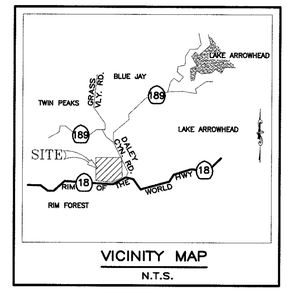
```
Maximum flow rates at confluence using above data:
       67.133       67.463
Area of streams before confluence:
        7.940        3.510
Effective area values after confluence:
       11.450       10.161
Results of confluence:
Total flow rate =     67.463(CFS)
Time of concentration =     9.860 min.
Effective stream area after confluence =     10.161(Ac.)
Study area average Pervious fraction(Ap) =  0.299
Study area average soil loss rate(Fm) =    0.052(In/Hr)
Study area total (this main stream) =      11.45(Ac.)
End of computations, Total Study Area =           11.45 (Ac.)
The following figures may
be used for a unit hydrograph study of the same area.
Note: These figures do not consider reduced effective area
effects caused by confluences in the rational equation.

Area averaged pervious area fraction(Ap) = 0.299
Area averaged SCS curve number =  75.0
```

CHURCH OF THE WOODS

DRAINAGE MAP
DEVELOPED

Upstream Node	Downstream Node	CN (AMC II)	Ap
1	2	75	0.10
2	3	75	0.10
4	3	75	0.75





VICINITY MAP
N.T.S.

0 40 80 160 240 320
SCALE: 1 INCH = 80 FEET

SEAL–ENGINEER

REGISTERED PROFESSIONAL ENGINEER
WILLIAM J. McKEEVER
No. 22502
Exp. 12-31-19
CIVIL
STATE OF CALIFORNIA

W.J. McKEEVER, INC.
CIVIL ENGINEERING
900 E. WASHINGTON STREET, SUITE 208 COLTON, CA 92324
PH:(909) 825-8048 FAX:(909) 825-8639

PREPARED BY: WILLIAM J. McKEEVER
R.C.E. NO. 22502
DATE: 9/24/18

DRAINAGE MAP
DEVELOPED

CHURCH OF THE WOODS
APN: 336-101-06

LAKE ARROWHEAD

SHEET NO. 1
OF 1 SHEETS

PLOT DATE: 4/24/18

APPENDIX "H"

CAPACITY CALCULATIONS

60" Storm Drain Capacity

OUTPUT INFORMATION

This report is for a channel running full.

The Flow Capacity is 504.7 cfs
The flow velocity is 25.71 fps

CHANNEL PROPERTIES

The friction factor 'n' = 0.0150
The channel slope = 0.0500 ft/ft

Round Channel:

Diameter = 5.000 ft
Flow Area = 19.63 sq-ft
Wetted perimiter = 15.71 ft
Hydraulic radius = 1.250 ft

APPENDIX "I"

PREVIOUSLY APPROVED WATER QUALITY MANAGEMENT PLAN

From: Dillon, Jonathan <jdillon@dpw.sbcounty.gov>

To: Duron, Heidi - LUS <Heidi.Duron@lus.sbcounty.gov>

Cc: 'gmeluski@wjmckeeverinc.com' <gmeluski@wjmckeeverinc.com>, Pham, Anthony <apham@dpw.sbcounty.gov>

Date: Friday, May 13, 2011 10:55 am

Subject: PH11697CF1; Church of the Woods; 0336-101-06

Heidi,

Land Development has completed the review of the Preliminary WQMP, dated May 02, 2011, for the Church of the Woods project mentioned above and find it acceptable. Review and acceptance of a finalized WQMP will be required prior to issuance of grading permits or land disturbing activity.

Thanks,

Jonathan Dillon
Land Development Division
Department of Public Works
San Bernardino County
(909) 387-7988

Attachments:

WATER QUALITY MANAGEMENT PLAN (WQMP)

For compliance with Lahontan Regional Water Quality Control Board

Water Quality Order No. 2003-2005-DWG
WDID No. 6B36SM40301

For:
Church of the Woods
Highway 18
Rim Forest, CA
APN 0336-101-06

Prepared for:
Church of the Woods
1410 Calgary Drive
P.O. Box 2000
Lake Arrowhead, CA 92352

Prepared By:
W. J. McKeever, Inc.
900 E. Washington Street, Ste. 208
Colton, CA 92324
Phone (909) 825-8048
Fax (909) 825-8639

WQMP Preparation Date
February 3, 2011
Revised March 24, 2011
Revised May 2, 2011

TABLE OF CONTENTS

ATTACHMENTS

ATTACHMENT A	MAINTENANCE MECHANISMS
ATTACHMENT B	VICINITY MAP, WQMP SITE PLAN
ATTACHMENT C	POLLUTANTS OF CONCERN
ATTACHMENT D	FLOW AND VOLUME BASED BMP DESIGN CALCULATIONS
ATTACHMENT E	EDUCATIONAL INFORMATION / BMP FACT SHEETS

WATER QUALITY MANAGEMENT PLAN (WQMP)

PROJECT SITE INFORMATION

Name of Project: Church of the Woods

Project Location: Highway 18, Rim Forest, CA

Size of Significant Re-Development on an Already Developed Site (in feet²): N/A

Size of New Development (in feet²): 1,001,880 SF

Number of Home Subdivisions: N/A

SIC Codes: 8661 Religious Organizations

Erosive Site Conditions?: Yes

Natural Slope More Than 25%?: Yes

WATER QUALITY MANAGEMENT PLAN (WQMP)

Check the appropriate project category below:

Check below	**Project Categories**
	1. All significant re-development projects. Significant re-development is defined as the addition or creation of 5,000 or more square feet of impervious surface on an already developed site. This includes, but is not limited to, additional buildings and/or structures, extension of existing footprint of a building, construction of parking lots, etc. Where redevelopment results in an increase of less than fifty percent of the impervious surfaces of a previously existing development, and the existing development was not subject to SUSMPs, the design standards apply only to the addition, and not the entire development. When the redevelopment results in an increase of more than fifty percent of the impervious surfaces, then a WQMP is required for the entire development (new and existing).
	2. Home subdivisions of 10 units or more. This includes single family residences, multi-family residence, condominiums, apartments, etc.
✓	3. Industrial/commercial developments of 100,000 square feet or more. Commercial developments include non-residential developments such as hospitals, educational institutions, recreational facilities, mini-malls, hotels, office buildings, warehouses, and light industrial facilities.
	4. Automotive repair shops (with SIC codes 5013, 5014, 5541, 7532-7534, 7536-7539).
	5. Restaurants where the land area of development is 5,000 square feet or more.
✓	6. Hillside developments of 10,000 square feet or more which are located on areas with known erosive soil conditions or where the natural slope is twenty-five percent or more.
	7. Developments of 2,500 square feet of impervious surface or more adjacent to (within 200 feet) or discharging directly into environmentally sensitive areas such as areas designated in the Ocean Plan as areas of special biological significance or water bodies listed on the CWA Section 303(d) list of impaired waters.
✓	8. Parking lots of 5,000 square feet or more exposed to storm water. Parking lot is defined as land area or facility for the temporary storage of motor vehicles.
	The project does not fall into any of the categories described above. (If the project requires a precise plan of development [e.g. all commercial or industrial projects, residential projects of less than 10 dwelling units, and all other land development projects with potential for significant adverse water quality impacts] or subdivision of land, it is defined as a Non-Category Project.)

SECTION 1 - INTRODUCTION AND PROJECT DESCRIPTION

1.1 PROJECT INFORMATION

Owner Information
Church of the Woods
1410 Calgary Drive
P.O Box 2000
Lake Arrowhead, CA 92352

Project Site Address
Highway 18
Rim Forest, CA

1.2 PERMITS – CONDITIONAL USE PERMIT, FISH & GAME STREAM ALTERATION, 404 ARMY CORPS OF ENGINEERS (TO BE OBTAINED)

1.3 PROJECT DESCRIPTION - COMMERCIAL

The Church of the Woods project includes an assembly/youth center, an auditorium and children's ministry, a maintenance building/caretaker unit, a 1,200 seat worship center, a chapel retreat building, various recreational fields and facilities, and parking. The facilities would be developed on 37 acres in the community of Rim Forest.

The proposed project would result in the development of approximately 23 acres of the 37-acre site (63 percent) of the project site (9.4 acres of structures, drives, walks and drainage features; 13.8 acres of sports fields, play areas, recreation, landscaping and landscaped manufactured slopes). The remaining 13.7 acres (37 percent) of the site would be retained as open space, including hiking trails and some fuel modification zones within the forested areas.

1.4 SITE DESCRIPTION

The project lies within the Lahontan Region. The proximate receiving waters are as follows: Little Bear Creek, Lake Arrowhead.

SECTION 2 - POLLUTANTS OF CONCERN

2.1 POLLUTANTS OF CONCERN (NOT REQUIRED FOR NON-CATEGORY PROJECTS)

The expected pollutants are bacteria/virus, heavy metals, nutrients, pesticides, organic compounds, sediments, trash and debris, oxygen demanding substances and oil & grease.

The proximate receiving waters for the point of discharge and all downstream receiving waters were identified using the most recent version of the Water Quality Control Plan for the Mojave River Hydrologic Area. The proximate receiving waters are as follows: Little Bear Creek, Lake Arrowhead.

The proximate and downstream receiving waters that were identified in the most recent list of Clean Water Act Section 303(d) (CWA 303(d) List) were none, verified with Lahontan Regional Board Southern Section.

Table 2.1 Pollutant of Concern Summary, which identifies the expected, potential pollutants as well as pollutants identified in the receiving waters.

TABLE 2.1 POLLUTANT OF CONCERN SUMMARY TABLE

Pollutant Type	Expected	Potential	Listed for Receiving Water
Bacteria/Virus	✔		Little Bear Creek
Heavy Metals	✔		
Nutrients	✔		
Pesticides	✔		
Organic Compounds	✔		
Sediments	✔		
Trash & Debris	✔		
Oxygen Demanding Substances	✔		
Oil & Grease	✔		
Other—specify pollutant(s):			

Table 2-1 (adapted from OC 2003)
Pollutants of Concern for Project Categories and Land Uses

Project Categories/Land Uses	General Pollutant Categories								
	Bacteria/Virus	Heavy Metals	Nutrients	Pesticides	Organic Compounds	Sediments	Trash & Debris	Oxygen Demanding Substances	Oil & Grease
Residential Development (Detached)	E	N	E	E	N	E	E	E	E
Residential Development (Attached)	P	N	E	E	N	E	E	P(1)	P(2)
Industrial/Commercial Development (>100,000 ft²)	P(3)	P	P(1)	P(1)	P(5)	P(1)	E	P(1)	E
Automotive Repair Shops	N	P	N	N	E(4,5)	N	E	N	E
Restaurants (>5,000 ft²)	E	N	N	N	N	N	E	E	E
Hillside Development (>10,000 ft²)	E	N	E	E	N	E	E	E	E
Parking Lots (>5,000 ft²)	P(6)	E	P(1)	P(1)	E(4)	P(1)	E	P(1)	E
Streets/Highways/Freeways	P(6)	E	P(1)	P(1)	E(4)	E	E	P(1)	E

E = expected.
P = potential.
N = not expected
(1) A potential Pollutant if landscaping or open area is present on site.
(2) A potential Pollutant if the project includes uncovered parking areas.
(3) A potential pollutant if land use involves animal waste.
(4) Including petroleum hydrocarbons.
(5) Including solvents.
(6) Bacterial indicators are routinely detected in pavement runoff.

SECTION 3- BEST MANAGEMENT PRACTICE SELECTION PROCESS

3.1 SITE DESIGN BMPS

1. *Minimize Stormwater Runoff, Minimize Project's Impervious Footprint, and Conserve Natural Areas*		
Maximize the permeable area. This can be achieved in various ways, including but not limited to, increasing building density (number of stories above or below ground) and developing land use regulations seeking to limit impervious surfaces.		
Yes ✔	No	
Describe actions taken or justification/alternative: *The project will provide permeable landscape areas in the parking lot and around the building. There will also be landscaped sports fields.*		
Using alternative materials or surfaces with a lower Coefficient of Runoff, or "C-Factor" may reduce runoff from developed areas.		
Yes	No ✔	
Describe actions taken or justification/alternative: *Not being proposed. Due to concern about product sustainability in a mountain environment.*		
Conserve natural areas. Concentrating or clustering development on the least environmentally sensitive portions of a site while leaving the remaining land in a natural, undisturbed condition can achieve this.		
Yes ✔	No	
Describe actions taken or justification/alternative: *37% of the site is being left natural.*		
Construct walkways, trails, patios, overflow parking lots, alleys, driveways, low-traffic streets, and other low-traffic areas with open-jointed paving materials or permeable surfaces, such as pervious concrete, porous asphalt, unit pavers, and granular materials.		
Yes	No ✔	
Describe actions taken or justification/alternative *Not being proposed due to concern about product sustainability in a mountain environment.*		
Construct streets, sidewalks, and parking lot aisles to the minimum widths necessary, provided that public safety and a pedestrian friendly environment are not compromised[1]. Incorporate landscaped buffer areas between sidewalks and streets.		
Yes ✔	No	
Describe actions taken or justification/alternative: *Hardscape areas are designed to minimum widths, landscape added and depressed 3" minimum below surrounding hardscape. Sports fields depressed 6".*		

[1] Sidewalk widths must still comply with Americans with Disabilities Act regulations and other life safety requirements.

Reduce widths of street where off-street parking is available[2].		
Yes	No ✔	
Describe actions taken or justification/alternative: *No street parking is proposed.*		
Maximize canopy interception and water conservation by preserving existing native trees and shrubs, and planting additional native or drought tolerant trees and large shrubs.		
Yes ✔	No	
Describe actions taken or justification/alternative: *Existing trees and shrubs where possible will remain in place. New landscaping areas are proposed.*		
Other comparable site design options that are equally effective		
Describe actions taken or justification/alternative: *Alternative building materials – roof of new buildings to be coated metal. Storm drain inserts will be placed in all new catch basins.*		
Minimize the use of impervious surfaces, such as decorative concrete, in the landscape design.		
Yes ✔	No	
Describe actions taken or justification/alternative: *No decorative concrete is proposed.*		
Use natural drainage systems.		
Yes	No ✔	
Describe actions taken or justification/alternative: *No natural swales remain on developed portion of site.*		
Where soils conditions are suitable, use perforated pipe or gravel filtration pits for low flow infiltration[3].		
Yes	No ✔	
Describe actions taken or justification/alternative: *Available landscape areas are not suitable.*		
Construct onsite ponding areas, rain gardens, or retention facilities to increase opportunities for infiltration, while being cognizant of the need to prevent the development of vector breeding areas.		
Yes	No ✔	
Describe actions taken or justification/alternative: *All landscape areas will be depressed 3" below top of curb, sports fields will be depressed 6" to promote infiltration and self contain pollutants, if any. Landscape areas sports fields can be seen in the Site Plan "Attachment B" of this report.*		

[2] However, street widths must still comply with life safety requirements for fire and emergency vehicle access.

[3]However, projects must still comply with hillside grading ordinances that limit or restrict infiltration of runoff. Infiltration areas may be subject to regulation as Class V injection wells and may require a report to the USEPA. Consult the Agency for more information on use of this type of facility.

2. *Minimize Directly Connected Impervious Areas*

Where landscaping is proposed, drain rooftops into adjacent landscaping prior to discharging to the storm drain.

Yes ✔	No	

Describe actions taken or justification/alternative: *All roof drains will exit into landscape areas where possible. Pop up emitters will be placed on roof drains to prevent erosion.*

Where landscaping is proposed, drain impervious sidewalks, walkways, trails, and patios into adjacent landscaping.

Yes ✔	No	

Describe actions taken or justification/alternative: *All impervious areas will be directed to a depressed landscape area, where possible.*

Increase the use of vegetated drainage swales in lieu of underground piping or imperviously lined swales.

Yes ✔	No	

Describe actions taken or justification/alternative: *All impervious parking and the building areas will be directed to a bioretention basin prior to leaving site.*

Use one or more of the following:

Yes	No	Design Feature
	✔	Rural swale system: street sheet flows to vegetated swale or gravel shoulder, curbs at street corners, culverts under driveways and street crossings
✔		Urban curb/swale system; street slopes to curb; periodic swale inlets drain to vegetated swale/biofilter.
✔		Dual drainage system: First flush captured in street catch basins and discharged to adjacent vegetated swale or gravel shoulder, high flows connect directly to municipal storm drain systems.
✔		Other comparable design concepts that are equally effective.

Describe actions taken or justification/alternative: *All landscape areas including sports fields will be depressed (landscape areas 3", sports fields 6").*

Use one or more of the following features for design of driveways and private residential parking areas:

Yes	No	Design Feature
✔		Design driveways with shared access, flared (single lane at street) or wheel strips (paving only under tires); or, drain into landscaping prior to discharging to the municipal storm drain system.
	✔	Uncovered temporary or guest parking on private residential lots may be paved with a permeable surface; or designed to drain into landscaping prior to discharging to the municipal storm drain system.
	✔	Other comparable design concepts that are equally effective.

Describe actions taken or justification/alternative: *Single access for church and sports facilities. Openings will be placed in berm at driveway returns to drain to adjacent landscape (See Site Plan).*

Use one or more of the following design concepts for the design of parking areas:

Yes	No	Design Feature
✓		Where landscaping is proposed in parking areas, incorporate landscape areas into the drainage design.
	✓	Overflow parking (parking stalls provided in excess of the Agency's minimum parking requirements) may be constructed with permeable paving.
	✓	Other comparable design concepts that are equally effective.

Describe actions taken or justification/alternative: *Landscape areas proposed in the parking lot and around the buildings will be incorporated into the drainage design. All parking areas will drain to the bioretention basin.*

3.2 3.2 SOURCE CONTROL BMP'S

Table 3.2 depicts the Source Control BMP's that will be used within the project. The checked BMP's will be implemented for the project.

The following items describe the responsible party(ies) and implementation of Source Control BMP's. Attachment A provides tables / fact sheets pertaining to this WQMP's applicable BMP's.

Education of Property Owners – Attachment E of the WQMP contains educational material pertaining to the training for property owners. Some of the educational materials discuss, but are not limited to, recycling grease and oil, pouring washwater into a mop sink, keeping the dumpster area clean and using dry cleaning methods for spills. These, along with the other educational materials can be found in Attachment E of the WQMP. Owners will familiarize themselves with the educational materials provided in Attachment E of the WQMP.

Activity Restrictions – The property owner shall adhere to the approved Water Quality Management Report. This includes material pertaining to activity restrictions such as the prohibition of blowing, sweeping or hosing debris into streets and storm drain inlets. This Water Quality Management Plan along with activity restrictions will be included in the lease agreements.

Employee Training / Education Program – The owner shall provide regular training sessions to employees regarding practices that will help protect contaminated runoff from entering the storm drain system. Initial training shall be performed at the initial hiring and, at a minimum, annually. Training for employees shall include the review of educational materials found in Attachment E of the WQMP and resources found on the County of San Bernardino Storm Water Program website (http://www.sbcounty.gov/stormwater/index.htm) and the State Water Resources Control Board (http://www.waterboards.ca.gov/water_issues/programs/stormwater/training.shtml) websites. More information can be found in the educational materials section found in Attachment E of the WQMP.

Street Sweeping Private Streets and Parking Lots – Street sweeping shall be conducted at least once quarterly and also prior to the rainy season. More information can be found in the educational materials found in Attachment E of the WQMP, specifically BMP SC-43.

Common Area Catch Basin Inspection – The property owner will provide inspection at least once each quarter to reduce the amount of sediment, garden waste and trash entering the storm drain system.

Landscape Planning (SD-10) – The property owner will provide landscaping within the parking lot and planters throughout the project area. Landscaping will correlate to the climate and soil and will be consistent with the county administrative design guidelines. All landscaped areas are depressed 3" below the top of curb to promote infiltration and self contain pollutants, if any. More information can be found in the educational materials found in Attachment E of the WQMP.

Roof Runoff Controls (SD-11) – Roof runoff pop up emitters will be placed at all areas where roof drains outlet into landscape areas adjacent to buildings.

Efficient Irrigation (SD-12) – Attachment E of the WQMP contains educational material discussing aspects of irrigation and landscape maintenance such as periodic testing and observation of the irrigation system to detect overspray, broken sprinkler heads, and other system failures. More information can be found in the educational materials found in Attachment E of the WQMP.

Alternative Building Materials (SD-21) – The new roof on the proposed building will be coated metal.

Trash Storage Areas (SD-32) and Litter Control – Trash storage areas are proposed within the project and its location can be seen in Attachment B of this report. Some practices include:

- All solid and liquid wastes, such as tallow, must be stored and transferred in watertight covered containers.
- The trash storage area has a permanent solid roof over it.

Hillside Landscaping – Hillside areas that are disturbed by project development shall be landscaped with deep-rooted, drought-tolerant plant species selected for erosion control.

Protect Slopes – All slopes will be landscaped and maintained to prevent erosion.

Energy Dissipater – The property owner will provide 20' x 40' grouted riprap splash pad with 6" minimum diameter rocks located on the northern end of the storm drain. The riprap splash pads can be seen in Attachment B of this report.

Storm Drain Signage (SD-13) – The Owner shall provide and maintain a stenciling or labeling of all storm drain inlets and catch basins constructed or modified within the project area with prohibitive language (such as "No Dumping – Only Rain in the Drain") and/or graphical icons to discourage illegal dumping.

Inlet Trash Racks (MP-52) – Inlet trash racks will be installed at all new catch basins. Trash racks will be inspected by the Owner on a periodic basis when street sweeping occurs. An additional inspection will be made prior to the rainy season.

Wash Water Controls for Food Preparation Areas – The property will be consistent with the California Health and Safety Code 27520, stating that food establishments shall have contained areas for floor sinks and/or mop sinks with sanitary connections for cleaning of kitchen floor mats and for disposal of wash waters containing kitchen and food wastes. Signs specifically stating the prohibition of discharging wash water to the storm drain shall be posted where appropriate.

Note: All source control BMP's mentioned are excerpts taken from the 2003 CASQA BMP Handbook.

TABLE 3.2 SOURCE CONTROL BMP SELECTION MATRIX

Project Category	Source Control BMPs																							
	Education of Property Owners	Activity Restrictions	Spill Contingency Plan	Employee Training/Education Program	Street Sweeping Private Street and Parking Lots	Common Areas Catch Basin Inspection	Landscape Planning (SD-10)	Hillside Landscaping	Roof Runoff Controls (SD-11)	Efficient Irrigation (SD-12)	Protect Slopes and Channels	Storm Drain Signage (SD-13)	Inlet Trash Racks	Energy Dissipaters	Trash Storage Areas (SD-32) and Lifter Control	Fueling Areas (SD-30)	Air/Water Supply Area Drainage	Maintenance Bays and Docks (SD-31)	Vehicle Washing Areas (SD-33)	Outdoor Material Storage Areas (SD-34)	Outdoor Work Areas (SD-35)	Outdoor Processing Areas (SD-36)	Wash Water Controls for Food Preparation Areas	Pervious Pavement (SD-20)	Alternative Building Materials (SD-21)
Significant Re-development																								
Home subdivisions of 10 or more units																								
Commercial/ Industrial Development >100,000 ft²	✔	✔		✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔								✔	✔
Automotive Repair Shop																								
Restaurants																								
Hillside Development >10,000 ft²	✔	✔		✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔									
Development of impervious surface >2,500 ft²																								
Parking Lots >5,000 ft² of exposed storm water	✔	✔		✔	✔	✔	✔	✔	✔	✔					✔									✔

* Provide justification of each Source Control BMP that will not be incorporated in the project WQMP, or explanation of proposed equally effective alternatives in the following table.

Justification for Source Control BMPs not Incorporated into the project WQMP			
Source Control BMP	Used in Project	Justification/Alternative*	Implementation Description
Education of Property Owners	✓		See Page 12
Activity Restrictions	✓		See Page 12
Spill Contingency Plan		*Not required per Co. of S.B. Business Emergency Contingency Guidelines*	
Employee Training/Education Program	✓		See Page 12
Street Sweeping Private Street and Parking Lots	✓		See Page 12
Common Areas Catch Basin Inspection	✓		See Page 12
Landscape Planning (SD-10)	✓		See Page 12
Hillside Landscaping	✓		See Page 12
Roof Runoff Controls (SD-11)	✓		See Page 12
Efficient Irrigation (SD-12)	✓		See Page 12
Protect Slopes and Channels	✓		See Page 13
Storm Drain Signage (SD-13)	✓		See Page 13
Inlet Trash Racks	✓		See Page 13
Energy Dissipaters	✓		See Page 13
Trash Storage Areas (SD-32) and Litter Control	✓		See Page 12
Fueling Areas (SD-30)		*No fueling areas proposed*	
Air/Water Supply Area Drainage		*No air/water supply area drainage proposed*	
Maintenance Bays and Docks (SD-31)		*No maintenance bays and/or docks proposed*	
Vehicle Washing Areas (SD-33)		*No vehicle washing areas proposed*	
Outdoor Material Storage Areas (SD-34)		*No outdoor material storage areas proposed*	
Outdoor Work Areas (SD-35)		*No outdoor work areas proposed*	
Outdoor Processing Areas (SD-36)		*No outdoor processing area proposed*	
Wash Water Controls for Food Preparation Areas	✓		See Page 13
Pervious Pavement (SD-20)		*Concerns about product sustainability in a mountain environment*	
Alternative Building Materials (SD-21)	✓	*Coated metal roofing*	See Page 12
*Attach additional sheets if necessary for justification.			

3.3 TREATMENT CONTROL BMPS (NOT REQUIRED FOR NON-CATEGORY PROJECTS)

The expected pollutants are bacteria/virus, heavy metals, nutrients, pesticides, organic compounds, sediments, trash and debris, oxygen demanding substances and oil & grease.

The treatment control BMPs that will be used for this project is a bioretention basin. This BMP will be used for treatment of the expected pollutants of concern.

Pollutant of Concern	Treatment Control BMP Categories							
	Biofilters	Detention Basins[2]	Infiltration Basins[3]	Wet Ponds or Wetlands	Filtration	Water Quality Inlets	Hydrodynamic Separator Systems [4]	Manufactured/ Proprietary Devices
Sediment/Turbidity	H/M	M	H/M	H/M	H/M	L	H/M (L for turbidity)	U
Yes/No? YES	✓							
Nutrients	L	M	H/M	H/M	L/M	L	L	U
Yes/No? YES	✓							
Organic	U	U	U	U	H/M	L	L	U
Yes/No? YES	✓							
Trash & Debris	L	M	U	U	H/M	M	H/M	U
Yes/No? YES	✓							
Oxygen Demanding Substances	L	M	H/M	H/M	H/M	L	L	U
Yes/No? YES	✓							
Bacteria & Viruses	U	U	H/M	U	H/M	L	L	U
Yes/No? YES	✓							
Oils & Grease	H/M	M	U	U	H/M	M	L/M	U
Yes/No? YES	✓							
Pesticides (non-soil bound)	U	U	U	U	U	L	L	U
Yes/No? YES	✓							
Metals	H/M	M	H	H	H	L	L	U
Yes/No? YES	✓							

3.4 BMP DESIGN CRITERIA

- The following Treatment Control BMP(s) (Flow Based or Volume Based) will be implemented for this project (***check "Implemented" box, if used***):

Design Basis of Treatment Control BMPs

Implemented	Treatment Control BMP	Design Basis
	Vegetated Buffer Strips	Flow Based
	Vegetated Swale	
	Multiple Systems	
	Manufactured/Proprietary	
✓	Bioretention	Volume Based
	Wet Pond	
	Constructed Wetland	
	Extended Detention Basin	
	Water Quality Inlet	
	Retention/Irrigation	
	Infiltration Basin	
	Infiltration Trench	
	Media Filter	
	Manufactured/Proprietary	

3.4.1 Flow Based Design Criteria

The flow based calculations for this report can be seen in Attachment D of this report.

3.4.2 Volume-Based Design Criteria

The volume based calculations for this report can be seen in Attachment D of this report.

SECTION 4 - OPERATION AND MAINTENANCE

4.1 OPERATIONS AND MAINTENANCE

The owner will implement long-term Operation and Maintenance (O&M) for each Site Design, Source Control, and Treatment Control BMP. The following table describes each BMP implementation (including special handling and placement of any wastes, BMP start up dates, and a schedule of frequency of O&M for each BMP). The following site design BMPs that require O&M were identified as:

4.1.1 O&M DESCRIPTION AND SCHEDULE

BMP OPERATIONS AND MAINTENANCE				
BMP Description	**Start up date**	**Maintenance responsibility**	**Funding source**	**Maintenance schedule**
Education of Property Owners Property owners will receive practical educational materials on general housekeeping practices that contribute to the protection of stormwater quality. Educational materials will utilize brochures obtained from the County of San Bernardino Stormwater Program (www.co-san-bernardino.ca.us/flood/npdes). Informafion will consist of educational materials found in Attachment E of this report.	*Before operations begin*	*Owner*	*Owner*	*Once upon initial occupancy of tenant and contracted services, and annually thereafter.*
Employee Training The owner will provide regular formal and informal training sessions to employees regarding general housekeeping practices that contribute to the protection of stormwater quality, BMPs, stormwater discharge prohibitions, wastewater discharge conducted during orientation and a follow-up annually thereafter. Training will consist of reviewing information on the County of San Bernardino Stormwater Program (www.co-san-bernardino.ca.us/flood/npdes). Further educational materials on this BMP can be found in Attachment E of this report.	*Before operations begin*	*Owner*	*Owner*	*Once upon initial hire date and annually thereafter.*
Street Sweeping Parking Lot Private parking lots will be swept at least quarterly of each year including prior to the storm season (October 1 – April 30 each year) in the late summer or early fall, to reduce the amount of sediment, garden waste, and trash entering from storm drain systems. Further educational materials on this BMP can be found in Attachment E of this report.	*Before operations begin*	*Owner*	*Owner*	*Quarterly*

Landscape Planning and Maintenance (SD-10) Landscaping throughout the project will include drought tolerant plantings resulting in water conservation. Landscaping will correlate to the climate, soil, related natural resources and existing vegetation of the project area. Ongoing maintenance will be consistent with the County Administrative Guidelines available at (http://www.co.san-bernardino.ca.us/landuseservices/Informational%20Handouts/Administative%20Design%20Guidelines-Jan%202002.pdf) or local equivalent, plus fertilizer and pesticide usage consistent with the instructions contained on product labels and with the regulations administered by the state Department of Pesticide Regulation shall be implemented. The owner will implement practices to maintain the landscaping, some of which include: 1. Inspect irrigation system if any signs of malfunction have occurred. 2. If malfunction found, repair the irrigation equipment immediately. 3. If mulch is used, replenish mulch. 4. Weeding and removal of litter if weeding and/or litter is visible. Further educational materials on this BMP can be found in Attachment E of this report.	*Before operations begin*	*Owner*	*Owner*	*Monthly*
Efficient Irrigation / Landscape and Maintenance (SD-12) The owner will practice methods that will minimize runoff of excess irrigation water across impervious surfaces and into the stormwater conveyance system. Methods include: rain triggered shutoff devices, use of mulch/wood chips, and strategic irrigation planning. Strategic irrigation planning includes but not limited to: flow reducers, shut off valves, use of programmable devices, and soil moisture sensors. The owner will implement practices to maintain the landscaping, some of which include: 1. Inspect irrigation system if any signs of malfunction have occurred. 2. If malfunction found, repair the irrigation equipment immediately. 3. If mulch is used, replenish mulch. 4. Weeding and removal of litter if weeding and/or litter is visible. Further educational materials on this BMP can be found in Attachment E of this report.	*Before operations begin*	*Owner*	*Owner*	*Monthly*
Trash Storage Areas (SD-32) / Litter Control The owner will implement common litter control. Some practices that will be implemented are: 1. All solid and liquid wastes, such as tallow, must be stored and transferred in watertight covered containers. 2. Notify all employees to utilize trash receptacles. Further educational materials on this BMP can be found in Attachment E of this report.	*Before operations begin*	*Owner*	*Owner*	*Daily*

Common Area Catch Basin Inspection The owner will conduct catch basin inspections throughout the project limits annually. In the late summer or early fall, and cleaned as needed or if the catch basin fills up to 25% of debris/sediment. Reports of the findings will be consistent with city/county rules and regulations	*Before operations begin*	*Owner*	*Owner*	*Bi-annually*
Storm Drain Inserts The owner will make sure all storm drain inserts are installed correctly and clean. (Remove existing grate/storm drain cover, install filter (or clean). Then replace grate/storm drain cover.	*Before operations begin*	*Owner*	*Owner*	*Quarterly*
Bioretention TC-32 The owner shall provide routine periodic inspection and maintenance of the landscape area. Maintenance to include pruning, weeding, removal and replacement of dead or diseased vegetation and trash pick up. The owner shall at the end of the wet season inspect for standing water. Should standing water be encountered, the owner will excavate and replace any material necessary to obtain proper filtration.	*Before operations begin*	*Owner*	*Owner*	*Monthly Unless Otherwise Indicated*

4.1.2 INSPECTION & MONITORING REQUIREMENTS

The owner will inspect and monitor all long-term O&M for each site design, source control, and treatment BMP's. All records of BMP O&M will be kept for a minimum of 3 years after the inspection of the applicable BMP. See BMP Operation and Maintenance table for O&M procedures.

4.1.3 IDENTIFICATION OF RESPONSIBLE PARTIES

Owner will be responsible for the operation and management of all BMP's mentioned in this report. The contact will be responsible for inspecting and maintaining the BMP's that require O&M (see section 4 "BMP Operations and Maintenance" table).

Responsible Party's Contact Information:

NAME	ADDRESS	PHONE	CONTACT
Church of the Woods	1410 Calgary Drive P.O. Box 2000 Lake Arrowhead, CA 92352	(909) 337-5483	Pat Hopkins

SECTION 5 – FUNDING

5.1 FUNDING

The funding source for all **treatment** control BMP's will be the Church of the Woods. The funding sources name, address, contact name and information (address, phone, etc.) are as follows:

Funding Party's Contact Information:

NAME	ADDRESS	PHONE	CONTACT
Church of the Woods	1410 Calgary Drive P.O. Box 2000 Lake Arrowhead, CA 92352	(909) 337-5483	Pat Hopkins

SECTION 6 - WQMP CERTIFICATION

6.1 CERTIFICATION

"This Water Quality Management Plan has been prepared for Church of the Woods by W. J. McKeever, Inc. It is intended to comply with the requirements of the County of San Bernardino requiring the preparation of a Water Quality Management Plan (WQMP). The undersigned, while it owns the subject property, is responsible for the implementation of the provisions of this plan and will ensure that this plan is amended as appropriate to reflect up-to-date conditions on the site consistent with San Bernardino County's Municipal Stormwater Management Program and the intent of the NPDES Permit for San Bernardino County and the incorporated cities of San Bernardino County within the Lahontan Region. Once the undersigned transfers its interest in the property, its successors in interest and the city/county shall be notified of the transfer. The new owner will be informed of its responsibility under this WQMP. A copy of the approved WQMP shall be available on the subject site in perpetuity. "

"I certify under a penalty of law that the provisions [implementation, operation, maintenance, and funding] of the WQMP have been accepted and that the plan will be transferred to future successors."

Applicant's Signature	Date
Applicant's Name	Applicant's Telephone Number

Attachment A
Maintenance Mechanisms

A-1.1 The Agency shall not accept stormwater structural BMPs as meeting the WQMP requirements standard, unless an O&M Plan is prepared (see WQMP Section 2.6) and a mechanism is in place that will ensure ongoing long-term maintenance of all structural and non-structural BMPs. This mechanism can be provided by the Agency or by the project proponent. As part of project review, if a project proponent is required to include interim or permanent structural and non-structural BMPs in project plans, and if the Agency does not provide a mechanism for BMP maintenance, the Agency shall require that the applicant provide verification of maintenance requirements through such means as may be appropriate, at the discretion of the Agency, including, but not limited to covenants, legal agreements, maintenance agreements, conditional use permits and/or funding arrangements (OC 2003)

A-1.2 Maintenance Mechanisms

1. **Public entity maintenance**: The Agency may approve a public or acceptable quasi-public entity (e.g., the County Flood Control District, or annex to an existing assessment district, an existing utility district, a state or federal resource agency, or a conservation conservancy) to assume responsibility for operation, maintenance, repair and replacement of the BMP. Unless otherwise acceptable to individual Agencies, public entity maintenance agreements shall ensure estimated costs are front-funded or reliably guaranteed, (e.g., through a trust fund, assessment district fees, bond, letter of credit or similar means). In addition, the Permittees may seek protection from liability by appropriate releases and indemnities.

   The Agency shall have the authority to approve stormwater BMPs proposed for transfer to any other public entity within its jurisdiction before installation. The Permittee shall be involved in the negotiation of maintenance requirements with any other public entities accepting maintenance responsibilities within their respective jurisdictions; and in negotiations with the resource agencies responsible for issuing permits for the construction and/or maintenance of the facilities. The Agency must be identified as a third party beneficiary empowered to enforce any such maintenance agreement within their respective jurisdictions.

2. **Project proponent agreement to maintain stormwater BMPs:** The Agency may enter into a contract with the project proponent obliging the project proponent to maintain, repair and replace the stormwater BMP as necessary into perpetuity. Security or a funding mechanism with a "no sunset" clause may be required.

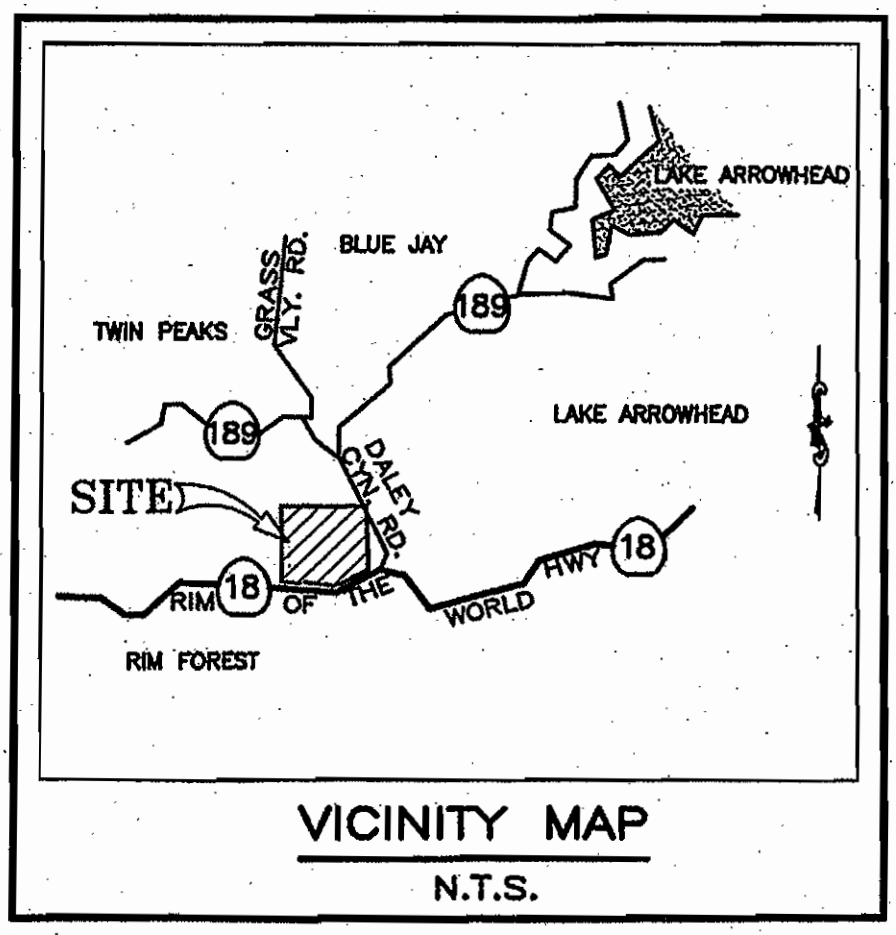
3. **Assessment districts:** The Agency may approve an Assessment District or other funding mechanism created by the project proponent to provide funds for stormwater BMP maintenance, repair and replacement on an ongoing basis. Any agreement with such a District shall be subject to the Public Entity Maintenance Provisions above.

4. **Lease provisions:** In those cases where the Agency holds title to the land in question, and the land is being leased to another party for private or public use, the Agency may assure stormwater BMP maintenance, repair and replacement through conditions in the lease.

5. **Conditional use permits:** For discretionary projects only, the Agency may assure maintenance of stormwater BMPs through the inclusion of maintenance conditions in the conditional use permit. Security may be required.

6. **Alternative mechanisms:** The Agency may accept alternative maintenance mechanisms if such mechanisms are as protective as those listed above.

Attachment B
Vicinity and Site Plan



VICINITY MAP

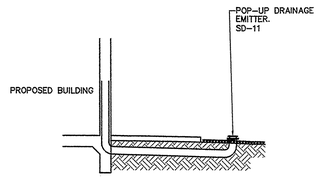
N.T.S.

PROJECT NAME
CHURCH OF THE WOODS

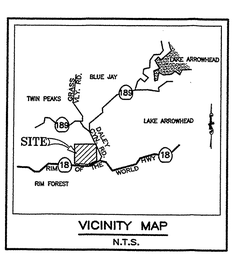
PROJECT LOCATION
HIGHWAY 18
RIMFORST, CALIFORNIA
COUNTY OF SAN BERNARDINO

CHURCH OF THE WOODS
WQMP SITE PLAN

Scale: 1" = 50'
0 25 50 100 150



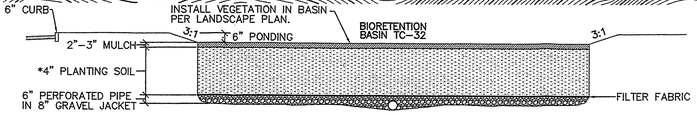
POP-UP EMITTER
NTS



VICINITY MAP
N.T.S.

LEGEND:

- INDICATES PLAY FIELD
- INDICATES ORNAMENTAL LANDSCAPE
- INDICATES LANDSCAPED MANUFACTURED SLOPE
- INDICATES GRAVEL SHOULDER (HIGHWAY 18)
- INDICATES NATURAL AREA
- INDICATES CONCRETE WALKWAY
- INDICATES 6' TUBULAR STEEL FENCE
- INDICATES ROOF DRAIN AND POP-UP EMITTER
- INDICATES WATER QUALITY INLET WITH INSERT



SECTION A-A
NTS

*PLANTING SOILS SHOULD BE SANDY LOAM, LOAMY SAND, OR A LOAM TEXTURE WITH A CLAY CONTENT RANGING FROM 10 TO 25 PERCENT. THE pH OF THE SOIL SHOULD RANGE BETWEEN 5.5 AND 6.5. THE PLANTING SOIL SHOULD INCLUDE A 1.5 TO 3 PERCENT ORGANIC CONTENT AND A MAXIMUM 500 ppm CONCENTRATION OF SOLUBLE SALTS.

W.J. McKEEVER, INC.
CIVIL ENGINEERING
900 E. WASHINGTON STREET, SUITE 208
COLTON, CALIFORNIA 92324
PH.: (909) 825-8045
FAX: (909) 825-8639

Attachment C
Pollutants of Concern

Pollutants of Concern

- *Bacteria and Viruses* – Bacteria and Viruses are ubiquitous microorganisms that thrive under certain environmental conditions. Their proliferation is typically cause by the transport of animal or human fecal wastes from the watershed. Water, containing excessive bacteria and viruses, can alter the aquatic habitat and create a harmful environment for humans and aquatic life. Also, the decomposition of excess organic waste causes increased growth of undesirable organisms in the water.

- *Metals* – The primary source of metal pollution in stormwater is typically commercially available metals and metal products. Metals of concern include cadmium, chromium, copper, lead, mercury, and zinc. Lead and chromium have been used as corrosion inhibitors in primer coatings and cooling tower systems. Metals are also raw material components in non-metal products such as fuels, adhesives, paints, and other coatings. At low concentrations naturally occurring in soil, metals may not be toxic. However, at higher concentrations, certain metals can be toxic to aquatic life. Humans can be impacted from contaminated groundwater resources, and bioaccumulation of metals in fish and shellfish. Environmental concerns, regarding the potential for release of metals to the environment, have already led to restricted metal usage in certain applications (OC 2003).

- *Nutrients* – Nutrients are inorganic substances, such as nitrogen and phosphorus. Excessive discharge of nutrients to water bodies and streams causes eutrophication, where aquatic plants and algae growth can lead to excessive decay of organic matter in the water body, loss of oxygen in the water, release of toxins in sediment, and the eventual death of aquatic organisms. Primary sources of nutrients in urban runoff are fertilizers and eroded soils.

- *Pesticides* -- Pesticides (including herbicides) are chemical compounds commonly used to control nuisance growth or prevalence of organisms. Relatively low levels of the active component of pesticides can result in conditions of aquatic toxicity. Excessive or improper application of a pesticide may result in runoff containing toxic levels of its active ingredient (OC 2003).

- *Organic Compounds* – Organic compounds are carbon-based. Commercially available or naturally occurring organic compounds are found in pesticides, solvents, and hydrocarbons. Organic compounds can, at certain concentrations, indirectly or directly constitute a hazard to life or health. When rinsing off objects, toxic levels of solvents and cleaning compounds can be discharged to storm drains. Dirt, grease, and grime retained in the cleaning fluid or rinse water may also adsorb levels of organic compounds that are harmful or hazardous to aquatic life (OC 2003).

- *Sediments* – Sediments are solid materials that are eroded from the land surface. Sediments can increase turbidity, clog fish gills, reduce spawning habitat, lower young aquatic organisms survival rates, smother bottom dwelling organisms, and suppress aquatic vegetation growth.

- *Trash and Debris* – Trash (such as paper, plastic, polystyrene packing foam, and aluminum materials) and biodegradable organic matter (such as leaves, grass cuttings, and food waste) are general waste products on the landscape. The presence of trash and debris may have a significant impact on the recreational value of a water body and aquatic habitat. Trash impacts water quality by increasing biochemical oxygen demand.

- *Oxygen-Demanding Substances* – This category includes biodegradable organic material as well as chemicals that react with dissolved oxygen in water to form other compounds. Proteins, carbohydrates, and fats are examples of biodegradable organic compounds. Compounds such as ammonia and hydrogen sulfide are examples of oxygen-demanding compounds. The oxygen

demand of a substance can lead to depletion of dissolved oxygen in a water body and possibly the development of septic conditions. A reduction of dissolved oxygen is detrimental to aquatic life and can generate hazardous compounds such as hydrogen sulfides.

- *Oil and Grease* – Oil and grease in water bodies decreases the aesthetic value of the water body, as well as the water quality. Primary sources of oil and grease are petroleum hydrocarbon products, motor products from leaking vehicles, esters, oils, fats, waxes, and high molecular-weight fatty acids.

Attachment D
Flow and Volume Based BMP Design Calculations

INSTRUCTIONS FOR ESTIMATING VOLUME- AND FLOW-BASED BMP DESIGN RUNOFF QUANTITIES[1]

1) Identify the "BMP Drainage Area" that drains to the proposed BMP element. This includes all areas that will drain to the proposed BMP element, including pervious areas, impervious areas, and off-site areas, whether or not they are directly or indirectly connected to the BMP element. Calculate the BMP Drainage Area (A) in acres.

2) Outline the Drainage Area on the NOAA Atlas 14 Precipitation Depths (2-year 1hour Rainfall) map (Figure D-1).

3) Determine the area-averaged 2-year 1-hour rainfall value for the Drainage Area outlined above.

A. Flow-Based BMP Design

1) Calculate the composite runoff coefficient, C_{BMP}, as defined in part A.2, above.

2) Determine which Region the BMP Drainage Area is located in (Valley, Mountain or Desert).

3) Determine BMP design rainfall intensity, I_{BMP}, by multiplying the area-averaged 2-year 1-hour value from the NOAA Atlas 14 map by the appropriate regression coefficient from Table D-1 ("I"), and then multiplying by the safety factor specified in the criteria—usually a factor of 2.

4) Calculate the target BMP flow rate, Q, by using the following formula (see Table D-2 below for limitations on the use of this formula):

$$\mathbf{Q = C_{BMP} \cdot I_{BMP} \cdot A}$$

where: **Q** = flow in ft^3/s

---

[1] Rainfall analysis to develop regression coefficients in Table D-1 and modifications to the NOAA Atlas 14 map were conducted by:

Hromadka II, T.V., Professor Emeritus, Department of Mathematics, California State University, Fullerton, and Adjunct Professor, Department of Mathematical Sciences, United States Military Academy, West Point, NY

Laton, W.R , Assistant Professor, Department of Geological Sciences, California State University, Fullerton

Picciuto J.A.., Assistant Professor, Department of Mathematical Sciences, United States Military Academy, West Point, NY

With assistance from:

Rene Perez, M.S. Candidate, Department of Geological Sciences, California State University, Fullerton, and

Jim Friel, Ph.D. Professor Emeritus, Department of Mathematics, California State University, Fullerton

Reported as follows:

1. Hromadka II, T.V., Laton, W.R., and Picciuto J.A., 2005. Estimating Runoff Quantities for Flow and Volume-based BMP Design. Final Report to the San Bernardino County Flood Control District.
2. Laton, W.R., Hromadka II, T.V., and Picciuto J.A., 2005. Estimating Runoff Quantities for Flow and Volume-based BMP Design (submitted). Journal of the American Water Resources Association.

I_{BMP} = BMP design rainfall intensity, in inches/hour

A = Drainage Area in acres

C_{BMP} = composite runoff coefficient

Table D-1: Regression Coefficients for Intensity (I) and 6-hour mean storm rainfall (P_6).

Quantity	Valley 85% upper confidence limit	Mountain 85% upper confidence limit	Desert 85% upper confidence limit
I	**0.2787**	**0.3614**	**0.3250**
P_6	**1.4807**	**1.9090**	**1.2371**

Table D-2: Use of the flow-based formula for BMP Design (CASQA 2003).

	Composite Runoff Coefficient, "C"			
BMP Drainage Area (Acres)	**0.00 to 0.25**	**0.26 to 0.50**	**0.51 to 0.75**	**0.76 to 1.00**
0 to 25	**Caution**	**Yes**	**Yes**	**Yes**
26 to 50	**High Caution**	**Caution**	**Yes**	**Yes**
51 to 75	**Not Recommended**	**High Caution**	**Caution**	**Yes**
76 to 100	**Not Recommended**	**High Caution**	**Caution**	**Yes**

If the flow-based BMP formula use case, as determined by Table D-2, shows "Caution," "High Caution," or "Not Recommended," considering the project's characteristics, then he project proponent must calculate the BMP design flow using the unit hydrograph method, as specified in the most current version of the San Bernardino County Hydrology Manual, using the design storm pattern with rainfall return frequency such that the peak one hour rainfall depth equals the 85th-percentile 1-hour rainfall multiplied by two.

B. Volume-Based BMP Design

1) Calculate the "Watershed Imperviousness Ratio", i, which is equal to the percent of impervious area in the BMP Drainage Area divided by 100.

Volume Based BMP Design Calculation Sheet

1) Calculate the "Watershed Imperviousness Ratio", i, which is equal to the percent of impervious area in the BMP Drainage Area divided by 100.

   Total drainage area = 11.36 Acres

   Impervious Area = 8.99 Acres

   Imperviousness Ratio = 8.99/11.36 = **0.79 - i**

2) Calculate the composite runoff coefficient CBMP for the Drainage Area above using the following equation: $CBMP = 0.858i^3 - 0.78i^2 + 0.774i + 0.04$

   $C=0.858(0.79)^3 - 0.78(0.79)^2 + 0.774(0.79) + 0.04 = 0.4230 - 0.4868 + 0.6115 + 0.04 =$ **.588 = CBMP**

3) Determine which Region the Drainage Area is located in (Valley, Mountain or Desert).

   Mountain

4) Determine the area-averaged "6-hour Mean Storm Rainfall", P6, for the Drainage Area. This is calculated by multiplying the area averaged 2-year 1-hour value by the appropriate regression coefficient from Table 1.

   0.85 x 1.9090 = **1.62 = P6**

5) Determine the appropriate drawdown time.

   a =1.963

6) Calculate the "Maximized Detention Volume

   $P0 = a \cdot CBMP \cdot P6 = 1.963 \times 0.588 \times 1.62 =$ **1.87 = P0**

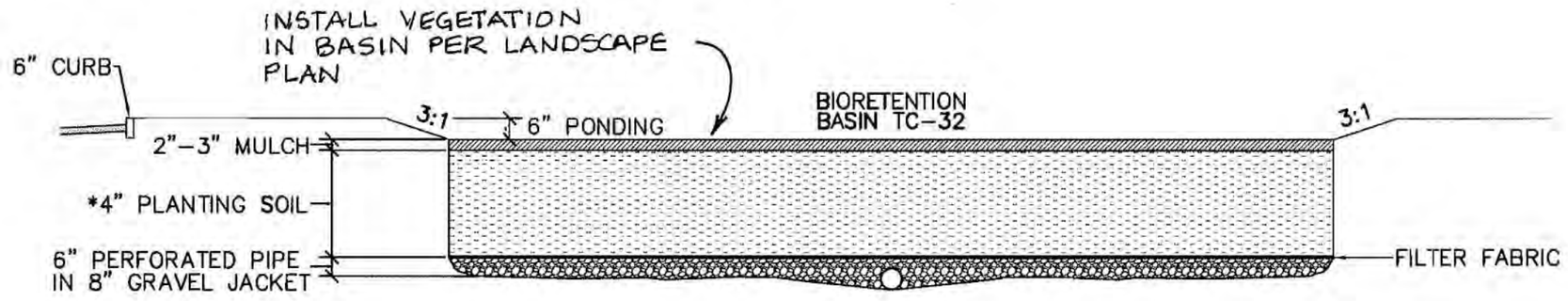
7) Calculate the "Target Capture Volume

   $V0 = (P0 \cdot A) / 12 = (1.87 \times 11.36) / 12 =$ **1.77 AC-FT = V0**

Bio-Retention Calculation Sheet

Volume required	77101	ft^3			
Depth of bed	4	ft	4	ft	min
Infiltration rate	3	ft/day	1	ft/day	min
Height of water above basin	0.5	ft	0.5	ft	max
Bed drain time	3	day	3	day	max
Surface Area (required)	7614.91358	ft^2			
Surface Area Provided	8050	ft^2			
Volume Provided	81506.25	ft^3			

Surface area provided is area on top of planting soil.



*PLANTING SOILS SHOULD BE SANDY LOAM, LOAMY SAND, OR A LOAM TEXTURE WITH A CLAY CONTENT RANGING FROM 10 TO 25 PERCENT. THE pH OF THE SOIL SHOULD RANGE BETWEEN 5.5 AND 6.5. THE PLANTING SOIL SHOULD INCLUDE A 1.5 TO 3 PERCENT ORGANIC CONTENT AND A MAXIMUM 500 ppm CONCENTRATION OF SOLUBLE SALTS.

TYPICAL SECTION

N.T.S.

Attachment E
Educational Information / BMP Fact Sheets

STORMWATER Pollution Prevention

LANDSCAPE MAINTENANCE

PRESORTED
STANDARD
U.S. POSTAGE
PAID
SACRAMENTO, CA
PERMIT# 000

San Bernardino County Stormwater Program
825 East Third Street · Room 127
San Bernardino, CA 94215-0835

STORMWATER Pollution Prevention

Stormwater Management Practices for Commercial Landscape Maintenance

Yard waste, sediments, and toxic lawn/garden chemicals used in commercial landscape maintenance often make their way into the San Bernardino County storm drain system and do not get treated before reaching the Santa Ana River. This pollutes our drinking water and contaminates local waterways, making them unsafe for people and wildlife. Following these best management practices will prevent pollution, comply with regulations and protect public health.

Recycle Yard Waste

Recycle leaves, grass clippings and other yard waste. Do not blow, sweep, rake or hose yard waste into the street. Try grasscycling - the natural recycling of grass by leaving clippings on the lawn when mowing. Grass clippings will quickly decompose, returning valuable nutrients to the soil. Further information can be obtained at www.ciwmb.ca.gov/Organics.

Use Fertilizers, Herbicides and Pesticides Safely

Fertilizers, herbicides and pesticides are often carried into the storm drain system by sprinkler runoff. Use of natural, non-toxic alternatives to the traditional fertilizers, herbicides and pesticides is highly recommended. If you must use chemical fertilizers, herbicides, or pesticides:

- Spot apply pesticides and herbicides, rather than blanketing entire areas.
- Avoid applying near curbs and driveways, and never apply before a rain.
- Apply fertilizers as needed, when plants can best use it, and when the potential for it being carried away by runoff is low.

Recycle Hazardous Waste

Pesticides, fertilizers, herbicides and motor oil contaminate landfills and should be disposed of through a Hazardous Waste Facility which accepts these types of materials. For information on proper disposal call, (909) 386-8401.

Use Water Wisely

Conserve water and prevent runoff by controlling the amount of water and direction of sprinklers. Sprinklers should be on long enough to allow water to soak into the ground but not so long as to cause runoff. Periodically inspect, fix leaks and realign sprinkler heads. Plant native vegetation to reduce the need of water, fertilizers, herbicides, and pesticides.

Prevent Erosion

Erosion washes sediments, debris and toxic runoff into the storm drain system, polluting waterways.

- Prevent erosion and sediment runoff by using ground cover, berms and vegetation down-slope to capture runoff.
- Avoid excavation or grading during wet weather.

Store Materials Safely

Keep landscaping materials and debris away from the street, gutter and storm drains. On-site stockpiles of materials must be covered with plastic sheeting to protect from rain, wind and runoff.

To report illegal dumping or for more information on stormwater pollution prevention, call:

1 (800) CLEANUP

or visit our websites:

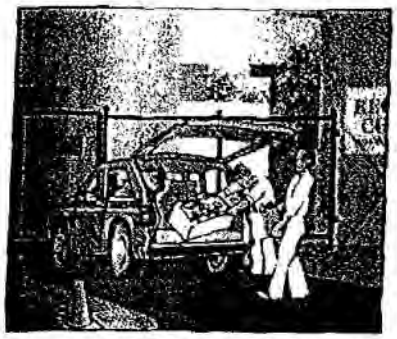
www.co.san-bernardino.ca.us/flood/npdes

www.1800cleanup.org

STORMWATER Pollution Prevention

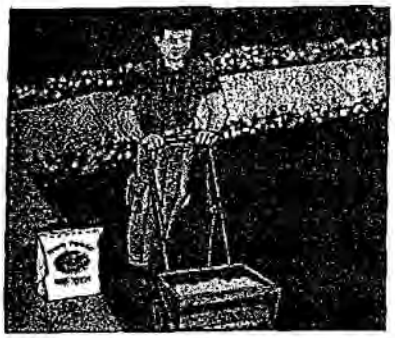
HOME & GARDEN

Yard waste and household toxics like paints and pesticides often make their way into the San Bernardino County storm drain system and do not get treated before reaching the Santa Ana River. This pollutes our drinking water and contaminates waterways, making them unsafe for people and wildlife. Follow these simple tips to prevent pollution and protect your health.

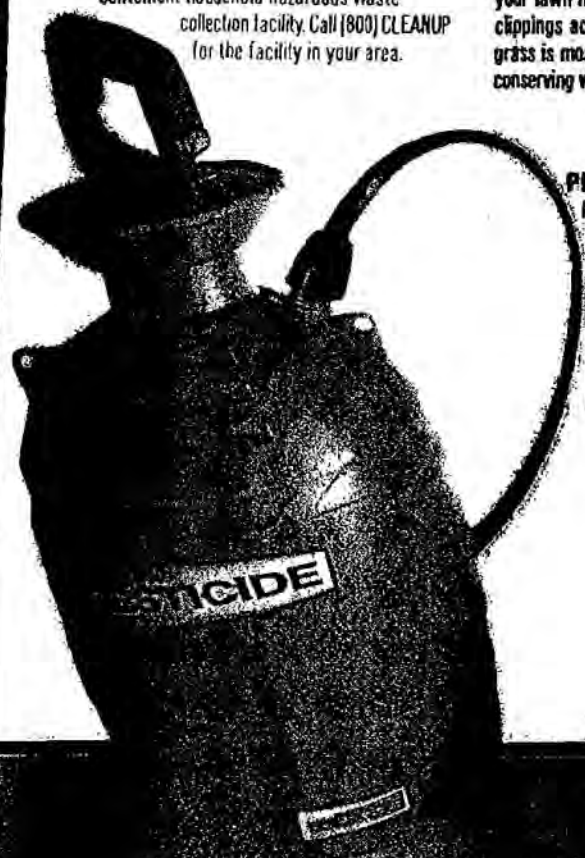


Recycle Household Hazardous Waste
Household products like paint, pesticides, solvents and cleaners are too dangerous to dump and too toxic to trash. Take them to be recycled at a convenient household hazardous waste collection facility. Call (800) CLEANUP for the facility in your area.

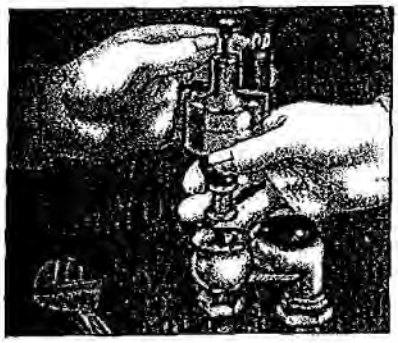
Disposing of Yard Waste
Recycle leaves, grass clippings and other yard waste, instead of blowing, sweeping or hosing into the street. Try grasscycling, leaving grass clippings on your lawn instead of using a grass catcher. The clippings act as a natural fertilizer, and because grass is mostly water, it also irrigates your lawn, conserving water.



Use Fertilizers & Pesticides Safely
Fertilizers and pesticides are often carried into the storm drain system by sprinkler runoff. Try using organic or non-toxic alternatives. If you use chemical fertilizers or pesticides, avoid applying near curbs and driveways and never apply before a rain.



Planting in the Yard
Produce less yard waste and save water by planting low maintenance, drought-tolerant trees and shrubs. Using drip irrigation, soaker hoses or micro-spray systems for flower beds and vegetation can also help reduce your water bill and prevent runoff.



Use Water Wisely
Cut your water costs and prevent runoff by controlling the amount of water and direction of sprinklers. The average lawn needs about an inch of water a week, including rainfall, or 10 to 20 minutes of watering. A half-inch per week is enough for fall and spring. Sprinklers should be on long enough to allow water to soak into the ground but not so long as to cause runoff.

For more information
tion prevention, call:

1 (800) CLEANUP

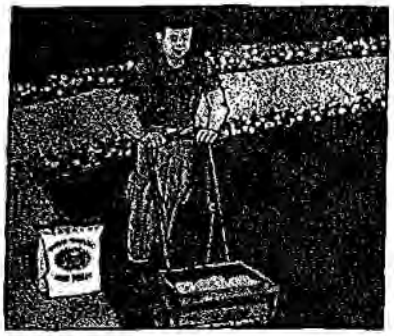
www.1800cleanup.org

Prevención de Contaminación del Desagüe

JARDIN Basura del jardín y otros toxicos caseros como pintura, pesticidas y otros mas acaban por llegar a los drenajes del Condado de San Bernardino y terminando en el Rio de Santa Ana. Esto contamina el agua que tomamos, haciendola peligorsa para la gente y la vida salvaje. Sigue estas practicas para prevenir la contaminación y protejer la salud publica.

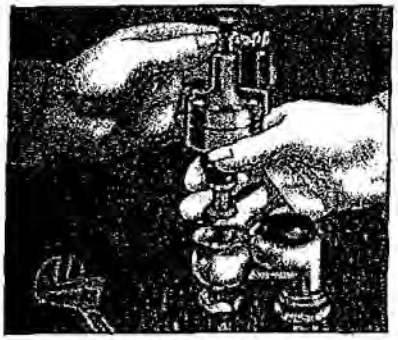
Disponiendo Desechos del Jardin
Recicla hojas, pasto y otras basuras del jardin en ves de soplarlas, barrerlas hacia la calle. El pasto sirve como fertilizante, y como el pasta es la mayoria agua tambien riega tu jardin, ahorrandote agua.

Reciclando Materiales del Hogar Peligrosos
Limpiadores del hogar como pintura, pesticidas, solventes y limpiadores son demasiado toxicos para tirarlos en la basura. Desechalos en un lugar de colección de desechos peligrosos. Llama al (800) CLEANUP para un lugar en tu area.



Usando Fertilizantes & Pesticidas Adecuadamente
Fertilizantes y pesticidas muchas veces terminan en los drenajes. Usa alternativas que no sean toxicas. Si tu usas fertilizantes y pesticidas con quimicos, no los uses cerca de las banquetas y cocheras y nunca los uses en tiempos de lluvia.

Cembrando en el Jardin
Reduce la basura del jardin y ahorra agua plantando arboles y plantas de bajo mantenimiento. Riega moderadamente con mangueras u otros metodos para las flores o vegetacion asi reduciras tu pago del mes y previenes el desagüe.



Usando el Agua Adecuadamente
Reduce el pago del agua y previene el desagüe controlando la cantidad y direccion de tus regaderas para el jardin. Solo necesitas regar de 10 a 20 minutos a la semana. Durante la primavera y otoño es la mitad. Las regaderas del jardin deverian estar ajustadas a que rieguen lo suficinete y evitar el desagüe.

[illegible] contaminación llamar al:

1 (800) CLEANUP

www.1800cleanup.org

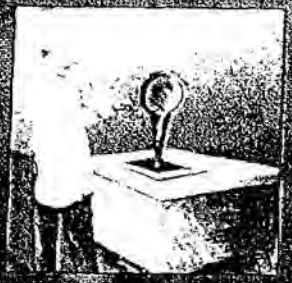
English side

Spanish side

Item: Fertilizer tip card **Actual size:** 4.125" x 5.5" **Advertiser:** San Bernardino County Storm Water Program
Agency: Industrial Strength Advertising **Date:** 9/10/03

GOOD CLEANING PRACTICES

FOOD AND RESTAURANT INDUSTRY



Recycle grease and oil. Don't pour it into sinks, floor drains or onto a parking lot or street. Keep grease bins covered and contained.
Reciclo la grasa y el aceite. No los tires en los lavaderos, las coladeras, el estacionamiento o en la calle. Mantén los recipientes de grasa cubiertos y guardados.

Keep dumpster area clean and lid closed. Don't fill it with liquid waste or hose it out.
Mantén el área del basurero limpia y la tapa cerrada. No lo llenes con desechos líquidos ni utilices la manguera para lavarlo.

Clean floormats, filters and garbage cans in a mop sink, washrack or floor drain connected to the sewer through a grease trap. Don't wash them in a parking lot, alley, sidewalk or street.
Limpia los tapetes de pico, los filtros y los botes de basura en el contenedor para trapeadores, lavavo, o en la coladera aprobada que llegue al drenaje. No los laves en el estacionamiento, los callejones, en la banqueta o en la calle.

Use dry methods for spill cleanup (sweeping, cat litter, etc.) Don't hose down spills.
Usa métodos secos para limpiar los derrames (barriendo, tierra para desechos de gato, etc.). No uses la manguera para limpiar los derrames.

Pour washwater into a janitorial or mop sink. Don't pour it out onto a parking lot, alley, sidewalk or street.
Arroja el agua de lavado al contenedor para trapeadores. No la arrojes en el estacionamiento, los callejones, en la banqueta o en la calle.

To report illegal dumping or spills. Para reportar actividades ilegales.

(800) CLEANUP

Ad title: Food & restaurant poster **Actual size:** 18" x 24"
Advertiser: San Bernardino County Storm Water Program **Agency:** Industrial Strength Advertising **Date:** 8/20/03

San Bernardino County
STORMWATER POLLUTION PREVENTION

HOME
GENERAL INFORMATION
POLLUTION PREVENTION FOR RESIDENTS
POLLUTION PREVENTION FOR BUSINESSES
HOUSEHOLD HAZARDOUS WASTE & OIL RECYCLING
POLLUTION REPORTING
EDUCATIONAL MATERIALS
PERMITTEES
LINKS

SEARCH

Landmark photos provided by Rob Soriano, Inland Valley Daily Bulletin Marketing Department.

STORM WATER POLLUTION PREVENTION FOR BUSINESSES

One of the most common types of pollution from businesses is contaminated water runoff, usually from cleaning and maintenance activities. Simple best management practices (BMPs) can prevent storm water pollution, and prevention is good business. It means clean water, clean neighborhoods and it shows your customers that you care about your community. For more information on municipal, industrial and construction National Pollutant Discharge Elimination System (NPDES) permits contact the Storm Water Program at (909)387-8109 or by email at StormWaterInfo@dpw.sbcounty.gov.

ON THIS PAGE...

■ Food & Restaurants:

Food waste, grease, cleaning fluids, mop water and trash from restaurant operations often make their way into the San Bernardino County storm drain system, and do not get treated before reaching the Santa Ana River. This pollutes our drinking water and contaminates waterways, making them unsafe for people and wildlife. Follow these best management practices to prevent pollution, protect public health and avoid fines or legal action.

- **Cleaning & Maintenance:** Clean equipment, floor mats, filters and garbage cans in a mop sink, wash rack or floor drain connected to the sewer through a grease trap. Don't wash them or pour wash water in a parking lot, alley, sidewalk or street. Sweep outside areas and put the debris in the garbage, instead of sweeping or hosing it into

For more information regarding **food and restaurants**, view or download these Acrobat files:

▸ Restaurants Fact Sheet

the parking lot or street.

- **Recycle oil & grease:** Oil and grease wastes can be recycled. Look in the yellow pages for rendering companies, or call (909) 386-8401 for disposal information. Don't pour oil or grease into sinks, floor drains or onto a parking lot or street. Keep grease bins covered and contained.
- **Dumpster areas:** Keep dumpster lids closed and the areas around them clean. Do not fill with liquid waste or hose them out. Call your trash hauler to replace any dumpsters that are damaged or leak. Do not wash down or steam clean trash enclosure area or trash bin unless you collect the water and dispose of it into the sanitary sewer. Hire a mobile pressure wash business that is familiar with the storm water regulations to clean these areas and make sure they provide you with a record of proper wastewater disposal.

- **Managing spills:** Use dry methods for spill cleanup, sweeping and using cat litter instead of hosing. Have spill containment and cleanup kits available for possible spills on your property. To report serious toxic spills, call (800) 33-TOXIC.
- **Handling toxic chemicals:** Dispose of all unwanted toxics materials like cleaners, solvents and detergents through a hazardous waste hauler. These items are not trash. Use non-toxic cleaning products whenever possible. For information on hazardous waste pickup, call (909) 386-8401.

FOOD & RESTAURANTS | AUTOMOTIVE SERVICES | CONSTRUCTION & DEVELOPMENT | LANDSCAPE & MAINTENANCE | ▲TOP
CARPET CLEANING | MOBILE VEHICLE MAINTENANCE | GEN. INDUSTRIAL & MANUFACTURING | REGULATORY INFORMATION

■ Automotive services

Oil, grease, anti-freeze and other toxic automotive fluids often make their way into the San Bernardino County storm drain system, and do not get treated before reaching the Santa Ana River. This pollutes our drinking water and contaminates waterways, making them unsafe for people and wildlife. Follow these best management practices to prevent pollution, protect public health and avoid fines or legal action.

- **Storing Hazardous Waste:** Keep your liquid waste segregated. Many fluids can be recycled via hazardous waste disposal companies if they are not mixed. Store all materials under cover with spill containment or inside to prevent contamination of

rainwater runoff.

- **Proper Disposal of Hazardous Waste:** Recycle used motor oil and oil filters, anti-freeze and other hazardous automotive fluids, batteries, tires and metal filings collected from grinding/polishing auto parts. Contact a licensed hazardous waste hauler. For more recycling information, call (909) 386-8401.
- **Cleaning Auto Parts:** Scrape parts with a wire brush or use a bake oven rather than liquid cleaners. Arrange drip pans, drying racks and drain boards so that fluids are directed back into the sink or the fluid holding tank. Do not wash parts or equipment in a parking lot, driveway or street.

- **Preventing Leaks and Spills:** Place drip pans underneath to capture fluids. Use absorbent cleaning agents instead of water to clean work areas.
- **Metal Grinding & Polishing:** Keep a bin under your lathe or grinder to capture metal filings. Send uncontaminated filings to a scrap metal recycler for reclamation. Store metal filings in a covered container or indoors.
- **Cleaning Spills:** Follow your hazardous materials response plan, as filed with your local fire department or other hazardous materials authority. Be sure that all employees are aware of the plan and are capable of implementing each phase of the plan. Use dry methods for spill cleanup (sweeping, absorbent materials, etc.). To report serious spills, call 911.
- **Washing vehicles:** Wash vehicles where the wash water can soak into grass, gravel or be diverted to nearby landscaping, away from the street and storm drains. Wash vehicles at a designated wash rack that is connected to the sanitary sewer or take vehicles to a professional car wash. Use soaps, cleaners and detergents that are labeled phosphate free or biodegradable. The safest products for the environment are vegetable based or citrus-based soaps.

For more information about **auto services**, view or download these Acrobat files:

- Auto Repair Fact Sheet
- Painting Tip Card

FOOD & RESTAURANTS | AUTOMOTIVE SERVICES | CONSTRUCTION & DEVELOPMENT | LANDSCAPE & MAINTENANCE | ▲TOP
CARPET CLEANING | MOBILE VEHICLE MAINTENANCE | GEN. INDUSTRIAL & MANUFACTURING | REGULATORY INFORMATION

■ Construction & development:

Soil, cement wash, asphalt, oil and other hazardous debris from construction sites often make their way into the San Bernardino County storm drain system, and flow untreated into local waterways. Follow these best management practices to prevent pollution, protect public health and avoid fines or legal action.

- **Store Mat... Safely:** Keep construction materials and debris away from the street, gutter and storm drains. Cover exposed stockpiles of soil, sand or gravel and excavated material with plastic sheeting, protected from rain, wind and runoff.
- **Preventing Erosion:** Avoid excavation or grading during wet weather. Plant temporary vegetation or add hydro mulch on slopes where construction is not immediately planned, and permanent vegetation once excavation and grading are complete. Construct diversion dikes to channel runoff to a detention basin and around the construction site. Use gravel approaches where truck traffic is frequent to reduce soil compaction and limit the tracking of sediment into the streets. For more information on erosion control, call (909) 799-7407.
- **Cleaning & Preventing Spills:** Use a drip pan and funnel when draining or pouring fluids. Sweep up dry spills, instead of hosing. Be ready for spills by preparing and using spill containment and cleanup kits that include safety equipment and dry cleanup materials such as kitty litter or sawdust. To report serious spills, call 911.

- **Maintaining Vehicles & Equipment:** Maintain and refuel vehicles and equipment at a single location on-site, away from the street, gutter and storm drains. Perform major equipment repairs and washings off-site. Inspect vehicles and equipment frequently for leaks, and prevent leaks from stored vehicles by draining gas, hydraulic oil, transmission, and brake and radiator fluids.
- **Ordering Materials & Recycling Waste:** Reduce waste by ordering only the amounts of materials needed for the job. Use recycled or recyclable materials whenever possible. You can recycle broken asphalt, concrete, wood, and cleared vegetation. Dispose of hazardous materials through a hazardous waste hauler or other means in accordance with the construction permit. Non-recyclable materials should be taken to a landfill or disposed of as hazardous waste. For recycling and disposal information, call (909) 386-8401.
- **Concrete and mortar application:** Never dispose of cement washout into driveways, streets, gutters or drainage ditches. Wash concrete mixers and equipment only in specified washout areas, where the water flows into lined containment ponds. Cement wash water can be recycled by pumping it back into cement mixers for reuse.

For more information about **construction and development**, view or download these Acrobat files:

- Construction Fact Sheet
- Excavation Fact Sheet
- Concrete & MortarApplication Fact Sheet
- Roadwork & Paving Fact Sheet

■ Commercial landscape maintenance:

Yard waste, sediments and toxic lawn and garden chemicals used in commercial landscape maintenance often make their way into the San Bernardino County storm drain system and do not get treated before reaching the Santa Ana River. This pollutes our drinking water and contaminates local waterways, making them unsafe for people and wildlife. Follow these best management practices to prevent pollution, protect public health and avoid fines or legal action.

- **Recycle Yard Waste:** Recycle leaves, grass clippings and other yard waste. Do not blow, sweep, rake or hose yard waste into the street. Let your customers know about grass cycling --the natural recycling of grass by leaving clippings on the lawn when mowing instead of using a grass catcher. Grass clippings will quickly decompose, returning valuable nutrients to the soil. You can get more information at www.ciwmb.ca.gov/Organics.
- **Use Fertilizers, Herbicides & Pesticides Safely:** Fertilizers, herbicides and pesticides are often carried into the storm drain system by sprinkler runoff. Use natural, non-toxic alternatives to traditional garden chemicals. If you must use chemical fertilizers, herbicides, or pesticides spot apply rather than blanketing entire areas, avoid applying near curbs and driveways and never apply before a rain.
- **Recycle Hazardous Waste:** Pesticides, fertilizers, herbicides and motor oil contaminate landfills and should be disposed of through a Hazardous Waste Facility. For information on proper disposal, call (909) 386-8401.

- **Use Water Wisely:** Conserve water and prevent runoff by controlling the amount of water and direction of sprinklers. Sprinklers should be on long enough to allow water to soak into the ground but not so long as to cause runoff. Periodically inspect, fix leaks and realign sprinkler heads.
- **Planting:** Plant native vegetation to reduce the need of water, fertilizers, herbicides and pesticides.
- **Prevent Erosion:** Erosion washes sediments, debris and toxic runoff into the storm drain system, polluting waterways. Prevent erosion and sediment runoff by using ground cover, berms and vegetation down-slope to capture runoff. Avoid excavation or grading during wet weather.

- **Store Materials Safely:** Keep landscaping materials and debris

For more information about **commercial landscape maintenance**, view or download these Acrobat files:

- Landscape Brochure
- Fertilizer Tip Card
- Pesticide Tip Card
- Home & Garden Fact Sheet

away fro[illegible]street, gutter and storm drains. On-site stockpiles of materials should be covered with plastic sheeting to protect from rain, wind and runoff.

■ Carpet cleaning:

Toxic chemicals and discharged waste water from carpet, drapery, furniture and window cleaning often make their way into the San Bernardino County storm drain system and do not get treated before reaching the Santa Ana River. This pollutes our drinking water and contaminates local waterways, making them unsafe for people and wildlife. Following these best management practices will prevent pollution, comply with regulations and protect public health.

For more information about **painting**, view or download these Acrobat files:

- Carpet Cleaning Brochure
- www.cabmphandbooks.com Look under Carpets & Upholstery BMP

These guidelines apply even if the cleaning products are labeled "nontoxic" or "biodegradable". Although these products may be less harmful to the environment, they can still have harmful effects if they enter the storm drain untreated.

- **Dispose of wastewater properly:** Wastewater from cleaning equipment must be discharged into a sink, toilet, or other drain connected to the sanitary sewer system within sanitary sewer discharge limits, or hauled off and disposed of properly. Wastewater should never be discharged into a street, gutter, parking lot or storm drain.
- **Filter wastewater:** Carpet cleaning wastewater should be filtered before discharging it to the sanitary sewer since fibers and other debris in the wastewater can clog pipes. The filtered material can be disposed of in the garbage, as long as the waste is not contaminated with hazardous pollutants.

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CARPET CLEANING | MOBILE VEHICLE MAINTENANCE | GEN. INDUSTRIAL & MANUFACTURING | REGULATORY INFORMATION

■ Mobile vehicle maintenance

Wash in a designated area that has been bermed up to contain the wash water.

For more information about painting, view or download these Acrobat files:

- Mobile vehicle maintenance brochure
- www.cabmphandbooks.com

Common water control devices are: recycling systems; pretreatment or sewer discharge systems; limited recycling systems; wash pits(portable vinyl wash pads), vacuum sludge filtering systems; wet-dry vacuums, sump pumps; drain covers; portable dams; vacu-brooms; oil absorbent pads, booms, pillows, and tubes; plastic sheeting; filter tubs; buckets; pans; and squeegees.

When cleaning engines using chemical additives like soaps, solvents or degreasers, the cleaning must be performed at a facility that has the equipment to properly process the

Look under Mobile Cleaning-Surface Cleaning

contaminated w[illegible]water runoff, or using a leak-proof ground cover device that will catch and contain all contaminated wastewater runoff for later disposal in a manner that complies with city, county, state and federal codes.

Wastewater from cleaning equipment must be discharged into a sink, toilet, or other drain connected to the sanitary sewer

■ General industrial & manufacturing businesses:

If you own, manage or help operate a business, especially an industrial or manufacturing company, you can help reduce storm water pollution. From environmentally friendly cleaning and maintenance activities, to recycling hazardous waste materials, businesses can do a lot to prevent storm water pollution.

- Review your cleaning and maintenance activities to look for ways to reduce runoff into the storm drain system, especially in outdoor areas like parking lots, loading docks and maintenance yards. Keep trash enclosure swept and trash bin lids closed.
- Train employees to wash vehicles and equipment indoors in a wash rack that is connected to the sanitary sewer or off-site at a commercial wash facility. Train janitorial staff to dispose of floor cleaning water in the sewer and not into the parking lot. Make sure that cooling towers, boilers, compressors, water softeners and other process equipment are connected to the sanitary sewer and do not discharge wastewater into the parking lot.
- If you use hazardous materials in your everyday business, like ink and solvents for commercial printing, or polishes and chemicals for car detailing or manufacturing after-market accessories, do not put these hazardous materials in the trash or pour them into the gutter. Take them to be recycled safely. Store chemicals, wastes, raw materials and contaminated equipment indoors or in a covered, spill contained area, to prevent exposure of these materials to storm water. For information on proper hazardous waste disposal, call (909)386-8401.
- Take advantage of less-toxic alternatives to dangerous chemicals. From detergents to drain openers, there are a lot of ways to get the same or better result without having to rely toxic substances.
- Looking for raw materials? San Bernardino County Materials Exchange Program, or SBCoMax is a partnership between the County and the California Integrated Waste Management Board, for businesses to provide used but usable materials to those interested in obtaining them. The program helps divert used materials from landfills,

saves resc ces and can save you money.

■ Regulatory information

The Federal Water Pollution Control Act prohibits the discharge of any pollutant to navigable waters from a point source unless the discharge is authorized by a National Pollutant Discharge Elimination System (NPDES) permit. The 1987 passage of the Water Quality Act established NPDES permit requirements for discharges of storm water. The NPDES permit program controls water pollution by regulating point sources that discharge pollutants into waters of the United States.

Industrial facilities and construction sites are regulated by the Regional Water Quality Control Board and State Water Resources Control Board, through general storm water permits. Most industrial, manufacturing or transportation businesses that store materials, products or equipment outdoors, or conduct vehicle washing or process operations outdoors are required to obtain coverage under the State Water Resources Control Board's General Industrial Activities Stormwater Permit. For more information about this permit, visit www.swrcb.ca.gov/stormwtr/industrial.html or contact your local storm water coordinator.

If your business conducts construction activities, including clearing, grading, stockpiling or excavation that results in soil disturbances of at least one acre, you are subject to the State Water Resources Control Board's General Construction Activities Stormwater Permit. To find out more about this storm water permit for construction, visit: www.swrcb.ca.gov/stormwtr/construction.html.

Cities and counties are regulated through permits issued by the Regional Boards. Since 1990, operators of large storm drain systems such as San Bernardino County's have been required to:

- Develop a storm water management program designed to prevent harmful pollutants from being dumped or washed by storm water runoff, into the storm water system, then discharged into local water bodies; and
- Obtain a National Pollutant Discharge Elimination System (NPDES) permit.

The NPDES permit programs in California are administered by the State Water Resources Control Board and by nine regional boards that issue NPDES permits and enforce regulations within their respective region.

San Bernardino County lies within the jurisdiction of the Santa Ana Region. This regional board issues a permit to the San Bernardino County Permittees, which includes the County

of San Bernardi.., San Bernardino County Flood Control District and incorporated cities of San Bernardino County. Since the program's inception, the County of San Bernardino has served as the principal permittee.

Documents & reports:

The following documents describe the regulations and programs for water quality in San Bernardino County. You can review the latest Basin Plan, National Pollutant Discharge Elimination System (NPDES) Permit and Drainage Area Management Plan (DAMP).

- **Basin Plans:** The document for each region of the State Water Quality Board's jurisdiction, including Santa Ana, is the Water Quality Control Plan, commonly referred to as the Basin Plan. It is the foundation for the regulatory programs of each regional board. The Basin Plan documents the beneficial uses of the region's ground and surface waters, existing water quality conditions, problems, and goals, and actions by the regional board and others that are necessary to achieve and maintain water quality standards.

  ▸Water Control Plan for the Santa Ana River Basin

- **Municipal National Pollutant Discharge Elimination System (NPDES) Permits:** The permits of each region outline additional steps for a storm water management program and specify requirements to help protect the beneficial uses of the receiving waters. They require permittees to develop and implement Best Management Practices (BMPs) to control/reduce the discharge of pollutants to waters of the United States to the maximum extent practicable (MEP).

  ▸Santa Ana Regional Water Quality Control Board Municipal NPDES Permit Order No. R8-2002-0012

- **Report of Waste Discharge:** The Report of Waste Discharge (ROWD) describes the San Bernardino Stormwater Program, implemented by the County and cities to comply with their jointly held stormwater permit. It is the principle policy and guidance document for the NPDES Stormwater Program.

  ▸Report of Waste Discharge 2000

- **San Bernardino County Storm Water Program Annual Status Report:** The Annual Status Report is a requirement of the NPDES permit for submittal to the Regional Boards and United States Environmental Protection Agency. The report presents an analysis and assessment of permit compliance activities.

▸Annual report - will be posted soon

San Bernardino County Storm Water Pollution Prevention

Current page: **Pollution Prevention for Businesses**
Document last modified: **6-25-2006**
URL of home page: **http://www.sbcounty.gov/stormwater**

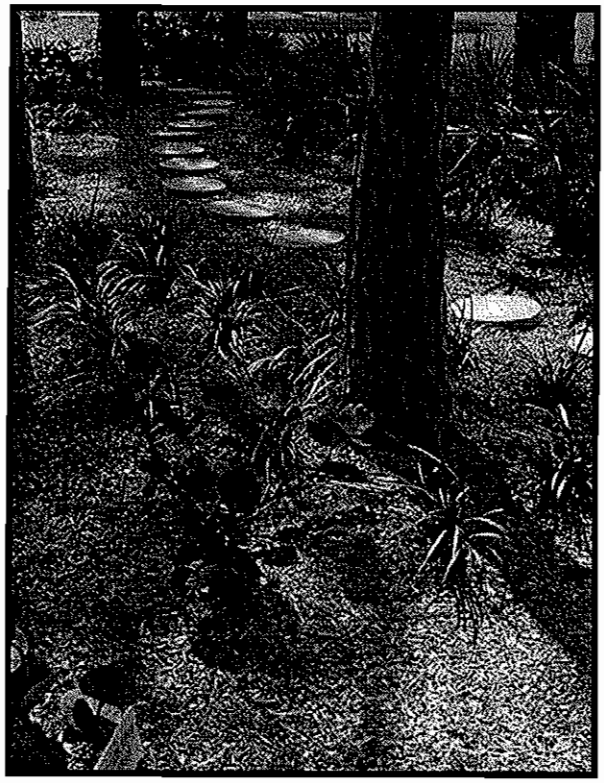
FOR MORE INFORMATION:
Call the San Bernardino County Storm Water Program
at (909) 387-8109
Email address: **StormWaterInfo@dpw.sbcounty.gov**

Web site maintained by S. GRONER ASSOCIATES, INC.
Email any problems or questions to sjurado@sga-inc.net

COUNTY OF SAN BERNARDINO HOME PAGE

▸ HOME PAGE
▸ GENERAL INFORMATION
▸ POLLUTION PREVENTION FOR RESIDENTS
▸ POLLUTION PREVENTION FOR BUSINESSES
▸ HOUSEHOLD HAZARDOUS WASTE AND OIL RECYCLING
▸ POLLUTION REPORTING
▸ EDUCATIONAL MATERIALS
▸ PERMITTEES
▸ LINKS

Site Design & Landscape Planning SD-10



Design Objectives

- ☑ Maximize Infiltration
- ☑ Provide Retention
- ☑ Slow Runoff
- ☑ Minimize Impervious Land Coverage
- Prohibit Dumping of Improper Materials
- Contain Pollutants
- Collect and Convey

Description

Each project site possesses unique topographic, hydrologic, and vegetative features, some of which are more suitable for development than others. Integrating and incorporating appropriate landscape planning methodologies into the project design is the most effective action that can be done to minimize surface and groundwater contamination from stormwater.

Approach

Landscape planning should couple consideration of land suitability for urban uses with consideration of community goals and projected growth. Project plan designs should conserve natural areas to the extent possible, maximize natural water storage and infiltration opportunities, and protect slopes and channels.

Suitable Applications

Appropriate applications include residential, commercial and industrial areas planned for development or redevelopment.

Design Considerations

Design requirements for site design and landscapes planning should conform to applicable standards and specifications of agencies with jurisdiction and be consistent with applicable General Plan and Local Area Plan policies.

Designing New Installations

Begin the development of a plan for the landscape unit with attention to the following general principles:

- Formulate the plan on the basis of clearly articulated community goals. Carefully identify conflicts and choices between retaining and protecting desired resources and community growth.
- Map and assess land suitability for urban uses. Include the following landscape features in the assessment: wooded land, open unwooded land, steep slopes, erosion-prone soils, foundation suitability, soil suitability for waste disposal, aquifers, aquifer recharge areas, wetlands, floodplains, surface waters, agricultural lands, and various categories of urban land use. When appropriate, the assessment can highlight outstanding local or regional resources that the community determines should be protected (e.g., a scenic area, recreational area, threatened species habitat, farmland, fish run). Mapping and assessment should recognize not only these resources but also additional areas needed for their sustenance.

Project plan designs should conserve natural areas to the extent possible, maximize natural water storage and infiltration opportunities, and protect slopes and channels.

Conserve Natural Areas during Landscape Planning

If applicable, the following items are required and must be implemented in the site layout during the subdivision design and approval process, consistent with applicable General Plan and Local Area Plan policies:

- Cluster development on least-sensitive portions of a site while leaving the remaining land in a natural undisturbed condition.
- Limit clearing and grading of native vegetation at a site to the minimum amount needed to build lots, allow access, and provide fire protection.
- Maximize trees and other vegetation at each site by planting additional vegetation, clustering tree areas, and promoting the use of native and/or drought tolerant plants.
- Promote natural vegetation by using parking lot islands and other landscaped areas.
- Preserve riparian areas and wetlands.

Maximize Natural Water Storage and Infiltration Opportunities Within the Landscape Unit

- Promote the conservation of forest cover. Building on land that is already deforested affects basin hydrology to a lesser extent than converting forested land. Loss of forest cover reduces interception storage, detention in the organic forest floor layer, and water losses by evapotranspiration, resulting in large peak runoff increases and either their negative effects or the expense of countering them with structural solutions.
- Maintain natural storage reservoirs and drainage corridors, including depressions, areas of permeable soils, swales, and intermittent streams. Develop and implement policies and

regulations to discourage the clearing, filling, and channelization of these features. Utilize them in drainage networks in preference to pipes, culverts, and engineered ditches.

- Evaluating infiltration opportunities by referring to the stormwater management manual for the jurisdiction and pay particular attention to the selection criteria for avoiding groundwater contamination, poor soils, and hydrogeological conditions that cause these facilities to fail. If necessary, locate developments with large amounts of impervious surfaces or a potential to produce relatively contaminated runoff away from groundwater recharge areas.

Protection of Slopes and Channels during Landscape Design

- Convey runoff safely from the tops of slopes.
- Avoid disturbing steep or unstable slopes.
- Avoid disturbing natural channels.
- Stabilize disturbed slopes as quickly as possible.
- Vegetate slopes with native or drought tolerant vegetation.
- Control and treat flows in landscaping and/or other controls prior to reaching existing natural drainage systems.
- Stabilize temporary and permanent channel crossings as quickly as possible, and ensure that increases in run-off velocity and frequency caused by the project do not erode the channel.
- Install energy dissipaters, such as riprap, at the outlets of new storm drains, culverts, conduits, or channels that enter unlined channels in accordance with applicable specifications to minimize erosion. Energy dissipaters shall be installed in such a way as to minimize impacts to receiving waters.
- Line on-site conveyance channels where appropriate, to reduce erosion caused by increased flow velocity due to increases in tributary impervious area. The first choice for linings should be grass or some other vegetative surface, since these materials not only reduce runoff velocities, but also provide water quality benefits from filtration and infiltration. If velocities in the channel are high enough to erode grass or other vegetative linings, riprap, concrete, soil cement, or geo-grid stabilization are other alternatives.
- Consider other design principles that are comparable and equally effective.

Redeveloping Existing Installations

Various jurisdictional stormwater management and mitigation plans (SUSMP, WQMP, etc.) define "redevelopment" in terms of amounts of additional impervious area, increases in gross floor area and/or exterior construction, and land disturbing activities with structural or impervious surfaces. The definition of " redevelopment" must be consulted to determine whether or not the requirements for new development apply to areas intended for redevelopment. If the definition applies, the steps outlined under "designing new installations" above should be followed.

Redevelopment may present significant opportunity to add features which had not previously been implemented. Examples include incorporation of depressions, areas of permeable soils, and swales in newly redeveloped areas. While some site constraints may exist due to the status of already existing infrastructure, opportunities should not be missed to maximize infiltration, slow runoff, reduce impervious areas, disconnect directly connected impervious areas.

Other Resources

A Manual for the Standard Urban Stormwater Mitigation Plan (SUSMP), Los Angeles County Department of Public Works, May 2002.

Stormwater Management Manual for Western Washington, Washington State Department of Ecology, August 2001.

Model Standard Urban Storm Water Mitigation Plan (SUSMP) for San Diego County, Port of San Diego, and Cities in San Diego County, February 14, 2002.

Model Water Quality Management Plan (WQMP) for County of Orange, Orange County Flood Control District, and the Incorporated Cities of Orange County, Draft February 2003.

Ventura Countywide Technical Guidance Manual for Stormwater Quality Control Measures, July 2002.

Roof Runoff Controls SD-11

Rain Garden

Design Objectives

- ☑ Maximize Infiltration
- ☑ Provide Retention
- ☑ Slow Runoff
- Minimize Impervious Land Coverage
- Prohibit Dumping of Improper Materials
- ☑ Contain Pollutants
- Collect and Convey

Description

Various roof runoff controls are available to address stormwater that drains off rooftops. The objective is to reduce the total volume and rate of runoff from individual lots, and retain the pollutants on site that may be picked up from roofing materials and atmospheric deposition. Roof runoff controls consist of directing the roof runoff away from paved areas and mitigating flow to the storm drain system through one of several general approaches: cisterns or rain barrels; dry wells or infiltration trenches; pop-up emitters, and foundation planting. The first three approaches require the roof runoff to be contained in a gutter and downspout system. Foundation planting provides a vegetated strip under the drip line of the roof.

Approach

Design of individual lots for single-family homes as well as lots for higher density residential and commercial structures should consider site design provisions for containing and infiltrating roof runoff or directing roof runoff to vegetative swales or buffer areas. Retained water can be reused for watering gardens, lawns, and trees. Benefits to the environment include reduced demand for potable water used for irrigation, improved stormwater quality, increased groundwater recharge, decreased runoff volume and peak flows, and decreased flooding potential.

Suitable Applications

Appropriate applications include residential, commercial and industrial areas planned for development or redevelopment.

Design Considerations

Designing New Installations

Cisterns or Rain Barrels

One method of addressing roof runoff is to direct roof downspouts to cisterns or rain barrels. A cistern is an above ground storage vessel with either a manually operated valve or a permanently open outlet. Roof runoff is temporarily stored and then released for irrigation or infiltration between storms. The number of rain

barrels needed is a function of the rooftop area. Some low impact developers recommend that every house have at least 2 rain barrels, with a minimum storage capacity of 1000 liters. Roof barrels serve several purposes including mitigating the first flush from the roof which has a high volume, amount of contaminants, and thermal load. Several types of rain barrels are commercially available. Consideration must be given to selecting rain barrels that are vector proof and childproof. In addition, some barrels are designed with a bypass valve that filters out grit and other contaminants and routes overflow to a soak-away pit or rain garden.

If the cistern has an operable valve, the valve can be closed to store stormwater for irrigation or infiltration between storms. This system requires continual monitoring by the resident or grounds crews, but provides greater flexibility in water storage and metering. If a cistern is provided with an operable valve and water is stored inside for long periods, the cistern must be covered to prevent mosquitoes from breeding.

A cistern system with a permanently open outlet can also provide for metering stormwater runoff. If the cistern outlet is significantly smaller than the size of the downspout inlet (say ¼ to ½ inch diameter), runoff will build up inside the cistern during storms, and will empty out slowly after peak intensities subside. This is a feasible way to mitigate the peak flow increases caused by rooftop impervious land coverage, especially for the frequent, small storms.

Dry wells and Infiltration Trenches

Roof downspouts can be directed to dry wells or infiltration trenches. A dry well is constructed by excavating a hole in the ground and filling it with an open graded aggregate, and allowing the water to fill the dry well and infiltrate after the storm event. An underground connection from the downspout conveys water into the dry well, allowing it to be stored in the voids. To minimize sedimentation from lateral soil movement, the sides and top of the stone storage matrix can be wrapped in a permeable filter fabric, though the bottom may remain open. A perforated observation pipe can be inserted vertically into the dry well to allow for inspection and maintenance.

In practice, dry wells receiving runoff from single roof downspouts have been successful over long periods because they contain very little sediment. They must be sized according to the amount of rooftop runoff received, but are typically 4 to 5 feet square, and 2 to 3 feet deep, with a minimum of 1-foot soil cover over the top (maximum depth of 10 feet).

To protect the foundation, dry wells must be set away from the building at least 10 feet. They must be installed in solids that accommodate infiltration. In poorly drained soils, dry wells have very limited feasibility.

Infiltration trenches function in a similar manner and would be particularly effective for larger roof areas. An infiltration trench is a long, narrow, rock-filled trench with no outlet that receives stormwater runoff. These are described under Treatment Controls.

Pop-up Drainage Emitter

Roof downspouts can be directed to an underground pipe that daylights some distance from the building foundation, releasing the roof runoff through a pop-up emitter. Similar to a pop-up irrigation head, the emitter only opens when there is flow from the roof. The emitter remains flush to the ground during dry periods, for ease of lawn or landscape maintenance.

Foundation Planting

Landscape planting can be provided around the base to allow increased opportunities for stormwater infiltration and protect the soil from erosion caused by concentrated sheet flow coming off the roof. Foundation plantings can reduce the physical impact of water on the soil and provide a subsurface matrix of roots that encourage infiltration. These plantings must be sturdy enough to tolerate the heavy runoff sheet flows, and periodic soil saturation.

Redeveloping Existing Installations

Various jurisdictional stormwater management and mitigation plans (SUSMP, WQMP, etc.) define "redevelopment" in terms of amounts of additional impervious area, increases in gross floor area and/or exterior construction, and land disturbing activities with structural or impervious surfaces. The definition of " redevelopment" must be consulted to determine whether or not the requirements for new development apply to areas intended for redevelopment. If the definition applies, the steps outlined under "designing new installations" above should be followed.

Supplemental Information

Examples

- City of Ottawa's Water Links Surface –Water Quality Protection Program
- City of Toronto Downspout Disconnection Program
- City of Boston, MA, Rain Barrel Demonstration Program

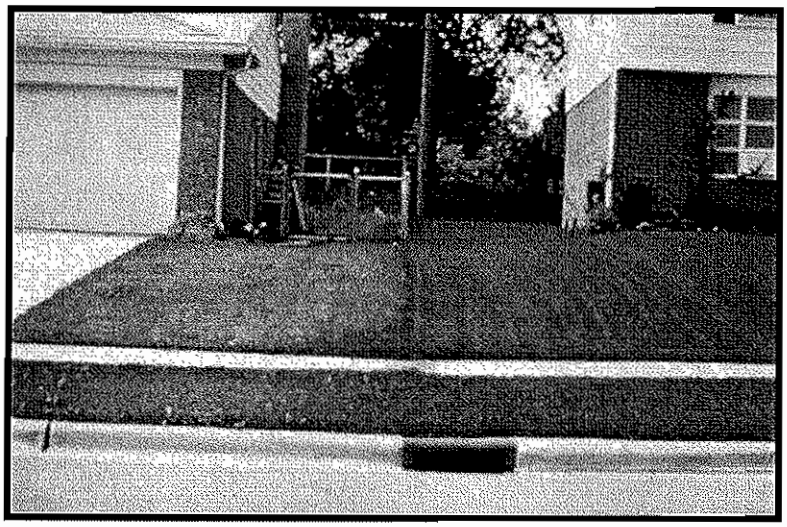
Other Resources

Hager, Marty Catherine, Stormwater, "Low-Impact Development", January/February 2003. www.stormh2o.com

Low Impact Urban Design Tools, Low Impact Development Design Center, Beltsville, MD. www.lid-stormwater.net

Start at the Source, Bay Area Stormwater Management Agencies Association, 1999 Edition

Efficient Irrigation SD-12



Design Objectives

- ☑ Maximize Infiltration
- ☑ Provide Retention
- ☑ Slow Runoff
- Minimize Impervious Land Coverage
- Prohibit Dumping of Improper Materials
- Contain Pollutants
- Collect and Convey

Description

Irrigation water provided to landscaped areas may result in excess irrigation water being conveyed into stormwater drainage systems.

Approach

Project plan designs for development and redevelopment should include application methods of irrigation water that minimize runoff of excess irrigation water into the stormwater conveyance system.

Suitable Applications

Appropriate applications include residential, commercial and industrial areas planned for development or redevelopment. (Detached residential single-family homes are typically excluded from this requirement.)

Design Considerations

Designing New Installations

The following methods to reduce excessive irrigation runoff should be considered, and incorporated and implemented where determined applicable and feasible by the Permittee:

- Employ rain-triggered shutoff devices to prevent irrigation after precipitation.
- Design irrigation systems to each landscape area's specific water requirements.
- Include design featuring flow reducers or shutoff valves triggered by a pressure drop to control water loss in the event of broken sprinkler heads or lines.
- Implement landscape plans consistent with County or City water conservation resolutions, which may include provision of water sensors, programmable irrigation times (for short cycles), etc.

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- Design timing and application methods of irrigation water to minimize the runoff of excess irrigation water into the storm water drainage system.
- Group plants with similar water requirements in order to reduce excess irrigation runoff and promote surface filtration. Choose plants with low irrigation requirements (for example, native or drought tolerant species). Consider design features such as:
  - Using mulches (such as wood chips or bar) in planter areas without ground cover to minimize sediment in runoff
  - Installing appropriate plant materials for the location, in accordance with amount of sunlight and climate, and use native plant materials where possible and/or as recommended by the landscape architect
  - Leaving a vegetative barrier along the property boundary and interior watercourses, to act as a pollutant filter, where appropriate and feasible
  - Choosing plants that minimize or eliminate the use of fertilizer or pesticides to sustain growth
- Employ other comparable, equally effective methods to reduce irrigation water runoff.

Redeveloping Existing Installations

Various jurisdictional stormwater management and mitigation plans (SUSMP, WQMP, etc.) define "redevelopment" in terms of amounts of additional impervious area, increases in gross floor area and/or exterior construction, and land disturbing activities with structural or impervious surfaces. The definition of " redevelopment" must be consulted to determine whether or not the requirements for new development apply to areas intended for redevelopment. If the definition applies, the steps outlined under "designing new installations" above should be followed.

Other Resources

A Manual for the Standard Urban Stormwater Mitigation Plan (SUSMP), Los Angeles County Department of Public Works, May 2002.

Model Standard Urban Storm Water Mitigation Plan (SUSMP) for San Diego County, Port of San Diego, and Cities in San Diego County, February 14, 2002.

Model Water Quality Management Plan (WQMP) for County of Orange, Orange County Flood Control District, and the Incorporated Cities of Orange County, Draft February 2003.

Ventura Countywide Technical Guidance Manual for Stormwater Quality Control Measures, July 2002.

Storm Drain Signage SD-13

Design Objectives

- Maximize Infiltration
- Provide Retention
- Slow Runoff
- Minimize Impervious Land Coverage
- ☑ Prohibit Dumping of Improper Materials
- Contain Pollutants
- Collect and Convey

Description

Waste materials dumped into storm drain inlets can have severe impacts on receiving and ground waters. Posting notices regarding discharge prohibitions at storm drain inlets can prevent waste dumping. Storm drain signs and stencils are highly visible source controls that are typically placed directly adjacent to storm drain inlets.

Approach

The stencil or affixed sign contains a brief statement that prohibits dumping of improper materials into the urban runoff conveyance system. Storm drain messages have become a popular method of alerting the public about the effects of and the prohibitions against waste disposal.

Suitable Applications

Stencils and signs alert the public to the destination of pollutants discharged to the storm drain. Signs are appropriate in residential, commercial, and industrial areas, as well as any other area where contributions or dumping to storm drains is likely.

Design Considerations

Storm drain message markers or placards are recommended at all storm drain inlets within the boundary of a development project. The marker should be placed in clear sight facing toward anyone approaching the inlet from either side. All storm drain inlet locations should be identified on the development site map.

Designing New Installations

The following methods should be considered for inclusion in the project design and show on project plans:

- Provide stenciling or labeling of all storm drain inlets and catch basins, constructed or modified, within the project area with prohibitive language. Examples include "NO DUMPING

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– DRAINS TO OCEAN" and/or other graphical icons to discourage illegal dumping.

- Post signs with prohibitive language and/or graphical icons, which prohibit illegal dumping at public access points along channels and creeks within the project area.

Note - Some local agencies have approved specific signage and/or storm drain message placards for use. Consult local agency stormwater staff to determine specific requirements for placard types and methods of application.

Redeveloping Existing Installations

Various jurisdictional stormwater management and mitigation plans (SUSMP, WQMP, etc.) define "redevelopment" in terms of amounts of additional impervious area, increases in gross floor area and/or exterior construction, and land disturbing activities with structural or impervious surfaces. If the project meets the definition of "redevelopment", then the requirements stated under " designing new installations" above should be included in all project design plans.

Additional Information

Maintenance Considerations

- Legibility of markers and signs should be maintained. If required by the agency with jurisdiction over the project, the owner/operator or homeowner's association should enter into a maintenance agreement with the agency or record a deed restriction upon the property title to maintain the legibility of placards or signs.

Placement

- Signage on top of curbs tends to weather and fade.
- Signage on face of curbs tends to be worn by contact with vehicle tires and sweeper brooms.

Supplemental Information

Examples

- Most MS4 programs have storm drain signage programs. Some MS4 programs will provide stencils, or arrange for volunteers to stencil storm drains as part of their outreach program.

Other Resources

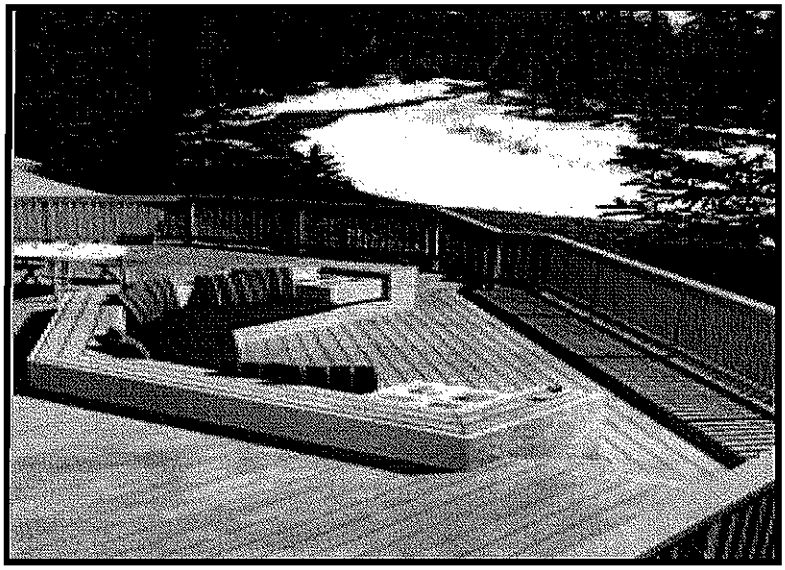
A Manual for the Standard Urban Stormwater Mitigation Plan (SUSMP), Los Angeles County Department of Public Works, May 2002.

Model Standard Urban Storm Water Mitigation Plan (SUSMP) for San Diego County, Port of San Diego, and Cities in San Diego County, February 14, 2002.

Model Water Quality Management Plan (WQMP) for County of Orange, Orange County Flood Control District, and the Incorporated Cities of Orange County, Draft February 2003.

Ventura Countywide Technical Guidance Manual for Stormwater Quality Control Measures, July 2002.

Alternative Building Materials SD-21



Design Objectives

- ☑ Maximize Infiltration
- ☑ Provide Retention
- ☑ Source Control
- Minimize Impervious Land Coverage
- Prohibit Dumping of Improper Materials
- Contain Pollutant
- Collect and Convey

Description

Alternative building materials are selected instead of conventional materials for new construction and renovation. These materials reduce potential sources of pollutants in stormwater runoff by eliminating compounds that can leach into runoff, reducing the need for pesticide application, reducing the need for painting and other maintenance, or by reducing the volume of runoff.

Approach

Alternative building materials are available for use as lumber for decking, roofing materials, home siding, and paving for driveways, decks, and sidewalks.

Suitable Applications

Appropriate applications include residential, commercial and industrial areas planned for development or redevelopment.

Design Considerations

Designing New Installations

Decking

One of the most common materials for construction of decks and other outdoor construction has traditionally been pressure treated wood, which is now being phased out. The standard treatment is called CCA, for chromated copper arsenate. The key ingredients are arsenic (which kills termites, carpenter ants and other insects), copper (which kills the fungi that cause wood to rot) and chromium (which reacts with the other ingredients to bind them to the wood). The amount of arsenic is far from trivial. A deck just 8 feet x 10 feet contains more than 1 1/3 pounds of this highly potent poison. Replacement materials include a new type of pressure treated wood, plastic and composite lumber.

There are currently over 20 products in the market consisting of plastic or plastic-wood composites. Plastic lumber is made from 100% recycled plastic, # 2 HDPE and polyethylene plastic milk jugs and soap bottles. Plastic-wood composites are a combination of plastic and wood fibers or sawdust. These materials are a long lasting exterior weather, insect, and chemical resistant wood lumber replacement for non structural applications. Use it for decks, docks, raised garden beds and planter boxes, pallets, hand railings, outdoor furniture, animal pens, boat decks, etc.

New pressure treated wood uses a much safer recipe, ACQ, which stands for ammoniacal copper quartenary. It contains no arsenic and no chromium. Yet the American Wood Preservers Association has found it to be just as effective as the standard formula. ACQ is common in Japan and Europe.

Roofing

Several studies have indicated that metal used as roofing material, flashing, or gutters can leach metals into the environment. The leaching occurs because rainfall is slightly acidic and slowly dissolved the exposed metals. Common traditional applications include copper sheathing and galvanized (zinc) gutters.

Coated metal products are available for both roofing and gutter applications. These products eliminate contact of bare metal with rainfall, eliminating one source of metals in runoff. There are also roofing materials made of recycled rubber and plastic that resemble traditional materials.

A less traditional approach is the use of green roofs. These roofs are not just green, they're alive. Planted with grasses and succulents, low- profile green roofs reduce the urban heat island effect, stormwater runoff, and cooling costs, while providing wildlife habitat and a connection to nature for building occupants. These roofs are widely used on industrial facilities in Europe and have been established as experimental installations in several locations in the US, including Portland, Oregon. Their feasibility is questionable in areas of California with prolonged, dry, hot weather.

Paved Areas

Traditionally, concrete is used for construction of patios, sidewalks, and driveways. Although it is non-toxic, these paved areas reduce stormwater infiltration and increase the volume and rate of runoff. This increase in the amount of runoff is the leading cause of stream channel degradation in urban areas.

There are a number of alternative materials that can be used in these applications, including porous concrete and asphalt, modular blocks, and crushed granite. These materials, especially modular paving blocks, are widely available and a well established method to reduce stormwater runoff.

Building Siding

Wood siding is commonly used on the exterior of residential construction. This material weathers fairly rapidly and requires repeated painting to prevent rotting. Alternative "new" products for this application include cement-fiber and vinyl. Cement-fiber siding is a masonry product made from Portland cement, sand, and cellulose and will not burn, cup, swell, or shrink.

Pesticide Reduction
A common use of powerful pesticides is for the control of termites. Chlordane was used for many years for this purpose and is now found in urban streams and lakes nationwide. There are a number of physical barriers that can be installed during construction to help reduce the use of pesticides.

Sand barriers for subterranean termites are a physical deterrent because the termites cannot tunnel through it. Sand barriers can be applied in crawl spaces under pier and beam foundations, under slab foundations, and between the foundation and concrete porches, terraces, patios and steps. Other possible locations include under fence posts, underground electrical cables, water and gas lines, telephone and electrical poles, inside hollow tile cells and against retaining walls.

Metal termite shields are physical barriers to termites which prevent them from building invisible tunnels. In reality, metal shields function as a helpful termite detection device, forcing them to build tunnels on the outside of the shields which are easily seen. Metal termite shields also help prevent dampness from wicking to adjoining wood members which can result in rot, thus making the material more attractive to termites and other pests. Metal flashing and metal plates can also be used as a barrier between piers and beams of structures such as decks, which are particularly vulnerable to termite attack.

Redeveloping Existing Installations

Various jurisdictional stormwater management and mitigation plans (SUSMP, WQMP, etc.) define "redevelopment" in terms of amounts of additional impervious area, increases in gross floor area and/or exterior construction, and land disturbing activities with structural or impervious surfaces. The definition of "redevelopment" must be consulted to determine whether or not the requirements for new development apply to areas intended for redevelopment. If the definition applies, the steps outlined under "designing new installations" above should be followed.

Other Resources

There are no good, independent, comprehensive sources of information on alternative building materials for use in minimizing the impacts of stormwater runoff. Most websites or other references to "green" or "alternative" building materials focus on indoor applications, such as formaldehyde free plywood and low VOC paints, carpets, and pads. Some supplemental information on alternative materials is available from the manufacturers.

Fires are a source of concern in many areas of California. Information on the flammability of alternative decking materials is available from the University of California Forest Product Laboratory (UCFPL) website at: http://www.ucfpl.ucop.edu/WDDeckIntro.htm

Trash Storage Areas SD-32

Description

Trash storage areas are areas where a trash receptacle (s) are located for use as a repository for solid wastes. Stormwater runoff from areas where trash is stored or disposed of can be polluted. In addition, loose trash and debris can be easily transported by water or wind into nearby storm drain inlets, channels, and/or creeks. Waste handling operations that may be sources of stormwater pollution include dumpsters, litter control, and waste piles.

Approach

This fact sheet contains details on the specific measures required to prevent or reduce pollutants in stormwater runoff associated with trash storage and handling. Preventative measures including enclosures, containment structures, and impervious pavements to mitigate spills, should be used to reduce the likelihood of contamination.

Design Objectives

- Maximize Infiltration
- Provide Retention
- Slow Runoff
- Minimize Impervious Land Coverage
- Prohibit Dumping of Improper Materials
- ☑ Contain Pollutants
- Collect and Convey

Suitable Applications

Appropriate applications include residential, commercial and industrial areas planned for development or redevelopment. (Detached residential single-family homes are typically excluded from this requirement.)

Design Considerations

Design requirements for waste handling areas are governed by Building and Fire Codes, and by current local agency ordinances and zoning requirements. The design criteria described in this fact sheet are meant to enhance and be consistent with these code and ordinance requirements. Hazardous waste should be handled in accordance with legal requirements established in Title 22, California Code of Regulation.

Wastes from commercial and industrial sites are typically hauled by either public or commercial carriers that may have design or access requirements for waste storage areas. The design criteria in this fact sheet are recommendations and are not intended to be in conflict with requirements established by the waste hauler. The waste hauler should be contacted prior to the design of your site trash collection areas. Conflicts or issues should be discussed with the local agency.

Designing New Installations

Trash storage areas should be designed to consider the following structural or treatment control BMPs:

- Design trash container areas so that drainage from adjoining roofs and pavement is diverted around the area(s) to avoid run-on. This might include berming or grading the waste handling area to prevent run-on of stormwater.
- Make sure trash container areas are screened or walled to prevent off-site transport of trash.

- Use lined bins or dumpsters to reduce leaking of liquid waste.
- Provide roofs, awnings, or attached lids on all trash containers to minimize direct precipitation and prevent rainfall from entering containers.
- Pave trash storage areas with an impervious surface to mitigate spills.
- Do not locate storm drains in immediate vicinity of the trash storage area.
- Post signs on all dumpsters informing users that hazardous materials are not to be disposed of therein.

Redeveloping Existing Installations

Various jurisdictional stormwater management and mitigation plans (SUSMP, WQMP, etc.) define "redevelopment" in terms of amounts of additional impervious area, increases in gross floor area and/or exterior construction, and land disturbing activities with structural or impervious surfaces. The definition of " redevelopment" must be consulted to determine whether or not the requirements for new development apply to areas intended for redevelopment. If the definition applies, the steps outlined under "designing new installations" above should be followed.

Additional Information

Maintenance Considerations

The integrity of structural elements that are subject to damage (i.e., screens, covers, and signs) must be maintained by the owner/operator. Maintenance agreements between the local agency and the owner/operator may be required. Some agencies will require maintenance deed restrictions to be recorded of the property title. If required by the local agency, maintenance agreements or deed restrictions must be executed by the owner/operator before improvement plans are approved.

Other Resources

A Manual for the Standard Urban Stormwater Mitigation Plan (SUSMP), Los Angeles County Department of Public Works, May 2002.

Model Standard Urban Storm Water Mitigation Plan (SUSMP) for San Diego County, Port of San Diego, and Cities in San Diego County, February 14, 2002.

Model Water Quality Management Plan (WQMP) for County of Orange, Orange County Flood Control District, and the Incorporated Cities of Orange County, Draft February 2003.

Ventura Countywide Technical Guidance Manual for Stormwater Quality Control Measures, July 2002.

Vehicle Washing Areas SD-33

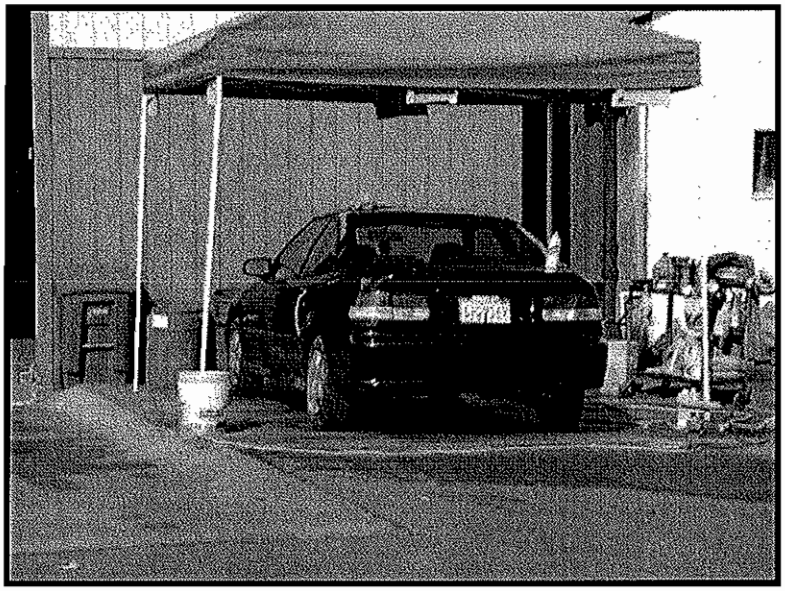


Photo Credit: Geoff Brosseau

Design Objectives

- ☑ Maximize Infiltration
- Provide Retention
- Slow Runoff
- Minimize Impervious Land Coverage
- Prohibit Dumping of Improper Materials
- ☑ Contain Pollutants
- ☑ Collect and Convey

Description

Vehicle washing, equipment washing, and steam cleaning may contribute high concentrations of metals, oil and grease, solvents, phosphates, and suspended solids to wash waters that drain to stormwater conveyance systems.

Approach

Project plans should include appropriately designed area(s) for washing-steam cleaning of vehicles and equipment. Depending on the size and other parameters of the wastewater facility, wash water may be conveyed to a sewer, an infiltration system, recycling system or other alternative. Pretreatment may be required for conveyance to a sanitary sewer.

Suitable Applications

Appropriate applications include commercial developments, restaurants, retail gasoline outlets, automotive repair shops and others.

Design Considerations

Design requirements for vehicle maintenance are governed by Building and Fire Codes, and by current local agency ordinances, and zoning requirements. Design criteria described in this fact sheet are meant to enhance and be consistent with these code requirements.

Designing New Installations

Areas for washing/steam cleaning should incorporate one of the following features:

- Be self-contained and/or covered with a roof or overhang
- Be equipped with a clarifier or other pretreatment facility
- Have a proper connection to a sanitary sewer

- Include other features which are comparable and equally effective

CAR WASH AREAS - Some jurisdictions' stormwater management plans include vehicle-cleaning area source control design requirements for community car wash racks in complexes with a large number of dwelling units. In these cases, wash water from the areas may be directed to the sanitary sewer, to an engineered infiltration system, or to an equally effective alternative. Pre-treatment may also be required.

Depending on the jurisdiction, developers may be directed to divert surface water runoff away from the exposed area around the wash pad (parking lot, storage areas), and wash pad itself to alternatives other than the sanitary sewer. Roofing may be required for exposed wash pads.

It is generally advisable to cover areas used for regular washing of vehicles, trucks, or equipment, surround them with a perimeter berm, and clearly mark them as a designated washing area. Sumps or drain lines can be installed to collect wash water, which may be treated for reuse or recycling, or for discharge to the sanitary sewer. Jurisdictions may require some form of pretreatment, such as a trap, for these areas.

Redeveloping Existing Installations

Various jurisdictional stormwater management and mitigation plans (SUSMP, WQMP, etc.) define "redevelopment" in terms of amounts of additional impervious area, increases in gross floor area and/or exterior construction, and land disturbing activities with structural or impervious surfaces. The definition of " redevelopment" must be consulted to determine whether or not the requirements for new development apply to areas intended for redevelopment.

Additional Information

Maintenance Considerations

Stormwater and non-stormwater will accumulate in containment areas and sumps with impervious surfaces. Contaminated accumulated water must be disposed of in accordance with applicable laws and cannot be discharged directly to the storm drain or sanitary sewer system without the appropriate permit.

Other Resources

A Manual for the Standard Urban Stormwater Mitigation Plan (SUSMP), Los Angeles County Department of Public Works, May 2002.

Model Standard Urban Storm Water Mitigation Plan (SUSMP) for San Diego County, Port of San Diego, and Cities in San Diego County, February 14, 2002.

Model Water Quality Management Plan (WQMP) for County of Orange, Orange County Flood Control District, and the Incorporated Cities of Orange County, Draft February 2003.

Ventura Countywide Technical Guidance Manual for Stormwater Quality Control Measures, July 2002.

Bioretention TC-32

Design Considerations

- Soil for Infiltration
- Tributary Area
- Slope
- Aesthetics
- Environmental Side-effects

Description

The bioretention best management practice (BMP) functions as a soil and plant-based filtration device that removes pollutants through a variety of physical, biological, and chemical treatment processes. These facilities normally consist of a grass buffer strip, sand bed, ponding area, organic layer or mulch layer, planting soil, and plants. The runoff's velocity is reduced by passing over or through buffer strip and subsequently distributed evenly along a ponding area. Exfiltration of the stored water in the bioretention area planting soil into the underlying soils occurs over a period of days.

Targeted Constituents

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

Legend ***(Removal Effectiveness)***

● Low ■ High ▲ Medium

California Experience

None documented. Bioretention has been used as a stormwater BMP since 1992. In addition to Prince George's County, MD and Alexandria, VA, bioretention has been used successfully at urban and suburban areas in Montgomery County, MD; Baltimore County, MD; Chesterfield County, VA; Prince William County, VA; Smith Mountain Lake State Park, VA; and Cary, NC.

Advantages

- Bioretention provides stormwater treatment that enhances the quality of downstream water bodies by temporarily storing runoff in the BMP and releasing it over a period of four days to the receiving water (EPA, 1999).
- The vegetation provides shade and wind breaks, absorbs noise, and improves an area's landscape.

Limitations

- The bioretention BMP is not recommended for areas with slopes greater than 20% or where mature tree removal would

be required since clogging may result, particularly if the BMP receives runoff with high sediment loads (EPA, 1999).

- Bioretention is not a suitable BMP at locations where the water table is within 6 feet of the ground surface and where the surrounding soil stratum is unstable.
- By design, bioretention BMPs have the potential to create very attractive habitats for mosquitoes and other vectors because of highly organic, often heavily vegetated areas mixed with shallow water.
- In cold climates the soil may freeze, preventing runoff from infiltrating into the planting soil.

Design and Sizing Guidelines

- The bioretention area should be sized to capture the design storm runoff.
- In areas where the native soil permeability is less than 0.5 in/hr an underdrain should be provided.
- Recommended minimum dimensions are 15 feet by 40 feet, although the preferred width is 25 feet. Excavated depth should be 4 feet.
- Area should drain completely within 72 hours.
- Approximately 1 tree or shrub per 50 ft^2 of bioretention area should be included.
- Cover area with about 3 inches of mulch.

Construction/Inspection Considerations

Bioretention area should not be established until contributing watershed is stabilized.

Performance

Bioretention removes stormwater pollutants through physical and biological processes, including adsorption, filtration, plant uptake, microbial activity, decomposition, sedimentation and volatilization (EPA, 1999). Adsorption is the process whereby particulate pollutants attach to soil (e.g., clay) or vegetation surfaces. Adequate contact time between the surface and pollutant must be provided for in the design of the system for this removal process to occur. Thus, the infiltration rate of the soils must not exceed those specified in the design criteria or pollutant removal may decrease. Pollutants removed by adsorption include metals, phosphorus, and hydrocarbons. Filtration occurs as runoff passes through the bioretention area media, such as the sand bed, ground cover, and planting soil.

Common particulates removed from stormwater include particulate organic matter, phosphorus, and suspended solids. Biological processes that occur in wetlands result in pollutant uptake by plants and microorganisms in the soil. Plant growth is sustained by the uptake of nutrients from the soils, with woody plants locking up these nutrients through the seasons. Microbial activity within the soil also contributes to the removal of nitrogen and organic matter. Nitrogen is removed by nitrifying and denitrifying bacteria, while aerobic bacteria are responsible for the decomposition of the organic matter. Microbial processes require oxygen and can result in depleted oxygen levels if the bioretention area is not adequately

aerated. Sedimentation occurs in the swale or ponding area as the velocity slows and solids fall out of suspension.

The removal effectiveness of bioretention has been studied during field and laboratory studies conducted by the University of Maryland (Davis et al, 1998). During these experiments, synthetic stormwater runoff was pumped through several laboratory and field bioretention areas to simulate typical storm events in Prince George's County, MD. Removal rates for heavy metals and nutrients are shown in Table 1.

Table 1 Laboratory and Estimated Bioretention Davis et al. (1998); PGDER (1993)

Pollutant	Removal Rate
Total Phosphorus	70-83%
Metals (Cu, Zn, Pb)	93-98%
TKN	68-80%
Total Suspended Solids	90%
Organics	90%
Bacteria	90%

Results for both the laboratory and field experiments were similar for each of the pollutants analyzed. Doubling or halving the influent pollutant levels had little effect on the effluent pollutants concentrations (Davis et al, 1998).

The microbial activity and plant uptake occurring in the bioretention area will likely result in higher removal rates than those determined for infiltration BMPs.

Siting Criteria

Bioretention BMPs are generally used to treat stormwater from impervious surfaces at commercial, residential, and industrial areas (EPA, 1999). Implementation of bioretention for stormwater management is ideal for median strips, parking lot islands, and swales. Moreover, the runoff in these areas can be designed to either divert directly into the bioretention area or convey into the bioretention area by a curb and gutter collection system.

The best location for bioretention areas is upland from inlets that receive sheet flow from graded areas and at areas that will be excavated (EPA, 1999). In order to maximize treatment effectiveness, the site must be graded in such a way that minimizes erosive conditions as sheet flow is conveyed to the treatment area. Locations where a bioretention area can be readily incorporated into the site plan without further environmental damage are preferred. Furthermore, to effectively minimize sediment loading in the treatment area, bioretention only should be used in stabilized drainage areas.

Additional Design Guidelines

The layout of the bioretention area is determined after site constraints such as location of utilities, underlying soils, existing vegetation, and drainage are considered (EPA, 1999). Sites with loamy sand soils are especially appropriate for bioretention because the excavated soil can be backfilled and used as the planting soil, thus eliminating the cost of importing planting soil.

The use of bioretention may not be feasible given an unstable surrounding soil stratum, soils with clay content greater than 25 percent, a site with slopes greater than 20 percent, and/or a site with mature trees that would be removed during construction of the BMP.

Bioretention can be designed to be off-line or on-line of the existing drainage system (EPA, 1999). The drainage area for a bioretention area should be between 0.1 and 0.4 hectares (0.25 and 1.0 acres). Larger drainage areas may require multiple bioretention areas. Furthermore, the maximum drainage area for a bioretention area is determined by the expected rainfall intensity and runoff rate. Stabilized areas may erode when velocities are greater than 5 feet per second (1.5 meter per second). The designer should determine the potential for erosive conditions at the site.

The size of the bioretention area, which is a function of the drainage area and the runoff generated from the area is sized to capture the water quality volume.

The recommended minimum dimensions of the bioretention area are 15 feet (4.6 meters) wide by 40 feet (12.2 meters) long, where the minimum width allows enough space for a dense, randomly-distributed area of trees and shrubs to become established. Thus replicating a natural forest and creating a microclimate, thereby enabling the bioretention area to tolerate the effects of heat stress, acid rain, runoff pollutants, and insect and disease infestations which landscaped areas in urban settings typically are unable to tolerate. The preferred width is 25 feet (7.6 meters), with a length of twice the width. Essentially, any facilities wider than 20 feet (6.1 meters) should be twice as long as they are wide, which promotes the distribution of flow and decreases the chances of concentrated flow.

In order to provide adequate storage and prevent water from standing for excessive periods of time the ponding depth of the bioretention area should not exceed 6 inches (15 centimeters). Water should not be left to stand for more than 72 hours. A restriction on the type of plants that can be used may be necessary due to some plants' water intolerance. Furthermore, if water is left standing for longer than 72 hours mosquitoes and other insects may start to breed.

The appropriate planting soil should be backfilled into the excavated bioretention area. Planting soils should be sandy loam, loamy sand, or loam texture with a clay content ranging from 10 to 25 percent.

Generally the soil should have infiltration rates greater than 0.5 inches (1.25 centimeters) per hour, which is typical of sandy loams, loamy sands, or loams. The pH of the soil should range between 5.5 and 6.5, where pollutants such as organic nitrogen and phosphorus can be adsorbed by the soil and microbial activity can flourish. Additional requirements for the planting soil include a 1.5 to 3 percent organic content and a maximum 500 ppm concentration of soluble salts.

Soil tests should be performed for every 500 cubic yards (382 cubic meters) of planting soil, with the exception of pH and organic content tests, which are required only once per bioretention area (EPA, 1999). Planting soil should be 4 inches (10.1 centimeters) deeper than the bottom of the largest root ball and 4 feet (1.2 meters) altogether. This depth will provide adequate soil for the plants' root systems to become established, prevent plant damage due to severe wind, and provide adequate moisture capacity. Most sites will require excavation in order to obtain the recommended depth.

Planting soil depths of greater than 4 feet (1.2 meters) may require additional construction practices such as shoring measures (EPA, 1999). Planting soil should be placed in 18 inches or greater lifts and lightly compacted until the desired depth is reached. Since high canopy trees may be destroyed during maintenance the bioretention area should be vegetated to resemble a terrestrial forest community ecosystem that is dominated by understory trees. Three species each of both trees and shrubs are recommended to be planted at a rate of 2500 trees and shrubs per hectare (1000 per acre). For instance, a 15 foot (4.6 meter) by 40 foot (12.2 meter) bioretention area (600 square feet or 55.75 square meters) would require 14 trees and shrubs. The shrub-to-tree ratio should be 2:1 to 3:1.

Trees and shrubs should be planted when conditions are favorable. Vegetation should be watered at the end of each day for fourteen days following its planting. Plant species tolerant of pollutant loads and varying wet and dry conditions should be used in the bioretention area.

The designer should assess aesthetics, site layout, and maintenance requirements when selecting plant species. Adjacent non-native invasive species should be identified and the designer should take measures, such as providing a soil breach to eliminate the threat of these species invading the bioretention area. Regional landscaping manuals should be consulted to ensure that the planting of the bioretention area meets the landscaping requirements established by the local authorities. The designers should evaluate the best placement of vegetation within the bioretention area. Plants should be placed at irregular intervals to replicate a natural forest. Trees should be placed on the perimeter of the area to provide shade and shelter from the wind. Trees and shrubs can be sheltered from damaging flows if they are placed away from the path of the incoming runoff. In cold climates, species that are more tolerant to cold winds, such as evergreens, should be placed in windier areas of the site.

Following placement of the trees and shrubs, the ground cover and/or mulch should be established. Ground cover such as grasses or legumes can be planted at the beginning of the growing season. Mulch should be placed immediately after trees and shrubs are planted. Two to 3 inches (5 to 7.6 cm) of commercially-available fine shredded hardwood mulch or shredded hardwood chips should be applied to the bioretention area to protect from erosion.

Maintenance

The primary maintenance requirement for bioretention areas is that of inspection and repair or replacement of the treatment area's components. Generally, this involves nothing more than the routine periodic maintenance that is required of any landscaped area. Plants that are appropriate for the site, climatic, and watering conditions should be selected for use in the bioretention cell. Appropriately selected plants will aide in reducing fertilizer, pesticide, water, and overall maintenance requirements. Bioretention system components should blend over time through plant and root growth, organic decomposition, and the development of a natural

soil horizon. These biologic and physical processes over time will lengthen the facility's life span and reduce the need for extensive maintenance.

Routine maintenance should include a biannual health evaluation of the trees and shrubs and subsequent removal of any dead or diseased vegetation (EPA, 1999). Diseased vegetation should be treated as needed using preventative and low-toxic measures to the extent possible. BMPs have the potential to create very attractive habitats for mosquitoes and other vectors because of highly organic, often heavily vegetated areas mixed with shallow water. Routine inspections for areas of standing water within the BMP and corrective measures to restore proper infiltration rates are necessary to prevent creating mosquito and other vector habitat. In addition, bioretention BMPs are susceptible to invasion by aggressive plant species such as cattails, which increase the chances of water standing and subsequent vector production if not routinely maintained.

In order to maintain the treatment area's appearance it may be necessary to prune and weed. Furthermore, mulch replacement is suggested when erosion is evident or when the site begins to look unattractive. Specifically, the entire area may require mulch replacement every two to three years, although spot mulching may be sufficient when there are random void areas. Mulch replacement should be done prior to the start of the wet season.

New Jersey's Department of Environmental Protection states in their bioretention systems standards that accumulated sediment and debris removal (especially at the inflow point) will normally be the primary maintenance function. Other potential tasks include replacement of dead vegetation, soil pH regulation, erosion repair at inflow points, mulch replenishment, unclogging the underdrain, and repairing overflow structures. There is also the possibility that the cation exchange capacity of the soils in the cell will be significantly reduced over time. Depending on pollutant loads, soils may need to be replaced within 5-10 years of construction (LID, 2000).

Cost

Construction Cost

Construction cost estimates for a bioretention area are slightly greater than those for the required landscaping for a new development (EPA, 1999). A general rule of thumb (Coffman, 1999) is that residential bioretention areas average about $3 to $4 per square foot, depending on soil conditions and the density and types of plants used. Commercial, industrial and institutional site costs can range between $10 to $40 per square foot, based on the need for control structures, curbing, storm drains and underdrains.

Retrofitting a site typically costs more, averaging $6,500 per bioretention area. The higher costs are attributed to the demolition of existing concrete, asphalt, and existing structures and the replacement of fill material with planting soil. The costs of retrofitting a commercial site in Maryland, Kettering Development, with 15 bioretention areas were estimated at $111,600.

In any bioretention area design, the cost of plants varies substantially and can account for a significant portion of the expenditures. While these cost estimates are slightly greater than those of typical landscaping treatment (due to the increased number of plantings, additional soil excavation, backfill material, use of underdrains etc.), those landscaping expenses that would be required regardless of the bioretention installation should be subtracted when determining the net cost.

Perhaps of most importance, however, the cost savings compared to the use of traditional structural stormwater conveyance systems makes bioretention areas quite attractive financially. For example, the use of bioretention can decrease the cost required for constructing stormwater conveyance systems at a site. A medical office building in Maryland was able to reduce the amount of storm drain pipe that was needed from 800 to 230 feet - a cost savings of $24,000 (PGDER, 1993). And a new residential development spent a total of approximately $100,000 using bioretention cells on each lot instead of nearly $400,000 for the traditional stormwater ponds that were originally planned (Rappahanock,). Also, in residential areas, stormwater management controls become a part of each property owner's landscape, reducing the public burden to maintain large centralized facilities.

Maintenance Cost

The operation and maintenance costs for a bioretention facility will be comparable to those of typical landscaping required for a site. Costs beyond the normal landscaping fees will include the cost for testing the soils and may include costs for a sand bed and planting soil.

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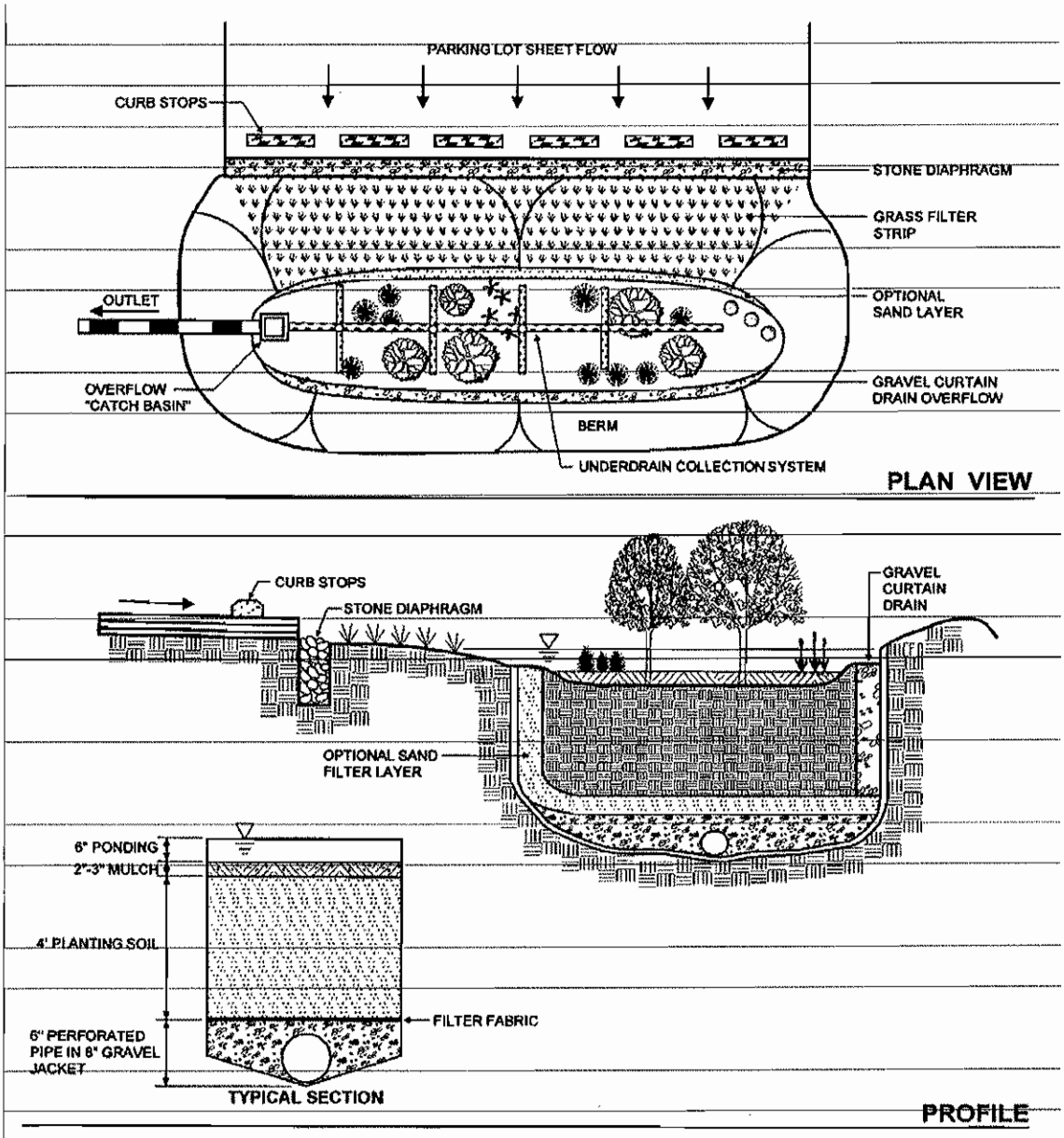

Schematic of a Bioretention Facility (MDE, 2000)

Drain Inserts MP-52

Description

Drain inserts are manufactured filters or fabric placed in a drop inlet to remove sediment and debris. There are a multitude of inserts of various shapes and configurations, typically falling into one of three different groups: socks, boxes, and trays. The sock consists of a fabric, usually constructed of polypropylene. The fabric may be attached to a frame or the grate of the inlet holds the sock. Socks are meant for vertical (drop) inlets. Boxes are constructed of plastic or wire mesh. Typically a polypropylene "bag" is placed in the wire mesh box. The bag takes the form of the box. Most box products are one box; that is, the setting area and filtration through media occur in the same box. Some products consist of one or more trays or mesh grates. The trays may hold different types of media. Filtration media vary by manufacturer. Types include polypropylene, porous polymer, treated cellulose, and activated carbon.

California Experience

The number of installations is unknown but likely exceeds a thousand. Some users have reported that these systems require considerable maintenance to prevent plugging and bypass.

Advantages

- Does not require additional space as inserts as the drain inlets are already a component of the standard drainage systems.
- Easy access for inspection and maintenance.
- As there is no standing water, there is little concern for mosquito breeding.
- A relatively inexpensive retrofit option.

Limitations

Performance is likely significantly less than treatment systems that are located at the end of the drainage system such as ponds and vaults. Usually not suitable for large areas or areas with trash or leaves than can plug the insert.

Design and Sizing Guidelines

Refer to manufacturer's guidelines. Drain inserts come any many configurations but can be placed into three general groups: socks, boxes, and trays. The sock consists of a fabric, usually constructed of polypropylene. The fabric may be attached to a frame or the grate of the inlet holds the sock. Socks are meant for vertical (drop) inlets. Boxes are constructed of plastic or wire mesh. Typically a polypropylene "bag" is placed in the wire mesh box. The bag takes the form of the box. Most box products are

Design Considerations

- Use with other BMPs
- Fit and Seal Capacity within Inlet

Targeted Constituents

- ☑ Sediment
- ☑ Nutrients
- ☑ Trash
- ☑ Metals
- Bacteria
- ☑ Oil and Grease
- ☑ Organics

Removal Effectiveness

See New Development and Redevelopment Handbook-Section 5.

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one box; that is, the setting area and filtration through media occurs in the same box. One manufacturer has a double-box. Stormwater enters the first box where setting occurs. The stormwater flows into the second box where the filter media is located. Some products consist of one or more trays or mesh grates. The trays can hold different types of media. Filtration media vary with the manufacturer: types include polypropylene, porous polymer, treated cellulose, and activated carbon.

Construction/Inspection Considerations

Be certain that installation is done in a manner that makes certain that the stormwater enters the unit and does not leak around the perimeter. Leakage between the frame of the insert and the frame of the drain inlet can easily occur with vertical (drop) inlets.

Performance

Few products have performance data collected under field conditions.

Siting Criteria

It is recommended that inserts be used only for retrofit situations or as pretreatment where other treatment BMPs presented in this section area used.

Additional Design Guidelines

Follow guidelines provided by individual manufacturers.

Maintenance

Likely require frequent maintenance, on the order of several times per year.

Cost

- The initial cost of individual inserts ranges from less than $100 to about $2,000. The cost of using multiple units in curb inlet drains varies with the size of the inlet.
- The low cost of inserts may tend to favor the use of these systems over other, more effective treatment BMPs. However, the low cost of each unit may be offset by the number of units that are required, more frequent maintenance, and the shorter structural life (and therefore replacement).

References and Sources of Additional Information

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