Appendix D

Selected Rain Gauge Index

This appendix contains hydrologic data needed for BMP design in accordance with volume-based and flow-based BMP design criteria included in many MS4 permits. For information on volume-based and flow-based BMP design criteria, refer to Section 5.5 of this handbook.

This appendix contains the following information.

Rain Gauge Index Map

The rain gauge index map provides a visual index for selecting a rain gage closest to the site where volume-based or flow-based BMP design criteria will be applied. The index map is for quick reference only: selection of a specific gauge for use in design should be based on the rain gauge data table which provides additional information about each rain gauge, such as latitude, longitude, elevation, and rainfall statistics, which should be considered when identifying a gauge most representative of the project site.

Rain Gauge Data Table

The rain gauge data table provides important information about the rain gauges included in this appendix. Rain gauges analyzed and included in this appendix represent a wide range of municipal stormwater permit areas, climatic areas, geography, and topography across California. Using the station location, latitude, longitude, elevation, and rainfall statistics, it should be possible to identify a gauge that is sufficiently representative of most sites in California, as there is generally less variation among sites across the State when the comparisons are made based on the frequent, small storms used for BMP design as opposed to the infrequent, large storms used for flood control design.

The rain gauge data table also tabulates estimates of mean storm depths (P₆). P₆ is used for volume design using the Urban Runoff Quality Management approach discussed in Section 5.5.1 of this handbook. The values in the table were extrapolated and approximated from the map included in the document, Urban Runoff Quality Management (WEF Manual of Practice No. 23/ASCE Manual of Practice No. 87, 1998, pages 176). Urban Runoff Quality Management references the document, Analysis of Storm Events, Characteristics for Selected Rain Gauges Throughout the United States (Driscoll, E.D., et al., 1989, U.S. EPA) for the source information. A future addition to this handbook may be an analysis of the data set for the tabulated gauges to determine site-specific values of P₆ for inclusion in this handbook.

Analysis of Rain Gauge Data

The rain gauge data for the stations identified in the range gauge table were analyzed to determine the basin volumes required to capture various percentages of annual runoff, and to determine various percentiles of hourly rainfall intensities. The basin-volume analysis is part of the California Stormwater BMP Handbook approach for volumetric-based design of BMPs (See
Appendix D
Selected Rain Gauge Index

Section 5.5.1). The hourly rainfall intensities analysis is part of the California Stormwater BMP Handbook approach for flow-based design of BMPs (See Section 5.5.2)

California Stormwater BMP Handbook Approach – Volume-Based Design

For each rain gauge, two charts (48-hour and 24-hour draw down times) contain four curves (Runoff Coefficient 0.25, 0.50, 0.75, and 1.00) each that show the Unit Basin Storage Volume required for various levels Capture of average annual runoff.

The charts are developed using a continuous simulation model, the STORM model, developed by the Hydrologic Engineering Center of the U.S. Army Corps of Engineers (COE-HEC, 1977). The version used for this study utilized the NetSTORM user interface. The Storage, Treatment, Overflow, Runoff Model (STORM) was applied to long-term hourly rainfall data at each site. STORM translates rainfall into runoff, then routes the runoff through detention storage. Key model assumptions are:

- Drainage Area = 100 acres
- Depression Storage = 0.06 inches
- Evaporation Rate = 0.15 inches/day
- Inter-event Time = 24 hours and 48 hours
- Time to Empty = 24 or 48 hrs
- Runoff Coefficients = 0.25, 0.50, 0.75, 1.00

The model results are presented on a unit basis, and are sufficient for use on most projects. Projects with drainage areas larger than 100 acres should be broken down into sub-areas and the method applied to each sub-area.

For more detail on the STORM model, use key words HEC and STORM on any major browser to locate numerous documents and publications related to the STORM model.

California Stormwater BMP Handbook Approach – Flow-Based Design

For each rain gauge, a cumulative hourly rainfall intensity chart is provided. The chart shows the percentile associated with each measured hourly rainfall intensity for the period of record. A key assumption is:

- Recorded values less than or equal to 0.01 inches per hour were not included in the analysis

A few gauges have incomplete data or data extrapolated by algorithm. No attempt was made to fill in completely missing data. Where accumulated data were available and extrapolated by algorithm, the extrapolated data were used. This situation occurs when a gauge that normally
reports hourly data is unable to report hourly data for a short period, but is able to report reliable accumulated data. A few gauges only reported rainfall in 0.1 inches per hour increments. These data were used directly without adjustment, and may result in a stair-step cumulative hourly rainfall intensity curve.

Given the number of years of record, the quality of data used overall is considered to be of sufficient quality for stormwater quality design.
NOTE:
RAIN GAUGE LOCATIONS ARE APPROXIMATE.
USE THE TABLE LOCATED IN APPENDIX D
TO FIND LATITUDE AND LONGITUDE OF
EACH STATION.
### RAIN GAGE DATA TABLE

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P6 is mean storm depth. Refer to Urban Runoff Quality Management (WEF/ASCE, 1998, Page 176)
Eureka WFO Woodley Island (2910) - Humboldt County, California

Capture / Treatment Analysis

Capture (% of Runoff)

Runoff Coefficient = 0.25
Runoff Coefficient = 0.50
Runoff Coefficient = 0.75
Runoff Coefficient = 1.00

48-hr Drawdown

Unit Basin Storage Volume (inches)
Eureka WFO Woodley Island (2910) - Humboldt County, California

Capture / Treatment Analysis

Unit Basin Storage Volume (inches)

Capture (% of Runoff)

Runoff Coefficient = 0.25
Runoff Coefficient = 0.50
Runoff Coefficient = 0.75
Runoff Coefficient = 1.00

24-hr Drawdown

Capture / Treatment Analyses

Eureka WFO Woodley Island (2910) - Humboldt County, California
Capture / Treatment Analysis

Redding Municipal Airport (7304) - Shasta County, California

Capture (% of Runoff)

Runoff Coefficient = 1.00
Runoff Coefficient = 0.75
Runoff Coefficient = 0.50
Runoff Coefficient = 0.25

48-hr Draindown

Redding Municipal Airport (7304) - Shasta County, California

Unit Basin Storage Volume (inches)
Oakland WSO Airport (6335) - Alameda County, California
Capture / Treatment Analysis

Capture (% of Runoff)

Runoff Coefficient = 0.25
Runoff Coefficient = 0.50
Runoff Coefficient = 0.75
Runoff Coefficient = 1.00

48-hr Drawdown

Unit Basin Storage Volume (inches)
Oakland WSO Airport (6335) - Alameda County, California

Capture / Treatment Analysis

Capture (% of Runoff)

Runoff Coefficient = 0.25
Runoff Coefficient = 0.50
Runoff Coefficient = 0.75
Runoff Coefficient = 1.00

Unit Basin Storage Volume (inches)

24-hr Drawdown

Capture / Treatment Analysis
San Jose (7821) - Santa Clara County, California

Capture / Treatment Analysis

Runoff Coefficient = 1.00
Runoff Coefficient = 0.75
Runoff Coefficient = 0.50
Runoff Coefficient = 0.25

48-hr Drawdown
San Jose (7821) - Santa Clara County, California

Capture / Treatment Analysis

Runoff Coefficient = 0.25
Runoff Coefficient = 0.50
Runoff Coefficient = 0.75
Runoff Coefficient = 1.00

Capture (Capture of Runoff) vs. Unit Basin Storage Volume (inches)

24-hr Drawdown

0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0

0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9

0 10 20 30 40 50 60 70 80 90 100
Sacramento 5 ESE (7633) - Sacramento County, California
Capture / Treatment Analysis

48-hr Drawdown

- Runoff Coefficient = 0.25
- Runoff Coefficient = 0.50
- Runoff Coefficient = 0.75
- Runoff Coefficient = 1.00
Capture / Treatment Analysis

Unit Basin Storage Volume (inches)

Runoff Coefficient = 1.00
Runoff Coefficient = 0.75
Runoff Coefficient = 0.50
Runoff Coefficient = 0.25

24-Hr Drawdown

Sacramento ESE (7633) - Sacramento County, California
Truckee Ranger Station (9043) - Nevada County, California

Capture / Treatment Analysis

Capture (% of Runoff)

Runoff Coefficient = 0.25
Runoff Coefficient = 0.50
Runoff Coefficient = 0.75
Runoff Coefficient = 1.00

24-hr Drawdown

Unit Basin Storage Volume (inches)
Capture / Treatment Analysis

Capture (% of Runoff)

Runoff Coefficient = 1.00
Runoff Coefficient = 0.75
Runoff Coefficient = 0.50
Runoff Coefficient = 0.25

48-hr Drawdown

Bakersfield Airport (442) - Kern County, California
Bakersfield Airport (442) - Kern County, California

Capture / Treatment Analysis

Runoff Coefficient = 0.25
Runoff Coefficient = 0.50
Runoff Coefficient = 0.75
Runoff Coefficient = 1.00

24-hr Drawdown

Capture (% of Runoff)

Unit Basin Storage Volume (inches)

Capture (% of Runoff)

Runoff Coefficient = 0.25
Runoff Coefficient = 0.50
Runoff Coefficient = 0.75
Runoff Coefficient = 1.00

24-hr Drawdown
Cumulative Frequency Hourly Rainfall Intensity

Bakersfield Airport (442) - Kern County, California
Bishop Airport (822) - Inyo County, California
Capture / Treatment Analysis

Capture (% of Runoff)

Runoff Coefficient = 0.25
Runoff Coefficient = 0.50
Runoff Coefficient = 0.75
Runoff Coefficient = 1.00

48-hr Drawdown

Unit Basin Storage Volume (inches)
Runoff Coefficient = 1.00
Runoff Coefficient = 0.75
Runoff Coefficient = 0.50
Runoff Coefficient = 0.25

24-hr Drawdown
Bishop Airport (822) - Inyo County, California
Cumulative Frequency Hourly Rainfall Intensity

Percentile vs. Rainfall Intensity (inches/hour)

- X-axis: Rainfall Intensity (inches/hour)
- Y-axis: Percentile

The graph shows the cumulative frequency of hourly rainfall intensities at Bishop Airport, Inyo County, California.
Capture / Treatment Analysis

Unit Basin Storage Volume (inches)

Runoff Coefficient = 1.00
Runoff Coefficient = 0.75
Runoff Coefficient = 0.50
Runoff Coefficient = 0.25

48-hr Drawdown

Capture (% of Runoff)

Santa Maria WSO Airport (7946) - Santa Barbara County, California
Santa Maria WSO Airport (7946) - Santa Barbara County, California
Capture / Treatment Analysis

Capture (% of Runoff)

Runoff Coefficient = 0.25
Runoff Coefficient = 0.50
Runoff Coefficient = 0.75
Runoff Coefficient = 1.00

24-hr Drawdown

Unit Basin Storage Volume (inches)
Oxnard Equipment Yard (168) - Ventura County, California
Capture / Treatment Analysis

Capture (% of Runoff)
Runoff Coefficient = 0.25
Runoff Coefficient = 0.50
Runoff Coefficient = 0.75
Runoff Coefficient = 1.00

48-hr Drawdown

Unit Basin Storage Volume (inches)

0.0 0.2 0.4 0.6 0.8 1.0 1.2 1.4 1.6 1.8 2.0
Runoff Coefficient = 1.00
Runoff Coefficient = 0.75
Runoff Coefficient = 0.50
Runoff Coefficient = 0.25

Capture / Treatment Analysis

Capture (% of Runoff)

Unit Basin Storage Volume (inches)

24-hr Drawdown

Oxnard Equipment Yard (168) - Ventura County, California
48-hr Drawdown Capture / Treatment Analyses

Los Angeles WSO Airport (5114) - Los Angeles County, California

Runoff Coefficient = 0.00
Runoff Coefficient = 0.25
Runoff Coefficient = 0.50
Runoff Coefficient = 0.75
Runoff Coefficient = 1.00

Capture (% of Runoff)

Unit Basin Storage Volume (inches)
Los Angeles WSO Airport (5114) - Los Angeles County, California
Capture / Treatment Analysis

Capture (% of Runoff)

Runoff Coefficient = 0.25
Runoff Coefficient = 0.50
Runoff Coefficient = 0.75
Runoff Coefficient = 1.00

24-hr Drawdown

Unit Basin Storage Volume (inches)
Laguna Beach (4650) - Orange County, California

Capture / Treatment Analysis

48-hr Drawdown

Capture (% of Runoff)

Runoff Coefficient = 0.25

Runoff Coefficient = 0.50

Runoff Coefficient = 0.75

Runoff Coefficient = 1.00

Unit Basin Storage Volume (inches)
Laguna Beach (4650) - Orange County, California

Capture / Treatment Analysis

Runoff Coefficient = 0.25
Runoff Coefficient = 0.50
Runoff Coefficient = 0.75
Runoff Coefficient = 1.00

24-hr Drawdown

Unit Basin Storage Volume (inches)

Capture (% of Runoff)
Silverado Ranger Station (8243) - Orange County, California

Capture / Treatment Analysis

Capture (% of Runoff)

Runoff Coefficient = 0.25
Runoff Coefficient = 0.50
Runoff Coefficient = 0.75
Runoff Coefficient = 1.00

24-hr Drawdown

Unit Basin Storage Volume (inches)
Riverside Citrus Experiment Station (7473) - Riverside County, California
Capture / Treatment Analysis

Capture (% of Runoff)

Runoff Coefficient = 0.25
Runoff Coefficient = 0.50
Runoff Coefficient = 0.75
Runoff Coefficient = 1.00

48-hr Drawdown

Unit Basin Storage Volume (inches)

Capture (% of Runoff)
Runoff Coefficient = 1.00
Runoff Coefficient = 0.75
Runoff Coefficient = 0.50
Runoff Coefficient = 0.25

24-hr Drawdown

Riverside Citrus Experiment Station (7473) - Riverside County, California
Victorville Pump Plant (9325) - San Bernardino County, California

Capture / Treatment Analysis

Unit Basin Storage Volume (inches)

Capture (% of Runoff)

Runoff Coefficient = 1.00
Runoff Coefficient = 0.75
Runoff Coefficient = 0.50
Runoff Coefficient = 0.25

48-hr Drawdown

Victorville Pump Plant (9325) - San Bernardino County, California
Victorville Pump Plant (9325) - San Bernardino County, California
Capture / Treatment Analysis

Capture (% of Runoff)

Runoff Coefficient = 0.25
Runoff Coefficient = 0.50
Runoff Coefficient = 0.75
Runoff Coefficient = 1.00

24-hr Drawdown

Unit Basin Storage Volume (inches)
Cumulative Frequency Hourly Rainfall Intensity

Victorville Pump Plant (9325) - San Bernardino County, California

Rainfall Intensity (inches/hour) vs. Percentile
San Diego WSO Airport (7740) - San Diego County, California

Capture / Treatment Analysis

- Runoff Coefficient = 1.00
- Runoff Coefficient = 0.75
- Runoff Coefficient = 0.50
- Runoff Coefficient = 0.25

Unit Basin Storage Volume (inches)

24-Hr Drawdown

Capture (% of Runoff)

San Diego WSO Airport (7740) - San Diego County, California
San Diego WSO Airport (7740) - San Diego County, California
Cumulative Frequency Hourly Rainfall Intensity

Rainfall Intensity (inches/hour)

Percentile

0.00 0.05 0.10 0.15 0.20 0.25

Hourly Rainfall Intensity

Percentile

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Rainfall Intensity (inches/hour)
Santa Susana Station (193) - Ventura County, California
Capture / Treatment Analysis

Capture (% of Runoff)

Runoff Coefficient = 0.25
Runoff Coefficient = 0.50
Runoff Coefficient = 0.75
Runoff Coefficient = 1.00

24-hr Drawdown

Unit Basin Storage Volume (inches)
Palm Springs Thermal Airport (48892) - Riverside County, California

Capture / Treatment Analysis

Unit Basin Storage Volume (inches)

Capture (% of Runoff)

Runoff Coefficient = 1.00
Runoff Coefficient = 0.75
Runoff Coefficient = 0.50
Runoff Coefficient = 0.25

24-hr Drawdown

Palm Springs Thermal Airport (48892) - Riverside County, California
Palm Springs Thermal Airport (48892) - Riverside County, California
Cumulative Frequency Hourly Rainfall Intensity

Hourly Rainfall Intensity (inches/hour)

Percentile

Rainfall Intensity (inches/hour)