Flood Routing and Groundwater Recharge Benefit Calculations

Three Case Studies

Steven M. Bell, PE, QSD
Why are we talking about groundwater projects at a floodplain management conference anyway?
Urbanization and Floodplains

- Natural floodplains enhance groundwater recharge
- Infiltration removes pollutants from water bodies
- Concrete channelization protects against flooding, but lessens recharge
- Pollutants remain within surface water
Urbanization and Floodplains

Depletion of aquifers

- Most aquifers in southern California have less water now than they did 20 years ago.
- Falling water levels mean more expensive to drill and to pump.
Urbanization and Floodplains

Nuisance flows

- Overwatering of landscaping
- Water quality issues
  - Motor oil
  - Fertilizer
  - Pet waste
  - Trash
- Wasted water
  - Particularly poor optics during droughts
In southern California, we do Recharge Projects

- Spreading Grounds
- Infiltration Basins
- Subsurface Infiltration Chambers
How to Design

Key design factors:
- Rainfall
- Primary purpose
- Size of watershed
- Jurisdiction

Recharge Project
More rainfall intensity = larger BMP
Primary Purpose

- Low Impact Development (LID) (Water quality)
- LID + Hydromodification (Water quality)
- Stormwater Recharge (Water quality) (Water supply)
- Flood Storage (Water quality) (Water supply) (Flood protection)
Watershed Size of Neighborhood project
Small regional project
Large regional project
Jurisdiction

Los Angeles County
- Runoff method: MODRAT
- Runoff losses based on impervious area
- Unit hydrograph peak at 80% of storm

Santa Barbara
- Runoff method: SBUH
- Runoff losses based on SCS curve numbers
- Unit hydrograph peak at 42% of storm

San Bernardino County
- Runoff method: Rational Method or Unit Hydrograph Method
- Runoff losses based on SCS curve numbers
- Unit hydrograph peak at 67% of storm
Three projects

Bohnett Park
John Anson Ford Park
Cactus Basin No. 4 & 5
Bohnett Park
- **Area 1**: 4.20 ac.
- **Area 2**: 1.65 ac.
Rainfall-Runoff
City of Santa Barbara Requirements

- SCS Type I rainfall distribution
- Santa Barbara Urban Hydrograph
Initial Abstraction

I<sub>a</sub> only a function of CN
Small P (WQ design storm) = Almost no Q
V<sub>WQ</sub> = 5,686 cf

75% of WQ rainfall lost due to I<sub>a</sub>

Soil Conservation Service Runoff Equation

\[ Q = \frac{(P - I_a)^2}{(P - I_a) + S} \]

where
Q = runoff (in.)
P = rainfall (in.)
I<sub>a</sub> = initial abstraction (in.)
S = potential maximum retention after runoff begins (in.)
MODRAT
Modified Rational Method

Q = c_i A

Runoff Volume (cf)

<table>
<thead>
<tr>
<th></th>
<th>SBUH</th>
<th>MODRAT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area 1</td>
<td></td>
<td></td>
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<tr>
<td>Area 2</td>
<td></td>
<td></td>
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<tr>
<td>Total</td>
<td></td>
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</tbody>
</table>

Increase of 174% over SBUH/SCS
Factoring in Infiltration Over 24 Hours

- Blue line: Storage Volume, Not Factoring Infiltration
- Green line: Storage Volume, Factoring Infiltration
Design

- Chamber system
- Diverts from storm drain
- Captures low flows
- Captures the one-inch, 24-hour storm
- Flood flows bypass upstream
- Fully infiltrates within 48 hours
- Pretreatment system for trash and sediment
Cactus Basins No. 4 & 5

How much water will recharge the Rialto-Colton groundwater subbasin in a year?
Rainfall

5 rain gauges, 90 years of daily rainfall data
Runoff

- Yield (fraction of daily precipitation that becomes runoff) calculated for each subarea and each day

\[ Y_j = \frac{(P_{24} - 1a)^2}{(P_{24} - 1a + S)P_{24}} \] (C.3)

where

- \( Y_j \) = 24-hour storm runoff yield fraction for subarea \( A_j \)
- \( P_{24} \) = 24-hour storm rainfall
- 1a = initial abstraction from (C.1)
- S = see (C.2)

(from San Bernardino County Hydrology Manual)
Antecedent Moisture Condition

- CN varies depending on amount of moisture in the soil
- CN calculated as a function of precipitation in previous week
  - <0.1” = AMC I
  - >0.1” = AMC II
  - >1.0” = AMC III
Calculation

Existing Model Run

Runoff from upper DA
Runoff from lower DA

Storage (previous/next day)

Infiltration

Outflow to Rialto Channel
Calculation

Proposed Model Run

Runoff from upper DA

Runoff from lower DA

Storage (previous/next day)

Storage (previous/next day)

Incidental Infiltration

Infiltration

Outflow to Rialto Channel
Infiltration Summary

Infiltrated Runoff (ac-ft/yr)

- Existing Conditions
- Proposed Conditions

Year
- 1926-27
- 1929-30
- 1932-33
- 1935-36
- 1938-39
- 1941-42
- 1944-45
- 1947-48
- 1950-51
- 1953-54
- 1956-57
- 1959-60
- 1962-63
- 1965-66
- 1968-69
- 1971-72
- 1974-75
- 1977-78
- 1980-81
- 1983-84
- 1986-87
- 1989-90
- 1992-93
- 1995-96
- 1998-99
- 2001-02
- 2004-05
- 2007-08
- 2010-11
- 2013-14
- 2016-17

Values range from 0 to 4,500 ac-ft/yr.
# Groundwater Recharge Benefit

<table>
<thead>
<tr>
<th>Metric</th>
<th>Existing Conditions (no build)</th>
<th>Proposed Conditions (build)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Annual Infiltration</td>
<td>1,365 ac-ft/yr</td>
<td>1,535 ac-ft/yr</td>
</tr>
<tr>
<td>Average Annual Runoff to Rialto Channel</td>
<td>1,281 ac-ft/yr</td>
<td>1,110 ac-ft/yr</td>
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</tbody>
</table>

Difference of 170 ac-ft/yr

Enough water to supply 1,800 Southern Californians per year
Drainage Area: 3.6 Sq. Mi.
Continuous Hydrograph

1,100 ac-ft per year on average: 11,500 Southern Californians
## Comparison

<table>
<thead>
<tr>
<th></th>
<th>Bohnett Park Project</th>
<th>Cactus Basins 4 &amp; 5</th>
<th>J.A. Ford Park Cistern Project</th>
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</thead>
<tbody>
<tr>
<td><strong>County</strong></td>
<td>Santa Barbara</td>
<td>San Bernardino</td>
<td>Los Angeles</td>
</tr>
<tr>
<td><strong>Purpose</strong></td>
<td>Water Quality</td>
<td>Flood Protection + Water Supply</td>
<td>Water Quality + Water Supply</td>
</tr>
<tr>
<td><strong>Watershed Size</strong></td>
<td>6 acres</td>
<td>2,963 acres</td>
<td>2,295 acres</td>
</tr>
<tr>
<td><strong>Rainfall</strong></td>
<td>Single-Event Design Storm</td>
<td>Continuous Hydrograph – 1-Day Increment</td>
<td>Continuous Hydrograph – 5-Min. Increment</td>
</tr>
<tr>
<td><strong>Design Methodology</strong></td>
<td></td>
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<tr>
<td><strong>Storage</strong></td>
<td>0.26 ac-ft</td>
<td>1,200 ac-ft</td>
<td>100 ac-ft*</td>
</tr>
<tr>
<td><strong>Annual Groundwater Recharge</strong></td>
<td>~3 ac-ft</td>
<td>170 ac-ft</td>
<td>1,100 ac-ft*</td>
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<td></td>
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<td>*Ultimate condition</td>
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Questions?

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