ASSESSING THE USE OF DRY WELLS AS AN INTEGRATED LID TOOL FOR REDUCING STORMWATER RUNOFF WHILE PROTECTING GROUNDWATER QUALITY IN URBAN WATERSHEDS

C. Bowles¹, M. Carr¹, F. Duenas², V. Kretsinger³, C. Meirovitz³, C. Nelson², N. Pi⁴, B. Washburn⁴, D. Wilson²

¹ cbec eco engineering: surface water hydrology
² City of Elk Grove & Willdan: Project recipient, stormwater engineering
³ Ludhorff & Scalmanini: groundwater hydrology
⁴ Office of Environmental Health Hazard Assessment, aquatic toxicology; QA/QC
Dry Wells

- Gravity fed excavated pits lined with perforated casing filled with gravel
- Deeper than wide
- Used in conjunction with LID systems to improve rate of stormwater infiltration and groundwater recharge
Goals of the Project
What we have learned about dry wells from others
- Portland – Underground Injection Control System Program
- Modesto – USGS
- Los Angeles – Water Augmentation Study
- Elk Grove Study
Goals of the Project

1. Assess safety of using dry wells to infiltrate stormwater run off
   - LID requirement of NPDES permit
   - Supports natural hydrologic regime
   - Reduce damage to aquatic ecosystem

2. Assess groundwater recharge capacity of dry wells
   - 30+ % of rain lost to runoff
   - Treat runoff as a resource
3. Investigate use of dry wells as climate change adaptation

- “I can state unequivocally that past and future climate change is making subsurface storage and recovery in the Central Valley critically important…"

- I predict that 10 years from now dry wells in urban areas of the Central Valley could become a major mechanism for recharging groundwater…”

- Graham Fogg, Professor, UC Davis Land Air and Water Resources, Letter of Support, 2012
Thirteen states have dry well regulations

One of the most developed programs is in Portland, OR

- 20,000 UICS in City – in some place, only SW management practice
- Principle underlying their program: If contaminants in SW are below the MCL levels, do not need to worry about GW contamination
- Extensive SW monitoring program
- Modeling of fate and transport of most common contaminants in the vadose zone
Typical UICS in Portland

- Catch basin
- Sedimentation manhole
- Dry well

http://www.portlandoregon.gov/bes/48213
Monitoring Program in Portland

- Designed by Oregon State scientist/statisticians
- Multi-million dollar effort over 7 years
- Stormwater only, little/no groundwater
- Contaminants evaluated
  - Metals
  - Volatile organics and semi-volatiles
  - PAHs
  - Pesticides and herbicides
- Key benchmark: maximum allowable discharge level - the MCL
• Common bad actors
  - DEHP
  - B[a]P
  - PCP

• Pentachlorophenol – pesticide, preservative on utility poles

• Fate and transport modeling: Soil binds PCP, limiting migration to < 4 feet

Average geometric mean (min/max)
PCP; Sample size = 30
Lessons from Portland

- Stormwater from streets might not be as contaminated as typically assumed
- Settling of solids important
- Appears to be a successful program
- Caveat:
  - CA geology: Contains many toxic metals (As, Cr) which could be mobilized by high specific conductivity, alkalinity of SW
  - Need to investigate this potential by-product of using a dry well system
Impacts of Dry Wells on Drinking Water Quality in Modesto

Hydrogeology, Water Chemistry, and Factors Affecting the Transport of Contaminants in the Zone of Contribution of a Public-Supply Well in Modesto, Eastern San Joaquin Valley, California

Scientific Investigations Report 2008–5156
U.S. Department of the Interior
U.S. Geological Survey
Background on Modesto Perc Spill

- Over 11,000 dry wells since the 1950s
- 1985 - PCE spill at Halford’s Cleaners contaminated groundwater detected
  - Associated with defective dry cleaning machines
  - PCE entered leaking sewer line
- Public supply well 11 contaminated

85 ppb PSW, 176 ppm soil
Background on Modesto

- Superfund site late 1990s
- Clean up and monitoring...... 2000+
- Some made the linkage: dry wells = groundwater contamination?
  - US EPA reports: conduit for PCE - sanitary sewer lines, not dry wells
USGS Study

- Study goal
  - Determine whether and how contaminants might enter drinking water supply wells

- Relevance of study for our purposes
  - Given long history of dry well use – assess long term potential risks to groundwater quality
USGS Study Design

- Analyzed water quality from 1 drinking water well
- Series of monitoring wells at various depths
  - Water table – up to 38 ft.
  - Shallow zone – 115 ft.
  - Intermediate zone – 200 ft.
  - Deep zone – 300 + ft.
- Monitoring wells along a gradient of agricultural and urban land uses as well as groundwater gradient
Conventional water parameters
  - pH, dissolved oxygen, major ions, water age
Gasoline related compounds (BTEX)
  - Benzene, toluene, ethylbenzene, xylenes
Pesticides
  - About a dozen pesticides including chlorinated forms, simazine and atrazine
Volatile organic compounds
  - Chloroform, PCE, TCE, ethyl benzene, xylene, etc.
Refrigerants
USGS: Brief Summary of Results

- Younger water (shallow depths) more susceptible to contamination
  - Mainly agriculture influences, e.g. nitrate
  - Uranium and arsenic contamination
  - Some evidence of typical urban contaminants, but below MCLs
- Older water (deeper zones)
  - No anthropogenic contaminants
Main Message from USGS Study

- No contaminants associated with urban runoff near the MCL in public supply well water
- Some urban contaminants present in shallow aquifer
- Possible mobilization of naturally occurring toxic metals
Ten year study by Council on Watershed Health and partners
- City of Los Angeles Department of Water and Power
- Metropolitan Water District of Southern California
- United States Bureau of Reclamation

Overall goal
- Assesses feasibility of the capture and infiltration of stormwater to augment local water supply (reduce dependency in imported water)
- Assess effects of infiltrating stormwater on groundwater quality
Office Building

- Roof runoff drained to dry well
- 31 ft. depth to water table
- Poorly infiltrating soils
- Groundwater and vadose zone monitoring wells
Private Residence

- Driveway sheet flow to dry well
- 200 ft. depth to water table
- Slow-moderate infiltrating soils
- Vadose zone monitoring
LA Study: Monitoring Program

- Stormwater samples taken during storm events for 5+ years
- Post-storm samples taken 2 – 10 days after event
- Analytes
  - General physical and chemical
  - Metals
  - Oil, grease, and vehicle-related contaminants
  - Volatile and semi-volatile organic compounds
  - Bacteria
Summary of Monitoring Results
Los Angeles Study

- Contaminants detected at high levels in groundwater were at low levels in SW
- Contaminants at high levels in stormwater were at low levels in GW
- Little evidence for a groundwater contamination
Worked with Bureau of Reclamation to develop model to:

- Estimate the maximum amount of recharge that might occur in area of study
- Currently ~600,000 acre/ft. becomes runoff
- Key finding: if 1\textsuperscript{st} \(\frac{3}{4}”\) rain of every storm on all property captured, about 47% of precip could be infiltrated, or ~578,000 a/f; enough for \(\frac{3}{4}\) million households
Area included in the GWAM
Groundwater Augmentation Model

Estimated for the Los Angeles Basin

Annual Precipitation Volume: 1,214,026 acre feet

<table>
<thead>
<tr>
<th>Category</th>
<th>Baseline Conditions (2002 SCAG Land-use)</th>
<th>3/4&quot; runoff diversion from pervious surfaces</th>
<th>3/4&quot; runoff diversion from impervious surfaces</th>
<th>3/4&quot; runoff diversion from all surfaces</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stormwater Runoff</td>
<td>601</td>
<td>513</td>
<td>295</td>
<td>207</td>
</tr>
<tr>
<td>Potential Groundwater Recharge</td>
<td>500</td>
<td>271</td>
<td>194</td>
<td>578</td>
</tr>
</tbody>
</table>
Elk Grove Dry Well Project
Vadose zone well: 55 ft. bgs; water table wells: 120 ft. bgs
Water collected prior to entering the dry well.

Water collected at the beginning of vegetated pre-treatment.
Water Quality Monitoring Plan

- Stormwater and groundwater samples collected for two years
  - Three wet weather stormwater samples
  - Three wet and one dry weather groundwater well samples
- Constituents to be tested
  - General physical & chemical
  - Metals (EPA 200)
  - Volatiles (EPA 8260)
  - Semi-volatiles (EPA 625)
  - Herbicides (EPA 515)
  - Pyrethroids (WPCL, DFW method)
  - TPH (EPA 8015)
  - Pyrogenic PAHs (EPA 8310)
  - Total coliform
Velocity sensor will permit monitoring of flow

Pressure transducer will provide info to verify initial estimate
<table>
<thead>
<tr>
<th>Task</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
</tr>
</thead>
<tbody>
<tr>
<td>Notice of Grant Award – Summer 2012</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Project Commencement - March 1, 2013</td>
<td></td>
<td></td>
<td></td>
<td>⭐</td>
<td></td>
</tr>
<tr>
<td>Task 1. Final Site Selection, Monitoring Study Design and Permitting</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Task 2. Dry Well and Monitoring Well Installation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Task 3. Stormwater Quality Monitoring (3 events per wet season)</td>
<td></td>
<td></td>
<td>⚫</td>
<td>⚫</td>
<td>⚫</td>
</tr>
<tr>
<td>Task 4. Groundwater Quality Monitoring (3 events per wet season; 1 event per dry season)</td>
<td>⚫</td>
<td>⚫</td>
<td>⚫</td>
<td>⚫</td>
<td>⚫</td>
</tr>
<tr>
<td>Task 5. Data Analysis and Interpretation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Task 6. Education, Outreach and Organizational Capacity Building</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6a. Prepare and publish two factsheets</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>6b. Prepare and publish a literature review</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>6c. Draft scientific paper</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>6d. Lessons Learned document</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>6e. Presentations at meetings/conferences</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6f. Development and maintain a project website</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Task 7. Project Assessment and Reporting</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7a. Submit Quality Assurance Project Plan and Monitoring Plan</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7b. Quarterly or annual reports</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7c. Final report</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Task 8. Project Administration</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Project Follow-up

- Need for long-term monitoring of surface and groundwater
- Use of dry wells a regional issue
- Long term monitoring plan would be best accomplished as regional undertaking
Thank you

**Contacts**

- Project director: Darren Wilson  
  dwilson@elkgrovocity.org
- Project manager: Connie Nelson  
  cnelson@elkgrovocity.org
- Toxicology/QA officer: Barbara Washburn  
  barbara.washburn@oehha.ca.gov
- Surface water hydrology: Melanie Carr  
  m.carr@cbecoeng.com
- Groundwater hydrology: Casey Meirovitz  
  cmeirovitz@lsce.com