Separating Fact from Fiction: Assessing the Use of Dry Wells as an Integrated LID Tool for Reducing Stormwater Runoff While Protecting Groundwater in Urban Watersheds

Proposition 84 (Prop 84) Storm Water Grant Program (SWGP) Planning Grant

Elk Grove, California

Final Project Summary – April 18, 2017

Background

Exhibit 1

Watershed urbanization can result in increased flood risks and degradation of water quality and aquatic habitat due to hydromodification. Low Impact Development (LID) techniques may help reduce these impacts. However, in many areas throughout California, the use of LID techniques is challenging due to poor infiltrative capacities with clay soils which are ubiquitous in many areas of the State. One solution is to bypass these low-permeability clay zones through the use of dry wells, vertical infiltration pipes which are deeper than they are wide. Studies have shown that when combined with pretreatment, dry wells can recharge the aquifer with little risk to groundwater quality. Furthermore, this combined approach will decrease stormwater runoff and may reduce the adverse impacts of hydromodification on receiving water bodies. The goal of this project was to further identify the benefits and potential risks of using dry wells to accomplish multiple objectives.

The project is located 15 miles south of the State's capital, in Elk Grove, California within the Strawberry Creek and Grant Line watersheds (Exhibit 1).

Project Description

The purpose of the project was to assess the risk of using dry wells, in concert with LID practices, to infiltrate stormwater and recharge the aquifer without adversely affecting groundwater quality.

Key Aspects

- The project was located at two sites: a light industrial vehicle maintenance/parking lot (City of Elk Grove Corporation Yard, 0.6 acre watershed) and at Strawberry Creek water quality basin (168 acre watershed) in a residential neighborhood.
- Four monitoring wells were constructed at each site: an upgradient well to determined baseline conditions, two downgradient wells and vadose zone well to monitor influent stormwater from dry well (Exhibit 2 and 3).
- At each site a dry well system was constructed with two pretreatment features, a sedimentation well and a dry well to store, cleanse and infiltrate stormwater (Exhibit 4).
- Water quality monitoring was performed five times for two years. Stormwater samples were collected from the dry well pretreatment system at two locations and post-storm event groundwater samples were collected from all groundwater monitoring wells.
- Over 200+ contaminants were analyzed which included volatile and semi-volatile organics, pesticides/herbicides, polycyclic aromatic hydrocarbons (PAHs), metals, and conventional water quality parameters.
- Flow rates were measured and estimates of groundwater recharge capacity were made.
- Vadose zone fate and transport modeling was performed to measure long term risks to groundwater quality.

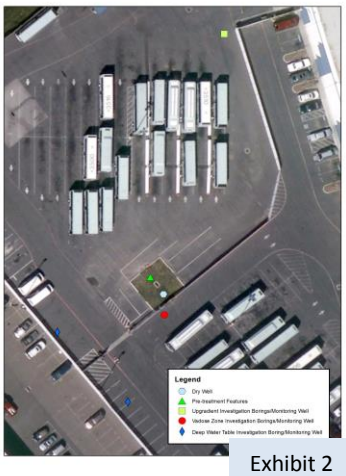


Exhibit 2

Exhibit 3

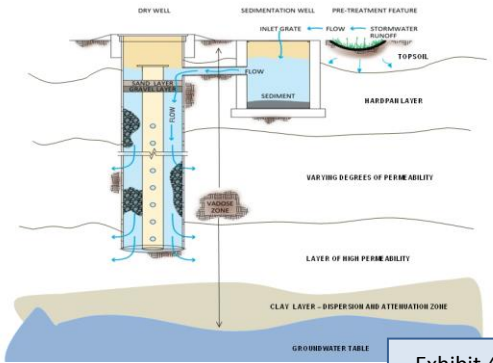


Exhibit 4

Project Performance

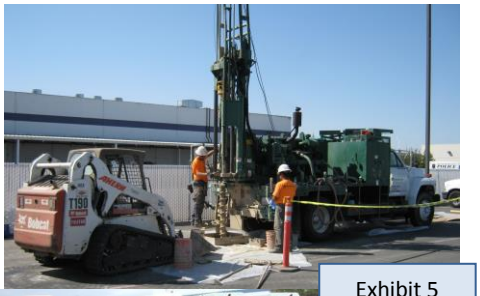


Exhibit 5

Exhibit 6

Tasks completed for this project include:

- Completed a variety of administrative functions including execution of State Water Resources Control Board agreement with amendments, task orders and agreements with subconsultant, Memorandum of Understanding with Cal/EPA's Office of Environmental Health Hazard Assessment (OEHHA), approval of the project by Elk Grove City Council, completion of CEQA and NEPA requirements (NOD and NOE), convening of a Technical Advisory Committee (TAC), quarterly invoices and progress reports, PEAP, and Annual Progress Report.
- Selected project sites, developed project design plans and specifications, and completed bid package, advertised and awarded construction contract.
- Constructed eight investigational borings/monitoring wells (Exhibit 5) and two dry well systems which consist of a dry well, a sedimentation basin, and vegetated pretreatment (Exhibit 6).
- Obtained well permits from the County of Sacramento, Environmental Health Management. The project's dry well permits were the first two permits issued by the County.
- Presented 27 presentations at meetings and conferences.
- Hosted the annual tour for the Regional and State Water Board members on October 1, 2014. Speakers addressed issues related to climate change, the drought and the ways in which dry wells might be useful as adaptation tools.
- Developed QAPP and MP.
- Performed stormwater and groundwater sampling for 2 years and submitted subsequent 90-Day Summary Reports.
- Completed vadose zone fate and transport modeling.
- Developed three factsheet, literature review (annotated bibliography), guidance document, and project website.
- Conducted final TAC meeting and presented project results.
- Developed well Closures/Abandonment Plan and Operations and Maintenance and MP.
- Submitted project data to CEDEN and GAMA.
- Submitted project assessment and reporting results, final Project Report and final Project Summary.

Project Findings

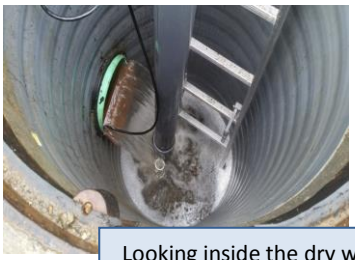
Monitoring event Corporation Yard

Results of the project showed that with rare exception, none of the 200+ contaminants that were analyzed were detected in stormwater or groundwater. Volatile and semi-volatile organics were rarely detected. PAHs were never detected in water, and there was a single detection of an herbicide in groundwater during the entire project. The class of contaminants that were regularly detected in stormwater were metals and pyrethroid pesticides. At the Corporation Yard, the concentration of aluminum in influent stormwater exceeded the Maximum Contaminant Level (MCL) by three-fold. Vegetated pretreatment reduced the concentration from 3 mg/L to 1 mg/L. Although the median concentration of aluminum in groundwater was below the reporting limit, it was occasionally detected at elevated levels. However, the fact that there were no differences in concentration between the upgradient and downgradient wells suggests that runoff passing through the dry well was not the source of this metals. One dimensional vadose zone modeling suggested that even using a worst-case scenario, quantifiable concentrations of aluminum would not reach the vadose zone within the modeling timeframe of 3,000 years. A similar pattern of detections in stormwater was observed for a number of pyrethroid pesticides, including bifenthrin, at the Strawberry Creek water quality basin. However, none was detected in groundwater. Vadose zone modeling suggested that most metals and hydrophobic pesticides would not reach the water table at quantifiable levels within the modeling timeframe.

In contrast to metals and organics, a few classes of contaminants were detected at elevated levels in groundwater. At both sites, nitrate concentrations exceeded the MCL in both upgradient and downgradient water table wells with low levels in stormwater. This pattern can be explained by long term leaching of nitrate out of the soil related to the historic agricultural uses of the land. A handful of detections of coliform bacteria were also measured in groundwater at the Strawberry Creek water quality basin, but this appears to be linked to infiltration through the entire basin, not the dry well.

While fate and transport modeling did not suggest a risk to groundwater quality from any of the contaminants measured in this project, analysis was also performed on water soluble pesticides such as imidacloprid. In contrast to hydrophobic pollutants, water soluble pesticides could pass quickly through the vadose zone. Additional research on potential risks linked to neonicotinoids and fipronil is recommended.

In addition to investigating potential effects on groundwater quality, estimates of the effectiveness of vegetated pretreatment were made. There was a 50-65% reduction in total suspended solid (TSS) and other contaminants concentration as they passed through the grassy swale or water quality basin. If the sedimentation well had been functioning properly, the removal efficiency would have likely been greater.



Looking inside the dry well

Stormwater recharge capacity through the two dry wells was also evaluated. The estimated mean volume of water that passed through the dry well at the Strawberry Creek water quality basin was 0.7 acre/feet (AF), while at the Corporation Yard, it was 0.2 AF. At the Corporation Yard, the small volume of runoff in the 0.6 acre drainage shed accounted for the low volumes. These estimates were based on the 2015-16 rain fall of 13 ½ inches. In a typical year of precipitation (about 18 inches), approximately 1 AF would have passed through the dry well at the Strawberry Creek water quality basin site. This volume can be used as an estimate; the actual amount would vary based on local soils and lithology.

Lastly, the results of reviewing scientific literature on dry wells presents a picture consistent with these results. The higher quality studies suggested that with proper pretreatment, siting and maintenance that dry wells pose minimal risk to groundwater quality.

Project Performance Measures

The main goal of the project was to assess the potential for groundwater contamination associated with the use of dry wells. Results of this project as well as studies and government reports that were reviewed all pointed to the same conclusion – there was no evidence that dry wells with pretreatment features posed a threat to groundwater quality. Another performance goal was to assess the effectiveness of various pretreatment features at removing suspended solids and contaminants from stormwater. Results showed that between 50-65% of solids and associated pollutants were removed by the vegetated pretreatment features. A third goal of the project was to determine how often the dry well system would require cleaning. This goal was not addressed because the sedimentation well did not function properly, little sediment accumulated, requiring no maintenance. As a result, no specific recommendations can be made. Education and outreach was another major focus of this project. Much of the concern regarding the use of dry wells stems from a lack of information and knowledge on the results of studies and the practices in other states. To address this issue, education and outreach efforts were conducted to reach a broad audience. These efforts included the development of fact sheets, a review of the literature, and multiple presentations in a variety of venues.

However, based on the experience gained from this project, it was determined that the Corporation Yard wells should be decommissioned due to the risk associated with a site that involves vehicle servicing and maintenance. This decision is consistent with the dry well guidelines in Washington and Oregon. This decision was vetted through the TAC, and members agreed that the wells at the Corporation Yard should be closed per the Well Closure/Abandonment Plan.

Recommendations

Management Practice	What it Achieves
Siting: Locate dry wells away from public supply wells	Avoids risk of transfer of contaminants to the boreholes of drinking water wells
Siting: Do not permit installation in contaminated soils	Avoids risk of mobilizing contaminants already present in soil
Siting: Do not permit installation near gas stations, vehicle servicing facilities, or businesses that use hazardous materials	Avoids risk of spills or stormwater runoff entering the subsurface through the dry well
Siting: Require a minimum vertical separation, commonly 10 feet, from the aquifer	Utilizes the vadose zone material to attenuate pollutants
Design: Require pretreatment to reduce the concentration of contaminants in stormwater entering the dry well	Reduces the concentration of pollutants entering the subsurface to a level that mitigates against degradation of the aquifer
Monitoring: Periodic monitoring for key contaminants collected as runoff enters the dry well	Ensures that pretreatment is effective and stormwater does not exceed criteria values
Maintenance: Periodic inspections and maintenance	Insures proper functionality and infiltration rates

Conclusion

Dry wells are beginning to become a viable option for stormwater infiltration in northern California. The risks associated with the use of dry wells are primarily linked to the potential to introduce pollutants into the aquifer. Data collected at the two project sites in Elk Grove did not show evidence of groundwater contamination linked to the dry wells. Modeling suggested there is only minimal risk of groundwater contamination associated with common urban contaminants -- such as PAHs, metals, and pyrethroid pesticides. Practices in other states and conclusions reached by US EPA suggest that with proper dry well siting, design, and maintenance, dry wells can be used safely.

All goals for the project were met and the City will continue to monitor and maintain the Strawberry Creek water quality basin site for 20 years.