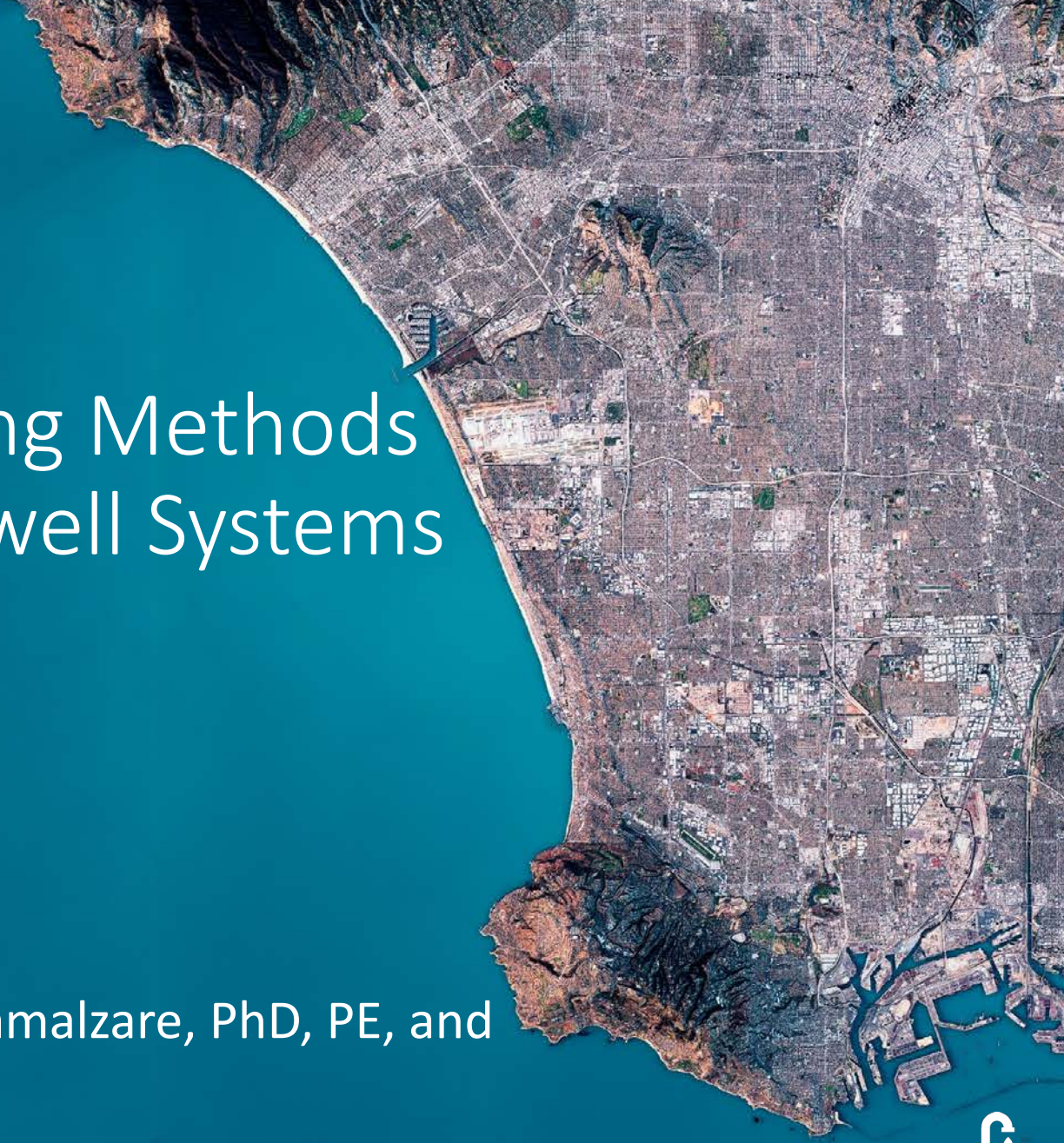
Evaluation of Infiltration Testing Methods for Design of Stormwater Drywell Systems

(*2021-2022 - funded in round 2*)



Scientific Studies Program

California State Polytechnic University, Pomona

Presentation by: Ali Sharbat, PhD, PE, Mehrad Kamalzare, PhD, PE, and Scott Kindred, PE, LHG

Reason for Study

- Utilize Measure W revenue effectively
- Drywells are expensive and we need good estimates of drywell capacity to invest wisely
- LA County methods for estimating the capacity of drywells (GS200.1) are not very accurate
- Inaccuracies in preliminary testing result in underestimating the infiltration rate
- The discrepancy has the potential to underestimate the actual capacity of drywells

Background

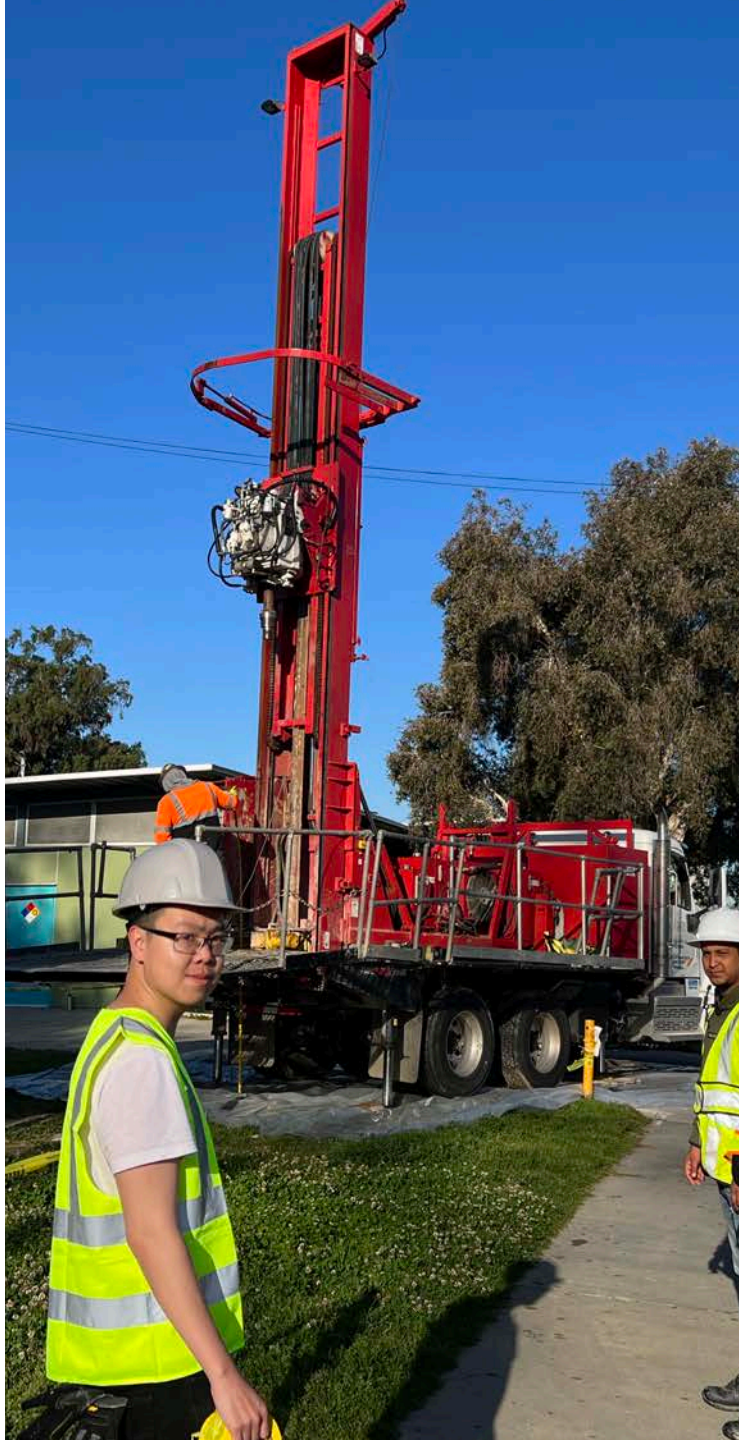
- Recently completed infiltration study funded by US EPA and managed by Washington State Department of Ecology

- Steady-state borehole permeability (SSBP) method for evaluating infiltration test results, and sizing stormwater infiltration facilities

- SSBP method relies on simple arithmetic equation with fitting parameter C_u

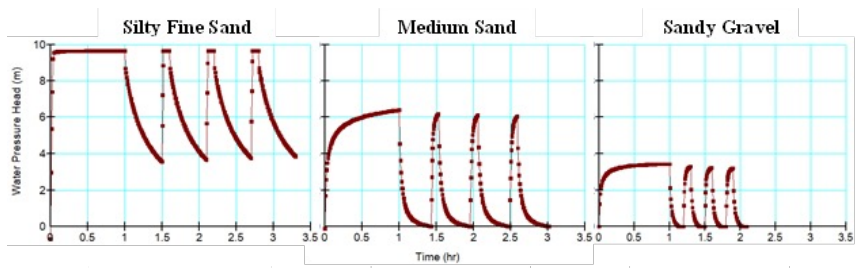
$$K_S = \frac{C_u Q}{2\pi H^2 + \pi r_b^2 C_u + \frac{2\pi H}{\alpha^*}} \qquad C_u = \left[\frac{(H/r_b)}{Z_1 + Z_2(H/r_b)}\right]^{Z_3}$$

- Numerical calibration provided accuracy of ± 13%

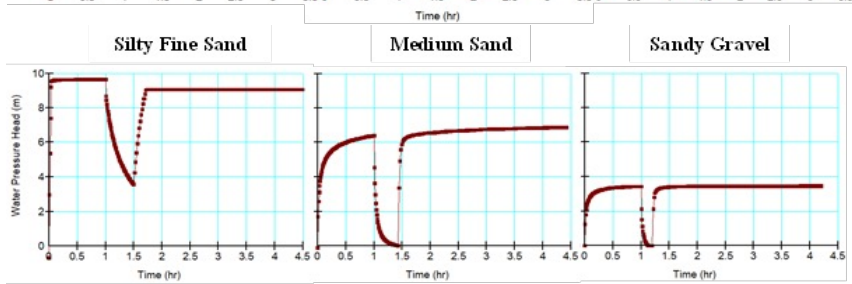


Numerical simulations to Evaluated Los Angeles County infiltration test methods for drywells provided in GS200.1

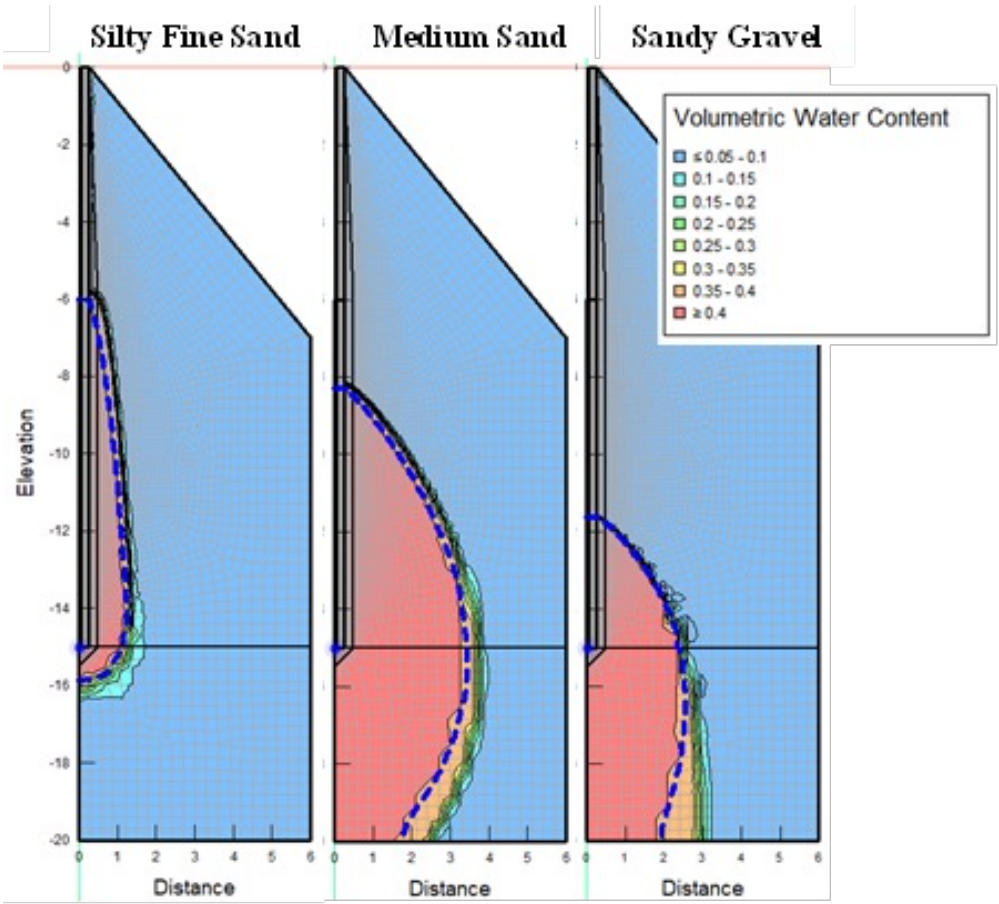
- GS200.1 specifies the falling-head or constant-head large-diameter boring (LDB) methods to estimate capacity of drywell
- Conducted numerical simulations of LDB tests, SSBP tests, and full-scale drywells
- Three soil types



Falling-Head LBD

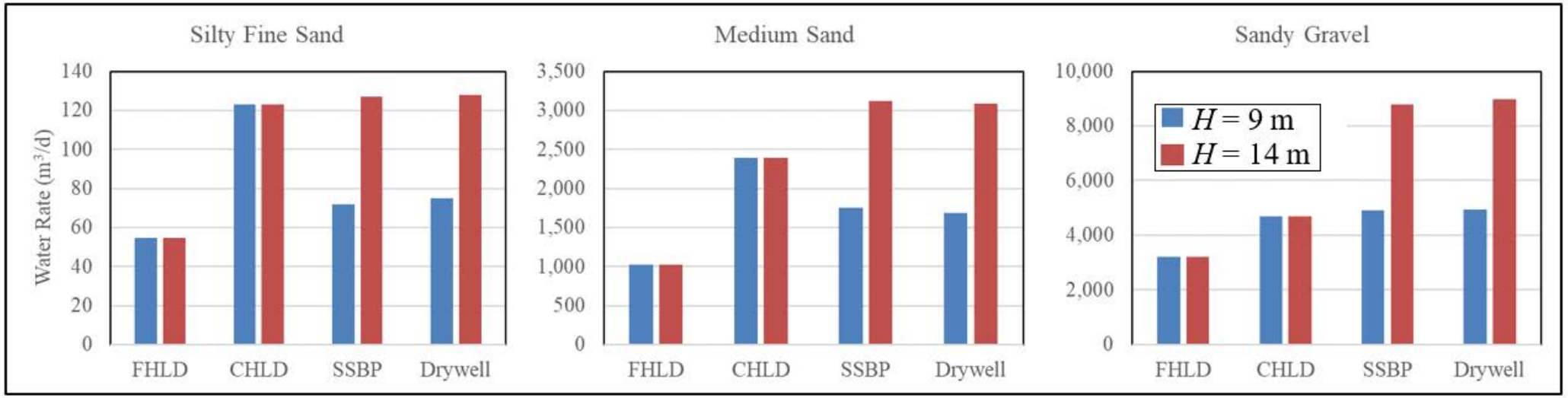


Constant-Head LBD



SSBP method more accurate than current GS200.1 methods

- Falling-head large diameter boring (FHLD) method underpredicts drywell capacity with errors ranging from -27% to -40%
- Constant-head large diameter boring (CHLD) method has errors ranging from -5% to +64%
- SSBP methods have errors ranging from -4% to +3%
- FHLD and CHLD methods cannot account for pressure head above filter pack interval

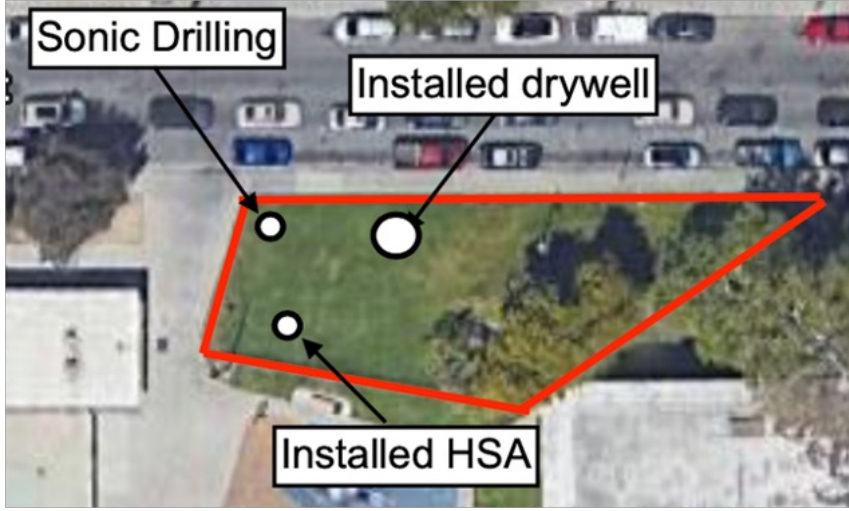


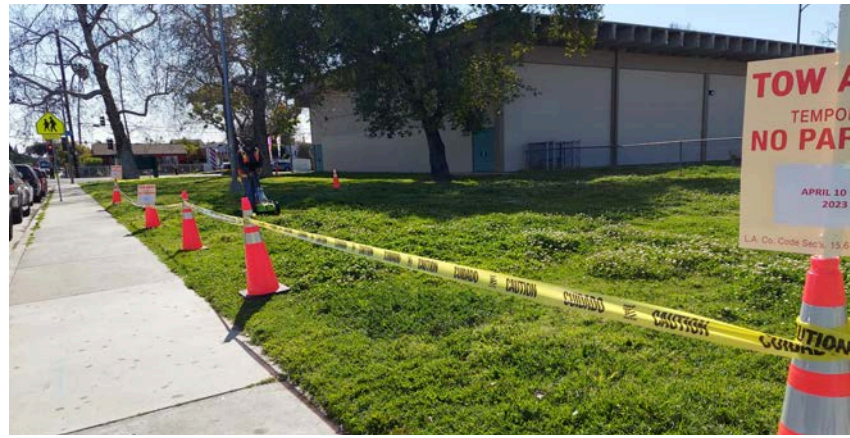
Scope of this study

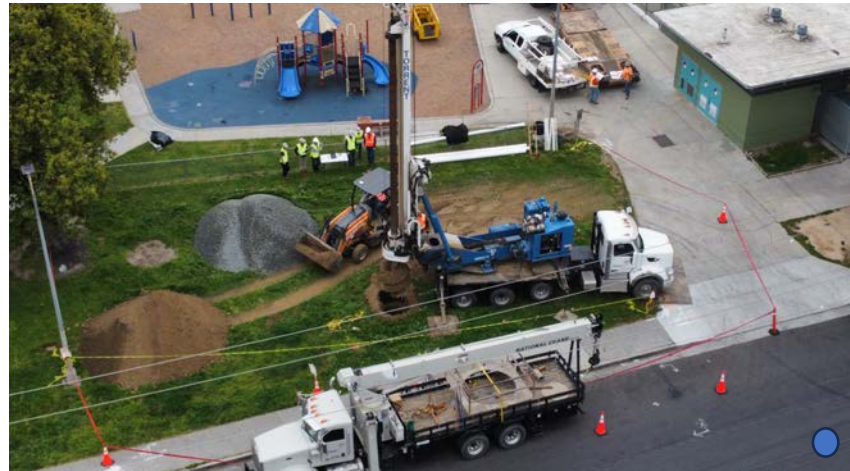
- Demonstrate SSBP (steady-state borehole permeability) method for estimating drywell capacity
- Conducting deep infiltration testing at 3 sites
- Conduct side-by-side testing of drywells and test-wells to determine if small-diameter test-wells can predict performance of drywells
- Determine if “well development” of test wells can improve capacity

South LA Site: Mary Bethune Park:

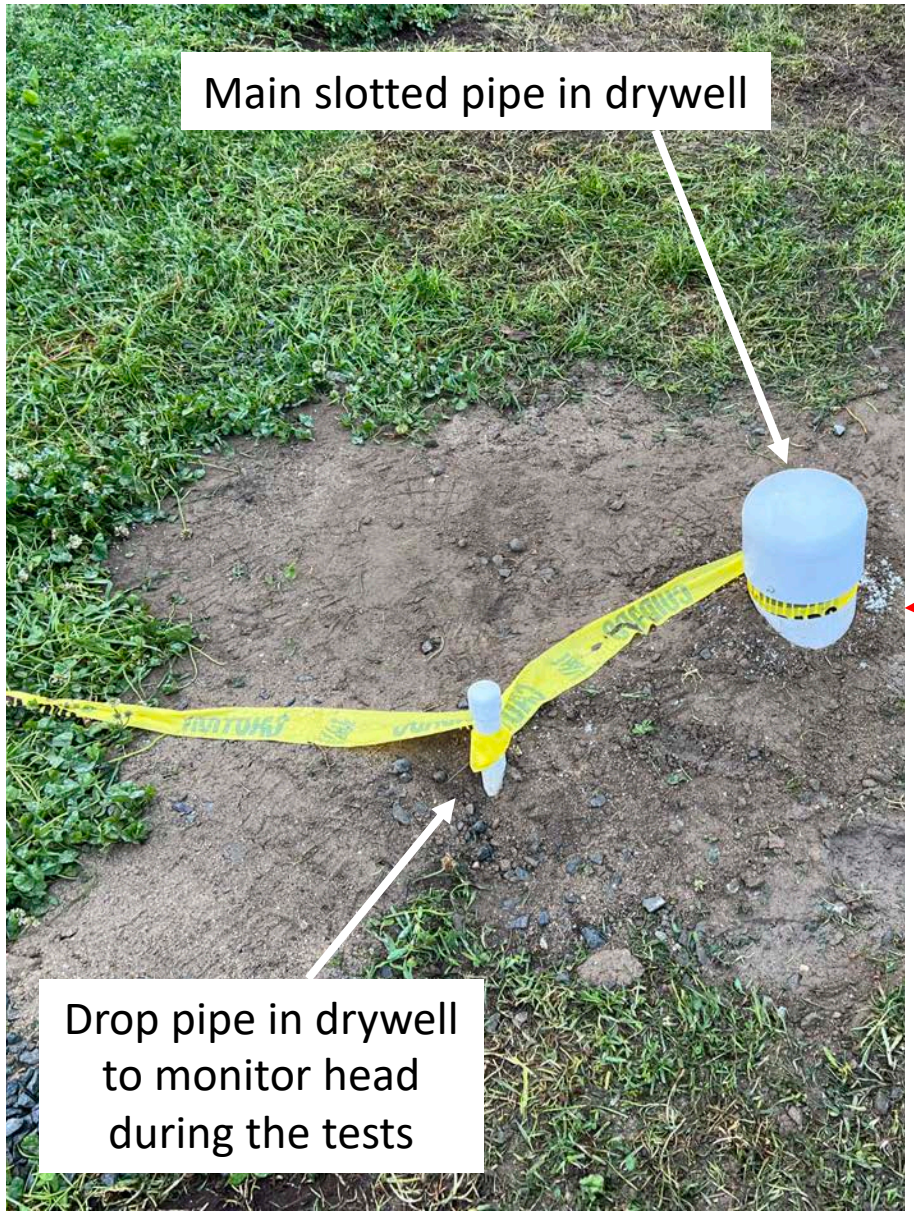
- Conducted two tests in **full-scale** drywell (48” dia.) with 14 days between tests (drop pipe in first test but not in second test)
- Conducted a single test in a test well drilled using **HSA** and completed with 3” dia. perforated pipe wrapped in fabric
- Conducted two tests in a test well drilled using **Sonic** drilling and completed with 2” dia. slotted pipe with no fabric
- All wells completed with sandpack from ~48-60 ft depth and 10 ft of screen/perf. pipe (relatively short interval)
- Wells were approximately 25 ft apart





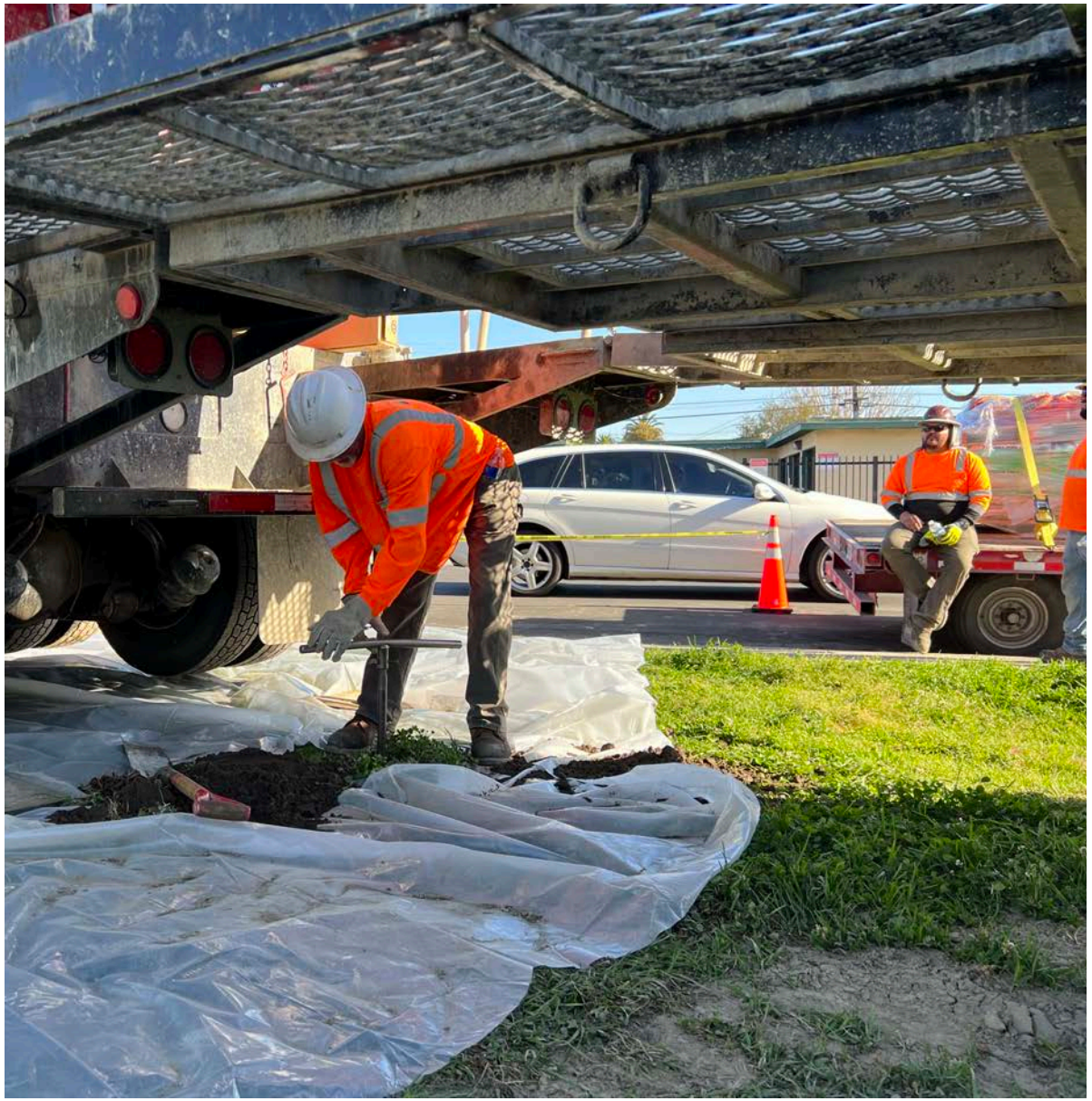


Full-Scale drywell installation in Bethune Park


Main slotted pipe in drywell
Drop pipe in drywell to monitor head during the tests


Installed drywell
Installed HSA Test well

Sonic Drilling installation test well



HSA drilling rig setting up at the predetermined location

All three installations at Mary Bethune Park

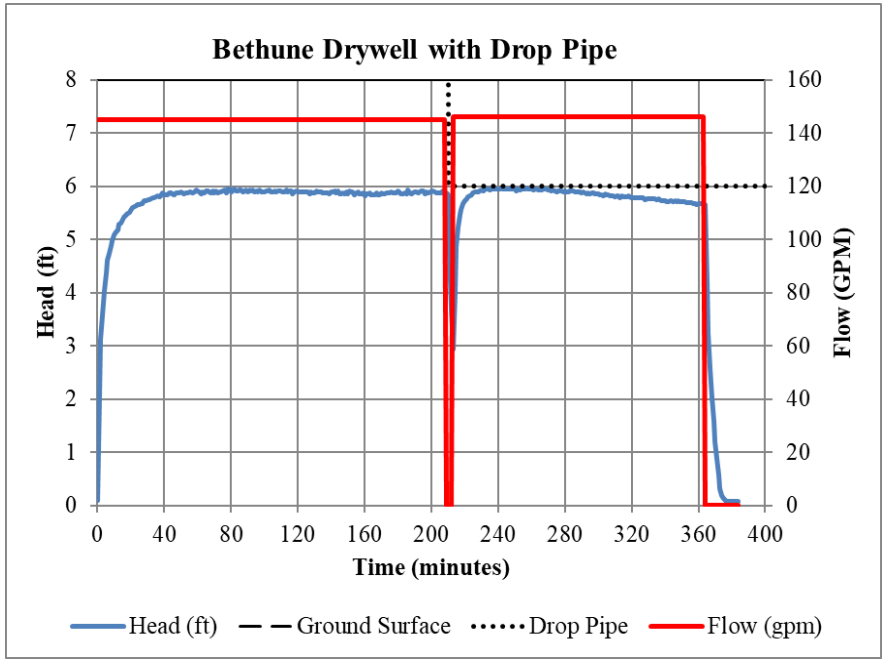
CPP team conducting test on different wells

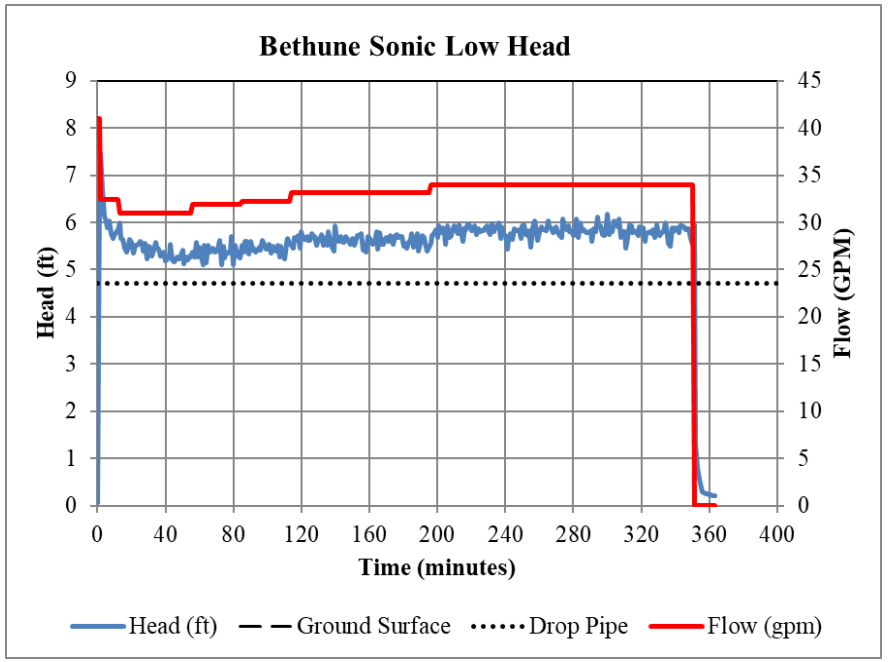
Site Restoration

Bethune Results:

Test	Test Date	Boring Diameter (in.)	Well Completion	Drop Pipe Below Water Level?	Head (ft)	Flow (gpm)	K_s (ft/day)
Drywell with Drop Pipe	4/12/2023	48	6-inch slotted	Yes	5.7	146	135
Drywell w/o Drop Pipe	4/26/2023	48	6-inch slotted	No	6.1	142	120
HSA High Head	4/14/2023	8	3-inch perf wrapped	Yes	59.2	31	4.4
Sonic H=6 ft	4/27/2023	6	2-inch slotted	Yes	5.9	34	105

- Drywell K_s was less in second drywell test, either due to clogging or elimination of drop pipe
- The HSA well provided a much lower K_s estimate than either the drywell or the sonic well, likely due to clogging
- Sonic K_s estimate was 22% less than the drywell (105 ft/day versus 135 ft/day) given same head elevation
- Tests reach steady state quickly and water drains out quickly (indicates no groundwater perching)
- No groundwater perching observed in test wells 25 ft away



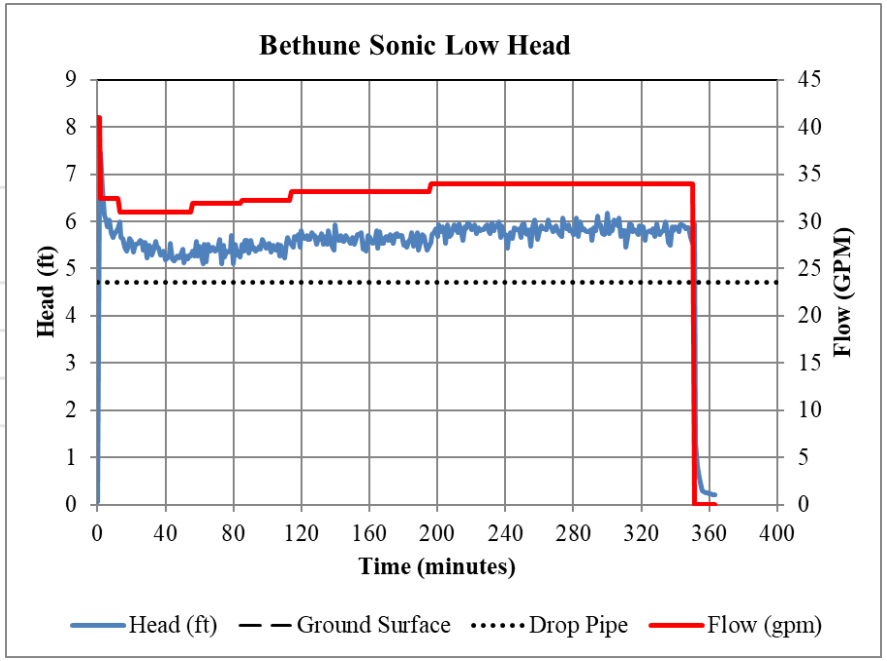


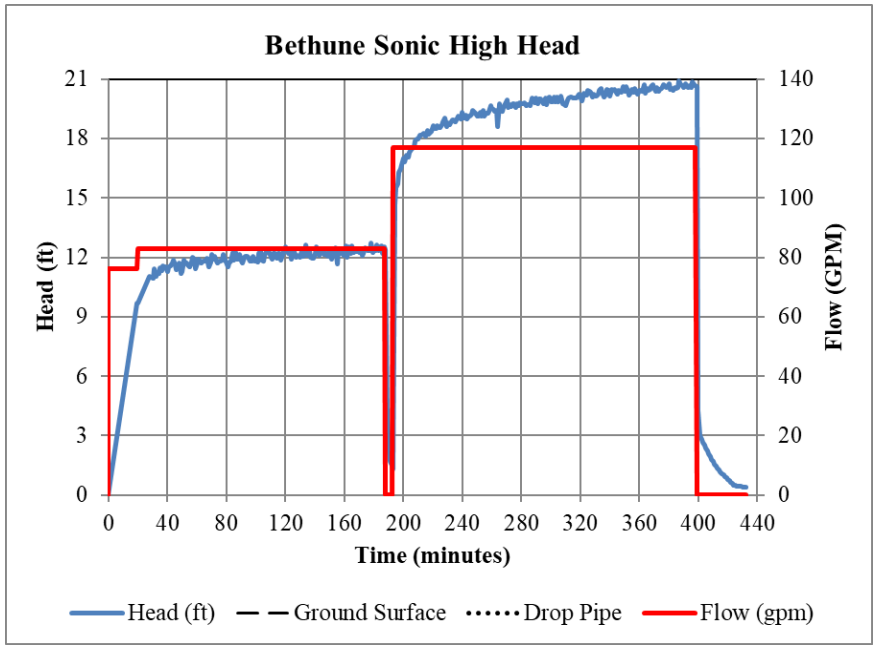
Bethune Sonic Results:

Test	Test Date	Boring Diameter (in.)	Well Completion	Drop Pipe Below Water Level?	Head (ft)	Flow (gpm)	K_s (ft/day)
Sonic H=6 ft	4/27/2023	6	2-inch slotted	Yes	5.9	34	105
Sonic H=12 ft	4/25/2023	6	2-inch slotted	No	12.5	83	80
Sonic H=20 ft	4/25/2023	6	2-inch slotted	No	20.7	117	52

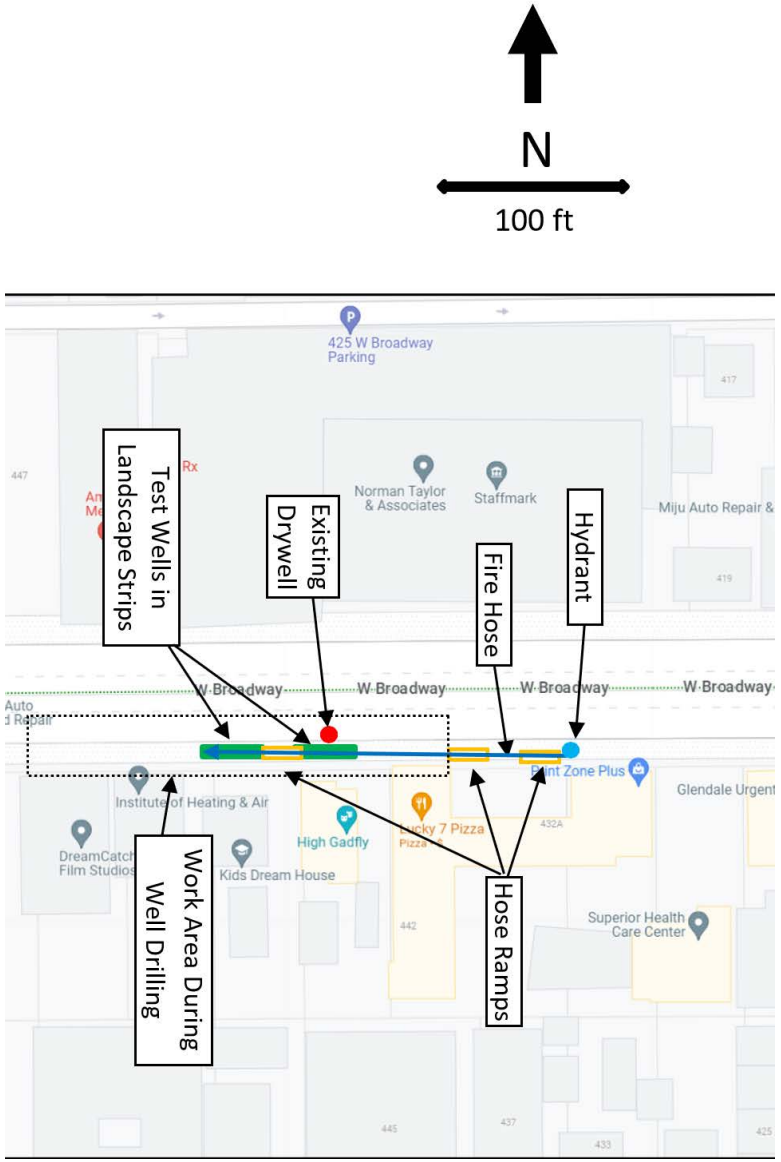
- Steady state was not achieved in high-head test, likely due to low permeability confining layer at top of filter pack

- K_s results in Sonic well decreased as flow rate and head increased
  - Likely due to head losses across screen and filter pack
  - 4-inch PVC screen recommended in permeable soils

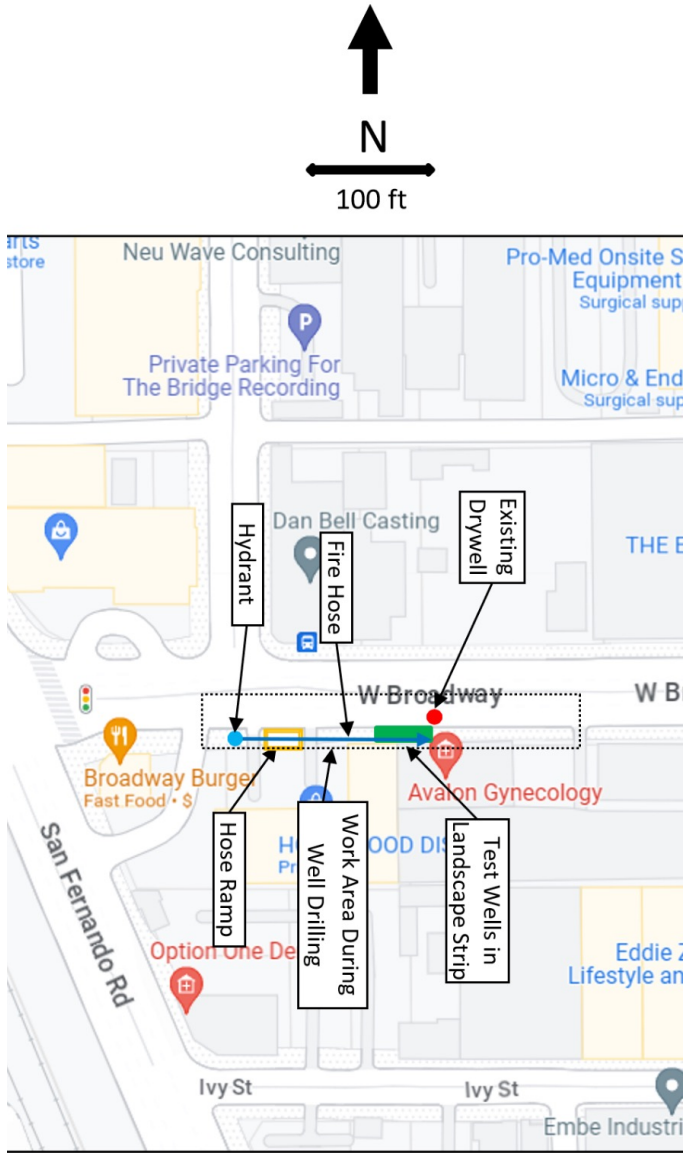




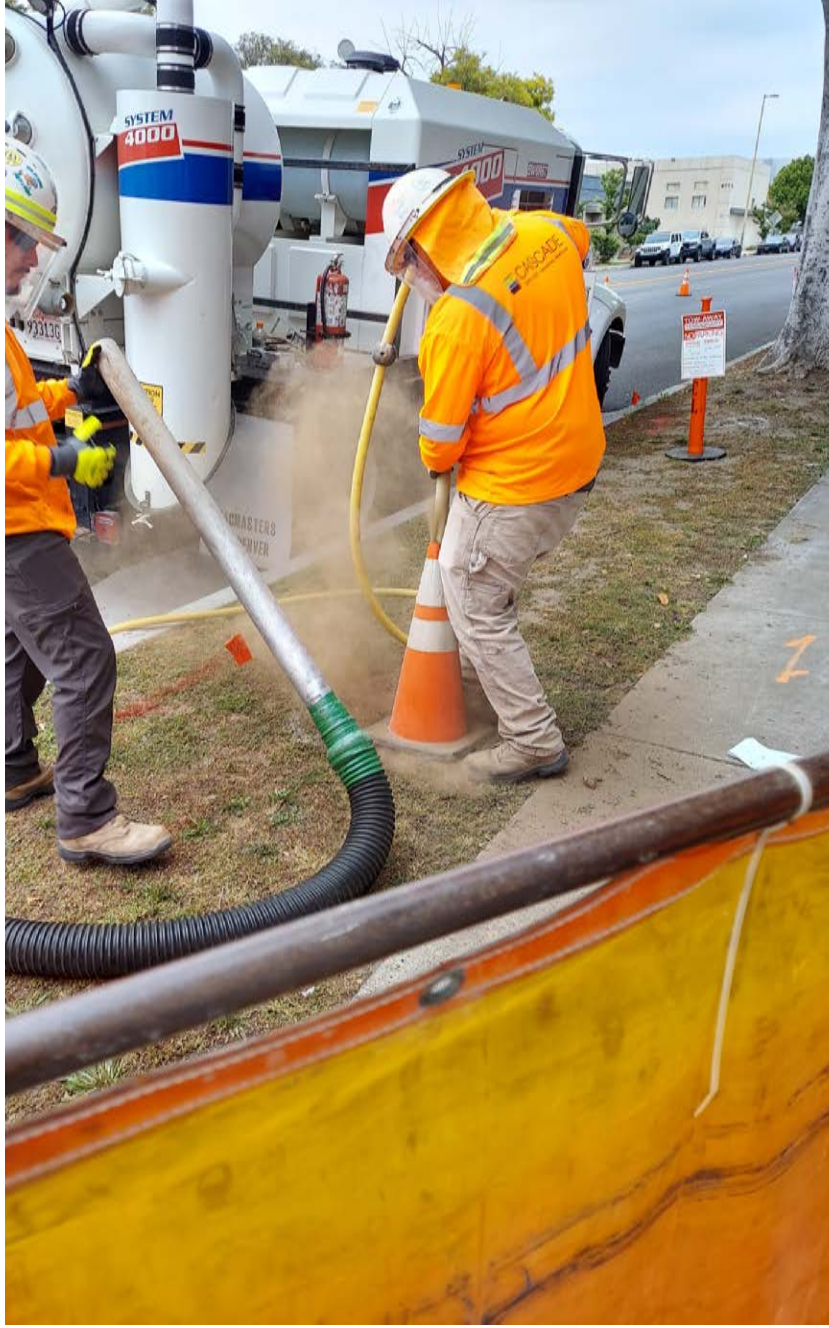
City of Glendale Sites



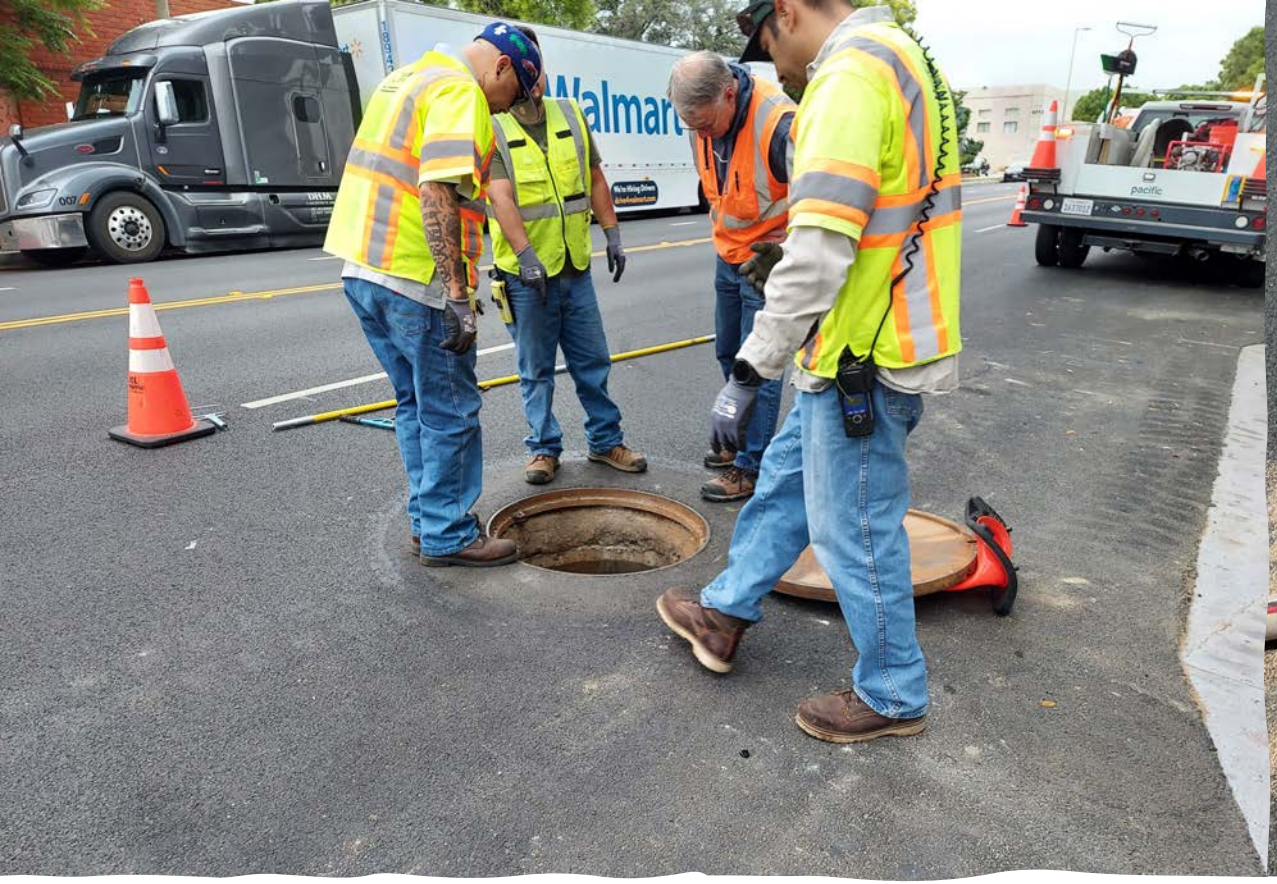
Glendale Site 1



Glendale Site 2



All well locations were potholed using vac-truck

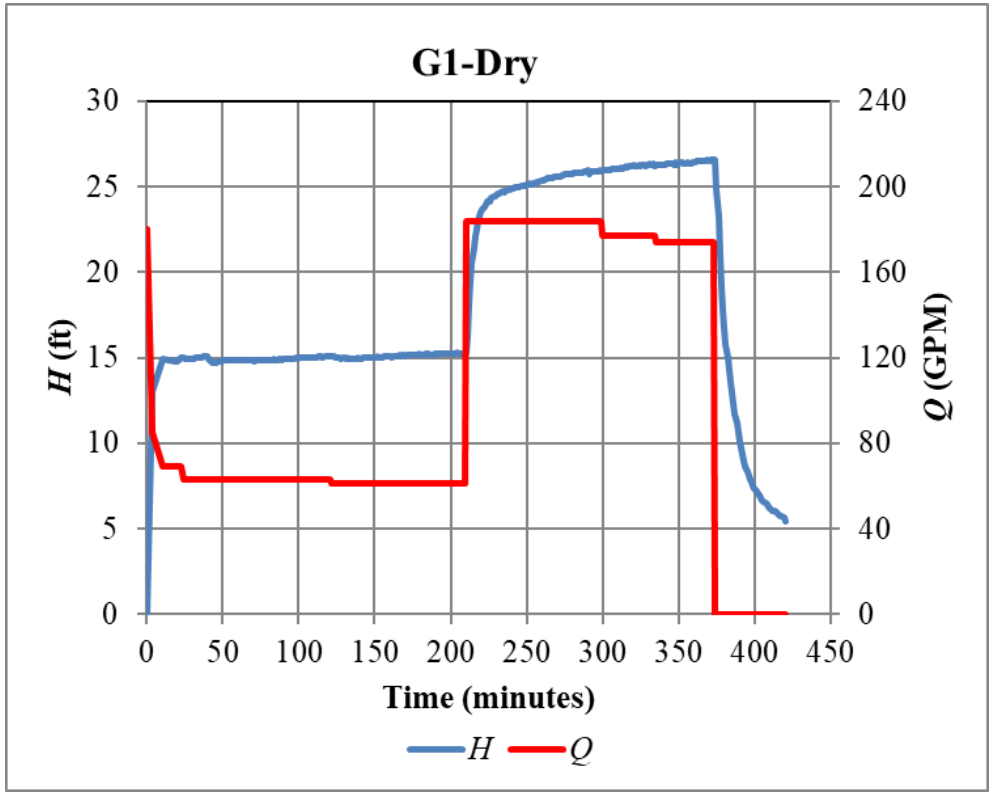


- **<u>Glendale Site 1 Field Testing:</u>**
  - Conducted low-head and high-head test on same day in existing full-scale drywell (48-inch diameter)
  - Drywell completed with gravel pack from ~15-45 ft depth and 10 ft of screen
  - Test wells were not constructed due to close proximity to utilities

Glendale Site 1 Results:

Test	Test Date	Boring Diameter (in.)	Well Completion	Drop Pipe Below Water Level?	Test Duration (min)	Head (ft)	Flow (gpm)	K_s (ft/day)
G1-Dry Low Head at 3.5 hr	6/2/2023	48	6-inch slotted	No	209	15	61	16
G1-Dry High Head at 6.2 hr	6/2/2023	48	6-inch slotted	No	370	26.5	174	20

- Low-head test (15 ft) for first half and high-head test (26.5 ft) for second half of test
- Not at steady-state after 370 minutes
- **K_s increased 25% from low-head to high-head test, likely due to higher K_s in upper part of well**



Glendale Site 2 Field Testing:

- Conducted a test in existing full-scale drywell (48” dia.)
- Conducted a test in a test-well drilled using HSA and completed with 2” dia. slotted pipe with no fabric
- Conducted two tests in a test-well drilled using Sonic
- All wells completed with filter pack from ~12-45 ft and 30 ft of screen
- Wells were approximately 20 ft apart

Sonic drilling rig

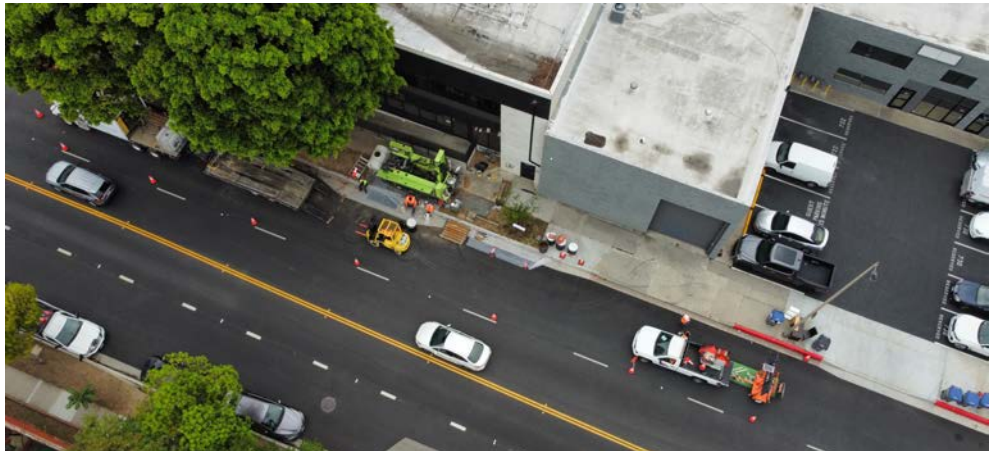
Lane closure in Site 2

Glendale Site 2 Field Testing:

- Test wells installed in very narrow grass strip
- Conducted *low-head* and *high-head* test on same day in full-scale drywell
- Conducted one test in HSA well and two tests in Sonic well (low head and high head)

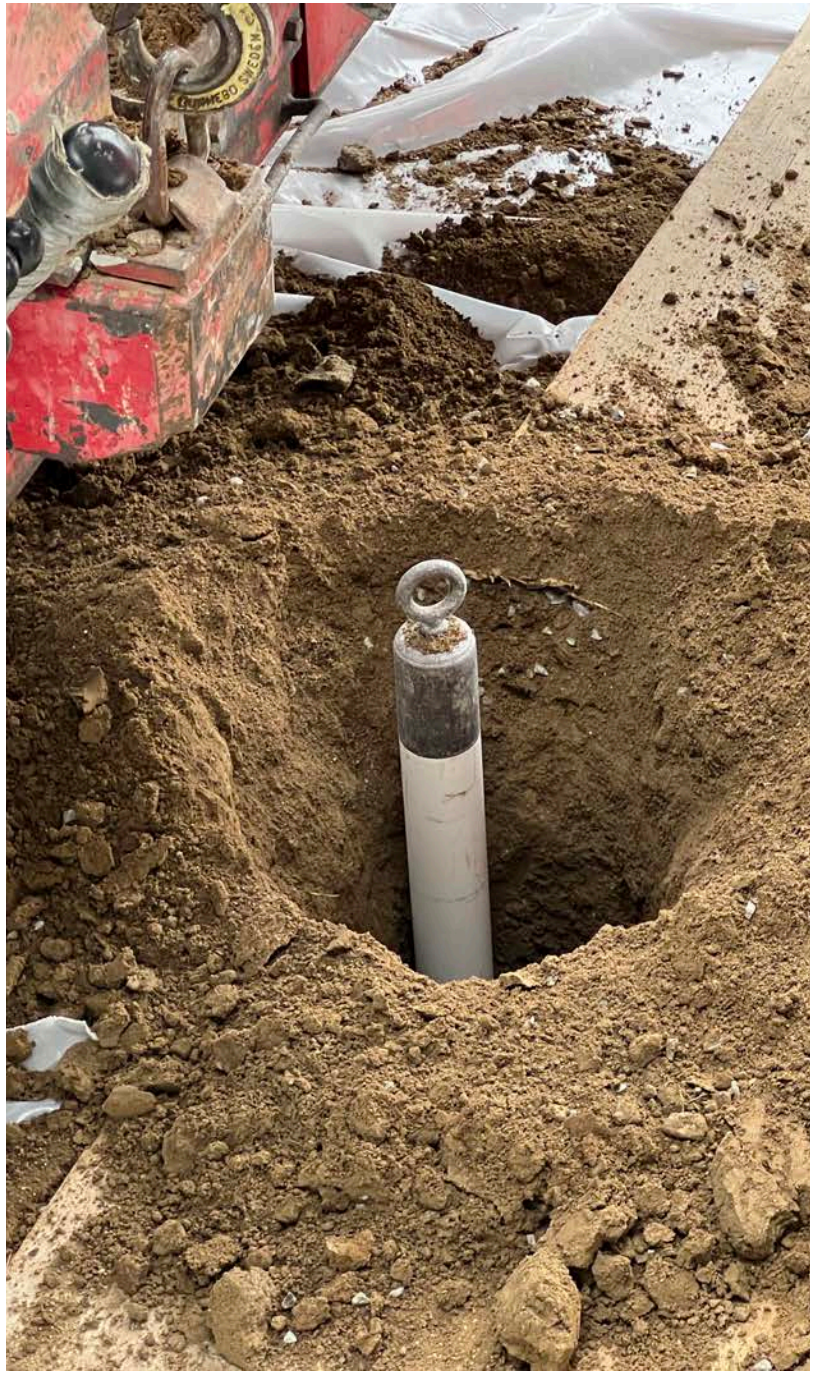
CPP Team in Glendale site 2 installing HSA test well

Limited access Sonic drilling rig



Installed HSA test well

Limited access HSA drilling rig



Sand #3 used to install the test-wells

Sonic soil samples

Well Design

Sonic Well Design

Project Name:

Project #:

Logged by:

Location: Broadway, Glendale, CA

Driller:

Ground Surface Elevation: NAVD-88 Surveyed

Start/Finish Date:

Exploration Method: Sonic

Depth to Water (ft BGS):

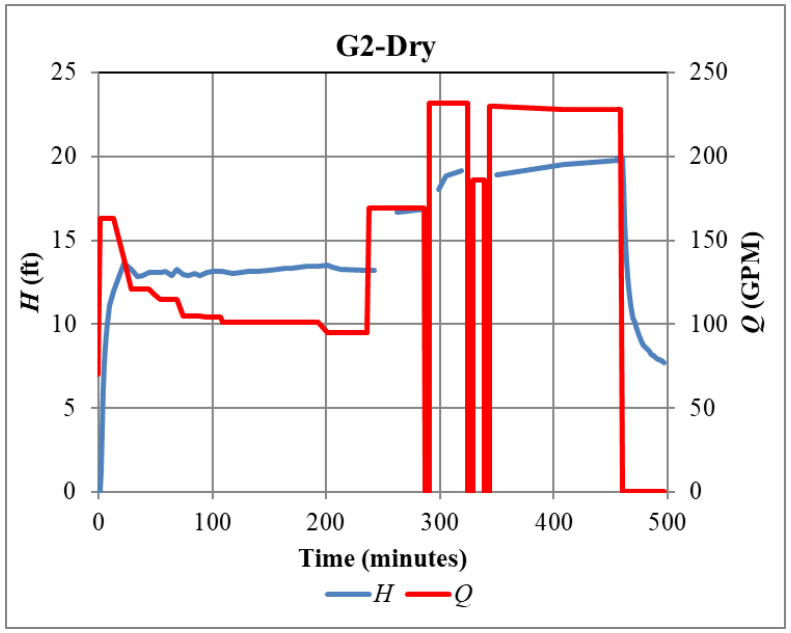
Sampling Method: Coring

Monument: None

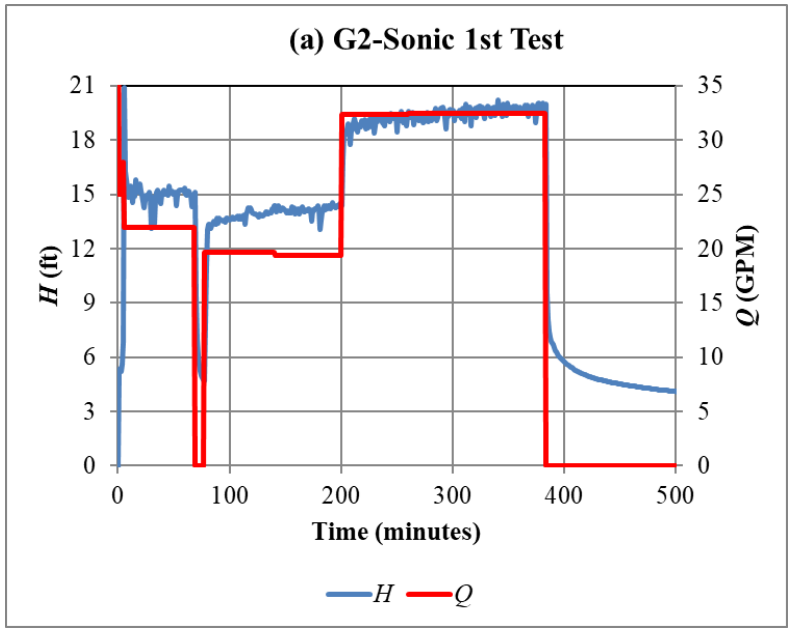
Depth (ft)	Elev (ft)	Sample Type/I.D.	Blow Counts	Water	USCS Class	Well Const.	Description
		Bag Core Samples				4-in. Solid PVC	0-5 feet: native soil backfill
							0-20 feet: 4-inch diameter PVC solid casing
5							no monument
						Bentonite Chips	5-14 feet: Bentonite chips
10							
15							14-45 feet: #3 sand
20							20-45 feet: 4-inch diameter PVC slotted pipe
25						#3 Sand	
30							
35							
40						4-in. Slotted	
45							45-55 feet: Bentonite chips
50						Bentonite Chips	
55							

Glendale Site 2 Results:

Test	Test Date	Boring Diameter (in.)	Well Completion	Drop Pipe Below Water Level?	Test Duration (min)	Head (ft)	Flow (gpm)	K_s (ft/day)
G2-Dry Low Head at 4.0 hr	6/2/2023	48.0	6-inch slotted	No	238	13.0	169	54.00
G2-Dry Low Head at 7.7 hr	6/2/2023	48.0	6-inch slotted	No	459	19.9	228	41.00
G2-HSA at 2.5 hr	6/4/2023	8.0	2-inch slotted	Yes	150	44.6	2.4	0.21
G2-HSA at 5.4 hr	6/4/2023	8.0	2-inch slotted	Yes	325	44.8	2.7	0.24
G2-Sonic Low Head at 3.3 Hr	6/3/2023	8.0	4-inch slotted	Yes	200	14.5	19	13
G2-Sonic Low Head at 6.3 Hr	6/3/2023	8.0	4-inch slotted	Yes	380	19.6	33	14



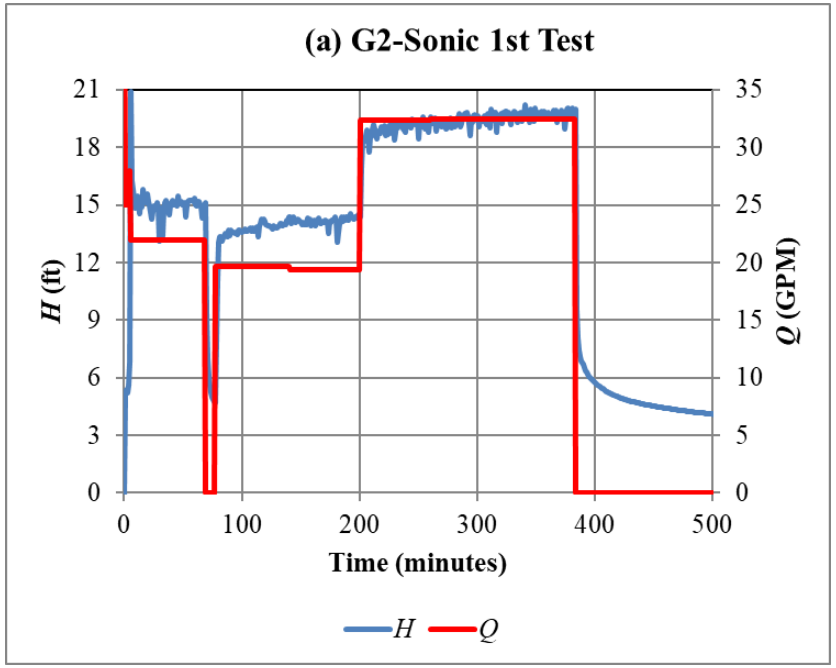
- Drywell test not at steady state after 460 min
- Sonic test underpredicts K_s in drywell by 66%
- HSA well clogged, even after well development

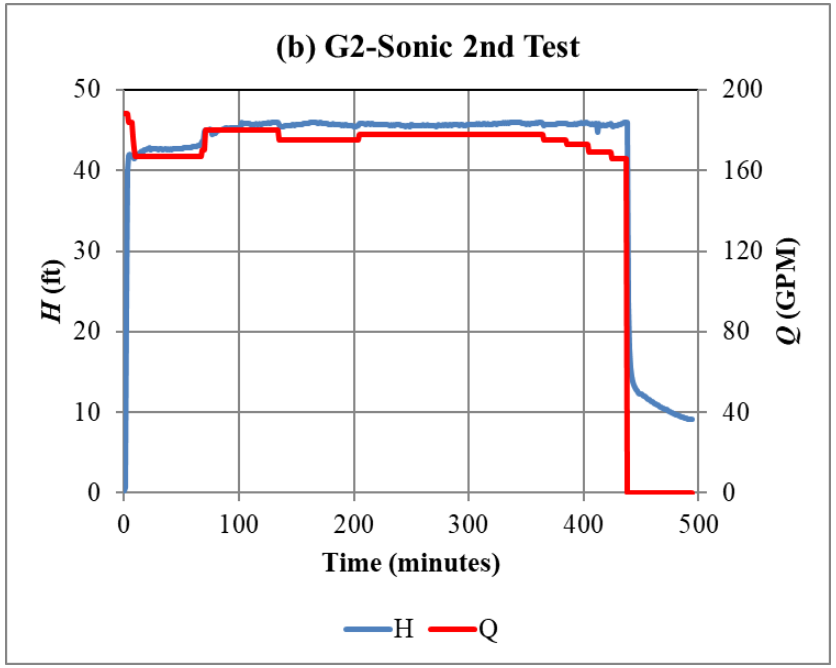


Glendale Site 2 Sonic Results:

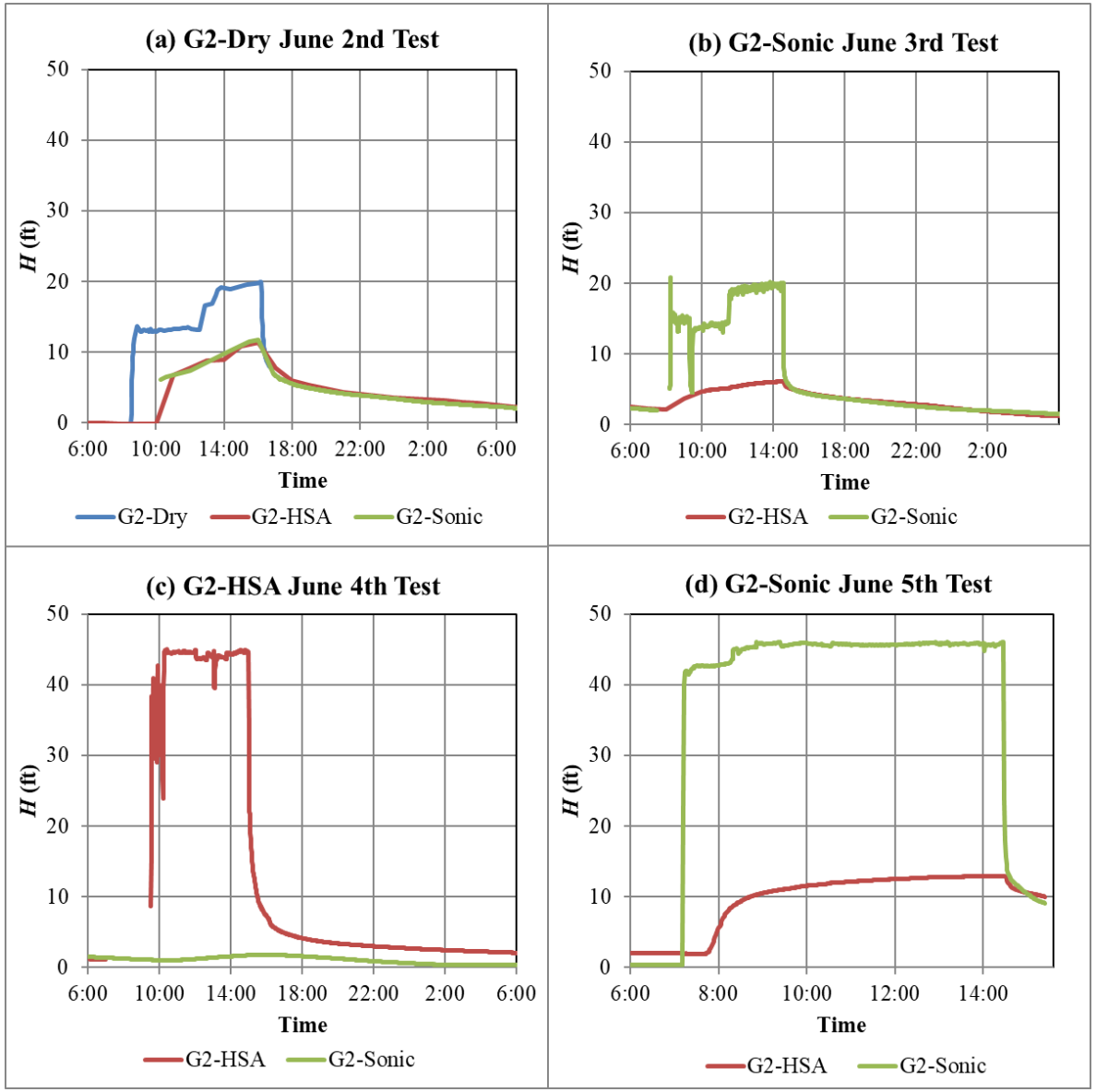
Test	Test Date	Boring Diameter (in.)	Well Completion	Drop Pipe Below Water Level?	Test Duration (min)	Head (ft)	Flow (gpm)	K_s (ft/day)
G2-Sonic Low Head at 3.3 Hr	6/3/2023	8.0	4-inch slotted	Yes	200	14.5	19	13
G2-Sonic Low Head at 6.3 Hr	6/3/2023	8.0	4-inch slotted	Yes	380	19.6	33	14
G2-Sonic High Head at 4.2 Hr	6/5/2023	8.0	4-inch slotted	Yes	250	45.6	178	16
G2-Sonic High Head at 7.3 Hr	6/5/2023	8.0	4-inch slotted	Yes	437	45.9	166	15

- Very little change in K_s at higher head
- Neither test achieved steady state
- Water did not drain quickly after water turned off





Groundwater Mounding at Glendale Site 2



- Groundwater mound was still evident after several days
- Explains why steady-state was not achieved
- May explain why Sonic test provided lower K_s than drywell

- Students played an important role during this study
  - Setting up test equipment
  - Collecting field data
  - Laboratory work
- Opportunity to interact with practicing engineer
- Provided significant training for the future workforce

Summary of Results

- **Hollow stem auger** wells are not suitable for infiltration testing due to severe clogging
- **Sonic** wells usually suitable for infiltration testing, although they may underestimate drywell performance by 20-60%
- Hydrant flow limited to ~140-230 gpm with typical meter and valve arrangement . ~50 gpm increase when meter/valve removed
- Groundwater mounding may significantly reduce capacity!

CPP Students (Patrick Nguyen and Gilberto Sosa) presenting the work at regional Creative Activities & Research Symposium (CARS) event.

Acknowledgement

Safe Clear Water Program – Measure W

Upper Los Angeles River (ULAR) Watershed

Special thanks to:

- LA County Public Work

  (Mr. Rafael Piamonte, Mr. Thuan Nguyen, Mr. Haris Harouny, Mr. Jose Urquizo, Ms. Karen Mendez, among others)
- LA County Department of Park and Recreation, DPR

  (Mr. Lee Barocas, Ms. Narine Hakobyan, Mr. Miguel Vazquez, Mr. Chris Elliott, among others)
- City of Glendale

  (Mr. Yazdan Emrani, Mr. Sarkis Oganesyan, Ms. Viktoriya Pakhanyan, Mr. Armen Avazian, Mr. Tahmasb Arasteh, Mr. Soroush Sheikhlar, Mr. Benjamin Gonzalez, Ms. Ani Azoyan, among others)
- Students at Cal Poly Pomona

  (Christian Santonil, Carolina Martinez, Fernando Garcia de Alba, Ziliang Wang, William Tsai, Ignacio Ramirez, Sammy Lozano, Patrick Nguyen and Gilberto Sosa)




QUESTIONS?