SAFE, CLEAN WATER PROGRAM

SCIENTIFIC STUDY SUMMARY

Regional Program Projects Module

STUDY NAME	Evaluation of infiltration testing methods for design of stormwater drywell systems
STUDY LEAD(S)	California State Polytechnic University, Pomona
SCW WATERSHED AREA(S)	Upper Los Angeles River
TOTAL SCW FUNDING REQUESTED	$ 554,684.00

Submitted On: Thursday, October 15, 2020

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OVERVIEW

The Scientific Studies Program is part of the Safe, Clean Water Regional Program to provide funding for activities such as scientific studies, technical studies, monitoring, and modeling. Watershed Area Steering Committees will determine how to appropriate funds for the Scientific Studies Program. The District will administer the Scientific Studies Program and will seek to utilize independent research institutions or academic institutions to carry out, help design, or peer review eligible activities. All activities to be funded by the Scientific Studies Program will be conducted in accordance with accepted scientific protocols.

This document summarizes a proposed Scientific Study, based upon inputs to and outputs from the web-based tool called the ‘SCW Regional Program Projects Module’ (https://portal.safecleanwaterla.org/projects-module/).

ORGANIZATIONAL OVERVIEW:

1 GENERAL INFORMATION

This section provides general information on the proposed Scientific Study.

1.1 Overview

The following table provides an overview of the study and the Study Lead(s):

Study Name:	Evaluation of infiltration testing methods for design of stormwater drywell systems
Study Description:	To provide accurate and cost-effective infiltration test methods that will result in more cost-effective drywell infiltration systems.
SCW Watershed Area:	Upper Los Angeles River
Latitude to Display On the SCW Portal Map:	34.22
Longitude to Display On the SCW Portal Map:	-118.37
Have There Been Other Similar or Related Studies?	Yes
If There are Similar or Related Studies Please Explain:	The methodology for developing calibrating fitting parameters for the steady-state borehole permeameter method is provided by Kindred and Reynolds (2020, Using the borehole permeameter to estimate saturated hydraulic conductivity for glacially over-consolidated soils. Hydrogeology Journal 28, 1909–1924).
Call for Projects year:	FY21-22
Total SCW Funding Requested:	$ 554,684.00
Study Lead(s):	California State Polytechnic University, Pomona
Additional Study Collaborators:	City of Los Angeles, and the County of Los Angeles
Additional Study Collaborators:	J. Scott Kindred, PE, CHG, Kindred Hydro, Inc.
Additional Study Collaborators:	John Gulliver, Ph. D., F. ASCE
Anticipated Study Developer:	California State Polytechnic University, Pomona
Primary Contact (if differs from submitter):	Precy Lynn Baltazar, Sponsored Programs Associate, California State Polytechnic University, Pomona

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2 DETAILS

This section provides an overview of the study details including problem statement and objectives.

2.1 Statement

The following describes the Study problem statement:

The current infiltration testing and drywell design methods provided in the Los Angeles County Department of Public Works GS200.2 document do not estimate the capacity of production-scale drywells. In many cases, it appears that the predicted capacities are much lower than actual drywell capacity, resulting in more drywells than needed and significantly higher construction and long-term maintenance costs. This is illustrated in Attachment 2: Evaluation of Current Drywell Testing and Design Methods. In other cases, the uncertainty in the measurements results in predicted capacities are higher than actual drywell capacity, resulting in fewer drywells that needed. The number and length of measurements required with the drywell method has never been adequately examined. This is one objective of the proposed research.

There are alternative, well-documented infiltration test methods that would provide more accurate predictions of drywell capacity, potentially at a lower testing cost. This study proposes to evaluate various existing and proposed infiltration testing methods to better understand the accuracy of each method and identify factors that may lead to uncertainty and inaccuracy.

2.2 Objectives

The following describes the Study objectives:

Specific objectives of this proposed scientific study are to:
1. Identify and evaluate infiltration testing methods that are suitable for estimating drywell capacity over a range of well diameters.
2. Evaluate drilling, well construction, and well-development methods to minimize smearing and other borehole effects.
3. Evaluate and refine testing methods to ensure suitable accuracy while minimizing test complexity and cost.
4. Ensure that the methods provided by this work are reviewed and accepted by stakeholders, including regulators, municipal stormwater managers, and geotechnical/hydrogeologic consultants that regularly conduct infiltration testing and design.

2.3 Summary

The following provides additional details on the Study including location of study, date to be collected, study methodology, etc.:

A summary of the study is provided in this write up. Additional details regarding the scope of work are provided in Attachment 3: Scope of Work. The proposed study includes the following tasks:

Task 1: Characterize Range of Typical Soil Types and Hydrogeologic Settings.
This task will identify and characterize the general types of soils and hydrogeologic settings in the Los Angeles basin that are suitable for drywell infiltration. This work will also identify and document the multiple concerns and factors associated with dry-well implementation that exist in LA County This information will be used to identify and refine testing methods that will be most effective to support design of drywell infiltration systems in the County and will be based on a literature review and interviews/workshops with local geotechnical and hydrogeologic experts. This task is not intended to provide generic hydraulic conductivity (Ks) values for use by the industry.

Task 2: Literature Review and Numerical Analysis of Infiltration Testing Methods that are Suitable for Drywell Design.
This task will include a literature review to identify proven and well-documented infiltration testing methods that are suitable for drywell design. The methods selected for evaluation will be evaluated by comparing the predicted results with numerical simulations of the tests for the range of soils and hydrogeologic settings typical of the Los Angeles Basin. Only those methods that meet the following criteria will be further evaluated in the field program:
1. A reasonably good fit between the results predicted by the method and results predicted by numerical simulations.
2. Field procedures that are feasible and cost-effective using equipment that is commonly used or readily available.
3. Analysis procedures that are simple to perform by geotechnical and hydrogeologic professionals.

The purpose of the numerical analysis is four-fold:
1. Develop calibrated fitting parameters used to define the shape function (C) for the steady-state BP methods.
2. Validate the proposed analytical methods.
3. Assess how layering and variability may affect the test results.
4. Help design the field tests.

Task 3: Planning the Field Program.
This task will utilize the information provided in the previous tasks to design the field program and includes the following activities:
1. Identify Test Locations. Three test sites will be selected that have varied soil conditions so that testing will be representative of a variety of soil conditions across Los Angeles County. Although tentative test locations have been identified, these locations may be modified based on the results of Task 1. The three potential sites, described in Attachment 2, include two potential sites within the City of Los Angeles and one site in Los Angeles County.

2. Document Drilling and Testing Procedures. Drilling and field-testing procedures will be developed in advance of going into the field. It is expected that multiple drilling techniques will be evaluated, including hollow step auger, bucket auger, flight auger, and Sonic drilling.

3. Permits, Equipment and Drilling/Testing Contractors. This task includes obtaining all permits, equipment, and drilling contractors to conduct the work. The project team includes consultants and researchers with extensive experience procuring these items.

Task 4: Drilling and Field Infiltration Testing.

The general approach for this task is to install and test approximately 12 test wells at three sites to evaluate various parameters such as borehole diameter, drilling methods, well development methods, infiltration test methods, etc.

Task 5: Outreach and Engagement.
The purpose of this task is to ensure that potential users of these drywell infiltration testing and design methods are engaged during the study and the methods meets their needs when the work is complete. Outreach and engagement will include:
1. Regular emails to present results and solicit feedback.
2. Workshops with interested stakeholders to present results and solicit feedback.
3. Presentations at conferences and technical meetings.

In addition to the City and County of Los Angeles, outreach will be targeted at stakeholders such as regulators, municipal stormwater managers, and civil/geotechnical/hydrogeologic professionals that regularly conduct infiltration testing and design.

Task 6: Documentation and Reporting
All the interim reports and field procedures developed in the previous tasks will be compiled and summarized in a single technical report. This technical report will summarize the results of the study and provide an evaluation of the testing methods, including accuracy, feasibility and cost of the field procedures, and simplicity of the analysis techniques. In addition, the report will recommend next steps toward improved infiltration testing and design and include a gap analysis to determine where additional information is needed. This report may be used to develop recommended modifications to GS200 document.

It is expected that one or more peer-reviewed papers will be produced and submitted to a technical journal for publication. This process will ensure that the study results are subject to technical review.

The results of this study will be summarized and presented to the Upper Los Angeles River Watershed Group and/or Watershed Area Steering Committee.

2.4 Additional Information

Additional information regarding Study details is provided as the following attachments:

Attachments for this Section	
Attachment Name	Description
Attachment 1_Drywell Project Summary.pdf	
Attachment 2_Evaluation of Current Infiltration Testing Methods.pdf	
Attachment 3_Scope of Work FINAL.pdf	

3 Outcomes

This section provides an overview of the anticipated Study outcomes and the nexus to water supply and water quality.

3.1 Nexus

The following describes the Study's nexus to stormwater, urban runoff and / or water supply:

Stormwater infiltration is critical to the Los Angeles region's stormwater management, water quality, and water supply goals. Stormwater drywells provide an efficient and effective means of reducing urban runoff and restoring hydrologic conditions by promoting deep infiltration. Recharging groundwater elevations with urban runoff during winter months means more local groundwater is available for water supply during dry summer months when demand is high.

3.2 Outcomes

The following describes the expected outcomes of the Study in terms of implementation of BMPs or development of tools or applications:

This study will provide a toolbox of infiltration testing methods that are cost-effective and provide more accurate estimates of drywell capacity. The study will provide a comparison of different methods (e.g., steady-head versus falling-head methods) that will determine if these methods provide comparable results and the pros and cons of each method. Because of the outreach and engagement activities, stakeholders in the stormwater community will participate in development of the methods, making it more likely that the methods will be readily accepted.

3.3 Benefits

The following describes how the Study is anticipated to improve water quality, increase water supply, or enhance community investments:

It is reported that many drywell systems are currently over-sized or deemed infeasible due to inaccuracies with the infiltration testing. As a result, site developers and municipalities are not getting the best value for their investment in stormwater infiltration. Accurate infiltration test methods and more cost-effective drywell infiltration systems means more stormwater management and groundwater recharge for the same investment, helping the community to meet stormwater management and water-supply objectives faster and cheaper.

3.4 Additional Information

Additional information regarding Study outcomes and its nexus to water quality and supply is provided as the following attachments:

4 Background

This section provides additional background on the Study.

4.1 Previous

The following describes previous / similar studies conducted and how previous efforts will be leveraged for the Study:

A cursory review of stormwater infiltration testing methods across the United States indicates that there is no consistent generally accepted methodology and the most commonly used methods (soil texture, grain size distribution, perc tests, double ring infiltrometer, pilot infiltration test) can be inaccurate and tend to focus on vertical infiltration rates suitable for sizing shallow infiltration facilities. Due to soil layering, vertical hydraulic conductivity can be significantly less than horizontal hydraulic conductivity. The only commonly referenced method potentially suitable for estimating the capacity of drywells is USBR 7300-89, which Los Angeles County includes in their recommended testing methods. However, the method requires modifications to be suitable for estimating the capacity of deep high flow-rate drywells and, as discussed in previous sections, can be inaccurate.

There are well-studied methods available in the soil-science literature that provide estimates of saturated hydraulic conductivity suitable for drywell design. A recent paper by Kindred and Reynolds (2000) demonstrates how one of these methods can be adopted for estimating the capacity of stormwater infiltration facilities, including drywells, in glacially over-consolidated soils. The Philip-Dunne Permeameter (Phillip 1993) is a falling head method that requires a minimal volume of water and less time to implement.

This study will have the advantage of building upon related grant-funded work from the Puget Sound Partnership (PSP) that will be conducted over the next year in Washington State. This work will be conducted by the City of Tacoma using a team led by Scott Kindred, who will also participate in this proposed scope of work. The PSP scope of work will focus on both shallow and deep infiltration testing methodologies and their application in Puget Sound hydrogeologic settings. The PSP work will not include the installation of new test wells and drywells, although it will include testing of existing small-diameter test wells. This proposed study will build on the PSP work with a focus on Los Angeles Basin hydrogeologic soils and settings and the installation and testing of wells with different diameters at multiple test sites.

The study will also benefit from the experience of John Gulliver, Professor at the University of Minnesota, who has been performing research on infiltration/permeameter testing for 17 years (Asleson et al, 2009; Olson et al., 2013; Paus et al., 2013; Ahmed, et al., 2014; Amed et al., 2015; Weiss and Gulliver, 2015; Garcia-Serrana et al., 2017a; Garcia-Serrana et al., 2017b; Garcia-Serrana et al., 2017c; Nestigen et al., 2018; Garcia-Serrana et al., 2018; Tecca et al. 2020a; Tecca et al., 2020b). The lessons learned include that the lateral inhomogeneity of soil (even engineered soil) is substantial, probably due to uneven compaction. Based upon this, the Gulliver group has made a detailed study of the number of measurements required to estimate a practice's or a region's effective value of saturated hydraulic conductivity. This knowledge base will be helpful in producing perspective on the experiments described herein.

References:

Ahmed, F., R. Nestingen, J.L. Nieber, J.S. Gulliver, R.M. Hozalski, A Modified Philip-Dunne Infiltrometer for Measuring the Field-Saturated Hydraulic Conductivity of Surface Soil, Vadose Zone Journal, 13(10), 2014.

Ahmed, F., J.S. Gulliver and J.L. Nieber, Field Infiltration Measurements in Grassed Swales, Journal of Hydrology, 530, 604–611, 2015.

Asleson, B.C., R.S. Nestingen, J.S. Gulliver, R.M. Hozalski, and J.L. Nieber, "Assessment of Rain Gardens by Visual Inspection and Controlled Testing," Journal of the American Water Resources Association, 45(4), 1019-1031, 2009.

Garcia-Serrana, M., J.S. Gulliver and J.L. Nieber, Infiltration Capacity of Roadside Filter Strips with Non-Uniform Overland Flow, Journal of Hydrology, 545, 451-462, 2017a.

Garcia-Serrana, M., J.S. Gulliver and J.L. Nieber, Non-Uniform Overland Flow-Infiltration Model for Roadside Swales, Journal of Hydrology, 552, 586-599, 2017b.

Garcia-Serrana, M., J.L. Nieber and J.S. Gulliver, Infiltration Flux for Parallel Strip Water Sources, Vadose Zone, 16(11), 2017c.

Garcia-Serrana, M., J.S. Gulliver and J.L. Nieber, Calculator to Estimate Annual Infiltration Performance of Roadside Swales, Journal of Hydrologic Engineering, 23(6), 04018017, 2018.

Kindred, J.S., Reynolds, W.D. Using the borehole permeameter to estimate saturated hydraulic conductivity for glacially over-consolidated soils. Hydrogeol J 28, 1909–1924 (2020).

Nestingen, R., B.C Asleson, J.S. Gulliver, R.M. Hozalski and J.L. Nieber, Laboratory Comparison of Field Infiltrometers, Journal of Sustainable Water in the Built Environment, 4(3): 04018005, 2018.

Paus, K.H., J. Morgan, J.S. Gulliver, T. Leiknes and R.M. Hozalski, Assessment of the Hydraulic and Toxic Removal Capacities of Bioretention Cells after 2 to 8 Years of Service, Water, Soil and Air Pollution, 225 (1803), 2013.

Philip, J.R. 1993. Approximate analysis of Falling-Head lined borehole permeameter. Water Resour. Res. 29:3763–3768.

Tecca, N.P., Gulliver, J.S., and Nieber, J.N. Siting Infiltration-Based Stormwater Control Measures using a Geographic Information Systems (GIS) Approach. J. Sustainable Water Built Environ. In revision, 2020a.

Tecca, N.P., Gulliver, J.S., and Nieber, J.N. Infiltration Measurement Systemic Bias and Precision Evaluated using a Finite Element Analysis. In Preparation, 2020b.

Weiss, P.T. and J.S. Gulliver, Effective Saturated Hydraulic Conductivity of an Infiltration-based Stormwater Control Measure, Journal of Sustainable Water in the Built Environment, 1(4), 2015.

4.2 Regulations

The following describes state and federal regulations in the study area that will be considered by the Study:

This study will address infiltration methods for Los Angeles County, currently addressed in Los Angeles County Department of Public Works GS200.2.

4.3 Additional Information

Additional information regarding the Study background is provided as the following attachments:

5 Cost & Schedule

This section provides an overview of the estimated cost and schedule for the Study.

5.1 Cost of Study

The following details the Study cost and breakdown of its cost by SCW Watershed Area.

Total funding requested: $ 554,684.00

The following is justification of the total funding requested amount:

This study will provide accurate and cost-effective infiltration testing methods that will improve the current approach for designing drywell infiltration systems. For an investment of less than $600,000, municipalities and site developers within Los Angeles County will likely save millions of dollars per year in the construction and maintenance of over-sized drywell infiltration systems.

The following table details the funding requested per year per watershed:

Funding Requested Per Year Per Watershed		
Funding Request Year	Watershed Area	Amount for Year
Year 1	Upper Los Angeles River	$ 554,684.00
Total Year 1		$ 554,684.00
Total Funding		$ 554,684.00

5.2 Funding Sources

The following is a summary of other sources of funding the have been or will be explored for the Study:

None.

Is additional funding anticipated to be leveraged as a Cost Share for this Project?

No

The following table details the additional funding already attained for the Study:

Additional Study Funding Sources		
Funding Type	Description	Funding Amount
None provided	N/A	N/A

5.3 Schedule

The following table details is a preliminary schedule required to design, permit, construct, operate, and maintain the Project:

Schedule Milestone Table	
Milestone Name	Completion Date
Anticipated Project Start	10/15/2021
Task 1 Interim Report: Typical Soil Types and Hydrogeologic Settings within Los Angeles County	12/15/2021
Task 2: Interim Report: Review of Infiltration Testing Methods Suitable for Drywell Design	03/15/2022
Task 3: Drilling and Testing Plan	05/15/2022
Task 4: Interim Report: Drilling and Field Infiltration Testing Results	09/15/2022
Task 5: Outreach and Engagement	10/15/2022
Task 6: Final Report: Evaluation of Infiltration Testing Methods for Drywell Design	10/15/2022

5.4 Additional Information

Additional information regarding Study cost and schedule is provided as the following attachments:

Attachments for this Section	
Attachment Name	Description
CalPolyPomona_Sharbat_ScientificStudiesProgram_Drywell_Proposed Budget revFNL.pdf	

6 ATTACHMENTS

Attachments are bundled and organized in the following pages, with cover pages between each subsection.

ATTACHMENTS FOR SECTION 2.3:

Illustrative Overview

ATTACHMENTS FOR SECTION 2.4:

Details

Problem: Current Testing Methods not well Suited for Predicting Drywell Performance

- Well Permeameter Test (USBR 7300-89) requires specialized equipment and can be inaccurate by 25-1,800%
- Boring Percolation Test (including High Flowrate Percolation Test) significantly underpredicts drywell performance
- Dry Well Percolation Test can underpredict or overpredict drywell performance based on ponding head in test

Solution: Numerous Methods in the Literature Provide Accurate and Cost-effective Alternatives

- Steady-state borehole permeameter methods (longer tests that require more water but test a larger volume of soil)
- Falling-head borehole permeameter methods (shorter tests that require less water but test a small volume of soil and can be difficult with a high permeability)
- Both types of methods provide saturated hydraulic conductivity that can be used to estimate drywell performance using a simple equation

Study Objectives

- Identify and evaluate infiltration testing methods that are suitable for drywell design over a range of well diameters
- Evaluate drilling, well construction, and well-development methods to minimize smearing and other borehole effects
- Evaluate and refine field testing methods to ensure suitable accuracy while minimizing testing complexity and cost
- Ensure that the methods provided by this work are reviewed and accepted by stakeholders

Scope of Work

- **Task 1: Characterize Range of Typical Soil Types and Hydrogeologic Settings**

  This task will identify and characterize the general types of soils and hydrogeologic settings in the Los Angeles basin that are suitable for drywell infiltration. This information will be used to identify and refine testing methods that will be most effective to support design of drywell infiltration systems in the County and will be based on a literature review and interviews/workshops with local geotechnical and hydrogeologic experts.

- **Task 2: Literature Review and Numerical Analysis of Infiltration Testing Methods that are Suitable for Drywell Design**

  This task will include a literature review to identify proven and well-documented infiltration testing methods that are suitable for drywell design. The methods selected for evaluation will be evaluated by comparing the predicted results with numerical simulations of the tests for the range of soils and hydrogeologic settings typical of the Los Angeles Basin. Only those methods that meet the following criteria will be further evaluated in the field program:

  - A reasonably good fit between the results predicted by the method and results predicted by numerical simulations.
  - Field procedures that are feasible and cost effective using equipment that is commonly used or readily available.
  - Analysis procedures that are simple to perform by geotechnical and hydrogeologic professionals.

  The purpose of the numerical analysis is four-fold:

  - Develop calibrated fitting parameters used to define the shape function (C) For the steady-state BP methods.
  - Validate the proposed analytical methods.
  - Assess how layering and variability might affect the test results.
  - Help design the field tests.

- **Task 3: Planning the Field Program**

  This task will utilize the information provided in the previous tasks to design the field program and includes the following activities:

  - Identify Test Locations
  - Documenting Drilling and Testing Procedures
  - Obtaining Permits, Equipment and Drilling/Testing Contractors

Scope of Work (cont.)

- **Task 4: Drilling and Field Infiltration Testing**

  The general approach for this task is to install and test approximately 12 test wells at three sites to evaluate the following:

  - Diameter of test well (8”, 18”, 48”)
  - Drilling method (hollow-stem auger, bucket auger, flight auger, and non-traditional methods such as sonic drilling)
  - Constant head vs. falling head tests
  - Test duration (i.e. how long or how much water is required to reasonable achieve steady state conditions).

- **Task 5: Outreach and Engagement**

  The purpose of this task is to ensure that potential users of these drywell infiltration testing and design methods are engaged during the study and the methods meets their needs when the work is complete. Outreach and engagement will include:

  - Regular emails to present results and solicit feedback.
  - Workshops with interested stakeholders to present results and solicit feedback.
  - Presentations at conferences and technical meetings.

  Outreach will be targeted at stakeholders such as regulators, municipal stormwater managers, and civil/geotechnical/hydrogeologic professionals that regularly conduct infiltration testing and design.

- **Task 6: Documentation and Reporting**

  Interim reports will be submitted at the conclusion of each task. All the interim reports and field procedures developed in the previous tasks will be compiled and summarized in a single technical report. This technical report will summarize the results of the study and provide an evaluation of the testing methods, including accuracy, feasibility and cost of the field procedures, and simplicity of the analysis techniques. In addition, the report will recommend next steps toward improved infiltration testing and design and include a gap analysis to determine where additional information is needed. This report may be used to develop recommended modifications to GS200 document.

  It is expected that one or more peer-reviewed papers will be produced and submitted to a technical journal for publication. This process will ensure that the study results are subject to technical review.

Outcomes

- **A Toolbox of Infiltration Testing Methods that are Accurate, Cost-Effective, and Accepted by Stakeholders**

  This study will provide a toolbox of infiltration testing methods that are cost-effective and provide more accurate estimates of drywell capacity.

  Comparison of these methods (e.g., steady-head versus falling-head methods) will determine if these methods provide comparable results and the pros and cons of each method.

  Because of the outreach and engagement activities, stakeholders in the stormwater community will participate in development of the methods, making it more likely that the methods will be readily accepted.

- **Drywell Systems that are Appropriately Sized and Cost-Effective**

  It is reported that many drywell systems are not sized properly due to inaccuracies with the infiltration testing. As a result, site developers and municipalities are not getting the best value for their investment in stormwater infiltration.

  Accurate sizing and more cost-effective drywell infiltration systems means more stormwater management and groundwater recharge for the same investment, helping the community to meet stormwater management and water-supply objectives faster and cheaper.

Detail Attachment 2: Evaluation of Current Drywell Testing and Design Methods

The Los Angeles County Department of Public Works GS200.2 document provides a variety of infiltration test methods. Most of these methods are designed for shallow infiltration testing and sizing of shallow infiltration facilities such as bioretention swales, infiltration trenches, permeable pavement and infiltration basins. These shallow facilities are generally dominated by vertical flow out of bottom of the facility and less flow out of the sides of the facility. Therefore, infiltration tests with low ponding heads that are dominated by vertical flow are best suited for sizing of shallow infiltration facilities.

Drywell performance is dominated by horizontal flow out of the sides of the facility and estimating drywell capacity should be based on infiltration tests that are also dominated by horizontal flow, generally vertical boreholes and test wells. The following methods from the GS200-2 document are most commonly used for estimating the capacity of drywells:

- **Well Permeameter Test (USBR 7300-89):** As outlined in USBR 7300-89 (Zanger 1953), this method is generally limited to relatively shallow boreholes (10 ft) because the flow-control system is not suitable for the high flow rates typical of deep borehole tests (although it can be adapted for use in deeper high flow-rate tests). The method is conducted by modifying the flow rate into the test well to maintain a constant head and it provides a simple equation to calculate the hydraulic conductivity of the native soil. It does not account for capillarity flux and numerical comparisons have shown that the results can be off by 25 to 1,800 percent (Reynolds 2013). Although the method is most accurate for longer test intervals and higher permeability soils, the high degree of inaccuracy for other scenarios is problematic.
- **Boring Percolation Test Procedure**: This method is similar to USBR 7300-89 although it is conducted by re-filling the test well at least eight times and measuring the rate of water drop between re-fills. Rather than calculating the hydraulic conductivity, the percolation rate is calculated by dividing the volume of water discharged in a given amount of time by the surface area of the test section. There is a high-flowrate version of this test that calls for maintaining a steady-state head for at least 2 hours.
  The major shortcoming of this procedure is that it calls for a maximum ponding depth of 12 inches of water, significantly less than the typical ponding depth in a drywell. In addition, as illustrated below, percolation rate is not strictly a soil parameter and is highly dependent on the geometry of the test facility (i.e., the ponding head/well radius ratio).

Well permeameter test being conducted at LAX project.

- **Drywell Percolation Test**: This method is similar to the high flowrate boring percolation test except it is conducted for at least six hours in a larger diameter boring (at least 18 inches in diameter). In addition, there is no limit on the ponding depth and this test can be conducted with a ponding depth that is similar to the proposed drywell. Unfortunately, this method has the same issue as the previous two methods since the end result is a percolation rate determined by dividing the volume of water discharged in a given amount of time by the surface area of the test section.

City of Los Angeles (North Hollywood) full-scale drywell percolation test

For additional detail on each test method, see Los Angeles County Department of Public Works GS200.2 https://dpw.lacounty.gov/gmed/permits/docs/policies/GS200.2.pdf .

The last two methods provide percolation rate (flow rate divided by surface area of the test interval) rather than saturated hydraulic conductivity (K_{sat}). Unfortunately, because the percolation rate is a function of both the soil permeability and the test geometry, the percolation rate derived using a typical test well does not accurately predict the flow capacity of a full-sized drywell. This was evaluated by conducting numerical simulations of a hypothetical drywell percolation test well (with a boring diameter of 50 cm) and a full-sized production drywell (with a diameter of 120 cm).

The first test assumed a steady-state ponding depth of 0.3 m and a duration of 2 hours and is intended to represent the high-flowrate borehole percolation test. The remaining two tests were conducted at two different ponding depths (4 m and 10 m) and a duration of 6 hours and are intended to represent the drywell percolation test. The drywell simulation was conducted at a ponding depth of 10 m and a duration of 6 hours and is intended to represent a large precipitation event. The soil was assumed to be a fine-medium sand with K_{sat} = 10 m/day. The results are summarized below:

Table 1: Percolation Rates for Various Sized Test Wells and Production-Scale Drywells Based on Numerical Simulations.

Well	Duration (hr)	Ponding Depth (H) (m)	Well Diameter (cm)	Steady Flowrate (m^3/day)	Surface Area (m^2)	Percolation Rate (m/day)
Test Well H=0.3 m	2	0.3	50	22.1	0.67	33
Test Well H=4 m	6	4	50	346	6.48	53
Test Well H=10	6	10	50	1,401	15.9	88
Drywell H=10	6	10	120	2,015	38.8	52

As shown in the table, the high-flowrate borehole percolation test (H = 0.3 m) provided a percolation rate of 33 m/day. The drywell percolation tests (H = 4 and 10 m) provided percolation rates of 53 and 88 m/day, compared with the production-scale drywell percolation rate of 52 m/day. These results indicate that the borehole percolation test will significantly under predict the performance of a drywell while the drywell percolation test could either underpredict or overpredict the performance of a drywell, depending on the ponding depth during the test and the diameter of the test well. Bottom-line, percolation rate is not a reliable indicator of drywell performance.

In practice, recommended design capacities for drywells are often much less than actual drywell capacity. Potential reasons why predicted capacities may be less than actual capacities include the following:

- Design engineers may be using low-head infiltration tests to estimate the percolation rate. Low-head percolation rates will be much lower than high-head infiltration rates due to the difference in pressure head.
- Infiltration tests wells installed using hollow stem auger drilling and other methods may result in sidewall smearing that reduces the apparent capacity of the test well.
- Based on the GS200.2 document, the measured percolation rates should be divided by a total reduction factor between 2 and 27. Using a higher reduction factor can dramatically underpredict the performance of a drywell.

Other issues with the current drywell testing and design methods include:

- Test wells are often completed over different depth intervals than the proposed drywells. This means the test results may not represent the same properties as the drywell infiltration interval.
- The USBR 7300-89 test, as written, is considered complicated and requires equipment that most geotechnical engineers are not accustomed to using.
- Due to the large diameter boring required, the drywell percolation test requires specialized drilling equipment that is not typically used for geotechnical site characterization.
- Another important factor that can affect drywell design and performance is the relationship between infiltration performance of various diameter holes and the optimal spacing between drywells. Currently, there is no clear guidance for drywell spacing, and the common practice is to space the drywell based on personal judgement of the individual engineer or experiences from previously installed drywells in the vicinity of the site.

The scope of work for this proposal will address these issues, evaluate the potential for "cleaning up" sidewall smearing using various development techniques, develop improved test well reduction factors, and evaluate alternative testing and design methods that may be more accurate and reliable, as well as less expensive.

Reynolds WD (2013) An assessment of borehole infiltration analyses for measuring field-saturated hydraulic conductivity in the vadose zone. Eng. Geol 159:119–130.

Zangar CN (1953), Theory and problems of water percolation. Engineering monogram no. 8. US Department of the Interior, Bureau of Reclamation, Denver, CO.

Detail Attachment 3: Scope of Work

The detailed scope of work provided below is designed to address the objectives outlined in the previous section. It should also be mentioned that in addition to the academic experts and industry professionals, there will be a team of students from the Cal Poly Pomona (California State Polytechnic University, Pomona) who will be involved in various aspects of this project for a period of nine months. This team will include about 20 senior Civil Engineering students who will be under supervision of two faculty members. The students' involvement in this project will be part of their Senior Project course.

Task 1: Characterize Range of Typical Soil Types and Hydrogeologic Settings.

This task will identify and characterize the general types of soils and hydrogeologic settings in the Los Angeles basin that are suitable for drywell infiltration. This information will be used to identify and refine testing methods that will be most effective to support design of drywell infiltration systems in the Los Angeles County. Characteristics that are relevant for infiltration include saturated hydraulic conductivity, grainsize distributions, porosity, residual moisture content, thickness of unsaturated zone, degree of layering and heterogeneity, etc. Following the approach demonstrated in Kindred and Reynolds (2020), it is expected that this information will be used to identify a limited number of archetype soils that represent the range of soils in the Los Angeles Basin that will be evaluated in Task 2 and 3 of this study. This work will be based on a literature review and interviews/workshops with local geotechnical and hydrogeologic experts.

An interim report will be prepared documenting the results of this work.

Task 2: Literature Review and Numerical Analysis of Infiltration Testing Methods that are Suitable for Drywell Design.

This task will include a literature review to identify proven and well-documented infiltration testing methods that are suitable for drywell design. Examples of potentially suitable methods include:

1) The steady state borehole permeameter (BP) method (e.g., Kindred and Reynolds, 2020).
2) The Philip-Dunne falling-head borehole permeameter methods: (e.g., Philip, 1993; Reynolds, 2011).

Both methods provide an estimate of saturated hydraulic conductivity that can be used to predict the capacity of drywells using a simple analytical equation (provided in Philip, 1993 and Kindred and Reynolds, 2020). Other infiltration testing methods suitable for drywell design may be identified by the literature review and may be included in the evaluation.

The methods selected for evaluation will be evaluated by comparing the predicted results with numerical simulations of the tests for the range of soils and hydrogeologic settings typical of the Los Angeles Basin. These numerical simulations will determine the accuracy of potential methods and evaluate modifications to the methods to improve accuracy. Although the steady state BP method has fitting parameters for normally consolidated soils (Zhang et al, 1998) and glacially over-consolidated soils (Kindred and Reynolds 2020), it may be necessary to determine new fitting parameters for the normally consolidated soils typical of the Los Angeles Basin. The approach demonstrated in Kindred and Reynolds (2020) will be used to calibrate new fitting parameters (if necessary).

Only those methods that meet the following criteria will be further evaluated in the field program:

1. A reasonably good fit between the results predicted by the method and results predicted by numerical simulations.
2. Field procedures that are feasible and cost-effective using equipment that is commonly used or readily available.
3. Analysis procedures that are simple to perform by geotechnical and hydrogeologic professionals.

The purpose of the numerical analysis is four-fold:

1. **Develop calibrated fitting parameters used to define the shape function (C) For the steady-state BP methods.** Field tests are not suitable for calibration because the analytical methods assume isotropic and homogeneous soils (not found in nature) while numerical simulations provide complete control over the soil parameters. Therefore, numerical simulations are the only way to develop fitting parameters for the steady-state BP methods. Fitting parameters were calibrated by Zhang et al. for normally consolidated soils back in the 1990's and by Kindred and Reynolds (2020) for glacially over-consolidated soils. The Zhang fitting parameters were focused on near-surface soils and we need to determine how well they work for the types of soils in the Los Angeles basin. Also, the Zhang fitting parameters were only calibrated for H/r ratios less than 22, and we need to calibrate for H/r ratios as high as 200.

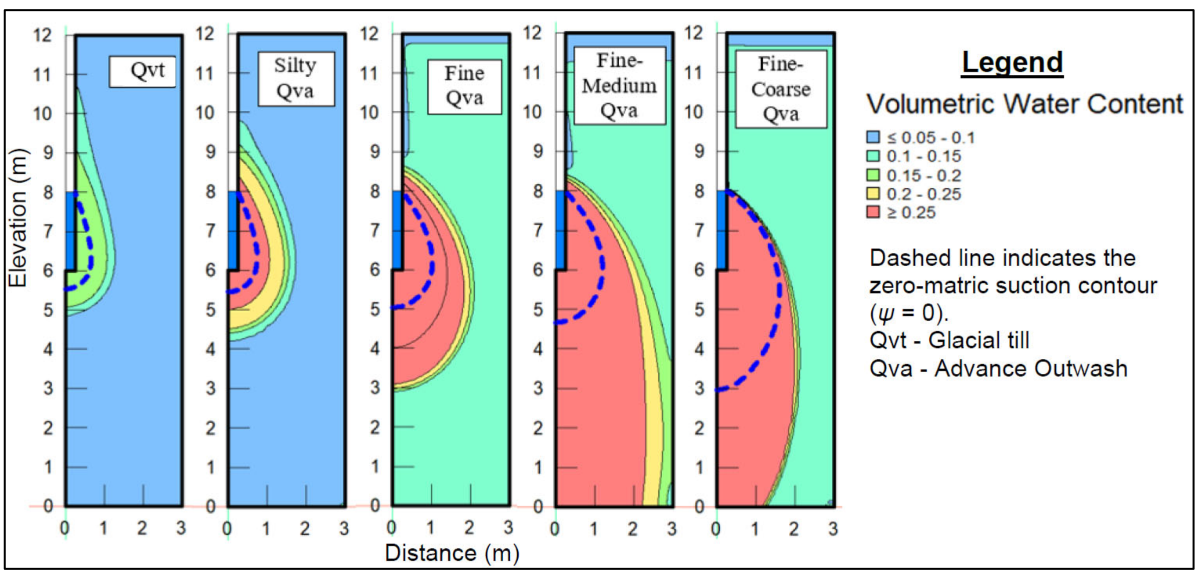
2. **Validate the proposed analytical methods**. As stated above, all of the proposed analytical methods assume isotropic and homogeneous soils, which rarely exist in nature. Therefore, it's not possible to determine the accuracy of the proposed analytical methods using field tests. As mentioned above, we have 100% control over the soil parameters in the numerical simulations. Also, using numerical simulations, we can test the analytical

methods for a very broad range of test configurations and soils types, much broader than the limited number of field tests that we will perform.

3. **Assess how Layering and Variability may Affect the Test Results.** Numerical simulations with layering and variability along the saturated interval will be conducted to determine the effects of real-world variability and evaluate the feasibility of using small-diameter test wells to predict the performance of large-diameter dry-wells.

4. **Help design the field tests**. The numerical simulations will also be used to refine the field program and will provide the following information:
   - Estimate flow rates, which affects the meter and valve setups.
   - Evaluate test durations.
   - Determine what screen lengths will facility both constant-head and falling head testing in the same well.
   - Evaluate minimum drywell spacing for different soils and scenarios.
   - Evaluate the effects of layering and groundwater mounding.

An interim report will be prepared documenting the results of this work.



Example of Numerical Modeling Results from Kindred and Reynolds, 2020

Task 3: Planning the Field Program.

This task will utilize the information provided in the previous tasks to design the field program and includes the following activities:

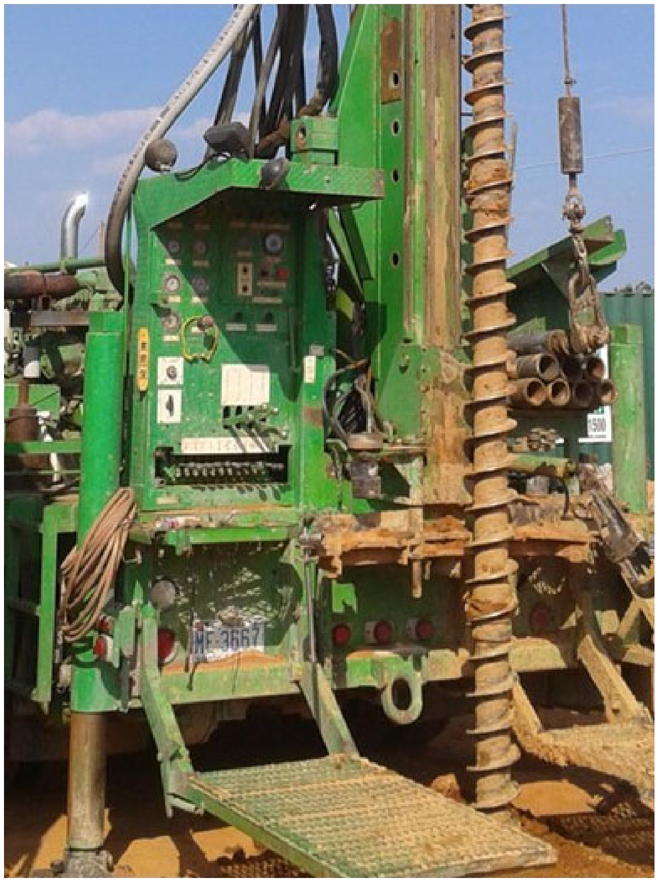
1. **Identify Test Locations.** Sites will be selected that have varied soil conditions so that testing will be representative of a variety of soil conditions across Los Angeles County.

Although tentative test locations have been identified, these locations may be modified based on the results of Task 1 (Characterize Range of Typical Soil Types and Hydrogeologic Settings). The two tentative sites are described below, and third site be identified after the test results of the first two locations in Upper Los Angeles River Watershed:

a. **Garvanza Park Rainwater Capture Project.** This site is located at N. Ave 63 in Highland Park (Council District 14). This project was completed by Los Angeles Sanitation & Environment - City of Los Angeles (LASAN) on May 2012 and includes an infiltration gallery and drywells designed to infiltrate 50 ac-ft/year of stormwater. The soil is not as good for infiltration and will be good to test and compare with other project sites with higher infiltration rates.
b. **Sun Valley Park Multi-Use Stormwater Infiltration.** This site is located at 8133 Vineland, Sun Valley (Council District 6) and was completed in 2006. This site has very good soil for infiltration and is designed to infiltrate 30 ac-ft per year of stormwater. The Sun Valley park project was partnership with City of Los Angeles (LASAN) and County of Los Angeles.
c. **Los Angeles County Project Site.** This project site will be in located after reviewing the test results of the two locations (Garvanza Park and Sun Valley Park). The third test site will be range of soil type to be in the middle of the two pervious locations and to compare the infiltrate rates.

2. **Document Drilling and Testing Procedures.** Drilling and field-testing procedures will be developed in advance of going into the field. These procedures will be based on the details of each potential test method, the experience of the project team, and feedback from the workshops. It is expected that multiple drilling techniques will be evaluated, including hollow step auger, bucket auger, flight auger, and Sonic drilling. A drilling and testing plan will be prepared as part of this task.

3. **Permits, Equipment and Drilling/Testing Contractors**. Street use and hydrant permits may need to be obtained before field work begins. In addition, it is expected that the field program will require the following equipment and contractors: fire hose, backflow preventer, valves and meter setups for a broad range of flows, pressure transducers and data loggers, and drilling contractors. The project team includes consultants and researchers with extensive experience procuring these items.



8" hollow stem auger typically used for infiltration tests.

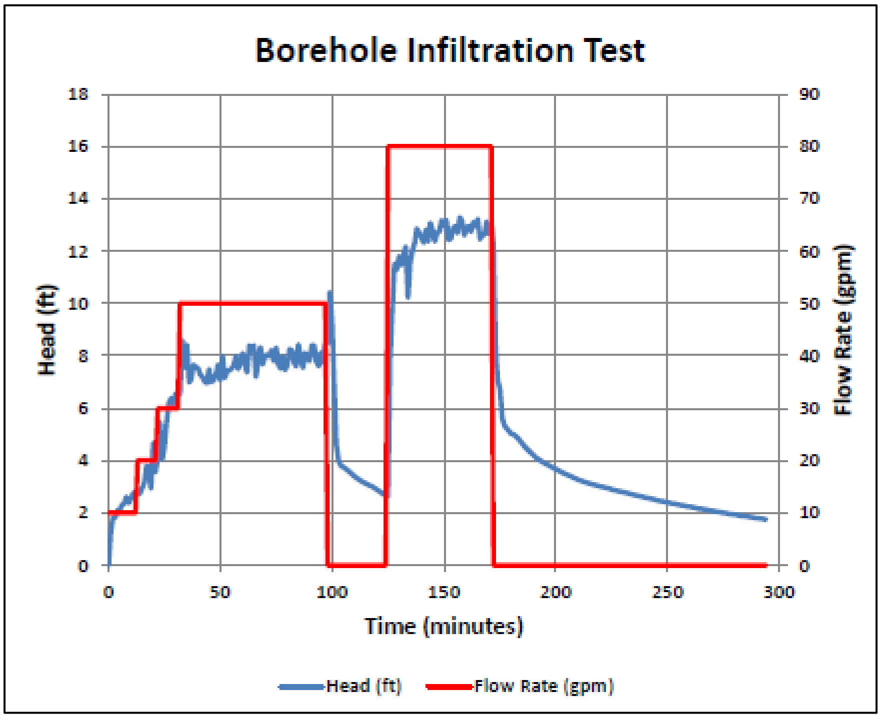
Task 4: Drilling and Field Infiltration Testing.

The scope for this task will be refined as part of Tasks 2 and 3. However, a tentative scope is provided here to illustrate the expected approach and level of effort. The general approach for this task is to install and test a large number of test wells at multiple sites to evaluate various parameters such as geometry, drilling methods, well development methods, infiltration test methods, etc. Potential variables that will be evaluated include:

- Diameter of test well (8", 18", 48")
- Drilling method of test well (hollow-stem auger, bucket auger, flight auger, and non-traditional methods such as sonic drilling)
- Constant head vs. falling head tests
- Test duration (i.e. how long or how much water is required to reasonable achieve steady state conditions

The test wells will be installed around a monitoring well that will extend to groundwater to allow measurement of water level changes during the infiltration tests. This information can be used to estimate aquifer parameters and evaluate potential mounding impacts. In addition, soil characteristics observed during drilling of the test holes will be compared with caving behavior when drilling the drywells to determine if there are soil characteristics that can be used to predict caving.

An interim report will be prepared documenting the results of this work.



Example of Steady State Borehole Infiltration Tests (K_{sat} = 67 ft/day)

Task 5: Outreach and Engagement

The purpose of this task is to ensure that potential users of these drywell infiltration testing and design methods are engaged during the study and the methods meets their needs when the work is complete. Outreach and engagement will include:

1. Regular emails to present results and solicit feedback
2. Workshops with interested stakeholders to present results and solicit feedback
3. Presentations at conferences and technical meetings

In addition to staff from the City and County of Los Angeles, the email list will include other interested stakeholders and may include regulators, municipal stormwater managers, and geotechnical/hydrogeologic consultants that regularly conduct infiltration testing and design. Email updates will be sent quarterly to the interested parties.

Up to four workshops with selected representatives from the City and County of Los Angeles, other Los Angeles basin municipalities, regulators, and consultants specializing in stormwater infiltration. It is anticipated that the workshops will be 2-4 hours long. The anticipated timing of workshops is as follows:

1. During Task 1 to solicit feedback regarding the range of soils and hydrogeologic settings typical of the Los Angeles Basin and to introduce the general scope of the project.
2. Following completion of Task 2 to solicit feedback regarding the proposed infiltration testing methods.
3. Following completion of the draft testing plan in Task 3 to solicit feedback.
4. Following completion of Tasks 4 to present results and solicit feedback.

An interim report will be prepared documenting the results of this work.

Task 6: Documentation and Reporting

All testing data from Tasks 4 and 5 will be compiled and analyzed to determine the relative accuracy of each testing method. Consideration shall be made for real-world application based on cost and ease of test method relative to total cost/scale of drywell project. It is expected that the level of testing and infiltration assessment will be scaled to match the scale of the proposed facility (I.e., a greater level of testing and assessment would be warranted for a large project compared with a small project). A technical report will be developed to summarize the study methods, results, and recommend next steps toward improved infiltration testing, estimating drywell capacity, and drywell spacing. This task will include a gap analysis to determine where additional information is needed.

The results of this study will be summarized and presented to the Upper Los Angeles River Watershed Group and/or Watershed Area Steering Committee.

A white paper will be produced and submitted to the Safe Clean Water Program to inform the design process of future stormwater drywell projects and circulate to all Program stakeholders. Recommended modifications to GS200 document will be provided to Los Angeles County GMED.

Below is a preliminary schedule required to design, permit, construct, operate, and maintain the Project.

Task	Start Date	End Date
Anticipated Project Start	Oct. 15, 2021	
Task 1: Typical Soil Types and Hydrogeologic Settings within Los Angeles County	Oct. 15, 2021	Dec. 15, 2021
Task 2: Interim Report: Review of Infiltration Testing Methods Suitable for Drywell Design	Dec. 15, 2021	Mar. 15, 2022
Task 3: Drilling and Testing Plan	Mar. 15, 2022	May 15, 2022
Task 4: Interim Report: Drilling and Field Infiltration Testing Results	May. 15, 2022	Sep. 15, 2022
Task 5: Outreach and Engagement	Oct. 15, 2021	Oct. 15, 2022
Task 6: Final Report: Evaluation of Infiltration Testing Methods for Drywell Design	Sept. 15, 2022	Oct. 15, 2022

References

Kindred, J.S., Reynolds, W.D. Using the borehole permeameter to estimate saturated hydraulic conductivity for glacially over-consolidated soils. Hydrogeol J 28, 1909–1924 (2020).

Philip, J.R. 1993. Approximate analysis of falling-head lined borehole permeameter. Water Resour. Res. 29:3763–3768.

Reynolds WD (2011) Measuring soil hydraulic properties using a cased borehole permeameter: falling-head analysis, Vadose Zone Journal, Volume 10(3):999–1015.

Zhang ZF, Groenevelt PH, Parkin GW (1998) The well-shape factor for the measurement of soil hydraulic properties using the Guelph permeameter, Soil and Tillage Research, 49(3):219-221.

ATTACHMENTS FOR SECTION 3:

Outcomes

ATTACHMENTS FOR SECTION 4:

Background

ATTACHMENTS FOR SECTION 5:

Cost & Schedule

Proposed Budget (Cal Poly Pomona)

Safe Clean Water Program, Los Angeles County DPW, Scientific Studies Program, Projects Year FY21-22

Tentative Dates: 10/15/2021 - 10/15/2022

ORSP Lead (Grants, admin contact): Lynn Baltazar — CPP ORSP

Cumulative — Proposal Number: 9402

A. Senior Personnel								
Name/Title	Annual Salary	Term			Effort mos.	Grant Funds	Matching	Project Costs
Ali Sharbat (PI)	$ 102,699	Overload			0.60	$ 6,847	$ -	$ 6,847
Ali Sharbat (PI)	$ 102,699	Summer			0.60	$ 6,847	$ -	$ 6,847
Mehrad Kamalzare (Co-PI)	$ 94,208	Overload			1.20	$ 12,561	$ -	$ 12,561
Mehrad Kamalzare (Co-PI)	$ 94,208	Summer			1.20	$ 12,561	$ -	$ 12,561
Yasser Salem (Co-PI)	$ 115,183	Overload			0.30	$ 3,839	$ -	$ 3,839
Yasser Salem (Co-PI)	$ 115,183	Summer			0.30	$ 3,839	$ -	$ 3,839
Subtotal						$ 46,494	$ -	$ 46,494
B. Other Personnel								
	Annual Salary / Mo/Hr Salary Rate / Hourly Rate	Term			Effort mos. / Total Mos./Hrs / Total Hours	Grant Funds	Matching	Project Costs
Student								
Undergraduate Student	$ 15.00	AY-SEM			440.00	$ 6,600	$ -	$ 6,600
Undergraduate Student	$ 15.00	Summer			440.00	$ 6,600	$ -	$ 6,600
Graduate Student	$ 17.00	AY-SEM			440.00	$ 7,480	$ -	$ 7,480
Graduate Student	$ 17.00	Summer			440.00	$ 7,480	$ -	$ 7,480
Subtotal						$ 28,160	$ -	$ 28,160
C. Fringe Benefits								
Name/Title		Term						
Ali Sharbat (PI)		Overload	13%			$ 890	$ -	$ 890
Ali Sharbat (PI)		Summer	13%			$ 890	$ -	$ 890
Mehrad Kamalzare (Co-PI)		Overload	13%			$ 1,633	$ -	$ 1,633
Mehrad Kamalzare (Co-PI)		Summer	13%			$ 1,633	$ -	$ 1,633
Yasser Salem (Co-PI)		Overload	13%			$ 499	$ -	$ 499
Yasser Salem (Co-PI)		Summer	13%			$ 499	$ -	$ 499
Undergraduate Student		AY-SEM	8%			$ 528	$ -	$ 528
Undergraduate Student		Summer	13%			$ 858	$ -	$ 858
Graduate Student		AY-SEM	8%			$ 598	$ -	$ 598
Graduate Student		Summer	13%			$ 972	$ -	$ 972
Subtotal						$ 9,000	$ -	$ 9,000
D. Equipment								
Item Description			Items that have an Acquisition/Unit Cost of $5,000 or more *Include Sales Tax and Shipping					
Subtotal	exclude from base					$ -	$ -	$ -
E. Travel								
From/to						Grant Funds	Matching	Project Costs
1. Domestic					Subtotal	$ 8,000	$ -	$ 8,000
Local travel (PI and research team to Los Angeles, mileage)					$ 8,000			
2. Foreign						$ -	$ -	$ -
Not applicable					$ -			
					$ -			
Subtotal						$ 8,000	$ -	$ 8,000
F. Participant Costs	Cost Description			Subtotal		Grant Funds	Matching	Project Costs
4. Other						$ 19,200	$ -	$ 19,200
	Student scholarship awards (24 students x $800 each)			$ 19,200				
Total number of participants	24							
Subtotal	exclude from base					$ 19,200	$ -	$ 19,200
G. Other Direct Costs	Cost Description					Grant Funds	Matching	Project Costs
1. MATERIALS AND SUPPLIES		Unit Cost	Quantity	Subtotal		$ 15,000	$ -	$ 15,000
	research testing student materials			$ 15,000				
2. PUB/DOC/DISS						$ 4,000	$ -	$ 4,000
	publication	$ 4,000						
3. CONSULTANT SERVICES						$ 120,000	$ -	$ 120,000
	TBD Local geotechnical field technician exper			$ 30,000				
	Geotechnical & Infiltration Expert: Kindred Hydro Inc.			$ 60,000				
	John Gulliver: University of Minnesota			$ 30,000				
4. COMPUTER SERVICES						$ 1,000	$ -	$ 1,000
	Software licences	$ 1,000						
5. SUBAWARDS					Subaward	$ -	$ -	$ -
					$ -			
6. OTHER								
c. Other						$ 165,000	$ -	$ 165,000
	Contractual services: Test Hole Construction: (5 holes x 3 sites)	$ 165,000						
Subtotal						$ 305,000	$ -	$ 305,000
H. Total Direct Costs								
Subtotal						**$ 415,855**	**$ -**	**$ 415,855**
I. Indirect Costs								
CPP Research Rate 35% MTDC			Base: $ 396,655					
Subtotal						**$ 138,829**	**$ -**	**$ 138,829**
J. Total Direct and Indirect Costs	Total Funding Request					**$ 554,684**	**$ -**	**$ 554,684**
Cost Sharing: None							$ -	

Budget Narrative for Safe Clean Water Program Proposal

A. Senior Personnel [Total funds requested: $46,494]

Dr. Ali Sharbat (PI) and Dr. Mehrad Kamalzare (Co-PI), and Dr. Yasser Salem (Co-PI), faculty members from the College of Engineering, will serve as the key personnel for the Cal Poly Pomona proposal to the Los Angeles County's Safe Clean Water Program- Scientific Studies module. Dr. Ali Sharbat (PI) will commit 0.6 effective months overload* and 0.6 effective months summer salary for the 12 months of duration of the project. Dr. Mehrad Kamalzare (Co-PI) will commit 1.2 effective months overload* and 1.2 effective months summer salary for the 12 months of duration of the project. Dr. Yasser Salem (Co-PI) and the Interim Chair of the Civil Engineering Department at Cal Poly Pomona will commit 0.3 effective months overload* and 0.3 effective months summer salary for the 12 months of duration of the project.

*Overload is a term exclusive to employees represented by the California Faculty Association (CFA) and refers to California State University (CSU) additional employment in excess of a full-time workload, or when appropriate, in excess of a full-time (100%) time-base. Additional employment limitations are based on time-base, not salary. A maximum of 125% time-base is allowed under certain circumstances. In the case of a federal grant or contract, the rate of pay for the additional employment must be the same as the CSU base rate of pay for the primary assignment. This means that they are allowed to work on these projects in addition to their regularly assigned duties without a reduction in those duties. There is no additional funding request for this overload salary; it is already included in the submitted budget.

As key personnel, Dr. Sharbat and Dr. Kamalzare and Dr. Salem are responsible for overseeing the project work to design and complete the tasks set out in this proposal. Funds are requested of the project to support personnel at the level of effort committed. As Cal Poly Pomona is a Hispanic serving academic institution and is a Predominantly Undergraduate Institution, faculty generally have teaching loads from which they need to be reassigned to complete externally funded projects with planned activities during the academic year.

All named faculty (i.e. Dr. Ali Sharbat, Dr. Mehrad Kamalzare, and Dr. Yasser Salem) are on 9-month Academic Year (AY) appointments:

Dr. Sharbat (AY Overload year 1) = $102,699 / 9 mos x 0.6 mos effort = $6,847

Dr. Sharbat (Summer 2021) = $102,699 / 9 mos x 0.6 mos effort = $6,847

Dr. Kamalzare (AY Overload year 1) = $94,208 / 9 mos x 1.20 mos effort = $12,561

Dr. Kamalzare (Summer 2021) = $94,208 / 9 mos x 1.20 mos effort = $12,561

Dr. Salem (AY Overload year 1) = $115,183 / 9 mos x 0.3 mos effort = $3,839

Dr. Salem (Summer 2021) = $115,183 / 9 mos x 0.3 mos effort = $3,839

B. Other Personnel [Total funds requested: $28,160]

For the duration of the project, funds are requested to support 1 graduate student (440 Hrs/AY; 440 Hrs/Summer) and 1 undergraduate student (440 Hrs/AY; 440 Hrs/Summer) of the project to participate in the research proposed. The students will be involved in the laboratory studies, design of experiments, and performing the experiments at the local sampling locations listed in tasks of this proposal. Student research assistants working on sponsored projects are paid hourly wages according to minimum wage bill for the State of California.

C. Fringe Benefits [Total funds requested: $9,001]

Fringe benefit rates at Cal Poly Pomona are:

Faculty during academic year overload= 13%

Faculty during summer = 13%

Students during academic year = 8%

Students during summer = 13%

Fringe benefits include FICA (OASDI), Social Security, worker's compensation, Medicare, SDI, health and life insurance package, and retirement. Fringe benefit percentage does not include tuition/ fee remission for graduate students.

D. Equipment [Not applicable]

No funds are requested for equipment. Equipment already existing in the Water Quality Lab and Energy Lab at Cal Poly Pomona will be used for this project.

E. Travel [Total funds requested: $8,000]

Funds are requested to support domestic travel expenses of the key personnel and student team members involved in the project. This local travel will cover local mileage and possibly per-diem expenses for extended local trips. Local trips are required as described in Task-4 of this proposal.

F. Participant Support Costs [Total funds requested: $19,200]

Funds are requested for the amount of $19,200 to support a class of Senior Project students (CE 4810. CE 4820, and CE 4830) over period of 9-months focused working on the subject of this project. Each student in the class will receive $800 in the form of scholarship supported by the project.

G. Other Direct Costs [Total funds requested: $305,000]

1. **Materials and Supplies –** Funds are requested for the total amount of $15,000 to spend on commercially available materials and supplies for the project. This would include: part and supplies for running the experiments in Task-4, soil and water sample collection and analysis, supplies and material to be used for experiments and geotechnical and water analysis lab supplies for the duration of the project.
   The materials and supplies costs are parts and pieces such as pumps, metal pipes, valves, hoses, tanks, control boards, electrical parts, filtration devices, sampling vials, sieves, and analysis kits. In addition, common laboratory materials and supplies such as research level salts, glassware, consumables, chemicals, and book resources will be purchased for the project. No single item over the amount of $5,000 will be purchased.

2. **Publication costs/Documentation/Dissemination –** Funds are requested for the total amount of $4,000 for publication of results and outcomes in journals, technical magazines, and/or proceedings.

3. **Consultant Services –** Funds are requested for the following consultants: 1) TBD local geotechnical field technician expert for $30,000, 2) Geotechnical & Infiltration Expert: Kindred Hydro Inc.: Scott Kindred for the amount of $60,000, 3) Geotechnical Expert: John Gulliver (University of Minnesota) for the amount of $30,000. Letters of commitment with breakdown of rates and services to be provided are attached.

4. **Computer (ADPE) Services –** Funds are requested for the amount of $1000 for software license upgrade for the senior project student team working on this project.

5. **Subawards –** Not applicable.

6. **Other –** Funds are requested for the total amount of $165,000 for contractual services (TBD) for test hole construction. Total of 3 sites are identified and each site will have 3 test holes.

H. Total Direct Costs [Total funds requested: $415,855]
The sum of sections A through G, as specified on the proposal budget.

I. Indirect costs [Total funds requested: $138,829]

Cost is calculated at rate of 35% based on modified total direct costs (MTDC) method for the recovery of facilities and administrative costs for state-funded on-campus projects. Rate is effective, per CSU Chancellor's office on July 1, 2021. The modified total direct costs (MTDC) base consist of all direct salaries and wages, applicable fringe benefits, materials and supplies, services, travel and up to the first $25,000 of each subaward (regardless of the period of performance of the subawards under the award), and shall exclude participant support costs.

Cal Poly Pomona Foundation, Inc. is the fiscal agent authorized by the California State Polytechnic University, Pomona (Cal Poly Pomona) to administer all externally funded activities.

Cost Sharing
None

Total Budget for the Proposed Project: $554,684

October 12, 2020

Civil Engineering Department
California State Polytechnic University, Pomona
3801 West Temple Ave, Pomona, CA 91768
Office: Building 17, Room 2671
Attn: Dr. Ali Sharbat

Dear Dr. Sharbat,

The purpose of this letter is to indicate that Kindred Hydro, Inc. is committed to participate in the study you are submitting to the Safe Clean Water Los Angeles Program titled: *Evaluation of infiltration testing methods for design of stormwater drywell systems*.

My anticipated budget includes 314 hours over a 12-month period, or 1.2 hours/day, at an hourly rate of $180/hr. The anticipated activities are summarized in Table 1 attached to this letter. The labor budget is $56,520. The only other associated costs are $3,500 in travel costs for a total budget of $60,020.

In addition to committing myself to performing these services for the quoted rate, this letter also serves to certify that I possess all applicable licenses required by law. Although I am a licensed Professional Engineer and Hydrogeologist in Washington State, I am not licensed in the State of California and thus I will not be able to stamp any of the work products. I am working under the assumptions that the University staff or other members of the team will stamp the work products, if necessary.

Finally, I attest that I am not presently debarred, suspended, proposed for debarment, declared ineligible, or voluntarily excluded from participation in transactions by any federal department or funding agency.

Regards,

J. Scott Kindred, PE, LHG
President
Kindred Hydro, Inc.

Kindred Hydro

Table 1: Tasks, Activities, and Anticipated Labor Hours

Task	Description	Hours
1	**Characterize Soils and Hydrogeologic Setting**	
	Data Review and literature search	8
	Interim Report	8
	Total Hours	**16**
2	**Literature Review and Numerical Analysis**	
	Literature review	10
	Numerical Assessment of selected methods	30
	Calibration of steady state method for LA soils	40
	Simulate field program	20
	Write report	20
	Total Hours	**120**
3	**Planning the Field Program**	
	Identify test locations	4
	Document drilling and testing procedures	12
	Permitting	2
	Equipment	8
	Drilling Contractors	4
	Total Hours	**30**
4	**Drilling and Field Infiltration Testing**	
	Drilling (3 dry wells and 12 wells with 720 ft of footage)	16
	Infiltration Testing	16
	Soil Samples (45)	2
	Data Analysis and Logs	36
	Interim Report	18
	Total Hours	**88**
5	**Outreach and Engagement**	
	Email Updates to Stormwater Managers (8)	8
	Workshops (4)	32
	Total Hours	**40**
6	**Documentation and Reporting**	
	Technical Report	20
	Total Hours	**20**
	Total:	314

John S. Gulliver, Ph. D.
Engineering Consultant
942 Forest Dale Rd.
New Brighton, MN 55112
651-636-4166
651-202-0786 (c)

September 30, 2020

Ali Sharbat PhD PE
Department of Civil Engineering
California Polytechnic Pomona

Re: Consultant to Evaluation of infiltration testing methods for design of stormwater drywell systems

To whom it may concern,

I have been asked to serve as a consultant on the project "Evaluation of infiltration testing methods for design of stormwater drywell systems." I have helped prepare the proposal, read the proposal and am willing to contribute to the proposed work. I attest that I am not presently debarred, suspended, proposed for debarment, declared ineligible, or voluntarily excluded from participation in transactions by any federal department or funding agency.

It is understood that this project will start on October 15, 2021 and conclude on December 15, 2022. I am willing to fulfill the required activities to ensure that this project is completed as described in the proposal. For any questions or clarification please contact me at gulli003@umn.edu.

Sincerely,

John S. Gulliver

Subject: FW:"Detail Attachment 2 Scope of Work"

Attachments: Letter of commitment.pdf

From: John Gulliver <gulli003@umn.edu>
Sent: Tuesday, October 13, 2020 10:51 AM
To: Ali Sharbat <sharbat@cpp.edu>
Subject: Ex: Re: "Detail Attachment 2 Scope of Work"

Breakdown of total costs of consultant services $30,000

Number of Hours at a rate of Hourly Rate:

Gulliver - 60 hours at $200/hr

Tecca - 180 hours at $100/hr

Tasks and activities:

Gulliver - Provide advice to tasks 2, 3 and 4. Participate in task 5 and 6. Supervise Mr. Tecca's participation.

Tecca - Participate in tasks 2, 3, 4, 5 and 6.

Associated costs:

Mr. Tecca will have for travel from San Diego to Los Angeles on multiple trips, and some associated expenses. $500 is allocated for these expenses (included).

Period covered;

The period of the project is October 15, 2021 through December 15, 2022. It is planned that the activities will take place during this period.