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Testimony before the Senate Committee on Labor and Regulatory Reform
State Senator André Jacque
January 13, 2022

Chairman Nass and Committee Members,

Thank you for holding this hearing on Senate Bill 501, allowing installation of certain groundwater recharge systems.

The Energy-Passive Groundwater Recharge Product (EGRP) is a technology that assists stormwater management and runoff prevention. These systems have been successfully implemented throughout much of the United States and internationally, and are used in both public and private sector applications. There has been a considerable amount of interest in the EGRP technology in Wisconsin, including by local government within my district. Unfortunately the installation process used for the EGRP is not allowed under NR 812.05 of the Wisconsin Administrative Code, as the Wisconsin DNR has a more stringent prohibition on the use of injection wells than most other states, none of which had anticipated the development of the EGRP Technology.

Senate Bill 501 allows this technology to be implemented in Wisconsin, specifically dealing with the technical issue of EGRP installation, without impacting any water quality standards. The passive design of the EGRP increases the infiltration rate in a low-impact, eco-friendly manner requiring no energy and no maintenance, successfully reducing standing surface water and flooding.

During installation, a series of EGRP devices are inserted vertically into the ground underneath natural topsoil, which allows water entering the EGRP network to be naturally filtered by the soil. The EGRP arrays initially capture surface water and subsequently dewater upper soils, thereby preparing the upper soil layer for the next wet-weather event. The water that enters, and contacts the EGRP, is then pushed outward into the various soil layers via capillary action, using naturally occurring movements of soil and earth. By accelerating infiltration into and through the near surface soils, the EGRP technology increases the volume of stormwater that can be stored, infiltrated, and ultimately recharged. Surface water that would have pooled or run off is captured below grade and filtered locally. The total volume of water to be infiltrated by the EGRP can be enhanced by pairing it with other common stormwater processing practices that capture peak stormwater volumes. The EGRP can work in concert with stormwater ponds, bioretention systems, and other subsurface storage systems. This "systems approach" captures stormwater runoff, stores the peak volume, adsorbs certain pollutants of concern, and allows large volumes of water to infiltrate over time, using fundamental physical principles to restore and optimize rates of water infiltration through the soil. Soil moisture can be managed both vertically and horizontally without the need of a water pump, heavy excavation, or continuous maintenance.

The EGRP System can function independently or in conjunction with established drainage systems to improve overall drainage performance, eliminate standing water, protect underground structures, and/or manage soil moisture. As described in the LRB Analysis, the EGRP consists of five-chambers. It is a hydrophobic polyethylene plastic device with base lengths of 5 to 40 feet, having a device diameter of 1.25 and 2 inches, a drill hole diameter 2.5 inches or smaller, and is installed vertically between 2 to 3 feet below the surface, and capped to restrict water flow.

Thank you for your consideration of Senate Bill 501.

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Senate Committee on Labor and Regulatory Reform

2021 Senate Bill 501

Allowing Installation of Certain Groundwater Recharge Systems
January 13, 2022

Good morning Chair Nass and members of the Committee. My name is Bruce Rheineck, and I am the Groundwater Section Chief for the Wisconsin Department of Natural Resources. Thank you for the opportunity to testify in opposition to Senate Bill 501 (SB 501), related to allowing installation of certain groundwater recharge systems.

The department opposes SB 501 due to the risks the bill poses to public health and to the drinking and groundwater resources of the state. The bill is in direct conflict with Wisconsin Administrative Codes and Federal rules. If passed it would endanger groundwater quality and could lead to Wisconsin losing primacy for the Underground Injection Control program.

SB 501 would represent a major policy change, by permitting, for the first time in the state, the disposal of stormwater by deep injection into the subsurface. The bill contradicts existing statutes specifically crafted to prohibit deep injection practices and to provide safeguards against endangering Wisconsin's underground sources of drinking water. Unlike other states, there are no aquifers in Wisconsin that have been designated for waste disposal; all are used for drinking water. To allow the installation of devices that allow deep injection of contaminated water and bypass the natural protection of soil is contrary to existing Wisconsin Administrative Code and federal regulations. This would be a dramatic shift from Wisconsin's record of protection of the groundwater resource, which serves as the sole source of drinking water for 70 percent of the state's population.

SB 501 requires the DNR to provide an exception to the use of wells and drillholes for the placement of any substance underground for the installation of certain groundwater recharge systems. These systems deliver stormwater quickly, as much as 43 feet below the ground surface. By the nature of its design, the product would do so in a manner where surface water containing bacteria, viruses and other contaminants would be channeled directly (untreated) into groundwater. According to the patent application assigned to Pajana Distribution (patent US20100260547A1), the product functions by creating vertical channels in the subsurface, which allow for standing water under hydrostatic pressure to bypass the normal filtering capacity of soil layers and to fall freely under gravity. To quote the patent application, "surface water is rapidly injected deep into the ground at the lower ends of the channel members". Without the full unaltered soil column to help absorb, retard, and degrade contaminants, there is a significant risk to water quality and public health. In addition to directly carrying surface pollutants deeper into the subsurface or directly to the water table itself, the recharged water could have lower pH and high dissolved oxygen. These factors can cause geochemical reactions contributing to water quality problems, including the release of arsenic and heavy metals.

Existing stormwater management best practices in Wisconsin are designed to capture stormwater runoff and infiltrate it into the ground over a period of days. These practices include infiltration trenches, infiltration basins, bioswales, rain gardens, pervious pavement, and other practices. Runoff gradually percolates through the bottom or sides of these installations, removing pollutants through sorption, trapping, straining, and bacterial degradation or transformation. None of these broadly accepted and implemented existing stormwater practices are designed to rapidly shunt standing water into the subsurface.

The bill would require multiple changes to NR 812 and 815 and would create an almost certain risk of violating 40 Code of Federal Regulations (CFR) part 142 and part 144. In particular, 40 CFR 144.12: "(a)No owner or operator shall construct, operate, maintain, convert, plug, abandon, or conduct any other injection activity in a manner that allows the movement of fluid containing any contaminant into underground sources of drinking water, if the presence of that contaminant may cause a violation of any primary drinking water regulation under 40 CFR part 142 or may otherwise adversely affect the health of persons." To comply with 40 CFR part 142 and part 144, the department would need to develop a new permitting program that reviews proposals for deep injection of fluids, which are currently prohibited. A new review process and new staff would be required for permitting approval, inspection, and long-term tracking. Additional staff would also be needed to address the increase in contaminated potable well incidents and to inspect facilities where these practices are deployed.

For the reasons outlined above, SB 501 poses serious risks to public health and to the drinking and groundwater resources of the state.

On behalf of the Department of Natural Resources, we would like to thank you for your time today. I would be happy to answer any questions you may have.

Wisconsin Wetlands ASSOCIATION

Wisconsin Wetlands Association Testimony on Senate Bill 501

Jennifer Western Hauser, Policy Liaison

On behalf of the Wisconsin Wetlands Association, I appreciate the opportunity to comment on Senate Bill (SB) 501 related to permitting installation of groundwater recharge systems. The Wisconsin Wetlands Association is dedicated to the protection, restoration, and enjoyment of wetlands and associated ecosystems through science-based programs, education, and advocacy. As you may know, wetlands are masterful at storing and slowing water, reducing flooding and damages, improving water quality, and replenishing groundwater. Wetlands also can have direct connections to groundwater and surface water.

As an organization with extensive work focused on helping Wisconsin communities reduce flood risks and damages, we are sensitive to the need for both natural and technology-based solutions and appreciate the authors' intent to share and discuss new technology for managing the storage and movement of water across Wisconsin's landscapes.

It is our position that there is no bad technology, but that technology inappropriately applied can cause more harm than good. We do not support this bill as written because it enables use of a specific water management system anywhere, for essentially any purpose, and provides no safeguards to protect waters of the state or adjacent property owners.

While we *can* imagine situations where this particular technology may benefit a landowner and could also be beneficial to the resource, there are also many circumstances where its use may not be appropriate or simply may not work.

While the bill subject is regulation of groundwater recharge systems, this technology also promotes surface water drainage and appears to function as a vertical drainage tile. With that in mind, we are particularly concerned about unintended consequences for wetlands.

We believe this proposal would benefit from additional consultation with experts in hydrology and hydrogeology who can offer objective feedback to help policy makers determine the contexts in which this technology might be appropriate, beneficial, and effective, and when it may be detrimental. Specifically, we encourage you to seek input from the Wisconsin Geologic and Natural History Survey, or even individually to members of the Examining Board of Professional Geologists, Hydrologists and Soil Scientists Board.

Further consultation with Wisconsin DNR, DATCP, Wisconsin Emergency Management, and statewide organizations representing municipalities and counties would also be beneficial as the proposal appears to have wide-reaching implications for policies and practices related to stormwater management, agricultural drainage, groundwater protection, floodplain management and flood risk reduction, among others.

As a final comment, we also recommend that the legislature request either a Wisconsin-based pilot project to demonstrate this technology, or at least a synthesis of available peer-reviewed literature to better understand how and where the use of the proposed groundwater recharge technology can help address Wisconsin-specific water management concerns.

We appreciate the opportunity to offer this feedback on SB 501 and respectfully request that this proposal be held to allow time for further input and consideration.

The EGRP® System

PARJANA®

855-727-5262

www.parjana.com

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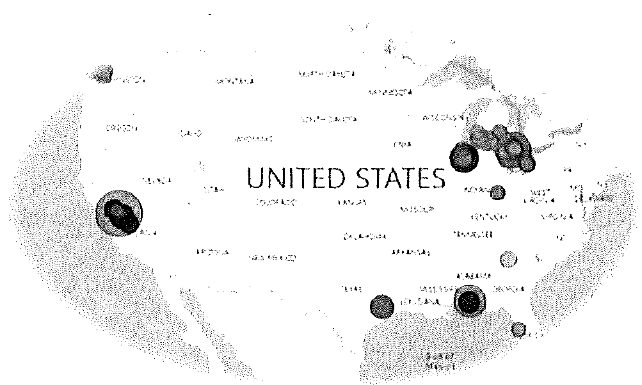
Introduction

Introduction - Parjana®

Parjana® was founded in Detroit, MI in 2012 to commercialize and further develop the **Energy-passive Groundwater Recharge Product** (EGRP®) system. The EGRP® was first installed in 1997.

Since its founding, Parjana® has:

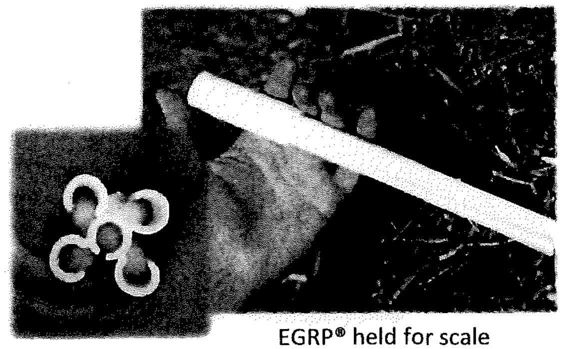
- Expanded its market reach across the U.S.
    - Notably in Midwest, West Coast, and Southeast states.
- Expanded its offerings to include residential, commercial, municipal, and agricultural programs.
- Participated in peer-reviewed case studies, and continues to collect and analyze data from new and existing installations.
- Sought collaborative partnerships to provide flexible and cost-effective solutions to sustainable water resource management.



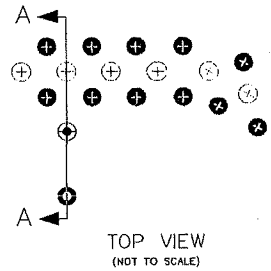
Introduction - EGRP® - Specifications

Product:

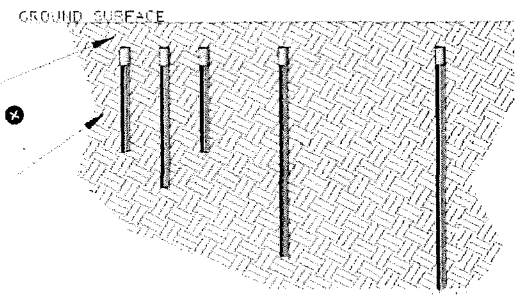
- 5-chamber, hydrophobic polyethylene plastic device
  - Installed in multiples, as an array
- Base length 5' - 40'
- Device diameter 1.25"
- Capped to restrict free water flow
- Installed vertically 2'-3' below surface
  - Drill hole diameter 1.75"



EGRP® held for scale



Example of system array

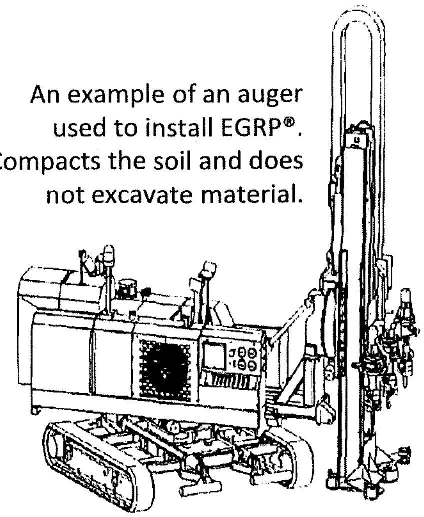


Cross-section of device's placement and distance from ground surface

Installation:

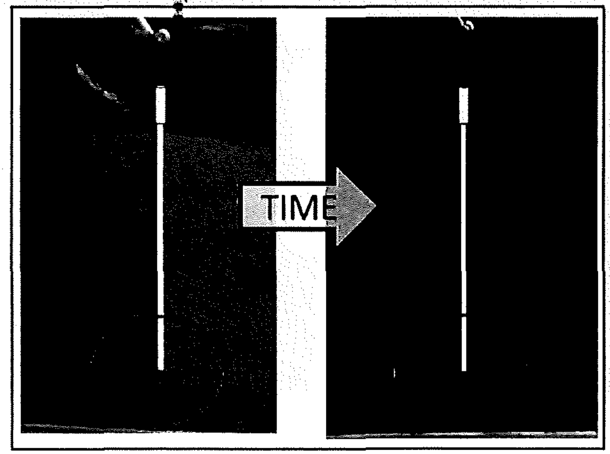
- System installation is performed by a certified installer using a compression auger.
  - The machine is 4'-wide and 16'-tall (clearance).
- Installation **does not** require **excavation** resulting in the permanent removal of ground material.
- Installation also **does not** require the **addition** of new ground materials or soils.

An example of an auger used to install EGRP®. Compacts the soil and does not excavate material.



PARJANA®

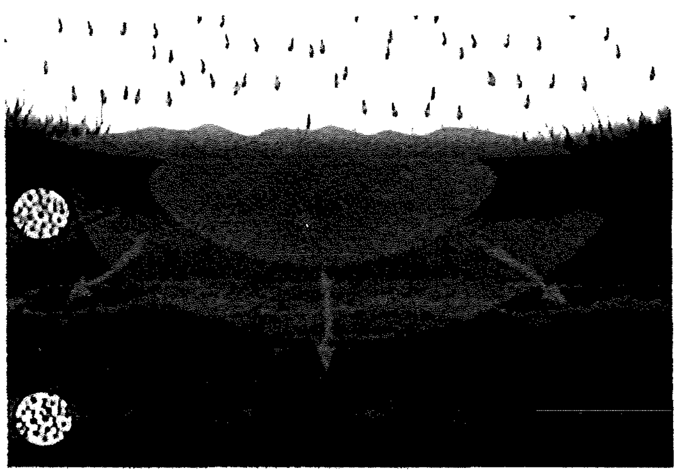
Introduction - EGRP® - Not a Conduit or Dry Well



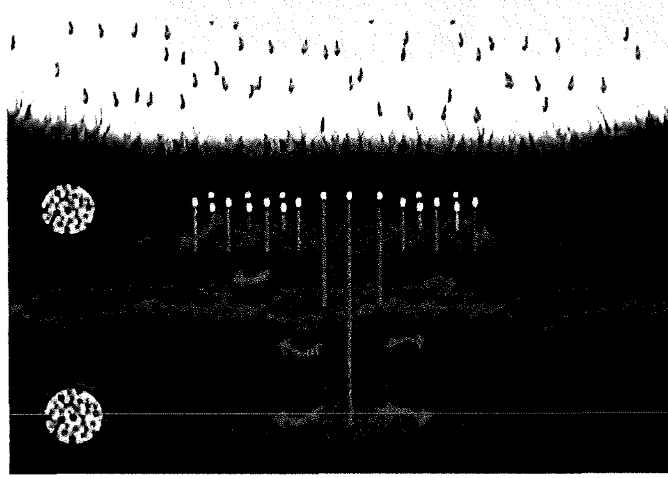
It is important to note that individual EGRP® devices and EGRP® systems **do not act as a conduit or dry well.**

This has been further confirmed by a Michigan State University study, which used a tracer to identify water movement within the EGRP® and surrounding soil.

The full results of this study - led by Dr. David Lusch, Professor Emeritus of Geography, Environment, and Spatial Sciences - can be provided upon request.



Water movement without EGRP®



Water movement with EGRP®

Introduction - EGRP® - Function

The image to the right is from an experiment demonstrating the difficulty for water to cross soil layers vertically.

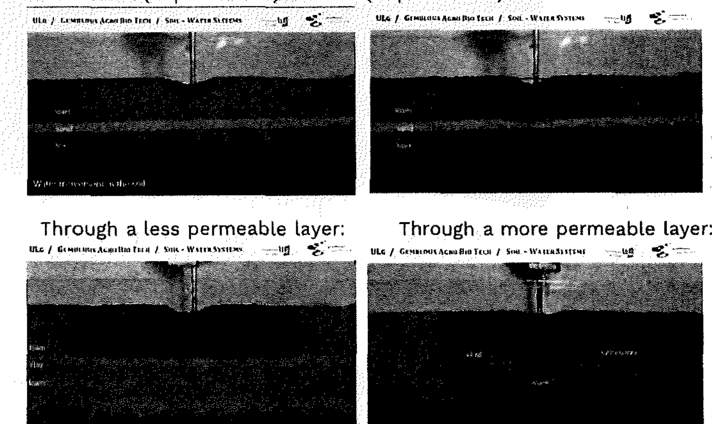
The EGRP® utilizes passive forces, such as the following, to enhance both the **horizontal** and **vertical** distribution of water through the soil matrix as it would perform in its 'ideal' natural state and without directly channeling water.

- Gravity moves water downwards until it reaches the system.
- Differential pressure (i.e., surface tension, hydrostatic pressure) helps to redistribute water through the soil from areas of high potential (energy) to low potential, until an equilibrium is achieved.
- Capillary action (i.e., adhesion /cohesion) between water and soil molecules also aids in directing water away from the EGRP®

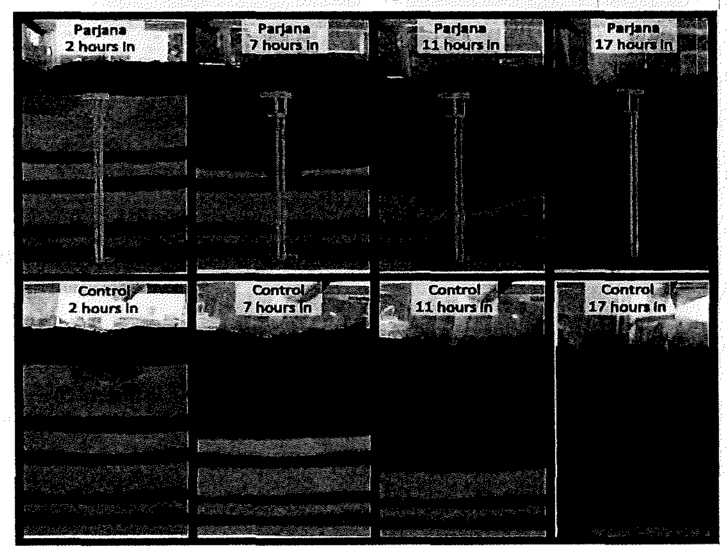
Note: water's horizontal distribution is typically wider than its vertical distribution and the depth of the EGRP® - however this can be dependent on soil saturation and other factors.

From loam (- permeable) to sand (+ permeable):

Through a less permeable layer: Through a more permeable layer:



Experiments showing that water "stops" at the edge of a new layer, even if more conductive than the current layer. The EGRP® facilitates the movement without channeling water down.



Introduction - EGRP® - Groundwater Levels and Water Quality

The EGRP® **supports and/or improves infiltration rates** while **maintaining a site's natural hydrogeological processes –** meaning no adverse affects to soil or water level/quality.

Water Quality:

- The EGRP® is **not a filtration technology.**
- Water is transported through neighboring soil particles - not the EGRP® - as it would be naturally, as EGRP® devices are **not** a conduit/drywell.
- Primary and secondary quality treatments would still be required, as needed.
- Studies have also shown **no difference** between **groundwater quality** at test and control sites, and **no horizontal nor vertical dissemination** of pollutants.

Groundwater Levels:

- Sites were monitored using piezometers.
- No visible mounding was detected. Observations indicate the system **helps groundwater levels recover** faster to baseline elevations after large rain events.
- There are **no demonstrated negative effects** on groundwater levels.

➢ Please reference the **Appendix** for a summary of the case studies supporting these conclusions. These studies and their results have been provided to the WI DNR.

Due Diligence and Environmental Site Assessments

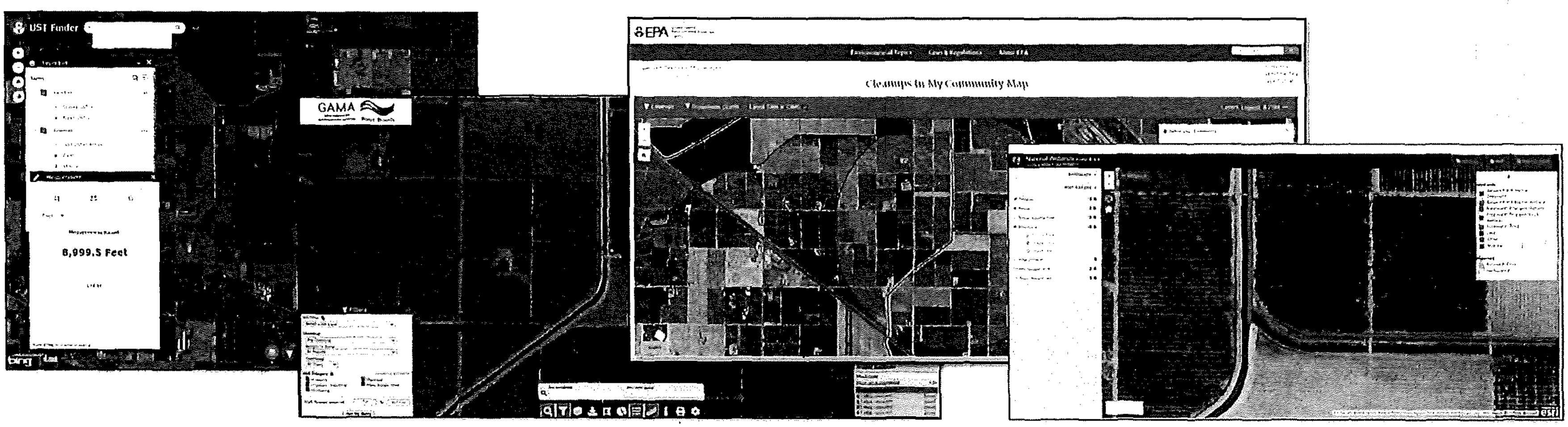
PARJANA®

Program Overview

Parjana® takes **due diligence** and thorough **environmental site assessments** seriously.

Prior to any design, each site undergoes a qualifying environmental assessment. These assessments are determined on a **case-by-case basis**, dependent upon the needs of the client and pursuant to local, state, and/or federal regulations.

This internal protocol allows Parjana® to easily collaborate with **program administrators** and authorities - utilizing available resources and data - to comply with the parameters set by a regulatory agency and participate in new or **existing compliance** and **reporting programs.**



PARJANA®

Program Overview

Parameters considered typically include the following, but may be more or less comprehensive dependent on site needs and local, state, and federal requirements:

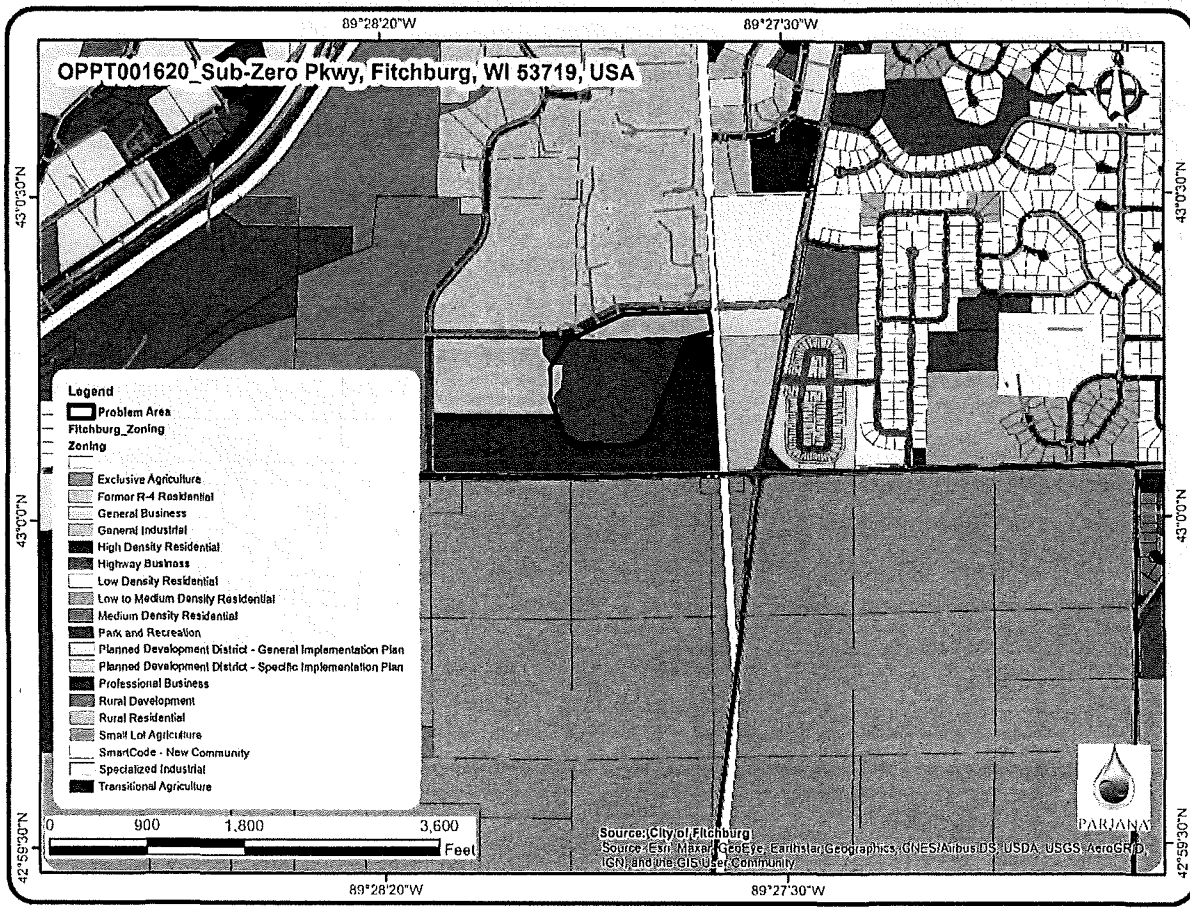
- **Installation distance to:** property boundaries / surface water / storage tanks / wellhead locations / contamination sites, incl. PFAS
- **Soil** : type / depth / permeability
- **Bedrock** : type / depth / permeability
- **Groundwater** : depth / direction / velocity
- **Water Quality :** surface water / source water / groundwater
- **Climate Data :** temperature / precipitation
- **Wetland and Watershed Delineations**
- **Elevation / Topography**
- **Land Use / Zoning**

Data for these and other parameters are sourced from a variety of official databases, including those from local/state agencies, federal agencies (e.g., U.S. EPA, NWI, DNR, EWG), and ArcGIS/ESRI.

ArcGIS: Aeronautical Reconnaissance Coverage Geographic Information System
DNR: Department of Natural Resources
EPA: Environmental Protection Agency
ESRI: Environmental Systems Research Institute
EWG: Environmental Working Group

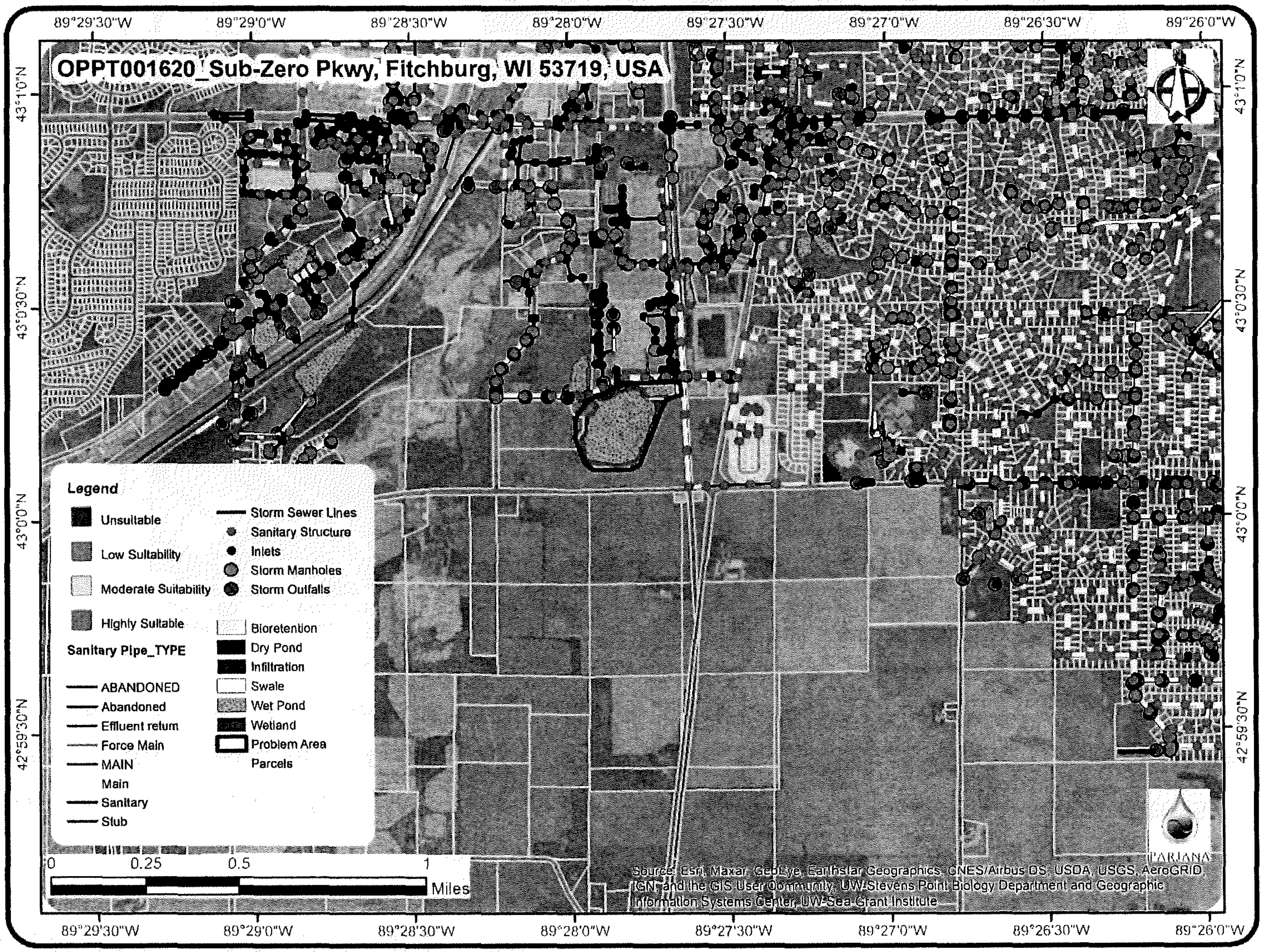
Site Example – Fitchburg, WI

The following **KMZ/GIS** files exemplify **federal and state-specific** parameters considered under Parjana®'s due diligence protocol, for a sample site at Sub-Zero Parkway, Fitchburg, WI 53719. The examples provided here are non-exhaustive.



Zoning demonstrates consideration of current and future intended land use.

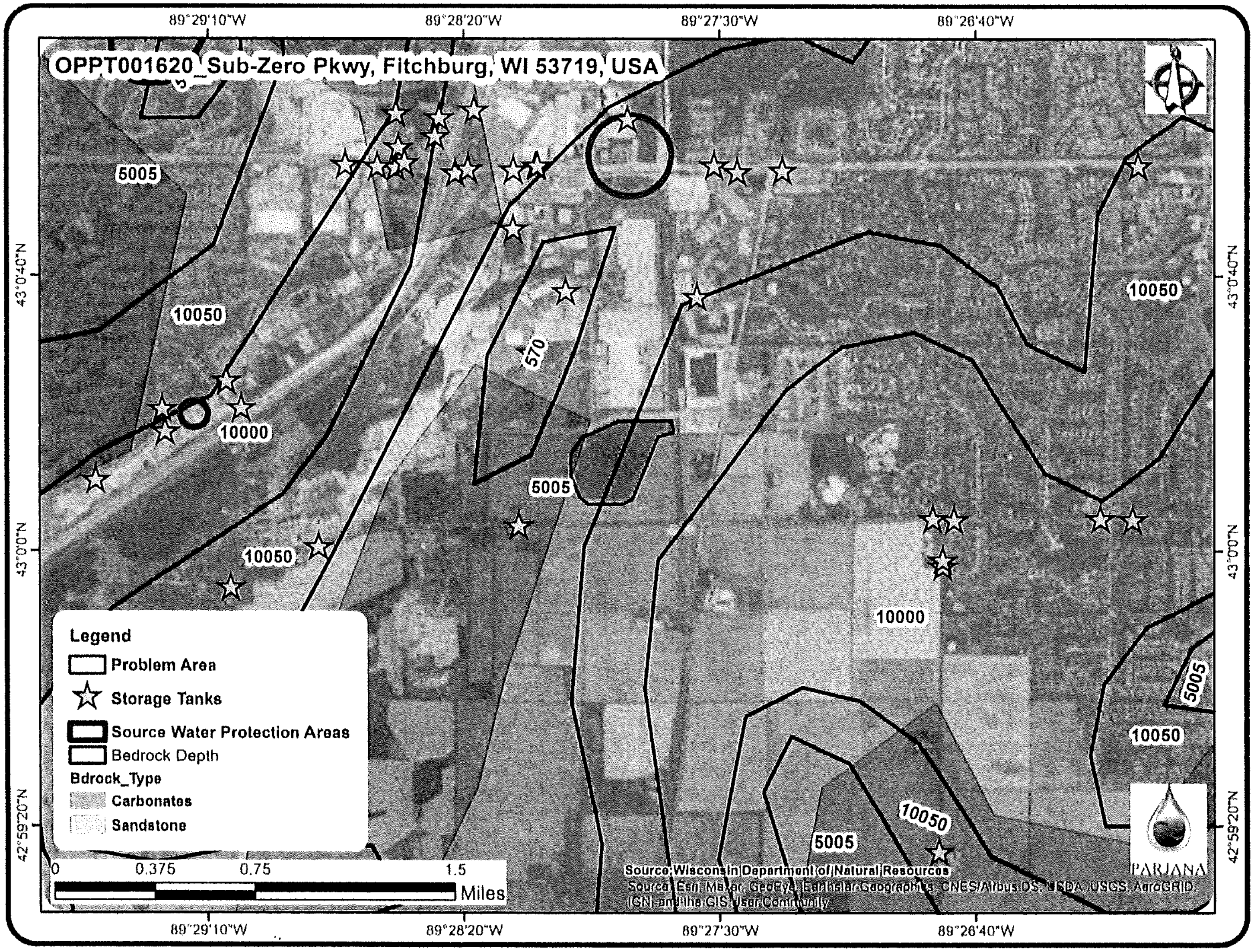
Site Example – Fitchburg, WI



For WI sites, Parjana® would regard state-specific wetland and drainage-way buffer requirements, including: 75ft from high quality wetlands; 50ft from floodplains and other wetlands; 10ft – 35ft from drainage ways. In addition, source water quality is considered. For example, this site would be "highly suitable."

PARJANA®

Site Example – Fitchburg, WI



For WI sites, Parjana® would take into consideration state-specific bedrock depth requirements. It is recommended that the base of the longest EGRP® be no less than 5ft above a bedrock layer, however this can vary state-to-state. For example, in WA, the base of the longest EGRP® may be 2ft or further from glacial till.

PARJANA®

Regulatory Discussion

PARJANA®

Class V Well Permitting in U.S. States

The following table outlines permitting and reporting requirements for the EGRP® and Class V Wells in some U.S. states. This list is non-exhaustive.

State	Inventory Notification	Inventory Registration	Permit	Installed	Details
California	✔			✔	• Inventory notifications submitted to U.S. EPA Region 9 • May vary by county
Florida			✔	✔	• Permits obtained through FDEP
Georgia			✔	✔	• Permits obtained through GA EPD • Also requires a Corrective Action Plan or equivalent report explaining the nature and extent of groundwater impacts of the proposed injection
Illinois	✔			✔	• Inventory notifications submitted to ILEPA. • A Class V Well owner may be required to obtain a "true permit" in rare cases
Kentucky			✔		• Permits obtained through U.S. EPA Region 4
Massachusetts			✔		• Requires a Groundwater Discharge Permit or UIC registration application, obtained through the MassDEP
Michigan			✔	✔	• Permits obtained through U.S. EPA Region 5
Nevada			✔		• Permits obtained through NDEP
New York			✔		• Permits obtained through U.S. EPA Region 2
North Carolina		✔			• Inventory registration submitted through NC DEQ. • Stormwater drainage wells do not require an individual injection well permit.
Ohio	✔			✔	• Notifications should be submitted to the OEPA within 30 days of installing a new well. • Notifications should include a completed UIC Class V Inventory Form
Pennsylvania	✔	✔	✔		• Permits, inventory notifications, and inventory registration submitted through U.S. EPA Region 3
South Carolina			✔		• Permits obtained through SC DHEC
Tennessee	✔				• Inventory notifications submitted through U.S. EPA Region 5
Texas	✔	✔		✔	• Inventory notifications and registration submitted through Texas CEQ Radioactive Materials Division
Virginia			✔		• Permits obtained through U.S. EPA Region 3
Washington		✔		✔	• Registration must be submitted to the WA Dep. Of Ecology 60 days prior to well construction
Washington D.C.			✔		• Permits obtained through the DOEE, but are not needed under certain criteria
Wisconsin	✔				• Inventory notifications submitted to the WI DNR

Appendix:
Parjana® Executive Summary

Executive Summary 2018

This report represents a brief discussion on several research projects conducted by or with Parjana® Distribution in collaboration with various government, private, and educational entities to validate the efficacy of the Parjana® Energy-passive Groundwater Recharge Product (EGRP®) system. These individual research projects generated experimental data documenting how the EGRP® system performs in various applications. The overall aim of conducting these research projects is to determine the efficacy of the EGRP® system in eliminating standing surface water without disturbing ecological balance. There are seven independent research projects that have been conducted to date that are summarized in this report (Table 1). Overall, findings of these research reports suggest that the EGRP® system successfully reduces standing surface water, significantly increases surface infiltration and does not have an adverse effect on groundwater quality. Additional information and reports to supplement this summary are available upon request.

Summary List of Research Investigations and Goals

Lawrence Technological University, Southfield MI

- To implement, monitor, and evaluate the efficacy of the EGRP® in a systems-based approach.
- To analyze the effect of the EGRP® on groundwater elevation and recovery time as a result of increased infiltration.

Michigan State University, East Lansing MI

- To analyze the effect of the EGRP® system on volumetric water content and soil moisture stabilization.
- To study the possible related impact of the EGRP® on plant-available water and its correlation to crop yield.

Belle Isle Shelter 5, Detroit MI

- To determine the efficacy of EGRP® system in reducing standing surface water.
- To determine the efficacy of the EGRP® system in reducing the volume of runoff being delivered to Detroit Water & Sewerage Department as part of combined sewer system.
- To explore the effect of the EGRP® system on groundwater levels and quality.

Coleman A. Young International Airport, Detroit MI

- To evaluate how the EGRP® system enhances surface water infiltration
- To evaluate whether the EGRP® system acts a straight vertical conduit to lower soil layers that might allow surface contaminants to enter shallow groundwater tables

Mettetal Airport, Canton MI

- To determine if the EGRP® system could assist in draining an existing sediment forebay with long-term ponding

Geneva International Airport, Switzerland

- To determine the impact of the EGRP® system on soil moisture distribution and shallow water table response in an area without standing water problems

Edgabston Cricket Club

- To determine the influence of the EGRP® system on the infiltration, surface firmness and soil moisture on an athletic field.

Lawrence Technological University, Southfield MI

The *National Demonstration of Scalable Integrated Drainage System to Mitigate Parking Lot Stormwater Runoff*, involves retrofitting parking lot storm collection drains to mitigate at least a 1-inch rain event in 24 hours.

Lawrence Technological University (LTU) is leading a collaboration of industry partners in a multi-state demonstration project featuring the implementation of an innovative and scalable integrated drainage design that significantly mitigates polluted parking lot stormwater runoff. The integrated drainage system includes three separate patented technologies combined in a novel approach including a porous pavement surface (parking performance maintained), an underground engineered soil storage reservoir (for stormwater storage and water quality filtration) and the Energy-passive Groundwater Recharge Product (EGRP®) (to improve infiltration and reduce runoff).

The research demonstration at LTU is the first site to be implemented of an overall five, with the remaining four set to be installed in Ohio, California, Florida, and Washington, D.C.

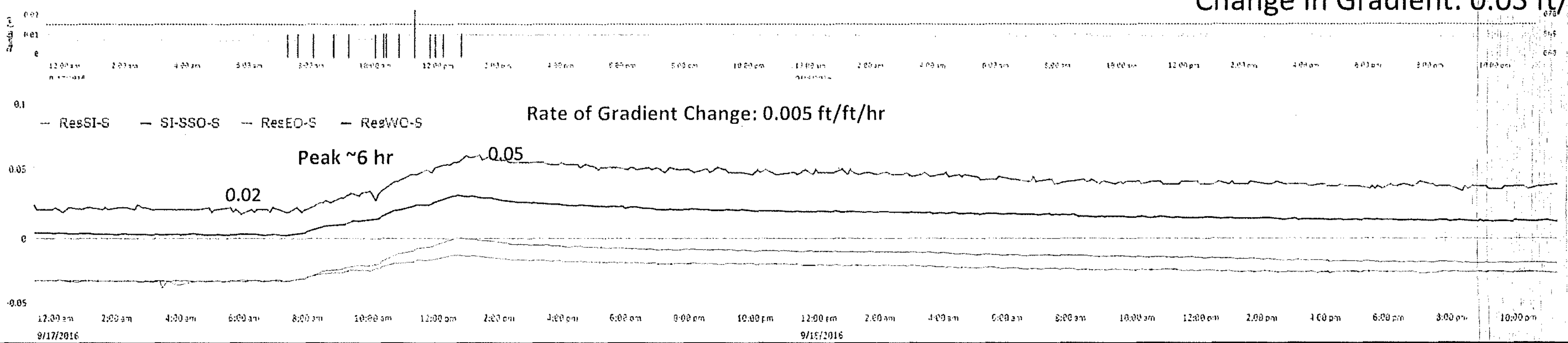
Lawrence Technological University, Southfield MI

Figure 1: Data Set 1 - Horizontal Hydraulic Gradients - Short Term

Sept. 17, 2016 vs Sept. 4, 2017

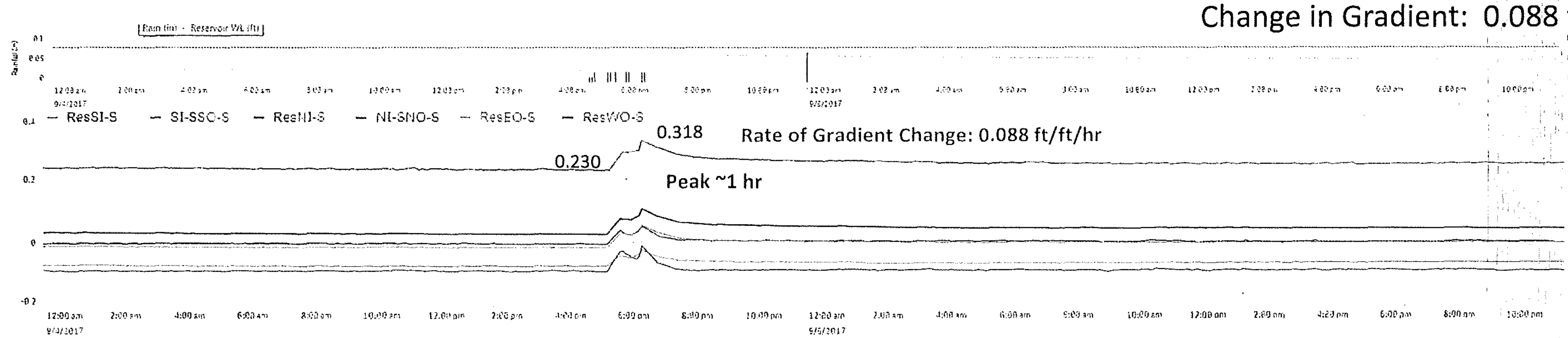
Total Precip: 0.21 in/8 hr
Change in Gradient: 0.03 ft/ft

Sept. 2016



Total Precip: 0.51 in/6 hr
Change in Gradient: 0.088 ft/ft

Sept. 2017



ResSI-S = Gradient between Reservoir and South Inside Shallow wells
SI-SSO-S = Horizontal Hydraulic Gradient between South Inside and Outside shallow wells
Applies for N, E, and W

*Preliminary data and modeling, courtesy of Drummond Carpenter, PLLC.
Graphs shown are not representative of final results.

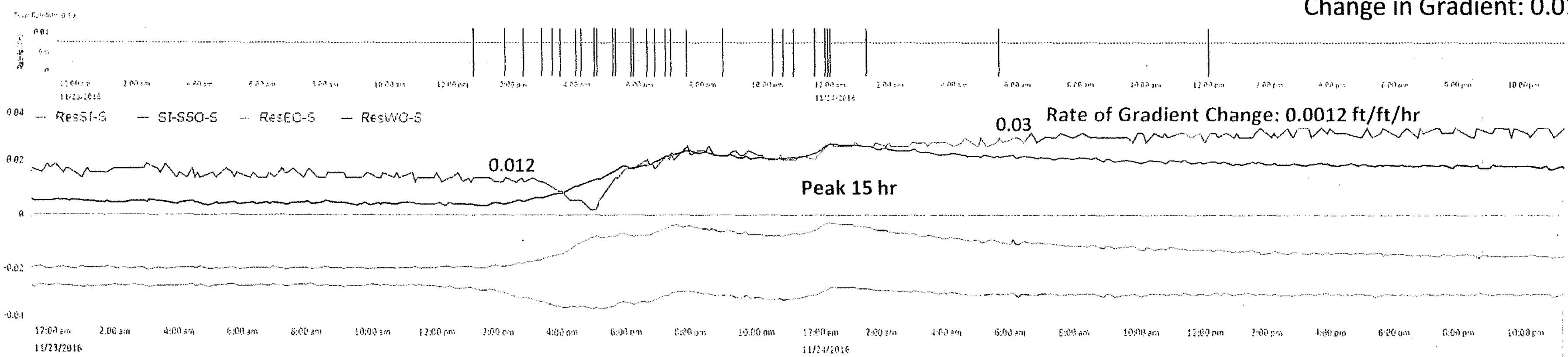
Lawrence Technological University, Southfield MI

Figure 2: Data Set 2 - Horizontal Hydraulic Gradients - Short Term

Nov. 23, 2016 vs Aug. 17, 2017

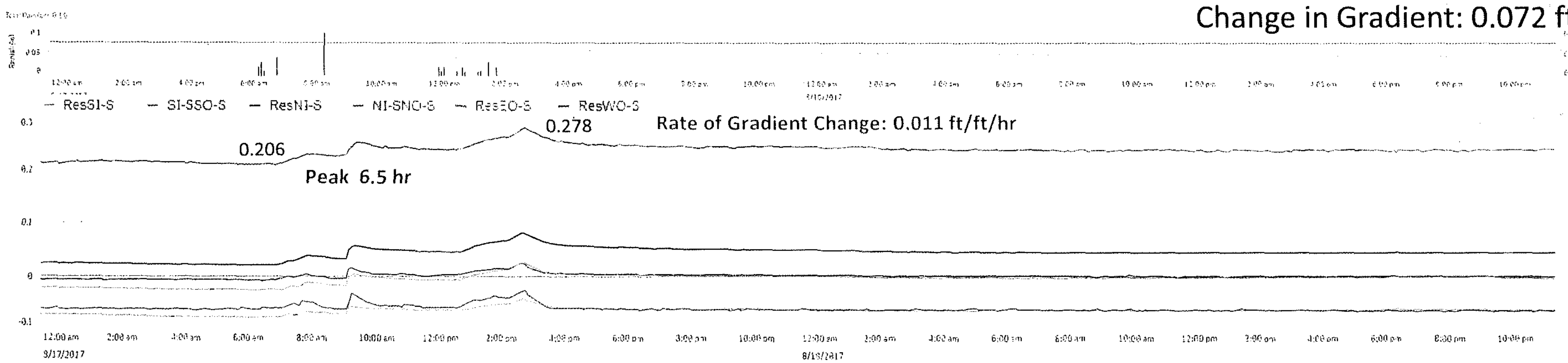
Total Precip: 0.51 in/13hr
Change in Gradient: 0.018 ft/ft

Nov. 2016



Total Precip: 0.59 in/8hr
Change in Gradient: 0.072 ft/ft

Aug. 2017



ResSI-S = Gradient between Reservoir and South Inside Shallow wells
SI-SSO-S = Horizontal Hydraulic Gradient between South Inside and Outside shallow wells
Applies for N, E, and W

*Preliminary data and modeling, courtesy of Drummond Carpenter, PLLC.
Graphs shown are not representative of final results.

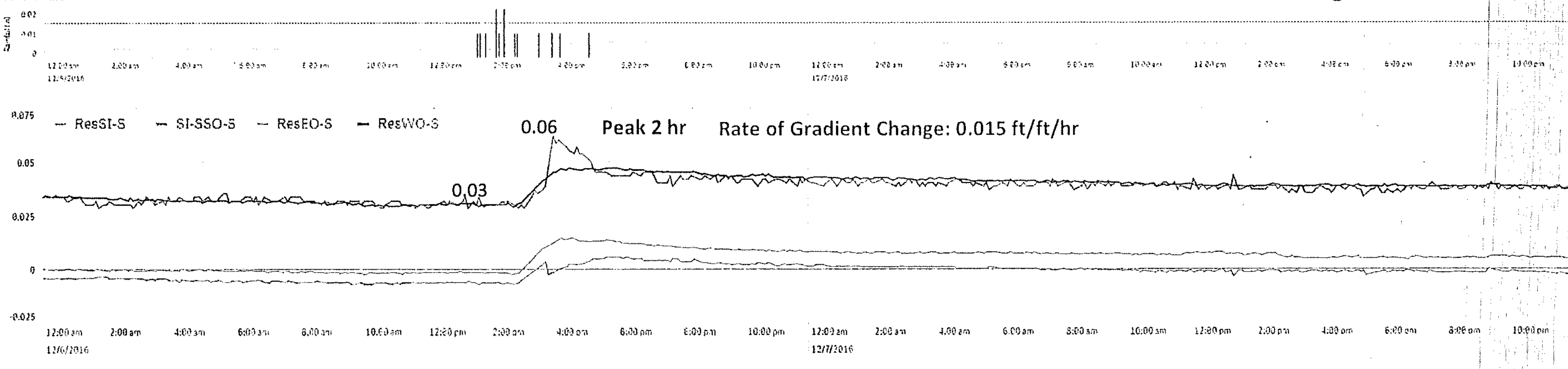
Lawrence Technological University, Southfield MI

Figure 3: Data Set 3 - Horizontal Hydraulic Gradients - Short Term

Dec. 6, 2016 vs Jul. 13, 2017

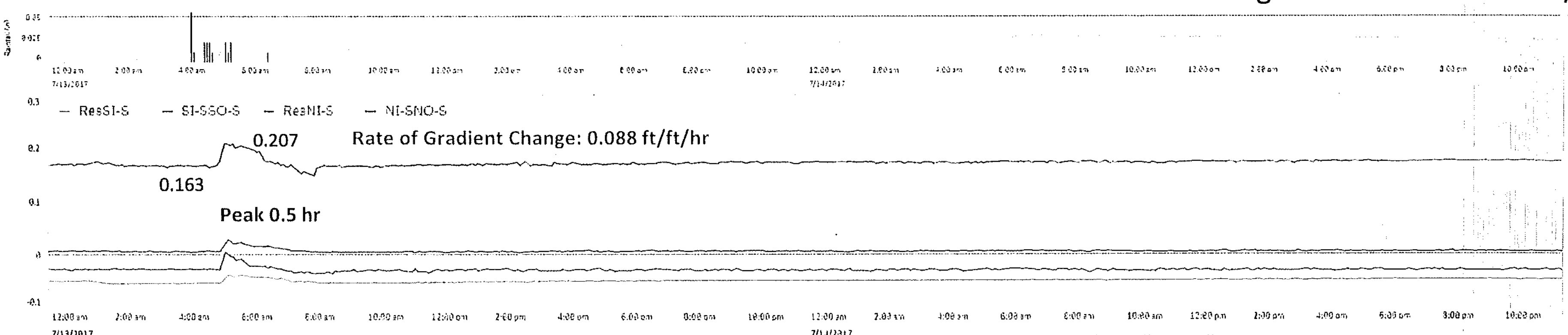
Total Precip: 0.21 in/3hr
Change in Gradient: 0.03 ft/ft

Dec. 2016



Total Precip: 0.30 in/3hr
Change in Gradient: 0.044 ft/ft

July 2017



ResSI-S = Horizontal hydraulic gradient between Reservoir and South Inside Shallow wells
SI-SSO-S = Horizontal hydraulic gradient between South Inside and Outside shallow wells
Applies for N

*Preliminary data and modeling, courtesy of Drummond Carpenter, PLLC. Graphs shown are not representative of final results.

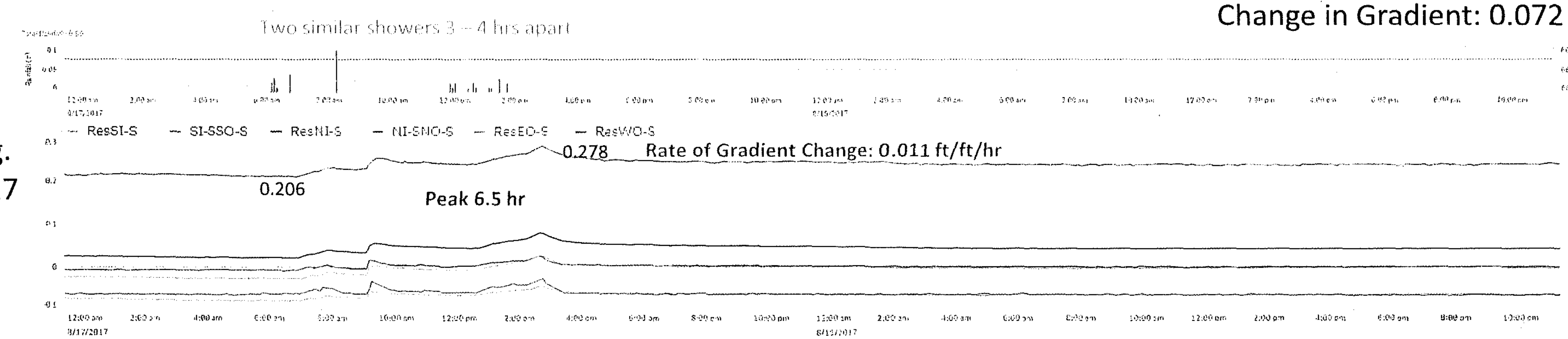
Lawrence Technological University, Southfield MI

Figure 4: Data Set 4 - Horizontal Hydraulic Gradients - Short Term

Aug. 17, 2017 vs Sept. 4, 2017

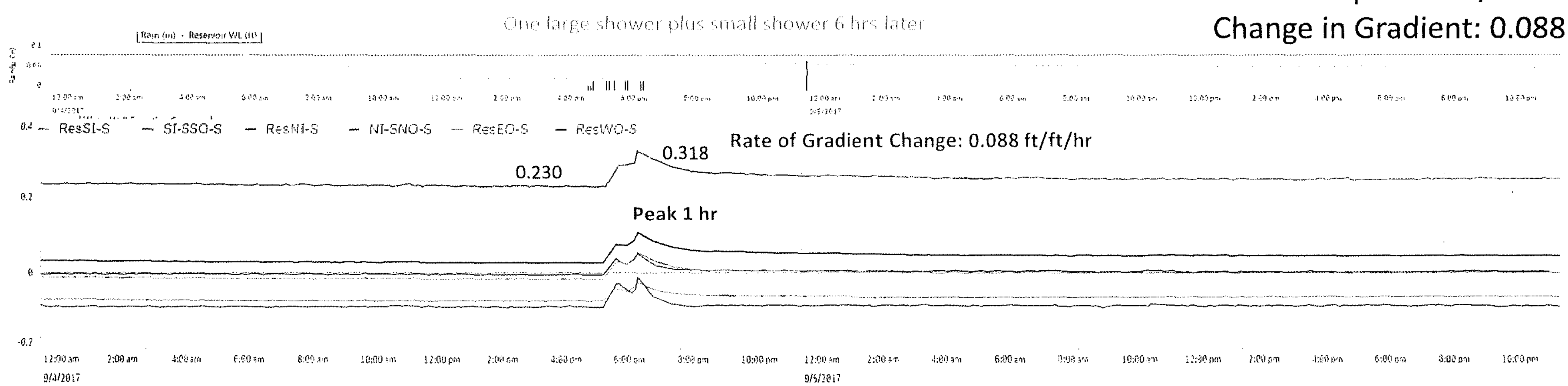
Total Precip: 0.59 in/8hr
Change in Gradient: 0.072 ft/ft

Aug. 2017



Total Precip: 0.51 in/6 hr
Change in Gradient: 0.088 ft/ft

Sept. 2017



ResSI-S = Gradient between Reservoir and South Inside Shallow wells
SI-SSO-S = Horizontal Hydraulic Gradient between South Inside and Outside shallow wells
Applies for N, E, and W

*Preliminary data and modeling, courtesy of Drummond Carpenter, PLLC.
Graphs shown are not representative of final results.

Lawrence Technological University, Southfield MI

Results:

A preliminary, 3rd party evaluation of the impact of the EGRP® on groundwater elevation and recovery time at the Lawrence Technological University site was conducted and compiled by Drummond Carpenter, PLLC. Specific findings were:

- Magnitude of change in groundwater elevation was greater during storm events in 2017 vs. 2016
- Groundwater elevations increased more rapidly during storm events in 2017 vs. 2016
- Groundwater levels recover to baseline elevations faster in 2017 vs. 2016
- Horizontal hydraulic gradients measured in the wells increased more rapidly during rain events in 2017 vs. 2016

The conclusion drawn from these initial results were that EGRP® acclimation has an apparent affect on groundwater elevations and groundwater recovery times.

Testing and analysis is scheduled to continue throughout 2018 and 2019 to mimic the dates and rain events sampled in the previous two years' datasets, for consistency.

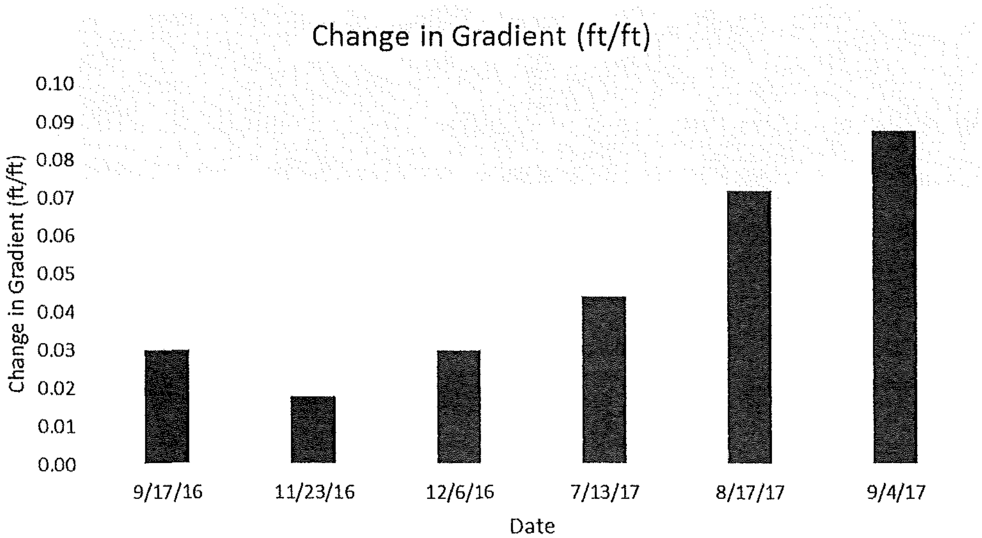


Figure 5: Change in hydraulic gradient (ft/ft) per date.

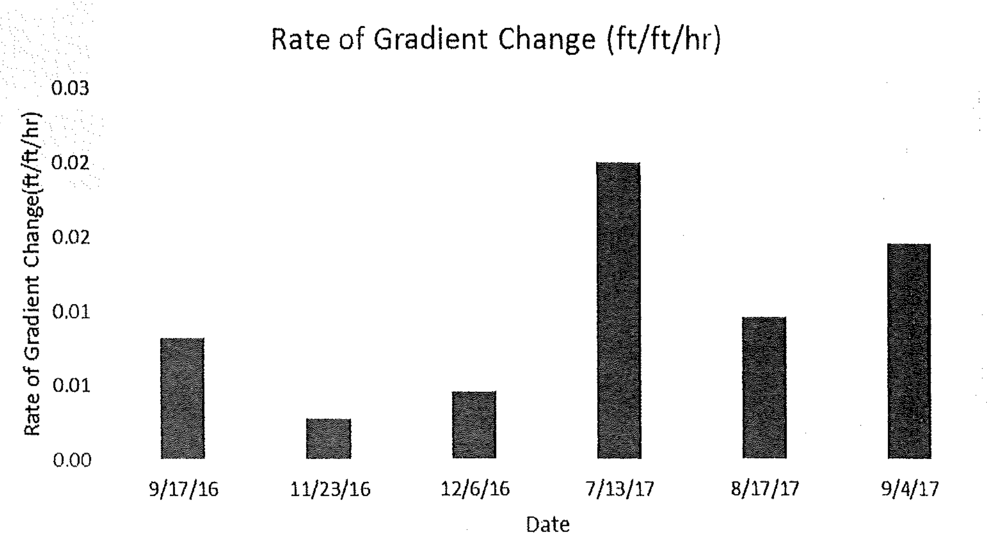


Figure 6: Rate of change in hydraulic gradient (ft/ft/hr) per date.

Michigan State University, East Lansing MI

A *2017 Statistical Analysis Summary* was submitted to Parjana® for research performed at Michigan State University (MSU) by Thomas A. Nikolai, Ph.D. The research study was first implemented at MSU's Hancock Turfgrass Research Center (HTRC) in October of 2015.

The EGRP® system was installed at the HTRC in a border area that had not previously been utilized for turfgrass research. The soil on the site is a Capac loam and the area was seeded in 2006 with a Rhino seed mix of 20% Raven Kentucky bluegrass (KBG), 20% Cascade chewings fescue, 20% Merit KBG, 20% Baron KBG, and 20% Stellar perennial ryegrass. The site received minimal fertility and pesticide inputs prior to the study and no fertilizer or pesticides have been applied to the site since installation of the product. The entire site, delineated in red in Figure 7, measures 210' by 85' (approximate latitude and longitude, for reference: 42°42'40.81"N, 84°28'20.17"W).

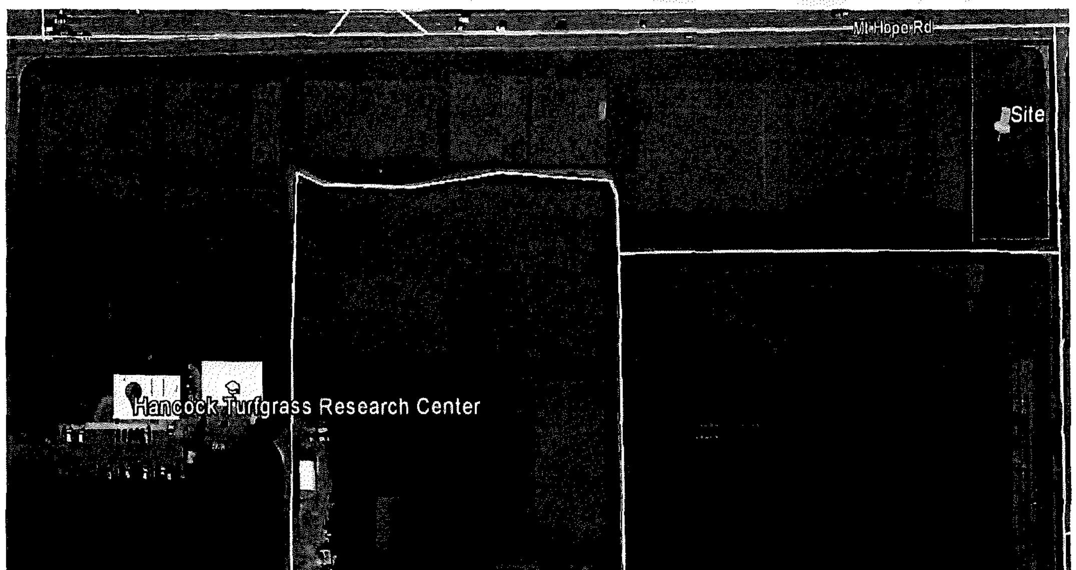


Figure 7: Site location relative to the Hancock Turfgrass Research Center.

The soil type at the project site is identified by the United States Department of Agriculture's Web Soil Survey as CaA – Capac loam, 0 to 4 percent slopes, C/D classification, and with a native infiltration rate between 0.01 and 0.14 inches per hour. The typical profile is represented as:

- Ap - 0 to 9 inches: loam
- B/E - 9 to 16 inches: clay loam
- Bt - 16 to 31 inches: clay loam
- C - 31 to 80 inches: loam

Surrounding soils are predominant other classifications of loams and sandy loams, including AnA – *Aubbeenaubbee-Capac Sandy loams and Co* – Colwood-Brookston loams.

Michigan State University, East Lansing MI

The study is comprised of three replications of two treatments (Figure 8), which include: 20' x 20' plots with the EGRP® system installed and 20' x 20' plots with no drainage installed. Each 20' x 20' treatment plot replication is separated by 45' east to west and 75' north to south to minimize the effects, if any, of the sphere of influence the EGRP® system may have on drainage in a check plot. Toro Turf Guard sensors were placed in each plot as follows. A line was made with twine between the NW and the SE corners of each plot. Sensors were placed 7 feet into the plot from the SE corner marker on that diagonal line (Figure 4). The top of the sensors were buried at a 4-inch depth below the soil surface which means the Turf Guard sensors probes are approximately 5 inches and 10 inches from the soil surface. Turf Guard sensors measure and record the volumetric moisture content (VMC) on 5-minute intervals 24 hours per day.

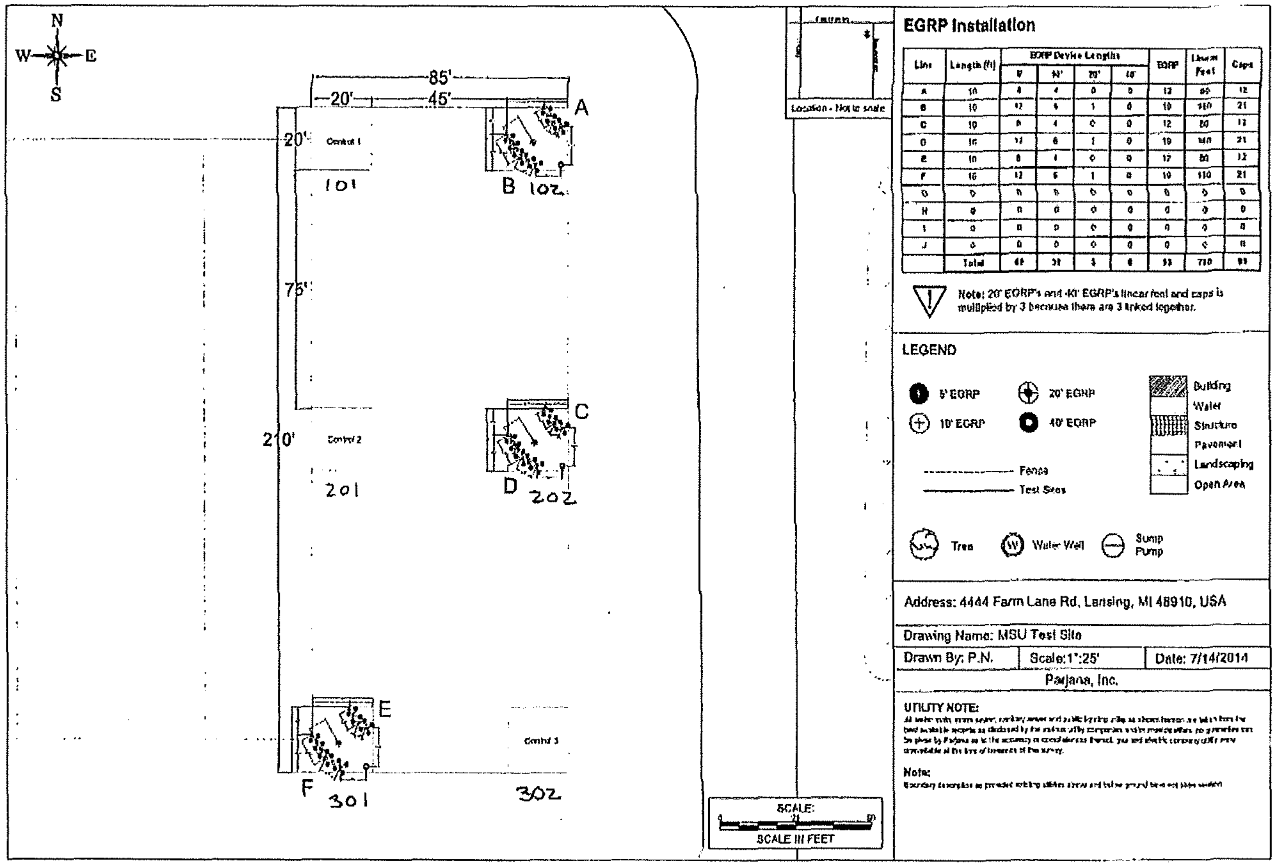


Figure 8: Site layout of the EGRP® installation at the Hancock Turfgrass Research Center.

Results:
24 VMC measurements are reported. Reported dates and times were chosen as they either followed, or were taken during, a rain event and VMC differences monitored via Site Vision® seemed apparent. It is pertinent to state that in the absence of a rain event there were little differences among the plots regarding moisture retention and that each treatment mean reported in the tables is the mean of three replications.

In Table 1, two dates, June 3 and 6 resulted in statistically significant differences within the 10% level and on both occasions the VMC in plots with the EGRP® system were drier. In Table 2, there are four dates with statistically significant data within the 10% level, July 21 and August 24, and two of those dates are also significant within the 5% level, July 10 and August 17. On all four of those occasions the VMC in plots with the EGRP ® system were drier compared to the control plots. In Table 3, there is a significant data set within the 5% level, September 22, and another within the 10% level, October 8, and on both occasions the VMC in plots with the EGRP ® system were drier. Though not statistically significant, of the remaining 16 measurements reported in Tables 1 through 3 each one resulted in VMC in plots with the EGRP ® lower than that of those without a drainage system.

Michigan State University, East Lansing MI

Table 1.

Volumetric moisture content obtained from a 5-inch depth.

	June 1	June 3	June 6	June 9	June 18	June 19	June 20	June 21
Time of measurement	11:55 PM	5:00 AM	12:10 AM	12:25 AM	10:25 PM	12:15 AM	12:20 AM	12:25 AM
Condition	Drying	Drying	Drying	Drying	Raining	Drying	Drying	Drying
EGRP®	30.1	27.6	24.8	22.6	36.7	34.8	31.5	29.4
Control	34.8	33.4	31.2	30.6	38.5	42.0	39.9	37.7
LSD @ 0.05	8.3	6.5	10.1	13.6	26.9	18.5	15.2	13.8
Probability	0.13	0.06**	0.09**	0.12	0.80	0.23	0.14	0.12

* LSD - Least Significant Difference; p=0.05.
** Data is statistically significant within a probability of 0.10.

Table 2.

Volumetric moisture content obtained from a 5-inch depth.

	July 7	July 10	July 21	July 27	Aug 15	Aug 16	Aug 17	Aug 24
Time of measurement	10:50 AM	7:55 AM	12:00 AM	12:50 PM	6:40 AM	11:30 AM	TIME	12:25
Condition	Raining	Drying	Drying	Drying	Raining	Drying	Drying	Drying
EGRP®	36.9	25.4 b	22.7	20.4	31.7	29	26.2 b	21.2
Control	41.8	33.5 a	31.8	29.6	32.8	34.9	33.3 a	29.8
LSD @ 0.05	6.3	6.2	11.9	15.9	6.6	13.8	3.3	12.9
Probability	0.44	0.03*	0.08**	0.13	0.86	0.21	0.01*	0.10**

* LSD - Least Significant Difference; p=0.05.
** Data is statistically significant within a probability of 0.05.
*** Data is statistically significant within a probability of 0.10.

Table 3.

Volumetric moisture content obtained from a 5-inch depth.

	Aug 31	Sept 22	Sept 22	Oct 7	Oct 8	Oct 9	Oct 10	Oct 11
Time of measurement	11:50 PM	6:55 AM	11:45 PM	10:20 PM	1:55 AM	3:50 AM	12:20 AM	11:35 AM
Condition	Drying	Raining	Drying	Raining	Drying	Raining	Drying	Raining
EGRP®	19.4	27.4	24.9 b	39.8	36.7	44.7	38.4	52.7
Control	28.5	30.1	31.3 a	46.1	42.9	48.8	44.5	59.3
LSD @ 0.05	16.8	6.8	4.2	37.5	9.8	22.5	10.3	16.3
Probability	0.14	0.67	0.02**	0.54	0.10***	0.51	0.13	0.22

* LSD - Least Significant Difference; p=0.05.
** Data is statistically significant within a probability of 0.05.
*** Data is statistically significant within a probability of 0.10.

Belle Isle Shelter 5, Detroit MI

Belle Isle, a 985-acre island in the Detroit River near the mouth of Lake St. Clair, is considered one of the jewels of the city of Detroit. Having recently been leased to The State of Michigan for thirty years, the Department of Natural Resources (DNR) has primary authority over its management within the Michigan State Park system (Greene 2013). The DNR intends to spend up to $20 million for park improvements and infrastructure upgrades to further enhance visitors, experience on the island (Litcherman 2013). This demonstration project was made possible through a grant from the Michigan Economic Development Corporation (MEDC) and was intended to vastly mitigate the expense of managing stormwater by DWSD.

Installation on Belle Isle consisted of eleven lines of diamond pattern EGRP® (Figure 10). The location of the EGRP® lines can be seen in *Figure 3 along with the overall study design information.* Belle Isle consists predominantly of interbedded sands and silty clays to a depth of approximately 20 feet. The potentiometric surface varied from 0.5 to 6 feet below the surface depending on rainfall and piezometric well location (ECT 2016).

Purpose:

The primary goals of this investigation were to determine if the EGRP® system could eliminate standing water on an approximately 24 acre parcel and decrease the volume of stormwater delivered to DWSD through the municipal combined sewer drain system thereby alleviating the cost associated with treatment.

A secondary goal was to explore the effect the EGRP® system has on groundwater.

Belle Isle Shelter 5, Detroit MI

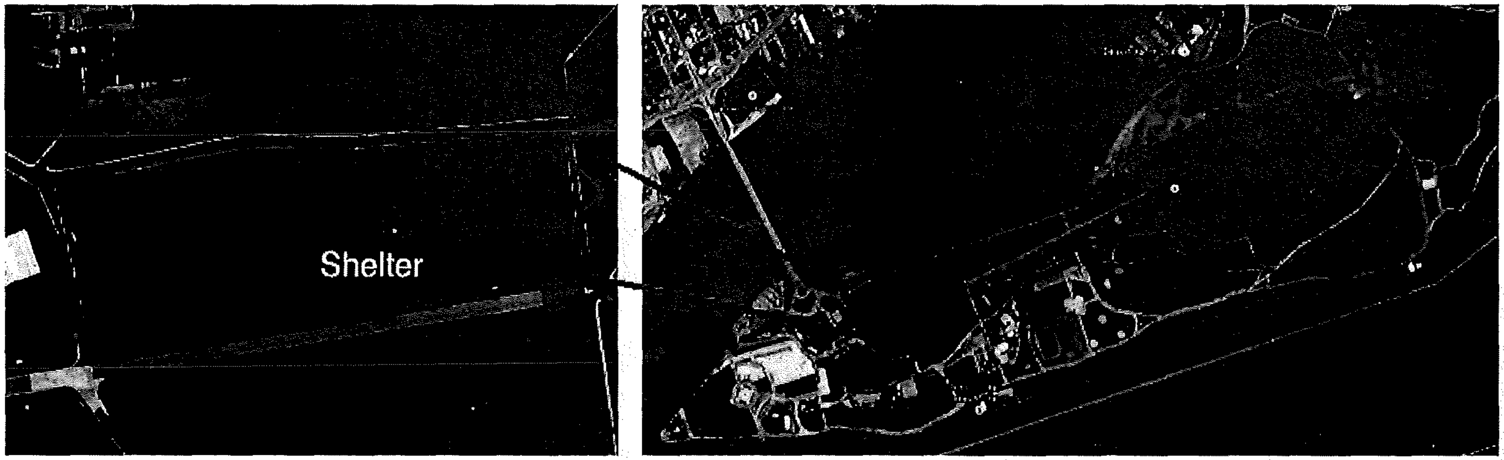


Figure 9: Test Area (Shelter 5) on Belle Isle

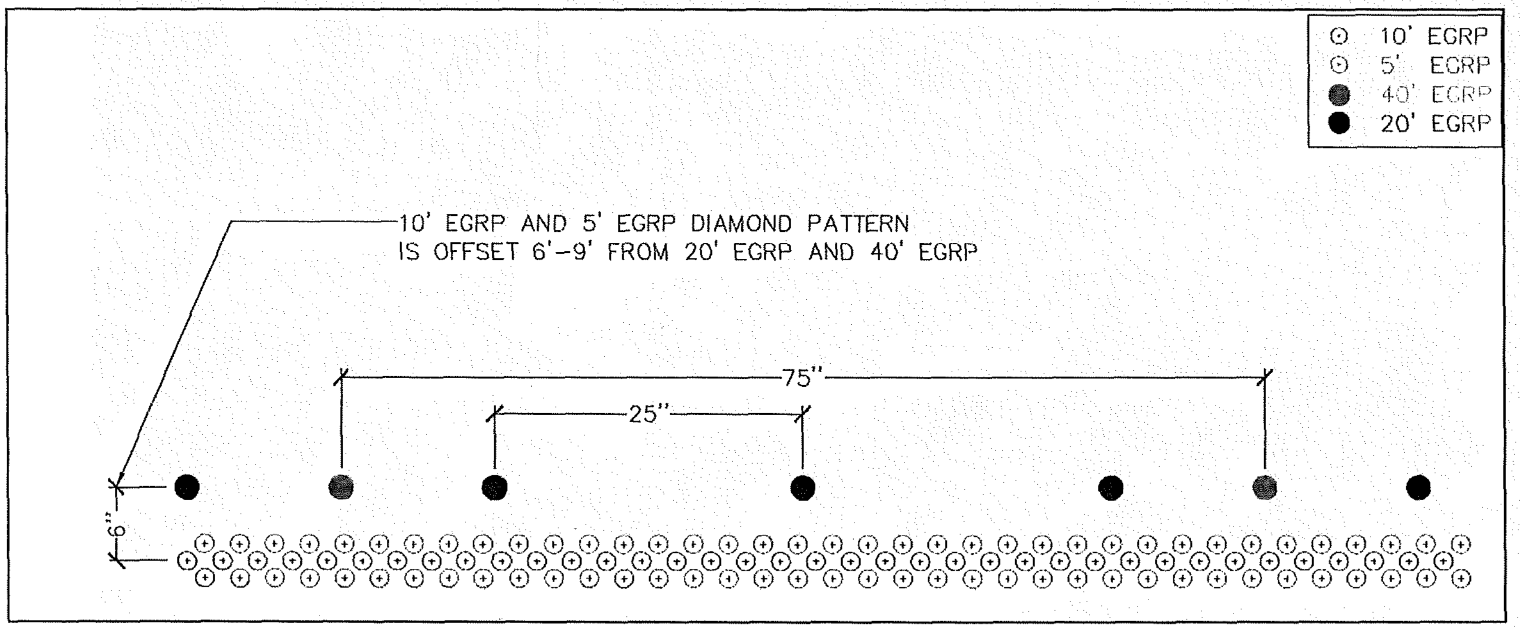


Figure 10: Configuration of EGRP® diamond pattern

Belle Isle Shelter 5, Detroit MI

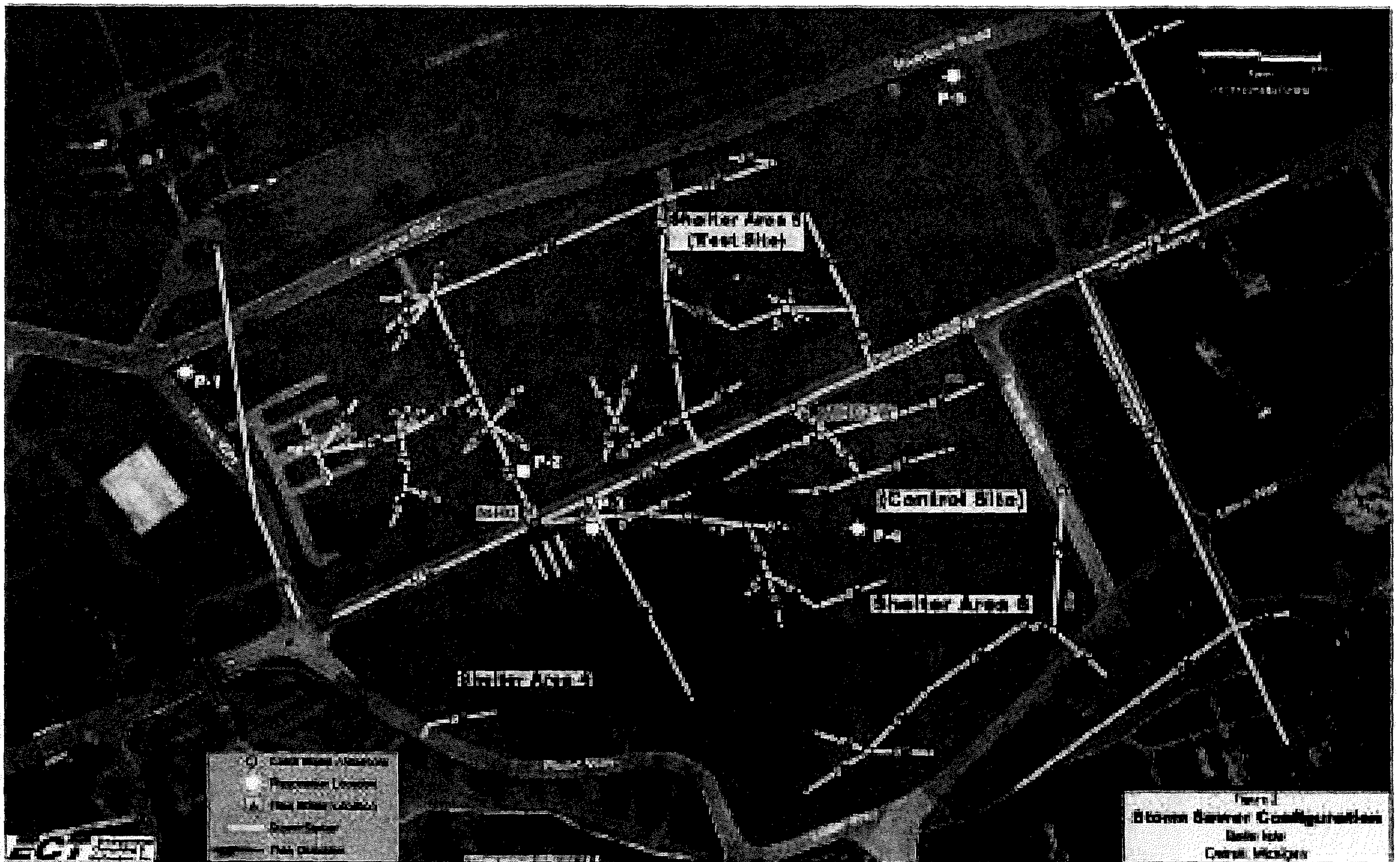


Figure 11: Locations of grey infrastructure and flow direction on Belle Isle (ECT 2016).

Belle Isle Shelter 5, Detroit MI

Results:

Figure 12 and 13 represent total cumulative in-pipe flow from test site before and after installation. Both figures are separated into three distinct time periods (Pre-Installation, Post-Installation, and Performance) with the cumulative flow and precipitation initialized to zero at the beginning of each time period for ease of interpretation. These figures graphically depict the main findings of the investigation which include (ECT2016):

- Prior to installation, the amount of runoff volume was nearly double the amount of rainfall volume due to the pipe network capturing water from a larger area of the island and possibly influenced by the Detroit River.
- After installation, the runoff volume is much less than rainfall volume.
- The rainfall has less direct impact on the amount of runoff from the site when comparing control site versus test site.
- There was an 80% reduction in the total amount of runoff volume from the test site.

In addition to in-pipe flow monitoring, groundwater elevation monitoring was conducted in 10-minute intervals at five monitoring well locations (Figure 14). Results suggest no effect on the local groundwater elevation related to the presence of EGRP®s with groundwater elevation fluctuating similarly in response to rain events on both the test and control sites (ECT 2016). Finally, on October 10, 2014 groundwater was collected from locations both in the control and test sites and measured for total phosphorus, chloride, total dissolved solids, and E. coli and there was no discernable difference between the two locations (ECT 2016). While no definitive conclusions can be made from a single data point, it is encouraging that there was no measured detrimental effects to groundwater quality post installation.

Belle Isle Shelter 5, Detroit MI

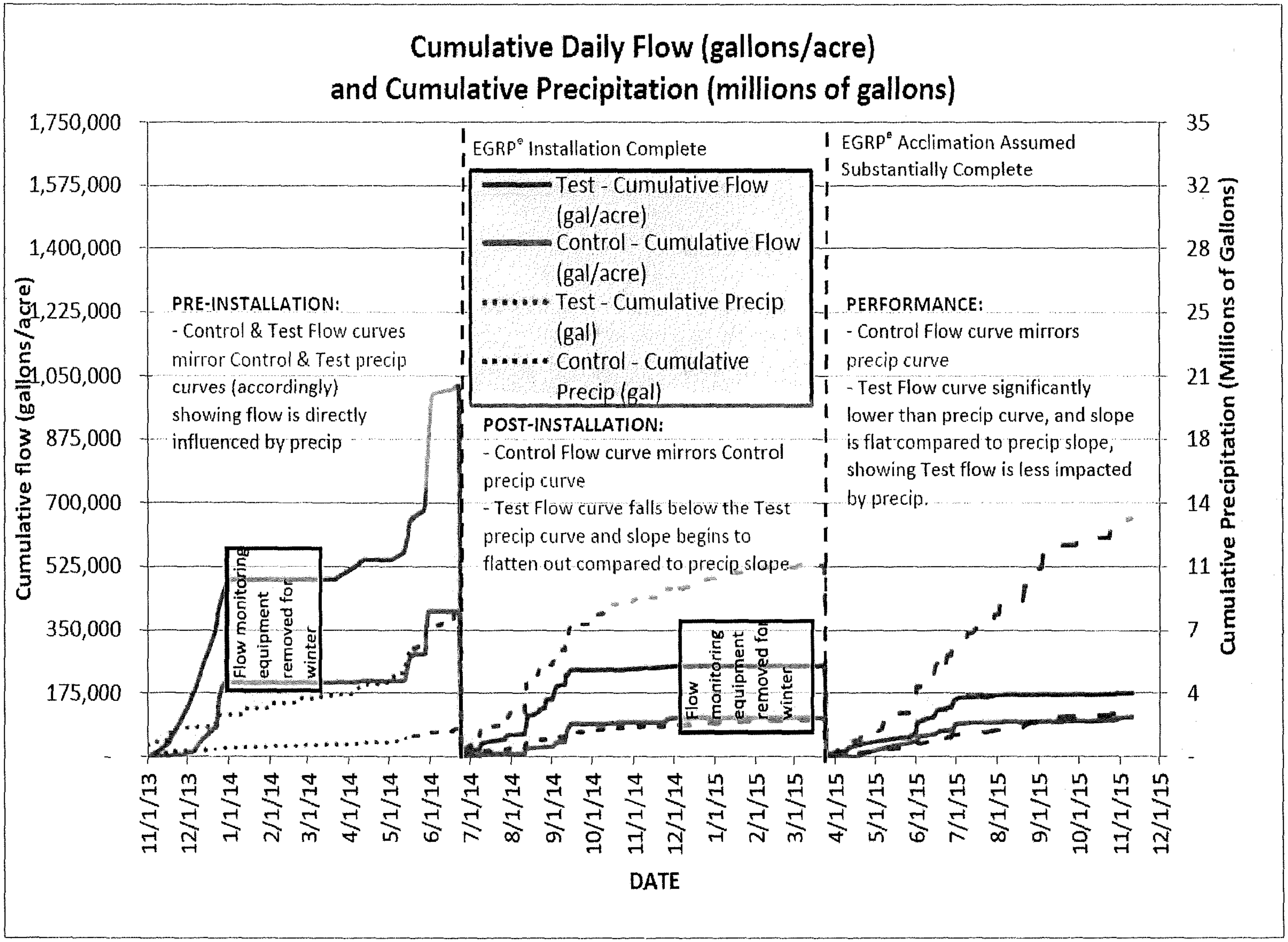


Figure 12: Cumulative daily flow and precipitation during study investigation (ECT 2016).

Belle Isle Shelter 5, Detroit MI

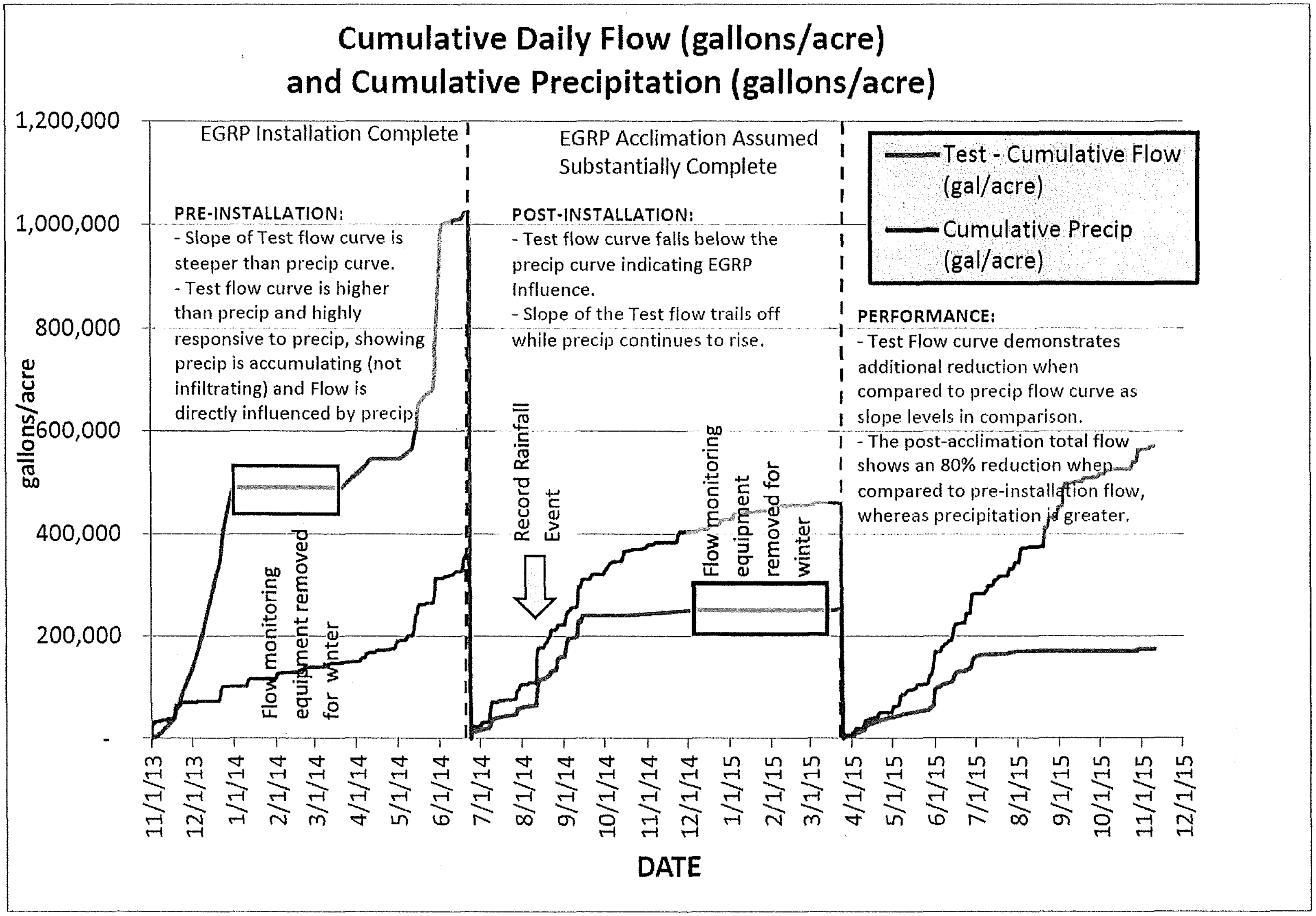


Figure 13: Cumulative daily flow and precipitation for test site during study investigation (ECT 2016).

Belle Isle Shelter 5, Detroit MI

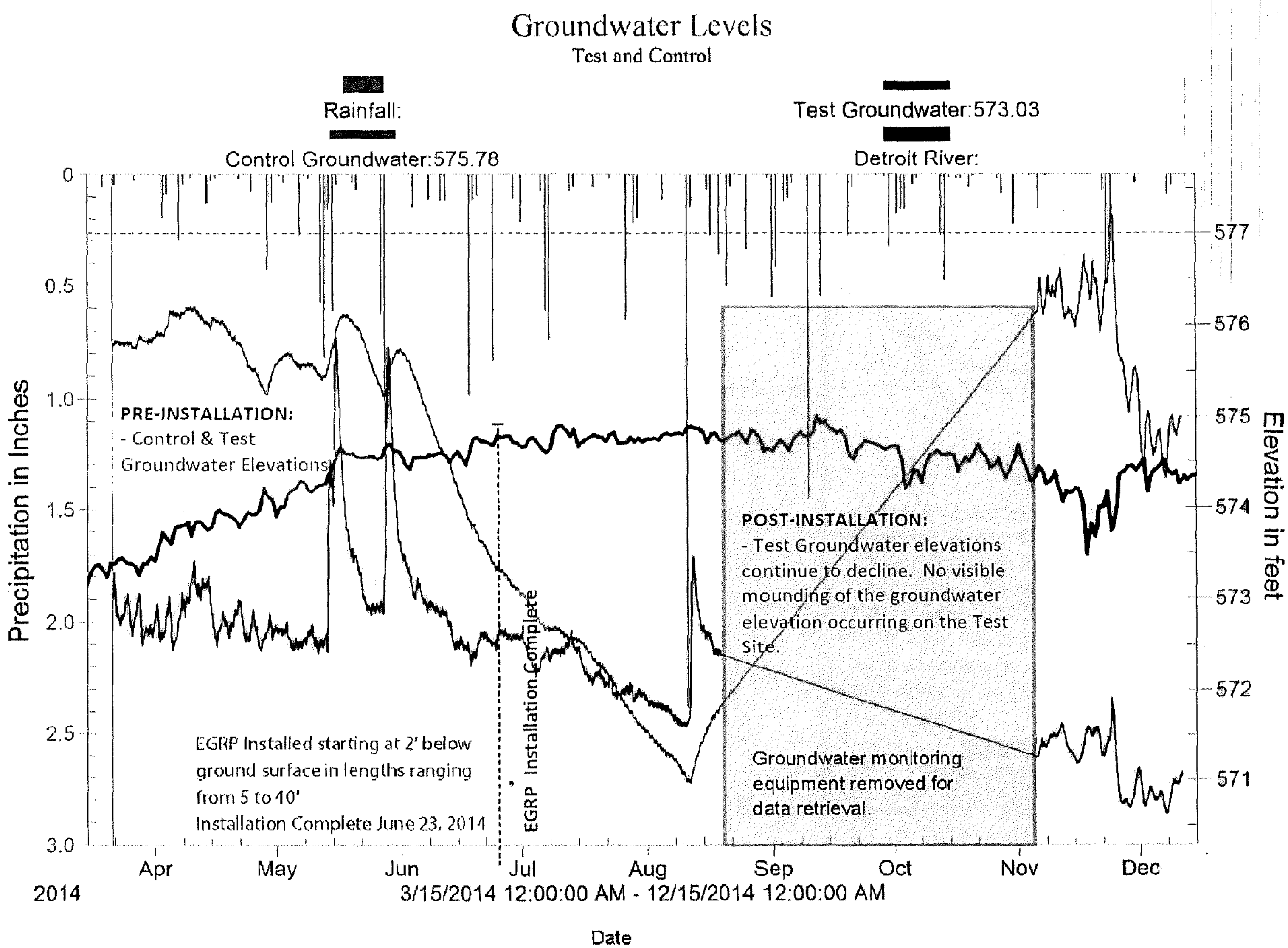


Figure 14: Groundwater and Detroit River water levels during investigation (ECT 2016)

Coleman A. Young International Airport, Detroit MI

This test site is located in the south west corner of the Coleman A. Young International Airport in Detroit, Michigan (Figure 15). This project was developed to address to the concerns of the Michigan Department of Environmental Quality (MDEQ) in regards to the EGRP® system's influence on the infiltration of surface water and its potential to accelerate surface water contaminates into the groundwater supply. The project was under the supervision of the MDEQ and conducted by Dr. David Lusch from Michigan State University (MSU) with consultation from Dr. Donald Carpenter from Lawrence Technological University (LTU). The testing involved the launching of a bromide slug into an infiltration pond where EGRP®s were installed. After the slug was launched a continuous water level of 6" was kept on the pond to simulate a "worst case" scenario of long-term ponding of storm water runoff.

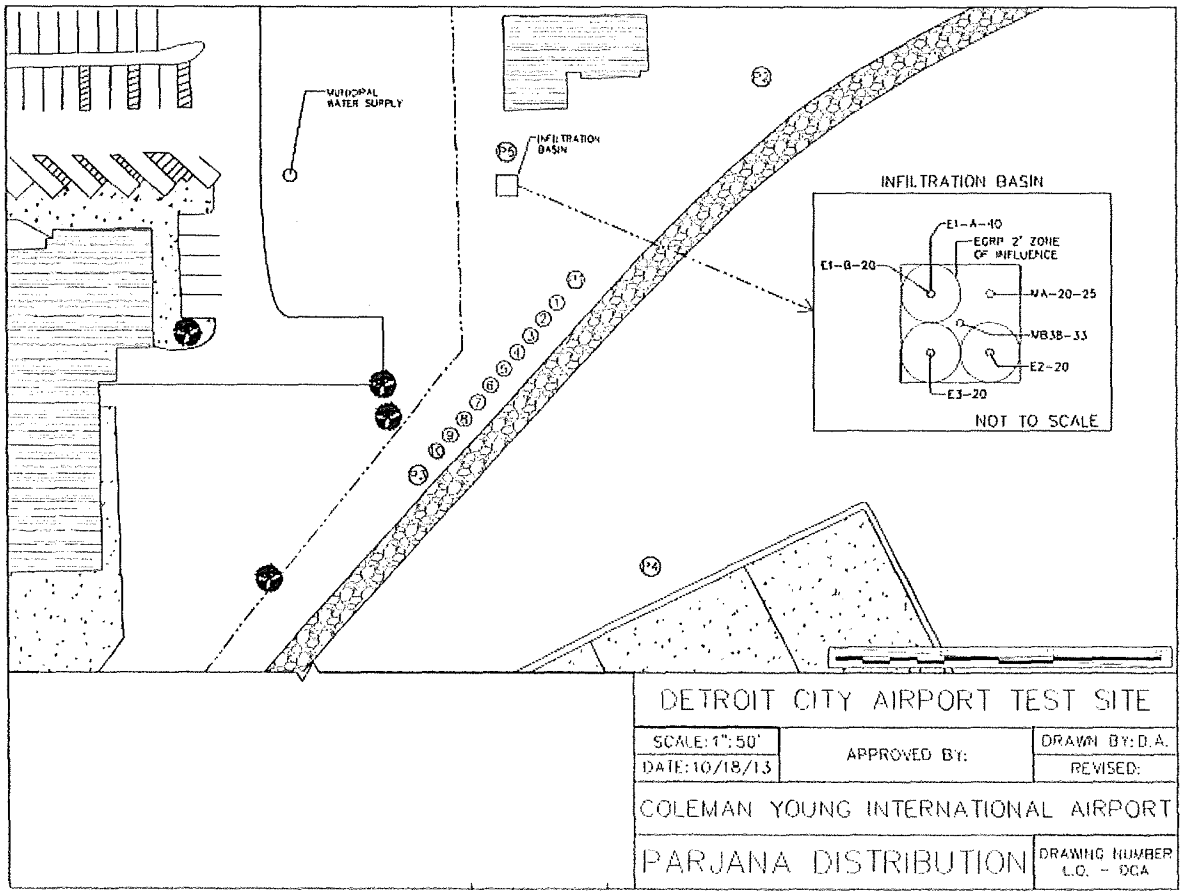


Figure 15: Site Layout for Coleman A. Young Infiltration Study

Table 4: Description of Monitoring Wells and EGRP®s show prior in Figure 15.

EGRP® AND MONITORING WELL DESCRIPTIONS

Sampling Well Name	Depth	Screen Interval	Description
MA-20-25	27.3'	25'-20'	1" Ground water monitoring well located in EGRP® infiltration basin
MB-38-33	38'	38'-33'	1" Monitoring well located in EGRP® infiltration basin
E1A-40	40'	40'	A 40' EGRP® device installed with a 40' ground water sampling tube
E1B-20	20'	20'	A sampling tube installed 20' below grade on the 40' EGRP® device
E2-20	20'	20'	20' triple EGRP® device installed with sampling tube 4" below grade
E3-20	22'	20'	20' triple EGRP® device installed with sampling tube 2' below grade
P1	22.55'	20'-15'	1" Ground water monitoring well located Southeast and downstream of infiltration basin
P2	40'	38'-33'	1" Ground water monitoring well located Northeast and upstream of infiltration basin
P3	27.5'	25'-20'	1" Ground water monitoring well located Southwest and downstream of infiltration basin
P4	40.8'	39'-34'	1" Ground water monitoring well located South and downstream of infiltration basin
P5	31.1'	29'-24'	1" Ground water monitoring well located North and upstream of infiltration basin

Coleman A. Young International Airport, Detroit MI

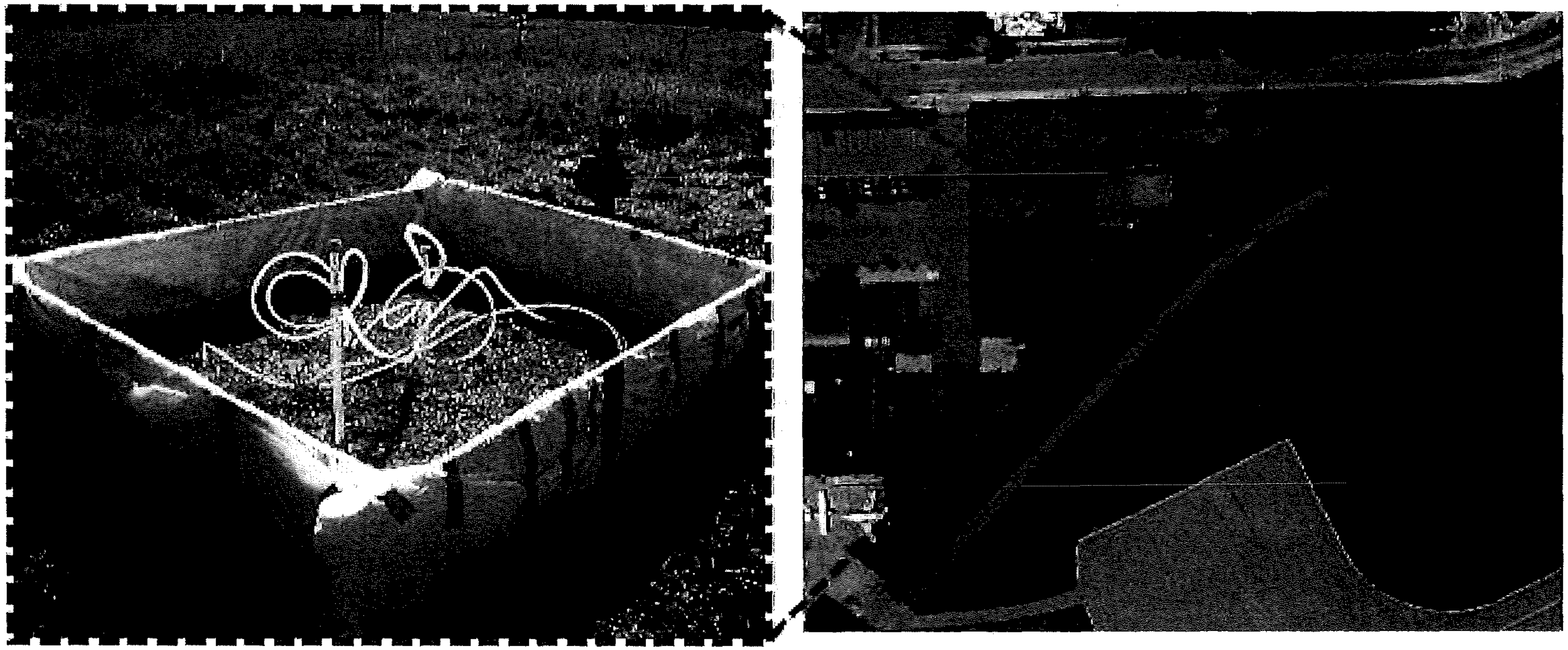


Figure 16: Aerial view of testing site at Coleman A. Young International Airport, Detroit, MI

Results:

Data showed that the EGRP® increased the infiltration rate of surface water 7 to 10 times the rate of native soil conditions (Lusch 2015). However, bromide concentrations were not detected at the bottom of the EGRP® installations until between 16 (E2-20) and 68 days (E3-20) after the slug test was administered. As such, the study also concluded that EGRP®s do not act as vertical drains or injection wells that allow water, along with its' constituents, to flow straight down to the bottom of the EGRP® systems (Lusch 2015).

Geneva International Airport, Switzerland

Parjana® EGRP® system was installed at Geneva International Airport (GIA) in late 2012 and was constantly monitored through piezometric testing for nearly two year (GADZ 2014). The goal for GIA was to reduce or eliminate water seepage into underground concrete chambers that are common at the airport; especially chambers that are remote from existing stormwater sewer systems. The research goal is to compare the effects of EGRP® device on shallow water tables and soil moisture distribution. Unlike other typical EGRP® installations, this location had no issues with standing surface water.

Geotechnique Appliquee Deriaz SA (GADZ) compared piezometric water levels between two different zones - one with and one without the EGRP® (Figure 17 and 18). The top soil layers were primarily silt and silty fine sands and were found to have low permeability. The deeper soil layer consisted of a well stratified preconsolidated sandy loam (glacial Moraine) with higher vertical permeability and significantly higher horizontal permeability (10 to 100 times greater) (PCS 2014). The 40 ft deep EGRP® installations on the four corners, and some of the shallower EGRP® installations, penetrate the deeper Moraine soils (Figure 10) (GADZ 2014).

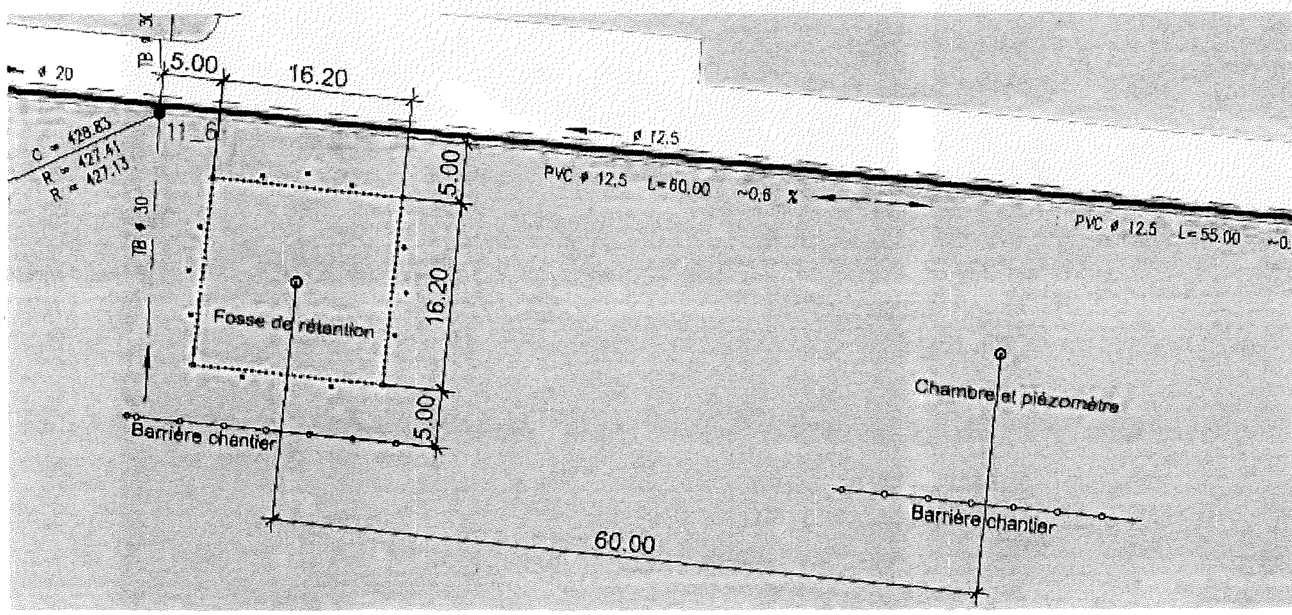


Figure 17: Test study layout adjacent to taxiway at GIA (GADZ 2014).

Geneva International Airport, Switzerland

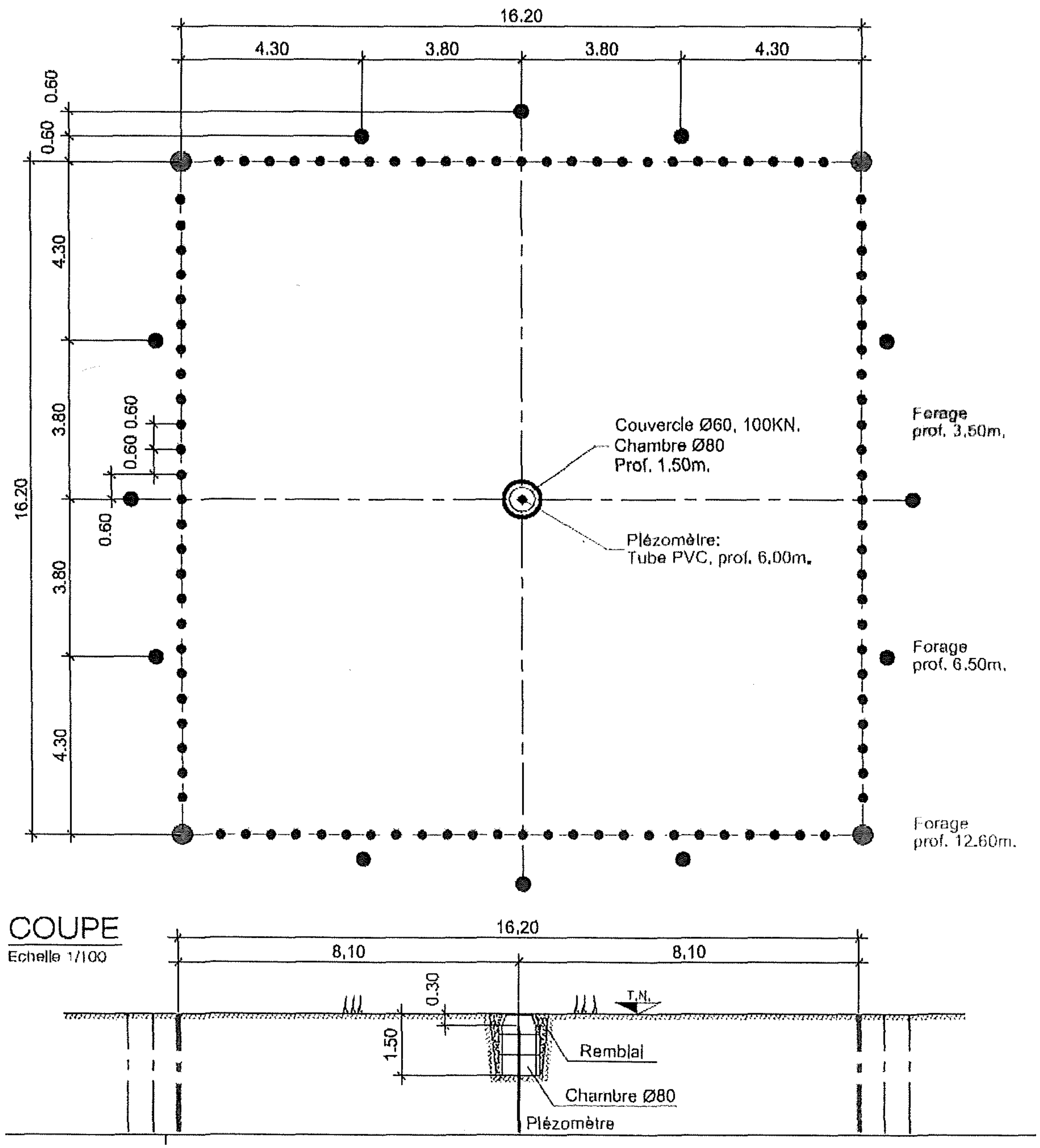


Figure 18: Layout of EGRP® system at GIA (GADZ 2014).

Geneva International Airport, Switzerland

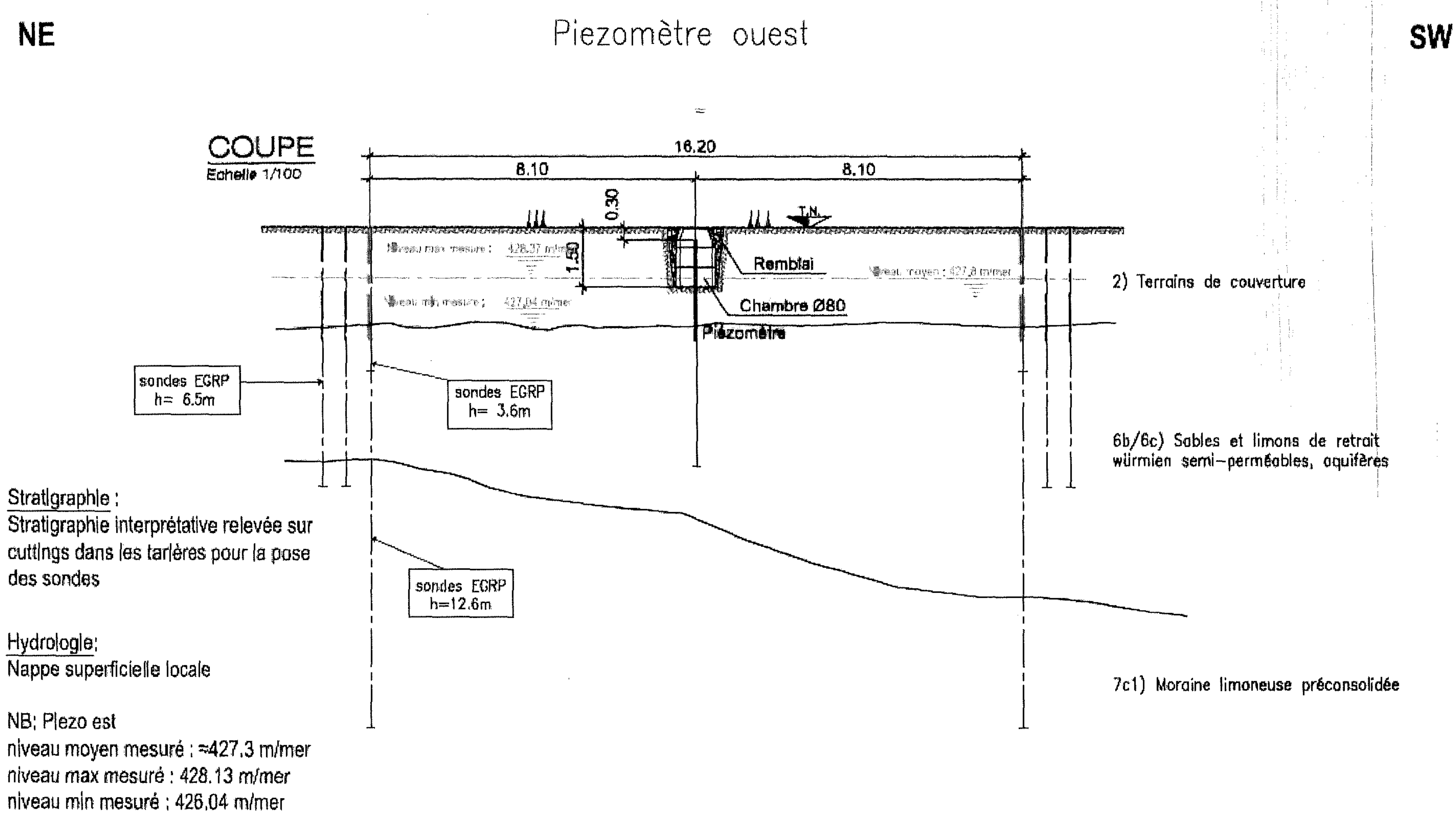


Figure 19: Cross-section of EGRP® installation through stratified soils (GADZ 2014).

Geneva International Airport, Switzerland

Results:

Initial results (PCS 2014) concluded that the level of water table reacts immediately in both zones during "extended" (over 24 consecutive hours) and "intense" (over 0.4 inch) rainfall periods. However, the impact of those rainfall events on increasing the water table level is clearly less in the EGRP® zone (average of 73% less). Likewise the lowering of the water table level after a rainfall event is often clearly less in the EGRP® zone. An example of this is visible in Figure 20 which presents the results of three months of testing (January to March) (GADZ 2014). The report also indicated the water table was higher in the area of the EGRP® system during dry periods. GADZ attributed this to the fact the EGRP® "worked to maintain a degree of saturation as constant as possible in the soil" and the EGRP® system is moving water vertically in both directions thereby creating communication between the surficial layers of topsoil and the permeable to semi- permeable soils beneath (PCS 2014).

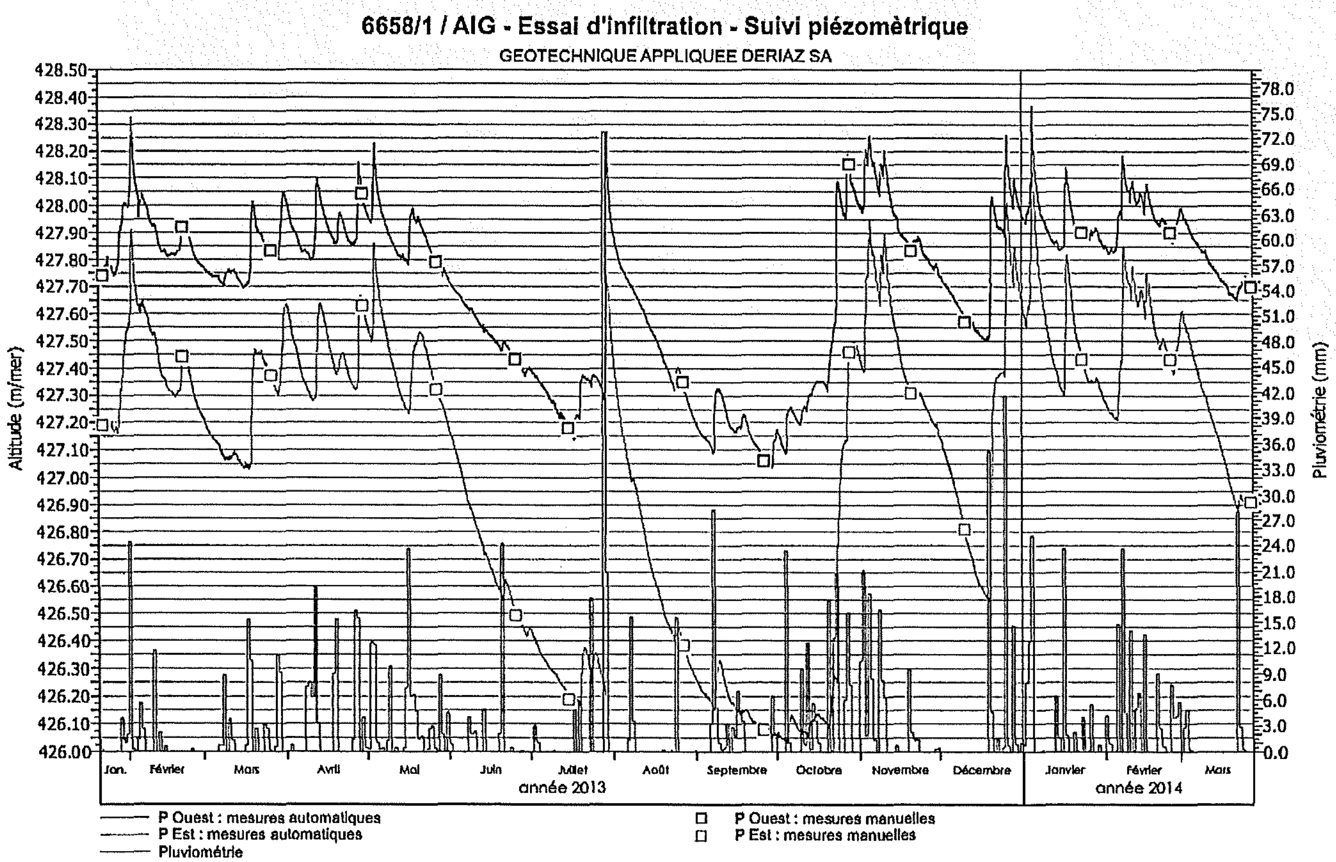


Figure 20: Comparison plot of variation of groundwater levels along with rainfall over period of time at the locations with and without EGRP®, installed at Geneva airport (GADZ 2014)[1].

[1]Original figure in French – groundwater elevation is on left axis and rainfall on right axis

Mettetal Airport, Canton MI

The site is located in the south-west corner of the Mettetal Airport in Canton, Michigan. Figure 21 shows the geographical location of the testing site in relation to the rest of the airport property and the layout of EGRP® installed around forebay. The test site consisted of an initial forebay where water flows and infiltrates into the larger detention pond. The forebay was originally designed for a 1–inch rain event. When there is a rain event above 1-inch or multiple rain events in a row, the water overflows and is released into the detention pond without filtration. Prior to the installation, the forebay did not adequately drain.

The testing was conducted by Mannik & Smith Group, Inc. (MSG 2015). The investigation included tracking water levels in the sediment forebay and four close proximity monitoring wells. The purpose of the investigation was to determine if the EGRP® system would reduce surface water in the forebay and eliminate water within 72 hours following a 1" rain event.

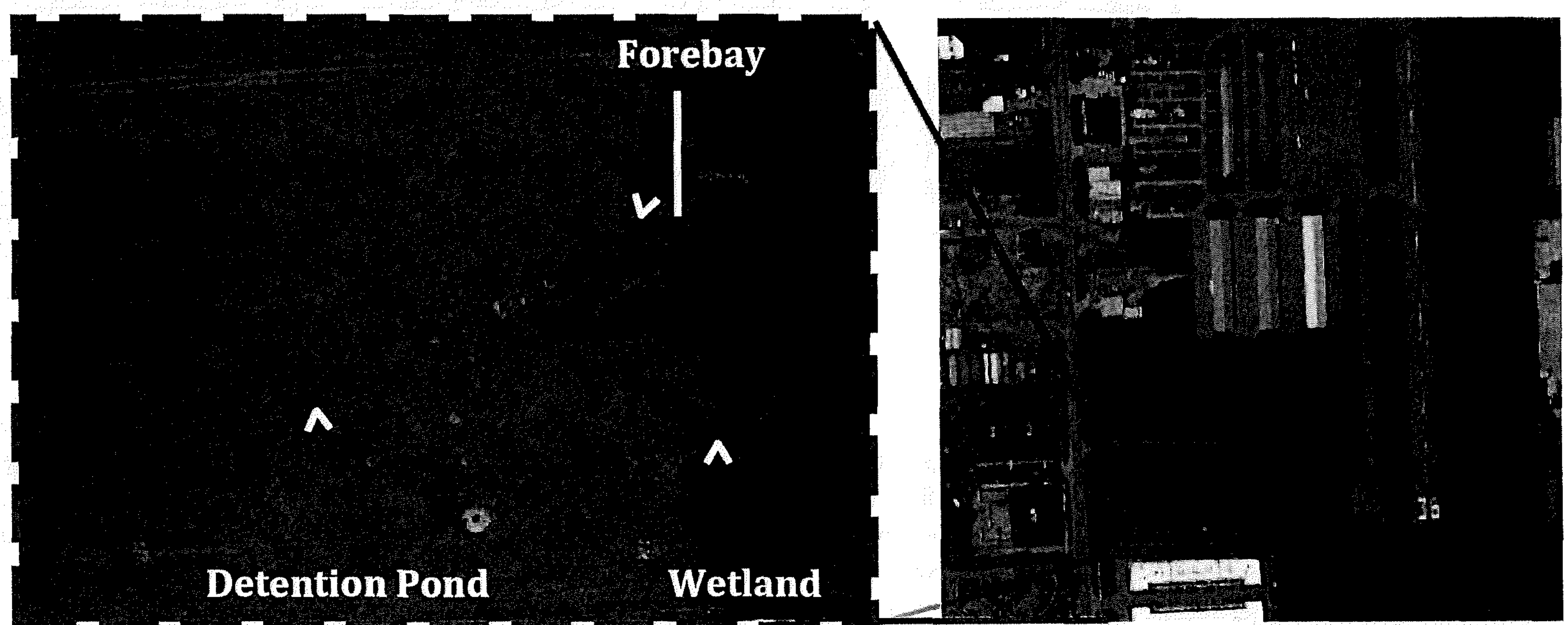
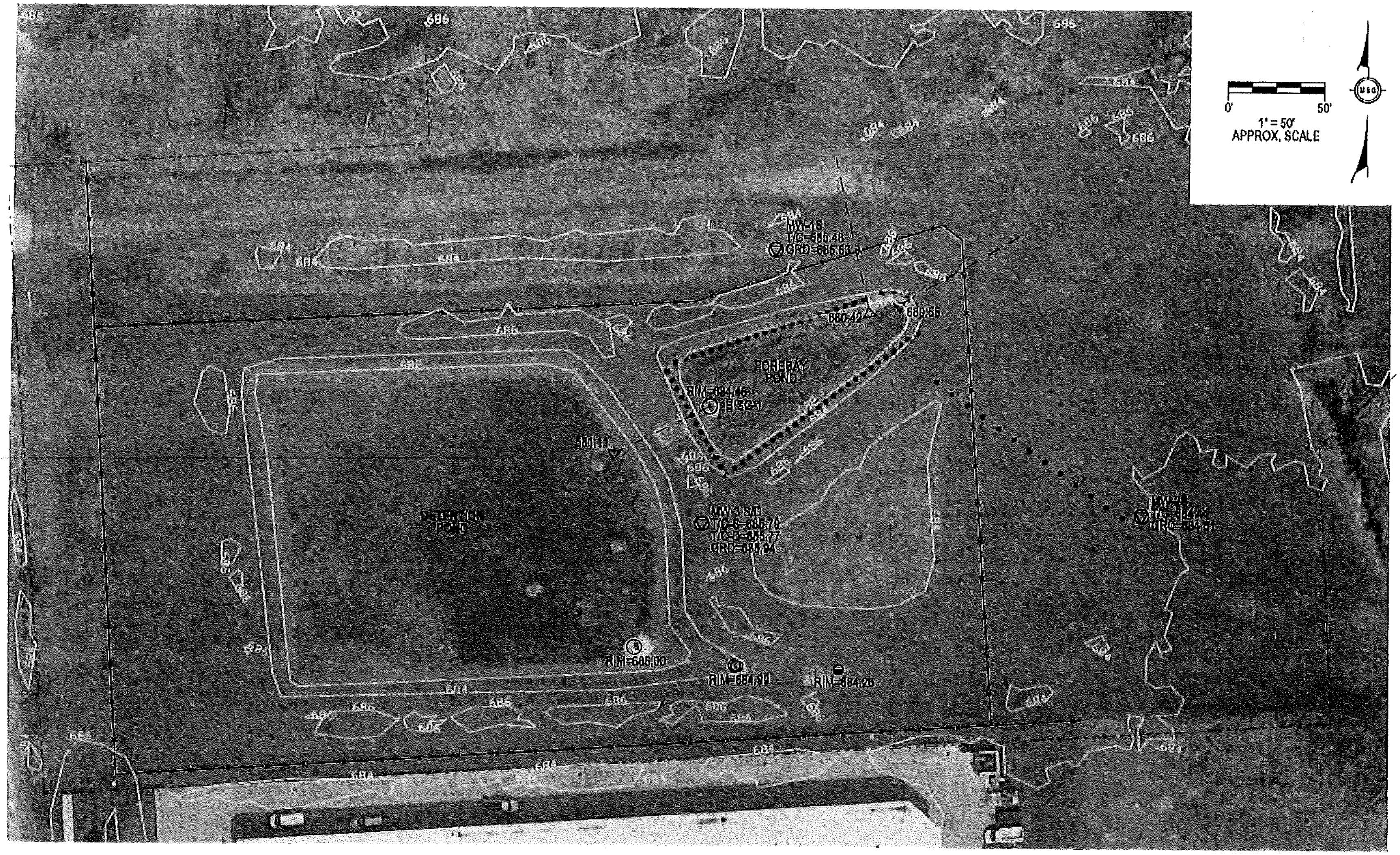


Figure 21: Geographical location and layout of Mettetal airport showing position of installed EGRP® System.

Mettetal Airport, Canton MI



NOTE: EGRP LAYOUT WAS ADAPTED BASED ON DESIGN DRAWING PROVIDED BY PARJANA DISTRIBUTION, DATED 9/9/13.

ELEVATIONS ARE REFERENCED TO A USGS BENCHMARK

LEGEND

MONITORING WELL
T/C = TOP OF CASING ELEVATION
GRD = GROUND ELEVATION
POND OUTFALL
POND INLET
STORMWATER UTILITY
STAFF GAUGE
FENCE
PROPERTY LINE
CATCH BASIN
OVERFLOW STRUCTURE
RIM = RIM ELEVATION
SINGLE 20' EGRP
TRIPLE 20' EGRP
CONTOUR (2' INTERVAL)

Figure 22: Layout of EGRP® system installed and location of monitoring wells (MSG 2015).

Results:

Figure 23 shows the water level decreasing to previous levels less than 72 hours after a 1" rainfall, which was the goal of the EGRP® system for this project. However, lack of pre- installation data and inconsistencies in variables during the course of the investigation means that MSG is unable to confirm the influence of the EGRP® system on improving infiltration (MSG 2015). MSG did determine that water levels in the shallow monitoring wells mimic the water levels in the forebay closely and are shown to be influenced by rainfall events almost immediately. This indicates good hydrologic connection between the forebay and shallow monitoring wells. Water levels in the deep monitoring well (located in underlying class soils) do not exhibit the same fluctuations and there appears to be no significant hydrologic connection. (MSG 2015).

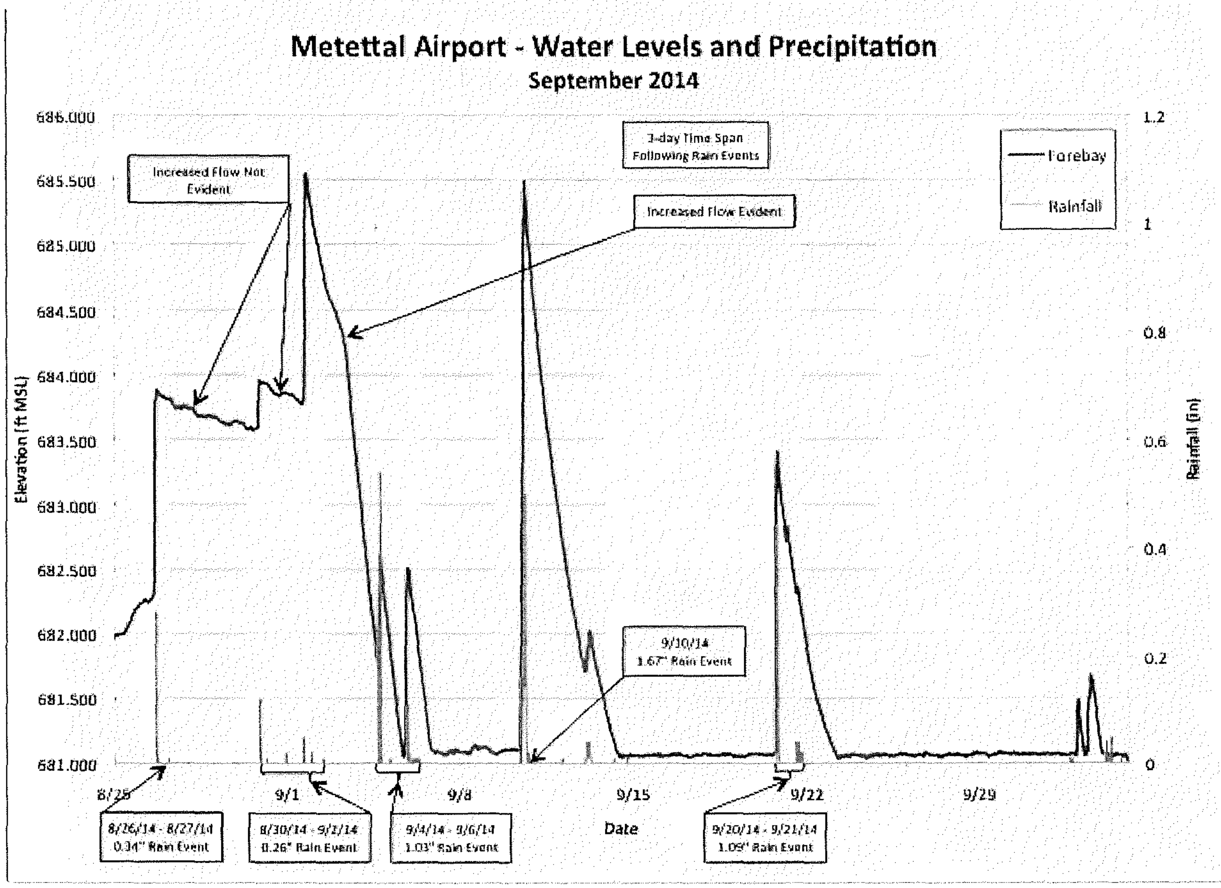


Figure 23: Metettal Airport water levels in response to precipitation (MSG 2015).

Edgbaston County Cricket Club Practice Area, Birmingham, UK

The Edgbaston County Cricket Club (Club) had an EGRP® system installed by Groundwater Dynamics in May of 2013 (GDL 2013) to improve drainage on a practice area that was known for standing water (Figure 24).

The overall soil profile was deemed of poor texture with high silt and clay content and compacted by use (Woodham 2014). STRI Ltd was commissioned by the Club to undertake an independent assessment of the practice area for infiltration, surface firmness, and soil moisture and how they might relate to the installation of the EGRP® system (Woodham 2014).

Results:

STRI Ltd found increased infiltration in areas that were previously deemed unusable for play by the Club (Woodham 2014) which is shown in Figure 25. They also reported that the turf health was in good health for the time of year (May) and that given recent inclement weather "the playing surface was relatively firm and dry (Woodham 2014)." They concluded that the drainage infiltration rates "are more promising and higher than could have been expected given the nature of the site" and were likely contributable to the EGRP® system (Woodham 2014). However, they are unable to confirm these results because there was no testing performed prior to installation. Finally, they conclude that surface firmness and moisture content do not appear to be correlated with the location of the EGRP® system and that excess moisture retention is more likely the result of "excess thatch and compaction" (Woodham 2014).

Edgbaston County Cricket Club Practice Area, Birmingham, UK

Figure 24: Edgbaston Cricket Ground practice field in Birmingham, England in March 13, 2014 at 5pm.

Figure 25 :Edgbaston Cricket Ground practice field in Birmingham, England on March, 14 2014 at 9 am.

References

Drummond Carpenter, PLLC. "Comparison of Groundwater Levels and Gradients: 2016 vs. 2017" April 17th, 2018.

Nikolai, Thomas A. "2017 Statistical Analysis Summary." Michigan State University. January 10th, 2018.

Environmental Consulting and Technology, Inc. (ECT). "EGRP® Pilot Demonstration Project on Belle Isle, Detroit Michigan Technical Memorandum" February 10, 2016.

Geotechnique Appliquee Deriaz SA (GADZ), "Test de l'aéroport de Genève Infiltration," August 25, 2014.

Greene, Jay. "Project to test storm water removal technology on Belle Isle" Crains Detroit Business Vol. 29 No. 41 October 7, 2013.

Groundwater Dynamics Ltd (GDL), "Edgbaston Cricket Stadium Installation," Video by Groundwater Dynamics Ltd. https://www.youtube.com/watch?v=aTJSV7wdse4. January 15, 2015.

Litcherman, Joseph. "Detroit signs deal to lease Belle Isle to state" Reuters. Tue Oct 1, 2013 6:15pm.

Lusch, David. "EGRP® Infiltration Test at Coleman Young International Airport," Final Report Submitted to MDEQ Groundwater Discharge Program, February 6, 2015, 43 pp.

Mannik Smith Group (MSG), "Forebay Infiltration Pilot Study: Mettetal Airport Application of Parjana®'s EGRP® System, Canton MI," Final Report Submitted to Parjana® Distribution LLC, January 16, 2015.

Parjana® Cleantech SA (PCS), Translation of the French language GADZ Report on Geneva Airport Infiltration Test, October 26, 2014.

Soils and Materials Engineers, Inc. (SME), "Draft Supplemental Work Plan to Test Parjana® EGRP®s Coleman A. Young International Airport Detroit, MI" SME Proposal No. PO2442. 12, July 18, 2013

Woodham, Paul. "Assessment of Edgbaston County Cricket Club Practice Area," A Report by STRI Ltd, April 1, 2014.