

WHITE PAPER REVIEW

Parjana EGRP[®]

Prepared by

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October, 2014

Introduction

In October 2013 Professor Herricks and Sidhartha Majumdar from the University of Illinois Center of Excellence for Airport Technology (CEAT) met with Andrew Niemczyk and Frank Muller from Parjana in Benton Harbor, MI. That meeting also included a conference call with Mr. Ryan King from the Airport Safety Research Branch (ANG E-261), FAA William J. Hughes Technical Center and staff of the Ft. Lauderdale Airport (FLL), including Mr. Carlos Hernandez. Mr Muller had presented a new technology to Mr. King in a previous meeting where Mr. Muller identified applications in airport safety management. The October meeting was arranged to review a possible application of the technology at FLL and establish a path forward.

At the October meeting the Energy-Passive Groundwater Recharge Product (EGRP[®]) technology was described and the possible airport safety applications reviewed. These safety applications revolved around the control of standing water on soil surfaces with applications to wildlife management and all areas where standing water on soil surfaces must be controlled. Staff from FLL indicated interest in the technology but needed more information on the technology to move forward. Parjana identified a number of locations where the technology was installed and also indicated that research was underway to better define performance characteristics of the technology. Professor Herricks agreed to undertake a review of the technology, visit field sites where the EGRP[®] technology was installed, and report on his findings. This White Paper is the report of those findings!

The EGRP[®] Technology

The EGRP[®] technology represents an innovative approach to standing water control using fundamental physical principles that apply to liquid water and water molecules. The actual physics of EGRP[®] operation has not been scientifically defined but it is possible to characterize the likely mechanisms of operation based on the design of the EGRP[®] apparatus and the results of field trials. This report provides a description of the apparatus and a proposed characterization of the mechanisms of function of the apparatus.

The EGRP[®] system is made up of multiple units that in turn have multiple elements. To address a problem the system is configured with multiple units, each unit with several elements, in a geometry that is designed to meet site specific conditions. The unit of operation is the EGRP[®] element. The element consists of five crescent-shaped plastic extrusions joined together. Element configuration is shown in Figure 1. Each element is installed vertically in a hole approximately 1.5 inches in diameter. A cap terminates the top of the element, Figure 2, which

is placed approximately 1 foot below the soil surface. The resulting soil layer acts as a filter as water infiltrates from the surface to be influenced by the EGRP[®] system. The cap also prevents the element from becoming a conduit for liquid movement. Elements may vary in length.

The passive design of the EGRP[®] is unique, and much different than traditional drainage technologies. My examination of the system suggests that element operation is based on a complex set of physical processes operating on water in liquid and molecular forms, which results in the distribution of water in the vadose zone. Each element facilitates the movement of liquid water from locations of higher concentration/density to areas of lower concentration/density. The actual physical processes involve diffusion of water molecules in the soil matrix that is governed by gravity, capillary action, osmotic forces, surface tension of the EGRP[®] and soil particles, and other mechanisms. These mechanisms take advantage of the EGRP[®] system to establish a connection between the near surface soils and the soil matrix along the full length of an element. When placed vertically in an area the unit facilitates the movement of water from the surface to the adjacent soil matrix. The mechanisms of this movement are passive depending on concentration/density differences and small scale forces acting on soil particles and water molecules. The overall infiltration of water is enhanced after EGRP[®] installation because the EGRP[®] elements provide a mechanism to change the way water is distributed in the soil matrix. The EGRP[®] element with open crescents uses the continuous surface of the element and close association with soil particles to facilitate water movement. It is the interaction between liquid water, and water molecules, with soil particles that is the foundation of EGRP[®] system operation. The result is that water can move more freely into the soil matrix, influencing soil surface conditions. The effect of the installation of the EGRP[®] system is a long-term change to surface soil saturation. The end result is that wet areas are “dried” and the capacity to address nuisance conditions is enhanced.



Figure 1. EGRP[®] tube extrusion showing crescent-shaped elements clustered together.

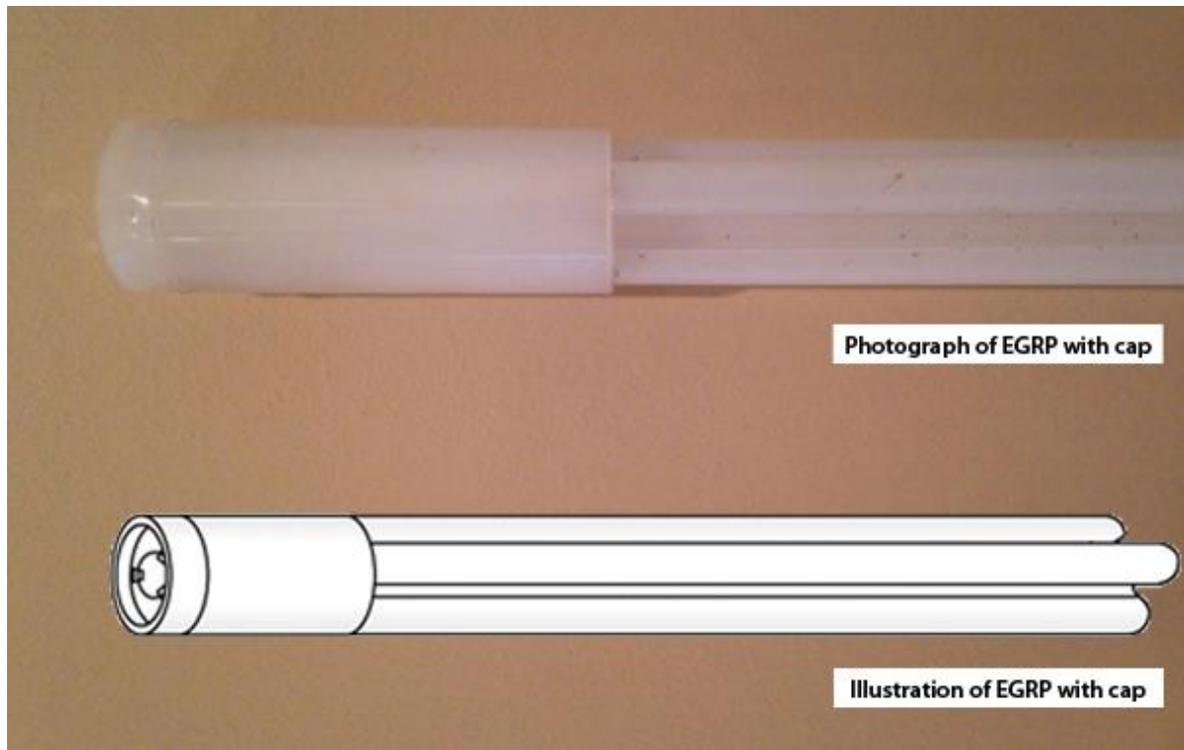


Figure 2. EGRP[®] tube cap.

Because the mechanisms of operation are complex and passive, no actual flow of water is typically observed. Further, guidance provided by Parjana notes that there will be a period of acclimation as the EGRP[®] system adjusts water movement in the vadose zone. The EGRP[®] system design is site specific with the design considering element depth, unit number, and system geometry. Figure 3 provides an example of EGRP[®] design components that includes elements of different depth, unit spacing, and system geometry.

Discussions with Parjana personnel indicate that design effectiveness has been empirically developed and that although research has not characterized and quantified the processes involved to fully support the design process, existing EGRP[®] system designs will meet performance criteria.

My characterization of basic function of the EGRP[®] system finds that the pathway created by the EGRP[®] unit equalizes water amounts from the surface through the depth of the unit. With units installed at different depths the surface water will be distributed over different volumes of soil at different rates. Since there is no direct contact between the tube and ponded surface water, the movement of water into the EGRP[®] is initially by infiltration, taking advantage of the natural filtration capability of the soil to minimize groundwater contamination. The EGRP[®] system then serves to distribute water in a large volume of soil defined by tube depth. Parjana has indicated that research is underway to not only better define design/performance relationships, but also determine the physical processes involved supporting better quantiation of process mechanics.

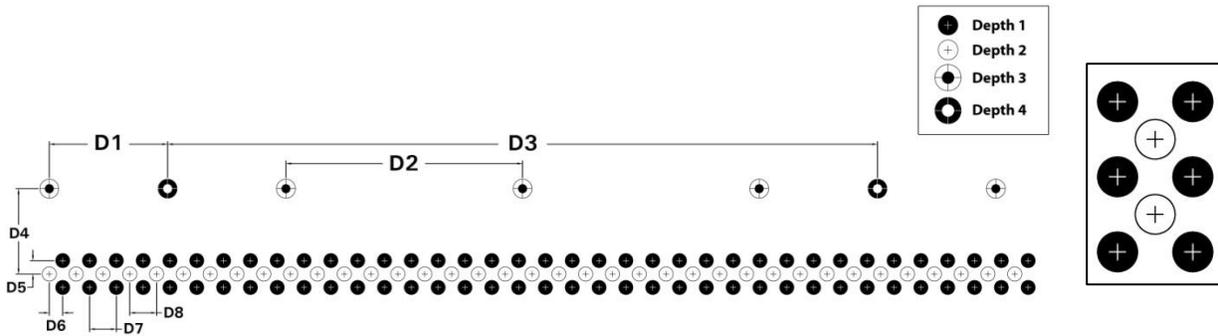


Figure 3. Example design of an EGRP[®] system installation showing the use of different depths and geometric configuration in the design.

Site Visits

As part of this review of Parjana EGRP[®] system technologies visits were made to locations where the EGRP[®] system was installed. At each of these sites Parjana had cooperated with clients or governmental agencies to monitor the effect of system installation.

The first Parjana installation visited was located at the Coleman A. Young International Airport (DET), Detroit, MI. The airport has two runways with commercial service facilities. The drainage problems included an area, Figure 4, where surface waters were interfering with airport facilities. Parjana installed an EGRP[®] system, which is being monitored by the Michigan Department of Environmental Quality (MDEQ). MDEQ developed a monitoring program and installed piezometers to measure differential soil water levels, Figure 5. Unfortunately, data from this monitoring was unavailable for this report.

A second installation was located at the Detroit Canton–Plymouth Mettetal Airport (FAA:1D2). The Mettetal Airport is a public use airport operated by the Michigan Department of Transportation. The airport is uncontrolled, and is used for corporate and general aviation. The airport has an area of 63 acres (25 ha) at an elevation of 696 feet (212 m). The airport has experienced drainage problems as well as problems with an existing storm water detention system not draining as designed. Parjana has installed an EGRP[®] system to address issues in storm water detention basins. At the time of my visit to the airport the installation of the EGRP[®] system had recently been completed. Figures 6 and 7 provide evidence of the installation where small mounds of dirt show the spacing and EGRP[®] elements. These pictures illustrate the relatively low impact produced by installation of the EGRP[®] system. Figure 6 illustrates the general geometry of the placement of EGRP[®] elements and Figure 7 provides an indication of unit spacing. Although no specific monitoring program was developed for this installation, a staff gage was installed for reference. Parjana provided information on EGRP[®] system influence on detention basin drainage. Figure 7 provides an illustration of detention pond condition at the time of the visit in November 2013, which is typical of poor drainage conditions. Figure 8 provides an illustration of the same pond 24 hours after a rainfall event at the end of June 2014 following approximately 6 months of EGRP[®] system operation.



Figure 4. Problematic area holding water at DET.



Figure 5. Michigan Department of Environmental Quality monitoring installation at DET.



Figure 6. Placement of EGRP[®] units associated with detention ponds at Detroit's Mettetal Airport.



Figure 7. Mounds of soil after installation of EGRP[®] units associated with detention ponds at Detroit's Mettetal Airport.



Figure 8. Detention basin at Detroit's Mettetal Airport in November 2013



Figure 9. The same detention basin as shown in Figure 8 24 hours following a June 2014 rain event that filled the basin.

The third airport installation visited was at the Geneva, Switzerland airport. This installation was also intended to address surface water problems at an airport. In this case the test installation included a reference site and a site where the EGRP[®] system was installed, Figure 10. The Geneva Airport installation was designed specifically to test the EGRP[®] system influence on surface soils. Two piezometer wells were installed adjacent to each other in an area of the airport that normally experienced wet soil conditions. One of these wells was at the center of an EGRP[®] system installation that is shown in the right hand side of Figure 10. The second piezometer was in an area with no modification other than the piezometer well. The piezometers were routinely monitored to provide approximately one year of post-installation monitoring, Figure 11. The results of monitoring have not been fully interpreted but there is a tendency to a reduction in groundwater elevation in the well surrounded by EGRP[®] units.

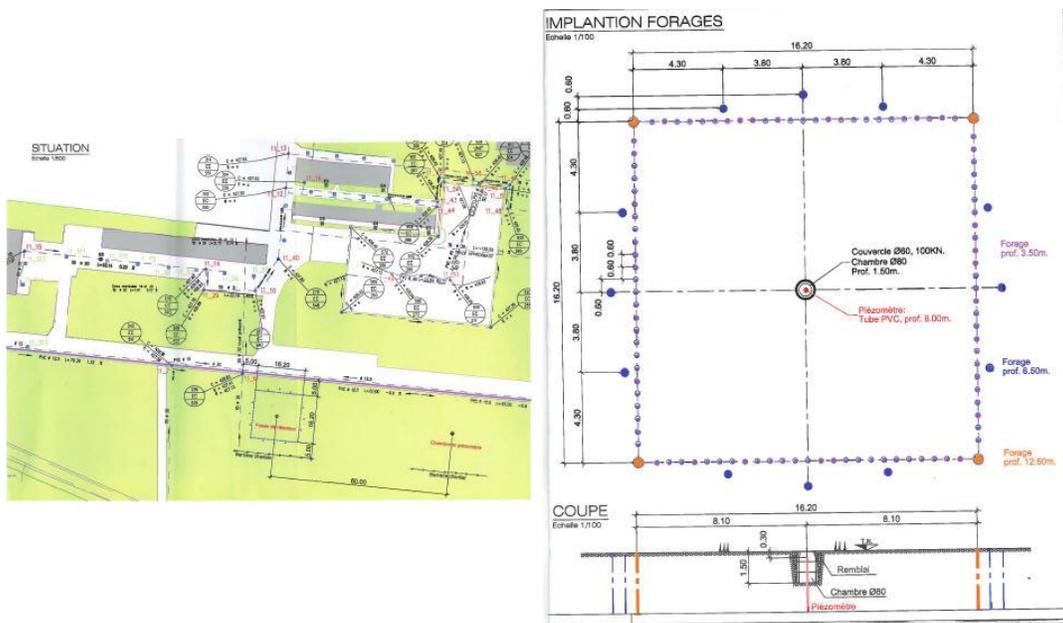


Figure 10. Illustration of the Geneva Airport EGRP[®] system installation.

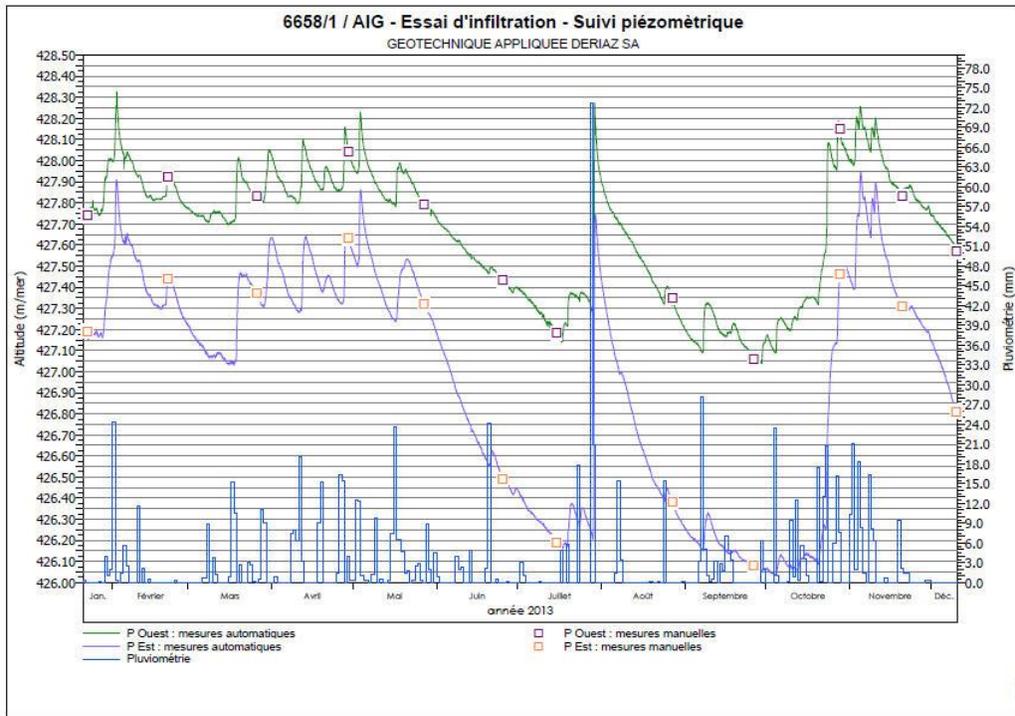


Figure 11. Results from piezometer monitoring of a reference and an EGRP[®] system.

Discussion and Conclusions

The intent of this white paper was to provide information on the Parjana EGRP[®] system. Following procedures established by the FAA Airport Safety Branch Professor Herricks has been regularly tasked with technology evaluation to determine possible applications in airport safety management. These evaluations examine technical issues but also include an assessment of the commercial status of the technology. The FAA's interest is not in development of new technology but in deployment of commercially available technologies to address airport safety issues.

The EGRP[®] system technology might best be described as novel and is unique in my over 40 years of experience in water resource management, including wetland design and operation. The system cannot be readily compared with existing surface drainage approaches and technologies that depend on pipes or channels to deliver water to holding basins. The EGRP[®] system is passive but has great capacity for water movement taking advantage of many mechanisms and processes. Conclusions from my analysis are: 1) the mechanisms and processes involved in the EGRP[®] are complex operating on water as a liquid and on water molecules; 2) the mechanisms of operation include the initial movement of water from the surface into the ground through infiltration. This movement is enhanced by the EGRP[®] system, which facilitates the further movement into the vadose zone by close association of EGRP[®] elements with the soil matrix; 3) The plastic extrusions of the element provide a path way and the crescent-shaped forms allow maximum contact with soil particles to enhance water movement; 4) Water is moved from higher to lower concentrations by mechanisms that include diffusion of water

molecules in the soil matrix, which is governed by gravity, capillary action, osmotic forces, surface tension of the EGRP[®] and soil particles, and other mechanisms resulting in a landscape system equilibrium between water input at the soil surface and distribution of water in the soil matrix; 5) The Parjana design establishes capacity and performance characteristics for an EGRP[®] system based on element depth, unit number and system geometry. The design, and design process, is a major proprietary element of the Parjana technology.

I found the information provided from monitoring of EGRP[®] systems that was provided by independent sources to be informative but not definitive. The DET monitoring data was not available for this report. The Detroit Mettetal Airport reporting was illustrative but not quantitative. The Geneva results identify both site differences and EGRP[®] system influence. The Geneva data suggest that there are differences between adjacent sites. The Geneva results also show the influence of rainfall on site conditions, which in turn suggest the influence of the EGRP[®] system. Early in the monitoring program the area was undergoing drought conditions and response to rainfall was different at the two sites. There also appears to be a more rapid change in water levels in the area where the EGRP[®] system was installed. Again, complete data was not available for this report.

When considering these results I have come to the conclusion that traditional groundwater level monitoring approaches are not fully appropriate for EGRP[®] system monitoring. Piezometers depend on open contact with the atmosphere in the well to establish a water level. Although a groundwater level may be indicative of EGRP[®] system performance, this approach to monitoring does not adequately measure the actual soil conditions or the real dynamics of water movement facilitated by the EGRP[®] system. Thus a piezometer measurement is only an indicator of groundwater condition and does not account for the likely mechanisms of movement from the surface to the soil environment that is related to an EGRP[®] system installation. I have reviewed this issue with Parjana personnel and research is underway to better define mechanisms of operation and the critical performance parameters important to some design specifications.

All this said the EGRP[®] works! Monitoring from Geneva indicate an influence of the EGRP[®] system on groundwater. The illustration from Detroit's Mettetal Airport points to the lowering of standing water in a detention pond following the EGRP[®] system installation. I have had the opportunity to evaluate studies of other installations and Parjana has an abundance of evidence of the efficacy of the EGRP[®] system. The process of integrating new technologies and new engineering approaches into accepted engineering practice is slow and the relationship between engineers and their clients typically result in very conservative decision making when a technology is not in a manual of practice. That situation exists for Parjana but should be changing as installation performance is demonstrated and research and monitoring efforts are completed.

My assessment is that the EGRP[®] system is fully commercial and it is being marketed worldwide.

I also feel that the EGRP[®] system will have many applications at airports. An obvious application will be the control of surface water that will be a needed element of wildlife habitat management on airport property. The EGRP[®] system can eliminate wet spots, improving

mowing effectiveness and controlling vegetation attractants. The EGRP[®] system can also provide a wide range of surface, and near-surface water management functions that can contribute to pavement stability and storm water management among possible applications. The EGRP[®] system adds a new tool to surface water management that may be particularly valuable in the highly constrained environment of airports.

I recommend that the FAA continue to follow developments in Parjana technologies. Considering that research on, and monitoring of EGRP[®] systems is ongoing, I also recommend that CEAT continues to interact with Parjana to confirm performance at airports.