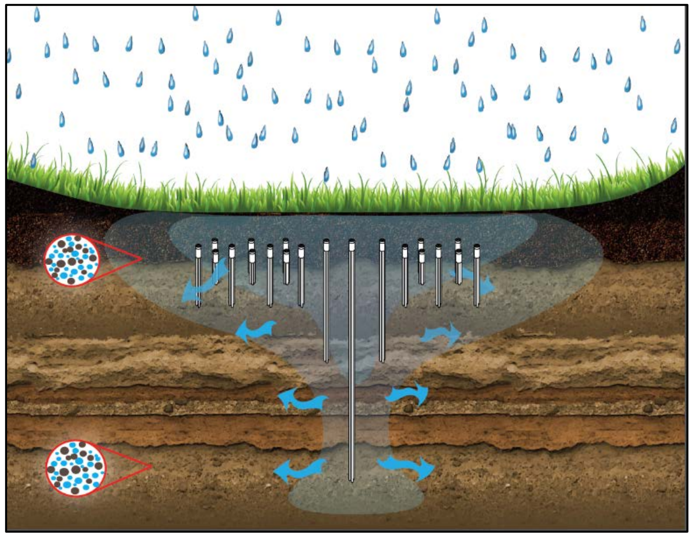
Integrating Stormwater & Groundwater Management with the EGRP®

What is the EGRP®?



Parjana® Distribution's innovative technology promotes surface infiltration through installation of Energy-Passive Groundwater Recharge Product (EGRP®) devices. By accelerating infiltration into and through the near surface soils, 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, filtered, and thereby improving water quality and reducing flooding.

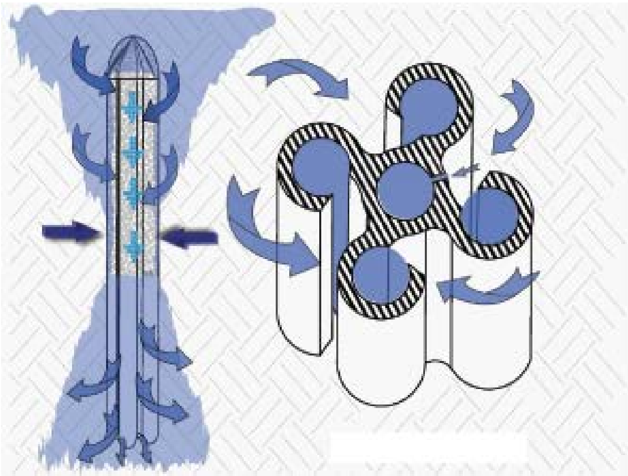
At each project site, a series of EGRP® devices are installed vertically into the ground underneath natural topsoil that allows water to be naturally filtered entering the EGRP®s. The devices can be operated with or without additional stormwater enhancement that can be used to increase volume storage and/or water quality. The many individual channels within the EGRP® arrays serve to initially capture surface water and subsequently dewater upper soils, thereby preparing the upper soil layer for the next wet-weather event.

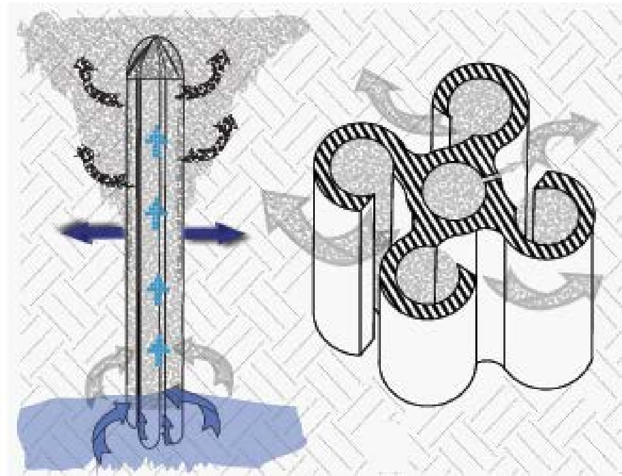
As the device fills with stormwater, water throughout the column is increased higher hydrostatic pressure and therefore increasing exfiltration into the most porous soils. At the same time, water in the upper region is drawn to the EGRP® along an established preferred flow path. This produces a column of saturated soil adjacent to the EGRP® that grows in diameter during a rain event and then contracts as that water proceeds through natural recharge processes. The larger number of very small columns lead to large improvements in infiltration efficiencies throughout the entire areas activated with the EGRP® systems.

Design Considerations

The EGRP® layout is designed utilizing an empirical model that requires knowledge of soil type, infiltration rates, area of influence, goal of the design, and impervious surfaces. The model uses real-world field data to optimize the spacing of the units in arrays customized for specific project needs given the expected soil transmissivity. The units are spaced closer together when soils are tight and/or there is a need to maximize the infiltration rate and further apart with more porous soils and/or locations that can tolerate short periods of standing water.

EGRP® channels enhance water movement into and out of the soils surrounding the device in a manner that increases over time. The illustration below depicts a "snapshot in time" of the general operation. The cap limit direct channeling of surface water to the top of EGRP®. The mechanisms of water movement through the EGRP® and into the soil cause the surrounding soils to alternate between saturated and unsaturated soils as water transfers from void space to adjacent void space.

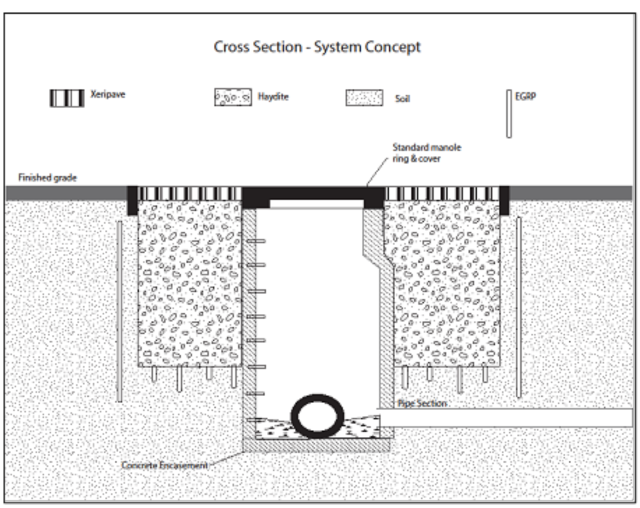


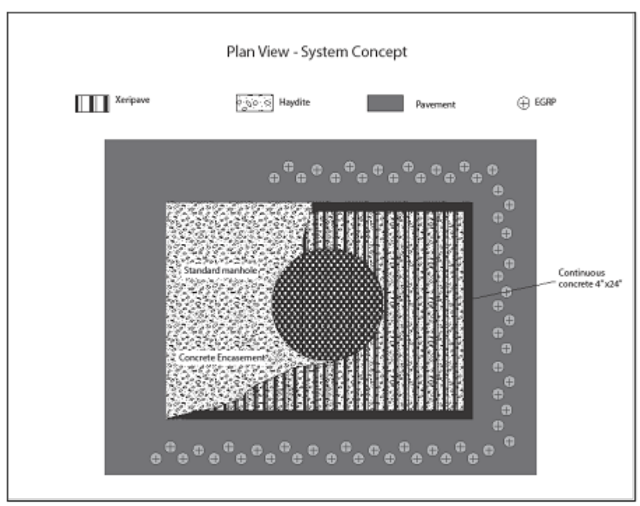


Augmenting Traditional Stormwater Practices

The total volume of water to be infiltrated by the EGRP® can be enhanced by pairing it with a traditional stormwater water practices that capture peak stormwater volumes, such as ponds, swales, or other storage devices. Other stormwater practices can be used to improve the water quality entering the EGRP® arrays. For example, the EGRP® technology can be paired with porous aggregate and pretreatment catch basins to effectively reduce stormwater volumes and improve the water quality of the infiltrated stormwater to reduce management costs and meet regulations. 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. As required by stormwater regulations, this systems approach results in reduced peak storm discharges, reduced downstream flooding, reduced stormwater runoff pollutant loadings, and an increase in recharged groundwater volumes.

The images below shows a cross section and top plan view of an existing stormwater manhole structure modification project utilizing this "systems approach". In the example, an area approximately 25'W x 25'L x 6' deep is cut out around the existing storm structure and storm sewer. Porous aggregate replaces the original engineered fill. EGRPs® are installed in a grid surrounding the aggregate. Pervious pavers are installed over the aggregate replacing traditional asphalt or concrete. Stormwater flows are captured by the aggregate until the pour volume is "full" after which the excess runoff flows into the storm structure. The catuered volume that is prevented from entering the





storm drain is stored in the pervious pavers and porous aggregate and ultimately infiltrated using EGRP® to rapidly incorporate the stored volume into the native soils.

No Adverse Effect to Water Quality

The EGRP® devices increase infiltration rate but also rely on native soils to cleanse the infiltrated water. EGRPs® are installed at least two feet below the top/ground elevation, with two feet of native soils. As a result, water introduced to the EGRP® devices have traveled through at least two feet of natural soil (and majority of the water has traveled further) before coming into contact with an EGRP® - thus pollutants with a propensity to physically filter and/or absorb are captured before entering a EGRP and are once again filtered as the water leaves the EGRP®.

In addition, time-dependent pollutants are also captured/reduced by the unit. The two-foot soil column that filters out pollutants, such as *E. coli,* substantially reduces the *E. coli* counts in two feet. Most of the research in this area has been done to document the effectiveness of drain fields and the same general principals applied to EGRP® installations. Notable references include Washington State Department of Health and University of Wisconsin white papers discussing vertical separation and efficacy in bacterial contamination and soil treatment. These studies, among others, document that the soil column above the EGRP® units can be expected to reduce the *E. coli* concentrations to acceptable levels. Other pollutants that are soluble are unabated by the soil column (e.g., salt and/or nitrates). Those pollutants, like salt, will pass through the soil column with or without EGRP®. The result will have no long-term impact on the groundwater quality.

Environmental Consulting & Technology, Inc., an independent, third-party entity, conducted a study on the EGRP® that demonstrated these water quality results. Summary of the study is included below.

Specifications

Name: EGRP® (Energy-Passive Groundwater Recharge Product)
Base lengths: 5’ (1.524 m), 10’ (3.048 m), 20’ (6.096 m) & 40’ (12.192 m)
Diameter: 1 ¼” (31.75 mm)
Color: Natural Transparent Clear, Colorless
Material: 100% Polyethylene

Each EGRP® has a central core with four crescents around the central core. EGRPs® are made of polyethylene and are chemically inert so as not to degrade in the soil. The plastic is rigid but flexible enough to meet the contraction and expansion required. The EGRP® has a smooth surface restricting siltation and/or clogging. Each EGRP® is capped to restrict the conduit for water free flow. The EGRP®s are placed underground, generally two to three feet below the surface in lengths of 5’ (1.524m), 10’ (3.048 m), 20’ (6.096 m) and 40’ (12.192 m). The diameter of the hole is 1 ¾” (31.75 mm).

Independent Testing and Results

There have been several independent studies conducted by third parties to validate the functionalities of the EGRP® system. Below are brief summaries and results of tests of the EGRP®.

EGRP® Test Site

Coleman A. Young Airport

The EGRP Test Site at the Coleman A. Young Airport in Detroit, Michigan was studied by the Michigan Department of Environmental Quality with validation from a distinguished senior research scientist at Michigan State University. The purpose of the study was to determine if the EGRP® allows free water-flow from the top of the EGRP® to the bottom.

Coleman A. Young Airport Results (Lusch, 2015):

- Analysis of the data collected supports the following conclusions:
  - The majority of the EGRP®s within the infiltration basin enhanced the local infiltration rate
  - The infiltration rates associated with two of the shallow EGRP®s were 7.4-8.6 times faster than the infiltration rate associated with native soil conditions
  - The infiltration rate associated with the deep EGRP® was 10.2 times faster than the infiltration rate associated with native soil conditions
- Analyses of both the shallow- and deep-data ***reject*** the hypothesis that EGRP®s function like a pipe, which allows shallow infiltration water to "free fall" to the bottom of the devices
  - Both the shallow- and deep-data demonstrate that infiltration at an EGRP® site occurs at a much slower rate than the "direct injection" hypothesis
  - Two of the three shallow EGRP®s exhibited a bromide breakthrough 16 days following the initiation of the slug infiltration
  - The third shallow EGRP® did not exhibit a bromide breakthrough during the 68 days of the second slug test - throughout the duration of the second slug test, the bromide concentrations from the EGRP® were very similar to those from the shallow monitoring well
  - The deep EGRP® exhibited a bromide breakthrough 23 days following the initiation of the slug infiltration
  - The large fluctuations in bromide concentrations from the deep monitoring well during the period 10/15/14 to 10/31/14 remain enigmatic and unexplained

EGRP® Test Site
Belle Isle

Environmental Consulting & Technology, Inc., an independent, third-party, was hired by the Michigan Economic Development Corporation to test the efficacy of the EGRP® system to eliminate standing water on a 24-acre parcel on Belle Isle, in Detroit, Michigan. A secondary goal was to evaluate the water quality effect the EGRP® system had on groundwater.

Results from the ECT test conclude that:

1. No standing water was observed at the test site after the EGRP® acclimated.
2. No measurable impact on the water quality of the affected groundwater was observed.
3. Stormwater runoff from smaller storms was eliminated from the test site.
4. The groundwater elevation was not impacted by the EGRP® installation.
5. The total runoff from the test site was reduced by 80% (as measured in the storm sewers draining the site).

The Belle Isle project results indicated that the EGRP® system:

- **Significantly stormwater runoff reduction –** At the test site, the stormwater volume data (normalized for rainfall volume) was compared using pre-installation volume vs. post-installation. Flow meters were installed in manhole structures to record storm sewer flow (gallons/day). The data indicated there was an 80% reduction in total flow (less than 6 million gallons/year in stormwater runoff compared to the pre-installation 55 million gallons/year).

- **Has no impact on the water table –** The soils at the Belle Isle site is predominantly interbedded sands and clays covered by "urban fill." The water table (potentiometric surface) was monitored at both the control site and test site using piezometers and results were recorded. Prior to installation, the between event stormwater flows as measured in the storm drains was nearly constant and increased following precipitation events. After the EGRP® installation, the between event flows were eliminated and the storm drains only transported water during and immediately after precipitation events. This data suggests that the EGRP® was successful in eliminating the near continuous infiltration/inflow (I/I) as well as inflow from the nearby Detroit River and pond on Belle Isle. Additionally, results prove the EGRP® was successful in reducing the amount of rainfall runoff that enters into the storm infrastructure.

- **Has no impact on groundwater quality –** The collected data did not show measurable change to shallow groundwater quality as a result of the EGRP® installation on the test area. A peristaltic pump was used to collect groundwater samples from test and control areas. The results have been compared with the Michigan Department of Environmental Quality Non-residential Drinking Water's cleanup criteria, and with average results from the Lake St. Clair Regional Monitoring Project (dry- and wet-weather). No changes in groundwater quality were observed between the test and control locations.

EGRP®
Frequently Asked Questions

Q. What is the EGRP® made of?
A. 100% polyethylene.

Q. Does this EGRP® leach any chemicals (VOC's or other) into the soil overtime?
A. Polyethylene is not known to leach any chemicals and is regularly used to hold drinking water products.

Q. Why is the EGRP® designed as a five-chamber system?
A. The EGRP® consists of four, crescent-shaped, plastic extrusions joined together by a central canal. The system is designed to expand and contract with the pressure found beneath the soil. The configuration maximizes the surface area to volume ratio while preventing premature fouling of the channels.

Q. How does the EGRP® "manage" water?
A. The EGRP® increases infiltration in a manner that water is rapidly infiltrated without introducing the non-soluble pollutants associated with stormwater and rapidly recovering after a rain event thereby being ready for the next event.

Q. How does the system work?
A. Many compare EGRP® to slotted well screens, but a much better comparison is a drywell (or "soak-away" in the United Kingdom or "soak well" in Australia). In both a traditional drywell and an EGRP®, the excess water leaves the device at a rate that is a function of hydrostatic pressure, the transmissivity, and the surface area of the wetted perimeter of the installed device. However, the multiple EGRP® devices provide a far greater surface area than a traditional dry well for a given volume - thus the rate of total water movement is similar but the EGRP® system drains faster, reducing more storm water runoff and promoting further groundwater recharge.

Q. What are the effects of different soils?
A. Different soil types have different effects on the EGRP® system. Tight soils, like clays and silt, are slow to "acclimate" and require a more dense installation. Clay has very small and compact particles, causing water to move very, very slowly through the soil column. Silt has fine particles and as a result impedes water flow in a manner similar to clay. Sand has large particles, allowing water to travel quickly and drain away. The EGRP® allows water to seek the path of least resistance along the length of the device and accelerate the dewatering process.

Q. How is it different from other systems?
A. Traditional stormwater management systems either capture peak events or rapidly transport stormwater off site – assuming infiltration will remain constant. The passive design of the EGRP® is unique in that it increases the infiltration rate in a low-impact, eco-friendly manner requiring no energy and no maintenance. The EGRP® provides a long-term solution that improves over time.

Q. Does it work in conjunction with other water management systems?
A. The EGRP® can be used in conjunction with other stormwater management solutions to reduce the size of the traditional practice by increasing rapid infiltration rates and volumes. By increasing the infiltration rate of a given site, the EGRP® can assist and enhance performance on traditional stormwater management structures and reduce maintenance of current systems, such as a bio swale, rain garden or retention/detention pond.

Q. What happens during the EGRP® acclimation period?
A. The performance of the EGRP improves over the first year of operation. Immediately following installation, water is allowed to "short-circuit" along in the void space surrounding the newly installed EGRP®. This short-circuiting does not support "normal" operation of the EGRP® system. Over time the soil boring collapses around the devices and the EGRP®'s direct connection with the vadose zone improves. The EGRP® system works from the bottom-up, opening the soil pores around the device in the lowest, compacted areas and gradually continues the process towards the surface. This gradual connection enables the EGRP® to expand and contract, distributing water molecules more evenly though the soil matrix.

Q. Does it have measurable performance standards?
A. Yes, the EGRP® effects and results have been measured in a number of third party studies.

Q. What support or documentation does the product have from the EPA, FDA, DNR or county agencies?
A. EPA region 5 (Great Lakes) has considered the EGRP® be placed under the Class 5 Well category (http://water.epa.gov/type/groundwater/uic/class5/index.cfm). Additional studies are ongoing and/or planned for the near future.