Eco-Stone® for Stormwater Remediation

Executive Summary

Water is a sustaining element of life and plays a vital role in maintaining our ecological system and its habitat. Under natural conditions rain infiltrates the soil to replenish the ground water. In vegetated areas, most water infiltrates the ground where it falls, as plants, leaves and organic matter diffuse the rain and let it soak naturally into numerous voids.

Stormwater Runoff – *Where Has All the Water Gone?*

As cities experience growth and land is developed, the impervious surfaces of buildings, asphalt and concrete pavements become major contributors to stormwater runoff. Pavements are the most ubiquitous as they are typically twice size of building structures. Pavements contribute to 2/3 of the increase of urban heat island and are responsible for 2/3 hydro carbon pollution deposited by automobiles.

Until recently, the principal concern with water has been safety, with the emphasis on directing and draining water off of paved surfaces, quickly and efficiently. But because rainfall is being deflected from its natural course of recharging the groundwater, planners are now focused on protecting precious water resources.

Water quality is also affected. The "first flush" of a storm, generally considered the first half-inch of rainfall or the runoff from the first 15 minutes of a storm, contains pollutants such as petroleum products, hydrocarbons, tire rubber and toxic metals. The pollutants find their way into watercourses, contaminating streams, reservoirs and aquifers. According to the EPA, non-point source pollution is the number one cause of water quality impairment in the U.S.

Retention, Detention, Collection and Restriction -*Traditional Mitigation Attempts*

Many municipalities have enacted laws to control stormwater runoff at, or, near pre-development levels by limiting the amount of impervious surfaces (pavement and roofs) through zoning regulations. In some areas of the country, some have gone as far to charge a stormwater utility fee to cover the costs of draining runoff from developments. Phase II of the Clean Water Act recently went into effect and now applies to municipalities under 100,000 in population as well as private developments less than 5 acres in size. To comply with the Clean Water Act, developers are now be required to apply for a Notice of Intent and submit site plans that contain a stormwater management plan addressing the impact the propose land use will have on water quality and quantity.

BMPs, or best management practices, often include retention ponds, detention basins and permeable pavements. Unfortunately, retention ponds render a large area of lot space unusable while detention basins do not eliminate runoff but merely delay it and may work collectively to increase peak flows. Where the quality of the water discharge is the issue, some site plans have chosen catch basin inserts to collect contaminants in an attempt to prevent them from entering the storm water pipe system. The most serious drawback to this method is that the inserts tend to clog with sediment, rendering the unit ineffective. Other methods include large vault stormwater filtration systems which require further treatment of the water prior to discharge from storage.

Porous Pavements – *Drain the Rain*

Permeable pavements play an important role in mitigating non-point source pollution, or NSP, by reducing stormwater runoff, increasing groundwater recharge and enhancing water quality. Permeable pavement also offers a valuable economic advantage to builders by allowing them to utilize their property to its fullest extent and derive the maximum return. Permeable pavements:

- *Increase amount of land allowable for use*
- *Can reduce runoff by as much as 100%*
- *Increase groundwater recharge*
- *Reduce retention requirements in other parts of drainage system*
- *Improve quality of water through soil filtration*
- *Reduce water temperatures*
- *Slow release of runoff*
- *Reduce downstream flooding*
- *Reduce overall project costs by offsetting costs of sewers and drainage structures*
- *Infiltrate sufficient water to control the peak rate of discharge.*
- *Slow water flow, allowing time for oxidation of some contaminants, filtering suspended solids and cooling the temperature of the water.*

Until recently, the choice of permeable pavements was limited to cast in-place asphalt or concrete that was comprised of only coarse aggregate commonly referred to as an "open-graded" or "popcorn" mix. The major disadvantage of these types of pavements is clogging and the inability to restore the porosity. Other options include grid-type pavers that have large openings and are typically used for areas with limited traffic such as overflow parking or access lanes for emergency vehicles and fire trucks.

Eco-Stone® Permeable Pavers – *Integrity, Strength and Drainage*

Eco-Stone is a porous paver that was designed specifically to reduce water run-off and improve groundwater recharge. What distinguishes Eco-Stone from other types of porous pavements and grid-type pavers is its size. Eco-Stone dimensions are 4 ½" x 9" and, as such, is classified as a "unit" paver that provides the same performance behavior as other interlocking unit pavers. Manufactured to have a minimum compressive strength of 8000 psi, the Eco-Stone units interlock to create a structural pavement capable of withstanding repeated traffic and heavy loads. Eco-Stone's unique design creates funnel shaped openings, which permit water to drain freely through the surface and recharge naturally into the ground. The patented configuration is conducive to rejuvenating their permeability with periodic cleaning when necessary. Eco-Stone's shape permits mechanical installation in a stack bond pattern and offers considerable cost savings over placement of individual units by hand for large-scale projects.

Construction – *Proven Techniques*

Construction of Eco-Stone pavements is similar to that of standard interlocking concrete pavers. The pavement consists of a base typically comprised of a well-draining granular aggregate consisting of a particle size generally ranging from 1/8" to 1" in diameter. Eco-Stone pavers serve as the wearing course and are placed on a bedding layer of EcoGrade Filtration Stone or stone sand ranging from 2-5mm in size. The same stone sand is used to fill the apertures and joints of the Eco-Stone pavement.

Design Guidelines – *Achieving Structural and Hydrologic Performance*

The objective of permeable pavements is to store the runoff and drain it back into the ground or into a drainage system. The design involves the construction of a sufficient base that prevents the pavement from becoming saturated and losing its load bearing capacity. The thickness of the base depends on the amount of storage required, the permeability and strength of the soil subgrade, and susceptibility to frost, as well as the anticipated traffic loads. The storage capacity will be determined by the stormwater regulation and rainfall intensity for the locality. In many cases, design for a 2 year, 24 hour storm is adequate.

Our experience has shown that the design for the base is site specific for every project according to the conditions and the drainage requirements. The report titled *Design Considerations for Uni Eco-Stone* provides useful information for any engineer familiar with soil mechanics and hydrologic design. Another valuable design tool is Lockpave® Pro, a Windows based software program in a CD format that quickly calculates structural and hydrologic design for Eco-Stone pavements.

In general, permeable interlocking concrete pavements owe their ability to absorb and store runoff from the use of open-graded aggregate bases. These are crushed stone bases whose particle sizes generally range from 1/8 to 1 in. The water storage capacity in an open-graded base depends on the percent of void spaces between the particles and the depth. The percentage of void space in an open-graded aggregate can be supplied by the quarry or tested. For example, ASTM No. 57 stone has an approximate void space of 40%. Therefore, every 2½ in. of base can store 1 in. of runoff.

A common misperception of permeable pavements is to consider them as an impermeable surface except for the openings. For example, it is incorrect to assume that because Eco-Stone has a 12% void area, 88% of the water will runoff the surface. Considerable research has demonstrated that with proper design, it is reasonable to expect that Eco-Stone will provide a permeable pavement capable of draining a 100-year design storm so that the runoff is zero or, at least equal to what is was before development.

Properly installed, Eco-stone pavements can be plowed using the same type of snow removal equipment used for conventional pavements. Although the openings will freeze over during severe cold and ice storms, the thermal mass of the concrete units absorb the rays of the winter sum. As the pavement warms, the ice melts and, unlike conventional pavements, gradually infiltrates into the base course.

Maintenance – *Keep It Draining*

Proper design and installation, including the use of the correct aggregates to fill the voids, coupled with a scheduled maintenance program can prevent the loss of porosity over time. The amount and type of traffic the pavement is subject to influences how often cleaning is required. The pavement should be kept clean of leaves and excess sand. When necessary, performance levels can easily be restored by periodic sweeping and cleaning with a device called a hydrovac. For commercial parking areas, we recommend this type of cleaning be performed once or twice a year.

Water Quality & Temperature – *A Natural Filter*

According to Bruce Ferguson, an associate professor in the School of Environmental Design at the University of Georgia and respected author with numerous studies on storm water remediation, soil has the ability to filter and improve the quality of water from runoff before it reaches ground water, streams and aquifers. Metals, phosphorus and other constituents of urban pollutants are accumulated over tens and even hundreds of years in the upper few inches of the soil in the base. When the soil's capacity to hold pollutants is exceeded, the contaminated soil may be dredging and replaced. Ferguson further cites a study where researchers, conducting a US geological survey, found that the concentration of nitrogen existing in groundwater was reduced after filtering through the soil.

Tests conducted at Guelph University, Ontario found that Eco-Stone pavements were capable of substantially reducing contaminants, including trace metals, and exhibited far less thermal impact than asphalt pavements by reducing thermal loading on surrounding surface waters.

The Challenge - *Thinking Outside the "Box"*

As we struggle with ways to protect our natural resources, a major challenge is to find a balance between protecting water quality and environmental resources and accommodating compatible economic growth. Understanding, regulating, and dealing with non-point pollution and stormwater are new concepts to the design community, builders and regulatory agencies. The goals of the players are often considered contradictory as some view development as disturbing land which imparts a negative environmental impact while others consider development as a logical response to population growth.

Traditional approaches in thinking, design and construction of customary methods of handling water must be re-evaluated. Until recently, a common goal of site engineers was to develop a plan to drain water from developed sites as rapidly as possible through the use of gutters, downspouts, pipes, curbs, catch basins and culverts. Civil engineers have been taught that proper pavement design is predicated on keeping water out of the pavement through the use of a base comprised of slow draining aggregates and sealed off with a watertight surface. While some renowned pavement experts now question this practice, the concept of constructing pavements with fast draining, open graded aggregates are foreign to many engineers.

Another aspect that cannot be ignored is costs. While cost is always an important factor, few improvements ever happen without some added costs associated with them. Though construction may, indeed, bear some additional costs in order to achieve compliance permitting development, it is far less than the unrealized gain from land that remains undeveloped.

BMP's - *There is No Magic Bullet!*

A wide range of federal, state, and local regulations to decrease runoff have been implemented over the past several decades. Remediation efforts are evolving toward a more comprehensive management of stormwater through land use zoning and many techniques, or best management practices, that require a combination of processes to improve the quality of our environment.

Permeable interlocking concrete pavements can serve an important role in mitigating storm water runoff for municipalities, regulatory commissions and developers. Yet permeable pavements need to be incorporated into a variety of measures. Some of the strategies, among numerous options, include:

- Landscape plantings
- Infiltration basins
- Reduced roadway widths
- Vegetated swales along the roadway & perimeter
- Capturing runoff from roofs
- Rehabilitating soil to increase infiltration

Conclusion – *The Four "C's"*

In general, the principals to strive for in stormwater management may be summarized as "The Four Cs": control, conveyance, collection and cleansing and should include measures to control and convey runoff, and to collect and cleanse the water from runoff on-site.

For more information about the provisions of the Clean Water Act, Phase II, please visit the web site: *www.epa.gov*. NEMO (Nonpoint Education for Municipal Officials) offers a wealth of educational information on building a watershed framework and may be contacted through the University of Connecticut CES, 1066 Saybrook Rd., Box 70, Haddam, CT 06438-0070 or by calling 860-345-4511. For additional information on Eco-Stone, please contact Ideal's Sales Office for literature and research reports.