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# CONCRETE PIPE NEWS

The Magazine of the American **Concrete Pipe** Association

American
**Concrete Pipe**
Association

## Concrete Pipe Grrreat for Sanitary Sewer

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**This issue:**
**Volume 61, Number 1**
**Winter 2009**

Concrete Pipe News is published four times each year by the American Concrete Pipe Association. It is designed to provide information on the use and installation of precast concrete pipe products for a wide variety of applications, including drainage and pollution control systems. Industry technology, research and trends are also important subjects of the publication. Readers include engineers, specifiers, public works officials, contractors, suppliers, vendors and members of the American Concrete Pipe Association.

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# content



Photo: Jason Sandusky, Peters Construction Company

# editorial

## Laser Video Post Installation Inspection Spreading Nationwide

Driven by legislation like the Government Accounting Standard Boards statement 34 (GASB 34) that requires all governments to adopt a formal capitalization useful life and depreciation policy for its capital assets, dwindling funds for infrastructure rehabilitation and replacement, and need for new infrastructure to meet current and future demand, states are taking a hard look at laser video profiling of sewers and culverts. These inspections are part of a much broader bundle of initiatives of municipal, state, and federal governments to meet the notion of sustainable development and sustainable infrastructure.

As of December 2008, 23 states specified mandatory deflection inspection. An additional eight states required or allowed laser-profiling technology for post-installation inspection. The University of Texas at Arlington, Center for Structural Engineering Research, has taken an interest in concrete technology and structural performance of pipelines through the work of Dr. Ali Abolmaali. His research on structural performance of HDPE culverts and sewers has been released for Texas, North Carolina, Virginia, Minnesota, Missouri, and Kansas. Studies of pipelines in other states are in progress. Deflection remains the greatest weakness of sewers and culverts constructed with flexible pipe that are heavily dependent upon the quality of raw materials and a proper installation. Laser video profiling is far superior to mandrel testing for helping determine service life of installed structures, because of the quantity and detailed data generated by the profilers.

In addition to the level and nature of deflection, or excessive deformation observed in flexible drainage systems, laser video profiling also documents cracking, inverse curvature, joint displacement, corrugation growth and buckling. Of the 3.5 miles of HDPE pipe studied by Dr. Abolmaali's team covering 38 sites in six states, all exhibited one or more failure modes and 70% were characterized by excessive deflection.

ACPA and the Florida Concrete Pipe Institute (FCPI) work extensively with the Florida Department of Transportation (FDOT) over several years to determine the state of its buried infrastructure, and to strive for fair and equitable specifications for all drainage pipe material. The introduction of laser video profiling played a major role in developing specifications for new road construction bids that do not default immediately to flexible pipe products because they have a cheaper material cost.

In late 2005, FDOT initiated the implementation of laser profiling. The specification was finalized by January 2006, so that it could be implemented in May, 2006. FDOT Section 430-4.8 states, "Based on contract pavement type, upon completion of placement of concrete pavement or the placement of structural asphalt, but prior to placement of asphalt friction course, dewater installed pipe and provide the Engineer with a video recording schedule allowing for pipe videoing and reports to be completed and submitted to the Department and reviewed prior to continuation of pavement." For pipe 48 inches or less in diameter, the engineer must be provided with a video DVD and report using low barrel distortion video equipment with laser profile technology, noncontact video micrometer and associated software. The specification goes on to describe consequences for sections of pipelines that fail to meet installed condition specifications. For example, PVC, HDPE, or metal pipe deflected 5% or more of certified actual mean diameter is to be replaced at no cost to the Department.

It is quite clear that FDOT has embraced laser video profiling to ensure that the infrastructure that it is assuming is a value-add to its inventory of sewers and culverts. The leadership demonstrated by FDOT and other state DOTs that have modified their specifications because of the level of detail provided by laser video profiling, is setting benchmarks for installed pipelines throughout the United States.

*Matt Childs, P.E.*
*President*
*American Concrete Pipe Association*

Feature Story

# Concrete Pipe Grrreat for Sanitary Sewer!

*By Robin Wolf*
*Director of Marketing and NovaBrik Sales Manager*
*Premarc Corporation*
*616-437-0781*

In the home of Tony the Tiger, mascot for Kellogg's Frosted Flakes cereal, concrete pipe has become grrreat for a sanitary sewer receiving approximately 920,000 gallons per day from the Kellogg cereal company. The 3,000-foot run of sanitary sewer was needed by the City of Battle Creek to replace an 80-year-old clay pipeline that collected sewage for treatment in a facility located 25 miles away in Fort Custer. The primary challenge that had to be overcome by the pipeline designers was the acidic characteristic of the sewage. A low pH threatened the service life of the concrete pipeline and a sewage spill, unless the concrete mix was fortified with an admixture that would resist the potential effect of sulfuric acid in the effluent.

Photos: Jason Sandusky, Peters Construction Company

There are some 300 miles of sanitary sewer mains located throughout the Battle Creek metropolitan area. Wastewater generated by residences and businesses must be cleaned and treated to meet all federal and state standards before it is discharged into the Kalamazoo River. The city prefers specifying concrete pipe for sewers greater than 24 inches in diameter. The acidic nature of the sewage, however, was the reason for first specifying the pipeline be SDR 26 PVC, despite the city's preference, and sections where the pipe would be buried deeper than 15 feet. The specification was changed to reinforced concrete pipe, once the client was assured that an admixture would destroy anaerobic bacteria responsible for the production of hydrogen sulfide gas ($H_2S$) when it makes contact with the concrete surface.

Anaerobic bacteria, which do not require oxygen for survival, form in raw sewage and produce hydrogen sulfide gas that has a distinct odor of rotten eggs. Factors that contribute to the rapid growth of Thiobacillus (a common form of anaerobic bacterium) are temperature, retention time, high biochemical oxygen demand ($BOD_5$), and turbulence. Turbulence from force mains, drop structures in manholes, steep grade changes, and pumping stations allows the hydrogen sulfide gas to release into the atmosphere in pipes and manholes. The gas is then converted into sulfuric acid ($H_2S0_4$) by the Thiobacillus bacteria that grow on surfaces of the concrete pipe and manholes above the wastewater flow. Only Thiobacillus can convert $H_2S$ to $H_2S0_4$.

Pipe designers at Premarc are familiar with several additives used in concrete mixes to resist the corrosion of concrete by acidic soils and sanitary sewage. The design team proposed the use of Con-Shield, a liquid admixture that molecularly bonds to the cement particles in a concrete mix, to enhance the performance of the concrete sewer to meet the design life of the pipeline. The active ingredient in the admixture forms a colorless, odorless, and positively charged polymer. When a single cell Thiobacillus bacterium comes in contact with the admixture, the cell membrane ruptures, and the organism dies. Since nothing is transferred to the dead cell, the admixture does not lose strength and is ready for contact by the next bacterium.

The city approved the use of the ConShield admixture in the concrete pipe cement mix designed for the project, and changed the specification. The challenge for the contractor, however, had just begun. The alignment of the new sewer was first planned within ten feet of the existing clay pipeline. When the clay pipeline was uncovered, its integrity was breached and sections of pipe began to collapse when exposed. The contractor had to bypass the clay pipeline from manhole to manhole to avoid causing a sewage spill. In addition, the contractor had to install the pipeline between August 1 and October 3, 2008 to meet MDOT's schedule for pavement replacement.

During the planning and design stage of a sanitary sewer, the potential biochemical profiles of the system was determined along with current rates of acid development, and projected rates for the design life of the sewer. Once determined, the pipe can be protected by additives and liners. Concrete pipe can also be produced with an increase in total alkalinity using calcareous aggregates. It is also common to increase the concrete cover over the reinforcement. Known as sacrificial concrete, the rate of deterioration of the system can be matched to the design life of the project.

Where acidic effluent is anticipated, designers need to determine the pH, including cyclic variations, as well as continuous or intermittent flow characteristics. The pH and total acidity for the design life of the system is critical. In addition, designers must determine the potential for the development of sulfuric acid due to potential changes to the environment of the interior atmosphere of the sewer. Technology is now in place for making concrete pipe more reliable than it has ever been before. Decades of research and development of many aspects of concrete pipe have enabled concrete pipe producers to change concrete mixes and pipe design to provide products that can withstand a complete range of underground environments and effluent profiles.

The Battle Creek concrete sanitary sewer that receives considerable effluent from the Kellogg Company was carefully designed with full knowledge of the nature of the sewage and design life of the pipeline. An innovative additive used to create a reinforced concrete pipe that can accommodate a sanitary sewer environment, has also contributed to the city's sustainable infrastructure.

| | |
|---|---|
| Project: | Sanitary Sewer<br>City of Battle Creek<br>Battle Creek, Michigan |
| Owner: | City of Battle Creek<br>Battle Creek, Michigan |
| Contractor: | Peters Construction Company<br>Kalamazoo Michigan |
| Quantities: | 40 feet of 12-inch diameter C-76<br>Class IV RCP<br>2,720 feet of 24-inch diameter C-76<br>Class IV RCP<br>240 feet of 30-inch diameter C-76<br>Class IV RCP<br>Ten 48-inch diameter manholes<br>Four 60-inch diameter manholes<br>Four 72-inch diameter manholes<br>Two 84-inch diameter manholes<br>One 96-inch diameter manhole |
| Producer: | Premarc Corporation.<br>Durand, Michigan |

The Premarc Corporation is Michigan's largest precast concrete pipe manufacturer. Founded in 1927 in Durand, Michigan by the Marsh family, the company first operated in the Flint and Lansing area but now has facilities in Cadillac, Grand Rapids and Clarkston, as well as Durand. Premarc's delivery fleet supplies the entire lower peninsula of Michigan and extends into Indiana. Products include precast reinforced concrete sanitary and storm sewer pipe, manholes, catch basins, wet wells, and pump stations. Bridge products include concrete boxes, and prestressed bridge beams. For more information, see *www.premarc.com*.

# NOW YOU KNOW.....

## Life Cycle Assessment or Least Cost (Life Cycle Cost) Analysis? They are NOT the Same.

*By Kim Spahn, P.E.,*
*Director of Engineering Services,*
*American Concrete Pipe Association*

The concrete pipe industry invests heavily in working with specifiers, regulators, and designers at all levels of federal, state and municipal governments to develop standards through scientific research and development that satisfy public demand for safe and durable products that perform as specified. When precast concrete pipe and boxes reach the job site, the concrete pipe industry continues to support its products by working with contractors to provide the information needed to construct sewers and culverts with service lives that match the design life of projects.

In the '90s, the concrete pipe industry took action to correct the decades-long practice of specifying products for pipelines based on lowest capital cost of products. This practice was becoming rampant, despite the knowledge throughout the construction industry that the pipe material with the lowest capital (first cost) may not be the most economical selection when it comes to matching service life to design life. Even today, infrastructure projects tend to be awarded based on lowest bid, which often includes the lowest priced capital cost of products. Specifications can be weakened by using alternative products and materials that have little consideration for long-term maintenance of structures and replacement costs.

Proper design of any hydraulic structure requires consideration of the different but interrelated fields of planning, specifications, hydrology, hydraulics, structures, installation, durability, maintenance, and economics. The first six elements are well established. The durability and economic aspects, however, are generally given less consideration and for many projects, pipe materials or systems are selected on an initial (or capital) cost basis only. To determine the most economical choice, the principles of economics must be applied through a least cost (life cycle cost) analysis (LCCA). In such analyses all factors affecting the cost effectiveness must be evaluated.

The LCCA technique evaluates the present value constant dollar costs to install and maintain alternative drainage systems (concrete, corrugated metal, PVC, HDPE) including planning, engineering, construction, maintenance, rehabilitation and replacement and cost deductions for any residual value at the end of the proposed project design life. The decision maker, using the results of the LCCA can then readily identify the alternative with the lowest total cost based on the present value of all initial and future costs.

The American Concrete Pipe Association used ASTM C1131 to develop a comprehensive LCCA practice which eliminates unreliable assumptions, resulting in a readily usable and accurate design aid. The practice uses the well established economic principles of present value which have been used by economists and other professionals for decades. ACPA's LCCA program, developed by Giffels is embodied in its PipePac software. PipePac includes the very important aspect of social costs not covered in C1131.

The environmental movement came alive in the '60s, matured through the '80s and '90s, and is now fully entrenched in the construction industry. The "green industry" is affecting long-established specifications and standards through legislation, codes, and best practices when standards and specifications do not go far enough in satisfying environment-related demands of the public. Rating systems such as LEED, environmental impact assessments, changing regulations in legislation like the EPA, public policies related to water conservation and use of materials, along with the ever-present scepter of climate change and unusual weather patterns are contributing to the requirement for life cycle analysis (LCA) of all building products and materials. LCA differs from LCCA in that an LCA for concrete pipe and boxes must ensure that the years of work invested in developing an LCCA are not lost to irrational public policy driven by large national and international issues of the day.

Life cycle assessment refers to the investigation and valuation of the environmental impacts of a given product or service caused or necessitated by its existence. It is a methodology for assessing the environmental performance of a product over its full life cycle. An LCA is undertaken by compiling an inventory of relevant inputs and outputs of a product system, evaluating the potential environmental impacts associated with those inputs and outputs, and interpreting the results of the inventory and impact analyses in relation to the objective of the product application. Among other considerations, an LCA would include basic inputs such as transportation, energy use, resource extraction effects, emissions to water, solid waste, emissions to air, resource use (depletion), and water use.

An international standard exists for undertaking a Life Cycle Analysis. The International Organization for Standardization (ISO) 14040-1997: Environmental Management – Life Cycle Assessment – Principles and Framework, specifies the general framework, principles and requirements for conducting and reporting life cycle assessment studies.

An LCCA can be one of the inputs into an LCA for concrete pipe. LCA is a new frontier for many industries. We understand and know how to help contractors, designers and specifiers in selecting products and materials based on a well-established tool of economists that determines the present value of all initial and future costs of a pipeline or culvert. Our industry is being drawn quickly into a marketplace that will require an LCA for pipe and boxes to satisfy the specifications of a green construction industry.

Note: Life Cycle Cost Analysis is included in PipePac and ASTM C1131.

# Americast Achieves Cradle-to-Cradle Certification

Americast, Inc. announced on July 17, 2008 that it has achieved Cradle-to-Cradle Silver certification from McDonough Baungart Design Chemistry (MBDC) for its reinforced concrete pipe (RCP). Americast approached MBDC for Cradle-to-Cradle certification to ensure that its corporate goal of being environmentally responsible is being met by the highest possible standards. Americast is the first and only manufacturer of RCP to achieve this recognition.

MBDC's Cradle-to-Cradle Division is a world-renowned company with a primary focus on ensuring that companies are manufacturing products that are not only environmentally responsible and free of dangerous toxins, but are also capable of being effectively reused once their designed useful life has ended. The use of Cradle-to-Cradle certified products is being adopted globally as companies and even governments strive to be more environmentally responsible.

The U.S. Green Building Council (USGBC) endorses Cradle-to-Cradle products in their LEED certification criteria and awards a LEED Innovation point to projects using a percentage of Cradle-to-Cradle certified products. By employing a least the following minimum percentages of Cradle-to-Cradle certified product, a building project can earn LEED innovation points:

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|---|---|
| Cradle-to-Cradle – Silver | 5% |
| Cradle-to-Cradle – Gold | 2.5% |
| Cradle-to-Cradle – Platinum | 1.75% |

# Innovative Product Application for Small Bridge Replacement

*By Hal Stratford, Technical Resource Manager*
*Hanson Pipe & Precast, Cambridge Ontario*
*1-888-888-3222*

Precast concrete elements are quickly becoming products of choice for the reconstruction and construction of large culverts and small bridges. The challenge is how to apply standard and modified precast products to meet project requirements. Provincial and municipal specifiers and designers recognize the sustainability of precast concrete products and understand that concrete mixes, and the design of elements, can vary to meet specific environmental conditions and construction requirements. Reconstruction of a small bridge on Commercial Road over Young's Creek in the Town of Port Ryerse on the shore of Lake Erie is an example where modified standard products were used to construct a unique structure over an environmentally sensitive creek, while maintaining this sole access during construction.

The existing bridge was a three span wooden structure originally built in 1954. A subject of innovative engineering itself at the time, it was upgraded in 1995 by transverse post tensioning that extended its service life to 2008. Reconstruction of the Port Ryerse Bridge was undertaken in two phases to provide uninterrupted travel on Commercial Road. Traffic was routed to the northbound lane of the old bridge for phase 1 while the southbound half was demolished and replaced. Likewise in the second phase, the reconstructed southbound half of the bridge was opened to traffic while the northbound half of the bridge was demolished and replaced.


Hanson shipped product for the first phase of the deck on September 22 and the second phase on November 10. The structure was fully functional by the end of November 2008. The construction site had limited space for storage of products, so just in time delivery became the best option to limit materials storage and mitigate construction activity.

Work on the bridge was regulated by Transport Canada and the Federal Department of Fisheries and Oceans. The Navigable Waters Protection Act ensure the protection of navigable waters in Canada by considering the impact of replacement works across any navigable waters. Projects can only proceed upon approval by Transport Canada. The Fisheries Act deals with management and monitoring of fisheries, conservation and protection of fish and fish habitat, and pollution prevention. Since Young's Creek is a fishery for migratory Rainbow Trout and several salmon species, construction activities were scheduled during a period that would have the least impact on the aquatic ecosystem.

Photos: Hal Stratford, Hanson Pipe & Precast, Cambridge Ontario

To accommodate site conditions, federal regulations, and the design parameters for the bridge, Hanson Pipe & Precast used modified standard products for modular construction. Precast units included seven flat slabs for construction of the center section of the deck and 14 L-shaped modified QuickSpan sections to complete the deck at the north and south ends of the bridge. Six of the 4.573 meter-long center slabs were 1.829 meters wide and one was 1.524 meters. Twelve modified 4.573 meter-long QuickSpan units were 1.829 meters wide and two were 1.525 meters. All precast units were skewed six degrees and the center slabs were produced from a special form built for the project. A divider with a six-degree skew was placed in the QuickSpan form to produce the specially designed L-shaped sections two at a time. To facilitate production, Hanson was supplied pre-assembled rebar mats for the

center spans and skewed assemblies of outside angled sections. The combined use of slabs and beams with modified QuickSpan units made the precast modular construction of the bridge possible. To complete the construction of the deck, a 150 mm concrete distribution slab was poured over the assembled units.

The precast units were placed on concrete pier caps and steel tube piles driven in place by pile driving subcontractor Rankin Construction. The general contractor, Clearwater Structures Inc., faced no unexpected challenges to the construction of the support system and deck of the bridge. The consulting engineers Gamsby and Mannerow used S-FRAME, a 3D modeling and analysis software to design the precast elements to the requirements of the Canadian highway Bridge Code.

Construction of the Port Ryerse Bridge is an example of how concrete pipe and box producers can apply existing products to projects with special design considerations. The 19.840-meter (65 foot-long) deck exceeded the standard size of a QuickSpan unit. Hanson engineers worked with Dave Grahlman, P.Eng., at Gamsby and Mannerow, to design a bridge with precast products to meet the challenges of uninterrupted access, staged construction, environmental impact, durability and good value. The modular precast concrete approach to replacing the bridge was only possible with support of the Engineering Division of Norfolk County's Public Works and Environmental Services Department. Design of structures with precast concrete is a sustainable solution with immediate returns in reduced construction costs and impacts.

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|---|---|
| Project: | Port Ryerse Bridge Replacement<br>Contract PW-E-08-050<br>Port Ryerse, Ontario |
| Owner: | Norfolk County<br>Simcoe, Ontario |
| Consulting Engineer: | Gamsby and Mannerow Limited<br>Guelph, Ontario |
| General Contractor: | Clearwater Structures Inc.<br>Ajax, Ontario |
| Quantities: | Six 4.573 meter-long center slabs, 1.829 meters wide<br>One 4.573 meter-long center slab, 1.524 meters wide<br>Twelve modified 4.573 meter-long QuickSpan units, 1.829 meters wide<br>Two modified 4.573 meter-long QuickSpan units, 1.525 meters wide |
| Producer: | Hanson Pipe & Precast<br>Cambridge, Ontario |

Hanson Pipe & Precast is the largest manufacturer of concrete pipe and precast products in North America. The company has participated in some of the America's largest public works, airport, and highway construction projects. State Departments of Transportation, major cities and counties, public authorities, the Army Corps of Engineers, major airports and numerous private entities are among Hanson's customers. Hanson Pipe & Precast is part of the Heidelberg Cement Group which employs 70,000 people across five continents, has leading positions in concrete and heavy building products, and is a global leader in aggregates. See *www.hansonpipeandprecast.com* for details.

# Tech Review.....

## CSO Problems Solved with RCP and Precast Concrete Boxes

*By American Concrete Pipe Association*

In many older cities, a combined sewer is a type of sewer system which provides partially separated channels for sanitary sewage, stormwater runoff, and snowmelt. Sanitary sewers provide backup capacity when runoff volumes are unusually high. Sewage was collected from residences, institutions, and businesses by a sanitary sewage system that also collected storm water from impervious surfaces like roofs and pavements. Combined sewers are antiquated systems that are vulnerable to combined sewer overflows. Such sewers are called combined sewer systems.

Construction of combined sewers in the late 19th to early 20th centuries was accepted practice because it was more economical than building two separate sewer systems, and sewage treatment was not a concern. When pollution of surface water started to be of concern in the 1960s and 70s, cities constructed large interceptor sewers to cut off the wastewater flows that discharged directly into surface water bodies and directed the sanitary sewage and stormwater to wastewater treatment plants, adding to their inventory of combined sewers. Nevertheless, excessive storms can result in too much combined sewage for a wastewater treatment plant to handle. The combined sewers were designed with relief pipelines that bypassed the treatment plant when there was excessive flow during a large storm. The excess sewage was released from the sewer system into a river or lake to prevent backup into the street or homes.

The Federal Clean Water Act of 1977 mandates that all discharges of pollutants into the waters of the United States must be authorized by a National Pollutant Discharge Elimination System (NPDES) permit. Some 1,200 cities manage combined sewer overflow (CSO) facilities within their interceptor sewer system. The 1994 CSO Control Policy of the Environmental Protection Act is a national framework for control of CSOs through the NPDES permitting program. It was implemented so that municipalities could meet the Federal Clean Water Act's pollution control objectives.

Municipalities now look at ways to mitigate the environmental effects of combined sewer overflow locations. One solution is to build a CSO facility, which consists of some low-level treatment, storage, and return of the sewage to the storm sewer. Typically, only screening of solids would be completed. Another solution is to divert sewage, which previously flowed directly into the receiving water body, into a large underground storage tank that would have the capacity to hold runoff from all but the largest storms. Once the storm passes, pumps in the facility would send the retained water back into the sanitary sewer system at a controlled rate to be treated under the normal dry-weather process. The result is the near elimination of raw sewage flowing into a watershed.

The most common solution is to separate the combined sewer systems completely with new trunk sewers for sanitary sewage and stormwater runoff characterized by pipe diameters in excess of 48 inches and miles of pipeline buried at great depths, along with service life expectations greater than 100 years. Because the systems are being replaced at times of greater population growth with much larger impervious surfaces in the cities, there are higher flow volumes and large diameter pipelines to accommodate development and population growth. Many older sewers were made of clay and small diameter concrete that no longer can meet the hydraulic needs of modern cities. Such systems are being replaced as part of sewer separation projects. Because cities have grown significantly since many combined sewers were first constructed, open cut construction to separate the sewers, may not be an option. Even though many are being replaced by open cut methods, trenchless technology is now a viable option to reduce the disruption to commerce and neighborhoods.

Reinforced concrete pipe and boxes are being used extensively in massive combined sewer separation projects in many cities. Lined and unlined concrete pipe with special admixtures is being used for sanitary and stormwater trunk sewers at all depths and soil conditions. Pipe is being jacked and tunneled into position and even used as tunnel liners. Precast boxes are filling a niche for the underground storage systems placed under parking lots and public spaces for storing stormwater for treatment and slow release into the environment. Precast concrete pipe and boxes are sustainable products that can be designed to match the design life of the sewers and detention/retention facilities planned for America's growing cities. Most of the massive sewer separation projects started in the late 20th century should be completed within the next 20 years. Combined sewers of the 19th and 20th centuries were constructed with concrete pipe. It's appropriate that these early sewers are now being replaced by larger concrete pipe and box systems to solve a problem created by the designers of combined sewers.

***1,000 feet of 72-inch diameter Class III RCP installed by open cut method.***

Photo: John Simpson, P.E., Sherman-Dixie

# Filling the Gap with Precast Concrete Drainage Products

*By Grant Lee*
*Canadian Concrete Pipe Association*

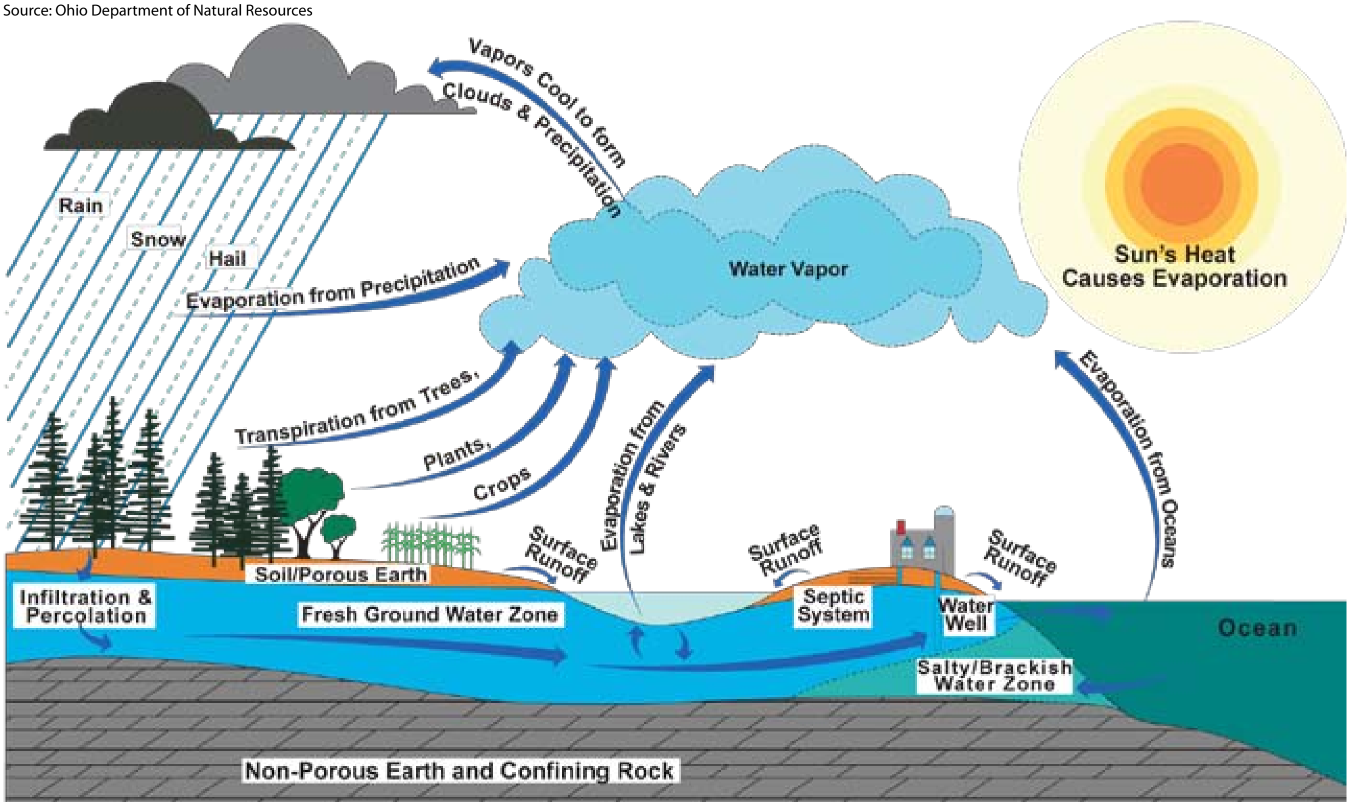
Experts agree that a changing global climate is a reality. The obvious question that arises from this fact is how countries will respond to these changes in the interests of protecting their citizens and resources. Globally, the issues of climate change are being publicized through the development of national plans and policies.

The most important ecological function affected by climate change, which can be assessed on a watershed basis, is hydrology. The hydrological cycle incorporates the components of precipitation, surface water storage, surface water conveyance, infiltration, groundwater flow, and evapotranspiration.

## Hydrologic Cycle

Precipitation falling to the ground has several routes. Some may fill depressions (become depression storage), some may penetrate the ground (infiltrate) to replenish soil moisture and groundwater aquifers, and some may become surface runoff. Water stored in surface depressions will eventually evaporate or infiltrate the ground surface.

Source: Ohio Department of Natural Resources



Water entering the ground may be directly evaporated, if adequate transfer from the soil to the surface is maintained. Vegetation which uses soil moisture, or shallow groundwater directly, can also transmit infiltrated water to the atmosphere by transpiration. Infiltrated water may replenish soil moisture deficiencies and enter storage, which may in turn help maintain dry weather stream flow.

Surface runoff flows to rivers and streams, which ultimately flows to the sea. An important landscape feature which affects the hydrologic cycle is surface storage as wet soils conditions, drainage swales, and wetlands. These areas function to hold and store a certain amount of precipitation during a storm and release it slowly over a number of days after the precipitation stops.

Changes in land use can affect the natural balance of runoff and infiltration. When lands are developed, the landscape generally becomes more impermeable as a result of increased surface areas of roads, roofs, walkways, parking lots and pavement. Infiltration after development can be affected by the choice of stormwater and grading management practices. The water that infiltrates into the groundwater system takes pathways through shallow and deep (regional) systems.

One major function of stream channels is to transport water and sediment downstream. The shape and location of stream channels in a natural setting will change continually in response to varying climatic conditions. A change in the balance between infiltration and runoff can have significant effects on the base flow of a stream. A reduction in the base flow may change the water temperature as well as the amount of water available for aquatic habitat during drier periods of the year. Watercourses are a reflection of their watersheds. All watercourses perform an important role for a sustainable environment. This role depends greatly upon their flow regimes, water quality and physical characteristics. They also serve valuable other functions to society including land drainage, serving as a source for water supply, and providing recreation opportunities.

Regional climate change and related impacts on the hydrologic cycle and associated infrastructure require consideration of various preventative, mitigation, and adaptive measures which, among others, include the following:

- Focus on preserving fresh water supply (surface and groundwater) and maintaining a positive ground-water pressure;
- Reducing system loss;
- Improving water use efficiency;
- Assessing alternative water supply (desalination, rainwater harvesting) and implications of each;
- Wastewater re-use and natural waste water treatment;

- Assessing agricultural water use during drought (irrigation activities);
- Reassessing water storage and operation;
- Planning for long term water shortages;
- Creation and implementation of drought management plans;
- Monitoring and detecting salt water intrusion;
- Protection of coastal infrastructure and facilities from a rising sea level;
- Assessing infrastructure response to more frequent and severe storm events and flooding;
- Rethinking building codes, environmental and energy guidelines and best practices;
- Matching service life of products and materials to design life of infrastructure; and
- Capture and control of storm-water and surface water.

By 2050 or so, the world population is expected to reach nine billion, essentially adding two Chinas to the number of people alive today. Those billions will be seeking food, water and other resources. The global recession in which we now find ourselves is a very clear statement that humankind is living in a global economy in every way. Climate change and population growth is placing demands on fresh water resources that were unimaginable until now. Watershed management plans driven by regional and national government policies for water conservation, and best practices to reduce the impact of humans on the hydrological cycle are providing opportunities never before considered for precast concrete drainage products. These opportunities, or gaps in technology, may be nothing more than realizing new ways of applying concrete pipe and boxes to help preserve the hydrological cycle locally, regionally, national or globally. However, producers of concrete pipe and boxes may take the initiative to introduce innovative precast products to complement traditional pipe and box designs to deal with ecological and environmental challenges associated with climate change.

Concrete pipe in North America has a long history of dependability and performance making concrete a preferred material for many traditional applications. Climate change and watershed planning will need more, not fewer applications of precast concrete products to provide a sustainable environment for the massive population growth expected over the next 40 years, and subsequent demand for fresh water supplies. By understanding the hydrological cycle and the impact of climate change, producers can develop even more precast concrete drainage products that may very well become the standard for buried infrastructure in the near future.

The American Concrete Pipe Association and National Precast Concrete Association is sponsoring *The Precast Show* which debuts February 20-22, 2009 at the George R. Brown Convention Center in Houston.

Developed by leading precast and pipe suppliers and manufacturers in the industry, *The Precast Show* will feature the latest equipment, products, and services. In addition to a huge trade show floor, the event will include technical education programming, plant tours, networking events and much more.

The *2009 Precast Show* is the ONLY trade show in North America specifically for precast and pipe manufacturers. NPCA and ACPA will hold all their educational sessions, annual awards, meetings, and special events in conjunction with the show.

Register now at *www.concrete-pipe.org*, or *www.precast.org/show/show.htm.*

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