Appendix G:

Stormwater System
Operations and Maintenance Plan

For the Proposed:

Retail Development

Located at:

580 Lake Road
Andover, Connecticut

Prepared for Submission to:
Town of Andover, Connecticut

November 16, 2021
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General Overview

This plan has been prepared in support of a Permit Application by Garrett Homes, LLC to the Town of Andover for the proposed retail development at 580 Lake Road. The subject parcel (Lot 2B) had been previously subdivided from the parcel to the southwest (Lot 2A). The lots are labeled on the Aerial Location Map in Appendix A. The property is located on the northwestern corner of the intersection of Lake Road and Jonathan Trumbull Highway (US Route 6) and is bordered by industrial zoned properties on all sides. The subject parcel contains a total area of approximately 54,034 SF (1.24 acres).

Under the current conditions, the subject parcel is a vacant lot with a grass groundcover. The subject parcel and the surrounding areas discharge to a culvert beneath US Route 6. The other contributing drainage areas to the culvert beneath US Route 6 include a commercial building (Benjamin Franklin Plumbing), a tree farm, residential area, and roadways. Land coverage includes impervious pavement, pervious lawn, and wooded areas.

The existing topography on the subject parcel varies from elevation 292 to about elevation 299 and in general slopes south to north. The subject parcel is at a lower elevation than the surrounding roads. A 15" RCP culvert located at the low point within the Route 6 right-of-way conveys the water under Route 6 to daylight on the northeastern side which ultimately flows into Hop River.

The proposed development on the subject parcel (Lot 2B) includes the construction of a +/- 10,640 SF retail building. The development will include parking, landscaping, a stormwater management system, and additional site and utility improvements typical of commercial-retail development.

The following Operations and Maintenance Plan was prepared specifically for this proposed development in the Town of Andover, Connecticut. The Plan was developed to satisfy the requirements of the Connecticut Department of Energy and Environmental Protection's 2002 Connecticut Guidelines for Soil Erosion and Sediment Control.

Purpose & Goals

The purpose of this Manual is to ensure that the stormwater management components are operated in accordance with all approvals and permits. The primary goal is to inform all the property managers about how the system operates and what maintenance items are necessary to protect downstream wetlands and watercourses. The secondary goal is to provide a practical, efficient means of maintenance planning and record keeping to verify permit compliance.

Responsible Parties

The Property Owner will be responsible for implementing the Plan on the property.

Maintenance inspections shall be performed by a qualified professional.

Some utilities located on the site will be owned and maintained by various utility companies in accordance with their standards. The property owner may maintain the service connections.

List of Permits & Special Conditions

The project will receive several permits, which may contain special conditions that require compliance by the property owner and maintenance contractors. This permit may include the following:

- Town of Andover Permits –Inland Wetlands and Watercourses Permit, Site Plan, Building Permit
- State of Connecticut – Encroachment Permit

Maintenance Logs and Checklists

The property owner will keep a record of all maintenance procedures performed, date of inspection/ cleanings, etc. Copies of inspection reports and maintenance records shall be kept on-site. Yearly inspection reports of the stormwater management system shall be submitted to the Town.

Forms

The following forms will be developed for annual maintenance. Copies of the forms will be kept on-site as part of the Storm Water Management Plan.

- Annual Checklist
- Quarterly Checklist
- Monthly Checklist

Employee Training

The property owner will have an employee-training program, with annual up-dates, to ensure that the qualified employees charged with maintaining the buildings and grounds do so in accordance with the approved permit conditions. All employees that have maintenance duties will be adequately informed of their responsibilities.

Spill Control

In addition to the good housekeeping and material management practices discussed in the previous sections of this plan, the following practices will be followed for spill prevention and clean-up:

- Manufacturer's recommended methods for spill clean-up will be clearly posted and site personnel will be made aware of the procedures and the location of the information and clean-up supplies.

- Materials and equipment necessary for spill clean-up will be kept in the material storage area on-site. Equipment and materials will include but not be limited to: absorbent booms or mats, brooms, dust pans, mops, rags, gloves, goggles, sand, and plastic and metal trash containers specifically for this purpose.
- All spills will be cleaned immediately after discovery.
- The spill area will be kept well-ventilated and personnel will wear appropriate protective clothing to prevent injury from contact with hazardous substance.
- Spills of toxic or hazardous material, regardless of size, will be reported to the appropriate State or local government agency.
- If a spill occurs, this plan will be adjusted to include measures to prevent this type of spill from reoccurring and how to clean the spill if there is another one. A description of the spill, the cause, and the remediation measures will also be included.

A spill report shall be prepared by the property owner following each occurrence. The spill report shall present a description of the release, including quantity and type of material, date of spill, circumstances leading to the release, location of spill, response actions and personnel, documentation of notifications and corrective measures implemented to prevent reoccurrence.

The property owner shall identify an appropriately qualified and trained site employee involved with day-to-day site operations to be the spill prevention and clean-up coordinator. The name(s) of responsible spill personnel shall be posted on-site. Each employee shall be instructed that all spills are to be reported to the spill prevention and clean-up coordinator.

Storm Water Management

System Components

The storm water management system has several components that are shown on the Grading and Drainage Plan (GD-1), that performs various functions in treating storm water runoff:

Catch Basins and Manholes

The property owner is responsible for cleaning the catch basins and manholes on the property. A Connecticut Licensed hauler shall clean the sumps and dispose of removed sand legally. The road sand may be reused for winter sanding, but may not be stored on-site. As part of the hauling contract, the hauler shall notify the property owner in writing where the material is being disposed.

Each catch basin shall be inspected every four months, with one inspection occurring during the month of April. Any debris occurring within one foot from the bottom of each sump shall be removed by Vacuum "Vactor" type of maintenance equipment.

During the inspection of each of the catch basin sumps, the hoods (where provided) on each of the outlet pipes shall also be observed. In the event that a hood is damaged or off the hanger, it shall be reset or repaired.

Hydrodynamic Separators (or approved equal)

The hydrodynamic separator manholes will be cleaned periodically during construction, and at the end of construction once the landscaped areas are fully stabilized.

For the first year of operation following construction, inspect each manhole once each month for the months of January, February, March and April, and once every four months thereafter. A graduated measuring device (stadia rod) shall be inserted into each grit chamber and measurements of any accumulations shall be recorded. Any debris, which has accumulated to within one foot of the water surface inside the grit chamber portion of each tank, shall be removed by vacuum "Vactor" type of equipment.

After the first year of operation, each manhole shall be inspected at a minimum, three times yearly with one inspection occurring in the month of April in the same manner as described above for the first season of operation. Any accumulations found to be occurring within one foot of the water surface shall be removed from the manhole and properly disposed off-site. Also, any floating material discovered during inspections shall be removed from the tank.

A detailed maintenance logbook shall be kept for each manhole. Information is to include, but not be limited to, the date of inspection, record of grit depth, condition of baffles, observation of any floatable, and date of cleaning performed.

Subsurface Stormwater Detention System

The underground detention system shall be inspected every six months in the months of April and October. Each of the inspection ports provided shall be opened and visually checked from the surface. Observation of grit inside of the detention system shall be noted and any deposits found to be 2 inches or more, as measured from the invert of pipe, shall be cleaned and removed. The subsurface detention system qualifies as a Confined Space under OSHA regulations, and any maintenance involving entry into the pipes should comply with OSHA Confined Space Entry Regulations.

Site Maintenance

Parking Lots

Parking lots and sidewalks shall be swept as necessary by the property owner, or at least once per year, to clean sediment, trash, and other debris. The property owner will sweep parking lots on the property in the spring to remove winter accumulations of road sand.

Pervious Pavement

Pervious Pavement areas shall be maintained and repaired per the manufacturer's recommendations and guidelines included at the end of this Appendix. Annual inspection is required in the spring after snow events have subsided for the year. The property owner shall; replenish paver joints with additional aggregate if the level is more than ½ in. below the bottom of the chamfer at the paver surface, inspect vegetation around pervious pavement perimeter for cover & soil stability and repair/replant as needed, inspect and repair all paver surface deformations (depressions/settlement) exceeding ½ in., repair paver heights offset by

more than ¼ in. above or below adjacent units, or offset by more than 1/8 in. lippage from paver-to-paver, replace cracked paver units of medium and high severity impairing surface structural integrity, check drains and outfalls (if existing) for the free flow of water. Remove any obstructions, check observation wells (if existing) to confirm reservoir is draining (based on last measurable rain event).

Landscaping

The management company retained by the property owner will maintain landscaped areas. Normally the landscaping maintenance will consist of pruning, mulching, planting, mowing lawns, raking leaves, etc. Use of fertilizers and pesticides will be controlled and limited to minimal amounts necessary for healthy landscape maintenance.

The lawn areas, once established, will be maintained at a typical height of 3 ½". This will allow the grass to be maintained with minimal impact from weeds and/or pests. The low-maintenance areas will be maintained as a meadow or allowed to revert back to natural conditions. Topsoil, brush, leaves, clippings, woodchips, mulch, equipment, and other material shall be stored off site.

Outdoor Storage

There will be no outdoor storage of hazardous chemicals, de-icing agents, fertilizer, pesticides, or herbicides anywhere around the building or on site.

Deicing and Snow Removal & Storage

The use of clean sand may be used to aid traction in conjunction with chemicals for deicing, snow melting and other related winter weather management. Sodium chloride should not be used as a deicing agent on the impervious surfaces due to potential effects to groundwater quality. Only calcium chloride or calcium magnesium may be used onsite as deicing chemicals. Snow shall be shoveled and plowed from sidewalk and parking areas as soon as practical during and after winter storms. Sand accumulation shall be removed from the site at the end of the winter season or appropriate time when seasonal snow has melted. Alternative deicing methods must be submitted prior to use onsite for review to the Town of Andover for approval.

MAINTENANCE SCHEDULE

During the First Year of Operation:		
Task:	Completion Date:	Manager's Initials:
JANUARY:		
Employee Training Program with Spill Program		
*Catch Basin and Hydrodynamic Separator Inspection		
FEBRUARY:		
*Hydrodynamic Separator Inspection		
MARCH:		
*Hydrodynamic Separator Inspection		
APRIL:		
*Catch Basin and Hydrodynamic Separator Inspection		
*Subsurface Stormwater Detention		
Sweeping of Paved Surfaces		
Pervious Pavement Routine Maintenance		
Shrub Fertilization		
Lawn Liming (if necessary)		
AUGUST:		
*Catch Basin and Hydrodynamic Separator Inspection		
OCTOBER:		
*Subsurface Stormwater Detention		
Tree and Lawn Fertilization		
Sweeping of Paved Surfaces		
Pervious Pavement Routine Maintenance		
DECEMBER:		
*Catch Basin and Hydrodynamic Separator Inspection		

*NOTE: Use appropriate worksheet found in this plan to conduct the inspection.

After the First Year of Operation:			
FOR YEAR_____			
Task:		Completion Date:	Manager's Initials:
JANUARY:			
Employee Training Program with Spill Program			
APRIL:			
*Catch Basin and Hydrodynamic Separator Inspection			
*Subsurface Stormwater Detention			
Sweeping of Paved Surfaces			
Pervious Pavement Routine Maintenance			
Shrub Fertilization			
Lawn Liming (if necessary)			
AUGUST:			
*Catch Basin and Hydrodynamic Separator Inspection			
OCTOBER:			
*Subsurface Stormwater Detention			
Tree and Lawn Fertilization			
Sweeping of Paved Surfaces			
DECEMBER:			
*Catch Basin and Hydrodynamic Separator Inspection			

*NOTE: Use appropriate worksheet found in this plan to conduct the inspection.

CATCH BASIN / CATCH BASIN INSERT INSPECTION LOG

Name of Inspector: Date:

Catch Basin ID	Condition (circle one)		Debris above 1’ within sump? (If yes then catch basin is to be cleaned)		Date of Catch Basin/Cleaning (if debris is greater than 1’)		Condition of Hood (if applicable, remove trash/debris if necessary)	Comments:
	Excellent							
	Fair	Poor	Yes	No	Yes	No		
	Excellent							
	Fair	Poor	Yes	No	Yes	No		
	Excellent							
	Fair	Poor	Yes	No	Yes	No		
	Excellent							
	Fair	Poor	Yes	No	Yes	No		
	Excellent							
	Fair	Poor	Yes	No	Yes	No		
	Excellent							
	Fair	Poor	Yes	No	Yes	No		
	Excellent							
	Fair	Poor	Yes	No	Yes	No		
	Excellent							
	Fair	Poor	Yes	No	Yes	No		
	Excellent							

On-site Procedures for Inspection and Maintenance of Catch Basin Inserts

• Secure traffic and pedestrian traffic with cones, barrels, etc.

• Clean surface area around each catch basin.

• Remove grates and set aside

• Clean grates, remove litter and debris that may be trapped within the grate

• Visually inspect condition of outlet hood and remove trash and debris from hood if necessary.

• Remove by vactor hose the debris that has been trapped in the trough area. Dispose of in accordance with local, state and federal regulatory agency requirements. Most debris that is captured in the trough or sump area will fall into the non-hazardous waste category.

• Visually inspect and check the condition of the trough area.

• Replace grate and lockdown as needed.

• Un-secure traffic control area.

• Complete service report and submit to facility owner.

SUBSURFACE STROWMATER DETENTION SYSTEM INSPECTION LOG												
Name of Inspector:							Date:					
Basin ID	Overall condition of Inlet Pipe (circle one)			Condition of Facility (circle one)			Debris and Sediment Removed from Basin?[1]		Inlets and Outlets are Clear and Functioning?		Date of Cleaning Performed	Comments
	Excellent	Fair	Poor	Excellent	Fair	Poor	Yes	No	Yes	No		
	Excellent	Fair	Poor	Excellent	Fair	Poor	Yes	No	Yes	No		
	Excellent	Fair	Poor	Excellent	Fair	Poor	Yes	No	Yes	No		
	Excellent	Fair	Poor	Excellent	Fair	Poor	Yes	No	Yes	No		
	Excellent	Fair	Poor	Excellent	Fair	Poor	Yes	No	Yes	No		
	Excellent	Fair	Poor	Excellent	Fair	Poor	Yes	No	Yes	No		
	Excellent	Fair	Poor	Excellent	Fair	Poor	Yes	No	Yes	No		
	Excellent	Fair	Poor	Excellent	Fair	Poor	Yes	No	Yes	No		
	Excellent	Fair	Poor	Excellent	Fair	Poor	Yes	No	Yes	No		
	Excellent	Fair	Poor	Excellent	Fair	Poor	Yes	No	Yes	No		
	Excellent	Fair	Poor	Excellent	Fair	Poor	Yes	No	Yes	No		
	Excellent	Fair	Poor	Excellent	Fair	Poor	Yes	No	Yes	No		
	Excellent	Fair	Poor	Excellent	Fair	Poor	Yes	No	Yes	No		
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	Excellent	Fair	Poor	Excellent	Fair	Poor	Yes	No	Yes	No		
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	Excellent	Fair	Poor	Excellent	Fair	Poor	Yes	No	Yes	No		
	Excellent	Fair	Poor	Excellent	Fair	Poor	Yes	No	Yes	No		
	Excellent	Fair	Poor	Excellent	Fair	Poor	Yes	No	Yes	No		
	Excellent	Fair	Poor	Excellent	Fair	Poor	Yes	No	Yes	No		

1 – Sediment deposits shall be removed from the subsurface detention basin when the deposited material reaches a height of 2” measured from the top of the stone bedding.

CONTECH®
ENGINEERED SOLUTIONS

CDS Guide
Operation, Design, Performance and Maintenance

CDS®

Using patented continuous deflective separation technology, the CDS system screens, separates and traps debris, sediment, and oil and grease from stormwater runoff. The indirect screening capability of the system allows for 100% removal of floatables and neutrally buoyant material without blinding. Flow and screening controls physically separate captured solids, and minimize the re-suspension and release of previously trapped pollutants. Inline units can treat up to 6 cfs, and internally bypass flows in excess of 50 cfs (1416 L/s). Available precast or cast-in-place, offline units can treat flows from 1 to 300 cfs (28.3 to 8495 L/s). The pollutant removal capacity of the CDS system has been proven in lab and field testing.

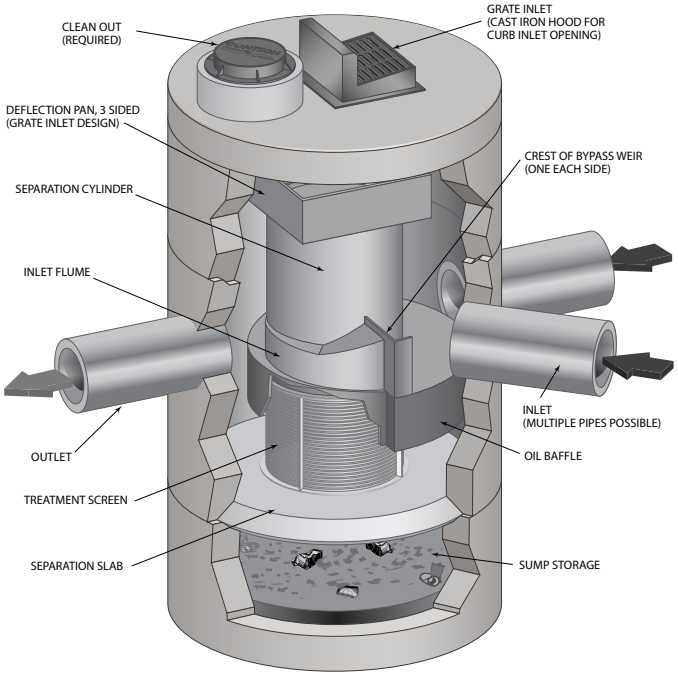
Operation Overview

Stormwater enters the diversion chamber where the diversion weir guides the flow into the unit's separation chamber and pollutants are removed from the flow. All flows up to the system's treatment design capacity enter the separation chamber and are treated.

Swirl concentration and screen deflection force floatables and solids to the center of the separation chamber where 100% of floatables and neutrally buoyant debris larger than the screen apertures are trapped.

Stormwater then moves through the separation screen, under the oil baffle and exits the system. The separation screen remains clog free due to continuous deflection.

During the flow events exceeding the treatment design capacity, the diversion weir bypasses excessive flows around the separation chamber, so captured pollutants are retained in the separation cylinder.



Design Basics

There are three primary methods of sizing a CDS system. The Water Quality Flow Rate Method determines which model size provides the desired removal efficiency at a given flow rate for a defined particle size. The Rational Rainfall Method™ or the and Probabilistic Method is used when a specific removal efficiency of the net annual sediment load is required.

Typically in the Unites States, CDS systems are designed to achieve an 80% annual solids load reduction based on lab generated performance curves for a gradation with an average particle size (d50) of 125 microns (μm). For some regulatory environments, CDS systems can also be designed to achieve an 80% annual solids load reduction based on an average particle size (d50) of 75 microns (μm) or 50 microns (μm).

Water Quality Flow Rate Method

In some cases, regulations require that a specific treatment rate, often referred to as the water quality design flow (WQQ), be treated. This WQQ represents the peak flow rate from either an event with a specific recurrence interval, e.g. the six-month storm, or a water quality depth, e.g. 1/2-inch (13 mm) of rainfall.

The CDS is designed to treat all flows up to the WQQ. At influent rates higher than the WQQ, the diversion weir will direct most flow exceeding the WQQ around the separation chamber. This allows removal efficiency to remain relatively constant in the separation chamber and eliminates the risk of washout during bypass flows regardless of influent flow rates.

Treatment flow rates are defined as the rate at which the CDS will remove a specific gradation of sediment at a specific removal efficiency. Therefore the treatment flow rate is variable, based on the gradation and removal efficiency specified by the design engineer.

Rational Rainfall Method™

Differences in local climate, topography and scale make every site hydraulically unique. It is important to take these factors into consideration when estimating the long-term performance of any stormwater treatment system. The Rational Rainfall Method combines site-specific information with laboratory generated performance data, and local historical precipitation records to estimate removal efficiencies as accurately as possible.

Short duration rain gauge records from across the United States and Canada were analyzed to determine the percent of the total annual rainfall that fell at a range of intensities. US stations' depths were totaled every 15 minutes, or hourly, and recorded in 0.01-inch increments. Depths were recorded hourly with 1-mm resolution at Canadian stations. One trend was consistent at all sites; the vast majority of precipitation fell at low intensities and high intensity storms contributed relatively little to the total annual depth.

These intensities, along with the total drainage area and runoff coefficient for each specific site, are translated into flow rates using the Rational Rainfall Method. Since most sites are relatively small and highly impervious, the Rational Rainfall Method is appropriate. Based on the runoff flow rates calculated for each intensity, operating rates within a proposed CDS system are

determined. Performance efficiency curve determined from full scale laboratory tests on defined sediment PSDs is applied to calculate solids removal efficiency. The relative removal efficiency at each operating rate is added to produce a net annual pollutant removal efficiency estimate.

Probabilistic Rational Method

The Probabilistic Rational Method is a sizing program Contech developed to estimate a net annual sediment load reduction for a particular CDS model based on site size, site runoff coefficient, regional rainfall intensity distribution, and anticipated pollutant characteristics.

The Probabilistic Method is an extension of the Rational Method used to estimate peak discharge rates generated by storm events of varying statistical return frequencies (e.g. 2-year storm event). Under the Rational Method, an adjustment factor is used to adjust the runoff coefficient estimated for the 10-year event, correlating a known hydrologic parameter with the target storm event. The rainfall intensities vary depending on the return frequency of the storm event under consideration. In general, these two frequency dependent parameters (rainfall intensity and runoff coefficient) increase as the return frequency increases while the drainage area remains constant.

These intensities, along with the total drainage area and runoff coefficient for each specific site, are translated into flow rates using the Rational Method. Since most sites are relatively small and highly impervious, the Rational Method is appropriate. Based on the runoff flow rates calculated for each intensity, operating rates within a proposed CDS are determined. Performance efficiency curve on defined sediment PSDs is applied to calculate solids removal efficiency. The relative removal efficiency at each operating rate is added to produce a net annual pollutant removal efficiency estimate.

Treatment Flow Rate

The inlet throat area is sized to ensure that the WQQ passes through the separation chamber at a water surface elevation equal to the crest of the diversion weir. The diversion weir bypasses excessive flows around the separation chamber, thus preventing re-suspension or re-entrainment of previously captured particles.

Hydraulic Capacity

The hydraulic capacity of a CDS system is determined by the length and height of the diversion weir and by the maximum allowable head in the system. Typical configurations allow hydraulic capacities of up to ten times the treatment flow rate. The crest of the diversion weir may be lowered and the inlet throat may be widened to increase the capacity of the system at a given water surface elevation. The unit is designed to meet project specific hydraulic requirements.

Performance

Full-Scale Laboratory Test Results

A full-scale CDS system (Model CDS2020-5B) was tested at the facility of University of Florida, Gainesville, FL. This CDS unit was evaluated under controlled laboratory conditions of influent flow rate and addition of sediment.

Two different gradations of silica sand material (UF Sediment & OK-110) were used in the CDS performance evaluation. The particle size distributions (PSDs) of the test materials were analyzed using standard method "Gradation ASTM D-422 "Standard Test Method for Particle-Size Analysis of Soils" by a certified laboratory.

UF Sediment is a mixture of three different products produced by the U.S. Silica Company: "Sil-Co-Sil 106", "#1 DRY" and "20/40 Oil Frac". Particle size distribution analysis shows that the UF Sediment has a very fine gradation (d50 = 20 to 30 μm) covering a wide size range (Coefficient of Uniformity, C averaged at 10.6). In comparison with the hypothetical TSS gradation specified in the NJDEP (New Jersey Department of Environmental Protection) and NJCAT (New Jersey Corporation for Advanced Technology) protocol for lab testing, the UF Sediment covers a similar range of particle size but with a finer d50 (d50 for NJDEP is approximately 50 μm) (NJDEP, 2003).

The OK-110 silica sand is a commercial product of U.S. Silica Sand. The particle size distribution analysis of this material, also included in Figure 1, shows that 99.9% of the OK-110 sand is finer than 250 microns, with a mean particle size (d50) of 106 microns. The PSDs for the test material are shown in Figure 1.

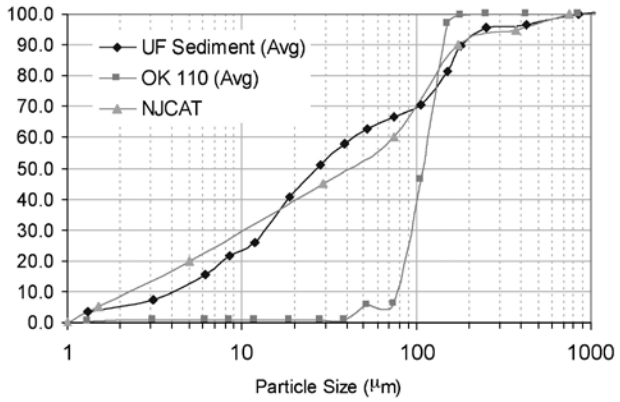


Figure 1. Particle size distributions

Tests were conducted to quantify the performance of a specific CDS unit (1.1 cfs (31.3-L/s) design capacity) at various flow rates, ranging from 1% up to 125% of the treatment design capacity of the unit, using the 2400 micron screen. All tests were conducted with controlled influent concentrations of approximately 200 mg/L. Effluent samples were taken at equal time intervals across the entire duration of each test run. These samples were then processed with a Dekaport Cone sample splitter to obtain representative sub-samples for Suspended Sediment Concentration (SSC) testing using ASTM D3977-97 "Standard Test Methods for Determining Sediment Concentration in Water Samples", and particle size distribution analysis.

Results and Modeling

Based on the data from the University of Florida, a performance model was developed for the CDS system. A regression analysis was used to develop a fitting curve representative of the scattered data points at various design flow rates. This model, which demonstrated good agreement with the laboratory data, can then be used to predict CDS system performance with respect

to SSC removal for any particle size gradation, assuming the particles are inorganic sandy-silt. Figure 2 shows CDS predictive performance for two typical particle size gradations (NJCAT gradation and OK-110 sand) as a function of operating rate.

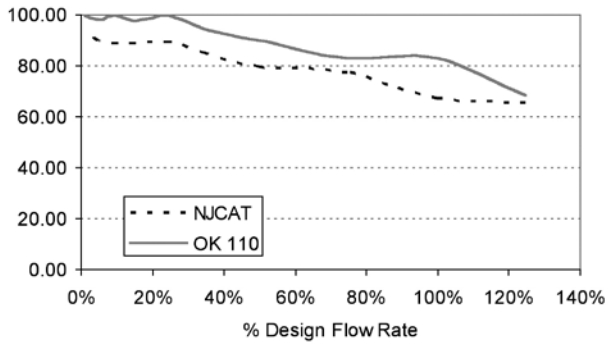


Figure 2. CDS stormwater treatment predictive performance for various particle gradations as a function of operating rate.

Many regulatory jurisdictions set a performance standard for hydrodynamic devices by stating that the devices shall be capable of achieving an 80% removal efficiency for particles having a mean particle size (d50) of 125 microns (e.g. Washington State Department of Ecology — WASDOE - 2008). The model can be used to calculate the expected performance of such a PSD (shown in Figure 3). The model indicates (Figure 4) that the CDS system with 2400 micron screen achieves approximately 80% removal at the design (100%) flow rate, for this particle size distribution (d50 = 125 μm).

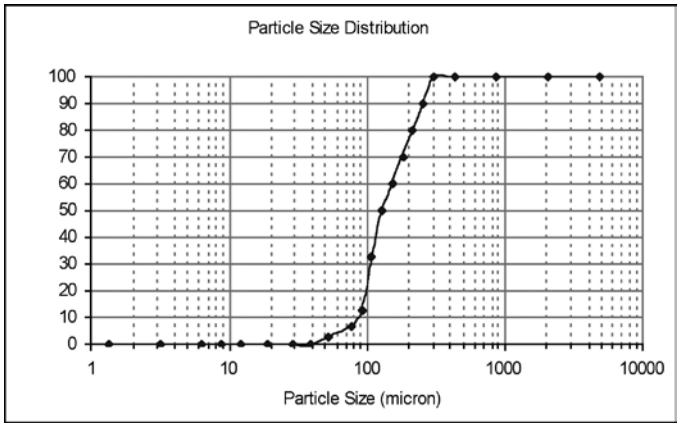


Figure 3. WASDOE PSD

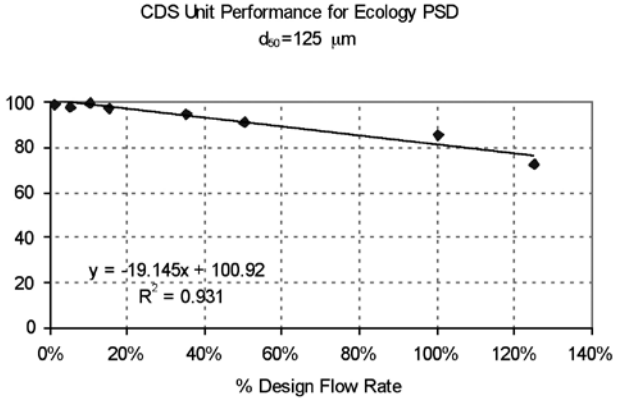


Figure 4. Modeled performance for WASDOE PSD.

Maintenance

The CDS system should be inspected at regular intervals and maintained when necessary to ensure optimum performance. The rate at which the system collects pollutants will depend more heavily on site activities than the size of the unit. For example, unstable soils or heavy winter sanding will cause the grit chamber to fill more quickly but regular sweeping of paved surfaces will slow accumulation.

Inspection

Inspection is the key to effective maintenance and is easily performed. Pollutant transport and deposition may vary from year to year and regular inspections will help ensure that the system is cleaned out at the appropriate time. At a minimum, inspections should be performed twice per year (e.g. spring and fall) however more frequent inspections may be necessary in climates where winter sanding operations may lead to rapid accumulations, or in equipment washdown areas. Installations should also be inspected more frequently where excessive amounts of trash are expected.

The visual inspection should ascertain that the system components are in working order and that there are no blockages or obstructions in the inlet and separation screen. The inspection should also quantify the accumulation of hydrocarbons, trash, and sediment in the system. Measuring pollutant accumulation can be done with a calibrated dipstick, tape measure or other measuring instrument. If absorbent material is used for enhanced removal of hydrocarbons, the level of discoloration of the sorbent material should also be identified

during inspection. It is useful and often required as part of an operating permit to keep a record of each inspection. A simple form for doing so is provided.

Access to the CDS unit is typically achieved through two manhole access covers. One opening allows for inspection and cleanout of the separation chamber (cylinder and screen) and isolated sump. The other allows for inspection and cleanout of sediment captured and retained outside the screen. For deep units, a single manhole access point would allows both sump cleanout and access outside the screen.

The CDS system should be cleaned when the level of sediment has reached 75% of capacity in the isolated sump or when an appreciable level of hydrocarbons and trash has accumulated. If absorbent material is used, it should be replaced when significant discoloration has occurred. Performance will not be impacted until 100% of the sump capacity is exceeded however it is recommended that the system be cleaned prior to that for easier removal of sediment. The level of sediment is easily determined by measuring from finished grade down to the top of the sediment pile. To avoid underestimating the level of sediment in the chamber, the measuring device must be lowered to the top of the sediment pile carefully. Particles at the top of the pile typically offer less resistance to the end of the rod than consolidated particles toward the bottom of the pile. Once this measurement is recorded, it should be compared to the as-built drawing for the unit to determine weather the height of the sediment pile off the bottom of the sump floor exceeds 75% of the total height of isolated sump.

Cleaning

Cleaning of a CDS systems should be done during dry weather conditions when no flow is entering the system. The use of a vacuum truck is generally the most effective and convenient method of removing pollutants from the system. Simply remove the manhole covers and insert the vacuum hose into the sump. The system should be completely drained down and the sump fully evacuated of sediment. The area outside the screen should also be cleaned out if pollutant build-up exists in this area.

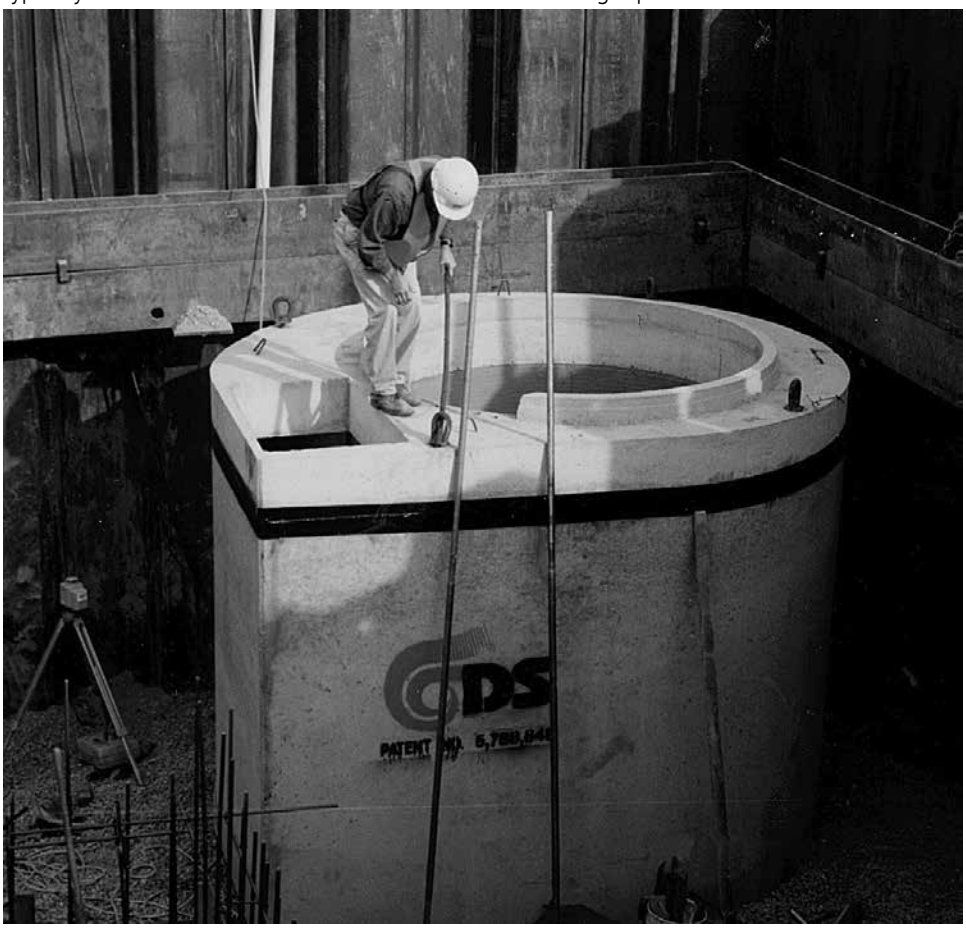
In installations where the risk of petroleum spills is small, liquid contaminants may not accumulate as quickly as sediment. However, the system should be cleaned out immediately in the event of an oil or gasoline spill. Motor oil and other hydrocarbons that accumulate on a more routine basis should be removed when an appreciable layer has been captured. To remove these pollutants, it may be preferable to use absorbent pads since they are usually less expensive to dispose than the oil/water emulsion that may be created by vacuuming the oily layer. Trash and debris can be netted out to separate it from the other pollutants. The screen should be cleaned to ensure it is free of trash and debris.

Manhole covers should be securely seated following cleaning activities to prevent leakage of runoff into the system from above and also to ensure that proper safety precautions have been followed. Confined space entry procedures need to be followed if physical access is required. Disposal of all material removed from the CDS system should be done in accordance with local regulations. In many jurisdictions, disposal of the sediments may be handled in the same manner as the disposal of sediments removed from catch basins or deep sump manholes. Check your local regulations for specific requirements on disposal.

CDS Model	Diameter		Distance from Water Surface to Top of Sediment Pile		Sediment Storage Capacity	
	ft	m	ft	m	y^3	m^3
CDS1515	3	0.9	3.0	0.9	0.5	0.4
CDS2015	4	1.2	3.0	0.9	0.9	0.7
CDS2015	5	1.5	3.0	0.9	1.3	1.0
CDS2020	5	1.5	3.5	1.1	1.3	1.0
CDS2025	5	1.5	4.0	1.2	1.3	1.0
CDS3020	6	1.8	4.0	1.2	2.1	1.6
CDS3025	6	1.8	4.0	1.2	2.1	1.6
CDS3030	6	1.8	4.6	1.4	2.1	1.6
CDS3035	6	1.8	5.0	1.5	2.1	1.6
CDS4030	8	2.4	4.6	1.4	5.6	4.3
CDS4040	8	2.4	5.7	1.7	5.6	4.3
CDS4045	8	2.4	6.2	1.9	5.6	4.3
CDS5640	10	3.0	6.3	1.9	8.7	6.7
CDS5653	10	3.0	7.7	2.3	8.7	6.7
CDS5668	10	3.0	9.3	2.8	8.7	6.7
CDS5678	10	3.0	10.3	3.1	8.7	6.7

Table 1: CDS Maintenance Indicators and Sediment Storage Capacities

Note: To avoid underestimating the volume of sediment in the chamber, carefully lower the measuring device to the top of the sediment pile. Finer silty particles at the top of the pile may be more difficult to feel with a measuring stick. These finer particles typically offer less resistance to the end of the rod than larger particles toward the bottom of the pile.



CDS Inspection & Maintenance Log

CDS Model: _____ Location: _____

Date	Water depth to sediment[1]	Floatable Layer Thickness[2]	Describe Maintenance Performed	Maintenance Personnel	Comments

1. The water depth to sediment is determined by taking two measurements with a stadia rod: one measurement from the manhole opening to the top of the sediment pile and the other from the manhole opening to the water surface. If the difference between these measurements is less than the values listed in table 1 the system should be cleaned out. **Note: to avoid underestimating the volume of sediment in the chamber, the measuring device must be carefully lowered to the top of the sediment pile**.

2. For optimum performance, the system should be cleaned out when the floating hydrocarbon layer accumulates to an appreciable thickness. In the event of an oil spill, the system should be cleaned immediately.

SUPPORT

- Drawings and specifications are available at www.ContechES.com.
- Site-specific design support is available from our engineers.

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The product(s) described may be protected by one or more of the following US patents: 5,322,629; 5,624,576; 5,707,527; 5,759,415; 5,788,848; 5,985,157; 6,027,639; 6,350,374; 6,406,218; 6,641,720; 6,511,595; 6,649,048; 6,991,114; 6,998,038; 7,186,058; 7,296,692; 7,297,266; related foreign patents or other patents pending.

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BELGARD
COMMERCIAL

OPERATION & MAINTENANCE GUIDE

for Belgard Permeable Interlocking Concrete Pavement Systems

BELGARD PERMEABLE PAVERS are produced by Oldcastle Architectural Products Group (APG) plants throughout North America and are manufactured in accordance with ASTM *C936 Standard Specification for Solid Concrete Interlocking Paving Units*, and ASTM C1782 *Standard Specification for Segmental Concrete Paving Slabs* in the United States. In Canada, pavers and slabs are manufactured in accordance with CSA A231.1/A231.2 *Precast Concrete Paving Slabs/Precast Concrete Pavers.*

Permeable Interlocking Concrete Pavement (PICP), like all types of permeable pavement, is a stormwater control measure that requires periodic inspection and maintenance to ensure long-term performance throughout the design life of the system. The type of maintenance differs from traditional impermeable pavements and maintenance methods can vary based on site-specific conditions.

All permeable pavements will collect sediment and debris which results in a decreasing infiltration rate over time. The rate of decrease depends on the sources of sediment. The surface infiltration rate reduction is gradual over time and most rain events are still infiltrated through the sediment filled joints. Gradual sedimentation captures suspended solids near the surface where routine maintenance can readily remove the sediment.

This document addresses the key inspection and maintenance requirements for Belgard permeable paver systems and does not address other types of permeable pavement systems or the cleaning and maintaining of standard concrete pavers. Belgard recommends that a site-specific Operations & Maintenance (O&M) Manual be developed, based on guidelines presented in this document, for large commercial and municipal projects.

Visit **www.BelgardCommercial.com** for a full collection of resources related to Belgard permeable pavers including typical details, guide specifications, laying patterns, and other reference material.

Oldcastle APG, a part of CRH International, is committed to delivering sustainable products that provide environmental benefits, including concrete products for stormwater management. Belgard permeable pavers are used throughout North America as part of a Low Impact Development strategy to infiltrate stormwater, reduce runoff, and associated flooding. Oldcastle's commitment to a cleaner environment extends beyond the products we manufacture and now includes a variety of post-construction maintenance programs for owners, municipalities, and facility managers. For more information about Oldcastle's commitment to the environment, go to **http://www.crh.com/sustainability.**

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CONTINUING EDUCATION AIA

icpi Interlocking Concrete Pavement Institute

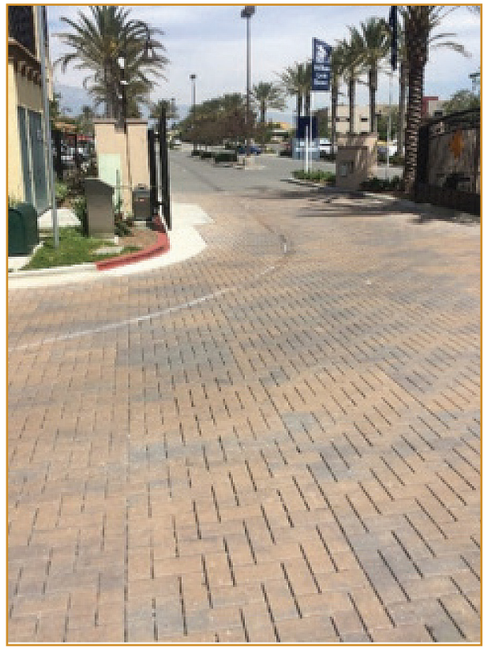
U.S. GREEN BUILDING COUNCIL

ASLA AMERICAN SOCIETY OF LANDSCAPE ARCHITECTS

SITE CONSTRUCTION PROTECTION FOR PICP SYSTEMS

Protecting PICP from excessive sediment buildup during construction is important to long-term performance and effective future maintenance efforts. Most sites build PICP systems first to protect the open-graded aggregates from debris, dirt, etc., and then the PICP is used for site access during construction. During the pre-construction meeting, various trades should review material flow that will impact or stain the paver surface, e.g. concrete trucks, dry wall, masonry, etc. These vehicles may utilize the pavement, but consideration on how washout and debris from these trades will impact the paver surface must be addressed. Excessive mud tracked on the pavers may cause excessive sedimentation in some areas but can be removed with a vacuum street sweeper at the conclusion of construction activities and prior to turning the project over to the owner. In addition, the PICP system can serve as an integral part of the project's Stormwater Pollution Prevention Plan if designated before construction with a plan to maintain and restore the PICP to full surface infiltration capacity. Oldcastle recommends that the PICP can be used by construction traffic if the joint material is removed and replaced upon substantial completion of the project, as necessary due to sedimentation. Surface infiltration testing must be performed and exceed 100 in/hr. unless otherwise specified by the construction documents.

An alternative solution to protect the PICP system would be to excavate to the final subgrade elevation and install the ASTM No. 2 aggregate to the depth shown in the construction documents (the layer can be increased in thickness to reduce the grade change as you enter the permeable paver area, as needed). The ASTM No. 2 aggregate can then be used by construction traffic and as a sediment trap. Once the final road construction can proceed, the top 6 to12 inches of ASTM No. 2 aggregate is excavated and the PICP system is built in its entirety as designed. Once final road construction begins, prohibit construction traffic access over the open-graded aggregate subbase and base materials.



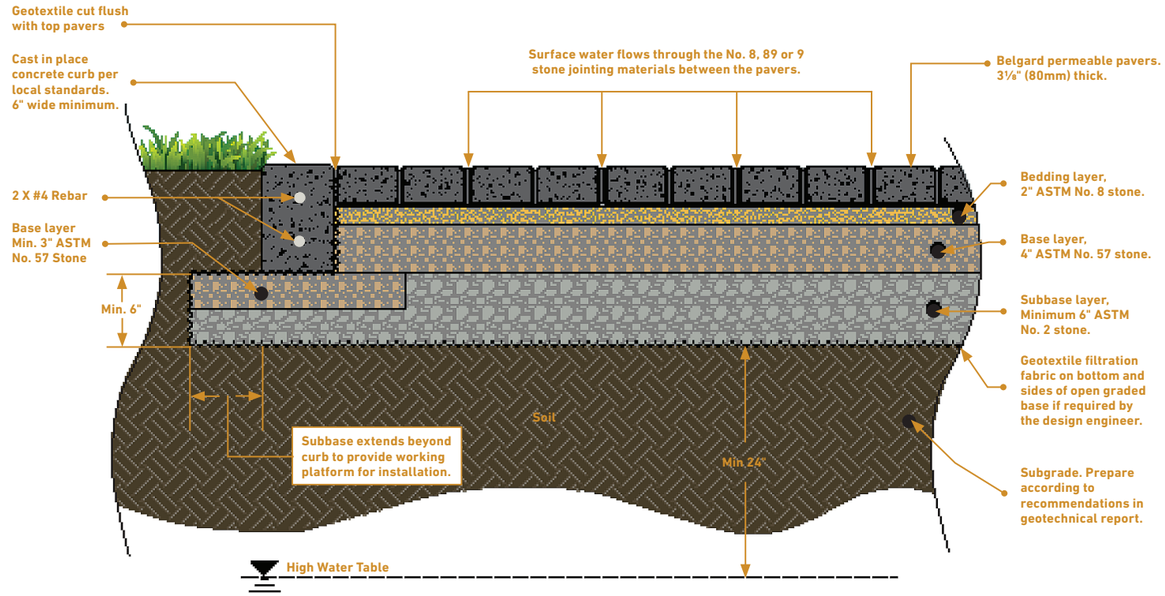
Another alternative solution would employ the use of a sacrificial layer of asphalt over the base (ASTM No. 57 aggregate). This approach would require the eventual removal of the asphalt layer and re-grading the base layer before proceeding with the setting bed layer and paver installation.

Each of these options would allow immediate traffic flow after the permeable pavers have been installed, compacted and joint fill added. Protection of the pavers may or may not be required based on the stage at which they were installed; the projected use by the trades; and needs of the property owner. Plywood, fabric with chips, tarps, and numerous other methods have been used in attempts to provide a protective layer over the paver surface, however, most have proven costly and ineffective.

POST-CONSTRUCTION (PUNCHLIST) INSPECTIONS AND CLOSE-OUT DOCUMENTS

When the PICP construction is complete, the owner or their representative should confirm that the newly built PICP was installed in general conformance with the construction documents. Confirmation that the proper materials and drainage were installed, through site visits and/or photographs, is recommended to ensure the long-term performance of the PICP system.

Example Construction Detail for a PICP System



Project close-out documentation should include all required information listed in the project specifications (inspection test reports, material certifications, etc.). A PICP Inspection should be conducted that includes, at a minimum, the items described below:

Belgard Permeable Paver Post-Construction (Punchlist) Inspection Checklist

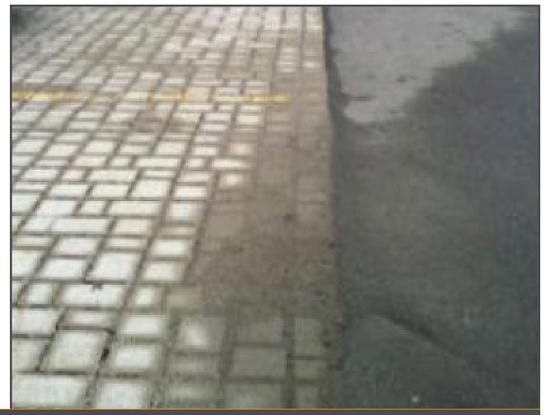
- ❑ The pavers utilized are the type, thickness, and dimensions specified in the construction documents.
- ❑ The edge restraint system is installed in general conformance with the construction documents.
- ❑ Paver joint openings are filled with the specified aggregate to the bottom of the chamfer of the paver.
- ❑ The area around the permeable paver perimeter is stabilized and covered with required vegetation or specified surface material
- ❑ Final paver surface elevations do not deviate by ± ⅜ in. over a 10ft. long straightedge.
- ❑ The surface elevation of the pavers is ⅛ in. to ¼ in. above adjacent utility structures, concrete collars, channels, curbing, or edge restraints within designated ADA routes. Note: Vehicular areas may be ⅜ in. above adjacent structures outside of ADA routes.
- ❑ Lippage is not greater than ⅛ in. between adjacent pavers.
- ❑ Cracked paver units (if applicable) have been removed and replaced.
- ❑ The installed surface slope is in general conformance with the construction documents.
- ❑ Drains and outfalls (if applicable) related to the PICP system are constructed and functioning in general conformance with the construction documents.
- ❑ Observation wells (if applicable) related to the permeable pavement system have been installed in accordance with the construction drawings and have been accessed to confirm the reservoir is draining as designed (based on rain event size).
- ❑ Surface infiltration testing in accordance with ASTM C1781, *Standard Test Method for Surface Infiltration Rate of Permeable Unit Pavement Systems*, has been conducted within 60 days post-installation, and results exceed 100 inches/hour unless otherwise specified by the construction documents.

Oldcastle recommends that the contractor return to the site along with the owner and/or their representative 6-months after substantial completion to observe the permeable paver system and refill joints where joint infill is ½" or more below the chamfer of the pavers. Designers should include this requirement in the project specificatoins to ensure that it is included in the contractor's bid.

TYPES OF PICP MAINTENANCE ISSUES

The following examples of PICP maintenance issues can provide visual indicators of issues that require corrective actions.

CONDITION OBSERVED: EXCESSIVE PONDING AFTER RAIN EVENTS.



POSSIBLE CAUSE: Sediment build-up in joints from contributory run-on.

CORRECTIVE ACTION: Verify correct joint fill is being used; identify possible sources of excessive run-on that can be mitigated, validate observation based on several rain events. Conduct ASTM C1781 testing and perform restorative maintenance, if needed.

CONDITION OBSERVED: LOSS OF JOINT INFILL.

POSSIBLE CAUSE: Scouring on slopes; improper joint infill used; pumping under traffic; improper sweeping during routine maintenance; and failure to refill joints as needed.

CORRECTIVE ACTION: Verify correct joint fill is being used; replace joint fill material to bottom of the chamfer of the paver.

CONDITION OBSERVED: SURFACE SETTLEMENT; DEPRESSIONS OR RUTS.

POSSIBLE CAUSE: Weak subgrade conditions; improper compacting of subbase/base during construction; excessive loading.

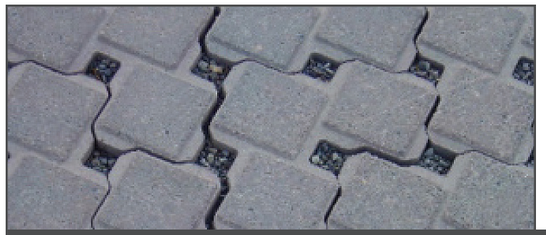
CORRECTIVE ACTION: Verify surface deformation is in excess of ½ inch using a 10-foot straight edge; contact a civil or geotechnical engineer to determine the cause of rutting and follow restorative action plan provided by the engineer *(see Structural Repairs section).*

CONDITION OBSERVED: DAMAGED PAVERS – CHIPS, CRACKS, SPALLS.

POSSIBLE CAUSE: Differential settlement; excessive loading, lack of joint infill.

CORRECTIVE ACTION: Determine causes of paver damage and correct the underlying conditions prior to replacing pavers *(see Structural Repairs section).*

CONDITION OBSERVED: EXCESSIVE IN-FIELD JOINT WIDTH (½")



POSSIBLE CAUSE: Improper or lack of joint infill; poor edge restraint system; settlement of subgrade, subbase, base, or bedding layer; utility trench failure.

CORRECTIVE ACTION: Re-instate pavers based on severity and frequency; evaluate surface for indications of settlement and address accordingly.

STRUCTURAL REPAIRS

PICP may require structural repairs during the life of the pavement to correct pavement distresses and to maintain an acceptable level of service. The most common distresses that affect the structural performance of PICP include damaged pavers and depressions and rutting. A more comprehensive list of distresses can be found in ASTM E2840 *Standard Practice for Pavement Condition Index Surveys for Interlocking Concrete Roads and Parking Lots.* While ASTM E2840 is specific to interlocking concrete pavers, most of the information provided is applicable to PICP. For large commercial projects (> 100,000 sf), Belgard recommends calculating a Pavement Condition Index (PCI), adjusted to accommodate PICP, in accordance with ASTM E2840 once every five years to identify areas of distress and to establish a maintenance schedule to assist the Owner in prioritizing maintenance needs and to establish a more accurate long-term maintenance budget.

Damaged Pavers

Damaged pavers include distresses such as cracking, chipping, or spalling. The severity of the distress can vary and will determine what restorative action, if any, is required.

DAMAGED PAVER SEVERITY LEVELS	
Low	One or two cracks with no separation, chips, or spalls in the pavers.
Medium	Advanced cracking with no separation, spalling, or chipping in the pavers but pavers are not disintegrated
High	Pavers are cracked into multiple pieces or are disintegrated from cracks, chips, and/or spalls.

Damaged pavers that are determined to be Low Severity should remain in place unless the frequency of breakage is greater than 1% of the surface area of the pavement. If this occurs, additional material testing and site investigation is recommended to determine the cause of the breakage. Damaged pavers determined to be in the Medium and High Severity Levels should be removed and replaced as described below.

Place the new replacement pavers to match the existing laying pattern. Compact the pavers in accordance with Belgard's guide specification for PICP. If the newly reinstalled paver is not flush to plus ⅛-inch with the surrounding pavers following compaction, it should be removed, and the thickness of the bedding layer should be modified to result in a flush to plus ⅛-inch surface following paver replacement and compaction. Once the desired grades are accomplished, sweep permeable joint aggregate into the joints and compact into place; repeat until the joints are full.

Depressions & Ruts

Depressions are areas of the pavement that have settled within the base, subbase, or subgrade and are typically not load related. Depressions can occur near the edge restraints, utility structures and penetrations, and at utility crossings. Ruts are depressions in the wheel paths of the pavement generally caused by repeated traffic loading and can occur in the base, subbase, and/or subgrade.

DEPRESSIONS & RUTTING SEVERITY LEVELS	
Low	¼ to ½ in. depth using a straight edge
Medium	½ to 1 in. depth using a straight edge
High	> 1 in. depth using a straight edge

For both depressions and ruts, the maximum depth determines the severity. Depressions and ruts of low severity shall typically remain in place but should be monitored during annual inspections for increased severity. Depressions and ruts with medium and high severity shall be evaluated by the engineer of record and the installing contractor to determine if repair is necessary and determine the underlying cause of the issue.

Once the underlying causes are identified, the engineer of record and the installing contractor should formulate a corrective action plan to address both the paver distresses and the underlying causes. The pavement shall be reinstated using the same procedure outlined in the Utility Repairs section of this document.

UTILITY REPAIRS

One advantage of PICP is that the pavers can be easily removed and reinstated for access to underground utilities. This important advantage allows the pavement surface to be utilized immediately after repairs are made.

Should utility repairs be required below the PICP surface, the pavers can be removed by hand using specialty equipment like paver extractors without the use of saw cutting equipment or pneumatic jack hammers. Once the first paver is removed, it is relatively easy to remove the remaining pavers to beyond the extent of excavation. Set the pavers aside for future reinstallation. Undisturbed pavers can be secured with a wood or metal frame as shown in the diagram.

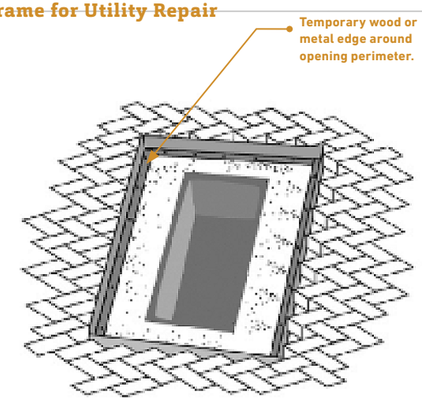
As excavation begins, remove and dispose of the bedding material (ASTM No. 8 Stone) and new aggregate used during reinstallation. The base and subbase, ASTM No. 57 and No. 2 stone respectively, can be reused during reinstallation, but should be carefully removed and stored separately to prevent intermixing. Storage locations for both the base and subbase should be carefully chosen to prevent contamination. Any aggregates that become dirty or contaminated should be discarded and replaced.

Where repairs require excavation into the underlying subgrade soil, Oldcastle recommends using flowable concrete fill (200 to 500 psi) to support the repaired utility. The open graded base cannot adequately fill under pipes or boxes, nor can it be compacted in these places. When pouring the flowable fill, use a plastic sheet or geotextile to prevent the flowable fill from seeping into the ASTM #2 Stone. A minimum 4 in. layer of flowable concrete fill should be used to cover a pipe or box structure.

When reinstalling the aggregates, place and level the subbase stone (ASTM No. 2) in no more than 6-inch lifts and use a plate compactor to compact each lift. The base stone (ASTM No 57) can be placed, leveled, and compacted in one 4-inch lift. The setting bed (ASTM No. 8) shall then be placed and screeded in one 2-inch lift without compaction.

When reinstalling the pavers, place the pavers level with the adjacent pavers, or slightly higher to account for settlement of the underlying materials (based on the depth of excavation). In either scenario, the bedding layer should be ⅛ in. higher so that once the pavers are reinstalled and compacted, they should be the same elevation as the adjacent units. Once the desired grades are accomplished, sweep jointing material into the joints and compact using a minimum 5,000 lbf plate compactor to vibrate the pavers into place. Repeat the process until the joints are full. Belgard can identify an authorized paver contractor to reinstate pavers, if required.

Paver Frame for Utility Repair



WINTER CONSIDERATIONS

Snow Removal

Snow removal may be accomplished with standard snow removal equipment used for impervious pavements. Whether it is a snow shovel, plow, power broom or blower, the same equipment may be used. Snowplow blades without a rubber tip or shoes may contact pavement but will not damage the pavers as edges are chamfered to reduce chipping. Steel blades or any metal used that abrades the paver may scratch the surface and leave rust marks from steel particles.

When using a snowplow or snowplow box, the utilization of rubber or plastic snow blades with properly adjusted skis/guides will prevent unwanted rust or scrape marks on the permeable paver surface. When using a snowblower, ensure the guides are properly adjusted to keep the rotating impeller from scraping and damaging the permeable paver surface and from displacing joint fill material. Plowed snow should not be piled on the permeable paver surface because winter sediment deposition can accelerate sedimentation. If snow must be piled on the permeable paver surface, a spring-time restorative cleaning is suggested in select areas to remove any sediment build-up.

Note: These same practices will prevent unwanted rust, scrape marks, and winter sediment on the surface of asphalt and concrete pavements.

Deicing Chemicals

The need for deicing chemicals on Belgard PICP systems should be significantly reduced compared to traditional impervious pavements or standard concrete pavers. If needed, use sodium chloride (ie rock salt) without sand. If air temperatures fall below 14 degrees Fahrenheit, calcium chloride may be used in moderation. Any deicing chemical should be used sparingly and in accordance with the manufacturer's application instructions. Never use magnesium chloride or materials containing ammonium nitrate and ammonium sulfate.

The use of sand or cinder mixes for snow or ice removal is not recommended because it can accelerate sedimentation.

A 2020 University of Toronto study on pavement deicing operations quantified some significant winter safety benefits when using PICP. Besides confirming that the use of permeable pavers can eliminate the occurance of snow melt refreezing and black ice formation, snow and ice on PICP can also melt and dry quicker when deicers are used. Most importantly, the research confirmed that a much lower deicing salt application rate is required on PICP compared to impervious asphalt. The study also demonstrated that PICP systems can attenuate and buffer the release of salt back into the environment, an important finding since there is concern about snowmelt and stormwater runoff environmentally damaging lakes and rivers. Contact a Belgard sales representative for a complete copy of *Deicing Operations for Permeable Interlocking Concrete Pavements* by the University of Toronto, dated April 1, 2020.

Snow & Ice Melt Systems

There are electric and liquid glycol melt systems that can be installed beneath Belgard Permeable paving systems that can reduce or eliminate the need for snow and ice removal. When considering the use of these systems, it is imperative that the guidelines and details established in ICPI's Tech Spec #12 *Snow Melting Systems for Interlocking Concrete Pavements* be followed. Because the snow melt system is below the permeable pavers, it is important to follow the maintenance requirements provided by the snow melt equipment supplier to ensure the long-term functionality of the system.

ANNUAL INSPECTION & ROUTINE MAINTENANCE PROGRAM

The following items are minimum requirements for any annual PICP maintenance program:

An annual inspection is recommended in the spring after snow events have subsided for the year. The purpose of the annual inspection is to assess the functional condition of the permeable pavers as a structural pavement and stormwater control measure. Once the annual inspection is completed, routine maintenance activities should be performed to correct any deficiencies.

- ❑ Replenish paver joints with additional aggregate if the level is more than ½ in. below the bottom of the chamfer at the paver surface.
- ❑ Inspect vegetation around PICP perimeter for cover & soil stability, repair/replant as needed.
- ❑ Inspect and repair all paver surface deformations (depressions/settlement) exceeding ½ in.
- ❑ Repair paver heights offset by more than ¼ in. above or below adjacent units, or offset by more than ⅛ in. lippage from paver-to-paver.
- ❑ Replace cracked paver units of medium and high severity impairing surface structural integrity.
- ❑ Check drains and outfalls (if existing) for the free flow of water. Remove any obstructions.
- ❑ Check observation wells (if existing) to confirm reservoir is draining (based on last measurable rain event).
- ❑ Conduct **Routine Maintenance** and increase frequency based on sediment loading.
- ❑ If evidence of surface excessive sedimentation exists, test surface infiltration rate using ASTM C1781. If pavement infiltration rate is < 100 in/hr. increase **Routine Maintenance** from annually to quarterly. If surface infiltration rates fall to 10 in/hr., employ a **Restorative Maintenance** program utilizing a high pressure air or vacuum methods to extract affected joint material and replace joint material with ASTM No. 8, 89 or 9 washed chip aggregates (based on original design requirements). In most cases, restorative cleaning will only be necessary in isolated locations. Retest surface infiltration rate to confirm reinstated areas exceed 100 in/hr. Repeat the restorative process as needed to exceed the 100 in/hr. criteria.

The initial routine maintenance cycle of a permeable pavement should commence 6 months from the PICP installation date, and be repeated every 12 months or more frequently as needed. The objective is to remove debris and sediment from the surface with standard sweeping equipment such as power or manual brooms, blowers, mechanical sweepers or regenerative air vacuums. Examples of routine maintenance equipment are shown on the following page.

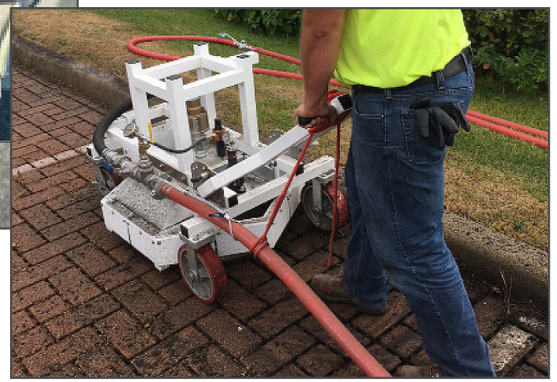
The Importance of Maintaining Joint Fill for Routine and Restorative Maintenance

While the focus is often on cleaning PICP joints, it is equally important to maintain aggregate in the joints not only for filtering sediment but to maintain paver to paver interlock providing structural stability. During the service life of the permeable paver system, joint material loss occurs through scour, migration, snow plowing, sweeping, and wheel suction from traffic, etc. It is imperative to replenish joint fill material as needed with the specified joint material in the construction documents (typically ASTM No. 8, 89, or 9) by sweeping joints full and removing the excess from the surface.

The use of water equipped sweepers or water assisted cleaning equipment to remove sediment within the joints or paver openings may be helpful. Excessive water will also create a slurry containing contaminants that may require special off-site disposal.

Lawn maintenance personnel should be instructed to blow grass clippings away from permeable pavement and blow off any grass clippings, plant debris, or leaves that are deposited on the permeable pavement during lawn maintenance and landscaping operations.

A dry mechanical or regenerative air type sweeper may be used during dry periods to remove encrusted sediment, leaves, grass clippings, etc. Vacuum equipment, air blowers or sweeper settings may require adjustments to prevent uptake of aggregate from the paver voids or joints. Leaf blowers or other standard onsite manual methods that are used for standard pavement maintenance may be employed to remove this surface debris.



Restorative Maintenance

In rare cases, excessive sediment loading can occur in PICP surfaces. These conditions are typically in isolated areas within the pavement (often along edges or drive lanes) and are usually due to excessive contributory run-on. Fortunately PICP, unlike other types of porous pavements, provides vertical filter columns (joints with specific aggregate infill) that allow for the capture and extraction of sediment build-up within the paver openings. Restorative maintenance can be done utilizing a number of different methods, although vacuum and high pressure air systems can best remove the entire 3 in. column of joint aggregates.

Sediment collects within the joint or paver openings (voids). As particles attach to the interior infill aggregates, the fine particles bind together. below the surface as shown below. The majority of the particulate or sediment travel is limited to the near surface and typically does not advance more than 1-2 inches below the paver surface and typically does not reach the bedding layer. The ability for PICP to collect sediment near the surface is a key advantage to this type of infiltration system. Maintenance can be easily performed on the near surface joint filters within a PICP system.

Municipal vacuum trucks, high-pressure air jets, and even a shop vac, may be used for restorative maintenance in smaller areas. For some projects, a high-powered pressure washer followed by high-powered vacuum suction such as a Ditch Witch FX30® vacuum excavator can be used for hot spot cleaning. This machinery is typically used for removal of accumulated sediment from catch basins and sumps. It is commonly available for rent in all markets and contractors have found this approach to be efficient for small projects.

Restorative maintenance should be attempted in a dry condition and if removal is not achieved, flooding the area with water will help release the sediment under pressure from the vacuum source (water may be effective for restorative maintenance).

The final task in restorative maintenance is to replace openings with joint fill (ASTM No. 8, 89, or 9) specified in the design by sweeping joints full to bottom of the chamfer of the paver surface. Remove excess chip materials from surface and the pavement is ready for use.

Maintenance Research

A 2020 University of Toronto study, *Maintenance Equipment Testing on Accelerated Clogged Permeable Interlocking Concrete Pavements* evaluated PICP restoration equipment based on surface infiltration testing before and after cleaning. Five different technologies were investigated: full vacuum sweeper, regenerative air sweeper, dry mechanical sweeper, water pressure washing, and a hybrid high pressure air/vac system specifically designed for permeable pavement. The study found that all cleaning technologies significantly improve surface infiltration rates. However, the high pressure air-vac hybrid (Typhoon Permeable Joint Excavator along with a PAVEVAC suction system) had the best and least variable results. The Typhoon system restoration was 2 to 6 times higher than the other systems and was the only technique able to fully restore surface infiltration rates.

A 2020 United States Geological Survey study, *Assessment of Restorative Maintenance Practices on the Infiltration Capacity of Permeable Pavement Assessment of Restorative Maintenance Practices on the Infiltration Capacity of Permeable Pavement*, evaluated different cleaning methods over a four-year period on three different types of permeable pavement. Researchers also found that all cleaning methods improve surface infiltration rates, however, the PICP system recovered and responded to cleaning far better than pervious asphalt or porous concrete. Researchers noted that PICP allows for sediment to be easily removed from surface openings, unlike fines that clog cast in-place permable pavement. The Typhoon system had the highest restored infiltration rates out of four cleaning methods tested, which included two different vacuum-assisted street cleaners and manual methods.

Contact a Belgard Sales Representative for copies of the latest maintenance research reports or for information about routine or restorative maintenance contractors in your market.

When is Restorative Maintenance Needed?

Restorative maintenance is sometimes required on older installations not routinely maintained. An indication that restorative maintenance is needed is when rainwater ponds on permeable paver surfaces. In addition, on some land development or phased construction projects, permeable pavers are installed early in the project and often are subjected to significant sediment loading prior to substantial completion or occupancy permit issuance. Project developers, HOAs, and municipal inspectors typically require that the PICP system is restored to full surface infiltration capacity for final acceptance and approval. On these projects subject to sediment loading, Belgard Commercial recommends a restorative maintenance program be implemented to restore the PICP infiltration rate and jointing material.

RESOURCES

The following resources address PICP design and maintenance and may provide additional guidance:

- *Permeable Interlocking Concrete Pavements,* latest edition a comprehensive design manual that provides specifications and information on construction and maintenance, published by The Interlocking Concrete Pavement Institute (ICPI)
- *ASCE 68-18 Permeable Interlocking Concrete Pavement,* a design standard providing design methodologies for both structural and hydrologic design of permeable paver systems by the American Society of Civil Engineers (ASCE) through the Transportation and Development Institute (T&DI)
- *ASTM E2840 Standard Practice for Pavement Condition Index Surveys for Interlocking Concrete Roads and Parking Lots* published by the American Society for Testing Materials (ASTM)

Go to BelgardCommercial.com to download PICP resources including:

- Guide specification
- Typical details
- Project Profiles
- Product Data Sheets (cut sheets)
- Color options
- Installation guidelines
- Inspection & Maintenance checklists

Belgard Commercial offers the following post-construction services:

- **Project-specific O&M Manual -** Belgard Commercial has developed O&M manual templates for commercial and municipal PICP projects to restore clogged areas with new joint fill and establish surface infiltration rates exceeding 100 inches/hour. Assistance with developing a project-specific O&M manual can be provided.
- **ASTM C 1781 Surface Infiltration Testing –** Belgard Commercial can provide surface infiltration testing along with a report documenting the methodology and results for municipal and commercial PICP projects.
- **Routine PICP Maintenance Program –** Belgard Commercial can recommend routine maintenance service contractors for commercial and municipal PICP projects. The frequency and cost of this program is quoted on a project-specific basis.
- **Restorative PICP Maintenance –** Belgard Commercial can facilitate restorative maintenance services on an as-needed basis to restore clogged areas with new joint fill and establish surface infiltration rates exceeding 100 inches/hr. Belgard Commercial will ensure that appropriate equipment will be operated by qualified and trained contractors. Projects that elect restorative maintenance will receive results of an ASTM C1781 surface infiltration test upon completion of the scope of work.

Belgard Commercial offers the following post-construction services:

- **Project-specific details**
- **Project-specific specifications**
- **Input on stormwater conveyance, storage, and water quality strategies**
- **Concept plans for alternative PICP designs**
- **Stormwater Management Plan reviews**
- **Cost analysis comparing PICP systems to conventional impervious pavement systems**
- **Life-cycle cost analysis comparisons**

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