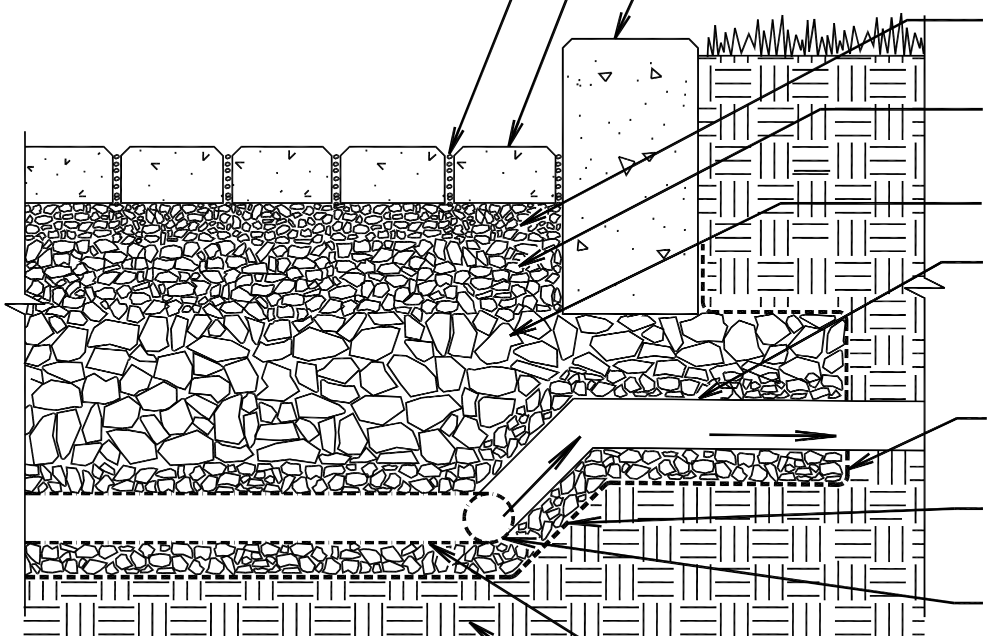
13.7 Appendix 6 – Details of Proposed SuDS

13.7.1 Permeable Paving

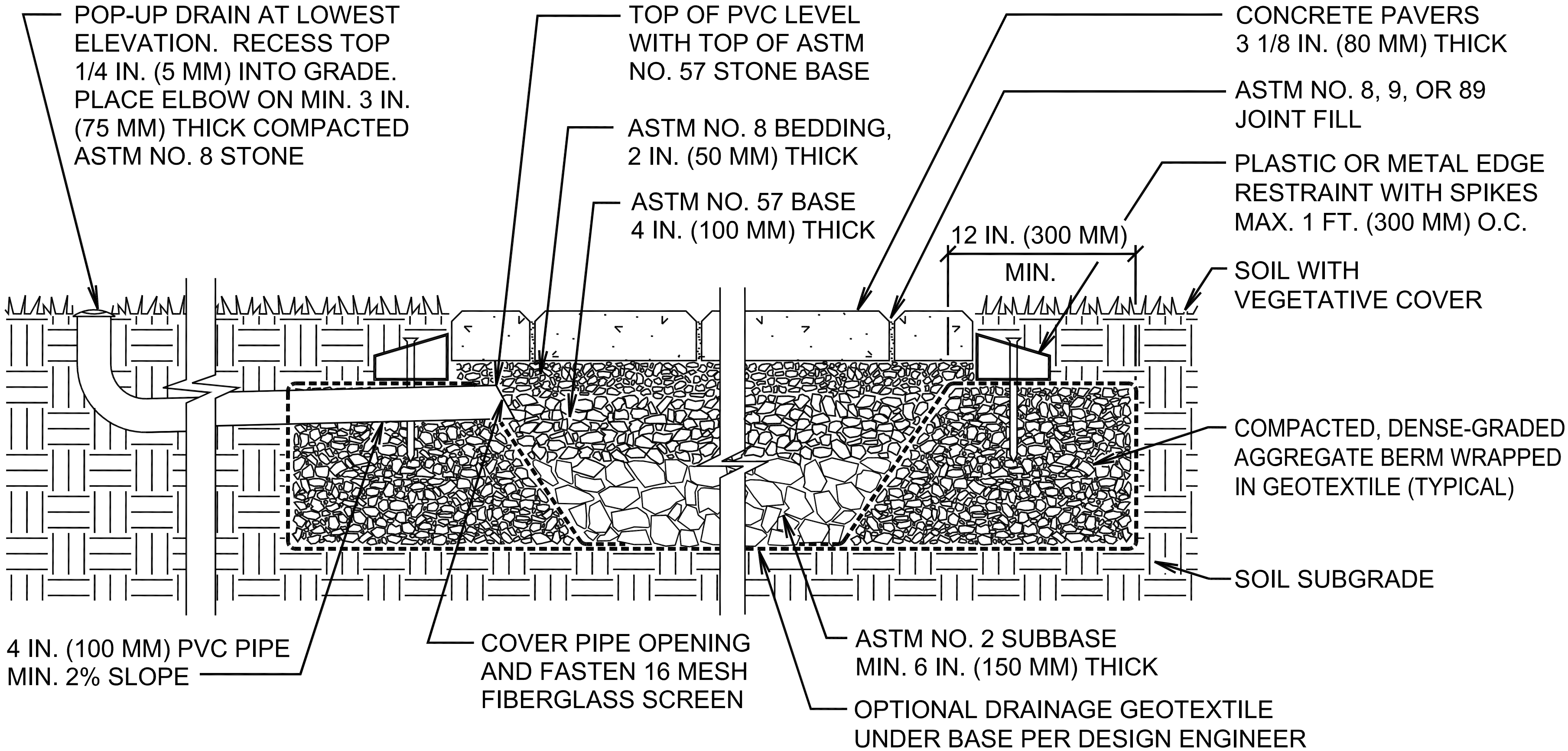


NOTES:

1. 2 3/8 IN. (60 MM) THICK PAVERS MAY BE USED IN PEDESTRIAN AND RESIDENTIAL APPLICATIONS.
2. NO. 2 STONE SUBBASE THICKNESS VARIES WITH DESIGN.
   CONSULT ICPI PERMEABLE INTERLOCKING CONCRETE PAVEMENT MANUAL.
3. NO. 2 STONE MAY BE SUBSTITUTED WITH NO.3 OR NO.4 STONE.
4. SELECT GEOTEXTILE PER AASHTO M 288.

PERMEABLE PAVEMENT WITH PARTIAL INFILTRATION TO SOIL SUBGRADE

DRAWING NO.	ICPI-69
SCALE	NO SCALE



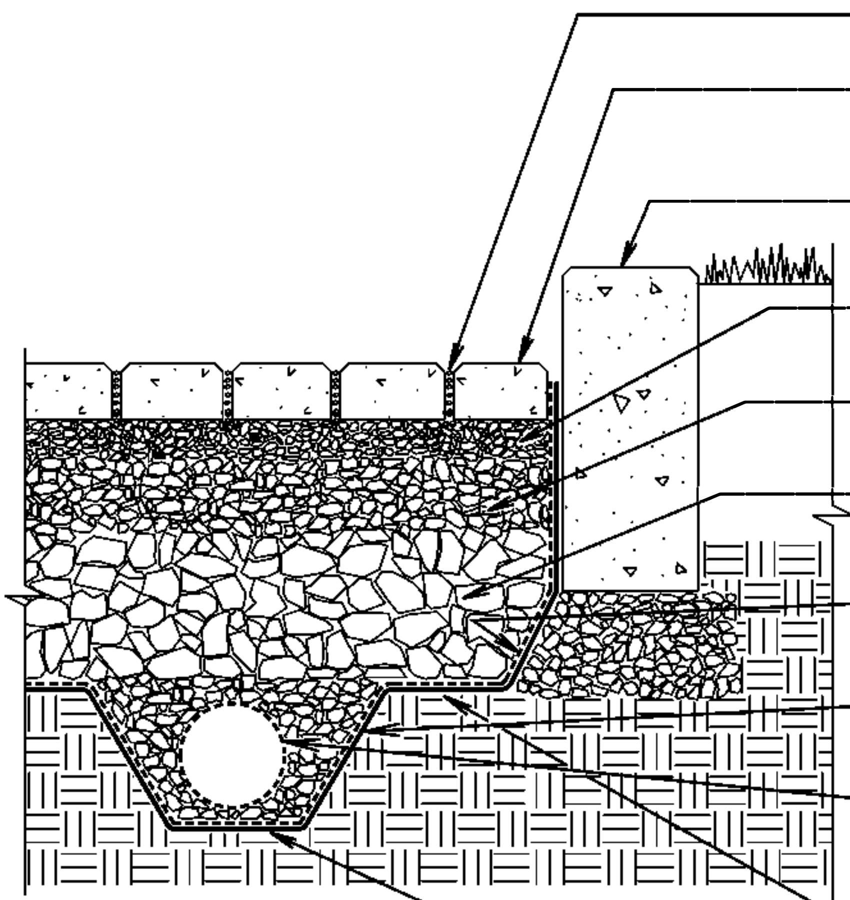
NOTES:

1. DESIGN, MATERIAL, AND CONSTRUCTION GUIDELINES TO FOLLOW ICPI GUIDE SPECIFICATIONS
2. DAYLIGHT DRAIN PIPE TO DRAINAGE SWALE. USE POP-UP DRAIN IN YARD (AS SHOWN) OR CONNECT TO STORM SEWER.
3. APPLY WATERPROOF MEMBRANE VERTICALLY AGAINST HOUSE FOUNDATION PRIOR TO PLACING SUBBASE AND BASE.
4. ALL SOIL SUBGRADES SHALL SLOPE TOWARD STREET.
5. SUBGRADE SOIL MAXIMUM CROSS SLOPE IS 0.5%. MAXIMUM LONGITUDINAL SLOPE IS 2% TOWARD STREET.
6. USE SOIL BERMS FOR LONGITUDINAL SOIL SUBGRADE SLOPES EXCEEDING 2% TOWARD STREET.
7. 5% MAXIMUM SURFACE SLOPE.
8. THICKER SUBBASE AND/OR ADDITIONAL DRAIN PIPES MAY BE REQUIRED IF DRIVEWAY RECEIVES RUNOFF FROM ADJACENT IMPERVIOUS SURFACES OR ROOFS.
9. NO. 2 STONE MAY BE SUBSTITUTED WITH NO. 3 OR NO. 4 STONE.
10. SELECT GEOTEXTILE PER AASHTO M 288.

PERMEABLE INTERLOCKING CONCRETE PAVEMENT DRIVEWAY WITH AGGREGATE BERMS

DRAWING NO. ICPI-79

SCALE NO SCALE



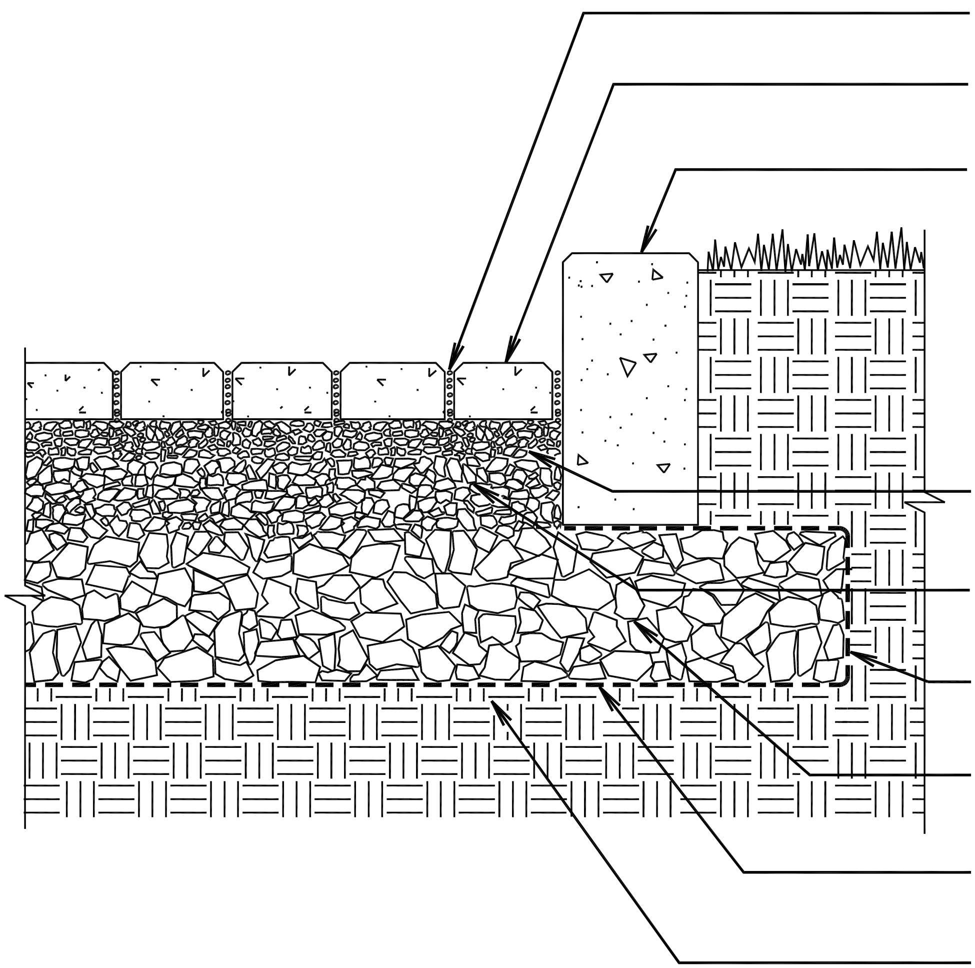
NOTES:

1. 2 3/8 IN. (60 MM) THICK PAVERS MAY BE USED IN RESIDENTIAL APPLICATIONS.
2. NO. 2 STONE SUBBASE THICKNESS VARIES WITH DESIGN. NO. 3 OR NO. 4 STONE IS ACCEPTABLE. CONSULT ICPI PERMEABLE INTERLOCKING CONCRETE PAVEMENT MANUAL.
3. PERFORATED PIPES MAY BE RAISED FOR WATER STORAGE FROM LARGE RAIN EVENTS WITH OUTLET(S) AT LINER BOTTOM TO DRAIN SMALL RAIN EVENTS.
4. SELECT GEOTEXTILE PER AASHTO M 288.

PERMEABLE PAVEMENT WITH NO INFILTRATION TO SOIL SUBGRADE

DRAWING NO. ICPI-70

SCALE NO SCALE



NOTES:

1. 2 3/8 IN. (60 MM) THICK PAVERS MAY BE USED IN PEDESTRIAN AND RESIDENTIAL APPLICATIONS.
2. NO. 2 STONE SUBBASE THICKNESS VARIES WITH DESIGN.
   CONSULT ICPI PERMEABLE INTERLOCKING CONCRETE PAVEMENT MANUAL.
3. NO. 2 STONE MAY BE SUBSTITUTED WITH NO. 3 OR NO. 4 STONE.
4. SELECT GEOTEXTILE PER AASHTO M 288.

PERMEABLE PAVEMENT WITH FULL INFILTRATION TO SOIL SUBGRADE

DRAWING NO. ICPI-68

SCALE NO SCALE

Stormwater Solutions for Homeowners Fact Sheet: Rain Gardens

Stormwater is rainwater and snowmelt that runs over the ground, picking up pollutants along the way—such as oil from roadways, silt and sand from exposed soil, nutrients from fertilizers, bacteria from pet waste, and pesticides from lawns. These pollutants are not treated or removed when the stormwater flows through a storm drain or directly to the nearest body of water, resulting in stormwater pollution that can contaminate shellfish beds and swimming areas, cause algae blooms and fish kills, and otherwise impact people, wildlife, and ecosystems. This runoff can also cause flooding and erosion on your property and beyond. To help address these problems, the Massachusetts Office of Coastal Zone Management (CZM) has developed Stormwater Solutions for Homeowners, a series of fact sheets on techniques to control runoff on your property and reduce stormwater contamination of local waters.

Introduction

Rain gardens are specially designed and planted depressions in the ground that collect, filter, and treat stormwater. These slightly sunken gardens allow collected water to be taken up by plants or slowly infiltrated (i.e., filtered into the ground), reducing the amount of water running off site. Rain garden soils—which are typically amended with mulch and sand to promote proper moisture levels and drainage properly—also remove pollutants (including metals, nutrients, sediments, oils/grease, and organic matter) before they reach groundwater or flow to coastlines and local waterbodies. By preventing stormwater from running into roads, storm drains, and waterways, rain gardens may also help reduce localized flooding and erosion. Rain gardens are an excellent choice for most properties and are a potential do-it-yourself project with many options for shape, plantings, and size (even small rain gardens provide great benefits). Planting a rain garden with flowering and fruiting plants, shrubs, and trees will also provide visual interest, as well as food and habitat for wildlife (see “Native Plants for Rain Gardens in Massachusetts” at the end of the fact sheet for recommendations, including options for coastal sites).

A rain garden planted along the road collects and filters stormwater before it runs off and drains to local waterbodies.

Rain gardens can be strategically located to collect and treat water flowing from roof downspouts, paved areas, or sump pumps, helping to reduce drainage problems and soggy areas in your yard—and because rain gardens more effectively capture and absorb rainwater than lawns, they make an excellent runoff-control alternative for yard areas. Rain gardens do require an appropriate soil depth to effectively treat stormwater, so they may not be suitable in areas with poorly drained or clay soils, ledge, or a high groundwater table. Be sure to follow the guidelines in this fact sheet for siting a rain garden to ensure success and avoid harmful effects.

Do You Need a Permit?

For properties near beaches, coastal banks, dunes, floodplains, rivers, salt marshes, wetlands, and other "resource areas" protected under the Massachusetts Wetlands Protection Act,* rain gardens can be particularly beneficial for helping to reduce stormwater impacts. Projects directly next to or within these resource areas, however, are likely to require a permit through the local Conservation Commission. To maximize benefits and avoid impacts to resource areas and adjacent properties, permitted projects must be properly designed, installed, and maintained. For example, rain gardens near coastal banks should be sited so there is no potential for infiltrated water to break out on the bank face and cause erosion problems. Also, a sufficient depth of soil must be maintained between the base of the rain garden and the water table to allow for proper filtration and treatment. Rain gardens must not be sited within wet resource areas, such as marshes, swamps, bogs, rivers, streams, ponds, and vegetated wetlands. During the construction of the rain garden, impacts must be minimized by providing erosion and sedimentation controls. The Massachusetts Department of Environmental Protection's *Structural BMP Specifications for the Massachusetts Stormwater Handbook* (Volume 2, Chapter 2) (PDF, 6.5 MB) provides additional information and design requirements for stormwater control projects proposed in wetland resource areas and buffer zones. Homeowners are encouraged to contact their local Conservation Commission before undertaking any work to determine whether a resource area exists, what permitting requirements may apply, and how to avoid impacts.

*MGL Chapter 131, Section 40 and corresponding regulations at 310 CMR 10.00.

Impacts to Neighboring Properties

Stormwater management practices must be designed to responsibly manage runoff from your property without transferring problems to neighboring properties, roads, and municipal drainage systems. Rain gardens, vegetated swales, and other techniques that collect and hold stormwater have the potential to overflow "muddy" water in major storms. When designing these options, be sure that there is enough area on your property to effectively capture and treat any overflow onsite. Management practices that redirect or divert stormwater—such as disconnecting/redirecting downspouts or re-grading the land surface—can similarly cause flooding problems in roadways or neighboring yards, basements, or leach fields (potentially causing a septic system failure). These projects must therefore be designed to ensure that no additional stormwater is transferred offsite. Carefully following design guidelines in the Stormwater Solutions for Homeowners fact sheets will help you avoid impacts to neighboring properties. If in doubt about offsite impacts, consult a professional, such as a civil engineer or landscape architect.

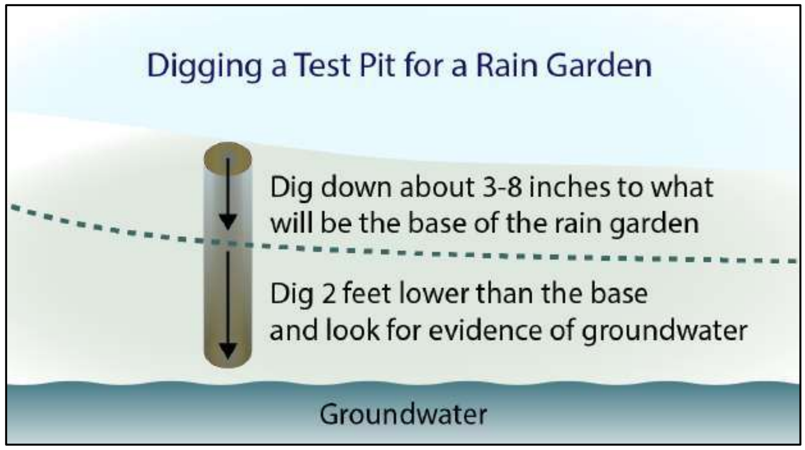
Size and Location for a Rain Garden

Even small rain gardens capture and treat stormwater, so a project of any size can be beneficial on your property. The "Technical Specifications for Calculating Rain Garden Size" section on page 10 of this fact sheet provides some advanced, optional steps for calculating a specific rain garden size for treating runoff. As a general rule, rain gardens should be at least 1/8 to 1/3 the size of the drainage area (i.e., the area that drains runoff to the rain garden) and 3-8 inches deep to fully treat stormwater. (The specific size needed to fully treat stormwater will vary depending on your soil type and slope, which affects how well water infiltrates into the ground—see the last two bullets of this section or the "Technical Specifications" section for details.) When choosing the rain garden location, follow these steps:

- **Find places where rain or runoff can easily be collected** - Look for relatively flat areas in your yard that are downslope from roof downspouts and impervious surfaces (i.e., surfaces that do not allow water to filter into the ground, such as rooftops or driveways). Rain gardens should be located at least 10 feet away from home foundations and at least 50 feet away from septic systems or wells. If necessary, you can more efficiently direct water to the rain garden by adding extensions to downspouts or piping water underground. Directing water through rocky or grassy drainage swales is another option to convey water while providing additional infiltration (for more information on swales, see *Stormwater Solutions for Homeowners Fact Sheet: Vegetated Swales*). Be sure that any overflow from the rain garden will not run onto neighboring properties or roadways. Also, be sure that all components of the project are located on your property and not the road right-of-way.

Water from a roof downspout runs through a rocky swale and into this small residential rain garden. The three photos show the sequence as native plants grew and filled in over time.

- **Check for groundwater** - Generally, at least 2 feet of soils are needed between the bottom of the rain garden and the water table to effectively filter out pollutants and protect groundwater. To check if the water table is too high, wait until the groundwater is normally at its highest (in the spring months, typically April through May), but not immediately after a heavy rain. Then, dig a hole 2 feet deeper than the planned base of your rain garden (see the "Digging a Test Pit for a Rain Garden" diagram). Leave the hole open for at least an hour, and if water seeps in or if you see soil mottling (a blotchy pattern of red, orange, or yellow that differs from the rest of the soil, indicating prolonged soil saturation from groundwater), gley (a sticky, waterlogged soil that is a green-blue-gray color), or organic muck, the location is unsuitable for a rain garden. An alternative to digging a hole is to drive rebar or a pipe into the soil and then pull it out and check if it is damp (like using an oil dipstick). If signs of groundwater are found, you will need to try another location.



- **Ensure the water drains properly** - A rain garden will not drain properly when located too close to the groundwater level, in an area with clay or silty soils, or in a low spot that tends to collect standing water. (Please note, however, that placing a rain garden directly uphill from soggy, low spots can be ideal.) You can assess the drainage rate by digging a hole at least 1-2 feet deep (again, this is best done in the spring, and you can use the same hole you dug to check for groundwater). If water seeps into the hole within an hour, the site does not drain properly. If the hole stays dry, fill it with water and then time how long it takes the water to seep into the ground. If it drains in less than 24 hours, the location properly drains. If it takes more than 24 hours or does not fully drain, try another location or amend the soil to improve drainage (additional informaton on amending soils is given in the "Rain Garden Base" section).
- **Determine the soil type** - Soil type also affects how well the rain garden will drain. A "ribbon test" can be used to determine soil type—dig down below the topsoil (since organic matter can interfere with results), grab a handful of soil, roll it in a ball, and squeeze. If the soil sticks together and forms a clump (or "ribbon") more than 1.5 inches long, it is clay soil with low infiltration rates. If it forms a weak ribbon that breaks at a length of approximately 1.5 inches or less, it is a silty soil with medium infiltration rates. Sandy soil, which has high infiltration rates, will not form a ribbon at all. The type of soil and its infiltration rate will help determine whether soil amendments are necessary and can be used to help determine the ideal size for a rain garden.

Rain Garden Base

__Dig Safe__ - At least 3 days before you plan to dig even a small hole in your yard, call Dig Safe at 811 for professional assistance in determining the location of underground utility lines!

Follow these instructions to build the rain garden base:

- **Dig/excavate the base** - Mark the perimeter of the rain garden. Then remove the sod, grass, or other vegetation and dig out the rain garden area to a depth of 3-8 inches. For larger rain gardens, an excavator may be needed to remove soil or regrade the ground surface. (When using heavy equipment, be careful to avoid compacting the soil, which reduces infiltration and limits the growth of plants.) To minimize potential erosion, ensure that the rain garden base is level so the water spreads out and drains evenly. You may also grade the rain garden base so that it pitches slightly to the center to help avoid washouts and erosion along the edges.
- **Amend the soils** - Rain garden soils need to retain enough moisture for plants to grow, but also provide enough drainage so that water does not pool for extended periods. For ideal soil conditions, use 50-60% sand, 20-30% topsoil, and 20-30% shredded bark mulch—blended together as much as possible. (Triple shredded mulch should be used because it can be incorporated into the soil much faster than coarser mulch, which helps reduce compaction and improve water infiltration.) Mixing compost with rain garden soils is typically not recommended due to compost's high phosphorus content. If the ribbon test showed that your soils are high in clay and silt, dig

down an additional 6-18 inches and replace the soil with a layer of gravel or crushed stone covered with the recommended mix of sand, topsoil, and shredded mulch. (Once these materials are added, you can perform another drainage test to see if water infiltrates within 24 hours.) In some cases, you may be able to simply add amendments (such as sand) to increase the infiltration capacity of the rain garden. Soils can also be topped with a layer of bark mulch (either before or after planting) to help retain moisture and nutrients while preventing erosion and compaction. (Triple shredded mulch is also recommended for this top layer since the finer fibers interlock, helping the mulch to stay in place and providing better weed control; do not use light-weight wood chips or straw because they are easily washed away.)

- **Build a berm** - A berm (a raised barrier) built on the downhill side of the rain garden is an option to help hold water and give it time to seep into the soil. The soil removed when digging the rain garden base can be used to build the berm. If a berm is used, it should be no more than 6-8 inches high—just enough for stormwater to pond to improve infiltration into the ground.

A berm built around the downhill sides of a rain garden helps hold stormwater. The rain garden soils have been amended with sand and a planting soil mix.

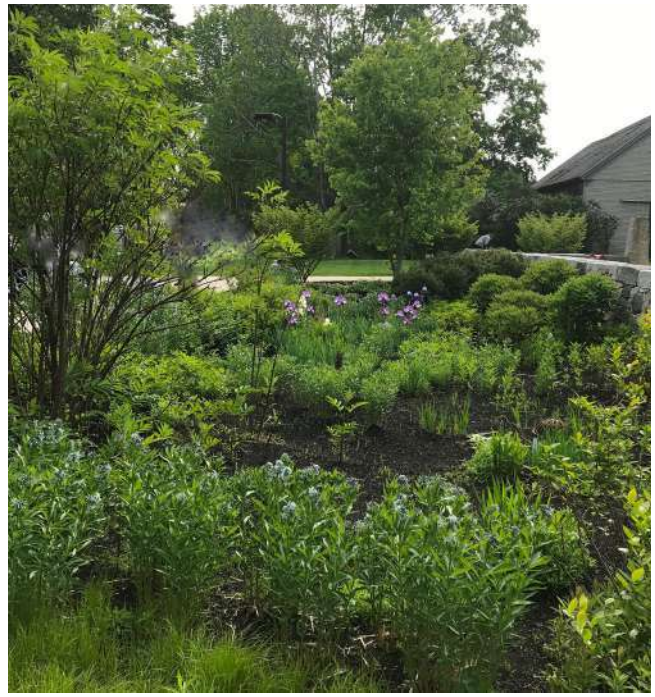
- **Prevent erosion** - To help prevent runoff from washing out the mulch or soil during heavy rain, the rain garden should be relatively level or only slightly sloped and contained by a berm. In addition, the mulch used should be finely shredded and the ground surfaces should be well vegetated. During construction, you may want to install a temporary erosion-control blanket made of natural fibers over the rain garden to protect the soil until the vegetation becomes established (the natural fibers in the blanket disintegrate in 6-24 months, and the root systems of the plants take over the job of stabilizing the site; for details, see CZM's *StormSmart Fact Sheet 5: Bioengineering - Natural Fiber Blankets on Coastal Banks*). Optional approaches for slowing the speed of runoff flowing into the rain garden include spreading a layer of crushed stone on the uphill side of the area or creating a small stone drainage path (or drainage swale) from the source of the runoff to the rain garden (see the illustration on page 7).

Rain Garden Plantings

Follow these guidelines to improve success of rain garden plantings.

- **Species selection and placement** - Choose hardy native species, which are well adapted to local conditions and typically do not require the use of chemical fertilizers and pesticides. Ideally, your rain garden should include a variety of plant species to ensure survival and diversity. All plants will need to tolerate some fluctuation in water levels and be able to withstand both wet and dry conditions (including droughts when soils drain completely for extended durations). Wet-tolerant plants should be placed in the wettest locations, such as in the deepest areas and where the water enters the rain garden. Plants better suited to moderate moisture or dry conditions should be placed on the edges and higher areas of the rain garden. To reduce initial planting costs, younger plants can be used—but since young plants do not necessarily thrive in standing water, for the first year you may need to dig out a small opening in your soil berm to allow water to drain. Rain gardens may also be planted with native grasses and mowed periodically. (Rain gardens should be mowed infrequently to prevent soil compaction and to allow the growth of longer grasses and deeper root systems, which more effectively treat stormwater.) The "Native Plants for Rain Gardens in Massachusetts" box at the end of this fact sheet lists plants that are appropriate for different moisture levels. For additional plant options, see the UMass Extension Rain Gardens fact sheet.

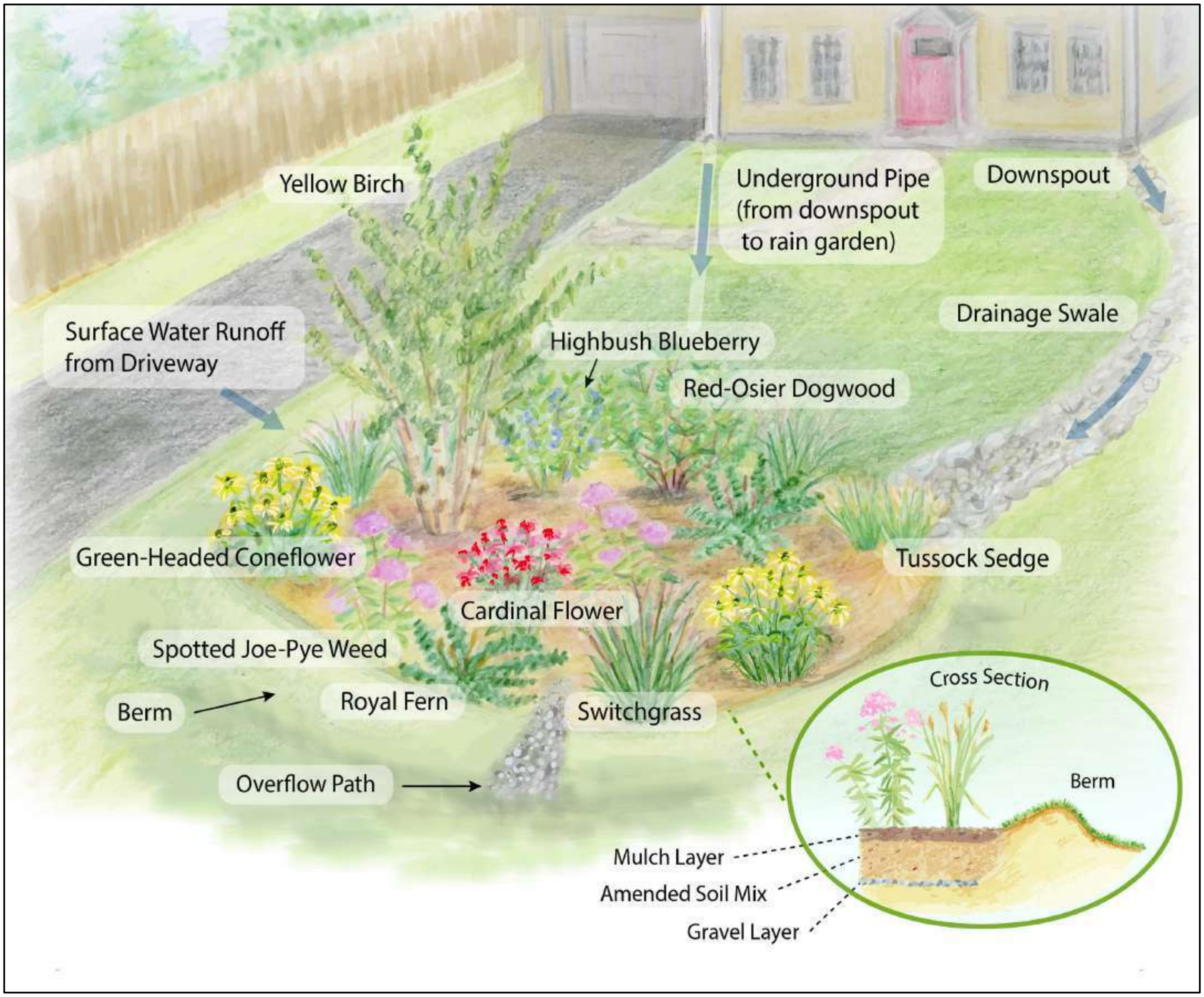
- **Aesthetics** - By planting trees, shrubs, perennials, and grasses that offer color, texture, light, and movement, rain gardens can be a source of beauty in your landscape. Planting a mix of species with different heights, forms, and flowering times can enhance appearance. Other useful design tips include placing taller flowers, shrubs, or trees behind shorter ones and arranging the plants in odd-numbered groupings. Spread plants out during the initial installation to give them room to grow—though it might look sparse at first, the plants will fill in and thrive throughout the years. Before digging, place the plants on top of the ground and move them around to find the best configuration. You can also design the shape of your rain garden to enhance the landscape, such as by creating a striking linear shape along a roadway or a more traditional round or kidney-shaped garden as landscape focal points.



This rain garden was planted with a variety of native trees, shrubs, grasses, and perennials to tolerate local conditions, provide wildlife habitat, and control runoff.

- **Planting instructions** - Plant each species at the appropriate time of year (generally spring or fall when more moisture is available) and follow the specific planting and care instructions.

Butterfly Milkweed (left), Red Columbine (middle), and White Turtlehead (right) can all be planted in the upper reaches of a rain garden where water tends to drain completely. Their long-blooming flowers are a colorful and attractive addition to a rain garden and an important nectar source for butterflies, bees, and hummingbirds.



This rain garden with native plants was sited at a low point in the yard to treat runoff from the driveway and rainwater from two roof downspouts (water is directed through a drainage swale from one downspout and an underground pipe for the other). The cross section shows the rain garden base—a layer of gravel, a 6-18" layer of soil mix, and a 2-3" layer of triple shredded mulch. The berm was built with soil removed when digging the rain garden base. An overflow path of crushed stone helps release heavy volumes of water in large rain events.

Management

These management steps can help ensure the long-term success of rain gardens.

- **Weed** - Weed newly planted rain gardens regularly to help the plants grow successfully and out-compete encroaching lawn grass and other undesirable plants. In particular, check for invasive species and remove them as soon as possible (see the Mass.Gov Invasive Plants website for more on identifying and managing these plants). Once the rain garden becomes established, less weeding will be required.
- **Prune, cut, and replace plants** - Only minimal pruning and cutting, such as removing dead or diseased limbs, is needed to keep established rain gardens in proportion and healthy. Avoid cutting or deadheading spent perennials in the fall so that they can continue to provide a seed source for birds and habitat for beneficial insects over the winter. Finally, when necessary, replace plants that have died.

- **Water** - Rain garden plants typically do not require watering once they become established. Newly planted vegetation, however, needs careful watering until the limited root system can effectively find and absorb water from the surrounding soils, particularly when planted in the hot, dry summer months. To ensure plant survival, follow the specific watering instructions on plant labels and seed packets. Adjust water levels if necessary for weather, time of year, and site conditions, such as soil type and sun and wind exposure (i.e., windblown areas, sandier soils, and dry, hot weather will warrant extra water). When watering larger perennials, shrubs, and trees, place an open hose (with a slow flow), a soaker hose, or drip tubing at the base of each plant, which will allow water to slowly seep into soils. You can water less each year, with only minimal watering needed in the third year, if at all. During long periods of drought, the rain garden will require watering. Use water that has been collected and stored in rain barrels to maximize your conservation efforts (see *Stormwater Solutions for Homeowners Fact Sheet: "Green" Lawn and Garden Practices* to find out how).
- **Greenscape** - Avoid using fertilizers, herbicides, and pesticides, and choose organic methods where possible (see Greenscapes.org for more information). *Stormwater Solutions for Homeowners Fact Sheet: "Green" Lawn and Garden Practices* has additional information on eco-friendly yard care methods that use less fertilizers and chemicals and promote the use of drought-tolerant native species that benefit the local environment.
- **Cover exposed areas with mulch or leaf litter** - If the soil dries out quickly, add 2-3 inches of organic bark mulch each spring to prevent moisture loss. (A finer mulch, such as triple shredded, is recommended.) Leaving leaf litter in place is another option for helping to retain moisture. Leaf litter also naturally fertilizes rain garden plants by releasing nutrients as the organic material decays and provides essential overwintering habitat for beneficial insects. Mulch and leaf litter can also help improve water infiltration and keep weeds down.
- **Remove sediment build-up** - Inspect rain garden areas once every 3-6 months, as well as after large storms, and remove excess sediment (such as silts) that may have accumulated from runoff. (Build-up of sediments decreases infiltration rates and smothers plants.)
- **Address any erosion impacts** - Inspect the area where water enters and exits the rain garden for signs of erosion and re-establish the vegetation or add gravel or pea-sized stone if needed to slow stormwater flow and reduce erosion impacts. Where berms show signs of washout or erosion, build them back up and replant with grass or other groundcover to stabilize the soils.
- **Minimize standing water** - To keep mosquitoes from breeding, check that water does not remain in the rain garden for longer than 24-36 hours. If water does not drain within this timeframe, create a temporary opening in the berm. If the problem persists, you may need to amend the soils to help improve infiltration. (Rain gardens with proper drainage, however, have the added advantage of serving as death traps for mosquito eggs and larvae when they regularly dry out!)
- **Expand rain garden size or create an overflow path as necessary** - If you find the rain garden is too small to hold and infiltrate the amount of water flowing into it, you can expand the size. Another option is to install a series of interconnected rain gardens or direct overflow to a drainage swale covered with crushed stone or stabilizing vegetation. To create an overflow path, dig a small channel (filled with a layer of gravel or pea-sized stone) from the rain garden to another rain garden or swale (for more on swales, see *Stormwater Solutions for Homeowners Fact Sheet: Vegetated Swales*). Make sure the runoff is not channeled directly to surface water, wetlands, municipal drainage systems, or your neighbor's yard.

Additional Information

- For related fact sheets, see the CZM Stormwater Solutions for Homeowners fact sheet website.
- The Massachusetts Executive Office of Energy and Environmental Affairs Raingardens factsheet (PDF, 1.2 KB), produced by GeoSyntec, describes how to design a rain garden and provides rain garden plant lists, sample plans, and photographs.
- The Massachusetts Department of Environmental Protection (MassDEP) *Structural BMP Specifications for the Massachusetts Stormwater Handbook* (Volume 2, Chapter 2) (PDF, 6.5 MB) has descriptions, design considerations, and pollutant removal efficiency information for various best management practices, including rain gardens.
- MassDEP's Massachusetts Clean Water Toolkit offers guidance on the prevention and control of nonpoint source pollution and gives links to many fact sheets, including Bioretention Areas (which use soil, plants, and microbes to treat stormwater before it is infiltrated or discharged).
- The Think Blue Massachusetts website, part of a stormwater awareness campaign of MassDEP and the Statewide Stormwater Coalition, provides information to residents, businesses, and developers about what they can do to reduce stormwater pollution in the environment, including methods for soaking up rainwater.
- Massachusetts Watershed Coalition has resources and information about protection and restoration of watershed ecosystems, including details, designs, and construction information on rain gardens.
- New Hampshire's *Homeowner's Guide to Stormwater Management* (PDF, 4 MB) provides guidance to help homeowners manage stormwater on their properties and includes detailed information on rain gardens. Their Soak Up the Rain program also has useful tips and information on methods to minimize stormwater runoff.
- New Hampshire's Native Plants for New England Rain Gardens (PDF, 7 MB) identifies native plants that are adaptable, available, and have been successful for the northern New England region.
- The University of Connecticut's Nonpoint Education for Municipal Officials (NEMO) program website provides many useful stormwater resources, including a Rain Gardens website and a link to a mobile device app designed to help homeowners properly install a rain garden on their properties.
- The Ecological Landscape Alliance website, which includes links to their newsletter, conferences, and webinars, offers design ideas and tips from professionals that install rain gardens and other ecological landscapes.
- The Greenscapes web page provides information on "green" lawn and gardening practices and includes a downloadable *Greenscapes Guide* that details information on how to use attractive, nature-friendly landscaping practices to reduce pollution, conserve water, support wildlife, and protect against climate change.
- Hingham's Rain Garden Installation video is an on-the-ground tutorial for building a rain garden, with details on how to dig and level the rain garden base, mix soils with compost, and select and install plants. *(Please note that compost is no longer recommended as a soil amendment for a rain garden; triple shredded mulch is recommended for its ability to stay in place, help reduce compaction, and lower nitrogen levels.)*
- The Association to Preserve Cape Cod's Rain Garden video showcases a recently installed rain garden as a natural and beautiful way to control storm water runoff and filter the groundwater.
- The U.S. Environmental Protection Agency (EPA) Soak Up the Rain: Rain Gardens website gives design details for rain gardens, including plant selection, soils, and maintenance requirements specific to Massachusetts.
- EPA's National Stormwater Calculator is a desktop application that estimates the annual amount of rainwater and frequency of runoff from a specific site. The calculator can also be used to help homeowners determine what mix of rain garden and other stormwater control options can be used to capture this runoff.
- CZM's Coastal Landscaping website provides information on landscaping coastal areas with salt-tolerant vegetation to reduce storm damage and erosion.

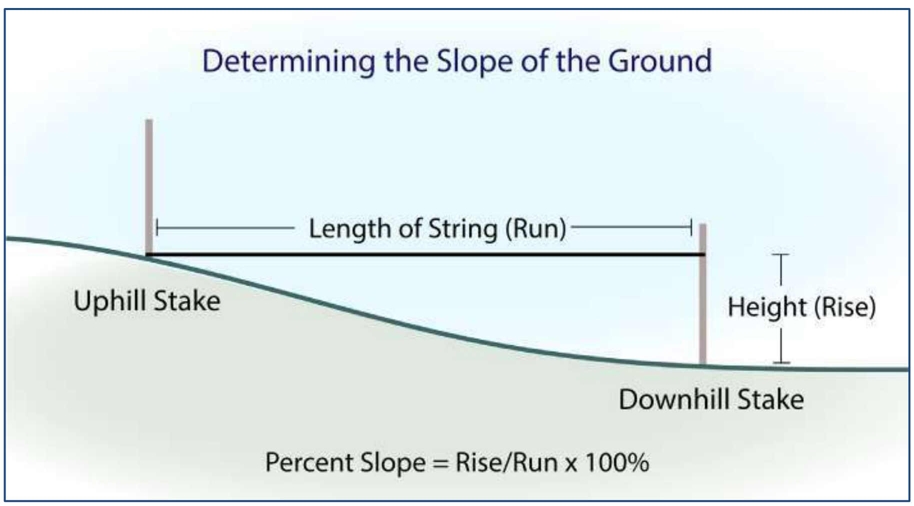
Technical Specifications for Calculating Rain Garden Size

While rain gardens of any size can provide benefits on your property, this section specifies how to more precisely calculate the size (depth and area) needed to fully treat stormwater from a typical storm in Massachusetts. Generally, a rain garden should be at least 1/8 to 1/3 the size of the drainage area to keep its water-level depths between 3-8 inches after a typical 1-inch rainfall. (Deeper water diminishes the ability of rain garden soils and plants to effectively treat and filter stormwater.) To specifically calculate the recommended size, follow these steps:

1. **Drainage area** - First, identify the area that slopes toward the rain garden. Then, calculate the portion of that area with impervious surfaces, which include rooftops, driveways, patios, and other areas that do not readily absorb water (including lawns where soils tend to compact, making it difficult for water to infiltrate). For rooftops, only include the roof area that runs into the particular downspouts that flow to the rain garden. *For an example calculation, assume that **400 square feet** of driveway, walkway, and lawn are in the drainage area. In addition, a 40-foot by 30-foot roof has half of its area sloping toward and draining to the rain garden (40 feet x 30 feet x 0.5 = **600 square feet**). When added to the 400 square feet of other impervious surface, this makes for a total drainage area of **1,000 square feet**.*

2. **Volume of runoff** - The rain garden should be built to hold runoff for a typical 1-inch rainfall. To calculate this figure in cubic feet, convert 1 inch to feet (1 inch ÷ 12 inches [per foot] = .08 feet). Then, multiply this number by the drainage area calculated in Step 1. *In this example, the volume of runoff from the drainage area is 1,000 square feet x .08 feet = **80 cubic feet***. (This volume figure will be used in Step 7 to ensure that the size of the rain garden is sufficient.)

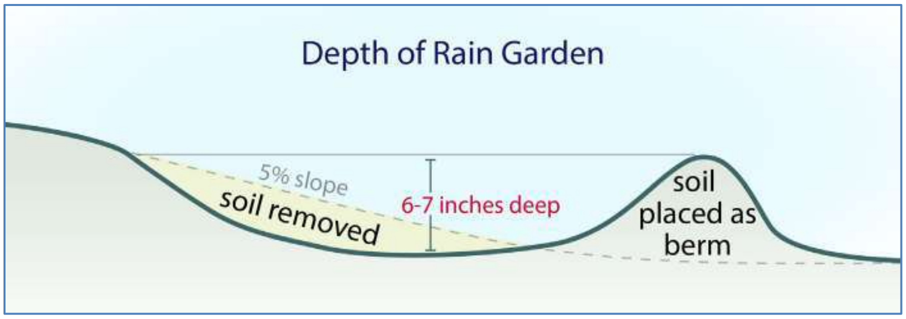
3. **Slope** - The slope of the ground where the rain garden will be located affects how deep the rain garden needs to be. The slope is calculated using this formula: (rise ÷ run) x 100%. (The run is the rain garden length, and the rise is the difference in elevation along that length.) To find these measurements, place one stake on the uphill end of the proposed rain garden and another on the downhill end and tie a string between them. (Run the string from the base of the uphill stake horizontally to the downhill stake; use a line level to ensure the string is horizontal.) The run is the length of the string, and the rise is the height measured from the ground level to the string along the downhill stake. *For example, a string 6 inches high at the downhill stake and 120 inches long from stake to stake has a slope of 6 inches ÷ 120 inches x 100% = **5%**.*



This diagram illustrates the stake and string method for finding the ground slope at the location of the proposed rain garden.

4. **Depth** - Use this slope/depth chart to find the recommended rain garden depth based on the calculated slope. *In this example, a 5% slope would require a rain garden depth of* ***6-7 inches****.*

SLOPE	DEPTH
< 4%	3-5 inches
5 - 7%	6-7 inches
8 - 12%	8+ inches



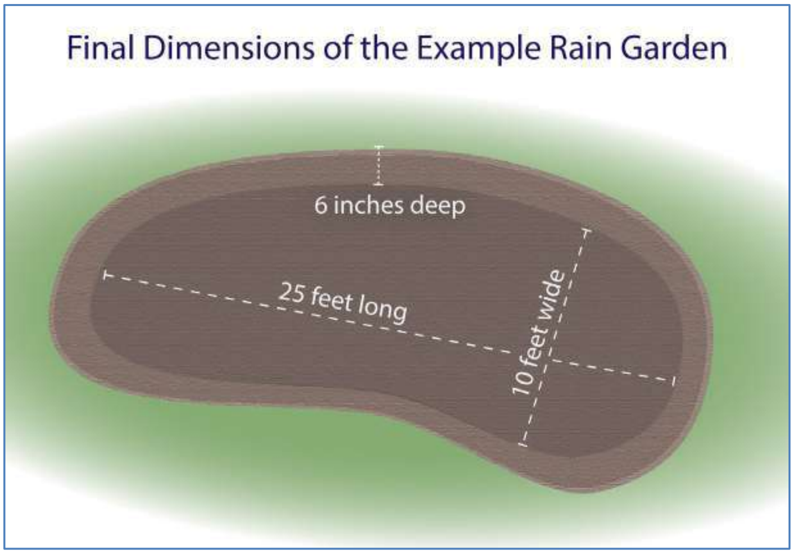
For a ground slope of 5%, a rain garden should be 6-7 inches deep. Soils can be removed from the uphill side of the slope to create the required depth and used to build a berm on the downhill side to contain the rain garden water.

5. **Size factor** - Once you know the appropriate depth, select the size factor for your soil type from this chart. *For example, if the soils were found to be silty during the ribbon test, the size factor would be* ***0.25*** *for the rain garden depth of 6-7 inches. (This 0.25 represents ¼ of the size of the drainage area and will be used in Step 6.)*

SIZE FACTOR	RAIN GARDEN DEPTH		
soil type	3-5 inches	6-7 inches	8+ inches
Sand	0.19	0.15	0.08
Silt	0.34	0.25	0.16
Clay	0.43	0.32	0.20

6. **Rain garden area** - Multiply the size factor by the drainage area calculated in Step 1 to determine the recommended square footage needed for the rain garden. *In this example, the drainage area of 1,000 square feet x 0.25 =* ***250 square feet****.*

7. **Final dimensions** - Select an appropriate length and width to create a total rain garden area that is equal to or greater than the area calculated in Step 6, and then check that the final dimensions are sufficient. *For example, you could choose dimensions of* ***25 feet long by 10 feet wide*** *to create a 250-square-foot rain garden. The final dimensions of our example rain garden would then be* ***25 feet long by 10 feet wide by 6 inches (or .5 feet) deep****. This rain garden could hold up to 250 square feet x .5 feet =* ***125 cubic feet of water****, which can easily treat the 80 cubic feet of runoff from the drainage area (calculated in Step 2).*



The final dimensions for the example rain garden are 25 feet long, 10 feet wide, and 6 inches deep. This rain garden could hold approximately 125 cubic feet of water.

Native Plants for Rain Gardens in Massachusetts

	High-Moisture Areas	Moderate-Moisture or Dry Areas
Perennials and Grasses	Blue Flag Iris (*Iris versicolor*)	Beebalm/Wild Bergamot (*Monarda fistulosa*)
	Cardinal Flower (*Lobelia cardinalis*)	Boneset (*Eupatorium perfoliatum*)
	Common Sneezeweed (*Helenium autumnale*)	Butterfly Milkweed (*Asclepias tuberosa*)
	Golden Alexanders (*Zizia aurea*)	Culver's Root (*Veronicastrum virginicum*)
	Great Blue Lobelia (*Lobelia siphilitica*)	Foamflower (*Tiarella cordifolia)*
	Marsh Marigold (*Caltha palustris*)	Foxglove Beardtongue (*Penstemon digitalis*)
	Royal Fern (*Osmunda regalis*)	Green-Headed Coneflower (*Rudbeckia laciniata*)
	Sensitive Fern (*Onoclea sensibilis*)	Indian Grass (*Sorghastrum nutans*)*
	Soft Rush (*Juncus effuses*)	Little Bluestem (*Schizachyrium scoparium*)*
	Spotted Joe-Pye Weed (*Eutrochium maculatum*)	Meadowsweet (*Spiraea alba*)
	Swamp Milkweed (*Asclepias incarnata*)	New England Aster (*Symphyotrichum novae-angliae*)*
	Swamp Rose-Mallow (*Hibiscus moscheutos*)	Pink Tickseed (*Coreopsis rosea*)
	Sweet Flag (*Acorus americanus*)	Red Columbine (*Aquilegia canadensis*)*
	Tussock Sedge (*Carex stricta*)	Seaside Goldenrod (*Solidago sempervirens*)*
	White Turtlehead (*Chelone glabra*)	Switchgrass (*Panicum virgatum*)*
Shrubs and Trees	Buttonbush (*Cephalanthus occidentalis*)	Arrowwood Viburnum (*Viburnum dentatum*)*
	Red-Osier, Silky, Gray Dogwoods (*Swida* spp.)	Black Chokeberry (*Aronia melanocarpa*)*
	Smooth Alder (*Alunus serrulata*)	Cranberry Bush (*Viburnum opulus*)
	Spicebush (*Lindera benzoin*)	Highbush Blueberry (*Vaccinium corymbosum*)*
	Swamp Rose (*Rosa palustris*)	Inkberry (*Ilex glabra*)*
	Sweetgale (*Myrica gale*)	Red Chokeberry (*Aronia arbutifolia*)*
	Sweet Pepperbush (*Clethra alnifolia*)*	Serviceberry (*Amelanchier* spp.)*
	Winterberry (*Ilex verticillata*)*	Yellow Birch (*Betula alleghaniensis*)

These plants are tolerant of coastal conditions, such as salt spray and wind, and may also be appropriate in rain gardens near roadways treated with salt or other deicers during the winter.

www.mass.gov/coastal-water-quality-program

Commonwealth of Massachusetts
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Executive Office of Energy and Environmental Affairs
Bethany A. Card, Secretary

Massachusetts Office of Coastal Zone Management
Lisa Berry Engler, Director

Massachusetts Department of Environmental Protection
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MANAGING STORMWATER RUNOFF FOR RURAL LANDOWNERS

Bioinfiltration Swales

Figure 1. A fully planted bioinfiltration swale[1]

Introduction

In rural areas, you may not have city services like storm drains that conveniently carry stormwater away, but there are still many ways to solve drainage issues. This fact sheet describes one of the ways you can manage drainage issues on your property. By removing standing water in your yard, preventing erosion, dealing with minor flooding, and redirecting water away from your building foundations, you will be protecting your investment and water quality in nearby lakes, streams, and marine waters.

This fact sheet provides general concepts about when bioinfiltration swales might help manage stormwater, including general design, construction, and maintenance guidelines. Consult with your local planning office after reading this document. Depending on the amount of stormwater flow, the design of a bioinfiltration swale and the construction may require professional expertise, such as a licensed engineer. In addition, an individual homeowner should not attempt to manage large-flow situations independently.

There are many considerations when determining how to best manage stormwater in a specific location. To assist you in making the best decision for your needs, please refer to the fact sheets on **Understanding Your Site Conditions** and **Options for Managing Surface Water Drainage**.

What is a bioinfiltration swale?

A bioinfiltration swale is a stormwater conveyance system that moves water from one place to another while allowing for infiltration and treatment. The swale consists of an excavated channel for stormwater with a gentle downgradient slope. There is vegetation planted on the channel bottom and sides. Bioinfiltration swales are an excellent alternative to standard ditches or traditional piped stormwater conveyance systems because they are designed to move water to locations that can handle excess stormwater while simultaneously treating and infiltrating the water as it moves through the swale.

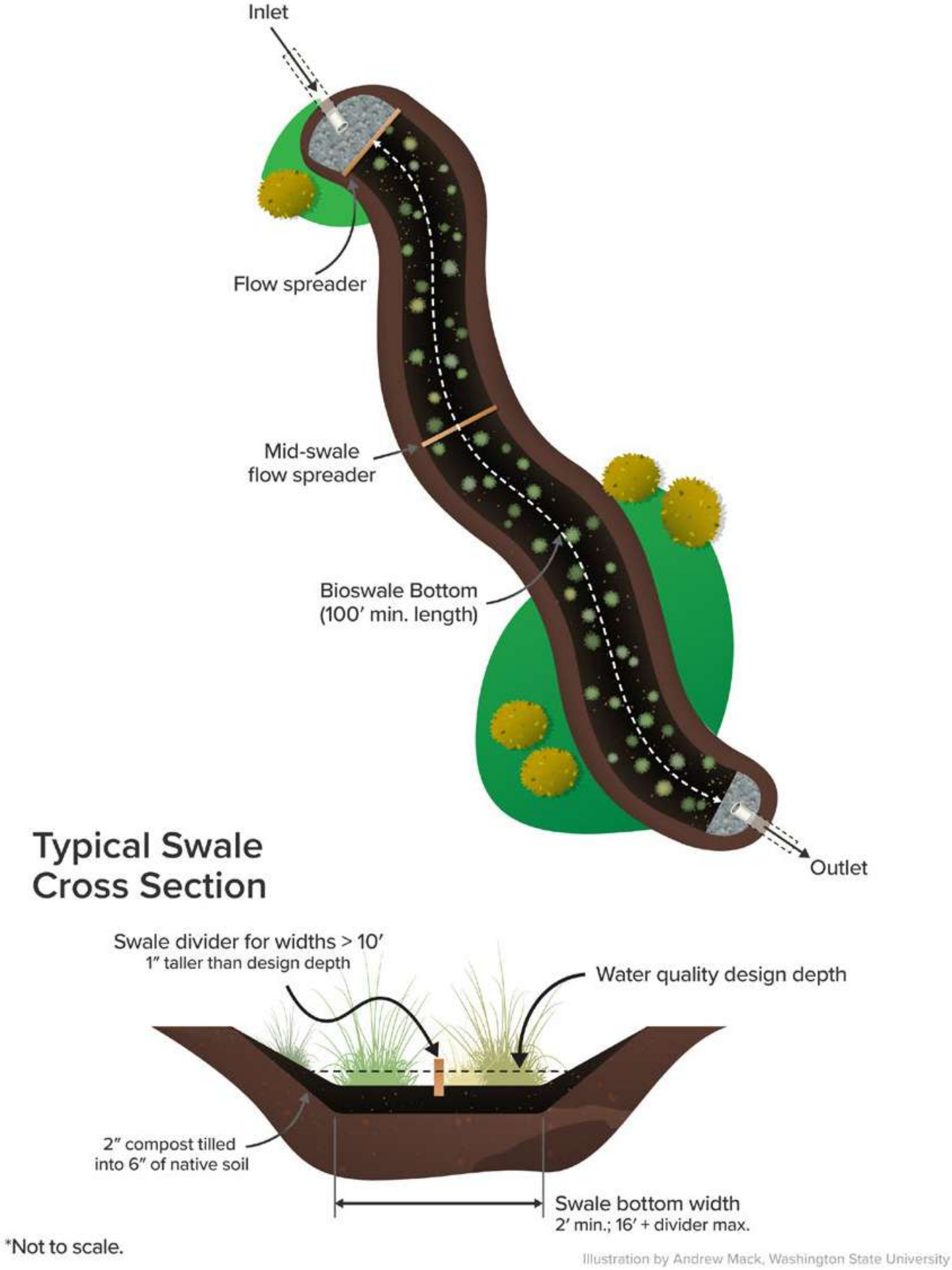

Figure 2. Anatomy of a bioinfiltration swale[2]

Figure 3. Juvenile coho salmon are impacted by high pollutant loads in the first flush of stormwater after a dry spell. Credit: D. McNamara

How do bioinfiltration swales improve water quality?

The primary way a bioinfiltration swale improves water quality is by reducing sediment in the flowing water. Sedimentation is a water quality issue because it fills in and smothers the gravel habitat that salmon and a host of other aquatic organisms depend on.

Sediment and associated particulate pollutants, such as heavy metals suspended in stormwater, are trapped by vegetation in the swale as the water slowly flows down the gentle slope. Therefore, a minimum vegetation cover of 70 percent is recommended[3] to treat stormwater adequately.

The soil used in bioinfiltration swales is usually amended to increase the organic matter and promote stormwater infiltration into the bottom of the channel. Amending the soil with compost helps promote infiltration of the "first flush" (see sidebar) of runoff, increasing pollutant removal[4]. Typically, compost is tilled into a depth of about six inches to ensure that it does not get washed out.

Bioinfiltration swales do not effectively remove dissolved pollutants such as nitrogen or metals. Therefore, other methods are recommended to treat dissolved pollutants upstream or downstream of the bioinfiltration swale.

How are bioinfiltration swales different from bioretention systems and drainage ditches?

Bioinfiltration swales are different from bioretention systems. Bioinfiltration swales are conveyance systems where most stormwater flows along the length of the system on a gradient from a high point to a low point.

Bioretention systems do ***not*** convey water across the landscape; they capture water, filter it, and retain it, allowing it to soak into the ground. A rain garden is an example of a bioretention system.

Drainage ditches are designed to ***move*** large volumes of water, usually quickly, to remove it from the area; thus, they are not designed to ***treat*** water quality. Table 1 compares bioinfiltration swales to other methods.

What is "first flush"?

After a long summer of dry weather, the first rainstorm is usually welcomed, but that rain runoff also delivers a summer's worth of pollution buildup to nearby streams and water bodies. During a dry spell, our roads, highways, sidewalks, driveways, and other hard surfaces accumulate sediment, heavy metals, oils, pesticides, fertilizers, and pollutants from various sources on the landscape. The first rain transports this unnoticed material into ditches, storm drains, and nearby water bodies. This is sometimes referred to as "first flush." For ***each*** storm event, there is also the "first flush," which is when enough rain has fallen and begins running off across paved areas and the landscape.

Table 1. Comparing infiltration methods

Features	Bioinfiltration Swale	Bioretention System / Rain Garden	Drainage Ditch
Designed for	Moving water slowly from one area to another, treating and infiltrating it along the way, thereby improving water quality and reducing some flooding.	Stopping water, treating, and infiltrating it onsite, thereby improving water quality and reducing flooding.	Moving water quickly from one area to another, reducing flooding.
How it works	Flat bottomed channel sloping at a slight gradient to slow water as it is conveyed. Dense plantings also slow water and sediment, to allow treatment while still moving water to a more desirable location. Effective for trapping sediment and associated pollution.	Flat bottom retains water and allows it to soak into the ground through a special soil mix designed to filter out pollutants.	U- or V-shaped bottom with varying downhill slope conveys large volumes of water from the area. Little to no water quality treatment.
General shape	Linear channel with gentle downhill gradient and gently sloping sides.	Any shape, but usually round or kidney-shaped to fit landscape. Flat bottom area for infiltration, gently sloping sides.	Linear with gentle downhill gradient. Sides are typically a 1:1 or 2:1 (H:V) slope.
Soils	Often amended with compost.	Special "Bioretention Soil Mix" (usually 60% sand, 40% compost), placed about 18" deep.	Native soils. No amendment.
Vegetation	Yes. 70% coverage minimum; hardy grass-like plants in treatment area.	Yes. Plants at the bottom and sides of the rain garden must be able to thrive in wet and dry conditions.	No. Not planted.
Mulch	No.	Yes. Up to 4" of arborists' woodchips or other mulch.	No.
Maintenance	Mowing. Leaf and sediment removal as needed.	Weed, remove sediment, clean inflow and overflow, and mulch as needed.	Removal of plants and sediment as needed.

Converting a drainage ditch to a bioinfiltration swale

The advantages of bioinfiltration swales are that they improve water quality and reduce the amount of stormwater by providing some infiltration. However, modifying a drainage ditch to a bioinfiltration swale can pose challenges: since drainage ditches are designed to move large volumes of water, they may be too steep or sized wrong to convey water as slowly as needed for a bioretention swale[4]. Therefore, it is recommended that only small drainage ditches are converted to bioinfiltration swales, with possible modifications to reduce the grade if necessary to slow conveyance.

Advantages and disadvantages of bioinfiltration swales

Advantages of bioinfiltration swales include:

- Reducing sediment and associated particulate pollutants.
- Conveying water and providing flood storage, potentially reducing downstream flooding.[5]
- Contributing to groundwater recharge when the existing soils below the bottom of a bioinfiltration swale consist of high-infiltration soils.[6]

The limitations of bioinfiltration swales include:

- They can be complex to size correctly and design; a professional is often required.
- If too much sediment accumulates in the swale, water cannot flow through the soil/plant interface, limiting the swale's ability to remove stormwater pollutants.[7]
- They are prone to be taken over by invasive plants if not planted or maintained correctly.
- They may be ineffective in removing pollution if improperly designed.

Bioinfiltration swales are not effective:

- For treating stormwater with high pollutant loads or high sediment loads.[6]
- Where soils are saturated for extended periods, because many plants will not survive if in wet conditions continuously, although some design and plant-selection adjustments can address this.[5]
- In arid regions, unless irrigation is provided as needed, since high plant density is critical to ensure particulate trapping—although some plant-selection choices can mitigate for this.
- If located downstream of runoff sources carrying pollutants that might kill vegetation in the bioinfiltration swale.

Design considerations

Bioinfiltration swales are somewhat complex to design. They must be able to transport stormwater continuously. In addition, bioinfiltration swales are designed to convey the most prominent peak flows and ensure that the "water quality design flow" is treated.[8]

The "water quality design flow" is the basis for calculating the dimensions of a bioinfiltration swale. This flow rate is at or below which 91% of the total runoff volume, will be treated[4]. Once the water quality design flow is determined, the bioinfiltration swale's bottom width and length can be calculated. A licensed civil/water resources engineer should make these design calculations.

The bottom width and length of the bioinfiltration swale define the "bioinfiltration swale area" (the area below the water quality design depth is known as the "swale treatment area"); this should be between 10 to 20 percent of the contributing area[6] feeding stormwater to the system.

Typical dimensions

The size of a bioinfiltration swale is dependent on the size of the contributing area and site constraints, but the typical dimensions of a bioinfiltration swale[8] are:

- ***Minimum*** bottom width 2 ft
- ***Minimum*** longitudinal slope 0.25 percent. (1 to 2 percent preferred)
- ***Maximum*** longitudinal slope 6 percent
- If the longitudinal slope exceeds 6 percent, check dams with vertical drops that do not exceed 12 inches are needed. In addition, the spacing between check dams should ensure that the slope does not exceed 6 percent between drop sections.[4]

Specific design and planting requirements pertain to the bioinfiltration swale area. For example, the side slopes of the bioinfiltration swale should be 3H:1V but cannot exceed 2H:1V.

Special circumstances

Flat terrain

When the terrain is flat, a typical bioinfiltration swale with a slope less than 0.25 percent will not meet the goals of water quality treatment; some essential refinements to the design are therefore needed. Two refinements that enable bioinfiltration swales to be installed in flat terrain are adding underdrains or designing them as wet bioinfiltration swales. These two refinements are broadly described below.

When an underdrain is needed

An underdrain is necessary to ensure that water in a bioinfiltration swale with a gentle slope will flow through the plant-soil interface to achieve some level of water quality treatment. A perforated pipe encased in drain rock is installed approximately one foot below the bioinfiltration swale bottom and 4-6 inches above the native soils below. Ensuring that water can flow freely to the underdrain pipe is critical.

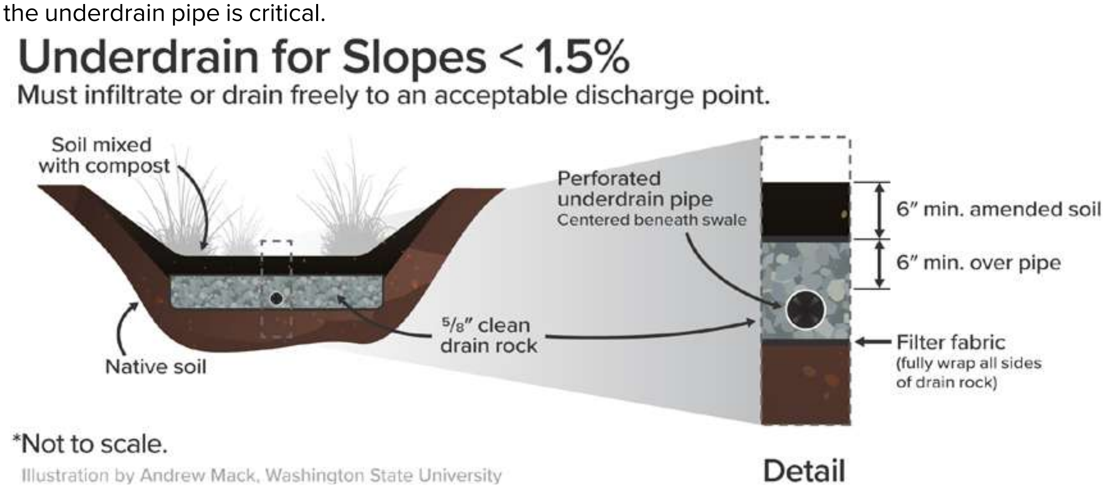

Figure 4. The details of a bioinfiltration swale with an underdrain[2]

Wet bioinfiltration swales are appropriate when drainage is needed in flat terrain, and the water table is close to the ground surface resulting in wet or saturated soils. This condition can also occur when there are compacted till soils or clayey soils. Therefore, plants must be chosen that can survive these specific soil conditions.

High Flows

If design flow velocity exceeds 4 cubic ft/sec, use a turf reinforcement mat.[8] High design flow velocities are expected when the bioinfiltration swale has a steep gradient. It is critical to provide erosion control after construction[10] and ensure that vegetation is well established in the newly constructed swale before runoff is allowed to flow into the bioinfiltration swale. It is also essential that weed sources are not introduced in the newly exposed soils of a bioinfiltration swale; existing weed roots should be thoroughly removed from the subsoil.

What to plant

Grass-like plants should be established across the whole worksite. If using seeds, apply in spring or fall by hydroseeding or broadcast application.[4]

The treatment area needs plants that provide a dense cover to limit erosion.[4] A minimum of 70 percent planting coverage should be the goal of any bioinfiltration swale planting design. The plants must withstand (remain upright) the forces exerted on them by the design water quality event.[4] The plants should be chosen to withstand the soil conditions within the bioinfiltration swale in terms of pH, compaction, soil moisture, or lack of moisture.[5]

Newly planted bioinfiltration swales must be protected from runoff until the plants are well established.[4]

King County approved two seed mixes for the treatment area for use in typical bioinfiltration swales; those mixes are detailed in Chapter 6 of the 2021 King County Surface Water Design Manual.[4] Plant recommendations for a wet bioinfiltration swale are also provided in that document. Please consult with a landscape or erosion control specialist for regions outside of western Washington for recommended plant mixes, fertilizer, and mulch.

For areas of the swale above the treatment zone, standard lawn mixes or landscape plantings can be used. Plants that can bind the bank soils to prevent erosion are critical in bioinfiltration swales that are likely to see high flows. A list of suitable ground covers and grasses for the regions above the treatment area zone can be found in Chapter 6 of the 2021 King County Surface Water Design Manual.[4]

Maintaining your swale

Periodic inspections and maintenance of bioinfiltration swales are critical for ensuring their proper functioning. The following is recommended for a well-functioning swale:

- Inspect swale twice a year at a minimum.[11]
- Remove deposited sediments and trash periodically.[3]
- Mow grass in the areas of the bioinfiltration swale above the water quality treatment zone monthly during the growing season—grass clippings from mowing should be removed and disposed of or composted.[4]
- Irrigate and prune plants.[3] A temporary irrigation system may be needed to ensure plants survive, especially if installed in the dry season.
- Remove leaf litter so it does not clog the system. Remove any volunteer trees/shrubs.
- Ensure there is no standing water after a storm event.
- Regrade swale if standing water persists[12] or if channelization or erosion has occurred.[4] If regrading is needed annually, there may be a more significant, more systemic issue with the bioinfiltration swale that might need to be addressed.
- Remove accumulated sediments up-grade of check dams (if any)[11] and from the head of the swale.[4]

In the first two years after planting, frequently check for excessively tall or nuisance vegetation during the growing season. After the first two years, check annually. Monitor plant health and identify causes for plant stress.[11]

Resources

For more information, visit Rural Stormwater Solutions (https://ruralstormwater.wsu.edu/resources/).

References

For links to these references, visit Rural Stormwater Solutions (https://ruralstormwater.wsu.edu/references/).

1. Guzzardo Partnership. Bioswale @First.
2. Washington Department of Ecology. *2019 Stormwater Management Manual for Western Washington*.
3. CalRecycle. *Biostrips and Bioswales*.
4. King County, Washington. *King County Surface Water Design Manual 2021*.
5. Clemson Cooperative Extension. *An Introduction to Bioswales*.
6. Capital Regional District. *Bioswales*.
7. Rebecca A Purvis, Ryan J Winston, William F Hunt, Brian Lipscomb, Karthik Narayanaswamy, Andrew McDaniel, Matthew S Lauffer, and Susan Libes. *Evaluating The Hydrologic Benefits of a Bioswale in Brunswick County, North Carolina (NC), USA*. Water, 11(6):1291, 2019.
8. CalTrans (California DOT). *Biofiltration Swale Design Guidance, 2012*.
9. Chesapeake Bay Foundation. *Infiltration trench maintenance*.
10. Oregon Department of Environmental Quality. *Construction Stormwater Best Management Practices Manual, 2021*.
11. King County, Washington. *King County Drainage Maintenance Standards for Commercial and Multifamily Drainage Facilities, 2008*.
12. City of Bothell. *Bioswales*.

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April 2022. Rural Property Surface Water Management Tools and Training: WQNEP-2020-WaStUn-00063

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13.8 Appendix 7 - Drainage Modelling

13.8.1 Drainage Layout

Map Legend

- Surface Water Manhole
- Foul Water Manhole
- Surface Water Inspection Manhole
- Flow Control Chamber
- Rainwater Down Pipe
- Modeled Storage Structure
- Treatment Plant
- Pumping Station
- Swale / Ditch
- Floodable Area (Detention Basin)
- Gravel Filtration Trench
- SuDS Bio-Retention Area / Rain Garden
- Soft Landscaping / Amenity Space
- Porous Tarmac
- Tarmac (Impermeable)
- Drainage Ditch
- Surface Water Pipe
- Perforated Pipe / Under drainage Channel
- Acco Drainage Channel
- Overflow Flow Route
- Drainage Rill (Surface Feature)
- Foul Water Pipe
- Foul Water Pumped Flow

Project ID:
SWDS - 2025 - 00034
Date:Nov 2025

Site:
Dun Elms, Nelsons Lane Hurst Wokingham, RG10 0RR

Title;
Drainage Management Plan (Surface Water and Foul)

STM Environmental Consultants Ltd

Issue :No.1.0

By :M. Ashdown

13.8.2 Drainage Results

Design Settings

Rainfall Methodology	FEH-22	Time of Entry (mins)	15.00	Connection Type	Level Soffits	Enforce best practice design rules	x
Return Period (years)	2	Maximum Time of Concentration (mins)	30.00	Minimum Backdrop Height (m)	0.200		
Additional Flow (%)	0	Maximum Rainfall (mm/hr)	50.0	Preferred Cover Depth (m)	0.550		
CV	0.750	Minimum Velocity (m/s)	0.75	Include Intermediate Ground	✓		

Adoptable Manhole Type

Max Width (mm)	Diameter (mm)	Max Width (mm)	Diameter (mm)	Max Width (mm)	Diameter (mm)	Max Width (mm)	Diameter (mm)
374	1200	499	1350	749	1500	900	1800

>900 Link+900 mm

Max Depth (m)	Diameter (mm)	Max Depth (m)	Diameter (mm)
1.500	1050	99.999	1200

STM_Links_SW Link Type

Template	Freeform Carrier	Shape	Circular	Barrels	1	Auto Increment (mm)	75	Follow Ground	x

Available Diameters (mm)

100	150

Circular Link Type

Template	Freeform Carrier	Shape	Circular	Barrels	1	Auto Increment (mm)	75	Follow Ground	x

Available Diameters (mm)

100	150

(Trench) Link Type

Template	Freeform Carrier	Barrels	1	Auto Increment (mm)	75
Shape	Rectangular	Height (mm)	599	Follow Ground	x

Available Diameters (mm)

100

(Trench) Link Type

Template	Freeform Carrier	Barrels	1	Auto Increment (mm)	75
Shape	Rectangular	Height (mm)	543	Follow Ground	x

Available Diameters (mm)

100

(Trench) Link Type

Template	Freeform Carrier	Barrels	1	Auto Increment (mm)	75
Shape	Rectangular	Height (mm)	800	Follow Ground	x

Available Diameters (mm)

100

(Trench) Link Type

Template	Freeform Carrier	Barrels	1	Auto Increment (mm)	75
Shape	Rectangular	Height (mm)	837	Follow Ground	x

Available Diameters (mm)

100

Circular Link Type

Template	Freeform Carrier	Shape	Circular	Barrels	1	Auto Increment (mm)	75	Follow Ground	x

Available Diameters (mm)

100	150

Circular Link Type

Template	Freeform Carrier	Shape	Circular	Barrels	1	Auto Increment (mm)	75	Follow Ground	x

Available Diameters (mm)

100	150

Circular Link Type

Template	Freeform Carrier	Shape	Circular	Barrels	1	Auto Increment (mm)	75	Follow Ground	x

Available Diameters (mm)

100	150

Circular Link Type

Template	Freeform Carrier	Shape	Circular	Barrels	1	Auto Increment (mm)	75	Follow Ground	x

Available Diameters (mm)

100	150

Nodes

Name	Area (ha)	T of E (mins)	Cover Level (m)	Diameter (mm)	Easting (m)	Northing (m)	Depth (m)
F4a			39.300	450	480698.071	172719.956	0.704
F3a	0.006		39.300	600	480722.577	172702.495	0.667
F2a	0.006		39.200	600	480750.024	172687.040	0.410
F1a	0.048		39.350	600	480775.945	172670.577	0.467
F3_Out			39.000	1200	480740.378	172725.946	0.780
F3	0.026	15.00	39.300	1200	480731.069	172713.733	0.800
13_OUT			38.150	1200	480707.973	172769.800	0.247
D1			38.300	600	480702.834	172754.165	0.350
BR			38.900	1200	480716.924	172743.990	0.909
F4	0.016	15.00	39.300	1200	480706.964	172731.033	0.837

Nodes

Name	Area (ha)	T of E (mins)	Cover Level (m)	Diameter (mm)	Easting (m)	Northing (m)	Depth (m)
10			39.000	1200	480732.573	172731.909	0.845
7			39.100	1200	480754.222	172715.370	0.758
F2_Out			39.100	600	480765.465	172706.831	0.674
F2	0.016	15.00	39.200	900	480761.042	172700.955	0.543
4			39.200	600	480779.042	172696.519	0.585
F1_Out			39.300	450	480789.304	172688.670	0.599
F1	0.014	15.00	39.200	900	480784.878	172682.732	0.450
1			39.300		480804.262	172677.515	0.129
2	0.005	15.00	39.300	450	480714.042	172725.060	0.700
3		15.00	39.300	600	480740.203	172703.640	0.650
5		15.00	39.300	600	480740.922	172703.017	0.500
6		15.00	39.300	450	480793.976	172675.998	0.450

Links

Name	US Node	DS Node	Length (m)	ks (mm) / n	US IL (m)	DS IL (m)	Fall (m)	Slope (1:X)	Dia (mm)	T of C (mins)	Rain (mm/hr)
1.000	6	F1	11.319	0.600	38.850	38.750	0.100	113.2	150	15.20	28.9
F1_Link	F1	F1_Out	7.406	0.600	38.750	38.701	0.049	150.0	150	15.35	28.7
1.002	F1_Out	4	12.920	0.600	38.701	38.615	0.086	150.0	150	15.61	28.4
1.003	4	F2_Out	17.049	0.600	38.615	38.501	0.114	150.0	150	15.96	28.0
2.000	5	F2	20.225	0.600	38.800	38.657	0.143	141.4	150	15.40	28.7
F2_Link	F2	F2_Out	7.355	0.600	38.657	38.570	0.087	84.5	150	15.51	28.5
1.004	F2_Out	7	14.118	0.600	38.426	38.342	0.084	168.1	225	16.20	27.8
1.005	7	F3_Out	17.421	0.600	38.342	38.226	0.116	150.0	225	16.47	27.5
3.000	3	F3	13.612	0.600	38.650	38.500	0.150	90.7	150	15.21	28.9
F3_Link	F3	F3_Out	15.356	0.600	38.500	38.295	0.205	74.9	150	15.44	28.6
1.006	F3_Out	10	9.822	0.600	38.220	38.155	0.065	150.0	225	16.62	27.3
1.007	10	BR	19.770	0.600	38.155	38.023	0.132	150.0	225	16.93	27.0
4.000	2	F4	9.262	0.600	38.600	38.463	0.137	67.6	150	15.13	29.0
F4_Link	F4	BR	16.343	0.600	38.463	38.354	0.109	149.9	150	15.46	28.6
1.008	BR	D1	17.380	0.600	37.991	37.950	0.041	423.9	300	17.31	26.7
1.009	D1	13_OUT	16.458	0.600	37.950	37.903	0.047	350.2	150	17.83	26.2

Name	Vel (m/s)	Cap (l/s)	Flow (l/s)	US Depth (m)	DS Depth (m)	Σ Area (ha)	Σ Add Inflow (l/s)	Pro Depth (mm)	Pro Velocity (m/s)
1.000	0.944	16.7	6.9	0.300	0.300	0.088	0.0	67	0.899
F1_Link	0.818	14.5	8.0	0.300	0.449	0.102	0.0	79	0.837
1.002	0.818	14.5	12.5	0.449	0.435	0.162	0.0	108	0.918
1.003	0.818	14.5	12.3	0.435	0.449	0.162	0.0	106	0.916
2.000	0.843	14.9	3.4	0.350	0.393	0.043	0.0	48	0.681
F2_Link	1.094	19.3	4.6	0.393	0.380	0.059	0.0	50	0.896
1.004	1.005	40.0	18.0	0.449	0.533	0.239	0.0	106	0.980
1.005	1.065	42.3	17.8	0.533	0.549	0.239	0.0	102	1.019
3.000	1.055	18.6	3.8	0.500	0.650	0.049	0.0	46	0.831
F3_Link	1.163	20.5	5.8	0.650	0.555	0.075	0.0	55	1.004
1.006	1.065	42.3	23.3	0.555	0.620	0.314	0.0	119	1.090
1.007	1.065	42.3	24.5	0.620	0.652	0.334	0.0	123	1.102
4.000	1.225	21.6	4.4	0.550	0.687	0.056	0.0	45	0.958
F4_Link	0.818	14.5	5.5	0.687	0.396	0.072	0.0	64	0.763
1.008	0.757	53.5	29.3	0.609	0.050	0.405	0.0	158	0.774
1.009	0.531	9.4	28.7	0.200	0.097	0.405	0.0	150	0.541

Pipeline Schedule

Link	Length (m)	Slope (1:X)	Dia (mm)	Link Type	US CL (m)	US IL (m)	US Depth (m)	DS CL (m)	DS IL (m)	DS Depth (m)
1.000	11.319	113.2	150	STM_Links_SW	39.300	38.850	0.300	39.200	38.750	0.300
F1_Link	7.406	150.0	150	STM_Links_SW	39.200	38.750	0.300	39.300	38.701	0.449
1.002	12.920	150.0	150	STM_Links_SW	39.300	38.701	0.449	39.200	38.615	0.435
1.003	17.049	150.0	150	STM_Links_SW	39.200	38.615	0.435	39.100	38.501	0.449
2.000	20.225	141.4	150	STM_Links_SW	39.300	38.800	0.350	39.200	38.657	0.393
F2_Link	7.355	84.5	150	STM_Links_SW	39.200	38.657	0.393	39.100	38.570	0.380
1.004	14.118	168.1	225	STM_Links_SW	39.100	38.426	0.449	39.100	38.342	0.533
1.005	17.421	150.0	225	STM_Links_SW	39.100	38.342	0.533	39.000	38.226	0.549
3.000	13.612	90.7	150	STM_Links_SW	39.300	38.650	0.500	39.300	38.500	0.650
F3_Link	15.356	74.9	150	STM_Links_SW	39.300	38.500	0.650	39.000	38.295	0.555
1.006	9.822	150.0	225	STM_Links_SW	39.000	38.220	0.555	39.000	38.155	0.620
1.007	19.770	150.0	225	STM_Links_SW	39.000	38.155	0.620	38.900	38.023	0.652
4.000	9.262	67.6	150	STM_Links_SW	39.300	38.600	0.550	39.300	38.463	0.687
F4_Link	16.343	149.9	150	STM_Links_SW	39.300	38.463	0.687	38.900	38.354	0.396
1.008	17.380	423.9	300	STM_Links_SW	38.900	37.991	0.609	38.300	37.950	0.050
1.009	16.458	350.2	150	STM_Links_SW	38.300	37.950	0.200	38.150	37.903	0.097

Link	US Node	Dia (mm)	Node Type	MH Type	DS Node	Dia (mm)	Node Type	MH Type
1.000	6	450	Manhole	Adoptable	F1	900	Manhole	Adoptable
F1_Link	F1	900	Manhole	Adoptable	F1_Out	450	Manhole	Adoptable
1.002	F1_Out	450	Manhole	Adoptable	4	600	Manhole	Adoptable
1.003	4	600	Manhole	Adoptable	F2_Out	600	Manhole	Adoptable
2.000	5	600	Manhole	Adoptable	F2	900	Manhole	Adoptable
F2_Link	F2	900	Manhole	Adoptable	F2_Out	600	Manhole	Adoptable
1.004	F2_Out	600	Manhole	Adoptable	7	1200	Manhole	Adoptable
1.005	7	1200	Manhole	Adoptable	F3_Out	1200	Manhole	Adoptable
3.000	3	600	Manhole	Adoptable	F3	1200	Manhole	Adoptable
F3_Link	F3	1200	Manhole	Adoptable	F3_Out	1200	Manhole	Adoptable
1.006	F3_Out	1200	Manhole	Adoptable	10	1200	Manhole	Adoptable
1.007	10	1200	Manhole	Adoptable	BR	1200	Manhole	Adoptable
4.000	2	450	Manhole	Adoptable	F4	1200	Manhole	Adoptable
F4_Link	F4	1200	Manhole	Adoptable	BR	1200	Manhole	Adoptable
1.008	BR	1200	Manhole	Adoptable	D1	600	Manhole	Adoptable
1.009	D1	600	Manhole	Adoptable	13_OUT	1200	Manhole	Adoptable

Manhole Schedule

Node	Easting (m)	Northing (m)	CL (m)	Depth (m)	Dia (mm)	Conn.	Link	IL (m)	Dia (mm)
F4a	480698.071	172719.956	39.300	0.704	450				
F3a	480722.577	172702.495	39.300	0.667	600				
F2a	480750.024	172687.040	39.200	0.410	600				
F1a	480775.945	172670.577	39.350	0.467	600				
F3_Out	480740.378	172725.946	39.000	0.780	1200	1	F3_Link	38.295	150
						2	1.005	38.226	225
						0	1.006	38.220	225
F3	480731.069	172713.733	39.300	0.800	1200	1	3.000	38.500	150
						0	F3_Link	38.500	150
13_OUT	480707.973	172769.800	38.150	0.247	1200	1	1.009	37.903	150
D1	480702.834	172754.165	38.300	0.350	600	1	1.008	37.950	300
						0	1.009	37.950	150
BR	480716.924	172743.990	38.900	0.909	1200	1	F4_Link	38.354	150
						2	1.007	38.023	225
						0	1.008	37.991	300
F4	480706.964	172731.033	39.300	0.837	1200	1	4.000	38.463	150
						0	F4_Link	38.463	150
10	480732.573	172731.909	39.000	0.845	1200	1	1.006	38.155	225
						0	1.007	38.155	225
7	480754.222	172715.370	39.100	0.758	1200	1	1.004	38.342	225
						0	1.005	38.342	225
F2_Out	480765.465	172706.831	39.100	0.674	600	1	F2_Link	38.570	150
						2	1.003	38.501	150
						0	1.004	38.426	225
F2	480761.042	172700.955	39.200	0.543	900	1	2.000	38.657	150
						0	F2_Link	38.657	150
4	480779.042	172696.519	39.200	0.585	600	1	1.002	38.615	150
						0	1.003	38.615	150
F1_Out	480789.304	172688.670	39.300	0.599	450	1	F1_Link	38.701	150
						0	1.002	38.701	150
F1	480784.878	172682.732	39.200	0.450	900	1	1.000	38.750	150
						0	F1_Link	38.750	150
1	480804.262	172677.515	39.300	0.129					
2	480714.042	172725.060	39.300	0.700	450	0	4.000	38.600	150
3	480740.203	172703.640	39.300	0.650	600	0	3.000	38.650	150
5	480740.922	172703.017	39.300	0.500	600	0	2.000	38.800	150
6	480793.976	172675.998	39.300	0.450	450	0	1.000	38.850	150

Simulation Settings

Rainfall Methodology	FEH-22	Analysis Speed	Fast	Additional Storage (m³/ha)	0.0	2 year (l/s)	2.5	Check Discharge Volume	✓
Rainfall Events	Singular	Skip Steady State	x	Starting Level (m)		30 year (l/s)	6.8	100 year 360 minute (m³)	277
Summer CV	0.750	Drain Down Time (mins)	1440	Check Discharge Rate(s)	✓	100 year (l/s)	9.1		

Storm Durations

60	360

Return Period (years)	Climate Change (CC %)	Additional Area (A %)	Additional Flow (Q %)	Return Period (years)	Climate Change (CC %)	Additional Area (A %)	Additional Flow (Q %)	Return Period (years)	Climate Change (CC %)	Additional Area (A %)	Additional Flow (Q %)
1	0	0	0	30	0	0	0	100	40	0	0
2	0	0	0	100	0	0	0				

Pre-development Discharge Rate

Site Makeup	Brownfield	SAAR (mm)	646	Growth Factor 2 year	0.88	QBar	2.9
Brownfield Method	Greenfield	Soil Index	5	Growth Factor 30 year	2.40	Q 2 year (l/s)	2.5
Greenfield Method	IH124	SPR	0.53	Growth Factor 100 year	3.19	Q 30 year (l/s)	6.8
Positively Drained Area (ha)	0.500	Region	6	Betterment (%)	0	Q 100 year (l/s)	9.1

Pre-development Discharge Volume

Site Makeup	Brownfield	Positively Drained Area (ha)	0.500	CWI	97.185	Storm Duration (mins)	360	Runoff Volume (m³)	175
Brownfield Method	Greenfield	Soil Index	5	Return Period (years)	100	Betterment (%)	0		
Greenfield Method	FSR/FEH	SPR	0.53	Climate Change (%)	0	PR	0.508		

Node BR Online Orifice Control

Flap Valve	x	Invert Level (m)	37.991	Design Flow (l/s)	2.0	Discharge Coefficient	0.600
Replaces Downstream Link	x	Design Depth (m)	1.000	Diameter (m)	0.031		

Node F1 Online Orifice Control

Flap Valve	x	Invert Level (m)	38.750	Design Flow (l/s)	4.0	Discharge Coefficient	0.600
Replaces Downstream Link	x	Design Depth (m)	0.500	Diameter (m)	0.052		

Node F2 Online Orifice Control

Flap Valve	x	Invert Level (m)	38.657	Design Flow (l/s)	4.0	Discharge Coefficient	0.600
Replaces Downstream Link	x	Design Depth (m)	0.500	Diameter (m)	0.052		

Node F3 Online Orifice Control

Flap Valve	x	Invert Level (m)	38.500	Design Flow (l/s)	3.0	Discharge Coefficient	0.600
Replaces Downstream Link	x	Design Depth (m)	0.500	Diameter (m)	0.045		

Node F4 Online Orifice Control

Flap Valve	x	Invert Level (m)	38.463	Design Flow (l/s)	2.0	Discharge Coefficient	0.600
Replaces Downstream Link	x	Design Depth (m)	0.500	Diameter (m)	0.037		

Node BR Bioretention Area Storage Structure

Underdrain Link Type	Circular	Underdrain Slope (1:X)	150.0	Base Inf Coefficient (m/hr)	0.00100	Time to half empty (mins)	328
Underdrain Diameter (mm)	225	Underdrain Height above base (m)	0.000	Side Inf Coefficient (m/hr)	0.00100	Main Channel Length (m)	100.000
Underdrain Velocity	Colebrook-White	Underdrain DS Node	D1	Safety Factor	1.0	Main Channel Slope (1:X)	175.0
Underdrain ks (mm) / n	0.150	Filter Conductivity (m/hr)	0.10000	Porosity	0.30	Main Channel n	1.000
Underdrain Length (m)	100.000	Filter Depth (m)	0.600	Invert Level (m)	38.600		

Inlet Node	Connects To
1	Storage

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	550.0	0.200	550.0	0.201	0.0

Node F1_Out Link Surround Storage Structure

Base Inf Coefficient (m/hr)	0.00100	Safety Factor	2.0	Invert Level (m)	38.701	Link	F1_Link	Diameter (mm)	150
Side Inf Coefficient (m/hr)	0.00100	Porosity	0.30	Time to half empty (mins)	6	Surround Shape	(Trench)		

Node F2_Out Link Surround Storage Structure

Base Inf Coefficient (m/hr)	0.00100	Safety Factor	2.0	Invert Level (m)	38.570	Link	F2_Link	Diameter (mm)	150
Side Inf Coefficient (m/hr)	0.00100	Porosity	0.30	Time to half empty (mins)	216	Surround Shape	(Trench)		

Node F3_Out Link Surround Storage Structure

Base Inf Coefficient (m/hr)	0.00000	Safety Factor	2.0	Invert Level (m)	38.295	Link	F3_Link	Diameter (mm)	300
Side Inf Coefficient (m/hr)	0.00000	Porosity	0.30	Time to half empty (mins)	664	Surround Shape	(Trench)		

Node BR Link Surround Storage Structure

Base Inf Coefficient (m/hr)	0.00000	Safety Factor	2.0	Invert Level (m)	38.354	Link	F4_Link	Diameter (mm)	150
Side Inf Coefficient (m/hr)	0.00000	Porosity	1.00	Time to half empty (mins)	472	Surround Shape	(Trench)		

Node F1 Porous Paving Storage Structure

Underdrain Link Type	Circular	Underdrain Length (m)	20.000	Side Inf Coefficient (m/hr)	0.00100	Time to half empty (mins)	176
Underdrain Diameter (mm)	150	Underdrain Slope (1:X)	150.0	Safety Factor	1.5		
Underdrain Velocity	Colebrook-White	Underdrain Height above base (m)	0.000	Porosity	0.30		
Underdrain ks (mm) / n	15.000	Base Inf Coefficient (m/hr)	0.00100	Invert Level (m)	38.750		

Inlets
F1a

Depth (m)	Area (m²)	Inf Area (m²)	Depth (m)	Area (m²)	Inf Area (m²)	Depth (m)	Area (m²)	Inf Area (m²)
0.000	775.0	775.0	0.300	775.0	804.6	0.301	0.0	804.6

Node F2 Porous Paving Storage Structure

Underdrain Link Type	Circular	Underdrain Length (m)	20.000	Side Inf Coefficient (m/hr)	0.00100	Time to half empty (mins)	98
Underdrain Diameter (mm)	150	Underdrain Slope (1:X)	150.0	Safety Factor	1.5		
Underdrain Velocity	Colebrook-White	Underdrain Height above base (m)	0.000	Porosity	0.30		
Underdrain ks (mm) / n	15.000	Base Inf Coefficient (m/hr)	0.00100	Invert Level (m)	38.657		

Inlets
F2a

Depth (m)	Area (m²)	Inf Area (m²)	Depth (m)	Area (m²)	Inf Area (m²)	Depth (m)	Area (m²)	Inf Area (m²)
0.000	360.0	360.0	0.300	360.0	380.2	0.301	0.0	380.2

Node F3 Porous Paving Storage Structure

Underdrain Link Type	Circular	Underdrain Length (m)	20.000	Side Inf Coefficient (m/hr)	0.00100	Time to half empty (mins)	432
Underdrain Diameter (mm)	150	Underdrain Slope (1:X)	150.0	Safety Factor	1.5		
Underdrain Velocity	Colebrook-White	Underdrain Height above base (m)	0.000	Porosity	0.30		
Underdrain ks (mm) / n	15.000	Base Inf Coefficient (m/hr)	0.00100	Invert Level (m)	38.500		

Inlets
F3a

Depth (m)	Area (m²)	Inf Area (m²)	Depth (m)	Area (m²)	Inf Area (m²)	Depth (m)	Area (m²)	Inf Area (m²)
0.000	420.0	420.0	0.300	420.0	441.8	0.301	0.0	441.8

Node F4 Porous Paving Storage Structure

Underdrain Link Type	Circular	Underdrain Length (m)	20.000	Side Inf Coefficient (m/hr)	0.00100	Time to half empty (mins)	560
Underdrain Diameter (mm)	150	Underdrain Slope (1:X)	150.0	Safety Factor	1.5		
Underdrain Velocity	Colebrook-White	Underdrain Height above base (m)	0.000	Porosity	0.30		
Underdrain ks (mm) / n	15.000	Base Inf Coefficient (m/hr)	0.00100	Invert Level (m)	38.463		

Inlets
F4a

Depth (m)	Area (m²)	Inf Area (m²)	Depth (m)	Area (m²)	Inf Area (m²)	Depth (m)	Area (m²)	Inf Area (m²)
0.000	500.0	500.0	0.300	500.0	523.8	0.301	0.0	523.8

Other (defaults)

Entry Loss (manhole)	0.250	Entry Loss (junction)	0.000	Apply Recommended Losses	x
Exit Loss (manhole)	0.250	Exit Loss (junction)	0.000	Flood Risk (m)	0.300

Approval Settings

Node Size	✓	Cover Depth	✓	Proportional Velocity	✓	Time to Half Empty	✓
Node Losses	✓	Minimum Cover Depth (m)	0.550	Return Period (years)	100	Return Period (years)	30
Link Size	✓	Maximum Cover Depth (m)	3.000	Minimum Proportional Velocity (m/s)	0.750	Discharge Rates	✓
Minimum Diameter (mm)	150	Backdrops	✓	Maximum Proportional Velocity (m/s)	3.000	2 year (l/s)	2.0
Link Length	✓	Minimum Backdrop Height (m)	0.200	Surcharged Depth	✓	30 year (l/s)	5.0
Maximum Length (m)	100.000	Maximum Backdrop Height (m)	1.500	Return Period (years)	2	100 year (l/s)	5.0
Coordinates	✓	Full Bore Velocity	✓	Maximum Surcharged Depth (m)	0.100	Discharge Volume	✓
Accuracy (m)	1.000	Minimum Full Bore Velocity (m/s)	0.750	Flooding	✓	100 year 360 minute (m³)	155
Crossings	✓	Maximum Full Bore Velocity (m/s)	3.000	Return Period (years)	30		

Approval Results

The network has been designed using IDF rainfall
It contains 22 nodes (1 outfall) and 16 links
The total impermeable area is 0.464 ha
5 online controls have been defined
8 structures have been defined, providing 123m³ of storage below the flood risk level
Infiltration based on BRE 365 has been applied at 6 of the structures
Simulations have been completed using FEH-22 summer storms from 15 to 1440 minute duration

10 manholes are smaller than that required by the library

Node	Required Dia (mm)	Actual Dia (mm)
D1	1200	600
F2_Out	1200	600
F2	1200	900
4	1200	600
F1_Out	1200	450
F1	1200	900
2	1200	450
3	1200	600
5	1200	600
6	1200	450

8 connections have combined exit and entry losses less than the recomended total

Node	US Link	DS Link	US Exit Loss	DS Entry Loss	Angle (degrees)	Recommended Node Losses
F3_Out	F3_Link	1.006	0.250	0.250	90	0.900
F3	3.000	F3_Link	0.250	0.250	79	0.900
D1	1.008	1.009	0.250	0.250	72	0.900
BR	F4_Link	1.008	0.250	0.250	92	1.200
F4	4.000	F4_Link	0.250	0.250	87	0.900
F2_Out	F2_Link	1.004	0.250	0.250	90	0.900
F1_Out	F1_Link	1.002	0.250	0.250	89	0.900
F1	1.000	F1_Link	0.250	0.250	90	1.200

No circular links have diameters < 150mm

No links have lengths > 100.000m

No links have lengths that differ from their coordinated length by more than 1.000m

5 links cross one or more other links

US Node	DS Node	Link	Network	Link	Easting (m)	Northing (m)
F1	F1_Out	F1_Link	FW	1.000	480785.924	172684.135
F2	F2_Out	F2_Link	FW	1.001	480761.919	172702.120
7	F3_Out	1.005	FW	1.002	480745.520	172722.018
F3	F3_Out	F3_Link	FW	2.001	480736.653	172721.058
F4	BR	F4_Link	FW	2.000	480710.891	172736.039

12 links have cover depth outside the range 0.550-3.000m

US Node	DS Node	Link	Minimum Depth (m)	Maximum Depth (m)
6	F1	1.000	0.300	0.300
F1	F1_Out	F1_Link	0.300	0.449
F1_Out	4	1.002	0.435	0.449
4	F2_Out	1.003	0.435	0.449
5	F2	2.000	0.350	0.393
F2	F2_Out	F2_Link	0.380	0.393
F2_Out	7	1.004	0.449	0.533
7	F3_Out	1.005	0.533	0.549
3	F3	3.000	0.500	0.650
F4	BR	F4_Link	0.396	0.687
BR	D1	1.008	0.050	0.609
D1	13_OUT	1.009	0.097	0.200

2 nodes have backdrops outside the range 0.200-1.500m

Node	US Link	DS Link	Backdrop (m)
F2_Out	F2_Link	1.004	0.069
F3_Out	1.005	1.006	0.006

1 link has full bore velocity outside the range 0.750-3.000m/s

US Node	DS Node	Link	Velocity (m/s)
D1	13_OUT	1.009	0.531

12 links have peak proportional velocity outside the range 0.750-3.000m/s during the 100 year return period

US Node	DS Node	Link	Velocity (m/s)	Event
6	F1	1.000	0.019	100 year 1440 minute summer
F1	F1_Out	F1_Link	0.606	100 year 60 minute summer
F1_Out	4	1.002	0.603	100 year 30 minute summer
5	F2	2.000	0.003	100 year 720 minute summer
F2	F2_Out	F2_Link	0.571	100 year 30 minute summer
F2_Out	7	1.004	0.728	100 year 15 minute summer
3	F3	3.000	0.009	100 year 480 minute summer
F3	F3_Out	F3_Link	0.419	100 year 480 minute summer
2	F4	4.000	0.186	100 year 30 minute summer
F4	BR	F4_Link	0.406	100 year 240 minute summer
BR	D1	1.008	0.294	100 year 30 minute summer
D1	13_OUT	1.009	0.566	100 year 360 minute summer

2 links have a surcharged depth greater than 0.100m during the 2 year return period

US Node	DS Node	Link	Surcharged Depth (m)	Event
F3_Out	10	1.006	0.204	2 year 360 minute summer
10	BR	1.007	0.268	2 year 360 minute summer

No nodes flood during the 30 year return period

No infiltrating structures failed to half empty in 1440 minutes during the 30 year return period

1 outfall has a discharge rate greater than 2.0l/s during the 2 year return period

US Node	DS Node	Link	Discharge Rate (l/s)	Event
D1	13_OUT	1.009	2.2	2 year 360 minute summer

No outfalls have a discharge rate greater than 5.0l/s during the 30 year return period

No outfalls have a discharge rate greater than 5.0l/s during the 100 year return period

1 outfall has a discharge volume greater than 155m³ during the 100 year 360 minute storm

US Node	DS Node	Link	Discharge Volume (m³)	Event
D1	13_OUT	1.009	216.3	100 year 360 minute summer

Rainfall

Event	Peak Intensity (mm/hr)	Average Intensity (mm/hr)	Event	Peak Intensity (mm/hr)	Average Intensity (mm/hr)	Event	Peak Intensity (mm/hr)	Average Intensity (mm/hr)
2 year 15 minute summer	102.910	29.120	30 year 180 minute summer	61.752	15.891	100 year 600 minute summer	27.340	7.478
2 year 30 minute summer	65.861	18.636	30 year 240 minute summer	48.173	12.731	100 year 720 minute summer	23.860	6.395
2 year 60 minute summer	43.585	11.518	30 year 360 minute summer	35.754	9.201	100 year 960 minute summer	18.919	4.982
2 year 120 minute summer	31.790	8.401	30 year 480 minute summer	27.433	7.250	100 year 1440 minute summer	13.056	3.499
2 year 180 minute summer	25.877	6.659	30 year 600 minute summer	21.965	6.008	100 year +40% CC 15 minute summer	544.479	154.069
2 year 240 minute summer	20.982	5.545	30 year 720 minute summer	19.197	5.145	100 year +40% CC 30 minute summer	358.130	101.338
2 year 360 minute summer	16.243	4.180	30 year 960 minute summer	15.265	4.020	100 year +40% CC 60 minute summer	240.249	63.491
2 year 480 minute summer	12.772	3.375	30 year 1440 minute summer	10.597	2.840	100 year +40% CC 120 minute summer	144.785	38.262
2 year 600 minute summer	10.402	2.845	100 year 15 minute summer	388.914	110.049	100 year +40% CC 180 minute summer	109.099	28.075
2 year 720 minute summer	9.211	2.469	100 year 30 minute summer	255.807	72.385	100 year +40% CC 240 minute summer	84.709	22.386
2 year 960 minute summer	7.468	1.966	100 year 60 minute summer	171.606	45.350	100 year +40% CC 360 minute summer	62.547	16.095
2 year 1440 minute summer	5.329	1.428	100 year 120 minute summer	103.418	27.330	100 year +40% CC 480 minute summer	47.883	12.654
30 year 15 minute summer	301.443	85.298	100 year 180 minute summer	77.928	20.054	100 year +40% CC 600 minute summer	38.276	10.469
30 year 30 minute summer	196.912	55.719	100 year 240 minute summer	60.507	15.990	100 year +40% CC 720 minute summer	33.405	8.953
30 year 60 minute summer	131.444	34.737	100 year 360 minute summer	44.676	11.497	100 year +40% CC 960 minute summer	26.487	6.975
30 year 120 minute summer	81.225	21.465	100 year 480 minute summer	34.202	9.039	100 year +40% CC 1440 minute summer	18.279	4.899

Results for 2 year Critical Storm Duration. Lowest mass balance: 99.73%

Node Event	US Node	Peak (mins)	Level (m)	Depth (m)	Inflow (l/s)	Node Vol (m³)	Flood (m³)	Status
480 minute summer	F4a	448	38.644	0.047	0.2	0.0000	0.0000	OK
360 minute summer	F3a	336	38.652	0.018	0.2	0.0000	0.0000	OK
30 minute summer	F2a	29	38.791	0.001	0.3	0.0000	0.0000	OK
30 minute summer	F1a	23	38.887	0.003	3.0	0.0000	0.0000	OK
360 minute summer	F3_Out	296	38.649	0.429	5.3	0.7506	0.0000	SURCHARGED
360 minute summer	F3	328	38.651	0.151	3.0	10.1760	0.0000	SURCHARGED
360 minute summer	13_OUT	328	37.945	0.042	2.2	0.0000	0.0000	OK
360 minute summer	D1	328	38.001	0.051	2.2	0.0144	0.0000	OK
360 minute summer	BR	304	38.648	0.657	5.7	12.8657	0.0000	FLOOD RISK
360 minute summer	BR Filter Layer	328	38.005	0.005	0.6	0.8418	0.0000	OK
480 minute summer	F4	448	38.643	0.180	2.6	16.4619	0.0000	SURCHARGED
360 minute summer	10	296	38.648	0.493	5.3	0.5579	0.0000	SURCHARGED
360 minute summer	1.007:50%	296	38.648	0.559	5.7	0.0000	0.0000	SURCHARGED
360 minute summer	7	288	38.649	0.307	5.0	0.3473	0.0000	SURCHARGED
360 minute summer	F2_Out	288	38.649	0.223	4.5	0.0657	0.0000	OK
360 minute summer	1.004:50%	288	38.649	0.265	5.1	0.0000	0.0000	SURCHARGED
180 minute summer	F2	116	38.745	0.088	3.0	4.4399	0.0000	OK
30 minute summer	4	26	38.674	0.059	4.5	0.0168	0.0000	OK
240 minute summer	F1_Out	172	38.737	0.036	1.8	0.0075	0.0000	OK
30 minute summer	1.002:50%	25	38.718	0.060	4.5	0.0000	0.0000	OK
240 minute summer	F1	164	38.883	0.133	6.1	14.3126	0.0000	OK
15 minute summer	1	1	39.171	0.000	0.0	0.0000	0.0000	OK
480 minute summer	2	440	38.643	0.043	0.1	0.0069	0.0000	OK
480 minute summer	4.000:50%	448	38.643	0.111	1.8	0.0000	0.0000	OK
360 minute summer	3	320	38.652	0.002	0.0	0.0005	0.0000	OK
360 minute summer	3.000:50%	328	38.651	0.076	1.5	0.0000	0.0000	OK
15 minute summer	5	1	38.800	0.000	0.0	0.0000	0.0000	OK
15 minute summer	2.000:50%	14	38.773	0.045	2.6	0.0949	0.0000	OK
240 minute summer	6	164	38.884	0.034	0.0	0.0054	0.0000	OK
240 minute summer	1.000:50%	164	38.884	0.084	3.6	0.0000	0.0000	OK

Link Event (Upstream Depth)	US Node	Link	DS Node	Outflow (l/s)	Velocity (m/s)	Flow/Cap	Link Vol (m³)	Discharge Vol (m³)
480 minute summer	F4a	Porous Paving	F4	-0.4	-0.036	-0.047		
360 minute summer	F3a	Porous Paving	F3	-0.3	-0.029	-0.033		
30 minute summer	F2a	Porous Paving	F2	0.0	0.000	0.000		
30 minute summer	F1a	Porous Paving	F1	0.0	0.003	0.000		
360 minute summer	F3_Out	1.006	10	5.3	0.421	0.124	0.3906	
360 minute summer	F3	F3_Link	F3_Out	-0.8	0.406	-0.039	0.2702	
360 minute summer	F3	Infiltration		0.1				
360 minute summer	D1	1.009	13_OUT	2.2	0.469	0.230	0.0758	78.9
360 minute summer	BR	1.008	D1	1.6	0.290	0.030	0.1082	
360 minute summer	BR	Filtration		0.6				
360 minute summer	BR Filter Layer	Underdrain		0.0	0.000	0.000	0.0316	
360 minute summer	BR Filter Layer	Infiltration		0.0				
480 minute summer	F4	F4_Link	BR	1.0	0.382	0.066	0.2877	
480 minute summer	F4	Infiltration		0.1				
360 minute summer	10	1.007	1.007:50%	5.2	0.351	0.124	0.3931	
360 minute summer	10	1.007	BR	5.7	0.338	0.135	0.3931	
360 minute summer	7	1.005	F3_Out	5.0	0.436	0.119	0.6929	
360 minute summer	F2_Out	1.004	1.004:50%	4.5	0.475	0.112	0.2806	
360 minute summer	F2_Out	Infiltration		0.0				
360 minute summer	F2_Out	1.004	7	5.0	0.505	0.126	0.2807	
180 minute summer	F2	F2_Link	F2_Out	1.4	0.541	0.072	0.0368	
180 minute summer	F2	Infiltration		0.0				
30 minute summer	4	1.003	F2_Out	4.5	0.715	0.313	0.1583	
240 minute summer	F1_Out	1.002	1.002:50%	1.8	0.504	0.121	0.0276	
240 minute summer	F1_Out	Infiltration		0.0				
240 minute summer	F1_Out	1.002	4	3.9	0.684	0.267	0.0364	
240 minute summer	F1	F1_Link	F1_Out	1.8	0.541	0.121	0.0243	
240 minute summer	F1	Infiltration		0.1				
15 minute summer	1	Bioretention Area	BR	0.0	0.000	0.000		
480 minute summer	2	4.000	4.000:50%	0.1	0.128	0.005	0.0423	
480 minute summer	2	4.000	F4	1.9	0.614	0.087	0.0733	
360 minute summer	3	3.000	3.000:50%	0.0	-0.002	0.000	0.0308	
360 minute summer	3	3.000	F3	1.6	0.502	0.087	0.0906	
15 minute summer	5	2.000	2.000:50%	0.0	0.000	0.000	0.0221	
15 minute summer	5	2.000	F2	2.6	0.965	0.177	0.0450	
240 minute summer	6	1.000	1.000:50%	0.0	-0.015	-0.003	0.0369	
240 minute summer	6	1.000	F1	3.6	0.660	0.216	0.0754	

Results for 30 year Critical Storm Duration. Lowest mass balance: 98.93%

Node Event	US Node	Peak (mins)	Level (m)	Depth (m)	Inflow (l/s)	Node Vol (m³)	Flood (m³)	Status
480 minute summer	F4a	488	38.751	0.155	0.4	0.0000	0.0000	OK
240 minute summer	F3a	240	38.763	0.130	0.7	0.0000	0.0000	OK
120 minute summer	F2a	92	38.840	0.050	0.8	0.0000	0.0000	OK
180 minute summer	F1a	144	38.981	0.098	5.3	0.0000	0.0000	OK
360 minute summer	F3_Out	360	38.754	0.534	9.6	1.0144	0.0000	FLOOD RISK
360 minute summer	F3	360	38.762	0.262	5.1	24.4140	0.0000	SURCHARGED
360 minute summer	13_OUT	368	37.957	0.054	3.6	0.0000	0.0000	OK
360 minute summer	D1	368	38.016	0.066	3.6	0.0188	0.0000	OK
360 minute summer	BR	360	38.752	0.761	10.8	38.9340	0.0000	FLOOD RISK
360 minute summer	BR Filter Layer	368	38.013	0.013	1.9	2.1653	0.0000	OK
480 minute summer	F4	480	38.751	0.288	4.4	32.8280	0.0000	SURCHARGED
360 minute summer	10	360	38.753	0.598	9.5	0.6762	0.0000	FLOOD RISK
360 minute summer	1.007:50%	360	38.752	0.663	28.4	0.0000	0.0000	SURCHARGED
360 minute summer	7	352	38.755	0.413	9.1	0.4667	0.0000	SURCHARGED
360 minute summer	F2_Out	352	38.755	0.329	7.9	0.1072	0.0000	SURCHARGED
360 minute summer	1.004:50%	352	38.755	0.371	9.2	0.0000	0.0000	SURCHARGED
120 minute summer	F2	92	38.839	0.182	8.2	12.0373	0.0000	SURCHARGED
30 minute summer	4	27	38.805	0.190	12.1	0.0538	0.0000	SURCHARGED
30 minute summer	F1_Out	26	38.842	0.141	2.3	0.0296	0.0000	OK
30 minute summer	1.002:50%	26	38.842	0.184	12.2	0.0000	0.0000	SURCHARGED
180 minute summer	F1	144	38.979	0.229	12.2	36.6238	0.0000	FLOOD RISK
15 minute summer	1	1	39.171	0.000	0.0	0.0000	0.0000	OK
480 minute summer	2	480	38.751	0.151	0.3	0.0240	0.0000	SURCHARGED
480 minute summer	4.000:50%	480	38.751	0.219	3.2	0.0000	0.0000	SURCHARGED
360 minute summer	3	360	38.762	0.112	0.1	0.0318	0.0000	OK
360 minute summer	3.000:50%	360	38.762	0.187	3.4	0.0000	0.0000	SURCHARGED
120 minute summer	5	92	38.839	0.039	0.1	0.0111	0.0000	OK
120 minute summer	2.000:50%	92	38.839	0.110	6.0	0.5812	0.0000	OK
180 minute summer	6	140	38.979	0.129	0.1	0.0205	0.0000	OK
180 minute summer	1.000:50%	140	38.979	0.179	9.7	0.0000	0.0000	SURCHARGED

Link Event (Upstream Depth)	US Node	Link	DS Node	Outflow (l/s)	Velocity (m/s)	Flow/Cap	Link Vol (m³)	Discharge Vol (m³)
480 minute summer	F4a	Porous Paving	F4	-0.9	-0.066	-0.122		
240 minute summer	F3a	Porous Paving	F3	-1.1	-0.076	-0.143		
120 minute summer	F2a	Porous Paving	F2	-0.8	-0.062	-0.097		
180 minute summer	F1a	Porous Paving	F1	-0.9	-0.062	-0.110		
360 minute summer	F3_Out	1.006	10	9.5	0.424	0.224	0.3906	
360 minute summer	F3	F3_Link	F3_Out	1.8	0.415	0.089	0.2703	
360 minute summer	F3	Infiltration		0.1				
360 minute summer	D1	1.009	13_OUT	3.6	0.541	0.381	0.1090	172.1
360 minute summer	BR	1.008	D1	1.7	0.290	0.032	0.1427	
360 minute summer	BR	Filtration		1.9				
360 minute summer	BR Filter Layer	Underdrain		0.0	0.000	0.000	0.1320	
360 minute summer	BR Filter Layer	Infiltration		0.0				
480 minute summer	F4	F4_Link	BR	0.9	0.400	0.064	0.2877	
480 minute summer	F4	Infiltration		0.1				
360 minute summer	10	1.007	1.007:50%	18.5	0.466	0.438	0.3931	
360 minute summer	10	1.007	BR	10.8	0.317	0.256	0.3931	
360 minute summer	7	1.005	F3_Out	9.1	0.444	0.215	0.6929	
360 minute summer	F2_Out	1.004	1.004:50%	7.9	0.458	0.197	0.2807	
360 minute summer	F2_Out	Infiltration		0.0				
360 minute summer	F2_Out	1.004	7	9.1	0.495	0.229	0.2807	
120 minute summer	F2	F2_Link	F2_Out	2.1	0.560	0.106	0.0972	
120 minute summer	F2	Infiltration		0.1				
30 minute summer	4	1.003	F2_Out	12.0	0.871	0.829	0.3001	
30 minute summer	F1_Out	1.002	1.002:50%	3.0	0.584	0.205	0.1125	
30 minute summer	F1_Out	Infiltration		0.0				
30 minute summer	F1_Out	1.002	4	12.1	0.854	0.835	0.1137	
180 minute summer	F1	F1_Link	F1_Out	2.4	0.593	0.168	0.0344	
180 minute summer	F1	Infiltration		0.1				
15 minute summer	1	Bioretention Area	BR	0.0	0.000	0.000		
480 minute summer	2	4.000	4.000:50%	0.3	0.144	0.015	0.0815	
480 minute summer	2	4.000	F4	3.1	0.685	0.145	0.0815	
360 minute summer	3	3.000	3.000:50%	-0.1	-0.012	-0.003	0.1081	
360 minute summer	3	3.000	F3	3.3	0.648	0.178	0.1198	
120 minute summer	5	2.000	2.000:50%	-0.1	-0.028	-0.007	0.0886	
120 minute summer	5	2.000	F2	5.5	0.654	0.372	0.1591	
180 minute summer	6	1.000	1.000:50%	-0.1	-0.015	-0.006	0.0955	
180 minute summer	6	1.000	F1	9.6	0.846	0.573	0.0996	

Results for 100 year Critical Storm Duration. Lowest mass balance: 98.96%

Node Event	US Node	Peak (mins)	Level (m)	Depth (m)	Inflow (l/s)	Node Vol (m³)	Flood (m³)	Status
480 minute summer	F4a	488	38.804	0.207	0.5	0.0000	0.0000	OK
240 minute summer	F3a	240	38.821	0.187	0.9	0.0000	0.0000	OK
120 minute summer	F2a	98	38.877	0.086	1.0	0.0000	0.0000	OK
180 minute summer	F1a	156	39.030	0.146	6.6	0.0000	0.0000	OK
360 minute summer	F3_Out	360	38.802	0.582	11.0	1.1355	0.0000	FLOOD RISK
240 minute summer	F3	244	38.820	0.320	8.7	30.6497	0.0000	SURCHARGED
360 minute summer	13_OUT	376	37.962	0.059	4.2	0.0000	0.0000	OK
360 minute summer	D1	376	38.023	0.073	4.2	0.0206	0.0000	OK
360 minute summer	BR	368	38.799	0.808	12.5	49.3404	0.0000	FLOOD RISK
360 minute summer	BR Filter Layer	376	38.017	0.017	2.5	2.7117	0.0000	OK
480 minute summer	F4	480	38.803	0.340	5.2	38.0485	0.0000	SURCHARGED
360 minute summer	10	368	38.801	0.646	10.9	0.7305	0.0000	FLOOD RISK
360 minute summer	1.007:50%	368	38.800	0.711	12.5	0.0000	0.0000	SURCHARGED
360 minute summer	7	360	38.803	0.461	11.2	0.5214	0.0000	FLOOD RISK
360 minute summer	F2_Out	360	38.804	0.378	11.7	0.1309	0.0000	FLOOD RISK
360 minute summer	1.004:50%	360	38.803	0.419	31.7	0.0000	0.0000	SURCHARGED
120 minute summer	F2	98	38.875	0.218	9.3	16.0544	0.0000	SURCHARGED
30 minute summer	4	27	38.883	0.268	14.1	0.0758	0.0000	SURCHARGED
30 minute summer	F1_Out	27	38.934	0.233	2.8	0.0671	0.0000	SURCHARGED
30 minute summer	1.002:50%	27	38.933	0.275	14.4	0.0000	0.0000	SURCHARGED
180 minute summer	F1	152	39.027	0.277	14.1	47.9184	0.0000	FLOOD RISK
15 minute summer	1	1	39.171	0.000	0.0	0.0000	0.0000	OK
480 minute summer	2	480	38.804	0.203	0.3	0.0324	0.0000	SURCHARGED
480 minute summer	4.000:50%	480	38.803	0.271	3.9	0.0000	0.0000	SURCHARGED
240 minute summer	3	240	38.820	0.170	0.1	0.0481	0.0000	SURCHARGED
240 minute summer	3.000:50%	240	38.820	0.245	5.8	0.0000	0.0000	SURCHARGED
120 minute summer	5	96	38.876	0.076	0.1	0.0215	0.0000	OK
120 minute summer	2.000:50%	96	38.876	0.147	7.6	1.0368	0.0000	OK
60 minute summer	6	41	39.036	0.186	0.4	0.0296	0.0000	FLOOD RISK
60 minute summer	1.000:50%	41	39.036	0.236	20.2	0.0000	0.0000	SURCHARGED

Link Event (Upstream Depth)	US Node	Link	DS Node	Outflow (l/s)	Velocity (m/s)	Flow/Cap	Link Vol (m³)	Discharge Vol (m³)
480 minute summer	F4a	Porous Paving	F4	-1.2	-0.074	-0.153		
240 minute summer	F3a	Porous Paving	F3	-1.4	-0.088	-0.184		
120 minute summer	F2a	Porous Paving	F2	-1.1	-0.077	-0.136		
180 minute summer	F1a	Porous Paving	F1	-1.2	-0.076	-0.153		
360 minute summer	F3_Out	1.006	10	10.9	0.425	0.256	0.3906	
240 minute summer	F3	F3_Link	F3_Out	1.4	0.418	0.066	0.2703	
240 minute summer	F3	Infiltration		0.1				
360 minute summer	D1	1.009	13_OUT	4.2	0.566	0.450	0.1228	216.3
360 minute summer	BR	1.008	D1	1.8	0.290	0.033	0.1584	
360 minute summer	BR	Filtration		2.5				
360 minute summer	BR Filter Layer	Underdrain		0.0	0.000	0.000	0.1840	
360 minute summer	BR Filter Layer	Infiltration		0.1				
480 minute summer	F4	F4_Link	BR	1.0	0.403	0.072	0.2877	
480 minute summer	F4	Infiltration		0.1				
360 minute summer	10	1.007	1.007:50%	10.8	0.358	0.255	0.3931	
360 minute summer	10	1.007	BR	12.5	0.353	0.295	0.3931	
360 minute summer	7	1.005	F3_Out	10.4	0.450	0.246	0.6929	
360 minute summer	F2_Out	1.004	1.004:50%	-11.1	0.472	-0.279	0.2807	
360 minute summer	F2_Out	Infiltration		0.0				
360 minute summer	F2_Out	1.004	7	-15.7	0.498	-0.393	0.2807	
120 minute summer	F2	F2_Link	F2_Out	2.1	0.566	0.107	0.1162	
120 minute summer	F2	Infiltration		0.1				
30 minute summer	4	1.003	F2_Out	14.0	0.903	0.967	0.3001	
30 minute summer	F1_Out	1.002	1.002:50%	3.5	0.603	0.241	0.1137	
30 minute summer	F1_Out	Infiltration		0.0				
30 minute summer	F1_Out	1.002	4	14.1	0.876	0.973	0.1137	
180 minute summer	F1	F1_Link	F1_Out	2.7	0.545	0.188	0.0955	
180 minute summer	F1	Infiltration		0.1				
15 minute summer	1	Bioretention Area	BR	0.0	0.000	0.000		
480 minute summer	2	4.000	4.000:50%	0.3	0.138	0.013	0.0815	
480 minute summer	2	4.000	F4	3.8	0.705	0.177	0.0815	
240 minute summer	3	3.000	3.000:50%	-0.1	-0.013	-0.004	0.1198	
240 minute summer	3	3.000	F3	5.6	0.750	0.303	0.1198	
120 minute summer	5	2.000	2.000:50%	-0.1	-0.038	-0.010	0.1340	
120 minute summer	5	2.000	F2	6.5	0.689	0.439	0.1776	
60 minute summer	6	1.000	1.000:50%	-0.4	-0.023	-0.021	0.0996	
60 minute summer	6	1.000	F1	19.9	1.220	1.194	0.0996	

Results for 100 year +40% CC Critical Storm Duration. Lowest mass balance: 80.43%

Node Event	US Node	Peak (mins)	Level (m)	Depth (m)	Inflow (l/s)	Node Vol (m³)	Flood (m³)	Status
360 minute summer	F4a	296	38.978	0.382	1.0	0.0000	0.0000	OK
480 minute summer	F3a	304	39.131	0.498	1.1	0.0000	0.0000	OK
120 minute summer	F2a	108	38.949	0.159	1.4	0.0000	0.0000	OK
360 minute summer	F1a	264	39.169	0.286	5.8	0.0000	0.0000	OK
360 minute summer	F3_Out	288	38.889	0.669	13.4	1.3544	0.0000	FLOOD RISK
360 minute summer	F3	248	39.281	0.781	9.1	38.9260	0.0000	FLOOD RISK
360 minute summer	13_OUT	320	37.970	0.067	5.4	0.0000	0.0000	OK
360 minute summer	D1	320	38.034	0.084	5.4	0.0238	0.0000	OK
360 minute summer	BR	304	38.884	0.893	15.5	52.5789	0.0000	FLOOD RISK
360 minute summer	BR Filter Layer	320	38.023	0.023	3.6	3.6374	0.0000	OK
360 minute summer	F4	296	39.289	0.826	8.8	42.0054	0.0000	FLOOD RISK
360 minute summer	10	320	38.887	0.732	13.2	0.8280	0.0000	FLOOD RISK
360 minute summer	1.007:50%	304	38.886	0.797	15.6	0.0000	0.0000	SURCHARGED
360 minute summer	7	296	38.891	0.549	22.2	0.6213	0.0000	FLOOD RISK
360 minute summer	F2_Out	312	38.893	0.467	14.8	0.1860	0.0000	FLOOD RISK
360 minute summer	1.004:50%	288	38.892	0.508	36.6	0.0000	0.0000	SURCHARGED
120 minute summer	F2	106	38.947	0.290	12.4	23.9392	0.0000	FLOOD RISK
30 minute summer	4	27	39.025	0.410	17.4	0.1161	0.0000	FLOOD RISK
30 minute summer	F1_Out	26	39.102	0.401	3.2	0.1500	0.0000	FLOOD RISK
30 minute summer	1.002:50%	26	39.103	0.445	20.1	0.0000	0.0000	SURCHARGED
360 minute summer	F1	280	39.165	0.415	1258.4	68.2815	0.0000	FLOOD RISK
15 minute summer	1	1	39.171	0.000	0.0	0.0000	0.0000	OK
360 minute summer	2	248	39.086	0.486	4.1	0.0773	0.0000	FLOOD RISK
360 minute summer	4.000:50%	248	39.087	0.555	13.6	0.0000	0.0000	SURCHARGED
360 minute summer	3	232	39.118	0.468	0.2	0.1324	0.0000	FLOOD RISK
360 minute summer	3.000:50%	232	39.118	0.543	12.0	0.0000	0.0000	SURCHARGED
120 minute summer	5	108	38.948	0.148	0.2	0.0420	0.0000	OK
120 minute summer	2.000:50%	106	38.948	0.219	10.6	2.3007	0.0000	SURCHARGED
30 minute summer	6	26	39.178	0.328	0.8	0.0522	0.0000	FLOOD RISK
30 minute summer	1.000:50%	26	39.178	0.378	29.7	0.0000	0.0000	SURCHARGED

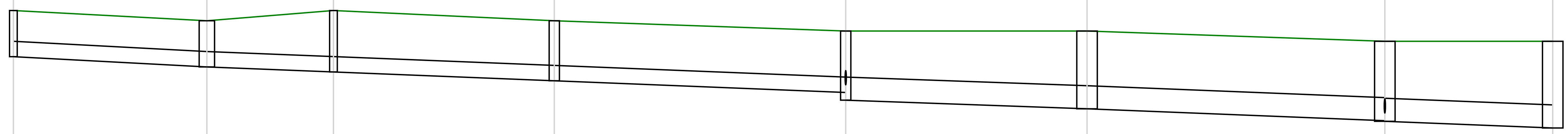
Link Event (Upstream Depth)	US Node	Link	DS Node	Outflow (l/s)	Velocity (m/s)	Flow/Cap	Link Vol (m³)	Discharge Vol (m³)
360 minute summer	F4a	Porous Paving	F4	-1.6	-0.092	-0.203		
480 minute summer	F3a	Porous Paving	F3	-1.6	-0.093	-0.212		
120 minute summer	F2a	Porous Paving	F2	-1.6	-0.098	-0.207		
360 minute summer	F1a	Porous Paving	F1	1.7	0.106	0.220		
360 minute summer	F3_Out	1.006	10	13.2	0.449	0.313	0.3906	
360 minute summer	F3	F3_Link	F3_Out	2.1	0.427	0.104	0.2703	
360 minute summer	F3	Infiltration		0.1				
360 minute summer	D1	1.009	13_OUT	5.4	0.606	0.572	0.1458	249.8
360 minute summer	BR	1.008	D1	1.8	0.290	0.035	0.1989	
360 minute summer	BR	Filtration		3.6				
360 minute summer	BR Filter Layer	Underdrain		0.0	0.000	0.000	0.2824	
360 minute summer	BR Filter Layer	Infiltration		0.1				
360 minute summer	F4	F4_Link	BR	1.4	0.406	0.097	0.2877	
360 minute summer	F4	Infiltration		0.1				
360 minute summer	10	1.007	1.007:50%	13.2	0.370	0.311	0.3931	
360 minute summer	10	1.007	BR	15.5	0.414	0.367	0.3931	
360 minute summer	7	1.005	F3_Out	12.7	0.484	0.300	0.6929	
360 minute summer	F2_Out	1.004	1.004:50%	-12.7	0.470	-0.318	0.2807	
360 minute summer	F2_Out	Infiltration		0.0				
360 minute summer	F2_Out	1.004	7	-17.3	0.524	-0.433	0.2807	
120 minute summer	F2	F2_Link	F2_Out	2.2	0.570	0.116	0.1295	
120 minute summer	F2	Infiltration		0.1				
30 minute summer	4	1.003	F2_Out	17.3	0.981	1.195	0.3001	
30 minute summer	F1_Out	1.002	1.002:50%	3.8	0.439	0.264	0.1137	
30 minute summer	F1_Out	Infiltration		0.0				
30 minute summer	F1_Out	1.002	4	17.4	0.989	1.204	0.1137	
360 minute summer	F1	F1_Link	F1_Out	3.0	0.559	0.208	0.1304	
360 minute summer	F1	Infiltration		0.1				
15 minute summer	1	Bioretention Area	BR	0.0	0.000	0.000		
360 minute summer	2	4.000	4.000:50%	12.8	0.728	0.592	0.0815	
360 minute summer	2	4.000	F4	6.7	0.884	0.309	0.0815	
360 minute summer	3	3.000	3.000:50%	10.6	0.602	0.569	0.1198	
360 minute summer	3	3.000	F3	5.9	0.733	0.314	0.1198	
120 minute summer	5	2.000	2.000:50%	-0.2	-0.027	-0.010	0.1779	
120 minute summer	5	2.000	F2	8.5	0.731	0.572	0.1780	
30 minute summer	6	1.000	1.000:50%	-0.8	-0.170	-0.049	0.0996	
30 minute summer	6	1.000	F1	29.2	1.661	1.754	0.0996	

Water Quality

Area (ha)	Intended Land Use	Entering via Node or Link	Name	SuDS Component	Pollution hazard indices TSS	Pollution hazard indices Metals	Pollution hazard indices Hydrocarbons	Pollution mitigation indices TSS	Pollution mitigation indices Metals	Pollution mitigation indices Hydrocarbons	Cumulative pollution hazard indices TSS	Cumulative pollution hazard indices Metals	Cumulative pollution hazard indices Hydrocarbons
		Node	F1_Out	Filter Drain				0.4	0.4	0.4			
		Node	F2_Out	Filter Drain				0.2	0.2	0.2			
		Node	F3_Out	Filter Drain				0.2	0.2	0.2			
		Node	13_OUT										
											Sufficient	Sufficient	Sufficient

13.8.3 Drainage Sections

STM environmental ENVIRONMENTAL CONSULTING . SOFTWARE & TRAINING	STM Environmental Consultants Model V1.0 SWDS - 2025 - 000034	File: STM SW Dun Elms V1.02.pfd Network: SW_DunElms M. Ashdown 18/12/2025	Page 1 Dun Elms, Nelsons Lane, Hurst, Wokingham RG10 0RR



A3 drawing

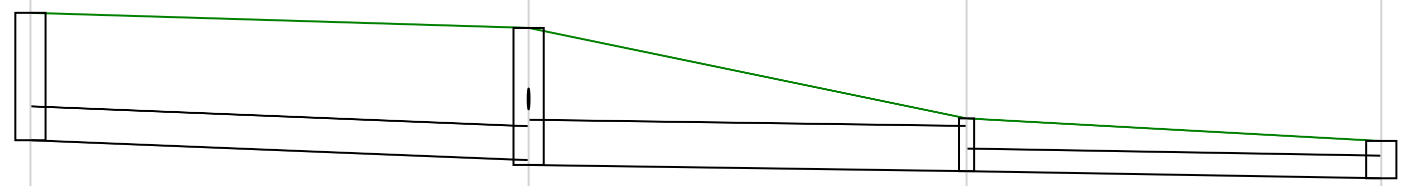
Hor Scale 300
Ver Scale 50

Datum (m) 34.000

Node Name	6	F1	F1_Out	4	F2_Out	7	F3_Out	10
Cover Level (m)	39.300	39.200	39.300	39.200	39.100	39.100	39.000	39.000
Invert Level (m)	38.850	38.750 / 38.750	38.701 / 38.701	38.615 / 38.615	38.501 / 38.426	38.342 / 38.342	38.226 / 38.220	38.155

Link Name	1.000	F1_Link	1.002	1.003	1.004	1.005	1.006
Section Type	150mm	150mm	150mm	150mm	225mm	225mm	225mm
Slope (1:X)	113.2	150.0	150.0	150.0	168.1	150.0	150.0
Length (m)	11.319	7.406	12.920	17.049	14.118	17.421	9.822

Node Name	10		BR		D1		13_OUT



A3 drawing

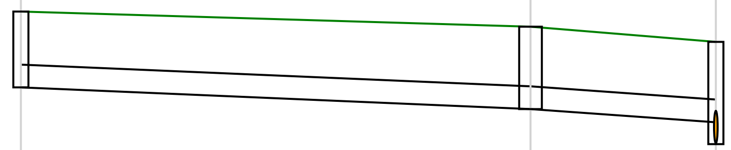
Hor Scale 300
Ver Scale 50

Datum (m) 34.000

	10		BR		D1		13_OUT
Link Name		1.007		1.008		1.009	
Section Type		225mm		300mm		150mm	
Slope (1:X)		150.0		423.9		350.2	
Cover Level (m)	39.000		38.900		38.300		38.150
Invert Level (m)	38.155		38.023 / 37.991		37.950 / 37.950		37.903
Length (m)		19.770		17.380		16.458	

STM environmental (ENVIRONMENTAL CONSULTING, SOFTWARE & TRAINING)	STM Environmental Consultants Model V1.0 SWDS - 2025 - 000034	File: STM SW Dun Elms V1.02.pfd Network: SW_DunElms M. Ashdown 18/12/2025	Page 3 Dun Elms, Nelsons Lane, Hurst, Wokingham RG10 0RR

Node Name	5		F2		F2_Out

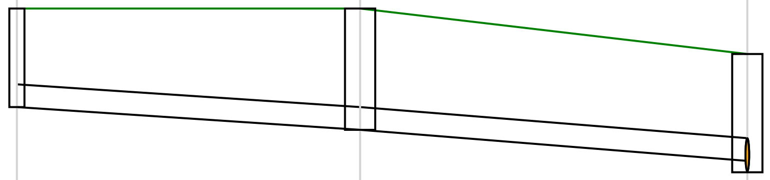


A3 drawing

Hor Scale 300
Ver Scale 50

Datum (m) 34.000

	5		F2		F2_Out
Link Name		2.000		F2_Link	
Section Type		150mm		150mm	
Slope (1:X)		141.4		84.5	
Cover Level (m)	39.300		39.200		39.100
Invert Level (m)	38.800	38.657	38.657	38.570	
Length (m)		20.225		7.355	



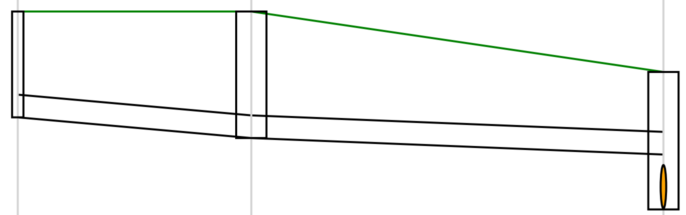
A3 drawing

Hor Scale 300
Ver Scale 50

Datum (m) 34.000

Node Name	3		F3		F3_Out
Link Name		3.000		F3_Link	
Section Type		150mm		150mm	
Slope (1:X)		90.7		74.9	
Cover Level (m)	39.300		39.300		39.000
Invert Level (m)	38.650	38.500	38.500	38.295	
Length (m)		13.612		15.356	

Node Name	2	F4	BR

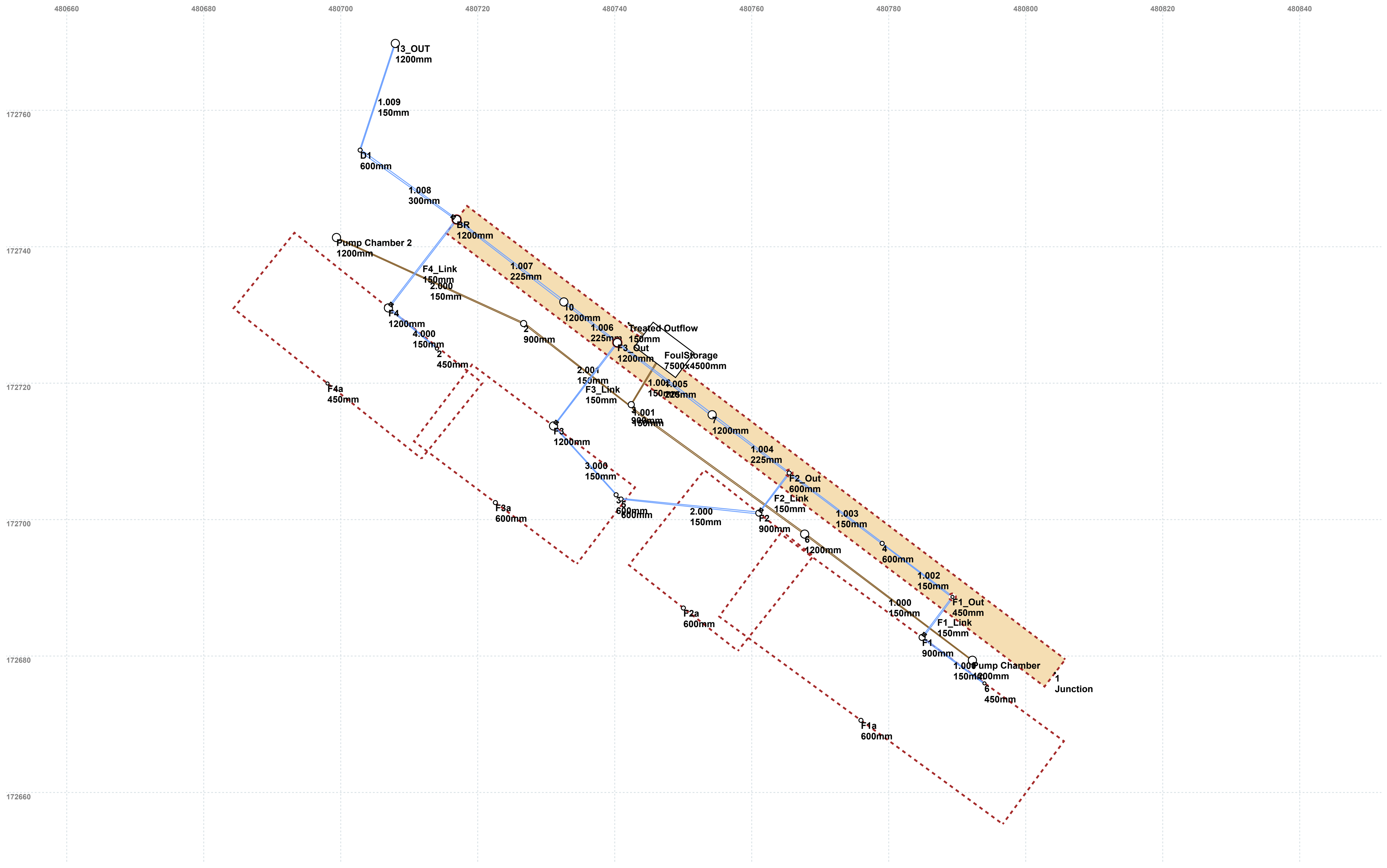


A3 drawing

Hor Scale 300
Ver Scale 50

Datum (m) 34.000

Link Name	4.000		F4_Link	
Section Type	150mm		150mm	
Slope (1:X)	67.6		149.9	
Cover Level (m)	39.300		39.300	38.900
Invert Level (m)	38.600	38.463	38.463	38.354
Length (m)	9.262		16.343	



13_OUT
1200mm
1.009
150mm
D1
600mm
1.008
300mm
BR
1200mm
Pump Chamber 2
1200mm
F4_Link
150mm
2.000
150mm
1.007
225mm
F4
1200mm
4.000
150mm
2
450mm
2
900mm
10
1200mm
1.006
225mm
Treated Outflow
150mm
F3_Out
1200mm
FoulStorage
7500x4500mm
F4a
450mm
2.001
150mm
F3_Link
150mm
1.005
225mm
1.001
900mm
150mm
F3
1200mm
7
1200mm
1.004
225mm
3.000
150mm
F2_Out
600mm
F2_Link
150mm
F3a
600mm
3
600mm
2.000
150mm
F2
900mm
1.003
150mm
6
1200mm
4
600mm
1.002
150mm
1.000
150mm
F1_Out
450mm
F1_Link
150mm
F2a
600mm
F1
900mm
1.000
150mm
Pump Chamber
1200mm
1
Junction
6
450mm
F1a
600mm

13.9 Appendix 8 – SuDS Maintenance Manual

All maintenance activities will be the responsibility of WS Planning & Architecture. They will appoint a management company to undertake the general maintenance duties within the site and will join service agreements with the suppliers and manufactures of the SuDS/Pumps when required.

The information presented below is taken from the CIRIA SuDS Manual (Report c753) and SuDS. Further details on installation and maintenance can be found detailed below and online.

13.9.1 Pervious Pavements

Maintenance Schedule	Required Action	Typical Frequency	Responsibility
Regular maintenance	Brushing and vacuuming (standard cosmetic sweep over whole surface).	Once a year, after autumn leaf fall, or reduced frequency as required, based on site-specific observations of clogging or manufacturer's recommendations - pay particular attention to areas where water runs onto pervious surface from adjacent impermeable areas as this area is most likely to collect the most sediment.	WS Planning & Architecture will be responsible for setting up the management company.
Occasional maintenance	Stabilise and mow contributing and areas.	As required.	
	Removal of weeds or manage using weed killer applied directly into the weeds rather than spraying.	As required - once per year on less frequently used pavements.	
Remedial actions	Remediate any landscaping which, through vegetation maintenance or soil slip, has been raised to within 50 mm of the level of the paving.	As required.	
	Remedial work to any depressions, rutting and cracked or broken blocks considered detrimental to the structural performance or a hazard to users, and lost material.	As required.	
	Rehabilitation of surface and upper substructure by remedial sweeping.	Every 10 to 15 years or as required (if infiltration performance is reduced due to significant clogging).	WS Planning & Architecture will be responsible for setting up the management company.
Monitoring	Initial Inspection.	Monthly for three months after installation.	
	Inspect for evidence of poor operation and/or weed growth - if required, take remedial action.	Three-monthly, 48h after large storms in first six months.	
	Inspect silt accumulation rates and establish appropriate brushing frequencies.	Annually.	
	Monitor Inspection chambers.	Annually.	

Many of the specific maintenance activities for pervious pavements can be undertaken as part of a general site cleaning contract (many car parks or roads are swept to remove litter and for visual reasons to keep them tidy). Therefore, if litter management is already required at the site, this should have marginal cost implications.

13.9.2 Rain Garden Maintenance

Maintenance Schedule	Required Action	Typical Frequency	Responsibility
Regular maintenance	Inspect for sediment and debris in inlet and outlet components	Quarterly; As required.	WS Planning & Architecture will be responsible for setting up the management company.
	Inspection & Cleaning of gutters and any filters on downpipes feeding into rain gardens as required.	Quarterly; As required.	
	Remove, replace and maintain vegetation as required; Ensuring cuttings are removed to prevent debris build up; Weeding of flower bed to maintain the desired vegetation, density and biodiversity - Vegetation management	Monthly inspections Summer; As required Quarterly during Winter month; Or as required.	
Remedial actions	Replace dead or overgrown vegetation as required.	As required.	
	Replacement of clogged geotextile (will require reconstruction of raingarden).	As required.	
Monitoring	Inspect silt traps / discharge points and note rate of sediment accumulation and ensure no erosion pathways forming.	Monthly in the first year and then annually.	
	Check raingardens are emptying as required following a storm event occurring.	After storms; When possible.	

Maintenance will be carried out manually. All monitoring and maintenance will be carried out by the appointed estate management company that undertakes the general landscaping maintenance.

13.9.3 SuDS Rain Water Butt Maintenance

Maintenance Schedule	Required Action	Typical Frequency	Responsibility
Regular maintenance	Inspect for sediment and debris in inlet and outlet components;	Quarterly; As required. Increase freq. to Monthly during Autumn;	WS Planning & Architecture will be responsible for setting up the management company.
	Inspection & Cleaning of gutters and any filters on downpipes feeding into the Rain Water Butts.	Quarterly; Increase freq. to Monthly during Autumn;	
Remedial actions	Cleaning of the water butt. Fully drain the water butt and clear out debris and enable access; Scrub out the inside of the butt or tank with a coarse brush, if accessible, using a proprietary cleaning product such as Just Water Butt Cleaner or garden disinfectant; Rinse with clean water; Cleaning of Gutters; Clean or fit a new filter;	Annually; Or as required.	
Remedial actions	Use water/empty water butts - to clean, water plants (inside & out); Empty water Butt more frequently during the winter, to allow for storage during storms and to keep the water fresh;	Once every two weeks; as required	

Maintenance will be carried out manually. All monitoring and maintenance will be carried out by the appointed estate management company that undertakes the general landscaping maintenance.

13.9.4 Surface Water Pump Maintenance

Maintenance Schedule	Required Action	Typical Frequency	Responsibility
Regular maintenance	Inspection of pumping chamber for sediment and debris in inlet and outlet components; Inspection of pumping chamber for sediment and debris in inlet and outlet components; Grounds & Housekeeping: a clean and tidy pump station is a healthy pump station. Grass, trees and shrubs should be maintained for ease of access and to maintain a proper operating buffer from vegetation.	Monthly	WS Planning & Architecture will be responsible for setting up the management company.
Regular maintenance	A typical service schedule will be included but is not limited to the following; Pump down sump on hand operation. Clean and check float level equipment. Check and adjust impeller/wear plate on pumps. Check oil bath lubrication if applicable. Check operation and wear of control panels/starters, including housing. Examine non-return and gate valves [if mounted in separate valve chamber and/or if accessible at time of service without undertaking a confined space entry]. Check pipework for leaks/wear/damage and report. Test run pumps and monitor performance leave running if possible and report if pumps not running and/or to correct characteristic. Replace or use parts/consumables necessary to bring station online, but only if within authorised limit. If necessary, report any defects/faults diagnosed. Our quotation for remedial repairs will automatically follow. Check motors and rotating elements of pumps for higher-than-normal temperature. Visually inspect pumps and motors for coating failure and oxidation and reapply protective coatings/paint as necessary. Inspection of electrical wiring and pumping station controllers Electrical Cables: Cables should be kept organized and tied-off in secure locations where available. Seals should be monitored to make sure they are in-tact. Contacts: Both the starter contacts and the alternator contacts should be inspected to make sure connections are good. Breakers: A failure to maintain the breakers can allow a simple surge to wipe out your controls or pumps.	Annual or bi-annual service.	WS Planning & Architecture will instruct the pump supplier to or suitable maintenance company to undertake schedules monitoring.
Remedial Actions	Replacement of parts, seals, wires, fuses; Lubricating moving parts; Pump replacement; Replace worn parts and ensure good operation of pumps through general maintenance; Grease / Lubricate / Replacing seals as required.	As required	WS Planning & Architecture will instruct the pump supplier to or suitable maintenance company to undertake schedules monitoring / repair works as required.

All maintenance and monitoring works will be scheduled and will follow the manufactures guidance and will be carried out by a qualified professional as required.

13.10 Appendix 9 – Foul Drainage

13.10.1 General Binding Rules

	Discharge to Ground Only
	Discharge to Surface Water
	Discharge to Ground or Surface Water
Red Text	General Binding Rules not Met. Permit Application Required

#	Discharge to Surface Water	Discharge to ground	General binding rule	Info	Criteria Meet?
1		x	**The discharge must be 2 cubic metres or less per day in volume.**	**10.8m^3** **Value is calculated of fully occupied; Unlikely to accurate volume**	**No**
2	x		The sewage must only be domestic.	Yes	Yes
3	x		**The discharge must be 5 cubic metres or less per day in volume.**	**10.8m^3**	**No**
4	x	x	The discharge must not cause pollution of surface water or ground water.	Sewage Treatment plan	Yes
5		x	The sewage must receive treatment from a septic tank and infiltration system (drainage field) or a sewage treatment plant and infiltration system.	N/A	Yes
6	x		The sewage must receive treatment from a sewage treatment plant.	Yes - Package Treatment Plant	Yes
7		x	The discharge must not be within a groundwater Source Protection Zone 1 or within 50 metres from any well, spring or borehole that is used to supply water for domestic or food production purposes.	No wells or BH within identified within 50m. Closest Well is 90m south of redline boundary.	Yes
8	x		For discharges in tidal waters, the discharge outlet must be below the mean spring low water mark.	N/A	N/A
9	x	x	All works and equipment used for the treatment of sewage effluent and its discharge must comply with the relevant design and manufacturing standards i.e. the British Standard that was in force at the time of the installation, and guidance issued by the appropriate authority on the capacity and installation of the equipment.	Yes	Yes
10	x	x	The system must be installed and operated in accordance with the manufacturer's specification.	Yes	Yes
11	x	x	Maintenance must be undertaken by someone who is competent.	Yes	Yes
12	x	x	Waste sludge from the system must be safely disposed of by an authorised person.	Yes	Yes
13	x	x	If a property is sold, the operator must give the new operator a written notice stating that a small sewage discharge is being carried out, and giving a description of the waste water system and its maintenance requirements.		Yes
14	x	x	The operator must ensure the system is appropriately decommissioned where it ceases to be in operation so that there is no risk of pollutants or polluting matter entering groundwater, inland fresh waters or coastal waters.		Yes

#	Discharge to Surface Water	Discharge to ground	General binding rule	Info	Criteria Meet?
For a new discharge, which is one that was started on or after 1 January 2015, the following general binding rules also apply:					
15	x	x	New discharges must not be within 30 metres of a public foul sewer.	No public sewers available within the 500m of the site.	Yes
16	x	x	For new discharges, the operator must ensure that the necessary planning and building control approvals for the treatment system are in place.	Yes	In planning currently;
17	x		New discharges must not be in or within: 500 metres of a Special Area of Conservation (SAC), Special Protection Area (SPA), Ramsar site, biological Site of Special Scientific Interest (SSSI), freshwater pearl mussel population, designated bathing water, or protected shellfish water; 200 metres of an aquatic local nature reserve; 50 metres of a chalk river or aquatic local wildlife site.	None identified within 200m of the site. SSSI Impact Risk Zones - for LPAs to determine likely impacts on terrestrial SSSIs and when to consult Natural England (See Link)	Yes Consultation with Natural England maybe required; LPA to decide.
18		x	New discharges must not be in, or within 50 metres of, a Special Area of Conservation (SAC), Special Protection Area (SPA), Ramsar site, or biological Site of Special Scientific Interest (SSSI), and must not be in an Ancient Woodland.	None identified within 50m of the site.	Yes;
19	**x**		**New discharges must be made to a watercourse that normally has flow throughout the year.**	**The drainage ditch does not have flow all year round.**	**No; General Binding Rules do not apply.** **Permit with the EA is required.**
20	x		For new discharges, any partial drainage field must be installed within 10 metres of the bank side of the watercourse.	Possible - drainage field would be located within Flood Zone 2 and 3;	Yes
21	x		New discharges must not be made to an enclosed lake or pond.	N/A	Yes
For a new discharge that started on or after 2 October 2023, the following two general binding rules also apply					
#	Discharge to Surface Water	Discharge to ground	General binding rule	Info	Criteria Meet?
22	x	x	A new discharge shall not use the same outlet as any other discharge if the combined volume of those discharges would exceed the volumetric general binding rules thresholds for groundwater or surface water.	Yes	Yes
23	x	x	A new discharge shall not be made to a discharge point within 50 metres of any other exempt groundwater activity or water discharge activity.	N/A	Yes

UK*

* INCLUDING NORTHERN IRELAND

WASTEWATER TREATMENT

Tricel® Maxus

Treatment Systems for 50+ Population Equivalent

Innovative design for superior performance

AMTIVO

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Quality Management

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GENERATIONS OF INNOVATION

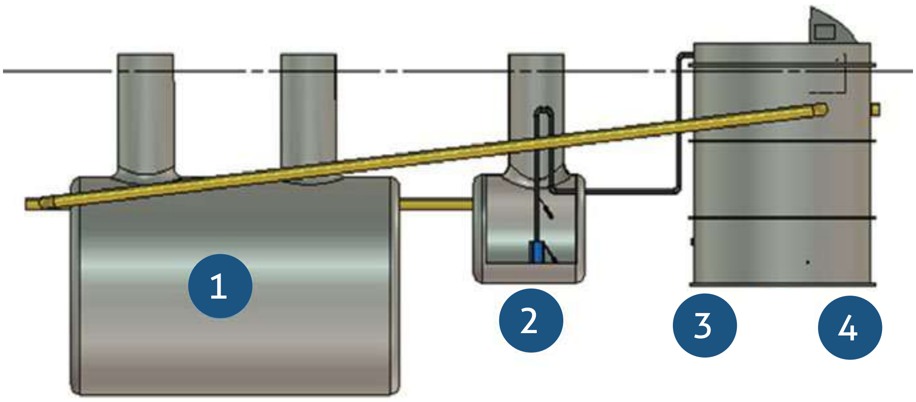
What is Tricel Maxus

Tricel Maxus wastewater treatment plants are designed to treat wastewater arising from human activity in applications greater than 50PE. Applications includes housing estates, hotels, restaurants, campsites, factories or retail units to name a few. These highly versatile systems are individually sized to suit every possible scenario over 50PE.

The Tricel Maxus operates on Submerged Aerated Filter (SAF) technology. The plant is controlled by the E-III control panel through which all electrical components are connected. They are robust and easy to install with multiple configurations possible to suit any site. Simple in operation, they are easy to maintain over the lifespan of the product.

How does it work

Tricel Maxus utilises highly effective SAF technology treating wastewater in 4 stages:



1. Wastewater enters into the Tricel Maxus system in **the settlement tank**. Here primary treatment occurs. Heavy solids are separated out of the wastewater and settle to form a sludge on the base of the tank. Lighter solids, such as oils, fats or grease, float to top of the wastewater and are retained with within the settlement tank.
2. From here the partially treated wastewater enters **the buffer tank**. The buffer tank will even out any fluctuations for the incoming water load. Pumps located at the bottom of the buffer tank feed the wastewater forward into the treatment plant.
3. In **the biological treatment zone**, the submerged aerated filter, with a large surface area for the microbes, is exposed to aeration as the wastewater passes through. The control panel adjusts the aeration to match the incoming flow to ensure extremely efficient operation.The system will never clog and does not need any maintenance or chemicals.
4. In **the clarifier**, bio sludge from the treatment process settles out of the treated liquid. Airlift pumps recirculate the bio sludge from the base of the tank back to the settlement tank. The fully treated liquid is now ready to discharge from the plant.

Key features & benefits

- **Excellent treatment** from proven SAF technology.
- **Ideal for seasonal loads of constant loads.** The control panel will automatically adjust to the incoming load to ensure optimum performance.
- **Extensively tested and ETA verified for holiday home applications.** System will go into power saving mode during periods of no flow and restart once flow is detected without the need for any manual inputs.
- **Swift back up and service located in the UK.** Range of service contracts available.
- **Full design engineered solutions offered.** Bespoke solutions offered for every unique site to ensure best performance. **GRP or Concrete settlement tank options.**
- **Flexible installation options to suit any site.** This can fit plants into difficult sites or simply save space.
- Versatile technology which **can adapt to different loadings or effluent strengths.**
- Simple operation using long life reliable components leading to **low running costs**. No moving parts within the plant making it easy to maintain.

Installations

▶ Installation with combined GRP settlement and buffer tanks.

▶ Treatment plant during installation.

▶ Remote settlement and buffer tanks to suit a site with restricted space.

▶ Installation with combined GRP settlement and buffer tanks.

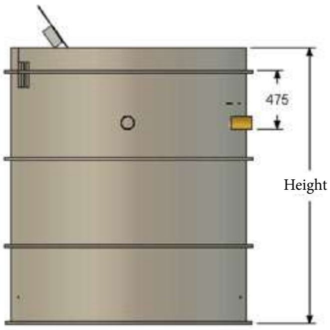
▶ Treatment plant during installation.

▶ Finished installation.

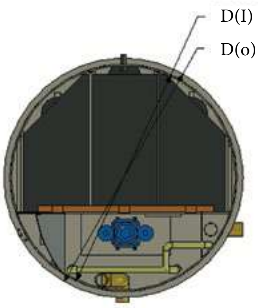
Technical characteristics/ Plant dimensions

Code	PE	Settlement And Buffer Tank*				Treatment Plant			
		Tank	L (M)	W (M)	H (M)	Plant Shape**	L (M)	W (M)	H (M)
66M5000	66	Settlement	6.60	1.64	2.05	Circular	2.00	2.00	2.20
		Buffer	1.60	1.64	2.05				
88M6000	88	Settlement	6.60	1.64	2.05	Circular	2.30	2.30	2.20
		Buffer	3.60	1.64	2.05				
112J25	112	Settlement	6.60	1.64	2.05	Rectangular	2.80	2.16	2.22
		Buffer	6.60	1.64	2.05				
154J50	154	Combined	5.70	2.87	2.70	Rectangular	3.30	2.16	2.22
175J75	175	Combined	6.17	2.87	2.70	Rectangular	3.95	2.16	2.22
238J100	238	Combined	9.05	2.87	2.70	Rectangular	5.45	2.16	2.22
294J50X2	294	Combined	10.89	2.87	2.70	Rectangular	6.60	2.16	2.22
385J75X2	385	Combined	14.12	2.87	2.70	Rectangular	7.90	2.16	2.22
560J100X2	560	Settlement	9.95	2.87	2.70	Rectangular	10.90	2.16	2.22
		Buffer	9.95	2.87	2.70				

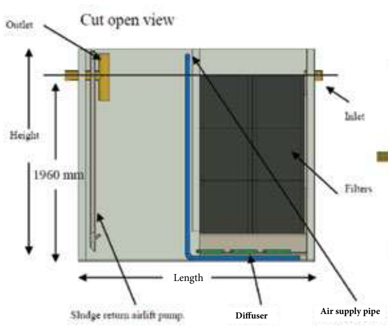
**All settlement and buffer tank dimensions are for GRP tanks as standard. Concrete options are available.*
*** Please note, the treatment plant is circular for up to 88PE and rectangular for plants over 88PE.*



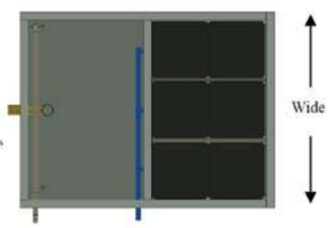
Profile view of circular shape



Top view of circular shape



Profile view of rectangular shape



Top view of rectangular shape

Tricel Group

Tricel is a world recognised global provider of **high-performance solutions.** Today, the company operates across multiple industries such as **Environmental, Construction, Water and Distribution**, including both composite materials and lubricants.

We occupy a unique position in the field of reinforced plastics, combining the technical expertise of **over 50 years in the press-moulding and composites industry.** Tricel is proud of being one of the largest manufacturers of wastewater treatment plants in Europe, and are regarded by regulators as the standard setters within the industry.

Tricel are **experts in Sheet Moulding Compound (SMC)** processes and produce the only wastewater treatment plant in Europe constructed from this material. This process gives the highest strength to thickness ratio of any tank on the market, and has no risk of corrosion over time.

Our company offers industry **leading innovative solutions** that our customers can trust, and with operations in 17 locations across Europe we supply a comprehensive range of products to **over 50 countries worldwide.**

Membership of governing bodies on wastewater treatment

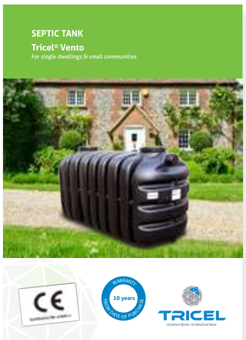
BRITISH WATER
expertise worldwide

British Water is the leading association representing suppliers, manufacturers, contractors, consultants and others in the UK water industry supply chain.

Maxus 1190247/4-UK-MAY2025

Our Full Range of Tricel® Wastewater Treatment Solutions

Tricel® Novo
Wastewater Treatment Plant



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Septic Tank

Tricel® Puraflo
Packaged Filter System

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TRICEL
GENERATIONS OF INNOVATION

Tricel Maxus Combi

Service & Maintenance Manual

Wastewater Treatment System for 50+ Population Equivalent

Engineering a green future

1425746/1-Maxus Combi IRE-UK-Oct 2025

Table of contents

This manual concerns procedures and guidelines for service and maintenance of the Tricel Maxus Combi treatment plant. Instructions for other equipment included in the specific project are found in separate manuals.

1 Introduction

The Maxus Combi system is designed to treat ordinary household wastewater. You may not lead any other water than grey- and black household sewage to the treatment plant unless specifically approved by Tricel.

1.1 Maximum load

The Tricel Maxus Combi systems are modular. Each module in a series increases treatment efficiency, each parallel series of modules increases flow. The plant allows for fluctuations in both concentrations and volume of the incoming water. However, if the average daily load exceeds the capacity of the designed system, a larger system or additional units must be installed.

1.2 Operation cost

System operation settings and power consumptions can be seen in the data sheet.

2 Precautions when working with wastewater

Protecting Workers from Infection

Along with “good” micro-organisms that break down sewage, wastewater contains disease-causing bacteria, viruses, fungi and parasites. When workers can’t avoid contact with sewage, management should provide the following protective equipment and services:

- Elbow-length rubber gloves
- Rubber pants and jackets
- Goggles
- Disposable mask to be worn in dusty sludge areas or areas with heavy aerosols.
- Commercial high temperature washing machines for work clothing.

Workers should also take the following precautions:

- Wash gloves before removing them.
- Wash hands before smoking and eating.
- Keep protective clothing and equipment out of eating areas.
- Keep work clothes and street clothes in separate lockers.
- Shower and change into street clothes before going home.
- Consider all cuts or abrasions to be infected. Flush them with large amounts of clean, running water and soap, and bandage them with a sterile dressing.
- Workers should have a tetanus booster every 10 years and workers, who have never been vaccinated for polio, should consult a physician about getting a vaccination.
- Workers should receive the hepatitis A vaccination. Workers working in sewers that may contain fresh blood or come into regular contact with used syringes or body parts should receive the hepatitis B vaccination.
- Trucks that carry materials contaminated with sewage should be washed frequently.
- Records should be kept of workers’ major and minor illnesses and complaints of irritation and discomfort.

Seek medical attention when you have diarrhea or are ill. Since doctors are often unaware of the connections between occupation and disease, be sure to inform your personal physician of job exposure to sewage.

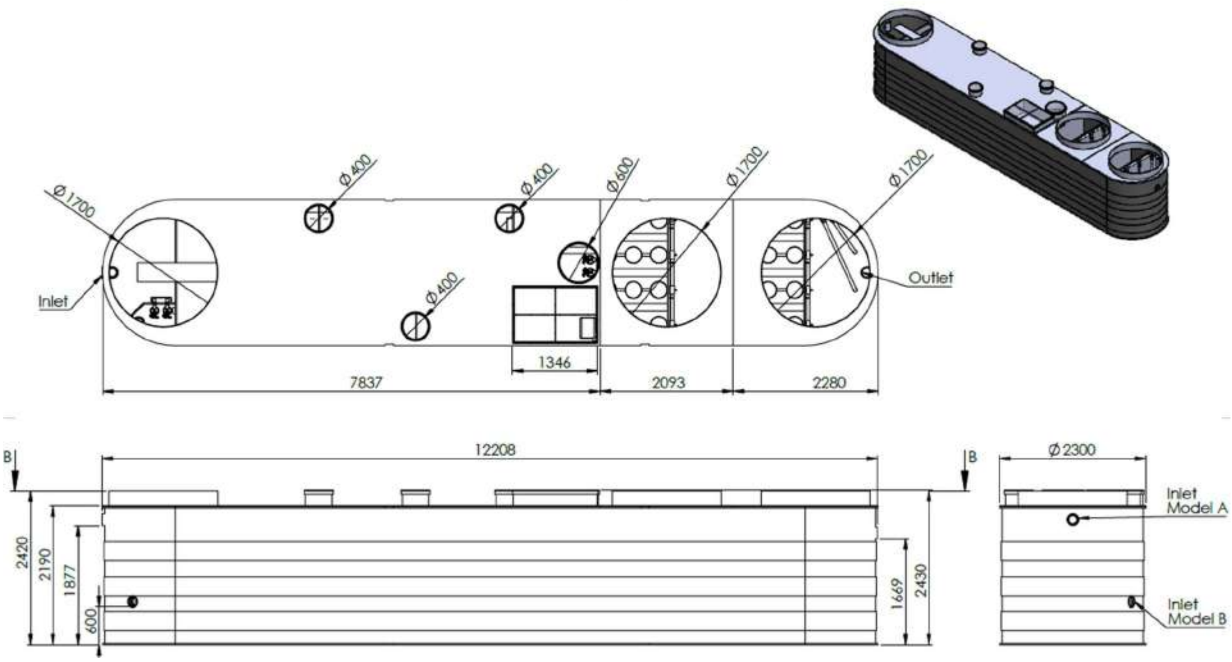
3 System

3.1 Configurations

Maxus Combi comes in two different standard versions, Maxus Combi A and Maxus Combi B. Each version is available in 9 different standard sizes.

Maxus Combi A has a high inlet, whereas Maxus Combi B has a low inlet, making it easier for the wastewater to gravitate into the unit. Examples of the two different models are seen in Picture 1.

For sizes, capacities etc. see separate Maxus Combi facts sheet.



Picture 1 – Maxus Combi 8A and 8B

3.2 Process

1. The water is pretreated in the septic tank, where larger particles are settled. From the septic tank, the water gravitates into the external buffer tank.

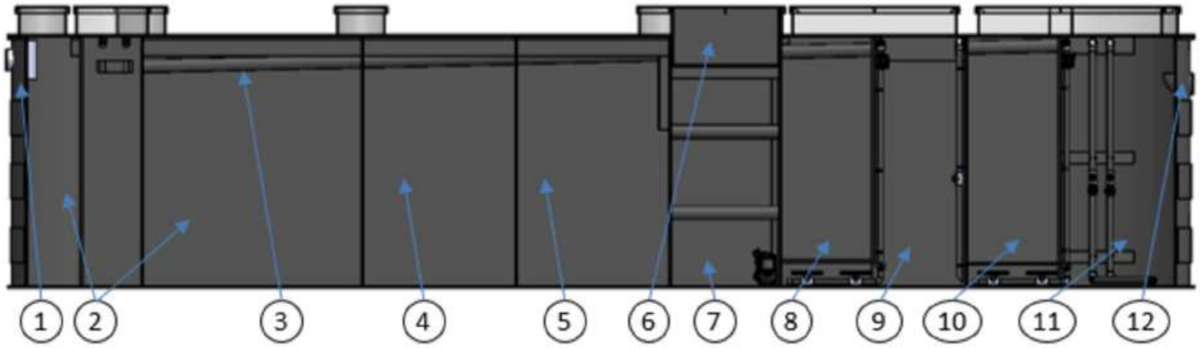
2. The buffer tank will even out any fluctuations for the incoming water load. A float switch placed close to the top of the buffer tank works as an emergency switch and runs the inlet pump continuously if activated.

3. In the biological treatment zone, the submerged bioblock filter, with a large surface area for the microbes, is exposed to heavy aeration. The system will never clog and does not need any chemicals.

4. Bio sludge settles in the settling zone. Airlift pumps in the bottom keep the settling zone clean by recirculating the bio sludge to the settling tank.

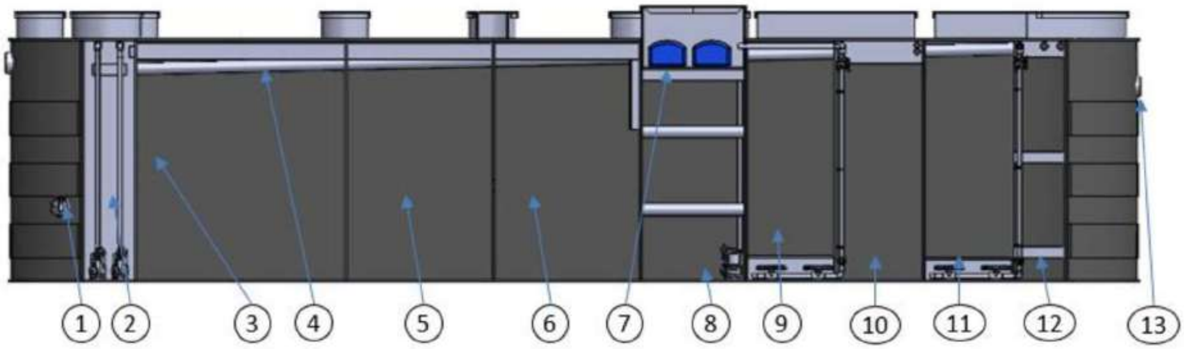
5. If disinfection of the treated wastewater is required, the integrated chlorine dosing or UV-treatment system placed at the outlet ensures that no bacteria will leave the system. This is needed if the water is to be reused.

3.3 Features – Model A



Item #	Function
1	Inlet
2	Septic tank chamber 1
3	Sludge return pipe
4	Septic tank chamber 2
5	Septic tank chamber 3
6	Tech box w. blowers and controller
7	Buffer tank w. 2 x inlet pumps
8	Biozone 1
9	Clarifier 1 w. air lift pumps
10	Biozone 2
11	Clarifier 2 w. air lift pumps
12	Outlet

3.4 Features – Model B



Item #	Function
1	Inlet
2	Pump well w. 2 x grinder pump
3	Septic tank chamber 1
4	Sludge return pipe
5	Septic tank chamber 2
6	Septic tank chamber 3
7	Tech box w. blowers and controller
8	Buffer tank w. 2 x inlet pumps
9	Biozone 1
10	Clarifier 1 w. air lift pumps
11	Biozone 2
12	Clarifier 2 w. air lift pumps
13	Outlet

4 Maintenance plan

Part	#	Function	Frequency
Initial security	0	Lock off area + safety equipment	At every service
Septic tank	1.1	Sludge level control and emptying	Every 2-12 months depending on size.
	1.2	Check for defects in partition	Half-yearly
Expiry Test	2.1	Take water sample in outlet	Half-yearly
Bio Zone	3.1	Water level control	Half-yearly
	3.2	Control of aeration	Half-yearly
	3.3	Oxygen Level Control	Half-yearly
	3.4	Check pH level	Half-yearly
	3.5	Control of foam formation	Half-yearly
	3.6	Control of air-pipes and unions	Half-yearly
	3.7	Clean Bio Blocks	Half-yearly
	3.8	Clean diffusers	Every 2 years
Clarifier + Outlet	4.1	Water level control	Half-yearly
	4.2	Sludge return function check	Half-yearly
	4.3	Control of float / top sludge pump	Half-yearly
	4.4	Checking the outlet	Half-yearly
	4.5	Replace floats / top sludge pump	Every 7 years
Pump well / Buffer Tank	5.1	Functional check of inlet pumps	Half-yearly
	5.2	Functional check of float	Half-yearly
	5.3	Check water level in pump well	Half-yearly
	5.4	Replace inlet pumps	Every 7 years
	5.5.	Emptying and flushing	Quarterly
Air blowers, control and solenoid valves	6.1	Functional control of Every blower	Half-yearly
	6.2	Replace membranes and coil housing	Every 3 years
	6.3	Replace pump relay	Annually
	6.4	Replace solenoid valve	Every 7 years

5 Detailed description of maintenance and safety

5.1 Initial Safety before Commencement of Maintenance

Lock off area and put on safety equipment

Work on the wastewater treatment plant must only be carried out by trained personnel who have completed Tricel's teaching and training in occupational safety and service of the wastewater treatment plant.

Prior to all maintenance of the plant, it is of the utmost necessity to ensure that the area is secured and closed off for unauthorized persons, I.e. the regulations of the sewage systems. This is for hygienic reasons, and so that no unauthorized person risks exposing themselves to danger in the form of falls etc.

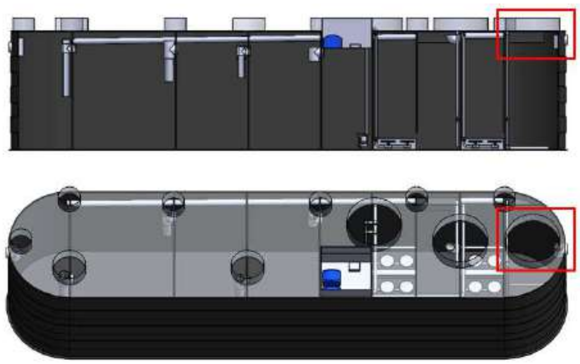
The barrier is made by locking the permanent barrier in the form of a permanently established fence, which is found at the treatment plant.

In addition, it is of the utmost necessity for every service personnel to wear the correct safety equipment as described.

All work on replacing or removing electrical components must be carried out without voltage. This is done via the main switch, the position of which is shown in the picture to the right. The main switch must be locked in the off position.

Work on electrical installations should only be carried out by personnel who have the necessary knowledge to work safely and correctly.

5.2 Maintenance of Outlet

Safety when taking a water sample	
To take a water sample, which is always the first thing to be done when servicing the plant, the lid for clearance zone must be opened. Work on the clarifiers may only be carried out by instructed personnel who have completed Tricel's training in occupational safety and service of the treatment plant. Prior to the maintenance and inspection of the outlet, it is of the utmost necessity to ensure that the area is off for unauthorized persons. Since the work of taking a water sample and other servicing work with the clarifier requires free access and an open hatch, it is important that all work around the open clarifier is carried out with utmost vigilance. It is a prerequisite for working with an open hatch to the clarifier that there are always two men present. The person who does not work with the clarifier observes and is ready to aid in the event of a fall. When taking a water sample, the necessary safety equipment for protection against wastewater must be used.	

5.2.1 Sampling of Outlet

To ensure that the plant treats the wastewater according to the specifications, it is important to measure the water quality of the effluent at every service.

To obtain as accurate a sample as possible, make sure the sample bottles are clean and that the sample is taken in the outlet clarifier near the outlet and at least 10 cm below the surface. Bottles with water samples should be stored cold, preferably in a freezer or in a refrigerator until analysed, or frozen as soon as possible. Outflow samples are analysed in a laboratory.

Sampling Point

5.3 Maintenance of Inlet pump well (Applies only for Maxus Combi B-version)

Safety and working environment before maintenance of pump well

Work on the pump well must only be carried out by instructed personnel who have completed Tricel's training in occupational safety and service of the treatment plant.

Prior to the maintenance and inspection of the inlet pump well, it is of the utmost necessity to ensure that the area is cited and blocked off for unauthorized persons.

The barrier is made by locking the permanent barrier in the form of the permanently established fence, which is found at the treatment plant.

5.3.1 Functional check inlet pumps and float switches

Perform float function control by using a hook on a rod and check that float switches and pumps work.

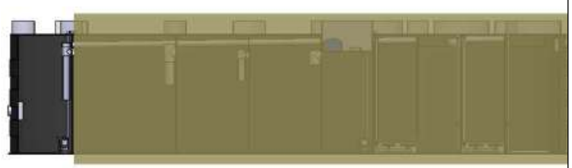
Visually recognize that water is pumped from both inlet sockets to chamber 1 in the septic tank.

Float switch 1 –Bottom float switch

Function: When this float activates, pump 1 runs constantly until the float deactivates because of lowered water level.

Float switch 2 – Top float switch

Function: When this float activates, pump 2 runs constantly until the float deactivates because of lowered water level.



ombi - Model B
Inlet pump well

5.3.2 Functional control of floats

The water level in the pump well must, during normal running conditions, be lower than the bottom float switch.

5.3.3 Replacement of pumps and floaters

Danger: This operation must account for the following: the safety assessment has a risk of electric shock. Before replacing this unit, the main switch must therefore be switched off and locked.

Disconnect the cord in the pump cabinet.

Mark height on float switches, and free the pump wires.

Cut off cable ties that acts as a wire holder.

Pull the wires out through the guide tube, using the old cables to pull new cables to the correct position.

Dismount pump connection.

Install new pumps + float via quick couplings in the pump well. It is not necessary to go into the pump well to change pumps.

Ensure that float switches are installed so that they cannot get stuck in pipes or each other.

Connect the pump to the connection box.

Complete function control.

5.3.4 Emptying and flushing of Pump Well / Buffer Tank

The pump well is emptied and flushed once annually by sludge suction, at the same time as the Septic tank.

5.4 Maintenance of Septic Tank

Safety prior to commencement of maintenance of Septic tanks

Work on the Septic tank must only be carried out by instructed personnel who have completed Tricel's teaching and training in work safety and service of the treatment plant.

5.4.1 Check that regular sludge removal is complete

Check via the log if the Septic tank has been emptied. If the water pumped into the Maxus Combi system is dirty, the Septic tank is presumably full and should be emptied. Emptying intervals should then be carried out more frequently. The emptying intervals depend on the load on the system.

5.4.2 Check for partition defects

Visually check for any deformities in the Septic tank through the manhole

5.5 Maintenance of Buffer tank

Safety and working environment before maintenance of pump well

Work on the pump well must only be carried out by instructed personnel who have completed Tricel's training in occupational safety and service of the treatment plant.

Prior to the maintenance and inspection of the inlet pump well, it is of the utmost necessity to ensure that the area is cited and blocked off for unauthorized persons.

The barrier is made by locking the permanent barrier in the form of the permanently established fence, which is found at the treatment plant.

5.5.1 Functional check inlet pumps and float switches

Perform float function control by logging on to the controller and manually run the pumps.

Perform float function control by using a hook on a rod, and check that float switches and pumps work.

Visually recognize that water is pumped from both inlet sockets to chamber 1 in the septic tank.

Float switch 1 –Bottom float switch

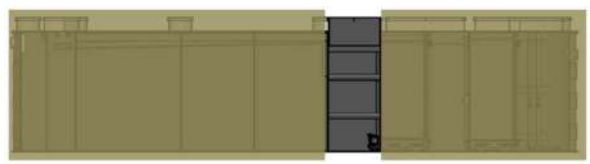
Function: When this float activates, pump 1 runs according to the timer in the controller. When the float switch is deactivated, the pump is turned off because of lowered water level.

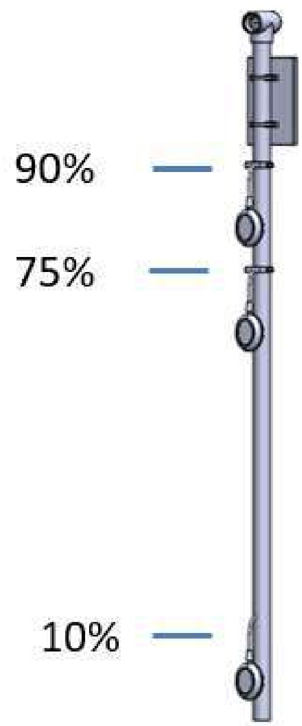
Float switch 2 – Middle float switch

Function: When this float activates, pump 1 runs for multiple cycles until the float deactivates because of lowered water level. If activated for more than three cycles the alarm will go off.

Float switch 3 – Top float switch

Function: When this float activates, pump 2 runs constantly until the float deactivates because of lowered water level.





To Note:

Function: the timer is set to activate the inlet pump 2 for 10 seconds every 24 hours. This will help prevent the pump from blocking and seizing

5.5.2 Functional control of floats

The water level in the buffer tank must, during normal running conditions, be between float switch 1 and 2.

5.5.3 Replacement of pumps and floaters

Danger: This operation must account for the following: the safety assessment has a risk of electric shock. Before replacing this unit, the main switch must therefore be switched off and locked.

Disconnect the cord in the pump cabinet.

Mark height on float switches, and free the pump wires.

Cut off cable ties that acts as a wire holder.

Pull the wires out through the guide tube, using the old cables to pull new cables to the correct position.

Dismount pump connection.

Install new pumps + float via quick couplings in the pump well. It is not necessary to go into the pump well to change pumps.

Ensure that float switches are installed so that they cannot get stuck in pipes or each other.

Connect the pump to the connection box.

Complete function control.

5.5.4 Emptying and flushing of Pump Well / Buffer Tank	
The pump well is emptied and flushed once annually by sludge suction, at the same time as the Septic tank.	

5.6 Maintenance of the Biozone

Security before maintenance of the Biozone	
The work with the biozone may only be carried out by trained personnel who have completed Tricel's training in occupational safety and service of the treatment plant. Prior to commencing the maintenance and inspection of the Biozone, it is of the utmost necessity to ensure that the area i closed off for unauthorized persons.	**NB: Two persons required when opening lid.** 
5.6.1 Water level control	
The water level in the Biozones should be at or up to 2cm above the bioblocks. Excessive water levels may indicate a blocked outlet. Low water levels may indicate that the Septic tank has just been emptied, or a possible tank leak.	

5.6.2 Control of aeration

Tricel treats the wastewater biologically. The technique is based on submersible aerated filters.

Submersible aeriation requires a good flow of air evenly distributed throughout the Biozone.

The Maxus Combi system is designed and adjusted to provide powerful aeration in the Biozone. Normally, there will be nothing to service in the Biozone as it is self-cleaning and maintains itself.

The picture on the right shows the image of an optimally aerated biozone.

Control must be carried out to make sure of uniform aeration throughout the biozone and that it bubbles from all diffusers.

5.6.3 Oxygen level control

Measure the oxygen level with a standard oxygen meter. The oxygen level should be> 70% in all chambers and is expected to rise through the chambers of the system. If the oxygen level is too low, contact Tricel for adjustment and troubleshooting.

5.6.4 Check pH level

The pH value must be greater than 6.5 and less than 8.5 in all chambers and is expected to fall only slightly through the plant.

For a pH level outside this norm area, the inlet water of the plant should be diagnosed. The pH value can be measured with simple pH strips, or a more advanced electronic pH meter.

5.6.5 Foam control

Until the bacterial culture is sufficiently effective, aeration of sewage can create foam, see Picture.

This is normal and will decrease after approx. 5 days of operation.

Recognized as a very bluish foam with inserts, it may be indicative of a large supply of strong detergents or chemicals. See the trouble shooting section for more details on this point.

5.6.6 Control of air pipes and unions for diffusers

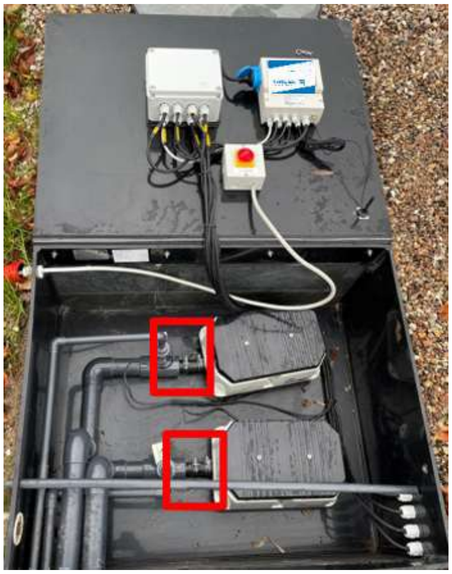
Perform visual inspection of all visible air pipes for cracks and fissures.

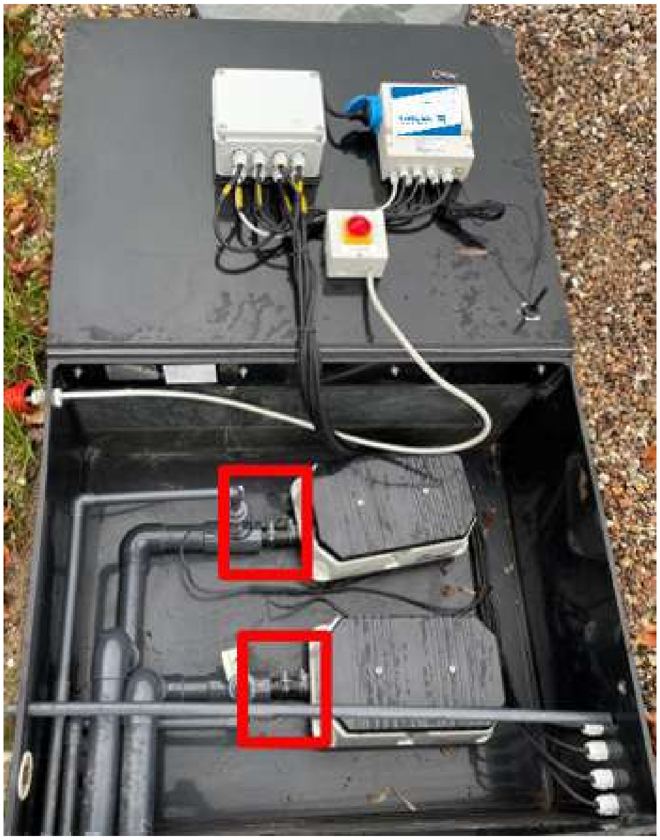
Perform visual check for condition of all visible unions to the air system. Tighten if hissing sound or visual leaks are recognized. If the Union is defective, it must be replaced.

5.6.7 Clean Bio Blocks

The bioblocks should not be cleaned under normal circumstances.

If the Bioblocks are particularly clogged, cleaning can be done by loosening the union, marked in the picture, and blowing compressed air from a hand-held compressor into the pipes, via a simple pipe adapter. This will cause temporary increased air scrubbing of the Bioblocks, and tear off excess Biofilm material.



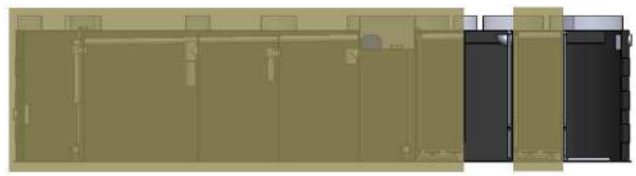
5.6.8 Clean diffusers	
Diffusers should not be cleaned under normal circumstances. If a diffuser is recognized to be stopped, cleaning can be done by loosening the union, marked in the picture, and blowing compressed air from a hand-held compressor into the pipes, via a simple pipe adapter. This will cause temporary increased air to be forced through all the diffusers.	

5.7 Maintenance of the Clarifier + Sludge Return

Safety and working environment before maintenance of Clarifier

Work on the clarifier may only be carried out by instructed personnel who have completed Tricel's training in occupational safety and service of the treatment plant.

Prior to the maintenance and inspection of the clarifier, it is of the utmost necessity to ensure that the area is closed off to unauthorized persons.

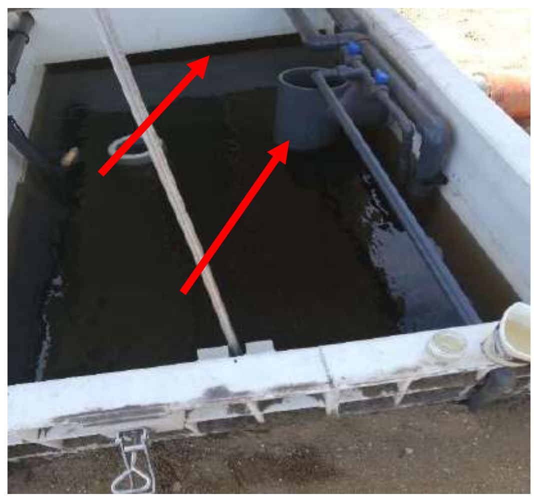


5.7.1 Water level control

The water level in the clarifier(s), should be at the level of the outlet to biozone two, respectively, for the first clarifier zone, and at the level of the final outlet for the second clarifier.

Excessive water levels may indicate a blocked outlet.

Low water levels may indicate that the Septic tank has just been emptied or may indicate a water leakage in the tank.



5.7.2 Sludge return function check	
The back flushing of bottom sludge is ensured through airlift pumps, marked by the red arrows, located in every clarifier(s). Airlift pumps supply air through solenoid valves located in control the cabinet. Test the flushing function of the sedimented bottom sludge by logging on to the controller and manually activate the sludge removal and sludge recirculation. Recognize visually and audibly that water is pumped through the two airlift pumps for the return rinse tube. The red mark the airlift pumps.	 

5.7.3 Checking the outlet	
Check that the outlet has free passage and allows the outlet water to pass freely. Water that high in level in the outlet indicates a clogged outlet.	

5.8 Air Blowers, Control and Solenoid Valves

Safety and working environment before maintenance of controls and blowers

Working with the blowers is associated with great danger in the form of electric shocks.

Therefore, work on these may only be carried out by instructed personnel who have completed Tricel's training in occupational safety and service of the treatment plant.

All work with the replacement or disassembly of electrical components must be done without voltage.

The main switch is locked and the locally applicable LOTO (Log out/Tag Out) procedure is followed.

5.8.1 Functional control of blowers

Look / listen / feel for leaks.

Listen / feel that all blowers are running.

Listen for unwanted noises.

Check if aeration in biozones is normal. The blowers must be maintained according to the manufacturer's instructions. Change of membranes and air filters according to manufacturer’s manual

5.8.2 Replacement of Membranes

Danger: In this operation, there is a risk of electric shock. Before replacing the membrane, the power supply must be removed, and the blower moved to a clean workstation.

Replacement interval: 3-4 years

For changing this:

Unscrew the blower housing.

Unscrew diaphragm block.

Replace membranes.

Reassemble the blower.

Perform functional check.

Reference is also made to the supplier's manual

5.8.3 Replace pump and blower relays

Danger: In this operation, there is a risk of electric shock. Therefore, before replacing this unit, the main switch must be switched off and locked. Follow local LOTTO procedure.

Only personnel with the requisite knowledge should perform work on electrical installations.

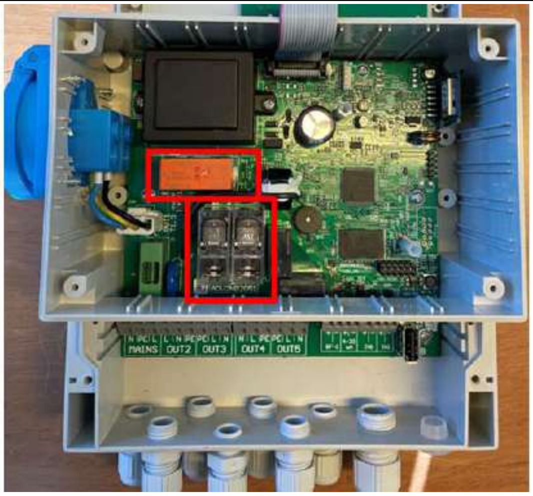
For replacement:

Turn off electricity supply via main switch.

Open the control box door to expose circuit boards.

Replace relay as depicted in the diagram.

Complete functional control.



5.8.4 Replace solenoid valve	
Danger: In this operation, there is a risk of electric shock. Therefore, before replacing this unit, the main switch must be switched off and locked. Follow local LOTTO procedure. Only personnel with the requisite knowledge should perform work on electrical installations. For replacement: Unscrew cable to solenoid valve in control box. Replace solenoid valve. Attach cord. Perform functional check.	

6 Troubleshooting

6.1 Aeration system

If the blower is in operation, air is fed to the diffusers at the bottom of the biozones. Air is evenly distributed to the system. The oxygen level must be above 70% in all aerated chambers.

Problems with diffuser or weak aeration in the Maxus Combi system can be related to blower failure, control, trachea and diffusers, or a general overload of the system.

Problem	Observation	Cause	Check	Solution
Oxygen level below 70%	Full aeration	Possible system overload	The inlet volume	Take a water sample of raw sewage.
	None or little aeration	Blowers worn, defective, or turned off	Make sure that all the blowers are in operation.	Check that the blower is running with normal sound. It is necessary to maintain the blower according to the maintenance manual.
		Air distribution system	Make sure the air distribution system piping is connected properly and that there are no leaks.	Feel and listen for any leaks in the air tubes from the blower and to the diffusers. Repair if leaks are observed.
		Diffusers	Some diffusers may not work	Double the aeration for a few minutes by closing the manual valves in other parts of the system, otherwise gently pushing on top of the diffusers using a stick through the bio-zone. It is always important that, all valves are closed.
		Bio-zone	Sludge has clogged the bio-zone.	Double the aeration for a few minutes by closing manual valves in other parts of the system or cleaning biozone with high water pressure / sludge suction

6.2 Sludge Return

Sludge return system pumps the biological sludge produced by the bacteria out of the treatment tank.

This ensures optimum performance of the plant and is an important functionality. A maximum of 20 cm of biological sludge must accumulate on the bottom of the tank. This can be measured with special sludge level tests carried out by Tricel's service techniques. If the sludge is rejuvenated to a level greater than 20 cm, the sludge return pump settings must be changed.

Sludge problems in the biological treatment system may also be related to failure of the controller, solenoid valve, air blower.

Problem	Observation	Cause	Check	Solution
Sludge Returns	Sludge in the system	Airlift pump - Functioning	Settings of the airlift pump	Change settings to open the valve for airlift pump for a longer period or more often
		Airlift pump – Not functioning	Functioning of solenoid valve	Separate a union after the blowers and check if air is blowing when solenoid valve is open.
			Functioning of airlift pump.	Remove the airlift pump from the tank and clean the sludge return pipes.

After the problem has been located and solved, sludge from the Maxus Combi unit must be removed before startup.

6.3 Hydraulics

It is important that inlet pumps ensure that variations in inlet volume are smoothened out using the buffer tank. When the peak flows are allowed to enter the biozone, the plant will not treat wastewater as expected. Water is supposed to be pumped automatically into Maxus Combi regularly, and the water level in the pump sump is expected to be low during normal operation.

Hydraulic problems can occur when new water is pumped into the system over a short period of time, or if the pipes are clogged.

Problem	Observation	Cause	Check	Solution
Hydraulic overflow	Septic tank/ Pump well	Water level high for longer periods	Controller is on and pumps run That water comes in from pump pipes	Check alarm unit in the control box. Green light should glow. Pumps must be turned on automatically
	WWTP	The water level rises high when being pumped	Check that internal pipe between chambers, as well as outlet pipes are not blocked	Clean pipes

6.4 The quality of the treated wastewater

If the cleaning requirement is not met, the actual inlet ratio should be checked. Investigate (volume, organic content or inhibitors) and check the mechanical and electrical equipment.

Action	Effect
Control mechanical /electrical equipment according to the maintenance manual	No defective components are accepted, the part must be replaced.
Control the pre-treatment equipment according to the maintenance manual	If there are discrepancies, correct these.
Measure sludge in the plant	No more than 20 cm of biological sludge on the bottom of the plant is allowed, otherwise sludge is removed manually with a pump and adjust sludge return timing in the control box.
Measure the oxygen content	The oxygen level must not be below 70%, otherwise the blower and air hoses must be changed
pH level is measured	The pH value must not be below 6.5 or above 8.5, otherwise the pH must be stabilized
Measure the inlet flow	The inlet flow must be stable and not higher than what the system is designed for.
Sample the incoming water	Analyze the sample inlet for the same parameters as outlet values and compare the concentrations against the design parameters

If none of the above solutions solve the problem, it is very likely that the biological processes in the pre-treatment or in the Tricel plant will not work properly. This may be due to high concentrations of antibacterial compounds such as e.g. hypochlorite or detergents that are toxic in such cases, the root chemicals must be found, and alternative solutions must be used. Please contact Tricel for further assistance.

7 Maintenance Checklist

Category	Section No	Description	Time frame	Completed (Yes/No)	Remark
Initial security	5.1	Lock off area + safety equipment	Every service		
Water sampling	5.2.1	Take water sample in outlet	Every service		
Inlet pump well (Model B only)	5.3.1	Control float switches and pumps	Every service		
Septic tank	5.4.1	Sludge level control and emptying	Every service		
	5.4.2	Check for defects in partition	Half-yearly		
Buffer Tank	5.5.1	Functional check of inlet pumps	Every service		
	5.5.2	Functional check of float	Every service		
	5.5.2	Check water level in pump well	Half-yearly		
	5.5.3	Replace inlet pumps	Every 7 years		
	5.5.4	Emptying and flushing	Half-yearly		
Bio Zone	5.6.1	Water level control	Every service		
	5.6.2	Control of aeration	Every service		
	5.6.3	Oxygen Level Control	Every service		
	5.6.4	Check pH level	Every service		
	5.6.5	Control of foam formation	Every service		
	5.6.6	Control of air-pipes and unions	Every service		
	5.6.7	Clean Bio Blocks	Half-yearly		
	5.6.8	Clean diffusers	Every 2 years		
Clarifier + Outlet	5.7.1	Water level control	Every service		
	5.7.2	Sludge return function check	Every service		
	5.7.3	Checking the outlet	Every service		
Air blowers, control and solenoid valves	5.8.1	Functional control of blowers	Every service		
	5.8.2	Replace membranes and coil housing	Every 3-4 years		
	5.8.4	Replace solenoid valve	Every 7 years		
Technician		**Seal**			**Date**

8 Alarms

The green LED next to "Running" lights up during normal operation.

In the event of an alarm, the "error" lamp will flash.

8.1 Alarm signals

Blink	Alarm type	What do the alarms mean?
Constant blink	Power failure to the system	No power, resets automatically
2 blink	Flows active at the same time as low pump power	Error in floating
3 blink	High level (floats active for 10 min)	Level does not drop even when the pump is running
4 blink	Inlet pump, low current level	Pump defective
5 blink	Inlet pump, high current level	Pump shorted
6 blink	Blower, low power level	Blowing defective
7 blink	Blower, high power level	Blowing short circuit
8 blink	Fuse burned	Internal security has blown
9 blink	Missing / dead battery	Battery is dead or not connected

9 Recommended spare parts

9.1 Recommended Spare Parts List for Maxus Combi

Component*	Expected Component replacement frequency
Blower diaphragm	3 years
Air filter for blower	1 years
Inlet pump and float switches	7 years
Control unit	10 years
Diffusers	15 years
Solenoid valves	10 years

*For specific brand and model; see project specific parts list

10 Seasonal fluctuations

10.1 Operation Without Wastewater for up to 6 Months

If limited or no wastewater is flowing to the Maxus Combi system for days or weeks at a time, Tricel recommends continually operating the system as normal. If the load is limited for longer periods, the system will automatically adjust operation to “off-season”-mode, which will reduce the power consumption significantly. The integrated sludge recirculation will keep the biology inside the treatment tank alive for many months, ready to handle untreated wastewater whenever the inlet flow returns to normal level.

For any questions not clarified in this instruction please contact Tricel directly.

Notes

Notes

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