

**MRC - 13 Design Standards (August 25, 2020 Version 1.2)**

NPDES Permit application number: PAD060076

Page 1 of 11

Municipality: Maiden Creek Township

County: Berks County

MRC Identification: BMP#3

1. **Runoff Capture** – The runoff from the 1.2-inch/2-hour storm from the contributing watershed that the MRC is intended to treat should be captured and managed by the MRC BMP, without overflow. The runoff is filtered through vegetated media or treated and filtered to the extent practicable through the on-site undisturbed soils or other acceptable treatment systems, and released through the underdrain as indicated in MRC Standard 2. The MRC BMP may be designed for offsetting when contributing non-regulated earth disturbance (either impervious area or compacted pervious areas) is present in the contributing drainage area. Uncompacted pervious surfaces outside the disturbed area should be bypassed to the maximum extent practical.

**NOTE 1** – Runoff from existing similar impervious and compacted pervious areas can be used to offset undetained areas. The runoff volume for the 1.2 inch/2-hour storm from the two areas must be equivalent (See Figure 2). In addition, the pollutant contribution as determined through land use of the two areas should be similar.

**NOTE 2** – A composite Curve Number is not adequate for the modeling of the 1.2 inch/2-hour storm due to the large error associated with averaging of initial abstractions for storms less than or equal to the 2-year/24hour storm event. Curve numbers must be separate for this analysis.

**In the space below, the licensed professional should document and demonstrate how this design standard was specifically addressed in the PCSM Report (Narrative, Calculations, H&H Model, etc.).**

To demonstrate this requirement is met, a model was created utilizing the HydroCAD software to run a 1.2-in/2-hour storm over the proposed drainage area for the MRC Basin. The 1.2-inch storm was then routed through the basin to confirm that the runoff is dissipated through the MRC orifice or held within the internal water storage area. The flow through the MRC orifice contributes to the “primary” discharge in the HydroCAD model.

**In the space below, the licensed professional should provide the cross reference (i.e. page number) to the specific location in the PCSM Report that addresses this design standard.**

The pond report for the 1.2-inch/2-hour storm is provided on pages 89-94 of the PCSM report.

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2. **Release Rate for the 1.2-inch/2-hour Storm** – The stormwater release rate from the MRC BMP for the 1.2inch/2-hour storm should not exceed 0.01 cubic feet per second (cfs) from the equivalent impervious area. To obtain the equivalent impervious area being managed by a MRC BMP, determine the total volume of runoff generated during the 1.2-inch/2-hour event from all pervious and impervious areas contributing to the MRC and divide by 0.0833 feet. This release rate is rounded to the nearest hundredth of a cfs (e.g., 1.576 ac. is 0.01576 cfs, rounded to 0.02 cfs). Routing is necessary to demonstrate compliance with the standard for release rate.

**MRC - 13 Design Standards (August 25, 2020 Version 1.2)**

NPDES Permit application number: PAD060076

Municipality: Maiden Creek Township

County: Berks County

MRC Identification: BMP#3

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<b>BMP No.</b>	<b>1.2 in/2-hr Storm Inflow (cf)</b>	<b>Equivalent Impervious Area (acres)</b>	<b>Max. Allowable Release Rate (cfs)</b>	<b>Calculated Release Rate (cfs)</b>
BMP#3	34,534	9.52	0.10	0.09

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The hydrograph from the 1.2-inch/2-hour storm is provided on page model on pages 89-94 of the PCSM report, while the equivalent impervious area and allowable discharge rate are provided on page 129 of the PSCM report as documentation this design standard is met.

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3. **Internal Water Storage (IWS)** – A volume for IWS should be provided that is at least one foot deep below the lowest structural outlet (i.e., the outlet for the underdrain) in the MRC BMP to encourage ET, infiltration and denitrification. To encourage ET, the overall soil media depth of a facility including the IWS can be no deeper than four (4) feet, and up to 50% of the IWS void volume can be included (only for vegetated MRC BMPs) as available storage during hydrologic routings to demonstrate compliance with the standards for the release rate (No. 2 above) and peak flow attenuation (No. 4 below). For soil media, a void space of 30% can be used to describe the soil volume storage and recovery. If a void space of 30% is to be used, the void space in the soil media in the IWS should be modeled at 15% ( $0.5 \times 0.3$  void space = 0.15 or 15%). If an alternate void space is used for soil media, specific data demonstrating the void space should be submitted. For non-vegetated MRC designs, the IWS must be above the underdrain, but below the outlet, to promote a change of the stormwater stored during rain events.

**Use of Liners and Infiltration** – The MRC BMP should not have an impervious liner installed unless environmental or geological conditions necessitate use of a liner, or if an existing structure would be damaged as a result of not lining the facility. Although MRC BMPs are for areas with infiltration limitations, whatever infiltration that can be achieved is encouraged. Measured saturated hydraulic conductivity rates are encouraged to be used in design and modeling.

**NOTE 3** – The presence of a project site in an area of known karst conditions does not, in itself, serve as evidence of the applicability of MRC to a project site or to the use of a liner to avoid infiltration. DEP and delegated CCDs reserve the right to request a detailed subsurface investigation where considered warranted to evaluate the likelihood of sinkhole formation as a result of post-construction stormwater management.

**MRC - 13 Design Standards (August 25, 2020 Version 1.2)**

NPDES Permit application number: PAD060076

Municipality: Maidencreek Township

County: Berks County

MRC Identification: BMP#3

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BMP No.	Bottom BMP Elevation (ft)	Media Depth (ft)	IWS Elevation (ft)	Void Space of Media (%)	Void space of IWS (%)	Liner Proposed (Yes or No)
BMP#3	327.50	2.5	328.50	30	15	Yes

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See the basin design information on pages 97-102 of the PCSM report as documentation this design standard is met.

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4. **Geomorphologic Peak Flow Management for the 2-year/24-hour Event** – The peak flow from the postconstruction 2-year/24-hour storm should be managed back to the pre-construction 1-year/24-hour storm peak flow, unless an approved and current Act 167 Plan or another requirement (such as limited capacity of a downstream channel) is more restrictive. In general, this rate is determined at the project point of interest. In the event the MRC drainage area is part of a larger overall site with non-MRC BMPs, only the MRC drainage peak flows should be managed back to the 1-year/24-hour level and overflows can be combined with flows from the non-MRC BMPs.

In situations where the pre-construction drainage area to the MRC BMP varies significantly compared to the post-construction drainage area, the post-construction drainage area boundary to the MRC BMP (using existing land uses) can be used to calculate the target pre-construction 1-year/24-hour rate, as long as all areas in question are in close proximity to the MRC BMP and drain to the same surface water. In cases where the BMP is managing additional volume to offset adjacent areas that could not be captured in the MRC BMP, the targeted pre-construction 1-year/24-hour release rate should be calculated based on the combined flow rates from the BMP drainage area and adjacent area.

**NOTE 4** – This standard is used to ensure that MRC does not contribute to channel-eroding flows in receiving surface waters.

**NOTE 5** – This release rate (0.01 cfs / equivalent impervious acre) is approximately the expected rate of interflow (lateral movement of stormwater to a stream) after a 2-year/24-hour storm event for a Pennsylvania non-karst watershed based on the NRCS curvilinear unit hydrograph. Releasing at this rate will produce a condition where baseflow contributions will be similar to that of an undeveloped area during and after storm events. As the level of outflow would be similar to what would be expected during and after the storm, it would not be expected to

**MRC - 13 Design Standards (August 25, 2020 Version 1.2)**

NPDES Permit application number: PAD060076

Municipality: Maiden Creek Township

County: Berks County

MRC Identification: BMP#3

impact the storm event's effects on flooding and erosion. This rate should also be used for karst watersheds unless it can be demonstrated that interflow on a particular project site differs from this standard (such a demonstration would be considered an alternative to the MRC Design Standard).

**Flows Greater Than 2-Year/24-Hour Storm** – The recommended design for MRC BMPs is to bypass storm events larger than the 2-year/24-hour storm to a rate control BMP; however, DEP understands that site and cost limitations may not allow for this bypass. When it is demonstrated by the licensed professional engineer that larger storm events cannot reasonably be bypassed, the MRC BMP surface component should be designed to manage the post-construction 10-, 50- and 100-year/24-hour storm event peak flows to their corresponding pre-construction rates and the MRC BMP should have an increased (i.e., more frequent) inspection and maintenance schedule that includes inspection and repair after extreme events (10-, 50- and 100-year/24-hour storm events).

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<b>BMP No.</b>	<b>Pre-Development 1-Year/ 24 Hour Peak Flow (cfs)</b>	<b>Post-Development 2-Year/ 24 Hour Peak Flow (cfs)</b>
BMP#3	10.91	1.09

**In the space below, the licensed professional should provide the cross reference (i.e. page number) to the specific location in the PCSM Report that addresses this design standard.**

The relevant hydrographs showing the allowable pre-development peak rate for the 1-year/24-hour storm and 2-year/24 hour post-development peak rate can be found on pages 45-47 and 58-62 of the PCSM report. The Long-Term Operation and Maintenance Schedule is on sheet C-647 of the accompanying Post Construction Stormwater Management Plans, prepared by Bohler.

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- 5. Stormwater BMP Manual** – Follow the design considerations for BMPs as presented in the Pennsylvania Stormwater Best Management Practices Manual (Stormwater BMP Manual) (363-0300-002), as revised. MRC may be incorporated into the design of any BMP by a licensed professional engineer.

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The proposed MRC BMP functions as BMP 6.6.3 (Dry Extended Detention Basin) and meets the general requirements outlined in this section of the PADEP Stormwater BMP Manual.

**MRC - 13 Design Standards (August 25, 2020 Version 1.2)**

NPDES Permit application number: PAD060076

Municipality: Maiden Creek Township

County: Berks County

MRC Identification: BMP#3

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See attached basin design information on pages 97-102 of the PCSM report and sheets C-647 of the accompanying Post Construction Stormwater Management Plans.

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**6. MRC BMP Selection** – Standard MRC BMPs include the following system types:

**a. Vegetated MRC** – Vegetation must be provided for 75% of the surface of the MRC BMP. Native vegetation should be selected by the licensed professional engineer in consultation with a professional that is knowledgeable in native plant ecology. Vegetation should be selected based on the plants’ ability to grow within the anticipated conditions considering the depth and duration of stormwater stored in the MRC BMP.

**b. Non-vegetated MRC: Porous Pavement** – Porous pavements with a storage bed require a vacuum street sweeping maintenance regime adequate for the drainage area characteristics; the vacuum street sweeping equipment must provide adequate suction capacity to remove particles on the pavement’s surface to provide a sufficient water quality demonstration and to maintain flow pathways.

**c. Non-vegetated MRC: Underground Storage Chambers** – Underground storage chambers must be accessible for maintenance, and for this reason underground storage is not recommended to be rock beds. The water quality demonstration is then made through the Quality Worksheet on the DEP Spreadsheet. DEP highly recommends that designers consider adequate pretreatment as necessary for system longevity.

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<b>BMP No.</b>	<b>System Type</b>	<b>Proposed Vegetation</b>	<b>Treatment</b>
BMP#3	Dry Extended Detention Basin (MRC)	Ernst Retention Basin Wildlife Seed Mix (ERNMX-127)	None

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Refer to Post Construction Stormwater Management Notes on sheet C646-C647

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7. **Pre-Development Site Characterization and Assessment of Soil and Geology** – Adequate and appropriate soils and geologic testing and evaluation must be performed to demonstrate the infiltration capacity of the entire project site to the satisfaction of DEP. At a minimum, one infiltration test for every 40,000 square feet of disturbed acreage should be performed with a minimum of four tests, equally distributed across a site. The infiltration tests must be done in the most accommodating soil horizon for infiltration as demonstrated by a deep hole test within 100 feet of the infiltration test. All other sections of Appendix C Protocol 1, Site Evaluation and Soil Infiltration Testing and Appendix C Protocol 2, Infiltration Systems Guidelines per the Stormwater BMP Manual (as revised) should be followed to clearly demonstrate the infiltration capability of on-site undisturbed soils at applicable elevations and for a variety of locations. Soil probes and infiltration test locations should be identified on the PCSM Plan drawing(s). The use of soil borings as a substitute for test pits can be used as a planning tool but will not generally be accepted for final design of infiltration MRC BMPs.

**NOTE 6** – The above recommended number of infiltration tests per disturbed area is to be based upon the disturbed area that is not considered a restoration activity or road maintenance activity. For example, a large sewer main installation project disturbs 30 acres in total, with 29 acres of disturbance for the sewer line installation (that will be covered by a restoration plan) and 1 acre of disturbance for a pumping station that requires a PCSM plan. The recommended number of infiltration tests would be based on the 1 acre, not 30 acres.

**NOTE 7** – The minimum number of tests can be reduced, if it can be demonstrated that the subsurface conditions are uniform; however, this is considered a deviation from MRC Design Standards, requiring an individual permit.

**NOTE 8** – Infiltration tests resulting in saturated hydraulic conductivities (as identified in the field) of less than or equal to 0.2 inch per hour (prior to application of a safety factor) classify as extremely limited. This is a saturated hydraulic conductivity representative of the lower part of the range of HSG C soils and HSG D soils.

**NOTE 9** – Research has shown that limited infiltration rates (i.e., less than or equal to 0.2 inch per hour) over time with an IWS can result in measurable losses from a BMP. Therefore, a designer can use results from the infiltration testing to describe infiltration losses for unlined MRC BMPs or utilize an infiltration rate of 0. Testing for infiltration rates should be performed as per Protocol 1 of Appendix C of the Stormwater BMP Manual (as revised). The recommendation in Protocol 2 of Appendix C that “soils underlying infiltration devices should have infiltration rates between 0.1 and 10 inches per hour” does not apply to MRC BMPs.

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A report by Whitestone Associates dated February 16th, 2022 documents the results of field testing performed. Whitestone performed 24 in-situ infiltration tests, most of which yielded no infiltration rates for

**MRC - 13 Design Standards (August 25, 2020 Version 1.2)**

NPDES Permit application number: PAD060076

Page 7 of 11

Municipality: Maidencreek Township

County: Berks County

MRC Identification: BMP#3

design. The geotechnical report also does not recommend infiltration on-site due to karst subsurface conditions. The report has been included with the PCSM report for reference.

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Refer to pages 165 of the PCSM report which contains the Infiltration Report prepared by Whitestone Associates, Inc.

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- 8. Separation Distance** – At least one foot of separation distance should be maintained between groundwater or the seasonally high-water table and the bottom footprint of the MRC BMP’s soil media; however, a two-foot separation is preferred. There is no minimum separation required between bedrock or hardpan and the MRC BMP’s soil media.

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The bottom of the proposed MRC BMP does not fall within one foot of groundwater or the seasonally high-water table. A liner is proposed to prevent stormwater from infiltrating into the karst subsurface which could cause damage and/ or safety concerns.

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Refer to pages 16 of the PCSM report which contains the Infiltration Report prepared by Whitestone Associates, Inc.

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- 9. Ponding Depth and Drawdown time** – The maximum ponding time (i.e., the time after the end of the storm event for stored surface water to lower to soil surface) should not exceed 72 hours for any storm event. In general, a maximum ponding depth (i.e., storage depth above BMP surface) of preferably one foot with a maximum of two feet at the peak of the 2-year/24-hour storm event should not be exceeded for the design of surface BMPs. In accordance with MRC Design Standard 4, the MRC could incorporate a multi-stage detention facility with the upper portions of the facility providing flow attenuation for storm events greater than a 2-year/24hour storm, to meet 25 Pa. Code § 102.8(g)(3). An engineered overflow structure or reinforced spillway / berm should be installed to provide safe conveyance for storm events greater than a 2-year/24-hour storm. Ponding depth for storms larger than the 2-year/24-hour storm should not exceed four feet, and drawdown to the MRC BMP surface should not exceed 72 hours for all design storms. For underground storage chambers and porous pavement MRC systems, drawdown to the IWS storage level should not exceed 7 days.

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**MRC - 13 Design Standards (August 25, 2020 Version 1.2)**

NPDES Permit application number: PAD060076

Municipality: Maidencreek Township

County: Berks County

MRC Identification: BMP#3

<b>BMP No.</b>	<b>2-Year/24 Hour Ponding Depth (ft)</b>	<b>100-Year/ 24 Hour Ponding Depth (ft)</b>	<b>100-Year/ 24 Hour Drawdown Time (hrs)</b>
BMP#3	0.76	2.77	72

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Refer to the numeric hydrographs on pages 135-137 of the PCSM report as documentation that this design standard is met.

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10. **Soil Media** – The selection of soil media should be done by considering anticipated pollutants to be treated and the vegetation that will be used. On-site soils should be evaluated for desired characteristics and infiltration capabilities as listed below. The depth of the soil media above the invert elevation of the underdrain pipe should be a minimum of 2 feet (24 inches) to provide pollutant removal. If on-site undisturbed soils are unsuitable for the purpose of providing IWS, an additional one to two feet of suitable soil media should be provided below the underdrain.

**Soil Media Drainage** – The designer will need to exercise caution when selecting a soil media, as there is a delicate balance between infiltration rate and residence time. To maximize water quality treatment, the residence time within the soil media used in MRC BMPs should be selected to be close to the parameters established for infiltration into native soils. The designer will need to select a soil media that provide the proper infiltration rate and ponding time to achieve water quality for the anticipated life cycle of the BMP.

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For the aboveground MRC basin, the soil media will be installed to a depth of 2.5 feet. The media shall have a void space of 30% and the facility shall dewater within 72 hours.

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Refer to the details provided on C-647 for media details and pages 135-137 for dewatering times.

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11. **Underdrain Design** – The licensed professional engineer can refer to PennDOT Publication 408 Section 610 for specifications of underdrains. However, underdrains should have a minimum flow rate of 10 gallons (1.34 cubic feet) per minute per linear foot of pipe not considering the flow control orifice or upturned elbow. For non-vegetated MRC BMPs, the underdrain should be located at the bottom of the IWS to promote movement of water from previous storms. There



**MRC - 13 Design Standards (August 25, 2020 Version 1.2)**

NPDES Permit application number: PAD060076

Municipality: Maiden Creek Township

County: Berks County

MRC Identification: BMP#3

may need to be multiple underdrains, or longer underdrains, to provide adequate design capacity for drainage. Section 6.4.7 (Constructed Filter) of the Stormwater BMP Manual (as revised) has recommended design standards for lateral spacing of multiple underdrains.

**IWS Outflow with Capped / Orifice Underdrain** – It is highly recommended that an upturned elbow or an elevated weir be designed at the outlet of the underdrain (see Figure 1). The upturned elbow or elevated weir will create a zone within the soil media, referred to as the IWS. Research has shown that IWS can reduce runoff volume and improve water quality treatment. The upturned elbow or elevated weir can also help if site conditions present daylighting issues for the underdrain’s discharge elevation. Underdrains should be capped within an outlet structure when used to allow access for maintenance. The cap should be drilled to provide an appropriately sized orifice. Figure 7 below provides an example of an underdrain detail. Note that all cleanouts and angles within the underdrain should not exceed 45 degrees. For lined, nonvegetated MRCs the underdrain leading to the upturned elbow should be located at the bottom of the IWS.

**Underdrain Aggregate Envelope** – A 6-inch stone envelope of AASHTO #57 should be placed around the underdrain. A geotextile (or pea gravel diaphragm) is needed around the aggregate envelope. Note that the stone should not be placed throughout the bottom of the BMP, but just in the envelope of the underdrain.

**Cleanout for Underdrain** – The underdrain(s) should be equipped with a clean-out for maintenance. The design of any clean-out should ensure that surface water does not enter the underdrain system through the top of the cleanout. Consideration must be given for cleaning and inspecting underdrains and access to the upturned elbow or elevated weir.

**Orifices** – An appropriately sized orifice is necessary on the outlet of the underdrain to control flow to the required release rate (see Figure 8). The orifice should be clean, smooth and sanded so that no burs or irregularities are present. The orifice should be on a plate or cap of sufficient thickness, and the edges of the orifice should be ground so that flow through the orifice is smooth. Orifices should be vertical. The orifice plate and other connections should be water-tight and accessible for maintenance. Control valves cannot be substituted for an orifice.

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<b>BMP No.</b>	<b>Perforated Underdrain Diameter</b>	<b>Orifice Diameter</b>	<b>100-Year/ 24 Hour Drawdown Time (hrs)</b>
BMP#3	4"	1-11/16"	72

**MRC - 13 Design Standards (August 25, 2020 Version 1.2)**

NPDES Permit application number: PAD060076

Page 10 of 11

Municipality: Maidencreek Township

County: Berks County

MRC Identification: BMP#3

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See the MRC BMP Detail provided on the PCSM Details sheet C-647 for the depiction of the underdrain installation with the BMP.

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12. **Discharge Flow Path** – The MRC BMP should be directed to a suitably vegetated flow path, which can safely convey the releases without erosion or loss of stability. The discharge should be dispersed through the use of a level spreader. A licensed professional engineer can provide an analysis, with calculations, which identifies that a level spreader is not necessary, or that discharge to a channel will not cause increased erosion.

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The MRC BMP will discharge to a level spreader that shall flow directly to Peters Creek. The flow rate in the 2-year/24-hour event has been reduced to below the 1-year/24-hour storm event thus avoiding any accelerated stream bank erosion.

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Refer to the hydrographs on pages 15 to 94 of the PCSM report that demonstrate post development flow rates have been reduced to prevent erosion.

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13. **Antidegradation Requirements** – Where the stormwater from the project site discharges to a special protection surface water, an MRC BMP can be used to satisfy the Antidegradation Best Available Combination of Technologies (ABACT) regulatory requirements from Chapters 93 and 102 (assuming that non-discharge alternatives do not exist).

**In the space below, the licensed professional should document and demonstrate how this design standard was specifically addressed in the PCSM Report (Narrative, Calculations, H&H Model, etc.).**

Stormwater from this MRC BMP discharges directly to a level spreader which flows to the Delaware River which has an Exceptional Value (EV) and Migratory Fishery (MF) Chapter 93 designated use.

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Refer to the statement about off-site discharge analysis provided on page 4 of the PCSM Report.

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**MRC - 13 Design Standards (August 25, 2020 Version 1.2)**

NPDES Permit application number: PAD060076

Municipality: Maiden Creek Township

County: Berks County

MRC Identification: BMP#3

**SEAL AND CERTIFICATION BY LICENSED PROFESSIONAL**

I, Cornelius Brown, P.E., do hereby certify pursuant to the penalties of 18 Pa.C.S.A. 4904 to the best of my knowledge, information and belief, that the accompanying report and drawings are in conformance with Chapter 102 of the rules and regulations of the Department of Environmental Protection.

