STATE OF MAINE
DEPARTMENT OF ENVIRONMENTAL PROTECTION

PAUL R. LEPAGE
GOVERNOR

PAUL MERCER
COMMISSIONER

November 10, 2016

Modular Wetland Systems, Inc. Corporate Office
398 Via El Centro
Oceanside, CA 92058
Attn: Zach Kent

Dear Mr. Kent:

The Modular Wetland System Linear (MWS-Linear) has been reviewed and accepted as an approved alternative to the General Standards (Section 4.C) of the Stormwater Management Rules (Chapter 500). Modular Wetlands Systems Inc. has provided the Department with (1) testing data showing that the system provides pollutant removal equivalent to the Chapter 500 General Standard Best Management Practices, and (2) extensive information demonstrating how MWS-Linear units may be sized to provide full treatment of 90% of an average annual runoff volume. Therefore, the Department will review and approve, on a case-by-case basis, the use of the MWS-Linear to meet the pollutant removal requirements of the General Standards (Chapter 500, Section 4 (C)(2)) when the system is sized, installed and maintained in accordance with the provisions that follow. This approval does not address the additional requirements for the channel protection or any control of peak flow events.

1. The structure must be installed, operated and maintained in accordance with the manufacturer's specifications. This approval is for water quality treatment with high flow rates.
2. The MWS-Linear must be sized in accordance with the manufacturer's published white paper "Technical Basis for MWS Linear® Sizing Approach: Attachment B: Maine," prepared by Geosyntec Consultants dated February 2016. The approach outlined in Attachment B provides design treatment intensities for three regions of the state that treat 90% of the annual runoff volume. Using this information, applicants can find the appropriate model unit sizing by assessing the contributing watershed's and model unit's time of concentration (Tc) and applying the Rational Equation. The calculated flow rate is then compared with the following MWS-Linear model chart to determine the appropriate model.

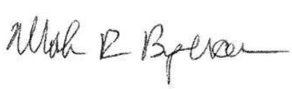
Model #	Dimensions	WetlandMEDIA Surface Area	Treatment Flow Rate (cfs)	Detention Time Adjustment to Tc (min)
MWS-L-4-4	4' x 4'	23 sq. ft.	0.052	6
MWS-L-4-6	4' x 6'	32 sq. ft.	0.073	4
MWS-L-4-8	4' x 8'	50 sq. ft.	0.115	4
MWS-L-4-13	4' x 13'	63 sq. ft.	0.144	6
MWS-L-4-15	4' x 15'	76 sq. ft.	0.175	5
MWS-L-4-17	4' x 17'	90 sq. ft.	0.206	4
MWS-L-4-19	4' x 19'	103 sq. ft.	0.237	3
MWS-L-4-21	4' x 21'	117 sq. ft.	0.268	3
MWS-L-8-8	8' x 8'	100 sq. ft.	0.23	5
MWS-L-8-12	8' x 12'	151 sq. ft.	0.346	5
MWS-L-8-16	8' x 16'	201 sq. ft.	0.462	6
MWS-L-8-20	8' x 20'	252 sq. ft.	0.577	4
MWS-L-8-24	8' x 24'	302 sq. ft.	0.693	4

3. As an alternative to flow based sizing the MWS-Linear can be configured in a volume based design. Upstream storage must be provided for the water quality/channel protection volume (WQv) consisting of the first 1.0 inch of runoff from impervious surfaces and 0.4 inch of runoff from lawn and landscaped areas. The WQv should be hydraulically isolated from any additional storage provided onsite by weirs or other means so that only the WQv is routed through the MWS-Linear. If channel protection storage is required, the WQv must be detained for a minimum of 24 hours and a maximum of 48 hours (emptying time). Storage can typically be provided in an underground facility such as corrugated metal pipe, polypropylene chambers, concrete vaults or similar. All storage systems must include sufficient maintenance access for the removal of accumulated sediment and debris. It is desirable that a pretreatment structure be located upstream of the WQv storage to facilitate capture of coarse solids and trash. In volume based designs the MWS-Linear must be sized in accordance with the tested hydraulic loading rate of no greater than 1 gpm per square foot of WetlandMedia surface area.
4. The MWS-Linear must incorporate a method to bypass runoff flows that are greater than the design flows. The manufacturer has described many ways to configure this bypass. The applicant must demonstrate that the proposed design meets all the manufacturer's specifications prior to submission for Department approval. Review and approval of the proposed design by the manufacturer will be sufficient to demonstrate conformance with the manufacturer's specifications.
5. If channel protection is required, the treated flow as well as the bypassed flow must be directed to a detention system/structure that will store the channel protection volume (CPv) consisting of the first 1.0 inch of runoff from impervious surfaces and 0.4 inch of runoff from lawns and landscaped areas. An external outlet control structure must control the flow out of the system such that the time of drawdown of the CPv must be no less than 24 hours and no greater than 48 hours.

6. The MWS-Linear must be delivered to the site with the internal components/plumbing fully installed. WetlandMedia will either be pre-installed or delivered in super sacks and installed after the concrete box is set in place. The MWS-Linear must be sealed to prevent debris and sediment from entering the system during construction. The activation of the MWS-Linear including opening of the protective mesh cover and installation of plant(s) can be performed only by the supplier (Modular Wetlands System, Inc. or its authorized dealer). The activation process must not commence until the project site is fully stabilized and cleaned (i.e., full landscaping, grass cover, final paving and street sweeping completed), minimizing the risk of construction materials contaminating the MWS-Linear device.
7. Prior to construction, a five-year binding inspection and maintenance contract must be provided for review and approval by the Department, and must be renewed before contract expiration. The contract will be with a professional with knowledge of erosion and stormwater control, including a detailed working knowledge of the proposed system. The first year's maintenance must be provided by the manufacturer to ensure that the system is operating according to the established specifications.
8. The overall stormwater management design must meet all Department criteria and sizing specifications and shall be reviewed and approved by the Department prior to use.
9. Each project must be reviewed and approved by the manufacturer for proposed use, layout and sizing of the system and for conformance with their design specifications. The system must be installed under the manufacturer's representative supervision.
10. This approval is conditional to on-the-ground experience confirming that the MWS-Linear's pollutant removal efficiency and sizing are appropriate. The "permit shield" provision (Section 14) of the Chapter 500 rules will apply, and the Department will not require the replacement of the system if, with proper maintenance, pollutant removals do not satisfy the General Standard Best Management Practices.

We look forward to working with you as these stormwater management structures are installed on new projects. Questions concerning this decision should be directed to Jeff Dennis at (207) 215-6376.

Sincerely,



Mark Bergeron, P.E.
Director, Bureau of Land Resources

C: Don Witherill, Maine DEP

White Paper

Technical Basis for MWS Linear® Sizing Approach

Prepared for:

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February 2016

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TABLE OF CONTENTS

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EXECUTIVE SUMMARY

The Modular Wetland System (MWS) Linear® is a multiple-stage treatment system that is designed to treat stormwater runoff at a given flow rate at the time the runoff occurs (i.e., “flow-based” sizing). This sizing basis is different from typical best management practices (BMPs), which are often sized to hold a given volume of stormwater runoff and treat it during and after a storm event (e.g., “volume-based” sizing). In cases when applicable BMP sizing requirements are based on a given design storm volume (e.g., capture the runoff from a 1-inch storm) or a long term capture efficiency (e.g., capture and treat 90 percent of long term runoff), a method is needed to determine the required design flow rate of a MWS Linear® system to provide equivalent long term capture efficiency of stormwater runoff volumes.

This white paper describes the technical basis for an MWS Linear® sizing approach that is formulated to provide treatment for an equivalent amount of long term runoff volume in comparison to traditional volume-based BMP sizing standards. Additionally, this white paper provides associated resources to assist designers with applying this sizing approach to projects.

The methodology described in this white paper is based on the results of long term continuous modeling, which was conducted to compare the long term capture efficiency of flow-based MWS Linear® systems to the long term capture efficiency of traditional volume-based BMPs or a capture efficiency-based regulatory standard. Analyses were conducted for ranges of precipitation patterns and site conditions that may apply to a project. The results of these analyses were then summarized in design tables and graphs so that they can be applied by project designers as part of a simplified approach without requiring project-specific continuous simulation analyses. This method allows the designer to calculate a design treatment flow rate and select an associated MWS Linear® model (i.e., size) that provides equivalent long term capture efficiency compared to the applicable volume-based or capture efficiency-based standard.

The sizing approach described in this white paper accounts for and/or allows the user to define: (1) project location (state and/or region); (2) applicable volume-based or capture efficiency-based BMP sizing standard that applies to this location; (3) drainage area; (4) drainage area percent imperviousness or runoff coefficient; and (5) time of concentration associated with drainage area. Notably, this sizing approach is based on the results of continuous simulation modeling using high resolution precipitation data (5-minute intervals). This resolution is necessary to account for the effects of short-duration, high-intensity precipitation in small urban catchments. These effects can be masked if analyses are conducted using hourly precipitation data.

Details regarding the modeling analyses supporting the sizing approach are provided in Attachment A. Detailed instructions and resources for sizing the MWS Linear® system in a specific state are provided in Attachment B.

1. INTRODUCTION AND PURPOSE

The Modular Wetland System (MWS) Linear® is designed to treat a given flow rate of stormwater runoff at the time the runoff occurs (i.e., "flow-based" sizing). This sizing basis is different from typical best management practices (BMPs), which are often sized to hold a given volume of stormwater runoff and treat it during and after a storm event (e.g., "volume-based" sizing). In cases when applicable BMP sizing criteria are based on a given design storm volume or a long term capture efficiency, a method is needed to determine the required design flow rate of a MWS Linear® to provide equivalent performance.

This white paper describes the technical basis for an MWS Linear® sizing approach that is formulated to provide treatment for an equivalent amount of long term runoff volume in comparison to traditional BMP sizing standards that are based on a specified design storm depth or long term capture efficiency. Additionally, this white paper provides associated resources for designers to apply this method to projects.

This white paper is organized into the following sections:

- Section 2 provides an overview of the MWS Linear® treatment system;
- Section 3 describes the methodology used to develop the long-term capture efficiency-based sizing approach for MWS Linear® systems;
- Section 4 summarizes the MWS Linear® sizing approach and associated resources available to designers; and
- Section 5 provides a summary and conclusions, including discussion of limitations and reliability.

Additionally, the following attachments support this white paper:

- Attachment A provides a detailed description of the modeling methodology used to support the sizing approach, including model inputs and assumptions.
- Attachment B provides state-specific sizing resources, including a stepwise sizing approach, design tables and worksheets.

State-specific versions of Attachment B have been produced for all states that are supported by this methodology. It is expected that additional or modified versions of Attachment B may be added in the future.

Attachment B can be used as a standalone document for project design. The remainder of this white paper and Attachment A provides the technical basis for the sizing approach.

2. OVERVIEW OF MODULAR WETLAND SYSTEM LINEAR

The MWS Linear® consists of multiple treatment components packaged within a two-part treatment chamber. The first chamber includes pre-treatment using gravity separation (settling) and media filter cartridges filled with BioMediaGREEN™. The second chamber includes horizontal flow through biofiltration media (WetlandMEDIA™) and vegetation. The outlet from the second chamber includes flow control to provide the appropriate residence time within the system. MWS Linear® systems are sized to provide complete treatment up to a specified treatment flow rate, which varies based on system size. Any flows larger than the treatment flow rate are bypassed and remain untreated.

MWS Linear® design flow rates can be found in MWS Linear® reference material on the MWS Linear® website, and are provided in Table 1 below.

Table 2-1: MWS Linear® Treatment System Models

Model Number	Dimensions	WetlandMEDIA Surface Area	Treatment Flow Rate (cfs)
MWS-L-4-4	4′ x 4′	23 sq. ft.	0.052
MWS-L-4-6	4′ x 6′	32 sq. ft.	0.073
MWS-L-4-8	4′ x 8′	50 sq. ft.	0.115
MWS-L-4-13	4′ x 13′	63 sq. ft.	0.144
MWS-L-4-15	4′ x 15′	76 sq. ft.	0.175
MWS-L-4-17	4′ x 17′	90 sq. ft.	0.206
MWS-L-4-19	4′ x 19′	103 sq. ft.	0.237
MWS-L-4-21	4′ x 21′	117 sq. ft.	0.268
MWS-L-8-8	8′ x 8′	100 sq. ft.	0.23
MWS-L-8-12	8′ x 12′	151 sq. ft.	0.346
MWS-L-8-16	8′ x 16′	201 sq. ft.	0.462
MWS-L-8-20	8′ x 20′	252 sq. ft.	0.577
MWS-L-8-24	8′ x 24′	302 sq. ft.	0.693

Prior testing of MWS Linear® for water quality treatment performance, and associated product certifications, has been conducted based on the design loading rates described in Table 1. The purpose of this white paper is to present the method for determining the treatment flow rate and associated model number needed to treat a given project drainage area.

3. METHODOLOGY FOR DEVELOPING MWS LINEAR® SIZING CRITERIA

3.1 Overview of Methodology

The sizing approach described in this white paper was formulated to provide treatment for an equivalent amount of long term runoff volume in comparison to traditional BMP sizing standards. Long term capture efficiency is the underlying metric used in this methodology. The methodology used to develop the MWS Linear® sizing approach consisted of four primary steps:

1. **Determine applicable sizing criteria for stormwater quality BMPs**. Regulatory sizing criteria in a given location are typically expressed as either a design storm volume (e.g., capture and treat the runoff from a 1-inch storm event), or a long term capture efficiency approach (e.g., capture and treat the 90 percent of long term runoff volume). In some cases, both options are available.
2. **Establish target long term capture efficiency for MWS Linear® sizing.** If long term capture efficiency was expressed in the applicable regulations, then this was set as the target long term capture efficiency. If only a design storm-based sizing criterion was provided, then continuous simulation was conducted for a representative BMP that was sized based on the design storm criterion to determine the level of long term capture efficiency provided by that BMP. See Section 3.2 for additional information.
3. **Determine MWS Linear® sizing required to achieve target capture efficiency.** Continuous simulation modeling was conducted for a range of MWS Linear® design flow rates, in various project locations (i.e., rainfall and evapotranspiration records), for a range of drainage area time of concentration (Tc) values to determine the required MWS Linear® design flow rates needed to achieve the target capture efficiency in each combination of conditions. See Section 3.3 for additional information.
4. **Develop sizing worksheets and supporting tables.** The results of step 3 were normalized by drainage area and runoff coefficients, so that these results can be applied to the drainage area characteristics that are most appropriate for each project. This was facilitated by converting each required size from step 3 to an equivalent required "treatment intensity." This required treatment intensity can then be applied to a given drainage area using the Rational Method to calculate the required treatment flow rate. To enable users to account for the equalization and detention within the forebay of the MWS Linear® facility in sizing analyses, the "detention time" was also calculated for each model and is intended to be added to the Tc value for the watershed. See Section 4 for additional information.

The methodology is summarized in the sections following and is described in detail in Attachment A.

3.2 Development of Target Long Term Capture Efficiency

Where the required long term capture efficiency of stormwater treatment BMPs is established as part of state regulations or guidance, this value was used as the target long term capture efficiency for MWS Linear® sizing. No additional analyses were conducted.

For states where long term capture efficiency was not included in regulatory BMP sizing requirements, continuous simulation modeling was conducted to estimate the long term capture efficiency that would result from the applicable volume-based sizing criterion. For each location, the applicable design storm event sizing criterion (e.g., 1 inch storm) and applicable BMP drawdown time (e.g., drain within 48 hours) were applied to a hypothetical one acre, 100 percent impervious catchment to determine the storage volume and discharge rates associated with the traditional volume-based BMP design. The USEPA Stormwater Management Model (SWMM) version 5.1.010 was used to model each scenario, including runoff generation and routing, to estimate the long term capture efficiency provided by the BMP. A long term rainfall record at 5-minute temporal resolution served as the primary meteorological input, supplemented with temperature-based estimates of evapotranspiration.

Volume-based BMPs are not sensitive to time of concentration within the range typically found in urban catchments (5 to 30 minutes) because they include substantial equalization storage volume typically greater than runoff volume that occurs in 30 minutes. A single representative Tc value of 10 minutes was selected for the purpose of modeling volume-based BMPs. In contrast, multiple catchment configurations represent different Tc values were analyzed for the flow-based MWS Linear® systems, as described below.

The gages used for each state analyzed are identified in the state-specific sizing package provided in Attachment B. Additionally, Attachment B contains a summary of applicable regulatory requirements and the resulting target long term capture efficiencies developed using this approach.

3.3 MWS Linear® Sizing Analysis to Achieve Target Long Term Capture Efficiency

To determine the MWS Linear® design flow rate needed to achieve the target long term capture efficiency for each region, a range of treatment flow rates were modeled for each combination of precipitation gage and drainage area Tc. A one acre, 100 percent impervious catchment was used as the standard drainage area for consistency with the approach described in Section 3.2 and to allow for normalization of the treatment flow rate to treatment precipitation intensity. Continuous simulation was used to model seven different drainage area Tc values draining to MWS Linear® with a range of treatment flow rates. MWS Linear® was assumed to capture all runoff flows up to the identified treatment flow rate. Flows in excess of the identified treatment flow rate were bypassed.

The flow rates modeled in each simulation were converted to an equivalent "treatment intensity" using an inverse form of the Rational Method, where the design treatment intensity corresponding to a given model run was calculated as:

$$I_{treatment} = Q/(A*R_v)$$

Where,

$I_{treatment}$ =	design treatment intensity, inches per hour (ranged from approximately 0.1 to 1 inches per hour)
Q =	modeled flow rate, cfs (ranged from approximately 0.09 to 0.95 cfs)
A =	tributary area, ac (set to 1)
R_v =	runoff coefficient of a 100 percent catchment (set to 0.95 for modeling purposes based on model estimates and regulatory references)

An example summary result of these continuous simulations is provided in Figure 1. Each symbol on this plot represents a different continuous simulation model run (10 to 15 years of rainfall-runoff-routing simulation in each run). As can be seen in this figure, the required treatment intensity to achieve a given capture efficiency (dashed line) is a function of the drainage area Tc. A longer Tc tends to result in more attenuation of the hydrograph on the catchment surface and a lower required treatment flow rate, and vice versa.

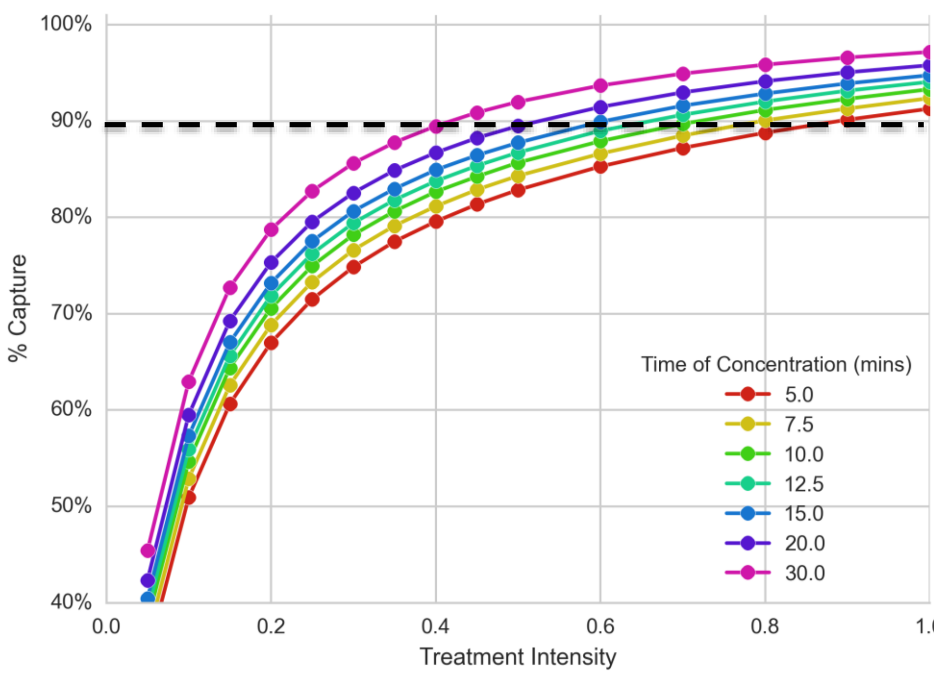


Figure 3-1: Example Nomograph of Capture Efficiencies for Various Treatment Intensities

For Example Purposes Only – Not Applicable for Sizing

Using the results from the batch continuous simulation modeling described in this section, coupled with the target long term capture efficiency calculated in Section 3.2, the required treatment intensities were summarized for each precipitation gage and Tc (See Table 2 in the next section). These results are provided in Attachment B as a key part of the MWS Linear® sizing worksheets. Details regarding the modeling of MWS Linear® systems are provided in Attachment A.

3.4 MWS Linear® System Detention Time

The detention storage provided in the pre-treatment chamber of the MWS Linear® has the effect of equalizing short-duration peak intensities and effectively lengthening the time of concentration. This detention time can be added to the catchment Tc to adjust the Tc used to estimate the required treatment intensity. The detention time for each MWS Linear® model was estimated based on the volume in the pre-treatment chamber divided by the design flowrate. These values are provided in Attachment B; they vary somewhat by MWS Linear® model.

4. SUMMARY OF MWS LINEAR® SIZING APPROACH

The results of the analyses described in Section 3 were distilled into a simple sizing approach to determine the required size of MWS Linear® systems to achieve the target long term capture efficiency. This sizing approach is supported by state-specific worksheets and sizing tables in Attachment B.

4.1 Overview of Sizing Approach

The sizing approach includes four primary steps, as described below.

Step 1: Determine applicable requirements

A. Determine project location.

B. Select the most representative rainfall gage from the gages included in Attachment B.

C. Look up the design treatment intensities associated with the selected gage in Attachment B.

Step 2: Determine drainage area properties

A. Determine the drainage area to the MWS Linear® Treatment System (in acres).

B. Estimate the runoff coefficient for the drainage area under the range of design treatment intensity that applies to the project location; utilize methods that are locally acceptable and represent site conditions.

C. Estimate the Tc of the drainage area under the range of design treatment intensity that applies to the project location. Utilize methods that are locally acceptable and represent site conditions. Alternatively, time of concentration can be estimated or interpolated using the drainage area flow path length and slope based on the table provided in Attachment B.

Optional Step 2a: Determine time of concentration adjustment for pre-filter detention storage provided in MWS Linear®

A. Using the table provided in Attachment B, identify the detention time associated with the MWS Linear® model number anticipated to be used for your drainage area. This step may require some iteration. If uncertain about the model number that will be required, select an initial assumption of three minutes for a 4 foot wide model and five minutes for an 8 foot wide model.

B. Add the identified detention time adjustment to the estimated Tc to obtain the adjusted Tc for use in MWS Linear® flow-based sizing.

Step 3: Conduct rational method calculations to determine required design flowrate

A. Based on the original or adjusted Tc, determine the required treatment intensity from the table provided in Attachment B. If the estimated Tc value is in between Tc values provided, linear interpolation between increments is acceptable.

B. Calculate the required treatment flow rate using the following equation (no unit conversion is needed):

$$Q_{treatment} = I_{treatment} * R_v * A$$

Where:

$Q_{treatment}$ = Required MWS Linear® treatment flow rate (cfs)
$I_{treatment}$ = MWS Linear® treatment intensity (inches per hour)
R_v = Drainage area runoff coefficient (unitless)
A = Drainage area (acres)

Step 4: Select MWS Linear® model number to provide required treatment flowrate

A. Select a MWS Linear® model with a treatment flow rate that is equal to or greater than the required treatment flow rate (see table in Attachment B).

B. If the required treatment flow rate is greater than that provided by any MWS Linear® treatment system model, split your drainage area into two or more sub-areas and go back to step 2.

C. Confirm that the detention time adjustment to Tc used in Step 2A is met or exceeded by the selected MWS Linear® model.

4.2 Supporting Sizing Resources

MWS Linear® sizing tables are provided for each region in Attachment B. Table 2 shows an example of how these tables are organized. This table is for example purposes above, based on the example model results presented in Figure 1. Actual tables are provided in Attachment B.

Table 4-1: Example MWS Linear® Sizing Table

Time of Concentration (minutes)	Required Treatment Intensity (inches per hour)
5	*0.85 (example)*
7.5	*0.76 (example)*
10	*0.67 (example)*
12.5	*0.61 (example)*
15	*0.56 (example*
20	*0.48 (example)*
30	*0.38 (example)*

For Example Purposes Only – Not Applicable for Sizing in Any Specific Jurisdiction

Attachment B also provides a template submittal form and instructions for conducting the calculations described in Section 4.1.

5. SUMMARY AND LIMITATIONS

The sizing approach described in this white paper has been formulated to provide treatment of an equivalent level of long term runoff volume compared to the traditional sizing criteria and methods that apply in a given location. The use of long term capture efficiency as an equivalency metric is appropriate and robust, as this metric has a direct relationship to control of pollutant loads.

The reliability and limitations of this sizing approach are discussed in the following bullets.

- Performance estimates were based on models which were not calibrated. This introduces some uncertainty. This uncertainty was mitigated by applying identical input parameters and modeling approaches for conventional BMPs and MWS Linear® systems, as appropriate. This has the effect of offsetting the majority of the uncertainty in model estimates. Additionally, modeling estimates of developed urban catchments have fewer sources of potential uncertainty and less need for calibration.

- The sizing approach requires the designer to estimate the runoff coefficient and Tc for the drainage area. Instead of prescribing a method, this approach leverages the well-established methods that are typically in place in local jurisdiction guidance for calculating and reviewing these parameters. An approach that engages the designer and reviewer to utilize professional judgement to select the values most appropriate for the site is believed to be more appropriate than a one-size-fits-all approach to prescribing these parameters.

- The analyses and criteria presented in this report are based on the assumption that the BMPs will be effectively designed and constructed consistent with a typical standard of care. It is inherent that design of non-proprietary BMPs provides a greater degree of freedom and associated professional judgment as part of preparing design calculations, design drawings, and specifications. This introduces a wider potential range of resulting designs and associated actual levels of performance. In comparison, there is likely to be substantially less variability in the design and construction of MWS Linear® systems, and therefore performance, compared to traditional non-proprietary BMPs. Therefore, MWS Linear® systems sized per this method are expected to provide more consistent performance than non-proprietary BMPs on a typical basis.

- Proprietary and non-proprietary systems are susceptible to decline in performance over time. This sizing approach is based on the rated design flow rates of MWS Systems. Ongoing operations and maintenance are required to sustain this performance.

Overall, the analyses are believed to result in a reliable design process for determining the size of MWS Linear® systems to achieve equivalent long term capture efficiency.

White Paper

Technical Basis for MWS Linear® Sizing Approach

Attachment B: Maine

Sizing Method and Worksheet for MWS Linear® Systems

MODULAR WETLANDS™

MAINE

B.1 SUMMARY OF STATE REQUIREMENTS

Stormwater BMPs in the state of Maine are required to be sized to achieve water quality control by sizing the facility for the water quality volume. The water quality volume is the storage needed to capture and treat the runoff from **90 percent of the average annual rainfall**. This is the applicable target long term capture efficiency for MWS Linear® sizing. Maine specifies four types of BMPs which may be used to meet water quality objectives including filtration BMPs. Proprietary BMPs must demonstrate equivalent pollutant removal, cooling, and channel protection to be used independently of a treatment train.

References

Maine Department of Environmental Protection. Maine Stormwater Best Management Practices Manual. http://www.maine.gov/dep/land/stormwater/stormwaterbmps/ . Accessed December 2015.

B.2 MWS MODEL RESULTS AND DESIGN TREATMENT INTENSITIES

Table B.2-1 summarizes the precipitation inputs for Maine locations that were modeled to support the sizing approach. These are also provided in the attached Figure 1.

Table B.2-1. Precipitation Inputs for Maine Locations

Location	ASOS Station ID (5 minute gage network)	Period of Simulation	Target Long Term Capture Efficiency (%)
Bangor	KBGR	2005-2015	90%
Millinocket	KMLT	2005-2015	90%
Portland	KPWM	2000-2015	90%

Figures B.2-1 thru B.2-3 provide the results of the continuous simulations of MWS Linear® capture efficiency for the Maine locations.

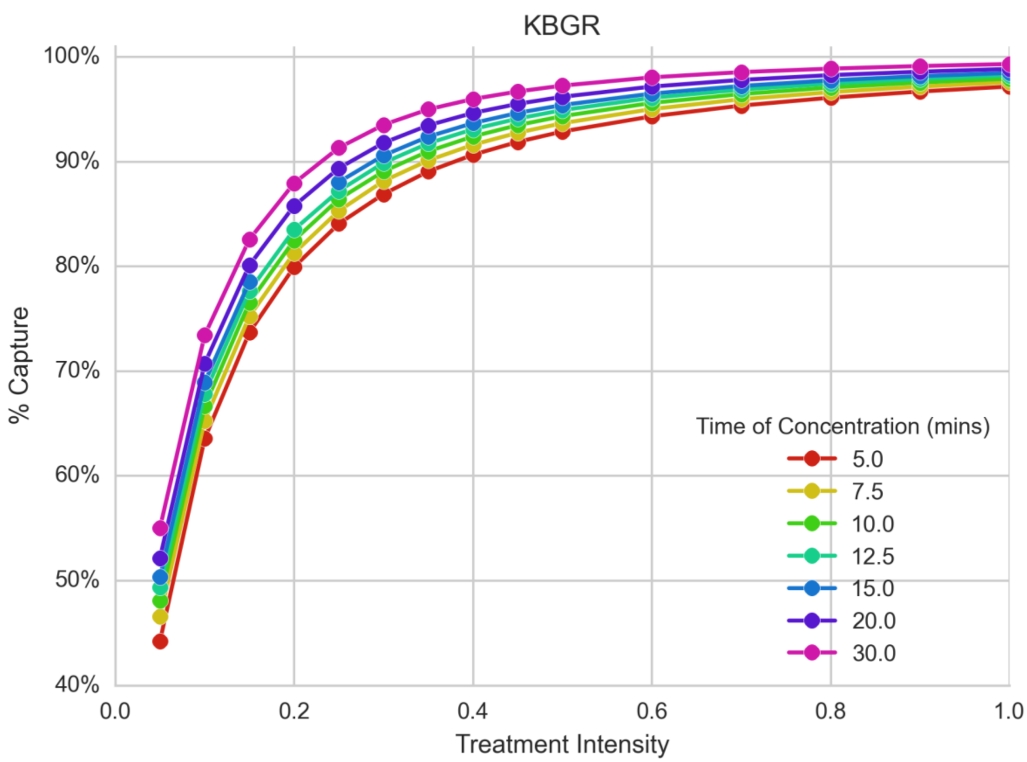


Figure B.2-1. Model Results for Bangor

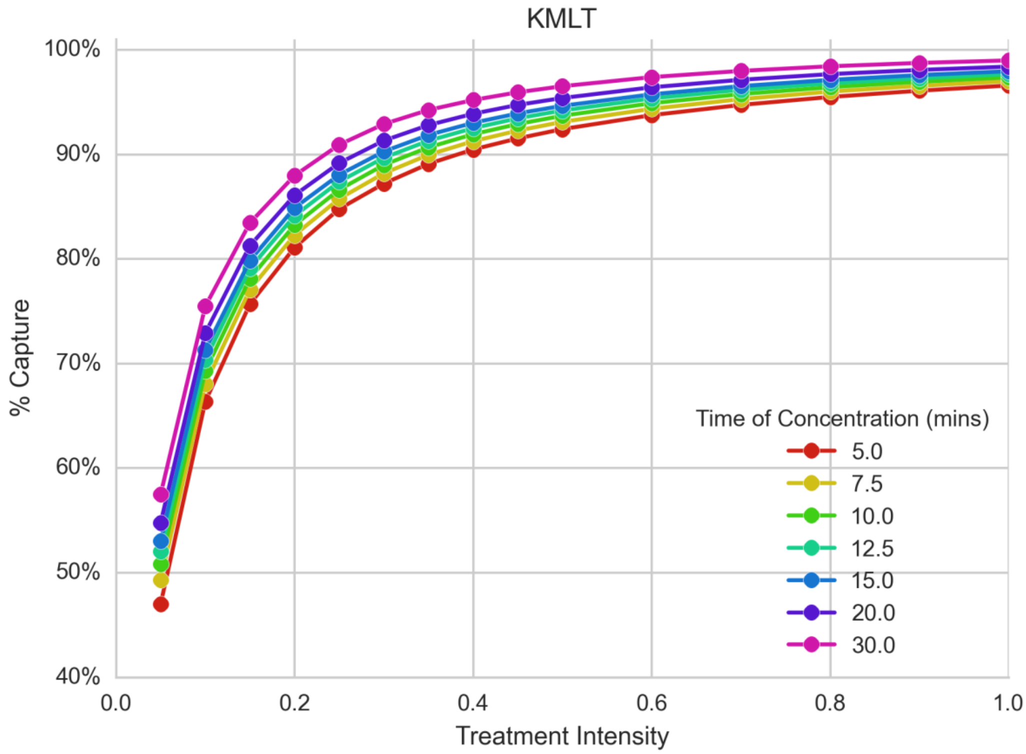


Figure B.2-2. Model Results for Millinocket

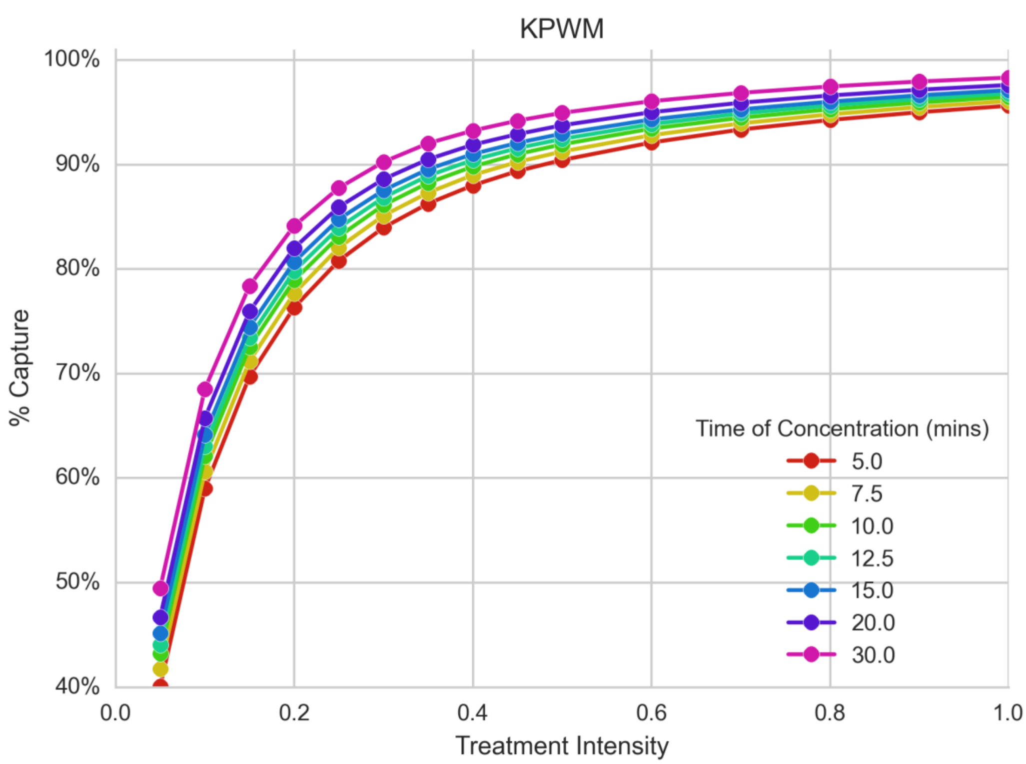


Figure B.2-3. Model Results for Portland

Table B.2-2 summarizes the required treatment intensities to achieve the target long term capture efficiency for each location.

Table B.2-2. Sizing Table for Maine Regions

Time of Concentration (minutes)	Design Treatment Intensity (inches per hour)		
	Bangor	**Millinocket**	**Portland**
5	0.38	0.38	0.48
7.5	0.35	0.35	0.44
10	0.32	0.33	0.41
12.5	0.30	0.31	0.39
15	0.29	0.29	0.37
20	0.26	0.27	0.34
30	0.23	0.23	0.29

B.3 SIZING INSTRUCTIONS FOR MWS LINEAR®

Step 1: Determine applicable requirements

A. Determine project location.

B. Select the most representative rainfall gage from the gages included in Table B.2-1 and Figure B.2-4 (attached).

C. Look up the design treatment intensities associated with the gage in Table B.2-2.

Step 2: Determine drainage area properties

A. Determine the drainage area to the MWS Linear® Treatment System (in acres).

B. Estimate the runoff coefficient for the drainage area under the range of design treatment intensity that applies to the project location; utilize methods that are locally acceptable and represent site conditions.

C. Estimate the Tc of the drainage area under the range of design treatment intensity that applies to the project location. Utilize methods that are locally acceptable and represent site conditions. Alternatively, time of concentration can be estimated using the drainage area flow path length and slope based on Table B.3-1, below. Interpolation from this table is acceptable.

D. Enter results in the Sizing Worksheet (attached).

Table B.3-1. Time of Concentration Corresponding to Flow Path and Slope

Flow Path Length (ft)	Slope (ft/ft)				
	0.01	0.02	0.03	0.04	0.05
	Time of Concentration (min)				
50	5	4	3	3	3
100	7	6	5	5	5
150	9	8	7	6	6
200	11	9	8	7	7
250	13	10	9	8	8
300	14	11	10	9	9
400	17	14	12	11	10
500	19	16	14	13	12
750	24	20	18	16	15
1000	29	24	21	19	18

Optional Step 2a: Determine time of concentration adjustment for pre-filter detention storage provided in MWS Linear®

The detention storage provided in the pre-treatment chamber of the MWS Linear® has the effect of equalizing short-duration peak intensities and effectively lengthening the time of concentration.

A. Using Table B.3-2, identify the detention time associated with the MWS Linear® model number anticipated to be used for the drainage area. This step may require some iteration. If uncertain about the model number that will be required, select an initial assumption of three minutes Tc adjustment for a 4 foot wide model and five minutes Tc adjustment for an 8 foot wide model.

B. Add the identified detention time adjustment to the estimated Tc to obtain the adjusted Tc for use in MWS Linear® flow-based sizing.

C. Enter results in the Sizing Worksheet (attached).

Step 3: Conduct rational method calculations to determine required design flowrate

A. Based on the original or adjusted Tc, determine the required treatment intensity from Table B.2-2. If the estimated Tc value is in between Tc values provided, linear interpolation between increments is acceptable.

B. Calculate the required treatment flow rate using the following equation (no unit conversion is needed):

$$Q_{treatment} = I_{treatment} * R_v * A$$

Where:

$Q_{treatment}$	=	Required MWS Linear® treatment flow rate (cfs)
$I_{treatment}$	=	MWS Linear® treatment intensity (inches per hour)
R_v	=	Drainage area runoff coefficient (unitless)
A	=	Drainage area (acres)

C. Enter results in the Sizing Worksheet (attached).

Step 4: Select MWS Linear® model number to provide required treatment flowrate

A. Select a MWS Linear® model with a treatment flow rate that is equal to or greater than the required treatment flow rate (see Table B.3-1).

B. If the required treatment flow rate is greater than that provided by any MWS Linear® treatment system model, split the drainage area into two or more sub-areas and go back to step 2.

C. Confirm that the detention time adjustment to Tc used in Step 2A is met or exceeded by the selected MWS Linear® model.

D. Summarize results in the Sizing Worksheet (attached).

Table B.3-2. MWS Linear® Models

Model #	Dimensions	WetlandMEDIA Surface Area	Treatment Flow Rate (cfs)	Detention Time Adjustment to Tc (min)
MWS-L-4-4	4′ x 4′	23 sq. ft.	0.052	6
MWS-L-4-6	4′ x 6′	32 sq. ft.	0.073	4
MWS-L-4-8	4′ x 8′	50 sq. ft.	0.115	4
MWS-L-4-13	4′ x 13′	63 sq. ft.	0.144	6
MWS-L-4-15	4′ x 15′	76 sq. ft.	0.175	5
MWS-L-4-17	4′ x 17′	90 sq. ft.	0.206	4
MWS-L-4-19	4′ x 19′	103 sq. ft.	0.237	3
MWS-L-4-21	4′ x 21′	117 sq. ft.	0.268	3
MWS-L-8-8	8′ x 8′	100 sq. ft.	0.23	5
MWS-L-8-12	8′ x 12′	151 sq. ft.	0.346	5
MWS-L-8-16	8′ x 16′	201 sq. ft.	0.462	6
MWS-L-8-20	8′ x 20′	252 sq. ft.	0.577	4
MWS-L-8-24	8′ x 24′	302 sq. ft.	0.693	4

SIZING WORKSHEET ______

Project Name: ____________________

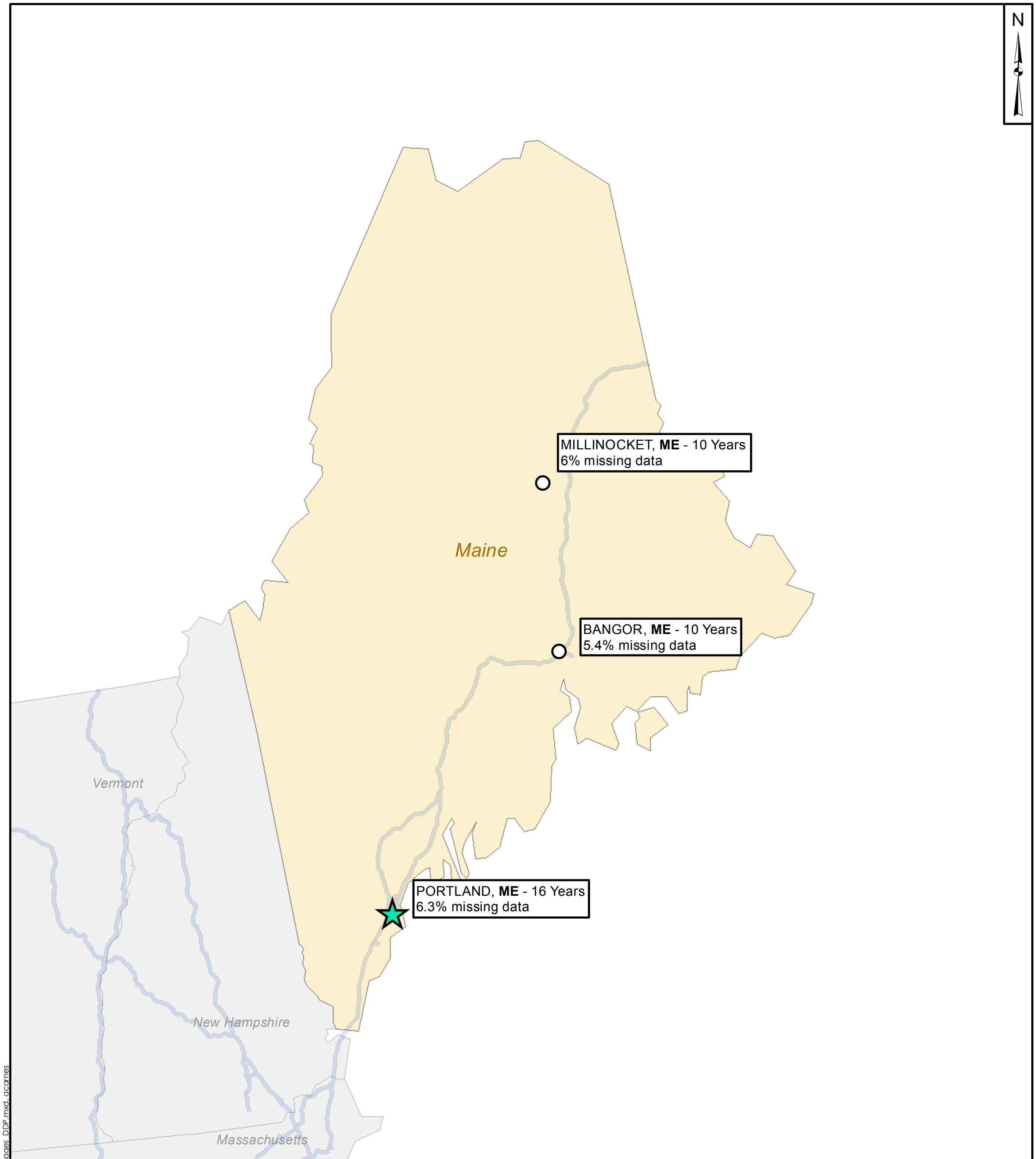
Project Location: ____________________

Precipitation Gage: ____________________

Drainage Area ID: ____________________

Drainage Area Properties and Calculations

Line #	Drainage Area Results	Value	Instructions
1	Acreage (A), ac		• Tabulate the acreage draining to the MWS Linear® system
2	Runoff Coefficient (R_v), unitless		• Estimate the composite runoff coefficient for the drainage area. • Utilize locally-accepted methods. • Provide supplemental calculations as an attachment to this worksheet**.**
3	Time of Concentration (Tc), minutes		• Estimate the Tc under the MWS Linear® system design intensity. • Utilize locally-accepted methods or Table B.3-1; • Provide supplemental calculations, if needed, as an attachment to this worksheet**.**
3a (optional)	MWS Linear® Model Detention Time, minutes		• Identify the detention time from Table B.3-2 corresponding to the expected MWS Linear® model.
3b (optional)	Adjusted Tc, minutes		• Adjusted Tc = (Line 3) + (Line 3a)
4	MWS Linear® Treatment Intensity (I), in/hr		• Look up required treatment intensity from Table B.2-1 using Tc or adjusted Tc; interpolate as needed.
5	Required MWS Linear® Treatment Flow Rate, ($Q_{treatment}$), cfs		• $Q_{treatment} = R_v * I_{treatment} * A$ • (Line 2)(Line 4)(Line 1)
6	MWS Linear® System Model		• Select appropriate model from Table B.3-2.
7	Provided MWS Linear® Flowrate, cfs		• Lookup treatment flowrate from Table B.3-2.
8	Is MWS Linear® System Model sufficient?	**Y/N**	• Line 7 must be equal or greater than Line 5.
9	Detention Time Provided by Selected Unit, minutes		• Lookup from Table B.3-2.
10	Does MWS Linear® provide assumed detention time?	**Y/N**	• Line 9 must be equal or greater than Line 3a; if not, adjust initial assumption in Line 3a.



Legend

- ○ State Gages with Period of Record = 10 years
- ★ State Gages with Period of Record = 15 years

1 inch = 50 miles

Maine Gages

MWS Linear® Sizing Resources

Geosyntec consultants

FEBRUARY 2016

Figure

1