Manufactured Treatment Device (MTD) Registration

1. Manufactured Treatment Device Name: Modular Wetland System Linear (MWS-Linear)

2. Company Name: Modular Wetland Systems, Inc.

Mailing Address: 2972 San Luis Rey Road
City: Oceanside
State: California **Zip:** 92058

3. Contact Name: Greg Kent

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City: Oceanside
State: California **Zip:** 92058
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4. Technology

Specific size/capacity of MTD assessed (include units):

The MWS-Linear Model # MWS-L-4-13 with Internal Bypass was assessed under the TAPE protocol. It was sized at a loading rate of 1 gpm/sq ft media surface area (WetlandMedia).

The MWS-Linear is available in various sizes, models and configurations. The smallest model has internal dimensions of 4 ft x 4 ft. The largest units can be 8 ft x 20 ft and larger. To treat higher flows several modules are placed side by side and connected in parallel. Standard height units are 4.13 ft from top (TC, FS, TG) to invert out. The MWS-Linear can be made as shallow as 2 ft and as deep as 8 ft with an active vegetated biofiltration bed. Underground configurations of the units can be installed at even greater depths. Because the MWS-Linear is a horizontal flow biofilter, changes in structure depths will not change media thickness and thus performance. This is an advantage over downward flow biofilters, whose shallower units require the media thickness to be reduced thus negatively affecting performance.

Regarding capacity, the MWS-Linear is sized and operates at its TAPE approved loading rate of 100 in/hr which is equal to 1 gpm/sq ft media surface area. The MWS-Linear is approved at this loading rate for TSS, phosphorus and dissolved metals. All MWS-Linear units are sized using this TAPE approved loading rate. Appendix E includes a standard sizing chart including the amount of drainage area each unit can treat. Sizing is based upon a method already accepted in the State of Virginia and currently used by other manufactures for standalone design. The MWS-Linear can also be used in standard volume based design in conjunction with storage BMPs. It is always recommended that sizing is done based upon local regulations which may vary from standard sizing charts.

Range of drainage areas served by MTD (acres):

The MWS-Linear can treat areas from a tenth of an acre to more than several acres. Its modular design allows it to be scaled from very small drainage areas to very large. Several large units can be installed "end-of-the line", connected in a parallel to treat very lager areas. Since the MWS-Linear is a horizontal flow biofilter it can accept inflow pipes several feet below the surface.

Include sizing chart or describe sizing criteria:

The MWS-Linear is sized using its TAPE approved loading rate of 1 gpm/sq ft of WetlandMedia surface area. This loading rate converts to an infiltration rate of 100 in/hr. The MWS-Linear is sized using the same method of other biofiltration BMPs traditionally used in the State of Virginia. As mentioned above, a sizing chart of the most popular models is included in appendix E, many other models are available. Sizing is for standard height units in a standalone design. The size of each model is the total footprint of the unit including pre-treatment chamber, biofiltration chamber and discharge chamber. There is no direct correlation between the foot print of the unit and surface area of the media since the MWS-Linear is a horizontal flow biofiltration system. Surface area per foot print area is much greater than downward flow biofilter systems.

The MWS-Linear can also be installed downstream of detention BMPs and thus can also utilize a volume based sizing method. The volume of runoff each model can treat will be dependent on required drain down times. For more information on volume based design please contact the manufacturer for sizing and configurations.

Intended application: on-line or offline:

The MWS-Linear was tested under the TAPE protocol with internal bypass. The MWS-Linear can be used in both online and offline application. The system utilizes a three chambered design including the pre-treatment chamber, biofiltration (wetland) chamber, and discharge chamber. The internal bypass feature allows runoff to be conveyed from the pre-treatment chamber directly to the discharge chamber without contact with the biofiltration chamber. This prevents scouring of previously captured pollutants in the biofiltration chamber.

Media used (if applicable):

WetlandMedia is a proprietary lightweight ceramic sorptive media blend. Unlike other biofiltration media it contains no organics which can leach nutrients. It also contains a layer of plant propagation media close to the surface to allow for faster plant propagation. This media is unique among biofiltration/bioretention BMPs.

5. Warranty Information:

The MWS-Linear is backed by a 5 year unlimited warranty. A copy of the warranty is provided in appendix A.

6. Treatment Type

Manufactured Bioretention System (horizontal flow)

Provide Infiltration Rate (in/hr): 100 in/hr which is equal to 1 gpm/sq ft media surface area.

NOTE: The MWS-Linear is TAPE approved for TSS and phosphorus at a loading rate of 1 gpm/sq ft surface area. It is also approved at the same loading rate for dissolved metals. It's the only BMP to have approval of all three at the same loading rate. It should be noted that approval be given to BMPs based upon their TAPE or other approved loading rate for phosphorus, and not an approval for phosphorus based upon approved loading rates of other protocols that only test for TSS.

7. Water Quality Treatment Mechanisms

- ☑ Sedimentation/Settling
- ☑ Infiltration – Optional
- ☑ Filtration – WetlandMedia
- ☑ Adsorption/Cation Exchange
- ☑ Chelating/Precipitation
- ☑ Chemical Treatment
- ☑ Biological Uptake

8. Performance Testing and Certification:

Performance Claim (include removal efficiencies for treated pollutants, flow criteria, drainage area):

The below removal efficiencies are averages of each pollutant from the TAPE field testing. The system was able to successfully meet target removal efficiencies at loading rates up to 1.21 gpm/sq media surface area. Sizing was done based upon Washington State sizing criteria to treat 91% of the annual rainfall. The MWS-L-4-13 with internal bypass was sized to treat 0.61 acres.

TAPE Removal Efficiencies:

- TSS Average Removal Efficiency – 85%
- Total Phosphorus Average Removal Efficiency – 65%
- Ortho-Phosphorus Average Removal Efficiency – 67%
- Total Kjeldahl Nitrogen Average Removal Efficiency – 45%
- Total Copper Average Removal Efficiency – 50%

- Total Zinc Average Removal Efficiency – 66%
- Dissolved Copper Average Removal Efficiency – 38%
- Dissolved Zinc Average Removal Efficiency – 50%
- Motor Oil Average Removal Efficiency – 95%

Specific size/Capacity of MTD assessed:

MWS-L-4-13 Vault Type with Internal Bypass sized at an orifice controlled loading rate of 1 gpm/sq ft of media (WetlandMedia). Surface area of the MWS-Linear is based upon the perimeter of the wetland cell multiplied by its height. Height can vary based upon site conditions.

Has the MTD been "approved" by an established granting agency, e.g. New Jersey Department of Environmental Protection (NJDEP) , Washington State Department of Ecology, etc.

☑ **Yes**; For each approval, indicate (1) the granting agency, (2) use level if awarded (3) the protocol version under which performance testing occurred (if applicable), and (4) the date of award, and attach award letter.

Washington State Department of Ecology
General Use Level Designation for:

- Basic Treatment (TSS) at 1 gpm/sq ft (100 in/hr)
- Phosphorus Treatment at 1 gpm/sq ft (100 in/hr)
- Enhanced Treatment (dissolved metals) at 1 gpm/sq ft (100 in/hr)

Tested Under: Technology Assessment Protocol – Ecology (TAPE) January 2011 Revision
Awarded in April 2014 – Award Letter (GULD) Attached in Appendix C.

Was an established testing protocol followed?

☑ **Yes**, (1) Provide name of testing protocol followed, (2) list any protocol deviations:

(1) Tested Under: Ecology (2011) in Technical Guidance for Evaluating Emerging Stormwater Treatment Technologies: Technology Assessment Protocol - Ecology (TAPE).

(2) No protocol deviations were made.

Provide the information below and provide a performance report (attach report):

For field tests:

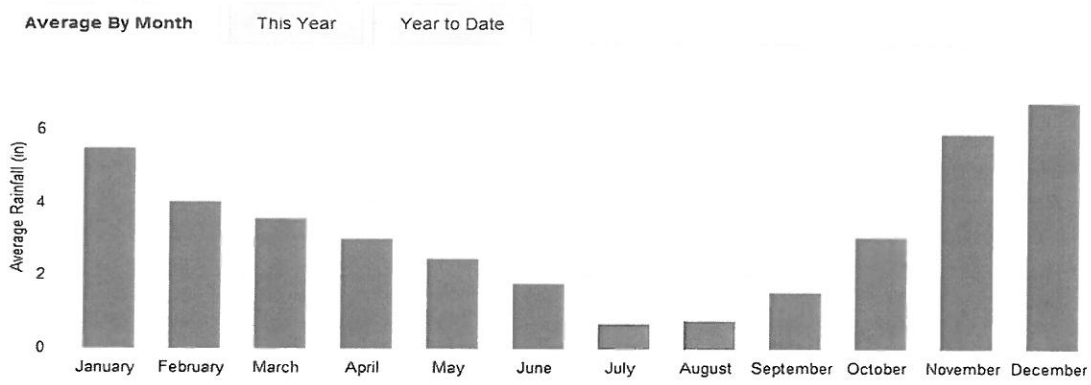
i. Provide the address, average annual rainfall and characterized rainfall pattern, and the average annual number of storms for the field-test location:

Albina Maintenance Facility - 3150 N Mississippi Avenue Portland, Oregon 97227.

Average annual rainfall – 42.9 inches (Portland Airport rain gauge). A comparison was done to the annual average rainfall in Richmond, VA which is 43.6 inches (http://average-

rainfall.findthebest.com/l/263/Richmond-Virginia). This shows that the MWS-Linear was tested in an area with almost identical annual rainfall totals. This strong correlation confirms that the MWS-Linear is tested in an area with similar rainfall to the state of Virginia. The annual average rainfall in Virginia is 44.39 inches.

Characterized rainfall pattern – Following is a monthly distribution of rainfall in Portland, OR:



A break down in the rainfall characteristics are provided below for the following locations:

Portland, OR – Avg. Event Duration – 15.9 hours, Avg. Event Intensity – 0.03 in/hr
Avg. Runoff – 0.48 in, Avg. Period Between Events – 122 hours
(Minton. 2011. Stormwater Treatment, Third Edition)

This was compared with information from two areas of Virginia.

Lynchburg, VA – Avg. Event Duration – 10.9 hours, Avg. Event Intensity – 0.09 in/hr
Avg. Runoff – 0.62 in, Avg. Period Between Events – 142 hours
(Minton. 2011. Stormwater Treatment, Third Edition)

Norfolk, VA – Avg. Event Duration – 9.9 hours, Avg. Event Intensity – 0.10 in/hr
Avg. Runoff – 0.67 in, Avg. Period Between Events – 138 hours
(Minton. 2011. Stormwater Treatment, Third Edition)

Average annual number of storms at field test location –

During the 14 month period of field testing there were a total of 81 storm events, this is in line with annual averages in this region.

Portland, OR – Avg. Annual Number of Storm Events - 70
(Minton. 2011. Stormwater Treatment, Third Edition)

Lynchburg, VA – Avg. Annual Number of Storm Events - 62
(Minton. 2011. Stormwater Treatment, Third Edition)

Norfolk, VA – Avg. Annual Number of Storm Events - 63
(Minton. 2011. Stormwater Treatment, Third Edition)

In general storm durations are lower and intensities higher in Virginia when compared to Oregon. With the exceptions of these differences, the annual rainfall and number of events are almost identical. In addition, since the rainfall intensity is generally higher in Virginia the amount of area a BMP will treat will be less. In general, the storm water quality treatment intensity in Virginia is about three times what it is in Oregon. Thus, it can be concluded that the overall loading on a BMP will be less as the total volume of runoff, a BMP will treat, will be about a third.

ii. Provide the total contributing drainage area for the test site, percent of impervious area in the drainage area, and percentages of land uses within the drainage area (acres):

The City of Portland Maintenance Facility includes a parking lot for trucks and heavy equipment as well as outdoor storage of stockpiles of rock and dirt debris and miscellaneous snow removal equipment. Stormwater from the parking area for trucks and heavy equipment on the south side of the facility is collected in a series of catch basins along the western edge of the lot. Estimated drainage area 0.61 acres based upon flow analysis. The site is greater than 90% pavement. The precise impervious coefficient was unknown due to the complexity of the site and multiple catch basins. Lack of curbing between pervious and impervious areas made it difficult to estimate how much pervious area drained to the impervious areas and ultimately the MWS-Linear.

iii. Describe pretreatment, bypass conditions, or other special circumstances at the test site:

The MWS-Linear consists of three chambers including the pre-treatment chamber, biofiltration (wetland) chamber and discharge chamber. The MWS-Linear for this test site was installed end-of-line downstream of several catch basins located on the test site. A diversion structure was placed upstream of the unit to divert flows to the system up to a certain level set by the top of diversion weir. No external pre-treatment was used since the MWS-Linear has its own internal pre-treatment chamber.

iv. Provide the number of storms monitored and describe the monitored storm events (amount of precipitation, duration, etc.):

81 qualifying storm events occurred from April 1, 2012, through May 31, 2013. During the April 14, 2012 through March 31, 2013 monitoring period, 28 storm events were sampled to characterize the water quality treatment performance.

Precipitation data from the sampled storm events was compared to the following TAPE storm event guidelines:

- Minimum precipitation depth: 0.15 inches
- Minimum antecedent dry period: 6 hours with less than 0.04 inches of rain
- Minimum storm duration: 1 hour
- Minimum average storm intensity: 0.03 inches per hour for at least half the sampled storms

Summary data related to these guidelines are presented in Appendix F for each of the 28 sampled storm events. This data shows the guideline for minimum precipitation depth (0.15 inch) was met during all storm events except the April 29, 2013 event, because it was determined that the precipitation gauge may have been overestimating rainfall by 17 percent. The minimum, median, and maximum precipitation depths across all 28 sampled storm events were 0.14, 0.51, and 2.27 inches, respectively. The guideline for minimum antecedent dry period (6 hours) was met for all 28 of the events. The storm duration criteria (1 hour) was also met for all 28 storm events except the April 19, 2013, event which was a short intense event lasting 0.3 hours. The April 19, 2013, event was included in the final analysis because it met other storm and sampling requirements. Antecedent dry periods during the sampled storm events ranged from 9.5 to 416.8 hours, with a median value of 33.3 hours. Storm durations ranged from 0.3 to 35.2 hours, with a median value of 10.0 hours.

v. Describe whether or not monitoring examined seasonal variation in MTD performance:

Detailed records were kept on each storm event over the duration of the field test. Upon analysis there was no statistical significance that seasonality has effect on removal efficiencies of monitored pollutants. See appendix F.

vi. If particle size distribution was determined for monitored runoff and/or sediment collected by the MTD, provide this information:

Particle size distribution was collected during the field test. Particle size distribution illustrations are provided in appendix F.

9. MTD History:

How long has this specific model/design been on the market?

The MWS-Linear has been on the market and in use since 2007.

List no more than three locations where the assessed model size(s) has/have been installed in Virginia. If applicable, provide permitting authority. If known, provide latitude & longitude:

Below is a list of MWS-L-4-13 models install in Virginia:

1. NASSCO Parking Lot - Corner of Relocated Ligon Street & Pearl Street – Norfolk, VA
2. Sheets Ruckersville - 1-61 Matthew Mill Rd – Ruckersville, VA
3. Holtzman Plaza - 1001 Friedens Church Rd – Mt. Jackson, VA

The MWS-Linear is available in various model sizes. All model sizes operate precisely the same. Larger units only have greater surface area and thus higher treatment flow capacities.

List no more than three locations where the assessed model size(s) has/have been installed outside of Virginia. If applicable, provide permitting authority. If known, provide latitude & longitude:

Below is a list of MWS-L-4-13 models install outside of Virginia:

1. Kent Corner (Popeyes) - 102nd Ave SE & SE 240th St – Kent, WA
2. City of Chula Vista Improvements – 144 First Ave. – Chula Vista, CA
3. Hoag Health Center - 19582 Beach Blvd – Huntington Beach, CA

The MWS-Linear has also been installed on various projects in Maryland, Pennsylvania, Texas & Florida among others. The MWS-Linear is also being utilized in Australia.

10. Maintenance:

What is the generic inspection and maintenance plan/procedure? (Attach necessary documents):

See attached appendix B. The MWS-Linear is a horizontal flow biofilter with a built-in pre-treatment chamber which prevents sediments, debris and oils from entering the biofiltration chamber and clogging the primary biofiltration media. This overcomes one of the main maintenance and performance challenges currently plaguing downward flow tree box systems, which offer no pre-treatment.

Routine maintenance of the MWS-Linear includes removing sediments and debris from the pre-treatment as needed. The pre-treatment chamber has very large storage capacities so maintenance on this chamber is needed once every 6 months on sites with very high loading. The pre-treatment chamber also houses pre-filter cartridges which prevent fine TSS and oils from migrating to the biofiltration chamber. As stated in the TAPE approval, all test sites are different and thus site specific maintenance requirements should be established based upon inspections during the first year.

Is there a maintenance track record/history that can be documented?

The MWS-Linear has been on the market since 2007 and has over 7 years of maintenance history. Records are available upon request from manufacturer.

Yes, track record exists; (provide maintenance track record, location, and sizing of three to five MTDs installed in Virginia [preferred] or elsewhere):

See appendix B for maintenance details of several units installed for many years.

Recognizing that maintenance is an integral function of the MTD, provide the following: amount of runoff treated, the water quality of the runoff, and what is the expected maintenance frequency for this MTD in Virginia, per year?

The MWS-Linear can be sized based upon state specific treatment goals. In the State of Virginia the MWS-Linear can be sized in flow OR volume based design to treat 90% of the annual runoff. Flow based sizing of the MWS-Linear can be done utilizing sizing methods already employed by other high flow tree box type systems as described below from Technical Bulletin 6:

> "To establish the sizing criteria the manufacturer has examined the rainfall distribution and frequency data from the mid-Atlantic region to size the filter surface area to treat 90% of the total annual rainfall volume. Pollutant removal data was also related to the filter surface area and drainage area relationships. The optimum filter surface area to drainage area ratio is 0.33%. For example, the required minimum size filter for ¼ acre of impervious surface would be 36 square feet of filter surface area."
>
> These numbers are based upon an infiltration rate of 100 in/hr (1 gpm/sq ft). The MWS-Linear along with another tree box system has TAPE GULD approval for phosphorus at this exact loading rate.

The MWS-Linear can also be sized using other flow based sizing criteria such as those currently employed by hydrodynamic separators or cartridge filter systems. Sizing of the MWS-Linear should always be done based upon regulations of the local jurisdiction.

The MWS-Linear can also be sized in a volume based design downstream, or integrated within an open or underground detention BMP. Due to the MWS-Linear's unique horizontal flow biofiltration technology it can accept inflow from detention systems several feet below finish surface. This allows the MWS-Linear to be used in a wide array of flow and volume based sizing methods.

The MWS-Linear was tested under the TAPE protocol in Portland, OR. The average amount of rainfall in Portland is almost identical to the average annual rainfall in Virginia. As such, it can be anticipated the average maintenance intervals will be similar. Maintenance procedures for sites with typical sediment loading will require removal of trash and debris once every 6 to 12 months and replacement of the media in the pre-filter cartridges once every 12 to 18 months.

Total life expectancy of MTD when properly operated in Virginia and, if relevant, life expectancy of media:

The life expectancy of the MWS-Linear is estimated at well over 50 years as the system structure is made of pre-cast concrete. All internal components are made of high-strength plastic and stainless steel. The system utilizes a pre-treatment chamber containing pre-filters to remove TSS and oils from migrating to the biofiltration chamber and therefore reducing the pollutant load on the media. It is estimated that the WetlandMedia contained within this chamber will last well over 10 years and up to 20 years before replacement is required. The WetlandMedia can also be backwashed and its surface cleaned if needed. This further extends is operational life. During TAPE testing the WetlandMedia demonstrated no loss in hydraulic conductivity over the duration of the field test. The media within the pre-filters will require replacement on average once per year.

For media or amendments functioning based on cation exchange or adsorption, how long will the media last before breakthrough (indicator capacity is nearly reached) occurs?

Since the MWS-Linear utilizes an advanced pre-treatment chamber containing pre-filters it is estimated the biofiltration chamber and its WetlandMedia can operate well over 10 years before breakthrough will occur. Most of the particulate pollutants and a portion of the dissolved nutrients and metals are captured by the media within the pre-filters therefore lessoning the load on the WetlandMedia.

For media or amendments functioning based on cation exchange or adsorption, how has the longevity of the media or amendments been quantified prior to breakthrough (attach necessary performance data or documents)?

The WetlandMedia is made of materials that contain various oxides. The oxides carry out the process of cation exchange to provide removal of dissolved metals and nutrients. The MWS-Linear received approval of enhanced treatment (dissolved metals) at a loading rate of 1 gpm/sq ft. This is the highest approved loading rate of any BMP with GULD approval for enhanced treatment. The system also was able to remove 67% of ortho-phosphorus during TAPE testing. This is the highest removal efficiency of any proprietary BMP ever tested under the TAPE protocol. This is attributed to the fact the WetlandMedia is 100% organic free. It is well known the organics can leach dissolved nutrients.

Secondly, the WetlandMedia is made of 100% cation exchange media as opposed to an inert media like sand mixed with a smaller percentage of cation exchange media commonly used in other biofilters. Therefore, the WetlandMedia has a larger cation exchange capacity than other biofiltration BMPs. The WetlandMedia also contains live vegetation with uptakes of nutrients and metals. The uptake of these pollutants acts as a cleaning mechanism between storm events, essentially removing nutrients and metals that have accumulated on the media. This further extends the cation exchange capacity of the WetlandMedia.

Analysis of the TAPE field test data did not indicate a reduction of removal efficiency during the duration of the monitoring. Some of the highest removal efficiencies occurred near the end of the 14 month monitoring indicating a ripening of the media. It is speculated that the biological attributes of the WetlandMedia had matured and improved performance. As beneficial bacteria colonized and establish within the media, and the plant's roots penetrate the biological processes of uptake, nitrification/denitrification become more prominent.

Is the maintenance procedure and/or are materials/components proprietary?

☑ No, not proprietary

Maintenance complexity (check all that apply):

Confined space training required for maintenance (only for underground models or units deeper than standard height.

Liquid pumping and transportation
Specify method: n/a

☑ Solids removal and disposal
Specify method: removal by hand or with vacuum truck

Other noteworthy maintenance parameter (describe):

The MWS-Linear pre-treatment chamber captures and stores TSS, oils, debris, trash, and other particulate pollutants preventing it from migrating to the biofiltration (wetland) chamber thereby significantly reducing the maintenance requirements of the primary filtration mechanism. The pre-treatment chamber contains pre-filter cartridges that require routine media requirements. Vegetated units require annual trimming of plants.

11. Comments

Include any additional explanations or comments:

It should be noted that TAPE requires TSS and Total Phosphorus be tested together. A technology tested under the protocol must prove to remove more than 80% of TSS and greater than 50% total phosphorus. Approval of BMPs under this evaluation for the State of Virginia should ensure the TAPE approved loading rate for phosphorus be a condition for BMPs seeking up to 50% phosphorus removal. Sizing of the BMP should be done only under the approved loading rate. It should be ensured that BMPs that have both NJ CAT testing and TAPE phosphorus approval not be allowed to substitute their higher NJ CAT approved loading rate for the TAPE approved GULD issued phosphorus loading rate. Appendix D provides tables of the TAPE GULD approved loading rates for BMPs with phosphorus approval.

12. Certification

Signed by the company president or responsible officer of the organization:

"I certify that all information submitted is to the best of my knowledge and belief true, accurate, and complete."

Signature: _____

Name: ZACHARIHA KENT

Title: Engineer

Date: 5/27/2014

NOTE: All information submitted to the department will be made publically accessible to all interested parties. This MTD registration form will be posted on the Virginia Stormwater BMP Clearinghouse website.