Performance Enhancing Devices for Stormwater BMPs

Water Treatment Residuals

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Roadside Ditch Management & PEDs

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Water Treatment Residuals (WTRs)

1. Definition & Applications

WTRs are the residuals from the drinking water treatment process. The material consists largely of solids derived from the raw water source, as well as flocculants used to promote settling of the solids. The flocculants typical consist of alum as well as an aluminum polymer (Polymeric Flocculant). Depending on the treatment plant, WTRs can also contain other water treatment by-products, including fluoride, filter backwash, lime, and/or activated carbon. The by-products can also contain small amounts of zinc or ortho-phosphorus.

Most treatment plants consider WTRs to be a by-product that must be hauled away, disposed of, or used for other purposes, such as land application. Using WTRs for stormwater could provide an alternative beneficial use.

WTRs can be used as an amendment to incorporate into roadside ditches or to blend into soil media used in other stormwater BMPs, such as bioretention and dry swales. WTRs can be incorporated into BMP retrofits where soil media will be added or replaced as part of the retrofit process (e.g., converting older practices or adding bioretention to a dry pond). Research indicates that WTRs can enhance a BMP's effectiveness in removing dissolved forms of phosphorus, and may have benefits for other pollutants (Hirschman et al., 2017).

See **Section 7** for a list of qualifying conditions in order for WTR amendments to qualify for enhanced nutrient removal as a performance enhancing device (PED).

2. Source Selection & Procurement

As almost every drinking water treatment plant generates WTRs, there are abundant opportunities to collect the product. Selecting an appropriate source requires some up-front investigation. The following considerations apply to selecting an appropriate source:

- The preferred WTRs will consist of raw water source solids and flocculants, and not a lot of additional by-products, especially those like ortho-P that would be detrimental for stormwater applications.
- The plant has a process to dry the material. The most effective process may be centrifuges, but many plants also use belt presses. For the plant, the purpose of drying the material is to allow it be hauled away in trucks. Some plants stockpile the material on-site for limited amounts of time, which allows for additional drying. At the plant, WTRs have the consistency of *play-dough*, but will continue to dry out if left exposed to air for several days. The dried material will have hardened blocks or clumps mixed with sand and fines. For stormwater applications, the vendor or party responsible for mixing into the soil media should ensure that the material can be incorporated evenly into the other soil mix components.
- The WTRs are relatively close to the application (e.g., location where the soil media is mixed) to reduce haul costs.
- Collecting and transporting WTRs can be authorized through the permits or contracts that the drinking water utility may hold with regulatory agencies (for handling/disposal) or third-party vendors (for alternative uses).

Visiting the plants and interviewing the managers and operators is recommended. Beyond finding suitable material, there are likely administrative steps and coordination with the local water utility. Many will have existing hauling contracts in place or other end-uses for the WTRs and permits from state regulatory agencies for handling the material. It will take some time to work through the process to obtain the WTRs in sufficient quantities for the intended application.

Several questions to ask the water utility manager include:

- What materials besides solids from the water source and alum go into the residuals ?
- What is being done with the existing WTRs? Are there contracts in place for hauling, disposal, and/or some other beneficial use?
- Is there a drying process? If so, what is it and is the average percent dry solids known? Is the processed (post-drying) material stored on-site for some length of time?
- On average, how much is generated on a daily basis? Are there seasonal differences or major differences in composition depending on weather events?
- Are environmental permits in place for handling, hauling, or disposal of the material? If so, what is the regulatory agency that manages the permit?
- What would be the process for obtaining occasional loads to use for stormwater applications? Who would be in a position to approve such a use?

The feasibility of using a certain WTR source will derive from these questions and additional follow-up discussions.

3. Material Testing

Representative samples of WTRs to be used for stormwater applications should be tested at a certified laboratory to confirm content. The purpose of testing is to ensure that the material has enough of the advantageous parameters (e.g., reactive aluminum) and acceptable levels of constituents that may have negative consequences for vegetation and/or receiving waters (e.g., zinc, phosphorus, soluble salts).

Another reason for testing is to check the fractions of sand, silt, and clay, and the texture classification so that soil media vendors (or those responsible for mixing the soil media component materials at sites) can incorporate the appropriate fraction of WTRs while meeting overall state-specific soil media specifications.

Table WTR-1 lists a variety of parameters that can be commonly tested at certified laboratories, and the expected ranges for WTRs. The ranges in the table are derived from WTR testing at three drinking water treatment plants across the Bay Watershed. Note that the ranges are expected values, but WTRs in other localities may not be within these ranges, as WTRs will vary based on the source water and the treatment process. This does not necessarily mean that the material is unacceptable for use, but may trigger a discussion with the plant manager or operator to see why a value may appear to be high or low. Weather conditions will also affect the results, so testing several times per year is recommended. A qualified soil scientist can also be consulted about results from a particular drinking water plant.

The table also provides notes, such as state soil media specifications for a particular parameter in the <u>total mix</u>. This refers to the standards that must be met once the sand, fines, and organic matter are blended together. This information may be relevant because soil media vendors will have to account for WTR components to ensure that the total mix still meets the relevant standards. In addition to ensuring the correct particle size distributions and other testing for the total mix, vendors may also want to conduct some type of permeability test on the mix to ensure adequate drainage though the media (e.g., ASTM D2434, which is currently expired, adapting ASTM E2396 used to measure permeability for green roofs, or perhaps a simpler equivalent). It is very important to know permeability of the media under various conditions, and thus field performance of the product.

Table WTR-1. Expected Ranges for WTRs

Parameter	**Expected Range[1]**	**Notes[2]**
Aluminum (ppm)	1800 – 3000; most will in 2500 range	This is aluminum content but not necessarily aluminum that is reactive (available for sorption of pollutants); further research is needed to develop common methods for isolating reactive Al.
Sand (%)	45 -- 80	State specifications for <u>total mix</u> have high sand content: 75 to 90%.
Silt (%)	20 -- 55	State specifications for <u>total mix</u> generally 10 – 20% fines & maximum of 10% clay.
Clay (%)	1 -- 7	
Texture Classification	Sandy Loam, Loamy Sand, or Silt Loam	Largely depends on solids from raw water source and perhaps recent weather/turbidity of source water.
Organic Matter (%) ASTM D2974	27 -- 45	State specifications can range from 1.5 to 4% by weight (Walkley-Black method) in <u>total mix</u>, although there is some debate about the efficacy of this standard and the long-term fate of OM in the media. In any case, vendors should anticipate OM from WTRs if mixing in.
Dry Solids (%)	18 -- 27	
pH	6.8 – 7.5	
Nitrogen Release (lb/A)	Approx. 130	
Mehlich III Extractable (ppm of P)	2 -- 5	Some state specifications for <u>total mix</u> are 18-40. The WTR values in this table are low, and would be expected to range based on the source water, weather, etc.
Calcium (ppm)	600 -- 2300	May be higher in areas with limestone or where lime is added to residuals for odor control.
Magnesium (ppm)	50 – 380	
Potassium (ppm)	30 -- 60	
Sodium (ppm)	60 -- 85	

Table WTR-1. Expected Ranges for WTRs		
Parameter	**Expected Range[1]**	**Notes[2]**
Iron (ppm)	40 -- 80	
Zinc (ppm)	1 – 14	
Soluble Salts (mmhos/cm)	0.15 – 0.30	MD specification for total mix is < 500 ppm (approx. 0.8 mmhos/cm).
Dry Loose Bulk Density (dried, ground, sieved) (g/cm3)	0.60 – 0.80	Lab methods vary, so values will also vary depending on method.

[1] Ranges were derived from testing of WTRs in Washington D.C., Richmond, VA, and Charlottesville, VA. WTRs in other localities may deviate from these values. In cases where there are significant deviations, it is recommended to discuss the values with the plant manager or operator.
[2] Column includes information on general ranges for the total mix of soil media. Depending on the specification, the total mix includes sand, fines, and organic matter in specific proportions. The values noted for a given parameter do not apply to every Bay jurisdiction, so it advised to check state-specific specifications to check if certain ranges apply for a given parameter.

4. Mixing The Material

Various research studies have recommended using WTRs at 5% by mass or 10 to 12% by volume. There is likely not enough research to hone in on an exact recommended ratio. Ten percent by volume seems like a supportable number for initial stormwater applications.

There are two ways to incorporate WTRs into a media mix:

1. Blend the WTRs as a soil media component into the other components. This means that the WTRs would be more-or-less consistently blended throughout the media. This method may be the most straight-forward for vendors that supply a "finished" product at the point of use. It also means, theoretically, that adsorption would take place throughout the soil media column.
2. Incorporate the WTRs into the top 12 to 16 inches of soil media at the site. This would assume that the WTRs are supplied to the site independent from the soil media and would need to be tilled in by the contractor. This is probably less desirable from the perspectives of construction process and quality control. The engineer of record would have to specify the amount of each material (soil media and WTRs), the incorporation method, and how the finished mix would meet state-specific specifications. However, research does indicate that blending WTRs into the top layer of soil media can be effective for removal of dissolved forms of phosphorus (Liu & Davis, 2014).

5. Risks

WTRs appear to have minimal risks. Potential risks include potential leaching of aluminum oxides into receiving waters, WTRs affecting hydraulic conductivity of the soil media (e.g., slow drainage or clogging), and aluminum affecting plant growth and development.

For the first concern, aluminum mobility is associated low pH environments (e.g. < 5), and stormwater tends to be only slightly acidic. As a general rule, pH levels greater than 5.5 should be maintained over time to reduce the risk of leaching, and periodic monitoring is warranted to test for aluminum oxides/polymers in the underdrain discharge. With regard to hydraulic conductivity, there is currently no evidence that WTRs would affect the ability of water to drain through the soil media. Most WTRs consist largely of sand and silt, so compositions are fairly consistent with the overall soil media.

Aluminum can certainly stress plant growth and development in acidic soils, so the pH of the combined soil media should be a screening criteria. Based on the values in **Table WTR-1**, WTR pH ranges from slightly acidic to slightly alkaline. If these values hold true for other WTR sources, plant toxicity should not be large concern.

Aluminum leaching, potential clogging, and potential plant toxicity should be monitored and evaluated as WTR amendments become more widely applied.

6. O&M Considerations

At this point, there are not enough field applications to indicate that vegetation plans or O&M procedures would change due to the addition of WTRs. Again, this may change as applications spread throughout the Bay Watershed. One possible O&M issue is "recharging" the WTRs as practices age and vegetation has to be removed and replaced. Some research indicates that WTR sorption lifespans may be as long as the practice itself, but there is certainly a possibility that sorption capacities would decrease over time.

For a practice that is undergoing major repairs, it would be worth considering removing the top layer of soil and replacing with a clean mix that contains new WTRs. Also, BMPs in the Bay Watershed must undergo a verification process to ensure the BMP is still present and performing as designed (CSN, 2014). This verification is intended to take place every two permit cycles for MS4s, or every 9-10 years. For practices with WTRs, this would be an ideal time to retest the soil media and ensure that (reactive) Aluminum and other key constituents are still present (see Table WTR-1) and to possibly add new WTRs to the top layer of media. Since there is not a long track record of WTR use, this procedure would generate valuable data on the longevity of WTRs in a blended media.

7. Qualifying Conditions for WTR as a PED

The following conditions summarize the use of WTRs to qualify for the PEDs pollutant removal credit:

- Sourced from appropriate water treatment plant using guidance from Section 2 of this fact sheet; material must be dried before mixing into soil media.
- Material tested as per Section 3 and Table WTR-1; note that the constituent ranges are based on limited testing, and professional judgement (e.g., soil scientist) should be used to evaluate specific results.
- Incorporate into soil media at 10% by volume; preferred mixing by qualified vendor using appropriate mixing equipment.
- Detailed O&M plan that addresses monitoring of health of vegetation to include possible signs of Aluminum toxicity, adaptive management of vegetation, and possible "recharging" of WTRs, as per Section 6.

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References

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Graphics

Figure WTR-1. Centrifuges used to dry WTRs at a water treatment plant

Figure WTR-2. Post-centrifuge WTRs being loaded onto contractor trucks to haul away for land application

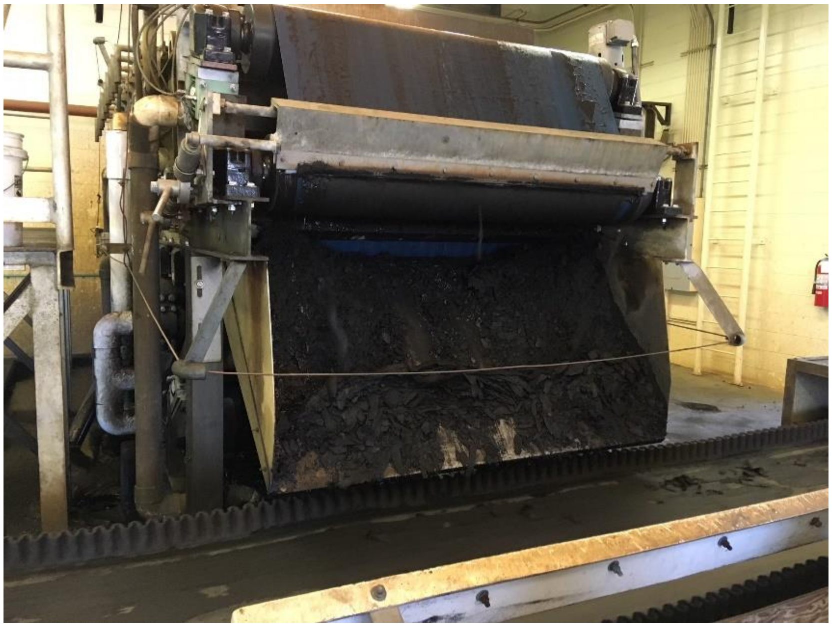

Figure WTR-3. Belt press used to dry WTRs at a smaller water treatment facility

Figure WTR-4. Stockpiled WTRs awaiting transport, which allows for some extra drying time