# 4.4.4 Alum Treatment System

**Limited Application Stormwater BMP**

**Description**: Alum treatment systems provide chemical treatment of stormwater runoff by means of adding liquid aluminum sulfate (alum) to sediment-laden runoff. The alum combines with phosphorus, heavy metals and suspended solids, causing them to settle-out of suspension.

## KEY CONSIDERATIONS

**DESIGN GUIDELINES:**

- Intended for areas requiring regional stormwater treatment from a piped stormwater drainage system where general application BMPs are not feasible.
- Typical drainage area > 50 acres.
- Typically consists of mechanical/electrical dosing system, chemical storage facilities, a downstream settling pond and floc drying beds.

**ADVANTAGES / BENEFITS:**

- High pollutant removal capability.
- Can be used as a regional stormwater treatment BMP.

**DISADVANTAGES / LIMITATIONS:**

- High capital, operations and maintenance costs.
- Requires more frequent maintenance than most other stormwater treatment controls.
- Generally, not cost effective for small sites.
- Potential for stormwater quality impacts must be evaluated prior to design/use of the system.

**MAINTENANCE REQUIREMENTS:**

- Requires trained system operator.
- Restock chemicals frequently.
- Inspect and maintain all components on a frequent, routine basis.
- Remove floc build-up from settling pond.

## STORMWATER MANAGEMENT SUITABILITY

- [x] **Water Quality**
- [ ] **Channel/Flood Protection**
- [ ] **Overbank Flood Protection**
- [ ] **Extreme Flood Protection**

## FEASIBILITY CONSIDERATIONS

| | |
|---|---|
| L | **Land Requirement** |
| H | **Capital Cost** |
| H | **Maintenance Burden** |

**Residential/Subdivision Use:** *No*

**High Density/Ultra-Urban:** *Yes*

**Drainage Area:** *50 acres minimum*

## POLLUTANT REMOVAL

| | |
|---|---|
| H | **Total Suspended Solids** |
| M | **Nutrients**: Total Phosphorus / Total Nitrogen |
| H | **Metals**: Cadmium, Copper, Lead, and Zinc |
| H | **Pathogens**: Coliform, Streptococci, E.Coli |

**L**=Low **M**=Moderate **H**=High

#### 4.4.4.1 General Description

The process of alum (aluminum sulfate) treatment provides treatment of stormwater runoff from a piped stormwater drainage system entering a wet pond by injecting liquid alum into storm sewer lines on a flow-weighted basis during rain events. When added to runoff, liquid alum forms the harmless precipitates of aluminum hydroxide [$Al(OH)_3$] and aluminum phosphate [$AlPO_4$]. These precipitates combine with phosphorus, suspended solids and heavy metals, which then settle-out in a downstream capture pond.

An alum treatment system generally consists of three parts: a flow-weighted dosing system that fits inside a storm sewer manhole; remotely located alum storage tanks; and a downstream settling pond that allows the alum, pollutants and sediments to settle out. (Kurz, 1998). Disposal of the floc that settles in the downstream pond is critical, because of the concentration of dissolved chemicals, and also because bacteria and viruses remain viable in the floc layer (Kurz, 1998). In addition to the settling pond, a separate floc collection pump-out facility should be installed to further reduce the chance of resuspension and transport of floc to receiving waterbodies. The pump disposes the floc into the sanitary sewer system or onto nearby upland areas or sludge drying beds. Permits (from the local utility) will be required to pump to the sanitary sewer, however. The quantity of sludge produced at a site can be as much as 0.5 percent of the volume of water treated (Gibb et al., 1991). Figures 4-66 and 4-67 provide photographs of an alum treatment system settling pond and dosing/injection system, respectively.

**Figure 4-66. Settling Pond for Alum Treatment System**
(Source: Georgia Stormwater Management Manual)

**Figure 4-67. Dosing/Injection Components of an Alum Treatment System**
(Source: Georgia Stormwater Management Manual)

The precipitate that is formed when alum is injected into the stormwater system is stable in sediments and will not re-dissolve due to changes in redox potential or pH under conditions normally found in surface water bodies. Laboratory or field testing may be necessary to verify feasibility and to establish design, maintenance, and operational parameters, such as the optimum coagulant dose required to achieve the desired water quality goals, chemical pumping rates and pump sizes.

Alum treatment systems can be expensive to construct and maintain. Capital construction costs depend primarily on the number of outfall locations treated rather than the size of the area draining to the system. Operations and maintenance expenses include costs for chemicals, power to the system, manpower for routine inspections and maintenance, and equipment renewal and replacement costs. In addition, regulatory agencies or wastewater utilities may require long-term monitoring of water quality downstream of alum treatment systems, which further increases maintenance costs.

#### 4.4.4.2 Stormwater Management Suitability

Alum treatment systems are designed primarily for large watersheds. They are designed solely for the purpose of treating stormwater quality and do not have the ability to provide channel or flood protection.

#### 4.4.4.3 Pollutant Removal Capabilities

The following design pollutant removal rates are conservative average pollutant reduction percentages for design purposes derived from sampling data, modeling and professional judgment.

- Total Suspended Solids – 90%
- Total Phosphorus – 80%
- Total Nitrogen – 60%

- Heavy Metals – 75%
- Pathogens – 90%

For additional information and data on pollutant removal capabilities for alum treatment systems, see the National Pollutant Removal Performance Database (2nd Edition) available at www.cwp.org and the International Stormwater Best Management Practices (BMP) Database at www.bmpdatabase.org.

#### 4.4.4.4 Application and Site Feasibility Criteria

The following basic criteria should be evaluated to ensure the suitability of an alum treatment system for meeting stormwater management objectives on a site or development.

General Feasibility

- Well-suited for large drainage areas that discharge into a closed body of water (e.g., a lake or pond).
- Suitable for use in high density/ultra-urban areas.
- Suitable for use as a regional stormwater control.

Physical Feasibility - Physical Constraints at Project Site

- Drainage Area – Typically 50 acres minimum for an alum treatment system.

#### 4.4.4.5 Planning and Design Standards

Alum treatment systems are fairly complex, and design details are beyond the scope of this manual. Further information can be obtained from the Internet and by contacting engineers who have designed and implemented successful systems. The Director of Engineering and Public Works (the Director) shall have the authority to set the design conditions for alum treatment systems on a case-by-case basis.

The following information is provided as guidance for the design of alum treatment systems.

- Injection points should be 100 feet upstream of discharge points.
- Alum concentration is typically 10 $\mu$g/l.
- Alum treatment systems may need to control pH.
- For new pond design, the required size is approximately 1% of the drainage basin size, as opposed to 10 to 15% of the drainage basin area for a standard detention pond.
- No volume requirement is required when discharging to existing lakes.

### 4.4.4.6 Inspection and Maintenance Requirements

**Note: Section 4.4.4.6 and the operation and maintenance document supplied by the alum system designer must be included in the Operations and Maintenance Plan that is recorded with the deed.**

Regular inspection and maintenance is critical to the effective operation of an alum treatment system as designed. It is the responsibility of the property owner to maintain all stormwater BMPs in accordance with the minimum design standards and other guidance provided in this manual. The Director has the authority to impose additional maintenance requirements where deemed necessary.

This page provides guidance on maintenance activities that are typically required for alum treatment systems, along with a suggested frequency for each activity. Individual alum treatment systems may have more, or less, frequent maintenance needs, depending upon a variety of factors including the occurrence of large storm events, overly wet or dry (i.e., drought) regional hydrologic conditions, and any changes or redevelopment in the upstream land use. Each property owner shall perform the activities identified below at the frequency needed to maintain the alum treatment system in proper operating condition at all times. Inspections and maintenance of the alum treatment system must be performed by a trained system operator..

| Inspection Activities | Suggested Schedule |
|---|---|
| • Dosing equipment – monitor dosage of alum and other chemicals. Also monitor the expected flows through the system.<br>• Perform routine inspection of dosing equipment and pump-out facility to ensure that all equipment is in proper operating condition.<br>• Inspect dosing equipment and storage facility for signs of leaks or spills.<br>• Inspect chemical amounts and restock if needed.<br>• Monitor pH and other parameters in the settling pond to determine potential negative impacts to receiving waters.<br>• Inspect settling pond for signs of damage, impending failure, poor water quality.<br>• Inspect storage capacity of settling pond and floc drying beds (if used). | Monthly or more frequently |
| **Maintenance Activities** | **Suggested Schedule** |
| • Adjust the dosage of alum and other chemicals and possibly regulate flows through the basin to ensure proper dosage and delivery of runoff to the settling pond.<br>• Perform maintenance and repair of pump equipment, chemical supplies and delivery system.<br>• Dredge settling pond and properly dispose of accumulated floc. | As Needed |

Knox County encourages the use of the inspection checklist presented below for guidance in the inspection and maintenance of the alum treatment system. The Director can require the use of this checklist or other form(s) of maintenance documentation when and where deemed necessary in order to ensure the long-term proper operation of the treatment system. Owners of alum treatment systems are encouraged to provide additional inspection/maintenance items to ensure the long-term proper operation of the treatment system. Questions regarding inspection and maintenance should be referred to the Knox County Department of Engineering and Public Works, Stormwater Management Division.

## INSPECTION CHECKLIST FOR ALUM TREATMENT SYSTEMS

Location: ______________________________________________ Owner Change since last inspection? Y N

Owner Name, Address, Phone: ______________________________________________

Date: __________ Time: ____________ Site conditions:______________________________________

| Inspection Items | Satisfactory (S) or Unsatisfactory (U) | Comments/Corrective Action |
|---|---|---|
| **Dosing System** | | |
| Dispensing proper dose? | | |
| Signs of leaks or spills? | | |
| In proper operating condition? | | |
| **Chemical Storage Facility** | | |
| Signs of leaks or spills? | | |
| Proper delivery of chemicals to dosing system? | | |
| In proper operating condition? | | |
| **Settling Pond** | | |
| pH and water quality condition? | | |
| Erosion on embankment? | | |
| Animal burrows in embankment? | | |
| Cracking, sliding, bulging of dam? | | |
| Blocked or malfunctioning drains? | | |
| Leaks or seeps on embankment? | | |
| Obstructions of spillway(s)? | | |
| Clear of debris and functional? | | |
| Sediment/floc accumulation? | | |
| Condition of concrete/masonry? | | |
| Metal pipes in good condition? | | |
| Control valve operation? | | |
| Pond drain valve operation? | | |
| Channels/spillways function, not eroding? | | |
| Other (describe)? | | |
| Other (describe)? | | |
| **Hazards** | | |
| Have there been complaints from residents? | | |
| Public hazards noted? | | |

If any of the above inspection items are **UNSATISFACTORY**, list corrective actions and the corresponding completion dates below:

| Corrective Action Needed | Due Date |
|---|---|
| | |
| | |
| | |
| | |
| | |

Inspector Signature:______________________________ Inspector Name (printed)__________________________

#### 4.4.4.7 References

Atlanta Regional Council (ARC). *Georgia Stormwater Management Manual Volume 2 Technical Handbook.* 2001.

Gibb, A., B. Bennet, and A. Birkbeck. *Urban Runoff Quality and Treatment: A Comprehensive Review*. Prepared for the Vancouver Regional District, the Municipality of Surrey, British Columbia, Ministry of Transportation and Highways, and British Columbia Ministry of Advanced Education and Trainiing. Document No. 2-51-246(242), 1991.

Harper, H.H. and J.L. Kerr. *Design, Alum Treatment of Stormwater Runoff: The First Ten Years.* Environmental Research and Design, Orlando, Florida, 1996.

Kurz, R. *Removal of Microbial Indicators from Stormwater Using Sand Filtration, Wet Detention, and Alum Treatment Best Management Practices.* Southwest Florida Water Management District, Brooksville, Florida, 1998.

*www.stormwaterauthority.org/assets/alum%20injection.pdf*

#### 4.4.4.8 Suggested Reading

Center for Watershed Protection. *Manual Builder.* Stormwater Manager's Resource Center. *www.stormwatercenter.net*

Maryland Department of the Environment. *Maryland Stormwater Design Manual, Volumes I and II.* Prepared by Center for Watershed Protection (CWP), 2000.

US EPA. *Storm Water Technology Fact Sheet: Sand Filters.* EPA 832-F-99-007. Office of Water. 1999.

Walker, W. *Phosphorus Removal by Urban Runoff Detention Basins.* Lake and Reservoir Management, North American Society for Lake Management, 314, 1987.

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