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Best Management Practices for Chemical Treatment Systems for Construction Stormwater and Dewatering

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16. Abstract

Chemical treatment systems (CTS) are implemented in areas where traditional, physical erosion and sediment control practices will not meet water quality goals for construction site runoff. The purpose of CTS is to reduce the amount of suspended sediment which would be released using conventional erosion control systems. The primary mechanism is the introduction of chemical flocculants into runoff, resulting in a binding of the suspended clays and silts together into larger particles which settle more quickly or can be filtered from the stormwater. Flow control through CTS is of vital importance for the proper dosing of stormwater runoff. All normal hydrologic analyses must be done to insure that reasonable peak flows are accounted for along with typical flows from designed storm events. Once analysis is adequately addressed, then the project can deal with the complexities of design and dose rate requirements.

The overall objectives of this book are twofold. First, it is designed to provide a technically credible basis for best management practices for the use of CTS for turbidity reduction on road construction projects. Secondly, it is designed to identify the most important variables to address when selecting chemical treatment best management practices for a particular site.

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Best Management Practices
for
Chemical Treatment Systems
for
Construction Stormwater and Dewatering

Technology Deployment Program
Western Federal Lands Highway Division
Federal Highway Administration
610 East 5th St.
Vancouver, WA 98661

SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yard	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
		NOTE: volumes greater than 1000 L shall be shown in m^3		
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
		TEMPERATURE (exact degrees)		
°F	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	°C
		ILLUMINATION		
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2
		FORCE and PRESSURE or STRESS		
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
		TEMPERATURE (exact degrees)		
°C	Celsius	1.8C+32	Fahrenheit	°F
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	foot-Lamberts	fl
		FORCE and PRESSURE or STRESS		
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

*SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380. (Revised March 2003)

List of Acronyms

BMPs	Best management practices
CTS	Chemical treatment systems
DADMAC	Diallyldimethyl ammonium chloride
EPA	Environmental Protection Agency
ESC	Erosion and sediment control
NPDES	National Pollutant Discharge Elimination System
NTU	Nephelometric Turbidity Unit
PAM	Polyacrylamide
SWPPP	Stormwater Pollution Prevention Plan
TSS	Total Suspended Solids

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Section 1 Introduction

Chemical treatment systems (CTS) are implemented in areas where traditional, physical erosion and sediment control practices will not meet water quality goals for construction site runoff. They are not intended to replace traditional erosion and sediment control (ESC) practices, which are the most important and cost-effective approaches to reducing sediment loads in stormwater discharge.

The purpose of CTS is to reduce the amount of suspended sediment which would be released using conventional erosion control systems. This sediment consists of clays and fine silts which are very slow to settle even under ideal conditions in settling basins. The primary mechanism is the introduction of chemical flocculants into runoff, resulting in a binding of the suspended clays and silts together into larger particles which settle more quickly or can be filtered from the stormwater.

Flow control through CTS is of vital importance for the proper dosing of stormwater runoff. All normal hydrologic analyses must be done to insure that reasonable peak flows are accounted for along with typical flows from designed storm events. Once analysis is adequately addressed, then the project can deal with the complexities of design and dose rate requirements.

Proper dosing, mixing, and settling time are needed for CTS to be effective. Also, matching the right flocculant to a specific sediment and water chemistry is important. In addition, disposal and final stabilization of the flocculated materials must be planned for in advance and monitored during system operation.

These best management practices (BMPs) focus on the design and use of active CTS, and do not directly address the use of passive systems. Active systems involve treating pumped stormwater using chemicals that are metered into the flow at a known dose rate. Passive systems use the flow of stormwater to dissolve the flocculant from a solid form (blocks, granules, socks, etc.) prior to a mixing and settling system. While the use of passive systems is not generally discouraged, this document is focused on active systems only.

Section 2 Rationale for Choosing Chemical Treatment Systems (CTS)

Sedimentation ponds are commonly used to treat construction site runoff prior to discharge, but they are only effective at removing larger particles by gravity settling. Smaller particles, such as clay and fine silt, tend to remain in suspension for a longer duration than typical design retention times for sedimentation ponds. Chemical treatment can reliably provide exceptional reductions of turbidity and associated pollutants and *should be considered where turbid discharges to sensitive waters cannot be prevented using other traditional BMPs*.

Chemical treatment involves the application of chemicals to stormwater to aid in the reduction of turbidity caused by fine suspended sediment. The technology is used to treat stormwater from temporary construction sites, as opposed to permanent stormwater treatment facilities.

Typically, chemical treatment (flocculant) is limited to waters with turbidity limits or other water quality standards. However, at times, there may be no regulatory reason to deal with turbid water, but there may be aesthetic, social, or political reasons to reduce sediment discharge and resulting turbidity in receiving waters.

The following are situations where CTS may be needed:

1. Sediment Retention Pond — Chemical treatment is an enhancement option when a pond of a required size or design cannot be constructed or is otherwise not sufficient to control turbidity. This may occur because of topographical constraints, difficult foundation conditions, or the presence of natural habitats of ecological value.
2. Physical Characteristics of Sediment Retention Pond — In some situations a pond of a required volume can be accommodated but the design of the pond cannot be optimized in terms of shape, depth, location of inlet and outlet, or energy attenuation of the inflow.
3. Soil Type — Most soils contain sufficient clay and silt to produce substantial turbidity in runoff. However, some soil types produce suspended sediment in stormwater runoff which is particularly difficult to settle in typical sediment retention ponds due to particle size and charge.

4. Sediment Generation Potential of Earthwork Area — In areas with highly erodible soils or steep long slopes, there is a high risk of increased erosion and sediment runoff from rainstorm events.
5. Use of the Earthwork Site & Construction Schedule — Some common uses of earthwork sites, particularly repeated machinery movements (e.g., on haul roads) can result in high sediment loadings in stormwater. Large areas of disturbance which cannot be stabilized with ground covers due to operational constraints will likely generate significant turbidity in stormwater runoff.
6. Performance of the Sediment Retention Pond — If a sediment retention pond does not perform adequately, addition of chemical flocculants may improve performance.
7. Construction Dewatering — Dewatering activities from construction sites, such as pumping accumulated water from excavation areas, can produce highly turbid discharge water, as distinguished from stormwater.

Section 3 Design for CTS

Approvals

1. The use of chemical treatment must have the advanced, written approval of the appropriate permitting authority in your particular state. For Federally authorized projects, this will be the Environmental Protection Agency (EPA) or an EPA designated agency.
2. The intention to use chemical treatment shall be indicated on the notice of intent for coverage under the construction general permit. Chemical treatment systems should be designed as part of the construction Stormwater Pollution Prevention Plan (SWPPP) or non-National Pollutant Discharge Elimination System (NPDES) equivalent, not after the fact.
3. Chemical treatment may be used to correct problem sites (i.e., CTS were not originally planned). The contractor must submit a plan to use CTS and receive formal written approval from the appropriate permitting authority prior to use.

Criteria for Chemical Treatment Product Use

Chemically treated stormwater discharged from construction sites must be non-toxic to aquatic organisms. The following protocol should be used to evaluate chemicals proposed for stormwater treatment at construction sites. Authorization to use a chemical in the field based on this protocol does not relieve the applicant from responsibility for meeting all discharge standards and receiving water quality criteria.

1. Treatment chemicals must be approved for use by the local or state permitting authority. Petroleum-based emulsions or carriers are prohibited.
2. Treatment chemicals must have already passed aquatic toxicity testing protocols, and so do not need to be reevaluated. Contact the appropriate permitting authority for a list of treatment chemicals that have been, or may be approved for use.
3. Prior to authorization for field use, jar tests shall be conducted in order to demonstrate that turbidity reduction necessary to meet the receiving water quality criteria can be achieved. Test conditions, particularly the dosage, should be indicative of field conditions. Although these small-scale tests cannot be expected to reproduce actual performance under all field conditions, they are indicative of treatment capability and indicative of various chemical dose rates required for effective treatment.

Treatment System Design Elements

Good erosion and sediment control practices should always be part of the overall stormwater management plan and treatment system design in order to minimize erosion and sediment loading. The design and operation of a chemical treatment system should take into consideration the factors that determine optimum, cost-effective performance. It is important to recognize the following:

1. The right chemical must be used at the right dosage. There is an optimum dosage rate for every combination of sediment and chemical. Dosing at lower or higher rates will result in reduced performance of the system. This is a situation where the adage "adding more is always better" is not the case. As stated previously, it is important to match a specific chemical to specific soil types. When mixing a dry concentrated flocculant solution for metering into the pumped stormwater during treatment, be sure to add the flocculant granules or powder *slowly, providing equal and uniform wetting* to an agitated or circulating tank of water. Adding the powder too quickly may produce gelatinous masses or "fish eyes" that will not dissolve. Flocculants may be provided as a concentrated solution or an emulsion, negating this concern. Various chemicals require different mixing times resulting in various floc sizes and settling rates, so it is important to follow the manufacturer's recommendations regarding handling, mixing, storage and dispersion of all chemicals.
2. A pH-adjusting chemical may be needed in the CTS to bring the pH into the chemical flocculant manufacturer's recommended operating range. *The pH adjusting chemical or gas must be mixed thoroughly into the stormwater to insure proper dispersion and contact*. This can be achieved in various ways after the chemical is introduced to the flow of the turbid water, including metering the chemical into the pump intake or routing the treated flow through corrugated pipe, static mixers, and/or tanks with baffles.
3. There must be a post-treatment settling or filtration system to remove the flocculated sediment. Chemically treated stormwater should never be directly discharged from the construction site. Settling basins designed to allow sufficient settling time are commonly used, preferably with surface discharge and porous baffles. Where space is limited, mechanical sand filters can remove the flocs and pump the sediment backwash sludge to isolated contained storage areas for decanting and final stabilization or disposal. The treated stormwater can be pumped into geotextile sediment bags. These will usually remove the flocs, but in doing so they will often clog relatively quickly and may need to be replaced frequently. This must be considered when determining the costs and the maintenance requirements of the CTS.
4. The settling basin will require periodic maintenance, so access should be readily available to clean accumulated sediment. Where baffles are used, most of the accumulation will occur in the inlet area of the basin and this can be the main access point. Mechanical sand filter backwash should be isolated from stormwater and must be prevented from discharging into surface waters.

Sizing Criteria

The combination of the sediment basin or other stormwater detention area and treatment capacity should be large enough to treat stormwater during multiple day storm events. Local permitting authorities may have flow control requirements regulating the volume of discharge during storm events and establishing sediment basin size, volume, and drawdown design criteria. Bypass should be provided around the chemical treatment system – into a settling pond – to accommodate extreme storm events. Primary settling should be encouraged in the sediment basin/storage pond. A forebay with access may be beneficial for maintenance and operational function.

There are two opposing considerations in sizing batch treatment cells. A larger cell is able to treat a larger volume of water each time a batch is processed. However, the larger the cell the longer the time required to empty the cell. A larger cell may also be less effective at flocculation, therefore requiring a longer settling time.

The simplest approach to sizing the treatment cell is to multiply the allowable discharge flow rate by the desired drawdown time. A 4-hour drawdown time allows one batch per cell per 8-hour work period, given 1 hour each for operations and for flocculation followed by 2 hours of settling. The permissible discharge rate governed by potential downstream effects can be used to calculate the recommended size of the treatment cells. Flow through and mechanical treatment systems are limited by pump and filter size as well as backwash duration. When sizing a mechanical system, filter maintenance and backwash duration must be considered to properly size the operational volume of the CTS. The following discharge flow rate limits apply, absent any local requirements:

1. If the discharge is direct or indirect to a stream, the discharge flow rate should not exceed 50 percent of the peak flow rate for all events between the 2-year and the 10-year, 24-hour event.
2. If discharge is occurring during a storm event equal to or greater than the 10-year storm, the allowable discharge rate is the peak flow rate of the 10-year, 24-hour event.
3. Discharge to a stream should not increase the stream flow rate by more than 10 percent.
4. If the discharge is directly to a lake or major receiving water, or to an infiltration system, there is no discharge flow limit.
5. If the discharge is to a municipal storm drainage system, the allowable discharge rate may be limited by the capacity of the public system. It may be necessary to clean the municipal storm drainage system prior to the start of the discharge to prevent scouring solids from the drainage system.
6. Runoff rates may be calculated using the Rational Method, unless another method is required by the local flood control agency, NPDES permitting authority, or agency that issued the grading permit.

Costs

The costs of a system and its operation will be highly variable depending on a wide range of factors. Some of these are listed below:

- Volume and pumping rate of water being treated.
- Turbidity levels of the source water and reduction in turbidity needed.
- Types of systems allowed by the permitting authority.
- Water chemistry, especially pH.

To provide some estimates of potential costs for a CTS, a detailed analysis of three different pumping rates is provided in Appendix B. This was done for a system that involved a flocculant (chitosan) and sand filtration. As the pumping rate increases, the cost per gallon drops considerably. At a little less than a million gallons per month, the cost is $0.021 per gallon. This drops to $0.009 per gallon as the rate approaches 5 million gallons per month. A system of this type is likely the most expensive due to its complexity and the cost of the chitosan. Substituting another chemical additive or polymer, such as polyacrylamide (PAM), in the same system may reduce costs, assuming they have similar performance. Again, remember that the right chemical at the right dosage must be used. Soil analysis with jar testing along with regulatory guidance will determine the correct polymer/additive that will meet the necessary requirements.

An alternative system involves only a settling basin after the chemical is introduced to the pumped water. This system is much simpler and has been shown to work well in many circumstances. The flocculant is pumped directly into the intake of the water pump and metered in at a rate to achieve the desired concentration. The water pump and hoses provide initial mixing and contact before discharge into the settling basin. By eliminating the sand filtration and controller modules and switching to a lower cost polymer/additive, the treatment cost per gallon is reduced by about 40%. This assumes there is room for a settling basin and does not include the basin construction cost. If the turbid water is in a holding pond, the treated water could be returned to the pond until the turbidity was reduced to the desired level, then released.

For small quantities of water, a variation on the above system is to pump the water into a geotextile bag (sediment bag). Again, the flocculant would be introduced into the pump intake. The resulting flocs have been found to stay inside typical sediment bags. However, the bags tend to clog, and the project budget would have to take into account the use and disposal of these. It is not possible to estimate accurately how many bags would be used because it depends on the amount of pumping and the turbidity of the pumped water. Nevertheless, many more bags would be used if there was no chemical treatment of the pumped water.

Location of CTS

In most cases, the sediment basin collecting stormwater will be at the lowest point on the project. CTS should be placed adjacent to the basin to allow convenient pumping. Usually they are placed close to the site perimeter to keep out of the way of construction activities. An access road that is reasonably all-weather needs to be installed to provide access to the system due to the need for frequent maintenance of these systems. The discharge from the CTS needs to be stabilized so that no erosion or scour occurs at the discharge point. A generalized layout is shown in Appendix B.

Section 4 Stormwater Treatment (Use of CTS)

Inspection and Maintenance

Chemical treatment systems must be operated and maintained by individuals with expertise in their use. Chemical treatment systems should be monitored continuously while in use. Test results must be recorded in a daily log kept on site, and all records turned over to the contracting agency at completion of CTS operation and upon request of the local permitting authority. The following monitoring should be conducted:

1. Monitoring — Minimal operational daily logs will include the following:
    a. pH conductivity (as a surrogate for alkalinity), turbidity, and temperature of the untreated stormwater.
    b. Rainfall (start of treatment shift).
    c. Total volume treated and discharged (for active CTS, not feasible for passive systems).
    d. Discharge time duration and flow rate.
    e. Type and amount of chemical used for pH adjustment.
    f. Amount of polymer used for treatment.
    g. Settling time (applies to batch treatments).
2. Compliance Monitoring — The following should be recorded:
    a. pH and turbidity of the treated stormwater.
    b. pH and turbidity of the receiving water.

Discharge Compliance

Treated stormwater must be sampled and tested for compliance with pH and turbidity limits. The sampling frequency may be established by the water quality standards or a site-specific discharge permit. Sampling and testing for other pollutants may also be necessary at some sites. Generally, the following apply:

1. *Turbidity must be no more than 5 NTUs (Nephelometric Turbidity Unit), a nationwide multi-sector standard, above background turbidity.* Background is measured in the receiving water, upstream from the treatment process discharge point.
2. *pH must be within applicable water quality standards and not cause a change in the pH of the receiving water of more than 0.2 standard units.* It is often possible to discharge treated stormwater that has a lower turbidity than the receiving water and that matches the pH. Treated stormwater samples and measurements should be taken from the discharge pipe or another location representative of the nature of the treated stormwater discharge. Samples used for determining compliance with the water quality standards in the receiving water should not be taken from the treatment pond for decanting. Compliance with the water quality standards is determined in the receiving water.

Operator Training

Each contractor who intends to use chemical treatment should be trained by an experienced system operator.

Standard BMPs

Erosion and sediment control BMPs should be implemented throughout the site to prevent erosion and discharge of sediment.

Section 5 Maintenance And Decommissioning

Sediment Removal and Disposal

1. *Sediment should be removed from the storage or treatment cells as necessary.* Typically for systems using flocculants, sediment removal is required at least once during a wet season and at the decommissioning of the cells. Also, when a sediment collection area has reached 1/3 capacity, the sediment should be removed and taken to a location where it can be stabilized (vegetated) or buried to prevent off-site transport. If sediment removal is not necessary during the life of the project, the sediment ponds can simply be filled in at decommissioning.
2. *Sediment remaining in the cells between batches may enhance the settling process and could reduce the required chemical dosage in the primary system.*
3. *When decommissioning, sediment must be stabilized away from drainages, which can include being incorporated into the roadway or being stabilized in-place.*

Adjustment of Settling and Retention Ponds

If stormwater detention ponds have been modified for use as sediment treatment ponds, then they must be restored to flow control mode as originally designed (e.g., baffles be removed, designed volume restored etc.).

Remove All Equipment and Chemicals from the Site and Store in a Safe Manner

All equipment and chemicals that were used on the site must be removed and stored in a designated and safe place.

Section 6 Monitoring Report of Chemical Treatment Systems

The use of CTS typically involves relatively high expenditures in areas of higher than average sensitivity. Because CTS are a relatively new technology for the construction industry, it is important to provide consistent reporting on these systems in order to properly evaluate them. The following are elements which must be included in the monitoring reports for all CTS.

- Rainfall: amounts and time.
- Amounts and types of chemical used (range of dosing rates & total amounts used).
- Volume treated.
- Volumes of flow in and out of CTS.
- Influent/effluent: pH, turbidity.
- Water quality of receiving waters: name, type, temperature, turbidity, pH.
- Schematic diagram and dimensions of treatment system used.
- Maintenance performed.
- Compliance data: thresholds both met and exceeded.

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Appendix A: List of Chemicals Typically Used for Treating Turbidity

There are many chemicals which are used to reduce suspended sediment in water. Each has its own benefits, costs, and risks for a particular application. In most cases, simple "shake" or batch tests are conducted to determine which chemical or combination of chemicals is most effective. Using any of these in CTS may be subject to local, state, or federal requirements for maximum use rates, aquatic toxicity data, or effluent toxicity testing. These requirements should be identified prior to selecting which flocculant to use on the site. The following are chemicals which have been used or tested in CTS for stormwater or similar environmental applications. The list is not intended to be exhaustive but to provide examples of the most common options in CTS. The list is separated into two sections: one for polymers and one for other additives.

Polymers

Chitosan — A cationic polymer made from chitin, which is derived from crab, shrimp, and other crustacean shells, can be used in CTS. Although a cationic polymer such as chitosan can be toxic to fish (as the gills of a fish have a negative charge), free polymer is unlikely to be released through a CTS described herein because it binds quickly to the suspended sediment in the untreated runoff. Even if free chitosan were released to surface water, it would immediately bind to any sediment in the surface water further decreasing the likelihood of adversely affecting aquatic life. In the state of Washington, where chitosan has been used widely on all types of construction projects since 2000, including DOT projects, there have been no incidences of harm to the environment.

Polyacrylamide (PAM) — A synthetic polymer, PAM is used to describe a wide variety of chemicals based on the acrylamide unit. When linked in long chains, some portion of the acrylamide units can be modified to result in a net positive, neutral, or negative charge on the PAM molecule. The positively charged, or cationic, PAMs are often not used for turbidity control because they can be toxic to fish and other aquatic organisms if they enter water bodies in sufficient concentrations. As is the case with chitosan, this effect has been shown to be greatly reduced in turbid water. The negatively charged, or anionic, PAMs are much less toxic to aquatic organisms and are widely used for erosion control in furrow irrigation agriculture. PAMs are also used in erosion control products. The reader should assume that all references to "PAM" in this document are to the anionic forms. In addition, only food-grade PAM is used because it contains very low (<0.05%) amounts of free acrylamide, which can be toxic but only at much higher concentrations.

Other Additives

DADMAC — Diallyldimethyl ammonium chloride is a cationic monomer which can bind the negatively charged sediment particles into flocs which can settle. This chemical can be polymerized into long-chain molecules commonly referred to as "poly-DADMAC." DADMAC exhibits a strong aquatic toxicity and its use should be carefully considered against other effective options that are significantly less toxic.

Gypsum — A naturally occurring mineral, gypsum is deposited widely around the earth. It is made up of calcium sulfate and water in the formula Ca(SO4)•2(H2O).

Alum — An aluminum sulfate material (Al2(SO4)3•16H2O), alum can be used for water clarification. It is often more efficient than gypsum but can acidify treated water if overdosed. It is widely used in the water treatment industry.

Aluminum and Iron Chlorides — Al and Fe cations bridge negatively charged sediment particles, causing them to coagulate and settle.

Appendix B: Examples of Chemical Treatment Systems and Costs

240,000 gpd Chitosan-Enhanced Sand Filter System Costs (Winter 2007)	
Sand filter (48" diameter, 4-pod system auto backwash 400 gpm output)	$3,500/Mo.
Sand (#30 grade crushed silica + under rock)	$2,500/once only
Mobilization cost	$500/once only
Demobilization cost	$500/once only
Chitosan	$9.00/10,000 gallons treated at 1 ppm
Chitosan	$27.00/10,000 gallons treated at 3 ppm[1]
20,000-gal pretreatment tank	$1,500/Mo.
Mobilization cost	$500/once only
Demobilization cost	$500/once only
Pumps (15 HP pond and 35 HP filter electric submersible with float level controllers)	$4,200/ Mo. (combined cost)
Secondary metering pump for pretreatment	$1,000/once only
Controller module (brain box)	$3,500/ Mo.
Mobilization/demobilization	$500/once only
100 KVA generator (diesel powered)	$3,000/Mo.
System assembly (40 hours) System disassembly (20 hours)	Varies with site location and complexity (estimated $10,000/once only)
System operator $85/hr	?
System performance data monitoring and reporting costs[2] (20 hrs/Mo. @ $75)	$1,500

1. Absolute worst case ultra-high influent turbidity (>3,000 NTU).
2. Data management, validation, and production of the monthly discharge monitoring report to ecology.

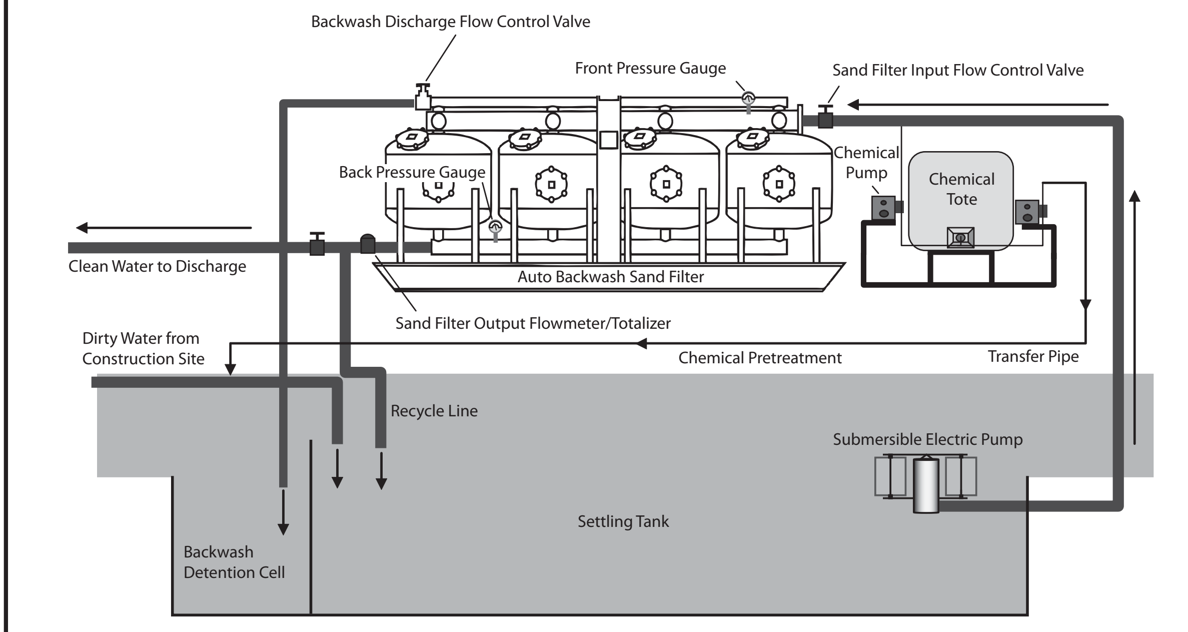
Once Only Costs – Does Not Include Physical Site Preparation	
Sand Filter	
Mobilization cost and sand filling	$1,000/once only
Demobilization cost	$500/once only
Pretreatment Tank	
Mobilization cost	$500/once only
Demobilization cost	$500/once only
Secondary metering pump for pretreatment	$1,500/once only
Controller Module (Brain Box)	
Mobilization/demobilization	$500/once only
System assembly (40 hours) System disassembly (20 hours)	Varies with site location and complexity (estimated $10,000/once only)
	$14,500

Hard Recurring Monthly Costs	
Sand filter (48" diameter, 4-pod system auto backwash 400 gpm output)	$3,500/Mo.
20,000-gal pretreatment tank	$1,500/Mo.
Pumps (15 HP pond and 35 HP filter electric submersible with float level controllers)	$4,300/ Mo. (combined cost)
100 KVA generator (diesel powered)	$3,000/Mo.
Controller module (brain box)	$3,500/ Mo.
System performance data monitoring and reporting costs[3] (20 hrs/Mo. @ $75)	$1,500
	$17,300

Variable Monthly Costs	
System operator $85/hr	?
Diesel cost @ $3.00 per gal with an average consumption of 6 gph	?
Chitosan (normal dose rate @ $9.00/10,000 gallons treated at 1 ppm)	?
Chitosan (high dose rate @ $27.00/10,000 gallons treated at 3 ppm[4])	?

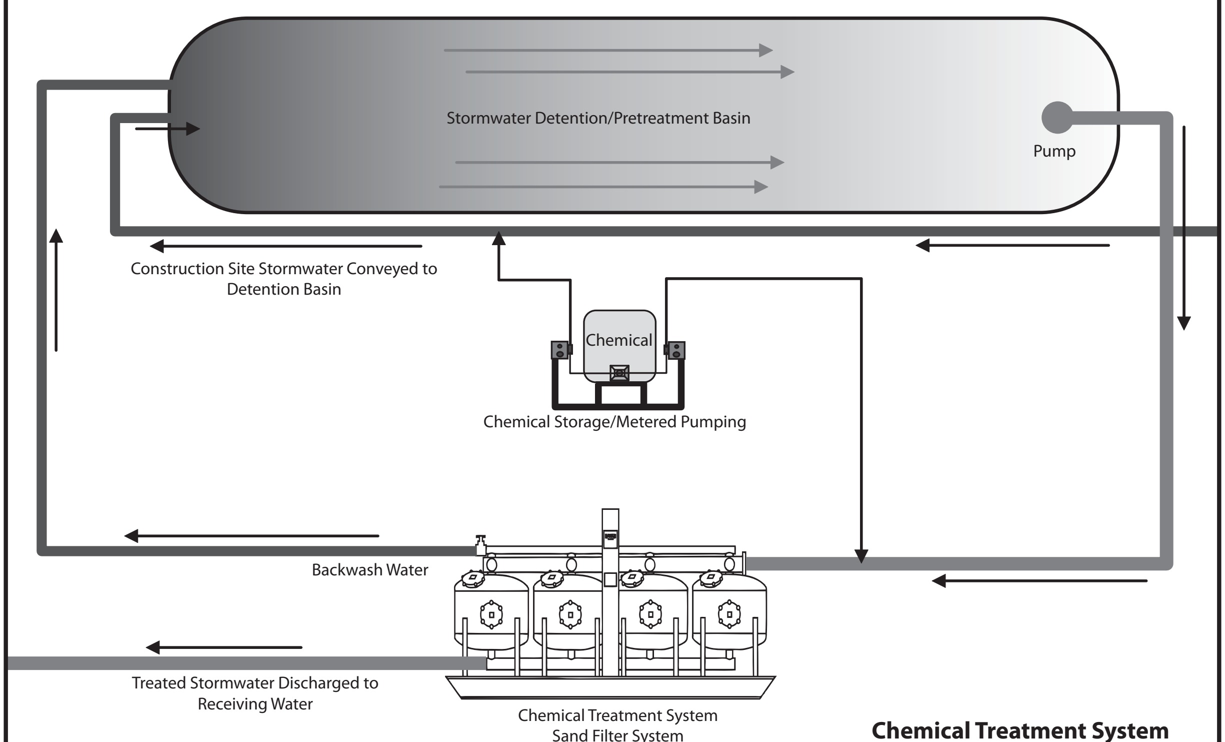
3. Data management, validation, and production of the monthly discharge monitoring report to ecology.
4. Absolute worst case ultra-high influent turbidity (3,000 to 10,000 NTU).

Pretreatment Using a Mobile Tank and the Additional Pump Adds Considerable Cost to the Treatment System.



Chemical Treatment System Schematic Using Mobile Tank for Pretreatment

If a Detention Basin Exists Onsite, It May Be Used for Pretreatment; Thus Saving the Cost of the Pretreatment Tank and the Extra Pump.



Chemical Treatment System Schematic Using a Detention Basin for Pretreatment

Estimating Total Monthly System Costs Based on Three Reasonable Scenarios

The cost to treat sediment-contaminated stormwater or dewatering water is directly related to the quantity of water treated. It is easy to see that if there was no precipitation or dewatering requiring treatment the total cost of this system would simply be $17,300 per month. There would be no labor or fuel costs and minimal reporting costs. But since this is not a practical expectation, three hypothetical use levels and calculated costs based on these assumptions are presented. Assume that on average the chitosan dose rate is 2 mg/L (1 mg/L for pretreatment and 1 mg/L for sand filtration). The use levels are:

- Light use defined as operating the system for 4 hours per day, 10 days out of the month (totaling 960,000 gallons treated per month).
- Moderate use defined as operating the system 6 hours per day, 15 days out of the month (totaling 2,160,000 gallons treated per month).
- Heavy use defined as operating the system 10 hours per day, 20 days out of the month (totaling 4,800,000 gallons treated per month).[5]

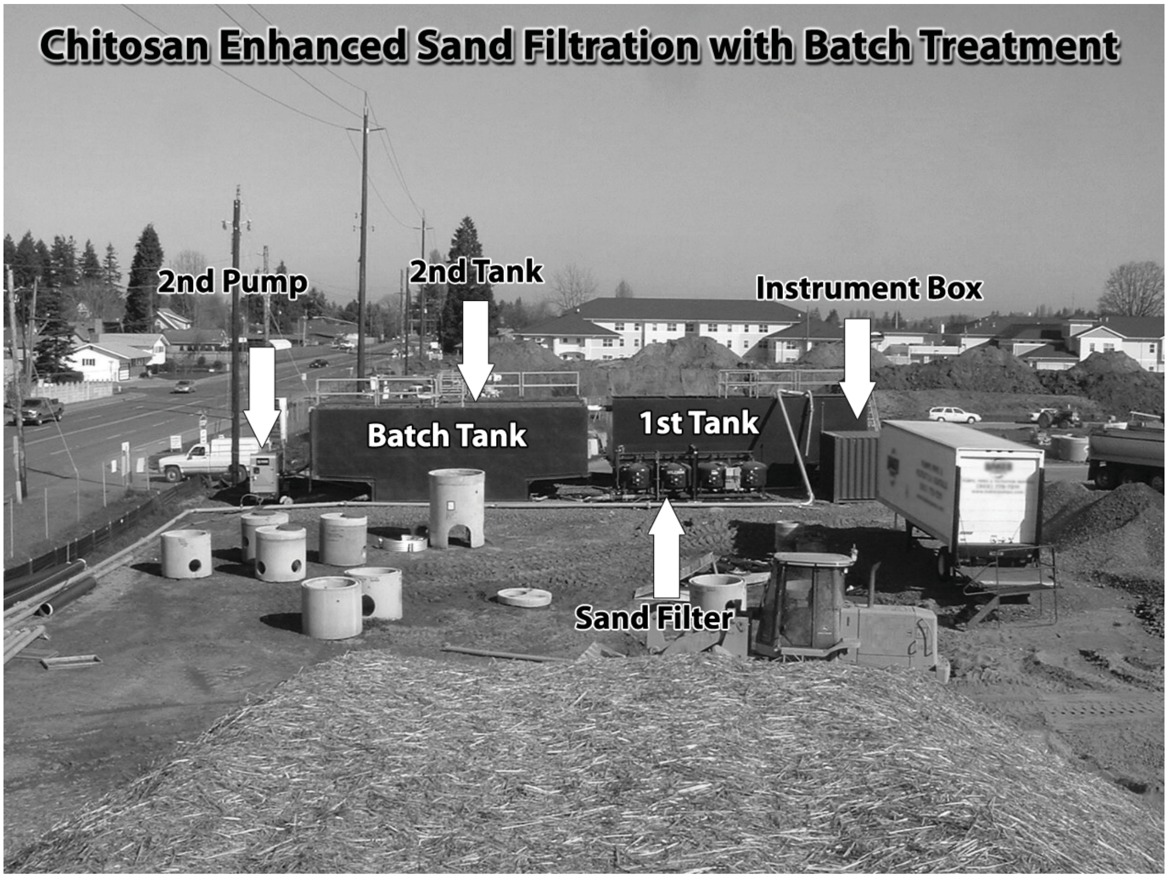
Scenario One

Light use defined as operating the system for 4 hours per day, 10 days out of the month (totaling 960,000 gallons treated per month).

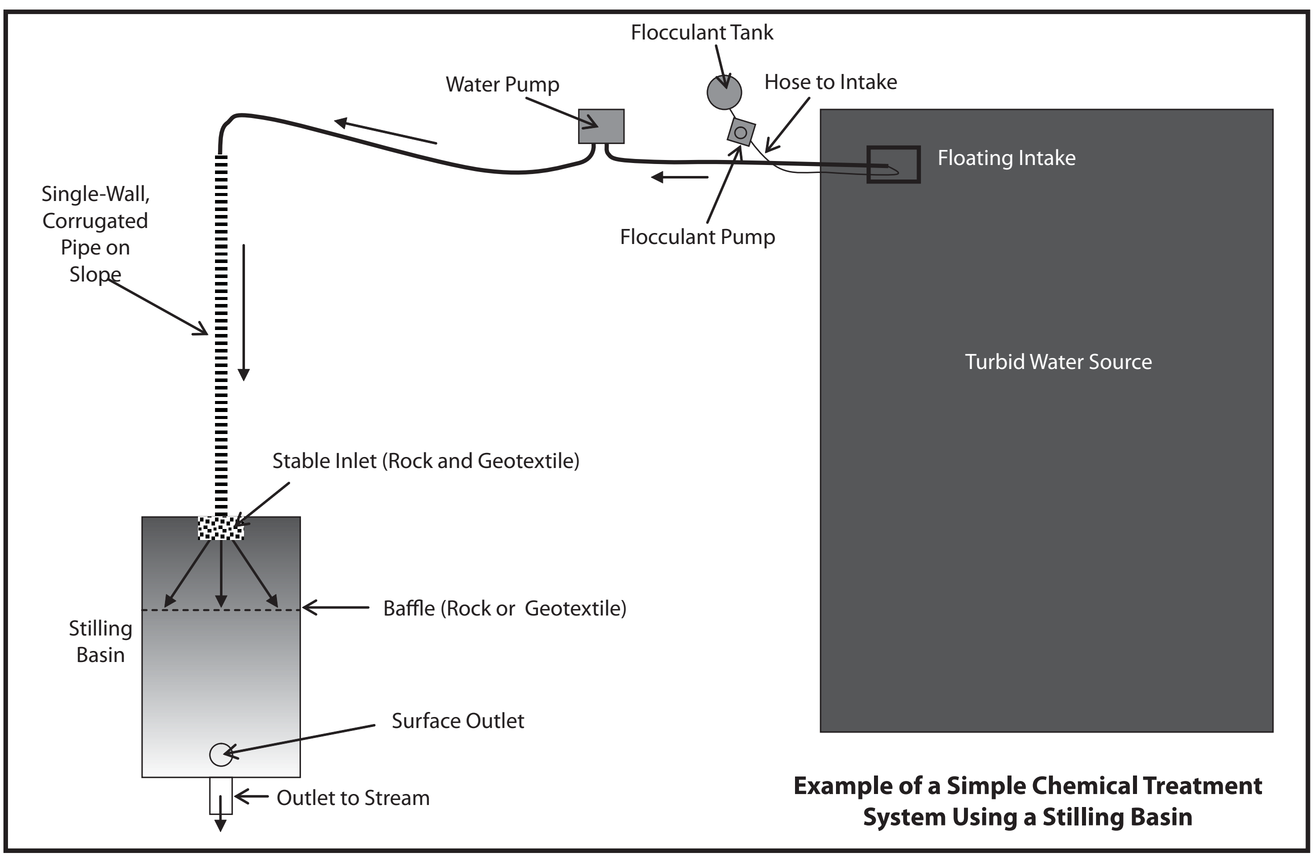
Variable Cost Element	Duration	Cost
Operating labor @ $85/hr	Reasonably expect 50 hours	$4,250
Fuel consumption (diesel)	40 hours @ 6 gph	$720
Chitosan consumption	2 mg/L based on previous assumption	$1,760
System performance data monitoring and reporting	10 hrs/Mo. @ $75	$750
Senior operator project oversight	Assume 2 site visits (1 hour each) @ $120/hr	$240
Meeting with regulatory personnel	2 hours @ $120/hr	$240
	Total Variable Costs	**$7,960**
	Hard Cost Elements	**$17,300**
	Total Hard & Variable Costs	**$25,260**
Considering the total cost of $25,260 divided by the total amount of water treated (960,000 gallons), the cost per gallon of water treated is $0.026 or $260 per 10,000 gallons of water treated to meet state discharge standards.		

5. Heavy use is most often associated with continuous dewatering activities, dredging, and unusually heavy or prolonged precipitation events.

Example of Sand Filter System with Chemical Enhancement and Batch Tanks for Settling.



Example Schematic for Dosing Flocculants at the Dewatering Pump Intake.



Scenario Two

Moderate use defined as operating the system 6 hours per day, 15 days out of the month (totaling 2,160,000 gallons treated per month).

Variable Cost Element	Duration	Cost
Operating labor @ $85/hr	Reasonably expect 105 hours	$8,925
Fuel consumption (diesel)	90 hours @ 6 gph	$1,620
Chitosan consumption	2 mg/L based on previous assumption	$3,956
System performance data monitoring and reporting	15 hrs/mo @ $75	$1,125
Senior operator project oversight	Assume 2 site visits (1 hour each) @ $120/hr	$240
Meeting with regulatory personnel	2 hours @ $120/hr	$240
	Total Variable Costs	**$16,106**
	Hard Cost Elements	**$17,300**
	Total Hard & Variable Costs	**$33,406**
Considering the total cost of $33,406 divided by the total amount of water treated (2,160,000 gallons), the cost per gallon of water treated is $0.015 or $150 per 10,000 gallons of water treated to meet state discharge standards.		

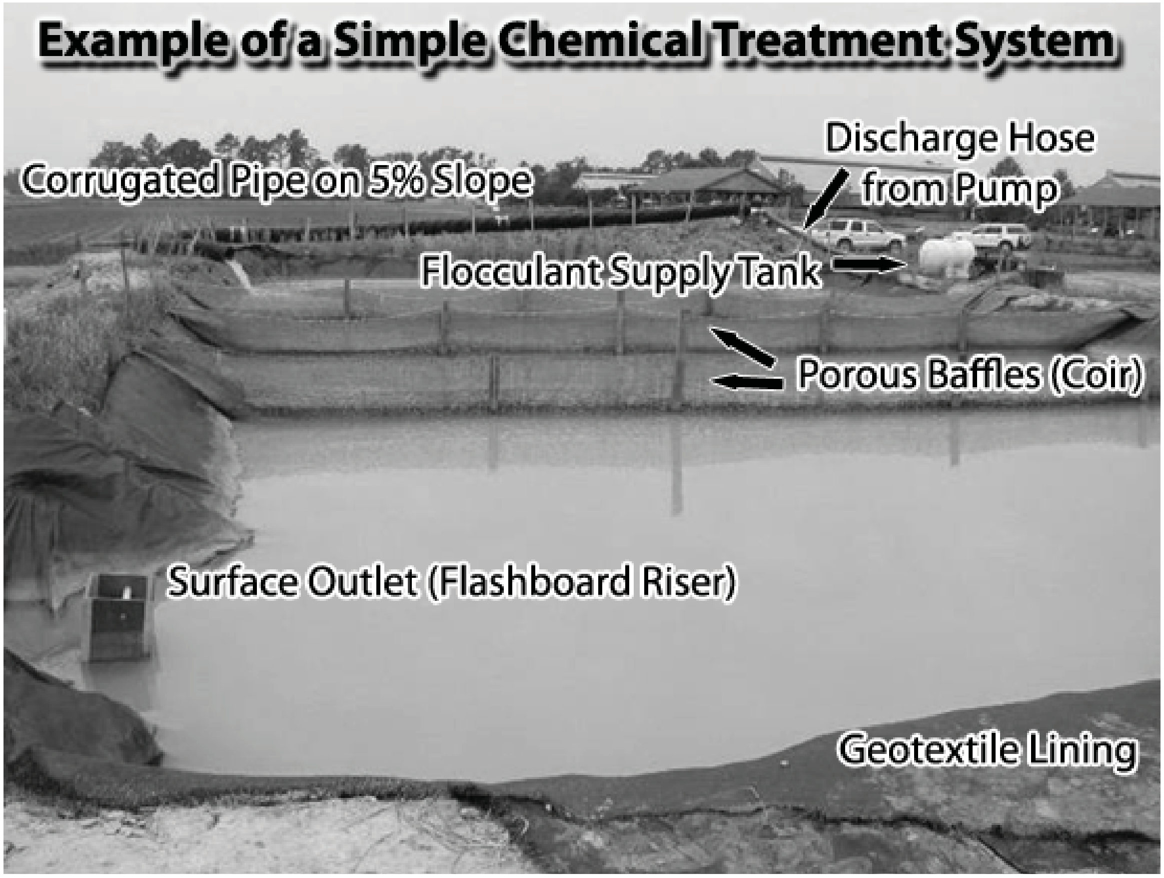
Scenario Three

Heavy use defined as operating the system 10 hours per day, 20 days out of the month (totaling 4,800,000 gallons treated per month).[6]

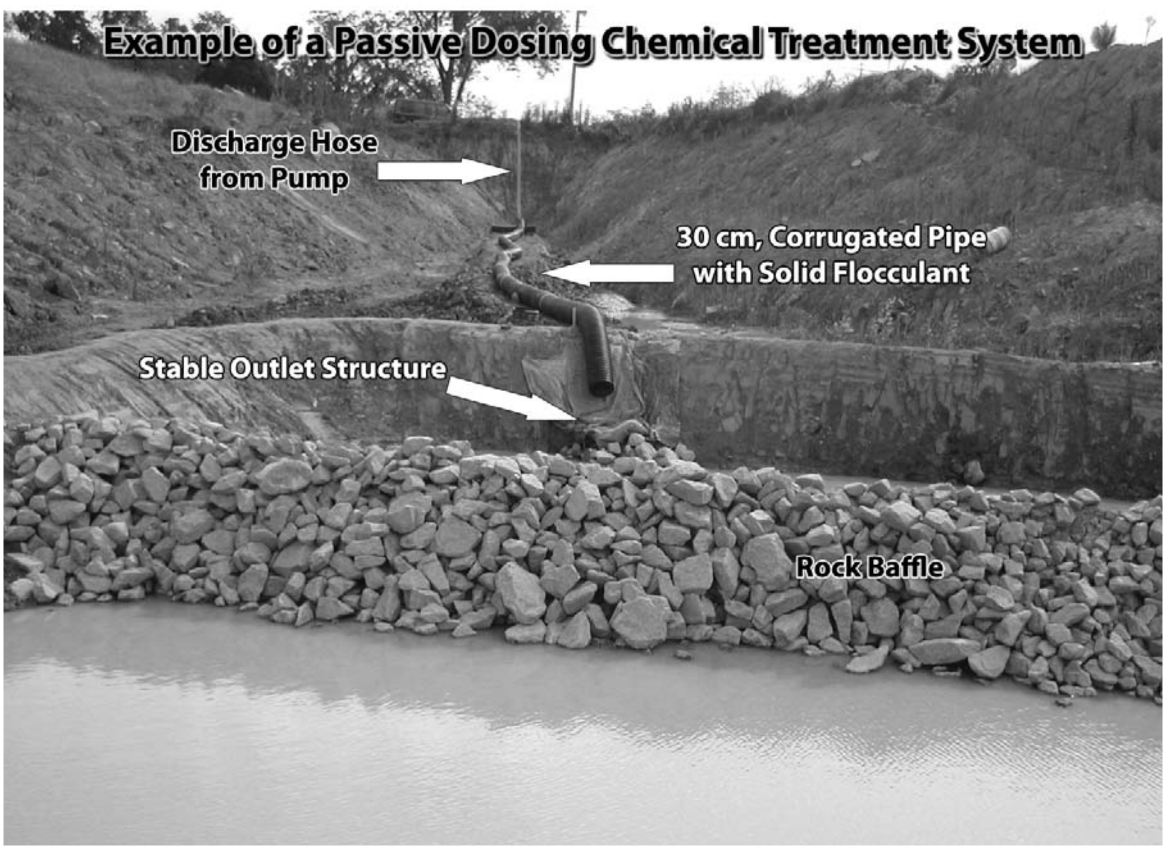
Variable Cost Element	Duration	Cost
Operating labor @ $85/hr	Reasonably expect 240 hours	$20,400
Fuel consumption (diesel)	200 hours @ 6 gph	$3,600
Chitosan consumption	2 mg/L based on previous assumption	$8,800
System performance data monitoring and reporting	20 hrs/mo @ $75	$1,500
Senior operator project oversight	Assume 4 site visits (2 hour each) @ $120/hr	$960
Meeting with regulatory personnel	2 hours @ $120/hr	$240
	Total Variable Costs	**$35,500**
	Hard Cost Elements	**$17,300**
	Total Hard & Variable Costs	**$52,800**
Considering the total cost of $52,800 divided by the total amount of water treated (4,800,000 gallons), the cost per gallon of water treated is $0.011 or $110 per 10,000 gallons of water treated to meet state discharge standards.		

6. Heavy use is most often associated with continuous dewatering activities, dredging, and unusually heavy or prolonged precipitation events.

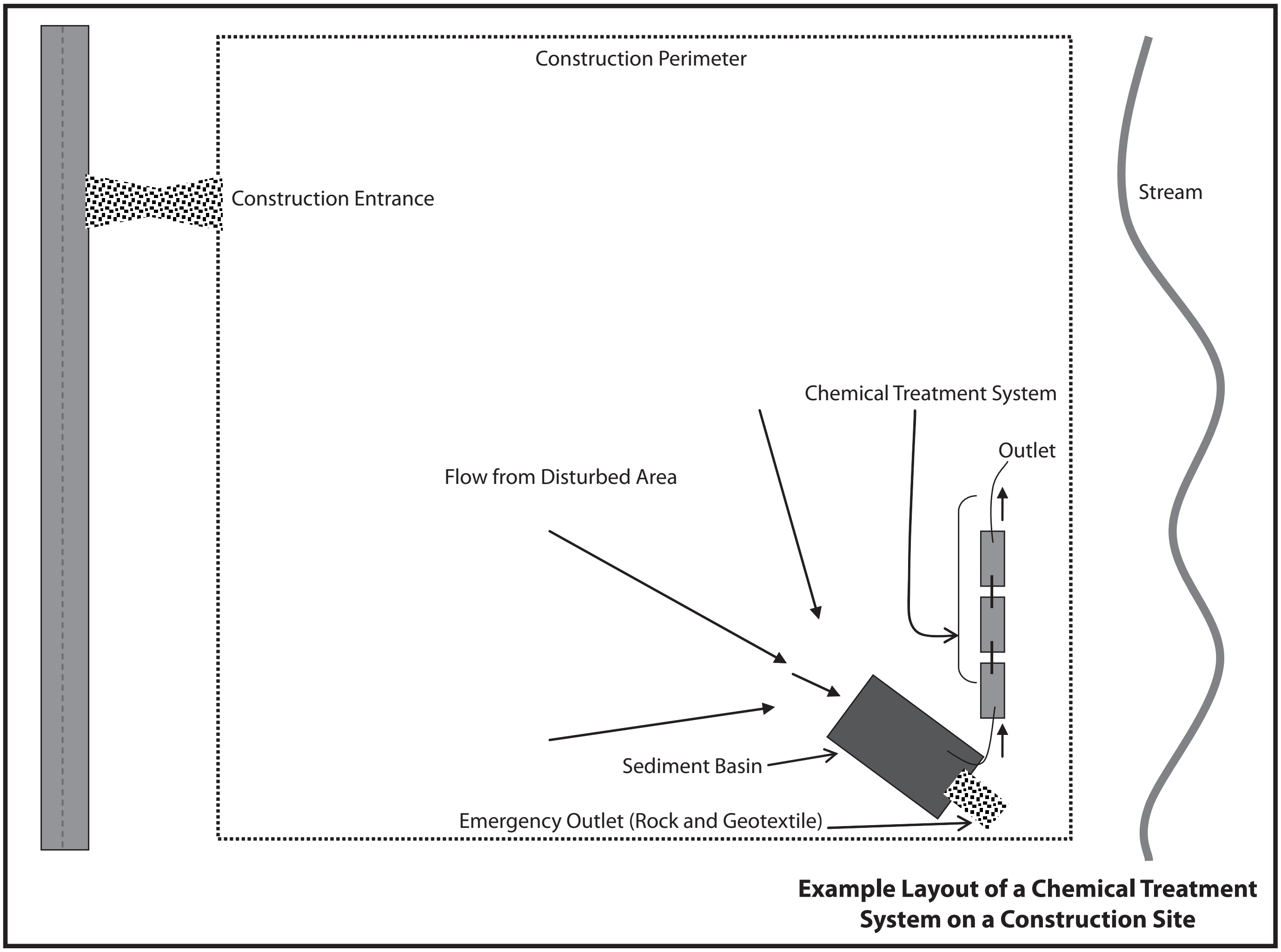
Example of Chemically Treated Discharge Water Being Mixed in a Corrugated Pipe Before Discharge into a Stilling Basin.



Example of Passive Dosing System by Pumping Turbid Water Through Corrugated Pipe Containing Solid Flocculants.



Typical Layout of a Chemical Treatment System on a Construction Site.



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