Quick Start Guide-Sterrett Passive Treatment System Operation and Maintenance

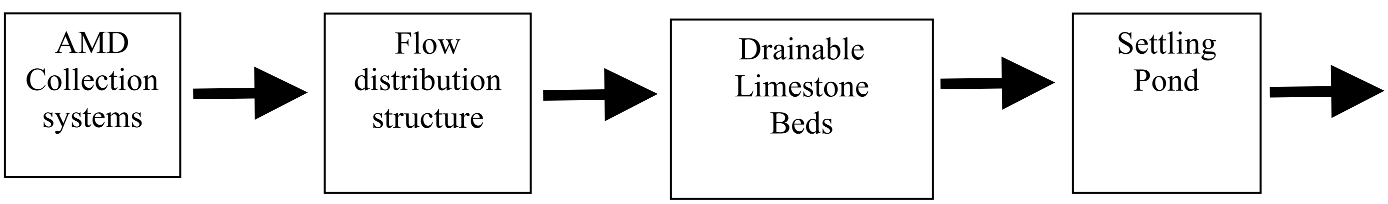
Introduction
This document is meant to provide basic information as a guide to the inspection, operation and maintenance of the Sterrett passive treatment system in the Scrubgrass Creek watershed.

Location
The treatment system is located in Irwin Township east of Georgetown Road, south of Burns Road., west of Pike Road. and north of Dog Hollow Road. The geographic location of the Sterrett passive treatment system is given in the following table.

System Name	Latitude	Longitude
Sterrett DLB's	**41.2295°N**	**79.9431°W**

The site is on private land behind a gated access road. Scrubgrass Creek Watershed Association personnel have permission to access the site for O&M of the treatment system. Access for other activities requires permission by the landowner or SCWA.

System basics
The system passively treats acid mine drainage (AMD) from an abandoned surface coal mine with limestone aggregate. The system consists of two AMD collection systems, one flow distribution structure, two drainable limestone beds (DLB) and one settling pond. A general flow schematic follows. The DLBs are automatically drained empty once/week when independent solar-powered computer-controlled gate values are activated. The draining water also flows to the settling pond.



Inspections
Site inspections should be conducted at least quarterly. A site inspection involves noting whether water is flowing through the system as intended and if there are maintenance needs to ensure proper system operation. Check for damage from rodents or vandals and debris blocking pipes. Measure pH and flow, if possible. Water flowing through any emergency spillway is one indication of a problem that requires immediate investigation and resolution. The solar-powered, computer-controlled drainage system should be checked to assure that the battery is charged and that the gate valve is operational.

Sampling
Samples should be collected at four locations at least twice per year: raw AMD into system collected from the flow distribution structure, effluent from each DLB and settling pond effluent.

Sterrett Passive Treatment System
Operation and Maintenance Plan
December 2015

Background
The Sterrett site is an abandoned surface mine that was operated by Pengrove Coal Company in the 1980s. The mining created acidic drainage contaminated with iron (Fe), aluminum (Al), and manganese (Mn) that was treated with hydrated lime and two settling ponds during mining operations and for a period afterwards. In 1993 Pengrove Coal declared bankruptcy and ceased all water treatment activities. Over the next 20 years various mining and reclamation groups investigated conditions at the site, but no AMD treatment occurred. In 2013 the Scrubgrass Creek Watershed Association (SCWA), working with Trout Unlimited (TU), was able to secure funding to install a passive treatment system at the site. The system was designed in 2014 and installed in 2015. This is the Operation and Maintenance (O&M) Plan for the Sterrett Passive treatment system.

Passive Treatment
The Sterrett passive treatment system uses limestone aggregate to add alkalinity to acidic waters and ponds/wetlands to remove/retain metals. The system is designed to operate with minimal intervention and infrequent maintenance. In order to assure that the system provides years of good treatment this operation and maintenance plan has been prepared to allow the caretakers to anticipate and identify maintenance needs and then implement maintenance work effectively.

The Sterrett system contains two underground mine water collection system that discharge to a flow distribution structure (FDS) where the separate flows are mixed and divided evenly between two drainable limestone beds (DLBs) arranged in parallel. A DLB is a pond filled with limestone aggregate. As water flows through a DLB, acidity is neutralized, alkalinity is generated and metals are precipitated. The excessive accumulation of metal solids in the limestone bed will cause it to plug and fail after months of treatment. To avoid this problem and maintain permeability, the DLB must be drained empty on a regular basis so that a majority of the metals solids are flushed from the aggregate. The draining, which occurs on a weekly schedule at the Sterrett site, is accomplished with a computer-controlled gate valve. A solar panel charges a battery that is used to power the computer and the actuator that operates the valve. When the DLB is draining it produces a high-solids effluent that flows to a settling pond where the solids settle. Between draining events, the limestone is flooded and water flows through continuously, producing an alkaline low-metal effluent. At the Sterrett site two DLBs discharge and drain to the same large pond that settles solids and produces the system's final effluent.

System Components
The layout of the system (generalized in Figure 1, see also the project as-built plans) consists of four primary components:

1. <u>AMD Collection Systems</u> collect contaminated ground water discharging north and south of the treatment system. The two AMD collection systems consist of buried plastic pipe

that collects AMD with "french drains" constructed with non-calcareous aggregate and perforated plastic pipe. The collected AMD is carried to the flow distribution structure in solid PVC pipe.

2. The Flow Distribution Structure (FDS) receives the collected AMD and distributes the mixed flow to the DLBs. See Figure 2
3. Two Drainable Limestone Beds (DLB) treat the AMD with limestone aggregate. The beds are drained empty weekly by opening a solar-powered device, computer-controlled gate valve. See Figures 3 and 4.
4. The DLBs discharge to a Settling Pond, where metal solids settle before final discharge from the system.

System Inspections

The system should be inspected quarterly. An inspection form is attached to this plan. This form can be used as-is or adapted for use by the inspection personnel. Use the "Notes" column to record any other relevant information about the site, such as signs of vandalism, sample numbers if lab samples are taken, or other information. This information should then be incorporated into a master spreadsheet containing water quality laboratory results that can be shared with others electronically and stored for historical purposes.

A system inspection involves visual observations and simple water sampling. The entire process will require about one hour. The system contains several locks all of which are opened with the same combination: 7292 ("SCWA" on a phone keypad).

The attached inspection form contains a checklist of items to be noted during a routine inspection. If no problems are apparent, then the inspection is complete. The finding of "no problems" should be recorded and preserved in the project files and entered into the spreadsheet. If problems exist, please refer to the attached "Troubleshooting Guide" and maintenance narrative.

Sampling

Sampling locations are shown in Figure 1. During each inspection the flow rate and pH of water leaving the DLB and settling pond should be measured. The DLBs are sampled at the two pipes discharging into the settling pond. Flows should be measured using a bucket and stopwatch to produce gallons per minute. The settling pond effluent is sampled at the weir in the outlet channel at the north end of the pond. The flow rate can be estimated by measuring the depth of water behind the weir or with a bucket and stopwatch. These data should be recorded on the inspection form so that changes in the system's performance over time can be recognized. Alkalinity is also a valuable field measurement, but requires a titrating device. If this is available, measure alkalinity of the treated water.

At least twice a year, sampling for laboratory analyses should be conducted. The samples should be analyzed by a qualified laboratory for standard AMD parameters (pH, conductivity, alkalinity, acidity, Fe, Mn, Al, total suspended solids, and sulfate). The laboratory should provide bottles and reagents necessary to properly collect the samples.

Passive Treatment System Inspection Form

Inspector ____ Date ____________________________

Recent weather (wet, dry, cold, hot) ____

Refer to Figure 1 for the inspection locations and sampling points included in this form

General Inspection Activities		Y/N	**Action**
Location	**What To Look For**		
AMD Collection Systems	Is water entering the FDS?		N
	Is the AMD collection area dry (no seeps)?		N
	Is water is backing up in the cleanout pipes?		Y
Flow Distribution Structure	Is the lid secure?		N
	Does the flow of water into the two risers appear equal?		N
	Is water flowing out of the overflow pipe?		Y
Drainable Limestone Beds	Is the water level lower than the top of the limestone?		N
	Is there water flowing out of the DLB?		N
	Is the Smart Drainage System battery charged?		N
	Is the Smart Drainage System gate valve functional?		N
	Is the effluent clear or cloudy		Y
Settling Pond	Is the pond discharging through the outlet weir?		N
Animal Problems	Is there evidence of beaver or muskrat activity in the system?		Y
ATV Problems	Is there evidence of erosion or damage due to ATVs?		Y
Berms	Are berms around the VFP and settling pond competent?		
	Is woody vegetation becoming established on the berms?		N
Vegetation	Is vegetation obstructing the flow of water or site access or obstructing SDS?		Y

Miscellaneous Observations: Detail any problems here

Flow and water sampling information

Location	**Flow (gpm)**	**pH**	**Temp**	**Alkalinity**	**Notes**
Raw					
North DLB out					
South DLB out					
Pond out					

Troubleshooting Guide

Problem	**Potential Cause**	**Solution**
Some or all of the AMD is not reaching the DLB	The pipeline is clogged	Clean the pipe to remove obstruction
	The water collection plumbing has failed	Re-construct the AMD collection system.
	FDS is clogged	Clear blockage from FDS
No flow out of DLB	DLB is refilling following flush event	Check again on different day of week or under higher flow conditions
	Outlet pipe blocked	Check for obstruction of outlet pipe. Remove any obstruction.
DLB water level is above the top of the limestone	Boards in water level control structure not set at proper elevation.	Compare water level behind boards in water level control structure to water level in DLB. Adjust height of boards as necessary.
	Loss of permeability due to metals solids accumulation.	Adjust SDS to increase frequency of flushing events
	Limestone has been consumed and the aggregate has settled.	Add more limestone to replace the limestone that has dissolved
DLB performance (pH, alkalinity) declines over time	Change in AMD chemistry or flow rate	Review data to determine if the chemistry or flow of the discharge has changed. Consider treatment system modification if change is considered permanent.
	Limestone has been fouled by metals solids	Wash and rinse limestone *in situ* and replenish with new limestone
	Limestone is being consumed	Add more limestone to replace the limestone that has dissolved
Damage to pipes, berms or structures	Muskrat activity is apparent from the presence of uprooted wetland plants and small huts made of mud and vegetation built in the pond	Contact the Pa Game Commission and request that the animals be removed or local trapper that can remove during legal trapping season.
	Beaver activity is apparent from dams constructed in channels	Contact the Pa Game Commission and request that the animals be removed or local trapper that can remove during legal trapping season.
	Vandalism	Repair damage, restrict access to site
Smart Drainage System not functioning	Low battery voltage	Test voltage of battery, replace if necessary. Check solar panel connection and orientation
	Equipment damage	Replace damaged parts
	Inconsistent charging	Removal of vegetation blocking solar panel
	Other problems	Contact manufacturer
Vegetation	Vegetation blocking water flow or site access	Remove vegetation
	extensive woody vegetation on berms	cut or remove

Settling Pond Combination Weir Flow Chart

Head (inches)	Flow (gpm)
0.5	0.2
1.0	0.9
1.5	2.6
2.0	5.3
2.5	9.2
3.0	14.5
3.5	21.3
4.0	29.8
4.5	40.0
5.0	52.1
5.5	102.8
6.0	195.3
6.5	314.7
7.0	455.6
7.5	614.8
8.0	790.2
8.5	980.3
9.0	1,183.7
9.5	1,399.6
10.0	1,626.9

Notes:
Make sure weir is free of debris prior to measurement. If debris is removed, allow ample time for equalization of pond. This could take hours.

Sterrett Passive Treatment System Maintenance Narrative

AMD Collection System

Description

Acid mine drainage (AMD) is collected in subsurface drains along the toe of the abandoned surface mine to the north and south of the system (see as-built plans) and piped to the treatment system. Subsurface collection (french drain) consists of perforated pipe in a bed of sandstone aggregate. A clay plug installed on the downstream side of the sandstone aggregate prevents water from following the outside of the pipeline and forces water into the perforated pipe. Most of the AMD was collected but elevation limitations made complete capture impossible. For this reason, there is still a small flow of AMD in surface water diversion ditch that flows directly to the settling pond.

Operation and Maintenance

The AMD Collection System should not require routine maintenance. Loss of flow to the treatment system combined with an appearance of surface seeps is an indication of blockage within the AMD Collection System. If blockage is apparent the cause of the blockage must be identified and removed. The pipeline cleanouts should be opened (by removing the screw holding the pipe cap on the cleanout) and inspected for evidence of excessive sludge buildup or water backup that would indicate downstream obstruction of the pipeline. If cleaning the pipelines does not solve the problem, the area with seepage (and blockage) should be excavated and the stone/piping replaced.

Flow Distribution Structure (FDS)

Description

The FDS is a vault that allows for mixing of collected AMD and management of flows to treatment cells (See Figure 2). AMD enters the FDS from two collection pipes. A baffle disrupts energy from the influent pipes and promotes stilling of the water. There are three outlet pipes. Two are upturned elbows set at the same elevation so that flow is split evenly between them. These carry flow to the drainable limestone beds. The third is set at a higher elevation and functions as a bypass. Under high flows or during maintenance, some or all of the flow can be directed to the settling pond. A baffle separates inlet pipes from outlet pipes. This baffle is held up off the bottom of the vault by two rocks that are about 2 inches thick which creates a gap for water to flow under the board. Forcing the water to flow down under the board encourages mixing of the flow and dissipates the current so that flow can be split evenly between the two DLBs.

Operation and Maintenance

Flow to either drainable limestone bed can be stopped by blocking the upturned elbows. The easiest way to do this is by installing a stub of 6” pipe inside the elbow. The FDS must be kept clear of debris and metals solids accumulation that obstructs flow. Flow through the bypass pipe to the settling pond should only occur under extremely high flow conditions or when flow is intentionally stopped to one or both of the drainable limestone beds during maintenance.

Drainable Limestone Bed (DLB)

Description

The DLBs each contain 1,760 tons of limestone aggregate arranged in a bed that is 3.5 to 4.5 ft deep (see Figures 3 and 4). In routine operations the bed is flooded and water flows from the inlet to the bottom drain. The water level in the bed is maintained by a water level control structure. The system is periodically drained to empty by opening a gate valve in the water level control structure. See the construction plans for design details for each system.

The bottom of the DLB slopes from the inlet side toward the outlet. Water enters the DLB from the FDS via a horizontal fountain. The horizontal fountain is an 8-inch perforated pipe just below the surface of the limestone. The upturned end of the fountain is visible above the level of the limestone. The purpose of the upturned elbow is to flood the pipe so water can be spread through the system via holes in the pipe and also provide an outlet for large flows. There is no other plumbing in this area. The horizontal fountain must be level to assure proper water distribution. Cleaning of limestone and/or limestone dissolution may eventually affect support of the plumbing. There are two stand-pipes that allow for the monitoring of water level in the limestone. These are not connected to the influent or effluent plumbing and are for observation only. These observation ports are located such that one is located on top of 12" effluent plumbing cap while the other is located near influent plumbing to observe differences in water level during flushing events to see if there are permeability problems within the limestone bed between the two pipes.

Water leaves the DLB via a 12-inch perforated pipe on the bottom of the bed. The 12-inch outlet pipe is roughly aligned with the long side of the bed parallel to the berm. Water level in the DLB is maintained by an inline water level control structure (WLCS). The WLCS is a PVC box with inlet and outlet pipes connected to its base and a series of boards that divide the interior of the box in half. Water backs up on one side of the boards in order to flow over and out the other side. Adding or removing boards raises or lowers the water level. These boards are either 5" or 7" in height permitting various combinations of board heights to be used to achieve the desired water level. Extreme care is to be taken when handling boards if using the tool install or remove boards since the boards are prone to falling off the tool into box. A 6-inch stand pipe is installed at the end of the end of the 12-inch perforated pipe on the bottom of the bed to mark the location of the pipe and also allow for monitoring of the water level in the limestone.

The WLCS is equipped with an electrically actuated gate valve that allows the DLB to be emptied automatically on a weekly basis. A solar panel and computer control unit is mounted on a pole next to the WLCS. This system is known as the "Agri Drain Smart Drainage System". Both normal flow and flush flow from the DLB discharges to the settling pond.

Operation and Maintenance

Instructions for operating the Agri Drain Smart Drainage System (SDS) are attached to this document. A copy of the manual is inside one of the SDS boxes at the system. The SDS uses a computer controlled linear actuator to open and close a gate valve installed inside the WLCS. A battery provides power to the computer and actuator and charge is maintained by a solar panel.

DLB Permeability

The water level in the DLB should be just below the limestone surface. Some water may be visible above the limestone due to irregularities in the limestone level, especially under high flow conditions when the water level will rise. If the entire limestone surface is submerged the outlet plumbing should be inspected for obstructions. If the water level inside the water level control structure is lower than the water level in the DLB then there is a permeability problem within the limestone.

DLB Effluent Quality

If the DLB effluent is cloudy or milky during normal flow (not during a flush event) then it is likely that aluminum has accumulated within the limestone that must be removed. One cause of this is failure of the automatic flushing system (SDS). Manually flush the bed and troubleshoot the SDS. If the SDS is working properly, begin implementation of DLB minor maintenance (below).

If the effluent of the DLB has pH below 6.0 under normal flow conditions, system monitoring should be increased to at least monthly. Two consecutive months of effluent pH between 5.5 and 6.0 indicates that minor maintenance actions should be taken to improve performance while plans are made for more permanent solutions. Effluent pH below 5.5 indicates that major maintenance is required and should be implemented as quickly as possible. Minor and Major maintenance activities are described below.

DLB Minor Maintenance

Temporarily increasing the frequency of flushing can address both the loss of permeability and declining effluent quality of the DLB. The SDS can be programmed to flush every day or every other day (see instructions provided by manufacturer). Increased flushing frequency will temporarily reduce the quality of the effluent but it may improve permeability. Once permeability is restored flushing interval can be lengthened to improve effluent quality.

DLB Major Maintenance

If flushing does not improve permeability or treatment performance, then the limestone requires mechanical cleaning. The goal of the cleaning is remove solids from the limestone bed. Simply mixing the stone, and moving the solids to the bottom of the bed where the plumbing is located, is NOT sufficient. Care must be taken to ensure that the dislodged solids are removed from the bed. A procedure for mechanically cleaning the limestone that has been used effectively at other sites follows:

1. Mobilize an excavator to the site. An excavator with minimum 1 cubic yard bucket should be utilized. A smooth bucket (no teeth) is recommended to prevent damage to pipes.
2. Empty DLB by opening the SDS valve (from the screen with four arrows press and hold ESC+arrow up).
3. Excavate limestone to locate and uncover perforated 12-inch outlet pipe on the bottom of the bed. The end of the pipe is marked with a 6-inch PVC stand pipe. Remove the end cap from the 12-inch outlet pipe (which is not glued).

4. Excavate a trench through the limestone (to the bottom of the bed) from the open end of the 12-inch outlet pipe to the upturned end of the influent fountain. The bottom of the DLB is sloped toward the 12-inch outlet pipe to help move solids out of the bed as the limestone is cleaned.
5. Pump water from the settling pond into the trench to carry solids out of the bed as limestone is cleaned. A self-priming 3" trash pump is sufficient but a 4" self-priming pump is preferred.
6. Clean limestone by dropping and mixing the stone in standing water. Impound water for washing by placing stone in the channel so that water backs up slightly. Alternatively, a stone box can be used as a wash basin if solids are carefully managed. Keep the stone box on dirty stone to avoid washing solids onto limestone that has already been cleaned.
7. Work from the influent toward the effluent being careful to keep clean and dirty stone separate. Occasionally solids will accumulate in the channel. These can easily be cleared by disturbing them with the excavator bucket. Monitor the outlet of the settling pond to ensure that the effluent is clear. If solids begin to discharge from the settling pond the "V" portion of the outlet weir can be sandbagged to create more storage. If solids release is a persistent problem, work should cease until the water in the settling pond clears then water can be pumped out of the settling pond to create additional storage before work resumes.
8. Replace the cap on the 12-inch outlet pipe and regrade stone to level. Additional limestone may be required to replace what has dissolved through treatment as well as make up for some settling.
9. Close the SDS valve and cleanup site as needed.

Settling Pond

Description

All flow passes through the settling pond where suspended metals solids are settled and retained. Water leaves the settling pond through a combination weir installed in a channel. The shape of the weir is intended to allow the settling pond to store and distribute flush flows so that the stream doesn't receive a surge of flow followed by a period with low flow as the DLB refills. The "V" part of the weir is for normal flow. During a flush event, the water level rises to the top of the "V" portion of the weir providing storage for the turbid flush flow. At the end of the flush the water level will lower gradually to the normal level. The broad rectangular portion of the weir is for passage of flush flows in the event the lower "V" portion is obstructed.

Operation and Maintenance

The settling pond should be inspected for obstruction of the outlet weir by debris, ice, vandalism or rodents. Berms should be inspected for rodent damage and leakage. Removal of trees and other woody type plants should be performed regularly to prevent establishment of these plants. Special attention should be paid to vegetation growth at the outlet of the pond that may obstruct flow. Any damage or obstruction should be repaired or removed promptly.

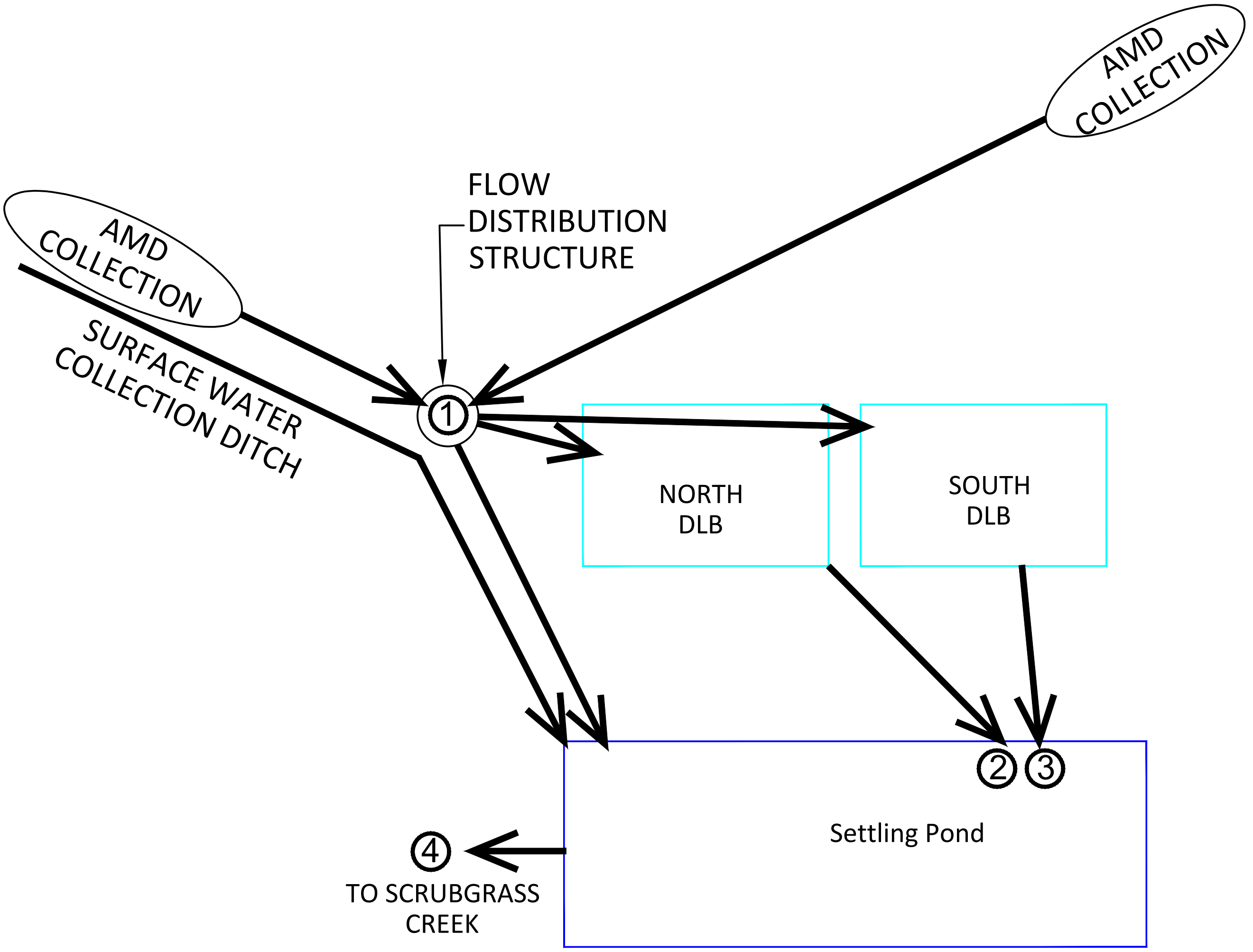
Sludge Cleanout

The settling pond is intended to collect solids produced by the DLBs. Eventually the accumulation of solids (sludge) will reach a point that degrades the ability of the pond to settle solids. When this occurs, it is necessary to remove the sludge. Two sludge disposal basins are located on the reclaimed mine spoil above the treatment system.

The first step would be to install temporary plumbing to bypass both DLB effluents around the settling pond. These bypass pipes would be used to minimize the amount of water handled during sludge removal. The SDS gate valve controllers should be turned off during pond cleaning operations.

The second step involves the siphoning or pumping of clear water from the settling pond to the stream. Siphoning allows for slow withdrawal of water setting upon the sludge that is to be pumped and will work throughout day and night without use of fuel. A section of filter sock and filter media upstream of the sock should be used to prevent solid particulates from the siphon/pump transfer to the stream.

The sludge should be pumped, using large diesel sludge pumps, from the pond to the basins. This activity is best conducted by an experienced mine water treatment company. The sludge pumping should occur in a manner that prevents the discharge of untreated water or high solids water.



Sampling			
Station Number	Description	Field Data to Collect	Special Instructions
1	Raw AMD	pH, Temp.	Collect sample on downstream side of baffle using bottle taped to pole or stick.
2	North DLB Out	pH, Temp., Alkalinity, Flow	Measure flow using bucket and stopwatch (preferred) or measuring height of water over WLC boards (see table in OM Plan attachments)
3	South DLB Out	pH, Temp., Alkalinity, Flow	Measure flow using bucket and stopwatch (preferred) or measure height of water over WLC boards (see table in OM Plan attachments)
4	Settling Pond Out	pH, Temp., Alkalinity, Flow	Measure flow at weir by measuring height of water over crest

Figure 1

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Sampling Plan

Sterrett Site Treatment System
O&M Plan

MUNICIPALITY: Irwin Twp.	DATE: December 2015	FILE NAME: Scrubgrass OM Plan.dwg
COUNTY: Venango, PA	DRAWN BY: NAW	SCALE: AS SHOWN

Number	Description
1	South collection system flow.
2	North collection system flow.
3	Flow baffle. Forces flow under baffle to encourage mixing and dissipate currents.
4	Outlet pipe to South DLB.
5	Outlet pipe to North DLB
6	Overflow pipe. Allows flow to be diverted directly to settling pond by either lowering baffle (3) or blocking outlet pipes (4 and 5).

Figure 2

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Flow Distribution Structure

Sterrett Site Treatment System
O&M Plan

MUNICIPALITY:	DATE:	FILE NAME:
Irwin Twp.	December 2015	Scrubgrass OM Plan.dwg
COUNTY: Venango, PA	DRAWN BY: NAW	SCALE: AS SHOWN

Number	Description
1	South DLB
2	North DLB
3	Observation ports (piezometers)
4	Influent fountain
5	South DLB Smart Drainage System
6	North DLB Smart Drainage System
7	Emergency overflow pipe
8	Cleanout access for south collection system

Figure 3

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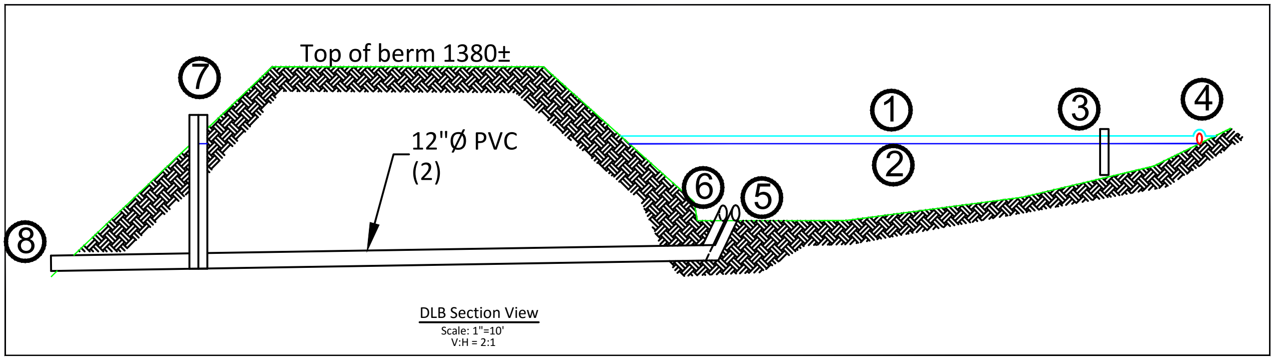
DLB Key Features

Sterrett Site Treatment System
O&M Plan

MUNICIPALITY: Irwin Twp.	DATE: December 2015	FILE NAME: Scrubgrass OM Plan.dwg
COUNTY: Venango, PA	DRAWN BY: NAW	SCALE: AS SHOWN



#	Description
1	Top of limestone (1,375.5±)
2	Normal water elevation (1,375.0±)
3	Observation port (piezometer)
4	Influent fountain
5	Perforated drain pipe (12"Ø PVC) in bottom of South DLB
6	Outlet pipe from North DLB (12"Ø PVC) passes through bottom of South DLB parallel to South DLB drain pipe
7	Inline water level control structure with Smart Drainage System
8	DLB outfall (12"Ø PVC)

Figure 4

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DLB Section View

Sterrett Site Treatment System

O&M Plan

MUNICIPALITY: Irwin Twp.	DATE: December 2015	FILE NAME: Scrubgrass OM Plan.dwg
COUNTY: Venango, PA	DRAWN BY: NAW	SCALE: AS SHOWN