U.S. ARMY CORPS OF ENGINEERS
BALTIMORE DISTRICT

DENTS RUN SITE 3893-PHASE II
SECTION 206, ACID MINE DRAINAGE

CONTRACT NO. DACA31-03-D-0009
BENEZETTE TOWNSHIP, ELK COUNTY, PA

OPERATION AND MAINTENANCE PLAN

Prepared for:

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Introduction

The Site 3893 passive treatment system is designed to address surface runoff contaminated by acid mine drainage (AMD) occurring in two unnamed tributaries of Porcupine Hollow, identified as Seep 8 and Seep 9. For each tributary, a check dam diverts up to the 90% flow into a pair of alkalinity-generating vertical flow wetlands (VFWs) operating in parallel. The design intent is that one of the paired VFWs may be taken off-line for maintenance during average flows, while the remaining on-line cell continues treatment for short periods. The VFW cell banks for Seep 8 and Seep 9 discharge to a common oxidation/precipitation basin (OPB) for metals precipitation at the confluence of the tributaries. The discharge from the OPB is then passed through a series of seven surface flow wetlands (SFWs) for final metals removal. Construction of the overall system may be staged in the order: Stage 1 – Seep 8 VFWs and OPB, Stage 2 – Seep 9 VFWs, and Stage 3 – SFWs. As such, all system components may not be initially present or have the same initial start dates for planning future maintenance.

The passive system design criteria and performance prediction sections from the Design Engineer's Report are attached with this Operation and Maintenance (O&M) Plan for reference. Individuals and organizations responsible for site O&M should review these materials for an understanding of the functions of the passive technologies utilized and the pre-construction expectations for their performance. The following are the recommended O&M activities for the individual system components. It is recommended that the site be inspected weekly for basic integrity and performance factors. A system component map and inspection checklist is attached with this plan for reference in the field.

General System

All pipes and flow controls should be regularly checked for blockage, and debris should be removed immediately. Specific areas of concern are the grates and orifice plates on the Seep 8 and Seep 9 inlet control boxes, the outlet water level controls on the VFWs and OPB, and the beaver levelers on the SFWs.

Vertical Flow Wetlands

VFWs rely on the hydraulic capacity of their substrates to permit downward water flow to their underdrains and prevent overtopping of the cell. Dissolved metals present in AMD, particularly aluminum, will tend to precipitate in the compost and limestone beds, reducing hydraulic capacity over time. Routine operation of VFWs involves gradually adjusting the difference between the standing water level in the cell and the discharge level in the outlet water level control to provide increasing driving head as compensation for loses of hydraulic capacity. Eventually, a point is reached where adjustments can no longer compensate for capacity losses, and the substrate must either be maintained or replaced.

In addition to the loss of void space and hydraulic conductivity, VFWs can decline in performance by the consumption of organic carbon in the compost, which is essential for sulfate reduction. Monitoring of both the influent and effluent for each cell should be conducted at least once a quarter to determine if there is a downward trend in alkalinity production in the VFWs and overall system performance. If such a trend is observed that could affect treatment goals, the compost will need to be replaced or supplemented with an acceptable source of organic carbon.

Under average flow conditions, the Site 3893 VFW cells are designed to maintain approximately 1 foot of standing water on top of the compost substrate. A formula is provided on the inspection checklist for estimating the flow at the VFW outlet water level controls based on the height of water above the stop logs, with measurements taken from the top of the inside rim of the control structure. The VFW cell inlet pipes are constructed with their bottom inverts at the minimum design water level for each cell, leaving 1 foot of freeboard up to the emergency spillway. Water levels will normally back up several inches above the inlet pipe inverts during higher flows, but should not overtop the pipes. If a cell water level is observed at greater than 0.5 feet above the inlet pipe invert, the water level should be adjusted downward by 1 to 2 inches at the water level control; however, minimum water levels should not be allowed to drop more than 2 inches below the pipe invert. Water levels are adjusted by removing and replacing the upper stop logs in the water level control. Stop logs are provided in heights of 5 and 7 inches, combinations of which can be used for incremental adjustments of 1 inch upward or downward. If under any flow condition the inlet pipe becomes completely submerged, a 5 inch stop log should be removed from the water level control for the initial adjustment.

The stop log top elevations should not be adjusted more than 0.5 feet below the inlet pipe invert. If the inlet pipe is persistently overtopped at this adjustment level, the cell substrate is losing significant hydraulic capacity and requires maintenance. Two potential methods of maintenance are flushing or stirring, described as follows:

- Flushing can be accomplished by removing the stop logs from the water level control and allowing the cell to free drain at a rapid rate. The water depth at the inlet pipe invert should be measured prior to flushing. The stop logs should be replaced to their original setting levels immediately after the cell is drained, and it is recommended that the compost substrate not be exposed to the air for more than 4 hours. The cell should be allowed to refill, and the stable water level measured at the inlet pipe invert for indication that the level has dropped compared to pre-flushing conditions. Several drain-and-fill cycles may be needed before improvements are observed. Flushing has not proven to be effective for long-term maintenance of hydraulic capacity in previous VFW systems, but may provide short-term improvements to extend substrate lives before replacement. Costs of flushing are essentially labor, estimated at approximately $2,000 per cell for two site laborers at $30/hr each for four days.

- Stirring or otherwise breaking up precipitate deposits in the compost bed may also increase hydraulic capacity. This approach has been used for VFWs subject to periodic surface drying of the compost by insufficient maintenance of cell water levels, apparently causing a more rapid formation of precipitate lenses or oxidized compost clumps. It is unknown whether similar deposits will form in permanently inundated VFWs as designed for Site 3893. Stirring of the upper compost surface by overhead equipment may be possible, but would likely require a large gradeall or similar machine at considerable expense. Another conceptual approach would be to draw down the VFW cell and allow the compost to dry sufficiently to permit a small, low ground pressure vehicle to tow a york rake or similar attachment across the compost surface. Fresh compost could be spread and incorporated into the surface at the same time to replace organic carbon losses. The surface would be rutted on completion, but could be leveled using a pressure hose. The effects of dewatering and raking on performance are not documented at this time. Costs of raking could vary considerably depending on the machinery used, but may be on the order of $5,000 per Seep 8 cell and $7,000 per Seep 9 cell.

If adequate hydraulic capacity is not restored by flushing or stirring, the compost should be replaced before the freeboard capacity is exceeded. Maintenance or replacement activities should only be conducted during low to average flow conditions (51 gpm maximum for the total Seep 8 flow or 105 gpm maximum for the total Seep 9 flow). Work may only be conducted on one VFW cell at a time out of the four present (two each at Seep 8 and Seep9) in order for the remaining on-line cells to maintain treatment. Flow may be diverted around the cell to be maintained by temporarily blocking the portion of the orifice plate leading to that cell from the inlet control box.

For compost replacement, the cell should be drained and allowed to dry sufficiently for a skid steer or other low ground pressure equipment to operate. Spent compost may be scraped by bucket and loaded into haul trucks for disposal. Care should be taken not to over excavate into the limestone bed if it is to remain in place. The characteristics of spent compost are not sufficiently documented to predict whether this material will be suitable for on-site disposal. It may be possible to spread it on the reclaimed mine site up-gradient from the treatment systems, but provision should be made for off-site disposal if needed. On-site loading and hauling within one mile is estimated to cost approximately $7,000 per Seep 8 cell and $13,000 per Seep 9 cell. Fresh compost may be spread on the exposed limestone bed using the same methodology as the original bed placement, typically a small bulldozer. The cost of new compost and placement is estimated at approximately $22,000 per Seep 8 cell and $40,000 per Seep 9 cell.

It is not currently known whether limestone substrates in VFWs must be replaced concurrently with the compost substrates. The compost presumably acts to protect the limestone to some degree from clogging and armoring, but the duration of this effect has not been documented for systems designed to the sizing standards of the Seep 8 and Seep 9 units. It is recommended that limestone replacement be included as a contingency option in any maintenance contract involving compost replacement. Care should be exercised in excavating spent limestone around the underdrain pipes to prevent damage. The characteristics of spent limestone are not sufficiently documented to predict whether this material will be suitable for on-site disposal. It may be possible to spread it on the reclaimed mine site up-gradient from the treatment systems along with spent compost, but provision should be made for off-site disposal if needed. On-site limestone loading and hauling within one mile is estimated to cost approximately $24,000 per Seep 8 cell and $37,000 per Seep 9 cell. The cost of new limestone and placement is estimated at approximately $57,000 per Seep 8 cell and $87,000 per Seep 9 cell.

No standard methodology has been developed for estimating the operational life of VFW substrates before maintenance or replacement is required. From studies of surface flow wetlands, aluminum sludge formation for open water precipitation is estimated at approximately 1 liter for every 10 grams removed, with a rate of about 1 liter per 20 grams of iron removed. Available void space in compost and limestone is approximately 40 percent. The aluminum and iron removal rates predicted for the Seep 8 VFWs equate to about 1.7 cubic feet per day of sludge formation in each cell. The substrate volumes in each Seep 8 VFW cell are approximately 35,234 cubic feet, and the hypothetical time required to fill the void spaces is about 23 years. Metals removal in the Seep 9 VFWs is predicted by these volume factors to generate about 11.4 cubic feet of sludge per cell per day. With cell substrate volumes of 58,267 cubic feet, this equates to a hypothetical void filling timeframe of about 6 years. In practice, sludge formation will not occur in all void spaces, so significant loss of hydraulic capacity will likely occur in a lesser timeframe. For the Seep 8 VFWs, this is conceptually estimated at about 15 years, and for the Seep 9 VFWs at about 5 years. It is anticipated that previous reclamation of abandoned surface mines in the headwaters of the unnamed tributaries will reduce influent loadings over time and increase the operational lives of the VFW substrates, but this effect cannot be predicted. Because of this uncertainty and the potential differences between wetland sludge and VFW sludge volume factors, the calculated substrate life estimates should be used only for conceptual planning purposes, and actual maintenance should be scheduled based on field observations of remaining hydraulic capacity.

Refer to Figure 1 for an overall map depicting the design conditions of the Seep 8 VFWs. Refer to Figure 2 for an overall map depicting the design conditions of the Seep 9 VFWs. A Operation and Maintenance Checklist has been included in Appendix A for use during system inspection once construction activities have been completed.

Oxidation/Precipitation Basin

Routine operation of the OPB should involve only debris clearing and assuring the proper water level in the basin. The stop logs in the outlet water level control should be set to maintain approximately 2 feet of freeboard under average flow conditions.

The OPB is designed with 20,000 cubic feet of storage capacity at average flows. The average sludge accumulation rate is estimated at approximately 1.6 cubic feet per day using the same volumetric generation rates as for the VFWs. This equates to an estimated cleaning cycle of about 34 years; however, cleaning should be based on actual measured accumulations and conducted before the storage capacity is reached. The sludge accumulation depths should be measured in the OPB at least once per year to determine whether the sludge storage capacity is being approached.

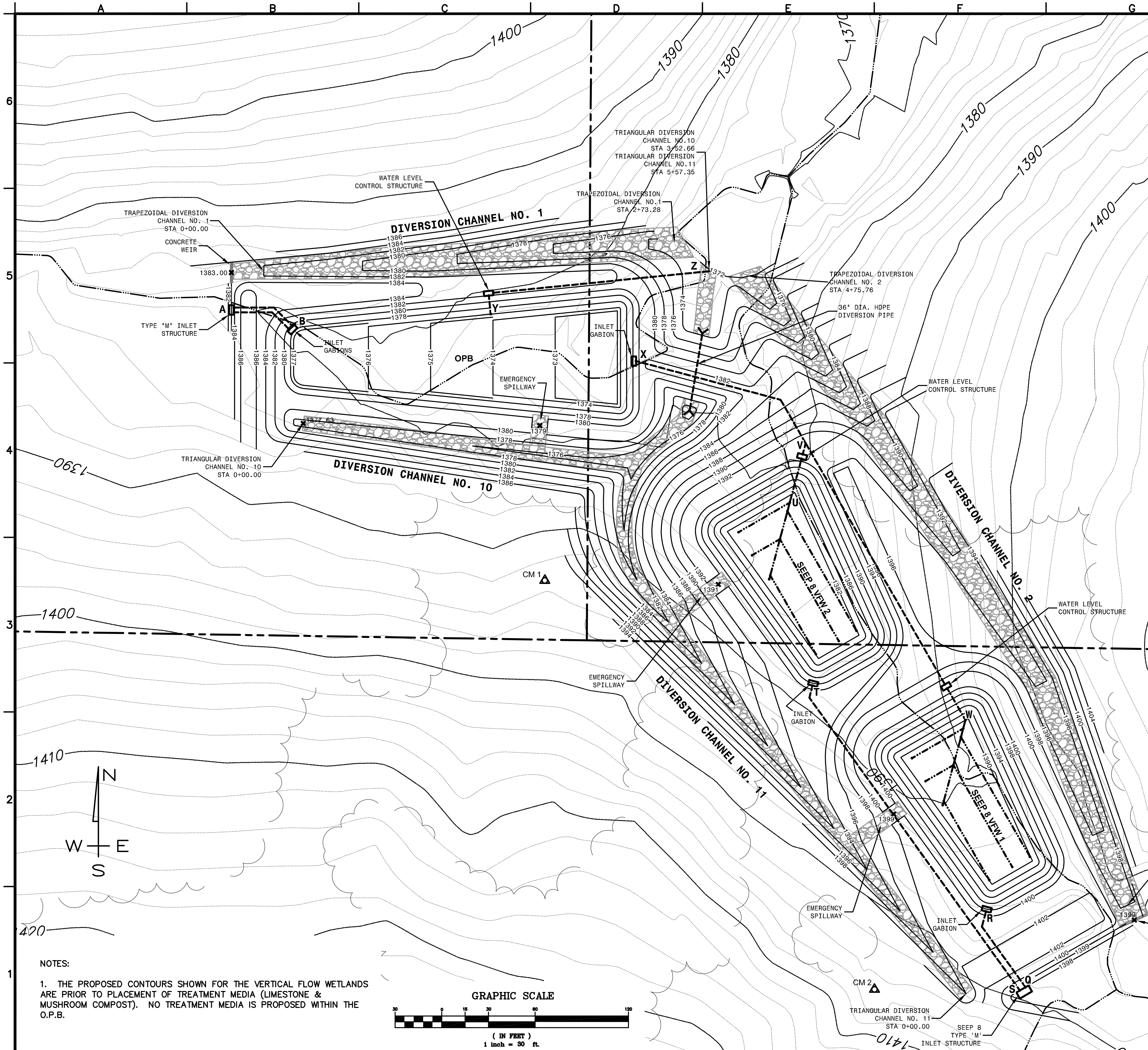
The OPB should be cleaned whenever the bottom sludge thickness has reached approximately 3 feet on the basin floor immediately below the inlet from the Seep 8 VFWs. Cleaning should be undertaken only during low flow periods. A bottom pumping and filter press or tank truck method may be necessary to remove the sludge with flows maintained from the Seep 8 and Seep 9 VFWs; diversion of flow around the OPB for draining is likely not feasible. A temporary sediment curtain should be installed at the OPB outlet during cleaning to prevent migration of disturbed sludge. OPB sludge formed by chemical treatment processes has typically been suitable for burial on abandoned mine sites, but the characteristics of passively formed sludge are not well known, and provision should be made for off-site disposal. Sludge disposal costs for other treatment systems have typically been in the range $20 to $25 per cubic yard for basic pumping. With hauling for on-site disposal, the cost to clean the OPB is estimated to be on the order of $60,000.

Refer to Figure 1 for an overall map depicting the design conditions of the OPB.

Surface Flow Wetlands

It is not anticipated that the SFWs will require sludge removal for the foreseeable future. The beaver pond levelers should be routinely inspected and cleared of any blockage. Any washout of protective riprap covering the dividing berms should be repaired immediately by replacing the riprap.

Refer to Figure 2 for an overall map depicting the design conditions of the Surface Flow Wetlands.



NOTES:

1. THE PROPOSED CONTOURS SHOWN FOR THE VERTICAL FLOW WETLANDS ARE PRIOR TO PLACEMENT OF TREATMENT MEDIA (LIMESTONE & MUSHROOM COMPOST). NO TREATMENT MEDIA IS PROPOSED WITHIN THE O.P.B.

SURVEY CONTROL DATA

SURVEY NOTE FOR SITES 3888 & 3893:

1. THE VERTICAL DATUM IS BASED ON NGVD29. THE HORIZONTAL DATUM IS BASED ON NAD83, PENNSYLVANIA STATE PLANE COORDINATE SYSTEM, NORTH ZONE.

CONSTRUCTION MONUMENTS*

MON.	NORTHING	EASTING	ELEVATION
CM 1	431128.4072	1801342.5349	1393.27
CM 2	430865.5480	1801554.3826	1404.85

*NOTE: THE LOCATIONS OF THE CONSTRUCTION MONUMENTS ARE PROPOSED. THE COORDINATES AND ELEVATIONS ARE BASED UPON THE PLAN DRAWING.

APPROVED:
A/E PRINCIPLE
SEAL:

US Army Corps of Engineers Baltimore District

Mark	Description	Date	Appr.

Mark	Description	Date	Appr.

Designed by:		Date: AUGUST, 2006	Rev.
Dwn by:	Ckd by:	Design file no.	
Reviewed by:		Drawing Number:	
Submitted by: Chief, Branch		File name: Plot date: Plot scale: 1"=30'	

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BALTIMORE, MARYLAND

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DENTS RUN SITE 3893 - PHASE II
SECTION 206, ACID MINE DRAINAGE
BENEZETTE TOWNSHIP, ELK COUNTY, PA

SEEP 8 VFWs AND O.P.B. DESIGN LAYOUT

FIGURE
1

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SURVEY CONTROL DATA

SURVEY NOTE FOR SITES 3888 & 3893:

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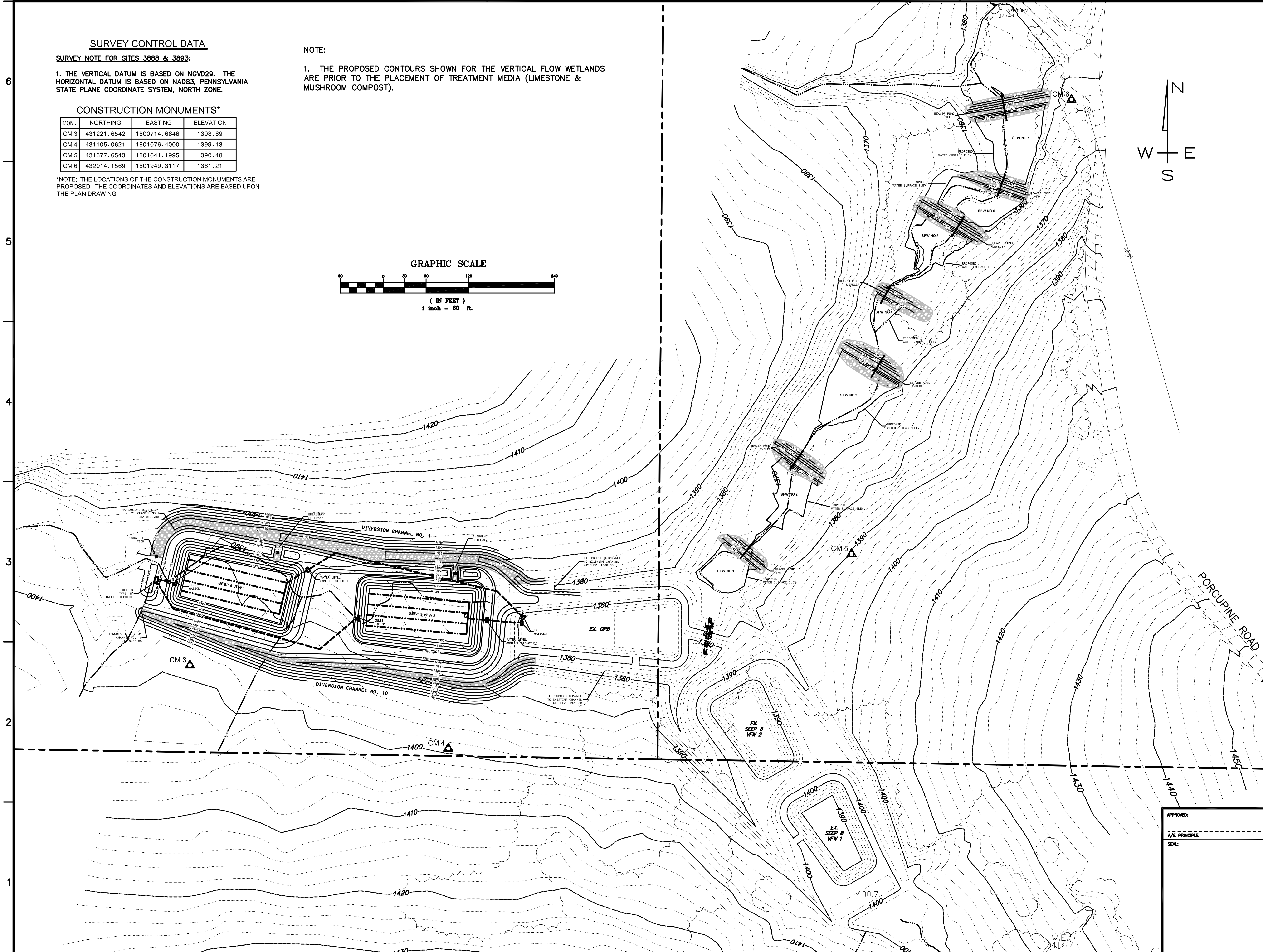
CONSTRUCTION MONUMENTS*

MON.	NORTHING	EASTING	ELEVATION
CM 3	431221.6542	1800714.6646	1398.89
CM 4	431105.0621	1801076.4000	1399.13
CM 5	431377.6543	1801641.1995	1390.48
CM 6	432014.1569	1801949.3117	1361.21

*NOTE: THE LOCATIONS OF THE CONSTRUCTION MONUMENTS ARE PROPOSED. THE COORDINATES AND ELEVATIONS ARE BASED UPON THE PLAN DRAWING.

NOTE:

1. THE PROPOSED CONTOURS SHOWN FOR THE VERTICAL FLOW WETLANDS ARE PRIOR TO THE PLACEMENT OF TREATMENT MEDIA (LIMESTONE & MUSHROOM COMPOST).



APPROVED:
A/E PRINCIPLE
SEAL:

US Army Corps of Engineers
Baltimore District

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Designed by:	Date: AUGUST, 2006	Rev.
Dwn by: / Ckd by:	Design file no.	
Reviewed by:	Drawing Number:	
Submitted by: Chief, Branch	File name: Plot date: Plot scale: 1"=60'	

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DENTS RUN SITE 3893 – PHASE III
SECTION 206, ACID MINE DRAINAGE
BENEZETTE TOWNSHIP, ELK COUNTY, PA

SEEP 9 VFWs AND SURFACE FLOW WETLANDS
DESIGN LAYOUT

FIGURE
2

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APPENDIX A
SITE INSPECTOR CHECKLIST

Dents Run Site 3893-Phase II
Passive Treatment System
SITE INSPECTION CHECKLIST

Inspector(s):____________________________________ Date:________________

General System

Inspect and clear blockage from:

- ☐ Inlet Control Boxes – Seep 8 & 9 VFWs
- ☐ Outlet Water Level Controls – Seep 8 & 9 VFWs
- ☐ Outlet Water Level Control – OPB
- ☐ Beaver Levelers – SFWs

Vertical Flow Wetlands

	VFW 8A	VFW 8B	VFW 9A	VFW9B
Depth to Stop Logs (*A* ft)[a]	_____	_____	_____	_____
Depth to Water (*B* ft)[b]	_____	_____	_____	_____
Water Depth at Inlet Pipe Invert (*C* ft)[c]	_____	_____	_____	_____
Flow Height ($H = A - B$ ft)	_____	_____	_____	_____
Flow Rate ($1495[1 - 0.2H]H^{3/2}$ gpm)	_____	_____	_____	_____
Design Flow Rates (average/maximum)	26/73 gpm	26/73 gpm	53/120 gpm	53/120 gpm

[a,b]Measure *A* and *B* from the top inside rim of the cell outlet water level control.

[c]Measure C from the bottom inside rim of the cell inlet pipe.

If *C* is greater than 0.5 feet, adjust stop logs down 1 to 2 inches; remove one 5 inch stop log if $C > 0.75$ ft.

If *C* remains at greater than 0.75 feet for several days after adjustment, arrange for substrate maintenance.

Oxidation/Precipitation Basin

Thickness of Bottom Sludge at Seep 8 Inlet ________ ft ☐ Estimated ☐ Measured

Arrange for OPB cleaning if thickness is approaching 3 feet.

Surface Flow Wetlands

Check for washouts of riprap and arrange for repairs if needed.

Notes/Maintenance Performed:____________________________________

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