Operation and Maintenance Plan

Rock Run Site

I. Site Overview

This Rock Run site contains four separate passive mine drainage treatment systems: Gaber Brown, Pond 4, Pond P, Pond 23. (The names of the systems reflect their designation during mining operations.) The locations of the systems are shown in Figure 1. The purpose of this document is to provide instructions for inspections, flushing, and maintenance of these treatment systems. The following sections discuss the general layout and treatment system elements of each of the four treatment systems.

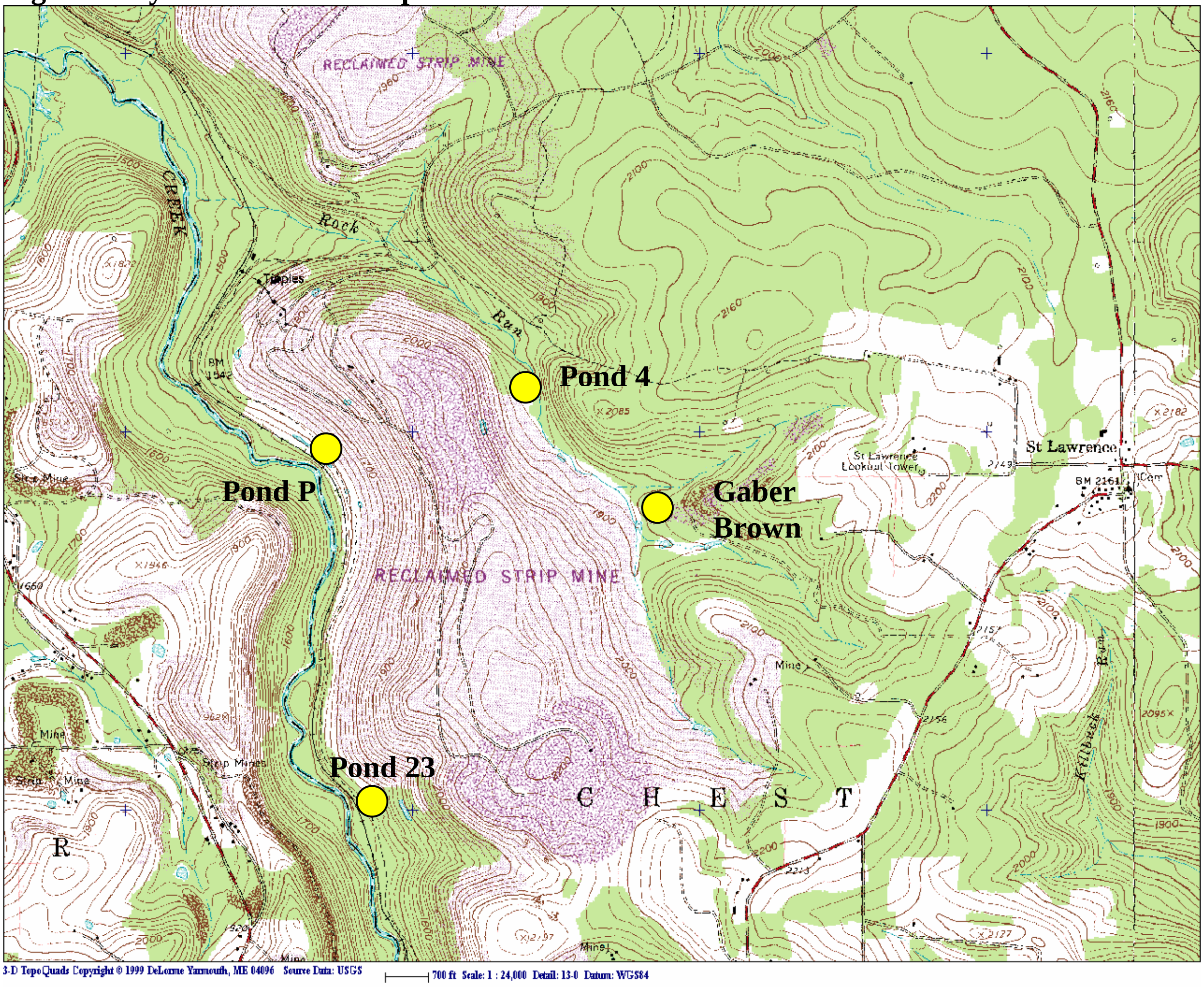
A. Common Design Features

The four treatment systems utilize a common design and have several common features. The discharges at each site are acidic and contaminated with aluminum (Al) and manganese (Mn). Iron (Fe) concentrations are very low. All of the systems are designed to neutralize the acidity with limestone aggregate and retain metal solids in settling ponds. The acidity neutralization occurs in *vertical flow ponds* (VFPs) that are designed with 4-5 feet of AASHTO #1 high $CaCO_3$ limestone. Water flows into VFPs on the surface and down through the limestone aggregate to a plastic pipe underdrain system. The underdrain collects the flow and transmits to a water level control structure (LCS) that discharges to a settling pond. The water level in the VFP is controlled, to a large degree, by number of boards in the level control structure. Each VFP also contains a layer of flush pipes placed one foot below the surface of the limestone aggregate. The purpose of the flush systems is to periodically remove metal solids that accumulate within the top 6 inches of the limestone aggregate. Flushing is accomplished by opening a buried valve. Each VFP has 2-4 flush zones. Each system has a single flush pond that is used to collect the flushate and retain solids. Flushing incurs infrequently. 99% of the time, water flows through the VFPs via the underdrain plumbing. At each system, the VFPs discharge to a common settling pond. At two systems the settling pond discharges to constructed or existing wetlands where the final discharge occurs (Pond 23 and Pond P). At two systems, the settling pond discharges to an oxic limestone bed whose purpose is to promote Mn-removing processes. The oxic limestone beds contain 4-5 feet of AASHTO #1 high CaCO3 limestone and flow occurs horizontally 6 inches below the surface of the limestone. The final discharge from the oxic limestone bed is either to the receiving stream (Pond 4) or to a small constructed wetland (Gaber Brown) that discharges to the receiving stream.

All systems contain at least two VFPs so that during major maintenance activities when one of the VFPs is off-line, the water will still be treated by the other VFP.

The systems were designed to prevent large flows from damaging the VFPs. In all cases the collected mine drainage enters an inlet distribution structure that rejects flow in excess of the maximum allowed. The maximum amount of flow varies between the systems and is adjustable. Flow passing the flow restrictor is split and piped to the VFPs. The total flow and proportional flow to each pipe (and VFP) can be adjusted.

Figure 1: System Location Map

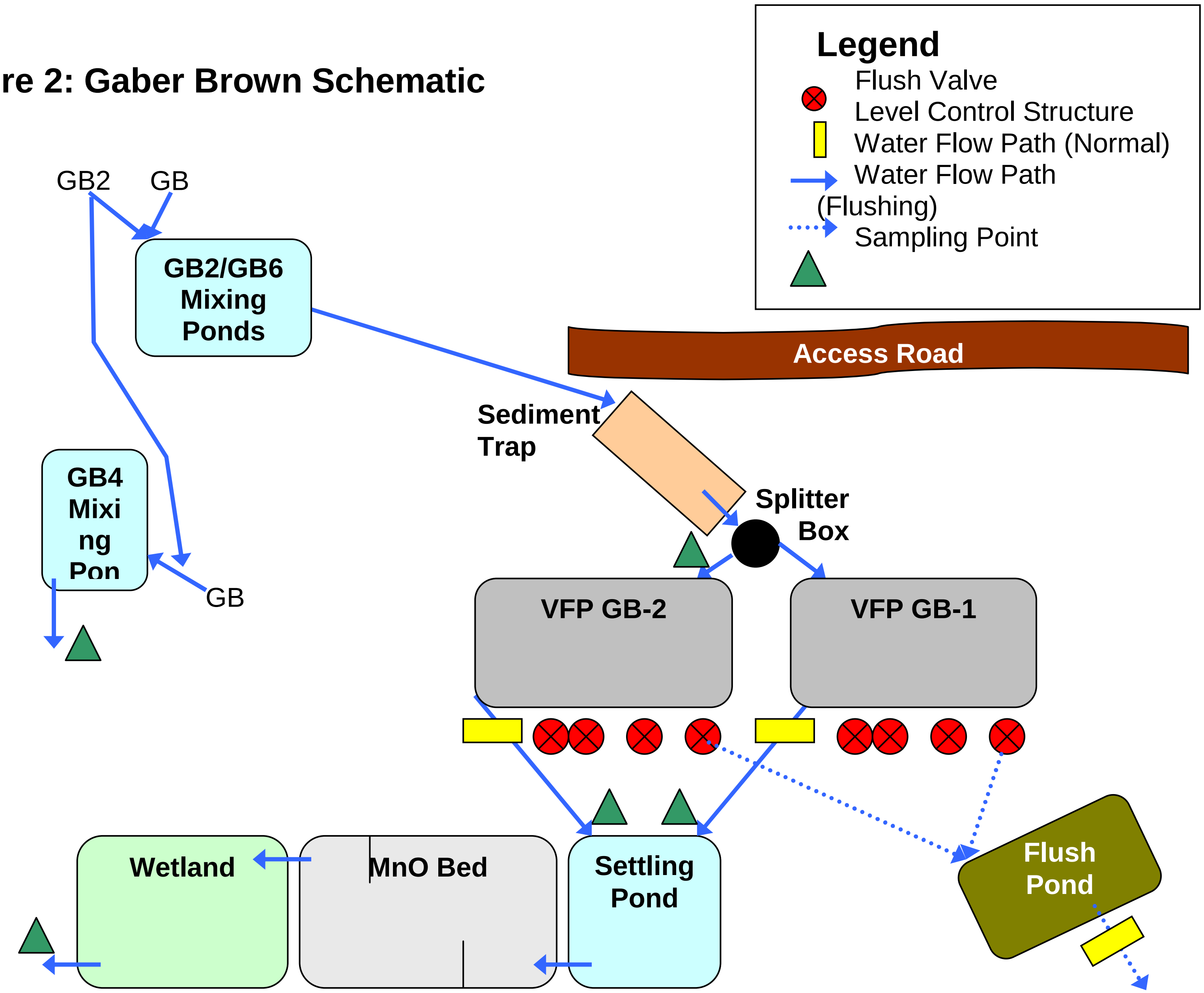


B. Gaber Brown

The Gaber Brown discharge is located between Rock Run and a tributary to Rock Run. Two discharges (GB2 and GB6) combine in two serially-connected mixing ponds and then flow down a long, rock-lined channel to a sediment trap. GB2 is a naturally alkaline flow, while GB6 is acid mine drainage. The sediment trap discharges through an inlet distribution structure, where a maximum of 100 gpm of flow goes to each of two identical vertical flow ponds (VFPs). During normal operation, the VFPs discharge through a water level control structure to a sediment pond. The sediment pond is followed by an oxic limestone bed, followed by a wetland. A separate flush pond collects water flushed from the VFPs and slowly releases it after flushing.

The Gaber Brown area also includes two treatment ponds for GB4, a small seep. These ponds are located between the GB2/GB6 mixing ponds and the main Gaber Brown system. The ponds are immediately down hill from the rock-lined ditch that connects these two areas. In order to treat GB4, a small pipeline carries some of the alkaline GB2 water. The two waters mix in two

Figure 2: Gaber Brown Schematic

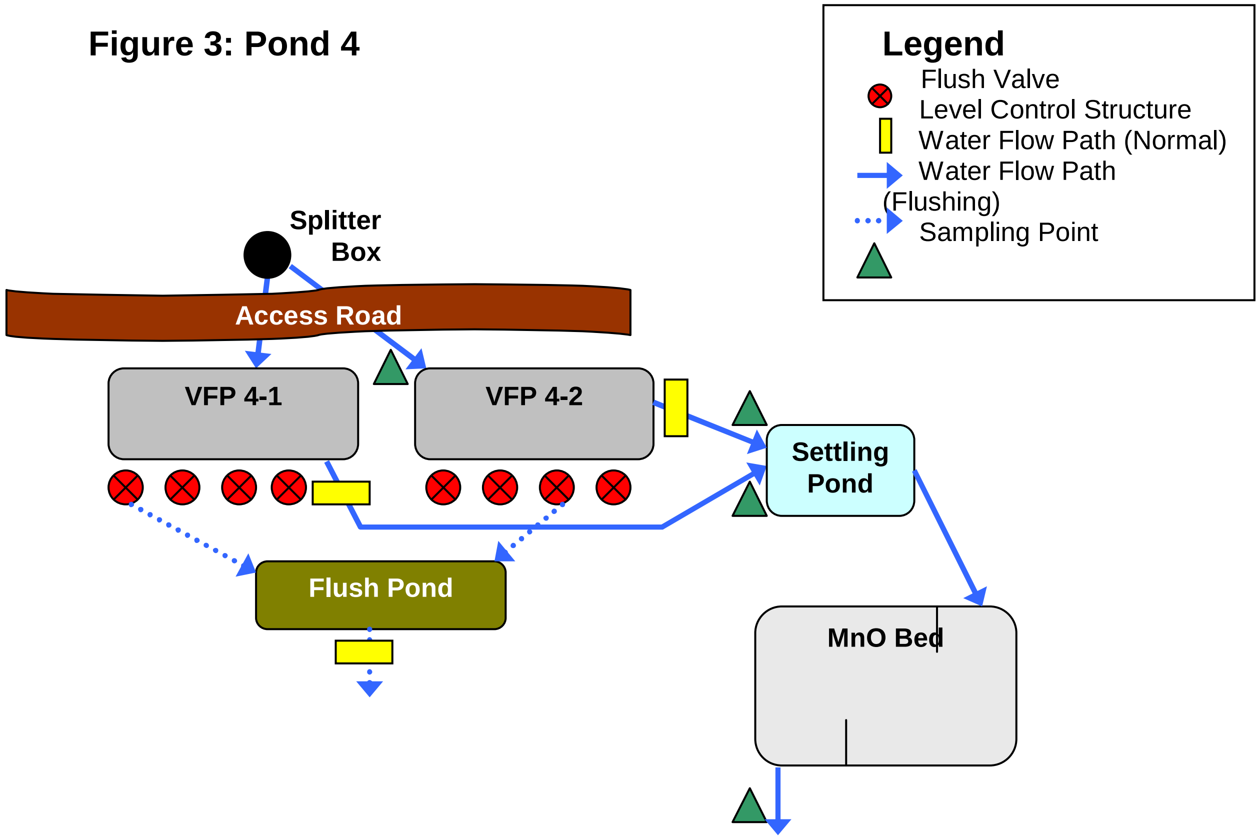


small ponds. This mixing allows the aluminum to form a solid and settle in the ponds. About 4 gpm of water from GB2 is required. This amount is adjusted via a valve at the GB4 pond location. The pipeline should be cleaned out every month by opening the valve and allowing it to flush until the water is clear (5-10 minutes).

C. Pond 4

The Pond 4 treatment system is located along Rock Run downstream of the Gaber Brown system. The discharges are collected along the hillside, then flow into an inlet distribution structure, where a maximum of 75 gpm of flow goes to each of two identical vertical flow ponds (VFPs). During normal operation, the VFPs discharge through a water level control structure to a sediment pond. The sediment pond is followed by an oxic limestone bed. A separate flush pond collects water flushed from the VFPs and slowly releases it after flushing.

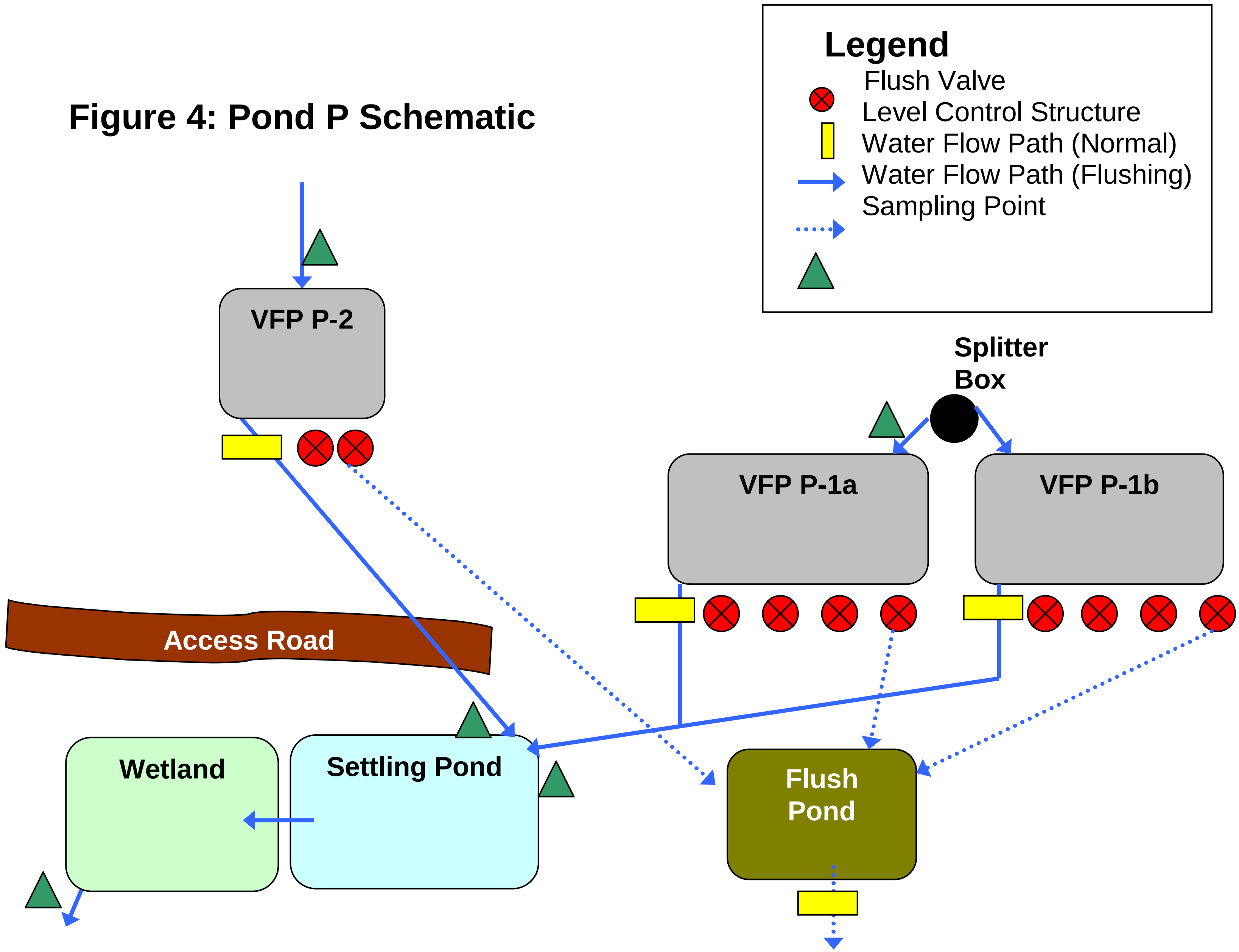
Figure 3: Pond 4



D. Pond P

The Pond P treatment system is located along Chest Creek. Two large, identical VFPs and one smaller VFP discharge to a common sediment pond and wetland. The two large VFPs treat water that is collected and distributed by an inlet distribution structure. A maximum of 80 gpm will flow to each of the larger VFPs. During normal operation, the VFPs discharge through a water level control structure to a sediment pond. The sediment pond is followed by a wetland. The wetland discharges through a flow measuring device. A separate flush pond collects water flushed from the VFPs and slowly releases it after flushing.

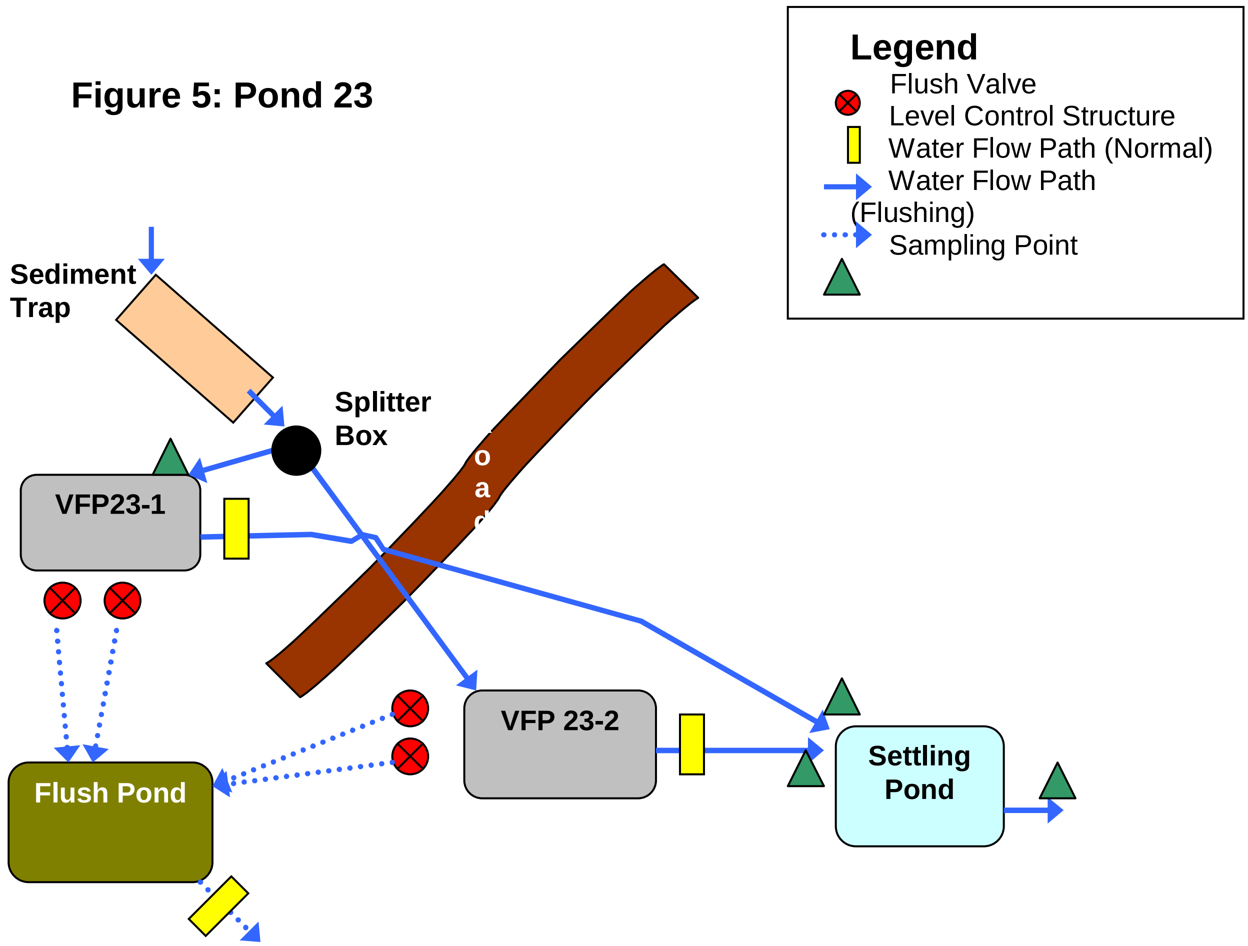
Figure 4: Pond P Schematic



E. Pond 23

The Pond 23 treatment system is located along Chest Creek. The discharge flows into a sediment trap and through an inlet distribution structure, where a maximum of 35 gpm of flow flows to each of two vertical flow ponds (VFPs). During normal operation, the VFPs discharge through a water level control structure to a sediment pond. The sediment pond discharges through a flow measuring device. The sediment pond is followed by a natural wetland. A separate flush pond collects water flushed from the VFPs and slowly releases it after flushing.

Figure 5: Pond 23



II. Treatment System Inspections

Each treatment system should be inspected monthly and after extreme precipitation or runoff events. While the inspection for each treatment system will be unique, there are many aspects that are common to all treatment systems. Key aspects of treatment system inspections include, in order of importance:

- Measuring flow rates and ensuring proper flow into the VFPs

- Checking the water level in the VFPs and adjusting the water level control boxes if necessary.
- Examining berms for sloughing or leakage
- Examining ditches and channels for blockage by leaves, sticks, etc.
- Checking the entire system for signs of vandalism
- Checking pipes, spillways, ditches, berms, and wetlands for signs of rodent activity.

Water sampling should be conducted quarterly at key locations in conjunction with inspections. More information on sampling is provided below.

The following sections provide general instructions for inspections. Inspection forms for each treatment system are included at the end of this document. An example of a completed inspection form for the Gaber Brown treatment system is also included. All completed inspection forms should be copied. One copy should remain with the field inspector's binder for reference in the field. The other copy should be stored with the project file.

A. Equipment

Equipment needed for routine treatment system inspections includes:

- Stopwatch
- Large bucket with gallons marked on inside of bucket
- Garden shovel or rake
- Key(s) to access inlet distribution structure and water level control structures

B. What to Look For

There is no substitute for walking around the entire treatment system. Each treatment cell should be "walked" and any problems should be noted on the inspection form. While not all problems will require immediate attention, it is important to note small problems so that their worsening is recognized.

For the inspection of each system, it is helpful to have the inspection forms from previous inspections on hand. Any potential issues that were identified previously should be checked with special care. A blank inspection form should be taken on each inspection and completely filled out.

The perimeter of each treatment system cell should be walked. Berms should be inspected for cracking, sloughing, or leaking. Pipes, channels, and spillways should be inspected for debris, and any debris should be removed. All valves, inlet control structures, level control structures should be examined for signs of tampering. Locks should be checked. The following sections discuss specific aspects of treatment system inspections.

C. Measuring Flow Rates

The most important places to measure flow rate are, in order of importance:

- Into each VFP
- Overflow from the distribution structure (if none, record zero)
- Total flow out of the system

At most stations, flow rates should be measured using the bucket and stopwatch method. To use this method, a bucket or tub with at least 5 gallons of capacity should be used. The bucket should be marked on the inside with permanent marker in 0.5 gallon increments. Start filling the bucket and start the stopwatch. Stop the stopwatch either when the bucket is filled or when the bucket is taken from under the flow. Record the number of gallons and the number of seconds. Repeat this procedure two more times, recording the gallons and seconds each time. For each recording, calculate the flow rate in gallons per minute:

$$\frac{\text{Water in bucket (gallons)}}{\text{Time on Stopwatch (seconds)}} \times 60 = \text{gallons per minute}$$

At some stations, permanent flumes have been installed to measure flow rates. Check the flume for debris and remove any debris before measuring. Allow the water level to return to normal before measuring. Use the dipstick attached to the flume to measure the flow rate. The dipstick reads the flow rate directly in gallons per minute (gpm). If the stick is missing, record the water depth in the flume. This depth can be converted to a flow rate later.

D. Measuring and Controlling VFP Water Levels

Each VFP on the site exits through a locked box called a "Level Control Structure" (LCS). The purpose of the LCS is to allow the operator to adjust the water level in the VFP either up (in preparation for flushing) or down (if it is too close to the emergency spillway or overflowing). The water enters the LCS on the side closest to the VFP and rises up to the level of the boards in the middle of the LCS before falling down and flowing out the other side of the LCS.

An important measurement of each VFP's performance is the amount of head that is required to push water through the limestone aggregate. This value is determined by comparing the water levels of the VFP surface and the VFP effluent. Both levels are measured relative to the elevation of the emergency spillway. The VFP surface water elevation is measured at the emergency spillway where a permanent gage has been painted on the liner material. The gage reads in distance below the emergency spillway, in inches. The effluent water elevation is measured in the LCS. On the inside of each LCS, the distance down to the emergency spillway is clearly marked. For instance, "E.S. Down 42" means that the emergency spillway for that VFP is 42 inches down from the top of the LCS. Measure the distance from the top of the box to the water level on the side of the LCS towards the VFP. Subtract to determine how far the discharge is below the emergency spillway. Given the above example, if you measured down 65" from the top of the LCS to the water, then the discharge elevation is 23 inches (65" – 42") below the emergency spillway.

The difference between the surface water elevation and the effluent water elevation is the head loss. In the example above, the water in the LCS was 23” below the emergency spillway. If the VFP surface water was 20” below the emergency spillway, then the head loss was 3 inches. (NOTE: the water level in the VFP should never be lower, that is, further below the emergency spillway, than the water level in the LCS.) The difference between these two numbers is a measure of how “plugged” the VFP has become. When the systems were built, these numbers were within 1 inch of each other because little head was needed to push water through the system. However, as the systems operate and accumulate solids over time, the surface level in the VFP will likely become higher than the water level in the LCS. The purpose of flushing is to slow the increase in head by removing a portion of the blockage. Flushing of each zone should occur whenever a difference of more than 3 inches develops between inspections.

The water level in the VFPs should always be between six inches and three feet below the emergency spillway. The optimal level is 2 feet below the emergency spillway. If the water level in the VFP is too high, boards can be removed from the LCS to lower the water level. If the water level in the VFP is too low, boards can be added to the LCS to raise the water level. The tool for adding and removing boards is stored in each LCS. The addition or removal of boards from a LCS should be recorded on the inspection and/or flushing form.

Over time, it is likely that flushing will not remove all of the solids in the VFP and the permeability of the aggregate will decrease. More head will be needed in the VFP to move water through the system. This head is supplied by removing boards from the LCS. This will allow the water to continue to push through the limestone. Flushing should still be performed on a routine basis.

Once all boards have been removed from the LCS, 8 – 9 feet of head will be available to push the water through the system. While plugging is the anticipated failure mode for these systems, the timeframe for that is not known. Planning for major maintenance activities should begin when the head required to operate the system under average flow conditions is 5-6 feet.

III. Treatment System Sampling

It may be useful to occasionally sample at various locations on the site in order to assess the performance of the treatment system. Sampling can also be useful if a problem develops or is suspected. This sampling may consist of only field parameters, which will be determined by the available equipment or of field parameters in conjunction with laboratory analyses.

A. Sampling Locations

The most important samples to take include:

- The influent to the VFPs (NOTE: If two VFPs share a common influent source, only one sample is needed. At Pond P, two influent samples are needed, one for VFP P-2 and another from one of the VFP P-1 ponds.)

- Effluent from each VFP (NOTE: A Pond P, the VFP P-1 ponds can only be sampled together as they enter the settling pond. The GB4 mixing pond effluent should also be sampled.)
- Final treatment system effluent.

For the entire site, sampling these locations requires 18 sampling points. The system schematics and site drawings show these sampling locations, which are listed below.

Gaber Brown	**Pond 4**	**Pond P**	**Pond 23**
GB4 Ponds Out	Pond 4 In	VFP P-2 In	Pond 23 In
GB VFP In	VFP4-1 Out	VFP P-1 In	VFP 23-1 Out
VFP GB1-Out	VFP 4-2 Out	VFP P-2 Out	VFP 23-2 Out
VFP GB2-Out	Pond 4 Final	VFP P-1 Out	Pond 23 Final
GB Final		Pond P Final	

If samples are consistently taken at these locations, it will be possible to determine how the VFPs and the overall systems are operating and if this operation has changed over time.

Other sampling locations may be added in order to gain additional information about the operation of the systems. These samples may be taken of the raw discharges (GB2 or GB4, for example), of the influent/effluent of other treatment system cells (such as oxic limestone beds, for instance), or during flushing activities. However, samples should be taken at the primary locations first, and additional sampling only done as an add-on.

B. Sampling Parameters and Methods

The most useful field parameters are flow rate (see Section IIC above), pH, and alkalinity. Flow rate can be measured with a bucket and stop watch at several locations within each treatment system. pH can be measured using color indicators or a pH meter. Alkalinity can be measured using a portable field titration kit (such as the digital titrator by Hach). While pH and alkalinity can also be measured in the laboratory, field measurements are more accurate and provide a basis for on-the-spot decision making.

Laboratory analyses provide more detail on the performance of the treatment systems. The analyses of interest for the Rock Run sites include: pH, alkalinity, acidity, total aluminum and total manganese. Most local laboratories offer a special AMD package that includes these parameters and several others.

C. Data

A standard system for naming the recommended sampling points has been established (see table above). The standard sample point names are listed on the attached site plan views.

Data should be reviewed regularly in order to determine whether problems are developing in a particular treatment system. Managing data in an electronic spreadsheet is a good approach. The typical spreadsheet is set up with the date, sample location, and analytical parameters as columns and each row as the results of one sample analysis. The spreadsheet can be set up with charts that automatically update with the input of new data. Parameters that should be tracked over time include:

- pH and alkalinity of each VFP effluent
- pH and alkalinity of each final system effluents
- head losses in each VFPs
- total flow rate into each system

While some fluctuation in each of these parameters is expected due to seasonal effects and changes in flow rate, tracking these parameters over time will allow for the identification of declines in treatment performance.

IV. Treatment System Flushing

The purpose of the VFPs is to remove aluminum from the water, which will need to be periodically flushed. Each VFP is divided into 2-4 zones, with one valve controlling each zone. Each zone should be flushed on a quarterly (4 times a year) basis. This schedule is based on the anticipated performance of the systems. However, if the water level in any of the VFPs begins to rise or the difference between the water level in a VFP and the water level in that VFP's level control structure rises rapidly, all of the zones in that VFP should be flush as soon as possible. These changes are readily apparent by examining the site inspection forms for several consecutive inspections.

A. Equipment

Equipment needed for treatment system flushing includes:

- Key to access inlet distribution structure and water level control structures
- Valve key (long metal T-rod)

Use the forms provided to record each flushing event.

B. Before Starting to Flush

Before each flushing event, it is ideal to have the flush pond as empty as possible and the VFPs as full of water as possible. After each flushing event, the flush pond should drain so that less than 1 foot of water remains. Water should then stop draining. If the pond does not drain, open the water level control box. The board that is next to the bottom board has several holes drilled in it. Check the board for debris. When removing and/or replacing the boards, firmly press down each board individually. Replace all of the boards in the flush pond so that the top of the boards is level with the emergency spillway on the flush pond.

If possible, it is ideal to build up water in the VFPs prior to flushing. To do this, add enough boards to the LCS to raise the water level in the VFP to within 6” of the emergency spillway. Depending on the influent flow rate, it may take several hours or days to completely fill the VFP.

C. General Flushing Instructions

Flushing the VFPs is essential to ensuring that they continue to operate properly. Follow these instructions:

1. Fill out the initial information on the flushing form.
2. Select a zone or zones to flush.
3. Note the water levels in the VFP you will flush, the level control structure for that VFP, and the flush pond.
4. Completely open the valve for one zone.
5. Leave the valve open until the flush pond is full **OR** until water runs completely clear.
6. Close the valve and replace the valve cover.
7. Record the new level in the VFP you flushed and the level control structure for that VFP.
8. IF the flush pond is not full, you can then flush more zones.
9. When you are done flushing zones in that VFP, return the boards in the level control structure to normal. If you plan on flushing another zone from that VFP in a day or two, leave the extra boards in.

The flush pond will slowly drain down over a period of 24 – 72 hours. After this point, you can conduct additional flushing, if necessary.

The duration of the flush event is dependent on the amount of solids being discharged from the limestone aggregate. All of the Rock Run systems were flushed in 2005. The flushed water was initially very turbid with grey and black particulates. After 5-10 minutes, the flushed water was clear and remained so for 30 minutes. At this time, it appears that a 5-10 minute flush may be appropriate for the Rock Run VFPs.

The channels carrying flush water to the flush ponds are designed to contain the flow of one flushing zone at a time. Simultaneous flushes into the same channel should not occur. It is feasible to conduct simultaneous flushes from VFPs that flush into separate channels (Gaber Brown, Pond 4, and Pond 23). Simultaneous flushing events will fill the flush pond faster. The operator should be careful not to overtop the flush pond.

For every flushing event, record all information on flushing form. Note any color of the flush water and anything unusual about the flush event. An example of a completed flushing form is attached.

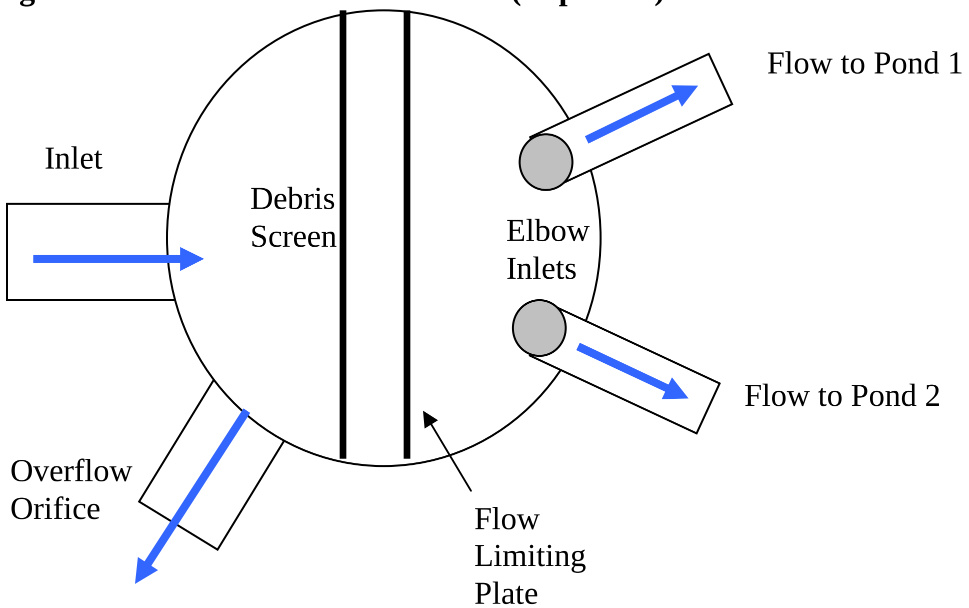
All completed flushing forms should be copied. One copy should remain with the field inspector’s binder for reference in the field. The other copy should be stored with the project file.

V. Potential Maintenance Issues and Remedies

A. Inlet Distribution Structures

All of the systems have an inlet distribution structure before the VFPs. Figure 6 shows a diagram of an inlet distribution structure from the top. The purpose of these structures is to limit the total amount of flow to the VFPs and to divide the flow equally between two VFPs. The distribution structures have locking lids to prevent vandalism.

Figure 6: Inlet Distribution Structure (Top View)



Inside each distribution structure, two plastic plates have been installed. The plate closest to the inlet is the debris screen. This plate has been perforated with numerous 1" diameter holes. This plate will catch sticks, leaves, or other debris that enters the distribution structure. The debris screen can be lifted out of the box for cleaning when necessary.

The second screen, which is closer to the elbows that send flow to the VFPs, is the flow limiting plate. This plate has been equipped with 2-3 orifices that have been sized to limit the maximum amount of flow that will be sent to the VFPs. The following table lists the total amount of flow allowed by the distribution structure at each system.

System	Maximum Flow into VFPs (gpm)
Pond 23	70
Pond P*	200*
Pond 4	150
Gaber Brown	200

**This is the maximum for all three VFPs combined. Approximately 80 gpm should be treated by each of the two larger VFPs. The smaller VFP should treat approximately 40 gpm.*

It is possible to change the maximum amount of flow, either by plugging one or more holes in the flow limiting plate or by drilling more holes to increase the amount.

Measure the flow into each VFP and the overflow from the inlet distribution structure (if any). Examine the flow rates and ask yourself these questions:

- Is the flow into each VFP approximately equal? If not, open the inlet distribution structure and clear any debris from the elbows that flow to the treatment system. If that does not succeed in making the flows equal, the elbows may need to be adjusted.
- Is the total into the VFPs equal to or less than the total allowable flow? If so, there should be no overflow. If there is overflow, there must be a restriction that partially blocking flow to the VFP inlet pipes. Open the inlet distribution structure and clear debris.
- Is the total into the VFPs more than the total allowable flow? If so, the VFP overflow structure is probably blocked. Open the inlet distribution structure and remove debris from the overflow outlet.

The inlet distribution structures should be opened and inspected annually, even if no problems are apparent. The trash screen can be removed and cleared of any debris in the holes. Replace this screen, then remove and clean the flow limiting screen. Remove any debris around the pipes to the VFPs and the overflow pipe.

The inlet distribution structures also allow the operator to shut off one VFP while it is being worked on and send all of the water to the other VFP. This can be done simply by capping the elbow that sends water to the VFP that needs maintenance, or by placing a short stand-pipe in that elbow. If maintenance is performed during moderate to low flow conditions, the remaining VFP will be able to adequately treat all of the flow.

B. Rodents and Other Pests

One common issue with treatment systems is damage by rodents. Beavers can build dams in treatment systems or on adjacent streams, flooding out the treatment systems. Geese pull up emerging wetland vegetation and create channels in the vegetation. The most common and serious problems are muskrats. Muskrats can destroy wetland vegetation, plug spillways, channels, and pipes, and tunnel into berms causing ponds to fail or drain. If muskrat activity is noted at a treatment system, a trapping program should be considered. Trapping is regulated by the PA State Game Commission. The Game Commission can identify local trappers and, if necessary, provide permission to trap out-of-season.

C. Solids Accumulation

There are two types of solids that may accumulate in the various ponds on the site. “Sludge” refers to metal hydroxides or oxides that will form as part of the mine drainage treatment. Aluminum and manganese are the primary metals of concern. Sludge is generally low in solids content and requires pumping. “Sediment” refers to sand, silt, and clay particles that result from erosion. Sediment is usually high in solids content and can be removed using a backhoe.

Eventually, sludge and sediment will accumulate in the ponds on site. The following table details the potential for sludge and sediment in each structure.

Pond	**Sludge Potential**	**Sediment Potential**	**Estimated Clean Out Schedule**
GB2/GB6 mixing ponds (2)	Moderate	Low	Every 10 years
GB4 treatment ponds (2)	Moderate	Low	Every 10 years
Gaber Brown Sediment Trap	Moderate	Moderate	When 2’ of sludge has accumulated
Pond 23 Sediment Trap	Low	High	When 2’ of sludge has accumulated
Flush Ponds (4)	Moderate	Low	When 1’ of sludge has accumulated
Settling Ponds (4)	Low	Low	Every 50 – 100+ years

When sediment and sludge accumulation begins to interfere with operations of the system, it must be removed. The solids expected in these ponds are not hazardous and can usually be disposed of on site by burial. Sludge in usually removed by pumping. Sediment can often be dewatered in place by removing flow water and then removed with a small excavator or backhoe.

Pond cleaning is a common activity on active mining operations. There are companies that perform sludge and sediment removal activities for the mining industry. The names of companies capable of performing periodic pond maintenance can be obtained from local mining companies or the PA DEP District Mining Office.

The flush ponds are intended to store sludge that is flushed from the VFPs. The sludge, which has high water content when flushed, will dewater to a dried dense material in the bottom of the ponds. Naturally dried iron oxide sludge (50% solids) has a density of about 20 lb of solids per ft^3. Assuming that the flush ponds must be cleaned out when sludge reduces the volume by 20% consumed, then the Gaber Brown, Pond 4 and Pond P flush ponds will require cleanout every 10 years. The Pond 23 flush pond will not require clean out for 45 years. The sludge could be removed by excavation or it could be slurried and removed with a pump. The sludge is not hazardous and can be buried on-site.

D. Limestone Replacement

Limestone-based passive systems can require major maintenance when the limestone is lost to dissolution or fouled by the accumulation of solids. The K&J systems will not fail because of the dissolution of limestone. Current dissolution rates suggest the loss of about 30 tons of limestone per year from the GB, Pond 4, and Pond P systems. The VFPs should function, from a limestone tonnage perspective, even when half of the limestone is dissolved. This will not occur for 100 years. Pond 23 and the oxic limestone beds have substantially lower dissolution rates and the life expectancy, from a limestone dissolution perspective, if even higher.

Major maintenance may be necessary to address the fouling of limestone aggregate through the accumulation of solids. Solids can coat limestone, decreasing its reactivity, and plug pores, decreasing the porosity and permeability. The loss of limestone reactivity will be realized through decreasing effectiveness of the VFP. This will be apparent from decreasing concentrations of alkalinity at the VFP effluent sampling points. The loss of permeability will be realized through increasing head requirements to operate the VFPs. This will be apparent from the increasing differences in the water level in the VFP and the level control structure.

Experiences with similar systems suggest that the performance of the systems will be impacted first by the loss of permeability and the need for increasing amounts of head (pressure) to push water through the plugged aggregate. The designers of the systems recognized this possibility and included several features that will delay hydrologic failure of the VFPs. As noted earlier, a portion of the solids in the VFPs can be removed through periodic flushing. If losses in permeability cause head losses, these losses can be countered through the adjustment of the water level control boxes.

When flushing and removing boards from the level control structure is no longer sufficient to allow operation of the VFP, some or all of the limestone will need to be replaced. If the metals have accumulated primarily on top of the limestone and/or in the top 1' of limestone, it may only be necessary to remove and replace this limestone. This could be carefully done using an excavator in order to preserve the flush plumbing network.

If more of the limestone has been fouled and is no longer useful, it may be necessary to remove and replace the flush plumbing along with the limestone. Preserving this plumbing may not be feasible, and future advances in design may warrant the replacement of this plumbing in order to take advantage of those advances.

In extreme cases, it may be necessary to remove all of the limestone and replace it with fresh limestone. In this case, the underdrain plumbing would also need to be preserved or replaced.

Fouled limestone that is removed from the systems can still be useful for other purposes, such as road construction. If the limestone is to be reused for another purpose, it should be washed in order to remove any particulates that can easily be removed. This can be done by power washing the limestone or by making small piles or windrows of stone which will be washed by rain. Any solids that wash off will be inert, but proper erosion and sedimentation controls should be in place. The washed limestone can then be used for any purpose other than mine water treatment.

E. Possible Schedule for Major Maintenance Activities

A schedule for major maintenance on the VFPs is highly uncertain because the K&J treatment system designs are unique, the mine water composition is unique, and the designers included features that should lessen the frequency of major maintenance. The systems were designed with an expectation that the VFPs would remove Al, but have negligible effect on Mn. The early sampling results indicate that the VFPs are removing all of the Al *and* most of the Mn. Because the physical characteristics of passively-precipitated Mn solids are unknown, it is difficult to project their effect on limestone reactivity or porosity. The following projections assume that the Mn solids are similar to Fe solids. If reliable information on the physical characteristics of Mn solids becomes available, the projections should be recalculated.

The major maintenance projections assume the following:

- Limestone aggregate density, 1.35 tons/CY
- Original limestone aggregate porosity, 40%
- Al solid, $Al(OH)_3$; Mn solid, MnO_2
- Al and Mn sludge water content, 85%
- Al and Mn sludge density, 10 lb/gallon
- Flushing effectiveness: 25% of solids removed
- Critical loss of porosity, 50%

The table below shows the results of sludge calculations using these assumptions. The major VFPs are calculated to loose 50% of their porosity after 13-17 years. At this time, it is likely that the VFPs will require major maintenance associated with the removal and replacement of limestone aggregate. 70% of the sludge that is projected to accumulate is Mn. If the removal of Mn by the VFPs decreases the length of time between major maintenance is expected to increase.

Calculated years to loss of 50% of aggregate porosity in the VFPs.
See the text for assumptions used to make these calculations.

	LS, tons	Porosity, gal	Al rem mg/L	Mn rem mg/L	Sludge, gal/yr	Flush rem, gal/yr	Pore loss % / yr	Years to 50% loss
Gaber Brown	6,000	359,000	3	20	14,000	3,500	3%	17
Pond 4	6,000	359,000	6	38	17,000	4,300	4%	14
Pond P	6,000	359,000	9	35	19,000	4,800	4%	13
Pond 23	1,200	72,000	3	7	1,000	250	1%	55

Gaber Brown Inspection Form (EXAMPLE ONLY)

Date: April 26, 2005 **Time:**10:00 AM **Inspector(s):**Kim Weaver, Hedin Environmental

Weather: Clear and windy, about 60 degrees. It rained a lot last night____________________

VFP GB-1 Flow Rate
__2.5___ gallons divided by _2.1__ seconds times 60 = ___71.4__ gpm
__3.0___ gallons divided by _2.6__ seconds times 60 = ___69.2__ gpm
__2.0___ gallons divided by _1.8__ seconds times 60 = ___66.7__ gpm Average = __69.1_gpm

VFP GB-2 Flow Rate
__3.0___ gallons divided by __2.5_ seconds times 60 = ___72.0__ gpm
__2.5___ gallons divided by __1.9_ seconds times 60 = ___78.9__ gpm
__3.0___ gallons divided by __2.4_ seconds times 60 = ___75.0__ gpm Average = _75.3__gpm
Total into VFPs = ___144.4_gpm

Overflow from Sediment Trap (if none, record 0 below)
_______ gallons divided by _____ seconds times 60 = ________ gpm
_______ gallons divided by _____ seconds times 60 = ________ gpm
_______ gallons divided by _____ seconds times 60 = ________ gpm Average = ___0___gpm

Wetland Exit Flow (flume) Wetland flow = __150___ gpm

VFP GB-1 Water Level in VFP = __30____ inches below Emergency Spillway
Water Level in LCS = __32____ inches below Emergency Spillway
Difference = ___2___ inches

VFP GB-2 Water Level in VFP = __20____ inches below Emergency Spillway
Water Level in LCS = __25____ inches below Emergency Spillway
Difference = ___5___ inches

✓	**Item/Area**	**What to Check**
	GB2/GB6 Mixing ponds	Clear debris from spillway between ponds; berms are stable
	Channel to Sediment Trap	Clear debris from channel; examine pipe crossing
	GB4 System	Proper ratio of GB2:GB4 waters; berms are stable
	Sediment Trap	Berms are stable; clear any debris from standpipe
	Inlet Dist. Structure	Measure overflow (if any); check screens and remove debis
	VFP GB-1	Measure flow into VFP; check berms
	VFP-GB-2	Measure flow into VFP; check berms
	Flush Pond	Note depth of water; clear debris if necessary; check berms
	Sediment Pond	Check berms; clear debris from spillway
	Oxic Limestone Bed	Check berms; clear debris from spillways
	Wetland	Measure flow; check berms; clear debris from spillway
	Site Access	Note any problems with site access
	Rodent Activity	Note any activity by muskrats, beavers, and geese
	Vandalism	Note any damage or attempted

Use the back of this form to record notes. Note any issues, new conditions, or measurements.

Gaber Brown Flushing Form (EXAMPLE)

Inspector(s): Kim Weaver, Hedin Environmental

VFP(s)	**Zone(s) To Be Flushed (circle):**			
GB-1	(A)	B	C	D
GB-2	(A)	B	C	D

Date and Time	**Action/Notes**
4/25/05, 10AM	Visited site and did inspection. Put boards in VFP GB-1 level control structure to 6” below emergency spillway. Note: flush pond is empty.
4/26/05, 9 AM	Level in VFP GB-1 is 5” below emergency spillway. Opened valve GB-1A. Water came out white/grey with small chunks visible.
9:10 AM	Water being flushed is much clearer.
9:17AM	Flush pond full to emergency spillway; closed Valve GB-1A. Returned boards in VFP GB-1 level control structure to how they were before flushing. Water level in VFP GB-1 is 12” below emergency spillway. Put boards in VFP GB-2 level control structure to 6” below emergency spillway.
4/27/05, 9 AM	Visited site. Flush pond is draining; approximately 2’ of water remain. VFP GB-2 is up to within a couple inches of the emergency spillway.
4/28/05, 10 AM	Visited site. Flush pond is completely drained. VFP GB-2 is 4” from emergency spillway. Opened Valve GB-2A. Water is cloudy/white.
10:15 AM	Flush pond full to emergency spillway; closed Valve GB-2A. Water remained cloudy the whole time. Returned boards in VFP GB-2 level control structure to how they were before flushing. Water level in VFP GB-2 is 10” below emergency spillway.
4/30/05, 9 AM	Visited site. Flush pond is empty. Water levels in both VFPs back to pre-flushing levels.

OVERALL NOTES

Valve GB-1A was a little hard to close completely. ______________________________________