Renovation of the Scrubgrass Treatment System

Final Report

Prepared by Scott Conservancy for the Pennsylvania Department of Environmental Protection Nonpoint Source Program

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Executive Summary

The Scrubgrass mine drainage treatment system was renovated to improve its treatment effectiveness, lessen long-term O&M costs, and improve its use as an educational facility. The system consists of a deep mine discharge, an electric aerator, and two ponds. Both ponds were full of iron sludge. The sludge was removed and captured on-site in geotextile bags. Iron Oxide Recovery, Inc., financed the iron recovery aspect of the project and is currently marketing the material as a pigment. Its pigment value was substantially decreased by the unavoidable mixture of mud with the iron sludge during its removal from the pond. The ponds were deepened by two feet to increase the system volume from 278,000 gallons to 467,000 gallons. Retention time for average flow increased from at most 10 hours (pre-project conditions) to 42 hours. Soils excavated from the ponds were disposed of off-site at a local soils recycling operation. The ponds were lined with a geotextile fabric and 12 inches of AASHTO #1 aggregate were placed on the bottoms. The aggregate bottom will support heavy equipment used in future sludge recovery operations. The geotextile fabric will prevent contamination of recovered iron with underlying clays, increasing its purity and saleability. The influent channel to the upper pond was extended to eliminate a short-circuiting problem. A limestone aggregate path was installed between the site entrance, the aerator, and the final discharge. A guard rail and gate were placed at the site entrance to prevent unauthorized or accidental access by vehicles. A four-foot chain link fence was placed between the path and the ponds.

The modifications only improved the system's treatment effectiveness by about 30%. Performance may improved with growth of the wetland plants in 2004. We are working with the aerator contractor to assure its optimal performance.

An operation and maintenance plan was developed. Iron Oxide Recovery, Inc., has agreed to take over routine site O&M and sludge management responsibilities in return for ownership of all sludge removed. This is the first case where long-term system O&M responsibilities have been traded for resources recovered from the polluted mine water.

Project Background

The Scrubgrass mine drainage treatment system is located in Scott Township, Allegheny County. It is located in a suburban environment. The system treats a discharge from a long abandoned underground mine in the Pittsburgh coal seam. The discharge has been monitored by a variety of groups since 1995. A complete listing of discharge flow and chemistry is present in the appendix . The discharge flow rate generally ranges between 125 – 375 gpm (average flow, 186 gpm). The discharge is net alkaline (average -43 mg/L net acidity as $CaCO_3$) and contains 60-90 mg/L Fe (average 73 mg/L).

The original system was designed for passive removal of iron through natural biogeochemical processes. Table 1 shows the major events that have occurred at the site. The system has been a lesson in the challenges of mine drainage treatment in urban/suburban areas. While originally envisioned as a 2 acre treatment system tucked into a hollow in suburban Scott Township, site constraints limited the actual system to 22,500 ft^2 (0.5 acre). The final design was impacted by a sanitary sewer line, a storm sewer line, a high pressure gas line, a railroad right-of-way, a road right-of-way, and flooding issues with the receiving stream, Scrubgrass Run. Unfortunately, while the size of the system decreased with each problem, the flow rate of the discharge remained at around 200 gpm. Optimistic sizing calculations indicate that a 1-2 acre system is necessary for effective passive treatment. The system is simply too small for the discharge. As a result, the passive system only removed about 40% of the iron.

Limited area is a common passive treatment challenge. In rural areas, it is often possible to pipe or move the discharge to a better location. This was not possible at the Scrubgrass site. Another solution for the treatment of net alkaline Fe-contaminated water is aeration. By increasing the oxygen content of the water and decreasing the CO_2 content of the water, iron oxidation should occur more quickly and better treatment should be achieved in a smaller area. This opinion resulted in the installation of an electric blower in 1998 by O-Two Environmental.

The blower improved treatment, but the final discharge remained highly degraded. Table 2 shows the average chemical conditions for the system in the year following installation of the blower. The data were collected by the Jim Fletcher, an inspector for the Greensburg District Mining Office. The data showed that only 40% of the iron was being removed by the system, even with the blower operating. The US Department of Energy also sampled the site following installation of the blower. Their summary data, shown in Table 3, reinforces the DEP data.

Table 1. Sequence of events at the Scrubgrass site, 1995 – 2003.

1994	Initial contact between Scott Conservancy and Chartiers Valley High School; Chartiers Valley High School class studies discharge site
1995	Final report on Scrubgrass Run Mine Drainage problems and solutions delivered by Chartiers Valley High School; proposal to construct system developed
Autumn 1996	Scrubgrass System constructed
1997	Monitoring and bypass installation
1998	Operation of system with bypass; DEP begins monthly monitoring of system
Spring 1999	Blower installed by O-Two Environmental
1999	System monitoring by DEP; blower experiments by US DOE; sludge accumulation problems evident; cost estimates for sludge removal and disposal obtained.
2000	Growing Greener Grant provided to renovate system
2001/02	Iron Oxide Recovery establishes feasibility of iron oxide production from mine drainage sludge at site in Westmoreland County
Autumn 2002	Major system renovations implemented by DeBaldo Brothers, Inc.
2003	Guardrail, fence, and path installed, lower wetland planted, final report to DEP

Table 2. Average chemistry of water flowing through the Scrubgrass system in the year following installation of the blower. (Data provided by PADEP. Eight sets of samples collected June 1999 – Nov 2000.)

	Flow	pH	alkalinity	Fe^{tot}	SO_4
Discharge		6.2	181	75	665
Between ponds	173	6.4	134	59	650
Final		6.5	111	43	654

Flow is gpm, alkalinity is mg/L $CaCO_3$, Fe and sulfate are mg/L

Table 3 Average chemistry of water flowing through the Scrubgrass system, May 2000 – August 2001 (Data provided by George Watzlaf, US Department of Energy. Average of three sets of samples.)

	O_2	pH	Acid	Fe^{tot}	Fe^{dis}	Ca	Mg	Na	SO_4
Discharge	0.3	6.2	-55	71	70	102	34	303	566
Blower	7.6	6.4	-58	74	69	103	35	310	562
Between Ponds	7.0	6.5	-57	62	53	101	35	304	582
Final	7.2	6.5	-58	62	53	101	35	304	582

Dissolved oxygen, Fe, Ca, Mg, Na, and sulfate are mg/L; acid is net acidity as mg/L $CaCO_3$

Several parties investigated the treatment problem. O-Two Environmental had based their installation on successful projects at other sites with similar water chemistry. Bob Hedin visited the Penn Allegheny site in northern Allegheny County and verified that the blowers were working very effectively. However, the Penn Allegheny system was different in several potentially important aspects. The pH of the discharge was 6.5 and the blowers raised the pH to 7 or higher. The sedimentation ponds following the blowers were much deeper than the Scrubgrass ponds. The retention times in the Penn Allegheny ponds was greater than 12 hours. Mr. Budeit (owner of O-TwoEnvironmental) estimated that the retention time for the sludge-filled Scrubgrass ponds was less than six hours.

In the autumn of 1999, George Watzlaf conducted studies at the Scrubgrass site to determine the effectiveness of the blower. The investigation compared system performance when the blower was turned on and turned off. The results indicated that the blower increased the oxidation rate of ferrous iron and removal of iron. It was noted that retention of water within the system was short and that increased retention would probably increase the effectiveness of the system. A summary of the DOE aeration experiment is provided in the Appendix.

Both Jim Fletcher and Don Budeit emphasized the need for sludge removal to improve the system's performance. In November 1999, bids were received from two sludge management companies. The cost to remove and dispose of iron sludge from the Scrubgrass system was estimated at $44,000 – 53,000. This liability had accrued in only three years.

Dissatisfaction with the treatment system's performance and concerns about the long-term costs of sludge management prompted a plan to deepen the ponds and thus increase the retention and increase iron precipitation. Sludge removal was recognized as a continual problem, so the plan included features that would facilitate future sludge removal. It was hoped that efforts by one of our partners, Bob Hedin, to produce a marketable iron product from treatment sludge, would be the basis of a much less expensive long-term sludge management process.

A proposal to renovate the Scrubgrass system was developed and submitted to the Growing Greener program. The project was funded through the Nonpoint Source Section 319 Program. The project was delayed for two years while Bob Hedin developed his iron recovery procedures. Once methods had been developed for the low-cost capture of pumped iron sludge, the project proceeded.

Project Objectives

The primary goals of the project were

1. to increase the depth of the ponds and thus increase iron oxidation and retention;
2. implement features that would lessen future O&M associated with management of iron sludge deposits.

Second goals of the project were:

1. increase accessibility to the site by the public through the installation of a path, bench, and signage;
2. increase safety features by installing a fence around the deep water portions of the system;
3. explore the marketability of iron sludge recovered as a consequence of the system's reconstruction.

<u>Project Achievements</u>

The project consultant was Hedin Environmental, a local consulting firm that specializes in mine drainage treatment projects. Hedin Environmental (HE) had been involved in the original construction of the Scrubgrass treatment system and was familiar with the site conditions. HE developed the redesign for the system. The redesign was constrained by site conditions and permitting issues.

- The original plan for the treatment system included larger ponds. The sizes were decreased because of the presence of a sanitary sewer, a storm water sewer, and an adjacent active railroad right-of-way. These limitations were reinvestigated. The limitations provided by these features had not changed. It was determined that the ponds could not be increased in size through lateral expansion.
- Flood plain issues constrained the construction of higher berms. Several times on the last ten years, Scrubgrass Run has flooded homes upstream of the treatment system. Changes to the flood plain that could conceivably decrease flood water storage would not be considered by PADEP without a detailed flood plain analysis. Even with such an analysis, approval of a plan that decreased storage could not be assured. A decision was made to develop a plan that would not affect the flood plain. The ponds would be enlarged by excavating downward. The excess cut material would be removed from the site.

The elements of the treatment system redesign are shown in Table 4. The ponds were deepened, resulting in an increase of volume by 70%. The upper pond and half of the lower pond were reconstructed with a geotextile liner and aggregate strip bottom. The geotextile separates the iron sludge from underlying mud pond bottom. The aggregate provides a "road" that will facilitate the movement of heavy equipment into the pond during future sludge recovery operations. Use of the site by the public was enhanced. A limestone chip path was placed on the outside berm that leads from the parking area to the blower and the final discharge point. The path will retain easy access to the site without the need for O&M for many years. A four-foot chain link fence was placed between the path and ponds. A concrete weir, originally installed by hand by a local Boy Scout troop, was reinstalled so that flow measurements will be more accurate in the future.

Table 4. Changes to the Scrubgrass system made in 2002/03.

Feature	Original	Redesign
Upper pond	179,000 gallon capacity	337,000 gallon capacity
Lower pond	99,000 gallon capacity	130,000 gallon capacity
Lower pond	Continuous 1.5-2.0 ft depth	Half of pond 4 ft deep pond; second half of pond 6-12 in deep wetland
Bottom of upper pond	Fill material, soft mud	Geotextile with 6 inch deep aggregate strip down middle
Bottom of deep portion of lower pond	Fill material, soft mud	Geotextile with 6 inch deep aggregate strip down middle
Second half of lower pond	12-18 inch water depth with sparse cattails	6-12 inch water depth replanted with sufficient cattails to yield dense stand in 2004
Safety	No fences	Four foot chainlink fence around public access portions of Pond 1 and Pond 2
Safety	Rotten wooden posts to keep cars from Pond 1	Metal guardrail
Path through system	Mowed grass	Limestone chip path along berms and to blower
System weir	Uneven installation with leakage around sides	Reinstalled level without any leakage

Contractors and Consultants

The project manager and primary consultant was Robert Hedin of Hedin Environmental (Mt Lebanon). Hedin Environmental was responsible for permitting, developing the restoration plans, identifying qualified contractors, negotiating prices, overseeing construction, and preparing project reports. Two subcontractors assisted Hedin Environmental. DEM Surveying used existing NRCS mapping to develop the Erosion and Sediment Control Plan and the Construction plan. GAI Consultants assisted in the design of the mine discharge collection structure and strategy.

The principle construction contractor was DeBaldo Brothers, Inc. The company was identified because of their experience with sludge handling and treatment pond construction. DeBaldo was provided with a set of construction plans and submitted a bid for $67,690. The bid, less than the estimated cost, was accepted. The construction occurred in October and November 2002. In the winter of 2003, Pittsburgh Fence Company, a regular contractor for Scott Township, was contacted about providing a security fence for the system. A plan was negotiated to install a guard rail, gate, and fencing along the upper and lower ponds for $8,500. The work was completed in June 2003. In the summer of 2003, Ecological Restoration, Inc. was contacted about planting the wetland in the lower pond and constructing a low-maintenance path through the site. A price of $8,300 was agreed upon. The work was completed in September 2003.

Project Activities

Project Activities are detailed below.

Temporary Stream Crossing

Access to the treatment system required construction of a temporary crossing over Scrubgrass Run. The crossing was permitted through a general permit. The crossing design (see attached plans) was reviewed and approved by the Allegheny County Conservation District and PA DEP. The crossing was constructed with three culverts covered with limestone aggregate. The crossing was removed at the completion of the project. The limestone aggregate was spread on the northern side of the creek, improving access to that portion of the site.

Collection of the Mine Discharge

One goal of the project was to collect the discharge in a manner that facilitated its manipulation during O&M activities. A plan was developed to capture the discharge in a specially fabricated HDPE box that directed the water into an AgriDrain water level control box. The discharge was excavated and the box was installed. However, when the unit was used to experimentally raise the discharge by 12 inches, seeps developed below the discharge area. The box was removed and discharge area excavated. It was discovered that the discharge actually arises from a buried and plugged structure located 4-5 feet lower than the current discharge. When excavated, the structure leaked mine drainage. The excavation was packed with clay and the collection box reinstalled. When the discharge was experimentally raised, the seeps developed again. Concerns about developing permanent seeps lower than the aerator resulted in the decision to abandon the collection system. The collection box was removed and aggregate was placed in the excavation. The discharge redeveloped at the pre-project elevation.

Influent Channel

The original influent channel discharged into the upper pond at a mid-point location. Short circuit flow from the influent directly to the pond effluent was evident. The influent channel was renovated by extending it to the eastern end of the pond. The extension was achieved with a 36 inch diameter corrugated plastic half-pipe placed immediately adjacent to the southern bank of the pond.

Upper Pond

The upper pond averaged 22 inches depth before the renovations. The pond was deepened to 48 inches. The side slopes were 2.5:1. A woven geotextile liner was placed throughout the interior of the pond. The bottom of the cell was covered with 12 inches of limestone aggregate (AASHTO #1). A ten foot wide strip of aggregate extends onto the western berm, providing access into the cell for heavy equipment during sludge removal activities.

Ditch Connecting the Upper and Lower Ponds

The ditch was cleaned out. A weir, installed previously through an eagle scout project, was reinstalled to eliminate leakage and improve flow measurements.

Lower Pond

The lower pond averaged 22 inches depth before renovation. The first half of the pond was deepened to 48 inches. The side slopes were 2.5: 1. A woven geotextile liner was placed throughout the interior of the excavated portion of the pond. The bottom of the excavated area was covered with 12 inches of limestone aggregate (AASHTO #1). A ten foot wide strip of aggregate extends onto the eastern berm, providing access into the cell for heavy equipment during sludge removal activities. The second half of the lower pond was not excavated, however the area was disturbed during sludge removal. The second half of the pond was planted with 2000 full size cattail plants.

Miscellaneous Site Improvements

The system is regularly visited by school and college groups. Renovations were made to enhance visits. The eastern end of the site abuts a Township road. A galvanized steel guard rail was installed between the road and the eastern end of the upper pond. Vehicular access to the site is possible along the northern berm of the upper pond. A galvanized steel gate was installed between the road and the berm.

A limestone chip path was installed between the site entrance, the blower, and the final discharge channel. The path was constructed by excavating a flat base and laying a geotextile fabric, which was covered with 8 inches of 2B limestone. Another 4 inches of processed concrete sand was placed on top of the aggregate and worked in. The result is a tight smooth path that should not need major maintenance for at least ten years.

A four foot high chainlink fence was installed between the path and upper and lower ponds. The fence extends to the aerator, preventing easy access to the aerator and discharge channel. The fence prevents visitors from accessing the ponds, but does not obstruct views of the system.

Access to Township property on the northern side of Scrubgrass Run was improved. This is the area used for iron sludge processing and storage. An aggregate road was installed between the township road and the iron storage area.

Sludge Recovery

The renovations required the off-site disposal of material excavated from the ponds. The ponds contained iron sludge and soil. A local company, Federouch Landscaping, agreed to accept waste soil for a $28 per load tipping fee. Federouch reprocesses waste soil and organic material into landscaping soil. Federouch would not accept iron sludge. The feasibility of disposing iron sludge at local sanitary landfills was investigated. Trucking and tipping fees for the sludge were estimated at $18,000.[1] However, landfills contacted were hesitant to accept a metal sludge unless testing had been performed to assure the material was not hazardous. No such testing was planned in the project work plan or budget.

An alternative plan was developed to collect and passively dewater and dry the sludge onsite. Bob Hedin, project consultant, would try to find a market for the material. Iron Oxide Recovery (IOR), a company owned by Bob Hedin, has successfully marketed iron sludge collected from a site in Westmoreland County to a pigment producer. If the Scrubgrass sludge could be collected in a clean form, it might have pigmentary value. IOR agreed to provide the equipment and materials necessary to process the iron sludge onsite in return for ownership of the product.

A plan was developed for onsite processing of the iron sludge. The contractor pushed the sludge with an excavator to sump where it was pumped to a screen. The screened sludge was pumped into large tube-shaped geotextile bags that are designed to retain solids while discharging clear water. All costs involved with the screening and dewatering were paid by Iron Oxide Recovery, Inc. By retaining the iron sludge onsite, the project costs were substantially lower than would have been realized had the sludge been trucked to a disposal site.

Samples of the sludge were collected and submitted to a private laboratory by IOR during the project (at IOR expense). Table 5 shows the chemical composition of the sludge samples. The in-place sludge was 89% FeOOH, with the balance being silica and aluminum minerals (clays). The recovered sludge was considerably more muddy. The iron oxide content was 71% and the silica and aluminum content rose to 26%. The mud was collected during the recovery when the bottom of the pond was unavoidably mixed with the iron sludge. The clays negatively impact the pigmentary value of the iron oxide. At two other sites, where it was feasible to better separate the pond bottoms and the iron oxide, the recovered iron oxide was 78-90% FeOOH.

Table 5. Composition of sludge samples collected from Scrubgrass system, November 2002. All values are percent.

	FeOOH	SiO_2	Al_2O_3	MnO	MgO	CaO	Na_2O	K_2O	Total
In-place	88.7 %	8.9	1.3	0.02	0.13	0.37	0.22	0.21	100.0
Recovered	71.1 %	21.1	4.8	0.04	0.48	0.77	0.31	0.79	99.8

<u>Marketability of Scrubgrass Iron Sludge</u>

In-place iron sludge from the Scrubgrass site is similar in composition to iron sludge that has been marketed by IOR for pigmentary purposes. If markets for quality iron oxide collected from mine water continue to develop, the recovery of saleable iron oxide from

[1] 300 tons of iron sludge at $50/ton tipping fee plus $10/ton trucking

the Scrubgrass system should be feasible in the future. The scenario is enhanced because the system was rebuilt with a liner system that should prevent contamination of iron oxide sludge with mud.

The iron oxide sludge collected in this project is inferior to materials recently marketed. The material may be saleable to IOR's current iron oxide customer, but not until other superior sources are exhausted. IOR is working with a local coatings company to determine the feasibility of making a wood chip colorant from the Scrubgrass material. Initial testing is encouraging. As of the writing of this report, the material had not been marketed.

Project Results

A primary goal of the project was to increase retention of water in the treatment system. Table 6 shows changes in the volume of the cells and the calculated retention time at 186 gpm, the average flow rate for the discharge.

Table 6. Changes in Volumes of Scrubgrass Ponds.

Unit	Original capacity (gallons)	2002 water (gallons)	Current capacity (gallons)
Upper Pond	179,000	103,000	337,000
Lower Pond	99,000	9,000	130,000
Total	278,000	112,000	467,000
Theoretical Retention (@86 gpm)	25 hours	10 hours	42 hours

The project increased by 70% the original capacity of the ponds and quadrupled the estimated capacity in 2002 before sludge removal. The theoretical retention increased from 25 hours to 42 hours. This retention time is in the 24-48 hour range that is generally recommended for passive systems designed for alkaline Fe-contaminated flows.

The system was redesigned to facilitate sludge removal. Between the system's construction in 1996 and 2002, sludge accumulation decreased the theoretical retention by 15 hours or sixty percent. (Don Budeit of O-Two Environmental contends that the retention was actually less than 6 hours.) The fast accumulation of sludge is a result of the undersized nature of the system and the use of an aerator to increase iron oxidation. The system modifications (geotextile liner and aggregate bottom) should make the recovery of marketable iron oxide product possible.

System Performance

The system's iron-removal performance is shown in Table 7 and graphed in Figure 1. Several stages of treatment efforts are evident in Figure 1. In 1997 the system was operated as constructed. In late 1997 a flow bypass was installed and in 1998 experiments were conducted to determine a flow rate at which a good final effluent resulted. Discharge iron concentrations of 5 mg/L were achieved at flow rates less than

25 gpm. However, 150-200 gpm of flow were bypassed directly to the stream. In June 1999, the blower was installed. The full flow was treated, but the discharge from the aerated system was not what was expected. Concentrations of Fe at the effluent were 40-50 mg/L. Renovations to the system were proposed and funded by PADEP. During the design period of 2000-2001, occasional sampling continued to show 40-50 mg/L Fe at the final discharge. The system was renovated in autumn 2002 and sampled in the summer of 2003. The data showed that the final discharge was improved over previous periods. The final effluent contained 31 mg/L Fe, the lowest value ever measured when then system was treating the full discharge flow. The system removed 79 lb/day of Fe, the highest measured iron removal since the summer the blower was installed.

While treatment since the renovations has been better than before, the performance of the system is still quite disappointing. When the system was renovated, it was thought that doubling the retention time would result in a discharge with less than 10 mg/L Fe. The performance may yet improve. The second half of the lower wetland was replanted in late summer 2003, with the hope that as the wetland vegetation establishes in 2004, more iron particulates will be retained. The filtration effect of dense vegetation could lessen the Fe concentrations by 5-7 mg/L. O-Two Environmental will be cleaning the blower in the next month – an action that might improve performance. The next parameter to address is pH. A moderate pH adjustment should increase both iron oxidation and sedimentation rates. This hypothesis will be discussed with our scientific partners at USDOE in the coming months.

Project Deliverables

The final report includes an appendix that includes:

- an Operation and Maintenance Plan
- copies of permitting documents.

Copies of the construction plans are attached. Because the system was installed as designed, these plans are as-builts.

A CD is attached that contains

- the final report in MS-Word format
- water sampling files in MS-Excel format
- project photos prepared in a Power Point presentation

Summary and Future Actions

The Scrubgrass treatment system has been renovated so that it has a longer retention time and larger sludge holding capacity. The renovation includes features that should allow the periodic recovery of clean iron oxide sludge. If the marketability of this material continues to develop, the value of the sludge should offset the long-term sludge management costs of the system. This is the first mine drainage treatment system designed for efficient resource recovery.

The performance of the system continues to be disappointing. The reasons for the poor performance are uncertain. Dissolved oxygen measurements indicate that the blower is effectively transferring oxygen to the water, and flow throughout the system remains oxidized. The pond renovations increased the systems theoretical retention by 70% over the original design and by 300% over the conditions in 2001/02. Despite these changes, iron removal has only increased by 20-30%. The problem may be related to the pH of the mine water which is lower than most net alkaline waters that are more effectively treating iron contaminated mine water. This hypothesis will be explored in the future.

The renovations have made the Scrubgrass site a more enjoyable and safer educational destination. A low-maintenance path directs visitors around the site and across the bridge to the discharge and blower. A four-foot fence prevents visitors from venturing into the deeper waters, but does not obstruct views. The reset weir provides accurate flow measurements. The site continues to be a magnet for local high school and college science classes.