Oven Run Site B Passive Treatment Systems
SRI O&M TAG Project #56 Request #1
OSM PTS ID: PA-57

Requesting Organization: Stonycreek-Conemaugh River Improvement Project (SCRIP)
Requesting Organization Representative: Pam Milavec
Municipality/County: Shade Township, Somerset County
Dates of O&M Work Performed: 2/28/19
BioMost O&M Construction Personnel: Ryan Mahony & Henry Thornton

Initial Request: On 7/19/18, Pam Milavec of SCRIP contacted Stream Restoration Incorporated (SRI) regarding the Oven Run B passive system. SCRIP and PA Department of Environmental Protection (DEP) Bureau of Abandoned Mine Lands (BAMR) had read the recommendations presented in the GenOn Kiski-Conemaugh OM&R Assessment report, which is available on Datashed, and requested that further evaluations including development of maintenance/rehabilitation options with cost estimates be provided for their consideration.

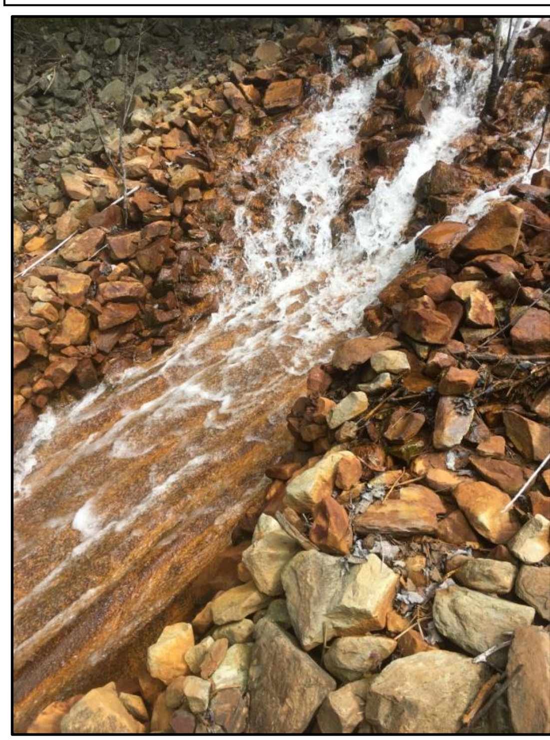
Initial Site Visit, Observations, Evaluation and Identified Needs:

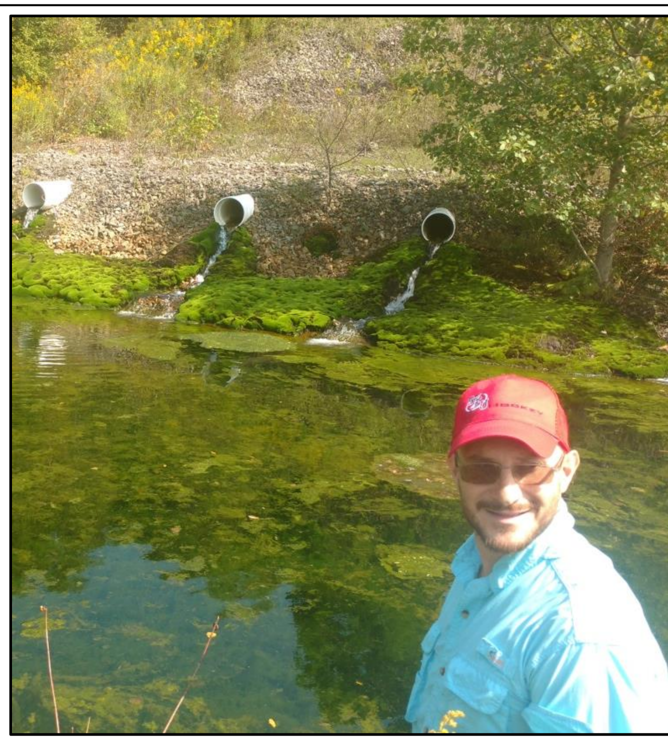
- A field meeting was held on 8/19/18 to discuss the site and initial ideas with representatives of SRI, BioMost, Inc. (BMI), Saint Francis University (SFU), PA DEP BAMR, SCRIP, PA Association of Conservation Districts (PACD), & Somerset Conservation District.
- Previous site investigations had been conducted under the GenOn project.
- Project partner SFU provided assistance in conducting additional investigations including collecting water samples, performing bucket tests, etc.
- Test pits were dug to evaluate the treatment media of SAP1 and SAP2.
- Limestone collected during test pit excavation were sent for laboratory analysis to determine percent calcium carbonate ($CaCO_3$), magnesium carbonate ($MgCO_3$) and calcium carbonate equivalency (CCE).
- Water quality data was been compiled and analyzed.
- An evaluation report (See Attached) was prepared that included a review of the existing system, conceptual passive and active designs along with cost estimates, and recommendations. The options were presented to SCRIP, PA DEP BAMR, and other interested parties. The passive treatment option was recommended.

Recommendations & Future Considerations:

- Obtain funding for system rehabilitation.

Top Left: Field meeting to discuss system maintenance needs and options.
Top Right: Iron precipitates clogging a pipe in the system.
Bottom Left: Final outlet spillway riprap had been washed away.
Bottom Right: Raw water inlet pipes and the forebay were functioning as designed.





Top Left: Test pits were dug in SAP1 to evaluate the treatment media.
Top Right: Large amounts of Fe and Al precipitates were present in the SAP1 media.
Bottom Left: SFU collected limestone from SAP1 & SAP2 which was used in bucket tests.
Bottom Right: Treatment media in SAP2 appeared to contain a lot of metal precipitates.

Oven Run B System Evaluation

Background

The Oven Run B passive treatment system was constructed by the PA Department of Environmental Protection in 1999 to treat acid mine drainage emanating from three sealed deep mine entries. The system was designed by Gwin, Dobson and Foreman, Inc., with modifications by BAMR. The current treatment system consists of a collection pond → SAPS→ Settling Pond → SAPS→ Settling Pond. According to a Passive Treatment System Evaluation report prepared by the PA DEP in May of 2008, the system was designed based on an average flow of 350 gpm, but capable of handling a maximum flow of 1,100 gpm. In July 2001, a flow distribution pipe was installed on top of SAP1. In October 2001, iron sludge and compost were removed from SAP1 and SAP2 and new compost was added.

The Oven Run B system was previously evaluated as part of the Kiski-Conemaugh Basin Treatment System O&M Assessment project completed by Stream Restoration Incorporated and BioMost, Inc. in December 2017, which was funded through the GenOn settlement funds administer by the Foundation for Pennsylvania Watersheds. Based upon recommendations made in that report, the Stonycreek-Conemaugh Improvement Project (SCRIP) and the PA DEP BAMR, have requested further evaluation and development of options, conceptual designs and cost estimates.

System Performance

A review of the available water quality data for the treatment system was conducted. The PA DEP and StreamTeam have sampled the site on a quarterly basis until approximately 2010 after which point monitoring appears to be conducted more sporadically. Individual sample dates and additional parameters are available on Datashed (www.datashed.org). Water quality of the discharge and passive treatment system has been broken into two tables. The first table provides average values from 1999 through 2009. The second table provides average values from 2010 through 2018.

The data has been split between these tables for several reasons. First, the quality of the discharge, which can be described as very acidic with high concentrations of iron, aluminum, and manganese, has significantly improved over time. By comparing the two tables, on average, the acidity has decreased by 30%, iron decreased by 50%, manganese by 37%, and aluminum by 32%. Second, the system was heavily monitored during the first few years after construction when the system was successfully operating. The system appears to have treated the discharge well for the first year and a half after which the treatment suddenly and dramatically decreased. A closer evaluation of the SAP data indicates that SAP1 worked exceptionally well for only about 4 months and SAP2 for about 18 months before treatment decreased. Third, even though treatment declined after the first 2 years, the system still provided treatment until about 2009. Because of the number of samples taken during those first two years, the lifetime average values of the system were largely skewed. Passive treatment data in the first table still remains skewed as it includes both good and poor treatment time periods that occurred during the first 10 years of operation. Based on current available data, the water quality of the effluent remains acidic with reduced, but still high concentrations of metals.

Oven Run B Water Quality Data (Average Values) (1999-2009)

Sample Point	Flow	Field pH	Lab pH	Alkalinity	Acidity	T. Fe	T. Mn	T. Al	SO_4
ORBI (Influent)	170	2.9	2.8	0	471	56.6	17.9	36.8	949
SAP1	174	4.3	4.0	14	222	38.9	16.9	23.0	1034
Pond 2	186	4.2	3.6	13	231	20.2	9.1	23.0	1024
SAP2	175	5.7	5.0	45	108	13.8	16.2	12.8	1047
ORBO (Effluent)	180	5.6	4.8	35	107	6.2	16.4	11.3	1018

Flow in gpm, pH in standard units, Alkalinity and Hot Acidity in mg/L as $CaCO_3$, Iron (Fe), Manganese (Mn) and Aluminum (Al) as total metal concentrations in mg/L

Oven Run B Water Quality Data (Average Values) (2010-2018)

Sample Point	Flow	Field pH	Lab pH	Alkalinity	Acidity	T. Fe	T. Mn	T. Al	SO_4
ORBI (Influent)	141	2.8	2.8	0	320	27.6	11.2	24.9	788
SAP1	NA	3.0	2.9	0	289	27.4	10.8	23.7	809
Pond 2	NA	3.1	2.8	0	300	24.7	10.4	24.4	821
SAP2	67	3.0	2.8	0	293	24.6	10.9	23.4	822
ORBO (Effluent)	130	3.2	2.9	0	267	22.5	11.2	23.0	756

Flow in gpm, pH in standard units, Alkalinity and Hot Acidity in mg/L as $CaCO_3$, Iron (Fe), Manganese (Mn) and Aluminum (Al) as total metal concentrations in mg/L

Existing Conditions Evaluation

A site investigation had previously been conducted on 10/22/2013 as part of the GenOn funded assessment. At that time, no water was flowing through the underdrain of SAP1. Instead, the water was flowing over the emergency spillway indicating either a portion of the undrain was plugged or the treatment media itself had become impermeable. Water was flowing through SAP2; however, water emanating from the primary outlet pipe was of poor quality indicating that there is probably significant short-circuiting within the pond. Interestingly, water flowing out of what appears to be a flush pipe was of significantly better quality. An initial short-lived dye test of SAP2 was conducted on that date to see if short-circuiting could be easily observed. Due to time constraints and the size of the pond, the dye test could only be observed for a short period of time. During the approximately 1.5 hours, no dye was observed in the effluent pipe. Observations of the dye plume on the surface of the pond indicated that the flow was moving towards the western ½ of the pond and not flowing through the eastern ½ of the pond. This may be due to the location of the flush pipe, which is also located on the western side of the pond. In addition, water from the final settling pond (Pond 3) was flowing out of both the emergency spillway and the effluent pipe indicating that the pipe may be partially plugged with iron and/or debris or the valve is broken.

As part of the current evaluation effort, a field meeting and site visit was conducted on 9/19/2018. In general, the system was found to be in essentially the same condition. SAP1 was overflowing at the spillway instead of flowing through the Agri Drain box. A portion of the flow from SAP2 was now overflowing at the emergency spillway. Pond 3 was still flowing over the emergency spillway and a portion of the spillway had been washed away. The evaluation of the system was conducted with assistance provided by project partner Saint Francis University (SFU). SFU conducted additional site investigations which included water sampling and field testing, collecting water for a titration test, opening stuck valves to drain the SAPS, participating in test pit evaluations of the treatment media, and conducting bucket tests.

Titration Tests

Because of the known iron plugging occurring at the site, the original concept for the passive system was to utilize low pH iron removal through the use of Oxidation Precipitation Channels (OPCs) [aka Terraced Iron Formations]; however during the initial site meeting conducted on 9/19/18, no low pH iron formation was observed to be occurring within the Collection Basin. As this was concerning, SFU was asked to conduct a titration of both the Raw untreated water (ORBI) and water overflowing SAP1 at the effluent spillway. Samples were titrated with sodium hydroxide to raise the pH to 3.5, 4.0, and 5.0. Filtered samples were collected at each interval and sent for laboratory analysis. Results are presented in the table below. Based upon the data, there was little if any change in iron concentration from the raw discharge to the spillway of SAP1 indicating very little if any low pH iron removal despite flowing on the surface of SAP1. Also, during the titration, most of the iron is removed by pH 3.5 and concentrations are below detection level by pH 4.0 indicating that the iron is predominately if not entirely in the oxidized ferric form. When the iron is predominately already in the ferric form, biogeochemical driven "low pH iron" removal tends not to occur in OPCs as the biological processes are believed to rely on oxidizing ferrous to ferric iron.

Titration Test Data

Sample location	STARTING FIELD pH	ADJUSTED pH	FILTERED IRON	FILTERED MANG	FILTERED ALUM
ORBI	2.5	--	15.30	6.23	12.31
		3.5	2.12	6.43	11.60
		4.0	<0.10	5.79	0.73
		5.0	<0.10	5.85	0.54
ORBSAP1 Overflow	2.5	--	14.78	5.94	11.74
		3.4	0.29	5.92	3.86
		4.0	<0.10	<0.05	1.28
		5.9	<0.10	0.15	1.06

Test Pits

Test pits (See attached photos) were excavated on 2/28/2019 using a small excavator. Five test pits were dug in SAP1 spread out across the length of the pond. Four test pits were dug in SAP2 with two towards the inlet end and two towards the outlet end of the pond. The test pits indicated some variability in thickness of compost layer, stone layer, and composition of stone. In general, SAP1 contained an algal mat over most of the pond often with a 1-3" layer of iron on top of 6-10" of compost and 2.5 to 4 feet of limestone. The test pit with the least amount of treatment media was located near the eastern berm close to the hillside and therefore may be due to the internal slope of the pond. Some of the test pits seemed to contain a mixture of AASHTO #1 and #57 limestone. It is uncertain why #57 limestone would have been placed unless possibly for bedding of pipes within the media. There also appeared to be some variability within the limestone as to where and how much iron and aluminum precipitates were observed; however, significant accumulation of metals within the treatment media were observed in all test pits. Test pits dug further away from the inlet had a thicker cleaner layer of limestone before precipitates were encountered which may indicate short-circuiting. The SAP2 test pits were similar, but with perhaps slightly less depth of treatment media and perhaps a slightly thicker layer of iron on top of the compost. During some of the test pits, a "lens" of what appeared to be a mixture of clay and limestone without the presence of iron and aluminum was observed. It is unknown if the clay was forming from the weathering of the limestone, washed in, or was placed there because the material had not been properly screened/washed. This material is likely not very permeable and could be contributing to the problem along with media and potentially piping/perforations plugged with precipitates.

Bucket Tests

Limestone collected from the test pits were utilized by Saint Francis University students to conduct three bucket tests (see attached data and graphs) to evaluate existing limestone effectiveness and treatment options. The limestone was washed prior to conducting the tests. AMD was collected from the raw discharge and added to the buckets filled with the washed limestone. Alkalinity, pH, and conductivity were measured at approximately 15 minutes, 45 minutes, 1 hour, 2 hour, 3 hours, 7 hours, and 18 hours of retention. Iron measurements were also periodically conducted. In general, the results indicated that with 7 hours of retention a pH of about 6.5, alkalinity >120 mg/l, and low iron and aluminum concentrations were obtained. As most of the iron was removed very quickly during the bucket test, this is further indication of the iron being in the ferric form and likely a major factor in creating maintenance issues in the system. While alkalinity production did continue, there was not a significant difference between 7 hours (~125 mg/l) and 18 hours (~135 mg/l) compared to more than twice the amount of retention time. The bucket tests indicate that the limestone was still effective in producing alkalinity and that auto-flushers utilizing at least 8 hours of retention time could be utilized. As the bucket tests are conducted under ideal laboratory conditions and do not simulate years of usage, BioMost recommends utilizing a designed retention of 10-12 hours, if feasible.

Limestone Analysis

After being used in the bucket tests a sample of the limestone collected from the test pits was sent to G&C Coal Analysis, Inc. to determine percent calcium carbonate ($CaCO_3$), magnesium carbonate ($MgCO_3$) and calcium carbonate equivalency (CCE). Results are provided in the below table. Combined with data generated by the bucket tests, the results indicate that the limestone should still be of sufficient quality to be used in passive treatment.

Limestone Analysis

Limestone Sample ID	Limestone Source	Bucket Test	$CaCO_3$ %	$MgCO_3$ %	CCE%
Upper VFP1	SAP1	Bucket 1	87.50	12.35	99.92
Upper VFP2	SAP1	Bucket 2	95.12	2.56	98.33
Lower VFP	SAP2	Bucket 3	91.99	6.42	99.06
Avg			91.5	7.1	99.1

General Conclusions

While the passive system initially provided satisfactory performance, over much of the life of the system, the performance has been relatively poor. Average data since 2010 indicates that the Oven Run B system has only been neutralizing about 16% of the acid and removing about 18% of the iron and 8% of the aluminum. A combination of short-circuiting to the underdrain and plugging of the media are likely factors for the sudden decrease in treatment shortly after construction. Observations of significant metal precipitates within the media during the test pits provides evidence of plugging within the media. Observation of "clean" stone and "lenses" of clay/limestone also indicate potential areas where the media was not receiving AMD, which is indicative of short-circuiting. In addition, the massive size of the treatment ponds are likely susceptible to short-circuiting as the water would likely start to move vertically through the media before spreading out evenly across the large surface area. It is our opinion that these issues can be overcome, and that the quality of the discharge is amenable to passive treatment especially considering improvements in understanding, design, and technologies available for use.

Oven Run B Design Parameters & Considerations

Both passive and active options have been considered for treating the Oven Run B discharge. Influent water quality characteristics used to develop conceptual designs for both options are provided in the table below. Due to significant water quality changes over time, only the chemistry data from 2010 thru present was used to represent the influent water quality characteristics; however, all flow data from 1999 thru present was utilized.

Influent Water Characteristics

Sample ID	Flow (gpm) *[Avg/Design/Max]*	Avg Acidity (mg/L)	Avg Diss. Fe (mg/L)	Avg Diss. Al (mg/L)	Avg Diss. Mn (mg/L)	Avg Acid Load (lb/day)	Avg Diss. Fe Load (lb/day)	Avg Diss. Al Load (lb/day)	Avg Diss. Mn Load (lb/day)
ORBI	161/200/367	320	23.1	25.2	10.5	533	37	42	18

The passive option utilized a design flow of 200 gpm (~78th percentile and a design life of ~20 years). Loading data for design purposes utilized values recorded from 2010 thru present and are derived from statistical averages of the individual data points. Please note that the active treatment option utilizes the average acid load (533 lb/day as $CaCO_3$ or ~98 Tons/year as $CaCO_3$) as a conservative approximation for the amount of chemical usage that is anticipated each year.

Metals Load Removal Design Targets (Maximum)

- The proposed treatment systems are anticipated to remove 85-100% of targeted contaminants (acidity, iron, and aluminum).
- 100% removal of acidity is expected, as the proposed systems are expected to produce an effluent with circumneutral pH, low metals concentrations, and containing measurable alkalinity.
- For calculation purposes, 95% removal of iron and aluminum is assumed for both the passive and active options; however, actual rates of removal will vary depending on site conditions, influent water quality, and flow rate.
- For calculation purposes, a 20% removal of manganese is assumed for the passive system as it is currently not being targeted for treatment while a 95% removal was assumed for the active option; however, actual rates of removal will vary depending on site conditions, influent water quality, and flowrate.

Projected Design Pollutant Load Reduction Treatment Goals

Sample ID	Flow (gpm) *[Design]*	Avg Acidity (mg/L)	Avg Diss. Fe (mg/L)	Avg Diss. Al (mg/L)	Avg Diss. Mn (mg/L)	Avg Acid Load (lb/day)	Avg Diss. Fe Load (lb/day)	Avg Diss. Al Load (lb/day)	Avg Diss. Mn Load (lb/day)
System Influent	200	320	23.1	25.2	10.5	533	37	42	18
Projected Removal (%)	-	≥ 100	95	95	~20 (P) 95 (A)	-	-	-	-
Estimated Load Reduction	-	-	-	-	-	≥ 533	35.2	39.9	3.6 (P) 17.1 (A)

**Passive and active options utilize essentially same treatment goals except for manganese which re distinguished using (P) and (A). Although no manganese specific removal components are proposed for the passive treatment option – there has been evidence of manganese removal within existing AFVFPs.*

Projected Effluent Water Quality

- pH 6 – 8
- Negative acidity
- Metals concentrations for iron and aluminum of < 1 mg/L (manganese not targeted for removal)

Other Considerations

- Oven Run B existing treatment components ponds are lined with synthetic liners. Reconfiguring the treatment system will likely render the existing liners unusable. Therefore, clay liners are proposed for components in which pond liners are deemed necessary. Clay liners are preferred in components that will require stirring as a regular maintenance activity.
- Clay for liners and embankment construction will need to be identified and sourced from an off-site location for this project.
- Regardless of which option is chosen, the existing treatment media will need to be removed and processed in some way.
- There are currently no sludge drying beds located on site.
- Electricity would need to be brought to the site for an active treatment system.

Passive Treatment System Option

Because the primary metals of concern are ferric iron and aluminum, plugging of the media is a concern. In addition, the extremely large size of SAP1 and SAP2 are also a concern as ponds of that size are much more likely to experience short-circuiting. To address both issues, we propose converting SAP1 into three individual 3,000-Ton Auto-Flushing Limestone Only Vertical Flow Ponds (AFVFPs) utilizing Agri Drain SmartDrain Technologies with each providing approximately 12 hours of retention time. Recent bucket test research conducted with SFU during design work for the Puritan system has indicated the benefits of batch treatment. During the research, water that was added into the bucket at one time, outperformed bucket tests where water was gradually added into the bucket. By utilizing this approach, the same sized pond with the same amount of limestone can provide longer retention times and better treatment. This also means that a smaller pond with less stone could be used to provide the same level of treatment. Typically for an auto-flushing system, the pond is often designed for a certain retention time (e.g., 12 hours), but that results in very little water obtaining the full retention time and a portion of the water having very small retention times. Approximately half of the water will have less than half of the retention time (e.g., <6 hours) and the other half of the water will have more than half of the retention time (e.g., >6 hours). The end result is having a pond that provides on average half (e.g., ~ 6 hours) of the designed (e.g., 12 hours). In other words, if 12 hours of retention time was desired, the pond would need to be designed for 24 hours. However, if all the water is dosed into the pond at essentially the same time, retention time within the limestone layer can be maximized while reducing the amount of limestone needed. In addition, there should be increased CO_2 production from longer contact time with the stone which should also increase alkalinity production.

To convert SAP1 into 3 AFVFPs, the following would need to occur:

- Remove compost layer for disposal (assumed to be placed on site)
- Wash and remove limestone
- Construct berms within the footprint of SAP1 to create 3 ponds
- Install HDPE underdrain and SmartDrain
- Placement of the washed limestone

Some of the challenges of converting SAP1 into 3 separate independent AFVFPS that provide batch treatment is providing equal distribution of flow to each AFVFP, providing sufficient retention time, and managing flushing. To do this we propose an innovative approach utilizing existing technologies. Batch treatment to each AFVFP could be provided by dosing the AMD from the existing Collection Basin to the 3 AFVFPs on an alternating basis utilizing a combination of Agri Drain SmartDrains and additional logic controls actuated by float switch signals. These would control which AFVFP the AMD is dosed to, how long water is retained in each AFVFP, and when they are flushed.

Due to improvements in water quality of the discharge as well as improved treatment efficiency of the AFVFPS, the entire footprint of SAP1 is not expected to be needed. We propose utilizing this space to increase the volume of the Collection Basin to provide enough water storage for dosing to the AFVFPs and the area could also be utilized as a place for a sludge drying bed, stockpiling of excess limestone or other uses.

The AFVFPs will flush into Sed Basin Pond 2, which will be able to be utilized as a flush pond with minor suggested improvements. The pond was evaluated and based upon available information should be able to retain approximately 6 flush volumes from the AFVFPs. To improve settling of precipitates and reduce short-circuiting, we also recommend installing a directional baffle curtain. In addition, a different outlet structure will be needed in order to split flows to the next stage of treatment.

Due to the large size and rectangular shape, SAP2 is also likely prone to short-circuiting. We recommend converting SAP2 into two mixed media Jennings-style Vertical Flow Ponds (JVFPs) that would operate in parallel. Each JVFP would provide 12 hours of retention and consist of 2,800 tons of limestone mixed with 2,100 CY of organic media (mushroom compost and woodchips). Utilizing JVFPs would improve sulfate removal while generating alkalinity and removing remaining metals. Limestone from the existing SAP could likely be washed and crushed at a cheaper cost than bringing in fresh stone. Ideally, the AFVFPs should remove a large portion of the ferric iron and aluminum and may even remove a portion of the manganese. It may be possible to convert SAP2 into 2 AFVFPs instead of the Jennings-style ponds at a reduced cost (est. $200,000); however, the water quality produced will likely not be as good. There may also be benefit of reduced maintenance costs over the life of the system.

Similar to SAP1, the entire footprint of SAP2 will likely not be needed. The area not needed could be reconfigured for use as a sludge drying bed or possibly expanding the size of Sed Basin Pond 2; however, utilizing the space for expansion of the settling pond may cause difficulties in splitting the flow to the JVFPs. This would need to be further evaluated.

Sed Basin Pond 3 would continue to be used as a polishing pond. The strange shape and location of inlets and outlets may contribute to short-circuiting. It may be possible to reconfigure the outlet structure and emergency spillway to encourage better utilization of the pond; however, this may not be necessary. One or more baffle curtains could also be utilized to improve settling. If these changes are not made, the emergency spillway should be repaired, and the outlet structure and associated piping should either be repaired or replaced.

Active Treatment System Option

A conceptual design and cost estimate for an active treatment system has also been provided. In order to convert Oven Run B into an active treatment system, all of the treatment media and underdrain piping from SAP1 and SAP2 would need to be removed. The piping would need to be disposed of off-site. The compost could likely be disposed on-site. The limestone would either be washed and then transported off-site for use by another treatment system, potentially used for the access road, or disposed of on-site. Whether utilizing the stone for passive treatment or road access, the stone will need to be removed from the existing system and washed prior to use. A portion of SAP1 and Sed Basin Pond 2 could be utilized for material fill placement and disposal area for the existing compost, limestone, sludge, etc.

To install an active system, the access road would need to be improved, extended and maintained to allow for regular chemical delivery. Once extended the access road would be approximately 1800 ft long and ten ft wide. A 100 ft X 100 ft chemical delivery pad and turn around would need to be constructed at what is currently the end of Sed Basin Pond 2 that would also house the lime silo utilizing hydrated lime and mixing tank with blower. Electricity is not currently available; therefore, an electric line will need to be brought to the site. It is uncertain whether the electricity would need to be brought from

Center Street (~1,200 ft) or Koontztown Road (~1,800 ft). It is also not known whether three phase power is available from either location. Cost to do this can be quite variable depending upon a number of factors. An approximately 600-foot long pipe would need to be installed to convey the discharge from the collection basin to the silo. Based on the calculated acidity load using AMDTreat, the system would utilize about 694 lb/day (127 ton/year). A 35-ton silo would need to be refilled about every 100 days (~ 4 times per year). SAP2 would be converted to a settling pond with baffle curtains. Sed Basin Pond 3 would continue to function as a final polishing pond. Most of SAP1 would be converted to a sludge drying bed. Sludge pump lines would need to be installed

Cost Estimates

A rough cost estimate for discussion purposes for both the passive and active options are provided in the below table. The table includes estimates for initial construction cost, maintenance costs, and an estimated 20-year total cost. Two passive options are provided. The first passive treatment option includes washing and re-utilizing the existing limestone which is a significant cost savings compared to purchasing fresh considered in the second passive option. The active treatment option essentially wastes the existing treatment limestone by excavating and disposing of it on-site. It would still be possible to wash and truck the limestone to a different site; however, that was not included in the cost estimate for the active option. As previously mentioned, the passive treatment option cost provided could be reduced (est. $200,000) by substituting AFVFPs for the two JVFPs.

Maintenance costs of passive treatment systems are much more variable and difficult to predict than active treatment systems. Factors include water quality, appropriate design, quality of construction, types of treatment components, and whether an active watershed group will be monitoring and taking care of the system. A passive system could last 5 to even 10 years without significant maintenance depending on a variety of factors and some have functioned for over 20 years with very little maintenance. When developing cost estimates for maintenance, we assume 1 major maintenance event every 5-7 years for both AFVFPs and JVFPs. That would be about 3 events in a 20-year period. Total O&M over the 20 years including inspections, water monitoring, etc., is estimated at ~$200,000 which would be annualized at roughly $10,000 per year with most years being less than that amount and some years being significantly more.

The cost estimate for the active system does not currently contain any redundancies in treatment. We would recommend having a backup lime delivery system, blower, and backup generator which would add an additional $100,000 to the cost of the system. An estimated annual cost of the active system includes sampling, labor, electrical, chemical costs, and sludge removal. This number is partly based on expenses at the Alder Run active treatment system which would be of similar design. As previously mentioned, the chemical cost was estimated based upon the average acid load of the discharge. The annual cost is estimated at $65,000 for a total cost of about $1,300,000 over 20 years. These costs do not take inflation into consideration, which would likely increase the total cost of the system.

Construction Cost Estimates Summary

Type of Treatment	Construction Cost (Estimate)	Annual Cost (Estimate)	20-Yr Cost (Estimate)
Passive Treatment System Rehab (existing stone) - 5 AFVFPs	$1,300,000	$10,000	$1,500,000
Passive Treatment System Rehab (existing stone) – 3 AFVFPS + 2 JVFPs	$1,500,000	$10,000	$1,700,000
Passive Treatment System Rehab (new stone) 5 AFVFPS	$1,800,000	$10,000	$2,000,000
Passive Treatment System Rehab (new stone) 3 AFVFPS + 2 JVFPs	$2,000,000	$10,000	$2,200,000
Active Treatment System	$1,200,000	$65,000	$2,500,000

Recommendation

BioMost recommends the passive treatment option as the water quantity and quality at the Oven Run B site appears very amenable to current passive treatment technologies. The passive treatment option also maximizes use of the existing treatment system's footprint and features, including cleaning and reusing the existing limestone for proposed treatment. Re-use of the existing stone is a tremendous cost savings at this site when compared to purchasing new treatment stone. For example, there is an estimated ~20,000 Tons of limestone present in the existing treatment components, this stone can be washed for roughly $5 per ton ($100,000) which will yield up to 5,000 tons of excess stone that can be stockpiled for additional use or to supplement the system as it ages. Oversized stone for the JVFPs could even be crushed and screened on-site if needed for ~$10 per ton which is still roughly half the price of buying new stone. The same amount of stone (if purchased new) would cost between $500,000 and $600,000 ($25 - $30 per ton) to have it delivered to the site, although only about 15,000 tons would be needed ($450,000). Both treatment options include the removal of the existing treatment medium and limestone. Washing and reusing the limestone provides an economical advantage with significant cost savings. In addition, active treatment systems require more frequent site visits and maintenance. In addition, even when passive treatment systems have maintenance issues, they typically provide some level of treatment, whereas when an active system stops working, the water typically receives no treatment.

Oven Run B Test Pit Photos

Test pit within Oven Run B SAP1. An algal mat covered the entire pond. Below the algae was often a layer of iron on top of the compost. The limestone was often coated in iron and aluminum precipitates, but there were also “lenses” of clean or mixtures of clay and limestone that did not appear to have contact with AMD.

In some areas within the SAPs, the stone looked fairly clean and fresh (Above) while other stone was heavily coated with iron and aluminum precipitates (Below).

Test pits within SAP2B (Above) were relatively similar. A layer of ice covered the pond, so it was uncertain if it was covered with algae. In general, SAP2B had a thicker layer of iron (Below) on top of the compost

Oven Run B Bucket Test Data

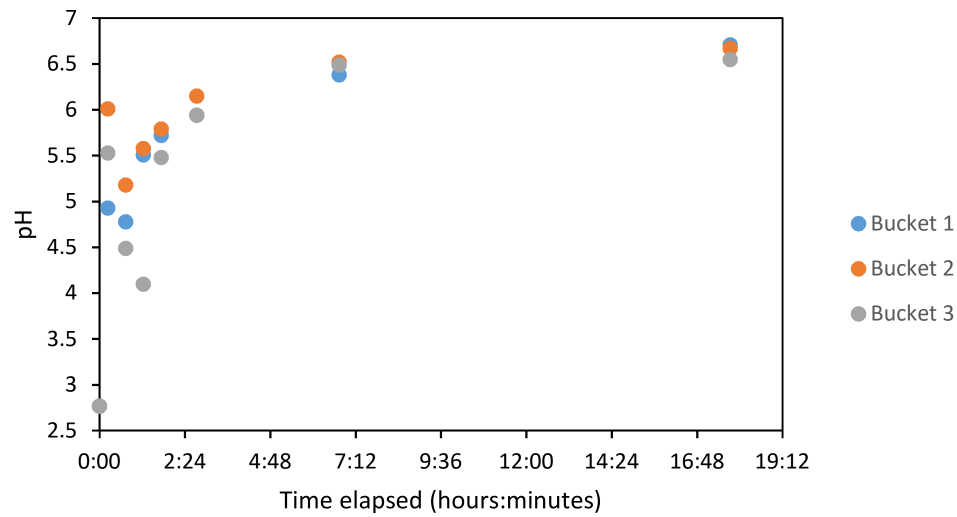
Date	Time	Date + Time	Time elapsed	Bucket	pH	SPC	Alkalinity	Fe
4/8/2019	14:16	4/8/2019 14:16	0:00	1	2.77			33.3
4/8/2019	14:30	4/8/2019 14:30	0:14	1	4.93	1091	5	0
4/8/2019	15:00	4/8/2019 15:00	0:44	1	4.78	915	15	0.7
4/8/2019	15:30	4/8/2019 15:30	1:14	1	5.51	1052	35	
4/8/2019	16:00	4/8/2019 16:00	1:44	1	5.72	1109	51	
4/8/2019	17:00	4/8/2019 17:00	2:44	1	5.94	1074	77	
4/8/2019	21:00	4/8/2019 21:00	6:44	1	6.38	1227	127	
4/9/2019	8:00	4/9/2019 8:00	17:44	1	6.71	1203	135	1
4/8/2019	14:16	4/8/2019 14:16	0:00	2	2.77			33.3
4/8/2019	14:30	4/8/2019 14:30	0:14	2	6.01	992	53	0
4/8/2019	15:00	4/8/2019 15:00	0:44	2	5.18	1020	27	0
4/8/2019	15:30	4/8/2019 15:30	1:14	2	5.58	1050	49	
4/8/2019	16:00	4/8/2019 16:00	1:44	2	5.79	1119	58	
4/8/2019	17:00	4/8/2019 17:00	2:44	2	6.15	1165	76	
4/8/2019	21:00	4/8/2019 21:00	6:44	2	6.52	569.1	126	
4/9/2019	8:00	4/9/2019 8:00	17:44	2	6.67	1255	138	0
4/8/2019	14:16	4/8/2019 14:16	0:00	3	2.77			33.3
4/8/2019	14:30	4/8/2019 14:30	0:14	3	5.53	1025	12	0
4/8/2019	15:00	4/8/2019 15:00	0:44	3	4.49	937	6	0
4/8/2019	15:30	4/8/2019 15:30	1:14	3	4.1	1038	11	
4/8/2019	16:00	4/8/2019 16:00	1:44	3	5.48	1083	27	
4/8/2019	17:00	4/8/2019 17:00	2:44	3	5.94	1188	57	
4/8/2019	21:00	4/8/2019 21:00	6:44	3	6.49	564.7	115	
4/9/2019	8:00	4/9/2019 8:00	17:44	3	6.55	1254	124	0

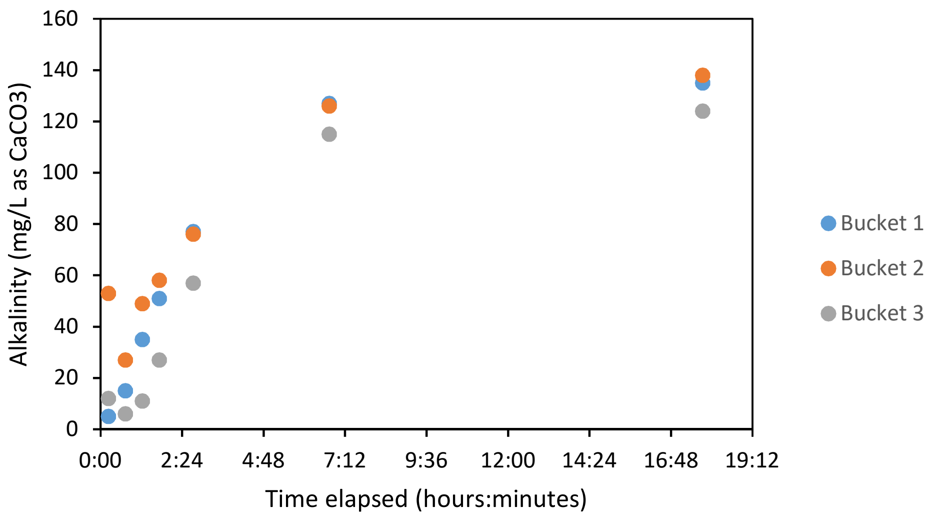
Original AMD: pH = 2.77; SPC = 1523

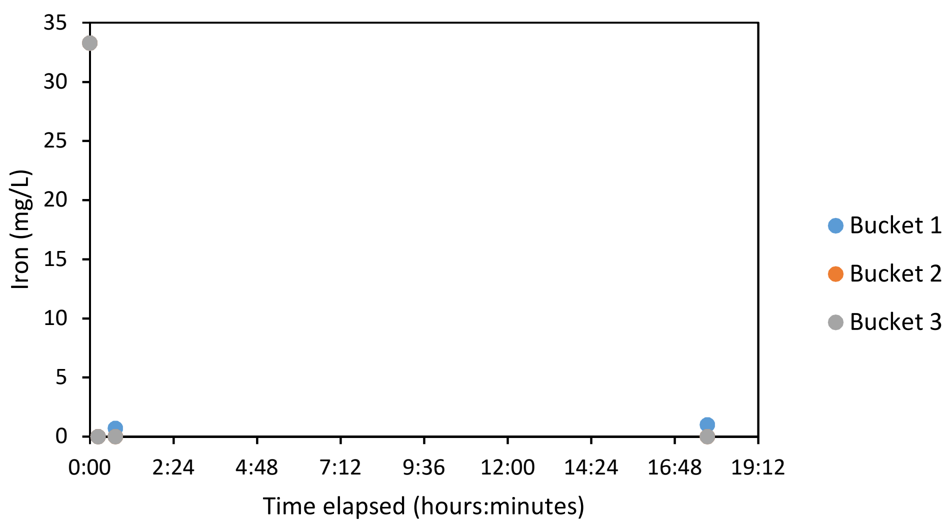
Took 8L of AMD water to fill up bucket to have water level just above the rock level

Rock height: 11 3/8 inch
Diameter of Bucket: 11 inch

Oven Run B Bucket Test Data







PRELIMINARY PASSIVE OPTION COST LIST - Rough Estimate				
Collection Basin Pond 1 (expansion)				
Description	**Quantity**	**Unit**	**Unit Cost**	**Cost TOTAL**
Excavation Earthwork Collection Pond Expansion	1170	CY	7.5	8,775.00
Liner (clay) preference toward clay (include est truck cost)	1225	CY	35	42,875.00
Liner Over-Excavation	1225	CY	7.5	9,187.50
Build Expanded Embankment in pond footprint	1100	CY	5	5,500.00
Agridrain Smart Drainage systems (installed)	3	EA	20,000	60,000.00
Piping to AFVFPS	1600	FT	10	16,000.00
Plumbing Fittings	1	JOB	1,000	1,000.00
Float Switches & logic Control for all systems	1	JOB	15,000	15,000.00
42" HDPE N-12 Culvert Pipe for casing (3)	45	FT	37.75	1,698.75
Misc Water Handling	1	JOB	5,000	5,000.00
			Sub Total	**165,036.25**
AFVFP 1 - 3				
Agridrain Smart Drainage System Installed	1	JOB	20000	20,000.00
42" HDPE N-12 Culvert Pipe for casing	15	FT	37.75	566.25
Earthwork for Berm	500	CY	7.5	3,750.00
Clay material for liner (includes est truck cost & install)	911	CY	35	31,885.00
Over excavation for liner install	911	CY	7.5	6,832.50
Placement of Stone	3000	T	4	12,000.00
Washing Existing Limestone (priced for a single pond)	3000	T	5	15,000.00
Piping	275	FT	12	3,300.00
Plumbing Fittings	1	JOB	1000	1,000.00
Seperation Geotextile	2102	SY	1	2,102.00
Spillways (estimate for rock and spillway)	1	JOB	4000	4,000.00
Misc Water Handling	1	JOB	5000	5,000.00
		1 Pond Sub Total		105,435.75
		3 Pond Sub Total		**316,307.25**

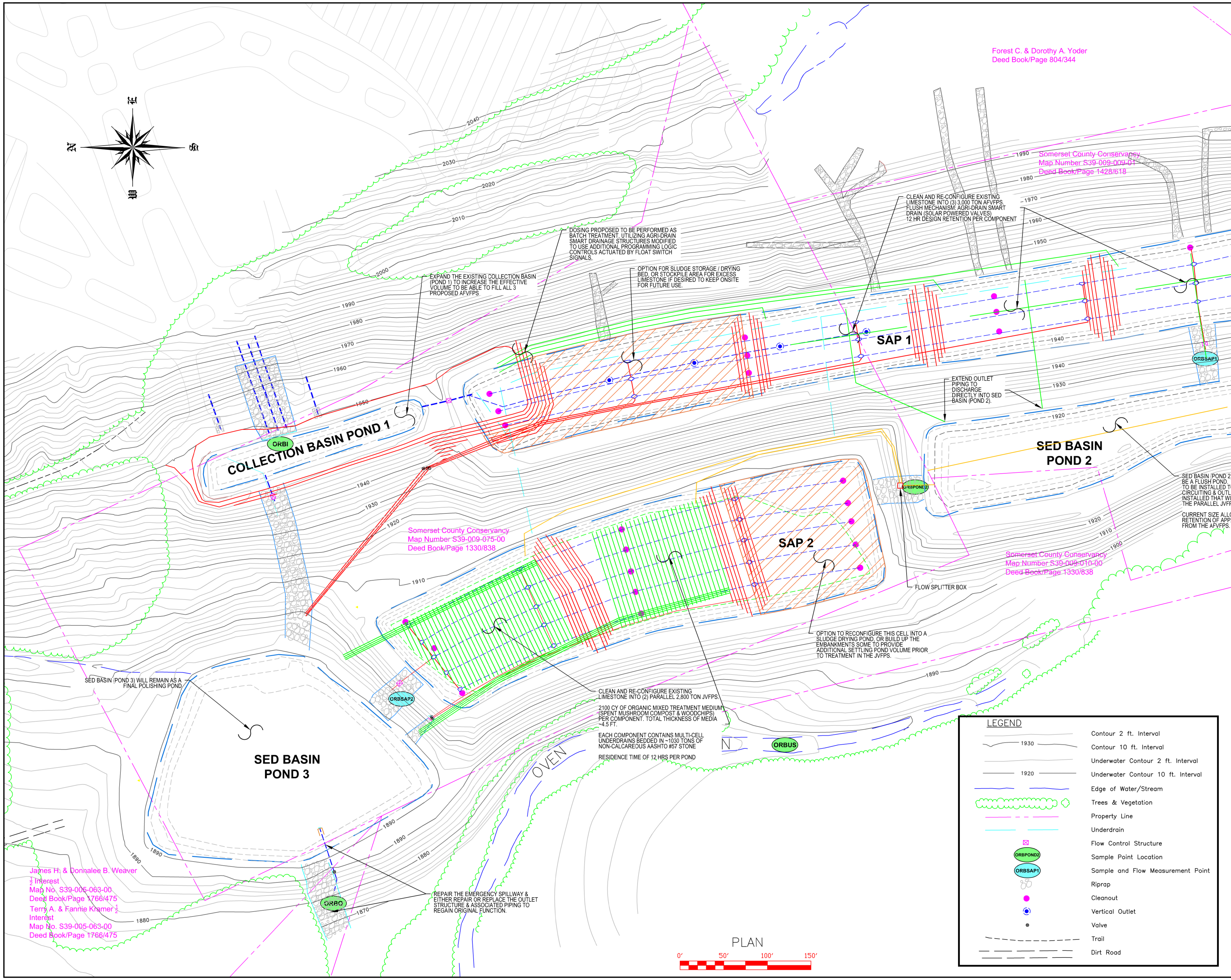
General Site Cost				
Description	**Quantity**	**Unit**	**Unit Cost**	**Cost TOTAL**
Revegetation Efforts	1	JOB	10000	10,000.00
E&S Controls	1	JOB	5000	5,000.00
SAP 1 excess washed stone	600	T	5	3,000.00
SAP 1 excess washed stone - placement / stockpile	600	T	3	1,800.00
SAP 2 excess washed stone	4675	T	5	23,375.00
SAP 2 excess washed stone - placement / stockpile	4675	T	3	14,025.00
Disposal of Ex. Compost and Iron sludge (SAP1) & Disposal of piping	4200	CY	10	42,000.00
Removal / Disposal of Ex Compost and Iron sludge (SAP2) & Piping Disposal	4200	CY	10	42,000.00
AGRI DRAIN Freight	1	JOB	726	726.00
HDPE Pipe Freight	1	JOB	450	450.00
Primer & Glue	1	JOB	500	500.00
			Subtotal	**142,876.00**
Sed Pond 2				
				-
Splitter Box (precast concrete)	1	EA	1000	1,000.00
18" Pipe oulet	40	FT	36	1,440.00
10" conveyance pipe to each pond	850	FT	10.05	8,542.50
Pump sludge from Settling pond to new sludge pond (if needed)	1	JOB	5000	5,000.00
Baffle Curtain (3ft) directional	350	FT	12.75	4,462.50
Misc/water handling	1	JOB	5000	5,000.00
			Subtotal	**25,445.00**

	JVFPs 1-2				
	Description	**Quantity**	**Unit**	**Unit Cost**	**Cost TOTAL**
	Earthwork to put embankment across existing pond (single embankment)	1500	CY	7.5	11,250.00
	Wash stone for JVFP (single Pond)	2800	T	5	14,000.00
	Crush Stone for JVFP (single pond)	2800	T	10	28,000.00
	Stone for Underdrain JVFP (purchase)	1027	T	30	30,810.00
	Stone for Underdrain JVFP (Placement)	761	CY	5	3,803.70
	Organic Material woodchip / compost (purchase)	2100	CY	25	52,500.00
	Organic Material woodchip / compost (placement)	2100	CY	5	10,500.00
	Pipe for Underdrain (for single pond)	4390	FT	10	43,900.00
	Installation for Underdrain	1	JOB	5000	5,000.00
	Misc/water handling	1	JOB	10000	10,000.00
	Clay for Liner (includes truck cost & install)	1000	CY	35	35,000.00
	Over excavated for clay liner install	1000	CY	7.5	7,500.00
	Geotextile	3000	SY	1	3,000.00
		1 JVFP Sub Total			255,263.70
		2 JVFPs Sub Total			**510,527.41**
	FINAL SED POND & SLUDGE DRYING PONDS				
	Repair to final sed pond outlet	1	JOB	15000	15,000.00
	Plumbing to make upper sludge drying pond & reconfigure	1	JOB	20000	20,000.00
	Plumbing to make lower sludge drying pond or additional sediment pond reconfigu	1	JOB	20000	20,000.00
				Subtotal	**55,000.00**
				TOTAL	**1,215,191.91**
			Contingency 13%		157,974.95
		Overhead & Profit 15%			182,278.79
		Estimated Grand Total			**1,555,445.64**

PRELIMINARY ACTIVE OPTION COST LIST - Rough Estimate				
Collection Basin Pond 1 & Silo / Mixing				
Description	**Quantity**	**Unit**	**Unit Cost**	**Cost TOTAL**
Silo / Mix Tank / Blower / Controls & Install	1	JOB	350,000	350,000.00
Piping to Silo	600	FT	37	22,200.00
Plumbing Fittings for collection to silo	1	JOB	5,000	5,000.00
			Sub Total	**377,200.00**
Reconfigure SAP2 to Settling Pond				
Clay material for liner (includes est truck cost & install)	3000	CY	35	105,000.00
SAP 2 Stone excavated and dispose of on-site	10271	T	7.5	77,032.50
Removal / Disposal of Ex Compost and Iron sludge (SAP2) & Piping Disposal [offsite]	4200	CY	10	42,000.00
baffle curtains	300	FT	12.75	3,825.00
Piping	275	FT	12	3,300.00
Plumbing Fittings	1	JOB	1000	1,000.00
Misc Water Handling	1	JOB	5000	5,000.00
		Sub Total		**237,157.50**

	General Site Cost				
	Description	**Quantity**	**Unit**	**Unit Cost**	**Cost TOTAL**
	Access Road geotextile	2777	SY	1	2,777.00
	Access Road Base Stone Purchase	1000	T	30	30,000.00
	Access Road Base Stone Placement	741	CY	4	2,962.96
	Access Road Top Coat Stone (purchase & placement)	250	T	33	8,250.00
	Access Road Misc Road Drainage & grading	1	JOB	25000	25,000.00
	Revegetation Efforts	1	JOB	10000	10,000.00
	E&S Controls	1	JOB	5000	5,000.00
	SAP 1 stone excavate and dispose of on-site	9615	T	7.5	72,112.50
	Disposal of Ex. Compost and Iron sludge (SAP1) & Disposal of piping (offsite)	4200	CY	10	42,000.00
	Bringing electricity to the site & Connections	1	JOB	30000	30,000.00
	Primer & Glue	1	JOB	500	500.00
			Subtotal		**228,602.46**
	FINAL SED POND & SLUDGE DRYING PONDS				
	Repair to final sed pond / polishing pond outlet	1	JOB	15000	15,000.00
	Plumbing to dewater upper sludge drying pond & install permanent sludge pumping lines	1	JOB	20000	20,000.00
			Subtotal		**35,000.00**
				TOTAL	**877,959.96**
			Contingency 13%		114,134.80
		Overhead & Profit 15%			131,693.99
		Estimated Grand Total			**1,123,788.75**

PRELIMINARY ACTIVE OPTION COST LIST - Rough Estimate				
Collection Basin Pond 1 & Silo / Mixing				
Description	**Quantity**	**Unit**	**Unit Cost**	**Cost TOTAL**
Silo / Mix Tank / Blower / Controls & Install	1	JOB	350,000	350,000.00
Piping to Silo (installed)	600	FT	37	22,200.00
Plumbing Fittings for collection to silo	1	JOB	5,000	5,000.00
			Sub Total	**377,200.00**
Reconfigure SAP2 to Settling Pond				
Clay material for liner (includes est truck cost & install)	3000	CY	35	105,000.00
SAP 2 Stone excavated and dispose of on-site	10271	T	7.5	77,032.50
Removal / Disposal of Ex Compost and Iron sludge (SAP2) & Piping Disposal [offsite]	4200	CY	10	42,000.00
baffle curtains	300	FT	12.75	3,825.00
Piping	275	FT	12	3,300.00
Plumbing Fittings	1	JOB	1000	1,000.00
Misc Water Handling	1	JOB	5000	5,000.00
		Sub Total		**237,157.50**
General Site Cost				
Description	**Quantity**	**Unit**	**Unit Cost**	**Cost TOTAL**
Access Road geotextile	3111	SY	1	3,111.00
Access Road Base Stone Purchase	1120	T	30	33,600.00
Access Road Base Stone Placement	830	CY	4	3,318.52
Access Road Top Coat Stone (purchase & placement)	280	T	33	9,240.00
Access Road Misc Road Drainage & grading	1	JOB	25000	25,000.00
Revegetation Efforts	1	JOB	10000	10,000.00
E&S Controls	1	JOB	5000	5,000.00
SAP 1 stone excavate and dispose of on-site	9615	T	7.5	72,112.50
Disposal of Ex. Compost and Iron sludge (SAP1) & Disposal of piping (offsite)	4200	CY	10	42,000.00
Bringing electricity to the site & Connections	1	JOB	50000	50,000.00
Primer & Glue	1	JOB	500	500.00
		Subtotal		**253,882.02**
FINAL SED POND & SLUDGE DRYING PONDS				
Repair to final sed pond / polishing pond outlet	1	JOB	15000	15,000.00
Plumbing to dewater upper sludge drying pond & install permanent sludge pumping lines	1	JOB	20000	20,000.00
		Subtotal		**35,000.00**
			TOTAL	**903,239.52**
		Contingency 13%		117,421.14
	Overhead & Profit 15%			135,485.93
	Estimated Grand Total			**1,156,146.58**



CONCEPTUAL DESIGN PASSIVE TREATMENT OPTION

SHEET 1 of 1 | Plan View

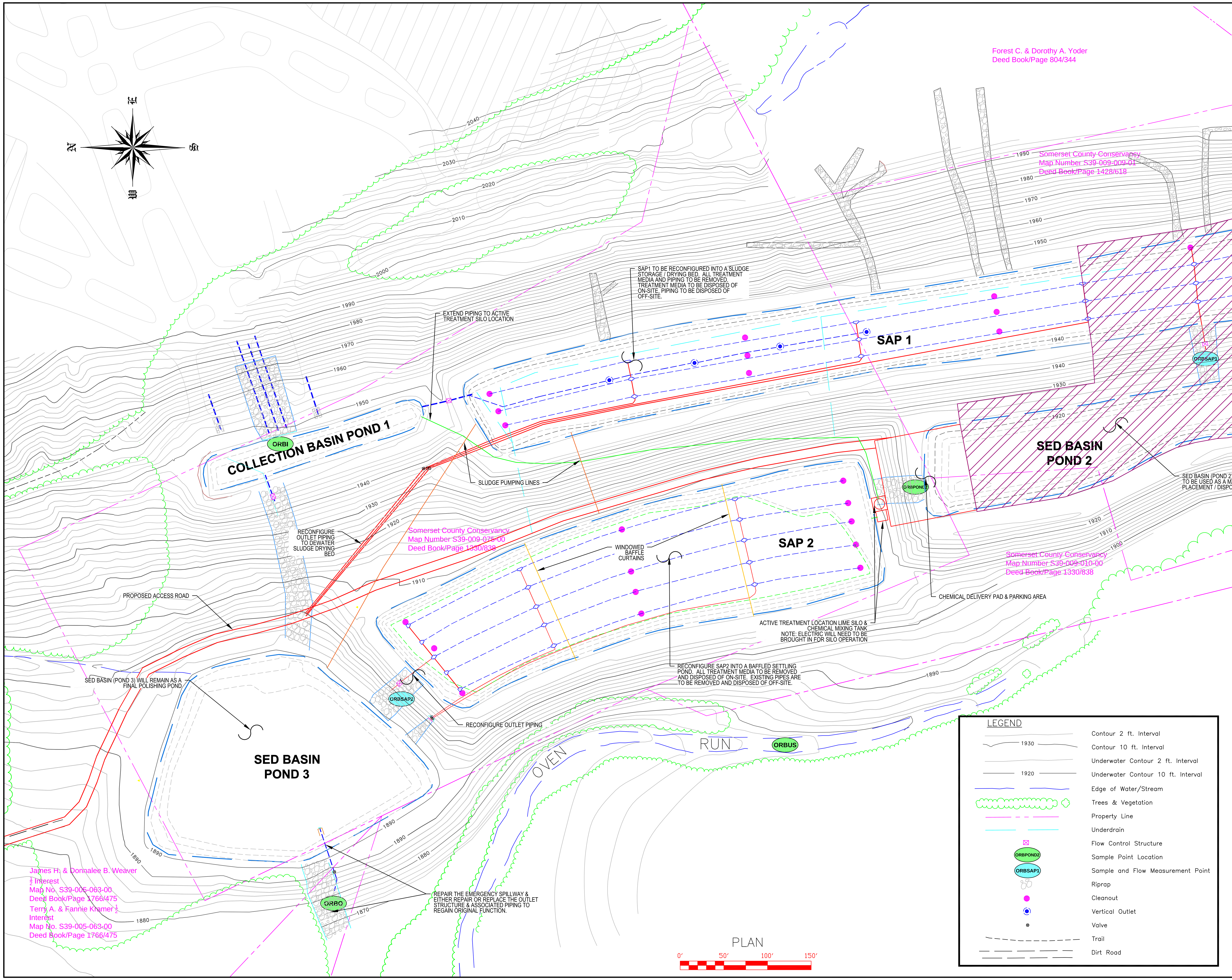
Plan View, Legend, & Notes

AMD RECLAMATION PROJECT
PASSIVE TREATMENT SYSTEM
RE-DESIGN / REHABILITATION
OVEN RUN B

PROJECT CENTER
LAT: 40° 06' 43.52" N
LONG: 78° 54' 42.80" W

for
PA DEP & S.C.R.I.P.
Oven Run Watershed
Shade Township, Somerset County, PA
Scale: 1" = 50' May 2019
BioMost, Inc. Mining and Reclamation Services
Mars, PA www.biomost.com

1116/Conceptual PTS



CONCEPTUAL DESIGN ACTIVE TREATMENT OPTION

SHEET 1 of 1	Plan View

Plan View, Legend, & Notes

AMD RECLAMATION PROJECT
PASSIVE TREATMENT SYSTEM
RE-DESIGN / REHABILITATION
OVEN RUN B

PROJECT CENTER
LAT: 40° 06' 43.52" N
LONG: 78° 54' 42.80" W

for
PA DEP & S.C.R.I.P.
Oven Run Watershed
Shade Township, Somerset County, PA
Scale: 1" = 50'   May 2019
BioMost, Inc. Mining and Reclamation Services
Mars, PA   www.biomost.com

1116/Conceptual ATS