

**Successive Alkalinity Producing Systems**  
**by**  
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**for the**  
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The first full-scale Successive Alkalinity Producing System (SAPS) was constructed in November of 1991 in Jefferson County, Pennsylvania at the “Howe Bridge Site” in the Mill Creek Watershed. SAPS were first described in the literature in April of 1994 in the proceedings of the International Land Reclamation and Mine Drainage Conference, and Third International Conference on the Abatement of Acidic Drainage.

SAPS were designed to go where no other acid mine drainage passive treatment system had gone before, and beyond. SAPS were designed to “ignore” oxygen, to increase pH, and to generate alkalinity commensurate with the iron removal needs of the mine drainage. A second generation SAPS, the Aluminator©, was developed to specifically treat aluminum contaminated flows, and has soundly proven its merit.

A brief preface may be in order for the SAPSaphobic. I recently described a SAPS treatment system to a regulatory agency individual who promptly and emphatically told me that I was not to use the word SAPS, that the system Damariscotta had designed was to be called a vertical flow pond. Always the calm one, I asked “pray tell why my good sir?”, and was told that every time that four letter word was uttered, a couple of guys collected a royalty (and apparently that was a bad thing). In that no royalty had trickled down to the inventors of the SAPS, I realized that we too would have to begin calling these treatment systems... *SAPS*! Say and do what you will, but by goodness, we’ll name our own imaginary dog.

While “vertical (downward) flow ponds” accurately describe the most basic aspect of the SAPS, a perforated pipe under a layer of limestone and compost does not a SAPS make. Kinetics do not always exist where potential lies. Optimum alkalinity does not automatically flow through a pipe buried in limestone.

- There are no revelations here. Water to stone contact time drives the SAPS treatment system. There are minimum and optimum times for reactions to develop. This has been a design given since SAPS day one. SAPS decreased treatment system footprints through volume rather than area considerations, which by default recognized the value of flow residence time.

The simplicity of the SAPS design is in dissolving a piece of limestone. The challenge arises in that we are attempting to control (in an open environment) the most unique and

powerful, and yet simple minded and onerous thing on the planet; i.e., water. Water's only concern is to find the shortest and quickest way from point A to point B. To complicate issues, the flow regime within a SAPS is constantly changing; limestone is dissolving, minerals are accumulating, and flow and head vary.

Control the flow, and control your success. A flow "short-circuit" in a system that functions through limestone dissolution will quickly become a preferential flowpath, which equally quickly leads to a loss of effective treatment. The certainty of this is absolute, as learning curves have proven. The point that still needs to be understood is that no matter how effective treatment is on day one, twenty, or nine hundred, SAPS remain victims of entropy, and decreased treatment efficiency is inevitable. However, well designed SAPS are easily renovated as necessary to maintain optimum treatment efficiency with time.

There are three SAPS/Aluminator© treatment systems located in the Coal Run watershed (Casselman River tributary) of southern Somerset County, Pennsylvania that are the focus of the following discussions.

Work accomplished through a teaming of landowners, the Southern Alleghenies Conservancy, the Pennsylvania Department of Environmental Protection, U.S. Congressman John Murtha, the U.S. Office of Surface Mining, the Somerset County Conservation District, Action Mining, Inc., and others to whom no slight is intended, has resulted in a model watershed initiative. This grouping of individuals has demonstrated what can be accomplished through cooperation and creativity. Damariscotta thanks them all for their many efforts and the opportunities we have had to contribute with these projects.

### **Coal Run:**

The Coal Run system was constructed and made operational in the spring of 2000. The system draws water directly from Coal Run with a maximum design flow rate of 300 gpm. The treatment system consists of an Aluminator© followed by a settling basin/marsh, SAPS, and final settling basin. A separate flush basin is included. The Aluminator© has bottom dimensions of 80' x 350', and includes 6,200 tons of AASHTO #1 limestone and 650 cubic yards of organic compost. There are eight distinct piping collection zones within the limestone, four each at two different levels.

The uppermost set of collection pipes within the limestone profile is for aluminum precipitate flushing purposes only. This level of pipes is intended to maintain a clear flowpath to the lower set of collection pipes and therefore maximize flow residence time within the stone. The lower series of pipes functions as a collection and discharge system to the settling basin and can be flushed as well. The first settling basin/marsh has an approximate capacity of 82,000 cubic feet of water.

The subsequent SAPS has a bottom footprint of 80' x 250', and includes 4,500 tons of AASHTO #1 limestone and 500 cubic yards of organic compost. There are four distinct

piping collection zones within the SAPS that function as a collection and discharge system to the final settling basin. These pipes can also be used to flush the system. The final settling basin has an approximate capacity of 34,000 cubic feet of water.

It should be understood that the design flow of 300 gpm was essentially a mandated quantity, and that basically every square foot of available construction area was utilized with this project. Primary attention was given to adequately sizing the (alkalinity generating) portions of the system. While the settling basin areas are feasibly undersized, they are as large as possible, and if and as necessary can be fitted with turbidity curtains to improve treatment effectiveness.

A characterization of the quality discharging the Coal Run system is provided in Table 1.

**Table 1. Coal Run Treatment System Characterization.**

<u>Sample Point</u>	<u>pH</u> <sup>1</sup>	<u>alkalinity</u> <sup>2</sup>	<u>acidity</u> <sup>2</sup>	<u>iron</u> <sup>3</sup>	<u>aluminum</u> <sup>3</sup>
Raw <sup>4</sup>	2.8	0	400	50	40
Raw <sup>5</sup>	3.2	0	220	20	15
Aluminator©	6.2	55	75	18	2
Settling Basin	6.1	30	40	1.5	0.8
SAPS	7.1	65	0	<0.3	<0.2
Final Discharge	7.0	60	0	<0.3	<0.2

<sup>1</sup>s.u.; <sup>2</sup>as mg/L CaCO<sub>3</sub>; <sup>3</sup>total mg/L; <sup>4</sup>design values; <sup>5</sup>more recent quality developed from additional mine drainage treatment in the watershed

While the reader may or may not be impressed with this level of treatment here and now in the spring of 2003, the design flow was generally considered “untreatable” via passive means at the time of construction. Nonetheless, the Casselman River has benefited from this collaborative effort.

## **Metro:**

The initial Metro projects consisted of two separate Aluminators©, each addressing an individual flow from circa 1930 deep mine seals. The respective discharges and treatment systems are referred to as M1 and M2.

The M1 Aluminator© was constructed in the spring of 2001 and has a bottom footprint of 70' x 140'. The M1 Aluminator© holds roughly 2,900 tons of AASHTO #1 limestone and 240 cubic yards of organic compost. This system is similar to the Coal Run Aluminator© design with eight distinct piping collection zones within the limestone, four each at two different levels. As with Coal Run, the upper four zones are for flushing purposes only. The M1 Aluminator© design flow was set at 85 gpm.

The M2 Aluminator© was constructed in the fall of 2001, and has a bottom footprint of 40' x 200'. The M2 Aluminator© incorporates 2,200 tons of AASHTO #1 limestone and

245 cubic yards of organic compost. The M2 system is constructed similarly to the Coal Run SAPS design with four separate piping collection and discharge zones. The M2 discharge is more greatly influenced by storm events than the M1 flow. A typical M2 flow may be 30 gpm, but short duration peaks of 200 gpm can be expected.

The discharge quality of the Metro Aluminators© is characterized in Table 2.

**Table 2. Metro (M1) and (M2) Treatment System Characterizations.**

<u>Sample Point</u>	<u>pH</u> <sup>1</sup>	<u>alkalinity</u> <sup>2</sup>	<u>acidity</u> <sup>2</sup>	<u>iron</u> <sup>3</sup>	<u>aluminum</u> <sup>3</sup>
M1 Raw	2.8	0	1,300	270	90
M1 Aluminator©	5.8	90	240	140	20
M2 Raw	2.7	0	1,400	290	110
M2 Aluminator©	5.8	100	410	170	25

<sup>1</sup>s.u.; <sup>2</sup>as mg/L CaCO<sub>3</sub>; <sup>3</sup>total mg/L

The reader needs to remember that this is limestone based, passive treatment. If we conservatively characterize the (average) treatment needs of the combined discharges at 100 gpm and 1,200 mg/L of acidity, the annual acid neutralization needs of the flows would be equivalent to about 263 tons.

The Metro Aluminators© were constructed with roughly 90% CaCO<sub>3</sub> limestone, thereby requiring the dissolution of less than 300 tons of stone per year for complete neutralization. The total cost of the M1 system was about \$165,000 and of the M2 system was about \$100,000. (As example and contrast only, the neutralization needs under this scenario equate to an *annual* treatment requirement of roughly 206,000 gallons of 20% NaOH.)

Additional work is ongoing at the Metro site, including the construction of two settling basins and a SAPS, all intended to further treat the combined M1 and M2 flows. The Aluminators© described above were only intended as Phase I of a multi-phased treatment effort. Facilities are also nearing completion to collect and process aluminum precipitates flushed from the two Aluminators© during maintenance events. Again, all of the partners listed above are to be commended for their efforts in this comprehensive mine drainage treatment and resource recovery strategy.

We have not described in any detail the piping collection systems within the limestone substrate of the SAPS or Aluminators©. To do so is beyond the scope of this general presentation. While SAPS appear quite simple in cross-section and theory, and are actually similar in design with any application, they are still quite site specific in their sizing needs and piping layouts. It would not be fair to anyone trying to develop a SAPS design to provide them with partial information towards this end.

The ultimate test of SAPS/Aluminator© technology is not in the theory, or in the design; the first is sound and the second should be: *Well planned and executed operation and maintenance of SAPS and Aluminators© is ultimately the most critical aspect of successful treatment.* Without effective and regular (as needed) O&M, design and construction monies would be better spent elsewhere.

- If you take nothing else from this paper, understand that flow control in a limestone based treatment system is critical to the success of the system period, and that proper O&M through flow control is key to sustained success.

As examples, we recently reviewed a “vertical flow pond” design for a 30 gpm flow that combined hundreds of feet of 4” diameter and over 100 feet of 12” diameter perforated piping as a single treatment zone over the approximate 20’ x 130’ bottom area of the treatment system. In this case, the mine drainage is being encouraged to exit the vertical flow pond without even introducing itself to the limestone. Remember, this is not a race from point A to point B; the slowest flow wins.

However, even the slow flow still needs to contact the limestone. January’s and February’s Coal Run Aluminator© effluent data showed decreasing pH and increasing aluminum and acidity concentrations. This winter’s 200 inches of snowfall led to decreased O&M, which led to increased aluminum precipitates on and within the pore spaces of the limestone, which led to decreased treatment efficiency. There are no treatment mysteries in either of these examples. It’s all about the f-l-o-w. Just don’t go with the flow.

Most significant advancements in the field of passive mine drainage treatment have developed through a path of hearty skepticism, followed by modest acceptance, and then dogmatic application of the technology. Well guess what? It’s time for another leap. *Any combination of thousands of milligrams per liter of acid producing mine drainage contaminants and thousands of gallons per minute of flow can be addressed through SAPS and Aluminator© treatment.* Resources can also be recovered to offset treatment costs.

If anyone has any questions concerning the capabilities of SAPS and Aluminators©, please don’t hesitate to contact either Doug Kepler or Eric McCleary at Damariscotta... phone: (814) 226-5792, or e-mail: [damariscotta@penn.com](mailto:damariscotta@penn.com).