# EARLY RESULTS FROM CALCIUM CARBONATE NEUTRALIZATION OF TWO WEST VIRGINIA RIVERS ACIDIFIED BY MINE DRAINAGE


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## Introduction

In 1992 the State of West Virginia initiated a stream restoration program directed to waters affected by acid mine drainage (AMD). The West Virginia Division of Environmental Protection (WV DEP) was placed in charge of the program. A technical committee, consisting of representatives from state and federal agencies and the private sector, was charged with developing data on priority streams and recommending methods for their restoration. The West Virginia Division of Natural Resources (WV DNR) has members on the committee because of their experience treating streams acidified by acid deposition. The first two streams selected for restoration are being treated using methods developed by the WV DNR and successfully applied to streams acidified by acid deposition. This paper briefly reviews these methods and their application to the Blackwater River in Tucker County and the Middle Fork River in Randolph, Upshur and Barbour counties.

## Background

The WV DNR began studying methods of treating lightly buffered acid streams in the late 1950's. The early history of this work has been reviewed previously by this author (Zurbuch 1984). One of the first methods tried was the placement of 2-inch diameter limestone aggregate in the bed of a small stream. The method was abandoned when after a short period of time the stone became coated with precipitates and non-reactive. A water powered rotary drum system was then developed that ground the limestone into a slurry within the drums for release into the stream.

By the mid-1970's acid deposition was seriously affecting some of the large trout streams in the state. The rotary drum system was improved so that it could be used in river situations (Genscoy et al. 1983, Zurbuch 1989). The chief improvements were a self-feeding mechanism and a 6-fold increase in slurried $CaCO_3$ output. The self-feeding drums have been highly successful in reversing the effects of acid deposition in the Cranberry River which is located in the southern portion of the Monongahela National Forest in West Virginia (Clayton and Menendez 1996, Menendez et al. 1996, Zurbuch et al. 1996).

During the development and testing of the self-feeding rotary drum it became apparent that sand size limestone particles in the slurry leaving the drum could neutralize the stream's acid loads on their own during periods the drum was inoperative. A separate research effort was started to investigate the possible use of quarry produced sand size limestone particles to treat acid deposition affected streams. Results of these first studies were very encouraging as reported by Ivahnenko et al. (1988) and Downey et al. (1994). The sand size particles did not become ineffective because of coating as the larger aggregate sizes had in earlier studies. A 5-year study to optimize the instream limestone sand treatment was completed in 1995 on selected tributaries of Shavers Fork of Cheat River (Menendez et al. 1994). The first results of the study were so positive the WV DNR began using instream limestone sand as a management technique for streams and in tributaries of lakes being affected by acid deposition.

Thus, as the West Virginia Stream Restoration Program was being started, the self-feeding rotary drum system and the use of instream placement of limestone sand were proven to be effective methods to restore streams acidified by acid deposition. The question to the stream restoration technical committee was whether or not these methods could be used to neutralize AMD. It was believed the rotary drum production of limestone slurry would neutralize the mine acid as well as it did the acid deposition. In this application it would simply be the capability of the drums to produce enough $CaCO_3$ slurry to generate alkalinity sufficient to neutralize the acid loads expected. It was determined that a 6-drum system on the Blackwater River just upstream of the first mine acid tributary would be effective. The station was placed into operation in late September 1994.

Use of limestone sand as a technique to treat AMD was not as easily transferred from the work with acid deposition streams. The possible coating of the limestone particles by the heavy mine drainage precipitates was a major concern. It was decided that a pilot study using the limestone sand would be appropriate in the Middle Fork River drainage. Tributaries being affected by only acid deposition and those affected by both acid deposition and AMD were selected for treatment. The treatments were made from late December 1993 to December 1994. The pilot study showed the sand worked as well if not better in AMD as it did in acid deposition affected streams. Based on the success of the pilot study an instream limestone sand project was designed to restore the entire 38 miles of the Middle Fork River. Site preparation and treatment were started in August 1995.

Early results from the treatment of the two rivers are summarized in the following sections. All chemistry data reported are from monthly and bi-monthly stream sampling.

## Blackwater River Rotary Drum Limestone Slurry Treatment

The lower 12 miles of the Blackwater River have been severely degraded by AMD for over 35 years. The major sources of acid enter from Beaver Creek and the North Fork (Figure 1). The limestone slurry treatment station is located one-half mile upstream of the town of Davis. It was constructed by the WV DEP and commenced operation in September 1994. It is operated for the WV DEP by the WV DNR.

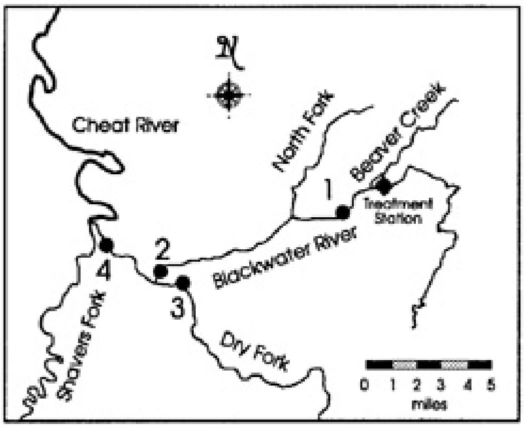


Figure 1. Locations of the Blackwater River rotary drum limestone treatment station and chemistry sampling stations.

The river's main treatment is by a rotary drum system. The water powered drums autogenously grind the limestone aggregate inside them into a slurry which is released into the river. The 6-drum station is identical to a station operating since January 1993 on the North Fork of the Cranberry River. About 800 tons of limestone aggregate are stored inside the treatment building and another 1,200 tons on an outside pad. The station's construction cost was $813,000. An existing dam was modified to supply the water power for the drums. The drums are automatically adjusted in their $CaCO_3$ output to changes in river flow. This is accomplished by using hourglass shaped weirs at the dam that maintain a constant percentage of river flow in the sluice supplying the drums. As river flow increases additional flow enters the sluice and more drums in the series are placed into operation. A flexible drive shaft from each drum axle powers a reciprocal limestone feeder. The limestone drops into a small hopper where it enters the drum via an inverted screw feed which is part of the drum axle. Small holes in each drum vane permit water to enter the drum and $CaCO_3$ slurry to exit. A backup limestone powder doser was constructed adjacent to the drum station. It is a Swedish designed system similar to that being used by Maryland to treat the North Branch of the Potomac River (Mills this proceedings). To present, it has only been operated to test its functioning. The limestone for both systems is obtained from the Germany Valley Limestone Quarry, Riverton, WV which is 36 road miles from the station. The limestone is high grade containing better than 98 % $CaCO_3$- In 1994 the aggregate cost $13.85/ton delivered and the powder $22.00/ton delivered. The drum station can add up to 100 grams per second of slurried $CaCO_3$ to the river flow. This amounts to 9.5 tons/day at high flow and with all 6 drums at maximum output. The designed treatment of $CaCO_3$ is a dosage of 28 grams per cubic meter of flow (28 mg/L).

The drum station has operated continuously since its startup. In its first year it used about 1,700 tons of limestone aggregate. The WV DNR and WV DEP are conducting chemical and biological evaluations of the effects of treatment. The chemical stations selected for analysis in this summary are shown in Figure 1. Station 1 is downstream 2 miles from the entry of Beaver Creek just before the river goes over Backwater Falls. Station 2 is at the mouth of the Blackwater where it joins with the Dry Fork River. Station I data are critical in showing the effect of treatment down to the junction with the highly acid North Fork. It is in this 4 1/2 mile section that the state hopes to develop a high quality trout fishery. Station 2 data show the effect of the treatment on the acid loads from the North Fork. A fishery was not anticipated in the 7 miles of the Blackwater below the North Fork. It was anticipated that the acid loading to the Cheat River would be significantly lessened. Station 3 and 4 were selected to show this. Station 3 is located on the Dry Fork River just before its junction with the Blackwater and Station 4 is located 3 miles down river after their joining.

Figure 2 shows the change in pH at Stations I and 2 from before treatment and during treatment. The chemistry in the river down to its junction with the North Fork (Station 1) has been successfully maintained in a range sufficient to produce a high quality fishery. Fish sampling in the Blackwater Canyon after one year of treatment confirms this. The number of species increased from 10 to 17 and the weight increased from 3.3 to 9. 1 lbs/acre. Some of the brown and rainbow trout fingerlings stocked after treatment began were collected in the survey. They were in good condition and had put on growth since being stocked. Additional biological studies are being conducted on macroinvertebrates, but it is too early in the study to show significant changes.

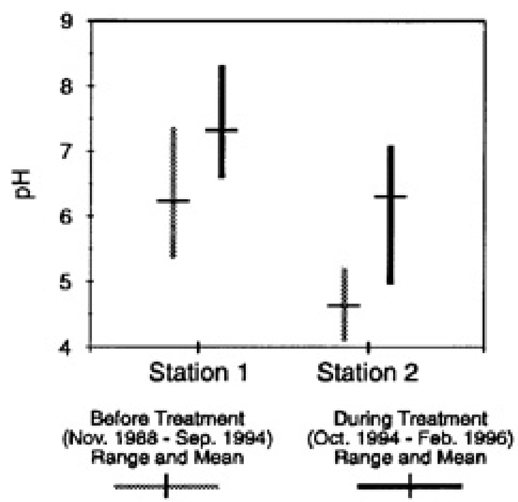


Figure 2. Changes in the Blackwater River pH from before to during limestone treatment.

The water quality of the section of the Blackwater from the junction of the North Fork to its mouth improved significantly but was not kept suitable for sustained fish inhabitance (Station 2, Figures 2 and 3). Reduction of the acid loading from the North Fork will probably be necessary to permit this.

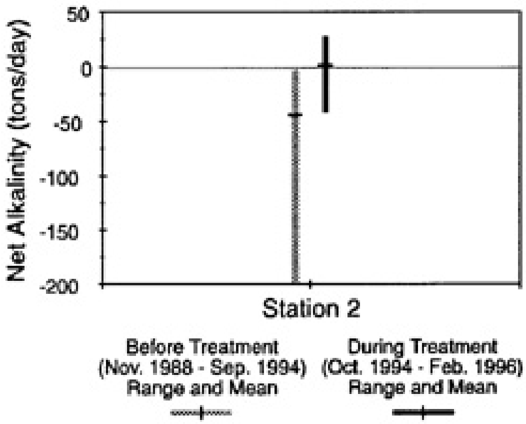


Figure 3. Changes in the Blackwater River net alkalinity at its mouth from before to during limestone treatment.

The reduction in acid loading and increase in alkalinity at the river's mouth are shown in Figure 3. This has increased the down river water quality of the Cheat River. As Figure 4 shows, the mean alkalinity of the Dry Fork River (Station 3) is minimally diminished after its mixing (Station 4) with the treated flows of the Blackwater River. Before treatment, the natural alkalinity of the Dry Fork was substantially reduced by its neutralization of the Blackwater's acid loads. Fishery surveys are scheduled in 1996 to see if the productivity of the upper Cheat River has been improved.

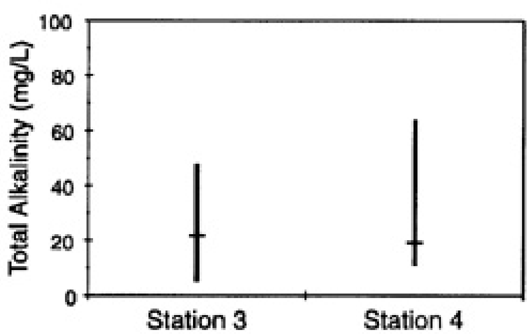


Figure 4. Comparison of alkalinity in the Dry Fork River just before to after mixture with the Blackwater River during limestone treatment (October 1994-February 1996).

## Middle Fork River Instream Limestone Sand Treatment

The Middle Fork River heads in Randolph County south of Adolph. It then flows northward 38 miles where it joins with the Tygart Valley River just upstream of Tygart Reservoir (Figure 5). The lower 32 miles of the river has been severely polluted by AMD for the past 23 years. The first entry of AMD occurs from Cassity Fork (Station 7) which also provides the most acid to the river. Downstream lesser AMD contributors are White Oak Run, Hell Run (Station 8) and Devil Run (Station 9). The upper 6-mile section of the Middle Fork from Adolph (Station 1) to Cassity Fork provided a hatchery stocked trout fishery until recent years. About 1980 this section of the river began to show the effects of acid deposition and eventually turned too acid for trout stocking for most of the spring.

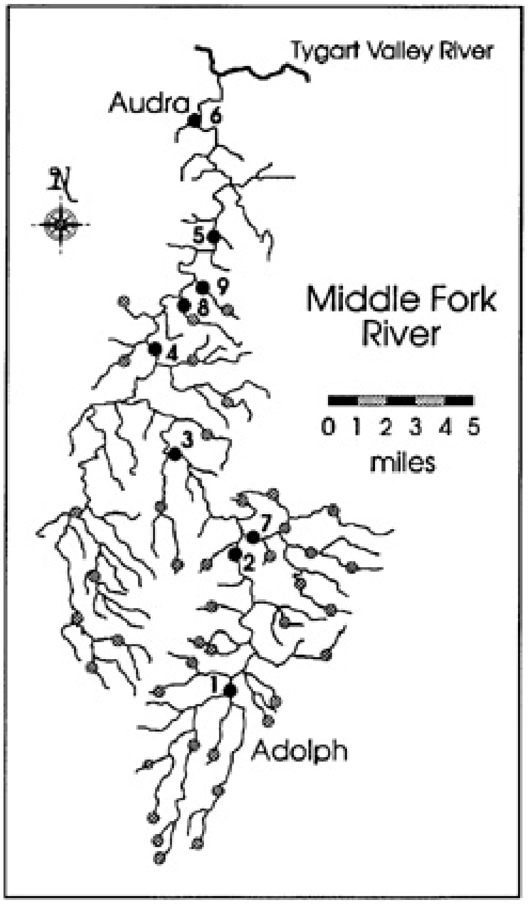


Figure 5. Middle Fork River chemistry sampling stations (numbered) and 1995 instream limestone sand treatment sites (unnumbered).

With the advent of the West Virginia Stream Restoration Program the Middle Fork was suffering acidification from both acid deposition and AMD. This not only rendered the main river fishless, it was also impacting the native brook trout and associated species in most of the tributaries.

The original proposal to the technical committee by the WV DNR was to treat the headwaters of the river in the Adolph area with limestone sand. From research using the technique on acid deposition affected streams the committee felt that enough alkalinity could be added to the river to return the trout fishery down to Cassity Fork. This alkalinity would then help neutralize some of the AMD entering from Cassity Fork. There had not been studies on use of the limestone sand in streams severely impacted by AMD. To gain some knowledge on this it was decided to treat a tributary of Cassity Fork and two other AMD tributaries-Hell Run and Devil Run. During this pilot treatment the committee was to investigate alternative methods of restoring the lower 32 miles of the River.

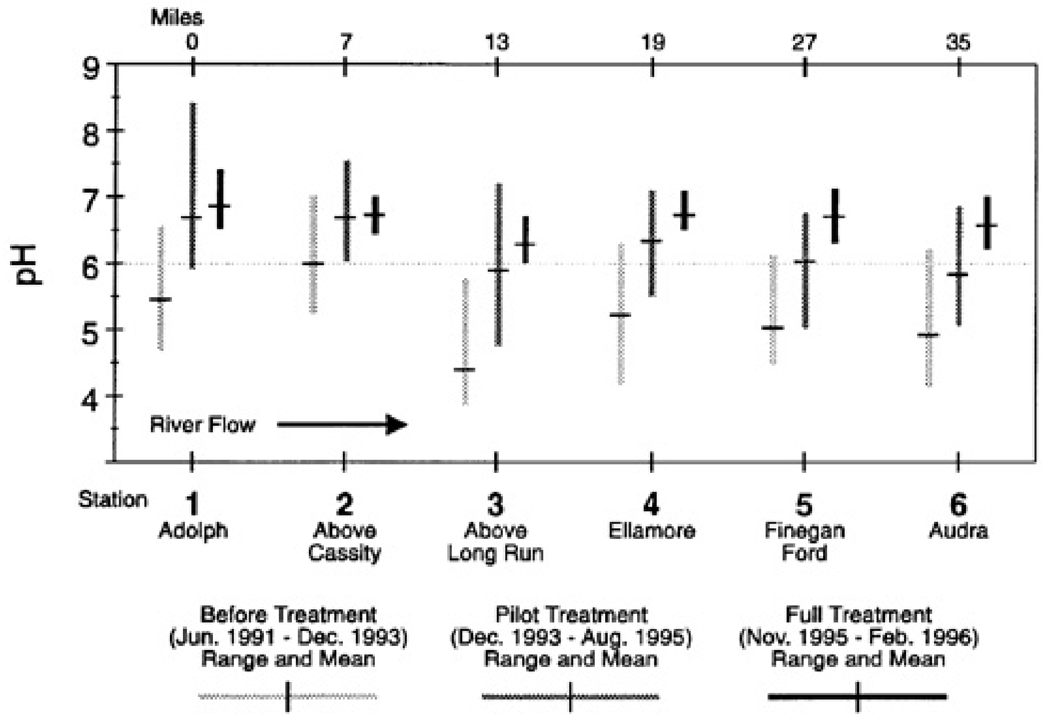


**Figure 6.** Middle Fork River pH response to instream limestone sand treatment as of February 22, 1996.

The treatments were based on previous research on acid deposition acidified streams. The most efficient treatment was the addition of the limestone sand at one site in the headwaters of the stream. During high flows, the sand was then moved downstream and mixed into the sediments. This approach was used for the headwater tributaries above Adolph. It was also used in the two AMD tributaries Hell Run and Devil Run. In both of these streams the AMD enters near their mouths. In Cassity Fork, the sand was placed directly in a tributary (Panther Run) containing AMD.

The pilot limestone sand treatment involved some 1,672 tons of > 98% calcium carbonate sand obtained from the Germany Valley quarry at Riverton, WV. The sand, originally produced for glass production, has a narrow range in particle size from 2.36 mm (No. 8 sieve) to 75 m m (No. 200 sieve) with a mean diameter about 425 gm. The sand was placed into the tributaries in December 1993. Additional sand was added to the Cassity Fork tributary in the spring 1994 and to the headwaters upstream of Adolph in December 1994. The basis for treatment of the acid deposition affected tributaries was to add 2X the annual acid loading the first year and then a supplemental treatment in the second year. The AMD streams were also treated with twice their estimated annual acid loading.

Figure 5 shows the location of chemistry stations I through 6 on the main river which have been selected to summarize the overall effects of treatment. Stations 7, 8 and 9 have been selected to show effects of the treatments on AMD loading in Cassity Fork, Hell Run and Devil Run respectively. Figure 6 shows the pH mean and range at the 6 main river stations prior to treatment, during the pilot treatment and following full treatment as discussed later. The pilot treatment resulted in a major improvement in the chemistry of the river. In the AMD tributaries the reduction of acid loading was significant. Figure 7 shows the estimated reduction in acid loading for Cassity Fork, Hell Run and Devil Run. The estimated loads if treatment had not occurred were based on what the flows experienced would have produced before treatment. Sediment analysis and the estimated acid load reduction in Cassity Fork both indicated nearly 100% dissolution of the limestone by fall of 1995. The anticipated precipitate coating of the sand size limestone was not a problem in the AMD streams. The success of the pilot limestone sand treatment in both AMD and acid deposition tributaries of the Middle Fork led to a full-scale treatment proposal. The stream restoration technical committee accepted the concept as a cost effective treatment for the river. State and federal agreement followed and treatment commenced in August 1995.

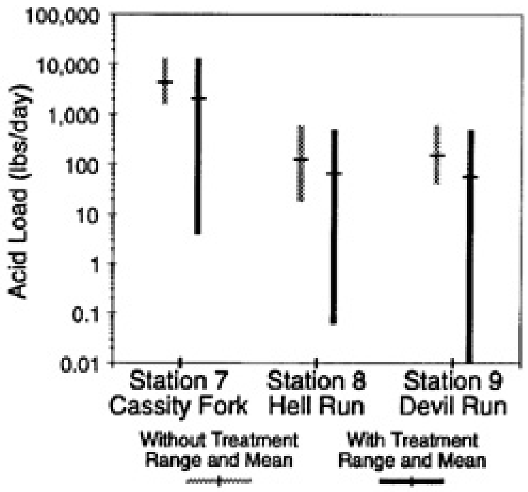


Figure 7. Reduction in acid load in three Middle Fork River AMD tributaries during the pilot treatment with limestone sand (December 1993 - August 1995).

Forty-one treatment sites were developed on 27 tributaries of the river from the headwaters down to and including Devil Run (Figure 5). They were constructed to provide easy and permanent stream access for the initial and following years treatments. The first year's full treatment was based on 4X the annual acid load for acid deposition tributaries and 2X the load for AMD tributaries. About 8,000 tons of limestone were scheduled for the drainage. The limestone sand was from the same source and the same type used in the pilot treatment. Its cost was $25.40/ton delivered to the treatment sites. In subsequent years it is planned to replenish the limestone sand with an amount equal to the annual acid load (consumption) which is about 2,000 tons.

Presently (April 1996) about 90% of the treatment has been completed. Above Long Run (Station 3, Figure 5) all of the sites had been completed and treated prior to mid-November 1995. The pH's shown in Figure 6 showing effects of full treatment include 7 bi-monthly samples from the last of November 1995 to the last of February 1996. To date the treatment has maintained pH above 6.0 for the entire length of the river. There is a mixing section and additional instream neutralization of AMD for a couple of miles below Cassity Fork. It is believed this is from limestone washed from Cassity Fork into the river and mixed into the river sediments. A full range of chemical, physical and biological studies are being conducted on the Middle Fork by the WV DEP and the WV DNR.

## Conclusions

It is too early in the treatment of the Blackwater and Middle Fork Rivers to be able to show successful biological restoration. In the case of the Blackwater, the 1996 biological sampling should provide sufficient data to predict the ultimate outcome of treatment.

The instream limestone sand treatment of the Middle Fork River is a first for a drainage of this size and a first in the attempt to neutralize AMD using this technique. The first hurdle for the sand is to maintain the water quality in the river high enough through the remainder of 1996 to permit fish reinvasion. The treatment, if successful, should provide an economic method for instream neutralization of

AMD. Additional research needs to be done to determine the most effective methods to treat AMD using limestone sand. Studies in addition to the those described above are underway and should help determine these answers.

## Acknowledgments

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