HEALING AN OPEN SORE
REHABILITATION OF FORMER SHALE QUARRIES IN NOVA SCOTIA

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Minerals of iron sulphide (pyrite, pyrrhotite, arsenopyrite) commonly occur throughout Nova Scotia. These minerals form a key component of Meguma Group deposits in mainland Nova Scotia, south and east of the Cobequid-Chedabucto Fault (Patterson, 1993). Formations in some areas can be very extensive, often with large exposed outcrops or as areas covered only by a thin veneer of soil and forest debris. Commonly known as shale or slate, the prevalence of these deposits, the ease of recovery and their physical properties have resulted in numerous small quarries throughout Guysborough, Halifax, Lunenburg and Queens counties. The cheap source of aggregate was typically used for rural roads and driveways. Depending on the nature and mineralization of the deposits, acid drainage was readily generated during open-pit quarrying (see, for example, Zentilli and Fox, 1997). The drainage plays a critical role in defining the aquatic environment of many Nova Scotian rivers and lakes (see, for example, Environment Canada, 1987).

The issue of acid drainage or acid mine drainage is well characterized, and extensive studies continue to be conducted to find an "optimum method" for treating the problem (e.g., Mine Environment Neutral Drainage - MEND; International Network for Acid Prevention - INAP; National Orphaned/Abandoned Mines Initiative - NAOMI; Acid Drainage Technology Initiative - ADTI). For larger sites or active base metal mining operations, funds are usually available to mitigate the drainage or rehabilitate the site. For the many small quarries occurring in Nova Scotia, the cost of rehabilitation has significantly outweighed the value of the recovered resource. Further, as the Government of Nova Scotia recognized the environmental impact of such quarries, operations were forced to close and the placement/dumping of such materials was strictly limited by regulation.

Abandoned, but not remediated, the exposed deposits resembled an open sore. Site drainage, combined with a lack of natural buffering capacity, readily reduced stream pH from 6.5 to 2 or 3, with significant impact on aquatic habitat. In some cases, the formation of acid drainage also resulted in the release of arsenic and other trace metals.

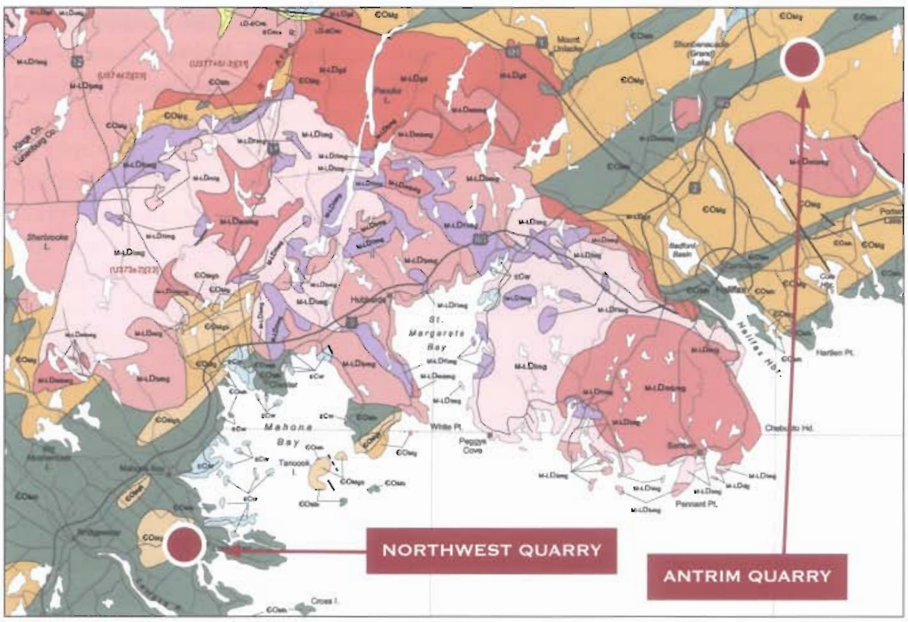

Figure 1. Location of Northwest Quarry in Lunenburg County and Antrim Quarry near the Halifax International Airport.

1997 aerial view of shale quarry at Northwest, Lunenburg County.

2001 view of Northwest shale quarry after rehabilitation.

As in other jurisdictions, various attempts have been made to address acid drainage. The 1991 illegal quarrying of a former pit in Northwest, Lunenburg County, Nova Scotia resulted in acidic discharge to Martin's Brook and significant fish mortality at an aquaculture operation near the mouth of the Brook. This site, consisting of two pits (0.8 and 2 hectares) was started in 1948 and used extensively in the 1960s and 1970s. In response to the fish kill, a local non-government organization (NGO) group, Bluenose Atlantic Canada Action Program, used waste drywall board to create a dyke that could also "neutralize" the effluent. However, as has been encountered elsewhere, the result was a concrete-like mass of material that provided only temporary relief. Further attempts included spreading the waste drywall over sections of the quarry, grinding the waste and spreading the material, and diverting the flow into a waste-lined pond. While each application addressed part of the effluent for a period of time, the end-result was a return to acidic drainage.

The availability of waste drywall was the result of a 1995 Government of Nova Scotia initiative to reduce volumes of wastes entering landfills and to divert these wastes to productive resources. While much of the public's attention has been given to composting and paper and bottle recycling, wastes from construction and demolition projects were also required to be diverted. In principal, this was a laudatory target; in practice, demolition wastes are not adequately sorted at the source and typically include large volumes of plaster board or drywall mixed with wood framing. Even after sorting, large volumes of mixed residue remained. Under IRAP funding, we began working with Halifax Construction and Demolition Recycling Ltd. (HCDR) to evaluate ways of making these wastes into a resource. Test plots of ground mixtures combined with compost identified a potential growth mixture for gravel pits and road shoulders. Thus was born "Remediation Matrix", but the question was posed – would this mixture work in shale quarries?

In 1998, the first large-scale trial of Remediation Matrix was attempted at the Northwest quarry. Mixture materials were carefully ground at the HCDR facility in Halifax, transported to the site and spread over all of the pit area to a depth of about 1 m. After natural consolidation of the material over a winter, the surface was covered with about 0.1 m of compost and seeded. Within six months, the site started to become a grassy field. Re-seeding in the autumn yielded a lush field of grass the following summer. Excess surface water drainage through the site resulted in sulphide odours during the next three years. This was mostly addressed by diverting surface drainage from other areas around the quarry site. Monitoring of Martin's Brook continued to show an increase in pH back to 6.5 and associated trace metal reductions; however, the community continued to express concerns about leachate from the construction and demolition materials used to create the Remediation Matrix.

In 1999-2000, a much larger trial of the Remediation Matrix was conducted at a quarry in Antrim near the Halifax International Airport. This 25-hectare site, consisting of two large pits, had been established in the 1950s and used until the late 1970s. The site drainage had a pH of 3. The resultant impact to Nuttall Brook created a very acidic aquatic habitat.

A total of over 10,000 metric tonnes of Remediation Matrix was placed in combination with a site drainage plan and drainage pipes. This large quantity of Remediation Matrix and compost was used to restore the natural topography and contours of the area, as well as remediate the acidic drainage.

Two key changes were made in the process: the Remediation Matrix materials were ground much finer than for the Northwest quarry to improve their chemical reactivity, and the amounts of drywall/plaster board were reduced to lessen the sulphide generation problem. By 2004, the former open sore had become two grassy fields.

The larger experiment also encountered "scale up" problems. Incomplete coverage of all shale materials resulted in the formation of bright orange iron oxide flocculant in any surface drainage, as the site drainage water, which had a pH of 7, encountered residual acidic drainage. The extensive use of compost often resulted in the application of incompletely "cured" compost, with resultant odour and ammonia discharge issues. These issues have been addressed, but highlight the need to apply materials in a very careful manner. The larger experiment also required a very extensive surface and groundwater monitoring program, and a semi-annual biological survey of the receiving steams.

The Remediation Matrix process can be best described as applying an "alkaline sponge" to the rock. The drywall/plaster neutralizes the chemical reaction, while decomposition of the organic material eliminates exposure to oxygen and further inhibits chemical and microbiological reactions. The acidic drainage is not only treated, but also prevented from forming. In combination with compost that has also been diverted from waste disposal, the use of Remediation

Matrix to rehabilitate shale quarries offers a "win-win" case – diversion of landfill wastes and shale quarry rehabilitation at a viable cost.

Additional information can be obtained by contacting the author. This paper was derived from a presentation of preliminary findings made by the author to the Canadian Land Reclamation Association annual conference in Halifax, NS, August 2001. ❑

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1999 summer aerial photograph of Antrim Shale Quarry.

July 1999 view of Antrim Pit 2.

August 2003 view of Antrim Pit 2 after application of matrix and before seeding.

June 2004 view of Antrim Pit 2.