The million dollar mistake

Steve Lalancette, president

Regeneration

In business, a million dollar mistake refers to an error that has three main characteristics. First, it's a big one. It has large consequences that are hard to correct. Second, it's definitely not intentional. Those responsible were doing their best. However, third and most importantly, it was avoidable.

Over the last 20 years, academic and commercial research and development initiatives have led to the creation of new restoration techniques where acid generating tailings are sequestered in highly stable structures. Covers with capillary barrier effects (CCBE), elevated water tables and covers with geomembranes are now commonly used as tools to rehabilitate mining sites no longer in operation. Prediction models estimated that these structures could remain stable for hundreds of years… Or so we thought.

Often considered as "icing on the cake", vegetation has not usually been taken into particular consideration in the design of these structures. The lack of understanding of biological concepts such as ecological succession or plant nutrition has led to the false beliefs that trees would not grow in what was seen as inhospitable conditions or that herbaceous covers would prevent their colonization.

But they do grow. In certain cases tree growth can be prolific and very rapid. And they do so on structures that were not designed to tolerate them.

With their extensive and often deep root systems, trees are now threatening the very integrity of structures that were constructed at high cost. Roots will grow across the capillary barriers of CCBEs and through most geomembranes. Through evapotranspiration, they also have a very important impact on water tables, each tree pumping hundreds of liters of water into the atmosphere every day. This will affect the saturation levels in CCBEs and the height of water tables, sometimes bringing them far below planned levels.

Therefore as an industry, we have made a million dollar mistake. The mistake was not intentional, but why was it avoidable?

A simple (if not simplistic) way to understand why tree grow on what looks like inhospitable structures is to understand what they are made of. First, they contain between 85% and 95% of water. Both CCBEs and elevated water tables contain water as part of their structure that can serve as water reserves for trees. Structures using geomembranes may not offer a water reserve *per se* but simple water retention from rainfall is often enough to initiate growth. Second, the three

major elements composing the dry mass of a tree, carbon, oxygen and hydrogen (up to 95% of dry mass, *i.e.* excluding water), are obtained from the atmosphere or from water.

Simplistically put, 99% of elements composing total tree mass are always available. Moreover, since trees use the sun as a source of energy, they do not need organic matter.

If we look at the remaining 1% of mass, we find that certain elements are essential to tree growth and survival even if required in small quantities. Three of them, nitrogen, phosphorus and potassium, are critical. They are usually present on mining structures, but not in a form which trees can use. Nitrogen is present in large quantities in the atmosphere (N_2) and phosphorus and potassium in various mineral forms. However, trees require nutrients to be in solution.

This is not a permanent obstacle to tree growth. Most tree species can develop symbiotic relationships with mycorrhizal fungi. Theses fungi are able to access nutrients, such as nitrogen, phosphorus and potassium, in organic form and certain mineral forms (phosphorus and potassium). These sources are unavailable directly to plants. Other species, such as members of the *Alnus* genre, also form symbioses with nitrogen fixing bacteria (*Frankiae*) that transform atmospheric nitrogen into chemical compounds that plants can use. Their growth on a structure will increase the amount of nitrogen available to other plants and facilitate the arrival of other tree species.

Most of the other essential elements are required in very small amounts and are usually present as water contaminants therefore accessible to plants. If not, they are often available through their fungal partners.

In a nut shell, nothing on CEBBs, elevated water tables or coverages with geomembranes will prevent the growth of trees. In fact, often nothing is completely lacking as far as their nutritional needs are concerned. Conditions on these structures are far from ideal, but not so that tree growth will be null. It might be slow, mortality rates might be high, but in the end tree growth is almost unavoidable.

The biological processes that underline tree growth are well known and have been known for quite a while. The type of ecological succession we are seeing on mining structures has been studied on other types of structures that are very similar, such as dams and dikes built for the production of hydroelectricity. By failing to take this knowledge into consideration the rehabilitation industry, which I consider myself part of, has failed and made a million dollar mistake.

We must therefore ask ourselves why we made such a mistake in order to prevent them from happening again. Far from being absolutes, a few aspects of

our industry have to be considered if we want to increase our ability to prevent such mistakes.

First, our industry is a young one. It simply did not exist 40 years ago. So even if it is easy to consider something as obvious after the fact, it is not always so clear beforehand. We still have much to learn and therefore must use an extra degree of caution when developing new solutions.

Second, our industry is complex. The rehabilitation industry includes a very wide array of expertise ranging from civil engineering to water treatment, hydrogeology to biology. There are therefore no such thing as a rehabilitation expert. Firms, academics and consultants must work together in order to tackle complex problems. Identifying the right people with the right expertise can be tricky, especially when we are unaware that certain aspects of a situation can be problematic simply because we are not an expert in that particular field. We must therefore refrain from making assumptions and refer to someone else as soon as we leave our own area of expertise. Partnerships and strategic alliances will become key to solve increasingly complex environmental issues.

Finally, we are a cost industry. We do not create revenues for our clients. Even if the environment is becoming an increasingly important part of corporate values, by its nature, it will always be under considerable strain to be as cost effective as possible. However, sacrificing on quality in order to reduce short term cost can be expensive in the long term.

Our failure to anticipate the impact of vegetation on rehabilitation structures in the mining industry is a good example of the type of challenges our industry is facing. Fortunately, solutions are now in place to control and prevent trees from colonizing confinement structures. Bio barriers and high resistance factor vegetation coverages will prevent tree seeds from germinating and might even kill young trees. New vegetation control techniques using fungi will kill adult trees and prevent their regrowth.

But for some structures, it is already too late and reconstruction cost will represent millions of dollars. Let us therefore see this as a reminder that we must remain open minded to the complementary expertise of our colleges (and competitors) if we want to avoid another million dollar mistake.

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