LANDFORM DESIGN INSTITUTE

Landform Design Quarterly

Winter 2021

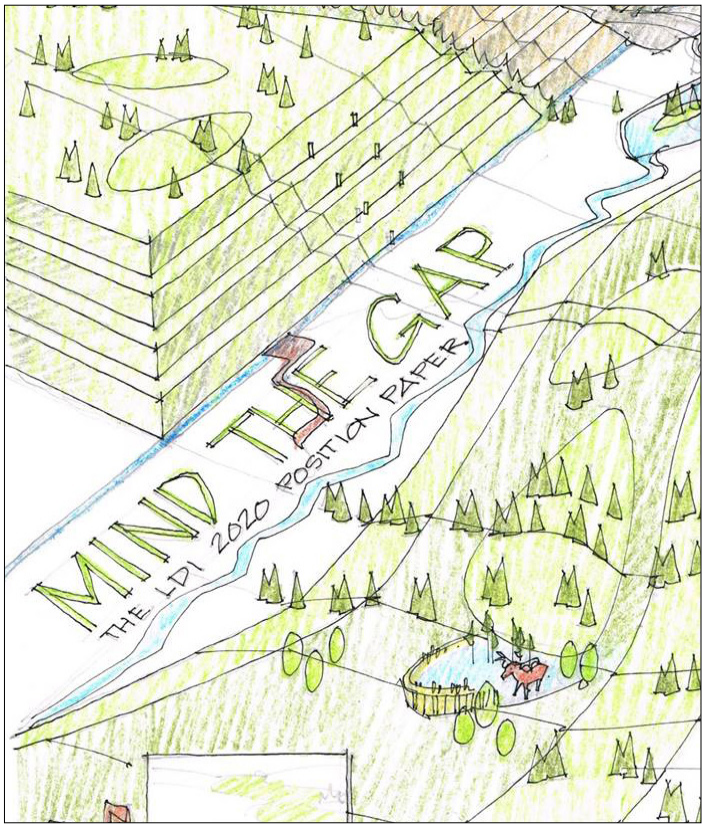
Forging ahead with a bold agenda for 2021

The Landform Design Institute is embracing an ambitious agenda for 2021. This will include recording podcasts, expanding our library, producing online lectures, and creating a series of video vignettes that supply how-to guidance on a range of topics of interest to our members and the broader landform design community. Also planned are discussion papers and technical reports resulting from the Board's 2020 gap analysis.

We begin the year with the release of a position paper. Working from the gap analysis, interviews with experts, and a literature survey, the paper will identify critical areas where the Institute can contribute to the global community of landform design practitioners and the advancement of landform design as an emerging discipline.

Using the position paper as a guide, the Institute will focus on three main subjects:

- **Education and training:** developing and delivering online courses, guest lectures, webinars, short courses and lectures, and university-based graduate-level courses
- **Developing how-to resources:** providing tools and checklists, technical reports, literature reviews, hot-topic videos, and textbooks to address gaps in current technologies
- **Supporting the global landform design community:** providing an extensive case history database available online, promoting discussion through the podcast, supporting a curated online library, hosting a case history symposium, and providing a membership directory to build a community of landform design participants that includes mine owners, practitioners, regulators, Indigenous communities, local communities, and stakeholders.



To this end, we are producing a new business and strategic plan. For the next six months, the Institute will be pursuing student, individual, and corporate members, as well as major sponsors. You can learn more about membership at: landformdesign.com. We hope you'll join the adventure.

Making landform design routine worldwide

The Landform Design Institute is dedicated to creating and supporting a community of landform design practitioners. Its intention is to help their teams design and build truly sustainable mining landscapes. Its mission is to make landform design routine in the mining industry worldwide by 2030.

A pit lake under development on the Eastern Slopes of the Alberta Rockies

Redefining perpetuity:
Challenges and benefits of pit lakes as fish habitat

by Jerry Vandenberg

When the word "perpetuity" arises in the context of mine reclamation, it usually implies eternal costs and liabilities, such as monitoring and management of human and ecological risks. While there is an inescapable element of permanence in mine reclamation, it need not be exclusively negative. What if long-term costs, liabilities, and risks can be offset by permanent benefits?

Pit lakes are either a liability or a benefit. A literature search for the term "pit lake" will produce multiple examples of acidic bodies of water. The ultimate symbol of a pit gone bad is the former copper mine near Butte, Montana, known as Berkeley Pit Lake. Drill down a little deeper, however, and examples of positive legacies will appear. One of the best ways to leave such a legacy is to reclaim the pit as fish habitat.

Broadly speaking, two types of fisheries have been created in pit lakes: recreational and commercial. Each poses unique challenges and offers several benefits.

Recreational fisheries are exemplified by the pit lakes on the eastern slopes of the Canadian Rockies, such as Silkstone and Lovett lakes. Each was created from former coal mines in the late 1980s, and they served as templates for some 20 more in the region. Through the design and development of these lakes, regional standards were set for lake dimensions, littoral zones, shoreline complexity, and habitat. The lakes now benefit recreational fishers and wildlife — in perpetuity.

Though commercial fisheries in pit lakes are less common, productive examples can be found worldwide. In West Virginia, both recreational fisheries and commercial aquacultural operations have been developed at former coal mines. Different geographies host a variety of fishes, from rainbow trout to channel catfish and largemouth bass. The introduction of commercial aquaculture resulted in a significant net reduction in closure costs while creating long-term regional employment.

Similarly, at a coal mine in Western Australia, treated mine waters feed a marron (crayfish) farm that has been turned over to local Aboriginal stewards, and runoff from the farm fertilizes a downstream pit lake to promote productivity. In Canada, the Niagara Escarpment is now home to a freshwater aquaculture operation in a former gravel quarry. Recently, a proposal was made to introduce land-based aquaculture to Canada that would have environmental benefits beyond the creation of jobs — specifically, reduced pressure on wild stocks.

Today, humans harvest salmon from one of two sources: wild ocean stocks or

Beginning with this issue, the Quarterly *will publish pairs of essays by LDI members exploring the nature of landform design. The Spring 2021 contributions will be written by members from Europe and Australia.*

penned Atlantic salmon farmed in estuaries and rivers. Each comes with negative environmental consequences, and the only debate is over which method is less harmful. By comparison, salmon raised in a mine pit (and byproducts from the farm) are isolated from the surrounding environment and wild stocks suffer no effects.

Converting a former mine pit into fish habitat is not without challenges. Pit lakes are a generally hostile territory for fish, with almost none of the productive littoral zones and nutrient-rich drainage required by self-sustaining aquatic ecosystems. Any endeavour is likely to require years of research. A good example can be found at British Columbia's Highland Valley Copper Mine, where biologist Heather Larratt and colleagues have been growing fish in small experimental pit lakes for 25 years with the goal of sustainable closure of the mine's larger pits. Their findings are directly applicable to mine closure, and the research has already revealed the importance of limitations in B vitamins when interactions between the water column and the sediments are restricted.

Environmental scientist Cherie McCullough, a pit lake expert with an academic and practical background in fisheries and aquaculture, has highlighted a few challenges with turning pit lakes into recreational or commercial fisheries. She points out that conditions in the pit lake must match the needs and tolerances of the fish. This means understanding the water chemistry, and possibly drawing on multiple methods to treat or control the chemistry if water quality poses bioaccumulation risks to food or does not meet the biological requirements of rearing. Palatability and, perhaps more importantly, the optics of using a former mine pit to raise fish destined for human consumption must also be taken into account.

Despite these challenges, case studies have shown that the benefits of returning pit lakes to service as fisheries can be perpetual. Whether those benefits offset the net liabilities will depend on site-specific constraints. But the benefits are worth considering when planning a mine closure project.

Landform design for pit lakes, and in particular beginning with the end in mind, can reduce costs, reduce risks, and increase acceptance and use. The Institute will be helping the global community to build on its end pit lake successes.

A professional chemist, Jerry Vandenberg is the principal of Vandenberg Water Science and a sessional instructor at the University of British Columbia in Canada.

Above: A kokanee salmon caught in the Highland Valley Copper Mine pit lake. Below: The Dusty Mac gold mine in British Columbia is now stocked with goldfish.

Land reclamation versus landform design:
Getting past language and labels

by M. Anne Naeth

Any discipline can be described with the appropriate terms. However, definitions are rarely universal and interpretations vary among and within practitioner circles and jurisdictions. Landform design and land reclamation are no exceptions.

Simply defined, land reclamation is the conversion of disturbed or damaged land to its former or other productive uses. Reclamation must encompass all disturbed components of an ecosystem, including, but not limited to, soils, hydrology, flora, and fauna. Land reclamation is an umbrella term that includes soil reclamation, revegetation, and contaminant remediation. It is what we do to clean up a mess that humans make, usually in the process of extracting natural resources. The term can also be applied to non-human disturbances, such as floods, landslides, and tornadoes, or when there is a transition of land use.

Numerous other terms are at least partially synonymous with reclamation, including renovation, rehabilitation, reconstruction, and recultivation. One commonly used term, ecological restoration, is defined as the process of assisting recovery and management of ecological integrity, and usually refers to a return to conditions prior to disturbance. Remediation refers to removal or reduction of a contaminant, unwanted element, or compound to acceptable levels. Revegetation refers to giving barren or denuded land a vegetated cover.

A tour of restored habitat in British Columbia.

Now consider landform design, which is an integrated and multidisciplinary process of construction of landforms and landscapes with a focus on achieving successful reclamation, most often in a mining context. Its main objectives are satisfying the needs and obtaining signoff from the mining company, regulators, and Indigenous and local communities, as they work together to manage costs and risks, minimize liabilities, and produce progressively reclaimed landscapes.

There are many more similarities between these two terms, including temporal, spatial, and procedural aspects. Both landform design and land reclamation, if done correctly, continue throughout planning, development, operations, progressive reclamation, closure, final reclamation stages, and afterwards. Both operate at regional, site, landscape, landform, element (patch), and microsite spatial scales.

The integration of all the disciplines involved in the processes, and what we ultimately achieve, will be judged at the landscape level.

Perhaps they can be better understood in terms of problems and solutions. The problem is the land has been altered in some undesirable way; it is disturbed. Such disturbances can undermine the carrying capacity of the land from both a wildlife and human perspective. The structure of the land can change, often in a major way. The solution is what you do about it: reclamation or landform design. Both have many roles to be filled by their practitioners, including economical, bio-physicochemical, technical, functional, and legal. The desired attributes in each case are multifaceted, and include esthetic, cultural, philosophical, and jurisdictional dimensions.

The history and development of landform design and land reclamation are similar. Earliest practices included filling the hole, making sure some type of vegetation was growing (greening), and then walking away. Current practices are more complex; now it's about biodiversity, sustainability, and resilience. Solutions must be technologically, economically, and culturally feasible, and must meet regulatory demands.

As an example, let's look at the first oil sands tailings pond in Canada, near Fort McMurray, Alberta. Landform designers developed a closure plan with a multidisciplinary approach. The

aim was to reclaim areas to be self-sustaining with equivalent capability to the pre-disturbance landscape, with end land uses for wildlife habitat, forestry, recreation, and traditional use. The design incorporated elements of the surrounding natural landscape including a shallow wetland, swales to collect surface runoff, and large hummocks and small surface features for drainage and topographic diversity.

Typical peat-mineral reclamation soils were enhanced, where needed, with an engineered cover to address acid rock drainage, naturally occurring radioactive materials, and potential bitumen migration to the reclaimed surface. All this came with a detailed landscape performance monitoring program.

Had this closure plan been developed by land reclamation practitioners it would not have been much different. They would have taken the big picture into account and worked with other experts to develop the engineered concepts around geotechnical stability and drainage. They would have talked about recontouring of the landscape, and focused more on soil properties and specific revegetation plans, perhaps incorporating other remediation methods for residual bitumen. But their vision and approach, and the outcome, would be similar.

Both landform design and land reclamation are about deep and broad integration across space, time, disciplines, communities, and financial ecosystems. The integration of all the disciplines involved in the processes, and what we ultimately achieve, will be judged at the landscape level. That is where we all come together, regardless of whether our business card refers to reclamation or landform design.

M. Anne Naeth is a Professor of Land Reclamation and Restoration Ecology at the University of Alberta in Canada.

Embracing online learning

by David Wylynko

Since the onset of the COVID-19 pandemic, instructors and students — including many LDI members — have had to adapt largely to online learning. Many benefits and drawbacks to this practice are emerging. The *Quarterly* asked two board members and a TAP member to reflect on their experiences.

Jerry Vandenberg, a lecturer at the University of British Columbia in Vancouver, Canada, was surprised to find that many students appreciate how online learning allows them to stay in their home communities, rather than live near the university and pay rent. The fact that many lectures are recorded also allows them to work during the day and attend class at night on their own time.

A big downside is that students can only watch labs on video rather than doing it in person. "Labs are irreplaceable. I cannot imagine how students will step into a position running instruments after only watching someone else do it."

For Anne Naeth, who runs graduate-level seminars, the biggest drawback in that she can't get to know the students well by video. But she also finds that video allows her to see each student close up, which wouldn't occur in in-person classes. "Based on their reactions, I might actually stop and go back or change the direction of the discussion."

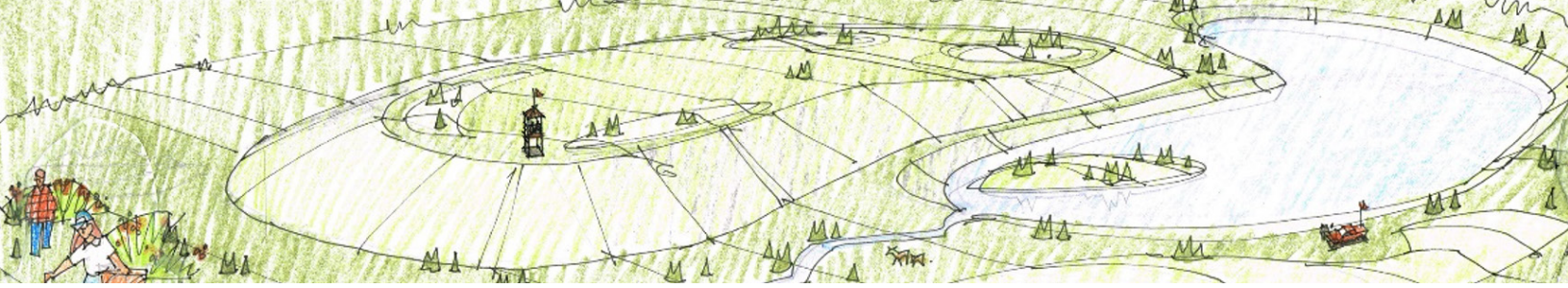
Naeth has noticed that the chat function becomes useful when a student is trying to get her attention or someone requires clarification, whereas during in-person classes students will be reluctant to interrupt.

Gord McKenna, LDI board chair, has been a guest lecturer several times since the spring at the University of British Columbia. He points out that the chat function can sometimes provide intriguing feedback that wouldn't happen in a silent room during a live lecture. "That is an ugly acid-rock drainage," one student wrote in reaction to a slide.

Another upside for McKenna is the shortened time commitment. You can log on, provide a lecture, and move immediately on to other work, rather than spending the better part of a day getting to and from the university and lecturing.

The Institute is looking forward to providing the best communications to its members in formats that work — online courses and webinars that will help those working and living in remote locations (which is the case for most mines), in-person courses at conferences, colleges, and universities that foster interpersonal relationships, and guidebooks and reference material made available in hard copy and on-line. The Institute is looking forward to working with members to learn what works best.

David Wylynko is LDI's Director of Communications and principal of the communications firm West Hawk Associates.



Three new members join Technical Advisory Panel

As 2020 drew to a close, the LDI was pleased to welcome three new members to the Technical Advisory Panel, bringing its number to 14 experts from Australia, Canada and the UK.

Jennifer McConnachie is a senior mine reclamation and closure specialist with Teck Resources Ltd. Jen was previously the Manager of Reclamation with the BC Ministry of Energy, Mines and Petroleum Resources and is a member of the BC Technical and Research Committee on Reclamation. She has close to 20 years of experience in mine reclamation in British Columbia, designing and implementing progressive reclamation and final closure at operations, developing and enforcing regulatory standards for all types and scales of mines in BC, and advocating for improvement of reclamation best practices. She holds a bachelor's degree in environmental science and geomorphology and a master's in environmental science from the University of Northern British Columbia.

Sean Shaw is an environmental geoscientist with 18 years of experience in the mining industry, including government, consulting, and academia. Throughout his career, Sean has focused on the characterization, quantification, modelling, and mitigation of mine wastes through all stages of mine life. He is currently the Director of Technical Operations, Major Mines Office, for the BC Ministry of Energy, Mines, and Low Carbon Innovation (EMLI). In this role he leads a team of geoscientists, geotechnical engineers and reclamation specialists responsible for the permitting and regulation of major mines in BC. Previously, he was a Senior Environmental Geoscientist with EMLI and before that worked as a consultant in the mining sector and a university researcher. He has a PhD in Aqueous Geochemistry from the University of Saskatchewan, an MSc from the University of New Brunswick and a BSc from the University of Guelph.

Steven Pearce is the technical director of Mine Environment Management Ltd. in Wales, UK. He is a principal level geo-environmental scientist with over 15 years of international experience in geo-environmental risk management. His areas of expertise include applied geochemistry, mine waste management, mine closure and rehabilitation, groundwater and human health quantitative risk assessment, and hydrogeology. Steven's professional experience has been predominantly in the sectors of mining, heavy industry, waste management and construction. Steven is currently supporting industry-lead research into the areas of carbon sequestration, optimization of mine waste planning, and the development of novel laboratory analysis techniques for mine waste characterization. He has a master's degree in environmental geoscience from the University of Birmingham, and is a fellow of the British Geological Society and an associate member of the UK-based Institute of Civil Engineers.

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CONTACTING THE LDI

5223 Laurel Dr.
Delta, BC, V4K 4S4
Canada
+1.604.838.6773
info@landformdesign.com

Web: landformdesign.com
Twitter: @LandformDesign