NATURAL PROCESSES: AN EFFECTIVE MODEL FOR MINE RECLAMATION

David Polster, M.Sc., R.P Bio.

Polster Environmental Services Ltd.
6015 Mary Street
Duncan, BC
V9L 2G5

ABSTRACT

Restoration programs based on the use of natural processes can reduce the costs of restoration while providing self-sustaining restored ecosystems that re-integrate with the local recovery trajectories. Natural processes have been restoring disturbance sites (Walker 2012) since the advent of terrestrial vegetation over 450 million years ago. By following how these processes operate these recovery processes can be harnessed for the reclamation of mining disturbances. The first step in developing a restoration program that uses natural processes is to identify the factors or filters that are preventing or constraining natural recovery. Polster (2009) listed eight filters that are common on many mine sites. Compaction, erosion and steep slopes are three of the most common filters at large mines. How do natural processes solve these problems? Using a model based on observation of these natural solutions to common problems, restoration systems for drastically disturbed sites can be developed. Flattening slopes and preparing the site using the rough and loose technique (Polster 2009) addresses these issues. Pioneering species such as willows, poplars and alder can be used to initiate the natural successional processes that will restore the site (Polster 1989). The addition of physical structures such as large woody debris and rock piles can aid in the return of the functions that were associated with these structures (e.g., habitat). The use of natural processes and the re-establishment of ecological functions associated with these processes can greatly benefit the recovery of degraded sites at little or no cost to industry. Examples are provided from the author's experience.

Key Words: Vegetation Succession, Natural Processes, Recovery, Restoration, Filters, Rough and Loose.

INTRODUCTION

The complexity of ecosystems makes it difficult to understand how they operate (Gonzales 2008). The study of this complexity on drastically disturbed sites such as mines and other major disturbances has only recently drawn the attention of scientists (Walker 2012). However, by looking at the ecology of naturally disturbed sites such as landslides (Walker and Shiels 2013) or talus slopes (Polster and Bell 1980) and the methods and conditions that natural systems use to establish vegetation on these sites, we can gain insights into how we can use these same processes to establish vegetation on sites we disturb. Restoration is defined by the Society for Ecological Restoration as the process of assisting the recovery of an ecosystem that has been degraded, damaged or destroyed (SERI 2004). In this paper I use the words reclamation and restoration interchangeably since reclamation seeks to re-establish productive, self-sustaining ecosystems on lands disturbed by mining. Effective reclamation therefore is ecological restoration. Public acceptance of large scars on the land caused by mining is waning. Providing effective restoration of mining disturbances is essential for the maintenance of social license.

Determining the factors that are preventing the recovery of the site is the first step in designing an effective restoration program for a disturbed mine site. The word 'filters' is used to describe the features that prevent recovery (Clewell and Aronson 2013). This term implies that the limiting factor will allow some species to occur but not others, much as a filter allows some things to pass but not others. The edge of a compacted roadway where only a few weedy species occur is an example. Compaction of the roadway coupled with lack of nutrients, possibly de-icing materials (salt and sand) from the road and the disturbance of road grading may all contribute to preventing non-weedy species from occurring. Filters can be abiotic (non-living) such as compaction and steep slopes, or biotic (living) such as weeds or a lack of propagules or excessive herbivory. The concept of ecological filters within the context of mine reclamation is described in greater detail below.

Natural systems have evolved a variety of ways of addressing the filters that prevent vegetation establishment. For instance, glacially compacted tills underlie many areas of Canada. These tills are as compacted as mine haul roads, and yet productive forests have established on them in the ten thousand years since glaciation. How does this happen? What can be done to mine haul roads so that it does not take ten thousand years for regrowth? Natural strategies for addressing filters are discussed further below.

The species that colonize disturbed sites provide functions and processes that assist the recovery of disturbed sites (Polster 1989). What are these functions and processes and how can we use them to assist in the recovery of sites disturbed by mining? These aspects of restoration of disturbed sites are discussed below.

FILTERS TO RECOVERY

Polster (2009) listed eight abiotic filters common in industry. **Steep slopes** are one of the most common filters on mine waste rock dumps. The continual movement of angle-of-repose (37^{o}) slope surfaces prevents the establishment of plant seedlings (Polster and Bell 1980). The lower portions of waste rock dump slopes and natural talus slopes are composed of coarse rock fragments with few fine textured materials to hold plant-available moisture and nutrients. The coarse rock at many mine sites creates an **adverse texture** filter. A lack of available plant nutrients is common at many industrial sites so **nutrient status** is another common filter. In some cases **adverse chemical properties** such as acid rock drainage or high salinity levels restrict the growth of plants. Dark substrates create **soil temperature extremes** that can limit plant growth. **Compaction, adverse micro-climatic conditions** and **excessive erosion** are other common filters at many sites.

Biotic filters can prevent recovery as well (Polster 2011). H**erbivory** (Green 1982), **competition** (Temperton et al. 2004), **propagule availability** (Temperton et al. 2004), **phytotoxic exudates** (GOERT 2011), **facilitation** and **species interactions** (Temperton et al. 2004) are all biotic filters. These filters may operate independently or they may combine with abiotic filters to create complex filters. For instance excessive erosion (abiotic filter) can be a problem on bare slopes. Seeding with an agronomic grass and legume cover has been the standard approach to deal with this problem. However, creating a dense stand of grasses and legumes can create habitat for small mammals (Green 1982) that then causes excessive herbivory and competition (Polster 2010). Care must be taken so that solving one problem does not create others. The following paragraphs present solutions to common filters that can be used at mines in British Columbia. These solutions are based on the strategies that are found in natural systems for addressing these filters. Solutions for mining problems can be found by observing how natural systems solve common filters.

STRATEGIES FOR ADDRESSING FILTERS

Steep, angle-of-repose rock slopes are composed of fine textured materials at the top of the slope grading into progressively coarser textured materials down the slope until the coarsest materials (often large boulders) are found at the bottom of the slope. These patterns occur on natural talus slopes (Polster and Bell 1980) as well as on mine waste dump slopes (Milligan 1978) and help explain why these slopes are inherently stable. Moisture that collects in the materials can freely drain out the bottom of the slope. How do natural systems address these problems? At the top of steep slopes the slope and fine textured materials results in erosion, moving the fine textured material down the slope. Plants colonize the fine textured substrates and eventually erosion is controlled. Although this is a slow process and one that is governed by chance events, there are a variety of soil bioengineering methods that can be used on steep slopes to address the slope / erosion issues (Polster 1999). These may be considered too expensive to use in a mining context; for example, the option of re-sloping large waste rock dumps can involve extensive machine time and be far more costly in the long run.

The coarse textured materials in the middle of a natural angle-of-repose slope are slowly revegetated by fine textured soils that wash from the slopes above through erosion or through the accumulation of organic matter that collects in the interstitial spaces between the rocks (Polster and Bell 1980). These natural processes are very slow. Soil bioengineering can be used to initiate (assist) the recovery processes on coarse textured substrates through a technique called pocket planting (Polster 2008). This treatment applies fine textured soils brought in to fill the voids between the rocks and create pockets of vegetation that then help the recovery processes on the remainder of the slope. The coarse materials at the bottom of the slope recover by the collection of organic material without contributions from above. Pocket planting can be used in coarse rock sites to expedite this process. Resloping waste rock dumps with heavy equipment moves the fine textured materials from the top of the slope down, covering the coarse materials lower on the slope. Wrap-around waste dumps can significantly reduce the costs of resloping (Milligan 1978).

Filters such as compaction, dark substrates, erosion and a lack of micro-sites can all be addressed through the use of a technique called ‘rough and loose’ (Polster 2011). Rough and loose surface configurations can be achieved by using a large excavator to open holes on the slope, dumping the material that is generated from the holes in mounds between the holes. The excavator, using a digging bucket (not clean-up), takes a large bucket full of soil and places it to the left of the hole that was just opened; half a bucket width from the hole so it is half in and half out of the hole. A second hole is then excavated half a bucket width to the right of the first hole. Material from this hole is then placed between the first and second holes. A third hole is now opened half a bucket width to the right of the second hole, with the excavated soil placed between the second and third holes. Care should be taken when excavating the holes to shatter the material between the holes as the hole is dug. The process of making holes and dumping soil is continued until the reasonable operating swing of the excavator is reached. The excavator then backs up the width of a hole and repeats this process, being sure to line up the holes in the new row with the space between the holes (mounds) on the previous row.

As the name implies, making sites rough and loose addresses compaction by breaking up the surface down to approximately one metre (depending on excavator size). This allows the soil to absorb moisture rather than flowing on the surface and therefore prevents erosion. North and south exposures are created so the dark substrates associated with coal mines can be ameliorated by planting on the north slopes. Conversely where cool temperatures limit plant growth such as in northern areas the south-facing slopes can be used. Roots freely penetrate the loose substrates allowing access to moisture and nutrients. Rough and loose substrates have an abundance of micro-sites where seeds can lodge and seedlings can grow. Rough and loose treatments can be applied to the upper covering on covers designed to control acid rock drainage or other adverse chemistry. The 'sponge' cover system (O'Kane et al. 2001) allows a forest to be developed on top of a cover that seals reactive wastes. Using the rough and loose treatment on this cover provides excellent growth of forest species thus enhancing transpiration and the effectiveness of the cover.

Poor nutrient status is a common filter, especially if mine wastes are compared to agricultural soils. However, when compared to natural substrates on disturbed sites such as might occur following a landslide or talus slope or on a river gravel bar, the nutrient status of mining wastes is equivalent. How do natural systems address nutrient deficiencies on these sites? Pioneering species colonize natural disturbances (Walker and del Moral 2003). Many of these such as alder are associated with nitrogen fixing organisms (Binkley et al 1982). Red Alder is the most common pioneering species in coastal British Columbia. Alder is often found colonizing forest landslides (Straker 1996) and is an important contributor to the nitrogen balance in forest ecosystems (Peterson et al 1996). Sitka Alder is an important species in Interior locations (Sanborn et al. 1997). In both cases, alder contributes nitrogen to the local recovering ecosystems. Other pioneering species such as Balsam Poplar have been implicated in the enhancement of nitrogen status of recovering ecosystems (Peterson et al. 1992). Lichens also fix nitrogen and contribute to the nitrogen status of forest ecosystems, especially in the north (Henriksson and Simu 1971).

Downed woody debris is an important source of nutrients in recovering forests. In addition, woody debris provides an important function in the control of erosion. Woody debris also provides habitat for a variety of plants and animals. Red Huckleberry, an important forest species in coastal British Columbia is often found growing on rotting logs and old stumps. Birds may play an important role in distributing this species as they perch on the debris. Similarly, woody debris forms important habitat for many small mammals, reptiles, amphibians and invertebrates. Including woody debris as piles and/or single pieces either standing or on the ground can contribute immensely to the creation of habitat and the cycling of nutrients on restoration sites. In addition, the cost of woody debris placement can be far less than the cost of chipping or burning.

Leaf litter is an important contributor to ecosystem health. The litter of Red Alder contributes substantial amounts of nitrogen to ecosystems where it occurs. Leaf litter can also protect bare soils from raindrop erosion. Leaf litter provides habitat for a variety of organisms important in the nutrient cycling processes of ecosystems. Leaf litter adds carbon to the soil providing an important carbon sequestration role. In some cases invertebrates need leaf litter to complete stages in their life cycles. There are opportunities to bring the spores and propagules of important soil organisms (e.g., mycorrhizal fungi) from forests to restoration sites by collecting leaf litter from the adjacent forest and scattering it on the restoration sites.

Establishing species that will provide structure for the developing ecosystem can expedite the recovery processes. The winter branches of Red Alder catch the spores of Swordferns as well as supporting the perching of frugivorous birds and soon the species they eat such as Salmonberry, start to show up in the understory (Polster 2010). Similarly, providing habitat for squirrels and chipmunks encourages the growth of mycorrhizal fungi as these small mammals collect the fruits of the fungi and cache them in various places in the forest. Understanding how these processes operate allows simple measures to be implemented during the restoration of the disturbed area that will build on the simple treatments that have been applied (e.g., making soils rough and loose, planting pioneering woody species and scattering woody debris). In some cases, supplying nest boxes for key species can bridge the gap between the open mining disturbance and when the pioneering species reach a level of maturity to provide the habitat.

Propagule availability can be an important element in ecosystem establishment. On large disturbed sites seeds of many species may not reach appropriate locations (Walker 2012). However, many pioneering species have developed effective means of distributing over large distances. The fluffy seeds of Balsam Poplar can be seen floating around at certain times in the spring. Similarly, the seeds of Sitka Alder can be found on the first winter snow in the fall. Although these seeds may travel long distances, in situations where parent plants are not available near the disturbed site or where the distances are too great, the lack of seeds of pioneering plants may be the limiting factor in the establishment of these species. Collection of the seeds of pioneering species and the application of these on disturbed sites can help overcome this filter. In some cases, animals can move the seeds of plants onto reclaimed areas. Providing perching sites or denning sites such as woody debris piles or rock piles can assist in this process.

Herbivory can be an important filter preventing recovery of some species. Small mammal (Green 1982) populations can explode under the cover of grasses and legumes that have been traditionally been used for reclamation. Similarly, populations of ungulates (deer and elk specifically) have responded positively to the extensive areas of grass and legume seeding at many mines. This has resulted in excessive herbivory and changes in the recovering ecosystems. Competition is another factor that can limit recovery. Careful study over sixteen years at the Island Copper Mine have identified that dense stands of seeded grasses and legumes can compete with planted woody species for moisture during periods of dry weather (Polster 2010). In some cases, seeded grass and legume species facilitate the establishment and growth of non-native weedy species (Polster 2010). This further complicates the establishment of productive, self-sustaining ecosystems as species such as Scotch Broom can inhibit tree growth by exuding a phytotoxic material. In some cases, specific species interactions such as between a plant and a pollinator can limit vegetation establishment. Wind pollinated pioneering species avoid this issue.

Incorporating biodiversity enhancements into the restoration of drastically disturbed sites can greatly improve the restoration work that is undertaken often at little or no cost. Resilience (Holling 1973) is built on redundancy. Providing a suite of nitrogen fixing species from trees and shrubs such as Red Alder and Sitka Alder to a diversity of shrub species including Soopolallie, Ceanothus and Wolf Willow (*Elaeagnus commutata*) as appropriate to the site being treated, that can all provide a similar ecological function, will ensure the restored site is prepared for future uncertainty. Similarly, the creation of rough and loose surface configurations ensures a level of topographic heterogeneity (Larkin et al. 2008) that will enhance diversity since it creates a variety of different habitats.

CONCLUSIONS

Natural recovery processes have been restoring disturbed ecosystems for millions of years. Following how these natural processes operate and the functions that various components provide can greatly enhance restoration operations and significantly reduce costs. Avoid spending money on seeding a cover of grasses and legumes that has been shown to limit recovery. Instead, seek to integrate natural processes into the restoration of disturbed sites and allow these natural processes to 'pay' for the recovery. Finding the filters that are preventing recovery is the initial step in providing a site that restores itself. In some cases, all that is needed is to create the appropriate surface conditions (e.g., rough and loose), add some woody debris and rocks as structure and apply some forest litter to re-establish nutrient cycling pathways. In other cases, planting of pioneering species will be required to provide the recovery functions associated with nitrogen fixation and the creation of ecological structure.

Social license is required to open new mines and effective reclamation of disturbances is essential to build and maintain social license. Expectations for the reclamation of new mines are significantly greater than in the past. The days of lakes being used as tailings disposal areas or that creek valleys could be used for the deposition of waste rock, exiting the rock drain as selenium contaminated stream, are past. Similarly, the thought that hyper-abundant ungulates wading in belly deep alfalfa can serve as a surrogate for biodiversity has been debunked (Martin et al. 2011). Restoring mining disturbances to enhance biodiversity is the future of mining. Natural processes and functions can provide that pathway.

REFERENCES

Binkley, D., K. Cormack Jr. and R.L. Fredriksen. 1982. Nitrogen accretion and availability in some snowbush ecosystems. Forest Science 28(4): 720-724.

Clewell, A.F. and J. Aronson. 2013. Ecological Restoration Principles, Values, and Structure of an Emerging Profession. Second edition. Island Press, Washington D.C. 303 pp.

Garry Oak Ecosystems Recovery Team (GOERT). 2011. Restoring British Columbia's Garry Oak Ecosystems: Principles and Practice. Garry Oak Ecosystems Recovery Team, Victoria, British Columbia. http://www.goert.ca/gardeners_restoration/restoration.php

Gonzales, E. 2008. The effects of herbivory, competition and disturbance on island meadows. Ph.D. thesis. University of British Columbia, Vancouver, British Columbia. 145 pp.

Green, J.E. 1982. Control of vegetation damage by small rodents on reclaimed land. IN: Proceedings of the 6th Annual British Columbia Mine Reclamation Symposium, Vernon, B.C., Technical and Research Committee on Reclamation, Ministry of Energy Mines and Petroleum Resources, and The Mining Association of British Columbia, Victoria, British Columbia.

Henriksson, E. and B. Simu. 1971. Nitrogen fixation by lichens. Oikos 22(1): 119-121.

Holling, C.S. 1973. Resilience and stability of ecological systems. Annu. Rev. Ecol. Syst. 4: 1-23.

Larkin, D.J., S.P. Madon, J.M. West and J.B. Zedler. 2008. Topographic heterogeneity influences fish use of an experimentally restored tidal marsh. Ecological Applications 18: 483-496.

Martin, T.G., P. Arcese and N. Scheerder. 2011. Browsing down our natural heritage: Deer impacts on vegetation structure and songbird populations across an island archipelago. Biological Conservation 144: 459-469.

Milligan, A.W. 1978. Waste Dumps – Design, contouring, and vegetation, Kaiser Resources Ltd. Operations. Paper presented at the 2nd Annual British Columbia Mine Reclamation Symposium. British Columbia Technical and Research Committee on Reclamation, Vernon, British Columbia. March 1-3, 1978.

O'Kane, M., S. Januszewski and G. Dirom. 2001. Waste rock cover system field trials at the Myra Falls Operations – A summary of three years of performance monitoring. IN: Proceedings of the 25th annual British Columbia Mine Reclamation Symposium. Campbell River, British Columbia, September 24th to 27th, 2001. Technical and Research Committee on Reclamation. B.C. Ministry of Energy, Mines and Petroleum Resources Victoria, British Columbia.

Peterson, E.B., G.R. Ahrens and N.M. Peterson. 1996. Red Alder Managers' Handbook for British Columbia. Canadian Forestry Services and BC Ministry of Forests, Victoria, British Columbia. FRDA II Report No. 240.

Peterson, E.B. and N.M. Peterson. 1992. Ecology, Management, and Use of Aspen and Balsam Poplar in the Prairie Provinces, Canada. Forestry Canada, Northwest Region, Northern Forestry Centre, Edmonton, Alberta. Special Report 1.

Polster, D.F. 1989. Successional reclamation in Western Canada: New light on an old subject. Paper presented at the Canadian Land Reclamation Association and American Society for Surface Mining and Reclamation Conference, Calgary, Alberta, August 27-31, 1989.

Polster, D.F. 2008. Soil Bioengineering for Land Restoration and Slope Stabilization. Course materials for training professional and technical staff. Polster Environmental Services Ltd., April 2008.

Polster, D.F. 2009. Natural processes: The Application of natural systems for the reclamation of drastically disturbed sites. Paper presented at the B.C. Technical and Research Committee on Reclamation, BC Mine Reclamation Symposium. Cranbrook, British Columbia, September 14-17, 2009.

Polster, D.F. 2010. Long term reclamation monitoring of vegetative covers at the Island Copper Mine, Port Hardy, B.C. Paper presented at the B.C. Technical and Research Committee on Reclamation, BC Mine Reclamation Symposium and the Canadian Land Reclamation Association Meeting, Courtenay, British Columbia, September 20-23, 2010.

Polster, D.F. 2011. Effective reclamation: Understanding the ecology of recovery. paper presented at the 2011 Mine Closure Conference and B.C. Technical and Research Committee on Reclamation, BC Mine Reclamation Symposium. Lake Louise, AB. September 18-21, 2011.

Polster, D.F. and M.A.M. Bell. 1980. Vegetation of talus slopes on the Liard Plateau, British Columbia. Phytocoenologia 8(1) 1-12.

Sanborn, P., R. Brockley and C. Preston. 1997. Ecological role of Sitka alder in a young lodgepole pine stand. Forest Research Note #PG-10. British Columbia Ministry of Forests, Prince George, British Columbia.

SERI. 2004. The SER Primer on Ecological Restoration. Version 2. October, 2004. Science and Policy Working Group. Society for Ecological Restoration International. Washington DC. Accessed March 25, 2012. http://www.ser.org/content/ecological_restoration_primer.asp

Straker, J. 1996. Regeneration on Natural Landslides. paper presented at the Coastal Forest Sites Rehabilitation Workshop. B.C. Forestry Continuing Studies Network. Nanaimo, B.C. October 31 - November 1, 1996.

Temperton, V.M., R.J. Hobbs, T. Nuttle and S. Halle (editors). 2004. Assembly Rules and Restoration Ecology. Island Press, Washington, D.C. 439 pp.

Walker, L.W. 2012. The Biology of Disturbed Habitats. Oxford University Press Inc. New York, NY. 319 pp.

Walker, L.W. and R. del Moral. 2003. Primary Succession and Ecosystem Rehabilitation. Cambridge University Press. Cambridge UK. 442 pp.

Walker, L.W. and A.B. Shiels. 2013. Landslide Ecology. Cambridge University Press. Cambridge UK. 300 pp.

Overcoming Northern Challenges

Proceedings of the 2013 Northern Latitudes Mining Reclamation Workshop and

38th Annual Meeting of the Canadian Land Reclamation Association

Whitehorse, Yukon September 9 – 12, 2013

CLRA | ACRSD
Canadian Land Reclamation Association
Association canadienne de réhabilitation des sites dégradés

Northern Latitudes Mining Reclamation Workshop

Table of Contents By Presentation Schedule

Wednesday:

Back To Tuesday

Eary, Russell, Johnson, Davidson and Harrington	Water Quality Modelling and Development of Receiving Environment Water Quality Objectives for the Closure Planning in the Keno Hill Silver District (paper not attached)
Knight	Galena Hill, Yukon, Ecosystem Mapping Project
Polster	Natural Processes: An Effective Model For Mine Reclamation
Dustin	Implementation of contaminated water management system upgrades to allow for dewatering of two open pits at the Vangorda Plateau, Faro Mine Complex, Yukon
Kempenaar, Marques and McClure	Tools for Arctic Revegetation: What's in Your Toolbox?
Smreciu, Gould, and Wood	Establishment of Native Boearl Plant Species On Reclaimed Oil Sands Mining Disturbances
Keefer	Twin Sisters Native Plant Nursery
Pedlar-Hobbs, Ludgate and Luchinski	Key Factors in Developing and Implementing a Successful Reclamation Plan
Chang, et.al	Effects of Soil Aggregates Sizes (paper not attached)
Heck	Phytoremediation of petroleum hydrocarbon impacted soils at a remote abandoned exploration wellsite in the Sahtu Region, Northwest Territories
Janin	Passive treatment of drainage waters: Promoting metals sorption to enhance metal removal efficiency
Stewart and Siciliano	Biological Soil Crusts and Native Species for Northern Mine Site Restoration
Nadeau and Huggard	Restoration Planning and Application of Ecological Succession Principals
Simpson	Defining Disturbance and Recovery - the influence of landscape specific ecological responses to oil and gas linear disturbances in Yukon

NORTHERN LATITUDES MINING RECLAMATION WORKSHOP

The Northern Latitudes Mining Reclamation Workshop is an international workshop on mining, land and urban reclamation and restoration methods. The objective of the workshop is to share information and experiences among governments, industry, consultants, Alaska Natives, northern First Nations and Inuit groups which undertake reclamation and restoration projects, or are involved in land management in the north or in comparable environments.

The first Workshop was held in Whitehorse, Yukon Territory, Canada in 2001 and it has been held every two years since, alternating between Canada and Alaska. The primary sponsors of the Workshop include the Yukon Geological Survey, Indian and Northern Affairs Canada, Natural Resources Canada, US Department of the Interior Bureau of Land Management, and the State of Alaska Department of Natural Resources.

CANADIAN LAND RECLAMATION ASSOCIATION

The CLRA/ACRSD is a non-profit organization incorporated in Canada with corresponding members throughout North America and other countries. The main objectives of CLRA/ACRSD are:

- To further knowledge and encourage investigation of problems and solutions in land reclamation.
- To provide opportunities for those interested in and concerned with land reclamation to meet and exchange information, ideas and experience.
- To incorporate the advances from research and practical experience into land reclamation planning and practice.
- To collect information relating to land reclamation and publish periodicals, books and leaflets which the Association may think desirable.
- To encourage education in the field of land reclamation.
- To provide awards for noteworthy achievements in the field of land reclamation.

ACKNOWLEDGEMENTS

The sponsoring organizations wish to acknowledge the work and support of all the people who made this conference a success, including:

- The Conference Organizing Committee: Alissa Sampson, Andrea Granger, Bill Price, David Polster, Diane Lister, Justin Ireys, Linda Jones, Mike Muller, Neil Salvin and Samantha Hudson.
- The Conference Papers and Posters Committee: Andy Etmanski, Bill Price, Chris Powter, David Polster, Diane Lister and Scott Davidson
- The Conference Sponsors (see next page)
- The Conference paper and poster presenters
- Dustin Rainey, Jocelyn Douheret and Brian Geddes for permission to use their photos on the Cover, Papers and Posters pages, respectively

CITATION

This report may be cited as:

Polster, D.F. and C.B. Powter (Compilers), 2013. Overcoming Northern Challenges. Proceedings of the 2013 Northern Latitudes Mining Reclamation Workshop and 38th Annual Meeting of the Canadian Land Reclamation Association. Whitehorse, Yukon September 9 – 12, 2013. 264 pp.