ALBERTA'S RECLAMATION RESEARCH PROGRAM[1]

by
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Abstract. Alberta was the first province in Canada with an environment department, the first to set up reclamation legislation, and the only province currently funding reclamation research. The key to our success lies in our cooperative approach with industry. Throughout the development, operating and reclamation phases, industry and government work together to ensure that all parties understand and accept the proposed activities and requirements. Where new reclamation approaches are being proposed, or where Alberta-based information is lacking, government and industry work together to collect appropriate data to allow for better decisions. The province established the Reclamation Research Technical Advisory Committee in 1978 to coordinate provincial government reclamation research and to fund and manage research where needed. Since that time, the program has produced over 60 technical reports to assist government, industry, and the public in making sound decisions.

Additional Keywords: Coal mining, oil sands mining, oil and gas.

Introduction

Sustainable economic development was defined in the 1987 National Task Force on Environment and Economy report as "development that ensures that the utilization of resources and the environment today does not damage prospects for their use by future generations". It is relatively easy to see how this concept can be applied to renewable resources such as forestry, where the soil surface is not drastically disturbed and the resource (trees) can be returned through reforestation. It is more difficult to understand how this concept can be applied to a "drastic" disturbance, such as a surface mine. One mechanism for achieving this is reclamation.

Alberta was the first province to develop regulations to ensure that disturbed lands are returned to productive uses. Indeed, the Land Surface Conservation and Reclamation Act, proclaimed in 1973, pre dates the National Task Force report by almost 15 years.

The Alberta Land Conservation and Reclamation Council is responsible for regulating surface disturbances in the province. The council consists of a chairman from Alberta Environment and two deputy chairmen from Alberta Forestry, Lands and Wildlife. The council oversees a reclamation research program, established in 1978, which identifies the most efficient methods for achieving acceptable reclamation in Alberta. Funding for the research program is provided by Alberta's Heritage Savings Trust Fund, Land Reclamation Program.

To assist with development and administration of the research program, the council appointed the inter-departmental Reclamation Research Technical Advisory Committee (RRTAC). The committee consists of 8 members representing the Alberta Government Departments of Agriculture, Energy, Forestry, Lands and Wildlife, and Environment, as well as the Alberta Research Council. RRTAC's mission is to coordinate and foster reclamation research in Alberta. Toward this end, the committee updates research priorities, reviews

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solicited and unsolicited research proposals, organizes workshops, and otherwise acts as the coordinating body for reclamation research in Alberta.

RRTAC conducts research in four major program areas, which correspond to Alberta's major industrial activities and biophysical regions: Plains Coal, where agricultural concerns are dominant; Mountains and Foothills Coal, where recreation, forestry, wildlife, and watershed concerns are the focus; Oil Sands, where wildlife and forestry concerns exist; and Oil and Gas, where agricultural and forestry concerns are examined. RRTAC also funds research under a general program which provides information of use to more than one program area.

The following sections outline the research approaches of each program. Projects within each program address one or more of the following objectives:

1. To develop methods that will ensure reclamation is an efficient and effective process.
2. To provide scientific data to enable sound decision making in the regulatory and operational reclamation stages.
3. To provide scientific data to evaluate the effectiveness of reclamation guidelines and criteria.

Plains Coal Reclamation Research Program

Coal mines operated in conjunction with electrical generating plants are the focus of this program. The Plains Coal Reclamation Research Program answers questions relating to reclamation of agricultural lands in plains coal mining zones. Reclamation in this context includes the traditional concerns about soil reconstruction and crop suitability, but we have also undertaken a great deal of work on the effects of mining and reclamation on groundwater.

By combining the results of soil reconstruction and groundwater studies, we can come to understand how mined landscapes function and how they can be designed to ensure a return to their original value. For example, if after mining, a saline water table reestablishes within a metre of the soil surface, the rootzone may become unsuitable for crops regardless of its original quality.

Five-year summary reports detailing the results of studies into how much subsoil is required over sodic spoil materials have been published. Sixteen reports on the Plains Hydrology and Reclamation Project have been published, including a summary report on this 10-year study.

More recently, the program has shifted its focus to evaluating the potential suitability of soil materials, located up to 14 m below the original soil surface, for use as subsoil. Materials buried this deep are usually considered to be spoil rather than subsoil. However, initial testing shows that they do not have any characteristics that would render them unfit for use as subsoils. The studies, to be conducted at a coal mine west of Edmonton, will compare these deeply buried materials with traditional subsoil materials in field scale plots. Laboratory testing of material chemistry, and water-holding and transmission characteristics will be completed this year. If the materials prove to be suitable, the company will be able to save substantially in materials-handling costs because they will not have to undertake traditional "subsoiling" operations; they will simply contour the "spoil" and replace topsoil.

The research program is jointly designed, managed, and funded by the provincial government and the coal industry. Alberta Power Limited, Edmonton Power, Fording Coal Ltd., Luscar Ltd., Manalta Coal Ltd., and TransAlta Utilities Corporation help construct research plots, while research and publication of the results are supported by the provincial government.

Mountains And Foothills Reclamation Research Program

Metallurgical and high-quality thermal coal mines are the subjects of research. The Coal Association of Canada, individual coal companies, and RRTAC work together in the jointly funded Mountains and Foothills Reclamation Research Program. The program's focus is on:

1. The creation of stable landscapes. This includes dump design (optimal slope, angles and lengths, and terracing) and pit backfilling.
2. Preservation of watershed integrity and water quality. Water flow and sediment control are of prime interest.
3. Reconstruction of a suitable growing medium. The goal is to make the best use of limited materials to improve the rootzone over rocky, nutrient-poor spoil.
4. Selection of suitable vegetation and proper planting techniques to ensure survival and growth. The goal is the creation of a self-sustaining cover that does not require long-term maintenance.

A major focus of the program has been the development of native grass species for use in the mountains and foothills. The work is conducted at the Alberta Environmental Centre in Vegreville. To date, the Centre has developed several suitable lines of *Poa alpina* and *Agropyron trachycaulum*, and is in the process of testing them at various locations in the mountains and on the plains with the goal of obtaining registration of the lines for use in reclamation. In 1989, RRTAC and the Centre began working jointly on a project to select suitable legumes for the region so that eventually a native seed mix of grasses and legumes could be made available for use.

Other studies have focused on: soil suitability for reclamation; return of wildlife habitat and suitable measures for success of the effort; methods for early prediction of tree growth; erosion from dump slopes; an evaluation of water quality regulations; and a review of sediment pond design models and alternatives to ponds.

Nine reports based on this program have been published. Future program plans include looking at suitable topsoil depths for growing trees and shrubs on both sloped and flat dumps.

Oil Sands Reclamation Research Program

The major disturbance is oil sand mining and extraction facilities. In order to pool resources and to avoid duplication of effort, RRTAC and industry initiated a joint research program in 1979. Priority research areas included propagation, establishment and management of woody plants, and soil reconstruction. In 1986, the program was expanded to include reclamation of tailings pond sludges. Syncrude Canada Ltd., and Suncor Inc., have been very active supporters of this program by providing research facilities and funds.

As in the mountains and foothills, proper reclamation in northeast Alberta will produce landform and plant community combinations which will fulfill their land use requirements without indefinite maintenance. The approach to revegetation is to identify the best woody species to plant in reclamation areas and to identify the best soil amendments for tailings sand.

We have recently completed a 5-year study at the Syncrude site evaluating the effects of various amounts of peat and clay on reconstructed soil quality and plant growth. Two depths of incorporation were tested. Ten species of trees and shrubs considered to be good revegetation candidates for the region were monitored for growth, reproduction, and insect and small mammal damage. A final report on the study will be available later this year.

Near the end of this study, Syncrude changed its materials-handling program. Rather than place the amendments on the tailings sand and then mixing them together, they have elected to place the original soil materials directly onto the sand and then plant trees and shrubs. However, the availability of these materials is restricted, so we are working with them to evaluate the potential for reducing the amount of replaced soil material while still ensuring a suitable growth medium. The study is looking at replacing 70 cm (their current approved level), 50 cm, and 30 cm of material rated "fair and better" (according to salinity, sodicity, and clay content), as well as 70 cm of "poor and better" material. Any of these options will provide the company with a much larger bank of available soil for replacement.

We recently completed a study that evaluated company data on native invasion of reclaimed tailings sand and overburden. The data clearly show the value of conserving the surface organic deposits (mostly peat) for native species regeneration. However, even with direct hauling of these materials to a site, there is still a requirement to undertake a revegetation program to ensure adequate plant establishment, especially for woody species.

Biological (plant species) and physical (slope, sand/sludge mixtures, and freeze/thaw cycles) methods for dewatering tailings pond sludge are also being investigated. The tailings sludge results from the extraction of oil from the sand. Following extraction, the tailings are slurried to large ponds where the sand settles out and is used to build the tailings dykes. The remaining materials settle very slowly, reaching a maximum density of approximately 30% solids. Rather than leaving this material in above ground tailings ponds, we are investigating ways to dry it out on land. By dewatering sludge, a material with considerably less volume and better engineering (trafficability) properties is created.

The studies initially focused on high water-use plant species that could be used to dewater the sludge. Two species, western dock and reed canary grass, were identified as being suitable. The next phase of the study involved in-field demonstrations of dewatering in large tanks and pits. At this time, it was discovered that sludge left over the winter and allowed to undergo a

freeze/thaw cycle dewatered from approximately 30% solids to 50% solids. The focus of the work then shifted to a combination of freeze/thaw and biological dewatering. Further demonstrations showed that this combination could dewater sludge enough to support movement by humans.

Current work is focusing on evaluating different methods of laying down the sludge to get maximum freezing, and identifying ways to remove the water expressed during thawing. More work is required to develop optimum planting methods for the two species on this material to get the final dewatering completed.

We have also: reviewed woody plant propagation, establishment and management methods; developed soil replacement strategies; and examined the potential value of inoculating tree and shrub species with mycorrhizae and N_2-fixing bacteria. Reports on these projects are available.

Oil And Gas Reclamation Research Program

Conventional oil and gas deposits are found in all three biophysical regions noted above, while heavy oil deposits are found in the northeast. Since these disturbance types create similar reclamation concerns (disposal of drilling wastes, compaction, soil handling at well sites and on pipelines, and residual herbicides) regardless of biophysical region, a separate program was developed to coordinate research. Industry representatives from Canada's major oil and gas associations assist in program management.

In 1985, RRTAC sponsored a two-day workshop on drilling-waste disposal in Alberta. As a result of this workshop, initial research focused on developing a manual that could be used by field staff to determine whether a drilling waste could be safely spread on a given soil. The manual was published in 1987 and recently went out of print. We decided to: revise it, based on field staff comments; incorporate new data; and add a computer program to help in the decision-making process.

The manual pointed to the need for detailed chemical characterization of sump fluids and solids before rational disposal decisions could be made. Thus, Phase II of the program concentrated on getting chemical data from drilling-waste types in various regions of the province. Drilling waste sumps from 3 regions of the province were sampled, and both the liquids and the solids were analyzed for a suite of chemicals. The wastes were from holes drilled with freshwater, NaCl, KCl, invert, and DAP muds.

Chemical variability, both vertically and horizontally, was examined and it was determined that the liquids varied most by depth, while the solids varied mostly by horizontal distribution. From this information, a detailed sump-sampling methodology was developed. The sump solids were also used in a greenhouse experiment to determine how much of the material could be added to a local soil and not significantly reduce plant growth. This was done to help determine potential landfarming rates of the various mud types. A report detailing the findings was published in 1989.

Arising from this study and the work of a government/industry committee looking at new guidelines for drilling-waste disposal, a much larger waste analysis was undertaken. Over 120 sumps were sampled throughout the province and a full chemical characterization was completed. In addition to the analyses undertaken in the first program, the wastes were screened for toxicity using trout and Microtox tests. The data from this study will be published late this year and will be used by the committee to help determine which parameters need to be analyzed to properly determine waste handling methods and to help set disposal limits. Industry's contribution to this study was $585,000, indicating the importance of the work to them.

The initial approach to the compaction problem was to determine which characteristics predispose a soil to compaction. The work was conducted at the Alberta Environmental Centre. This laboratory study looked at the effects of moisture content and soil structure on the forces needed to compact various soils.

Phase 2 set out to find the best field method for identifying and quantifying compaction. Several techniques were evaluated on well sites in northeastern Alberta. Staff at the Centre developed an inexpensive penetrometer for use in the field by government and industry personnel as a simple tool for evaluating relative compaction on and off well sites and other disturbed areas. The penetrometer was tested on 20 well sites. The data clearly showed that the problem is not simple; some well sites exhibited soils with much higher penetration resistance, while others had higher resistance off-site. However, the penetrometer was found to be helpful in quickly gaining a "feel" for the site, both horizontally and vertically. Results from these two studies are expected to be published later this year.

Phase 3 of the work was designed to determine the relationship between compaction level and plant growth. The study was set up to evaluate the effects of 2 soils, 3 levels of compaction, and 4 levels of topsoil on the growth of a compaction-sensitive species (barley). Plots were constructed by excavating the soil, compacting the subsoil to known densities, and replacing the appropriate topsoil depth. Measurements of soil strength and crop yield are taken each year and will eventually be used to help relate penetration resistance data to yield.

The knowledge gained from these studies will allow operators to avoid compaction wherever possible, and allow regulatory personnel to identify compacted areas.

The approach to the residual herbicide problem was to evaluate the effectiveness of activated carbon in binding the herbicide; thus rendering it unavailable to affect crops. The study found that a ratio of 200 parts activated charcoal to 1 part herbicide active ingredient was required to bind the herbicide. Factors such as time since incorporation of charcoal, soil organic matter content, and soil moisture were also found to be important in determining the effectiveness of the treatment. A report on this work was released in 1989.

There was considerable interest expressed in this study and we decided that a field study was needed to test the method. We need to refine the amounts of charcoal required, because of its high cost, and to examine other possible binding agents, such as manure and sawdust. However, before that study was undertaken, we felt that we needed a better handle on the extent of the problem. We also need to know if the problem is increasing or whether it is a concern only on old sites, and that herbicide application on newer sites is being better controlled. Results indicate that there are going to be a very large number of older well sites coming up for abandonment in the near future and many of these will have some form of soil sterilant problem to deal with. Although the companies are controlling herbicide use to a much greater extent than in the past, there will still be some sites with problems in the future. Therefore, we will be going ahead with the field study this year.

Soil handling on pipelines is an expensive process. The cost of this has to be balanced with the need for soil protection and conservation. The provincial government has identified several soil types which we feel require selective handling of the various soil layers in order to ensure that the replaced soil is capable of providing a suitable rootzone for plant growth. We call this procedure "three-lift" (topsoil, upper subsoil, lower subsoil or, in mining terms, topsoil, subsoil, and spoil) to distinguish it from "two-lift" (topsoil, subsoil). Industry feels that we have not effectively demonstrated the need for this extra soil handling and so a workshop was held to review the concerns of both parties and to set an agenda for resolving these concerns. The participants agreed that some soils warranted three-lift (or some other procedure), and that more effective criteria were required to determine which soils required three-lift. The workshop proceedings have been published.

We have undertaken a small project in southern Alberta to evaluate the effects of 2 topsoil stripping widths, 3 revegetation strategies (none, native mix, and crested wheatgrass), and grazing/no grazing on soil and range condition on a reclaimed pipeline. Three sites on different soils will eventually be set up and evaluated for 3 years.

There are times when a company cannot determine in advance when a pipeline will be required. In these cases, the company may need to collect soil information for materials-handling planning purposes in the winter. Regulatory agencies are somewhat sceptical of the data arising from these surveys and so we commissioned a consultant familiar with the methods used to: prepare a detailed review of the methods; identify situations where winter surveys are suitable or not suitable; and identify special sampling required to make up for the winter conditions. The report will be available this year.

General Program

The General Program has produced a number of reports on a wide variety of topics. We have held workshops on: native shrubs in reclamation, reconstruction of forest soils, coal ash, effects of coal mining on eastern slopes hydrology, and revegetation methods for mountains and foothills. We have also prepared 2 bibliographies and a detailed 1500 page international literature review, which is being used as a text book at the University of Alberta.

A major accomplishment of the program was the production of a manual of plant species suitability for reclamation. This manual has been used by revegetation specialists throughout the province. When it sold out in 1988, we decided to update, reformat, and reprint it. The second edition was published in 1989.

Current projects in this program include: a review of the effects of storage on topsoil quality; a review of the erosion-control products used in Alberta; an evaluation of the current handbook for determining land

capability as it applies to reclamation sites; a review of methods for analysis of physical properties of reclaimed soils and identification of those that may be worth future research; and development of a user guide for pit and quarry reclamation.

Cooperation

Research may be undertaken by government (RRTAC), by industry (individual companies or associations), or as a joint effort. RRTAC feels very strongly that the cooperative research approach is the best route to follow. Cooperation facilitates agreement on reclamation research priorities, ensures that research addresses real field concerns, avoids duplication of effort, and reduces costs for both parties. Most importantly, cooperative research ensures that both parties have a stake in the objectives and results, which translates into early implementation of changes in operations and planning.

RRTAC's most successful projects and programs have developed with the assistance of joint government and industry technical committees that help establish research objectives and methodologies, monitor progress, and review final reports. RRTAC benefits from the knowledge and expertise possessed by industry personnel, from access to research sites and data, and, in many cases, from research funds or field services. Industry benefits from the knowledge and expertise possessed by government personnel, from access to research funds, from having a voice in the objectives and directions of the research, and from site-specific research data. Given our success in the past, we will continue to pursue a policy of joint work with industry.

Coordination

One of RRTAC's main functions is the coordination of all provincial government reclamation research. To accomplish this, members of government departments most likely to be involved in reclamation research were appointed to RRTAC. The members are responsible for ensuring that their department's views and activities are brought forward, and for relaying research results and implications back to their senior staff. Since the initial appointments, other departments have undertaken reclamation research and RRTAC will be making efforts to include the needs of these departments in the future.

Coordination is critical to the success of RRTAC in meeting its mandate to provide up-to-date information on reclamation activities to government agencies and industry. The word "coordination" does not imply an intent to take over all research. Rather, the intent is that RRTAC would be aware of all research and act as a clearinghouse for information. RRTAC has the ability to offer advice on research design and on past experience with research contractors, and may also be able to provide research funding and management. Perhaps most importantly, RRTAC can let departments know if work has already been done, so that money and valuable time is not wasted.

RRTAC's mandate to coordinate reclamation research does not formally extend to industry or to educational institutions. However, the advantage of a central body with information on research activities from all sectors is undeniable. The more information RRTAC has available to pass on, the better the decisions reached by the recipients of the information.

For these reasons, RRTAC will continue to expand its interactions with the province's universities and technical colleges, companies, and industrial associations. While this will require additional time and effort on the part of all concerned, the results are expected to generate considerable benefits. We will also continue to provide reclamation information to the public through the RRTAC publication series.

Future Directions

In the spring of 1989, funding for RRTAC work was extended for another 5-year term. To determine the most important areas requiring research, RRTAC undertook a project to develop a questionnaire, distribute it to government and industry staff involved in reclamation, and to tabulate the results. Two-hundred and twenty-one questionnaires were sent out and 119 were returned. Respondents were asked to list their top 10 research needs and to identify where in the province this need was most apparent and the disturbance type to which the need applied. A list of research needs and disturbance types was supplied; however, the respondents could also add their own. The research needs were catalogued for each of the main RRTAC programs listed above and then assigned priorities based on the number of respondents identifying each need (frequency) and the average level of importance assigned to the topic by each respondent (priority). Research needs for other disturbance types not currently being addressed by RRTAC were also catalogued, and the information passed on to other agencies with an interest in these areas.

The greatest number of responses was obtained for the Oil and Gas program. Within this program, pipelines had the highest number of responses, followed by well sites. The Mountains and Foothills program had the second largest number of responses, followed by Oil Sands and Plains Coal, which were tied. Of the areas not currently under RRTAC programs, chemical disturbances and industrial sites were the most frequently mentioned.

Of particular note, and of some concern to RRTAC, were the number of people identifying issues that have been addressed, or are being addressed currently, in one form or another. Although each site has its own peculiarities and will, therefore, require special research, this indicates that RRTAC has a great deal of work to do in communicating what the program is doing and what we have done. There were a number of calls for more, and better, dissemination of research results. This will be a primary focus of the Committee in the coming years.

Another point brought out by the project was the large number of responses that could be placed in the broad category of policy and procedures. A number of respondents suggested the need for more, or better defined, guidelines and standard methods to be applied in the reclamation and evaluation of sites. Ecology of reclamation sites was another area of concern to a number of respondents.

The information from this study, plus information gathered from the members of RRTAC and the program committees, is being used to help recommend the future direction of reclamation research in Alberta.

Summary

RRTAC has proven to be very successful in providing information to both the government regulatory authorities and to industry. One of the reasons for this success has been the cooperation between government and industry in developing research goals and objectives, and in jointly managing the projects. Funding from industry, either directly in terms of contract dollars, or in terms of site construction costs, has greatly increased the scope and quality of the research undertaken.

Since its inception in 1978, RRTAC has produced over 60 reports and workshop proceedings on a wide variety of topics. The reports are available at a small cost from Publication Services, Queen's Printers, 11510 Kingsway Avenue, Edmonton, Alberta, Canada T5G 2Y5.

Through the work of RRTAC and the regulatory controls provided by the Land Surface Conservation and Reclamation Act, Alberta's non-renewable resources can be extracted in a manner that meets the goals of sustainable development.