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MEASURING SUCCESS IN LAND RECLAMATION - A JOINT GOVERNMENT AND INDUSTRY WORKSHOP NOVEMBER 8, 1984

ENERGY RESOURCES CONSERVATION BOARD BUILDING
640 - 5 AVENUE S.W.
CALGARY

JANUARY 1985

INDEX

W O R K S H O P

MEASURING SUCCESS IN LAND RECLAMATION

Land Conservation and Reclamation Council, Alberta Environment
Alberta Chapter, Canadian Land Reclamation Association

DATE: Thursday, November 8, 1984

TIME: 9:00 A.M. to 4:00 P.M.

PLACE: 11th Floor, Hearing Room
Energy Resources Conservation Building
640 - 5 Avenue S.W.
Calgary, Alberta

OBJECTIVES:

1) To define the concepts of land capability, productivity, and land use in reclamation and discuss their inter-relationships.

2) To discuss systems for measuring capability and productivity and the implications to reclamation planning and operations.

3) To strike a joint government/industry committee to develop a working paper for future discussion and resolution of the topic.

AGENDA:

9:00 Opening Remarks, Workshop Chairman - Phil Lulman

9:10 Concepts of Land Capability, Productivity, and Land Use and their Inter-relationships - Dr. Bill Schafer, Montana State University, Bozeman, Montana

10:00 Coffee

10:15 Translation of Productivity to Capability through the Research Program - Dr. Paul Ziemkiewicz, Chairman, Reclamation Research Technical Advisory Committee

10:45 Systems for Rating Land Capability and Productivity - Dr. Wayne Pettapiece, Soil Survey, Agriculture Canada

11:15 Implications of Capability to the Regulatory Process - Larry Brocke, Chairman, Development & Reclamation Review Committee

12:00 Lunch

1:30 Discussion Groups

3:00 Coffee

3:15 Reports from Discussion Group Chairmen

DELEGATES

ALBERTA AGRICULTURE

Leon Marciak
Alfred Birch

ALBERTA ENERGY AND NATURAL RESOURCES

Paul Ziemkiewicz

ALBERTA ENERGY RESOURCES CONSERVATION BOARD

Ivan Weleschuck
Khalid Jamil
Braham Prasad
Dave Henderson

ALBERTA ENVIRONMENT

John King
Craig Palmer
Ralph Dyer
Howard Slavinski
Chris Powter
Larry Brocke
Neil Chymko
Bruce Patterson
Stan Tracy
Tim Bossenberry

ALBERTA FOREST SERVICE

Jeff Bondy
John Benson

ALBERTA POWER

J.C. Gunn
Jivan Kayande

ALBERTA PUBLIC LANDS

L. Winnick
D. Lloyd

ALBERTA RESEARCH COUNCIL

Terry Macyk
Bob Fessenden

ALBERTA SOIL SURVEY

Wayne Pettapiece

BOW VALLEY INDUSTRIES

Gary Mott

BP CANADA

David F. Porter

CANADIAN SUPERIOR OIL

Ed Kustan
Lynn Graves

CANSTAR OIL SANDS LTD.

S.E. Stephansson

CANTERRA ENERGY

Dave McCoy

CARDINAL RIVER COALS

Gerry Acott

CHEVRON

R.L. Dryden
Clayton Rouse

CROWSNEST RESOURCES

Malcolm Ross

DOME PETROLEUM LTD.

Dennis Lang

EDMONTON POWER LTD.

Les Johnston

ESSO RESOURCES

Gord Lambert
Al Kennedy

FORDING COAL

Julia Fulford

GREGG RIVER RESOURCES

Marlin Murphy

GULF CANADA RESOURCES INC.

Lin Callow

HOME OIL

Jim Wursee

LUSCAR LTD.

Rick Ferster
Bob Logan
Ken Crane

MANALTA COAL LTD.

Karen Natsukoshi
Kevin Beingessener

MOBIL OIL CANADA LTD.

John T. MacKenzie

MONTANA STATE UNIVERSITY, BOZEMAN

Bill Schafer

NORTHWESTERN UTILITIES

Hugh Allen

NOVA

Jim Campbell
A.W. Fedkenheuer

OBED MOUNTAIN COAL

Eric Beresford
Tim Adamson

PANCANADIAN PETROLEUM LTD.

Stuart Lunn

SHELL CANADA

Doug Mead

SMOKY RIVER COAL

Dave Fawcett

SUNCOR INC.

Don Klym
Roy Wood

SYNCRUDE CANADA INC.

George Lesko
Don Thompson

TRANSALTA UTILITIES CORPORATION

John Railton
Phil Lulman

OPENING REMARKS

Phil Lulman

I would like to wish you all a very good morning and to express my appreciation, and that of all of us who have put this workshop on today, for coming and taking time out of your week.

The question we are faced with today is: How do we establish a system or systems for measuring success in reclamation? That is a challenge that has been going on for quite sometime for all of us, in one way or another. We have tried to apply some useful process and have either failed in part, or we have succeeded in part. But, we have never really all got together and talked about it and directed our attention to finally getting a system that we are comfortable with, we know that will work, and, at the same time, gives us a sure footing for all the work we do from the planning right through to the certification of our reclaimed land.

We are certainly looking forward to taking this process on beyond today. This is not the start and the finish. This is just the beginning, and we hope to be able to develop ways of continuing the discussion so that everybody has a chance to look at the problem and then formulate a response.

There has been an evolution of thought in this business but perhaps one of the major problems that we have all stumbled on is semantics - "what does a word mean"? We all know that we carry around some different images in our minds of what a word will mean and today we hope we can bring those images down to a single focus and instead of it being a blurred image it can be a sharp image. Of course, we have asked for the Chairmen of the working groups this afternoon to deal with this focusing process and then for you to respond to some questions that we have prepared in the meeting notes.

Let me very briefly explain the meeting notes in front of you for today. The top sheet is an agenda which is self-explanatory.

The next list of confirmed delegates, as of October 31, is not guaranteed to be true and complete. We will update the list after the meeting and circulate it to you all, so that you will at least know who was here. Then we have working groups and we will be splitting up into those after the lunchbreak. The Chairmen are the people at the top left of each list. So, to give you an example, Group One's Chairman is Terry Macyk.

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The next sheet on which there are a series of questions is intended to set the stage for discussions and I would emphasize that those questions are just there to stimulate some discussion - to prompt you in the discussion group this afternoon. The Chairmen of the working groups may use the questions as a way of directing the discussion.

The next 2 pages are questions that we would like you to answer personally and to give us those sheets either at the end of this session or if you have to, send it back to us from your work place, but we would prefer to collect them from you today if we could.

At the back of this package is material that, to most of you, is very familiar. It has names of soil groups, it has copies of maps of topography, it shows plans of soil replaced on reclaimed areas, and it talks about land use. Please don't feel that we are going to go through an examination here in detail. This, again, is provided to you all as a means of asking questions about the systems for measuring success in Reclamation and it will become, I think, clearer during the working groups that these maps and the attached printed material for land use will be of value to you as a working group. It all sounds like it's very open ended and that is exactly how it is intended to be, we want this to as open a dialogue as we can achieve with the one day available to us.

Finally, I would just like to welcome two very special guests we have here. Bill Shaffer from Bozeman, Montana, who has very generously given his time to talk to us about some of the experiences that are unique to the reclaimed areas in the U.S. Northwest. But the experiences are not unique to that area, and Bill will bring some very valuable insights on some of the pitfalls and some of the highlights. Again, I have asked him to speak to the subject and then it is open to the floor for discussion. I know he will more than welcome the opportunity to talk to you about any, and all, aspects of what has evolved in reclamation in the U.S. Northwest.

Wayne Pettapiece also has generously come and offered to talk to us about systems for measuring capability and inventories of land use and soils. I know Wayne will inject a most valuable aspect to this process in understanding the systems that are presently being used and some of the more conventional aspects of land management.

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I would like now to open the workshop. My function here, I hope, is to keep things running smoothly. If you have any questions or concerns, come and ask me. I would like John King, the Chairman of the Alberta Land Conservation and Reclamation Council, to say a few words about the background and the direction that we are going to take in this whole process.

Thank you again for coming.

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John King

Thank you, Phil.

As Phil did, I would certainly like to thank you for taking the time and effort to attend this workshop with us. It's an important one for everyone and we appreciate you being here.

Just a few brief comments, but I think they are important.

I am aware of the concern amongst some people that the disposition (inclination) to discuss 'capability' might infer there is a change in reclamation standards. I would like to give you as much assurance as I can that this is not the case. We don't see, and I certainly do not see, that there is any inferred change whatsoever in our standards because of discussing capability. I don't see any change at all, from yesterday to today, to tomorrow, along that line. So, I would like to give you that assurance and hopefully, by keeping that in mind, you will feel comfortable discussing 'capability' and 'productivity'.

I would take the point of view, and hopefully it would be right, that the discussion of 'capability' is simply the discussion on the method of how we are to measure whether or not we have reached that standard. Once again, we are not talking about the standard itself but the measurement of whether the standard has been achieved at the end of the day and, at that point, whether the certification can be given and the security refunded to the company.

If anybody has any better ideas, certainly feel free to bring them forward. We would like to hear about and discuss them and take them into account. It is not a closed issue at any point.

I Certainly hope that today's workshop will result in a good exchange of ideas and that everybody will feel comfortable in having had the opportunity, as Phil emphasized, to bring your points forward so when we leave here today, everything that you feel is important to you has been discussed.

Thank you very much.

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CONCEPTS OF LAND CAPABILITY, PRODUCTIVITY AND LAND USE AND THEIR INTER-RELATIONSHIPS

Dr. Bill Schafer
Montana State University
Bozeman, Montana

I would like, first of all, to thank the Alberta Environment people for paying my freight up here. I left about 4:30 this morning and I think someone in the audience must have tipped off Customs because they made us pull everything out of the airplane and take it into the building, but I'm really glad to be here.

I am Bill Schafer and I am with Montana State University. I have worked on and off in Land Reclamation Research as a soil scientist since about 1975. It might be interesting to some of you in the audience to know that land capability measurement is really not a very vital issue in the States. Maybe you are familiar with that fact. We just don't have that much discussion with regulatory people, or agency people, or industry people about this particular topic. Most of the concerns in reclamation are related to hydrology, particularly groundwater and, also, to vegetation success. So, they use reference areas to measure success of vegetation, so in a way they are looking at productivity but they are also very concerned about diversity of plant communities. So, the emphasis is very different and since my particular interest is in the area of capability, I enjoy meeting with you here today.

As I understand it, my responsibility will be to discuss, in a general way, the concepts of capability and productivity and, also, I would like to talk about potential because I think that is another concept that we need to discuss. I also have a few slides to go through later on as a case study.

I would hope that we can keep this an open discussion and if you have any questions, or comments to add, or disagreement, or agreement, or whatever, please feel free to share those comments.

I think, really, that the concepts of land capability, productivity, and potential (and I guess, the more I thought about them in preparation for this meeting, the less well I understand them because there is a lot of overlap and they don't fit together extremely well), but, they really all boil down, I think, to three different systems of looking at the same thing and answering the same question which is, what is the value of this particular piece of land? What is it worth, or what can it produce? So, I think it is just three different kinds of ways of looking at land value. I think, to maybe set the stage, I would like to develop a scenario of how we might use these different systems.

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Let's take the sojourn of a city person, who has no farming experience, who wanted to get into farming, got tired of the rat race and goes into farming. So, we might have this person talking to a rural appraiser, trying to buy some real estate and looks at several parcels of land. He asks well which is best, which is the best buy, or which is the best value. So the real estate person says, 'Well, here's a nice parcel of land. It's a section, 640 acres, and it produced 60 bushels of dry land wheat last year and the ten year county average is only 40 bushels. So, you see it is an excellent piece of ground'.

The guy says, 'Great, I'll buy it'. So he buys the property, he goes out and the next year he talks to his neighbours and finds out their traditional farming practices, the varieties of wheat, and the fertilizer. So, the next year he grows 20 bushels of wheat. He can't make his interest payments, he's about to lose his place, and he doesn't know what to do. The bank says 'Hire an Agricultural Consultant and he will tell you what to do'.

So, the Agricultural Consultant comes out and identifies several facts for him. First of all, he finds out his soil is outwash, glacial outwash. It is very sandy and has pretty low organic matter, somewhat acid pH. While the neighbours surrounding his place generally had glacial till, which is clay loam in texture, it turns out that that particular year was fairly dry, his neighbours had good stored soil water and he, of course, didn't because he had sandy soil and, as a result, he had lower yields while his neighbours had 40 bushels rather than the 20 that he got.

There was high rainfall the previous year so that he had lost most of his nitrogen from the profile and the fact that it was a wet year explained why he had pretty good yields, he had 60 bushels and so did his neighbours, better than the county average for the last ten years. The consultant decided that probably his property could yield potentially, with good management, about 80 percent as much as the neighbours' on a long term average. But, in order to achieve this he would have to have a higher nitrogen rate because he has less organic matter, he would have to add more nitrogen and probably would have to put some lime on because low pH was not real suitable for small grain production.

He was also having a wind erosion problem because it was so sandy, so in order to not have soil degradation problems, which yield really doesn't measure, and, in order to stop the soil degradation he would have to go to a 'no till' type of farming system which, because he didn't have the equipment, would cost more money and unless he did that, his productivity would probably go down hill.

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The consultant also said his land was very well suited for another crop, however, for potatoes. He would probably be able to grow seed potatoes and make three or four times as much money as he would make in small grains if he would put about $600,000 into the property in irrigation systems, and pumps, and storage, and all this kind of thing. I think this example does show some of the complexities of land capability evaluation.

Just to kind of finish this off, the next week this same person was offered three times as much money as what he paid for the property by a real estate developer because it was going to go into condominiums. So then the farmer starts to think, what am I going to do, and here is what he concluded. First of all, productivity, of course, is better under a better level of management, then it is under a poor level of management. He found out that, productivity, or yield, is a very tricky measurement to use because it is a function not only of the soil but also of the climate and the management so, when he was told that that property yielded 60 bushels it was a little bit misleading and he had to look at a long term average and he had to know the level of management, of course.

He also found out the productivity alone didn't really tell him very much about degradation because, although he could produce 50 or 60 bushels of wheat, he had this terrible wind erosion problem and 10 years down the line the soil would be gone, so it didn't tell him much about degradation. He found out that his capability for small grains was really just so-so. He had to apply some pretty special management to grow small grains, but his capability for potatoes was pretty high, but neither system really told him how much money he could make because the capability system told him he could grow grain, but he would have to put so much more money into it that he would probably be losing money in the process. The same way with potatoes, he could grow potatoes but only if he was to invest another $600,000, which was capital he didn't have. So, I think you begin to see some of the complexities of the real life examples in using any of these systems.

I guess the final thing is some land use choices, for example going into condominiums, are more profitable than others, and profitability is not determined solely by land characteristics. In this case, his closeness to a city, or to a recreational area, was more important. So, of course he sold the property and was no longer in farming, but that might give you some introduction and I think if you think about it during the day, help you see some of the drawbacks to certain systems and some of the advantages to others.

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Let's talk generically about these different measures of land value. First of all, productivity. The way they are used in the States for reclamation, is to use reference areas to measure production for several years on particular areas, on the reclaimed area and off the reclaimed area. The approach is based on the fact that productivity is a function of land characteristics, climate, and management. I don't think that I can stress enough how important management is.

I have worked with small grain producers in Montana for a number of years. We have identified that in most of the better grain growing areas of the State that the potential yield annually is around 50 to 60 bushels, but the county wide averages are more like 40, or 35 and the difference there is simply management. The varieties chosen, the tillage methods, the planting date, the nitrogen fertilizer, there are so many variables involved that management really is a strong determiner of land characteristics. But, when you do apply the appropriate level of management, we have done some studies looking at differences in soil properties, we find that, in fact, soil properties do affect potential yields and so there is a strong determiner there.

We found, for example, in a study of several hundred small grain producing soils in Montana that the most important soil property affecting yield was depth to lime, or depth to calcium carbonate and that influenced 40 percent of the difference in the yield on just that one property, and there were several other properties involved. Water holding capacity was another very, very important one. Those two factors alone explained about 60 percent of the difference in yields observed across the state.

To use a productivity approach, you would basically measure the performance, or yield, on the mined area and a reference area, for several years to filter out climatic effects and then make a comparison. The obvious advantage of productivity measurement is it provides a qualitative measure. It is very easy to make comparisons between mined and unmined land. It gives you an accurate comparison, you can see a real difference, and it is very easily understood. This will produce 40 bushels, this will 50 bushels, this is three tons, this is four tones, or whatever.

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Dissadvantages. First of all it is very costly. Cost depends on how rigorous you are, how many different land uses you evaluate, and how many years you run your trials, but it is costly. It takes a lot of time to get accurate comparisons, because data from one year can be very misleading, and I think 3 years would be an absolute minimum, and five years would be preferrable. It's very land use specific and as we saw in the earlier example, soils that may be good for one use, like small grain production, or for potatoes, may be poor for small grain production, or vice versa. So, it is very land use specific. It does not measure resource degradation. Yields can be maintained for a number of years, in the short term, even though there are degradation problems. It doesn't measure the economic impacts of offsite problems, like sedimentation, and it does not evaluate economic factors. It didn't tell that small grain producer that in order to grow that 50 bushels of wheat he'd have to spend half again more money than his neighbors who could grow 50 or 60 bushels of wheat, so it doesn't tell us about those differences.

We could go on and talk about the capability systems. The one that I am familiar with is the U.S.D.A. Land Classification System, which is very similar to the Canadian Land Inventory System, almost identical. I will talk a little bit about our system, there is one other class we have stuck in that makes it different, but the concept is the same. It's surprising when you read the definition of capability. It's the 'suitability of land for use without permanent damage' and I think if you look at the historical development of land capability classification it was developed by the S.C.S. in the States and it grew out of the concern of the wind erosion that became such a problem in the thirties. So, there is a strong bias towards resource conservation in that system, but as you begin to look, at least in the States, on how that system is used, it has slowly creeped from that point of looking at sustainability of yields and lack of resource degradation to where now it is used very strongly for estimating productivity, or potential, or yields. In fact, it is so strongly identified with estimating yield that it is now used for our definitions of prime farm land. Prime farm land is anything with land capability, Class 1 and 2 and so we now see it used very strongly for looking at productivity, or estimating productivity.

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I am sure you are familiar with how capability systems are used and each different one differs but basically it is qualitatively ranked soils into classes and subclasses and groups, based on critical levels of key soil and land properties, and climate properties. As a result, it's advantages are it is very inexpensive, rapid and easy to use, and it is repeatable. Since you are looking at soil properties you don't have to wait five years to measure yields, or production. Another advantage is that you can measure, in fact, you could even predict before mining occurs what the productivity would be, based on the mine plan. So, there are a lot of advantages to a capability system.

Ideally it applies over broad geographic areas for many land uses. When you look at the land capability classification system, it doesn't identify capability for a specific use. It talks generically about capability for agriculture, it could be range forage production, it could be pasture, or hay, or small grains, it doesn't really identify that. But, I say ideally, because I don't think it really holds true to that particular characteristic. Also, it evaluates degradation. A strong bias within that system addresses the resource conservation problems with production on those kinds of soils.

Disadvantages. I would have to say that it is not really as flexible as they say it is. For example, if you look at how the land capability classification system has been used for defining prime farm lands, if it was really a good estimator of productivity, or potential, they wouldn't have had to develop these other classes of important farm lands. They have prime farm lands, but they found out that, for example, soils on which trees were grown, which were very good for orchard production, weren't ever prime farm lands. They are often sloping and fairly high in rock fragment content, didn't have those kinds of characteristics you like to see in a soil for wheat production. So, they had to define a whole new set of characteristics for soils of state wide or local importance. I think they found out that it is not as flexible as they thought it was, and it really is much more land use specific than they thought. When you really get down to brass tacks, it was probably developed for corn production in the midwest, and that sort of fits okay for wheat production in the West, in the Great Plains, but it doesn't fit as well for specialty crops, and probably not as well for pasture and range.

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They also, if you look at soil survey reports, there is a land capability class, if it is irrigated and there is a class if it is dry land. Dry land irrigated production, the characteristics you would like, are very, very different, and so they have two separate rating systems for each. So really, it's not as broadly applicable as they would like us to believe. It really is pretty land use specific. It does not provide a quantitative measure of performance and so, as a result, it is harder to make comparisons between two different parcels of land, and it does not account for the interaction of yield and management very well.

That brings us to this last system, and it is one that isn't very well understood, but it is just looking at the potential. Now the U.S.D.A. is developing a system for rating soil potentials, called the Soil Potential Index System, and it tries to kind of combine some of the advantages of both productivity measurements and capability measurements. The basic approach is to measure yield, or performance level, let's say we're talking about agriculture. So, you measure yield, and you measure it in terms of dollars per acre of income. Then you measure the cost of treatments, or management that you have had to apply to attain that level of yield and then, also, subtract out the cost of continuing limitations. So, it could be the cost of erosion from that land as a result of producing that yield. There will be real social cost associated with that, or it could be any number of continuing limitations. Maybe if it is irrigated and there is some erosion and you have to clean out your ditches every so often, that is a continuing cost, continuing limitation. So, it is a very strongly economically biased system and it should give us a pretty good index of what the net return would be to a farmer using that land. So, it is the kind of system that the farmer in our first example, would have liked to have seen, because it would have given him some idea of how his land would return money to him compared to other soils in the area.

Now, there are obviously some difficulties with that system. I guess the advantages, first of all, it gives a quantitative measure of net value of the land. It gives an accurate comparison of performance, and the comparisons are relatively easy. The soil potential index, they will choose the highest yielding soils in a particular geographic area and rank them as 100. Then soils that yield less than that, would have a ranking of say 80, or 60, or 40, or whatever, so it is a quantitative measure.

Disadvantages, there are no standard methods that are readily available for collecting the kind of data you need to look at soil potential index. It would be very, very costly. It would be very location specific. They suggest not going broader than a county wide area for applying the system. So, there are some real problems, very limited geographic applicability.

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I guess, as a summary, in the last page of this handout, I've got kind of a table comparing the different measures of land value, productivity, capability, and potential and I ranked them in terms of their difficulty, their reliability, how land use specific they are, whether they are quantitative or not, whether they predict degradation, and whether they would be suitable for mined land. You may, or may not, agree with some of the conclusions I have here, but it might be something just to look at. I think, when you go across that table, there is really no clear cut choice as to which is best. Maybe there is another system that's out there that is waiting for us to look at, I don't know. Let's hope not, it's already complicated enough.

They each have their own advantages and disadvantages, and I think the more we know about the systems, and the better we understand them, the better users of these systems we can be. I guess maybe one approach to use in the future would be to look at how they interact. At least in the States, there's been very little research that's been done on comparing productivity to capability and I think that you are far ahead of us in that regard. With that kind of verification of a capability system that has been verified by looking at productivity I think that might, perhaps, be a very good way to go.

I think that is probably enough just to get us started thinking about some of these concepts. I do have some slides I could show, we did a study of five major mines in the Northern Great Plains where we ranked soils into land capability classes, I might go through that, but lets have some time for discussion.

John Railton, TransAlta Utilities. I have two questions. One, it's apparent from what you said that you have been applying it to agricultural systems but we have more uses than just agriculture uses, that we have to look at and therefore, I would like you to comment on the applicability of this system to these uses. The other question is that I once read an article that said that 70 percent of productivity is related to the precipitation which falls in an area. So, we are dealing with 30 percent of the variability and when we are dealing with biological data we are lucky if we can be 80 percent accurate. How do you resolve that kind of a dilema?

Bill Schafer. I guess the first question was how do you apply it to other uses. The soil potential index system can be readily applied to other uses. That is one of the reasons it was developed by U.S.D.A. I think it's only been used in about three counties, or one use in each county, so it doesn't have much of a track record but, ideally, you can measure yield, or performance in terms of net return in dollars per acre. So, yield could be in so many dollars per acre. Say $3.00 per bushel for 40 bushels of wheat would be $120.00 gross return for wheat production. If it was used for a housing development, we could hire some economists somewhere that could tell us what the dollar value of that would be on an annualized basis. Obviously, there are some real measurement problems with that approach but, conceptually, one could do it and then also subtract out the cost of treatments. Let's say you where going to build a housing development on a particular kind of soil, you are comparing two soils, let's say one had a high content of smectite - type clay, that would shrink and swell and the other one didn't. In order to build on the one that had high clay content, you would have to build a pad type of foundation which is going to cost more money. Let's say $2,000 per home and if there are four homes per acre, that's $8,000.00 of additional cost you would have to go to, to be able to build on that soil and have the houses perform as well as they did on this soil. In other words, so they wouldn't fall down. So, that would be a cost of treating that soil. So, I guess if you could buy the land for $8,000.00 an acre less, with everything else being the same, then it would be equal potential. So that would be the basic concept to use in the Soil Potential Index.

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Capability. Unless you developed an entirely different system, I don't think that it would apply very well to non-agriculture uses. As I discussed, I think when you read what has been written about Land Capability Classification, or the Canadian Land Inventory System, it states that it's fairly broad in it's selection of land use, but it really is not. I think it's oriented strongly towards field, or row crops. For example, where I live in Bozeman, they would rank pretty low in land capability class, but they produce 60 to 70 bushels of wheat year in, year out. It's extremely deep, well-drained soils that are silt loam in texture and they're loess-derived. These soils are tremendous for agriculture that's why they built the town there, so they could take it out of production. They are lousy for roads and highways, and lousy for foundations because they have such high hydraulic conductivity that during the winter when all the moisture comes up to the surface, and then it freezes and thaws about every night and the roads fall apart, and so do the foundations. So, that particular soil is excellent for small grain production, very poor for residential development. Out where our airport is located, there's a huge gravel bar and it's just the opposite. So, really I don't think the land capability class system, unless you redid the criteria would work very well for other uses, and that's about our only choices.

Jeff Bondy, Alberta Forest Service. How would the Americans approach the productivity or capability in regards to the Forest resource in Montana and in other states?

Bill Schafer. Yes, I am not very familiar with it. The question was how do American's select the woodland suitability? They don't use land capability classification for that at all. The S.C.S. for their county soil survey program has developed a woodland site index, and I am not very familiar with it's use. The forest service has several different methods of looking at site index. So, they are just totally different systems, using different criteria.

John Railton, TransAlta Utilities. I once read that 70 percent of productivity is due to the precipitation input and, therefore, we are concerned, in soil parameters, with 30 percent variability, however, when we are measuring biological phenomenon, we are lucky if we are 80 percent accurate. How do we resolve the dilema and is it worth being concerned unduly with the measurement of soil parameters, and other parameters, if you are only dealing with 10 to 20 percent of the variability?

Bill Schafer. I guess, I agree with you that productivity is a function of soil, climate, and management and the way I preceive us measuring productivity is by measuring productivity we want to get at differences of land characteristics, we want to qualify those differences. So, what we do is we'll put out field trials on two reference areas, one that's mined and one that isn't. Then we would measure it over a number of years and since we are geographically in the same area, we are measuring those under the same climate, for five years. So, productivity is a function of those three factors. We have held management the same, and we are measuring it over the same time period, and we know our climate is the same, so those two factors will not influence productivity and that only leaves land characteristics to influence yield. So, by designing our experiments in that way then really 100 percent of the variability could be attributed to land characteristics. So, it's all in the way we set up our experiments then, that productivity will give us some index. It is a real problem, I know. S.C.S., and it often gets critized because they will go out and they will just talk to landowners and say what are your yields and then they will develop a county wide yield average for each particular soil. There is no consideration of management in that and as a result their yield estimates are not always reliable. So, as long as we design our experiments to hold those other two factors constant, then we really are measuring differences in land characteristics.

John Railton, TransAlta Utilities. What do you say to the farmer who, at the public meeting says, ah, but if you go a half section down the road, here, I'll tell you the grain is not the same down there as it is over here. Would you say it averages out?

Bill Schafer. It does happen. You will get rain tracks that go through, and you will get six inches of rain out of it in one place and nothing out of it in the other place. But, there is always that perception that it is different at the home place and I don't know how you get around it. We challenge farmers to put out rain gauges.

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Tim Adamson, Obed Mountion Coal. Storie took every ground, every single parameter of the soil you could imagine and tried to relate it to the productivity of the soil and he came up with a fist full of comparisons, but statistically after he had compared all of them, he could reduce them to about four major criteria: rooting depth, texture, slope and a miscellaneous one. After listening to you talk about all the systems you mentioned and the problems associated with them, what do you think about the Storie Index?

Bill Schafer. Yes, I went to school for my Masters Degree at the University of California, Davis, and the story was that Californians developed that system for California, and it's still used in California and not very widely throughout the rest of the world because it is more difficult to use. But, it's another system of looking at capability and I think it has a lot of advantages. I didn't want to get into specific systems, but certainly that would be another possible method to use and it's more quantitative. That is one advantage it has over land capability classes, it is more quantitative.

Again, that 100 would be the best soil for a particular area and then poorer soils would have ranking somewhat lesser than 100. But, certainly it has merit as a potential system to use.

Tim Adamson, Obed Mountain Coal. Could I ask if you think that the mining commission would develop something like that Storie Index for the kind of soils.

Bill Schafer. I think if there was enough yield or performance data available you certainly could develop that kind of system. I personally like the Storie index system better than the land capability classification, but it is not used very widely, nor is it well understood, so I stayed away from it in my research. But, we did a multiple area study where we looked at, as I mentioned earlier, wheat production, and the factors that were the most important were water holding capacity, depth to lime, we have a lot of soils with lime at the surface which have low phosphorus availability so that cuts down on yield, and it was actually correlated with consistence in the "C" horizon, but it integrated several factors relating to soil profile development and leaching. So, those are the three factors that controlled most of the differences in the yield. We find the same thing, yes.

Rick Ferster, Luscar. I'll backtrack a little bit, just so this might help us out this afternoon. I am beginning to understand that whether we talk about potential productivity or capability it's always towards a specific end land use, so we have to identify tnat land use or field crop, or whatever it may be, before we decide on one system to measure it, is that correct?

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Bill Schafer. That is my bias. Now, I don't think that's a concept that's universally held, that's one of the issues today, but my bias is that that's basically true. That unless you decide upon a land use or evaluate for a particular use, then you really can't make a very reliable estimate of capability.

Rick Ferster, Luscar. And the second part is, you are saying that we can't make a reliable estimate of capability unless we revise the approach. So, if you were to revise the approach then that means it would be applicable as a standard measurement.

Bill Schafer. I think there are some systems available for relating to agricultural uses. I think if you were going into woodland uses, or some other kind of built-up urban, or residential use, you would have to develop different practices.

I think that since we are short on time, I'll probably skip these slides. Don't skip the slides? Okay, I'll go ahead and use some more time then.

George Lesko, from Syncrude. When you reclaim the soil or finish the reclamation of the mined out land, you start off with a rooting zone and depending on what kind of material you have, you start up a soil development process, and the process usually improves the soil characteristics. You build up a structure, build up the internal drainage, and build up the organic material content to improve water holding and exchange capacity, etc. How are they going to take into account this potential development and soil improvement in the system.

Bill Schafer. That is a good question. We don't take it into account. There is a little bit of a bias in the land capability classification system put out by U.S.D.A. to not look at those properties that are easily changed by management. They explicitly avoid looking at organic matter content as a measure of capability, and I will talk about this in the slides, so I will just mention it briefly here. They don't look at soil structure and those kinds of things because tillage, or management can change those and as a result we tend to avoid those kinds of properties that are going to change rapidly during the initial stages of soil development. But, what we don't take into account is the fact that sodium could move upwards from a subsoil layer into the topsoil and salts could also do the same thing and those kinds of changes are, perhaps in our area, and some areas of the States, pyrite could oxidize and cause the pH to drop over a period of several years. We don't take those things into account and it's a real concern. We need to be aware of those kinds of processes and what impact they could have on capability.

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Perhaps I'll just go through these slides, and if you have any questions as we go through, please stop me.

Following is the narrative to a slide set.

Mining for the attractive looking coal reserves in the Northern Great Plains has lead to an increasing concern about capability in the States, not as much concern as we see here in Canada, but still some concern and the primary land uses in, let's say, Eastern Montana, Wyoming, and Western North Dakota, is for range forage production with a limited amount of dry land, small grain production.

Soils in the area date from the last major glaciation and they vary in terms of development. I won't encumber you with the soil taxonomic names, because we have a different system, but they vary pretty much as a result of differences in topography. We will see some comparisons, and take a look at the capability of some of the natural soils later on in the slides.

The purpose of the study that I am discussing today was to look at the land capability of soils, both on and off the mined areas. As we've discussed, the Land Capability Classifications System is based upon soil and landscape factors for placing soils into one of several classes. Classes 1 and 2 in our system are considered prime farm lands, but because of our severe climate, we essentially don't have any of this kind of land unless it's irrigated.

Class 3 land would represent our best dry land grain producing soils with fairly flat topography.

Class 4 soils are what we call marginal for cultivated crop production, and I would say this is pretty marginal. Erosion becomes more of a problem, and there is some serious potential for resource degradation with Class 4 soils.

Class 5 soils which is a class you don't have in the Canadian Land Inventory, are basically wet lands, soils that are flooded frequently, that have poor drainage, or swampy ground, or whatever, so this would be Class 5.

Class 6 would be soils that are not suitable for cultivated crops, but that could support substained grazing uses.

Class 7 lands would be some of the poorer example of these range soils, maybe some of the steeper slopes, or shallower soils, and here we go with Class 8 land. There isn't much you can do with it.

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We looked at 5 different mine areas in the Great Plains, Western North Dakota, three in Montana, and one in Wyoming, and we ranked the capability of soils before and after mining.

We prepared soil maps of the same parcel of land based on pre-mined soil surveys, then we went back into the mining area after reclamation, did a soil survey, and then looked at capability.

I'll just run through a brief summary at the Apex Mine in Gilette, Wyoming. We have a comparison at the top of unmined land, and what the land capability class was, in terms of relative percentages for a randomly selected parcel. It was a little bit of Class 3 land, about 20 percent was Class 4, the majority of it was Class 6 and there was quite a bit of Class 7, because of some problems with salinity. Then after mining we saw, surprisingly, an increase, or an improvement in land capability class. There was nearly 40 percent Class 4 lands, 50 some percent Class 6 and just a little bit of Class 7.

At the Decker Mine in southwestern Montana we found a similar relationship. Almost all of it was Class 6 before mining, and after mining we saw an improvement until the majority of it was Class 4.

The Western Energy Mine at Colstrip, which has been researched to death, as far as I can see, we found there that in the unmined landscape soils were a little bit better. There was a fair amount of Class 3 and 4 land. It had not been broken out into small grain production, it was still in range forage, and about 15 percent was Class 6. No chemical problems. The primary determinor of capability, was relief.

After mining there was 70 percent Class 3 and 4 land and I would guess that most farmers can probably make some money farming that particular piece of ground in the Western Energy Mine.

This is also at the Western Energy Mines. It's some reclamation that pre-dates our reclamation laws of '73, and it's sort of a mess. We found again, before mining, a similar suite of unmined soils, of land classes, but, after mining there was a decrease in capability, and about 45 percent of it was Class 7, and only 30 percent was Class 4, or better.

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Then we went out to North Dakota where they have some prime farm lands, because of higher precipitation, and we found that 60 percent of the soils were Class 2 and then there was a smattering of other classes. But, then after mining, again, we had a decrease in capability. We were only going to get about 34 percent Class 4 or better. There was quite a bit of Class 6 land because of some sodium problems.

In summary, looking at the 5 mines as a composite, we found a slight improvement in capability on the average. We weren't able to regenerate those prime farmland soils. The methods that were used just couldn't re-establish the same capability, but a real favorable response in terms of capability. We concluded that, on the mines where there was an improvement in capability, it was because of an increase in the root zone depth. This soil is a paralithic contact of soft sandstone and ten inches deep. That was pretty common in some of these areas. So, we improved, or increased, the root zone depth and we decreased the composite slopes for the mined areas. Those were the two main ingredients that caused us to improve the capability.

At the mines where we saw a decrease in capability it was because of, number one, a sodium problem. At Decker, and largely at Glen Harold, we had a problem wih sodium moving upward into the topsoil layers which caused a degradation in soil properties and reduced capability. Erosion was a primary problem at the Western Energy Pit 6 area, which decreased capability.

As we stepped back from this study we said, we seem to have looked at lots and lots of studies where there has been a comparison of yield before and after mining with the same level of inputs, and, quite frequently, if you are looking at grain production, or corn production, or whatever, you can't quite attain the same yields on mined land as you can on unmined land. Yet, our capability system said we were better off than we were before mining. So, we said can we really sustain yields like this on mined land, or is there something in that land capability classification system that we are just not picking up. We felt as if this was partially our problem, because the land capability system does not look at properties which are likely to change as a result of short term management, like organic matter content, pore continuity, internal drainage, soil structure. We know all these things are very important to nutrient cycling and air and water movement in the profile, yet we are not really measuring them with our land capability classification system, nor do we know a good way to measure them. As a result, we probably are missing some of these factors that are hard to measure, but yet they do influence yield. So, perhaps that is one drawback, or shortcoming, of the system.

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The other thing that concerned us was this specificity of land use. We felt as if we had done a good job of portraying how dry land fields, or dry land cultivated crops, or forage would respond on these soils, but we didn't feel as if it had pointed out to us how irrigated production would do, or how well suited the land was for wildlife production. I know, for you hunters in the crowd, if you are hunting deer, you always find them in Class 7 and 8 land and, perhaps, if wildlife is an important end use for reclaimed land then we need to develop a system that looks specifically at suitability for these kinds of uses.

Leon Marciak, Alberta Agriculture. I was wondering if you have done any work, or have any comments on inter-capability class comparisons? Do you have direction for that?

Bill Schafer. Well I guess that is easy to answer, we haven't worked on it, no. But, I think that certainly would be the appropriate direction to go, and, also, to be able to, esstentially, verify the capability system by looking at yield, or performance, and I think that is a real needed step. If we are going to be using capability, we need to do some varification.

Phil Lulman. I wonder if you could just describe a little of what you see happening in the future for you and measuring reclamation success. What's in the cards for you?

Bill Schafer. Actually, not very much. I think the way the regulatory groups are working right now, there is an implicit assumption that, if the mining company does what they say they will do in their mining plans, they will take material, put it back in the same slopes, and in the same place, and put as much topsoil back as they say they will, it is going to be fine. So, there is very little emphasis on actually measuring capability of soils. The strong emphasis right now is in measuring reference areas, measuring the success of re-vegetation, and it is almost entirely grown back into a bit of grasses and forbs and some shrubs. So, we are looking very strongly at that and productivity is only one part of what they are interested in. They are interested in diversity and meeting the native species requirements, and these sorts of things, so in the short term horizon I don't see much increasing emphasis down south looking at productivity. Maybe they will sometime in the future, but I don't see it.

Rick Ferster, Luscar. Just to continue on with whay you were saying, if they put back the soil where they sav they are going to, and slope the wav they say they are going to, when it comes back for certification what's the point in measuring if they have done all those things? What else can they do?

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Bill Schafer. I guess there are a lot of ways of looking at that. I guess one reason for measuring soils after reclamation would be to find out if there are these kinds of problems with upward sodium movement, with salinization problems, and these kind of things. I guess I could think of examples where you had appropriate kinds of materials to use in reclamation, but if you put them together in the wrong way, or if you use, lets say, scrapers out there for redepositing your soils and it was wet, you could create a compacted zone and even though your materials were of appropriate physical and chemical quality, because of the way you handled it during reclamation you could create a very severe problem. I have seen that pretty frequently, if scrapers have been used.

There are lots of specific kinds of problems that could develop so I think it is important to look at capability and I think it's an oversight that we are not looking at it more carefully. I think we are picking up some of that by looking at these reference areas and determining production. But, I think a direct assessment of soils would be appropriate, it is appropriate.

John Railton, TransAlta. Are you saying then that you should first off determine the land use and then take the appropriate capability system and see whether the capability required for that land use is met?

Bill Schafer. Yes, that would be my bias.

Tim Adamson, Obed Mountain Coal. What are some of the weaknesses, some inherent characteristics in the soil of salinization, like pH does change. Could you give us an idea how long you think we should be looking at the soils to come to some useful assessment of land capability?

Bill Schafer. I guess my feeling is that you probably can pretty well guess where you are going to have problems with sodium, or salts, or acids, if you are looking at sulphur content, and so that before you ever are done replacing soil you would know what to look for, you would know what you are concerned about, and if you have a concern about salinization or sodification, it seems to me that five to seven years is about how long it takes to reach it's equilibium. If you know that you are going to have those problems, you are looking at that kind of a time frame. If you don't have those sorts of problems, then I would think a couple of years for compacted zones to breakup and water movement to sort of reach some kind of equilibruim then one or two years would be a more appropriate sort of time span to fully begin to look at capability.

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Marlin Murphy, Gregg River Resources. Could you enlighten us a little bit on the reference areas. Are they held for the length of the mining project or until reclamation is complete and are they on the mine site itself, or off the mine site?

Bill Schafer. They are both. They select reference areas and selected plant communities off the mined area and they begin to monitor those as mining begins and they will continue to monitor them clear through mining. As they develop some reclamation with plant communities then they will develop and establish reference areas within the mined area which they have to, I think, run a comparison for at least five to ten years, depending on the bonding period and ten years would be the longest. But, I think most of the mines are bonded for ten years so they have to have a ten year comparison, both on and off the mine site, before they will release the bond. Our bond release is the same as certification.

John Railton, TransAlta Utilities. What process do they go through when they are looking at these wildland communities? They are taking more and more care in determining the requirements of the individual species, so, therefore, they must be obligated to look at what species am I going to plant in this area, which determines the type of wildland habitat. How do they reconcile that?

Bill Schafer. I don't know if there is a fixed way in which they decided upon plant communities and species. It is more interaction between the mining companies and regulatory staff. I think it's a proposal that the mining companies will put together in their permit and reclamation plan which is either approved, or denied, or modified by the regulatory people. I guess, I don't know the exact process that they always go through. There is a little bit done in terms of assessing the needs, then they'll have public meetings and those kind of things. That is pretty minimal, so I guess you might say it is up to the whims of the regulatory agency as to what they are looking for at the end. In fact, it changes from year to year, what they would like to have.

Rick Ferster, Luscar. Referring to reference areas. It is my understanding that reference areas are off the mine site and mined lands are compared with the reference areas for 5 to 10 year segments. Once you have your first track of land certified, is the bond period (5 to 10 years) reduced or do they just keep on moving the reference areas as mining proceeds?

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Bill Schafer. I don't know for sure, but I think they just keep it at ten years. Each parcel is handled separately and it is all ten years, so each separate parcel will be ten years. We are just getting to the point now where people are just starting to get bond release and so it is obviously a re-evaluation of that.

Steph Stephansson, Canstar Oil Sands. You mentioned diversity, what degrees of diversity are acceptable?

Bill Schafer. That is beyond my field. I really can't tell you that. I don't know what measures of diversity they use, they have to have predominently native species, unless they have some kind of an exception to that rule, but I don't know what measure of diversity they use.

Phil Lulman. Our next speaker is Paul Ziemkiewicz and I think he's probaby well known to all of you. Paul is very much front and centre in the whole Reclamation Research end of the business and he is going to enlighten us on putting the productivity and capability aspects together.

LAND CAPABILITY WORKSHOP
November 8, 1984

Sponsors:

Land Conservation and Reclamation Council
Alberta Environment
Canadian Land Reclamation Association

Speaker:

Bill Schafer
Soil Scientist
Montana State University

OUTLINE:

1. Techniques to assess land value
   A. Productivity
   B. Capability
   C. Potential

2. Example application of three measures of value

3. PRODUCTIVITY

4. POTENTIAL

5. CAPABILITY

6. DEFINING A LAND USE

7. APPLICATION OF THE USDA-LCC
   For assessing mined land productivity (slide set)

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DEFINITION OF CONCEPTS

PRODUCTIVITY (REFERENCE AREA)

Approach: Productivity is a function of land, climate, and management. To evaluate mined land, measure performance for specified land uses for several years under identical management on mined land as well as on selected natural reference areas.

Advantages
- provides quantitative measure
- accurate comparison of performance
- easily understood

Disadvantages
- costly
- land use specific
- does not measure resource degradation
- does not evaluate economic factors

CAPABILITY (USDA-LCCS, CLI)

Approach: Qualitatively ranks soils into classes, based on critical levels of key soil and climate factors.

Advantages
- inexpensive, rapid, repeatable
- ideally applies over broad geographic area for many land uses
- evaluates degradation

Disadvantages
- not really land use flexible
- mined land soils do not fit well
- does not provide quantitative measure of performance
- does not account for yield/mgt

POTENTIAL

Approach: Measure performance of soils in specific area, and evaluate cost of treatments (management) to attain that level of performance, as well as cost of continuing limitations. Rank soils quantitatively in relation to net value.

Advantages
- quantitative measure of net value
- accurate comparison of performance
- comparisons easy

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Disadvantages
- no standard methods
- costly
- land use specific
- limited geographic applicability

Measure of land value	Difficulty/ expense	Reliability	L.U. specific	Quantitative	Predicts degradation	Suitable for mined land
PRODUCTIVITY	moderate	moderate	high	yes	no	good
CAPABILITY	low	low	low	no	yes	poor
POTENTIAL	high	high	high	yes	yes	good

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TRANSLATION OF PRODUCTIVITY TO CAPABILITY THROUGH THE RECLAMATION RESEARCH PROGRAM

P.F. Ziemkiewicz, Chairman
Reclamation Research Technical Advisory Committee

INTRODUCTION

While listening to Bill Schafer's Presentation it occurred to me that Canadians and Americans approach land classification from very different perspectives. In Canada, land classification as applied to reclamation follows our tradional emphasis on soils and landscape. Canadian land classification is applied, literally, to the entire country often before settlement and land use occur. Vegetation cover is used for mapping purposes but always the principal parameters of interest are soil and landscape. In the western United States, land classification in the Canadian sense is not applied. Rather, the key parameters of interest in reclamation planning are vegetation oriented and generally classify land according to its rangeland capability. These parameters usually include: species composition, yield, and aerial cover. This fundamental difference affects the contexts in which much of our land use terminology is applied.

The Canadian approach to land classification and its application to the reclamation planning and certification process will be implicit in my presentation. But I will focus upon the application of soil criteria in meeting provincial reclamation objectives.

PROVINCIAL OBJECTIVES

The reclamation goal in Alberta is to build landscapes which will be as useful to man as in the premining state. This involves landscaping, soil reconstruction and revegetation. My objective to-day is to outline a method for evaluating which soil reconstruction strategies will meet Provincial objectives. The Provincial approach to soil reconstruction includes:

1. Identification of premining soil resources
2. Development of soil salvage and replacement plan
3. Implementation
4. Certification

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Soil reconstruction is one of the major items when evaluating reclamation certification. The soil survey and implementation components of soil reconstruction are straight-forward and follow accepted methodologies. The difficult part involves development of the soil reconstruction plan. This is where premining soil conditions are matched to reconstructed soil profiles. If the original soils and overburdens could be removed and replaced without disturbance there would be no problem. However, a certain amount of mixing will occur as soil horizons are removed and replaced and even the spoil behaves differently from unmined bedrock. In short, reconstructed topsoils and subsoils will be different from their unmined predecessors. Therefore development of the soil reconstruction plan faces the problem of equating the reconstructed soil with the premining soil. Since the factor to be equated in this case is "usefulness to man" we must ultimately focus on the reconstructed soils capability to grow useful plants. At the planning stage this information would eliminate much of the uncertainty over whether a particular reconstructed soil would meet the reclamation objectives. Predictive power is particularly important in soil reconstruction since:

1. Moving unnecessary volumes or types of soil is expensive and wasteful.
2. It is nearly impossible to adequately upgrade poorly reconstructed soils.
3. Defining the relationship between soil reconstruction technique and crop productivity will allow us to measure capability in terms of soil reconstruction technique (e.g. quantities and qualities of salvaged and replaced soil materials).

To summarize, in order for the planning process to be effective, relationships must be defined between soil reconstruction strategies and crop productivity. My presentation will outline our methods and progress toward identifying these relationships.

THE RESEARCH PROGRAM

The Problem

The plains coal seams are usually overlain by bedrocks which contain a high proportion of swelling clays. When exposed to the elements the bedrock shales and sandstones break down into a material that is sticky when wet and very hard when dry. This severely hinders plant growth and agricultural operations. Above the bedrock lie glacial deposits which are usually free of the most adverse properties of the bedrock though they lack the plant nutrients and organic matter characteristic of the overlying topsoil.

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Rebuilding a soil profile is one of the major problems in cropland reclamation in Alberta. A soil must be built on levelled overburden which will be as productive as the original soil. Existing evidence indicates that placing topsoil and a buffering material over the spoil is the most efficient method for achieving this goal (Figure 1). However, we do not know how much capping material is needed. Also, where topsoils or subsoils are in short supply, other amendments may be useful in soil building. In addition to soil reconstruction, certain agricultural practices like green manuring and legume cropping may help rebuild the soil.

In many plains areas the coal seams are the major source of domestic water. What will happen when the coal is removed and overburden fills the mined-out pit? The behavior of the post-mining groundwater system will affect water users and could influence future agricultural potential. However, prior to the Reclamation Research Program, little was known about the effects of surface mining on groundwater in Alberta.

Mining on Agricultural Land

Cropland is surface mined in two major zones in Alberta: The Ardley Zone running southeast from Mayerthorpe to Red Deer and the Horseshoe Canyon Zone which runs parallel and to the east from Barrhead through Camrose to Drumheller. The Ardley Zone is surface mined near Lake Wabamun to provide coal to the Wabamun and Sundance power plants. Two additional power plants, Keephills and Genesee are presently under construction and will extend mining southward to the town of Genesee. The Horseshoe Canyon Zone is mined on either side of the Battle River between Forestburg and Halkirk. These mines supply the Battle River Generating Station. Another power plant and mine are being developed to the south at Sheerness (Figure 2).

Approach

Mining in the Ardley and Horseshoe Canyon Coal Zones involves two different sets of soils, overburden and climate. Also, soil reconstruction and groundwater cannot be studied in isolation. For example, if after mining a saline watertable re-establishes within a foot of the soil surface the topsoil, regardless of it's original quality, will quickly become unsuitable for crops. So in both the Ardley and Horseshoe Canyon Zones we are identifying the best methods of reconstructing soils and at the same time we are studying what happens to the groundwater after mining.

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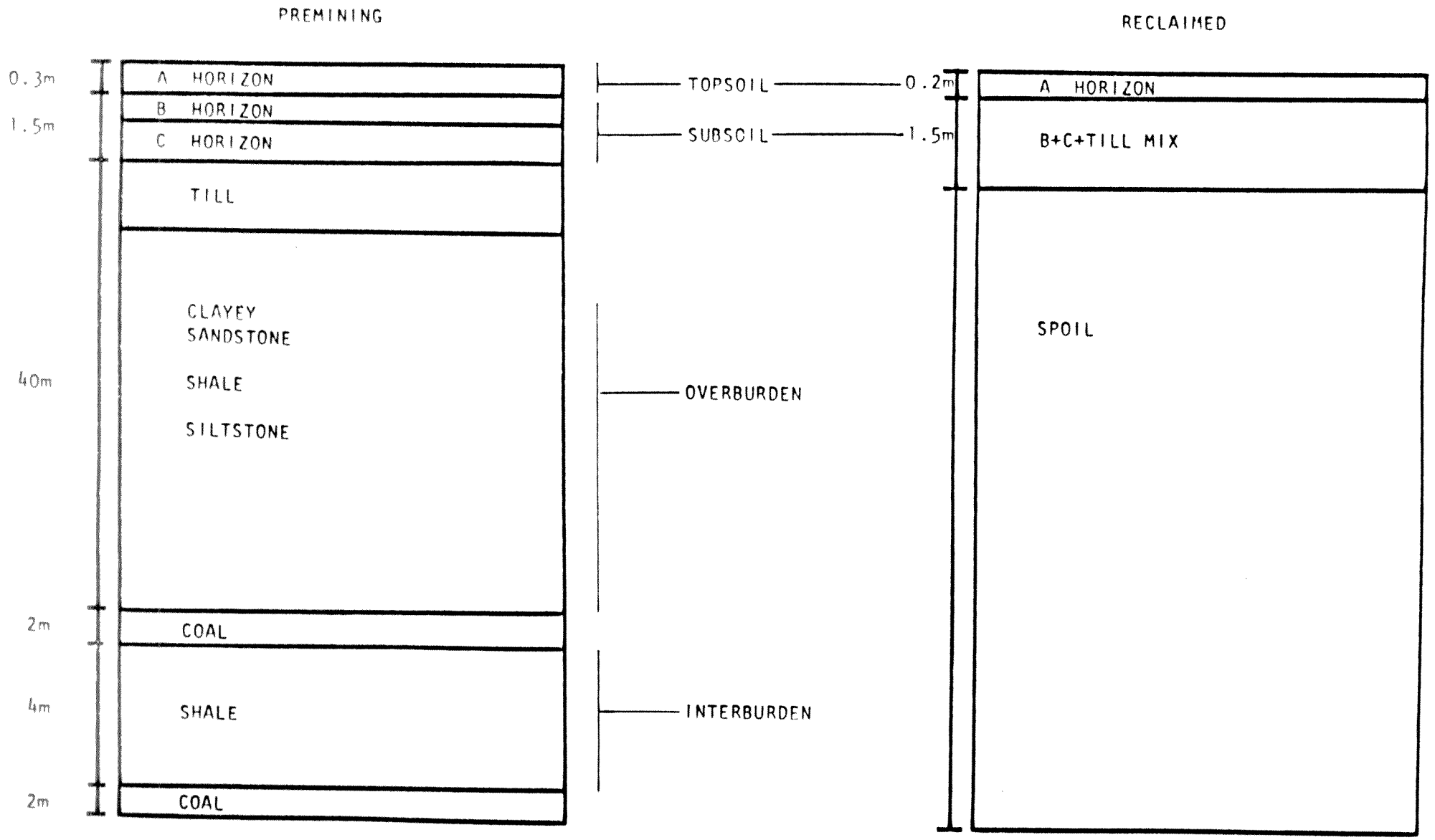
FIGURE 1 — GENERALIZED PROFILES



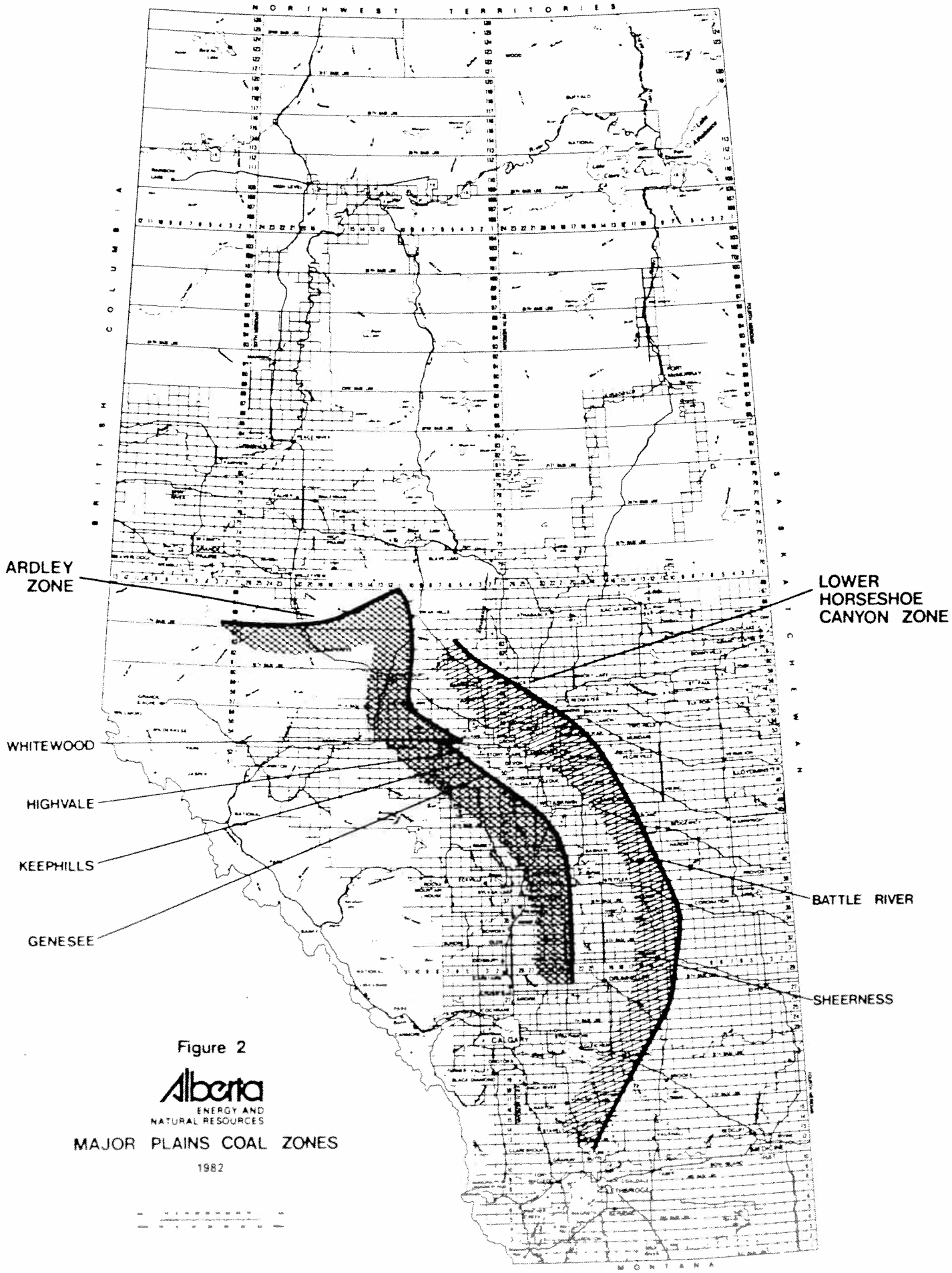


Figure 2

Alberta
ENERGY AND NATURAL RESOURCES

MAJOR PLAINS COAL ZONES

1982

A) RECLAMATION OF COAL MINED LAND

Plains Coal Reclamation Research Program

The Plains Coal Reclamation Research Program (PCRRP) has been designed by the Provincial Government and members of the Coal Industry to answer questions relating to groundwater and soil reconstruction in both of our Plains Coal Mining Zones. Two main projects have been established:

1) The Plains Soil Reconstruction Project will tell us how to rebuild agricultural soils after mining and

2) The Plains Hydrology and Reclamation Project will describe what happens to groundwater during mining and after reclamation and how to rebuild the landscape to maximize the agricultural potential.

By combining the results of these experiments we will develop a picture of how mined landscapes work and how they can be designed to ensure the return of their original values.

These projects are installed both at the Highvale and Battle River mining areas. Both are designed for five years of intensive study with the possibility for further monitoring beyond that period. I will discuss only the Soil Reconstruction Project today.

The program has been jointly designed and managed by Provincial Government and Coal Industry personnel. The projects are also funded by both Industry and Government. For example, Alberta Power Ltd., Luscar Ltd., Manalta Coal Ltd. and TransAlta Utilities Ltd. constructed the Test Plots at Battle River and Highvale while research and maintenance activities for the Soil Reconstruction and Hydrology Programs are supported by the Government from the Heritage Savings Trust Fund.

1. Battle River Soil Reconstruction Project (82-5-LES)
   L.A. Leskiw, Pedology Consultants Ltd.

2. Highvale Soil Reconstruction Project (82-13-SCH)
   L.A. Panek, Montreal Engineering Co. Ltd.

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Grain and forage yields are being evaluated on a series of soil reconstruction plots at the Battle River and Highvale Mining Areas. Treatments include: depth of subsoil (0 to 3 m thicknesses) over sodic spoil, use of bottom ash as an impediment to upward salt migration, use of coal ash and gypsum as soil amendments and reconstruction of solonetzic topsoils using different horizons and mixtures. Lateral salt migration through reconstructed soils over spoil slopes is also being studied. The project began in 1979 at Battle River and construction was completed at Highvale in 1982 (Figures 3 and 4).

Status: Cropping and Soil Sampling began at Battle River in 1982 and we now have two crop years of data. The first crop was grown at Highvale in 1983. Each site will be studied intensively for at least five years.

RESULTS

The following histograms indicate 1983 yield data from the Battle River and Highvale soil reconstruction plots. Three of the experiments from Battle River are presented: Subsoil Depth, Bottom Ash and Torlea. The two former experiments have both small grain and forage treatments while the latter is planted to forage only. 1983 was the first crop year at Highvale so only grain yields are shown. The treatment yields are compared with 5 year average yields within the same County (1975-1979). Yields within Canadian Land Inventory classes are indicated on each histogram with standard deviations of the mean and sample size (A). The local crop data was suggested and provided by Leon Marciak of Alberta Agriculture.

At Battle River, grain yields were consistently far below County averages and showed no treatment effects (in either the subsoil depth or the bottom ash experiments. 1983 was a drought year in eastern Alberta and this may have overcome the treatment effects. Many local farmers in 1983 had better grain yields nonetheless. Forage yields in the Subsoil Depth, Bottom Ash and Torlea experiments were nearly double those of local solonetzic soils even at the lowest treatment levels and equal to the best local soils with mid-range treatment levels. Bottom Ash incorporation in the reconstructed soil had a very strong positive effect on yields. This was only the second crop year at Battle River and at least five years of results are required before reliable conclusions can be drawn (Figures 5, 6 and 7).

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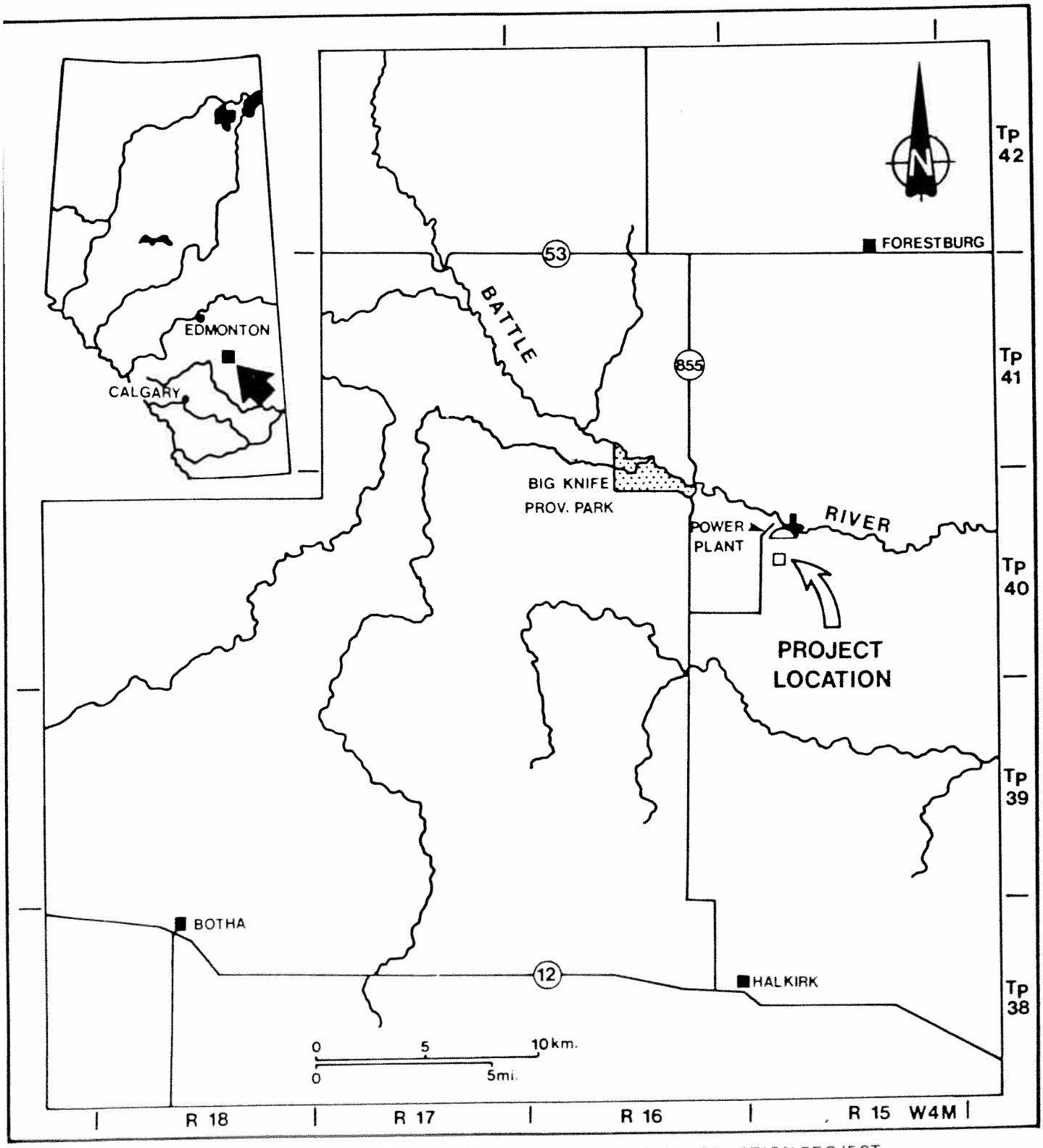


FIGURE 3a. LOCATION MAP, BATTLE RIVER SOIL RECONSTRUCTION PROJECT

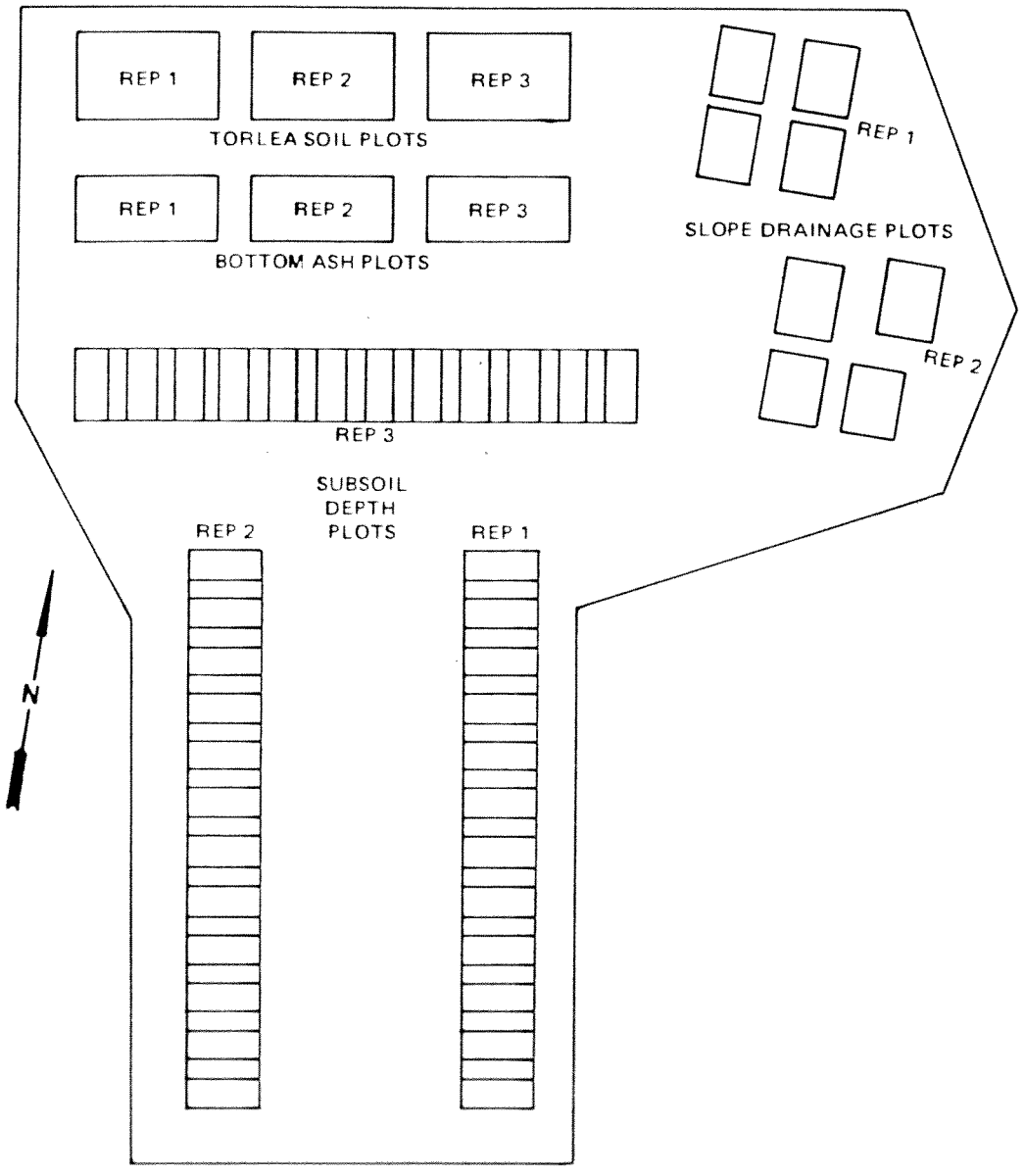
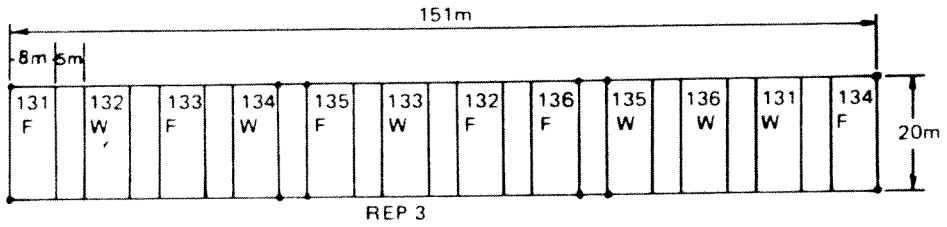
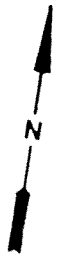
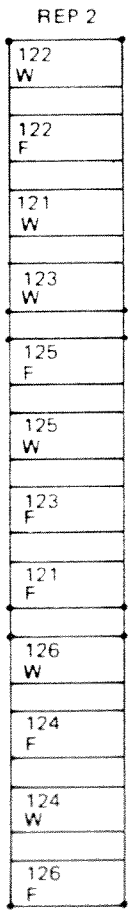
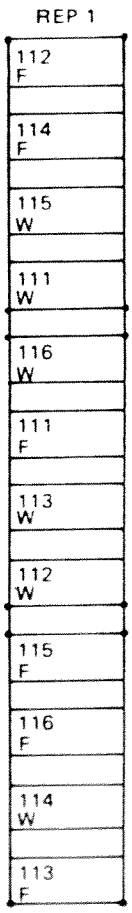


FIGURE 3b COMPOUND LAYOUT, BATTLE RIVER SOIL RECONSTRUCTION PROJECT









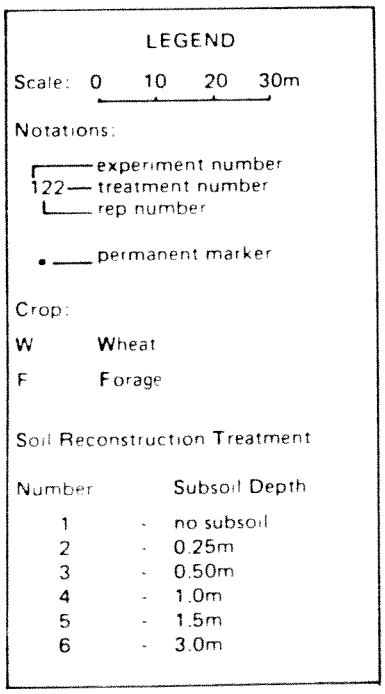


FIGURE 3c. PLOT LAYOUT – SUBSOIL DEPTH EXPERIMENT, BATTLE RIVER SOIL RECONSTRUCTION PROJECT

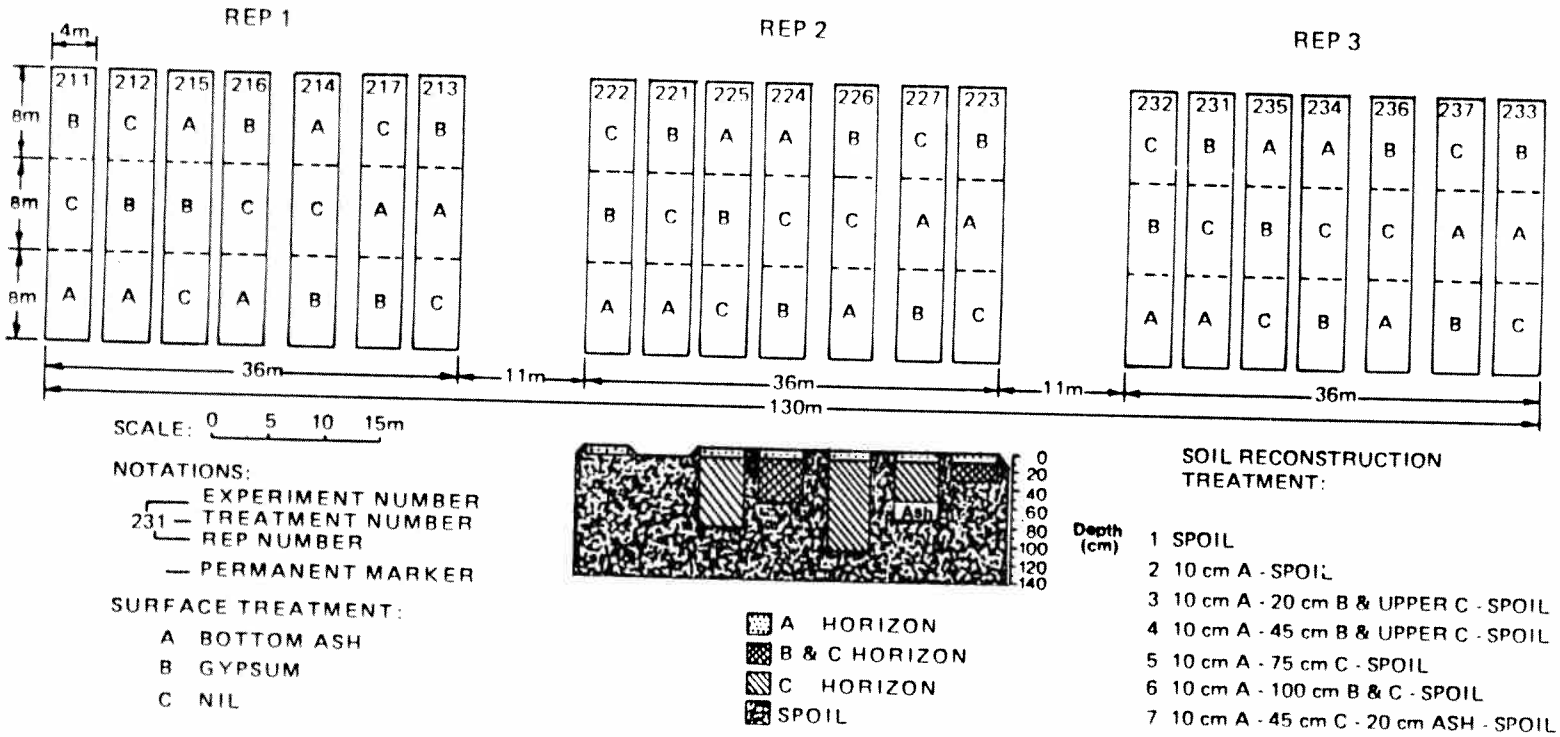


FIGURE 3d. PLOT LAYOUT – TORLEA SOIL EXPERIMENT, BATTLE RIVER SOIL RECONSTRUCTION PROJECT

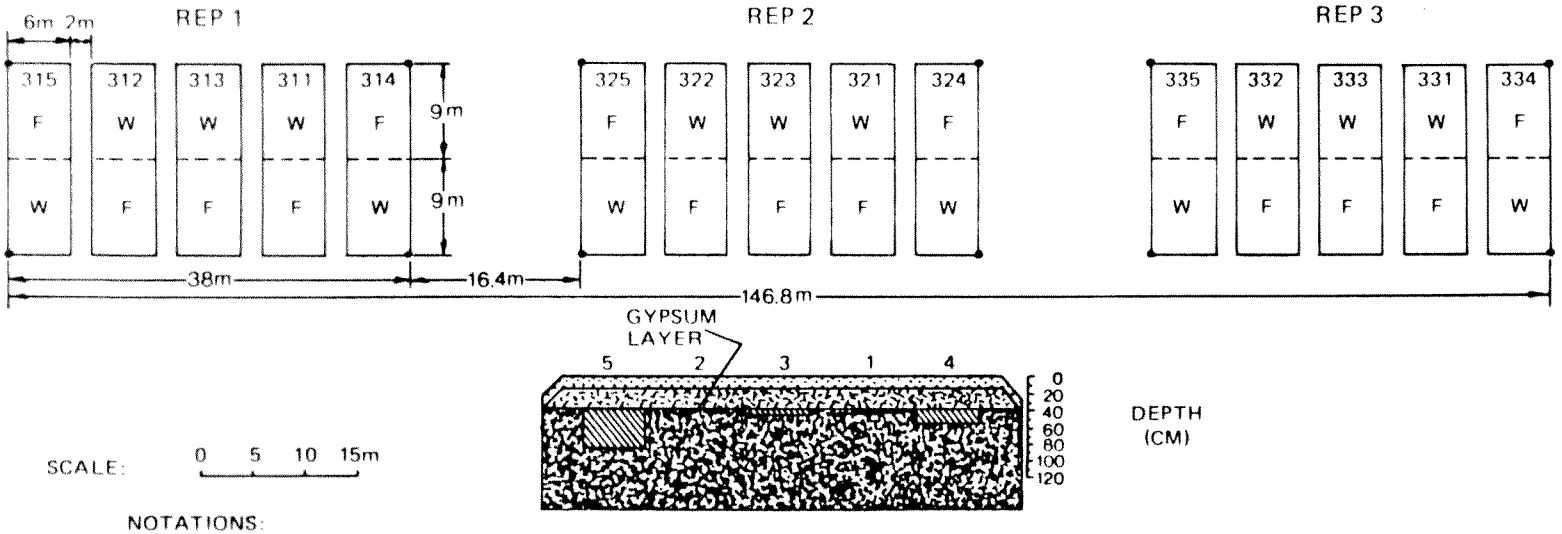
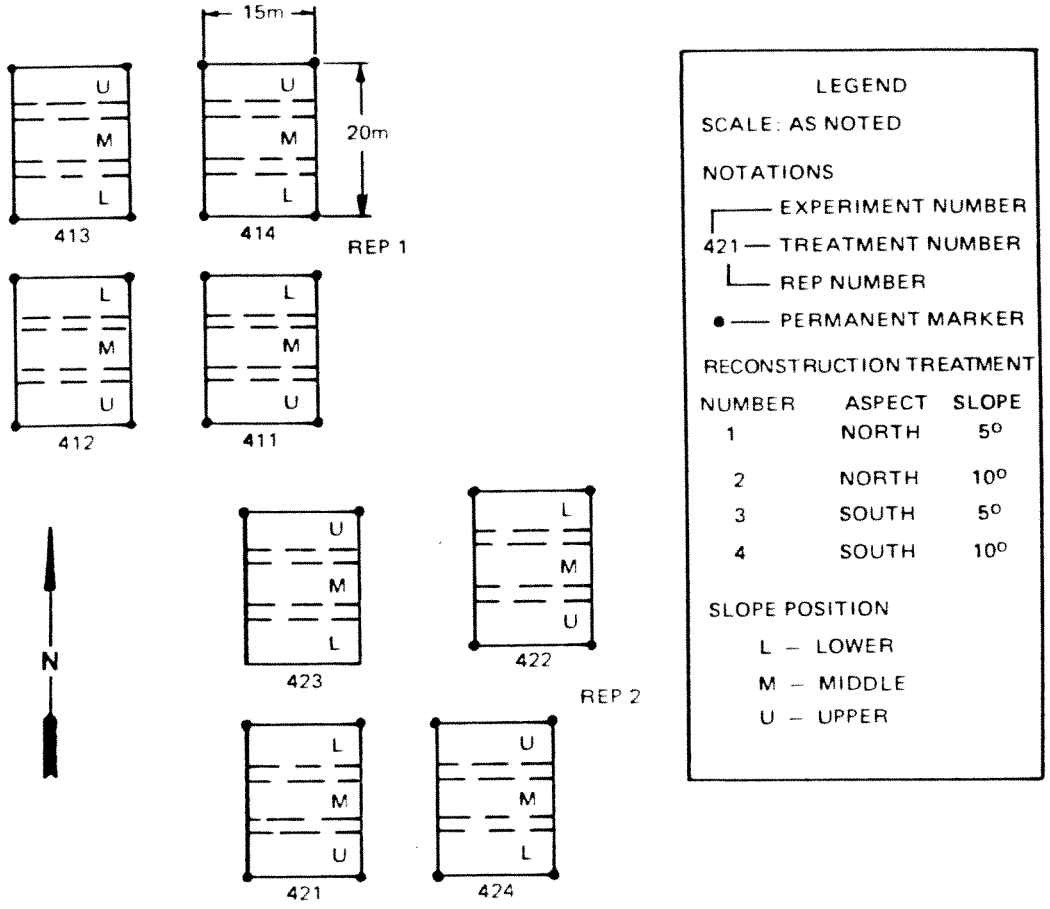


FIGURE 3e. PLOT LAYOUT — BOTTOM ASH EXPERIMENT, BATTLE RIVER SOIL RECONSTRUCTION PROJECT



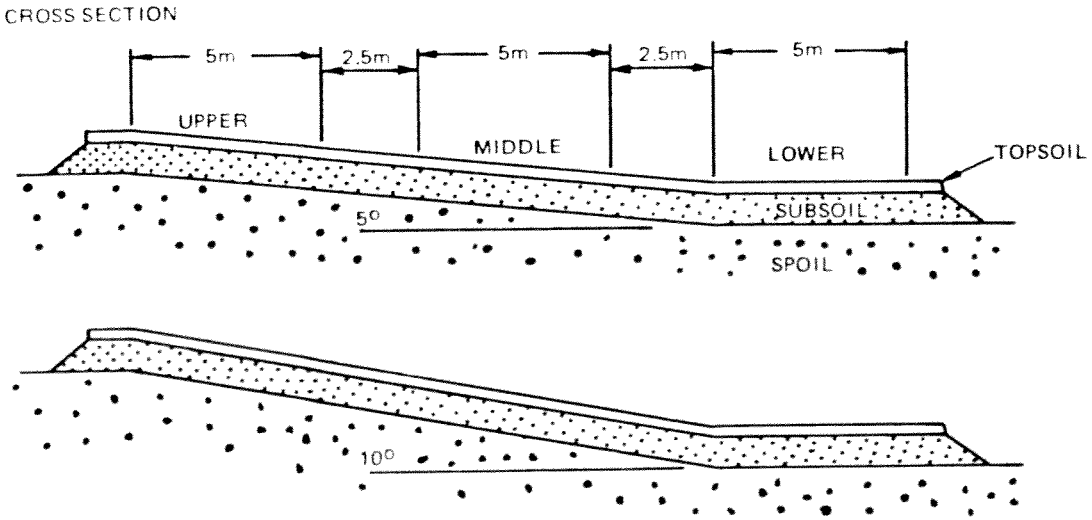
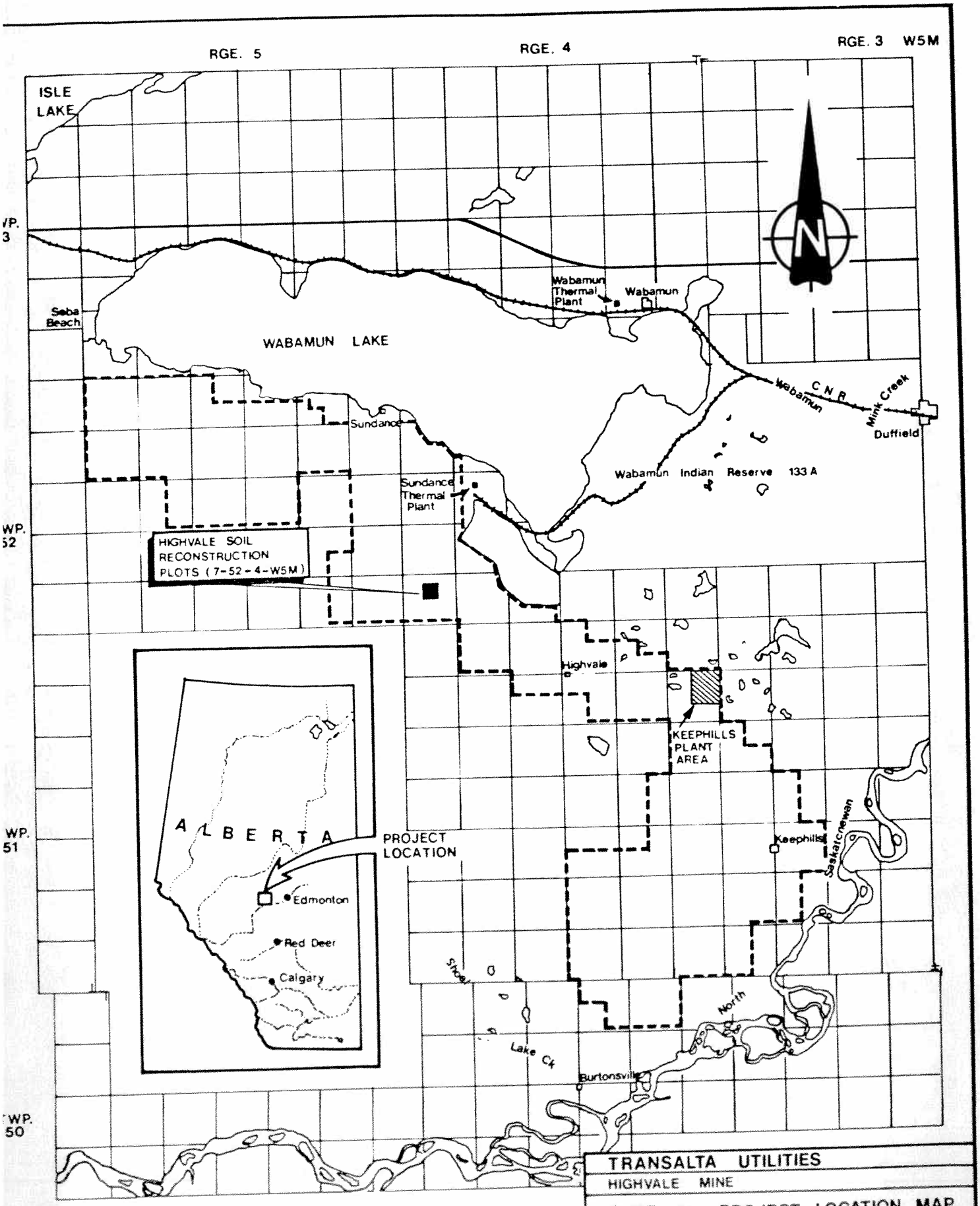


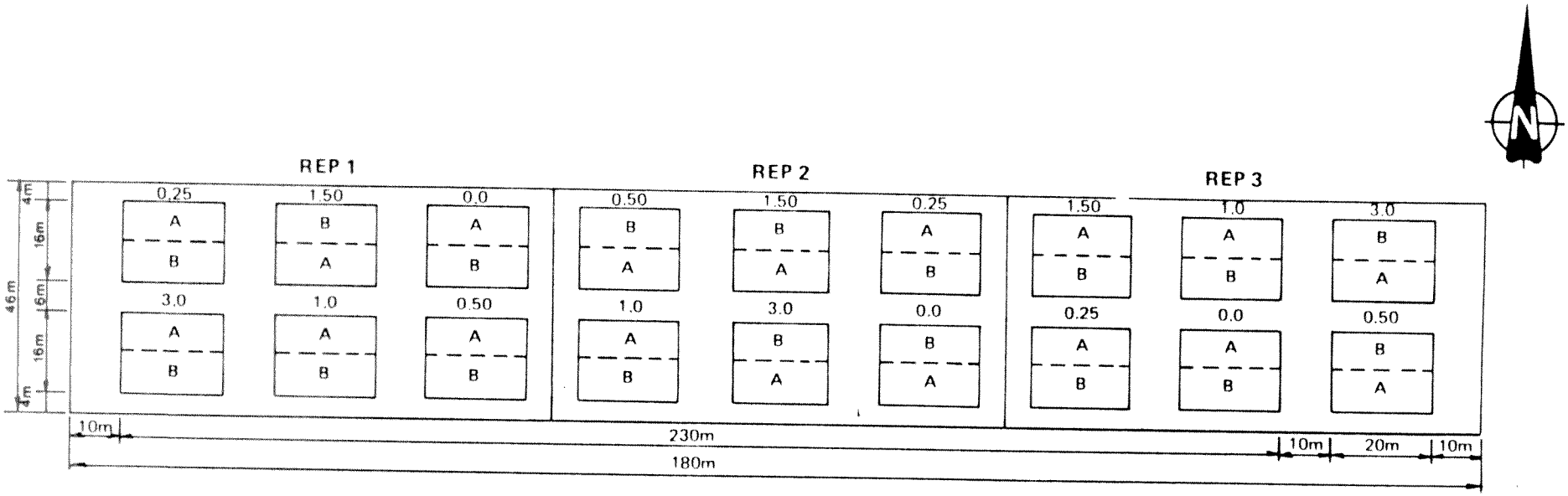
FIGURE 31. PLOT LAYOUT – SLOPE DRAINAGE EXPERIMENT, BATTLE RIVER SOIL RECONSTRUCTION PROJECT



TRANSALTA UTILITIES

HIGHVALE MINE

FIGURE 4a PROJECT LOCATION MAP, HIGHVALE SOIL RECONSTRUCTION PROJECT



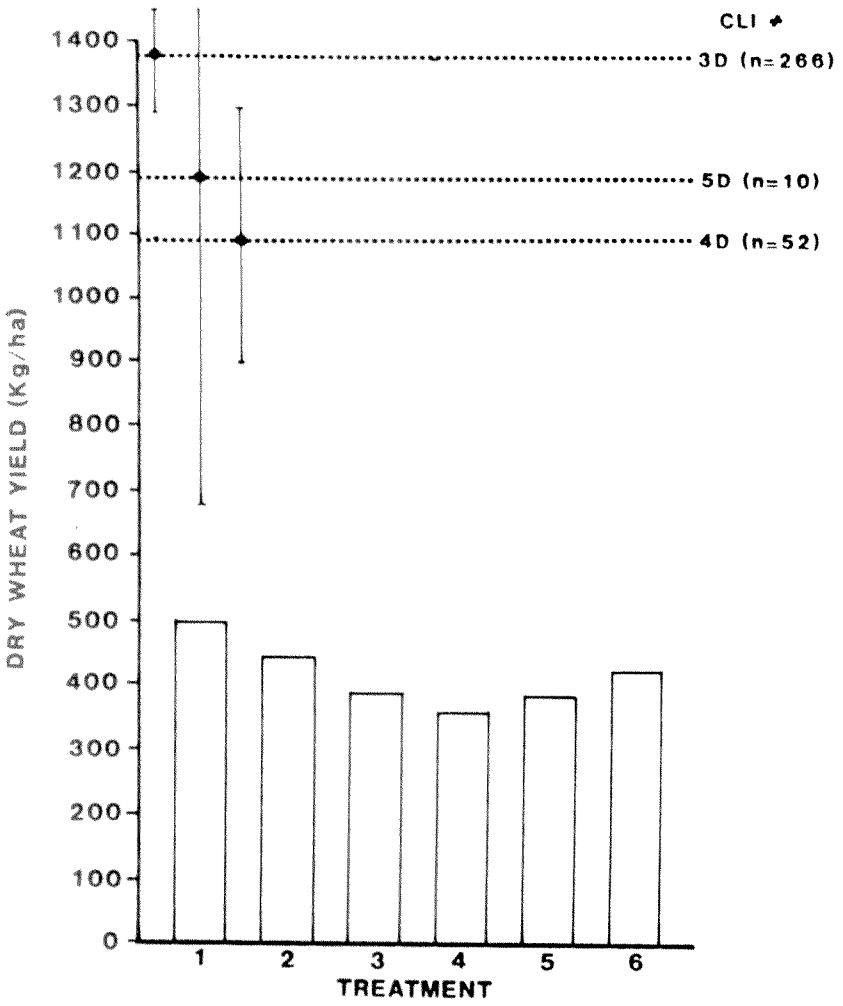
A - ALFALFA (RAMBLER) AND BROMEGRASS (CHARLTON)
B BARLEY (KLONDIKE)
0.0 NO SUBSOIL
0.25 0.25m SUBSOIL
0.50 0.50m SUBSOIL
1.00 1.00m SUBSOIL
1.50 1.50m SUBSOIL
3.00 3.00m SUBSOIL

FUGURE 4b.

HIGHVALE SOIL RECONSTRUCTION PROJECT

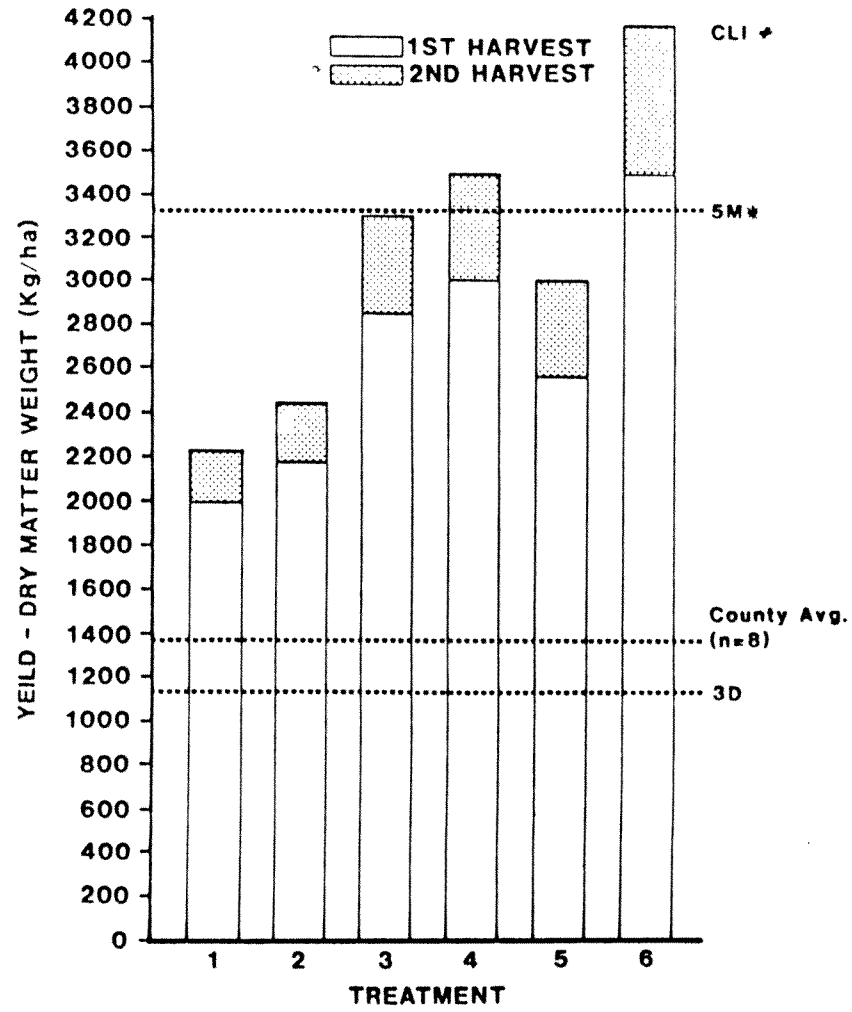
SUBSOIL EXPERIMENT LAYOUT

Fig. 5a



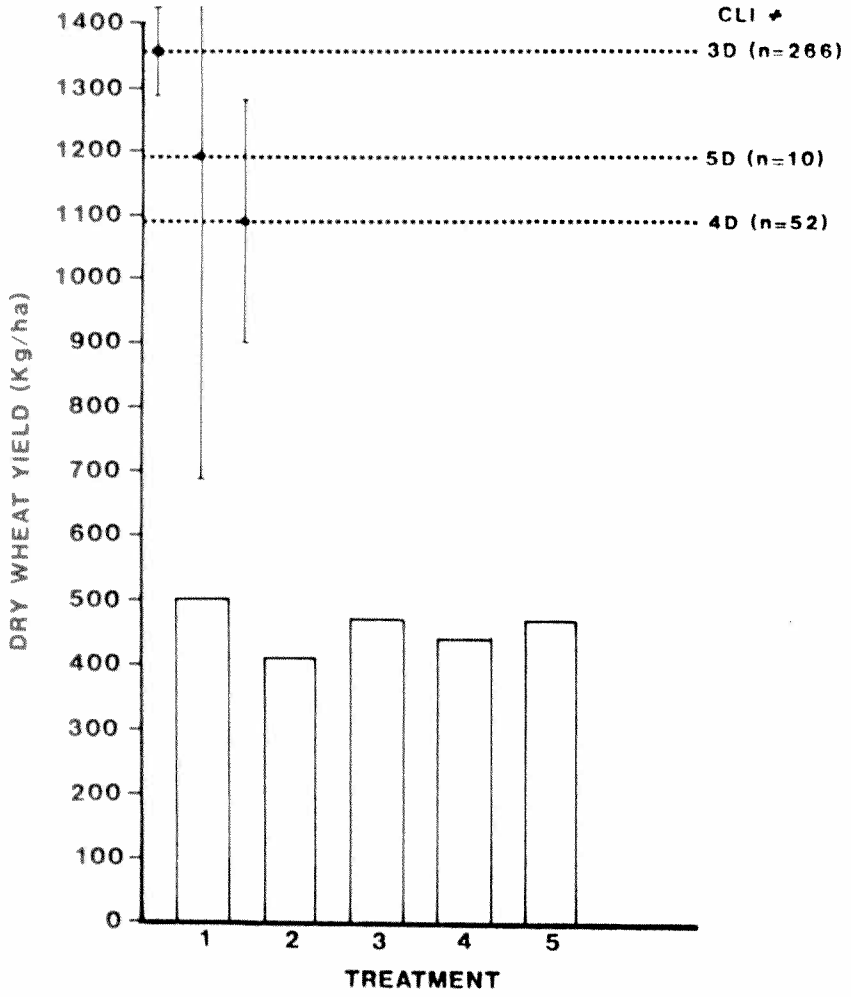
Treatment	Soil Reconstruction
1	15 cm topsoil/spoil
2	15 cm topsoil/25 cm subsoil/spoil
3	15 cm topsoil/50 cm subsoil/spoil
4	15 cm topsoil/100 cm subsoil/spoil

Fig. 5b



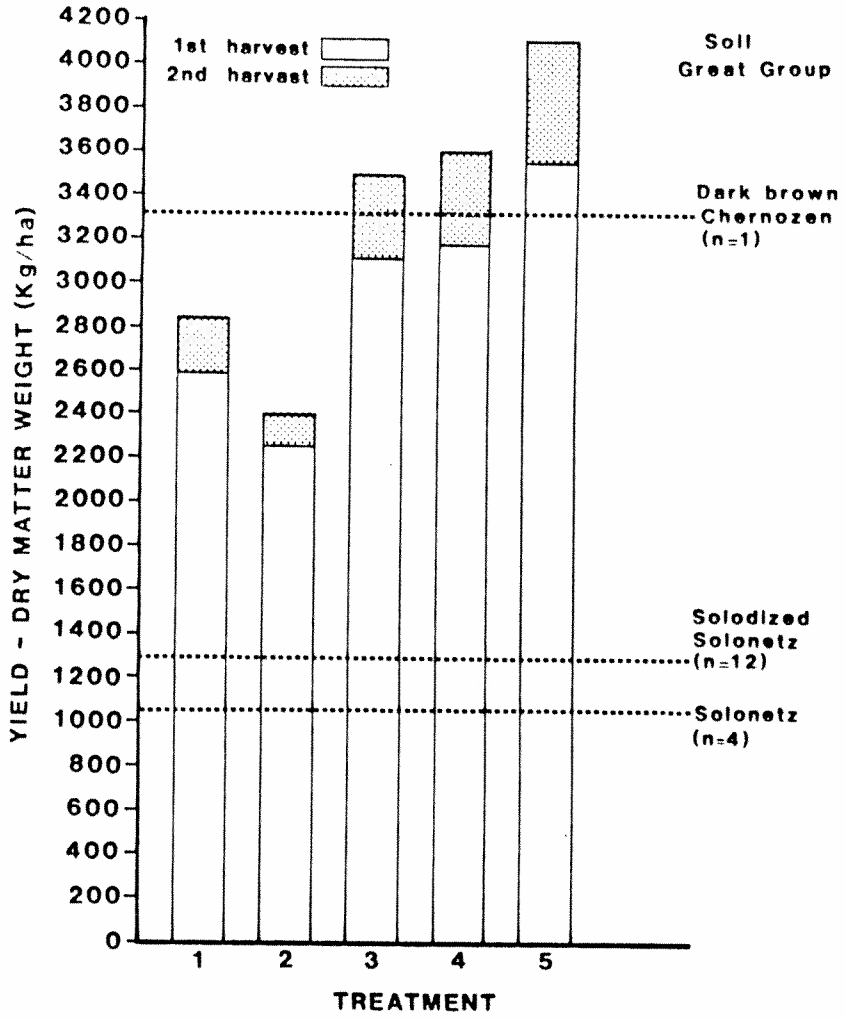
Treatment	Soil Reconstruction
1	15 cm topsoil/spoil
2	15 cm topsoil/25 cm subsoil/spoil
3	15 cm topsoil/50 cm subsoil/spoil
4	15 cm topsoil/100 cm subsoil/spoil
5	15 cm topsoil/150 cm subsoil/spoil

Fig. 6a BATTLE RIVER BOTTOM ASH EXPERIMENT
1983 WHEAT YIELDS



Treatment	Soil Reconstruction
1	15 cm topsoil/25 cm subsoil/spoil
2	15 cm topsoil/25 cm subsoil/gypsum (20 T/ha)/spoil
3	15 cm topsoil/25 cm subsoil/5 cm bottom ash/spoil

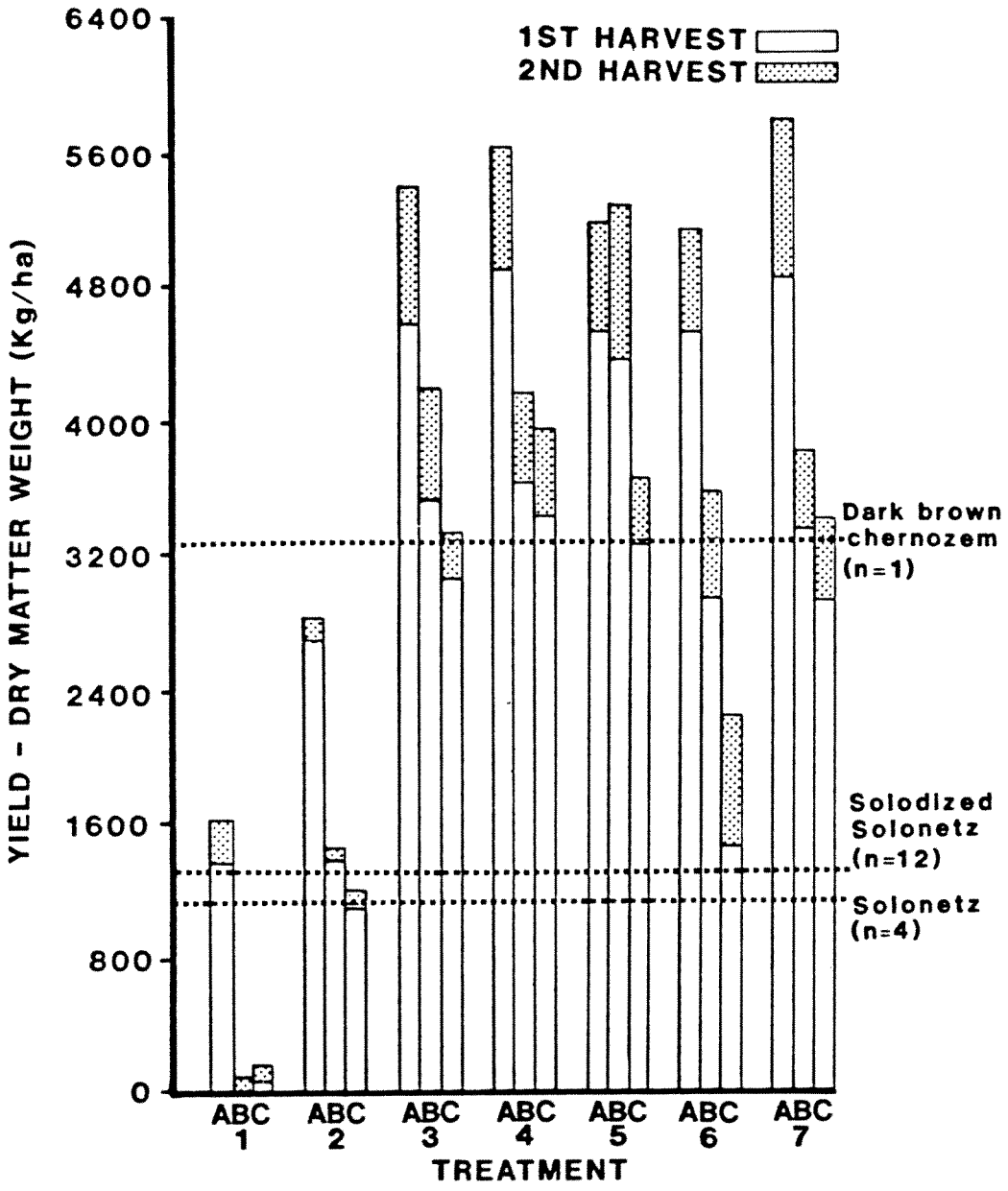
Fig. 6b BATTLE RIVER BOTTOM ASH EXPERIMENT
1983 FORAGE YIELDS



Treatment	Soil Reconstruction
1	15 cm topsoil/25 cm subsoil subsoil/spoil
2	15 cm topsoil/25 cm subsoil/gypsum (20 T/ha)/spoil
3	15 cm topsoil/25 cm subsoil/5 cm bottom ash/spoil

Fig. 7

BATTLE RIVER TORLEA SOIL EXPERIMENT
1983 FORAGE YIELDS



A, B, and C respectively signify surface amendments of 15 cm of Ash, 20 T/ha gypsum and a control.

Treatment	Soil Reconstruction
1	Spoil
2	10 cm topsoil/spoil
3	10 cm topsoil/20 cm B and upper C horizons/spoil
4	10 cm topsoil/45 cm B and upper C horizons/spoil
5	10 cm topsoil/75 cm C horizon/spoil
6	10 cm topsoil/100 cm C horizon/spoil
7	10 cm topsoil/45 cm C horizon/20 cm Ash/spoil

The Highvale plots we first planted and harvested in 1983. Therefore only grain yields were taken. The results indicate a trend toward increased yields up to 1.0 m of subsoil. Yields exceeding or matching local Class 1 land were achieved with subsoil depths of 1.0 m or more while yields equivalent to Class 3 and 5 land were achieved at 0.5 m of subsoil depth (Figure 8).

CONCLUSION

Early results of the Battle River and Highvale Soil Reconstruction Projects indicate that, in all but one case, crop yields are a function of soil reconstruction method. The specific nature of the functions cannot be reliably extended into future performance until at least five years of results are compiled.

Of immediate significance is the fact that the soil reconstruction plots are providing the means of achieving specific post mining agricultural productivity goals by identifying the appropriate soil reconstruction methods. The early results indicate that manipulation of material selection and quantities in soil reconstruction will allow mine planners and regulatory staff to reestablish a wide range of agricultural capabilities in the post mining landscape. The treatments presently under study in the field plots, so far at least, achieve yields which generally bracket the range of local crop yields. The one exception is grain yield at Battle River which is well below local averages and has not yet responded to different soil reconstruction treatments.

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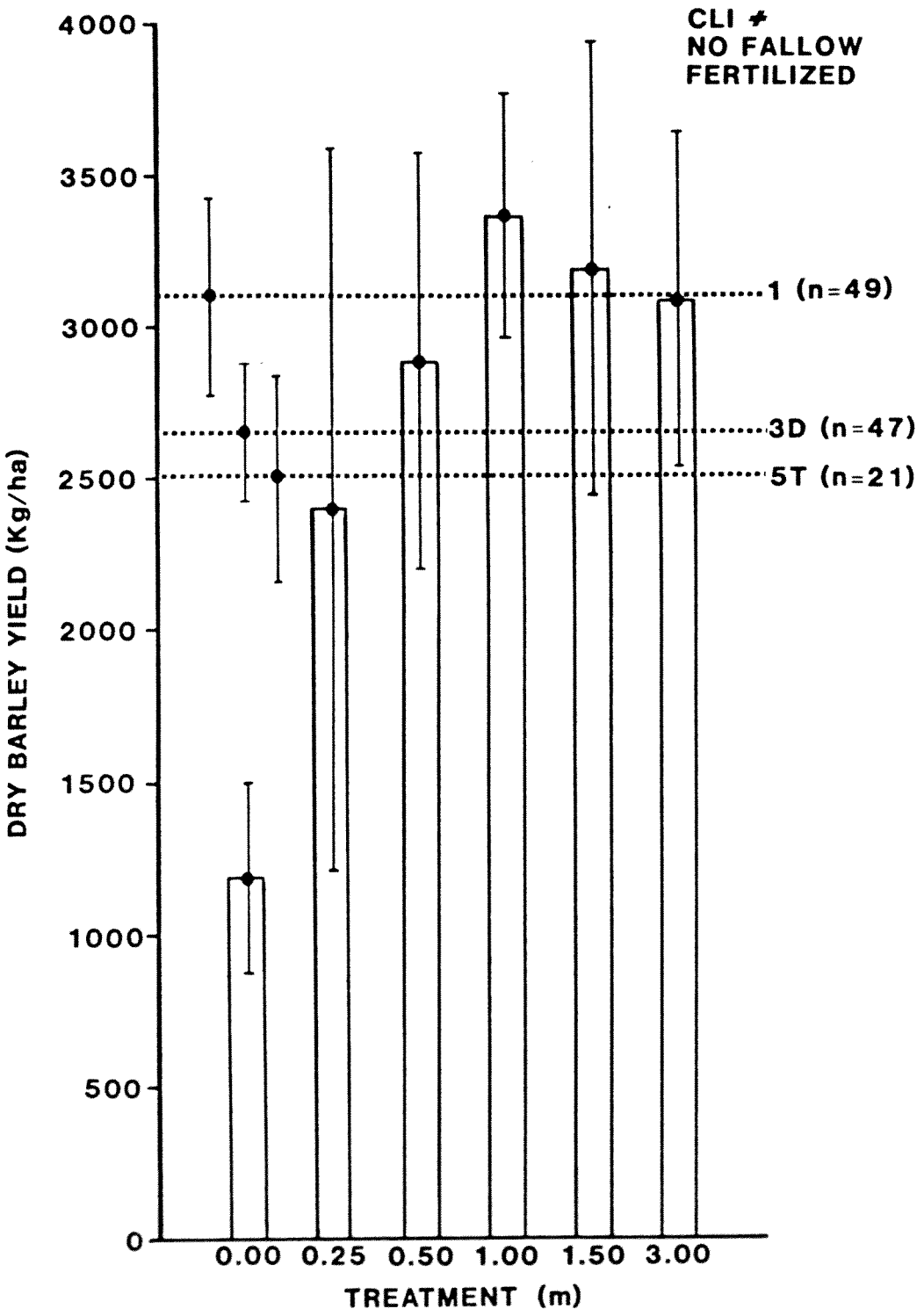
Fig. 8



HIGHVALE SOIL RECONSTRUCTION PROJECT
SUBSOIL DEPTH EXPERIMENT
1983 BARLEY YIELDS

Dave McCoy, Canterra Energy. How long will the experiment run for?

Paul Ziemkiewicz. Until the funding runs out. They are all planned to terminate at five years. That is with the intensive sampling, the full range of soil monitoring and crop monitoring. Beyond that, I would be surprised if someone doesn't maintain them and look for yields, and simple things like that even on a year or two basis, but, they are all planned for five year.

Dave McCoy, Canterra Energy. What decision would you make if, in fact, sodium were migrating to the surface, and the money was running out at the end of five years, what would you decide?

Paul Ziemkiewicz. We would have to find out whether the sodium was coming up in relation to, or independent of, the crop and the subsoil deptn. If it is coming up 8 inches, for example, right across the board on all crops, then all we have to say is, you have a built-in buffer now of 8 inches that is going to be contaminated. Then we can base the recommendation on that. If it turns out to be a function of the crop type that is strongly influenced by alfalfa versus grain, then we will have to look at that, too. But, they will all be identifiable trends and we will be able to sort out the factors based on what we see over the first five years.

Dave McCoy, Canterra Energy. Am I right in thinking this is a continuous problem applicable to being summer fallowed?

Paul Ziemkiewicz. There is no fallow in this experiment, no.

Dave McCoy again. Do you think that's realistic in terms of the practice in the area?

Paul Ziemkiewicz. You find both kinds of farming practices out there, some are fallowed regularly, some are not. Certainly, in reclamation the last thing you want to do is fallow, you don't want an excessive moisture built up in these soils, early on in the game. They tend to be more permeable than surrounding soils, so the last thing you want is water building up, pulling water and salts up, into the profile.

John Railton, TransAlta Utilities. Your diagrams and your confidence intervals show that less than one metre would also meet your requirements, so the question for the regulator is, is he pushing industry and economics to achieving the upper end of the scale, or an average end of the scale, and has the regulator come to grips with that philosophical question?

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Paul Ziemkiewicz. That's a good question. One of the things, bearing in mind these are early results, we will have to identify is whether these results are consistant through time and how much slop you are going to see from one year to the next, how wide that confidence interval is going to be. Obviously, the law says you return capability, which, in this case, would mean that you are hitting the average.

John Railton, TransAlta Utilities. You are equating capability mainly to soil parameters...

Paul Ziemkiewicz. That's correct.

John Railton, TransAlta Utilities. I guess in some of your plots you have taken slope into consideration, but mainly what you presented was soil parameters, that's where you are going in this exercise.

Paul Ziemkiewicz. Yes. To keep it simple I left the slope out. On the slope plots what we are looking for is trying to identify the amount in volume of lateral flow of water and saline seep at the toe of slopes. Whether you get the affect of the north versus the south slope, the affect of a 5 versus a 10 degree slope, I didn't want to bring that in today.

Don Klym, Suncor. Did you say the soil is denser at the beginning and it will become less dense?

Paul Ziemkiewicz. Yes, that is scraper application. Particularly with these clayey tills. We didn't really have a big density increase out at Highvale where the subsoil is a sandier material. It's Paskapoo tills, it's a much lighter material. Out at Battle River, where we have a very clayey type of till, the soil comes up very dense. It's bulk density is about 1.75 to 1.9. Results from North Dakota indicated similar trends early on but they tend to lighten up and the work that Terry's done on older areas that were ripped and unripped out at Diplomat Mine, indicate that through time, loosening does occur. Freeze, thaw, drying, cracking, that sort of thing. So we expect the bulk density to lighten up through time.

Tim Adamson, Obed Mountain Coal. Some people argue that the crisis of the capability rating for a farmer comes specifically in the poor years. That's when the judgement of the farmer as to which crop he's going to grow is really important. I was just wondering what you think, given the climatic features of these areas, whether in the five year periods you are going to be monitoring these plots you are going to actually get the poor crunch year which the farmer is looking for?

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Paul Ziemkiewicz. Well, you've got some of the worst years in history out at Battle River, I know that, so far, and they could get worse. That's a gamble we have to take, we have to have a schedule, we have a fixed budget, that will be the best data available and better than what we had before, but whether it is 100 percent confident, it will never be that.

Chris Powter, Environment. Two questions. Would the five year running average be what the regulator would base a decision on, and two, the graphs that you showed took the five year average just up to 1982, if you included up to 1984, it would probably have made a great deal of difference.

Paul Ziemkiewicz. In Battle River they certainly would have dropped considerably and we would have been closer to the target, yes.

I want to repeat that as interesting as that data is, I am not flogging that 5 years as the ultimate goal. What you are looking for there is as much control as possible, how the farmer treated his land. I know that farmers either underestimate or overestimate what they actually got so there is a human element involved in all these estimates. As to the actual kind of control we don't know what the farmer did a couple of years previously, maybe he had it in a full legume rotation and then went into grain and that may bump his yields.

What we are looking for in the validation of Terry Macyk's capability rating system, is the comparison and the control on unmined lands where you do have an idea what's going on, a tight control over what kind of management took place.

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SYSTEMS FOR RATING LAND CAPABILITY AND PRODUCTIVITY

Dr. Wayne Pettapiece
Soil Survey
Agriculture Canada

The topic I was given to talk on was systems of rating land capability and productivity. Bill introduced, very well, the whole business of capability. He talked about some of the things I was going to talk about as well. I don't think that's necessarily bad, because I wasn't going to disagree with him at all. What I will try to do then is re-orient the talk just a little to build on what he said. I think I won't talk about specific systems because I did run into another little bit of a problem as I started to think about it. I realized that, in fact, the systems are not the end in themselves, they are kind of an aid, if you will.

I tried to have a look beyond that and say, well, just what is the issue and I think that has been brought up here as well. Paul, brought that out quite clearly. What you are trying to do, is to assess a reclamation effort, and I thought that really it is a little more basic than that as well.

What you are talking about is assessing any piece of land, let's not make it too specific. Certainly what is driving the whole thing is this statement that was just made of restoring to a condition equal or better than before disturbance. But, really I think, the thing that we are talking about here is how do you assess a piece of land. So, again, rather than talk about any one particular system, what I thought I might do, would be just to run over an approach. Just to start asking questions, see where we get, see what, if anything, will fall out of it, we can just have a look at approaches.

A whole lot of these, in fact, have been covered, and in fact, a lot of the questions that were raised in the audience, have, in fact, pointed out these same kinds of concerns. So, we've got an issue, lets have a look at it and see where we go from there.

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The first question, certainly, was, is it as good as before? As soon as you start to look at that the first thing that comes to mind, as Paul mentioned, is in terms of productivity. That's the first thing you think of, and I think that is logical. We talk about yields of crops but somebody else brought up the point, that well, yields of crops is one thing, we've got a variety of situations here, we are not always on crop land, can you do yields on other kinds of things. Can you do yields of trees, can you do yields of ducks, or deer, or rabbits, or whatever else you want. It's still a natural resource and you can still talk in terms of productivity. So, it seems that you might be able to do that. Some are going to be a little more difficult than others, I would think, and certainly the time factor has been raised.

When I was thinking about it, I came up with just about exactly the same numbers as the other speakers here have. Because of our climatic variations if you want any kind of an idea of productivty, and you are just measuring yields, you're probably going to have to go at least five years, that seems like a good number, it's not new, it seems reasonable. A lot of people don't want to wait five years, you can do what Paul was suggesting. You can come up with some kind of a model, or a bit of an equation, and you can test it. If you've got some function of climate, plus some function of soil, it gives you a yield. On a given year, you plug in that on your little model. Does it work? If it works, fine, maybe test it one more year and if it is still working, you can feel pretty confident you've got an answer. So, maybe you can cut this productivity thing down to a couple of years, and I think maybe that's not bad on agricultural lands. Trees are going to be a little harder, I think. So, it would seem possible to do some things in productivity.

There are some problems, certainly. One of them is this subjectivity of management that Bill brought up. Management controls yields, you just can't underestimate the amount that management controls yields. So, if you are going to talk about productivity, you are going to have to have some pretty strict standards on what you are talking about. How much fertilizer is put on, all those other kinds of things, what kind of weed control. I think you have to realize that if you are going to compare them you've got to compare similar situations, before and after.

Certainly it has been raised, what crop is being tested. Are you talking about wheat or are you talking about forage, are you talking about trees. What if it's not cropped at all, what kinds of things can you do then?

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Well you can do your research test plots, you can have a plot next door to it, or you can maybe take some results from somebody else, if it is near by. Make some comparisons. Again, you have to recognize controls. If you are going to compare them, you've got to compare the same thing. Is it the same kinds of soils? - you can't compare, as Bill suggested, a sandy soil and a clayey soil, it's probably not going to work, particularly if you have areas where you have moisture deficiencies, you've got a problem. So, you are going to have to have some controls in there. Climate control is another one, you can compare things from Montana to Alberta, maybe. What about from Ontario to Alberta, or what about from Germany? You are going to have to be a little bit careful. And, certainly this other thing on time, comes in. If you are going to grow pine, or white spruce, are you going to do that in ten years. I think you are going to be pretty lucky to get an answer in ten years. So, you do have a time thing, depending on which area you are. If you are in farm country, agriculture areas, you've got one kind of time restraint. Into another area where you are going to look at productivity in terms of animals, or trees, wildlife, I think you've got another time control that may be a little bit excessive. So, that's a problem.

Another problem that has certainly been raised, is this one of an end land use. It's pretty hard to compare productivity without stipulating specifically the end land use, and I guess that follows, if it is going to be as good or better than it was before, does that automatically mean that the end land use had to be exactly the same as the initial land use. I think that is the implication, but I would sure hope that that's not right, because I think you are losing a lot of opportunities. If you are saying that, you are being very restrictive. You are not even allowing an opportunity for improving it to some land use that either you or society feels is a little bit better. So, if you are going to use productivity, these are some of the implications.

The other one that, it is not a very good term, but I wondered about was, universality. Can you apply the same kind of an approach to all situations? And again, depending on the kinds of crops, the kinds of end use, it would appear that, in fact, you can't use productivity, maybe the same way in all situations. It would be nice to do it and as Paul indicated, yield appears very definitive. It is a nice neat figure, it's a single number, and we all like single numbers. But, when you start to look behind it, you can see there's a whole lot of, if you do this, then you get that, if you do this, you get something else. So, there is a lot of support stuff goes in behind the yield figure and I am afraid it is a little bit of an illusion in many cases. So, I recognize there were probably four main problems.

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Are there some alternatives? Well, yes there are, and certianly we have heard about them. We have heard about the capability, I won't go into it anymore than just to say 'a capability', because it was interesting. The next thing I thought of after capability, was potential, which was also mentioned earlier. If it's capable for agriculture, I guess then the next question is, how capable, or how high is the potential, or for forestry or wildlife? Now, you can start to make some decisions.

The other thing if you get specific, if you want to talk about a specific crop, or a specific end use, you can talk about suitability. Is it highly suited, is it poorly suited, and then you can start to make some comparisons. So, really, what it all came out to, and I started thinking about those things, is that you had to know the end use. Once you knew the end use then you could start to decide on some of the kinds of parameters that maybe you wanted to measure. This is one of the problems with these capability things, as Bill mentioned, if you don't have a lot of good measuring things to work with. But, if you know what your end use is, maybe you can start to think about some of the parameters. If it is agriculture, for example, you want the slopes pretty low, there is a parameter that you can identify, if you want to irrigate it, and you want to use flood irrigation, it's got to be even lower. If you want to use it for range land and wildlife, maybe you'll just want to go the other way. Bill indicated, maybe you want a diverse situation, you want some sloughs, you want some hills, those are the kinds of things you may want.

Turn it around, if you want to do it the other way. If you know the parameters you have got then certainly you can go back and have a look at what end use might it be used for. Again, going back to those others, you can have a look at what's most suitable, or what is the highest potential, or what's the thing capable of, and you can ask yourselves those kinds of questions. Then you could start to make some decisions. You can start to plan. I think I'm hearing there isn't a whole lot of room for planning and a gut feeling is that I'd like people to be able to plan. So, there are some alternatives.

Bill talked about a capability system, the U.S. one, and he indicated that, in fact, it was very similar to the Canadian, and it is. It's really not surprising because the one came from the other. In the top three classes, we're talking about capability of sustained production, then we get a marginal thing, and then we get some classes that are kind of down on the bottom end. Once you start talking in those kinds of terms, then I think you're talking in terms of options, and I think that's not bad.

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The classes represent degrees of limitation for a particular use, in this case, small crop agriculture. It is specific. The other concept that it does show, is that a Class 4 may be marginal because it reduces the options you have. It may be very highly capable for one particular thing, or highly suited to one crop, but it restricts your options. If economics change and you can only grow one crop, you could be in a little bit of trouble. Grass seeds in the Peace River country is a good example. If that's all you can grow, you can go broke.

Just very quickly then, that's what one capability system can do.

But, again, there are some problems with that as well, and, it was mentioned that it's not very specific, and, if you haven't got something that's very specific, you are starting to get a little bit wishy-washy, and a little bit subjective, you're then going to be in trouble. So, the next question would be, well, if that would seem like a good approach, can you, in fact, make it a little more objective. Can you add specifics to the thing? Well, I thought, let's just have a look at it, see what we can do.

One of the things, for sure, is that we know when we're talking about capability, there are basically those three aspects, climate, soils, and landscape. That's not very specific yet. Lets have a look at climate. What are the kinds of things you might use as parameters. Certainly, length of season for most biological things is important. So is something to do with moisture and something to do with heat, or energy. Those are the basic three things that go into a system. That's still not very specific as far as something to measure, but we are starting to get some parameters, maybe.

Length of season, how are you going to measure it? Frost free period is one, maybe growing season length is more appropriate. Moisture, you could have used mean annual precipitation, you can use mean seasonal precipitation, you can go growing season defict. You have a lot of options yet, but we're getting a little bit closer.

Well, let's take length of season and we'll follow that one down. We could use frost free period. Well, the next question comes, are you going to use a 0^{o} Centigrade frost free period or are you going to use a -2^{o} killing frost. Or, are you going to use growing season, which is a kind of a mean daily temperature above 5^{o}. I guess the next question then was, does it really matter. As long as you decide on one and you go ahead and use one, as long as it kind of relates to what you want to do, is that good enough, and, maybe it is.

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Let's say that, in fact, we've decided that the frost free period and 0° Centigrade is a good measure. That's something we're going to measure. The next thing you have to know, though, is, what level of that is important. Are you going to index it, going to put it in boxes, or what are you going to do with the thing.

Certainly, there are a couple of ways you can handle it. One is you could put it into, if you will, a class system like the CLI 1 to 7, and you can say, well, the break between Class 1 and Class 2 is about 90 days. Anything above 90 we'll call Class 1, anything below 90 is somewhere down below. Then you could put in another limit at the bottom of Class 2, and Class 3, and so on. I think you could do that.

The other thing you might do is use an index like this. Somebody mentioned the Storie system. What it does, is take a parameter and puts it onto a 1 to 100 index. Maybe you might want to do something like that. You might say, well, 100 days is no limitation for what I want, I'll make that equal to 100. By the time I'm down to 75 days, I'm down to 50%, or something like that. So you could index it or you could put it into classes. There are a lot of options here.

If you've got all those options, and that's just on climate, what are you going to do on something like soils? It was suggested that we might have upwards of 90 characteristics and it might boil down to about four. I think that's probably a pretty good estimate because so many things are interrelated. So, it may be, for example, if you had a look at the soils aspect, maybe you just want to look at the surface, 0 to 20 cm. That's often used as a thickness. Or maybe 0-100 cms?

So, let's break it up into a surface and a sub-surface. What kinds of things might you want to look at. Maybe you want to look at organic matter, texture, structure, salinity, bulk density. You've got a lot of options, and, maybe at the end, if you want to simplify it, you could come up with some factor or function of surface and some function of the subsoil and throw the whole thing together and get some soil factor, and then you've got an index that you can use. It's a possibility.

Organic matter, for example, for agricultural purposes, seems to fit fairly closely into a scale as shown. If you are looking at it as a nutrient source, 5% organic matter might be equal to 100. By the time you get down to 2% organic matter in that surface, maybe you are only looking at about 50% of the reserve.

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This is taking a capability system and then breaking it down, or making it more specific. Remember, we are just talking about an approach. We are not talking about specifics. This was just kind of a train of thought as one went through a process. How would you try to tackle the problem?

What we've just done, basically, was to identify some environmental parameters and developed a bit of an index, or a yardstick to measure them. If you put the whole thing into a capability framework so you can do some planning and I think that you may have a useful approach.

I tried to take a look at what would happen if you compared two kinds of crops. In this case, I suggested wheat and spruce. If we looked at frost free period, and we have a rating of 0 to 100, and for wheat we need at least 100 days frost free period to equal 100, maybe 75 days is 50. Spruce is not nearly so critical from that point of view. Maybe, in fact, it's 60 and 0 to give you the same kind of index, but, I think you have that option. You can set up indexes for each particular crop, or each land use. In fact, you might decide for spruce that mean daily temperature is much more important and you might want to use a different scale, even. So, again, we are just looking at options.

When I got through all that, I took a look and said, well, what kinds of things have fallen out of this that I might be able to make some kind of a statement on. And, first, with regard to a rating system, I think it's very clear that the approach must be objective. You've got to have some things that you can measure. There is no room for gut feeling in this kind of a system because you're working with a variety of people. Somebody else has got to be able to go out and do the same thing.

I think it's quite clear that the approach must be flexible. We've got a variety of situations, we've got foothills, we've got forested plains, we've got agricultural plains, there are a whole lot of things there.

I think the third thing is that it really should fit into a planning process. I don't think you want it to be too restrictive. I think you want to be able to recognize some options and maybe take advantage of those options.

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Okay, given all that, what are some of the problems that are identified in the overall process, and this is going back now to the original assessment business, and I've heard some of these quite a few times already this morning. But, first of all, the final land use must be identified and agreed on before you even start or you're going to be in trouble. Now, it can be as broad as "lands for wildlife and grazing". It could be very broad but, at least, we've defined it. Or, it could be as specific as "irrigation for corn production".

You would use a different set of parameters in both those cases but you have a defined end land use. Based on that land use you could come up with a set of parameters and indices. You can get your parameters, what things are important, what things you are going to measure, and then, what kind of a scale are you going to measure them on, and you have to agree to those ahead of time, as well.

You want topsoil, how much topsoil do you want? Well, beforehand we said 6" is what it's going to be. Okay, that's what you've got. Then you have a look at what your pre-situation is. If you've got 12" of topsoil, you're not going to have a problem, if you've 3" you might have a problem, you might have to bring it in, but you have to assess the situation.

Then you develop your reclamation procedures and you do these in terms of these same parameters that you used previously. You are always talking, then, the same kinds of terms and everybody is talking the same terms. So, you develop your reclamation procedures, you want so much topsoil, you want so much subsoil, you want such and such a slope for this particular end land use. Everybody knows what it is. When the whole thing is finished, you assess it again, using those same parameters, you compare it to the specs, simple - it made it, or it didn't make it.

Well, it's not quite that simple, I guess, but you get the idea. If we're talking the same parameters all the way along and you use the same parameters in your planning and everybody has agreed to them beforehand, it shouldn't be too difficult, I wouldn't think, to agree to them at the end.

Now, I can say all this because I'm kind of talking as an outsider and maybe that's why it does make it easier but there seems to be some things there that fell out. Now, some of them were explicit, some of them were kind of implicit but I think they were there.

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So, just as a kind of a wrap-up, I guess, there is maybe one point that I would like to stress. It's really got nothing to do with rating systems per se but it affects the process. It's this idea that it's necessary to be absolutely correct whenever you're doing anything and reclamation is no exception. It's really nice to know what parameters you are using and to know absolutely, without any doubt, that that's what you have to have. But, that doesn't happen too often and, also, it's not absolutely necessary to be correct to get a system that's going to work.

I think it's more valuable that people will agree on something. Once you've reached some certain minimum level of security, then I think the other things, the absoluteness, is less important. You can become empirical as long as both sides agree, before and after, this is what you're going to do, and this is what you're going to achieve, and this is how we're going to measure it, that becomes important. Right of wrong doesn't enter into it anymore, subjectivity doesn't enter into it anymore, you've got a set of rules and it becomes very definitive. And, I think one should maybe remember that when they are trying to work out some of these things, and hopefully, they can all be negotiated, but I don't know.

Thank you very much and I would accept questions, too. The answers may be a little more difficult but the questions should be easy.

Bob Fessenden, Research Council. Just a comment. I would like to support your statement of need for agreement up front whether or not the parameters or criteria used for reaching some way of rating a piece of land are absolutely correct. I would just like to add one more further advantage to that is that once you define, in an explicit an objective way, how you are using the parameters to arrive at some kind of a rating, that then becomes the known hypothesis for any research that's done and you don't get into this problem for trying to research all the permutations and combinations which we often find.

Wayne Pettapiece. That's really a good point. Then you've got something to direct your research towards. It gives you some objectives. Any time you come up with an empirical kind of measuring stick, you have to recognize that that's what it is and, surely, you try to prove them, and, if, in fact, they're proven to be wrong well then don't stick with them for ever and ever, you've got to be prepared to change it, as well.

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Rick Ferster, Luscar. Yes, that's true, Bob, but carrying it one step further, and I like your approach, it's very logical. Basically, we all acknowledge that we don't know what the parameters are right now but we all acknowledge that we have to work with the state of the art and go from there. We've talked a lot about time in terms of five years for an agricultural situation, and ten years for spruce, or whatever it may be. Why are we looking at time at all if we've met the parameters, then why do we have to wait ten years or five years.

Wayne Pettapiece. I'd agree. That's why it's nice to go back to a capability thing, then you can set up your specs and you can take time out of it. You don't have to have time in there. Yes, I agree. It's one of the advantages.

John Railton, TransAlta. There's another advantage of your points. If they're measurable parameters then the planner can go to the operator. The operator can equate those parameters to cost and then you automatically have an easy way of determining the cost effectiveness of requests on the reclamation procedure.

Wayne Pettapiece. Yes, good point.

George Lesko, Syncrude. I am very much in agreement with your train of thought, at least, from my point of view, it's a favourable approach to the problem. You don't have to consider all the parameters which enter into the productivity or capability of the land, like climate is 70% of the capability but can we manipulate climate? No. So, I guess we should concentrate on parameters which we can manipulate because that's the only way to get up to the standard which we want to approach. So in this case, we should really just look at parameters in topography and the soil properties.

Wayne Pettapiece. As long as you recognize the environmental limits that climate's going to put on any reclamation effort.

George Lesko, Syncrude. That's a given, you recognize what is the limitation and that's it, but when you build up the parameters of what you have to attain and what you have to measure, I think you have to stick to landscape and soil.

Chris Powter, Environment. You mentioned that just because a land parcel is under land use X in the pre-mined condition, it doesn't necessarily have to be returned to that same land use if better use can be made of it. Do you think the public would go for something like that on producing farmland?

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Wayne Pettapiece. I don't know, but I'm saying I would like to see the option of being able to do that. I don't want it to be so restricted that we only can do that. That, I think, was the point I was making. I would hope that, in most cases, in fact, a logical conclusion would be if it's being farmed, it would end up being farmed. But, there are a lot of places where it's not being farmed and maybe it's quite capable with the change to the topography to make it into farmland. So, what I was afraid of, is if you just went with productivity and it had to be the same as it was before, I think Bill can maybe follow-up, I read some examples down in southeastern U.S. where that got carried to ridiculous extremes. Where they cut down a mountain for coal and they built the bloody mountain back up again so it was the same as it was before. I don't think we want to get into that kind of a situation, that's the only point.

As far as that 70% stuff on the climate, I would agree with that but don't forget it's that last little 10% where all your profit comes from. That's the really important one and if that's the one you can manage, that's the one you better know something about.

Malcolm Ross, Crowsnest Resources. You can always look at the reverse and if an area is being farmed, maybe it shouldn't be.

Wayne Pettapiece. Right on.

John Railton, TransAlta Utilities. There's another imperative here and that's after you do your reclamation, unless you're in a land developing business, and our position is that we will not be in a land developing business, you have to be able to get rid of that land.

Wayne Pettapiece. Okay. You are not, but the people that you deal with in the government, are very much in the land development business, if you will. They provide the guidelines for land use for the province of Alberta and, if you can negotiate with them, the land use that's suitable for the overall planning of a region, whether it's a municipal plan, or whether it's a regional plan, or whether it's a provincial plan, then I think that's the way you've got to go.

John Railton, TransAlta. If you designate that land as wildland you then have a marketing problem, because...

Wayne Pettapiece. Yes, I see what you're getting at.

John Railton, TransAlta. So, through the free enterprise system, you will probably be dealing with something that is marketable in one way or the other.

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Wayne Pettapiece. Well, I would hope that that could be negotiated. Again, ahea f time when you're setting up what you're trying to do, but I see your point.

Malcolm Ross, Crowsnest Resources. I thought John was going to mention another problem that does occur and, correct me if I'm wrong somebody, but I believe that the mandate of the Reclamation Division of Alberta Environment is to restore the soil to a particular capability, or whatever is decided, and yet, the land use may be determined by the local county, or MD Development Board, which varies with time, and may vary considerably, and I think...

Wayne Pettapiece. ...from election to election.

Malcolm Ross, Crowsnest Resources. Exactly. So, land use may not be a factor that you can control very, very easily.

Wayne Pettapiece. But, I think, Malcolm, to answer your question, if you don't know what your end use is going to be, I don't see how you can come up with a reclamation procedure. Now, your end use may be so broadley defined that you only work certain parameters and that's okay, and that leaves it open, but I think you have to have something up front that says either we will, or we won't.

Malcolm Ross, Crowsnest Resources. I'm not disagreeing with you, I'm agreeing with you, but I'm saying that we might know what your doing, but...

George Lesko, Syncrude. One more question, not necessarily to Wayne. Alberta has a very interesting land classification, which is political, the Green Zone and the agricultural area. Now, does it mean that if you are working in the Green Zone you are limited strictly to forest related land uses, or do we have still some options left over. I don't know who can answer this question.

John Benson, Alberta Forest Service. What are you referring to in terms of a forestry land use.

George Lesko, Syncrude. In the Green Zone we are not supposed to do agricultural reclamation unless they change their policy for reclamation. I just wonder what is the situation and how flexible are we in that.

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John Benson, Alberta Forest Service. How flexible? Well, if it's part of the permanent forest land base, I would presume it's supposed to come back to that. However, there have been changes in the permanent forest land base and they will always be going on as long as we are all around and, what we have found, however, is there is very little actually moving all one way, some coming back as well as some coming the other way. In many cases reclamation can be used to improve or change the land use in some of the mining operations where we have nearby land uses that may be more practical, i.e. reclaiming forest base lands to an agricultural use in areas where farming is expanding.

George Lesko, Syncrude. Let us say, let us assume an alternate land use of wild game ranching, which is just about anywhere in the Green Zone. Is there any potential possibility for this?

John Benson, Alberta Forest Service. You assume that. We would be open to consider a proposal for this type of land use.

Ken Crane, Luscar. I would like to point out that not all capabilities are biological and maybe, even though we are having a time interpreting the standard it doesn't necessarily imply that it has to be a biological capability and trade offs of pressure on land use patterns in a region maybe could be accommodated at a mine site better than they could be across a whole region. To go to one extreme is all terrain vehicles on recreation uses; get people out of one area and concentrate them into others. So, when we are looking at rating reclamation success, or particular land uses, there are a lot more options that may be there other than just biological ones and ones that can be measured by soil parameters. Equal productivity, or equal to or better than, is not a return of everything to as it was there before. I think that is probably a subject for a lawyer, or a legal interpretation of the standard may be advisable.

Phil Lulman. Larry would like to come up and say a few words and if, indeed, as he says those words, there are other questions that occur to you, or any of these people who've spoken this morning, please don't hesitate to ask them.

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IMPLICATIONS OF CAPABILITY TO THE REGULATORY PROCESS

Larry Brocke

To reiterate what John said this morning, and what has been voiced as a concern over the last several months, the trend of using 'capability' in reclamation does not constitute a change in the standard. The standard stays the same, as has been stated in a number of policy documents and other documents that have come out over time. I think it's been pointed out very clearly this morning by the speakers, and all were very good and informative I thought, that the issue really is, how do we measure the success of reclamation? How do we determine if the standard has been met? I think that's the crux of it all.

I was going to say a lot of things about the problems associated with these questions but they have all been said at least once. I don't need to repeat them.

The implications to the regulatory process, I think, are more than obvious, time being the biggest one. The object is to get to some means of measurement that reduces the time whereby there is a comfort level for saying reclamation is done. That has implications for industry and government, such as, when can reclamation certificates be issued, when can security be released, when can everybody be comfortable? That's what we are here for today, to toss around all the ideas we possibly can, and, as Phil mentioned, this morning, this is the start, this is not the end.

So, let's go to this afternoon and really knock this around.

John Railton, TransAlta Utilities. The question I had when John gave his presentation was, what standard? The question I had when you were talking was, what standard? Because, without denoting the standard that you are trying to meet it is difficult to get to it. So, if the standard is equal usefulness, that's one thing, but if the standard is some finite value for some parameter, then we really don't have standards outlined specifically.

Larry Brocke. I think you know exactly, John, what the words are in the Coal Policy, but I will read them anyway.

John Railton, TransAlta Utilities. I don't call those standards.

Larry Brocke. Well that's what the standards are.

John Railton, TransAlta Utilities. It's a semantical difference, then.

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Larry Brocke. Well, probably, it's vague enough to give that impression, but, in any event, that's what we have.

> "Disturbed land will be returned to a state that is useful or productive to man, or at least to the degree it was before disturbance".

The question is, how do we measure that?

Dennis Lang, Dome Petroleum. It occurs to me that there has been a significant maturity taking place in the development of reclamation standards, from a scientific point of view. I don't see the same maturity taking place from a jurisdictional point of legal government. They started out with this policy statement on returning of "equal to, or better than", and it raised up a whole bunch of arguments right away on productivity, capability, end land use, or post-mining, or post-disturbance land use. Since land use has been identified as one of the key sort of issues, and since land use is a jurisdictional thing rather than a technical one, it seems that there is time now for the government to sit down and say, should we restructure the way land uses are determined on these areas that are up for a major disturbance, like some major surface mines. And, maybe that land use decision should be made at the time that it is decided that there should be a mine there. The D & R Committee would then be able to make a recommendation on a land use and then allow the developer to work towards a specific land use.

Since the D & R Committee can't make that decision now, the developer can't do it, it's so fuzzy, it's maybe time that those kinds of decisions were looked at, as well, in order to facilitate better reclamation.

Larry Brocke. I can't argue with your rationale, Dennis. Everybody knows that is there and everything is subject to municipal planning, to bylaws that can appear with elections, with different pressures, that are subject to change at, almost will, forever. I don't know how we react to that in terms of reclamation for a particular activity, I really don't.

Dennis Lang, Dome Petroleum. Well, in looking at some of Paul Ziemkiewicz's slides on reclamation to seed grain in torlea soil, for instance, it seems obvious to me that you will never get equal to, or better than reclamation on the agricultural productivity there. You will get it on grazing land but not on seed grains. So, right away you are limiting a certain land use that may have taken place before mining and, at the moment they make the decision if they are going to permit mining, they are writing that themselves.

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Larry Brocke. No. I think that's where Malcolm's statement came in, where it may be going on there before but it probably shouldn't be.

Dennis Lang, Dome Petroleum. Well, possibly.

Larry Brocke. Just because a fellow is out there farming doesn't mean that it's the best thing to be doing there, trying to grow wheat where he shouldn't be. There is this cultural business in there, too, and other than telling the landowner, "Joe, you are to grow alfalfa and nothing else, and your neighbour is to grow wheat". That's not functional either. That's one of the fallings down of using land use as a parameter in reclamation. We've got to strive toward this capability, or potential, or whatever you like to call it, somewhere there, I think.

Malcolm Ross, Crowsnest Resources. While you feel that telling individuals what they can grow and can't grow may not occur here, there are examples of it around the world, where people are told, on the basis of erosion potential in farm areas, where they should put erosion control structures, and what they can do on particular slopes, and if they are in contravention, they will be fined.

Larry Brocke. I have made the statement at other meetings, and I always get chased out the door, but are you suggesting that agriculture should also be a regulated surface operation?

Malcolm Ross, Crowsnest Resources. I would think that there might be justification for that, yes.

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WORKSHOP
MEASURING SUCCESS IN RECLAMATION
November 8, 1984, Calgary

WORKING GROUPS

GROUP ONE

Terry Macyk
Leon Marciak
S.E. Stephansson
Doug Mead
Chris Powter
Gord Lambert
Bruce Patterson
John T. MacKenzie
Gary Mott

GROUP TWO

Alfred Birch
Gerry Acott
Don Klym
Jeff Bondy
Julia Fulford
Stan Tracy
Bob Fessenden
Hugh Allan

GROUP THREE

Roy Wood
Ivan Weleschuk
Dave McCoy
Mark Lesky
Jim Campbell
John Benson
Braham Prasad
Dennis Lang

GROUP FOUR

Al Fedkenheuer
Khalid Jamil
Clayton Rouse
George Lesko
John Gunn
Lin Callow
Rick Ferster
David F. Porter

GROUP FIVE

Bob Logan
Craig Palmer
Malcolm Ross
Don Thompson
Jivan Kayande
Jim Wursee
Marlin Murphy
Eric Beresford

GROUP SIX

John Railton
Ralph Dyer
Alan Kennedy
Lorne Winnick
Karen Natsukoshi
Ken Crane
Lynn Graves
Tim Adamson

GROUP SEVEN

Howard Slavinski
Les Johnston
Neil Chymko
David Lloyd
Tim Bossenberry
Stuart Lunn
Dave Henderson

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GROUP ONE

Chairman - Terry Macyk

Our group did not specifically address the nine questions that were presented in the outline because we felt that there are criteria and technical data available to respond to many of the points, perhaps at least the first five points and, furthermore, that in considering the diversity of types of disturbances which occur one would really have to develop a set of answers for each particular type of disturbance or area of the province. We concentrated on the next six questions in the handout and had more of a general discussion.

We looked at the land use issue for a few moments and want to reiterate that in terms of looking at land use one should consider other uses in addition to the biological ones.

We also suggested that land use should be resolved up front in any development as much as possible. It's fairly understandable at this point, that we're not going to be able to suggest one specific land use but, if we are to have flexibility in land use that that flexibility involve compatible uses. For example, if it's agriculture and subdivision development, that type of thing, as opposed to saying we want wildlife and agriculture, as possible alternatives.

In other words, flexibility, but flexibility to a certain point.

In terms of adopting a system, we felt that overall capability is beneficial relative to productivity. If one is to consider productivity as a system at this point it probably would be most applicable, or useful, in agriculture because that is where we have more of a data base to draw on.

In other words, one would be able to use the agricultural yield type of information that is available which perhaps, is not readily available relative to forestry, wildlife, and some of the other uses.

Some of the positive points in terms of using capability, we felt, were that a capability system can be universal in the sense that if one were to develop a capability system for agriculture, relative to reconstructed soils, that the system could be used throughout the province. Whereas, if one were to adopt a productivity system, one would have to gather data at each individual specific site or disturbance, especially in the unmined setting, to provide comparisons.

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The other advantage is one that Bill Schafer pointed out - that capability can allow for a quicker turnaround time in certification or in terms of assessing success. In other words, if you adopt a one-shot effort of looking at the characteristics of your reconstructed soils and develop capability ratings for those areas, maybe then you can be satisfied that that is, indeed, all you have to do.

Now, one of the weak points in using capability is how does one reconcile the change that might occur in reconstructed soils with time. For example, if you go to your capability rating very quickly after the reconstruction takes place, you have a certain set of parameters, or a certain set of properties, or characteristics. Now, in many instances, it's not likely that you're going to get major change in the soil properties and you're not likely to get major changes in capability. In specific instances, perhaps if you're looking at a salinity problem, or drainage problems, you may have changes. But, overall this isn't really an insurmountable problem. I think that the issue can be handled with continuation of some of the research that's ongoing in terms of looking at some of the problems relative to change and, also, just going back and making reassessments in certain time frames. For example, it might be five years for a certain area, it might be ten years in another area. So, really, the problem of how capability changes with time in reconstructed soils, can be handled.

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GROUP TWO

Chairman - Alfred Birch

Our group didn't just deal specifically with the individual questions that were outlined but we did have a general discussion that touched on a number of fairly relevant points.

We started off talking about end land use and came to the conclusion, reasonably quickly, that we had to take that as fairly well defined. We did, however, discuss the required degree of specificity of definition of that land use and felt that it should only be as specific as required to set standards for the particular type of use being contemplated.

In other words, if we're talking about irrigated versus dry land agriculture then there are going to be some parameters that need to be defined and, therfore, that decision may need to be made before the reclamation procedures are decided on. As Terry mentioned, we saw a need for flexibility there.

I think the general conclusion that we came to was that capability, or a set of soil characteristics and parameters are suitable for developing predictive tools of future productivity ranges. This should be the goal of reclamation research at this point so that we can have the ability to predict future productivity without having to wait for productivity to be observed, and, as Terry mentioned, there is benefit here of avoiding the time delay.

We had a representative of the forest industry and, obviously, there the delay is even longer, and the need for these predictive tools is greater. But, because we don't have those predictive tools yet, we're still in a phase where there needs to be this post-reclamation monitoring period of five years or so.

We noted also that there is a possible problem in that there may be subsequent improvement, or development of soils, and also, subsequent deterioration or degradation. So, these possibilities need to be examined in research similar to what Paul was reporting on this morning on the soil reconstruction plots, and so on.

In agreement with what Wayne said this morning, we felt that while this research is going on we just have to set the best standards we can and make the best guesses that are possible at this point rather than requiring perfect information.

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We didn't feel that the C.L.I. system was a necessary requirement for definition of reclamation standards, that there just needed to be agreement on what the relevant parameters were to achieve levels of productivity that were desirable.

In the forestry area we discussed things like depth of soils, moisture holding capacity, slope, aspect, and other factors like that. We didn't speak specifically about agricultural parameters that need to be defined but felt that these were more or less readily available and relate to different areas of the province to pragmatic situations, too.

The focus needs to be on those manageable characteristics or parameters in the soil reconstruction process, and the definition of the selection of those parameters will depend on what the available material is to work with in the reconstruction process, type of disturbance that is being contemplated, and the end use that is required.

We talked a bit about the pipeline situation and saw that as a bit different situation. With respect to pipelines we felt that there needed to be more long range research of the type that is being done on coal mines so that similar standards can be defined for pipeline reclamation.

There were a number of other issues that we touched on that we didn't complete the discussion, or come to a conclusion. One was what does one do about aquatic productivity of wetlands, and production of wildlife in wetland situations. We saw that as an issue for definition with the Fish and Wildlife interests.

The need for groundwater re-establishment, or reclamation with respect to groundwater, is another issue that needs to be considered but, while it is technically feasible to reconstruct it there may be situations where that is not quite achievable on economic grounds.

I think there was a need for more work in the forestry area to help define the productivity parameters. We might not be quite as far along in that regard as we are with agriculture and soil characteristics that are required for adequate productivity.

That's it.

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GROUP THREE

Chairman - Roy Wood

Our group consisted of Industry and government so it's encouraging that we found some consensus.

Our group felt that the criteria must be specific to the type of disturbance and to location. For example, linear disturbances, coal mines, and oil sands would require different criteria. Deep disturbances in potentially saline areas, present a much greater risk of reclamation problems than others and, therefore, would require different criteria.

The group felt that we should build criteria based on a defined end use. Although we recognize the need for flexibility we also believe you should generally aim to get back, or close to, the original capability and productivity of the land.

The group felt that it's essential for regulators, and operators to get together up front to agree on the specific criteria for a project, and to accept responsibilities that go with that agreement. Together they should specify and define capability, which we regarded as mainly soil criteria, using such parameters as soil design, topography, as well as addressing specific problems relevant to the particular development.

We felt that the performance should be monitored over time to see that the agreed parameters are being met.

We felt that there should be a first level of certification based on achievement of the agreed soil design with a partial, and substantial, bond release. A second level of certification based on a measure of productivity, such as crop yield, should follow.

In summary, we felt that an end use definition is central to the reclamation planning process and a capability system should be the primary method of judging reclamation success.

Although we did go through the detailed questions, I don't think I'm going to answer them in detail.

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GROUP FOUR

Chairman - Al Fedkenheuer

First of all the Group would like to emphasize that we endorse Wayne Pettapiece's statement of this morning regarding the importance of identifying the desired end land use before determining the specific assessment system to be used to evaluate reclamation success.

1. What criteria can be used to measure and check success of reclamation?

In terms of criteria to use for measuring reclamation success, we felt capability was best because the others are certainly influenced by management techniques. Also, an assessment using a capability system could be initiated and completed earlier than for other systems.

The group was assuming that climate was being considered and also that basically one cannot alter climate, especially on a macro basis.

There were a number of areas within capability which the group felt were important to consider. The first of these dealt with agriculture and more specifically, drainage, fertility and soil depth. Drainage was considered important as it is governed by slope and texture. Another item is fertility and not so much the available nutrients, but more what the nutrient pool is. Within the nutrient pool, organic carbon and pH were considered important. Another item considered to be important was soil depth.

Other areas considered to be important within capability are cultivatability, water holding capacity and site specific soil problems. Cultivatability, how easy is it to till the soil, should be considered as it to is related to slope and stoniness. Water holding capability because it is related to soil depth and texture. Site specific soil problems such as salinity, toxicity or depth to a restricting layer should also be considered.

In terms of wildlife the group felt that basically the same parameters would be used as for agriculture with the proviso that the values attached to those parameters for wildlife would be different. In addition, micro-climate, established vegetation and topography need to be considered in light of the particular species being geared for on the site. Prevention of soil erosion also needs to be part of the program.

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2. How long before development do you have to start collecting data?

   The group felt a time cannot be specified. It is site specific and a function of the end land use.

   It also depends on the amount of data already available. If there is little information available, it would only be long enough to go out and perhaps do a soil survey, collect any necessary soil samples, have them analyzed and interpret the results. This is not necessarily a very long time.

3. How long after reclamation is carried out do you have to continue collecting data?

   Data collection is carried out until the capability parameters have been successfully met.

   This group also discussed and endorses the partial certification and bond release already mentioned by Roy Wood of Group Three. This is the idea that after initially replacing soil material for example, some portion of the reclamation bond money would be released.

   At this time the group started running out of time so we started looking for the easy question's to resolve and moved to Item 5.

5. What resources are required to collect the data?

   Money and people.

7. After certification, what should the relative time frames be for bond release and land disposal?

   After certification, the time frame should be immediately, if not sooner.

That's all we have. Thank you.

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GROUP FIVE

Chairman - Bob Logan

Our group was made up primarily of industry people so some of these points are probably somewhat more of an industrial perspective.

1. What criteria can be used to measure and check success of reclamation?

   As far as the criteria go, we are coming to a point where key reclamation objectives can be set at the beginning of an operation, or every five years as a plan progresses. One part of the reclamation objectives we felt was key, would be a land use plan, but we didn't dwell on it other than to say let's set some objectives as to what we are aiming towards on a particular property. Develop an acceptable plan from that base and then, as far as criteria for judging success, it would be based on performance against this particular reclamation plan. It would involve soil handling, degree of levelling, and whatever else you might include in your plan.

   We discussed which criteria would be applicable by considering a reclamation inspector's check list - what would he look for at the end of the day? It was felt that he should be using the approved reclamation plan and judging performance against what was agreed to the outset would be done. Some of the particular things you would want to look at, we felt, would be the soil (both quality and quantity), topography, drainage, and there are probably others.

   Productivity monitoring could be a part of this assessment, but we felt, perhaps it's more of a research aspect to check on the assumptions you made when you developed your plan.

2. How long before development do you have to start collecting data?

   As far as pre-development data collection, we felt that it probably takes somewhere in the order of five to seven years to get a major project off the ground these days and that this approval process time frame gives you adequate time to collect background data.

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Another point that came out in regard to this data is that while much of what is collected is for government applications, a lot of it the companies are doing themselves for their own uses; weather monitoring, soils, and groundwater information that is used for mine planning and related activities.

3. How long after reclamation is carried out do you have to continue collecting data?

Post-development monitoring, we felt, depends to a certain degree on what the criteria are and what your final objectives are, but somewhere in the range of one to five years should be looked at as far as checking the land to see that you made your objectives.

Longer term monitoring is not ruled out in the sense of research to confirm assumptions used to develop the reclamation plan.

4. How frequently does data collection have to be carried out?

We felt that basically if you go in after the land is levelled and the soil is back on, with initial plantings done, one check is going to tell you pretty much whether you've met most of the criteria.

Again, there is a longer term research component needed as well.

5. What resources are required to collect the data?

These things we felt, again, are going to vary depending on what particular criteria you set out on a project. But it's probably key to know ahead of time to have spelled out - just what resources, what information, you have to collect. Know it ahead of time so you can plan the collection program and know what it's going to cost you.

6. What are the effects of the system on development and reclamation planning?

Our group was leaning towards a land capability method, as far as a system for measuring success. It was felt that there was an advantage in that we would know up-front what we have to do, be able to better plan out our operations in the field. It would eliminate to a large degree requirements for post-mining vegetation monitoring.

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7. After certification, what should the relative time frames be for bond release and land disposal?

The general consensus was that bond release and land disposal should occur (or be able to occur) immediately upon certification. One shouldn't have to wait for a full mine site to be completed, but each legal block of land should be released as an operation progresses. Certainly in the plains region, you could finish off a quarter section at a time.

We suggest another way of bond release - a phased-in approach. That is, you are credited as you complete the major steps in reclamation. For example, once you've completed levelling and put soil on, you may have 90 percent of your reclamation complete. Perhaps you should be credited. At the least, the amount of security held would be more in the line with the actual remaining disturbance.

8. What administrative requirements might be needed to maintain the system?

Administration wise, we discussed a couple of things.

One is that we felt any system should be run through the existing Reclamation Council framework. One of the problems that we've noticed has been that the D & R Committee is involved in the setup of the plans (and if we want an approved plan at the front then the D & R Committee is an obvious group to be involved in setting that up jointly with the Company), but these people, at least as the system stands, are essentially not involved at the certification stage.

For certification we have reclamation inspectors in local areas coming out, looking, and there's some question as to the qualifications for these people to evaluate success. Also, we know from our experience, there's an enormous amount of pressure put on these people to make decisions on reclamation success and I don't know that they should be left out there on their own, they should have some help. So, perhaps representatives from the D & R Committee, appropriate to a particular land use, should be involved in the certification, we suggest something along that line.

9. What are the relative costs of the systems?

We really didn't address this topic.

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GROUP SIX

Chairman - John Railton

Group Six got down to question 6. I don't know if there is any significance in that, or not.

1. What criteria can be used to measure and check success of reclamation?

   First, we tried to put down some criteria. We felt that slope was important. Under soil quality, with respect to physical parameters, one should look at such things as: bulk density, water holding capacities, stoniness, and percent saturation. From a chemistry point of view, most certainly, the two prime items were SAR and pH. This selection of criteria could be partially dictated by the fact that there's a number of us who work on the plains, more than in the mountains. So one has got to keep that in mind. With respect to soil drainage, one should look at texture. Rooting depth is also important.

   We raised the issue of public use. If you come up with some final land plans, we hope that the capabilities have been specified. If the public doesn't want that use and the local people don't see that it's worth anything, you've done your planning for naught. So, there's more than just the provincial government's ratification for your plans. You have to have the support and groundswell of opinion of the local people. Otherwise you are in for it.

   We felt that pipelines were different than oil sands and mining projects. The large, broad area of extraction developments require a different set of criteria and approach than linear impacts.

   We felt that there had to be a definition of the standard, and we thought that the statement, which is called a standard, is really a political philosophy which shows an intent. It is subject to political interpretation, and isn't anything that was very easy to work with in terms of a question like capability. In terms of anyone being able to transform that statement into an operational plan by which you can do reclamation, more of those parameters that we mentioned under criteria would need to be specified.

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2. How long before development do you have to start collecting data?

With respect to collection of data, we felt that you need baseline data. We felt that with respect to soils, one year was probably all you needed. You want to know what part of the soil classification system you are dealing with.

3. How long after reclamation is carried out do you have to continue collecting data?

We felt that it might be five years after you do your reclamation before you would get your certificate. You might have to gather enough data to establish the meaning of variation on your reclaimed land and to have an idea of how well you are doing.

On the other hand, we had people that were saying the capability approach is a one-shot deal. You have two opinions. By this point we came up with the distinction that if one was going to do capability for wildlife, different things would be measured than for capability for agriculture. We were getting different messages when we talked to some of the leaders of this workshop. There is quite a dichotomy of opinion in the group on this issue. Tnat requires resolution.

After reclamation it might be two to four years before you would see any changes, so there may not be any use in looking for changes in your reclaimed land except on a two or a four year basis. That's borne out in the Whitewood Mine. You're wasting your money if you go back the second year and measure the same thing because the variabilities are so great you're not going to see any change, no trends at all.

The frequency with which you go back to collect data has to be related to the parameters. Some parameters will change faster than others so you would be wise to determine which parameters determine what kind of a frequency of a measurement is required. Again, we felt that measurement for soils would be done one way, but measurement for ungulates would be done a different way.

4. How frequently does data collection have to be carried out?

How frequently? Annual data collection would have to be carried out. We said annually and this was dependent upon the biological requirements of the species under concern. That was one faction. The other faction felt two to four years.

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5. What resources are required to collect the data?

The resources? We didn't really know what that question meant. We said money. No company wants to spend $500,000 every year doing what is essentially, an Environmental Impact Assessment for the monitoring. So, you have to select parameters, and a commitment from the organization to fulfill what they perceive the need is to satisfy the regulation or license requirement.

6. What are the effects of the system on development and reclamation planning?

When we got to the effects of the system on reclamation, we perceived that whatever system is set up will dictate your operational requirements in terms of slope, in terms of replacement and in terms of rooting depth.

But, then we digressed because we believe the experts came here and said land use is important. That's what we heard and we agree with it. But, we hear the people who are putting together this workshop saying forget about land use and just dwell on capability. We were having trouble reconciling how you do that. That's a fundamental obstacle.

We've got two factions here. One coming and saying yes, measure capability. We can agree with capability, but we are saying capability for specific land uses. I think it's a matter of sitting down and discussing the issue more and understanding what each means from their point of view.

That's where we got to.

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GROUP SEVEN

Chairman - Howard Slavinski

We nad some very interesting discussions and we basically followed the outline provided.

Essentially, we looked at capability versus productivity as a means to assess the success of reclamation. It was generally concluded that we preferred capability over productivity, although on linear or small disturbances, productivity may have value. We concentrated on the value of capability for large non-linear disturbances.

1. What criteria can be used to measure and check success of reclamation?

   Using capability, characteristics can be defined. Most are soil related, others are land form, and landscape parameters. We didn't go into the detail because there are probably some parameters that can be used across a wide variety of situations, in others more site specific parameters would have to be used.

2. How long before development do you have to start collecting data?

   To be able to compare you have to collect data before disturbance occurs, to assess both the present capability and also to assess the parameters in relation to soil reconstruction, because of the inherent characteristics that you're going to evaluate on your reclaimed land.

3. How long after reclamation is carried out do you have to continue collected data?

   Essentially, we consider looking at capability, and I use this term loosely, as a one-shot evaluation. So, if the results indicate successful reclamation has occurred, based on the standards that are set, then you are finished. If the testing results are negative, there is a negative assessment, then further monitoring to determine mitigation to the problem, will have to occur.

5. What resources are required to collect the data?

   We think these standards are essentially set in looking at soil parameters.

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6. What are the effects of the system on development and reclamation planning?

We had a little bit of a problem with this to start with, but we came up with two points. Yes, capability does affect development and reclamation planning because essentially we know the parameters which are going to be assessed, planning will concentrate on insuring that these parameters are met. Secondly, capability will be able to be used to evaluate trade-offs and, therefore, reclamation options that may be available on various sites.

7. After certification, what should the relative time frames be for bond release and land disposal?

Again, we found question 7 somewhat confusing in that, first of all, what time frame should be used when certification occurs? Essentially, when standards are met. As we understand things, as soon as certification occurs, security is returned. The last part of question 7, land disposal, the conclusion was it's none of government's business unless governed by a provincial statute.

8. What administrative requirements might be needed to maintain the system?

We didn't want to get into question 8.

9. What are the relative costs of the systems?

We started out saying that productivity is more costly than capability, but there are a lot of costs and you have to sit down and really balance the two off. Generally, you would say that since productivity is a time control factor that potentially it is more costly, but we think there is lots of room for discussion.

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CLOSING REMARKS

Phil Lulman

I would like to thank all of you, Chairmen and participants alike, for all your contributions. They obviously are going to be a very important part of the next phase of this whole undertaking and let me, very briefly, explain what, in fact, is going to happen.

First and foremost, we are going to turn to all those organizations that represent our different interests be they coal, oil, gas, pipelines, and ask those organizations to select an individual to sit on a joint committee to actually set down the facts in a working paper. That working paper will address some of the conclusions we have reached today. It may, in fact, go beyond those conclusions and recommend some action that may have to be taken.

We're also going to pull together all those comments that the Chairmen have made, as well as some of the questions and answers we've had today, from the morning session, and have those circulated to you all so that you can see the results of this meeting.

By early next year, meaning probably the April-May period, we would very much hope to come together once more with the results of this joint committee where there would be something very tangible in the form of a working paper.

It sounds like a pretty ambitious schedule but we are very, very keen to keep the ball rolling here because, if nothing else, it might identify some very large gaps which exist which need to be addressed outside of this forum. The sooner we start to work on those gaps the better off we will all be because then we can start putting things in perspective for our own plans and the developments that are underway already.

The joint committee will be responsible to John King, Chairman of the Council, and I want to express my thanks to John for taking his time and, also, providing so much support to all of us in getting the work up and running. I think it's most gratifying to find the support.

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Larry Brocke

I would ask everybody to join me in thanking Phil for the tremendous job he's done in putting this thing together and making it run. Thanks Phil.

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84-11-01

NAME: _____

AFFILIATION: _____

WORKSHOP ON MEASUREMENT OF RECLAMATION SUCCESS

FOR ALL DELEGATES

After discussion within your work group is complete, we would appreciate your answers to the following questions. This sheet will be used to compile a summary of the workshop conclusions.

1. What system would you choose to judge reclamation success?

2. If you did not consider either productivity or capability to be appropriate systems, describe the main features of any other your would use.

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3. Why would you choose this system?

4. What are the strong and weak points of this system?

5. How important is it to have a system related to land use?

6. If land use must be considered, is a separate system required for each major land use?

MEASURING SUCCESS OF LAND RECLAMATION
Summary Results of Joint Industry Government Workshop

L. A. Leskiw and A.G. Twardy[1]

INTRODUCTION

On November 8, 1984 a workshop was held for industry and government personnel responsible for land reclamation. These personnel plan, operate, regulate and monitor reclamation programs in the coal, oil, gas, oil sands and pipeline industries. The workshop objectives were to discuss methods applicable to measuring the success of reclamation programs and to provide responses to six written questions dealing specifically with methods for assessing reclamation results.

Pedology Consultants was commissioned by the joint Government/ Industry Steering Committee to compile, condense and submit this analysis based on the responses to the questions returned from each workshop delegate.

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1 Senior Pedologists and Principals, Pedology Consultants.

METHODS

The Consultants read the papers presented at the workshop, reviewed the answers to the questions, and attended two meetings with the Joint Government/Industry Steering Committee regarding this review. Questions were analyzed with respect to content and results were tabulated according to respondents' backgrounds.

In analyzing content, a number of conventions/definitions were adopted to facilitate the review processes and these were: a respondent is a workshop delegate who replied to the questions; a response is an answer to a question for questions 1, 2, 5 and 6, or a "point" made under questions 3 and 4. It follows that for questions 3 and 4 there are many more responses than respondents. Definitions for technical terms, for example, capability, suitability, etc., as used by the reviewers are given in the appendix. While these were not necessarily the definitions used by the respondents, it is assumed that they were at least similar and, therefore, would not change the overall results. Terms, phrases or statements quoted from the questions are shown in quotation marks but they are not referenced to maintain anonymity.

Respondents were grouped under two categories:

1. Industry (40%) or Government (60%) sectors;
2. Mining (50%) or Oilsands (25%) or Other (25%) (Oil, Gas, Pipelines) sectors.

   (Several respondents work in more than one sector.)

Personnel in Industry are thought to be generally involved in planning, supervising and to a lesser extent, monitoring reclamation activities. Personnel in Government are mostly involved in the regulatory processes but about a third are conducting research and monitoring. To our knowledge, all respondents have at least ten years experience in reclamation related activities and one or more University degrees.

The findings and opinions expressed in this analysis arise from those of the respondents. However, the authors have taken the liberty of grouping "points" that were worded slightly differently by different respondents and in so doing may have occasionally misinterpreted a respondent's meaning. If such errors were made, we as authors take responsibility and we apologise.

RESULTS AND DISCUSSION

A total of 65 delegates attended the workshop of which 57 were expected to respond to the questions, and twenty-eight or about 50 percent did. The questions and results of analysis follow.

Question 1: What system would you choose to measure reclamation success?

Ninety-three percent of the respondents favored using a capability system. Many provided supporting comments, which generally match those given under Question 3. One respondent suggested adding a "Storie Index" to help quantify the rating procedures. The Agricultural Rating System Working Group of the Soils Inventory Subcommittee is using this approach.[2]

Two respondents favored other systems: one "Productivity", the other "Reclamation Performance". The latter was described as:

> "Performance against an approved plan, developed and negotiated between industry and government. The plan should be based on the objective of returning previously established land capability criteria. Specific criteria could be set considering; (1) practicalities of industrial operations (e.g. soil movement limitations), and (2) desired land use. Factors which can be manipulated in the field should be emphasized".

It was interesting that three respondents from Industry, all working in the Oil, Gas and Pipeline sector, suggested that capability be "tempered with productivity data". Is this perhaps a result of their dealings with many farmers who are likely more aware of productivity than capability? (Author's question).

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[2] A. Twardy: understanding based on participation on the Subcommittee.

Question 2: If you did not consider either productivity or capability to be appropriate systems, describe the main features of any other you would use?

Only eighteen percent of the respondents had this question answered. (The others obviously favored the capability classification.) Respondents felt that basically a capability system should be used but that capability should be constantly evaluated by productivity. In other words, productivity should be used to complement capability parameters and ratings.

The respondents were roughly divided between Government and Industry and also among the three sectors of reclamation activities.

The main points given in support of the "Reclamation Performance" alternative (Question 1) were:

" - Assess pre-development land capabilities.
- Decide/set land use goals for a project area.
- Set criteria of parameters to be met for specific land use (slopes, soil depths, vegetation type).
- Develop reclamation plan.
- Agree to plan and yardstick.
- Assess reclamation performance.
- Review periodically land use objectives and criteria, and allow for changes due to experience gained from operations."

Question 3: Why would you choose this system?

Most answers were directed towards the capability system and therefore also covered part of Question 4. Nevertheless, the following are a list of points listed under Question 3 which respondents considered when they chose a capability system.

- "capability allows for a quick assessment of the reclamation and permits the granting of a reclamation certificate sooner than other systems"

  11 responses: split between Government and Industry: half from Mining the rest from Oilsands and Other sectors.

- "capability is flexible and can be applied to all forms of end land use"

  6 responses: mostly Industry: mostly Other sector.

- "capability facilitates planning and is easy to use"

  6 responses: split between Government and Industry: mostly Other sector.

- "capability is a complete, defineable and reproducible system"

  6 responses: mostly Government: mainly Other sector and some from Mining.

- "capability is economical (inexpensive, quick)"

  5 responses: mostly Government: mostly Mining sector.

- "capability is not influenced by management or weather"

  5 responses: split between Government and Industry: split between Mining and Oilsands sectors.

- "capability can easily be applied to a property"

  4 responses: mainly Government: mainly Mining sector.

- "capability is 'predictive', or indicates 'potential'"

  3 responses: Industry: one from each sector.

- "capability is accepted by industry"

  2 responses: Government: Mining sector.

The following points were each mentioned once.

- "information on capability is currently available. If upgrading is required then a standard is available for comparing or assessing reliability of the new information",

- "capability provides industry with a system which can be clearly defined, costed and integrated into a planning process by industry and government. Productivity checks provide control on final acceptability, sound reclamation and credibility",

- "maintain land use options and allow definition of trade-offs".

Question 4: What are the strong and weak points of this system?

Once again, most answers were directed towards the capability system. Many of the points suggested in Question 3 were also indicated as strong points in Question 4. A summary of the points and responses to each, under Question 4, follows:

Strong Points

- "capability allows for a quick assessment of the reclamation and permits the granting of a reclamation certificate sooner than other systems"

  12 responses: split between Government and Industry: half Mining, remainder divided between Oilsands and Other sectors.

- "capability is economical (inexpensive, quick)"

  8 responses: five Government, three Industry: half Mining, remainder split.

- "capability can be easily applied to a property"
  7 responses: mainly Government: mainly Mining sector.

- "capability facilitates planning and is easy to use"
  6 responses: mainly Industry: split among all sectors.

- "capability is a complete, defineable and reproducible system"
  5 responses: split: split between Mining and Other sectors.

- "capability is flexible and can be applied to all forms of end land use"
  3 responses: mainly Industry: Mining and Other sectors.

- "capability is not influenced by management or weather"
  3 responses: mainly Industry: mainly Mining sector.

- "information on capability is currently available. If upgrading is required then a standard is available for comparing or assessing reliability of the new information".
  3 responses: mainly Industry: Mining and Oilsands sectors.

- "fits the Reclamation Council"
  2 responses: Industry: Mining and Oilsands sectors.

The following were each mentioned once:

- "maintain land use options",

- "capability classification is predictive",

- "capability classification allows for degradation (erosion assessment)".

Weak Points

- "capability system has a lot of built in assumptions; parameters to be measured and limits are not well defined",
  12 responses: Mainly Industry: mostly Mining and Other sectors.

- "capability may change with time, to be confirmed by more research",
  12 responses: split between Government and Industry: mainly Mining sector.

- "capability system lacks economics and management input",
  3 responses: Industry: Mining and Oilsands sectors.

- "who is responsible for long term monitoring?"
  2 responses: split: Mining and Other sectors.

The remaining were single points given.

- "capability may not be applicable to non-vegetative end land uses e.g. lakes, commercial development, etc."

- "who is responsible for mistakes and subsequent mitigation?"

Question 5: How important is it to have a system related to land use?

All respondents (100 percent) indicated that it is very important to have a system related to land use. Most thought that land use should be agreed on before development begins because it aids reclamation planning. The Coal Policy (1976) stresses that future use of land should be established at the outset and that communities have a role to play in its determination.

In situations where a specific land use is not going to be obvious over the long term, there must be leeway to ensure that the land is returned to a state which will not exclude potential land uses in the future. Land use is difficult to predict, therefore, flexibility of systems should deal with flexibility of land use. One respondent suggested that the system should incorporate "specialized" land capability criteria and then be evaluated for a particular land use.

Question 6: If land use must be considered, is a separate system required for each major land use?

The word "system" in this question was confusing. About one third of the respondents thought the question meant an entirely new system for each major land use and answered the question "No". They followed with comments like "some landscape and soil characteristics may be used for different land uses with appropriate differences in their levels".

The respondents who answered "Yes" provided supporting comments, such as, "only in broad categories: agriculture, wildlife, forestry" but "not for specific crops within agriculture". The "Yes" respondents generally thought the basic system would remain the same but criteria in the capability system would have to be different for each land use. Furthermore, the majority of respondents stated that these different criteria and end land uses should be integrated into one overall plan - an integrated approach.

One delegate recommended that experts and working groups should be established to identify what parameters are necessary for assessing the capability for various uses. These parameters should be fully quantified so that capability can be measured for agriculture, forestry, wildlife, recreation, etc. He suggested that a good place to start was the CLI System. Others indicated similar comments as well as an eagerness to "get on with the job"!

SUMMARY AND RECOMMENDATIONS

About half of the workshop delegates replied to the questions, representing a good cross-section of Government and Industry as well as Mining, Oilsands and Other (Oil, Gas, Pipeline) sectors. Such a "cross-section" combined with the respondents having considerable relevant experience has led to a list of very important recommendations and supporting points which are highlighted below:

- Use a capability classification approach.
  - it allows quick assessment and granting of reclamation certificate,
  - it is economical (inexpensive),
  - it is easily applied to various disturbance activities, and to all forms of end land use,
  - it facilitates planning and is easy to use.

- Improvements should be made to the present capability approach.
  - assign quantitative limits to various categories that are now based on judgement. A Storie Index modification may be appropriate. Climate, soil and landscape parameters should be considered, and productivity levels should complement the ratings.
  - require a better understanding of long term effects of reclamation and possible impacts on capability ratings. More research and monitoring are needed.

- The classification system must be related to land use.
  - Most respondents thought that land use should be agreed on before development begins because it aids reclamation planning. In situations where a specific land use is not going to be obvious over the long term, there must be leeway in the system to ensure that the land is returned to a state which will not exclude potential land uses in the future.

- Each major land use (e.g. agriculture, forestry) requires a separate analysis of capability. However, parameters for distinguishing classes/subclasses should have common quantitative limits where appropriate, and the various capability/land use evaluations should be integrated into one overall plan.

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APPENDIX

Definitions of technical terms as used by the Consultants.

Agricultural land use - includes use of land for dryland farming, irrigated farming, intensive livestock, animal specialty, horticulture, agriculture, experimental and institutional farms (Task Force on Urbanization, Alberta Land Use Classification p. 157 in Scace, 1981).

Capability - focuses upon the nature and degree of limitation imposed by the physical characteristics of a land unit on a certain use (Smit, et.al.).

Productivity - refers to the physical yield that would be expected from a given use on a particular land unit, usually assuming specified management practices and input levels (Smit, et.al.).

Reclamation - The concept of reclamation of land has been defined as including all desirable and practicable methods for:

a) designing and conducting a surface disturbance in a manner that minimizes the effect of the disturbance and enhances the reclamation potential of the disturbed lands;

b) handling surficial material in a manner that ensures a root zone that is conducive to the support of plant growth where required for future use;

c) contouring the surface to minimize hazardous conditions to ensure stability and to protect the surface against wind or water erosion.

d) although the loss and re-establishment of groundwater aquifers is a major consideration in reclamation technology present knowledge does not permit specifying guidelines other than stating an objective of replenishing the groundwater source for beneficial use. (Alberta Soils Advisory Committee, 1981).

Suitability - compares outputs from the land unit to the required inputs and associated environmental conditions (Smit, et.al).

System - a definite scheme or method of procedure or classification (The Merrian-Webster Dictionary).

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