RESEARCH COUNCIL OF ALBERTA

Preliminary Report 56-1

Round-table Conference

on

Groundwater in Alberta

September 27th, 1955

Price 50 cents

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September 27, 1955

Research Council of Alberta
University of Alberta
Edmonton, Alberta
1956

PARTICIPANTS AT ROUND-TABLE CONFERENCE ON GROUNDWATER IN ALBERTA

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Mr. J. W. Foster, Groundwater Geologist, Research Council
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Mr. F. E. Balshaw, Water Works Engineer, Calgary Power Ltd., Calgary
Mr. J. A. Beveridge, City Commissioner, Red Deer, Alberta
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Dr. O. J. Walker, Head, Department of Chemistry, University of Alberta

F O R E W O R D

On Tuesday, September 27, 1955 the Research Council of Alberta sponsored a round-table conference on groundwater resources and development in the Province of Alberta, attended by twenty-seven professional and technical men from Alberta and British Columbia. This meeting, held in the Senate Chamber of the University of Alberta, Edmonton, was the first of its kind in Western Canada and served to point up the vital place which water supplies take in the economic health and welfare of a growing country.

The Research Council of Alberta is actively establishing a program for better scientific information in matters of groundwater geology and hydrology, dedicated to the people of Alberta.

* * * * *

Mr. Foster:

I wish to welcome you to the University of Alberta on behalf of the Research Council. We are here for an important piece of work. I know we will find it worthwhile, and I hope you will also find it enjoyable. Each of us in this chamber is specially interested in one way or another with the groundwater resources of Alberta, perhaps in their development, their conservation and protection, their legal nature, their chemistry, or perhaps their role in the economic and industrial future of this province. We have some common ground on which to start.

A good research program in groundwater requires, among other things, an appreciation of the problems and special interests of a wide variety of technical people. The Research Council of Alberta wants to gain through this insight into the needs, and to guide its work accordingly. We will all profit through the interchange of our ideas.

The success of this conference will be measured by our individual gains and our collective accomplishment. The conference has not been planned as a lecture series but as a true round-table. I urge that we avoid formality.

ROUND-TABLE CONFERENCE ON GROUNDWATER IN ALBERTA

Morning Session

Mr. Foster:

It is appropriate that we commence our session this morning with a few remarks by Dr. Grace, Director of the Research Council, who might briefly cover some of the activities which are undertaken by the Council, other than the field of groundwater. May I introduce Dr. Grace?

Dr. Grace:

Mr. Chairman and Gentlemen. First, I would like to say what a pleasure it has been to have Mr. Foster with us. He is from Illinois and -- just to let you know who he is -- he comes, with a number of years' experience, from the Groundwater Division of the Illinois Geological Survey. Those who should know, tell me that the Illinois Survey is pretty well a pattern of what geological survey and research organizations should be. If the contact I have had with Mr. Foster is indicative of the caliber of that organization, they certainly stand very high.

Now very briefly, since most of you know something about the Research Council, we have the honor of being the only Provincial research organization that goes back as far as 1921. To cut a long story very short, perhaps the major work of our organization has been on the problem of fuel. Nevertheless the development of the resources of Alberta for the people of Alberta in the true spirit of conservation is the main objective of our organization. We have strong research groups working on oil and coal in its various forms. Oil-sands investigation has been one of the major projects over the past years and, of course, we have done work on natural gas. I will pass over the development program on geology, but I will say this -- the geological investigation, started in 1919 under the direction of a committee headed by the late Dr. Allan, led to the formation of the Research Council. We are happy that the Council has strengthened its geological effort and we feel it is making a contribution, the scope of which you will get in a moment. Council takes a very strong part in the Alberta soil surveys and also has two effective service groups. An oil-testing laboratory helps to maintain the standards in petroleum products, does research, and is available for commercial testing. There is a group of industrial engineers who represent the Technical Information Service of the National Research Council, and who are available to industry, to the government, and to anyone who needs technical advice, and are also in a position to carry out special projects. In addition the Council has broader interests, including detailed research projects and committees; for instance, one on industrial pollution which has not undertaken very much in the way of specific work, is keeping a watchful eye on the situation and is prepared, in its own laboratories or elsewhere, to face and undertake research on any emergent problems that may arise.

We are looking forward to moving into our new Research Council Building which is in the very latest stages of completion. We hope to make the physical transformation in a little more than a month from now. I trust that on another occasion this group may be welcomed in our own Research Council conference room in the new building. I would like to take this opportunity to say that it is a great pleasure to have you with us.

Mr. Foster:

Also, as a preliminary to our groundwater discussion, it would be fitting to have Dr. Gravenor, who is Acting Chief Geologist of the Research Council, bring us up to date on what has been done in the field of geology by the Council.

Dr. Gravenor:

I am glad to have an opportunity of talking to this group on behalf of the geological section of the Research Council. I have been introduced as Acting Chief Geologist, and I think that illustrates nicely the co-operation which the Research Council enjoys with the University, inasmuch as many of my activities at present are in the Department of Geology of the University. Co-operation is further indicated in the case of Mr. John Wall of the Research Council of Alberta and Dr. Stelck of the University of Alberta, who have been working on microfossils in the rock formations of the Peace River country. This latter research has been designed to help the oil industry and actually has little to do with the matters which are to be discussed here. Dr. Byrne, who is our clay mineralogist, joined Council a few years ago from the University of Illinois. He is originally a native of Alberta and a graduate of this University. The Research Council has recently published a report by Dr. Byrne on bentonites of Alberta and their commercial significance. Mr. George Collins of our geological staff has been working on the Athabasca Valley oil-sands for a number of field seasons, and I hope that we will have a publication on that particular phase of our work next year.

Although we have a rather small geological staff at the present time, we have released approximately ten publications of a geological nature this year. Mr. Bayrock and myself have been working on glacial geology. This type of work ties more closely to the field of groundwater than the other geological work undertaken by Council. The Research Council for the past few seasons has operated a small drilling apparatus for soil testing and shallow glacial-drift study. Although this apparatus is not suitable for deep groundwater studies, it is proving extremely valuable in surficial work. We hope that in the future our geological efforts will expand. To add to Dr. Grace's remarks, I would like further to express our hope that Mr. Foster will agree to aid in setting up our groundwater program.

Mr. Foster:

We can perhaps best start our discussion by a few brief statements from me regarding groundwater. If you have any points to make, I would be very glad to have you gain the floor to make remarks, in order to put them into our record of proceedings.

A water supply of sufficient quantity and suitable quality and temperature is a paramount requirement of an area competing for industrial growth, economic improvement and basic stability. No one at this conference need be reminded, I am certain, that without good water in abundance there is no happy life. Without water there is no life at all.

Now, surface waters are generally well understood. They can be observed, measured, and readily tapped. But sources underground and out of sight are more complex, difficult to evaluate and often poorly exploited. Availability of groundwater in most areas is controlled essentially by a fixed set of geologic conditions which man has little or no capacity to change. Engineers can increase the amount of water stored in a surface reservoir by raising the height of a dam, but such man-made modifications of underground water potential are impossible or extremely difficult under present technology.

Though groundwater supply evaluation and development is fraught with problems, groundwater must not be discredited; groundwater is one of our most precious -- probably the most indispensable -- of our geologic resources.

The fact that groundwater is renewable on a year to year or decade to decade basis, quite unlike resources such as silver, coal and oil, means that we do not normally mine groundwater -- we only borrow it from nature by changing its natural course, accelerating the return of water to the ocean or to the sky.

In regard to conservation, I do not consider true groundwater conservation to be an abstinence from use or miserly use of groundwater -- rather, it is judicious and beneficial use in light of natural conditions and in light of what is available. For example, in the Bow Valley in the general vicinity of Calgary there are enormous deposits of water-bearing sand and gravel of large potential. These deposits are virtually saturated with water. The only recharge which can take place in areas of no pumping is that which balances the groundwater moving away under natural gradient. Recharge of groundwater into the gravels would greatly increase by infiltration of rainfall, snow melt and surface streams if the withdrawal of groundwater were expanded. This illustrates the point that groundwater potential is not alone controlled by how much water is there in the formation now or next week, but (1) how readily it can be withdrawn and (2) how readily the withdrawn water can be replaced with new water. This is the key to the role which geology plays in the groundwater resource picture.

My studies in Alberta this summer have been principally to assay the long-term groundwater potential of Alberta and to try to predict some of the serious problems which this province will face in the next 10 or 20 years in this field of groundwater.

It is impossible, of course, to predict these problems without knowing something about the economic future of Alberta. We are represented here by people who are in a position to predict, for example, the industrial growth of Alberta and where that industrial growth will concentrate. From this information we can compare those areas with the geological situation and know precisely whether those areas are going to be areas of famine or areas of plenty. I wonder if Dr. Gravenor would review for us the geology of Alberta from the International Boundary all the way to the 60th parallel, regardless of the population pattern of the province, and give us a brief rundown of the underground environment so critical to the occurrence of groundwater resources.

Dr. Gravenor:

Very briefly, Alberta is underlain by a sequence of sedimentary rocks which in most cases dip towards the Alberta-British Columbia boundary. To illustrate this point, at Fort McMurray there are only a few hundred feet of sedimentary rocks over granite, while at Edmonton there are about 7,000 feet of sediment over granite. Approaching the foothills there are from 10 to 20 thousand feet of sediment. The surface rocks in Alberta are mainly Cretaceous and Tertiary sandstones. In most instances these are the rocks from which groundwater will be removed. Limestones and "chemical" sediments are found only in the mountains and in the northeastern part of the province. So far as the surficial materials are concerned, we have a glacial cover over almost all the province. Prior to glaciation there was a normal drainage pattern over much of the province. To a certain extent the ancient streams flowed in the same direction as those at the present time, that is, the drainage trend was generally northeasterly and easterly.

Glaciers then moved across the province in a southwesterly direction, and this ice brought with it material from the Precambrian Shield and other areas over which the ice advanced. When the ice deposited its load of debris, it filled in the preglacial drainage patterns and smoothed out the topographic irregularities. For example, the preglacial course of the Red Deer river was north and just east of Lacombe, where a preglacial valley now exists. This ancient Red Deer valley was blocked off by the glacier moving in from the northeast, causing the waters of the Red Deer river to flow east and south in the new gorge, near Alix. So you can see the effect of glaciation was quite pronounced in the province, especially with regard to preglacial drainage. Of course, this is an important factor insofar as groundwater is concerned in that, if we know the location of preglacial valleys, then we have the opportunity to exploit their groundwater potential.

Aside from the preglacial valleys, there is a thin cover of glacial debris over bedrock which is of the order of 20 to 30 feet in thickness. Generally speaking, this thin layer is usable only for low capacity wells and, indeed, in many cases it is non-productive of water.

Mr. Foster:

It is interesting to compare the bedrock geology of Alberta with that of the Great Plains of the United States, which are famous for such aquifers as the Dakota sandstone. One of the world's most famous artesian basins extends east from the Rockies to eastern Nebraska, Kansas, and South Dakota. In this vast basin the Dakota sandstone yields groundwater at countless locations. The Dakota formation has been famous largely for its strong artesian pressures. Geologists have presumed that part of that pressure comes about because the Dakota sandstone dips easterly from its high outcrop in the foothills of the Colorado Rockies.

The point I wish to make is, that we are not so fortunate here in Alberta as in the Great Plains of the United States, inasmuch as the Cretaceous formations which occupy much of the area of central Alberta do not dip strongly and they do not outcrop over wide areas in the foothills. That means that water in the sandstones of the Cretaceous in central Alberta simply does not have a good opportunity to flush out and be replaced with meteoric waters from the surface. This sluggish nature of water in Alberta sandstones creates a water quality problem here. Furthermore the Cretaceous sandstones are, generally speaking, not well situated for recharge from the surface, and the permeability of the formations is low to moderate. One area where these sandstones are being tapped for municipal water supply is at Wetaskiwin. Mr. Maggs of Calgary Power Ltd. is with us today and has had considerable experience with Cretaceous sandstones. How many wells do you have, Mr. Maggs?

Mr. Maggs:

We have just finished drilling No. 24.

Mr. Foster:

And what is the maximum amount of water you are obtaining, say from any one well?

Mr. Maggs:

About 25,000 gallons per day is the maximum, less than 30 gallons per minute safe yield.

Mr. Randle:

There is no indication that this will be sustained. There are many indications that it will not be sustained.

Mr. Foster:

That is a good point to make, sir, because the sandstones are overlain by tight shale. Those shales do not help the recharge characteristics of the sandstones of that area. So it looks like many communities, such as Wetaskiwin, which are looking forward to a continually expanding groundwater program, can temporarily enjoy additional well construction but they must look in the long term future either to surface water or for possible water-bearing sand and gravel deposits, the presence of which cannot be ruled out of the question without detailed study.

I think our last discussion leads us appropriately into a general discussion of water shortages. I look upon groundwater shortages as falling into three classifications: economical, mechanical, and natural. I shall attempt to point out examples of each.

(1) Economic Shortage - In the city of Chicago there are literally hundreds of wells approximately 1500 feet deep which penetrate Cambrian sandstones. These wells are generally capable of yielding at least 500 gallons per minute, many capable of yielding over 2,000 gallons per minute. In the late 19th century when some of the first deep water wells were drilled in that area, the artesian pressure in the Cambrian sandstone was sufficient so that the wells actually flowed. Many of the wells had a specific capacity of approximately one to three gallons per minute per foot of drawdown. Pumping the average well at 1,000 gallons per minute, perhaps

resulted in the water level dropping to approximately 500 feet before stabilizing. At the present time, the formations are still 100 per cent saturated with water but we have had a loss of artesian pressure, so that now industries find non-pumping artesian water levels of approximately 400 feet. The sandstone formation is far below that depth and still has the ability to produce approximately one to three gallons per minute per foot of drawdown. But to produce the same amount of water, say 1,000 gallons per minute, they may have to pump from as deep as 850 feet. This means that industries in that area now are getting much less water at a given pumping level than did industries many years ago. Now, most industries in the Chicago area have the option of buying water from the metropolitan water district which obtains its supply from Lake Michigan. Where 15 or 30 years ago it was a clear advantage for the average industry to maintain its own deep well supply, many of them are nearing the economic level where it is cheaper for them to purchase water from the water district. Each gallon of groundwater is becoming increasingly costly to them and the industries are suffering what we consider an economic shortage. The cost of obtaining groundwater is locally reaching the point where some industries are seeking alternative sources. There are many other examples of economic water shortages but that will serve as one. (2) The second type of groundwater shortage is one which we hear about frequently and that is the mechanical shortage. For example, a two-mile four-inch water main from which a large number of services have been constructed, results in a water shortage which is just as real to the housewife as any other form of water shortage. Such a condition results in an increasing cost of producing water and perhaps water rationing which is basically caused by mechanical conditions and not natural ones. The alleviation of mechanical water shortages should be no farther away than a competent analysis of the trouble.

(3) A third type of water shortage is the one which gets most of the blame but which is only partially responsible. This shortage is caused by poor geologic conditions or climatic conditions unfavorable to the support of a perpetual groundwater supply. This type is a real water shortage, one which is caused by basic natural conditions. I would like to point out that there is a very great difference between our suffering from a temporary mechanical shortage and our suffering from a shortage of water that is caused by deficiency in natural conditions.

Virtually all of our country was settled without any recognition of the natural conditions which exist below the surface of the earth and without any recognition of the natural potential of the area. As our demands for water increase, it is an unavoidable certainty that the areas which are poorly endowed with water, are the areas where the first natural water shortages take place. It may actually take a long time before the good and the bad areas can be distinguished, merely through a growth of the demand for water. But eventually the good and the bad will be quite obvious. Although surface water potential is more easily recognized than groundwater potential, the same type of natural water shortage can actually take place in the case of surface waters. To a woman in her kitchen who turns on the water tap and finds no water, the shortage to her is a very real and apparent one, but she is in no position to recognize the basic cause of such a shortage. I think that the people here are in a good position to analyze the various shortage problems in Alberta, to recognize the problems for what they are, and to seek the solutions to these problems with sound planning. Inasmuch as Alberta is a young and underdeveloped region, she is in an enviable position to exercise foresight in avoiding serious water shortage. For example, Mr. Maggs, at Wetaskiwin, have you been able to keep ahead of your water demand through sound engineering and planning, despite the difficulty that has been experienced in the locating and construction of high-capacity water wells?

Mr. Maggs:

Generally speaking we have, but our demand is now growing steadily and whether we can maintain the supply is somewhat open to question.

Mr. Foster:

Are there other areas in this province that may have come to the attention of people here, which are attempting to attract industrial growth and are finding themselves in an unfavorable situation in regard to a continually expanding water demand? It would be very beneficial if we could have information on a great many communities in this situation so that their individual problems can be studied. I happen to be a little more familiar with the Wetaskiwin problem because of correspondence with Mr. Maggs and because my attention had been drawn to that area as one in which a good contribution can be made, with the possible discovery of sources of water in glacial deposits. I would be glad to have you, Mr. Hamelin for example, mention various areas in Alberta where a delicate problem exists relating to the source of water supply.

Mr. Hamelin:

Well, I hesitate to mention any specific towns. However, I think I can generally say the towns in the Peace River region, east of Edmonton, east of Calgary, east of Red Deer, and generally east of the line between Edmonton and Lethbridge have been very reluctant to make any plans for attracting industries which might require large volumes of water, because these towns have always considered themselves as having inherent natural shortages of water. Generally speaking, the amount of test drilling that has been done up to date has not changed that attitude. Whether supplies can eventually be found that will change this situation, I hesitate to say, but from experiences in the past the local people have been doubtful of these possibilities.

Mr. Foster:

Mr. Hamelin has pointed out that there are many communities that lie generally west of the 4th Meridian and east of the 5th, where they are finding that the only formations available to them, at least through random location of wells, are the Cretaceous sandstones which are locally extremely tight. In some exceptional areas there are not water-bearing sandstones and the bulk of formations below the community are impermeable shales; I look upon that general region as one where our glacial studies can be most valuable inasmuch as we have an opportunity of pointing out within that broad region very limited areas in which deposits are suitable for very carefully engineered wells in sand and gravel. We do not know nearly as much as we should know about the occurrence of glacial sand and gravel in Alberta. Of all the places in the province, surely the area between the 4th and 5th Meridians, north of the International Boundary and south of Lac La Biche is where our glacial studies can be of greatest importance, economically speaking. I cannot illustrate too strongly to you that when we think of high-capacity well construction, we must think in terms of high permeability. We must not worry too much about the recharge problem unless it is obviously going to be a problem. We must spend more time working out the details of good well location and construction, in order to gain maximum amount of yield and minimum well interference.

This would be a good moment to indicate to you what I have in mind when I speak of high-capacity wells. Let us consider first a good domestic or farm supply; we think in terms of 3 to 10 gallons per minute. It does not take much of a geologic formation to yield that much water and it does not take much in the way of well construction to yield that much water, although I am a great believer in careful well construction even in the case of small rural supplies, not only for long life of wells but for continuous safe yield from a sanitary point of view. I think that Mr. Hogge and other sanitary engineers here are quick to point out that many a failure in a farm and domestic water supply is not due to any failure of natural conditions, but due to a failure of the well contractor to make the right kind of well for the geologic situation, resulting, perhaps, in a diminishing yield of that well or resulting in hazardous bacterial quality of water obtained from that well.

In the case of small industrial or school wells, we may think in terms of 20 to 50 gallons per minute. It takes a considerably better formation and considerably better well construction to yield that much water for a long period of time. A medium industrial supply, I consider, is one which demands upwards of 200 gallons per minute. A major industrial supply may require upwards of 500 gallons per minute which approaches 1,000,000 gallons per day. I would like to point out that there are a number of areas in Alberta which could support properly constructed and engineered water wells yielding 3,000,000 gallons per day each, which is something in the order of 2,000 gallons per minute. Such wells are extremely rare in Alberta at the present time, I think partly due to failure by the people of Alberta to recognize that such high-capacity wells are practical in many areas and possibly their own immediate areas. I would like someone from this group, for example, Mr. Hainstock of International Water Supply Ltd., to mention a few of the high-capacity wells, not necessarily in Alberta but in Western Canada, with which he may be familiar.

Mr. Hainstock:

All of the very high-capacity wells that I know of are directly associated with sand and gravel deposits in the glacial drift or in the alluvium of major stream valleys. I know of no large capacity bedrock wells; that takes in Alberta. I know of a few which probably produce more than 150 gallons per minute from the bedrock but the majority are in about the 25 gallon per minute class.

Referring to the point which you brought up about various towns looking into the future, not only for industrial requirements but for additional town requirements, I would strongly recommend that they and everyone here definitely consider further investigations of the unconsolidated deposits for future supplies. Personally, I am very reluctant to think that many of the bedrock formations will be able to meet growing requirements. In some of the towns in Alberta which have limited water supplies, for example, the community of Vermilion which has good sand gravel deposits in a nearby stream valley, careful attention should be given to such potential sources.

Mr. Foster:

That illustrates very well a point which I wish to put across to the group, namely, that the solid bedrock formations are certainly not encouraging for high-capacity well construction, probably not beyond the

100 gallon per minute class, and in many areas the best available well construction may fall far below that class.

I think one of the most rewarding pieces of work which the Research Council and other provincial organizations can do is, to educate the industrial people and the municipal representatives that if they have very favorable sand and gravel deposits available to them for well construction, they should use those deposits rather than revert carelessly to alternative sources of water. I think with regret of the towns of Banff and Jasper, which have gone to elaborate engineering to obtain surface waters for town supply. Of course, both are located in very famous surface water areas. There are some enormous sand and gravel deposits occupying the Athabasca valley, immediately in and near the town of Jasper. I am sure that I could engineer a water well which Mr. Hainstock or Mr. Hamelin or other contractors could execute, that could very adequately supply from a single well all the water Jasper could hope to use. I think the same holds true for Banff and several other communities situated in the Bow River valley. Communities should not go to great expense to pipe water and to protect valuable surface waters where such engineering is not necessary.

In the use of surface waters, the waterworks people must cope with seasonal changes in the temperature, chemistry, and turbidity of water. Where conditions are favorable for groundwater, the engineering of water supplies should make use of those natural conditions. That in my opinion is the key to efficient water development and basically the key to water conservation. Water that is left in the ground, is of no value to anyone. It has value only when we can tap it and make use of it.

I wonder if we can take a few minutes now to look at the geography of Alberta and what the future holds in way of the concentration of industry and population. I think appropriate along this line is a letter which Dr. Grace received from Mr. Oberholtzer, Deputy Minister of Industries and Labour, covering this very point. I would like to have Dr. Grace read the letter at this time and officially enter it into the proceedings of this meeting.

Dr. Grace (reads letter):

Dear Dr. Grace:

I have your letter of September 9th and I am very sorry that it will be impossible for me to be in attendance at your groundwater meeting, September 27th. However, I am setting down a few random thoughts which may be of some assistance to you.

(1) For the past several years new industries have been coming into the province at the rate of something of the order of $100,000,000.00 of new investment per year. This has been almost equalled by the amount of extension to existing industries. Of course, not all of these new industries are users of large quantities of water.

(2) The value of Alberta's manufactured products has increased from approximately $100,000,000.00 in 1939 to well over $500,000,000.00 in 1954, or in other words, an increase of $100,000,000.00 worth of production every four years. The progress in the last 15 years has been very steady and I personally can see no reason why it should fall off perceptibly in the next 20 to 50 years.

(3) Speaking optimistically, our industrial potential seems almost unlimited. However, our water supply is definitely limited and it may be that industrial development might be badly hampered by the shortage of water if careful planning is not undertaken at the present time.

(4) I am especially concerned with chemical plants, that usually require considerable quantities of water, and it is in this field particularly where real expansion in Alberta is anticipated. The Trans-Canada Pipeline project, once underway, will provide large quantities of raw materials for this type of plant. In regard to chemical production, it could be suggested that we, in Alberta, are somewhat in the same stage of development as the Southern States were ten years ago. Their growth has continued unabated and we can expect to do the same.

Finally, we would respectfully suggest that although we anticipate the province's population will grow steadily, it is probable that the industrial expansion will increase even more rapidly, and proportionately, industrial demands on water supplies will increase at a more rapid rate than the domestic requirements, which themselves are serious.

In conclusion, I should like to offer the assistance of this Department in any way possible in further studies of this nature.

J. E. Oberholtzer,
Deputy Minister of Industries
and Labour

Mr. Foster:

Does anyone have comment to make on Mr. Oberholtzer's letter and are there any statements which should be entered into the proceedings on this subject? Perhaps Col. Parsons could give us a few remarks regarding expectations in the Calgary area relating to future industrial growth.

Col. Parsons:

Well, Mr. Foster, after hearing Mr. Oberholtzer's letter regarding Alberta's expectations, I can certainly agree with it. It appears to me that in another 20 years we are going to be scratching for water in many areas. So far as Calgary is concerned, we appear to be very fortunate in having excellent sources of groundwater. When I talk to people, I usually point out to them that Alberta seems to be in the same situation that Colorado was 20 years ago, so far as industrial expectations and population growth are concerned. Perhaps Mr. Oberholtzer would place Alberta only 10 years behind Colorado, but our thinking is along the same lines.

I was hoping today to get some indication that the Provincial Government is going to undertake some sort of survey of groundwater. What I have in mind is the need for someone to show us what areas have a great natural industrial possibility so far as water is concerned. I have always felt that a survey of this nature will be required sooner or later, and it may as well be started right now. There must be areas in this province which are definitely unsuitable for industrial expansion, and there must be areas which are suitable. I was glad to hear that the geologists are working on mapping the glacial deposits, because I think we all agree that most of the bedrock formations are too tight. I think that is about all I have to offer at this time.

Dr. Grace:

I would like to assure Col. Parsons and the other gentlemen who are here that a survey of Alberta's groundwater situation has already been started by the Research Council under Mr. Foster's direction. Mr. Lang, Secretary to the Research Council, was the first to point out the significance of this whole problem to me. I think he got some of his ideas on the subject from Dr. Allan and other geologists. We hear so much about irrigation and irrigation water development. To me, it has been a bit of a shock to learn that in the not too distant future the livelihood of some of our major communities, or communities which could become very much larger, will be jeopardized by lack of appreciating the whole water problem. This problem is one which does require most careful planning and research of the highest order. I don't know whether it is fair to ask, but what is the estimate, Mr. Fleming, as to the future population of Alberta, some 2,000,000?

Mr. Fleming:

The Department of Labour has come up with a figure of 1,800,000.

Dr. Grace:

So we foresee an accelerating industrial development and it behooves all of us to see that the whole water program in Alberta is handled in the most effective manner.

Mr. Randle:

For what year is that estimate relating to population growth, Mr. Fleming?

Mr. Fleming:

1985. We have just completed some second guessing in regard to Alberta's future population, judging the future by the past and by the natural potential which we have -- in other words, taking in as many factors as we can think of, in order to arrive at our prediction.

Mr. Randle:

I think that is reasonably conservative.

Mr. Fleming:

There are so many variables involved in this problem.

Mr. Foster:

Geographers are the first to recognize the significance of the barrier of the Rocky Mountains in affecting the population growth pattern in Alberta. Calgary undoubtedly enjoys its favorable location relative to passes in the mountains, such as Kicking Horse used by the Canadian Pacific Railway. Edmonton, of course, is the gateway to the north country, including the Peace River valley, but at the present time it does not benefit by any ready transportation contact with the west coast, other than the Canadian National Railways through Yellowhead Pass. I have a suspicion that eventually there will be greatly improved road access into British Columbia west of Jasper, and that as a result there will be improved industrial development both east and west of Edmonton. Certainly, Calgary has a great situation there at the present time, by having what is probably the most ready access to the west coast. Col. Parsons, don't you think that is an important factor in Calgary's present and future expectations?

Col. Parsons:

That is one of our main talking points, and certainly the location of Calgary transportation-wise accounts for population growth. Of course, our present oil situation is very important, too.

Mr. Foster:

Looking into the very distant future, what do you picture in the way of transportation lines across the Rockies? Are we going to find ourselves in Alberta with a situation like Colorado where they have a number of heavily used highways across the mountains? For example, west of Red Deer there is no existing pass being used and one cannot expect the Red Deer area to enjoy a location as favorable as Edmonton and Calgary.

Col. Parsons:

I think the geographical pattern was established some 40 years ago.

Mr. Seibert:

Well, we have Crowsnest, Kicking Horse, Yellowhead, and Pine Pass into the Peace River country. They seem to be the only ones left.

Mr. Foster:

Would you go so far as to say population is going to increase principally on the outskirts of those passes rather than between them, that is, rather than on north-south lines?

Col. Parsons:

I don't think you should overlook this north-south trend. I could give some population trends in the United States. Montana is getting along very nicely and Wyoming also. Of course, they do not conform to the general high percent increase of the rest of the United States. I think possibly Alberta, one of these days (I don't know whether Mr. Fleming will take this into account) will slow down a bit, probably due to water.

We have some pretty round figures in our own minds as to what the population of Alberta will stand in the water situation. I think if we get to 2,000,000 we are pretty nearly half-way there.

Mr. Foster:

So far as rural development is concerned the geology in most areas seems to me well situated for farm supply, because formations such as the Cretaceous sandstones may yield 10 gallons per minute. They resist attempts of greater yields. I think greater yields are possible in some areas. In my opinion we can look forward to continued increase in rural demand from these sandstones without serious effects of water shortage, because I think the sandstones will recharge to satisfy the domestic demdnd but cannot recharge to the demands of a continually expanding community. So I think we can settle the rural areas in many regions in Alberta to several families per square mile, without affecting the long-term yield of those formations. I wonder if my opinion is shared by the well contractors who are here. Have you ever found cases of well interference in rural areas where the demand is not very heavy?

Mr. Hamelin:

No, I wouldn't say so; not with these small capacities, presuming that the wells have not been spaced closer than 500 feet.

As well contractors, we are most interested to learn specifically just what the Research Council can hope to do in their survey, what they are doing, and what their plans are. We are continually put in the position of estimating what water supply we can hope to obtain for this particular town, or for some particular industry, and we have neither the staff nor the finances to do any test-drilling to determine some of these general factors. In the past, the principals involved have not been interested in having us do too much at their expense. As far as my business is concerned, I feel that in your organization more publicity can be given to the fact that, while you may not have a test-drilling program for reference, at least you have the trained personnel who would give some information on what the locality would supply. I would be glad if you would even care to take sides in the matter of well construction, because we are only too happy to do it properly. So often the financial set-up for drilling a well seems to raise quite a barrier; we are supposed to do the job in the most suitable manner. We do run into these problems. Sometimes they are not even interested in proper screening.

Mr. Foster:

I am glad you brought that up, because that is certainly going to be an important part of this discussion, specifically, how can the provincial agents help in the wiser development of these larger water supplies. I have on the agenda for this afternoon a little more specific examination of well construction and well specifications as set up by consulting engineers. I would like to suggest that we discuss the matter frankly and find out precisely the responsibilities of these various agencies that are concerned with water.

I would like first to indicate what I consider to be the responsibilities of the Research Council so far as groundwater is concerned, looking into the longer picture. In the first place, we are not in the position of competing with the consulting engineers. We are, however, in a position to act as a liaison between, say, the community officials or the engineer who represents the community, and the vast bulk of technical information available to anyone from the various agencies of this province. Anyone who is connected with the Research Council in this capacity should be thoroughly acquainted with the drilling contractors and with their problems, and it would be my ambition here to be able to interpret the scientific information that I could obtain from such agencies as the Water Resources Branch and the Conservation Board in Calgary, to summarize that scientific data, and make it available to the community and the consulting engineers and also, to the well contractor.

I would like to be in a position to make suggestions on well specifications to help the consulting engineer establish specifications that are fair not only to him, but also to the well contractor who is about to bid on a particular job. Those are some of the more specific suggestions. I think that in our research we should look for new and better techniques to improve well yield. There are artificial means of increasing well yield which go far beyond the simple use of acid or dynamite. Further, in regard to the responsibilities of the Research Council, I would like to point out that we are attempting right now to build a better library of groundwater geology information which has up until now been widely scattered in the various provincial agencies and in people's minds. There are a lot of people who know a lot of things about ground water and if we can put that information into technical form available to the public and the consultants, it will certainly be a significant contribution. Basically, the Research Council would be in a position to improve the technique by which groundwater is developed. Specifically, I foresee the Council's responsibilities in the groundwater field as follows:

1. To locate, map and publicize potential sources of major supplies of groundwater.
2. To conduct research in the engineering of water wells, aimed especially at improving well yields, their length of life and the physical and bacterial quality of the water.

3. To assist all interested parties make evaluations of the worth of aquifers and the permanency of water supply in specific areas.
4. To advise consulting engineers in the preparation of water well specifications, particularly in way of designing wells to match the geology.
5. To prepare letter-type reports on groundwater possibilities in Alberta in response to inquiries.
6. To establish a modest and effective water level observation program, designed to keep a long-term check or inventory on available groundwater.
7. To assume whatever additional responsibilities in groundwater research may be proper and needed in the future.

Our responsibilities do not enter the surface water field and I do not foresee where they would, except as surface waters may affect the recharge of groundwater formations. I wonder if this would not be a good point to have Don. Bowman, who is here representing the Water Resources Branch, brief the group on the basic responsibilities of his organization. I will also ask Mr. Pow, who is Chief Geologist with the Petroleum and Natural Gas Conservation Board, to give us information on the geological data which they have on hand there and which the Research Council will use to a very great extent in their work on groundwater. Mr. Bowman might have a few words to say here.

Mr. Bowman:

The Department of Water Resources is charged with the administration of the Groundwater Control Act. This act is primarily designed to prevent wastage of groundwater, that is with respect to artesian wells, and also to collect information with regard to groundwater supply and to provide for licensing of water-well drillers. This particular act in Section 5 gives the Director the right to inspect wells, records, equipment, and so forth. Section 6 describes steps to be taken in the event a flowing artesian well is not controlled.

Mr. Foster:

Does that include the drilling of shot holes for seismic work?

Mr. Bowman:

No, not particularly that. Section 7 makes the owner of a well responsible to take such precautions as are necessary for the safety of persons, livestock,and other property, and for the prevention of damage by reason of the presence or escape of water. Section 10 gives the Lieutenant Governor in Council authority to make regulations respecting the conservation, development,and control of groundwater. The regulations set out the procedure to be taken by a well driller to obtain a permit to drill water wells in the province; only one such permit is required each year. Every operator is required to submit a record of boring operations to the Director for every hole drilled. No. 4 pertains to artesian wells and provides for proper control to prevent loss of groundwater.

It will be of interest to the group to learn of a compilation of data which I have made from the registration file of Water Well Drillers in Alberta. This file is maintained by the Water Resources and Irrigation Department. The following list indicates the type and number of drilling apparatus currently in use in the province:

Cable tool	63
Hydraulic rotary	39
Jetting	21
Diamond	3
Auger-bucket	6

These drilling tools are operated by the 117 drilling contractors who are registered with the Department.

Mr. Hamelin:

With regard to the record forms, I would like to make a suggestion. I find it quite difficult to give you a proper log on this form because the printing requesting information is so close to the diagram on the side. In order to give you a proper log, I am forced to write over the printing that is on the form.

One other suggestion I would like to make (not with my own company in mind) -- in order to keep the smaller water-well drillers supplying you with information, you might considering sending a stamped envelope after they have sent in the formation and thereby encourage them to send more information.

Mr. Bowman:

I agree with you. I don't particularly like the type of log we have, with that inadequate sketch on the side. I would actually prefer that the well driller draw up his own log. Such changes can probably be incorporated in another printing.

Mr. Foster:

The point is that even though the Groundwater Act does require the well drillers to be registered with the Water Resources Department and to furnish logs of the wells they drill, the logs actually received represent a very small percentage of the total wells drilled. The enforcement of the act is extremely difficult and can only be done with the co-operation of the drillers; that has certainly been my experience elsewhere. I am hoping that co-operation will improve as time goes on.

Mr. Pow, would you outline to the group the responsibilities of the Petroleum and Natural Gas Conservation Board?

Mr. Pow:

Our work is only indirectly related to groundwater, in that we must make sure that aquifers are protected when oil wells are drilled. Therefore, the Board enforces certain casing requirements, and to do so, it has to keep in mind where the deepest potentially economic aquifer is.

Sometimes we have to keep in mind that while a shallow aquifer may presently be used in that part of the province, a deeper aquifer may have to be used sometime in the future, and possibly those deeper aquifers should be protected. We are not always in a position to protect the deeper aquifers because we may not be aware of their presence or depth. If the surface casing in oil wells does not go deep enough, the aquifer will be exposed to an open well and exposed to capture by lower thief sands. The main problem, I think, is keeping these valuable aquifers from being exposed to an open oil well. In addition to protecting these aquifers, there is also the danger of core holes and shot holes which possibly are drilled with close spacing and which are not plugged. These open a sequence of sands which might also expose the aquifer to lower thief sands. That is also a danger which falls under the jurisdiction of the Department of Mines and Minerals, who require the plugging of core holes beyond a certain depth.

While groundwater resources are not the responsibility of our Board, we do have certain information with regard to groundwater on hand. Firstly, the Board supplies water-well drillers with a well data form meant to be used for wells over 500 feet. The purpose of that is to require a license if the well is over 500 feet. The license is accepted and approved by the Board. The forms have blank spaces on which the most important information is reported. I must admit that there has not been too much supervision in this phase of the Conservation Board's work. Drillers should be aware of the importance of these forms for deep wells. Due to our being so busy with matters related to oil wells, we sometimes overlook the importance of water-well data. We will be turning the water-well forms over to the Research Council, since they are now becoming more active in the field of groundwater resources.

The second type of information that we have, consists of core hole logs. Core holes are drilled to depths of between 400 and 1,000 feet, specifically for the purpose of mapping the shallow stratigraphic markers which in turn indicate structures at greater depths. Core holes are logged with electric logs. These are of value in determining the location of permeable material. We have such logs for just about every core hole drilled in the province, and they form a vast file classified by location. These logs are the property of the Department of Mines and Minerals, but I believe they would be available to any organization doing groundwater research. These files are confidential to oil companies, because we do not want them used by competitive companies to guide where the structures might lie. From the slim-hole electric logs we have no quantitative way of determining the permeability of formations, but in a qualitative manner it is possible for a geologist to determine the general zones of sandstone permeability. Some logs are much more valuable than others in this regard.

The third type of information which the Conservation Board has, again coincides fairly closely with the Department of Mines and Minerals. Photostatic copies of all reports to the Department of Mines and Minerals relating to the drilling of seismic shot holes, are sent to the Board. Seismic shot holes are generally drilled to depths of 50 to 200 feet. Whenever an artesian flowing condition is found in these shot holes, the provincial code requires that a report of this condition be made out and furnished the Department of Mines and Minerals in Edmonton. This report is supposed to include the location of the shot hole, its depth, and other pertinent information relating to the flowing condition of the well. The Conservation Board maintains this file by location.

The fourth general type of information filed by the Conservation Board is made up of general Dominion Government groundwater survey reports.

In the early thirties the Dominion Government completed a type of groundwater survey up to about Township 11. These reports are largely compilations of data obtained from conversations with well owners, giving such information as the depth of the well, the general water-yielding ability of the well, and water quality. Current Dominion Government work in groundwater in Alberta is being conducted by Dr. Max Stalker. These reports supply a great deal of basic information concerning conditions in the areas covered, but the reports do not contain much interpretation.

The Conservation Board has a fairly extensive file of water analyses. These pertain mostly to deeper formations because the analyses relate to oil-field studies, but there are many instances where information on relatively shallow formations is received and filed. These analyses are quite significant in that some formations appear to contain a characteristic water quality. In one area which we have studied, certain sandstones contain water which has a characteristic radical, for example, the SO_4 radical. In this particular area the next lower sand contains water which is characteristically low in the SO_4 radical. The importance of this information will come when actual correlations can be made on the basis of typical chemical radicals. From such work it would be possible to know, for example, whether a series of wells all produce from one aquifer or whether they produce from a number of different sandstone members of the same formation.

Unless Mr. Greenwood has something to add at this point, I think that covers the activities of the Conservation Board insofar as groundwater resources are concerned.

Mr. Foster:

It is my understanding that the Conservation Board has engineers scattered throughout the province to enforce the requirements that are set up by the Board, for example, the setting of surface casing.

Mr. Pow:

That is correct, and I might add that if any well contractors in the province discover areas where formations are not being adequately protected by our current casing requirements, we would be glad to know about those areas. The Conservation Board would consider increasing the casing requirements in areas so reported, although it may be impractical to protect all of the potential aquifers because some of them are so deep.

Mr. Foster:

It seems to me that the well contractors are in an excellent position to assist the Conservation Board in the protection of the fresh waters. This protects their own interests by maintaining good groundwater conditions.

One other agency of the Provincial Government which is concerned with groundwater, water quality, and well construction is the Division of Sanitary Engineering of the Department of Health. Mr. Hogge who represents that division is here, and I believe is willing to spend a few minutes giving us information on the activities of his division.

Mr. Hogge:

Our responsibilities in the field of groundwater result from the Public Health Act which provides authority for the protection of groundwater supplies. One of the regulations with which we are in close touch is that which prohibits the discharge of sewage into underground disposal. We find that old wells in particular are apt to be called upon for such use if we are not careful.

Just to give you a general picture of our work, it would be well to read into the records some data which I have concerning communities in Alberta which obtain groundwater supplies. At the end of last year we had 131 Alberta communities with public water supply systems. Seventy-four of those systems were using groundwater as a source of supply and 57 were using surface water. Population-wise, the percentage is reversed because such cities as Calgary, Red Deer, Lethbridge, Medicine Hat, and Edmonton use surface water at the present time. In 1951 the total population of Alberta was approximately 900,000. The number of people served by municipal water systems was 471,000; this is a little better than 50 per cent of the total population. Among these municipal supplies, approximately 86 percent are served by surface waters and only 14 per cent of the people are served by groundwater. On the other hand, almost 50 per cent of the people of the province depend upon private, domestic, or farm supplies, and it would be safe to say that at least 90 per cent of these obtain their supplies from groundwater sources. To sum up then, certainly more than 50 per cent of the people of Alberta depend upon groundwater for their livelihood.

Mr. Foster:

Thank you for making those very significant points. One point on which I am not entirely clear, Mr. Hogge, relates to the Public Health Act and its reference to the use of water wells for the disposal of surface water.

Mr. Hogge:

No provisions have been made, to my knowledge, concerning this matter by the Public Health Act, but I think we have the authority to make regulations concerning the use of wells for underground disposal of contaminating water.

Mr. Foster:

Is it necessary that approval from your Department be gained before wells can be used for subsurface disposal of waste water?

Mr. Hogge:

I would have to check on that.

Mr. Foster:

I believe any plans for water works improvement in municipal supplies must be approved by the Department of Health prior to new construction.

Mr. Hogge:

That is correct.

Mr. Foster:

One weakness in the general system of municipal water supply development in Alberta concerns the fact that despite Government aid in financing water works systems, little or no serious investigation is made of the permanency of the source of supply. It seems to me that investigations of this order should be at least comparable to the investigations required by private bonding companies in areas where they are the principal source of financial backing. For example, at present it would seem to me quite possible that a community could finance through the Provincial Government a water works system, presumably based on a 25-year period of use, and later discover that the source of supply was by no means adequate for that length of time, under the engineering that had been approved and paid for. There is no group or agency responsible for assuring the permanency of the supply over the finance period. Is this correct?

Mr. Hogge:

We have records that indicate that a number of towns, a few years ago, had precisely this type of problem in that their groundwater supply appeared inadequate after the distribution system had been installed. The procedure which is followed now in establishing water works systems is that, the consulting engineer draws the preliminary plans of the over-all system.

In the case of groundwater supplies we require a special clause which gives an assurance, at least on paper, that the supply is adequate for the system which is being engineered. I believe the consulting engineers depend almost entirely on the well contractors for such assurance, and none of the engineers feel that they are in a position to undertake detailed studies along these lines. We do require that these agents for the town provide our department with information indicating that sufficient testing and well construction has been accomplished to assure the supply. I think in many cases the water-well contractors are reluctant to be specific in their statements concerning the supply.

Mr. Foster:

I would like to ask one of the consulting engineers present for remarks on this point of discussion. I am interested in knowing precisely what methods of evaluation of long period of supply are made and what improvements can be suggested concerning the present development system.

Mr. Thierman:

I think we must rely principally upon the water-well contractor for detailed information about the supply. We would like to get each individual community to undertake a test-drilling program involving say two or three thousand dollars, but when we as engineers come up with such a proposition, all we get is a blank stare. This is particularly true with the smaller communities which are working on a very low budget. We have the general attitude that the water-well driller is the expert, and we rely on his ability to tell us what is there and what we can expect in the way of permanency of supply. To some extent we evaluate the condition by examination of records on well yield, water level drawdown, and water level recovery. The information which I have on groundwater in this province is, that groundwater is very lacking in some areas. Generally speaking, the bedrock is no better than a poor to fair source. I don't think we have found bedrock yielding more than 20 or 25 gallons per minute. We appreciate the need for finding sand and gravel sources of groundwater, but there again, we are very severely restricted by finances. We quite often find that apparently the only sand and gravel sources are located one or two miles from town and it may be economically impractical to bring water from such a distance.

Mr. Randle:

I would like to say, with all due respect to the consulting engineers and to the drillers, that unless they have had experience in the area concerned, I would not value their statements very much relating to the water supply. As Mr. Thierman pointed out, many communities and even industries are unwilling to spend sufficient money for a proper evaluation of their natural conditions. In many instances they can not economically handle it. It seems to me that the Provincial Government itself should take a lead and should provide funds to make a survey, either by actual drilling or by other tests.

A number of years ago I had a great deal to do with the late Dr. Allan of the University and the Research Council, a man whom we all respected very much. Basically he could speak only in generalities, though he knew the geology of the province very well. Even he could not forecast, without some actual drilling, the sustained delivery of the well. For example, in the Camrose area we have a number of sandstone formations, one around 180 feet deep, another around 140 feet deep, with which we did some development work. On our well No. 3, work was continued for some time and the results were most promising. On the strength of that success we later drilled another well and we found that when the second well was pumped, the yield of the first dropped very low, something around 15 per cent of its former production. Quite obviously there was interference between these wells. This was confirmed by repetitive tests.

Mr. Foster:

How far apart were those wells,sir?

Mr. Randle:

Approximately 150 feet. However, in the Wetaskiwin area we have not noticed any interference between wells.

Mr. Maggs:

We have had the odd case, but in general there has been no well interference.

Mr. Randle:

To explain further, the first well was capable of about 14,000 IGD and the second well capable of 19,000 IGD; when the second well was pumped for a day or so, the yield of the first well dropped to about 3,000 IGD. There is no such serious interference nor anything approaching such interference,in the Wetaskiwin area.

Our No. 5 well at Wetaskiwin, which was drilled in 1930, originally yielded approximately 40 gallons per minute with a 40-foot drawdown. The top of the sandstone formation lay at approximately 140 feet, the pumping level was about 125 feet. Today, that well will not yield 5,000 gallons per day with the pump set at about 230 feet. One might assume the area around the well has actually been depleted of its groundwater. However, one might go 2,000 feet from this location and get a good well. Dr. Allan had the opinion that these aquifers are lenticular.

From all this discussion involving several government departments (we know all these personally and we think they are doing a good job with the equipment, time and information available to them), it does seem to me some of that work could be effectively centralized in one department. The population of this province is going to grow and except for the cities that are fortunate to be located on a large river, the communities have a problem and a growing problem of meeting water needs. I think the job will be done most economically by central authority. I believe such a department should be adequately equipped and staffed to act as leaders and not merely to establish files of information. They should also have the responsibility of disseminating some of this information to such people as well drillers, municipal authorities and others. This would be a very good thing; I spoke to Premier Manning about it many years ago. I do feel that he has had this in mind for some time. The late Dr. Allan has spoken of these matters, too. It is my hope that out of this conference some approach can be made to the Provincial Government to provide funds for the purpose of making a survey of the whole water problem.

Mr. Foster:

It is quite clear that the present attack is not satisfactory, and will not effectively meet the growth of these problems. It appears that the consulting engineers are not in a position to undertake studies which the town is unwilling to support. The drilling contractors are being abused when they are asked to make a judgment without the funds for whatever test-drilling is necessary to make that judgment. Vast improvement can be made in our approach insofar as specific assays of groundwater potential are concerned.

I would like to call this morning session to a close and we will adjourn for lunch. We will meet back here at approximately 1:30.

Afternoon Session

Mr. Foster:

One aspect of groundwater development which is of interest to everyone, not only the contractor but the consumer and the government officials who are concerned with our water resources, is the legal aspect of groundwater as a resource. We are all fairly familiar with the legal aspects of the recovery of oil, minerals, and sand and gravel, but this elusive subject of groundwater is a rather perplexing one. There is a tremendous variation of water codes in North America, and it is of interest to us to know the legal position in Alberta. We have been fortunate this summer in having working with us, not only in legal investigations but in other phases of my work, a senior law student at the University of Alberta, who has been willing and able to go into the legal aspects of groundwater development. I would have Mr. Ingram at this time present a brief summary of the legal aspects of groundwater development.

Mr. Ingram:

I have prepared a full report on this subject which will be available at the Research Council for anyone to refer to, but for our purposes this afternoon, the law with regard to groundwater will be stated in its simplest form. Let me begin with the precaution that any legal advice that you get for nothing, is probably worth what you paid for it, and that the report this afternoon is only a guide. So if you should run into any legal problem, it would be unwise to rely strictly on what I give you here.

The main consideration with regard to groundwater is, that it is a resource, an asset, lying under a person's land, and like any other asset we are interested in the ownership. It is my opinion that the law in Alberta is very clear on this subject; we are not too concerned with who owns it, but rather who may use it. The right to use groundwater is best set out in Halsbury's Laws of England* as follows:

> "The owner of land containing underground water, which percolates or flows by unknown channels to a neighbor's land, may divert or appropriate it as he pleases, so that his neighbor may have no underground water in his land, or so that the stream which he owns may be diminished in consequence of the underground water which has been appropriated, not coming into his stream. This right of diversion or appropriation may be exercised whatever the motive may be, and it matters not how long his neighbor has enjoyed the use of the percolating water for the neighbor acquires no rights in law, because water in an unknown channel or percolating water cannot be the subject of prescription or grant. Consequently, any person may by drainage or other works on his own land drain his neighbor's well, for this is a case of '<u>damnum absque injuria</u>' (which may be defined as an injury which does not give rise to a cause of action)."

Groundwater forms a special legal category distinct from water flowing in a defined channel, water in the ocean, or water in a permanent lake or pond. Groundwater is a common reservoir on which anyone may draw, but in which no one has any rights prior to appropriation of it. The law in Alberta has not developed beyond this stage. The owner of land, or anyone claiming a right to the water through the owner, may appropriate anything under the land including water and whatever may be dissolved in it, and a neighboring landowner has no legal cause of action merely because such appropriation has drained his well or cut off percolating water which would have gone into his stream. You do not own the water while it is in the ground but by bringing it to the surface you may appropriate it and own it absolutely as you would any personal property. I think that sums up, for practical purposes, anything you might be interested in with regard to the ownership or use of groundwater.

You may wonder why the law in Alberta has not developed beyond this stage. I think there are some very good reasons. I won't go into

* Halsbury's Laws of England, 2nd edition, vol. 33, page 601.

detail except to say this, the cases which decided our law are English cases and were decided over a century ago. At that time absolutely nothing was known about the geological or hydrological aspects of groundwater. The subject was a complete mystery and the courts merely dealt with each case as it arose, usually from the point of view of real property law. These cases are authorities in Alberta and to the best of my knowledge after some investigation, there has been no change whatsoever. In the United States considerable change has been made. My opinion as to why the law is as it is, is supported by the comments of a later court. Lord Penzance of the Judicial Committee of the Privy Council, in a case late in the last century, refers to the leading cases which decided the law as I have stated it and His Lordship says,

> "The court in both cases cited dwelt upon the extreme difficulty if not impossibility of pursuing the courses of this natural percolation of water so as to bring together cause and result with that reasonable degree of certainty which ought to attend the enforcement of a legal right, and relied upon this difficulty as a prominent reason for declaring damages of this description to be damnum absque injuria."

While it is clear that knowledge in respect to groundwater has come a long way since that time, the law has not changed. If you are interested in the conservation and development of this resource and the protection of underground waters, the present state of Alberta law is not in your favor. Let me illustrate. One landowner having a well in the centre of Calgary, if it were possible from a geological point of view, could consume any amount of water and do anything he wanted with that water except injure his neighbor with it, once it was on the surface. No one else in the city of Calgary, even if he were able to completely drain that aquifer, would have any right to restrain him from that kind of activity. I hope I have made the position fairly clear.

With regard to pollution, that is the changing of the natural qualities of the water (a typical instance of which was mentioned by the Sanitary Engineer -- the throwing of refuse into an old well and thereby contaminating the local groundwater), again I think the law is quite clear. For most purposes, pollution of underground water stands in the same position as pollution of a surface stream. A person whose underground water is contaminated, whether it be by an oil company in allowing salt water to enter a freshwater sand or by anyone else in any other manner,definitely has an action against the person contaminating it. There might be an exception to that. If an oil company has met the requirements set out for the depth of casings by the Conservation Board, and fresh water is still contaminated, I would not care to express a definite opinion one way or the other as to the oil company's liability. It seems to me on general principles that an oil company which meets the prescribed standard of care would probably not be liable.

Mr. Greenwood:

They can't hold the Conservation Board responsible.

Mr. Ingram:

Very generally speaking, if the government sets a standard of care and an individual meets that standard of care, he could not be held liable, but where it is obvious that a danger is created by a person's activities and the standard of care prescribed is merely a minimum, that person would still be liable if his conduct was not reasonable under the circumstances.

Mr. Greenwood:

The Board regards the casing requirement as a minimum.

Mr. Ingram:

That being the case, the oil company may still be liable if the standard of care adopted were not reasonable with regard to all the circumstances. There has been some difficulty in being precise as to the law in Alberta because of a lack of litigation on this subject. I would suggest that the Water Resources Branch, the Conservation Board, and other government departments such as the Public Health Department, have carried on so much administrative work by way of informal arbitration that there has been just no litigation. People generally have preferred to deal with your departments rather than take disputes to the courts.

We should consider the position of groundwater once it has been brought to the surface. Fortunately, there is an Alberta case which came before the Supreme Court in 1945. In that case the plaintiff sought and was given both an injunction and damages because of an uncontrolled artesian well on the defendant's land which flowed onto the plaintiff's land and caused damage. This illustrates that once groundwater is brought to the surface, it is dealt with by the courts in the usual terms of civil liability.

I would like to give you very briefly some ideas on what the American States have done with this subject. The common law of England was adopted by most of the American States before these leading English cases, and so American courts were not bound in any way to follow them. In certain areas of the United States, especially the Southwest where there is a scarcity of water relative to the demand, it is obvious that a strict application of common law rules would have a most inequitable result and so certain special rules have grown up. Many of the Eastern States still follow the English common law doctrines with just a few minor changes. A distinction is generally drawn in American law between groundwater which merely percolates in the subsoil,and groundwater which is contained in a saturated aquifer in a fairly definite area. American courts deal with these classes in slightly different ways. The English common law rule, whereby you can take whatever you find under your land, has been applied, especially in the East, to groundwater which merely percolates through the subsoil. But with regard to an artesian basin or a saturated aquifer, different rules are applied. Here the rules that are applied seem to me to be very similar to the rules applied at English law with regard to water in a stream or river. The various States have been free to develop their own law and with the exception of constitutional or interstate matters the differences, especially in different regions, are more striking than the similarities. The attitude towards groundwater in the United States is different from our own and this can be seen in the fact the American Restatement of the Law deals with it under the head of civil liability, whereas we here in Canada, following English precedents, look upon groundwater as being under the head of real property.

I will not attempt to examine the Reasonable Use theory nor the Prior Appropriation theory in any detail. These have been applied in varying forms in different regions of the States. But I would like to outline very briefly a legal setup which is different from our own and which may give you some idea as to how ours may someday develop. Under the Reasonable Use theory, every issue before the court as to the liability for the use of groundwater is dealt with as one of fact, of reasonableness. I can only give you some idea as to how the reasonableness or otherwise is decided. A landowner will be liable for unintentional injury through the use of water only where such harmful use is negligent, reckless, or ultra-hazardous. This terminology illustrates the attitude that the use is a question of civil liability and not a question of real property rights. Where the harm is intentional, an action will lie only if the harmful use is unreasonable. A use is unreasonable unless the utility of the use outweighs the gravity of the harm. American courts attempt to determine if the utility of the use outweighs the gravity of the harm. The utility of the use is determined by considering the social value attached to the primary purpose for which the use is made, the suitability of the use to the character of the locality, the impracticability of preventing or avoiding the harm, and where the water is used. The factors which go into a consideration of the gravity of the harm are: the extent of the harm, the social value attached to the particular use interfered with, the suitability of such use to the character of the locality, the burden placed on the injured landowner to avoid the harm, and where the water interfered with was used. As you can see, a lot of rather nebulous factors are considered by American courts in determining the reasonableness of a use.

Alberta courts, and Canadian courts generally, are reluctant to attempt to weigh such matters. For the present at least, Alberta law stands as I have stated it. While our law is much simpler and more readily predictable in any particular case, it is easy to see that inequitable results may be the price of simplicity and that some changes are necessary for any extensive program of conservation and development.

I wonder if my friend,Mr. Gisvold, who has done work on the subject,would care to correct me or to add anything to what I have said.

Mr. Gisvold:

The ownership of groundwater in Alberta is vested in the owner of the land. It is regarded as an incident of his property. He may make whatever use of the water he wishes, even though he diverts water which would go to a neighbor's well. There is no limitation to the use to which he may put the water as there is with surface water. The only limitations are those which flow from the groundwater control line, but the Groundwater Control

Act does not change the ownership of the groundwater as the Resources Act does for surface waters. The Lieutenant Governor in Council may make regulations with regard to the use and control of groundwater. I don't see anything in the Groundwater Control Act with regard to pollution of underground waters, but the Lieutenant Governor in Council may make such regulations. There is a general limitation that water must not be used in such a way as to cause nuisance to another landowner. If you ask me what a nuisance is, I can only tell you that there is no agreed-upon definition of the word, but such factors as the benefit to the landowner and the damages to the other person would be considered.

Mr. Ingram:

I would like your opinion as to how wide the powers are given under Section 10, to make regulations respecting any other matter incidental to the conservation, development, and control of groundwater. Do you think this section is wide enough to give the Lieutenant Governor in Council power to change the law with regard to ownership and use of groundwater?

Mr. Gisvold:

No, I don't think so. It is not the intention of this act to change the ownership of groundwater from private to public hands, and I don't think the Lieutenant Governor in Council could make such a regulation. There is nothing to prevent a landowner from depositing polluted materials on the surface of his land in the regular use of the land. It is impossible to fertilize land, cut timber, or raise cattle without depositing polluted material on the surface of the land. These materials may be carried underground and pollute water there. The landowner is limited, of course, in that no nuisance may be caused and there is also a limitation with regard to surface water. No such deposit may be made within a certain distance of streams, rivers and lakes. With regard to sewage, it is necessary to have permission from the proper government authority.

Mr. Foster:

I would like to ask Mr. Hogge of the Provincial Health Department to what extent protection can be given a municipal water supply against the construction of high-capacity wells. Is there anything within your jurisdiction to protect a municipal water supply from damage?

Mr. Hogge:

That would be a matter with regard to quantity rather than quality, and would come under the Groundwater Control Act, rather than our department.

Mr. Foster:

It would then come under the jurisdiction of the Water Resources Department. What is your opinion, Mr. Bowman?

Mr. Bowman:

Our department has no authority to protect such municipal supplies under the present act.

Mr. Foster:

Then it appears that at present there is no clear-cut protection for these supplies.

Dr. Grace:

Is it safe to conclude that the fact that American law east of the Mississippi is closer to the British Commonwealth is a factor stemming largely from the greater resources of water, and that in the northwest, a region more analogous to Alberta, the situation has become so critical it has been necessary to make some refinement in the legal approach? In other words, looking ahead within the lifetime of a good many of you here, to the time when this province will have over 2,000,000 people, it may become necessary that we too make some refinements in the legal approach.

I was just thinking of a little farm that I have on the side of a valley where I can dig down about 4 feet and get water. I visualize putting in a bulldozer to make a hole which would drain off the water from the plateau above me so that I might irrigate. Now, if those acres which are contiguous to me, in a dry year are super-desiccated by my irrigation operations, I gather that I would be perfectly within my own rights; I would be draining water off my own property and indirectly damaging my neighbor, may be damaging him very seriously. I would gather that presently not very much could be done to me -- not that I am planning on doing this tomorrow!

Mr. Foster:

That appears to be the case. Actually very little necessity has been found for any groundwater allocation, except in those regions where the demand for water exceeds the total available water that can be pumped. In those cases, it becomes absolutely essential that some allocation be made, because if there were not, everyone would be in a mad scramble for all the water they could get and some stage of depletion would be reached. At the present time I do not visualize any areas in the Province of Alberta where there is likely to be in the very near future more pumping than nature can actually provide for. But for example, in the Calgary area where we are dealing with a highly permeable formation in which the effect of pumping extends over a wide area more quickly, as opposed to an area of low permeability such as Wetaskiwin, the high permeability formation of sands and gravels of the Bow River valley may be over-developed locally, and there is likely to be a necessity of allocating water. It has been our suggestion in the States, to those areas where there is allocation at the present time or where there is likely to be allocation necessary in the future, to keep records of the amount of water actually pumped as to quantity, chemistry, and temperature of the water. In most areas where allocation is made, it has been found necessary to give some preference on the basis of prior use. For instance, in California the prior use of water was taken very heavily into consideration when allocations were made; so I would recommend that industries, for instance in the Calgary area where there is heavy pumping, maintain records that are presentable so that in the future they may protect the right to water which they may have established by prior use.

Mr. Greenwood:

We already have a case in my particular area, of an industrial plant apparently lowering the water table enough to cause a few farm wells to go dry. This occurred in the area southwest of Edmonton and there was no legal action taken, to the best of my knowledge. We have been fortunate so far, but this is something that is with us right now and not merely something we can foresee in the future. Large plants, such as those to be connected to the Alberta trunk line gas-gathering system, are certainly very hard on the water supply as compared to the communities in which they are situated, and I think that some regulation along this line will certainly be required very shortly.

Mr. Foster:

I wonder if anyone else here knows of any cases, not necessarily those that have reached the courts, of damage due to excessive pumping of wells.

Mr. Hainstock:

I don't know of any in Alberta. In Saskatchewan there have been one or two. Unfortunately, where the municipality puts in a fairly large well and there is any depletion of local wells, whether it be due to a lack of precipitation or anything else, the blame seems to be thrown back on the municipality. From a strictly legal point of view, I do not know how the individuals could prove that one well was actually the cause of the depletion of their own. Another point on which I would like some legal opinion is this: one may locate a well in alluvial material alongside a stream in which flows surface water; the well would obtain its water by direct infiltration of the surface supply and may be pumped at such a rate as to deplete the surface water in the stream; what would be the legal position with regard to surface water rights?

Mr. Gisvold:

There has been a case on that exact point, and it was decided that no action would lie.

Mr. Ingram:

As long as the water comes into the well or onto the land by percolation and is not in a defined channel or course, it is quite clear that the landowner may use it if he pleases.

Mr. Gisvold:

You mention a very important point in talking about 'proof', and that is, if we are to introduce new rules, we must consider that the courts need facts to work with and it is necessary to know more than is known at the present time before more definite rules can be drawn up. It seems to me that it will be necessary to have a special court with experts, because these questions would always be decided on the basis of expert knowledge. An ordinary judge has no qualifications to decide a case on the basis of information presently available.

Mr. Greenwood:

That is particularly true in connection with drilling for oil and gas. Most landowners tend to blame the nearest oil company for a lot of things, and it has always been a very serious problem to prove liability one way or the other, for instance, whether a particular well has become naturally depleted or an oil well has actually drained it. I think Mr. Gisvold has made a very good point with regard to the importance of the matter of 'proof'. I have run into the problem several times and I would like the whole thing taken out of my hands.

Mr. Randle:

To come back to these water wells that have apparently been depleted, we have had one or two cases; usually it has been the case of a shallow drilled well being depleted by a deeper well.

Mr. Maggs:

Often it is just a shallow pump setting.

Mr. Randle:

As a matter of fact, we have often lowered an individual's pump just as a matter of public relations, and I was wondering if this was true in the case quoted by Mr. Greenwood. It would be interesting to know the relative well depths and pump settings.

Mr. Greenwood:

On close examination, it appeared that the well when originally drilled just touched this water-bearing sand; this was satisfactory until the plant came along and drew water from the same zone, with the result that the water level dropped. We don't know whether it was due to the plant pumping or merely to a natural drop, but the water level dropped below the well depth. The company, even though we felt that they were not obligated to do so, deepened the well by about 20 feet and no complaints have been heard from the owner so I guess he is back producing again. That is a difficulty, of course, a lot of farmers do not know what is in their well or how deep it is.

Col. Parsons:

I wouldn't be surprised if you had a lot more of these problems in the Pincher Creek district.

Mr. Greenwood:

There is a good possibility.

Mr. Foster:

In these cases we have been dealing with a situation where the total available groundwater still exceeds the demand, so that by drilling deeper wells or lowering the pump setting we can alleviate the problem. The time will come in some areas when, regardless of what temporary remedial measures are taken, the total demand will exceed the amount the earth will produce, so that both the initial producer and the damaging producer will suffer. There is a distinction in the way we deal with these problems. In one case we are still short of the total available supply; in the other case we are dealing with a problem where we are approaching or possibly exceeding the total available supply. It is necessary to realize which situation we are dealing with. In the cases which have been mentioned, I am sure the total available supply still exceeds the demand placed on it.

If there are no other comments regarding the legal aspects of groundwater, I would like to get on to the subject of water quality. Since I am not a chemist, I would like this part of the discussion carried on principally by someone else. The chemistry of municipal water supply seems to fall, in general terms, into two broad groups. In one group, the water is extremely hard but possibly low in total minerals. In the other group, the water supplies are not necessarily hard, indeed, they may be sodium soft, but they have extremely high total mineralization. Does that seem to cover the two main groups? Mr. Hogge, you may be able to answer that.

Mr. Hogge:

Yes, I would say that there are the two broad categories, the hard and the soft. There are also the sulphates in some areas.

Mr. Foster:

I would like to say here regarding future sources of high-capacity waters and the construction of high-capacity wells, there will be increased attention to sand and gravel sources. Often the more sand and gravel sources are pumped, the better will become the quality of the water contained in them. The more we step up the circulation of meteoric waters falling on the earth and percolating into these gravels, the better will be the quality of the water we draw from the gravels. That is a further reason for encouraging the development of sand and gravel sources. When it comes to the tighter sandstone formations of the Cretaceous, we are dealing with low permeability and cannot foresee in the immediate future any significant change in the water quality, regardless of the pumping done. I would like to ask Mr. Maggs of Wetaskiwin whether he has noticed any substantial change in the water quality, relative to pumping in the sandstone formations.

Mr. Maggs:

No, I would say that there has been no material change.

Mr. Foster:

That seems to be consistent with what we could expect from that type of water source. Does either Mr. Noble or Prof. Walker have any comments to make here?

Prof. Walker:

Mr. Chairman, I have not prepared any comment. I came here more or less as an observer. I might say that there is a possibility that the sodium bicarbonate water, such as they have at Wetaskiwin and a number of other deep sources that are being used at the present time, might be looked upon as brought about by some type of base exchange. Whether that would ever be rectified by continued drawing of water, is pretty hard to say. In the case of other surface waters which we look upon as being hard, there is quite a variation in the hardness and also in the salt content, and I think that in this province we have a very great variety even with regard to so-called soft water.

Mr. Foster:

It has been my observation that the waters contained in the alluvial deposits, for instance here in the North Saskatchewan valley at Edmonton and further northeast toward Fort Saskatchewan, have an amazingly high mineral content -- far higher than we have experienced in the midwestern United States with similar geology. I cannot entirely account for it, other than possibly the fact that the bedrock has been contributing some water to the alluvium. The bedrock water is highly mineralized and discharging into the alluvial sands and gravels of the river valley. Another explanation is that the mineral make-up of the sands and gravels causes considerable variation in water quality. I understand that one well was drilled recently in the alluvium near Fort Saskatchewan, but the water quality was sufficiently poor that the well was abandoned. I wonder whether the drilling contractors have had any experience in that line.

Mr. Hainstock:

I think normally you will find a fairly high degree of hardness. Generally, the closer you approach the mountains, the harder the water becomes, and I think a lot of the alluvial materials deposited from the front of the mountain-sheds have a fairly high degree of limestone which would contribute to the hardness of the water. As you go further east, you are getting out of these deposits into a different type of deposit, and perhaps obtain a little softer water.

Mr. Foster:

I am sure as you get out into the Plains, the alluvial deposits are composed to a greater extent of Cambrian or Precambrian crystalline rocks, which do not tend to make water particularly hard.

Mr. Hainstock:

In many areas the hardness is about 300 parts per million in most alluvial waters. In some areas the hardness runs around 300 to 400 parts per million. That is about the least you will encounter.

Dr. Gravenor:

I think your original comment that some of the water is coming from the bedrock, is probably correct because we have done a fairly extensive survey of the mineralogy of the alluvial deposits, and we find that there is an increase in lime concentration as one approaches the foothills area. With regard to the mineralogy of these alluvial sands and gravels, there is nothing in them that would contribute to sulphates so far as I can see, whereas bedrock underlying this area contains very high quantities of sulphates; so I think some of the groundwater in the alluvial deposits comes from the local bedrock.

Mr. Foster:

I am sure one of the functions of the Conservation Board requirements for casing of oil drillings, is to protect such formations that may be relatively deep and that may be relatively low in chloride. I have examined a number of electric logs filed in the Conservation Board, and I know that in southern Alberta there have been indications of groundwater low in chloride content, such as the Milk River sandstone, to depths of over 850 feet. The Milk River sands, I think, are one group of sands that are not protected by the Conservation Board casing requirements. Is that right, Mr. Pow?

Mr. Pow:

Yes, I believe so. Our requirements call for some type of surface casing which is never of very great depth, and very often you will run into cases where, partly through our ignorance of the existence at depth of freshwater bearing sands, we do not require casing that will adequately protect a formation such as the Milk River sands.

Mr. Foster:

Well, the Milk River sands provide a good source of water in that area. At Foremost, for example, very successful wells for municipal purposes have been constructed into the Milk River sandstones.

Mr. Greenwood:

A point of interest in that regard is that a survey was conducted in the south area to find a means to dispose of formations waters, and it was found that these formation waters themselves were of lesser chloride content than the freshwater sands and the surface waters, in those particular areas. The Board in conjunction with the Prairie Farm Rehabilitation

Administration conducted an experiment to use formation waters for irrigation. This points up the fact that all formation waters are not necessarily contaminants of so-called freshwater sands.

Mr. Foster:

At what depth would they lie?

Mr. Pow:

I would say at about 3,200 feet.

Mr. Foster:

Is it your impression that these waters would be suitable for irrigation?

Mr. Pow:

Close to it, I think.

Mr. Greenwood:

Another point of interest in that regard is, the flow of this formation water which had been separated from the oil, was sufficient to supply several ranches in that particular area. We were inclined to shut these wells off because they were not complying with our regulations, and the local ranchers protested because we would have been shutting off their water supply altogether. This water was not from an upper formation, but from formation waters at considerable depth.

Mr. Foster:

Perhaps Mr. Hogge would have comment to make with regard to the problems that arise from a water supply of poor quality. Has there, for example, been a municipality seeking to obtain approval for their municipal water supply plant, and this approval has been unobtainable because of the poor quality of the water?

Mr. Hogge:

There have not been very many. Generally speaking, in areas of the province where the municipal supply is not of high quality, the people become accustomed to using the poorer quality water. The situation does not seem to be very much different whether people obtain the water from their own wells or from a municipal supply. Certainly some water is unsuitable for a common carrier where people may be exposed to a sudden change in water. There are certain side effects which we always caution them about. Some waters are not suitable for watering the lawns and gardens. The iron content of some groundwater is high enough to require treatment to remove the iron. We also have hydrogen sulphide in the odd well and natural gas in some areas.

Mr. Foster:
I believe that Western Water Wells Ltd. constructed the wells supplying the town of Foremost. Did natural gas cause any serious problem with regard to the completion of the wells?

Mr. Hamelin:
No, not that I am aware of. I have a chemical analysis in my notes here.

Mr. Foster:
Perhaps we should put that on record.

Mr. Hamelin:
Chemical analysis of the two wells drilled for the town of Foremost in March, 1954:

Depth of the wells - 760 feet
Total solid content - 1,042 p.p.m.
Ignition loss - 40
Hardness - 10
Sulphates - 0
Chlorides - 72
Alkalinity - 825 (bicarbonate of soda)
Nitrates - 0
Nitrites - 0
Iron - 1.2

And they like that water.

Mr. Foster:
The chlorides are surprisingly low. The Milk River sandstones into which these wells were drilled, are exposed on the surface in a large area in the Sweetgrass Arch in extreme southern Alberta. I understand the Milk River sands extend quite far north. Actually, on the electric logs, I believe they show even up into the Edmonton area. Do you happen to know,

Dr. Gravenor, whether they come this far north?

Dr. Gravenor:

It is probably their equivalent. They are not classified as Milk River sandstones this far north.

Mr. Foster:

Undoubtedly, somewhere along about Township 9 or 10 the chloride content becomes very high, because I know that our examination of the electric logs showed that there was a very definite limit on the north side, at least for the low chloride water.

Col. Parsons:

Mr. Foster, would you like to say something on what the Ionics Corporation of Boston has done with regard to demineralization of water?

Mr. Foster:

I attended a talk at the American Institute of Mining Engineers on the experiments conducted by this Boston firm, in which they are using a membrane technique for demineralizing water. I think that much of their work has been in connection with sea water and the possibility of turning sea water into water of usable quality. While we are on the subject, I wonder if Prof. Walker might give us a very brief picture of the basic problem that is involved in dechloriding water that is unusable economically, whether it be sea water or water from any of our formations here which are extremely high in chlorides.

Prof. Walker:

I am afraid I haven't had the experience on that particular point to give you a complete picture, but I do know that there have been developed recently a number of fairly successful methods which first take out the cations, that is the metallic ions, and then proceed to remove the chlorides, sulphates, and so on. There are a number of different types, some for taking out the positive ions and some for taking out the negative ions. One of the companies actually has a type of resin which is suitable for removing bicarbonate from water supplies, and I understand that they have made some attempts in the case of Alberta waters. I spent quite a bit of time on the chemical and precipitation methods of removing bicarbonates, but I am afraid my research did not get very far with the job. In recent years they have turned out units that contain both types of resins and are able to take out both types of ions at the same time, simply by combining the two different resins. I understand that in some of the experiments conducted on sea water they have been using electrical methods or having water travel through some permeable membrane. I think there are several groups working on that problem, some on the Pacific coast as well as some on the eastern coast. They seem to be having fair success. I have seen some of their reports but it is a little too early to say how successful and how economic the whole thing will be.

Mr. Foster:

The greatest emphasis in research in demineralizing water is found along the Pacific coast and lately along the Atlantic coast where, if an economic method can be found, they will have on hand an unlimited supply of water. Here in Alberta, however, it does not seem to me that in the foreseeable future we are going to be finding great use for highly mineralized water, and we are therefore resigning ourselves, for the time being at least, to the search for waters which are naturally fresh. I think it is interesting to note that we have enormous quantities of groundwater in this province which are available for pumping but which are not at the present time used because of their extremely poor quality. I have not made much of a study of the deeply buried formations that are highly mineralized because they are not currently economic. There are places apparently where large quantities of bedrock water could be pumped if the day comes when we want to make use of highly mineralized water.

Mr. Stanley:

Mr. Chairman, I wonder if I could make a few remarks with regard to Dr. Walker's comments. Down in Texas where they are doing a lot of work using membrane and electrolytic methods, they are also using another method, the exact name of which I forget, but the principle of it is to freeze the water, concentrate the ions at one end and use the water after it is thawed. That method has been found quite a bit cheaper than distillation methods because it takes less energy to freeze and thaw water, than it does to distill it. I don't know whether that method has reached the practical stage yet, although the electrolytic process has.

Mr. Foster:

That is a very interesting point, and I am glad you brought it out. Are there any other comments with regard to water quality?

Col. Parsons:

Going back to what Mr. Greenwood said about the ranchers complaining that their source of water was shut off; perhaps we can do something about the demineralization of water. I think he brought something to our attention that a lot of us had never thought about -- farmers enjoying water that is not fit to go into surface water.

Mr. Stanley:

I think there is quite a field. I notice from Mr. Hamelin's records that the concentration of soda in that water at Foremost is just about double what is recommended by the United States Public Health Service. Soda can be readily removed by an ion exchange process, using a hydrogen exchange unit and aeration, and you don't need both cation and anion exchange to demineralize it.

Mr. Seibert:

I would like to ask Mr. Noble or Dr. Walker whether that analysis Mr. Hamelin read, corresponds to the bedrock wells -- we call them deep wells -- that are about 200 or 300 feet deep around the Edmonton area. The

Foremost analysis seems to be similar to the analysis of water on our farm near Edmonton.

Prof. Walker:

We seem to find this type of water in some of the wells, while in others we find just straight hard water. Is this not right, Mr. Noble?

Mr. Noble:

Pretty much.

Mr. Hamelin:

I could give you a comparison of the water at Foremost with that at Kitscoty, which has a well 260 feet deep.

	Foremost	Kitscoty
Total solid content	1,042	1,128
Ignition loss	40	80
Hardness	10	105
Sulphates	0	339
Chlorides	72	6
Alkalinity	825	460 (nature of alkalinity being the same)
Iron content	1.2	0.2

Mr. Pow:

There is just one more thing I would like to mention and that is the relationship between the hardness of the water and its proximity to a particular formation. It is my impression that water in glacial drift is generally the hard water, but water in the Edmonton formation is generally soft because the bentonite in the Edmonton formation will react with the water, forming a sodium sulphate salt. I think that the water that comes in contact with the Edmonton formation would be affected by the sodium and would consequently be soft. I think there is a relationship between the hardness or softness of water, and whether the water is in glacial drift or in the Edmonton formation.

Prof. Walker:

That would just be the base exchange to which I referred earlier.

Mr. Foster:

I have been wondering whether the sodium content is sufficiently high in any place, to be hazardous to people with high blood pressure. Do you have any data on that, Mr. Hogge?

Mr. Hogge:

No, we have no data on it although we certainly appreciate that a high sodium concentration will aggravate a condition of high blood pressure or a nervous condition.

Mr. Noble:

It seems that the sodium content is high in much of the province, especially in the south. This condition is fairly general in an area running from the foothills about two-thirds of the way across the province, up through the Edmonton district and then curving in an arch through the Grande Prairie district. The sodium content in this area is really too high for people suffering from heart trouble.

Mr. Foster:

How about nitrate and its effect upon a blood condition in babies known as methemoglobinemia?

Mr. Noble:

I know that over the last 20 years on the land of a friend of mine, the water level has dropped considerably so that the nitrates and phosphates can now flow down to the water. Whereas previously only those contaminants in the immediate vicinity of a well would have an opportunity to reach the water, now the contaminants from a much greater distance, sometimes several miles, may affect the water in the well.

Mr. Foster:

I wonder how many of the domestic farm water wells actually have a chemical analysis made on them. I presume that is voluntarily done. Would you know, Mr. Noble?

Mr. Noble:

It is voluntary. Five or six years ago we did about 300 analyses a year, and this year we did close to 3,000.

Mr. Hogge:

The doctors of the Health Units have made a practice of checking the water supply whenever there are expectant mothers in the vicinity; and there have not been many blue babies in the province although there has been the odd one.

Mr. Greenwood:

We have undertaken several surveys inquiring into the chloride contamination of groundwater, and we have found that almost invariably there have been more wells showing a high nitrite or nitrate content, than show a high chloride content. Mr. Hogge and the Board undertook a big survey this summer throughout the province, and I know that in my district there were quite a few wells that showed this tendency. They were usually close to the barnyard.

Mr. Foster:

Are you presuming that most of this nitrate contamination comes about through the use of fertilizer?

Mr. Greenwood:

This tendency is usually seen in very shallow wells.

Mr. Foster:

This seems to indicate that the source is agricultural fertilizer. But there are cases on record where a very high nitrate content is found with no association with contaminants on farms.

Prof. Walker:

There is very little nitrate used in Alberta fertilizers; most of them are ammonium phosphate.

Mr. Foster:

So the contaminant is very likely more of the barnyard type.

Mr. Noble:

I have noticed this summer that the nitrate content seems to be higher in wells which are very close to barnyards.

Mr. Foster:

This points nicely to the fact that the well contractors and particularly the smaller contractors who are doing work for domestic and farm supplies, have a great responsibility in careful selection of the location of wells. The decision as to the exact location of a well is usually left to the discretion of the well contractor. In some cases the property owner will have a definite preference, but if the well contractor is aware of the proper casing, he is in a position to alleviate the problem of high nitrate content in many instances.

I would like to direct the discussion for the remainder of this round-table towards the engineering of water wells and the recovery of water from the earth. I recognize a very big difference between a hole in the ground and a properly engineered water well. I am sorry to relate that many of the wells in Alberta are merely holes in the ground, with a little surface casing to protect the well from caving in from the top. They are dangerous from a bacterial point of view; they obtain only a fraction of the amount of water that is obtainable at the site; and I, for one, would like to see a great improvement in well construction, particularly among the smaller drillers who concentrate on the domestic and farm supplies. A municipality that wants a new well constructed will call in consulting engineers who draw specifications which are submitted to the Divisional Sanitary Engineer for approval.

My present concern is the setting up of specifications for actual well construction. Without prior detailed information of the area, it is unfair to well contractors who are bidding on specifications, that these specifications should bind the contractor to agreements which he may not be able to fulfill. For example, it has come to my attention that some contractors have been required to produce a given amount of water from a given depth with a certain pump setting. It is quite practical in some well-studied areas actually to predict subsurface conditions in sufficient detail to permit such specifications. To the best of my knowledge, however, such specifications are impractical here in Alberta, and I don't think consulting engineers should require the contractors to bid on rigid specifications without prior detailed study. On the other hand, the consulting engineers and their clients should be protected from faulty well construction by making certain specifications. In the case of the development of sand and gravel sources, prior test drilling should be undertaken before the specifications for the final well are drawn up. There are few places in North America where sand and gravel conditions are so well-known at a proposed drilling site that it is possible for detailed specifications to be drawn up without a pilot test hole, virtually at the site of the proposed well.

I would like to encourage consulting engineers who are dealing with the construction of municipal and industrial wells in sand and gravel deposits to set up their programs so that sufficient test drilling is undertaken to prove the occurrence, character, and extent of the sand and gravel. The test drilling should be done prior to making the specifications. I think that once this drilling is undertaken it is quite possible to set up specifications that are fairly exact, that is, the depth of the well, the size of the well, the length of the casing, the probable length of the screen, and under some circumstances the size of a gravel pack where one is used. However, it is often desirable in the case of a gravel-packed well to defer the selection of the gravel-pack material until the final well has been sunk and samples from the formation are examined, and the pack can then be selected on the basis of these samples.

My attention was called recently to the fact that a government department had requested bids on the construction of wells in an area where little detailed information was available and reliable contractors were expected to bid on well construction where they were not permitted, except at their own expense, to drill test holes to determine the situation. The contractors should not be expected to do this. It is not reasonable to expect contractors to go to considerable expense in the hope of obtaining a particular contract; such testing should be a part of the engineering program. I wonder if I might have a comment from some of the contractors here on these points.

Mr. Hamelin:

I would like to mention a village east of Edmonton; I don't remember which municipal engineering firm handled this case. The village wanted a municipal water supply and contacted our firm. This well was drilled to a total depth of 260 feet and, according to my log, a water supply was encountered at 245 to 250 feet in a sandy shale. This well was pumped for at least our minimum of 24 hours and, while I don't remember the exact yield, I presume it was in the 20 - 25 gallon a minute range. That is all that was required of us and that is all we were able to give them. I do not remember any test hole in this case.

The point I want to make is, that I presume they have proceeded to install a complete water works system on the basis of a single hole in the bedrock, where we happen to have encountered a formation about 5 feet thick that was of sufficient porosity to start their system. We have been referred to as "the experts", and I want to put on record that we were never given an opportunity to act as experts. I would like an explanation of what assurance they could possibly have that this system is going to be in operation three years from now, on the basis of the information my company was able to give them. Is this the proper way to do things?

Mr. Foster:

The point seems to be well taken and in that case it seems that inadequate investigation was made as to the potential supply at this particular town prior to the approval of the water works plans. Better assays of conditions should be made before such construction is undertaken. It is quite possible that a well located 300 yards away would not have encountered conditions as favorable as were encountered at that particular site, or on the other hand, conditions at another location may be more favorable.

In the case of bedrock formations, it is sometimes unjustifiable, economically, to drill a small test hole in the hope of predicting conditions at any particular site. I appreciate the economics of the situation and in many cases it is justifiable for the consulting engineers to ask that well construction be undertaken rather blindly. There may not be very much difference in the cost of drilling a four-inch test hole as compared to an eight-inch hole that could be completed as a well. My earlier point was principally in regard to sand and gravel sources where high-capacity wells of specialized construction may be located.

Mr. Hainstock:

With regard to what Mr. Hamelin has mentioned, I would like to add that I do not think sufficient information can be obtained from test holes to predict well-field capacity. Test drilling gives you a clue as to what well-field capacity might be, if the test drilling is done intelligently, but I think for some purposes,(for example, the province approving a loan on a 25- to 30- year basis) test drilling alone would not really be sufficient. It would be necessary to make use of the wells for some time because it may be a matter of years before it is realized that the well field is being over-pumped.

Mr. Foster:

My remarks concerning test drilling were aimed toward the better location and design of the permanent well, and not toward estimating the long-term potential of the formation. In order to do that, it is usually necessary to have one or more pumping wells and several observation wells. Consulting engineers should urge, in the case of sand and gravel sources and certain other sources such as sandstones, that observation wells be constructed in the vicinity of the pumping well in order that a record may be maintained of the influence of the pumping well on the surrounding area. Such information, if it is accurate and complete, may be used by a central agency to make accurate estimates of the potential of the area. Without this information it becomes necessary to start from scratch and obtain whatever water well data is available and whatever information with regard to well influence may be procured. In the case of a town setting up a new system, it would be very beneficial to have at least two observation holes, even if they are just sand points. So long as they represent the water level in the formation being pumped, they will be of tremendous value to the town and to the engineer in the future whenever an evaluation of water conditions is attempted. Such information is valuable in determining the location of an additional permanent well.

It has been my experience, not only in the States but also here in Alberta, that record-keeping of this type by the towns is generally poor. Consulting engineers are in a position to encourage improvement in the maintenance of such records by their clients, the towns and industries. I have observed that where a water system is operated by one of the larger private companies, such as Calgary Power Ltd., records are considerably better. They seem to appreciate more the economic importance of keeping records of water levels and of the volume of water pumped, for future use in assessing their condition.

Mr. Hamelin:

Would you care to discuss with us what you consider minimum development, and whether or not you feel that some forms of development are superior to others? I am referring to sand and gravel formations.

Mr. Foster:

Mr. Hamelin has raised the question of well development, by which we mean the methods of increasing the yield of any particular well, either chemically or mechanically. Treating the formation in the vicinity of the well in order to obtain a maximum fluid entry is one of the fundamentals of well development. In a well which is pumping one million gallons per day, the velocity of the fluid flowing into the well bore is very high, especially if the well screen is fairly short. Back from the well into the formation, the velocity of the fluid diminishes greatly so that at a distance of even a hundred feet from the well the velocity is measured in terms of inches per month.

Our primary point of interest in well construction is not so much what lies back 100 feet from the well, although there must be water there and the formation must be permeable. We are interested primarily in the condition of the formation directly in contact with the well. That condition is determined partly by the method of well construction and partly by what is done after the well is completed.

Within the last twenty years in the United States and in southern Ontario, the drilling method known as "reverse hydraulic" has become quite common in water well construction. This method is generally considered to be best for the construction of high-capacity water wells in most unconsolidated formations. In the reverse hydraulic technique, a light mud is forced down the outside of the stem and carries the cuttings upward through the centre of the stem. This method requires equipment quite different from the standard rotary equipment, but I foresee the day in the near future when its use will be found economic here in Alberta and elsewhere in Western Canada. The advantage of this technique is that the water-bearing formation is not contaminated with drilling mud and is left in virtually the same condition in which it is found. The problem of permeability in the formation in the immediate vicinity of the well is thereby minimized.

With regard to the techniques employed in improving the condition of the formation around the well bore, the most common technique is that of repeated surging and bailing. Water is forced under pressure into the formation and then the well is bailed, causing a resurge of water toward the well bore. Fine materials in the formation about the well tend to be removed. Such practice involves very careful selection of well screens. Several of the contractors, especially the larger ones, use commercial well screens which are designed for proper well development. (I understand there are some problems involved in obtaining high quality metal well screens from the United States.) The selection of proper screening with scientifically designed openings is essential to the proper engineering of the well, the point being that if you are to withdraw fine material from the formation adjacent to the well bore, it is necessary that you select your well screen so that the slots are sufficiently large to pass fine material but at the same time the slots are sufficiently small so that the bulk of the formation remains around the well bore in adequate volume to prevent caving from above. The end result is that you have, within about three feet of the well bore, the highest permeability that may be obtained in the formation. The fine materials, which reduce permeability, are removed and a high velocity of water movement into the well is permitted whenever pumping takes place.

If I were a consulting engineer planning a well in a sand and gravel formation, I would arrange the specifications so that the well contractor would be paid on a time-basis for well development such as surging and bailing or any other type of development necessary to obtain the maximum amount of water from the formation. This is not idle talk -- I know of a number of cases where the capacity of a well has been tripled by the use of carefully selected well screens and the removal of the fine materials in the formation about the well bore. When you are dealing with costs of ten to thirty thousand dollars for the construction of a sand and gravel well, I am sure that in the long run it pays both the consumer and the contractor to make that well the best possible at that particular site. The time required for proper development of a well must be judged in each individual case, ranging generally from several hours to several days.

Mr. Pow:

I would like to know whether anyone can tell me how many rotary rigs are being used, in comparison to the number of cable tool rigs, and how formations are being detected when rotary rigs are used. Are they being detected by loss of circulation? I understand that a saturated formation is sometimes not detected because there is an equilibrium between water pressure and mud pressure, but in a poorer formation which is not saturated, there may be loss of circulation.

Mr. Foster:

I would like any contractors here to comment on that. I must say it is very common in the States for test drilling to be undertaken with slim hole rotary, and one of the better indications of permeability, when drilling through tight glacial till in search of permeable sand and gravel, is loss of drilling mud from the mud pit because the permeable formations will normally sap some of the drilling mud. In such test drilling a complete record of mud losses is usually required.

You have mentioned formations which may be only partly saturated. I am not convinced that any of the bedrock sandstones are only partly saturated, but that may be the case. I am sure there are cases where the formations are under great variations of pressure. Varying pressures in the formations possibly account for the curious behaviour of the drilling mud. While variations in the drilling mud may be brought about by varying degrees of saturation, it is my opinion that varying hydrostatic pressure in the formation is the more likely cause.

Mr. Hainstock:

Most of our prospecting in glacial drift is done with the rotary drill, although there are some areas where the formations have too many boulders. We have found in glacial drift, where you get your mud loss, there you find your water. You will get more mud loss in a saturated formation than in an unsaturated one. I think that it is just about the reverse of what Mr. Pow has said.

Mr. Toplika:

You will also find some places where there is loss of circulation but no water, and then again you will find wells with abundant water where there has been no loss of circulation. Usually when cuttings contain sand, you can expect water. Loss of circulation alone would fool you 50 percent of the time in bedrock in Alberta.

Col. Parsons:

Do you ever change over from rotary tools to cable tools when you find that situation?

Mr. Toplika:

No.

Mr. Hamelin:

It is the same old problem, rotary against cable tool. With the rotary drill we have heard the admission that 50 percent of the time one cannot tell from loss of circulation mud, whether the formation is sufficiently water-bearing to justify stopping drilling operations, putting in casing, and developing a hole. With the cable tool method, no circulation mud is being carried under pressure into the hole. I do not care to take sides between these two techniques, but I have not been too successful in attempting to bring in water wells with rotary equipment. I am willing to admit that this may be partly due to not having sufficiently trained operators. With the cable tool you can be sure what is there, but it takes longer to drill a hole and your labor charges are higher than with rotary equipment. I would like to ask Mr. Foster whether in his discussion of the reverse hydraulic method, he intended to compare it with the rotary method.

Mr. Foster:

Principally so, yes.

Mr. Hamelin:

And not as against cable tool equipment?

Mr. Foster:

That is correct. The objectionable feature of standard rotary equipment for water well drilling is eliminated in the reverse hydraulic technique. I have seen both cable tool and reverse hydraulic equipment used with great success in making high-capacity wells in sand and gravel formations. I do not think this is the time or place to discuss in detail the advantages and disadvantages of cable tool, as compared to the reverse hydraulic techniques. There are very many factors involved and in a particular case, a decision might well rest on the economics of the situation; I would think the well contractors would be in the best position to judge the merits, then. Are there any other comments to make?

Mr. Thierman:

From your comments, Mr. Foster, I would judge that you were referring principally to high-capacity wells.

Mr. Foster:

Yes.

Mr. Thierman:

That is fine, and I think you would find that any consulting engineer in the business would agree with you. In this province we are faced with the problem of small communities of 300 to 500 people, where only a relatively small water supply of 25 to 30 gallons per minute is needed, and we do not have any $30,000.00 to work with -- it just is not there. Our problem is to attain a standard of well development investigation which can be done economically and from which we can give a reasonable assurance of results. With our economic limitations, we do not expect to be able to give guarantees. As far as the engineer is concerned, the problem is obtaining the relatively small supply required, as economically as possible and without tieing up large sums of money in test drilling programs, which no one would deny are desirable, but are not necessary. When we start talking to small municipalities in terms of $5,000 or even $2,000 or $3,000,we are met with a blank stare, and there is little the engineer can do about that.

Mr. Foster:

I am not unaware of the economic limitations facing small municipalities seeking to establish town water systems. But I believe strongly that a town is better off in the long run, to tap a source of water which has a greater potential than is needed to meet an immediate demand. Any town seeking to establish a 25 gallon per minute water well if the present demand is 24 gallons per minute, would benefit by a geological study which might result in finding a source of 200 gallons per minute; this would end the water supply problem for a long time to come for that town. If the town is satisfied with a source providing 25 gallons per minute, when that is virtually the present demand, it can expect trouble followed by more trouble.

Col. Parsons:

I would like to ask one question. What is the reaction of municipalities to the suggestion that an observational or a test well be drilled?

Mr. Thierman:

Generally negative. I agree 100 percent with Mr. Foster's remark that it would be wiser to look for 200 gallons per minute and not be satisfied with 25, but I have yet to meet anyone with the courage, when faced with a well which meets the immediate demand to say, "No, you can not have this water".

Mr. Foster:

There are undoubtedly many occasions in which a town has been satisfied to drill at random to obtain a supply of 25 gallons per minute, that may be virtually assured by local reputation. I mentioned that because the town may not consider the possibility of a source of 200 gallons per minute being available. A geological evaluation of the district would place them in a position of knowing whether they would have to be satisfied with random bedrock wells or whether they have the possibility of finding a source of 200 or even 1,000 gallons per minute. I do not say that if a formation capable of yielding 1,000 gallons per minute is discovered, they should immediately go to the greater expense of constructing a well which would produce more water than they can use, but my point is that they should be willing to be a little more farsighted than they sometimes are in their expenditure of funds, to evaluate the potential of their district.

Mr. Thierman:

Possibly that should be one of the objects of this meeting. We have frequently recommended what you have just said, namely, that numerous test holes be drilled in order to explore the potentiality of the area. This might well involve the expenditure of some $5,000. Someone else would offer to put down a hole for $500. It does not take much imagination to foresee the outcome and who would be putting down the proposed hole. That situation is very typical. We have often gone to great lengths to persuade a town to make a survey, but that sometimes is quite a battle.

Mr. Foster:

I appreciate the difficult position you are in.

Dr. Grace:

Mr. Chairman, I know nothing about these details but it seems to be generally agreed that it is theoretically desirable for a town in a dubious area, groundwater-wise, to make numerous test holes. You use the term "geological study". As our program develops, we hope to have more and more information on the groundwater picture geologically. Such information would not give you precise locations for wells. If it happens we have made a geological study of a particular area where a consulting firm is trying to get the job of finding water, am I right in surmising that while our information may not make test drilling unnecessary, it would enable a test drilling program to be carried on more intelligently and effectively?

Mr. Foster:

That is perfectly right, Dr. Grace. It is my feeling that when our program develops we will be able to go to our accumulated data in our investigation of a specific case, particularly in the problem of sand and gravel formations, and suggest the areas which would be suitable for test drilling and those which are geologically unsuitable. I would say, that would be one of the responsibilities of an efficiently operated Geology Section of Council and well within the responsibility of the Provincial Government.

Dr. Grace:

And obviously the more detailed geological groundwater surveys would probably be starting in the dubious areas.

Mr. Foster:

The end result will be the encouragement of towns to carry out more and better test drilling programs and to construct better located and better engineered water wells, which, of course, is the purpose of this entire program.

Mr. Toplika:

In one town we drilled four holes within a radius of 100 yards, with an entirely different result in each instance. In one hole there was a supply of about 20 gallons per minute; in the second there was gas; in the third we found nothing except a little water; and in the last hole we encountered nothing but a lot of sand. Three of the holes have been abandoned and the original one, which was drilled two years ago, is being used.

Col. Parsons:

It seems to me that observation wells should be drilled at the same time as the supply well.

Mr. Thierman:

I think anybody would agree with that. The problem seems to be that in order to put down observation wells and also test wells, money is required, and the municipalies just do not have the money. Some other solution will have to be found, perhaps in the matter of financing.

Mr. Foster:

It is often practical to turn test holes into observation holes, and I am sure that some of the contractors here have done that. For instance, test holes might be drilled with a four-inch rotary, and then casing set in and an observation well constructed.

Mr. Stanley:

The government will not approve the loan until the water supply is proven, and yet we are finding that it takes money to prove the supply. That seems to be an impassé.

Mr. Foster:

In closing, I would like to make a few remarks. If we were to look at the earth from 200 miles above it, we would hardly dream that water ranks with disease as one of man's most perplexing problems. We would see that some two-thirds of the earth is covered with water, and we might even suspect that there is more water beneath the surface of the earth than on the surface, which is pretty much a fact. Alberta is in the situation of being a relatively undeveloped area and yet having sufficient wealth to make possible planning whereby the future expansion of this province and the development of its resources may be done intelligently, with greater calm and with less confusion than is often possible. I am a firm believer in the proposition that many of our water problems are predictable and that they may be avoided if sufficient thought is given in advance of the approach of those problems. It was Dr. Grace's intention and mine here today, to see what those problems are and what can be done about them in the long-term picture.

Among the programs which I think the Research Council of Alberta is justified in establishing, is a water-level observation program, designed to keep a record of variations in water levels and water tables at key locations in the province.

A second program which I think the Research Council of Alberta is likely to enter, is an investigation of various geophysical techniques of locating water sources. This summer I have experimented with a technique designed to locate permeable aquifers within the glacial drift by means of an instrument which measures electrical earth resistivity. I have done sufficient work with this technique in Alberta this summer to recognize that it has real possibilities. I think the Research Council should pay attention to this technique as an available means of locating permeable sands and gravels. It also has value in locating sand and gravel bodies for road-building purposes and other commercial uses.

Dr. Gravenor:

I do not know how much work has been done on chemical treatments to increase the yield of water. You know, for example, in the oil industry they use acidizing treatments, hydrofracturing treatments, and so on. Some of the treatments might be used in groundwater. There is a great deal of gypsum in Alberta sediments which is the source of much of the sulphate. Have you ever tried using ammonium chloride in order to open up this area immediately around the well bore? If we know the mineralogy of the sands, we might be able to predict the kind of chemical treatment to use around the well screen in order to get the greatest permeability in that region. I would suspect that would be a very good line of approach.

Mr. Foster:

I think that would be one phase of research which the Council could carry on in co-opeation with the contractors and the municipalities. You mentioned hydrofacturing treatment; some experiments have been carried on in the southwestern United States with hydrofacturing of tight formations for the purpose of improving yield. It is questionable whether this method is economic. Hydrofracturing is a technique by which the formation is subjected to pressure sufficient to actually fracture the bed along roughly horizontal lines. The method is usually accompanied by the injection of sand grains to maintain the fractures and is used extensively in the oil industry, where it is unquestionably economic.

I feel that equipment could be designed for commercial use in water wells, for instance, in the Cretaceous sandstones in central Alberta which are low in permeability and might be improved by the technique. I would like an experiment conducted, say at Wetaskiwin, to see whether the yield would be increased sufficiently to make the technique economic. There is some question as to how much it would cost. In the oil industry it is very expensive but their equipment is designed to work at great depths, and I do not see why shallow equipment could not be made. I visualize investigations into these techniques as being the responsibility of the Research Council.

Mr. Stanley:

How effective are these resistivity tests for deep wells, say over 150 feet?

Mr. Foster:

In central Illinois we have worked over what is called the Teay bedrock valley, which is an ancient course of a mighty river lying some 100 to 150 miles north of the present Ohio river. The sands and gravels of the ancient Teay valley are in places buried by over 200 feet of tight glacial till, which is non-water-yielding. The gravels contained in the valley are very productive, some wells yielding over 3,000,000 gallons per day. We have been able to map the location of favorable areas for test drilling by integrating the results of standard geological methods with electrical earth resistivity prospecting. I have not done work in Alberta to depths greater than 150 feet, but I see no reason why we should not be equally successful here, except, however, that most of the sand and gravel formations in Alberta are not deeper than 150 feet.

The most successful prospecting by earth resistivity has been with the so-called Gish-Rooney system, where four electrodes are used in a straight line, spaced equally. The earth is excited with a slow pulsating DC current and the potential drop ratio between two inner electrodes is measured. Water-bearing sand and gravel in Alberta has a resistivity generally between 4,000 and 12,000 ohms per cubic centimeter, while non-water-yielding glacial till composed of a mixture of clay, silt, and sand has a normal resistivity of under 4,000. That has been the conclusion I have drawn from my work here this summer. I can see that this technique will be a very successful approach to some groundwater problems.

If there is no further discussion, I would like to draw the meeting to a close and to thank you all for giving the conference your time and effort. I hope we will gather again.

<u>Dr. Grace</u>:

I do wish to point out that progress in this particular field is going to depend upon the co-operation of us all. No one can do it alone. We represent a number of agencies and a diversity of interests, but as we go from this meeting I hope each of us takes back to our particular group a greater awareness of the magnitude of the problem and its fundamental importance, not only today, certainly tomorrow and very definitely the day after tomorrow. I feel sure that we can count on the able interest of each other. I want to thank Mr. Foster for being here, for his interest in Alberta, and his skilled leadership in focusing attention in a co-ordinated way on a very important matter.