Intragaz

# ASSESSMENT REPORT
# ON
# SPECIAL LICENCE N° 4/98

## To search and prospect for salt and potash in the Beaver Brook area, Colchester County, Nova Scotia

**Submitted to the Minister of Natural Resources of Nova Scotia for the period of July 2nd, 1998 to July 1st, 1999**

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# SUMMARY

We have compiled and analyzed all available data on our Beaver Brook Special Licence No. 4/98 to assess its potential for underground storage of hydrocarbons in salt deposits. The location and access to our licence is described in Appendix 1 and a detailed tabulation of its claims can be found in Appendix 2.

The salt in the Beaver Brook deposit is Visean in age and is part of the Carboniferous Windsor Group. The geological structures in the area are mainly controlled by normal faults and salt tectonics.

One well drilled, on the Beaver Brook Licence penetrated a hundred meters of medium to high grade salt before reaching its total depth at 730 m, still in the salt. An interpretation of the gravity data over the Beaver Brook anomaly suggests the presence of a thick salt section exceeding 1700 m. If this is the case, this salt deposit could be adequate for gas storage. We note, however, that this salt thickness is somewhat at odd with the much thinner salt section found in the Shubenacadie area.

Beaver Brook is too far from the main Maritimes and Northeast Pipeline to make economic sense, as a storage project directly connected to this pipeline. A pipeline connection between Beaver Brook and the lateral pipeline linking Halifax to the main Maritimes and Northeast Pipeline, being about 25 km long, is within the realm of possibility. However, the economic viability of this scenario could depend on the storage demand of clients in Halifax and the possibility of swapping gas between the storage facility, the lateral and the main pipeline. Pending the results of our in house market study, we have decided to keep the Beaver Brook Licence for an additional year.

# 1. INTRODUCTION

This report summarizes the first year of exploration work performed on the Special Salt and Potash Licence No. 4/98 located in the Beaver Brook area, Colchester County, Nova Scotia.

Two companies were involved in the exploration work : Intragaz Inc. and Sofregaz U.S. Inc.

Intragaz is a company that specializes in the development and operation of underground storage reservoir for natural gas. Currently, Intragaz exploits two storage facilities in Quebec. Data collection, library searches, compilation, geological and geophysical reviews, general technical appraisal and analysis were performed by Intragaz' staff : Mr. Yves Duchaine, senior geologist, Mr. Donald Leavy, senior geophysicist and Mr. Simon Dupéré, senior reservoir engineer and manager of this project. Intragaz staff combines more then 60 years of experience in the oil and gas industry.

Sofregaz U.S. Inc. is a Houston, Texas, based company that specializes in project involving underground storage of hydrocarbons. Sofregaz has a staff with extensive experience in developing storage facilities in salt deposits. The representatives of Sofregaz who were involved in this project were : vice-president engineering and operation, senior geophysicist/geologist, senior engineer and engineer.

The recent development of gas reserves near Sable Island and its future production through the Maritimes and Northeast pipeline has prompted Intragaz to take a serious look at the potential for storage facilities in Nova Scotia. Two main routes seem open in that direction : conventional exploration for onshore hydrocarbons fields or the development of caverns in salt deposits. Since numerous salt deposits have been documented in Nova Scotia but no oil or gas field has yet been found onshore, Intragaz was leaded to focus on a study of the numerous salt occurrences.

During the first year of our Special Licence, our main objective was to investigate our **SITE SELECTION.**

The site selection for salt cavity development starts with exploration of subsurface salt resource. It involves geophysical work, seismic studies aimed at determining depth, subsurface geometry, stratigraphic sequences, thickness, horizontal extent and cap rock.

During the initial phase of site selection, all existing available data are first collected and organized. This includes library searches, geological and hydrological reports, maps, suite of logs, aerial photographs, former drilling, oil and gas exploration results, seismic, gravity, aeromagnetic surveys, etc.

The second step of site selection is the assessment of storage prefeasibility. Various technical, environmental and economic assessment factors are reviewed for each of the geologically most favorable sites to further refine the selection of the overall best sites.

Other considerations involve access, surface topography, water resources and disposal sites. The making-up of the salt mass, physical properties of salt samples, as well as the extent and the nature of insoluble must be carefully determined. Salt domes are particularly well suited to the development of large cavities due to their huge vertical extension. Sometimes, excessive tectonic folding and highly insoluble impurities create cavity shape control and stability problems. In layered rock, where there are few problems to impurities and internal tectonics, the thickness and depth of salt and the nature of overburden become dominating factors in design.

Therefore this report will review our investigation of our site selection in the following manner :

- How data collection and compilation were performed,
- Current geological understanding;
- Geophysical data interpretation;
- Storage prefeasibility analysis.

## 2. DATA COLLECTION AND COMPILATION

In order to select the best prospects for salt deposits to be used for underground storage, the first step was to gather all the pertinent data already published. This information was available either as paper copies, microfiches or digital data. The most useful sources of information are listed below :

1- The Nova Scotia Department of Natural Resources library and internet listing;

2- The Geological Survey of Canada digital list of reference (GEOSCAN);

3- The international geological database GEOREF;

4- The Oil and Gas publications (Oil and Gas Journal, OilWeek, American Association of Petroleum Geologist, Journal of Petroleum Technology, Society of Exploration Geophysicist, Canadian Society of Petroleum Geologist, etc.);

5- The scientific papers published by salt and potash organizations (Gas Research Institute, Solution Mining Research Institute, Salt Institute, etc.);

6- All documents available from firms specialized in hydrocarbon storage in salt deposit (PB-KBB, Sandia Laboratories, Sofregaz, etc.);

A lot of internal work dealt with digital data, their formatting and transfer to our in-house database. In the majority of cases such as geological maps, well locations, sample description, bedding information, formation tops encountered in wells, cross-sections and structure, the data had to be digitized from scratch directly from the original data or from in-house generated models.

The topographic base maps as well as some geological maps were purchased through the Nova Scotia Geomatic Center.

Geological as well as gravity models were built on each prospect to enhance our geological understanding of the salt occurrence.

Of the two hundreds publications that were studied, about fifty-five were deemed to be directly relevant to our compilation.

We collected and compiled data for thirty-nine salt occurrences known to the present in Nova Scotia. Each site was evaluated and ranked based on thirteen criterions. This laborious task was extremely important in order to evaluate our prospect from the others.

# 3. GEOLOGY

## 3.1. Regional geology

In Nova Scotia, all the salt deposits already identified are confined to the lower Carboniferous sequence also known as the Maritime Basin.

The pre-Carboniferous basement, aged from late Precambrian to Devonian, has been put in place within two different geological events : the Ordovician taconic orogeny, which affected all the northern part of the Appalachian Basin and the late Devonian Acadian orogeny. Each of these orogenies has been attributed to the collision of different plates and micro-continents. We do not expect any significant evaporite deposit during the pre-Carboniferous because no restricted type environment facies has been recognized. All the sequences have undergone regional metamorphism, granitization and intense deformation.

The Carboniferous Basin is the largest intermountain basin in the Appalachian mountain system. It has an area of about 150 000 km$^2$ with about 70 % offshore, in the Gulf of St-Lawrence and beneath the continental shelf. The Avalon terrane underlies most of the offshore portion of the basin. It is believed from a preponderance of evidences that this terrane is composed of Precambrian igneous and metamorphic rocks that accreted to North America in mid-paleozoic time.

Most of the sedimentary sequence consists of a continental type deposit, reddish in color due to oxidizing condition and containing a mixture of shale, siltstone, sandstone and conglomerate. The regional studies conducted all over the basin and existing geophysical data suggest that the tectonism which affected the basin is of the strike slip type, largely characterized by lateral motion along faults. Although no major orogenies occurred during the Carboniferous period, the rocks were strongly deformed by local faulting and salt tectonism.

The sedimentary sequence of the Carboniferous rocks can be divided in three major cycles in response to the local tectonic events.

HORTON CYCLE : This cycle was initiated after the Acadian orogeny. The deeper parts of the basin were in-filled by an immature clastic type of deposit : a mixture of shale, siltstone, sandstone and conglomerate. The field data suggests that together with normal faulting, oblique or transcurrent tectonic occurred in this cycle. Some evaporite and halite beds were recognized in few wells in New Brunswick (Gautreau) and in Wallace in Nova Scotia. However, the salt purity and thickness does not meet the minimal requirement for development of underground storage cavern. The Horton cycle closed with the inversion of the basin which was followed by a major period of erosion.

WINDSOR-MABOU CYCLE : The next cycle began with the renewed subsidence of the basin. Deposition started with a coarse grain terrestrial unit, the Hillsborough formation. As the subsidence progressed below sea level, a transgression by the restricted Windsor Sea occurred. The hot and dry condition led to the deposition of carbonates followed by anhydrite and finally halite and sylvite. The salt beds present within this cycle are the main targets for our exploration. After this period, the more humid condition that prevailed was favorable for the deposition of a clastic type deposit from the top of Windsor and through the Mabou. Faulting and diapirism, within individual sub-basin, appear to have had a dominant control over the sedimentation. The low relief areas were filled by a thick Mabou clastic sequence while the high relief areas formed by salt diapirism prevented, in some cases, the deposition of Mabou.

CUMBERLAND-PICTOU : Salt tectonism persisted locally during the Cumberland-Pictou. However, in general, this third and last tectonic cycle was initiated by a regional phase of gentle subsidence that affected the entire Maritimes Basin. Sedimentation was locally rapid in the depot center but slower over the New Brunswick platform. The subsidence and sedimentation phase end in early Permian with a final period of uplift and deformation.

The post Permain tectonism affecting the Maritimes onshore Basin is negligible and confined to existing fault (minor displacement) and local flowage of Windsor group salt into the overlying formations.

### 3.2. Prospect geology

The Beaver Brook salt deposit is located approximately 14 km southwest of Truro, in Colchester county, Nova Scotia. The area lies 6 km east of the Shubenacadie River and 8 km south of Cobequid Bay .The licence is accessible by paved road from Truro. Halifax can be reached in less than two hours by the highway 102. A small railroad passes through the area from Truro (**Figures 1 and 2**).

The Beaver Brook salt deposit is located in the Minas sub-Basin in what Giles (1977) describes as a severely deformed part of this basin. Our look at the surface geology would suggest to characterize the area as moderately deformed, especially comparing the highly deformed salt deposits present in the Cumberland sub-Basin or Cape Breton Island.

The surface geology was mapped by Stevenson (1958) and Giles and Boehner (1979). Our current version of the surface geology is shown in **Figure 2**.

The presence of a significant amount of evaporites was not expected until the early 60's when a gravity survey was conducted over the entire province by Nova Scotia Research Foundation. This survey discovered a significant gravity low in the Beaver Brook area.

Two wells have been drilled over the Beaver Brook gravity anomaly. The first one was abandoned at 428 meters before encountered the main salt mass. The second well was drilled to 733 meters and the last 100 meters consists of medium to high-grade salt (81 to 98 % NaCl).

The Horton outcrops to the north of the area and its dips range between 30 to 60 degrees. The Windsor rests unconformably over the Horton but accordingly to the dip readings over the outcrop, the contact is believed to be of a fault type. The presence of Upperton is deducted from regional geology as it has not been observed in the field or in the wells. The presence of a fault at the south end of the gravity low is inferred from the rapid changes of the formation dips at outcrops. This fault is interpreted to be the southern limit of the Beaver Brook salt core. From well description, we know that Windsor outcrops over the center of the Bouguer anomaly.

To the north of Beaver Brook, a thin layer of the Triassic Annapolis formation rests unconformably over the Carboniferous sequence.

A mixture of limestone, dolostones, clastic rocks, anhydrite and gypsum, which is a typical sequence within the Windsor, overlay the salt. The bedding dip over the core shows angle ranging from $10^0$ to $45^0$. The lowest section appeared to be more folded with dip reaching $80^0$.

The overall trend, according to the local geology and gravity anomaly, is east-west. The presence of the lower anhydrite bed (Carrols Corner or Upperton formation) has not been confirmed at the surface but extrapolated from regional stratigraphy.

It would appear that the bromine content of the salt indicates that, during its deposition, the brine concentration was probably low and did not reach potash salt deposition stage (Boehner, 1986).

# 4. GEOPHYSICS

## 4.1. *Geophysical data*

Our search of relevant geophysical data available in the Beaver Brook area shows that :

- **Seismic data**

  Some seismic was acquired by Chevron on road #2 south of Truro in 1982. This data is about 10 km to the east of our Beaver Brook prospect. According to Chevron's initial plan for this survey (AR-81-005), this line was to be shot about 6 km west of the Beaver Brook prospect. It is not clear why this change of plan occurs. Perhaps it is related to the generally poor reflection imaging where the Windsor outcrop. In one of their reports describing the results of their 1982 survey, Chevron states that the data quality in this area can be best described as very poor. For the reason, no interpretation or maps were included with their report.

- **Aeromagnetic data**

  Aeromagnetic data in the area are available from the Nova Scotia Department of Natural Resources and the Geological Survey of Canada. The data shows fairly quiet zone of magnetic variations where sedimentary basins area present.

- **Gravity data**

  A full set of digital Bouguer gravity data covering the whole of Nova Scotia was obtained from the Nova Scotia Department of Natural Resources. This allowed us to contour this data set honoring closely the measured gravity values. The resulting maps (**Figures 4 and 5**) compare approximately with the one published by Boehner (1986) and Howie (1988). However, our maps appear to be much more accurate, in particular as far as properly depicting the rapid variations of the gravity present near geological faults.

We used the minimum curvature algorithm within the Geographix software package to contour the data.

The gravity data is very sensitive to the presence of salt and geological faults in the subsurface. In the next section, we try to examine some of the constraints on the geology provided by the gravity data set.

### *4.2. Interpretation of the gravity data*

Our interpretation of the gravity data consists in calculating the gravity response generated by a geologically realistic model and to compare this response with the one that was measured in the field. The initial parameters of the model, that is the density contrasts and geometry of the different bodies of rocks, are crudely based on the geology of the area. These parameters are then fine tuned interactively until a reasonable good fit is obtained between the measured and calculated gravity response.

To calculate the gravity response, the software IGAO 2.5 D was used. In this software, a 2D cross-section of the geology is modeled by a series of polygons. Each polygon is assigned a density contrast with respect to some background regional density value. In the third dimension, each polygon may extend to a finite length and this length may differ from one polygon to the next. However, each polygon must remain unaltered in the third dimension and they must extend symmetrically on each side of the cross-section. It is along that cross-section that the Bouguer gravity calculation is made. In effect then, the models used in the calculation are true 3D models but due to the limitations imposed on the model in the third dimension, the software is generally referred to as two-and-a-half dimensional.

A more detail map of the gravity near our Beaver Brook prospect is shown on **Figure 6**. Also shown on this figure is the outline of Intragaz' Salt and Potash Special Licence and the location of the well SD-2 drilled on this licence. The gravity stations used to draw the Bouguer gravity map are shown in **Figure 7.** We note that the gravity station coverage is fairly good east of our licence, but is barely adequate north, west and south of our licence. In fact, north of our licence, we must go to the north of Cobequid Bay to obtain some additional gravity coverage. Even if our limited gravity station coverage may give a somewhat misleading map of the gravity field outside our licence we have, nevertheless, tried an interpretation of the data.

The measured Bouguer gravity was digitized along profile AA' on **Figure 6** and plotted with a series of + in the upper part of **Figure 8**.

The geological model used to fit the measured gravity is shown in the lower half of **Figure 8**. The continuous line shows the calculated response of the model in the upper graph of **Figure 8**. The background density used in the model, 2.60 gr/cc, is about the one we would expect for the Carboniferous clastic section. It is based on the Gulf Hasting well drilled in the Cumberland Basin.

In the model of **Figure 8**, the polygon 1 represents the salt mass whereas polygons 2, 3, 4 and 5 represent anhydrite of the Carrols Corner Formation. For each of the polygons, we use an extension of 10 km in the third dimension.

The density of the salt and anhydrite were taken to be 2.20 gr/cc and 2.90 gr/cc respectively. The top of the main body salt was taken as 630 m consistent with the SD-2 well. A geological model of the gravity interpretation is shown in **Figure 9**.

The results of the modeling are somewhat surprising. The geology of the area was suggesting a thickness for the salt probably in the range of 300 to 600 m whereas the model suggests a thickness of 1700 m covering the interval of 630 to 2300 m. Moreover, almost any realistic variations in the parameters of the models would only lead to an even thicker salt section. An exception to this rule could be the case where a substantial regional variation in the gravity exists in the area. We have not taken into account such regional trend in our simple model because we feel the distribution of gravity station used to measure the field were not adequate to do so. Another possibility that would result in a thinner salt section would be that salt is present much closer to the surface than 630 m, somewhat to the south of the SD-2 well.

To sum up, our model would suggest that in the Beaver Brook prospect, salt can probably be found in an adequate depth interval for gas storage.

## 5. STORAGE PREFEASIBILITY

The major factors that govern the time and cost to develop storage in salt deposit are cavern depth, salt thickness and salt purity. Once these are known, the optimum cavern leaching rate can be determined and leaching procedure designed. The process of screening for salt deposit storage prospect involves selection of sites having favorable combinations of depth, thickness and purity; leaching is then designed to satisfy the requirements of cost and storage development timing for each site. Once these factors have been determined, the potential development prospects are compared on the basis of additional factors including location, accessibility, environmental concerns, fresh water availability and brine disposal capacity.

Generally, the greater, the salt thickness, the most attractive, the development prospect due to the pressure and temperature effect on base gas ratio, the most favorable cavern depth is approximately 1000 m. Temperature and pressure also affect the minimum and maximum wellhead pressure and these in turn determine the horsepower for deliverability and injection. The number of caverns created will determine the cost and duration of leaching and the number and cost of cavern wells. The number of caverns will also be a function of salt purity; the greater, the percentage of impurities, the greater, the number of caverns.

This work, which is still on going, consists of the actual assessment of storage prefeasibility for the Beaver Brook area. A comprehensive storage prefeasibility study should review the technical, environmental and economical factors.

Our preliminary assessment are summarized below :

### *5.1. Technical factors*

- **The extent of the salt deposit**

  The extent of the salt deposit was generally assessed by the extent of the gravity anomaly associated with it and by well control.

  We note that the salt occurrences do not need to cover large tract of land in order to be interesting. A substantial amount of gas can be stored in several caverns within one square mile. However, very small salt deposits may be bounded by a series of faults which can render difficult the development of the cavern as the precise location of these faults are generally poorly defined.

  In the case of the Beaver Brook anomaly, the main gravity low covered an area of about 8 $km^2$.

- **Depth of the salt**

  The deeper the salt the higher the pressure at which gas can be stored and thus the better the economics related to the project. However, as salt cavern may become mechanically unstable at depth greater than about 1650 m, this depth can be considered as the maximum depth of interest to explore for salt.

  In Beaver Brook, the main salt body was encountered at 630 m in one of the wells.

- **Thickness of the salt**

  The larger the height over which salt is sufficiently pure so that we can develop a single cavern, the better is the economics of the project.

  The interpretation of the gravity anomaly over the Beaver Brook anomaly suggests a thickness in excess of 1700 m.

- **The salt purity**

  There are two aspects related to salt purity :

  - The amount of insoluble associated with the salt

    The amount of soluble is synonymous to the grade of the salt. A medium to low grade salt may produce so much insoluble material that cannot be removed from the cavern that it can severely limit its development and hence its economics.

    In the Beaver Brook well SD-2, an analysis was performed on the core taken in this interval between 631 m and 733 m. The results suggest the presence of a medium to high grade salt.

  - The beds of sediments other than salt that are encountered within the salt section

    When the salt section is interbedded with thick sections of anhydrite, gypsum, carbonate, sandstone or shale, then the size of the cavern that can be developed might be severely limited. Moreover, in salt deposit associates with complex structures, the insoluble material may present themselves as vertical or highly tilted walls that prevent the lateral development of the cavern.

    In the last 100 m of the SD-2 well drilled in Beaver Brook, a layer of about 6 m was found to have a low salt content (25 % NaCl).

- **Cap rock**

  The rock on top of the cavern must be sufficiently impermeable so as to preclude any leak of natural gas. Salt is often the material of choice for the cap rock but in some cases this may severely restrict the size of the cavern that can be developed.

  The sandstone section encountered above the salt in the Beaver Brook wells suggests that the salt should be used as the cap rock for the cavern in this case.

- **Geological structure associated with salt**

  Salt basin relatively undeformed by tectonic events have the advantage of presenting a salt section nearly horizontal, and, if thick layer of insoluble material are present, their lateral distribution can often be predicted in advance. Such is generally not the case in highly deformed basins.

In the case of Beaver Brook, it is believed that the salt is only moderately deformed.

- **Distance from the main pipeline**

In general, the nearer is the cavern from the main pipeline, the better is the economics. The pipeline that linked the cavern to the main pipeline is generally of a high diameter to account for the high gas deliverability of the cavern and its cost is proportional to its length.

In our first phase of screening, we did consider potential storage facilities near lateral of the main pipeline. In particular, the lateral that will link the main pipeline to Halifax could be interesting should enough market develops near Halifax. Also, the laterals for gas and condensates that will link Goldboro to Port Hawkesbury could open the door for condensate and gas storage on Cape Breton, if new chemical industries are attracted to the area.

The lateral to Halifax will be about 25 km from the Beaver Brook anomaly.

## *5.2. Environmental factors*

- **Water availability**

The water need for the washing operations can be fresh, slightly brackish or sea water. Although it is preferable to have water as fresh as possible to obtain maximum dissolving rates, relatively low levels of dissolved solids would not seriously affect the development rates which can be achieved. Brine returning from a developing cavern will be about 95 % saturated, so good salt removal is still possible using sea water with a saturation of approximately 9 %.

As each cubic meter of fresh water dissolves about one third of a cubic meter of salt, significant source of fresh or sea water are required to develop large underground cavern. The proximity of these sources of water to the cavern will greatly influence the cost of the project.

In the Beaver Brook case, it might be possible to obtain some water either from the Shubenacadie River, 6 km to the west, or from the Cobequid Bay, some 8 km north.

- **Brine disposal capability**

The disposal of the brine produced during the leaching of the cavern, if done with pipelines to the sea, could be both costly and environmentally challenging. A major problem associated with the pipelines used to dispose of the brine and to provide the fresh water is that they must be built at the start of the project before we can fully assess the chance of success of a given prospect.

In the case of a development of Beaver Brook, assuming we can dispose of the brine in Cobequid Bay, this would represent a distance of about 8 km.

- **Other criterions**

  Accessibility to the site by road or train, the presence of powerline nearby and the interest of local landowners may influence the economics of the project.

  In the case of Beaver Brook, there is a paved road that goes through our licence. Moreover, there is a powerline a few kilometers east of our licence and the Canadian National Railroad that links Halifax to Truro is about 10 km east.

### *5.3. Economical factors*

The M&NE project involves the construction of a 558 km, 30" pipeline from Goldboro, Nova Scotia to St-Stephen, New Brunswick. The purpose of the pipeline is to transport gas produced from Sable Island to the Canadian/U.S. border, where M&NE pipeline is to join with the U.S. portion of the Maritimes project and to deliver gas in Nova Scotia and New Brunswick along the route of the pipeline. The 30" pipeline, without compression, is capable of transporting initially at least 530 000 mmbtu/d. The Sable Offshore Energy Producers (SOEP) will commit all production from six fields in the Sable Island Offshore area to the Maritimes project. The initial deliverability from those six fields is estimated at 450 000 mmbtu/d.

Pending on the market demand and Sable Island production, the need for storage will evolve. Since surge storage to accommodate seasonal demand cycles is a normal component of a natural gas transmission system, it is logical to consider a salt deposit in Nova Scotia to provide this function.

An economic analysis would be very speculative at this point because of the lack of data regarding the market itself and the specific needs for storage. However, economical factors, which will affect the suitability of specific sites, include proximity to storage substance, distribution system and market, availability of water and brine disposal.

# 6. CONCLUSIONS AND RECOMMENDATIONS

- The Beaver Brook prospect, based on the gravity modeling, could have an adequate depth interval for gas storage;
- Results from one well suggest that the salt mass consists of medium to high grade salt;
- The prospect is approximately 25 km from the lateral pipeline that will link Halifax to the main Maritimes Northeast Pipeline.

At this stage, we recommend to keep our Beaver Brook Licence for further exploration.

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The geophysical aspect of the attached report was prepared by me, Donald Leavy, and is based on my personal examination of the data.

d) This work was performed between July 1998 and July 1999.

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b) Qualifications

Education : Bachelor of Engineering Physics

Experience : Thirteen years experience in the oil and gas industry and the gas underground storage industry as a reservoir engineer and manager.

c) Personal examination

The storage prefeasibility aspect of the attached report was prepared by me, Simon Dupéré, and is based on my personal examination of the data.

d) This work was performed between July 1998 and July 1999.

e) Not relevant.

f) Not relevant.

Signature : Simon Dupéré
Simon Dupéré

Date : August 12, 1999

# APPENDIX 1

## LOCATION AND ACCESS

The Beaver Brook Licence is located in Colchester County about 14 km south west of Truro. The Shubenacadie River flows about 6 km west of Beaver Brook and the Cobequid Bay is located about 8 km north (see **Figure 1 and 2**).

Small paved roads link the licence to the main highway connecting Truro to Halifax, providing easy access. A major powerline is located a few kilometers east on our licence and the railroad line between Truro and Halifax is about 10 km to the east.

Some limited exploration activities were performed in this area, in the past, with the consent of local landowners.

# APPENDIX 2

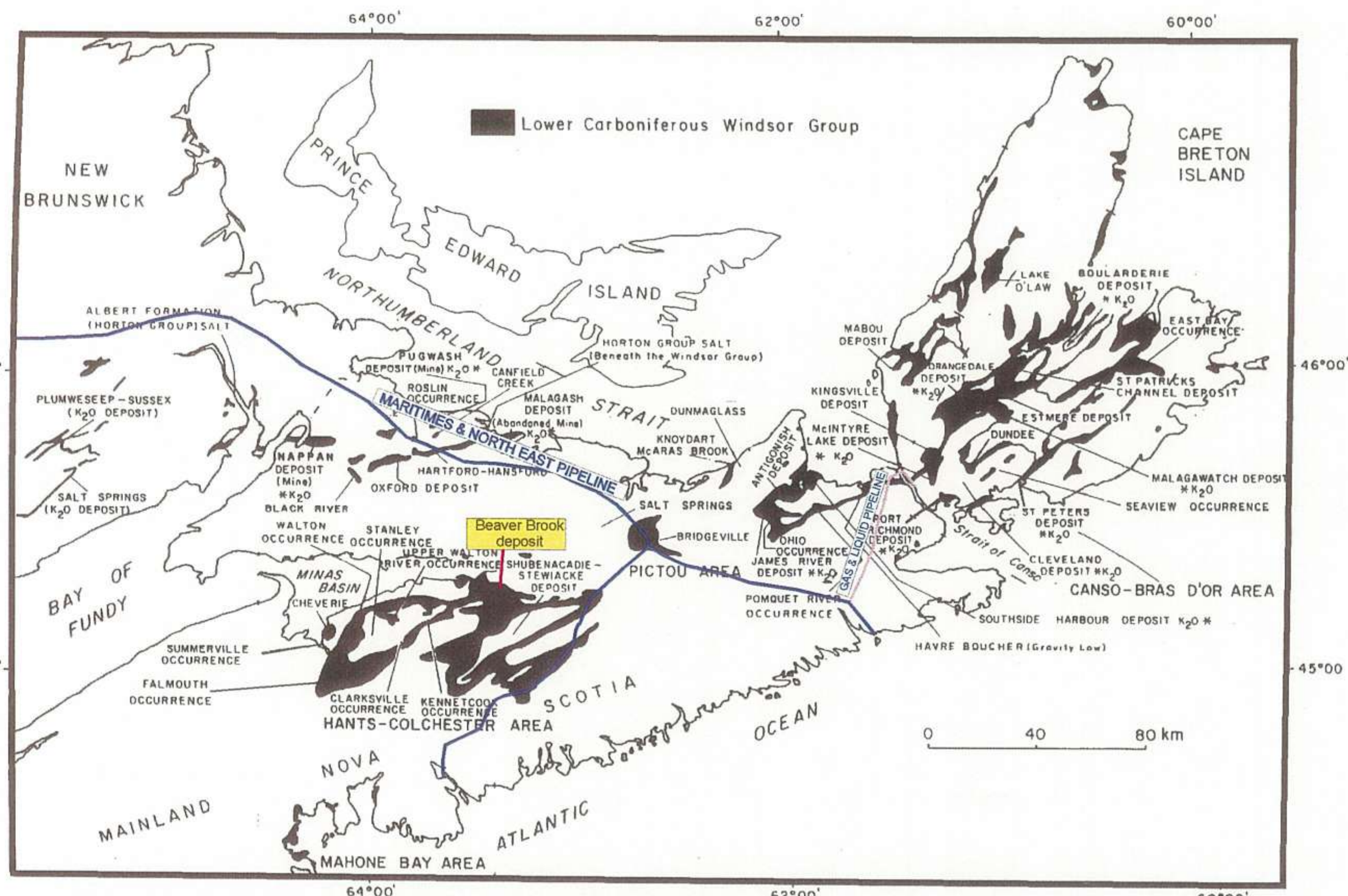
The Beaver Brook Special Licence No. 4/98, located in Colchester County, is shown on **Figure 10**.

This licence was granted by the province of Nova Scotia to Intragaz and Company, Limited Partnership of Trois-Rivieres-Ouest, province of Quebec, for a period commencing on July 2, 1998 and ending on July 1, 2001.

This Special Licence to search and prospect for salt and potash covers about 2760 acres.

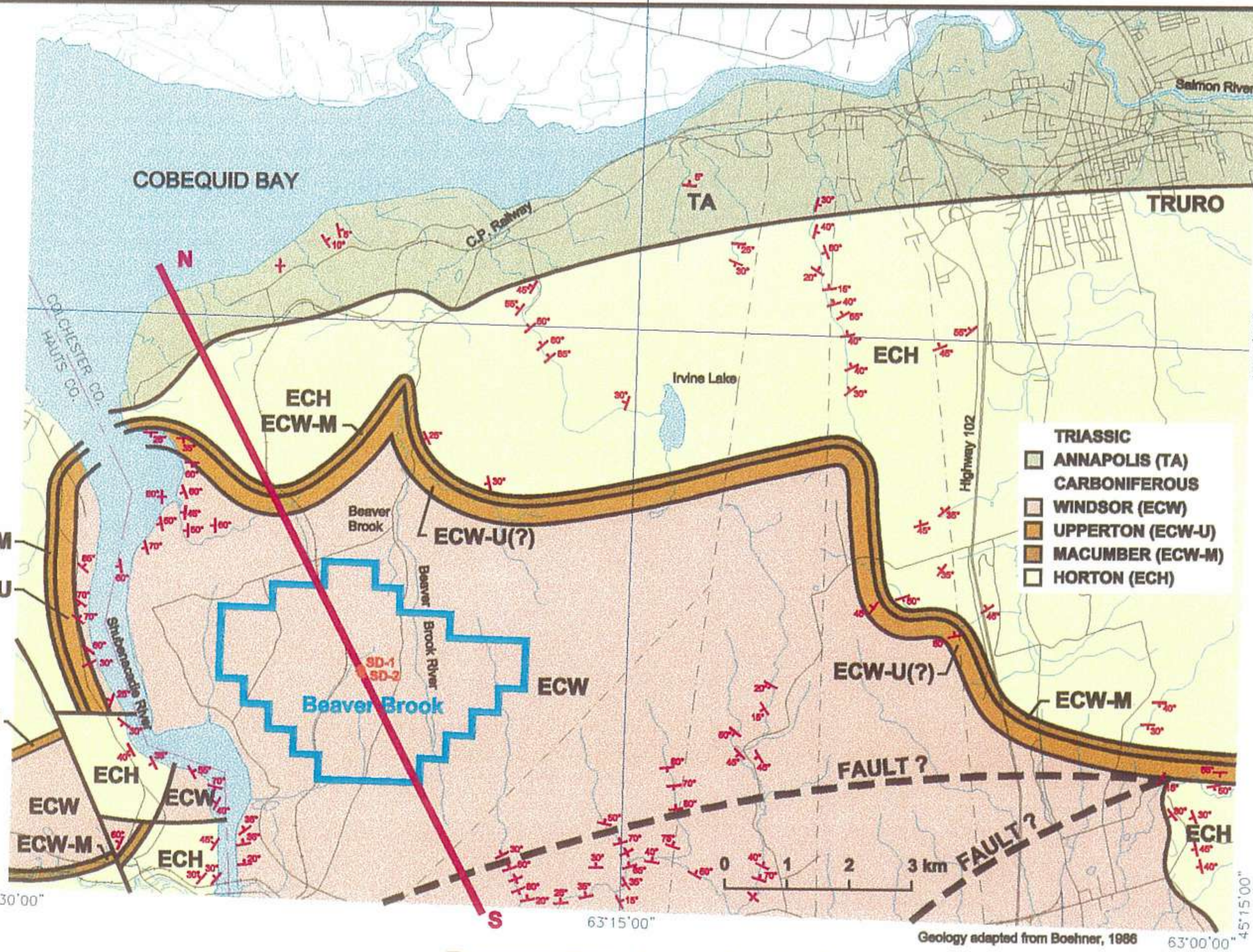
We give below a detailed listing of the claims included in this licence.

| Claim | Tract | Reference map |
|---|---|---|
| JPQ | 15 | 11 E 6 B |
| EFGH JKLM NOPQ | 16 | 11 E 6 B |
| MNO | 17 | 11 E 6 B |
| BCDE FGHJ KLMN | 32 | 11 E 6 B |
| ABCD EFGH JKLM NOPQ | 33 | 11 E 6 B |
| ABCE FGHJ KLMN OPQ | 34 | 11 E 6 B |
| ABH | 39 | 11 E 6 B |
| BCDE F | 40 | 11 E 6 B |




Modified from R.C. Boehner , Bulletin 5 ,1986, Nova Scotia Department of Natural Resources.

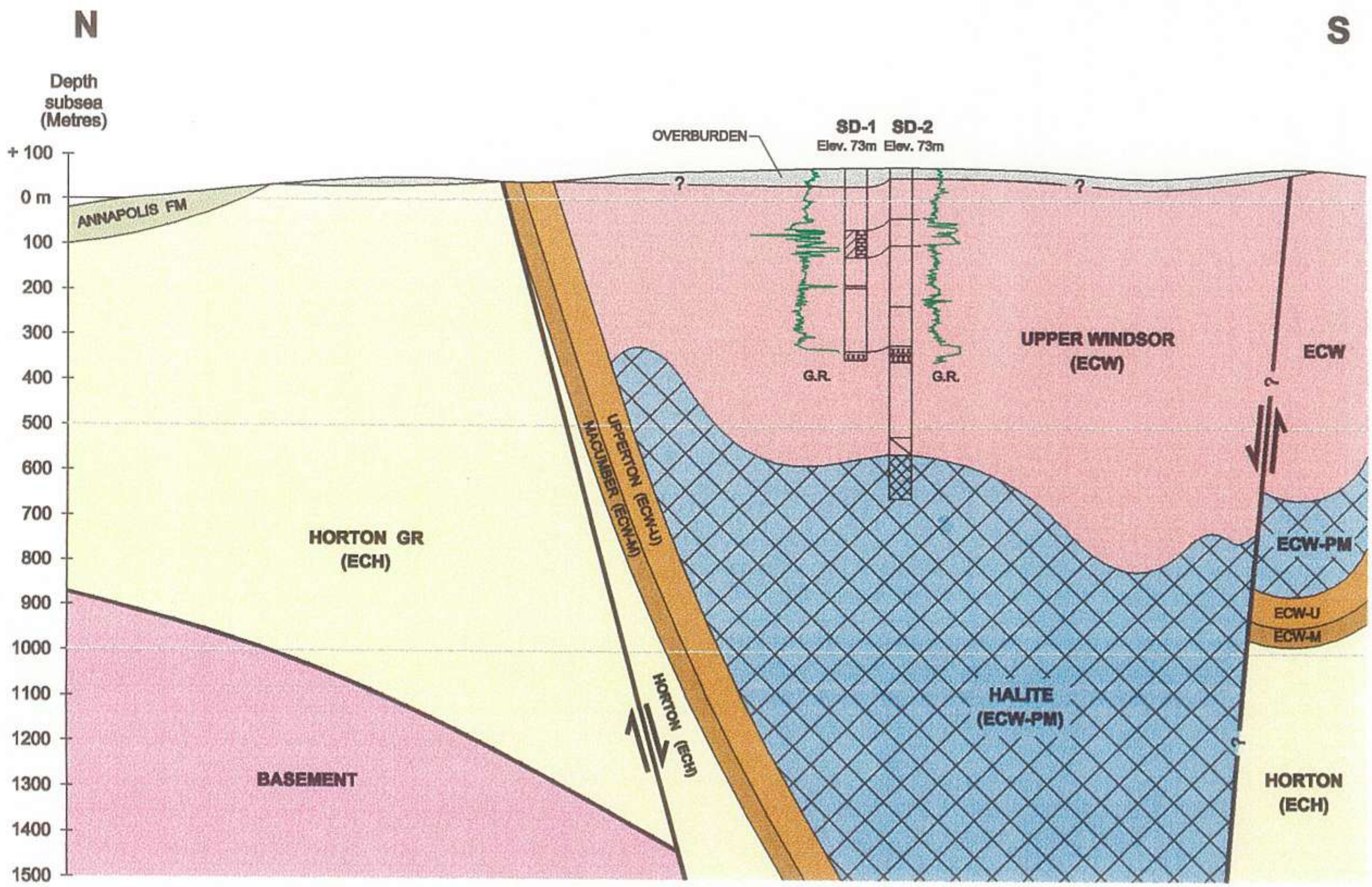
**Figure 1**




**Beaver Brook geological map**

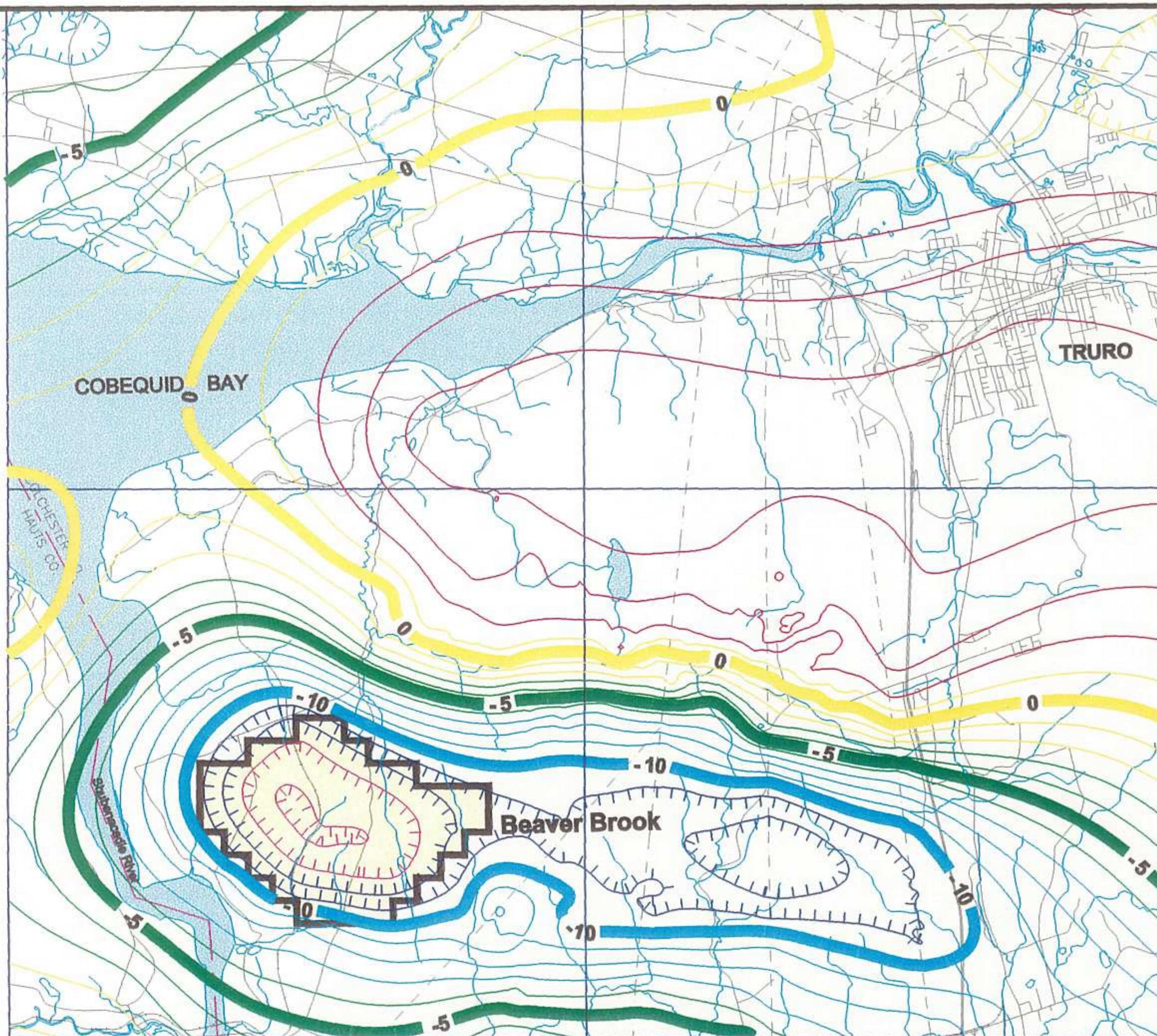
Figure: 2

# GEOLOGICAL CROSS-SECTION
# BEAVER BROOK




AutoCAD LT Fichier: Beaver Brook geological section.dwg

Figure: 3

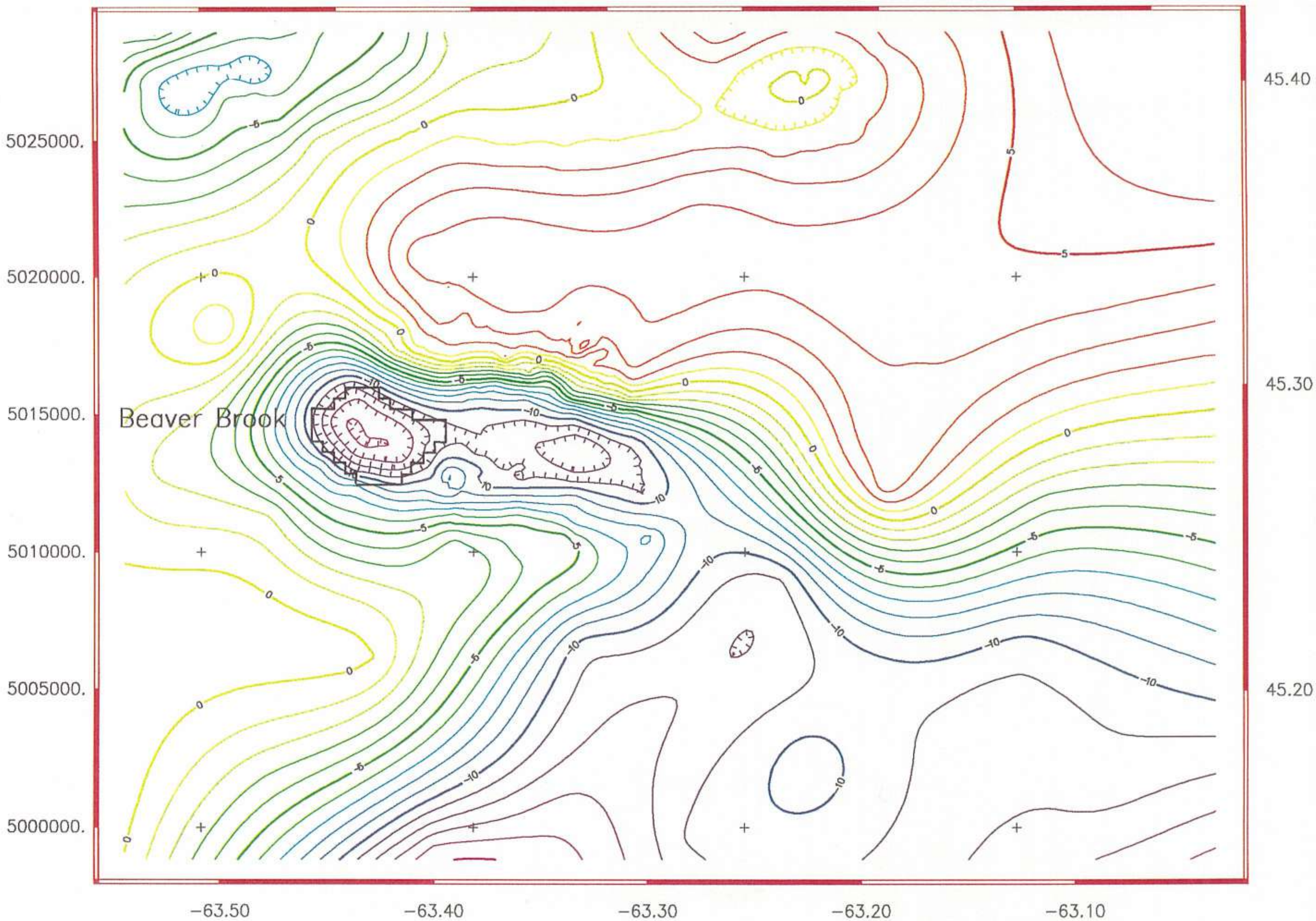



Intragaz

**Regional gravity near Intragaz Beaver Brook Salt and Potash licence**

| | | |
|---|---|---|
| Vérifié par: Donald Leavy | | C.I. : 1 milligal |
| Dessiné par: Dominique Carignan | | Mise à jour |
| UTM Nad 27 | Échelle: 1:100 000 | June14 .99 |

Figure: 4

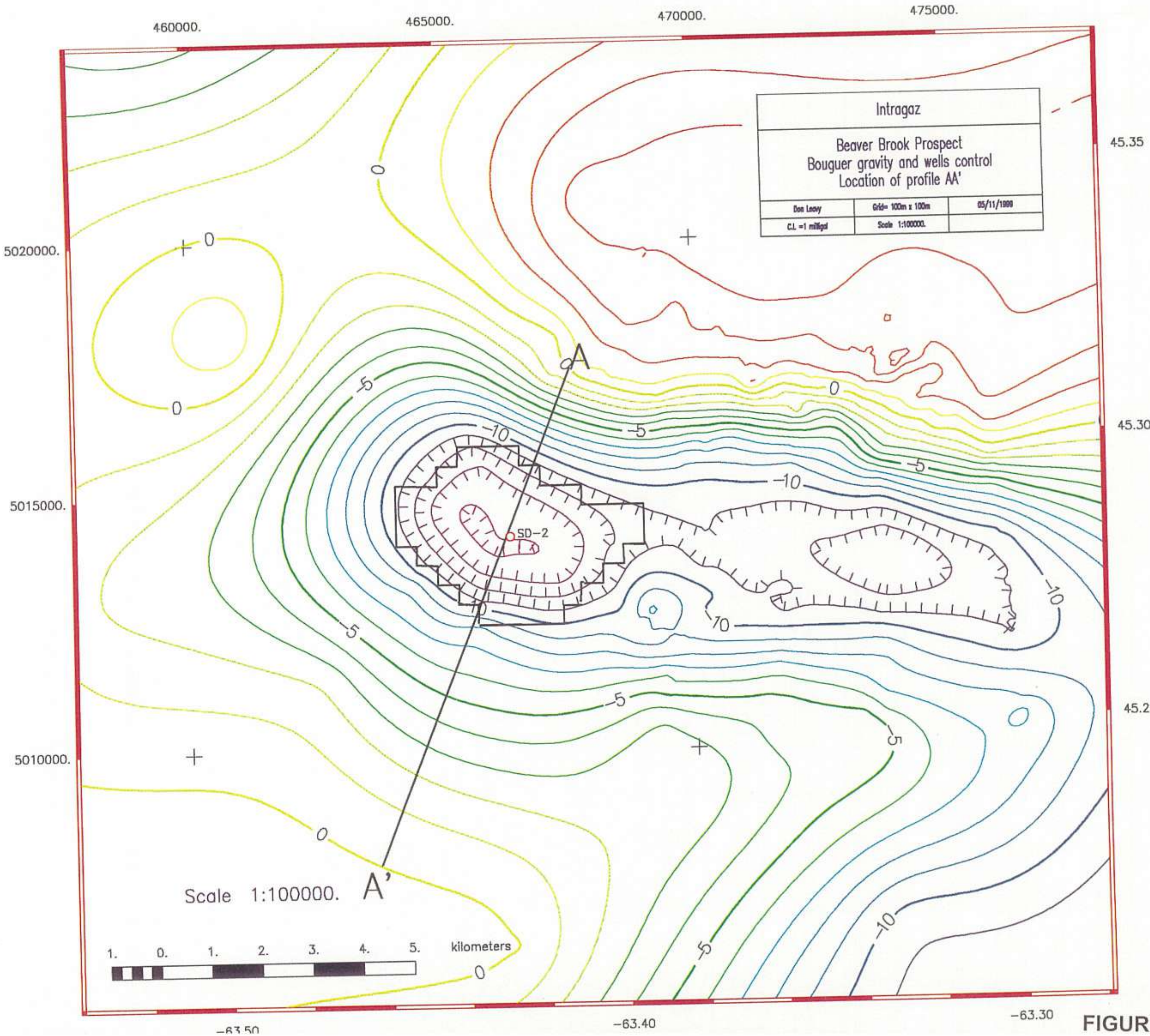



Scale 1:200000.

2. 0. 2. 4. 6. 8. 10. kilometers

| Intragaz | | |
|---|---|---|
| Regional Bouguer gravity near the Beaver Brook Prospect | | |
| Don Leavy | Grid : 100m x 100m | 05/25/1999 |
| c.i. : 1 milligal | Scale 1:200000. | |

FIGURE 5



Intragaz
Beaver Brook Prospect
Bouguer gravity and wells control
Location of profile AA'
Don Leavy
Grid= 100m x 100m
05/11/1999
C.I. =1 milligal
Scale 1:100000.
460000.
465000.
470000.
475000.
5020000.
5015000.
5010000.
45.35
45.30
45.25
-63.50
-63.40
-63.30
SD-2
A
A'
Scale 1:100000.
kilometers


FIGURE 6

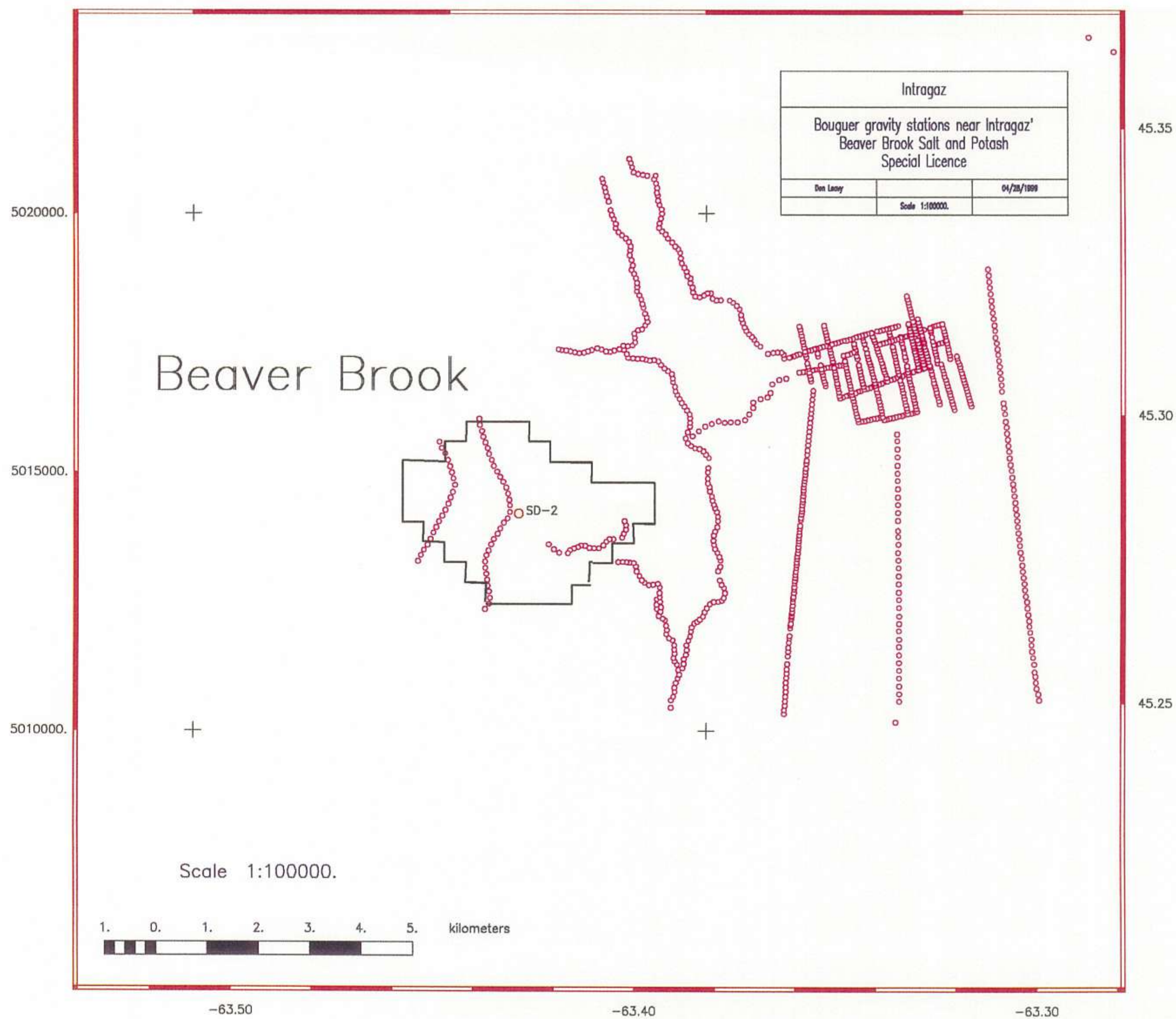
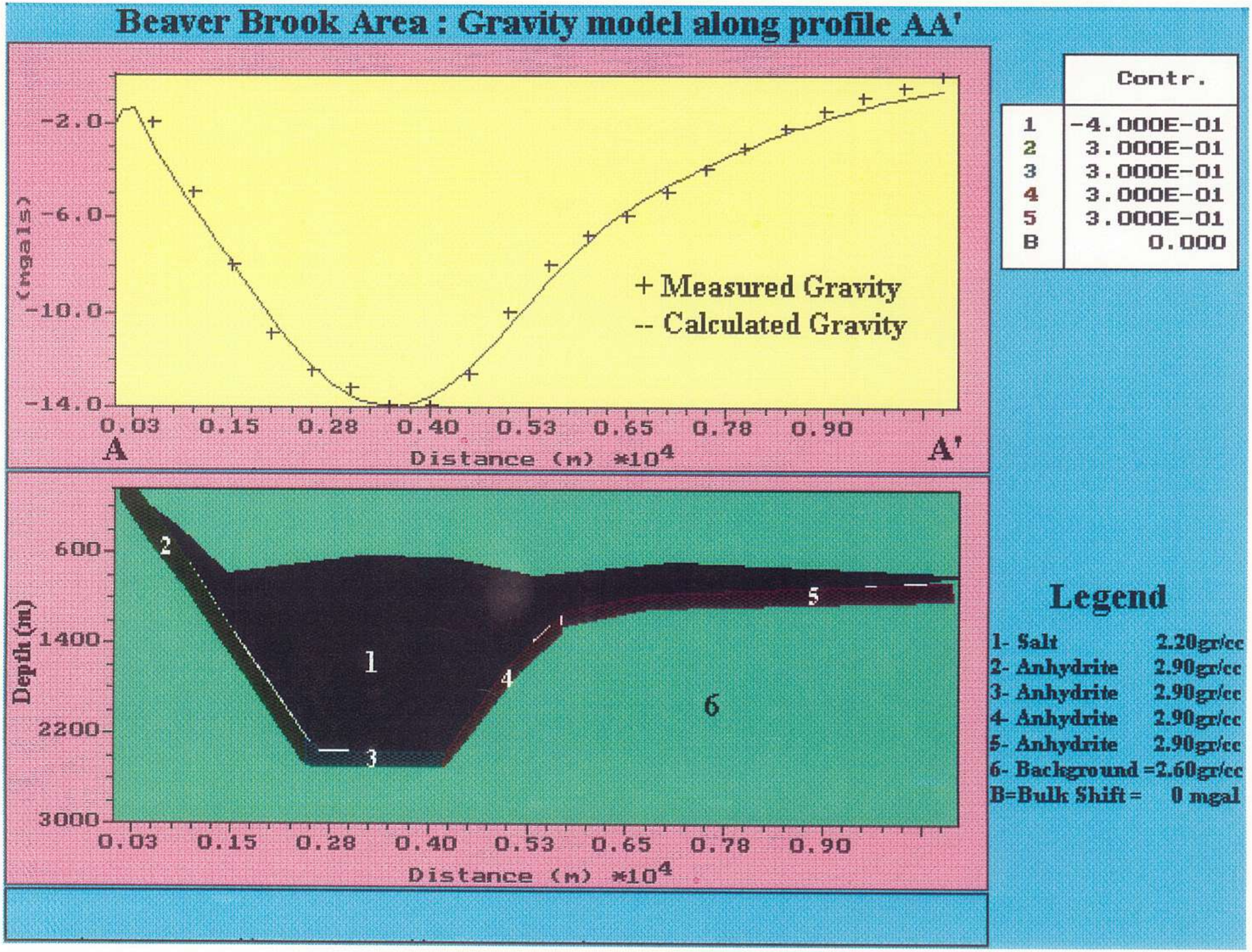

Intragaz
Bouguer gravity stations near Intragaz' Beaver Brook Salt and Potash Special Licence
Don Leavy
04/28/1999
Scale 1:100000.
Beaver Brook
SD-2
5020000.
5015000.
5010000.
45.35
45.30
45.25
-63.50
-63.40
-63.30
Scale 1:100000.
1. 0. 1. 2. 3. 4. 5. kilometers

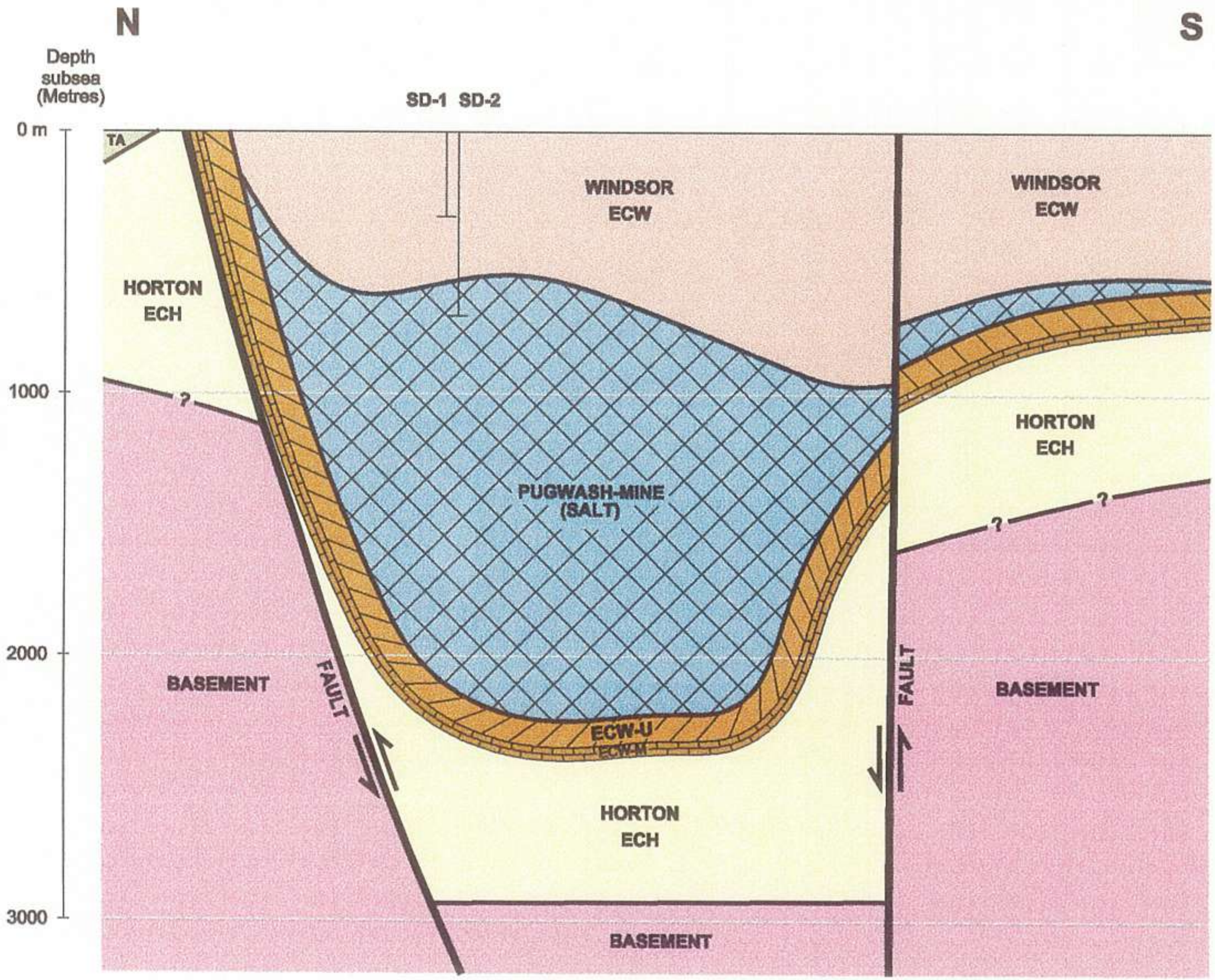
FIGURE 7



Beaver Brook Area : Gravity model along profile AA'
(mgals)
-2.0
-6.0
-10.0
-14.0
+ Measured Gravity
-- Calculated Gravity
0.03 0.15 0.28 0.40 0.53 0.65 0.78 0.90
A
A'
Distance (m) *10^4
Contr.
1 -4.000E-01
2 3.000E-01
3 3.000E-01
4 3.000E-01
5 3.000E-01
B 0.000
Depth (m)
600
1400
2200
3000
1
2
3
4
5
6
Legend
1- Salt 2.20gr/cc
2- Anhydrite 2.90gr/cc
3- Anhydrite 2.90gr/cc
4- Anhydrite 2.90gr/cc
5- Anhydrite 2.90gr/cc
6- Background =2.60gr/cc
B=Bulk Shift = 0 mgal

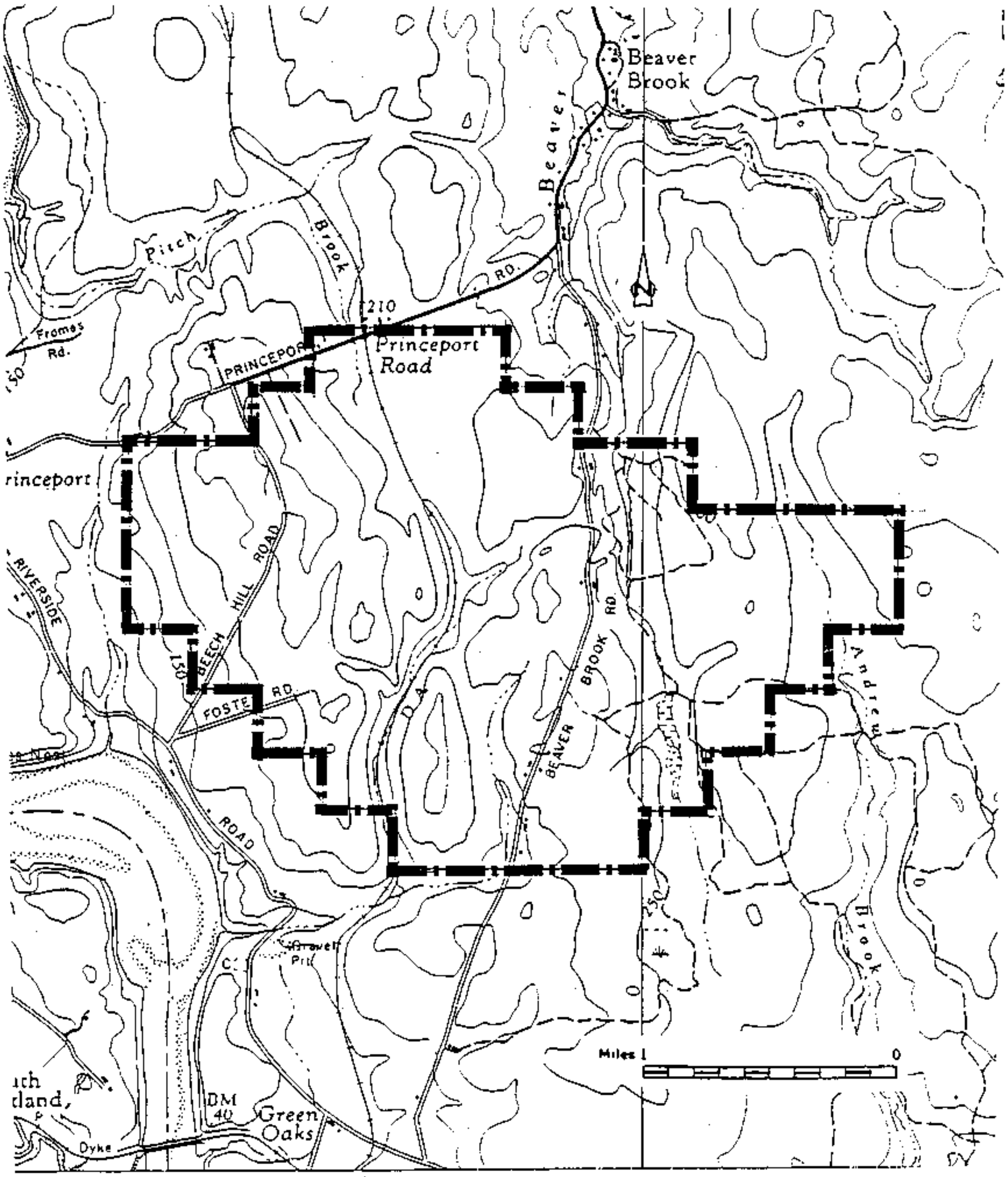

FIGURE 8

# GEOLOGICAL MODEL BASED ON THE BOUGUER ANOMALY
# BEAVER BROOK




AutoCAD LT Fichier: Beaver Brook model based.dwg

FIGURE 9




General Location Map

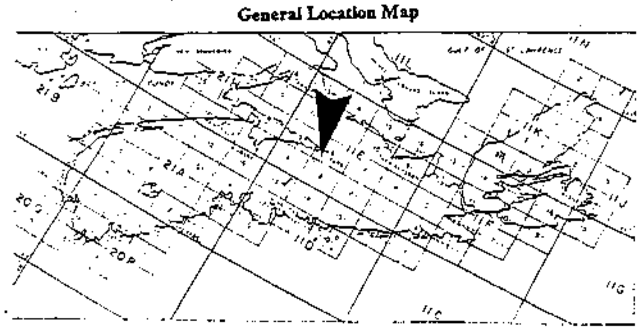


Figure 10, Beaver Brook Special Licence No. 4/98

Nova Scotia Department of Natural Resources

Map 11 E 6 B
Refs.________

# Form No. 10 - Statement of Assessment Work Expenditures

(N.B. Complete as necessary to substantiate the total claimed)

RE: Exploration Licence No.: SL 4/98 Date of issue : July 2nd 1998

| | Type of work | | Unit | Amount spent |
|---|---|---|---|---|
| 1 | Prospecting | | days | |
| 2 | Geological mapping | | days | |
| 3 | Trenching/Stripping/Refilling | | m2 | |
| 4 | Assaying & whole rock analysis | | # | |
| 5 | Other laboratory________ | | # | |
| 6 | Grid: | | | |
| | a)Linecutting | | km | |
| | b)Picket setting | | km | |
| | c)Flagging | | km | |
| 7 | Geophysical Surveys: Airborne: | | | |
| | a)EM | | km | |
| | b)Mag or Grad | | km | |
| | c)Radiometric | | km | |
| | d)Combination | | km | |
| | e)Other________ | | km | |
| 8 | Geophysical Surveys: Ground: | | | |
| | a)EM | | km | |
| | b)Seismic Soundings | | # | |
| | c)Magnetic/telluric | | km | |
| | d)IP/Resistivity | | km | |
| | e)Gravity | | km | |
| | f)Other ________ | | km | |
| 8 | Geochemical Surveys: | | | |
| | a)Lake, stream, spring(seds/water) | | samples | |
| | b)Rock/core/chips | | samples | |
| | c)Soil/Overburden | | samples | |
| | d)Gas Method | | samples | |
| | e)Biogeochemistry | | samples | |
| | f)Sample collection | | days | |
| | g)Other ________ | | | |
| 10 | Drilling: | | | |
| | a)Diamond (#holes/m) | / | m | |
| | b)Percussion (#hole/m) | / | m | |
| | c)Rotary (#hole/m) | / | m | |
| | d)Auger (#holes/m) | / | m | |
| | e)Reverse circulation (#holes/m) | / | m | |
| | f)Logging, supervision, etc. | / | days | |
| | g)Sealing (# holes) | | | |
| 11. | Other: (describe) | | | |
| | 1. Data collection and compilation | | | $ 6,317.00 |
| | 2. Geological and geophysical analysis and modeling | | | $14,214.00 |
| | 3. Storage prefeasability | | | $11,055.00 |
| | SUBTOTAL | | | |

Overhead costs

| | | |
|---|---|---|
| 12 | Secretarial Services......... | |
| 13 | Drafting Services......... | |
| 14 | Office Expenses (rent, heat, light etc.)......... | |
| 15 | Field Supplies......... | |
| 16 | Compensation Paid to Landowners......... | |
| 17 | Legal Fees......... | |
| 18 | Other(describe)________ | |
| | TOTAL | $31,586.00 |

I hereby certify that the above information is true and correct and that it has not before been submitted for assessment work credit.

As Manager – Underground Storage Development (Position in Company or Licensee) I am duly authorized to make this certification.

Dated at Trois-Rivières-Ouest in the Province of Québec this 28th day of June 1999.

Name and address of licensee: Intragaz and Company, limited partnership
6565, boul. Jean XXIII, Trois-Rivières-Ouest (Québec) G9A 5C9

Signature

RECEIVED JUN 30 11 31 AM '99 NATURAL RESOURCES