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GROUNDWATER RECHARGE AND CONTAMINATION: SENSITIVITY ANALYSIS FOR CARBONATE AQUIFERS IN SOUTH-EASTERN ONTARIO - THE JOCK RIVER BASIN STUDY

by

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A thesis submitted to the School of Graduate Studies in partial fulfillment of the requirements for the degree of M.Sc. in Geology

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i) Abstract

The Jock River Basin was selected as a case study representative of carbonate aquifers in South-Eastern Ontario, where development is increasing demands for groundwater. Monthly hydrochemical and isotope data were used to define aquifer recharge and response to recharge events. Groundwater discharge is important in maintaining the river base flow and wetlands. Deep bedrock groundwater recharge (between 10 to 25 m below bedrock surface) occurs in areas of shallow discontinuous overburden. Groundwaters show a high degree of mixing, but despite mixing impact by anthropogenic activity as road salting and nitrate pollution has been documented. In areas of thick overburden (>2m) two artesian confined interconnected aquifers have been identified, i) a highly permeable basal overburden - upper bedrock aquifer and ii) a deeper fractured bedrock aquifer. Circulation rates can be in a matter of days in the shallow aquifer, implying sensitivity to drought and development. While shallow groundwaters are highly sensitive to seasonal recharge, deeper bedrock groundwaters show essentially no temporal variations in chemistry and isotopes despite their shallow depth (<25m). Their homogeneity and their low tritium content suggest a mean circulation time on the order of several decades. Susceptibility to mining and long term contaminant loading is a concern for long circulation time bedrock groundwaters. Isotope measurements suggest reversals of hydraulic gradients during periods of high groundwater consumption from both aquifers. The measurements show that these gradient reversals allow for rapid transport of surface waters into the aquifers. Conditions may allow for rapid introduction of contaminants in the long circulation time bedrock groundwaters.

i) Résumé

Le bassin de la Riviere de Jock fut choisi comme étude de cas typique des aquifères carbonatés du sud-est de l'Ontario, où le développement accroît la demande en eau souteraraine. Des donnés hydrochimiques et isotopiques mensuelles furent utilisées pour définir la recharge de l'aquifère ainsi que sa réaction aux événements de recharge. La décharge en eau souterraine est importante pour maintenir l'écoulement de base (base flow) et les marécages. La recharge en eau souterraine se produit dans les zones de mort-terrain peu profondes et discontinues. Malgré le mélange élevé que démontrent les eaux souteraines, l'impact de l'activité humaine, tels le salage des routes ou la pollution par les nitrates, fut documenté. Dans les zones plus épaisses de mort-terrain (>2m), deux aquifères artésiens, confinés et interconnectés, furent identifiés, i) un aquifère très perméable dans la zone située à la base du mort-terrain et au haut de la roche-mère, et ii) un aquifère fracturé dans la zone plus profonde de la roche mère. Les taux de circulation peuvent être une question de jours dans l'aquifère peu profond, ce qui implique une réponse rapide à la sécheresse et au développement. Bien que les eaux souterraines peu profondes soient très sensibles à la recharge saisonnière, les eaux plus profondes que l'on retrouve dans la roche-mère ne démontrent aucune variation temporelle quant à leur chimie ou aux isotopes, et ce malgré leur petite profondeur (<25 m). Leur homogénéité et leur basse teneur en tritium suggèrent un temps de séjour de plusieurs décénnies. La susceptibilité à l'exploitation minière et à l'apport à longue échéance de contaminants constituent un soucis pour ces eaux ayant un temps de séjour élevé. Les données isotopiques suggèrent des renversements de gradients hydrauliques pendant les périodes de grande consommation d'eau souterraine provenant des deux aquiferes. Les données démontrent que ces renversements permettent le transport rapide des eaux de surface jusqu'aux aquifères. Ces conditions peuvent permettre une introduction rapide de contaminants dans les eaux souterraines ayant un temps de séjour prolongé dans la roche-mère.

ii) Acknowledgments

I would like to thank Dr. Ian Clark of the University of Ottawa for his positive, supportive advice and assistance in the completion of this study. Special mention goes to Mr. Andy Robinson of A.J. Robinson & Associates Inc. for his assistance in funding this thesis and provision of office resources for many of the computer analyses completed for this thesis. The Ministry of the Environment and Energy Research and Technology Branch provided the main source of funds to this research and made this exciting project possible. Special thanks to Mr. Brian Kaye of the MOEE for his assistance during the progress of this study.

My appreciation and thanks are extended to Ana-Maria Farmakis-Velderman with spending many hot and cold hours of sampling in the study area. Her love and support during the study program has contributed to the completion of this thesis. I thank my father, Mr. Alexander Velderman in the review support of this thesis.

I would like to thank the residents of the Goulbourn, Beckwith and Nepean Townships, in particular to those people that provided me with ready access to their waterwell. I thank them for putting up with me on many Sundays. Furthermore I would like to thank them for the warmth and friendship during the course of this study. As I enjoyed many happy moments with these residents, I felt also with their hardships. The passing away of Mr. Mark Hamel of Richmond and Mr. Brophy of Nepean at the completion of this study were very difficult. I wish strength to both families.

Further thanks are extended to Mr. Richard Pook who operates an amateur weather station in the Carleton Place area. Mr. Pook has collected several rain water samples for use as isotope input function in this study.

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1.0 Introduction

1.1 Background

Development in rural Eastern Ontario relies mainly on groundwater for water supply. Groundwater development has greatly accelerated during the last decade. Little is known about the short and long term effects of this development on the water quantity and quality of the aquifers. Present studies have mainly focused on the local effects of sustainability through the evaluation of short term pumping tests. In most hydrogeological studies the underlying assumption is that continuity exists within aquifer formations. However the origin of recharge to groundwater is seldom identified by applied physical methods. In addition renewability of the groundwater is not addressed. Renewability not being appropriately addressed could lead to potential upconing of deeper potentially more mineralized groundwater, leakage from more mineralized water-bearing zones and contaminated overburden water or severe draw down of aquifers with associated changes in groundwater flow patterns.

The current study was initiated to provide additional chemical and isotopic information on limestone aquifers in Eastern Ontario. Using this information an understanding of groundwater flow systems can be inferred. The information could be further applied in the assessment of vulnerability and sustainability of groundwater development.

1.2 Purpose and Objectives

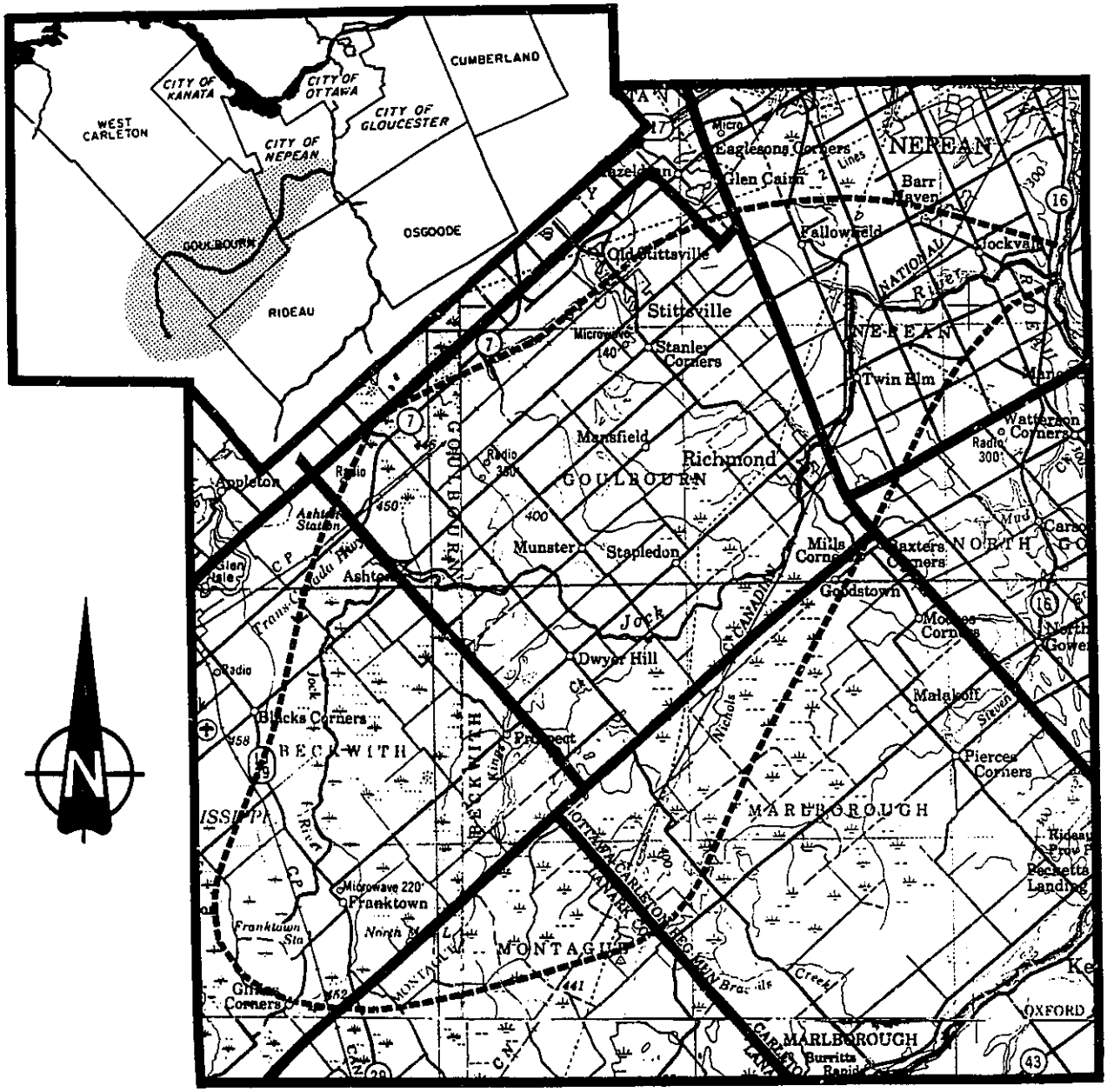
This study examines the chemical characteristics of the groundwater in the Jock River Basin (Figure 1), which is approximately 600 km^2 in surface area. Inorganic groundwater chemistry in conjunction with isotope content are used to explain and identify the following processes in the Jock River Basin:

- groundwater recharge
- the groundwater flow paths and hydrostratigraphic units
- the seasonality of recharge
- the sensitivity of groundwaters to contamination

1.3 Scope of Work

The initial phases of the study have involved a detailed review of existing data on the geology and the hydrogeology. This review included an interpretation of the study area surficial and bedrock geological mapping. In excess of 4700 waterwell records available in digital formats were analyzed to obtain bedrock surface topography, overburden thickness and mean potentiometric surface of the bedrock aquifer. The records were further used to locally analyze stratigraphy.

Flow data collected from the Jock River (NWRI, 1993) provided insight into the aquifer baseflow and yearly precipitation cycles. An amateur weather station in the headwater region provided precipitation samples used for determining the isotope input function. The fieldwork involved sampling of Jock River surface water. Eight sampling locations were designated along its course at regular



Scale 1:250.000 base map after NTS 31 G

0 5 10 km

FIGURE 1 - STUDY AREA

LEGEND

Township Boundary

Jock River Drainage Basin

intervals (Figure 2). A total of 24 bedrock and overburden aquifer sampling stations were sampled along several transects perpendicular to the Jock River. Groundwater samples were collected from the different aquifer lithological areas. Groundwater sampling stations included private wells, communal wells and monitoring piezometers. Selected sampling stations were sampled on a monthly basis over a period of 16 months. All other stations were sampled once in summer and once in late fall. The chemical characteristics measured include main inorganic chemical and physical constituents of groundwater as well as its isotopic composition (Appendix A).

1.4 Study Area

The study area is located in South-Eastern Ontario. The western boundary is situated in Beckwith Township near the Hamlets of Franktown and Blacks Corners. The eastern boundary is formed by the Rideau River which flows from south to north. The maximum east west dimensions of the drainage basin are approximately 60 km while the maximum north south dimensions are 30 km. The drainage basin encompasses an area of approximately 600 km^2. The study area includes the following Townships: Montague, Rideau (formerly Marlborough and North Gower), Beckwith, Goulbourn, and Nepean. The lion share of the study area is located in Goulbourn Township. The Townships are subdivided into lots and concessions. Lots and concessions are irregular in each township and as such the Universe Transverse Mercator Grid System was used to locate wells, water samples and other points of significance.

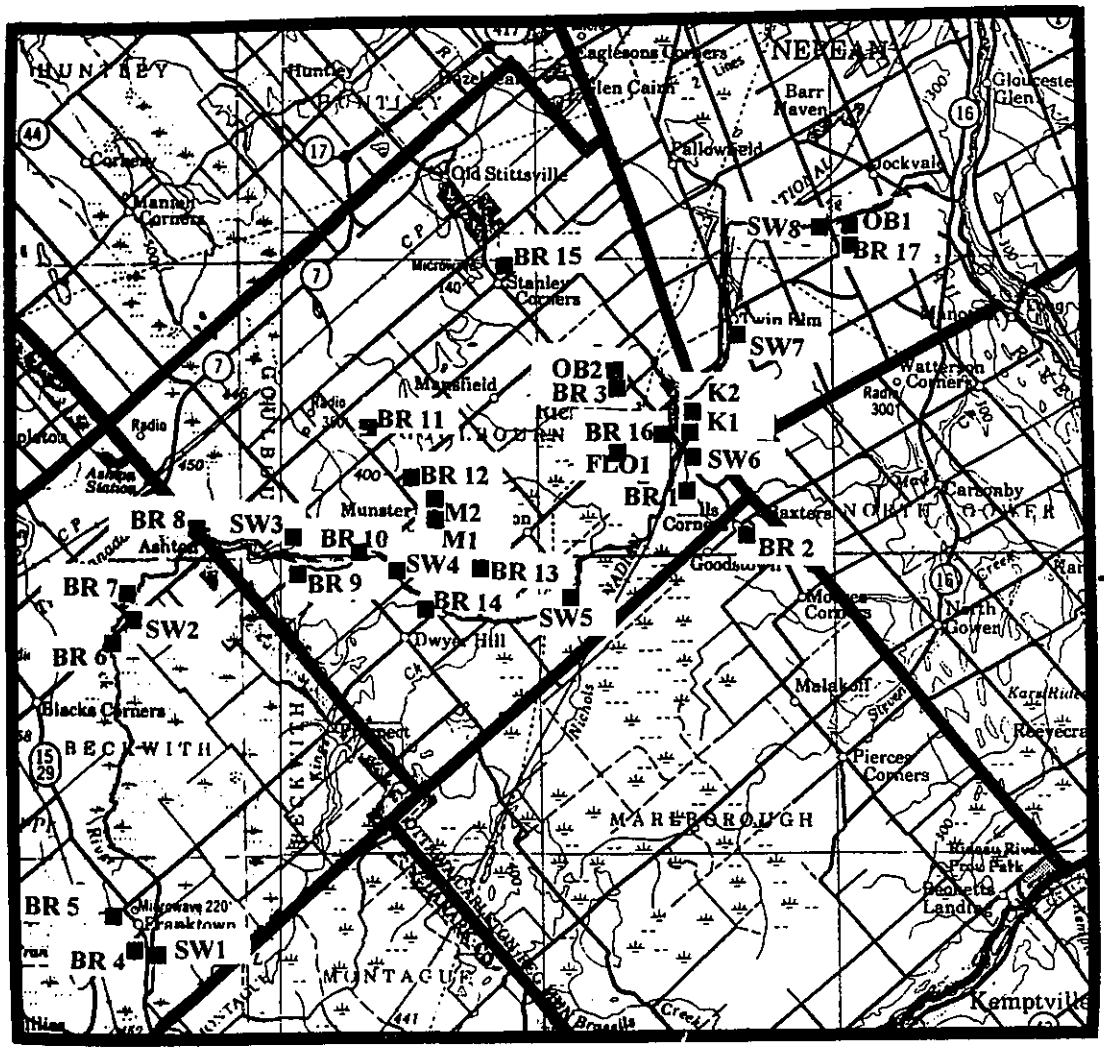


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FIGURE 2 - SAMPLING LOCATIONS

LEGEND

BR 12	**Bedrock groundwater sampling site**
OB2	**Overburden groundwater sampling site**
SW3	**Surface water sampling site**
M1	**Munster communal well**
K2	**Kings Court communal well**
FLO1	**Artesian well**

The study area was selected because it contains many groundwater settings typical of South-Eastern Ontario. In general the study area may be subdivided into two main regions. The western region is characterized by shallow soils (<2m) over carbonate rock types, with an average surface gradient of 0.001. Local gradients may be steeper due to a local relief of 10 m. The eastern region is characterized by thick overburden deposits (>5m) of glacial origin. These deposits vary from gravel to sandy deposits of beach and glacio-fluvial origin to clay deposits of glacio-marine origin. The area has an average topographic gradient of 0.0003.

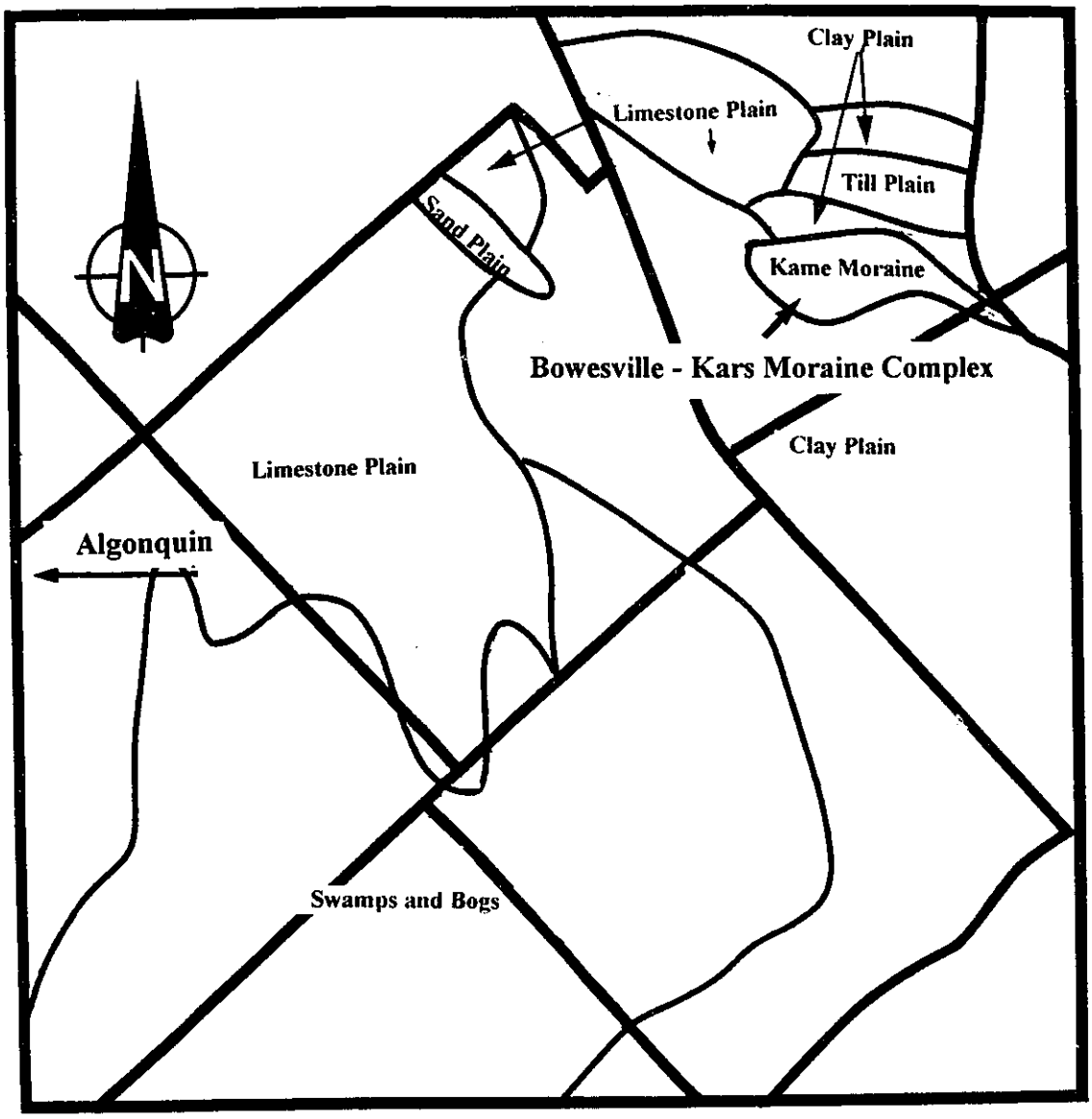
2.0 Geological Setting

2.1 Physiography

The Jock River Basin is located due south of Ottawa (Figure 1). The river has a total length of 58 km, flowing from an elevation of 155 m above mean sea level (amsl) to a low of 80 m amsl.. The head water regions of the river basin are characterized by bedrock outcropping. The river crosses numerous marshes where its course splits into various undefined channels. Poorly drained areas are associated with widespread marshland.

Various glacial landforms characterize the area. The western part of the study area is part of the Smith Falls Limestone Plain (Chapman and Putnam, 1984)(Figure 3). The limestone plain is characterized by shallow till over rock. Solution fractures in the exposed bedrock are not uncommon. Narrow sand eskers are found in the marshes and stand as ridges above the surrounding limestone plain. At the extreme west the study area is flanked by the perimeter of the Algonquin Highlands physiographic region. The granitic Precambrian basement is the dominant rock type and surficial unit of the Highlands.

The eastern part of the study area is characterized by a clay plain (Ottawa Valley clay plains)(Chapman and Putnam, 1984), which is abutted on its eastern flank by the Bowesville Kars moraine complex. This feature stands as a topographic high 10 m above the clay plain (Figure 3). The clay plain thickness is up to 30 m in the center of the study area.



Scale 1:250.000 base map after NTS 31 G

Refer for reference to Figure 1

0 5 10 km

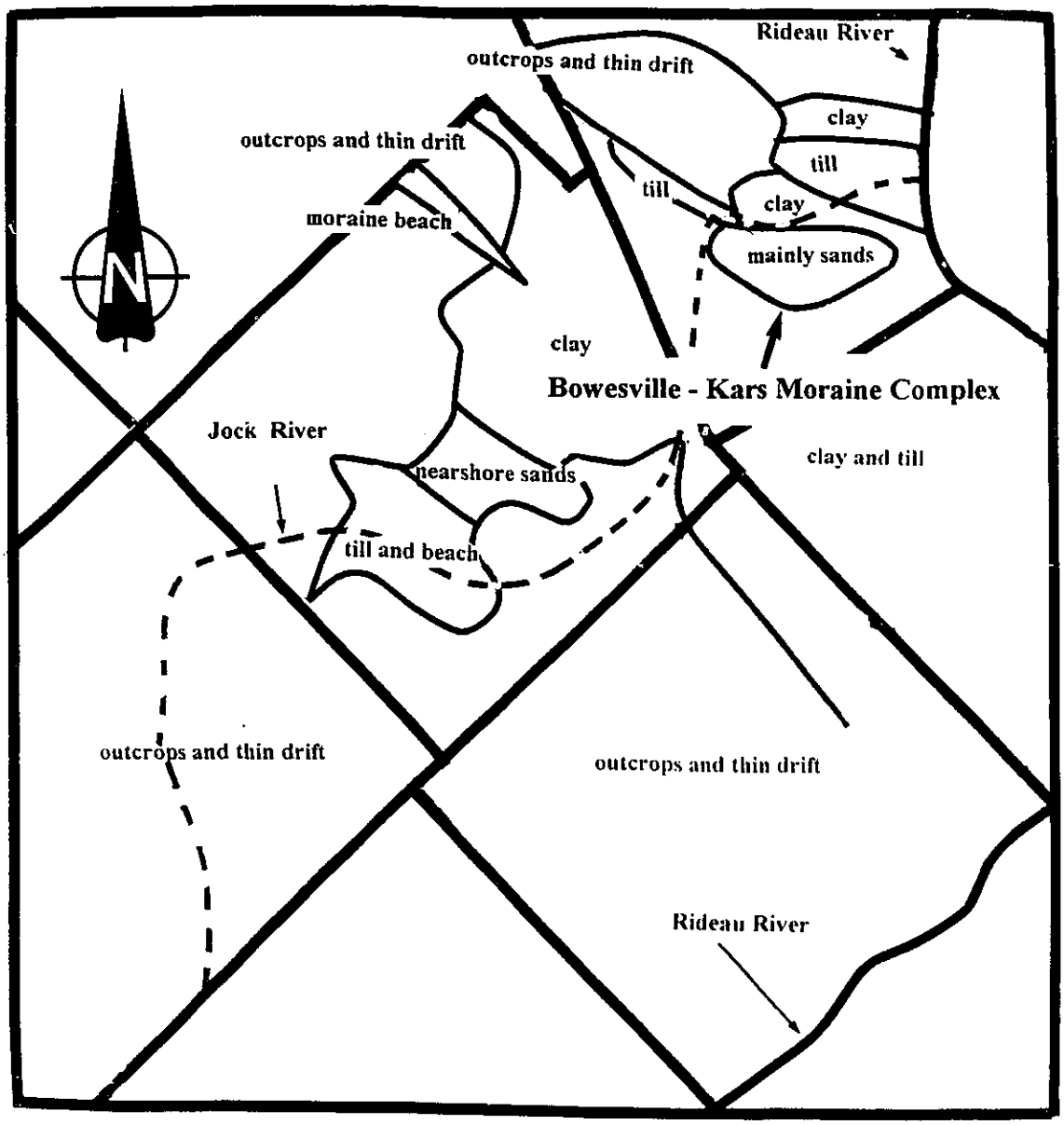
FIGURE 3 - Physiographic Regions

2.2 Overburden Geology

The section below describes the overburden geology, going from headwaters to downstream areas of the Jock River. The regions near the river's drainage divide are characterized by thin drift and outcrops. In this area, mainly in the marshes, various small extent sand deposits are found. Ringrose et al.(1990) map these as glacio-marine beaches and eskers. Going towards the center of the basin and eastward, overburden materials increase in thickness. From west to east a sequence of materials is noted as discussed below.

The first deposit of significant thickness is a sandy bouldery till. The Richard (1983) map refers to this deposit as beach and till. Ringrose et al. (1990) refer to it as a ground moraine. The waterwell records show that this deposit may underlie all the other overburden units and is commonly referred to as basal gravel. Thicknesses of this deposit are greatest in buried bedrock valleys (Geo-analysis Inc., 1987)(refer to Figure 4 for till outcrop area).

Further east, nearshore sands are the surficial deposit. These deposits are flat-lying and abut a plain of clay and fine grain size till deposits. Thicknesses of materials vary from several metres up to several tens of metres. Ringrose et al.(1990) refer to the nearshore sands as glacio-marine beaches and the clays as a glacio-marine plain. Further east near where the Jock River meets its discharge point at the Rideau River the topography rises 20 m above the surrounding till and clay plains. The topographic high has been mapped by Richard(1984) as part of the Bowesville-Kars outwash complex. Ringrose et al. (1990) map it as kame moraine. A typical overburden cross- section along the axis (west- east) of the



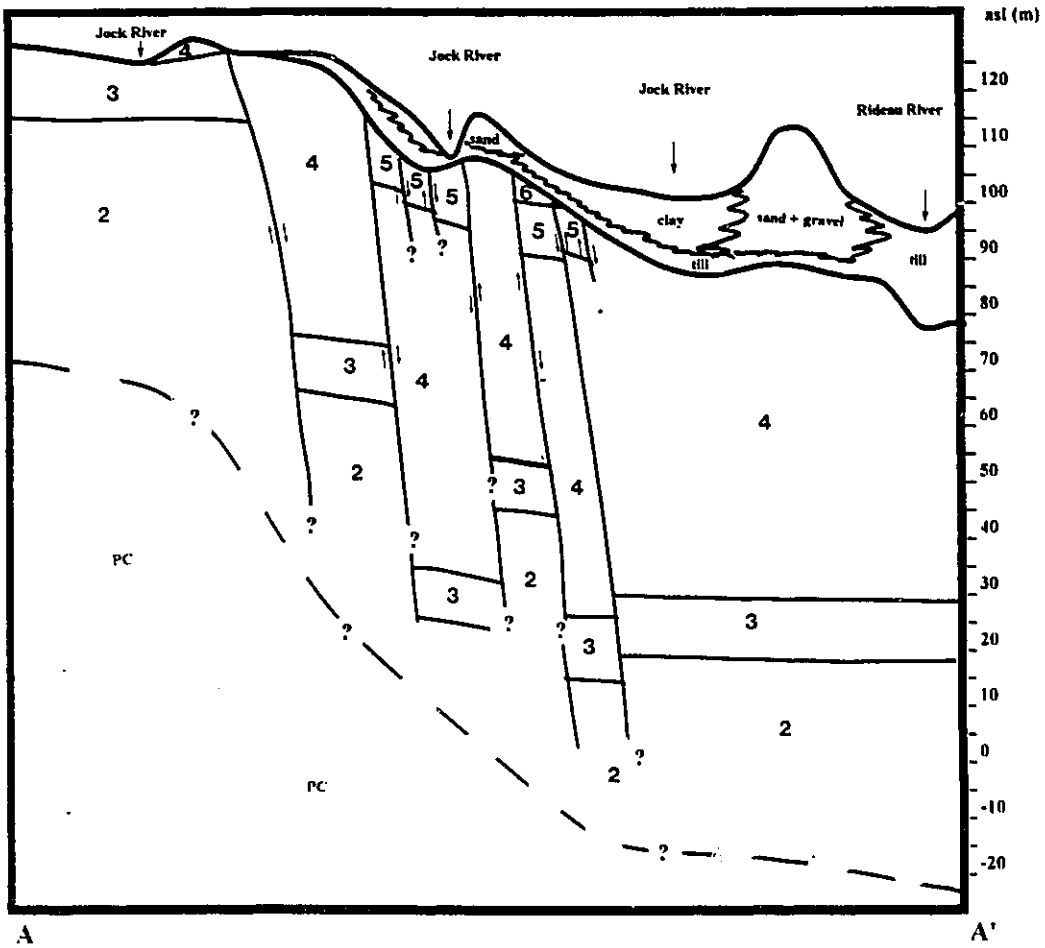
Scale 1:250.000 base map after NTS 31 G

Refer for reference to Figure 1

FIGURE 4 - Generalized Overburden Geology

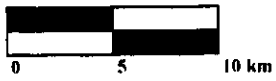
0 5 10 km

stream is provided in Figure 5. Similarly a cross- section is provided perpendicular (north-south) through the basin in Figure 6. The cross-section locations are shown in Figure 7.



Geology after Williams (1991), unit thickness inferred from Williams (1991) and MOEE waterwell records

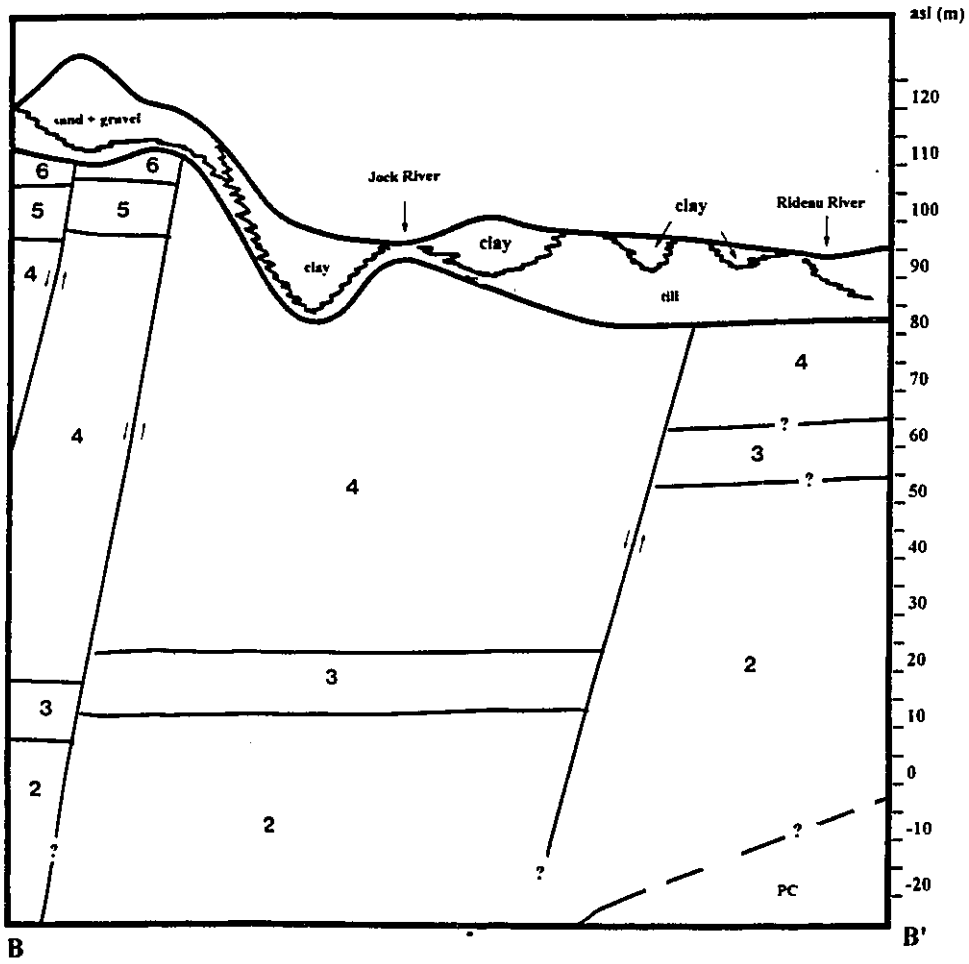
Figure 5 - Cross- section through the Jock River Basin (W-E)



Refer to Figure 7 for cross- section location

LEGEND

6	-	Shadow Lake Formation
5	-	Rockcliffe Formation
4	-	Oxford Formation
3	-	March Formation
2	-	Nepean Formation
PC	-	Precambrian



Geology after Williams (1991), unit thickness inferred from Williams (1991) and MOEE waterwell records

Figure 6 - Cross- section through the Jock River Basin (N-S)

Refer to Figure 7 for cross- section location

LEGEND

0 5 10 km

6	-	Shadow Lake Formation
5	-	Rockcliffe Formation
4	-	Oxford Formation
3	-	March Formation
2	-	Nepean Formation
PC	-	Precambrian

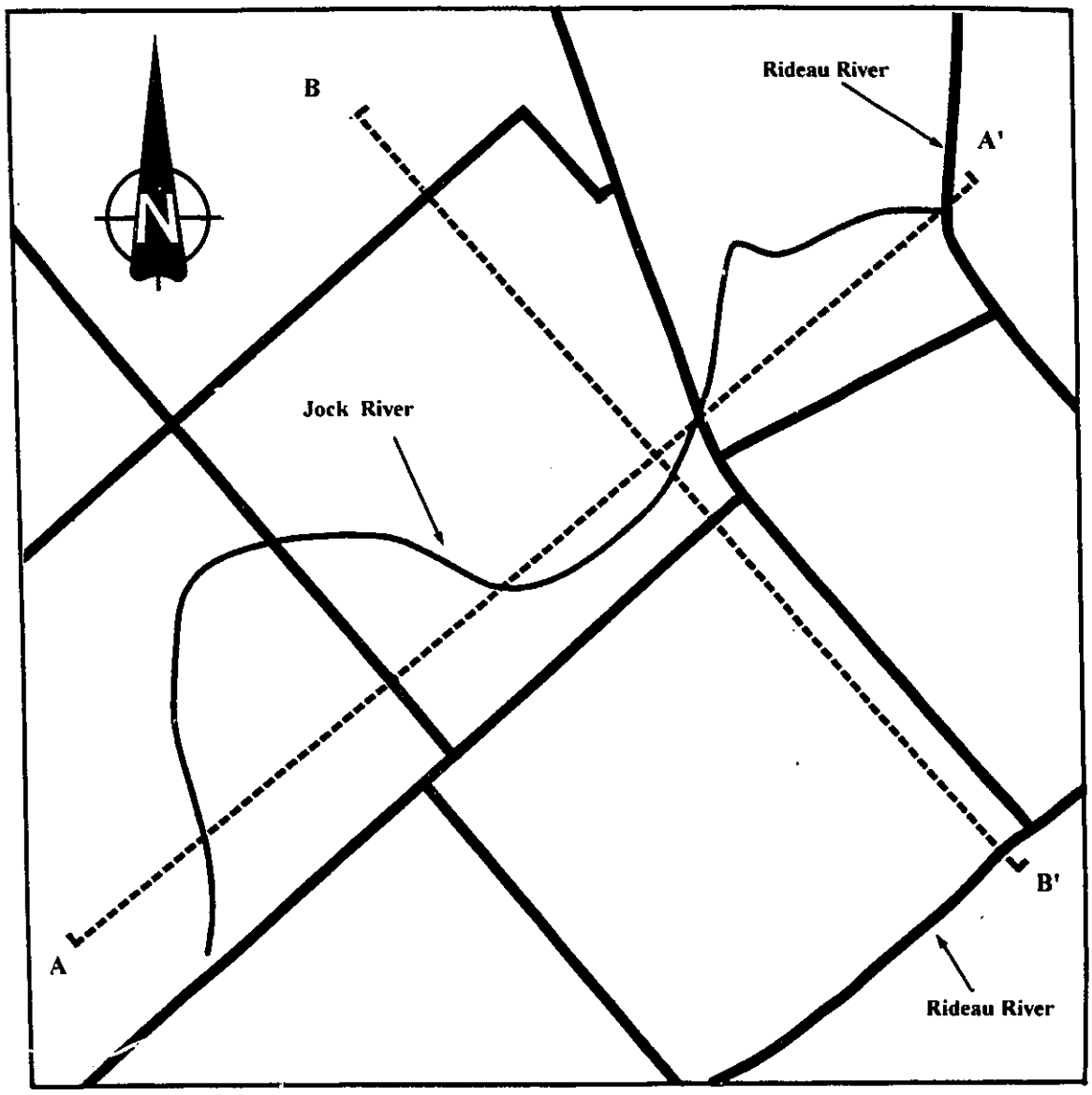
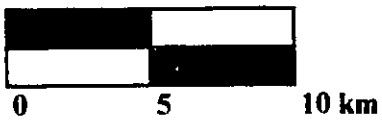


Figure 7 - Cross- section Location Map



2.3 Bedrock Geology

The western part of the Jock River Basin lies adjacent to the Frontenac axis. The Frontenac axis is an outcropping of Precambrian basement, a regional ridge of mainly crystalline shield trending north and south. The Precambrian units extend to the west. Carbonate sequences of the St-Lawrence lowlands are found to the east. The distribution of geological units is shown in Figure 8.

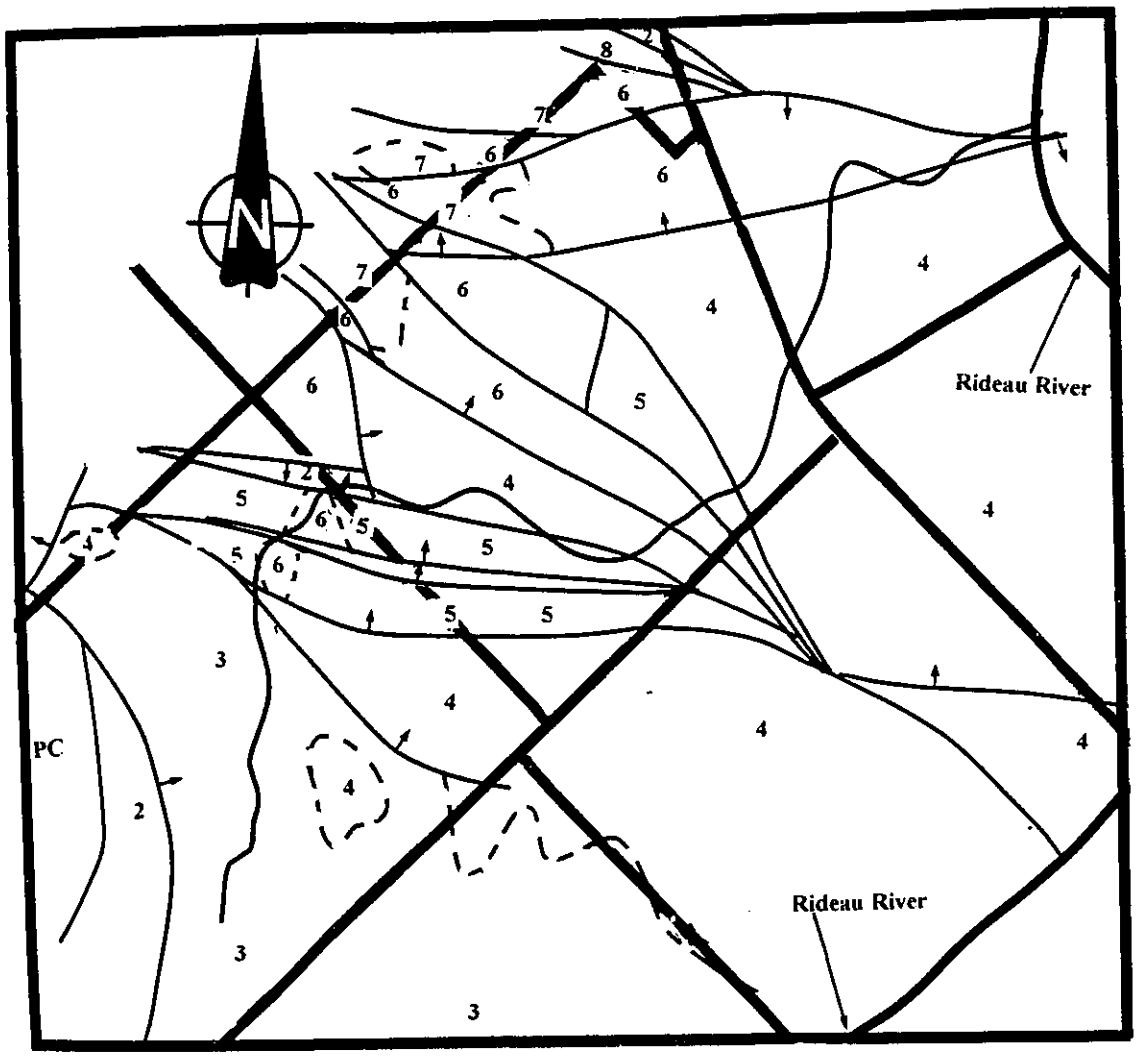
The sedimentary sequence of the St. Lawrence lowlands unconformably overlies the Precambrian basement in the Jock River Study area. This sedimentary sequence of Paleozoic age (Williams, 1991) typically increases in age from east to west in the St-Lawrence - Ottawa Valley Lowlands. In the description of the Paleozoic geological units the nomenclature as defined by Williams (1991) rather than Wilson (1946) will be consistently applied throughout this study. The Paleozoic rocks in the Jock River Basin are of the Ordovician Period. Its lithostratigraphic sequence has been provided in Table 1.

Cross-sections along the east west axis and north south through Richmond of the Jock River Basin have been provided in Figure 5 and Figure 6 respectively. The geology section has shown that the area has a complex stratigraphy and structure. The structure is controlled by the Ottawa Graben. Mapping by Williams (1991) has shown the Precambrian units in the west to be unconformably overlain by the Paleozoic successions. The east west Paleozoic stratigraphy gets younger going east by faulting rather than in stratigraphic sequence. The younger units are

GROUP	FORMATION	MEMBER
OTTAWA	BOBCAYGEON	UPPER
		MIDDLE
		LOWER B
		LOWER A
	GULL RIVER	UPPER
		LOWER
	SHADOW LAKE	
CHAZY	ROCKCLIFFE	
BEEKMANTOWN	OXFORD	
	MARCH	
POTSDAM	NEPEAN	

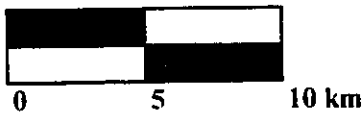
after Williams(1991)

TABLE 1 - LITHOSTRATIGRAPHIC SEQUENCE



Scale 1:250.000 base map after NTS 31 G/SW – Geology after Williams(1991)
Refer for reference to Figure 1

Figure 8 - Bedrock Geology



LEGEND

8	-	Bobcaygeon Formation
7	-	Gull River Formation
6	-	Shadow Lake Formation
5	-	Rockcliffe Formation
4	-	Oxford Formation
3	-	March Formation
2	-	Nepean Formation
PC	-	Precambrian

Fault

Geological contact

more exposed in the northern part of the Jock River Drainage Basin as faulting caused more vertical displacement. The Oxford Formation is the most dominant unit in the southern part of the study area and conformably overlies the March Formation. The almost horizontal plane the units have is notable. The bedrock surface topography reflects the structure and stratigraphic sequences found in the study area. Harder upfaulted bedrock units (i.e. Ottawa Group) stand as ridges above the surrounding area. In the flat lying bedrock regions (Oxford Formation, March Formation) marshes are found, expressing the poor drainage associated with these terraines.

2.4 Stratigraphy

2.4.1 Precambrian

Precambrian rock types outcrop west of the study area (Williams, 1991) and consist of highly deformed metasedimentary and metavolcanic rocks which have been intruded by felsic to mafic plutons (Williams, 1991). The outcrop areas to the west are part of the Central Metasedimentary Belt of the Grenville Province of the Canadian Shield (Williams, 1991).

2.4.2 Potsdam Group- Nepean Formation

Lower Ordovician Sandstones of the Nepean Formation unconformably overlie the Precambrian units. The Nepean Formation is the upper unit of the Potsdam Group, its lower member, the Covey Hill Formation, is not represented in the study area.

The Nepean Formation

The Nepean Formation was named after Nepean Township (Williams, 1991). A road cut along the Queensway, a main highway corridor through the City of Ottawa and its suburbs, was proposed as the principal type section. The Nepean Formation outcrops in the extreme western areas of the study area (Figure 8). Alternating beds of calcareous sandstone and quartz arenite characterize these outcrops. The formation is believed to underlie all of the study area (Williams, 1991).

The sandstones consist of fine to coarse quartz sand grains. Variable amounts of hematite coatings are reported (Williams, 1991). Cements observed include calcite and quartz. The sandstones are thinly bedded in the western part of the study area. Williams (1991) reports thinly to massively bedded sandstones for other outcrop areas. Numerous small brown weathering spots are observed on the mainly buff coloured rock. These may originate from diffusion of iron derived from detrital pyrite, magnetite, or ilmenite grains into the surrounding pore spaces (Williams, 1991). Powell and Klugman (1979) report an average drill core analysis of 96.6% SiO_2 , 0.2% Fe_2O_3, 1.1% Al_2O_3, 1.8% CaO, and 0.1% MgO.

The depositional environments in the St Lawrence Lowland area have been reported as lower intertidal to subtidal and minor facies of storm and wave dominated facies (Wolf and Dalrymple, 1985). A thickness of 45.5m has been reported by Bernius as cited in Williams (1991).

2.4.3 The Beekmantown Group- March and Oxford Formations

March Formation

The formation was named after March Township, now the City of Kanata. The formation consists of interbedded quartz sandstone and dolostone. The formation conformably overlies the Nepean Formation (Wilson, 1946). Wilson (1946) defined the March contact with the Nepean Formation as the top of the highest occurrence of sand in any quantity , or the top of the uppermost sandy bed. The contact between the March and Oxford Formations is difficult to distinguish as it

is marked by the difference between dolomitic sandstone and sandy dolostone, which are similar in appearance (Williams, 1991).

The March Formation outcrops mainly in the upper reaches of the Jock River. It has been documented to exist beneath the overlying formations (MOEE waterwell records.). Thicknesses up to 6.6 m have been documented in the study area.

Williams (1991) describes the March Formation as outlined below. The formation consists of interbedded quartz sandstone, dolomitic quartz sandstone, sandy dolostone and dolostone. Shale partings are present throughout the formation. The quartz sandstones of the March Formation are of similar character as the Nepean Formation. The sandstones range in colour from white to light gray, brown to reddish brown, and green. The quartz grains are subrounded to well rounded. Two types of cement, calcite and quartz have been documented. Crossbedding, ripple marks and burrows are common.

The facies of dolomitic quartz sandstone and sandy dolostones are described as brownish to bluish grey in colour. The units are thinly to thickly bedded and contain fine to medium crystalline carbonate and well rounded, fine to coarse grained quartz sands. Williams (1991) notes that the dolostones of the March Formation are lithologically similar to those of the overlying Oxford Formation. The dolostones are brownish to greenish grey in colour. The dolostones are thinly to thickly bedded, sublithographic to finely crystalline. Burrows, algally bound laminae and calcite filled vugs are common. Powell and Klugman (1979) report an average drill core analysis of 41.1% SiO_2 , 0.73% Fe_2O_3, 2.77% Al_2O_3, 19.9% CaO, and 10.1% MgO, and 26.8% loss on ignition. The depositional

environment of the March Formation is supratidal to subtidal.

The Oxford Formation

The Lower Ordovician Oxford Formation conformably overlies the March Formation. The contact between the formations is at the uppermost sandy bed in the March Formation. The upper contact with the Rockcliffe Formation is disconformable. The Oxford Formation is most often the surficial bedrock unit in the study area.

The mainly dolostone Oxford Formation has commonly occurring shale interbeds of which some may be glauconitic. Well rounded quartz sand occurs in some beds. Quartz sandstone occurs as interbeds up to 30 cm thick. The dolostones of the Oxford Formation are brownish to greenish blue gray in colour. They are thinly to thickly bedded sublithographic to medium crystalline. Oolitic interclastic beds have been observed in outcrops of the study area. The outcrops in the Jock River basin show dolostones characterized by desiccation cracks, conchoidal fractures, stylolites, burrows, and soft sediment deformation structures.

The chemical composition of the Oxford Formation as reported by Hewitt (1964) on a section near Iroquois is as follows: 9.34% SiO_2 , 1.00% Fe_2O_3, 4.94% Al_2O_3, 26.48% CaO, and 17.29% MgO and 39.79% loss on ignition. The Oxford Formation was deposited in a supratidal to intertidal hypersaline depositional environment. Thicknesses in excess of 200m have been reported. Thickness of this formation in the study area is in the order of 60m. This estimate is based on the numerous waterwell records in the study area.

2.4.4 Chazy group-Rockcliffe Formation

The Rockcliffe Formation is found mostly in the northern half of the study area. The formation is a part of the Chazy group of the Middle Ordovician (Williams, 1991). The formation overlies the Oxford Formation disconformably. The Rockcliffe Formation is named after its type section in a neighbourhood of the same name in Ottawa.

The Rockcliffe Formation is subdivided into lower and upper members. Interbedded quartz sandstone and shale occur in both members, but the upper member is distinguished by additional limestone and silty dolostone interbeds. Exposures in the Jock River area occur near Ashton. The exposures show a green buff weathered sandstone, some localities show a friable shale interbedded.

Williams(1991) describes the Rockcliffe Formation as consisting mainly of interbedded quartz sandstone and shale. The lower member, with its higher abundance of sandstone, occurs in the Jock River Basin. The sandstones are fine-grained and light grey to light greenish grey in colour, very thinly to thickly bedded and may be calcareous. Dark green shaly partings may be present. The shales near Ashton are maroon coloured. Williams (1991) reports shale units up to 2.5 m thick. A basal quartz pebble conglomerate is reported by Williams (1991). It is very thinly to medium to thickly bedded. The basal gravel is not exposed in the Jock River Basin.

The Rockcliffe Formation was deposited in a supratidal to subtidal intracontinental

shelf environment (Williams, 1991). The occurrence of shallow water facies in the study area is consistent with Williams' observation that deeper water environment deposits are found farther east from the Frontenac axis (i.e. shales and silty dolostone). An estimate of thickness based on waterwell logs is in the order of 10 m.

2.4.5 Ottawa Group

Shadow Lake
Gull River
Bobcaygeon
Verulam
Lindsay Formations

Wilson proposed the Ottawa Formation in 1937. The formation consisted of limestone with interbeds of silty dolostone, shale and quartz sandstone. Uyeno (1974) raised Wilsons Ottawa Formation to Group status. The application of Williams and Rae (1983) adopted version of stratigraphy from South Central Ontario will be followed. In the Jock River drainage basin only the Shadow Lake, Gull River and Bobcaygeon Formations are found and are discussed below.

Shadow Lake

The conformable upper contact with the overlying Gull River Formation is defined at the base of a dolostone and dolomitic limestone (Liberty, 1969; Williams, 1991). Two units exist, but only the upper unit is recognized in the study area

where it disconformably overlies the Rockcliffe Formation. The contact is defined as the upper limit of shale interbeds greater than 10 cm thick.(Williams,1991).

The Shadow Lake Formation is believed to exist in the northern fringes of the study area, where upper members have been mapped as the surficial unit.

The lithologic description has been extracted from Williams (1991). The formation consists of calcitic to non-calcitic silty sandy dolostone, with shaly partings and thin interbeds of calcareous quartz sandstone. The dolostones are described as sublithographic to finely crystalline, very thinly to thickly bedded and slightly greenish grey in colour. The sandstone interbeds are fine grained, but coarse grained quartz is present in some beds.

The depositional environment has been interpreted as a supratidal environment (Williams,1991). Williams(1991) notes a thickness of the Shadow Lake Formation of between 2.5 to 2.8 m.

Gull River Formation

The Gull River Formation comprises the upper part of the lower phase and lower part of the middle phase of the Ottawa Group. The formation is found in the northern fringe of the study area near the Village of Stittsville and near Barrhaven.

The formation is of the Ordovician Period (Liberty, 1969). A Blackriveran age is indicated by the shelly fossils (Barnes et al. 1981). The formation conformably

overlies the Shadow Lake Formation and consists of interbedded lithographic limestone and dolostone. The upper contact is the base of a generally massive high purity limestone unit (Williams, 1991, p87). A lower and an upper member are distinguished.

The lithology of the unit is described below. The lower member of the Gull River consists of interbedded limestone and silty dolostone. Quartz sandstone and shale interbeds also occur. The limestones are lithographic to finely crystalline and thinly to thickly bedded. The rock is dark grey to brownish grey. Intraclastic beds are noted, shelly fossils and burrows are common and stromatolitic beds occur. Stromatolitic beds have been observed near Ashton at surface water sampling location SW 4 (Figure 2). The description of the dolostone is almost similar to that of the limestone. The colour is light greenish grey to dark greenish grey (Williams, 1991, p90). The silty dolostone has shaly partings. The dolostone beds are up to 2 m thick (Williams, 1991).

Williams (1991) describes the sandstones as fine to coarse grained, and varying from calcitic to non calcitic. The colour of the sandstone is light grey to greenish grey. The shales are black.

The upper member has been described as lithographic to finely crystalline limestone with shaly partings (Williams, 1991). The colour of the upper member is medium to dark grey. The unit is thinly to thickly bedded and fossils are common. Many of the beds are intraclastic. Both the upper and lower member of the formation were periodically deposited in an exposed nearshore environment followed by long periods of a supratidal environment (Williams, 1991). The

lower member is in the order of 42 m thickness and the upper member is in the order of 9 m in the study area.

Bobcaygeon Formation

This formation is the uppermost bedrock unit (youngest) in the Jock River Basin (Williams, 1991, Jacques Whitford, 1990). The unit is found discontinuously in the north of the basin on down faulted blocks. The strata are equivalent to the middle phase of the Ottawa Group except for the lowest middle phase which is assigned to the upper part of the Gull River Formation (Williams, 1991). The Ordovician Formation is of Blackriveran to Rocklandian age (Barnes et al., 1981).

Williams (1991) notes that three members can be distinguished. The lower member has high resistance to erosion and generally stands as upland pavements. In the study area the lower member is exposed in a quarry near Stittsville.

The formation is described as an interbedded lithographic to coarsely crystalline fossiliferous limestone with shale partings. The limestones are very thinly to massively bedded. The colour is light to dark grey to brownish grey.

Williams (1991) describes the lower member of the Bobcaygeon Formation as an interbedded lithographic to coarsely crystalline limestone with subordinate shaly partings. He describes the middle member as being similar to the lower member with the difference that the middle member has shaly beds and undulating shaly partings. The shaly beds are characterized by their nodular structure. The upper

member is similar to the lower member with the exception that it contains dolomitized zones up to 20 cm thick. The depositional environment was an intracontinental shelf environment. The thickness of the formation varies from 50 to 90 m in the Ottawa area.

2.5 Structural Geology

Joints

A typical joint set strike of 015, 055, 100, 145 is measured in the Ottawa -St. Lawrence Lowland Area (Williams, 1991). Joints usually strike at right angles resulting in rectangular blocks at outcrops. The 100 degree joint direction is reported to be the most dominant. Williams (1991) reports that the joints have been widened by carbonate dissolution. The common filling in joints is calcite, minor pyrite, barite, celestite in places. The joint spacing increases with bed thickness and is typically varies from 30 to 100 cm and greater. Joint spacing decreases in proximity to faults (Williams, 1991).

Faults

The Ottawa -St. Lawrence Lowland is transected by numerous steeply dipping normal faults. The faults in the Jock River area form part of a major tectonic feature, the Ottawa- Bonnechere Graben. Referring to information provided by Williams (1991) a maximum vertical displacement of 120 m is measured across the basin. The Jock River Basin is bounded by the Rideau River Fault on the east side of the study area. Vertical displacement along this fault line is in excess of 100m. The Jock River itself would also appear to follow fault traces in the central

one third of the study area. The vertical displacement along these fault traces is less significant. The study area is characteristically more intensely faulted in the northwestern part than the remainder.

3.0 Hydrogeology

A review of the geology as provided in Chapter 2 has shown that the study area is mainly underlain by carbonate bedrock sequences. The overburden is composed of glacial or post glacial material. The sections below will describe in detail the behaviour of groundwater movement in these deposits.

3.1 Physical Hydrogeology

The principal aquifers in the Jock River basin are located in either the coarse grained overburden deposits or the carbonate bedrock units. The flow in each type of deposit is genetically different (Freeze and Cherry, 1979). The flow in the overburden units is mainly controlled by flow in a porous media. The flow in the carbonate bedrock on the other hand is controlled by fractures.

The carbonate bedrock in Eastern Ontario is usually characterized by an upper weathering layer with some karstic features. This weathered layer is most profoundly developed where limestone has been elevated above the groundwater table (Stringfield and Legrand, 1966). This suggest that high permeability zones could be expected at disconformable contacts. These zones occur from oldest to youngest at the following boundaries: Precambrian-Nepean, Oxford-Rockcliffe and at the present bedrock surface. In South-Eastern Ontario the weathered upper surface is usually in the order of 5m thick with hydraulic conductivity rapidly decreasing with depth (Drillers Logs, Dyke, 1986). Paleo-karst features are observed and include solution fractures and collapsed sink holes (Eagleson

Corners). These paleo-karst features may be also present at depth.

Hydraulic conductivity may also be developed near fault systems (Wilson, 1990). Increased hydraulic conductivity would be expected due to fracturing, conversely aquifers may be cut off from their recharge areas (Geo-analysis, 1990) effectively restricting aquifer potential. In large parts of the dolostone and limestone aquifers groundwater flow occurs under confined conditions. In some parts the aquifers have artesian conditions. Further detail is provided in the sections following.

3.1.1 Hydrostratigraphy

3.1.1.1 Overburden Aquifers

The overburden aquifers are found in the sand and gravel overlying the carbonate rock types. The main overburden aquifers, from oldest to youngest, are described below.

A basal gravel till is usually found where overburden deposits are present (Figure 4). Ringrose et al. (1990) refer to it as a ground moraine although it likely originated as subaqueous outwash. The deposit originated during the regression or stagnation of the continental ice sheet. The thickness of this unit varies from tens of centimeters to several metres (local drillers). Thicknesses are usually greatest in bedrock surface valleys. Pumping rates in excess of 40 Lpm have been reported. Many wells bypass this till unit as it is more costly to screen the well than to proceed several tens of metres more in the bedrock units. Also an objective is to provide sufficient depth for drawdown in the well. The basal gravel till is

overlain by either a massive glacial till or a dense marine clay. The till outcrop areas are in the western part of the study area. Many of these till outcrop areas are covered by marshes and wetlands. A clay aquitard on top allows for artesian confined conditions in the basal gravel aquifer in eastern parts of the study area.

An unconfined aquifer exists near the confluence of Jock and Rideau Rivers. Here the topography rises 10 to 20 metres above the surrounding till and clay plains. The deposit has been mapped as part of the Bowesville - Kars outwash complex (Figure 4)(Kame moraine as mapped by Ringrose et al., 1991). High yields have been recorded and numerous overburden wells have been constructed in this deposit. Sporadic shallow overburden wells have been constructed in the overburden elsewhere. Well completion is usually in the upper five metres of unconsolidated deposits. These wells are absent in the Ministry of the Environment & Energy (MOEE) waterwell records as they are completed by excavation rather than by licensed driller. The watertable in the overburden is close to the surface. Watertable fluctuations in the surficial overburden aquifers are believed to be small due to large specific yield values (0.2-0.3). Conversely the basal gravel aquifer will show large potentiometric surface fluctuations due to confined conditions and its limited thickness.

3.1.1.2 Bedrock Aquifers

The bedrock aquifers in the study area from oldest to youngest are described below. The best producing aquifers in the study area have been identified as the bedrock units below the Rockcliffe Formation (Williams, 1991). Flow in these aquifers is mainly controlled by fracture flow.

Precambrian outcrops are found along the extreme western edge of the study area. The Precambrian is generally a good source of groundwater. The variable nature of the fracture pattern makes the prediction of water quantity difficult. The Precambrian aquifer underlies all of the study area, but is only utilized where the other bedrock formations are not present.

The Nepean Formation has been reported to be a good groundwater producer by Brandon (1960). The aquifer is best developed along the top and the base of the formation (Brandon, 1960). Reasons were not given by Brandon, but it is likely due to a coarse deposit on the unconformable boundary with the Precambrian and a weathered layer between the overlying March Formation. Flow in this aquifer will be mainly by fractures as the primary porosity of the sandstones has been reduced by cementation.

The aquifer outcrops only in a thin up thrown wedge in the west central part of the study area. The Nepean Formation is believed to underlie all of the study area at greater depth (Sobanski,1969).

The March and Oxford Formations are aquifers of very similar nature to the Nepean Formation aquifer. The difference is that these aquifers have a carbonate rock type. Fractures are enhanced by dissolution of carbonates. Some karstic features have been documented in the study area. However cave formations with underground streams do not exist. Water bearing zones occur at distinct depths but not throughout (Drillers records). The overlying Rockcliffe Formation is also a good groundwater producer (Sobanski, 1969). The sequences of the Ottawa

group on the other hand are referred to as poor and variable producers (Sobanski,1969). Sections of the Ottawa Group are massive limestones and fracturing is not as extensive as in the previously mentioned units. Depth to water tables in the bedrock aquifers is typically in excess of 5m from the bedrock surface in recharge areas. The potentiometric heads are artesian in the confined bedrock aquifers further east and flowing wells are documented in the Richmond area. Elevations of 4m above the ground surface have been reported. These elevations are less than that of the highest surface elevation found in the basin and suggests that recharge could be within the basin. Monitoring of flow rates of the artesian well (FLO1) demonstrates an aquifer pressure response to recharge events and heavy extraction (e.g. in June 1992 the artesian flowing well did not flow, while significant flow rates were observed in the fall and spring of 1992). In a high transmissivity aquifer, and especially karst, pressure variations are transmitted very quickly and over very large distances. Waterquality will be discussed in the sections following.

4.0 Methodology

4.1 Sampling Location Selection and Chemical Analyses

The study was initiated in September of 1991, with a preliminary review of the field conditions. Subsequently a survey of wells evenly spread throughout the study area was undertaken. The selection of wells was arbitrary with preference given to those well owners that were willing to have their wells sampled at regular intervals. The initial survey yielded a total of 16 wells consisting of 15 bedrock wells and 1 overburden well (well descriptions have been provided in Table 2). Additional wells were included later in the program to provide a better understanding of the flow system. These wells included two bedrock wells, an overburden piezometer and four communal wells.

Wells BR1, BR3, BR5, BR16, BR17, OB1, OB2 were subjected to a monthly sampling schedule. All others were sampled once in November of 1991 and once in June of 1992. Communal wells M1, M2, K1, K2 and an artesian well (FLO1) were sampled in August and October of 1992. Field measurements were taken of pH, conductivity, alkalinity, hydrogen sulphide, odour, appearance and temperature. Samples were submitted to the University of Ottawa laboratory for inorganic chemical analysis and for deuterium (δ^2H) and oxygen-18 ($\delta^{18}O$) isotope analysis on selected samples. All monthly sampling stations were submitted for both analyses. Tritium samples were submitted for analysis to the University of Waterloo Environmental Laboratories.

Table 2 - Well Record Information

Well Id	Year drilled	Static(m)	Test Flow (Lpm)	Elevation (m asl)	Water bearing zone (m) depth to	Casing length (m)	Geology (m) below surface
BR1	81	3.0	73	99.1	21.6	mln 6m	Till 3.4
							Limestone 22.9
BR2	57	2.4	23	100.6	10.7	6 m	Till 6.1
							Limestone 24.7
BR3	86	4.5	50		24.4	20.2m	Clay 13.5
					31.0		Till 19.2
							Limestone 32
BR4	81	5.5	280	137.1	22.9	6 m	Boulders 2.1
							Sandstone 24.4
BR5	69	5.5	13.6	144.8	18.9	6 m	Gravel 0.6
							Limestone 17.4
							Sandstone 18.9
BR6	84	3.0	227.3	129.5	10.4	6 m	Sand 1.2
							Sandst /Limest16.8
BR7	88	6	45		16.4	6 m	Soil 1
							Shale 3
							Limestone 18.4
BR 8	63	3	45.5	129.5	27.4	6 m	Clay 3.7
							Limestone 30.5
BR 9	78	Flowing	70	115.8	39.3	6m	Clay 2.4
							Limestone 39.3
BR 10	50	Flowing		112.8	22.3	no rec	soil 0.3
							Clay 1.2
							Limestone 22.6
BR 11	86	7.62	90		18.29	6 m	Sand 0.6
					30.48		Limestone 32
BR 12	63	6.1	90	120.4	21.3	6 m	Clay 0.9
							Limestone 22.9
							Sandstone 27.4
BR 13	84	7.6	136	112.8	13.7		Clay 1.2
					17.7		Broken Sdst 5.5
							Limestone 18.7
BR 14	88	1.8	55	113.4	24.4	6 m	Clay 3.6
					29.6		Limestone 31.6
BR 15	90	10.6	23		48.8	12	Sand 9.1
					124.9		Boulders and Gravel 10.6
							Limestone 134.1
BR 16	64	1	100	94.5	24	12	Clay 10
							Limestone 25
BR 17	91	7	45		28		Sand Gravel 20
							Limestone 31
							Sand 5.5
OB1	45	2	13.6				Clay 3.5
OB2	92	0.3	2		2.5-3.5	0-2.5	Clay 11.3
FLO1	90	flowing 4m +	32.2		35.6	12.2	
							Limestone 37.2
M1	69	18.2	818		21,33,45	8.8	Shale Lmst 34.7
					100, 112		Lmst 90.5
							Lmst sdst 99.5
							sdst 116
M2	73	19.1	681		43	9.8	Shale Lmst 35
					55		Lmst 91
					107, 111		Lmst sdst. 101 sdst 122
K1	70	4.4	909		37	19.8	Clay 3.6
					66		Limestone 67
K2	71	8.5	909		24,32	19.5	Clay 3.6
					50,58		Limestone 49.9 Sdst 79.2

Appendix A describes the sample collection and analysis methodology in detail. The results are provided in Appendix B. The chemical analysis show a mainly positive mass balance (cation excess), similar to as quoted in Wilson (1990). Wilson reported this as being caused by dissolved suspended calcium carbonate in the preserved cation samples which could have formed as a result of temperature changes or natural turbidity of the aquifer. The positive mass balance is attributed to analytical bias rather than to dissolved suspended calcium carbonate as most samples were filtered on collection. Geochemical modelling is provided in Appendix C. A description of sampling sites is provided in Appendix D. The sampling program was complemented with a detailed review of waterwell records, stream gauge records (NWRI), precipitation records and existing water quality studies (RMOC).

The review of MOEE waterwell records included the analysis of the computerized database. Review of the stream gauge records (NWRI, 1993) was completed to evaluate the recharge discharge balance of the groundwater system. Long term water table measurements would have been invaluable to complete this study. To date long term records do not exist.

4.1.1 Review of MOEE Waterwell Records Methodology

The Ontario Ministry of the Environment and Energy (MOEE) waterwell record was entered into digital format starting in 1972. The record provides the characteristics of waterwells in Ontario. Presently the database is only available to staff at the MOEE in its digital format, but Geo-analysis Inc. was able to obtain

the digital well records for Eastern Ontario. It is unfortunate that the system data are not more publicly available as it would improve many hydrogeological and engineering studies. The non availability has cost tax payers additional funds for duplication of data entry efforts by other government agencies and the private industry. The Geo-analysis database contains approximately 40,000 waterwell records. Most of the waterwells were constructed after 1946, when legislation was introduced in Ontario requiring every well contractor to submit a waterwell record after completion of well construction. Updating of the digital format was discontinued by the MOEE in 1986 when funding was restricted.

Geo-analysis Inc. designed a Dbase IV subroutine to easily access the waterwell database. Information as follows can be queried:

- Surface Elevation
- Location: Universal Transverse Mercator (UTM) coordinates, county, township, city, village, lot and concession
- Geology
- Type of water
- Depth to static level
- Pumping test and well yield
- Well construction (Casing length, well depth, water-bearing zones)
- Date of completion
- Name and address of owner and driller

The database provides the well format in both Spans™(trademark Intera-Tydac Technologies) compatible format or ASCII format. Both formats allow the use of Geographic Information Systems (GIS) for data interpretation. The well records

for the study area were extracted in ASCII format and subsequently analyzed using a contouring package Surfer®.

Waterwell records have inherent errors, some are dependent on the diligence of the driller involved and others are dependent on the data entry process. The kriging methodology for contouring was selected. Kriging gives an indication of trends rather than actual interpretation of surfaces and thicknesses. Kriging is a regional variable technique, its algorithm assumes an underlying linear variogram. The advantage of the methodology is that statistical trends are displayed. The statistical relationship will smooth out noise. However since the method projects trends, results are more unpredictable in areas of low data density. Additional information is provided in section 5 on the analyses of the waterwell records.

4.2 Use of Inorganic Chemistry

Water samples in this study were analyzed for the main inorganic constituents of groundwater. Analyses were completed by the University of Ottawa inorganic chemistry laboratory. Laboratory measured anions include: chloride, sulphate, nitrate, and nitrite as well as phosphate, flouride and bromide. Measured cations include: calcium, magnesium, sodium, potassium, iron, manganese, lead, silicon, zinc, and copper. The above data provide extensive information on the properties of the groundwater.

The data obtained are used in various ways to show:

- relative and absolute abundance of chemical constituents of groundwater

- temporal variations in groundwater chemistry
- chemical change along a section or path in an aquifer
- chemical facies
- reaction processes

Relative and absolute abundance of groundwater constituents can be depicted in various ways. Classic illustrative techniques include bar, stiff, pfeifer and pie diagrams.

Temporal trends in chemical composition can be evaluated by plotting component concentrations versus time. A heavily fluctuating concentration may suggest rapid recharge and/or little mixing. Conversely a straight line could suggest little sensitivity to recharge and/or a high degree of mixing.

The change in chemistry along a path in an aquifer is determined by plotting selected component concentrations along a cross section of an aquifer or on a plan view. Quite often the plot is cluttered and the facies approach may, in that case, yield a better illustrative and evaluation tool. The classification of facies (Domenico et al., 1990) is based on the concept that recharged waters are most abundant in calcium, magnesium and alkalinity (bicarbonate). Dissolved cations along the groundwater flow path will at first show calcium and magnesium as dominant species, slowly increasing in sodium content until sodium and potassium are the most abundant in the discharge area. Similarly for anions, alkalinity will be of high concentration in a recharge area with increasing chloride and sulphate concentration along the groundwater flow path, until sulphate and chloride concentrations are dominating in the discharge area. This is due to increased

contact time with the host rock and loading of chemicals along the groundwater flowpath. The most conservative ions will eventually dominate in the discharge area.

Inorganic chemistry is also useful in determining water rock interaction. This water rock interaction was evaluated using SOLMINEQ software (Kharaka et al., 1988). Such software allows for a rapid evaluation of the stability fields of numerous minerals and provides insight into the reactivity of the groundwater. The software also allows for calculation of the degree of saturation for various mineral phases..

Inorganic chemistry can also be used to explain origins of contaminants in groundwater. Common applications include the use of nitrates as a tracer to document agricultural and domestic sewage disposal impacts. A concentration ratio of sodium versus chloride close to 1:1 can indicate of pollution by road salt. Conversely it could indicate evaporite dissolution, the existence of paleo seawater or the upwelling of deep brines.

4.3 Use of Environmental Isotopes

Important stable isotopes of oxygen in groundwater studies are oxygen 16 and oxygen 18. Oxygen 16 is the most abundant. Hydrogen has only two stable isotopes, ^{1}H and ^{2}H. The former is about 6700 times more abundant than deuterium. Stable isotope concentrations in the earth's hydrological cycle vary because of partitioning or fractionation processes.

Radiogenic isotopes have variable concentrations due to decay or generation and lend themselves to age determination. Stable isotope spatial variability is due to fractionation during phase transitions, chemical reactions, biological processes and transport.

Stable isotope variations (Gat, 1980) are measured relative to a reference standard concentration, rather than as absolute concentrations. Both hydrogen and oxygen are commonly expressed as the permil difference from the international standard Standard Mean Ocean Water (SMOW). This relationship is internationally accepted as

$$\delta^{18}O = \frac{(R_{sample} - R_{smow})}{R_{smow}} \times 1000 \text{ ‰}$$

where delta is the relative difference in the ratio of heavy to the light isotope in the sample R (i.e. $^{18}O/^{16}O$ or $^{2}H/^{1}H$) with relation to SMOW. It is usually reported in the form $\delta‰ = \delta \times 1000$ (i.e. ‰ ^{18}O and ‰ ^{2}H).

4.3.1 Processes Controlling Isotope Variations in Groundwater

Concentrations of stable isotopes in waters are essentially controlled by two processes. Vapour liquid fractionation (i) during evaporation and condensation of water, a process which depends on temperature. Under equilibrium processes vapour is isotopically lighter (ii) with respect to deuterium and ^{18}O than the water (liquid). The dominant effect is (ii) continued depletion of a vapour mass and subsequent precipitation is heavy in isotopes during rain out (Rayleigh

distillation). A global correlation between isotopic depletion in precipitation and low T exists, because rain- out takes place only under conditions of decreasing temperatures. These fractionation processes can be expressed in several ways:

- Altitude effects , i.e. cooling with elevation creates depletion with regard to heavy isotope content.
- Amount of rainfall: small storms have a higher content of heavier isotopes than large storms, due to evaporation during rainfall.
- The farther away from the evaporation sources the more depleted the stable isotope content will be relative to SMOW. This is mainly controlled by rainout as a vapour mass evolves. Along a weather trajectory heavy isotopes get depleted in vapour through rainout of the isotopically enriched condensed phase. With distance from the evaporation source this Rayleigh fractionation process will be manifested as progressively depleted precipitation. Characteristically the values of δ^2H and $\delta^{18}O$ plot on a straight line with distance from the source.
- Seasonal variations of temperatures will result in depleted winter precipitation relative to summer precipitation. Groundwater recharged during colder past climates will be depleted relative to groundwater recharged in warmer modern climates.

Evaporation prior to and during infiltration may alter the isotopic content of the water. This may typically lead to an enrichment in dry regions, but is not as pronounced in temperate climates with a water surplus (Gat, 1980). Also more recharge to the aquifer will occur with large precipitation events. The net result will be a bias to recharge during cold periods and/or more humid spells. Once the

stable isotopes have entered into an aquifer, mixing processes will smooth out seasonal variations.

Changes in oxygen isotope content can provide evidence of recharge taking place, i.e., if the isotope value of the groundwater is close to the isotope value of the infiltrating water this could lead to the interpretation that the groundwater is identical to the recharged water. Groundwaters with close isotopic composition to recharged water may be indicative of rapid recharge. Other information, such as radioisotope data is nevertheless necessary to come to an absolute conclusion with regard to the origin of the groundwater.

Fontes (1980) showed that stable isotopes of oxygen and hydrogen are poor indicators for infiltration determination on an annual scale, because of smoothing out of seasonal and inter-annual peaks in the unsaturated zone. Hooper and Schoemaker (1986), Bottomley, Craig and Johnston (1986) and Moore (1989) have shown that these stable isotopes may be useful on an annual basis under selected circumstances. In these studies pre-snowmelt groundwater stable isotope content was compared with snowmelt content. The studies showed that particularly in first order stream basins, the contribution from shallow groundwater during spring melt could be determined, because of the large contrast between shallow groundwater and meltwater isotope content. The meltwater represents isotopically depleted winter precipitation. All investigators reported interference from spring storms, which were closer in isotopic composition to groundwater. The research in all studies concludes that during large discharge events the contribution from shallow groundwater to peak runoff is in the order of 50 to 60 percent. Sklash and Farvolden (1979) outline conditions under which these

isotopes can be used to evaluate turn over times and base flow contributions. These are:

- The isotopic content of new water is distinguishable from the old water content
- The new water maintains a constant isotopic composition throughout the event
- The groundwater and vadose zone water are isotopically equivalent or vadose zone contributions are insignificant
- The surface water storage is minimal

In the study area the first three conditions apply. Surface storage in the study area is significant, but allows for a significant signature due to evapotranspiration.

Recharge areas can be defined on the basis of the altitude effects on environmental isotopes. Altitude differences (<150 m) across the study area are likely insufficient to generate any observable isotope differentiation.

Sklash et al. (1976) evaluated the runoff mechanisms of several streams in Canada. They determined that the summer storm stream water was remarkably more enriched in the heavy stable isotopes than the average isotope composition of the groundwater. With this knowledge they attempted to estimate the groundwater runoff contribution to storm flow by mass balance methods. They showed that at least 50 percent of groundwater contributed to storm run-off. They showed that with combined use of $\delta^{18}O$ and specific conductivity data contribution sources of the following could be identified in stream water:

- Direct rainfall
- Direct run-off
- Groundwater discharge

The source of mineralization in groundwaters can be deduced from isotopes, but have to be supported by chemical studies. Mineralization is commonly attributed to the following sources:

- Road salt
- Dissolution of evaporite deposits
- Brines from depth
- Residual seawater
- Long resident waters

Mitchell (1990) and Séguin (pers. comm. 1993) in groundwater chemistry studies in the Ottawa area attribute salinity to paleo sea waters. Through evaluation of chemical composition of groundwater sea water is determined as the origin of salinity. Findings of Mitchell (1990) and Séguin (pers. comm. 1993) are supported with stable isotopes of oxygen by comparison to data from Desaulniers et al.(1981). The apparent depletion of δO^{18} is attributed to mixing of seawater with paleo meltwater from fossil origin, rather than from a depleted recharge event in Eastern Ontario, e.g. spring melt.

Wilson (1990) supports, with the aid of oxygen isotopes, the existence of different recharge areas and flow systems for bedrock aquifers underlying the Carleton University Campus at Ottawa. Using the $\delta^{18}O$ value two different types of groundwater are identified, with one being slightly more depleted in $\delta^{18}O$. Wilson

explains the difference by the isotopically more depleted water being from an earlier recharge event, than the more enriched water. This finding supports chemical data indicating two different aquifers beneath the university campus.

4.4 Tritium

Tritium is the radioactive isotope of hydrogen and has a half life of approximately 12.3 years, concentrations are expressed as tritium units (TU) where 1 TU= 1 ^{3}H atom per 10^{18} atoms of ^{1}H. Tritium is continually produced by bombardment of cosmic rays on nitrogen in the upper atmosphere, but the most important source was generated during nuclear testing in the late 1950's into the early seventies. Prior to bomb testing the atmospheric level of tritium was about 10 TU. During the 1960's this number was several thousand TU in rainwater. Presently values between 50 and 100 are recorded in the northern hemisphere (Brown, 1989). Tritium in groundwater is not greatly affected by chemical processes. Prebomb period water (1953) should be free of tritium by present laboratory procedures (detection limit 0.2 TU) whereas post 1953 water contains sizeable levels of tritium. Mixing of sources makes use of tritium data on itself an uncertain method of age determination. Some indication of mean residence times can be estimated however from the location on the decay curve.

5.0 Results

5.1 Review of Waterwell Records

As a legislative requirement the waterwell records in Ontario are compiled by the Ministry of Environment and Energy Ontario (MOEE). The MOEE waterwell records are available on a computerized database for the period 1945-1985. The database for the study area encompasses information on 4718 waterwell records (4460 bedrock and 258 overburden). Figure 9 shows the location of waterwell records. Significant additional well construction has occurred since this date, but exact numbers are unknown.

For each well sampled, the MOEE database was searched and matches were made with the wells of the sampling program (Table 2). For post 1985 wells the MOEE Kingston provided waterwell records from their hard copy files. Where well records were not available, the five closest wells were selected to provide an understanding of the aquifers intersected. In such a case an average of these five wells is provided as the well description in Table 2.

The waterwell records were entered in DBASE IV format for analysis of the following:

- average potentiometric surface of all bedrock aquifers over the period 1945-1985 (Figure 10)
- overburden thickness (Figure 11)
- bedrock surface (Figure 12)

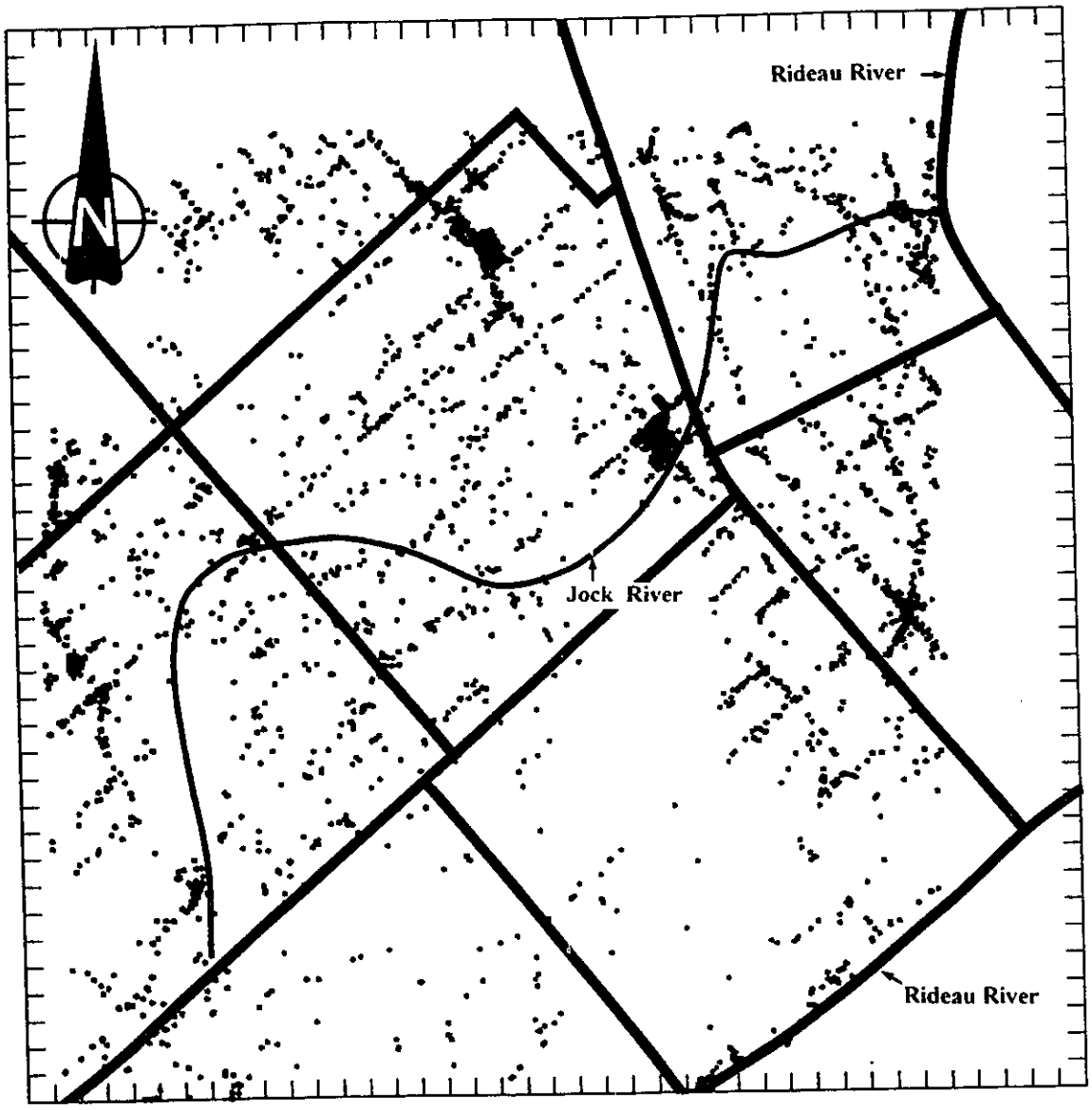
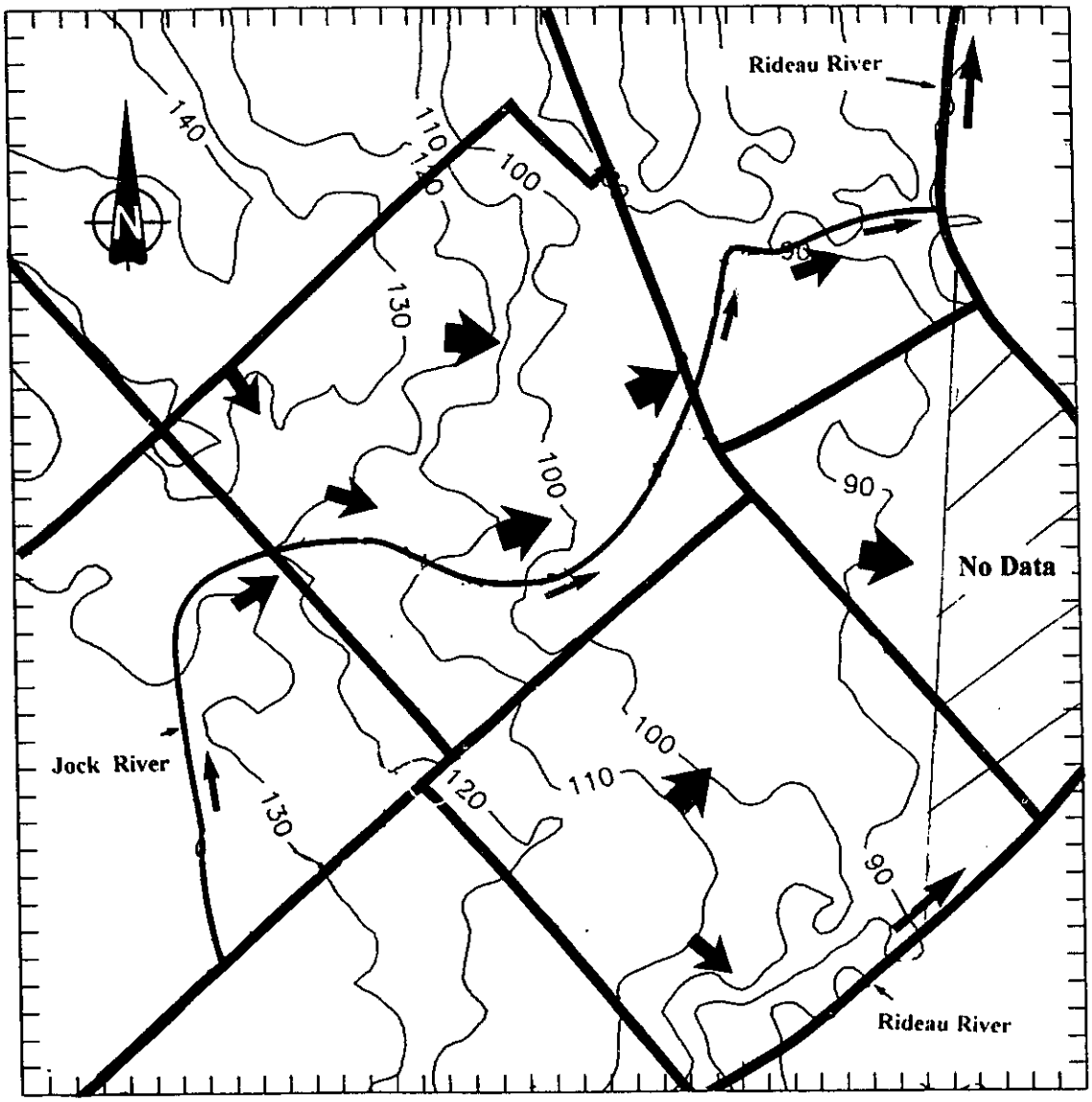


Figure 9 - Location of MOEE Water Wells



Scale 1:250.000 base map after NTS 31 G

Refer for reference to Figure 1

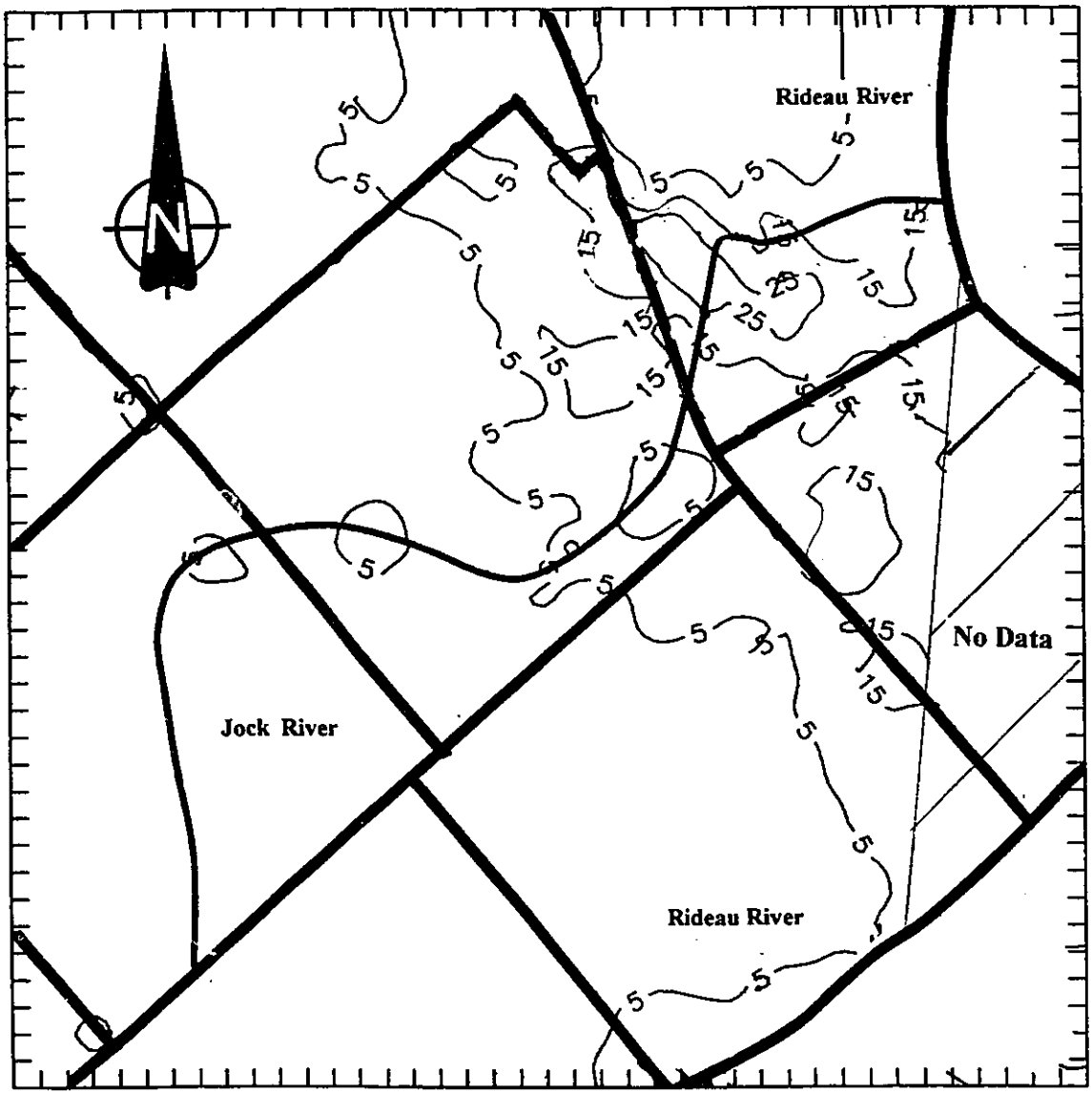
Figure 10 - Average Bedrock Potentiometric Surface

0 5 10 km

contour interval in metres asl

Bedrock Groundwater Flow

River Flow



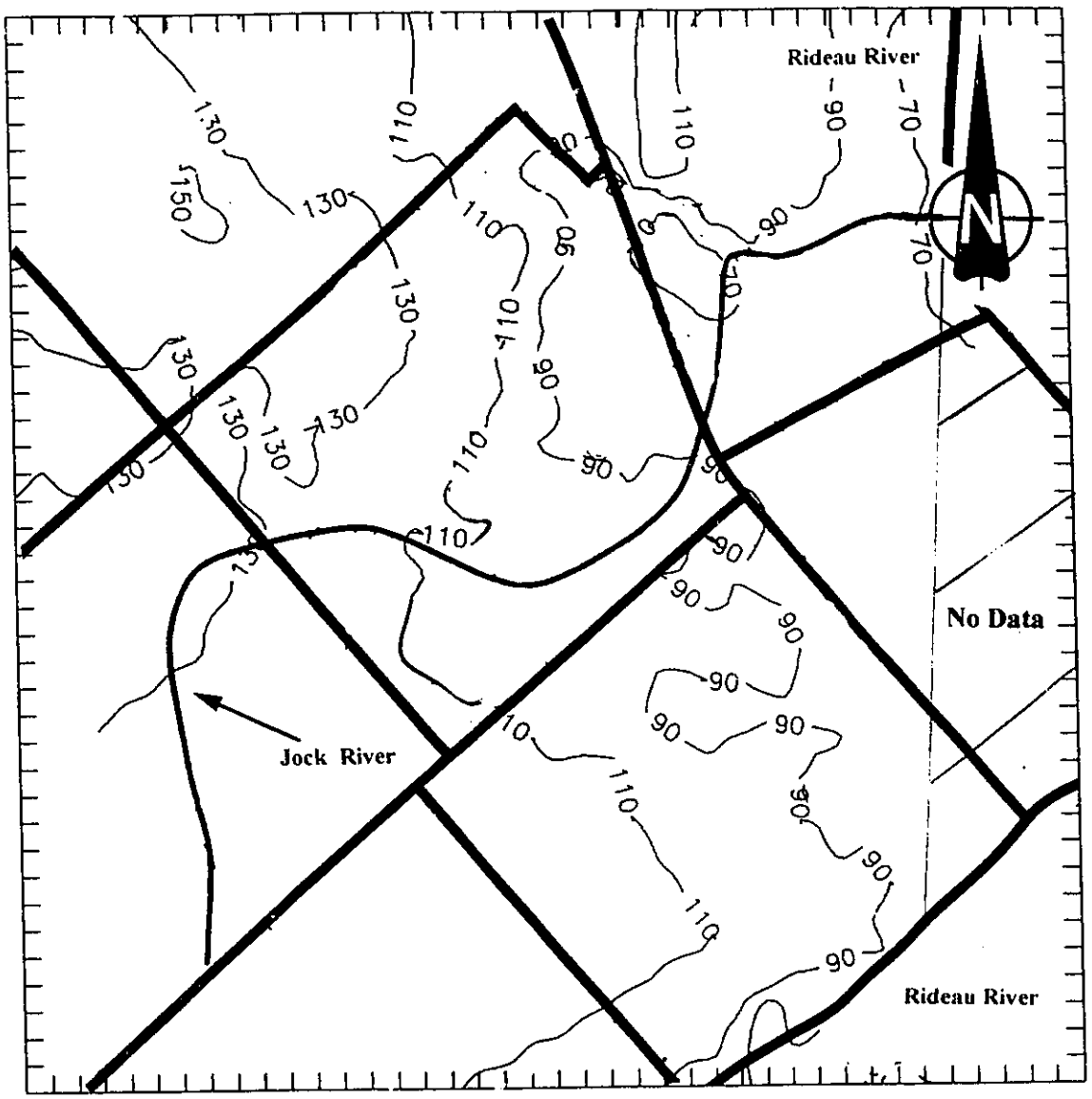
Scale 1:250.000 base map after NTS 31 G

Refer for reference to Figure 1

Figure 11 - Overburden Thickness

0 5 10 km

contour interval in metres



Scale 1:250.000 base map after NTS 31 G

Refer for reference to Figure 1

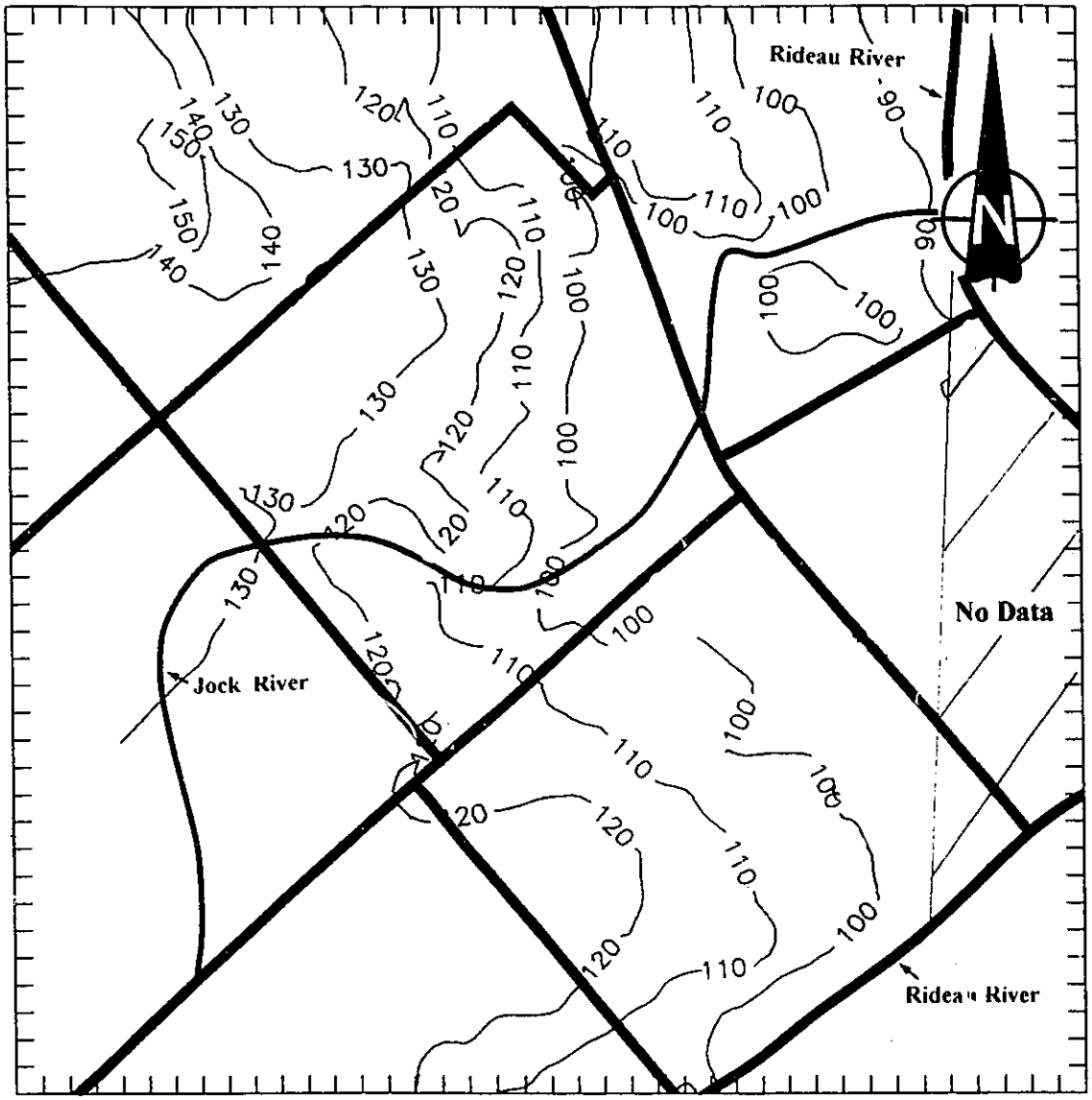
Figure 12 - Bedrock Surface Topography

0 5 10 km

contour interval in metres asl

- topography (Figure 13).

Discharge and recharge areas for the bedrock are defined at a preliminary level. A plot has been made of the artesian wells where static water levels were above the ground surface upon completion (Figure 14). Such wells are mostly found near the river (discharge point) but artesian wells are also found upgradient. If discharge is defined where the potentiometric surface is mainly above the bedrock surface, waterwell records show that the average bedrock potentiometric surface is mostly above the bedrock surface along the Jock River, suggesting discharge conditions (Figure 15). The large discharge area is attributed to the increase of slope of the bedrock surface in the area where overburden thickness increases. Two characteristic discharge areas are recognized: one in the western part of the study area relating to a wide bedrock valley of low relief and one in the eastern area relating to a increased slope of the bedrock surface. Figure 16 shows the area where potentiometric surface of the bedrock groundwater mainly lies below the bedrock surface. This area is inferred to be the recharge area, if recharge areas are defined as areas with thin overburden and topographic highs. The potentiometric surface (Figure 10) also shows that a low gradient occurs in the eastern part of the study area. This flattening may be attributed to restricted outflow at the Rideau River (Figure 11) or to increased permeability in the shallow water-bearing units.



Scale 1:250.000 base map after NTS 31 G

Refer for reference to Figure 1

Figure 13 - Surface Topography

0 5 10 km

contour interval in metres asl

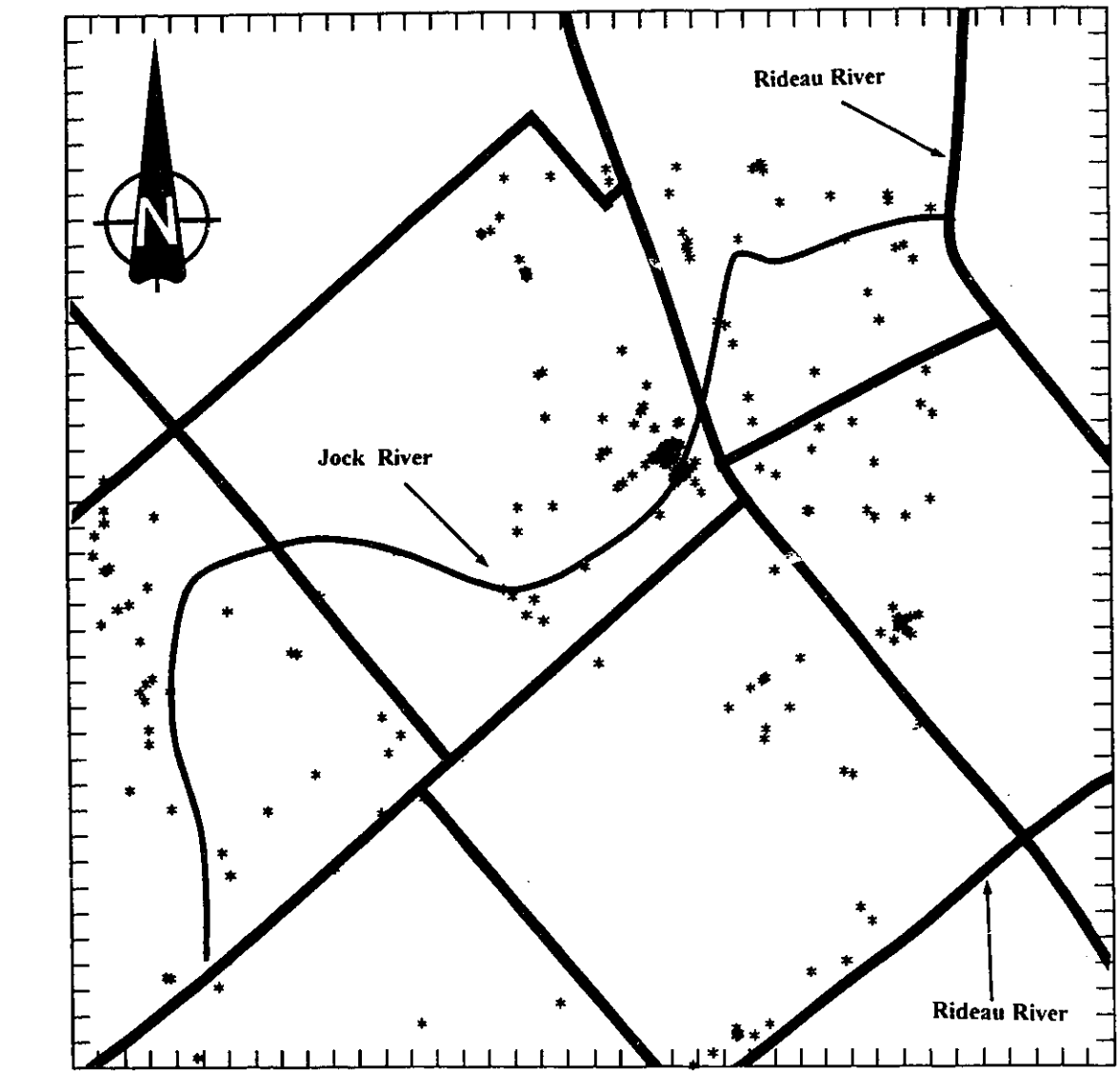


Figure 14 - Bedrock Wells with Potentiometric Head within 1m from Surface or above Surface

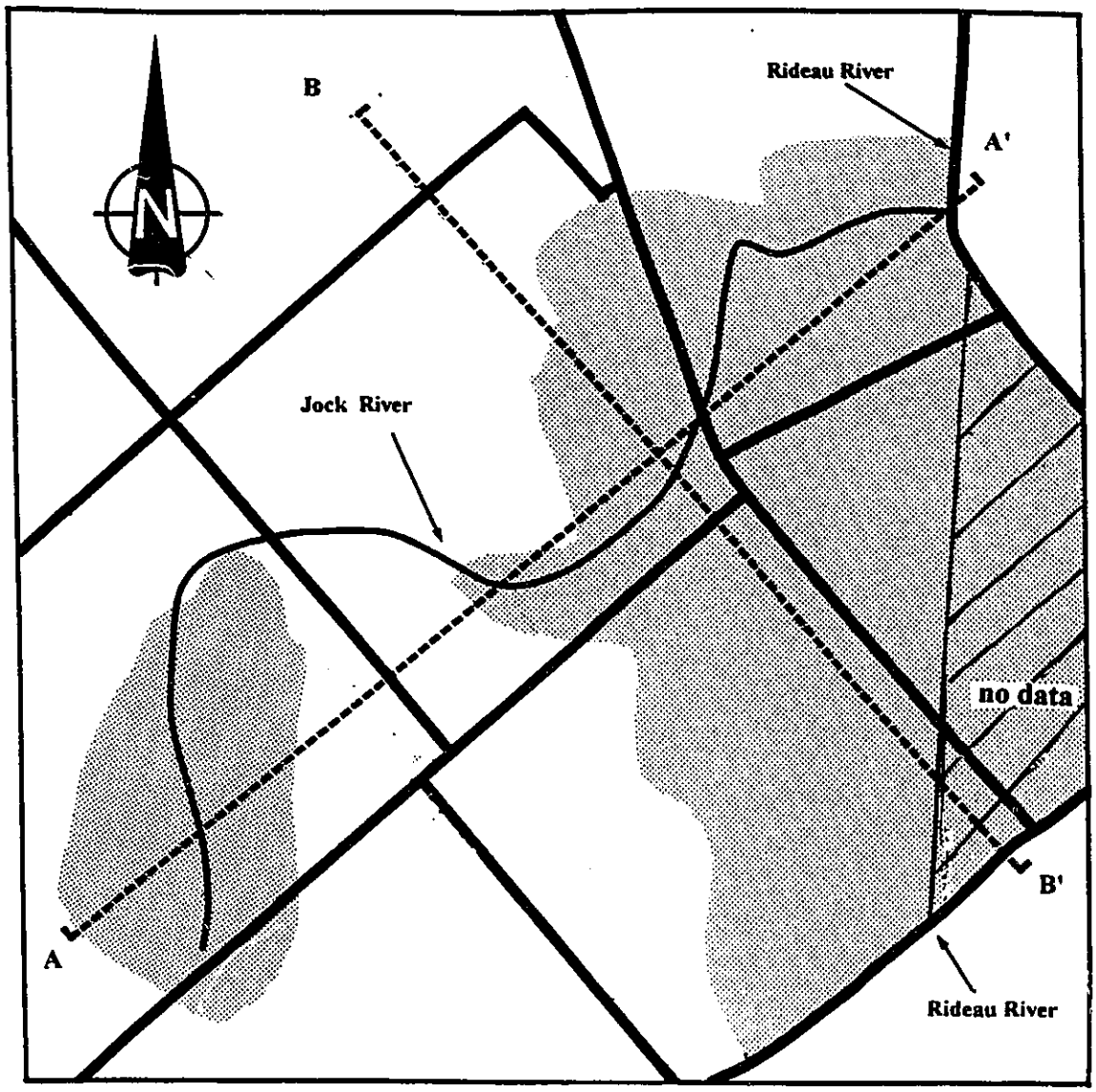


Figure 15 - Bedrock Groundwater Discharge Area

Discharge Area

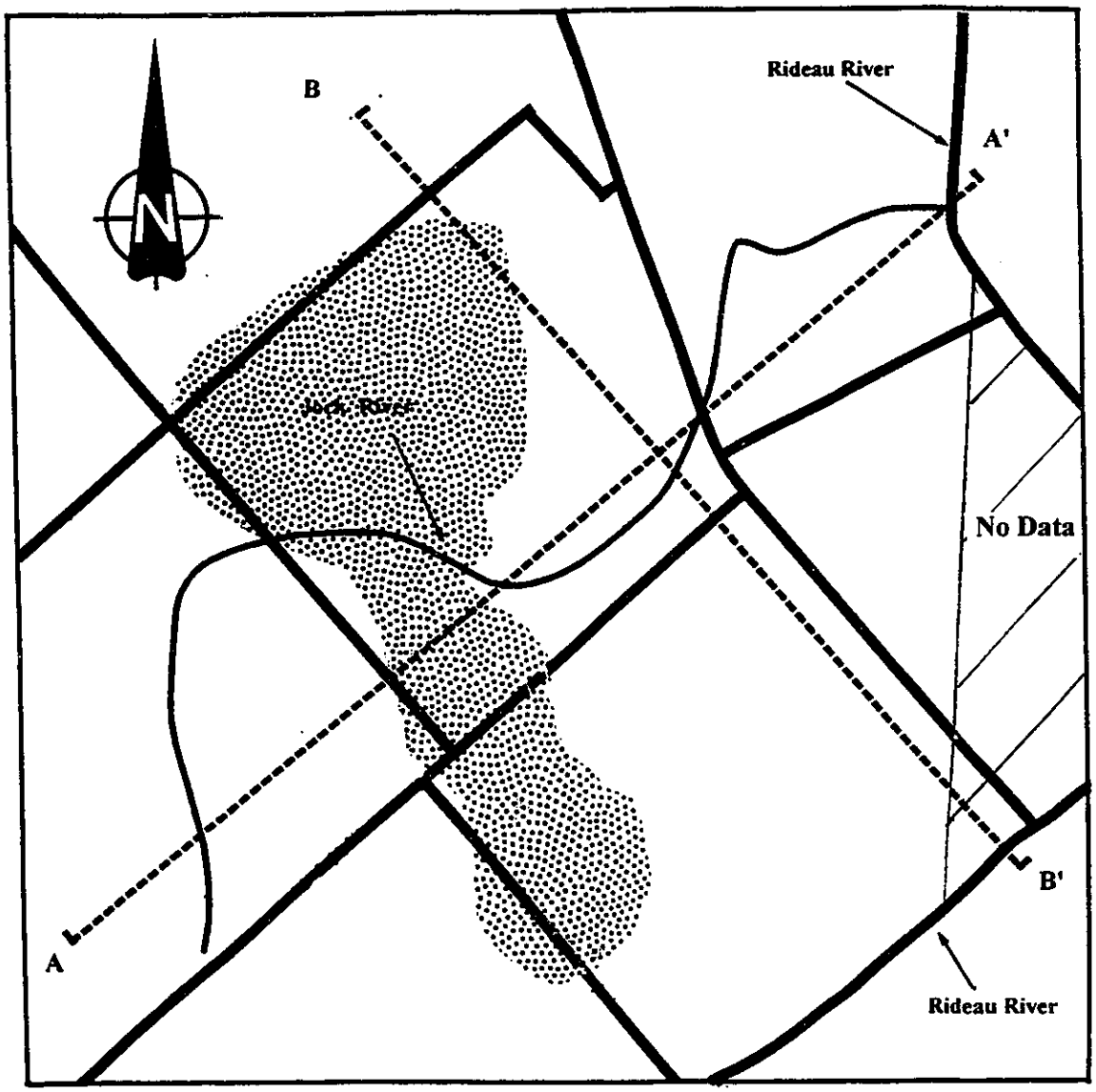
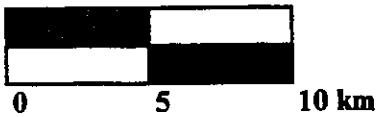
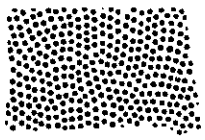


Figure 16 - Deep Bedrock Groundwater Recharge Area





Recharge Area

The overall interpretation of waterwell records shows that:

- most wells tap the bedrock groundwater
- most wells bypass a bouldery gravel deposit as well as the weathered bedrock surface and will tap several water-bearing zones at typical of depths typically between 10 and 25 m below the bedrock surface. Waterwells are typically completely cased through the overburden, bypassing the bedrock surface gravel (till) and fractured surface of the bedrock. Thus avoiding screening of the wells and providing a cost savings.
- the potentiometric surface is almost flat in areas of significant overburden. This relates either to the significant hydraulic conductivities found in these areas or to the restricted outflow at the Rideau River.

5.2 Review of Stream Flow Data

Stream flow data collected at Richmond (Figure 1) by Environment Canada, Environmental Information Management Division (NWRI, 1993) of the last decade were reviewed. The information was complemented by observations during the study period and provided information on the yearly groundwater recharge cycle.

The Jock River head waters start just south of Franktown. Its main channel disappears in the Goodwood Marsh south of Franktown. This marsh is several tens of square kilometers in size. The overburden is thin in this area. The main channel reappears just north of sampling location SW 2 (Figure 2). Here water is coloured by the tannins and lignins of the marsh environment. The river continues from SW 2 in a distinct bedrock channel with several pools and rapids. The river channel has been noted to be dry at Ashton (SW3, SW4) in August, 1991 and August, 1993. The Jock River is fed by several bedrock springs in the river bottom just north of SW 5 during periods of low flow. Beyond SW5 it enters the Richmond Marsh and the surface water traverses several kilometres of marsh land. Just west of Richmond the main channel reforms and continues on a clay and till surface. From Richmond onward the stream continues as a meandering lowland stream discharging in the Rideau River.

Data of a typical stream flow year at the Richmond gauging station are shown in Figure 17. The precipitation and flow of the river is high in the months of October and November and drops off during frost conditions until the beginning of March when a strong peak is observed indicating spring melt. Periods of high flow

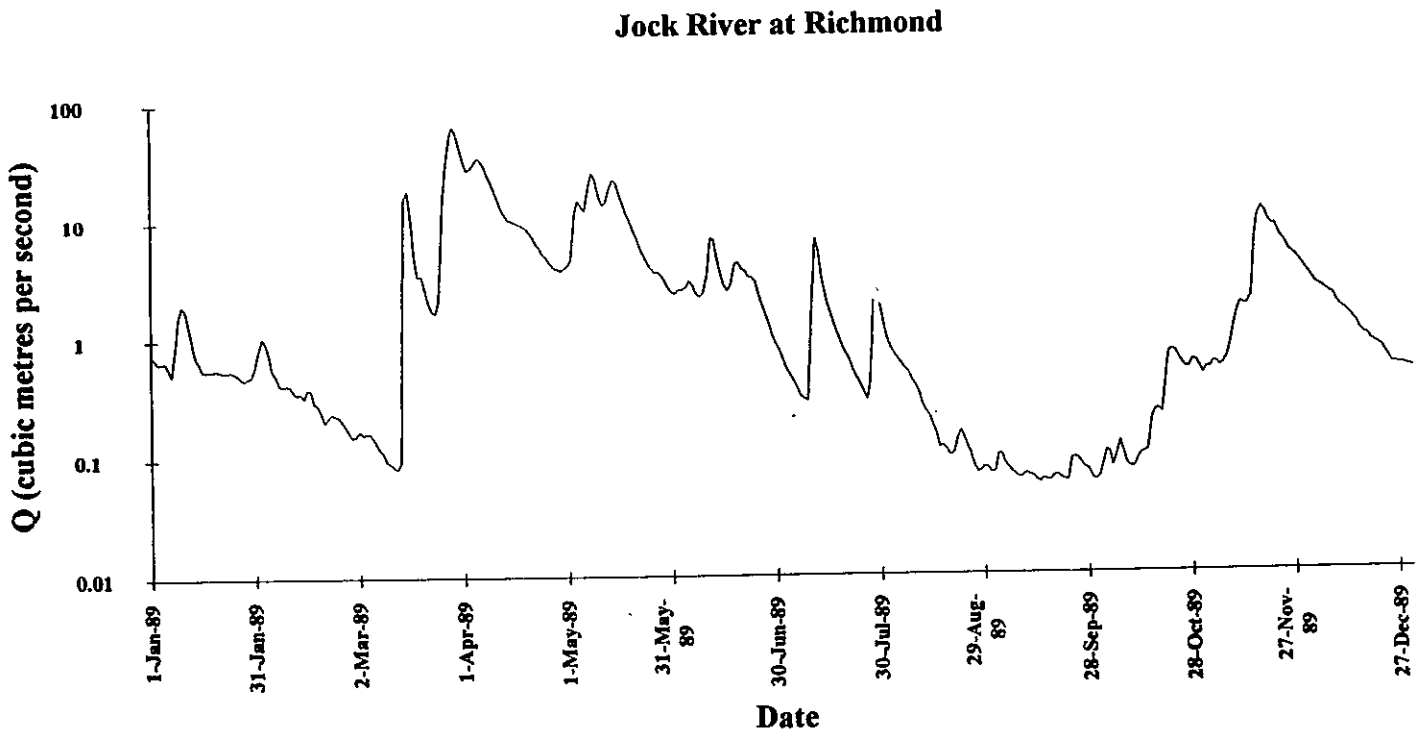


Figure 17 - Typical Stream Flow Year

continue to the beginning and middle of June when individual large precipitation events become important to streamflow. Beyond the middle of July, the stream flow drops significantly for a period of three months, with smaller peaks from short event (thunderstorms) rainfall superimposed. The river is mainly sustained by groundwater discharge (base flow). Figure 18 shows the stream flow for a dry year. Spring and fall are significant flow events with a steady decrease due to lack of precipitation in summer and winter. The river flow cycles of the present monitoring period are presented in Figure 19. The Figure shows that continuous precipitation in the period kept river levels high, with the exception of a dry May and June. Precipitation picks up in July and makes for a wet summer , unusual for the Ottawa area.

5.3 Groundwater Chemistry

Information of the groundwater chemistry is based on data collected from the sampling runs. Carbonate bedrock aquifers dominate in the study area and the chemistry review below will mainly focus on these aquifers. Table 3 shows the measured chemical range which is typical of a freshwater carbonate aquifer. Chemical modelling using the software package Solmineq (Kharaka, 1988) shows that the waters are saturated and supersaturated relative to carbonates (Appendix C). Such saturation would be expected in carbonate and dolomitic host rocks (Dominic and Schwartz, 1991, Freeze and Cherry, 1979).

Water quality information from several aquifers was analyzed. Table 4

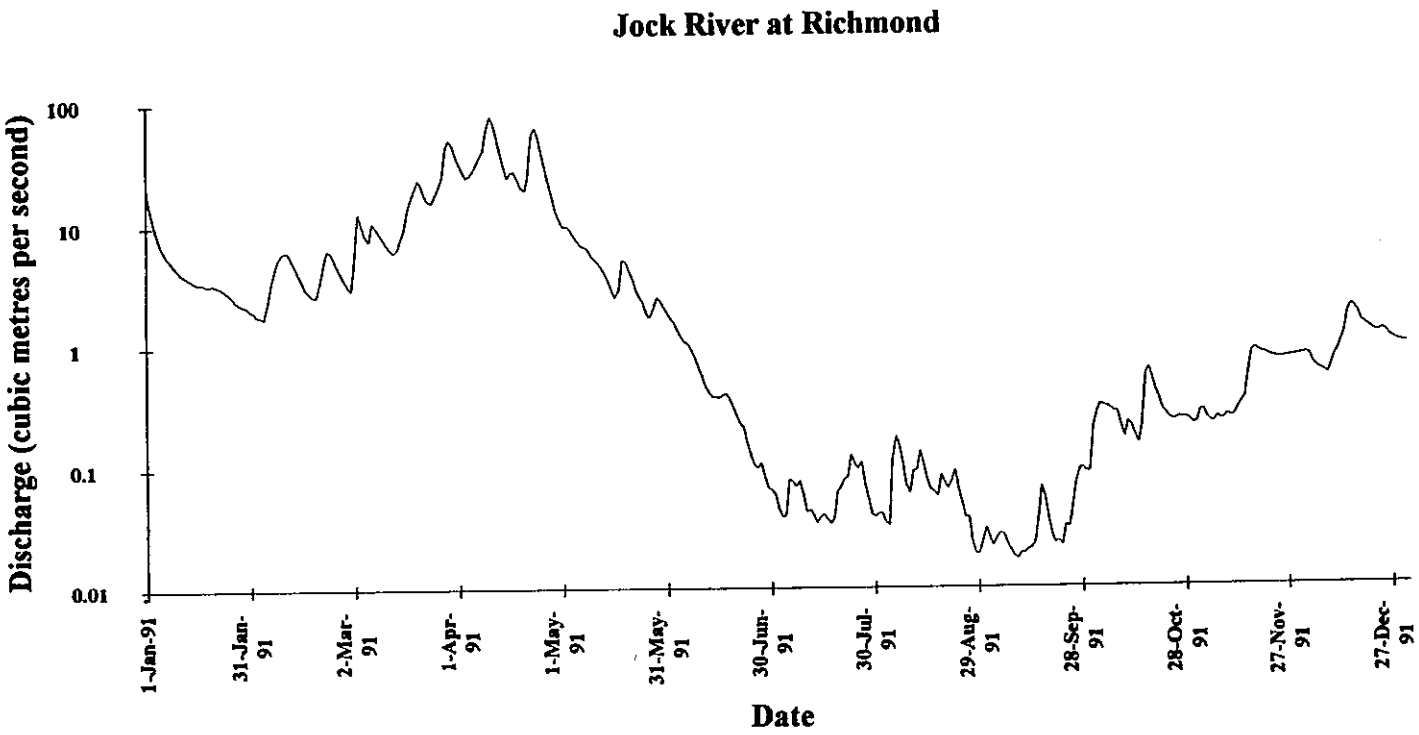


Figure 18 - Stream Flow for a Dry Summer

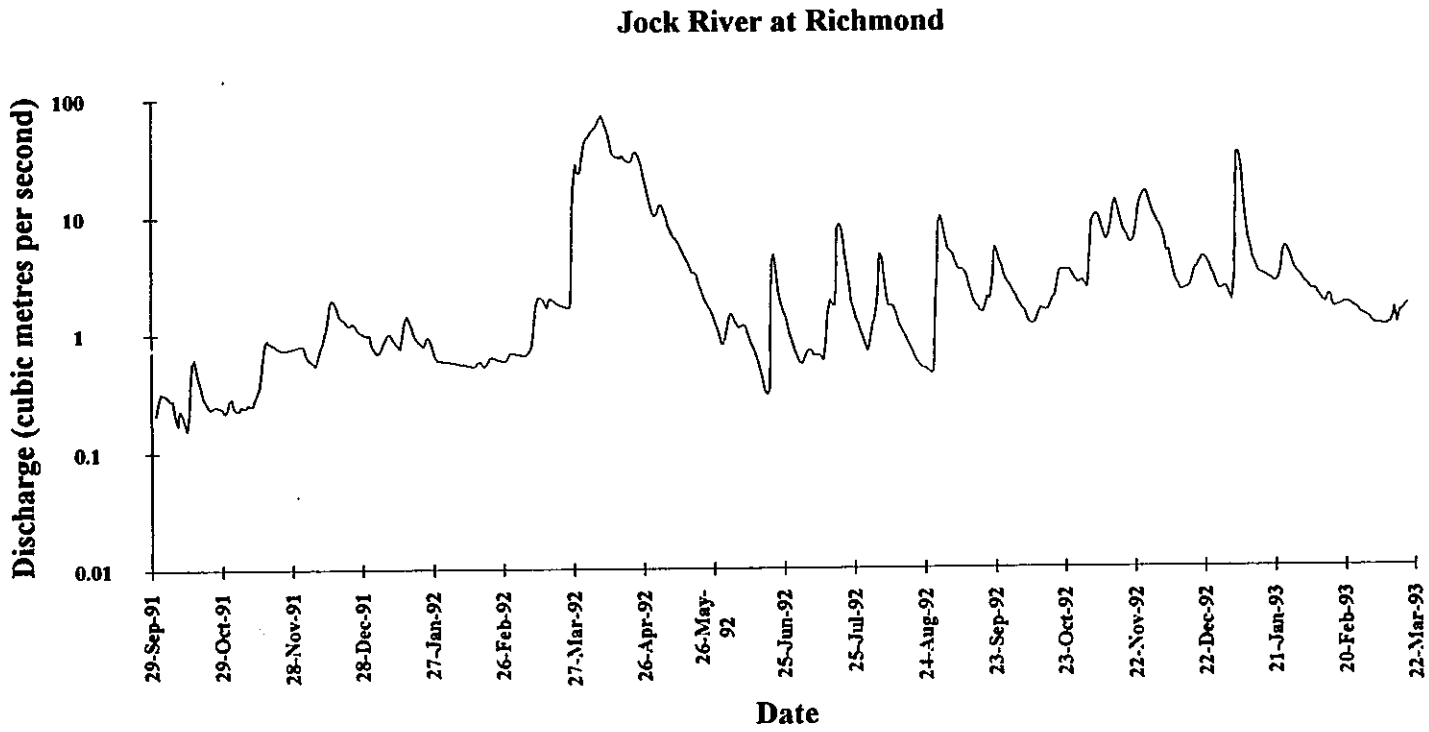


Figure 19 - 1991-1993 Stream Flow Data

pH	6.17-8.52
Alkalinity(mg/L)	112-417
Conductivity(uhos/cm)	243-2800
Fluoride(mg/L)	<0.7
Chloride(mg/L)	1-928
Nitrite(mg/L)	<0.1
Nitrate(mg/L)	<0.2 - 7
Bromide(mg/L)	<0.1
Sulphate(mg/L)	4-100
Aluminum(mg/L)	0.01-1.02
Boron(mg/L)	0.01-1.00
Barium(mg/L)	<0.51
Beryllium(mg/L)	<0.005
Calcium(mg/L)	1.34-125.19
Chromide(mg/L)	<0.01
Cobalt(mg/L)	<0.01
Copper(mg/L)	<0.01-0.44
Iron(mg/L)	<0.005-0.35
Potassium(mg/L)	<0.02-52
Lithium(mg/L)	<0.01-0.12
Magnesium(mg/L)	1- 47
Manganese(mg/L)	<0.005-0.09
Sodium(mg/L)	4- 474
Nickel(mg/L)	<0.04
Phosphorus(mg/L)	0.05-1.10
Lead(mg/L)	<0.07
Silicon(mg/L)	0.14- 6
Strontium(mg/L)	<0.04- 5
Zinc(mg/L)	<0.005-1.27

Table 3 - Range of Chemical Concentrations Bedrock Wells

AQUIFERS	WELL NUMBERS
Surface Overburden deposit	OB1, OB2
Basal Gravel/Fractured Bedrock Surface	BR1, BR2, BR3, BR8, BR9, BR13,BR14, BR15, BR16, BR17
Ottawa	BR 11, BR 12, BR7, BR 15
Rockcliffe	BR 14
Oxford	BR 1, BR 2, BR 3, BR 9, BR10, BR13, BR 16, BR 17, FLO 1, K1, K2 , M1, M2
March	BR 4, BR 5, BR 6, M1, M2
Nepean	BR 8, K1, K2, M1, M2
Precambrian	none

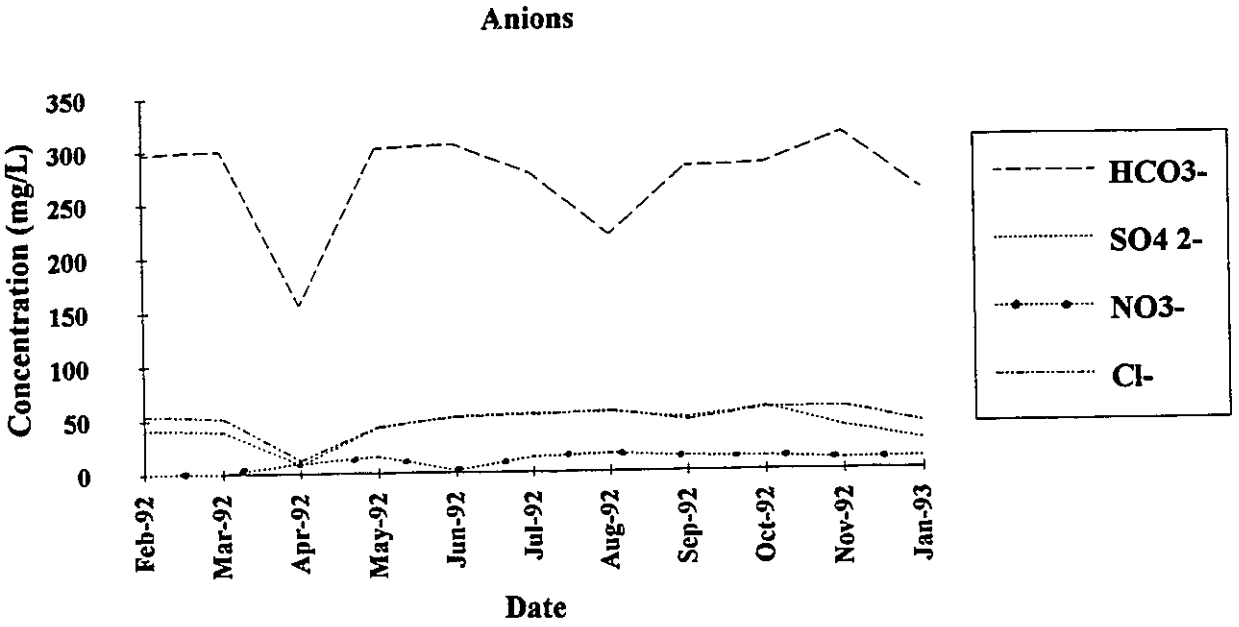
Table 4 Aquifers Intersected by Monitoring Wells

summarizes which aquifers are perceived to be tapped from the given wells selected. Review of the chemistry results show that most of the waters are calcium-magnesium-bicarbonate facies. Selected sites BR5, BR2 would classify as calcium sodium-chloride sulphate bicarbonate facies. The Ottawa Group can be distinguished as having a higher calcium concentration than the other bedrock aquifers. This can be attributed directly to the rock types (i.e. the Ottawa Group bulk composition is more magnesium poor than the Oxford and March Formations). The Ottawa Group groundwaters also have higher concentrations of total dissolved solids, i.e., 750-1000 ppm vs. 350-500 ppm for the other formations.

Sulphate concentrations in the Jock River Basin are generally low, i.e., below 100 mg/L. The higher concentrations are found in the Ottawa Group aquifers and may be attributed to oxidation of pyrite found in the host rock. Elevated concentrations of sodium and chloride are found in the area, and are discussed in detail in section 5.3.3..

5.3.1 Temporal Variations in Groundwater Chemistry

For each monthly sampled well the inorganic constituents were plotted against time. A typical time sequence for selected parameters in overburden well OB 1 is shown in Figure 20. Overburden sampling points show a response to the major spring infiltration and suggests that a large component of meltwater enters the water table. In the shallow overburden sampling points OB1 and OB2, this melt



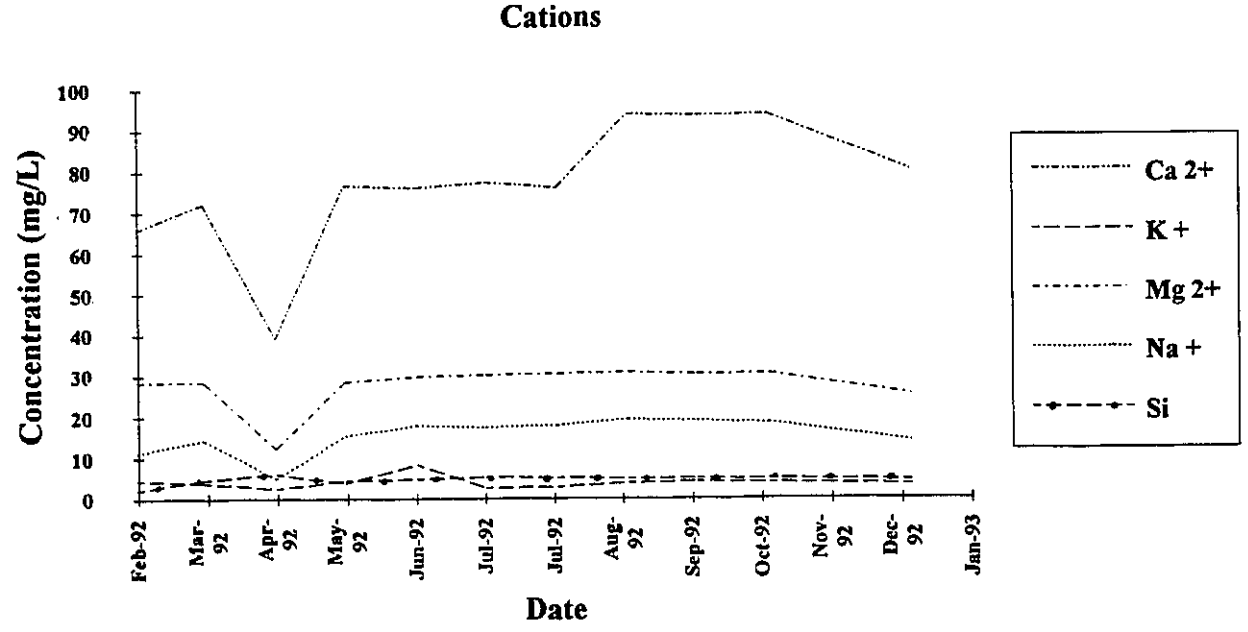


Figure 20 - Overburden Chemical Concentrations

water is distinguishable and shows concentrations of the main inorganic constituents at least half the original concentration in the spring time. The remainder of the year shows several dips depending on the period considered. Figure 20 shows that nitrate is persistent in OB1 (2-5 mg/L). The well is located topographically down gradient from a barn and a septic system, which are likely the source of the measured nitrate.

Shallow bedrock sampling points with little overburden show high sensitivity to surface contamination. BR 5 is a well in an area of very thin overburden with fractured sandstone and limestone bedrock. Water quality fluctuations are much less than in an overburden well. High concentrations of dissolved solids particularly sodium and chloride are noted. The concentration of chloride is directly related to sodium. The well is located next to a highway intersection. The origin of sodium chloride may be from road salt used in the winter time. Also the concentration of nitrate in this well has been observed to fluctuate from below detection limits to near the present MOEE drinking water limit of 10 mg/L (Nitrate as N). Both road salt and nitrate occurrence show that the bedrock aquifer is highly susceptible to contamination. Other wells in shallow overburden (areas less than 2m) tapping the bedrock aquifers include BR -7, BR-10, BR-11,BR-12, BR-13, M-1, M-2. None of these wells show high concentrations of sodium chloride as detected in BR 5. Only BR12 has detectable nitrate. Characteristics of these other wells are that usually a thin veneer of clay loam overlies the bedrock surface and that they tap limestone rather than sandstone.

Wells BR1, BR3, BR 16, BR17 are wells that have overburden greater than 3m overlying the bedrock surface. The first three wells have clay overburden, the

last well has sand overburden. Wells BR1, BR 16,and BR 3 in order of increasing overburden thickness are located along a south north line through Richmond. All three wells tap a reported water-bearing zone 10 to 15m below bedrock surface. Static water levels were within several metres from the ground surface at the time of drilling. The wells all show a similar geochemical variation with time, with Total Dissolved Solids within a range of +/- 20 % (Figure 21). Exceptions are noted for the Summer of 1992 when a major decrease in chemical load suggests dilution by recharge.

Some exceptions are noted in BR 1 (Figure 22) as follows:

- sulphate concentrations fall during the summer
- at the end of the summer concentrations of calcium rapidly decrease only to rapidly return to previous concentrations
- alkalinity drops along with the sulphate decrease
- chloride shows a drop in May and January.

In BR 3 two dips are noted in the anions chloride and sulphate (Figure 22) , one in April-May and the other September November. Decreases are compensated by an increase in alkalinity rather than by a decrease in cations in the overall mass balance. The changes are attributed to timing in pump cycles when sampling the wells. The wells sampled tap into deeper confined zones however they may also tap the till - upper bedrock surface aquifer. Depending on where in the pumping cycle the sample is taken a mixture of two aquifer zones can be sampled. In addition the quantity contributed from each aquifer may vary with time due to a varying hydraulic head in each aquifer.

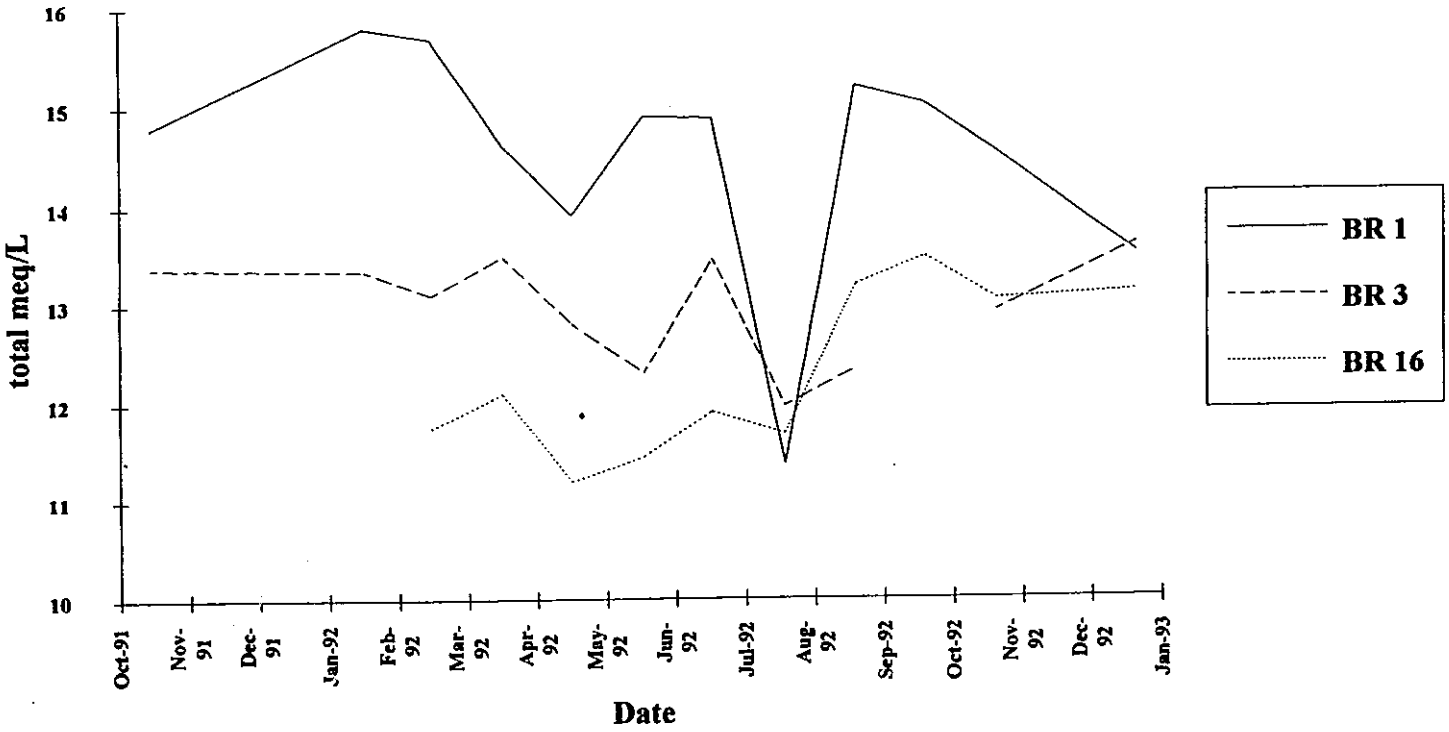


Figure 21 - Variations Total Dissolved Load- Richmond Wells

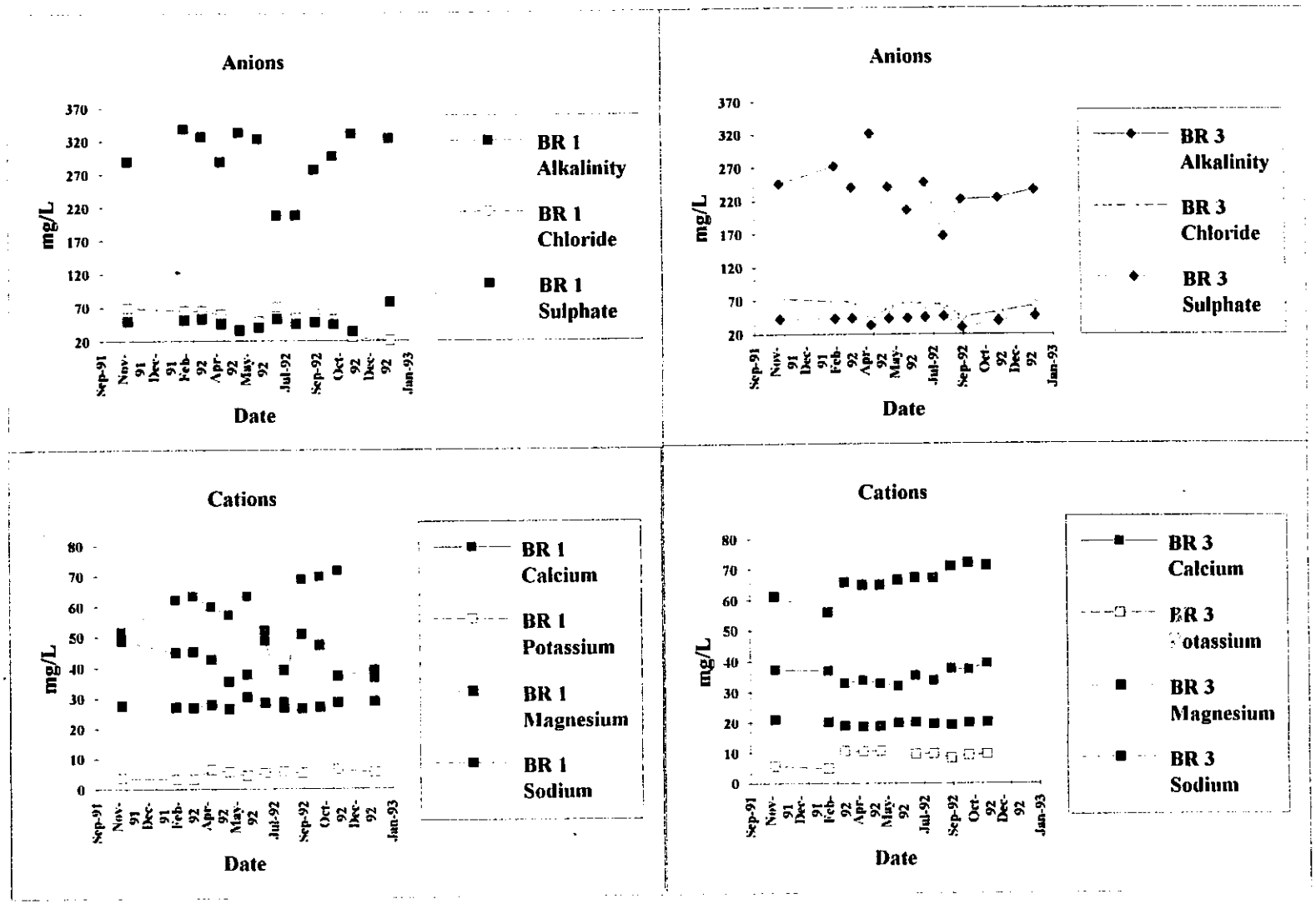


Figure 22 - Geochemical Variations BR1 and BR3

Well BR 17 is located close to well OB1. The well shows the occurrence of nitrate as seen in OB1 . The observations show that even though a large sequence of overburden (>10 m) is present the well is still susceptible to surface contamination. The well also shows higher sulphate concentrations in summer than in winter, i.e. 60 mg/L vs. 45 mg/L.

Main inorganic chemistry data for four communal wells were obtained from the RMOC. The data date back as far as 1980 and have provided insight into the water quality changes over time in the groundwater of the Jock River area. The communal wells tap several aquifers and thus provide a mixture of sources. Review of the records does not show any long term trends (Figure 23). A 130 mg/L concentration of chloride is noted which is repeated with time for K1 and K2 and similarly a 70 mg/L concentration for M1 and M2 is repeated with time. The chloride concentration of 130 and 70 mg/L respectively is attributed to groundwater rock interaction. The communal wells further along the flow path (Richmond (K1)) have higher chloride baseline concentrations than those in the recharge areas (Munster (M1)). A wide range in chemical concentrations is noted. Fluctuations are attributed to natural variations in the aquifer, sampling and analysis errors, and timing of sampling relative to the pumping cycle. A matching in peaks and valleys of chemical concentrations is noted between the two well groups that are located at least 15 km away from each other. This suggests that yearly variations in aquifer water quality can be documented over a large area within one interconnected aquifer system (and that changes are not due to sampling and analysis errors or timing in the pumping cycle). Matches between K1 and M1 in Figure 23 occur during the following periods: fall 1982, fall 84 and spring 84, spring 1988, fall 1989. The valleys in chloride concentrations match

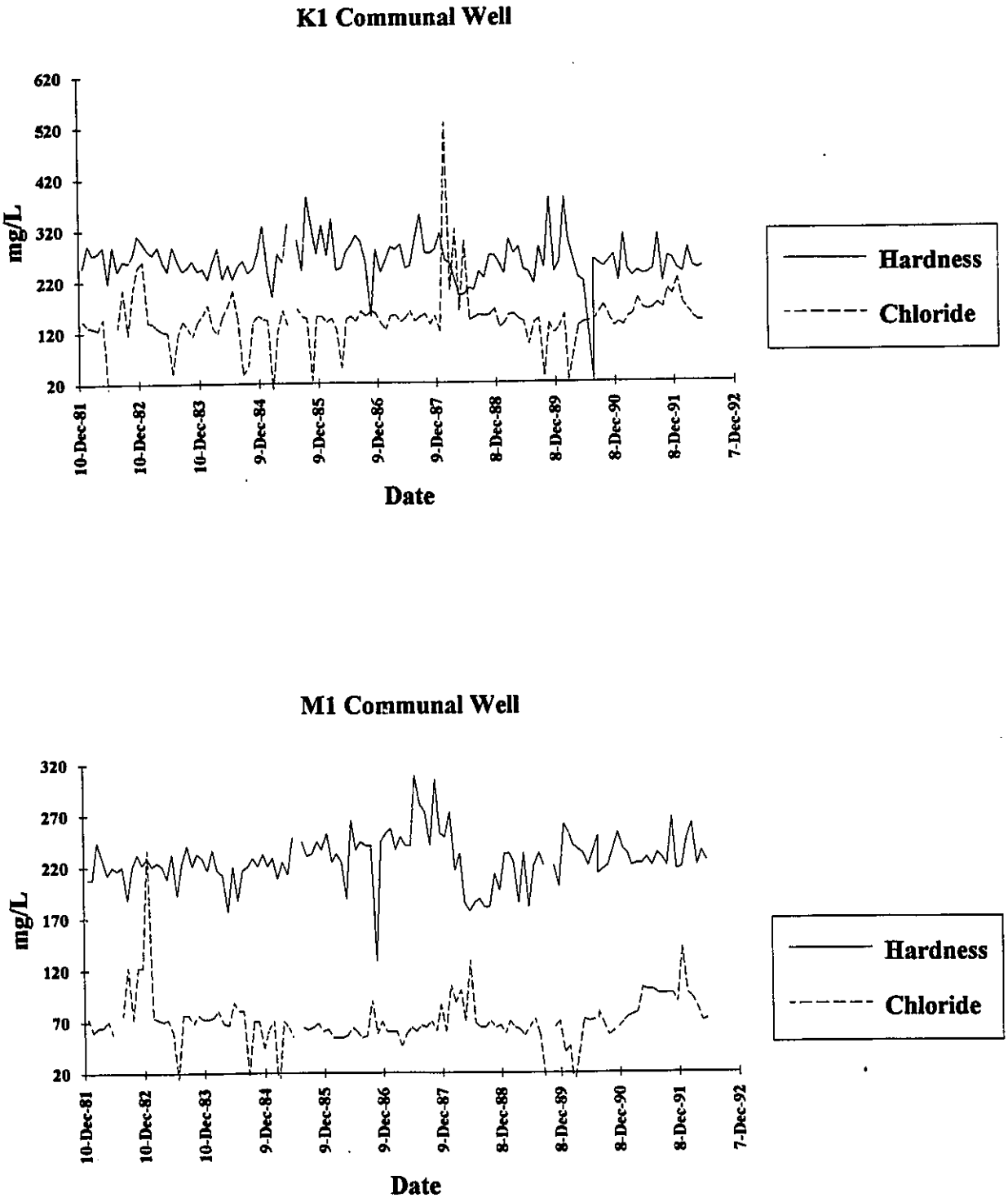


Figure 23 - Geochemical Variations of Communal Well Water

with wet periods. Peaks do not match with periods of drought and hardness does not show any match either (e.g. drought of the summer of 1985, summer of 1989). The match suggests that even though the communal wells are drilled to great depths (>100m) they are sensitive to rapid recharge events. While the hardness gives an indication of the groundwater rock interaction, chloride concentrations may be attributed to anthropogenic sources expressed as fluctuations in Figure 23. A concern for other contaminant introduction exists.

Hydrogen sulphide concentration in groundwaters was measured by Hach Method in the field and by cadmium precipitation method with subsequent laboratory measurement. Despite frequently observing hydrogen sulphide odour at sampling location BR 1 and BR 12, both methods yielded hydrogen sulphide concentrations below detection limits of 0.1 ppm in all wells.

Despite the effort to bypass treatment units, it would appear that water quality results on some occasions are affected by the sodium - hardness exchange process of water softening units. Sampling locations affected are BR7 and BR9, where sodium concentrations are high and divalent cations (Ca and Mg) are very low in concentration.

5.3.2 Sodium Chloride Occurrence

The chemical character of the waters found in the study area is dominated by the dissolution of limestones and dolostones. Elevated sodium and chloride concentrations are present (Figure 24). Sources of Na- Cl salinity may be as follows:

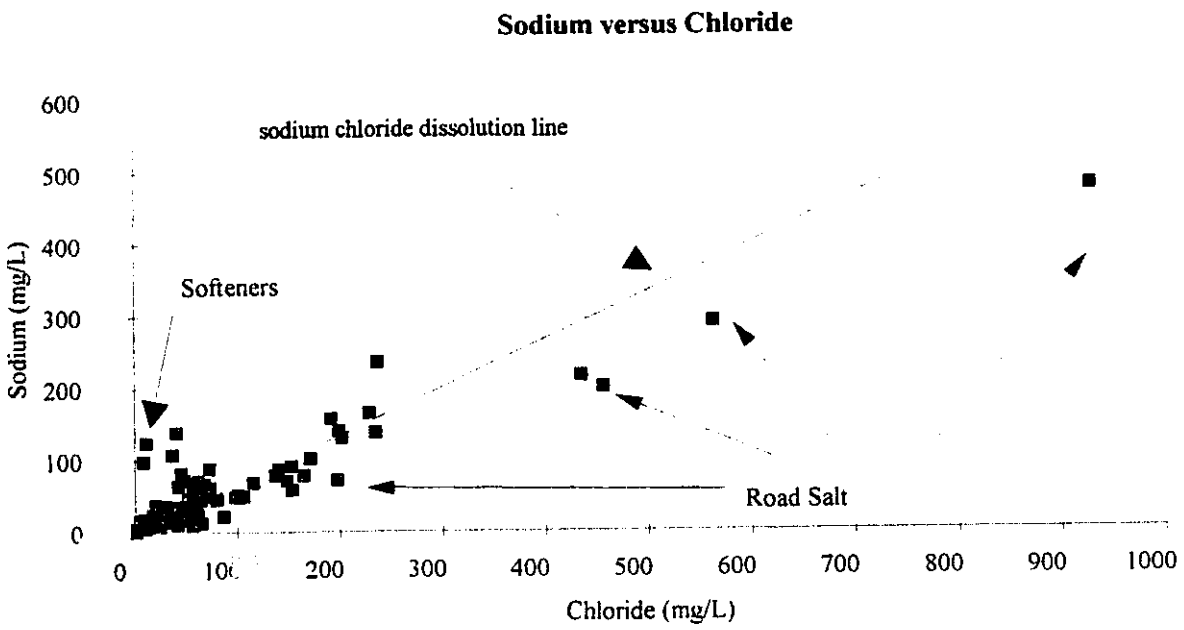


Figure 24 - Origin of Sodium Chloride

- Cation exchange - Through cation exchange sodium on clays and shale can be replaced by calcium, magnesium and strontium ions in solution. Source of sodium in the Ottawa Formation may the occurrence of numerous shale interbeds, whereas in the Richmond area the source may be the marine clay overlying the aquifers. For marine clays the values would plot as values plotting above the sodium chloride dissolution line in Figure 24, but none were observed.

- Remnant sea water - The Champlain Sea following the last glacial period has deposited significant thicknesses of clay in the study area. Very dilute seawater could still exist in the deep aquifer and or sodium chloride may still be released from the clays through leakage between hydrostratigraphic units. Concentrations of sodium chloride would plot below the sodium chloride dissolution line due to a relative chloride excess in seawater.

- Road Salting - Roads in Eastern Ontario are covered in the winter months with a mixture of sodium chloride and calcium chloride salts. Concentrations of sodium chloride would therefore plot below the sodium chloride dissolution line as chloride is also introduced with calcium chloride.

- Other sources - Mixing of numerous other contributing sources may result in points plotting on the sodium chloride dissolution line. Sources may include halite dissolution, septic systems, fertilizer, etc..

5.4 Isotope Assessment

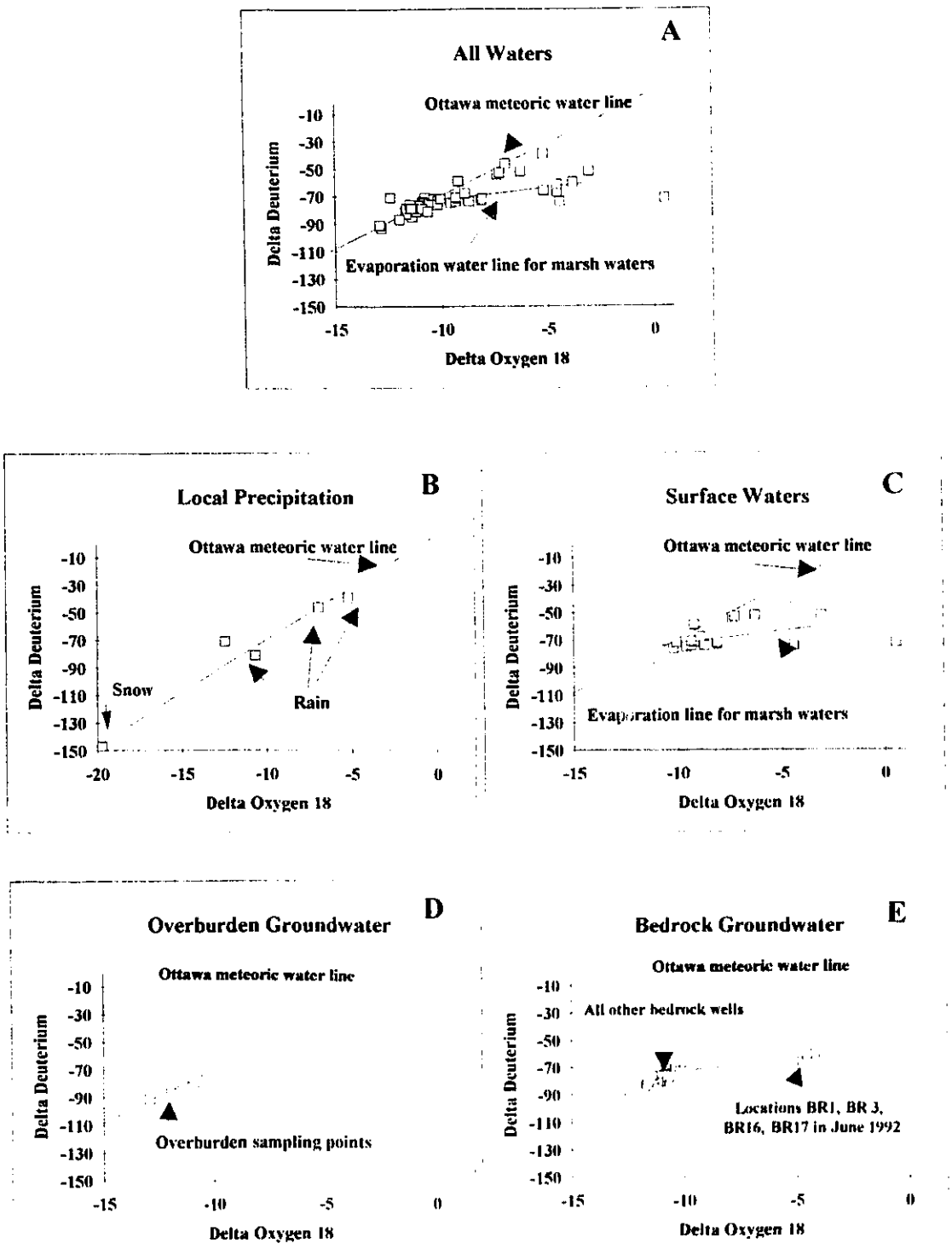
All surface and ground water samples were analyzed for their oxygen 18 ($\delta^{18}O$) and deuterium ($\delta^{2}H$) values. Results have been provided in Appendix B along with tritium (^{3}H) analysis on selected wells. Results have been plotted in Figure 25 along with the Ottawa area Meteoric Water Line(MWL) (Fritz et al., 1987). Fritz et al. (1987) show that in most temperate regions the isotopic composition of shallow groundwaters in recharge areas closely resembles the average local meteoric composition. In Figure 26 monitoring location BR 5 shows the typical local recharged groundwater $\delta^{18}O$ variation in the Ottawa area.

In the study area $\delta^{18}O$ values varied during the study period as follows:

Precipitation: $\delta^{18}O$	-19.74‰ (Snow) to -5.18‰ (Rain)
Surface Water: $\delta^{18}O$	-14.60‰ (Spring) to -0.51‰ (Fall(evaporated))
Groundwater: $\delta^{18}O$	-12.93‰ to -4.55‰

Similarly for $\delta^{2}H$ measured ranges during the study period are as follows:

Precipitation: $\delta^{2}H$	-147‰ (Snow) to -71‰ (Rain)
Surface Water: $\delta^{2}H$	-73 ‰ to -59‰
Groundwater: $\delta^{2}H$	-85‰ to -60‰



Ottawa meteoric water line after Fritz et al. (1987)

Figure 25. - Isotopic Composition of Waters in the Jock River Basin

Period September 1991- June 1993

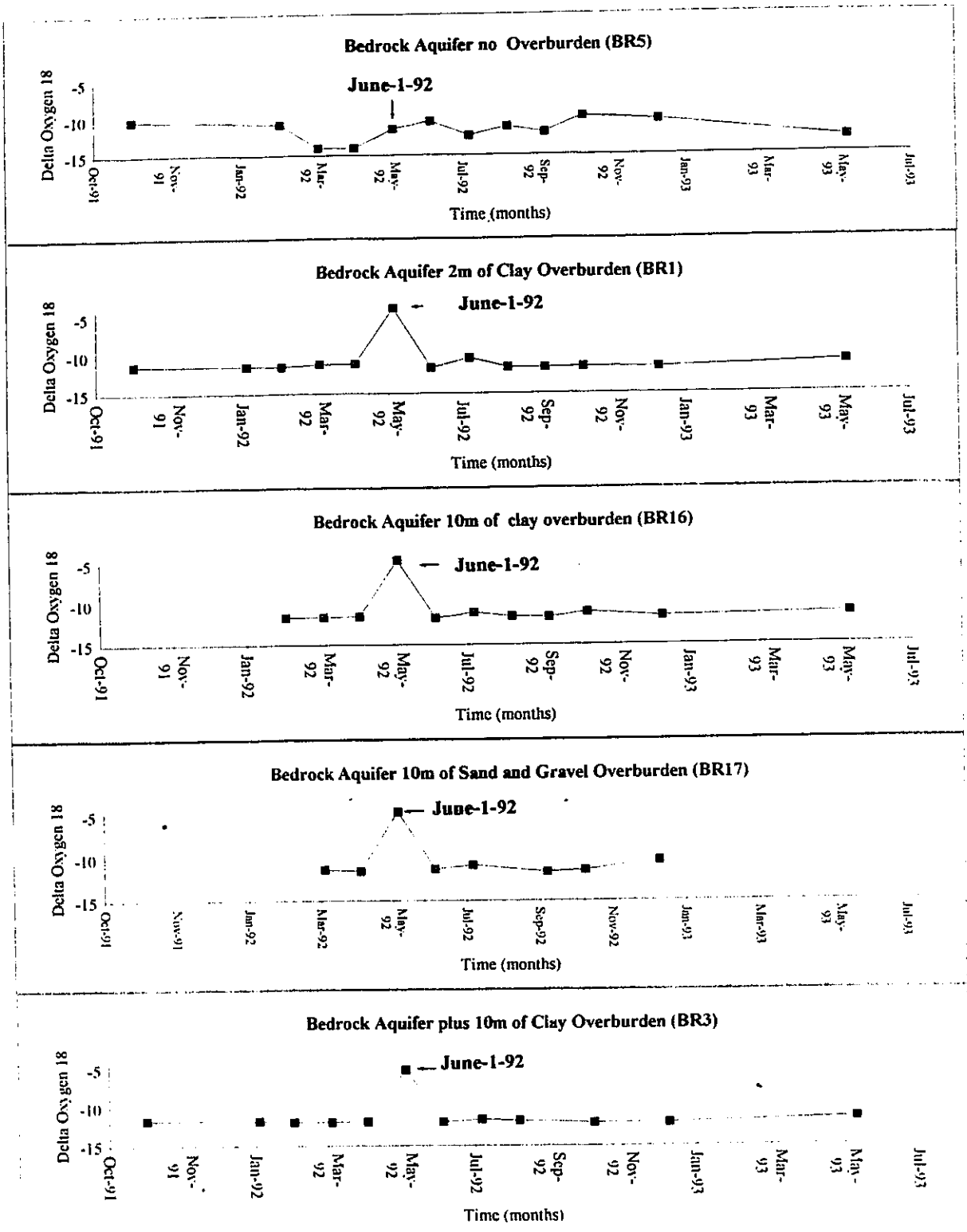


Figure 26 - Oxygen 18 Variations - Bedrock Wells

Tritium concentrations varied as follows:

Surface waters: 24.3 -to 43 TU

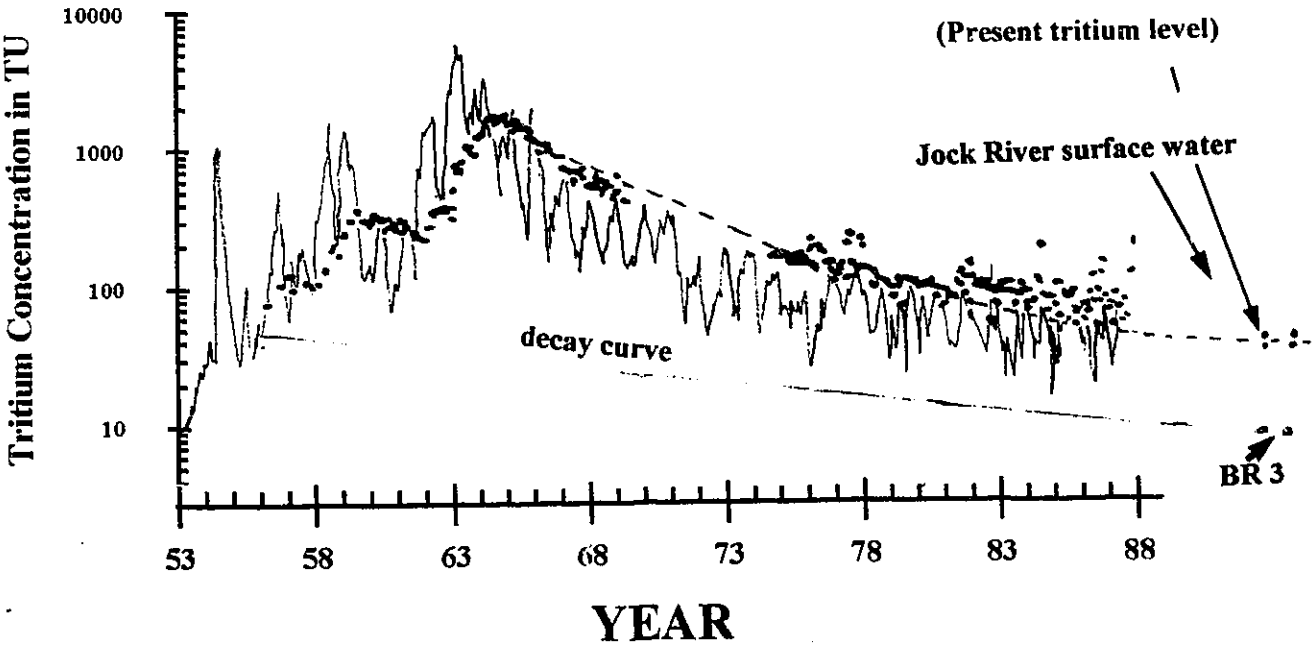
Ground waters: 7.6 -to 43 TU

The tritium results provide a range which falls within that of modern day, with the exception of the value 7.6 (Figure 27). This value indicates that a component of pre 1953 is present in some of the wells with less than about 20 TU. The δ^2H and $\delta^{18}O$ data suggest that all of the groundwater tapped by the wells was recharged from local precipitation during climatic conditions similar to the present. Further details are provided in the sections following.

5.4.1 Isotopes of Precipitation and Surface Water

5.4.1.1 Stable Isotopes

Figure 25 shows five scatter plots of δ^2H and $\delta^{18}O$ values. Two of these are surface waters and precipitation presented separately. The figure shows that three of four samples of rain fall on the local meteoric water line as established by Fritz et al. (1987). Snow precipitation falls also on the meteoric waterline and is more depleted in deuterium and oxygen.



LEGEND

T in River Calculated

T in River Observed Ottawa River

T in Ottawa Precipitation

Figure 27 - Tritium in Ottawa Precipitation and Ottawa River after Brown (1989)

The surface water plot (Figure 25C) shows three types of surface water. These are as follows:

- Precipitation
- Evaporated marsh waters with kinetic enrichment of δ^2H and $\delta^{18}O$
- Jock River water representing discharging bedrock groundwaters.

Most surface waters plot along the Ottawa meteoric water line. However evaporation effects are evident in marsh waters. The Jock River has several shallow marshes along its course where major evaporation of surface water can take place. In these areas evaporation isotope effects are expected particularly in summer. These evaporation effects would mainly show as a straight line deviation from the local meteoric water line. The slope of the line depends on the local kinetic conditions of evaporation (evaporation rate) and is typically between 3 and 5. Discharged groundwaters in surface waters are mainly found at Richmond and down stream. The discharging groundwaters are clustered between -11 and -12 ‰ for $\delta^{18}O$. These values are similar to those found in the bedrock groundwater.

Sampling points SW1, SW 4, SW5, SW6, SW7, SW8 in June all show a narrow range of $\delta^{18}O$ values (between -8 and -9 ‰ Appendix A) . This permil range suggests that a large component is from discharging groundwater as precipitation is more enriched in the summer. The more depleted values can only be attributed to a component of groundwater in the river water. The sampling run in November 1991 shows a more enriched $\delta^{18}O$ for all sites. This represents seasonal effects which are only partially attenuated by shallow groundwater systems. The data show that the only location where groundwater discharge is not important is at

SW2. Here evaporation results in more enriched values of $\delta^{18}O$ and $\delta^{2}H$.

5.4.1.2 Tritium in Surface Waters

Tritium measurements of surface waters have yielded concentrations between 27 and 40 TU. The concentrations fall within the range as reported by Brown(1989) for modern precipitation (Figure 27).

5.4.2 Isotopes in Groundwater

5.4.2.1 Stable Isotopes

Figure 25 (d) and (e) show that for most wells oxygen 18 and deuterium values cluster near a calculated mean value of $\delta^{18}O$ of -11.0‰ and $\delta^{2}H$ of -75.0‰. This clustering represents an average isotopic composition of groundwater recharge in the study area. Some temporal variations are noted in June of 1992. Their single peak occurence could indicate a sampling frequency that is too low. Bi-weekly or weekly sampling may have shown additional variations. The June variations are described in section 5.4.2.3.

No particular pattern is present in the areal variation of $\delta^{18}O$. The absence of trends is likely the result of sampling of wells that draw from multiple water-bearing zones. The small range of $\delta^{18}O$‰ demonstrates a high degree of mixing in the aquifers discussed below.

5.4.2.2 Tritium in Groundwater

Tritium analysis (Appendix B) of groundwaters show a range between 24.1 and 41

TU which corresponds to modern waters based on testing of the surface waters. Tritium contents for well BR 17 show a source of water that has recently been recharged as its values fall within the surface water range. Wells BR1 and BR 16 (concentrations between 16 and 20 TU close to present day precipitation) also represent recently recharged groundwaters. The measurement of 7.6+/- 0.6 TU at BR3 represents mixed a sample of waters with a mean residence time of greater than 40 years with a more modern component (Figure 27). It is observed that the thicker the clay at the site the lower the ^{3}H measurement, illustrating the increasing groundwater flow path length.

5.4.2.3 Temporal Variations of Isotopes in Groundwater

Unconfined bedrock groundwater shows seasonal variations (mean $\delta^{18}O$ -12.0‰, St. dev. 1.0, based on 28 data points) (Figure 26) while confined bedrock groundwaters have little seasonal variation (mean $\delta^{18}O$ -11.1‰, St. dev. within analytical error 0.15, based on 56 data points)(Figure 26). However an anomaly is noted in June 1992 (Figure 26) in all four confined aquifer wells sampled on a monthly basis (BR1, BR3, BR16, and BR 17). These anomalous data plot on the evaporation line for marsh waters in Figure 25. Figure 25 shows that most surface waters plot below the MWL and outside the precipitation envelope. The surface waters are part of an extensive marsh system and the isotopic content illustrates the isotope effects associated with evaporation of surface waters. All samples collected during the summer of 1992 from location SW2 (in the marsh area) plot on the evaporation line whereas samples from SW6 (at Richmond) show these evaporation effects much less (Figure 28). The depleted results at SW6 are attributed to a large component of discharging groundwaters. Surprisingly this evaporation effect is also noted in confined bedrock wells BR1, BR3, BR16 and BR 17 in June of 1992

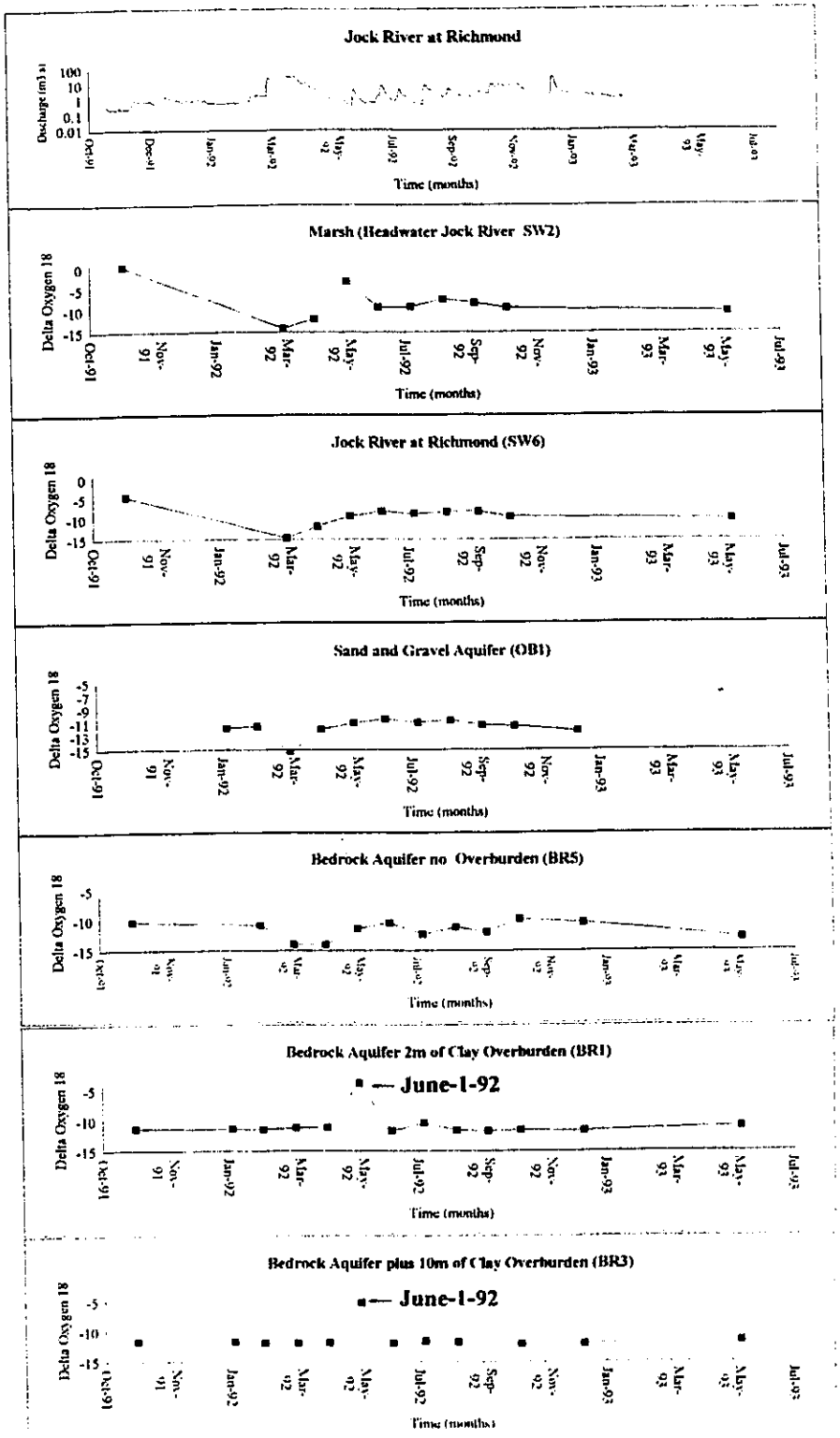


Figure 28 - Oxygen 18 Variations in the Jock River Basin

(Figure 26). At any other time these wells show a remarkable steadiness in their isotope $\delta^{18}O$ composition. The steadiness suggests a well mixed groundwater (Figure 28). These wells have common features as follows:

- The basal gravel and Oxford and March Formations are intersected
- Overburden overlies the bedrock.
- They are located in area that has been mapped as bedrock groundwater discharge zone (Section 5.1). The steadiness can be attributed to dispersion processes within the aquifer system and is similar to findings by Sklash et al. (1976) on an aquifer in South Western Ontario. Sampling locations where this steadiness is absent are characterized by groundwaters in phreatic aquifers (BR5)(Figure 28).

The unusual isotopic fluctuation noted for June 1992 is observed in both $\delta^{18}O$ and $\delta^{2}H$ and reflects a deviation from the MWL due to evaporation (Figure 25). An evaporation effect in this aquifer can only be attributed to contributions of surface (marsh) water during this period. Marsh waters are the only source of water in this basin which shows an evaporation effect. This can be accounted for by an understanding of the limestone aquifer system, and water budget (Appendix E) in the sampling year. The wells with the June 1992 $\delta^{18}O$ fluctuation are all located in an area where a clay overburden with a thickness in excess of 2 m is present. One aquifer with two main zones underlies this part of the study area. The upper zone is the bedrock surface fractured- basal till aquifer. The deeper water-bearing fracture zone is between 10 to 25m below the bedrock surface (Geo-analysis(1990) and this study). Both zones are confined and under artesian conditions. All samples were taken from private wells which characteristically:

- intersect several water-bearing zones

- bypass the upper aquifer to tap the deeper bedrock zone

The occurrence of marsh waters in these wells in June can be understood as discussed below. The deeper bedrock zone discharges to the basal gravel zone. The upper bedrock /basal gravel zone is a rapid flow system with hydraulic conductivities equivalent to a coarse gravel. It discharges directly into the marsh area (Figure 29). The deeper bedrock aquifer receives recharge from throughout the basin. (Figure 30). The deeper bedrock aquifer also has to be coupled to an area of higher elevation to account for the flowing artesian pressure head of up to 3m above surface found in the bedrock aquifer (Geo-analysis Inc. 1990). These areas may be associated with the gravel deposits in the Stittsville area, the heights south of Richmond or the Munster heights area (Figure 1). The pressure head in the deeper fracture zones is normally greater than that of the basal gravel/ upper bedrock aquifer; a condition that persists for most of the year. Groundwater from the deeper fracture zone water then discharges to the basal gravel aquifer. The measured $\delta^{18}O$ and $\delta^{2}H$ values for the deeper groundwaters plot on the local meteoric waterline. However during periods of high water consumption (lawn watering , filling of pools, car washing) the potentiometric surface of the deeper bedrock zone falls. This results in a groundwater flow reversal where the head of the bedrock zone falls below that of the basal zone and starts recharging from this zone rather than discharging to it. The confined nature of the basal gravel zone results in an area of influence that extends into the marshes thereby drawing marsh water into the aquifers. This situation occurred in June of 1992. Figure 28 compares the discharge data of the Jock River with that of the sampling period. The figure shows that the baseflow recession curve subsequent to the spring thaw had no major precipitation event until the middle of June. Review of precipitation

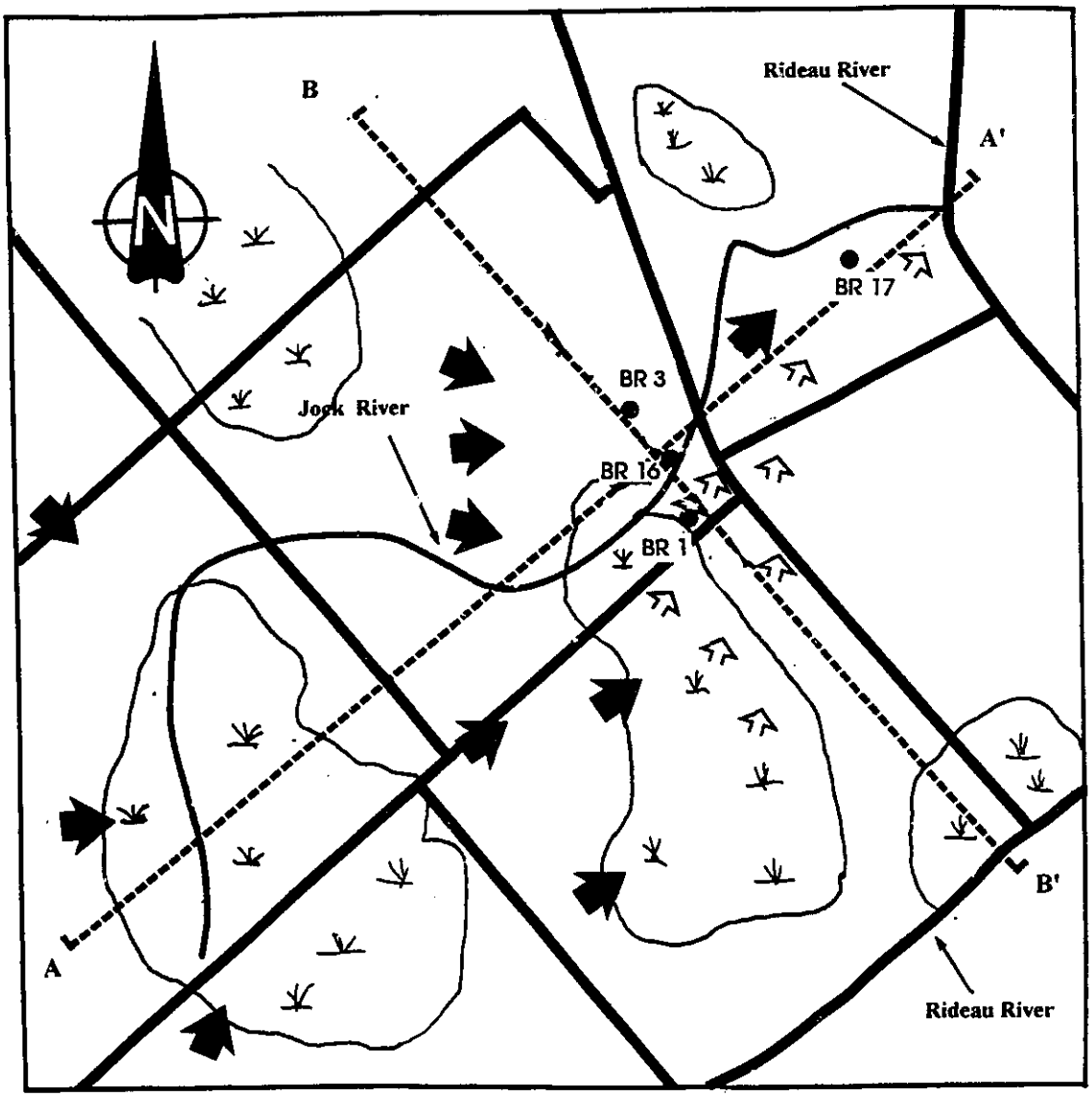
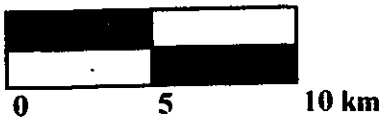


Figure 29- Groundwater Source Areas



Normal groundwater flow

Groundwater flow response due to pressure head drop

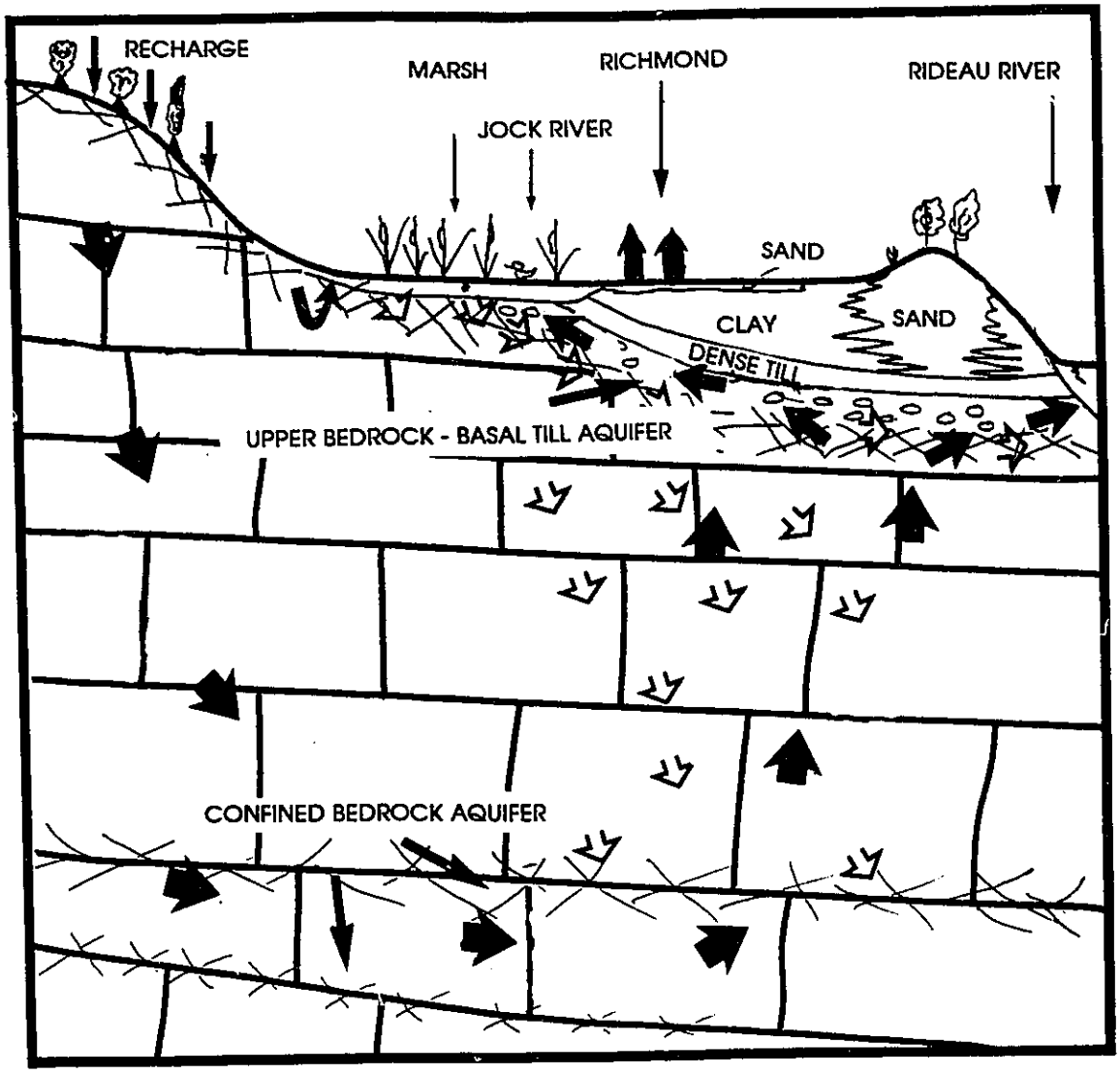


Figure 30 Schematic Cross-section of Aquifers

Groundwater flow response due to pressure head drop

Normal groundwater flow

Horizontal Scale

0 1 Km 2 Km

Vertical Scale

0

10 m

20 m

records show that sampling coincided with a period of six weeks with only three major precipitation events prior to sampling. Furthermore the water budget (Appendix E) for the period shows an evaporation deficit. Increased water consumption due to dry conditions could be expected during this period. This dry period was followed by a wet summer with few consecutive dry periods and the situation did not occur again.

However the sampling frequency may also have been marginally high enough to just see the flow reversal in June. More flow reversals may have taken place during the summer in response to shorter evaporation deficit events. A greater frequency could get a better definition of reversals (i.e weekly to biweekly sampling).

Monthly monitoring of the phreatic aquifer groundwaters do not show this enrichment of $\delta^{18}O$ in June. This is because they are recharged by direct infiltration and are not connected to surface water sources. Pumping in the phreatic aquifers releases water from storage by desaturation restricting the cumulative impact of the withdrawal.

Location BR17 further downgradient, which taps the same aquifer as BR1, BR3, BR16, shows the peak response in June (Figure 26). This would suggest that the basal gravel fractured bedrock zone is quite extensive in the lower reaches of the Jock River, extending from Richmond east to the Rideau River. Confined conditions are confirmed by M.M. Dillon (1993) nearby BR 17.

This inferred flow reversal suggests that the high density of wells in Richmond

has a significant cumulative cone of depression during periods of high groundwater consumption. The pumping causes a potentiometric drop of several to some ten metres in the down gradient area of groundwater flow with a cone of influence in the order of some ten kilometres in the confined bedrock aquifer. The drop is measurable as an isotope fluctuation caused by a groundwater flow reversal from the marsh to the basal gravel to the bedrock aquifer. The overlying sand deposit aquifer at BR17 is tapped by OB1 which does not show the isotope $\delta^{2}H$ and $\delta^{18}O$ peak seen in BR17. This suggests that BR17 does not tap the sand aquifer.

6.0 Conclusions

6.1 Flow system

The chemical analysis and isotopic composition of the bedrock groundwater show very little variation in the basin despite various fault zones and different limestone and sandstone formations being intersected (Figures 5 and 6). Results may suggest very thorough mixing and the existence of a single contiguous flow system, but mixing may also take place in wells. Deeper bedrock water-bearing zones have been reported to be pressurized in areas of significant overburden (Geo-analysis, 1987, 1990, 1991). Long flow paths occur in downgradient areas of the Jock River, whereas short flow paths occur in the upper reaches of the drainage system. Overburden thickness increases gradually towards the east and is significant in the lower reaches of the river (i.e. greater than 10m) (Figure 8) . The thick overburden sequence creates confined conditions in the shallow bedrock aquifer. The following can be concluded about the groundwater flow system:

- The data suggests that the deeper limestone aquifers behave as confined systems.
- Yields are generally improved by deeper drilling with no deterioration in water quality in most of the area (Jacques Whitford 1990). Some increased mineralization may occur however, but is still within MOEE drinking water guidelines.
- In areas of thin overburden, water quality fluctuations and ^{3}H in the bedrock aquifers suggest short residence times, characteristic of recharge environments.
- In areas of thick low permeability overburden, isotope data suggest that deeper

water bearing zones have mean circulation times of decades.

- The shallow water-bearing zones (basal gravel, weathered bedrock surface) in this area of thin overburden discharge to the marsh (Figure 29). Flow in these shallow systems is rapid.
- Shallow phreatic aquifers in regions of bedrock outcrop or sandy overburden show strong seasonal waterquality fluctuations and have seasonal mean circulation times.
- Recharge areas for the confined bedrock aquifer are believed to be located where the upland plateaus outcrop or are overlain by sands (Figure 30).
- Deep confined aquifers have potentiometric surface fluctuations that allow for groundwater flow reversals during periods of high extraction. The flow reversals recharge surface water into the confined bedrock aquifer over periods in the order of days.
- Where the basal gravel till bedrock surface aquifer zone is confined, surface water flow is sustained by deeper artesian groundwater in the fractured carbonate which discharges through this upper permeable zone.

6.2 Implication for Groundwater Exploitation

The study area has a predominantly rural character, with village concentrations of population including Richmond, Munster Hamlet and south Stittsville. Low density development is unlikely to impact on the aquifer budget significantly in this area of annual precipitation surplus. Assuming that 5000 wells evenly distributed are presently tapping the aquifers in the study area and with a household consumption of 2000 L/day, this would result in a yearly groundwater consumption equivalent to 6mm of precipitation a year or less than 1% of the yearly precipitation. Potential detrimental exploitation impact however exists in those areas of higher density development (south Stittsville and Richmond). Such impact is particularly notable during periods of high consumption. Monitoring of flow rates of the artesian well (FLO1) demonstrates an aquifer pressure response to recharge events and heavy extraction (i.e. in June 1992 the artesian flowing well did not flow). In a high transmissivity aquifer, and especially karst, pressure variations are transmitted very quickly. Only isotopes and geochemistry can document actual groundwater movement, mass transfer, mixing and contamination.

One main groundwater flow system with two zones is recognized in the study area:

- Shallow surficial weathered bedrock basal gravel zone
- Deeper locally pressurized confined bedrock zone

The shallow bedrock flow system discharges to the marsh lands in the study area. During this study it has been observed that large tracts of the marshland become

dry during a low precipitation summer. The Jock River was dry at location SW3 (Figure 2) during most of the late summer and early fall of 1991. Traditionally the end of the summer is very dry, but it is not known whether the marsh drying out has been occurring historically. In the Richmond area shallow wells tapping the shallow surficial bedrock zone have been reported to dry out during long term drought summer periods. The shallow aquifer is thus unreliable for water supply in the upslope regions of the basin. Further east closer to the Rideau River this aquifer zone is confined and has been used with success for long term communal supply (Geo-analysis 1982).

The deeper confined bedrock aquifer zone, at a depth between 10 to 20 m below the bedrock surface aquifer has a reliable water supply. It is tapped by most wells in the study area. Mean circulation rates in excess of several decades have been measured using tritium values. These long circulation times would decrease under increased use, through increased surface water input into the system. At present water quality differences are absent between highly developed areas and sparsely developed areas suggesting that development has had negligible effect on the water quality. This interpretation would be strengthened with the sampling of more wells.

The review of the Richmond Kingscourt (K1, K2) and Munster (M1, M2) Communal Wells (RMOC, 1993) has shown no appreciable trend in water quality during development. A high variability in chloride concentrations has been documented over the past 10 years. Some major increases in excess of the MOEE drinking water limit and decreases in chloride concentrations are observed in all four wells. These major decreases appear to be related to with major precipitation

events and illustrate rapid recharge with poor mixing. The increases do not show relation to precipitation events but may reflect year to year variations in the flow system. Other extreme variations that show no relation between wells can be attributed to contaminant input. (Road salting, sewage lagoons etc.) In high density development areas wells tap the deep bedrock aquifer at much shallower depths than the communal wells. Deeper water is of good quality, but more mineralized than shallower private well water. Effects of over development leads to a confined aquifer zone with a lower pressure head than the shallow bedrock basal gravel till aquifer zone. This induces leakage to the deeper aquifer zone from the basal gravel zone. The end result would likely be a seasonal decline of the watertable levels in the marsh lands and Jock River.

6.3 Sensitivity to Contaminants

Groundwater is of potable quality. Nitrate contamination occurs at some monitoring wells in unconfined aquifers. Smith et al. (1993) have shown, that contaminants remain at low concentrations in a limestone aquifer due to the rapid movement in the shallow system. In the Jock River Basin, a shallow system with such rapid movement exists. The deeper system under confined conditions may also have much slower groundwater velocities. High concentrations may occur in short lived events, but are not picked up due to the widely spaced occurrence of sampling events. Activities in the recharge areas will affect the water quality of the deeper confined aquifer zone although effects on water quality would be observed on different time scales. These recharge areas are located in areas of no soils and thin sands, where attenuation of contamination in the subsoil will be small due to limited contact time. Longlived contaminants could therefore affect the water quality of the deeper aquifer users. The shallow phreatic aquifer is more frequently tapped in the areas where overburden is thin and here sensitivity to contamination has been documented.

The long residence times of the deeper bedrock aquifer may make it susceptible to contaminant accumulation. The phreatic aquifer would be less sensitive to cumulative contamination due to its rapid circulation time, but the potential for transient contamination is high due to short flow paths. In the study area artesian bedrock aquifers are sensitive to surface water contamination because of flow reversals during periods of heavy extractions.

6.4 Long Term Groundwater Quality

Review of communal wells has shown no appreciable trends in inorganic water quality over the last 13 years. The communal wells are located in developed areas and the measurements suggest that present practices have resulted in negligible cumulative measurable impact. Some fluctuations in chloride and hardness concentrations have been noted which may be attributable to anthropogenic contaminant input. Differences in main chemical composition between sampling locations in developed and undeveloped areas are small, and can be attributed to the high degree of mixing as observed with the isotope measurements.

Groundwater quality appears to be most threatened by point source pollution. This pollution has been measured at the following sites:

- BR2 - nitrate impact- from barn or septic system sources
- BR5 - nitrate impact and sodium chloride- source septic system and road salting
- BR 17 and OB 1 as nitrate impact and rapid fluctuations in dissolved content . The source could be septic systems or industrial activities nearby (i.e. Trail Road Waste Disposal Facility).

The study has shown that in areas of mainly groundwater discharge and long flow paths, gradient reversals can occur due to heavy extractions. These gradient reversals allow for rapid entry of surface water in the groundwater system, allowing rapid contamination. Releases of substances in the recharge area will enter the aquifer possibly with little attenuation, given the carbonate setting transport will be fast within the flow system.

7.0 Recommendations

This study has shown that the waters drawn from limestone aquifers of the Jock River Basin indicate a high degree of mixing. The mixing may be due to the intersecting of several aquifer zones by wells or due to true interconnectivity of aquifer zones. In order to evaluate this, monitoring wells should be installed at discrete zones for the deeper and shallower water-bearing horizons. Long term monitoring on a monthly to bi-weekly basis for water quality parameters should be initiated. The information will provide detailed understanding of: i) the relationship between the aquifers, and ii) the extent of surface infiltration during periods of heavy pumping.

Additional analysis of ^{14}C and tritium should be completed on those wells in the deeper artesian zones. The potential exists that the tritium measured in this study originates from the shallow zones intercepted by the wells and that the deeper water-bearing zones are tritium free. Such tritium free water has been documented by Wilson(1990) near Carleton University. This would imply that the deeper waters are much older, and susceptible to mining.

Continued sampling of the monitoring locations would be prudent to document that the seasonalities found in this study are recurring. Additional monitoring points should be selected to document the daily and weekly fluctuations of groundwater quality over short term "sensitive" periods such as spring recharge, and periods of summer drought. It may be sufficient to select type settings and study these in

detail to later apply this basin wide.

To maintain sustainability of groundwater production and quality it is recommended on the basis of the above to protect marshlands and to restrict development in areas of shallow soils and bedrock outcrops where little attenuation of contaminants takes place. This not only refers to domestic activities but also to agricultural activities. Past agricultural activities and suburban development practices have had no significant long term effect on the bedrock aquifers of the study area. However some anthropogenic contamination occurs at point locations. Future planning should proceed with continued water quality and water table monitoring of the various type settings identified in this study and further study of the relationship between the marsh and the shallow bedrock, basal till flow system.

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Appendix A - Sample Collection and Methodology

The purpose of this Appendix is to provide an outline of the methodology followed for sample collection preparation and analysis of water samples collected during this study. Additional information can be found in the following documents:

a) Environmental Isotope Geochemistry, Application and Sampling Techniques, Appendix I in Phase I Report Environmental Isotope Study of the Sultanate of Oman, Cansult, 1985

and

b) Sampling for Water Quality, Water Quality Branch, Inland Waters Directorate, Ottawa, 1983

For the purpose of this study the objective of analysis was for the following:

Physical Measurements - Temperature, pH, Colour, Conductivity,

Chemical Measurements -

Anions - Chloride, Bicarbonate(Alkalinity), Sulphate, Sulphide (Hydrogen Sulphide), Phosphate, Nitrate, Nitrite, Fluoride, Bromide

Cations - Calcium, Magnesium, Sodium, Potassium, Iron, Manganese, Barium and Strontium

Some measurements were also taken for Beryllium, Chromium, Cobalt, Copper, Lithium, Nickel, Lead, Zinc

Isotopic Measurements -

Oxygen 18, Deuterium, Tritium

SAMPLING TECHNIQUES

Surface water sample collection.

Eight sampling sites were established along the Jock River. Sampling sites corresponded to bridge sites to allow for ease of access. Sampling was always completed on the upgradient site of stream flow. Sampling was only completed during ice free conditions. Samples were collected using a 1m long bailer. Three water volumes were collected to create a composite sample. Prior to filling of bottles the waters were filtered.

Groundwater collection

A total of 24 groundwater sampling sites were part of the program. All wells with the exception of OB2 are wells that are in regular use. Water was allowed to run for 5 minutes to ensure that the aquifer groundwater was sampled. Homeowner assurance was requested that all softeners and treatment systems were bypassed. In all cases the same tap was used for repeat sampling.

FIELD TESTS

All field tests were completed on a filtered sample.

Alkalinity

Alkalinity was field determined by acid titration. Sulphuric acid was used to lower

the pH to a value of 4.3 the bicarbonate- carbonate inflection point. The inflection point was determined by titrating to pH 4.3 using factory prepared colour indicator added to the solution.

pH

The pH electrode was calibrated prior to first and subsequently every four hours of use. Prior to sample measurement the pH probe was checked against the pH 7 buffer. The probe was rinsed with distilled water between each sample measurement.

Temperature

Temperature was measured using a standard mercury thermometer. The measurement was taken upon sample collection and recorded.

Conductivity

A digital conductivity meter was used for conductivity measurements. Temperature corrections were made on the instrument as appropriate. A factory conductivity standard was used between samples to confirm measurements. The probe was rinsed with deionized water and dried subsequent to each measurement.

Sample Collection for Laboratory Analysis

Isotopes

Samples for analysis of Oxygen 18 and Deuterium content were collected in airtight prerinsed 250mL plastic containers, no air space was left.

Tritium samples were collected in airtight 1 L plastic containers, no air space was left.

Repeat analyses were completed on selected samples to confirm laboratory results.

Anions

Anion analyses were completed using a High Pressure Liquid Chromatograph in the laboratory. The methodology allowed for the collection of samples in 100 mL plastic bottles. Prior to filling the sample was filtered where necessary.

Cations

Cation analyses were completed using a Inductive Coupled Plasma (ICP) chromatograph. The methodology allowed for the collection of samples in 100 mL plastic bottles. Prior to filling the sample was filtered. Upon completion of sampling the pH of the bottle contents was lowered to less than 2 using 3 drops of concentrated reaction grade nitric acid.

FIELD QUALITY CONTROL

Quality control for the inorganic chemistry involved the preparation of one duplicate sample prepared in the field per 10 samples analyzed. This was completed to evaluate the magnitude of errors owing to contamination, random errors, and any other variabilities which may have been introduced during the sampling process. The charge balance of the submitted samples is generally less than 5 percent and is considered acceptable. Review of the duplicates has shown a high level of repeatability.

Appendix B - Chemistry and Isotope Results

Sampling Location	Date	Oxygen 18	Deuterium
BR1	Nov-91	-11.27	-81
BR1	Feb-92	-11.41	
BR1	Mar-92	-11.43	
BR1	Apr-92	-11.16	
BR1	May-92	-11.09	
BR1	Jun-92	-3.79	-60
BR1	Jul-92	-11.67	
BR1	Aug-92	-10.35	
BR1	Sep-92	-11.62	
BR1	Oct-92	-11.65	
BR1	Nov-92	-11.55	
BR1	Jan-93	-11.62	
BR1	Jun-93	-10.94	-77
BR10	Nov-91	-11.54	-80
BR10	Jun-92	-10.74	-80
BR11	Nov-91	-11.04	-76
BR11	Jun-92	-11.05	-77
BR12	Nov-91	-10.82	-71
BR12	Jun-92	-11.05	-77
BR13	Nov-91	-10.92	-74
BR13	Jun-92	-10.85	-75
BR14	Nov-91	-11.29	-77
BR14	Jun-92	-10.69	-77
BR15	Nov-91	-11.25	-76
BR15	Jun-92	-11.06	-79
BR16	Mar-92	-11.67	
BR16	Apr-92	-11.62	
BR16	May-92	-11.57	
BR16	Jun-92	-4.55	-67
BR16	Jul-92	-11.76	
BR16	Aug-92	-11.06	
BR16	Sep-92	-11.55	
BR16	Oct-92	-11.67	
BR16	Nov-92	-11.03	
BR16	Jan-93	-11 58	
BR16	Jun-93	-11.23	-79
BR17	Apr-92	-11.33	
BR17	May-92	-11.50	
BR17	Jun-92	-4.55	-61
BR17	Jul-92	-11.26	
BR17	Aug-92	-10.79	
BR17	Oct-92	-11.63	
BR17	Nov-92	-11.41	-82
BR17	Jan-93	-10.32	

Sampling Location	Date	Oxygen 18	Deuterium
BR2	Nov-91	-10.38	-72
BR2	Jun-92	-11.11	-80
BR3	Nov-91	-11.69	-81
BR3	Feb-92	-11.76	
BR3	Feb-92	-11.76	
BR3	Mar-92	-11.89	
BR3	Apr-92	-11.89	
BR3	May-92	-11.84	
BR3	Jun-92	-5.17	-66
BR3	Jul-92	-11.90	
BR3	Aug-92	-11.60	
BR3	Sep-92	-11.75	
BR3	Nov-92	-12.03	
BR3	Jan-93	-12.01	
BR3	Jun-93	-11.45	-82
BR4	Nov-91	-10.78	-76
BR4	Jun-92	-11.10	-77
BR5	Nov-91	-10.17	-73
BR5	Mar-92	-10.76	
BR5	Apr-92	-13.98	
BR5	May-92	-13.99	
BR5	Jun-92	-11.39	-85
BR5	Jul-92	-10.39	
BR5	Aug-92	-12.27	
BR5	Sep-92	-11.10	
BR5	Oct-92	-11.92	
BR5	Nov-92	-9.75	
BR5	Jan-93	-10.24	
BR5	Jun-93	-12.85	-93
BR6	Nov-91	-11.18	-80
BR6	Jun-92	-11.31	-81
BR7	Nov-91	-11.53	-79
BR7	Jun-92	-11.66	-83
BR8	Nov-91	-10.59	-76
BR8	Jun-92	-11.19	-81
BR9	Nov-91	-11.37	-79
BR9	Jun-92	-11.42	-79
FL01	Oct-92	-11.62	-79
K2	Aug-92	-11.44	-76
M1	Aug-92	-11.62	-79
M2	Aug-92	-11.49	-76
OB1	Feb-92	-11.77	
OB1	Mar-92	-11.44	
OB1	Apr-92	-15.47	
OB1	May-92	-11.92	
OB1	Jun-92	-10.94	-79
OB1	Jul-92	-10.39	
OB1	Aug-92	-10.89	
OB1	Sep-92	-10.62	
OB1	Oct-92	-11.33	
OB1	Nov-92	-11.43	-79
OB1	Jan-93	-12.23	
OB2	Jun-92	-12.93	-91
OB2	Jul-92	-12.95	
OB2	Aug-92	-12.84	
OB2	Sep-92	-12.40	
OB2	Nov-92	-11.97	-87

Sampling Location	Date	Oxygen 18	Deuterium
SW1	Nov-91	-7.36	-54
SW1	Jun-92	-9.26	
SW2	Nov-91	0.51	-72
SW2	Apr-92	-14.13	
SW2	May-92	-11.81	
SW2	Jun-92	-3.05	-52
SW2	Jul-92	-9.19	-59
SW2	Aug-92	-9.00	
SW2	Sep-92	-7.28	
SW2	Oct-92	-8.20	
SW2	Nov-92	-9.26	
SW2	Jun-93	-10.20	-76
SW4	Nov-91	-7.24	-53
SW4	Jun-92	-9.57	-75
SW5	Nov-91	-8.71	-74
SW5	Jun-92	-9.31	-74
SW6	Nov-91	-4.41	-74
SW6	Apr-92	-14.60	
SW6	May-92	-11.71	
SW6	Jun-92	-9.20	-72
SW6	Jul-92	-8.13	-73
SW6	Aug-92	-8.71	
SW6	Sep-92	-8.19	
SW6	Oct-92	-8.10	
SW6	Nov-92	-9.32	
SW6	Jun-93	-10.05	-72
SW7	Nov-91	-6.25	-52
SW7	Jun-92	-9.32	-71
SW8	Nov-91	-8.09	-72
SW8	Jun-92	-8.90	-68
Rain 1	Nov-92	-6.96	-46
Rain 2	Sep-92	-5.18	-39
Rain 3	Aug-92	-12.41	-71
Rain 4	Mar-92	-10.67	-81
snow	Feb-92	-19.74	-147

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LAB#	SAMPLE	EH3	
40111	06/93/SW2	24.3 +/- 1.7	
40112	06/93/SW6	26.7 +/- 1.9	24.1 +/- 1.7
40113	06/93/BR1	20.0 +/- 1.4	19.9 +/- 1.4
40114	06/93/BR3	7.6 +/- 0.6	
40115	06/93/BR16	17.1 +/- 1.2	

Condensed Data output for File ISO$- 930054 Clark/Barend 02/26/93 LOCATION 0 -4

LAB#	Sample	18Osmow	2H	3H	EH3	13C	18Opdb	34S	18Oso4
38683	49 June 92 SW2			40 +/- 8					
38684	71 June 92 BR17			43 +/- 8					
				40 +/- 8					
38685	57 June 92 BR3			10 +/- 8					
38686	2 November 91 SW2			41 +/- 8					
38687	55 June 92 BR1			20 +/- 8					
				21 +/- 8					
38688	70 June 92 BR16			19 +/- 8					
				20 +/- 8					

SAMPLE ID	DATE	pH	HCO3- mg/L	COND umhos/cm	F- mg/L	Cl- mg/L	NO2- mg/L	Br- mg/L
BR1	Nov-91	7.74	289.35	686	0.70	68.97	< 0.1	< 1
BR1	Feb-92	7.20	338.00	865	0.70	64.77	< 0.1	< 1
BR1	Mar-92	7.69	326.00	1063	0.70	64.29	< 0.1	< 1
BR1	Apr-92	7.69	288.00	939	0.70	59.08	< 0.1	< 1
BR1	May-92	7.53	332.00	868	0.70	36.35	< 0.1	< 1
BR1	Jun-92	7.58	322.00	918	0.70	48.91	< 0.1	< 1
BR1	Jul-92	7.22	207.00	813	0.70	69.92	< 0.1	< 1
BR1	Aug-92	7.31	206.90	674	0.70	54.29	< 0.1	< 1
BR1	Sep-92	7.51	275.48	810	< 0.5	59.88	< 0.5	< 0.6
BR1	Oct-92	7.20	295.91	760	< 0.5	51.64	< 0.5	< 0.6
BR1	Nov-92	7.47	329.40	740	< 0.5	24.77	< 0.5	< 0.6
BR1	Jan-93	6.88	322.08	711	< 0.5	20.31	< 0.5	< 0.6
BR1 repeat	Nov-92	7.47	329.40	740	< 0.5	31.86	< 0.5	< 0.6
BR10	Nov-91	7.87	206.67	584	0.70	28.16	< 0.1	< 1
BR10	Jun-92	7.76	301.00	736	0.70	35.81	< 0.1	< 1
BR11	Nov-91	7.85	204.70	766	0.70	36.43	< 0.1	< 1
BR11	Jun-92	7.90	382.00	1150	0.70	40.72	< 0.1	< 1
BR12	Nov-91	7.24	185.62	766	0.70	64.74	< 0.1	< 1
BR12	Jun-92	7.88	316.00	817	0.70	58.82	< 0.1	< 1
BR13	Nov-91	7.62	322.00	571	0.70	12.23	< 0.1	< 1
BR13	Jun-92	7.55	354.00	726	0.70	6.11	< 0.1	< 1
BR14	Nov-91	7.51	191.40	344	0.70	42.06	< 0.1	< 1
BR14	Jun-92	7.52	332.00	786	0.70	5.01	< 0.1	< 1
BR15	Nov-91	7.58	169.25	900	0.70	148.18	< 0.1	< 1
BR15	Jun-92	7.46	288.00	1418	0.70	45.32	< 0.1	< 1
BR16	Mar-92	7.80	289.00	874	0.70	26.88	< 0.1	< 1
BR16	Apr-92	7.56	282.00	726	0.70	23.43	< 0.1	< 1
BR16	May-92	7.76	272.00	741	0.70	28.38	< 0.1	< 1
BR16	Jun-92	7.62	280.00	770	0.70	25.11	< 0.1	< 1
BR16	Jul-92	7.34	268.00	644	0.70	28.62	< 0.1	< 1
BR16	Aug-92	7.60	238.00	547	0.70	23.39	< 0.1	< 1
BR16	Sep-92	7.83	280.41	660	< 0.5	26.08	< 0.5	< 0.6
BR16	Oct-92	7.60	290.36	680	< 0.5	26.13	< 0.5	< 0.6
BR16	Nov-92	7.09	292.80	650	< 0.5	17.39	< 0.5	< 0.6
BR16	Jan-93	7.08	295.24	613	< 0.5	17.28	< 0.5	< 0.6
BR1repeat	Jun-92	7.58	322.00	918	0.70	50.61	< 0.1	< 1
BR17	Apr-92	7.37	270.00	783	0.70	21.88	< 0.1	< 1
BR17	May-92	7.64	231.65	1087	0.70	48.22	< 0.1	< 1
BR17	Jun-92	7.80	244.00	801	0.70	45.04	< 0.1	< 1
BR17	Jul-92	7.58	244.00	722	0.70	60.88	< 0.1	< 1
BR17	Aug-92	7.86	187.54	595	0.70	54.99	< 0.1	< 1
BR17	Oct-92	7.27	273.60	770	< 0.5	61.11	< 0.5	< 0.6
BR17	Nov-92	6.88	290.36	780	< 0.5	47.74	< 0.5	< 0.6
BR17	Jan-93	7.08	290.36	689	< 0.5	47.02	< 0.5	< 0.6
BR1repeat	Jul-92	7.22	207.00	813	0.70	66.35	< 0.1	< 1
BR1	Aug-92	7.31	206.90	674	0.70	55.02	< 0.1	< 1
BR2	Nov-91	7.42	289.35	1115	0.70	197.47	< 0.1	< 1
BR2	Jun-92	7.55	289.00	1042	0.70	105.70	< 0.1	< 1
BR2repeat	Jun-92	7.55	289.00	1042	0.70	100.61	< 0.1	< 1
BR3	Nov-91	8.03	245.68	658	0.70	73.08	< 0.1	< 1
BR3	Feb-92	7.39	272.00	763	0.70	68.14	< 0.1	< 1
BR3	Mar-92	8.05	240.00	954	0.70	68.29	< 0.1	< 1
BR3	Apr-92	7.86	322.00	822	0.70	42.31	< 0.1	< 1
BR3	May-92	7.90	241.00	985	0.70	59.70	< 0.1	< 1
BR3	Jun-92	7.60	206.00	941	0.70	66.80	< 0.1	< 1
BR3	Jul-92	7.53	248.00	643	0.70	64.65	< 0.1	< 1
BR3	Aug-92	7.88	166.70	585	0.70	63.71	< 0.1	< 1
BR3	Sep-92	7.68	222.40	730	< 0.5	45.19	< 0.5	< 0.6

SAMPLE ID	DATE	pH	HCO3- mg/L	COND umhos/cm	F- mg/L	Cl- mg/L	NO2- mg/L	Br- mg/L
BR3	Nov-92	7.72	224.48	750	< 0.5	53.21	< 0.5	< 0.6
BR3	Jan-93	7.42	236.68	662	< 0.5	62.04	< 0.5	< 0.6
BR4	Nov-91	7.29	184.35	657	0.70	51.65	< 0.1	< 1
BR4	Jun-92	7.51	288.00	746	0.70	44.47	< 0.1	< 1
BR5	Nov-91	7.34	255.33	1205	0.70	199.00	< 0.1	< 1
BR5	Feb-92	7.27	340.00	1157	0.70	137.36	< 0.1	< 1
BR5	Mar-92	7.44	177.43	1548	0.70	171.00	< 0.1	< 1
BR5	Apr-92	7.27	203.14	959	0.70	115.30	< 0.1	< 1
BR5	May-92	7.21	112.00	2740	0.70	456.00	< 0.1	< 1
BR5	Jun-92	7.41	348.00	1380	0.70	235.00	< 0.1	< 1
BR5	Jul-92	6.80	178.12	2800	0.70	928.00	< 0.1	< 1
BR5	Aug-92	6.17	257.49	1680	0.70	435.00	< 0.1	< 1
BR5	Sep-92	6.84	379.75	1400	< 0.5	228.97	< 0.5	< 0.6
BR5	Oct-92	6.91	357.91	2380	< 0.5	562.27	< 0.5	< 0.6
BR5	Nov-92	6.92	417.24	1385	< 0.5	237.05	< 0.5	< 0.6
BR5	Jan-93	6.91	319.64	1158	< 0.5	191.35	< 0.5	< 0.6
BR6	Nov-91	7.68	262.00	719	0.70	55.96	< 0.1	< 1
BR6	Jun-92	7.63	282.00	622	0.70	23.91	< 0.1	< 1
BR7	Nov-91	7.92	333.03	456	0.70	7.43	< 0.1	< 1
BR7	Jun-92	7.28	338.00	630	0.70	11.19	< 0.1	< 1
BR8	Nov-91	7.40	215.65	1181	0.70	165.00	< 0.1	< 1
BR8	Jun-92	7.51	371.00	1356	0.70	153.00	< 0.1	< 1
BR9	Nov-91	7.91	256.60	481	0.70	8.47	< 0.1	< 1
BR9	Jun-92	7.80	272.00	594	0.70	9.90	< 0.1	< 1
FLO1	Oct-92	7.31	294.03	690	< 0.5	28.49	< 0.5	< 0.6
K2	Aug-92	7.90	156.50	1012	0.70	140.54	< 0.1	< 1
M1	Aug-92	7.80	150.60	770	0.70	72.75	< 0.1	< 1
M2	Aug-92	7.80	207.40	836	0.70	56.82	< 0.1	< 1
OB1	Feb-92	7.40	297.05	807	0.70	41.20	< 0.1	< 1
OB1	Mar-92	7.65	300.27	1046	0.70	39.41	< 0.1	< 1
OB1	Apr-92	7.78	156.00	387	0.70	8.02	< 0.1	< 1
OB1	May-92	7.20	302.00	851	0.70	41.85	< 0.1	< 1
OB1	Jun-92	7.65	305.00	1026	0.70	52.11	< 0.1	< 1
OB1	Jul-92	7.41	276.00	783	0.70	54.17	< 0.1	< 1
OB1	Aug-92	7.56	218.80	671	0.70	54.87	< 0.1	< 1
OB1	Sep-92	7.35	281.82	810	< 0.5	48.92	< 0.5	< 0.6
OB1	Oct-92	7.28	284.40	810	< 0.5	58.79	< 0.5	< 0.6
OB1	Nov-92	7.31	312.32	840	< 0.5	39.84	< 0.5	< 0.6
OB1	Jan-93	7.07	258.64	601	< 0.5	26.99	< 0.5	< 0.6
OB1repeat	Jun-92	7.65	305.00	1026	0.70	51.84	< 0.1	< 1
OB2	Jun-92	7.66	199.27	1142	0.70	98.25	< 0.1	< 1
OB2	Jul-92	7.17	202.00	865	0.70	80.83	< 0.1	< 1
OB2	Aug-92	7.57	190.52	805	0.70	101.59	< 0.1	< 1
OB2	Sep-92	7.32	344.99	1100	< 0.5	153.48	< 0.5	< 0.6
OB2	Nov-92	7.25	353.80	1050	< 0.5	100.58	< 0.5	< 0.6
OB2	Jan-93	6.83	326.96	856	< 0.5	80.01	< 0.5	< 0.6
SNOW	Feb-92	4.30	3.00	-	0.70	0.92	< 0.1	< 1
SW1	Nov-91	7.53	188.35	851	0.70	86.76	< 0.1	< 1
SW1	Jun-92	7.43	282.00	560	0.70	36.90	< 0.1	< 1
SW2	Nov-91	7.44	212.64	402	0.70	8.71	< 0.1	< 1
SW2	Apr-92	6.60	120.00	308	0.70	11.21	< 0.1	< 1
SW2	May-92	7.00	121.00	431	0.70	9.38	< 0.1	< 1
SW2	Jun-92	7.41	206.00	365	0.70	8.44	< 0.1	< 1
SW2	Jul-92	7.03	184.00	384	0.70	1.86	< 0.1	< 1
SW2	Aug-92	7.10	179.00	292	0.70	7.81	< 0.1	< 1
SW2	Sep-92	6.82	183.65	380	< 0.5	9.98	< 0.5	< 0.6
SW2	Oct-92	6.92	197.74	420	< 0.5	14.73	< 0.5	< 0.6
SW2	Nov-92	6.73	168.36	410	< 0.5	17.88	< 0.5	< 0.6

SAMPLE ID	DATE	pH	HCO3- mg/L	COND umhos/cm	F- mg/L	Cl- mg/L	NO2- mg/L	Br- mg/L
SW2 repeat	Oct-92	6.92	197.74	420	< 0.5	8.00	< 0.5	< 0.6
SW4	Nov-91	8.52	229.30	1196	0.70	202.00	< 0.1	< 1
SW4	Jun-92	8.40	244.00	397	0.70	13.15	< 0.1	< 1
SW5	Nov-91	7.74	311.19	592	0.70	37.18	< 0.1	< 1
SW5	Jun-92	8.19	222.00	441	0.70	14.75	< 0.1	< 1
SW6	Nov-91	8.16	191.08	423	0.70	17.37	< 0.1	< 1
SW6	Apr-92	7.30	114.00	243	0.70	9.65	< 0.1	< 1
SW6	May-92	7.92	162.00	368	0.70	7.70	< 0.1	< 1
SW6	Jun-92	7.80	322.00	430	0.70	13.79	< 0.1	< 1
SW6	Jul-92	8.23	238.00	397	0.70	12.67	< 0.1	< 1
SW6	Aug-92	7.88	169.68	412	0.70	14.84	< 0.1	< 1
SW6	Sep-92	8.07	218.41	440	< 0.5	13.92	< 0.5	< 0.6
SW6	Oct-92	7.73	230.15	510	< 0.5	19.82	< 0.5	< 0.6
SW6	Nov-92	7.91	229.36	520	< 0.5	12.40	< 0.5	< 0.6
SW7	Nov-91	8.20	223.84	591	0.70	45.29	< 0.1	< 1
SW7	Jun-92	8.10	288.00	470	0.70	21.58	< 0.1	< 1
SW8	Nov-91	8.12	169.25	723	0.70	54.49	< 0.1	< 1
SW8	Jun-92	7.75	184.00	504	0.70	22.98	< 0.1	< 1

SAMPLE ID	DATE	NO3- mg/L	SO4-2 mg/L	Al mg/L	B mg/L	Ba mg/L	Be mg/L
BR1	Nov-91	< 2	49.48	0.11	0.23	0.41	<0.002
BR1	Feb-92	< 2	50.63	< 0.01	0.18	0.45	<0.002
BR1	Mar-92	< 2	52.99	0.02	0.19	0.45	<0.002
BR1	Apr-92	< 2	44.93		0.17	0.49	<0.002
BR1	May-92	< 2	35.35		0.19	0.37	<0.002
BR1	Jun-92	< 2	39.92		0.15	0.41	<0.002
BR1	Jul-92	1.66	52.91		0.17	0.42	<0.002
BR1	Aug-92	< 2	45.09		0.15	0.30	<0.002
BR1	Sep-92	< 0.6	47.59	0.77	0.19	0.44	
BR1	Oct-92	< 0.6	44.33	0.78	0.19	0.44	
BR1	Nov-92	< 0.6	33.87	0.93	0.16	0.43	
BR1	Jan-93	< 0.6	76.66	<.01	0.20	0.33	
BR1 repeat	Nov-92	< 0.6	39.95	<.01	0.16	0.42	
BR10	Nov-91	< 2	54.78	0.08	0.18	0.14	<0.002
BR10	Jun-92	< 2	54.69		0.18	0.14	<0.002
BR11	Nov-91	< 2	97.07	0.12	0.92	0.04	<0.002
BR11	Jun-92	< 2	100.02		1.00	0.03	<0.002
BR12	Nov-91	7.21	50.98	0.12	0.18	0.18	<0.002
BR12	Jun-92	< 2	40.76		0.21	0.18	<0.002
BR13	Nov-91	< 2	57.77	0.10	0.29	0.12	<0.002
BR13	Jun-92	< 2	53.81		0.13	0.12	<0.002
BR14	Nov-91	< 2	38.32	< 0.01	0.09	0.18	<0.002
BR14	Jun-92	< 2	53.75		0.10	0.20	<0.002
BR15	Nov-91	6.20	38.00	< 0.01	0.03	0.12	<0.002
BR15	Jun-92	< 2	44.27		0.02	0.12	<0.002
BR16	Mar-92	< 2	42.05		0.18	0.08	<0.002
BR16	Apr-92	< 2	43.05		0.17	0.08	<0.002
BR16	May-92	< 2	39.71		0.17	0.05	<0.002
BR16	Jun-92	< 2	44.60		0.16	0.07	<0.002
BR16	Jul-92	1.66	44.48		0.17	0.08	<0.002
BR16	Aug-92	1.66	45.17		0.18	0.07	<0.002
BR16	Sep-92	< 0.6	45.45	0.67	0.17	0.08	
BR16	Oct-92	< 0.6	44.98	0.71	0.18	0.08	
BR16	Nov-92	< 0.6	44.84	0.72	0.16	0.08	
BR16	Jan-93	< 0.6	46.75	<.01	0.17	0.08	
BR1repeat	Jun-92	< 2	41.80		0.16	0.33	<0.002
BR17	Apr-92	< 2	55.84		0.01	0.14	<0.002
BR17	May-92	< 2	58.25		0.01	0.13	<0.002
BR17	Jun-92	1.66	48.28		0.01	0.13	<0.002
BR17	Jul-92	8.81	43.99		0.01	0.14	<0.002
BR17	Aug-92	10.57	46.26		0.02	0.14	<0.002
BR17	Oct-92	5.14	49.05	0.88	<.008	0.17	
BR17	Nov-92	4.90	50.18	0.83	<.008	0.17	
BR17	Jan-93	7.51	52.21	<.01	<.008	0.15	
BR1repeat	Jul-92	< 2	55.37		0.18	0.34	<0.002
BR1	Aug-92	< 2	45.22		0.15	0.37	<0.002
BR2	Nov-91	< 2	36.94	0.03	0.01	0.27	<0.002
BR2	Jun-92	< 2	27.01		0.02	0.11	<0.002
BR2repeat	Jun-92	< 2	27.71		0.02	0.10	<0.002
BR3	Nov-91	< 2	42.63	0.07	0.27	0.05	<0.002
BR3	Feb-92	< 2	43.08	< 0.01	0.25	0.06	<0.002
BR3	Mar-92	< 2	43.82		0.27	0.05	<0.002
BR3	Apr-92	< 2	33.86		0.27	0.06	<0.002
BR3	May-92	< 2	43.06		0.26	0.06	<0.002
BR3	Jun-92	< 2	43.89		0.26	0.05	<0.002
BR3	Jul-92	1.66	45.55		0.27	0.05	<0.002
BR3	Aug-92	< 2	46.52		0.27	0.05	<0.002
BR3	Sep-92	< 0.6	30.09	0.44	0.25	0.06	

SAMPLE ID	DATE	NO3- mg/L	SO4-2 mg/L	Al mg/L	B mg/L	Ba mg/L	Be mg/L
BR3	Nov-92	< 0.6	39.87	0.50	0.25	0.06	
BR3	Jan-93	< 0.6	47.35	<.01	0.26	0.06	
BR4	Nov-91	< 2	32.42	< 0.01	0.02	0.40	<0.002
BR4	Jun-92	< 2	31.60		0.02	0.44	<0.002
BR5	Nov-91	< 2	28.62	< 0.01	0.01	0.22	<0.002
BR5	Feb-92	11.87	24.52	0.12	0.01	0.18	<0.002
BR5	Mar-92	10.18	24.25		0.02	0.11	<0.002
BR5	Apr-92	< 2	15.87		< 0.008	0.11	<0.002
BR5	May-92	< 2	19.76		< 0.008	0.23	<0.002
BR5	Jun-92	< 2	25.38		0.02	0.23	<0.002
BR5	Jul-92	1.66	34.63		0.02	0.51	<0.002
BR5	Aug-92	2.48	33.61		0.02	0.28	<0.002
BR5	Sep-92	6.37	26.57	0.41	0.02	0.18	
BR5	Oct-92	5.30	29.72	0.72	0.02	0.41	
BR5	Nov-92	1.84	27.69	0.26	0.01	0.16	
BR5	Jan-93	27.06	23.84	<.01	<.008	0.16	
BR6	Nov-91	< 2	20.40	< 0.01	0.44	0.14	<0.002
BR6	Jun-92	< 2	18.27		0.43	0.15	<0.002
BR7	Nov-91	< 2	24.19	0.04	0.22	0.10	<0.002
BR7	Jun-92	< 2	26.35		0.20	0.00	<0.002
BR8	Nov-91	29.71	39.67	< 0.01	0.09	0.31	<0.002
BR8	Jun-92	24.98	39.90		0.12	0.27	<0.002
BR9	Nov-91	< 2	18.98	< 0.01	0.27	0.01	<0.002
BR9	Jun-92	< 2	24.52		0.29	0.12	<0.002
FLO1	Oct-92	< 0.6	53.16	0.72	0.18	0.08	
K2	Aug-92	< 2	52.28		0.23	0.09	<0.002
M1	Aug-92	< 2	68.67		0.46	0.04	<0.002
M2	Aug-92	< 2	65.81		0.33	0.06	<0.002
OB1	Feb-92	< 2	53.86	0.06	<0.005	0.14	<0.002
OB1	Mar-92	< 2	51.63		0.01	0.16	<0.002
OB1	Apr-92	9.35	12.27		0.01	0.08	<0.002
OB1	May-92	15.44	42.88		0.02	0.13	<0.002
OB1	Jun-92	1.66	50.71		0.02	0.15	<0.002
OB1	Jul-92	14.29	53.06		0.02	0.14	<0.002
OB1	Aug-92	16.50	56.26		0.01	0.14	<0.002
OB1	Sep-92	13.60	47.06	0.96	0.01	0.16	
OB1	Oct-92	12.30	57.29	1.02	<.008	0.15	
OB1	Nov-92	10.11	57.94	1.02	<.008	0.15	
OB1	Jan-93	10.25	42.98	<.01	<.008	0.13	
OB1repeat	Jun-92	16.53	51.24		0.01	0.14	<0.002
OB2	Jun-92	1.66	32.71		0.09	0.11	<0.002
OB2	Jul-92	< 2	26.59		0.16	0.03	<0.002
OB2	Aug-92	< 2	29.55		0.09	0.03	<0.002
OB2	Sep-92	8.18	35.13	0.08	0.10	0.04	
OB2	Nov-92	< 0.6	31.54	0.82	0.08	0.04	
OB2	Jan-93	3.80	27.66	<.01	0.06	0.05	
SNOW	Feb-92	4.43	< 4		0.01	0.01	<0.002
SW1	Nov-91	< 2	68.06	0.04	0.02	0.06	<0.002
SW1	Jun-92	< 2	< 4		0.01	0.07	<0.002
SW2	Nov-91	< 2	8.49	< 0.01	0.01	0.08	<0.002
SW2	Apr-92	< 2	21.05		0.01	0.05	<0.002
SW2	May-92	< 2	8.40		0.01	0.05	<0.002
SW2	Jun-92	< 2	< 4		0.01	0.07	<0.002
SW2	Jul-92	1.66	< 4		0.01	0.08	<0.002
SW2	Aug-92	< 2	< 4		0.02	0.06	<0.002
SW2	Sep-92	< 0.6	< 5	0.13	0.01	0.08	
SW2	Oct-92	< 0.6	< 5	0.19	<.008	0.07	
SW2	Nov-92	< 0.6	< 5	0.21	<.008	0.06	

SAMPLE ID	DATE	NO3- mg/L	SO4-2 mg/L	Al mg/L	B mg/L	Ba mg/L	Be mg/L
SW2 repeat	Oct-92	< 0.6	< 5	0.08	<.008	0.07	
SW4	Nov-91	< 2	34.75	< 0.01	0.24	0.10	<0.002
SW4	Jun-92	< 2	6.82		0.04	0.07	<0.002
SW5	Nov-91	< 2	38.07	< 0.01	0.09	0.17	<0.002
SW5	Jun-92	< 2	9.71		0.03	0.08	<0.002
SW6	Nov-91	< 2	8.61	< 0.01	0.04	0.06	<0.002
SW6	Apr-92	< 2	18.06		0.01	0.04	<0.002
SW6	May-92	< 2	13.51		0.02	0.06	<0.002
SW6	Jun-92	< 2	8.42		0.02	0.07	<0.002
SW6	Jul-92	1.66	8.22		0.03	0.07	<0.002
SW6	Aug-92	< 2	9.36		0.03	0.05	<0.002
SW6	Sep-92	< 0.6	< 5	0.24	0.02	0.07	
SW6	Oct-92	< 0.6	< 5	0.33	0.02	0.07	
SW6	Nov-92	< 0.6	14.15	0.31	<.008	0.06	
SW7	Nov-91	< 2	19.81	< 0.01	0.10	0.07	<0.002
SW7	Jun-92	< 2	13.53		0.03	0.06	<0.002
SW8	Nov-91	< 2	30.91	0.02	0.06	0.10	<0.002
SW8	Jun-92	< 2	15.42		0.04	0.07	<0.002

SAMPLE ID	DATE	Ca+2 mg/L	Cr mg/L	Co mg/L	Cu mg/L	Fe mg/L	K+ mg/L	Li mg/L	Mg+2 mg/L	Mn mg/L
BR1	Nov-91	51.68	<0.008	<0.008	<0.005	<0.005	3.65	0.03	27.71	<0.005
BR1	Feb-92	62.17	<0.008	<0.008	0.01	<0.005	3.24	0.02	27.07	<0.005
BR1	Mar-92	63.33	<0.008	<0.008	<0.005	<0.005	3.18	0.02	26.92	<0.005
BR1	Apr-92	59.82	<0.008	<0.008	<0.005	0.01	6.32	0.02	27.90	<0.005
BR1	May-92	57.15	<0.008	<0.008	<0.005	0.01	5.55	0.02	26.45	0.01
BR1	Jun-92	63.29	<0.008	<0.008	<0.005	<0.005	4.31	0.02	30.38	0.01
BR1	Jul-92	48.59	<0.008	<0.008	<0.005	<0.005	52.85	0.02	28.46	<0.005
BR1	Aug-92	28.82	<0.008	<0.008	<0.005	<0.005	5.66	0.02	26.96	<0.005
BR1	Sep-92	68.73				<.01	5.26		26.58	<.002
BR1	Oct-92	69.62				<.01			27.06	0.00
BR1	Nov-92	71.65				<.01	6.30		28.52	<.002
BR1	Jan-93	36.47				<.01	5.29		28.77	<.002
BR1 repeat	Nov-92	63.22				<.01	7.49		28.58	0.01
BR10	Nov-91	65.04	<0.008	<0.008	0.01	<0.005	2.97	0.02	29.23	<0.005
BR10	Jun-92	64.44	<0.008	<0.008	0.01	<0.005	4.23	0.02	29.02	0.01
BR11	Nov-91	27.47	<0.008	<0.008	<0.005	<0.005	3.91	0.08	21.67	<0.005
BR11	Jun-92	25.01	<0.008	<0.008	<0.005	0.02	6.90	0.08	16.70	<0.005
BR12	Nov-91	76.42	<0.008	<0.008	0.01	<0.005	6.76	0.01	28.88	<0.005
BR12	Jun-92	86.53	<0.008	<0.008	0.01	<0.005	4.99	0.01	26.07	0.01
BR13	Nov-91	54.26	<0.008	<0.008	0.01	<0.005	3.36	0.02	29.25	<0.005
BR13	Jun-92	82.08	<0.008	<0.008	0.01	<0.005	3.62	0.01	30.77	<0.005
BR14	Nov-91	58.25	<0.008	<0.008	<0.005	<0.005	3.29	0.01	32.12	<0.005
BR14	Jun-92	75.72	<0.008	<0.008	<0.005	<0.005	4.39	0.01	33.59	0.01
BR15	Nov-91	81.73	<0.008	<0.008	0.01	<0.005	1.55	0.01	15.79	<0.005
BR15	Jun-92	70.00	<0.008	<0.008	<0.005	<0.005	2.95	<0.005	16.80	<0.005
BR16	Mar-92	42.69	<0.008	<0.008	<0.005	0.01	6.76	0.02	24.18	<0.005
BR16	Apr-92	57.23	<0.008	<0.008	<0.005	<0.005	6.09	0.02	23.22	0.01
BR16	May-92	42.97	<0.008	<0.008	<0.005	0.01	5.96	0.02	22.59	<0.005
BR16	Jun-92	45.46	<0.008	<0.008	<0.005	<0.005		0.02	23.89	<0.005
BR16	Jul-92	49.03	<0.008	<0.008	<0.005	0.01	5.77	0.02	25.19	<0.005
BR16	Aug-92	58.49	<0.008	<0.008	<0.005	<0.005	5.52	0.02	24.42	<0.005
BR16	Sep-92	71.56				<.01	5.40		25.04	<.002
BR16	Oct-92	71.44				<.01	5.92		25.35	0.01
BR16	Nov-92	70.20				<.01	5.48		24.79	<.002
BR16	Jan-93	70.35				<.01	5.93		25.14	<.002
BR1repeat	Jun-92	38.94	<0.008	<0.008	<0.005	<0.005	3.07	0.02	29.29	<0.005
BR17	Apr-92	65.22	<0.008	<0.008	<0.005	0.01	7.38	<0.005	26.65	<0.005
BR17	May-92	64.60	<0.008	<0.008	<0.005	<0.005	5.45	<0.005	28.85	<0.005
BR17	Jun-92	54.21	<0.008	<0.008	<0.005	<0.005		<0.005	25.32	<0.005
BR17	Jul-92	53.60	<0.008	<0.008	<0.005	<0.005	7.93	<0.005	25.61	<0.005
BR17	Aug-92	58.54	<0.008	<0.008	<0.005	<0.005	7.91	<0.005	26.52	<0.005
BR17	Oct-92	77.64				<.01	7.94		28.67	<.002
BR17	Nov-92	81.52				<.01	7.80		28.21	<.002
BR17	Jan-93	41.58				<.01	7.51		28.76	<.002
BR1repeat	Jul-92	29.59	<0.008	<0.008	<0.005	<0.005	3.67	0.02	27.31	<0.005
BR1	Aug-92	53.61	<0.008	<0.008	<0.005	<0.005	3.40	0.02	28.26	<0.005
BR2	Nov-91	70.37	<0.008	<0.008	<0.005	<0.005	20.45	<0.005	47.81	<0.005
BR2	Jun-92	51.15	<0.008	<0.008	<0.005	<0.005	7.53	<0.005	35.47	<0.005
BR2repeat	Jun-92	47.77	<0.008	<0.008	<0.005	<0.005	4.65	<0.005	35.58	<0.005
BR3	Nov-91	37.40	<0.008	<0.008	<0.005	<0.005	5.63	0.03	21.12	<0.005
BR3	Feb-92	37.02	<0.008	<0.008	<0.005	<0.005	4.92	0.03	20.21	<0.005
BR3	Mar-92	32.91	<0.008	<0.008	<0.005	<0.005	10.57	0.03	18.92	<0.005
BR3	Apr-92	33.79	<0.008	<0.008	<0.005	0.01	10.47	0.03	18.69	0.01
BR3	May-92	32.79	<0.008	<0.008	<0.005	<0.005	10.61	0.03	18.80	0.01
BR3	Jun-92	31.90	<0.008	<0.008	<0.005	<0.005		0.03	19.92	<0.005
BR3	Jul-92	35.39	<0.008	<0.008	<0.005	<0.005	9.57	0.03	20.16	<0.005
BR3	Aug-92	33.74	<0.008	0.01	<0.005	<0.005	9.68	0.03	19.66	<0.005
BR3	Sep-92	37.72				<.01	8.36		19.28	<.002

SAMPLE ID	DATE	Ca+2 mg/L	Cr mg/L	Co mg/L	Cu mg/L	Fe mg/L	K+ mg/L	Li mg/L	Mg+2 mg/L	Mn mg/L
BR3	Nov-92	37.41				<.01	9.31		20.03	<.002
BR3	Jan-93	39.37				<.01	9.58		20.23	<.002
BR4	Nov-91	49.65	<0.008	<0.008	<0.005	0.01	1.92	<0.005	22.23	<0.005
BR4	Jun-92	71.18	<0.008	<0.008	<0.005	<0.005	2.33	<0.005	21.61	0.04
BR5	Nov-91	49.94	<0.008	<0.008	<0.005	<0.005	1.08	<0.005	21.72	<0.005
BR5	Feb-92	81.85	<0.008	<0.008	0.01	<0.005	1.07	<0.005	19.38	<0.005
BR5	Mar-92	39.23	<0.008	<0.008	<0.005	0.01	2.53	<0.005	17.65	<0.005
BR5	Apr-92	50.28	<0.008	<0.008	<0.005	<0.005	1.70	<0.005	10.98	<0.005
BR5	May-92	64.86	<0.008	<0.008	0.01	0.01	1.84	<0.005	16.25	<0.005
BR5	Jun-92	79.05	<0.008	<0.008	<0.005	<0.005	1.94	<0.005	19.78	<0.005
BR5	Jul-92	97.36	<0.008	<0.008	<0.005	<0.005	3.60	<0.005	26.36	<0.005
BR5	Aug-92	56.06	<0.008	<0.008	<0.005	<0.005	2.73	<0.005	26.73	<0.005
BR5	Sep-92	44.57				<.01	1.71		18.26	<.002
BR5	Oct-92	125.19				<.01	3.49		25.95	<.002
BR5	Nov-92	45.85				<.01	2.01		14.72	<.002
BR5	Jan-93	77.10				<.01	1.47		15.69	<.002
BR6	Nov-91	53.92	<0.008	<0.008	<0.005	<0.005	4.70	0.04	47.81	<0.005
BR6	Jun-92	55.85	<0.008	<0.008	<0.005	<0.005	5.58	0.03	28.11	0.01
BR7	Nov-91	50.75	<0.008	<0.008	<0.005	<0.005	3.58	0.12	27.43	<0.005
BR7	Jun-92	1.34	<0.008	<0.008	<0.005	<0.005	0.89	0.02	1.29	<0.005
BR8	Nov-91	89.04	<0.008	<0.008	0.01	<0.005	10.05	0.01	25.94	<0.005
BR8	Jun-92	96.27	<0.008	<0.008	0.04	<0.005	12.67	<0.005	22.96	<0.005
BR9	Nov-91	4.15	<0.008	<0.008	<0.005	<0.005	0.57	0.02	1.55	<0.005
BR9	Jun-92	51.23	<0.008	<0.008	0.01	0.22	4.78	0.02	23.81	0.01
FLO1	Oct-92	65.05				0.02	5.05		24.60	<.002
K2	Aug-92	40.87	<0.008	<0.008	<0.005	<0.005	8.11	0.03	27.92	<0.005
M1	Aug-92	26.92	<0.008	<0.008	<0.005	0.01	7.51	0.04	21.95	<0.005
M2	Aug-92	50.46	<0.008	<0.008	<0.005	<0.005	6.78	0.03	27.07	<0.005
OB1	Feb-92	65.74	<0.008	<0.008	0.01	<0.005	2.14	<0.005	28.44	<0.005
OB1	Mar-92	72.09	<0.008	<0.008	0.01	0.01	4.64	<0.005	28.44	<0.005
OB1	Apr-92	39.18	<0.008	<0.008	0.01	<0.005	6.05	<0.005	12.43	<0.005
OB1	May-92	76.50	<0.008	<0.008	0.44	<0.005	3.93	0.01	28.63	0.02
OB1	Jun-92	75.97	<0.008	<0.008	<0.005	<0.005	8.27	<0.005	29.79	<0.005
OB1	Jul-92	77.16	<0.008	<0.008	<0.005	<0.005	2.63	<0.005	30.14	<0.005
OB1	Aug-92	75.95	<0.008	<0.008	<0.005	<0.005	2.77	<0.005	30.45	<0.005
OB1	Sep-92	93.69				<.01	3.90		30.73	<.002
OB1	Oct-92	93.30				<.01	4.18		30.32	<.002
OB1	Nov-92	93.55				<.01	3.93		30.41	<.002
OB1	Jan-93	79.96				<.01	3.47		25.38	<.002
OB1repeat	Jun-92	76.35	<0.008	<0.008	0.01	<0.005	2.44	0.01	29.87	<0.005
OB2	Jun-92	42.09	<0.008	<0.008	<0.005	<0.005	9.84	0.01	26.14	<0.005
OB2	Jul-92	32.37	<0.008	<0.008	<0.005	<0.005	8.75	0.01	23.36	<0.005
OB2	Aug-92	78.88	<0.008	<0.008	<0.005	<0.005	5.60	0.01	24.29	<0.005
OB2	Sep-92	110.00				<.01	7.73		27.70	<.002
OB2	Nov-92	106.60				0.01	9.85		26.91	<.002
OB2	Jan-93	106.32				<.01	11.33		26.36	<.002
SNOW	Feb-92	1.10	<0.008	<0.008	<0.005	<0.005	0.32	<0.005	0.19	0.01
SW1	Nov-91	68.39	<0.008	<0.008	<0.005		0.78	<0.005	25.52	0.08
SW1	Jun-92	67.31	<0.008	<0.008	0.13	<0.005	1.35	<0.005	16.96	<0.005
SW2	Nov-91	51.95	<0.008	<0.008	<0.005	0.01	0.72	<0.005	13.14	<0.005
SW2	Apr-92	35.31	<0.008	<0.008	<0.005	0.00	2.00	<0.005	10.24	<0.005
SW2	May-92	34.09	<0.008	<0.008	<0.005	0.04	0.98	<0.005	8.58	<0.005
SW2	Jun-92	47.68	<0.008	<0.008	0.06	0.22	0.31	<0.005	11.32	0.02
SW2	Jul-92	50.59	<0.008	<0.008	0.01	0.35	0.02	<0.005	12.29	0.05
SW2	Aug-92	41.80	<0.008	<0.008	0.01	<0.005	0.18	<0.005	9.95	<0.005
SW2	Sep-92	52.98				0.22	1.35		12.04	0.03
SW2	Oct-92	57.81				0.07	0.88		13.71	<.002
SW2	Nov-92	49.13				0.03	1.53		13.42	<.002

SAMPLE ID	DATE	Ca+2 mg/L	Cr mg/L	Co mg/L	Cu mg/L	Fe mg/L	K+ mg/L	Li mg/L	Mg+2 mg/L	Mn mg/L
SW2 repeat	Oct-92	56.28				0.08	1.64		14.34	<.002
SW4	Nov-91	73.58	<0.008	<0.008	0.01	<0.005	5.46	<0.005	23.52	<0.005
SW4	Jun-92	56.24	<0.008	<0.008	0.01	0.12	0.87	<0.005	13.09	0.02
SW5	Nov-91	58.92	<0.008	<0.008	<0.005	<0.005	3.10	0.01	25.75	<0.005
SW5	Jun-92	58.17	<0.008	<0.008	<0.005	0.10	0.85	<0.005	17.36	0.05
SW6	Nov-91	47.59	<0.008	<0.008	<0.005	<0.005	1.35	<0.005	19.59	<0.005
SW6	Apr-92	31.78	<0.008	<0.008	<0.005	0.01	3.85	<0.005	7.37	<0.005
SW6	May-92	40.48	<0.008	<0.008	<0.005	0.02	1.02	<0.005	11.45	<0.005
SW6	Jun-92	57.39	<0.008	<0.008	<0.005	0.07	0.65	<0.005	17.19	0.09
SW6	Jul-92	62.04	<0.008	<0.008	<0.005	0.04	0.70	<0.005	16.78	0.01
SW6	Aug-92	46.18	<0.008	<0.008	<0.005	0.04	1.12	<0.005	16.02	<0.005
SW6	Sep-92	60.85				0.16	1.69		14.45	0.01
SW6	Oct-92	71.68				0.13	2.83		17.22	0.01
SW6	Nov-92	63.27				0.04	2.64		15.27	0.01
SW7	Nov-91	52.23	<0.008	<0.008	<0.005	<0.005	2.79	<0.005	19.53	<0.005
SW7	Jun-92	59.93	<0.008	<0.008	<0.005	0.10	0.92	<0.005	17.16	0.06
SW8	Nov-91	59.16	<0.008	<0.008	0.01	<0.005	2.66	<0.005	20.39	<0.005
SW8	Jun-92	60.05	<0.008	<0.008	<0.005	0.13	1.29	<0.005	17.85	0.06

SAMPLE ID	DATE	Na+ mg/L	Ni mg/L	P mg/L	Pb mg/L	Si mg/L	Sr mg/L	Zn mg/L	S mg/L	meq+	meq-
BR1	Nov-91	48.77	<0.01	0.10	<0.03	3.62	0.65	<0.005	17.54	7.07	7.72
BR1	Feb-92	44.91	0.01	<0.05	<0.03	3.42	0.64	<0.005	18.94	7.37	8.42
BR1	Mar-92	45.15	0.02	<0.05	<0.03	3.17	0.63	0.03	19.81	7.42	8.26
BR1	Apr-92	42.61	<0.01		<0.03	3.21	0.58	<0.005	15.26	7.30	7.32
BR1	May-92	35.43	0.01		<0.03	3.22	0.56	<0.005	3.12	6.71	7.20
BR1	Jun-92	37.71	<0.01		<0.03	3.61	0.68	<0.005	5.17	7.41	7.49
BR1	Jul-92	52.01	<0.01		<0.03	3.23	0.61	<0.005	3.59	8.38	6.49
BR1	Aug-92	39.14	<0.01		<0.03	3.64	0.59	<0.005	1.63	5.50	5.86
BR1	Sep-92	50.86		<.1		3.41	0.61		16.46	8.00	7.19
BR1	Oct-92	47.16		<.1		3.47	0.60		15.20	7.79	7.23
BR1	Nov-92	37.19		<.1		3.79	0.62		13.34	7.74	6.80
BR1	Jan-93	39.05		<.1		3.93	0.64		13.63	6.05	7.45
BR1 repeat	Nov-92	35.64		<.1		3.80	0.62		13.39	7.28	7.13
BR10	Nov-91	20.22	0.02	<0.05	<0.03	4.36	1.95	<0.005	20.50	6.61	5.32
BR10	Jun-92	24.64	<0.01		<0.03	4.27	1.83	<0.005	13.72	6.78	7.08
BR11	Nov-91	107.57	0.01	<0.05	<0.03	4.35	4.97	<0.005	35.18	7.93	6.40
BR11	Jun-92	138.47	<0.01		<0.03	3.86	3.91	<0.005	8.40	8.82	9.49
BR12	Nov-91	12.68	0.02	0.06	<0.03	6.02	1.84	<0.005	19.91	6.91	6.05
BR12	Jun-92	12.09	<0.01		<0.03	5.62	1.79	<0.005	18.32	7.12	7.69
BR13	Nov-91	10.88	0.02	<0.05	<0.03	5.39	1.87	<0.005	21.64	5.67	6.82
BR13	Jun-92	4.18	<0.01		<0.03	4.06	1.14	0.02	31.03	6.90	7.09
BR14	Nov-91	11.23	0.02	<0.05	<0.03	4.22	1.15	<0.005	14.24	6.12	5.12
BR14	Jun-92	16.27	<0.01		<0.03	4.21	1.16	<0.005	13.83	7.36	6.70
BR15	Nov-91	70.55	0.02	<0.05	<0.03		1.31	<0.005	14.64	8.49	7.85
BR15	Jun-92	82.13	<0.01		<0.03	3.67	1.33	<0.005	18.23	8.52	6.92
BR16	Mar-92	25.01	<0.01		<0.03	3.64	2.22	<0.005	14.34	5.38	6.37
BR16	Apr-92	22.87	0.04		0.05	3.27	2.19	0.01	14.39	5.92	6.18
BR16	May-92	22.06	<0.01		0.04	3.30	1.80	<0.005	14.50	5.12	6.09
BR16	Jun-92	22.65	<0.01		<0.03	3.65	2.26	<0.005	14.23	5.22	6.23
BR16	Jul-92	25.02	<0.01		<0.03	4.15	2.31	<0.005	14.29	5.76	6.15
BR16	Aug-92	24.88	<0.01		<0.03	4.54	2.65	0.03	16.52	6.15	5.53
BR16	Sep-92	25.70		<.1		4.16	2.43		15.64	6.92	6.28
BR16	Oct-92	27.79		<.1		4.01	2.54		15.78	7.04	6.43
BR16	Nov-92	25.44		<.1		3.86	2.41		15.40	6.82	6.22
BR16	Jan-93	24.24		<.1		3.84	2.46		15.55	6.82	6.30
BR1repeat	Jun-92	37.44	<0.01		<0.03	3.71	0.67	<0.005	18.38	6.06	7.58
BR17	Apr-92	16.64	<0.01		0.05	3.85	0.22	<0.005	19.22	6.36	6.20
BR17	May-92	17.19	<0.01		<0.03	4.21	0.23	<0.005	6.15	6.48	6.37
BR17	Jun-92	19.58	<0.01		<0.03	4.10	0.20	<0.005	14.19	5.64	6.30
BR17	Jul-92	23.37	<0.01		<0.03	4.21	0.21	<0.005	12.24	6.00	6.77
BR17	Aug-92	24.34	<0.01		<0.03	4.39	0.24	0.01	12.80	6.36	5.76
BR17	Oct-92	25.45		<.1		4.32	0.23		16.24	7.58	7.31
BR17	Nov-92	23.45		<.1		4.35	0.22		16.99	7.65	7.23
BR17	Jan-93	21.96		<.1		4.52	0.22		17.44	5.62	7.29
BR1repeat	Jul-92	51.96	<0.01		<0.03	3.34	0.62	<0.005	15.33	6.08	6.42
BR1	Aug-92	40.37	<0.01		<0.03	3.64	0.68	<0.005	0.55	6.84	5.88
BR2	Nov-91	71.27	<0.01	0.13	<0.03	5.24	0.19	<0.005	12.89	11.07	11.08
BR2	Jun-92	49.77	<0.01		<0.03	4.29	0.15	<0.005	6.16	7.83	8.28
BR2repeat	Jun-92	51.21	<0.01		<0.03	4.55	0.16	0.04	19.26	7.66	8.15
BR3	Nov-91	61.19	<0.01	0.11	<0.03	6.23	4.74	<0.005	14.87	6.41	6.98
BR3	Feb-92	56.02	0.02	<0.05	<0.03	4.60	4.54	<0.005	15.89	6.07	7.28
BR3	Mar-92	65.81	<0.01		0.07	4.14	3.89	<0.005	14.39	6.33	6.77
BR3	Apr-92	64.88	<0.01		0.03	3.94	3.88	<0.005	14.29	6.31	7.18
BR3	May-92	64.94	<0.01		<0.03	4.22	3.87	<0.005	4.86	6.28	6.53
BR3	Jun-92	66.53	<0.01		<0.03	4.62	4.20	<0.005	13.77	6.12	6.17
BR3	Jul-92	67.20	<0.01		<0.03	4.94	4.37	<0.005	3.60	6.59	6.86
BR3	Aug-92	67.02	<0.01		<0.03	4.81	4.64	<0.005	3.59	6.46	5.50
BR3	Sep-92	70.83		<.1		4.83	4.27		15.68	6.79	5.55

SAMPLE ID	DATE	Na+	Ni	P	Pb	Si	Sr	Zn	S		
		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	meq+	meq-
BR3	Nov-92	72.09		<.1		4.70	4.34		15.50	6.91	6.01
BR3	Jan-93	71.14		<.1		4.78	4.43		15.79	6.99	6.61
BR4	Nov-91	25.08	<0.01	0.08	<0.03	2.62	0.21	<0.005	10.31	5.45	5.15
BR4	Jun-92	23.62	<0.01		<0.03	2.43	0.18	<0.005	8.91	6.42	6.63
BR5	Nov-91	139.77	0.02	0.10	<0.03	1.75	0.14	<0.005	9.07	10.39	10.39
BR5	Feb-92	78.70	0.03	<0.05	<0.03	1.51	0.12	0.06	9.14	9.13	10.15
BR5	Mar-92	100.63	<0.01		<0.03	1.51	0.09	<0.005	14.39	7.85	8.40
BR5	Apr-92	68.13	<0.01		<0.03	0.90	0.06	0.01	6.07	6.42	6.91
BR5	May-92	199.81	<0.01		<0.03	0.74	0.10	<0.005	12.15	13.31	15.11
BR5	Jun-92	137.00	<0.01		<0.03	1.65	0.16	0.01	14.11	11.58	12.86
BR5	Jul-92	474.80	<0.01		<0.03	1.41	0.24	<0.005	17.00	27.77	29.84
BR5	Aug-92	215.10	<0.01		<0.03	1.84	0.20	<0.005	16.12	14.42	17.23
BR5	Sep-92	164.12		<.1		1.76	0.12		9.20	10.93	13.34
BR5	Oct-92	290.00		<.1		1.74	0.20		11.02	21.12	22.43
BR5	Nov-92	234.31		<.1		1.62	0.10		9.46	13.76	14.13
BR5	Jan-93	155.73		<.1		1.35	0.10		7.95	11.97	11.57
BR6	Nov-91	10.71	<0.01	0.09	<0.03	7.51	4.51	<0.005	10.68	7.21	6.30
BR6	Jun-92	8.35	<0.01		0.04	4.06	3.67	0.00	10.76	5.61	5.68
BR7	Nov-91	6.91	0.04	<0.05	<0.03	3.78	3.44	<0.005	9.03	5.18	6.17
BR7	Jun-92	124.60	<0.01		<0.03	3.62	0.04	<0.005	5.68	5.62	6.40
BR8	Nov-91	77.86	0.03	<0.05	<0.03	3.13	1.42	<0.005	15.65	10.22	9.49
BR8	Jun-92	90.33	<0.01		<0.03	2.97	1.46	0.06	5.78	10.95	11.63
BR9	Nov-91	98.15	0.02	<0.05	<0.03	4.68	0.12	<0.005	8.61	4.62	4.84
BR9	Jun-92	18.88	<0.01		<0.03	4.58	1.84	0.01	8.08	5.46	5.25
FLO1	Oct-92	36.52		<.1		3.79	2.13		17.98	7.02	6.73
K2	Aug-92	86.07	<0.01		<0.03	4.60	3.56	<0.005	23.64	8.29	7.62
M1	Aug-92	87.38	<0.01		<0.03	4.02	2.83	0.01	20.33	7.14	5.95
M2	Aug-92	53.70	<0.01		<0.03	4.22	2.73	0.01	11.41	7.25	6.37
OB1	Feb-92	11.33	0.02	<0.05	<0.03	4.55	0.24	0.31	18.81	6.17	7.15
OB1	Mar-92	14.36	<0.01		<0.03	3.92	0.24	1.27	18.68	6.68	7.11
OB1	Apr-92	4.99	<0.01		<0.03	2.53	0.11	0.31	14.48	3.35	3.19
OB1	May-92	15.51	<0.01		<0.03	4.52	0.24	0.76	14.07	6.95	7.27
OB1	Jun-92	17.87	0.02		<0.03	4.75	0.26	0.12	14.19	7.23	7.55
OB1	Jul-92	17.39	<0.01		<0.03	5.20	0.29	0.19	14.64	7.15	7.39
OB1	Aug-92	17.99	<0.01		<0.03	5.07	0.29	0.28	16.34	7.15	6.57
OB1	Sep-92	19.25		<.1		5.02	0.27		19.96	8.18	7.20
OB1	Oct-92	19.03		<.1		4.90	0.26		19.51	8.13	7.71
OB1	Nov-92	18.47		<.1		4.88	0.26		19.43	8.12	7.61
OB1	Jan-93	14.03		<.1		4.47	0.22		14.76	6.81	6.06
OB1repeat	Jun-92	17.99	<0.01		<0.03	4.92	0.28	0.25	19.26	7.11	7.79
OB2	Jun-92	48.09	<0.01		<0.03	6.89	0.19	0.01	15.85	6.59	6.74
OB2	Jul-92	45.61	<0.01		<0.03	6.72	0.19	0.01	14.47	5.74	6.14
OB2	Aug-92	48.28	<0.01		<0.03	6.99	0.21	0.04	16.94	8.18	6.60
OB2	Sep-92	58.05		<.1		7.61	0.21		12.13	10.53	10.85
OB2	Nov-92	50.80		<.1		6.32	0.21		10.51	10.03	9.29
OB2	Jan-93	45.05		<.1		5.77	0.21		10.37	9.76	8.25
SNOW	Feb-92	1.48	<0.01		<0.03	0.03	0.01	0.01	23.35	0.14	0.08
SW1	Nov-91	21.91	<0.01	0.08	<0.03	2.75	0.10	<0.005	24.49	6.48	6.95
SW1	Jun-92	18.40	<0.01		<0.03	0.78	0.07	0.09	21.74	5.59	5.66
SW2	Nov-91	5.77	<0.01	0.09	<0.03	2.75	0.16	<0.005	2.04	3.94	3.91
SW2	Apr-92	8.29	<0.01		0.03	1.63	0.05	0.11	18.68	3.02	2.72
SW2	May-92	6.04	<0.01		0.05	0.43	0.05	0.05	3.12	2.69	2.42
SW2	Jun-92	8.54	<0.01		<0.03	1.14	0.09	0.16	15.81	3.69	3.61
SW2	Jul-92	5.32	<0.01		<0.03	5.53	0.11	0.01	16.64	3.77	3.07
SW2	Aug-92	5.39	<0.01		<0.03	2.98	0.09	0.02	20.46	3.14	3.15
SW2	Sep-92	6.61		<.1		4.42	0.10		1.14	3.97	3.29
SW2	Oct-92	8.21		<.1		2.06	0.10		1.22	4.41	3.66
SW2	Nov-92	9.34		<.1		1.96	0.09		1.78	4.02	3.26

SAMPLE ID	DATE	Na+ mg/L	Ni mg/L	P mg/L	Pb mg/L	Si mg/L	Sr mg/L	Zn mg/L	S mg/L	meq+	meq-
SW2 repeat	Oct-92	8.30		<.1		2.09	0.10		1.29	4.41	3.47
SW4	Nov-91	129.86	<0.01	1.10	<0.03	5.43	1.29	<0.005	13.64	11.39	10.18
SW4	Jun-92	9.21	<0.01		<0.03	0.14	0.25	0.01	2.09	4.31	4.51
SW5	Nov-91	23.20	<0.01	0.09	<0.03	1.60	0.65	<0.005	12.86	6.15	6.94
SW5	Jun-92	9.71	<0.01		<0.03	0.20	0.26	0.01	3.23	4.77	4.26
SW6	Nov-91	10.65	<0.01	0.07	<0.03	4.66	0.31	<0.005	2.07	4.48	3.80
SW6	Apr-92	5.60	<0.01		<0.03	1.57	0.16	0.02	6.06	2.53	2.52
SW6	May-92	5.59	0.01		0.04	0.43	0.14	0.01	4.19	3.23	3.15
SW6	Jun-92	9.23	<0.01		<0.03	0.67	0.25	0.01	3.26	4.70	5.84
SW6	Jul-92	10.53	<0.01		0.04	2.51	0.35	0.01	10.55	4.95	4.46
SW6	Aug-92	9.14	<0.01		<0.03	2.17	0.24	<0.005	11.38	4.05	3.39
SW6	Sep-92	8.89		<.1		3.02	0.26		2.77	4.68	3.97
SW6	Oct-92	11.30		<.1		1.91	0.30		3.41	5.58	4.33
SW6	Nov-92	8.70		<.1		2.32	0.23		4.83	4.88	4.40
SW7	Nov-91	26.79	<0.01	0.10	<0.03	2.08	0.59	<0.005	6.33	5.45	5.36
SW7	Jun-92	14.45	<0.01		<0.03	0.79	0.38	<0.005	4.00	5.05	5.61
SW8	Nov-91	23.32	<0.01	0.12	<0.03	2.80	0.92	<0.005	10.58	5.71	4.95
SW8	Jun-92	15.85	<0.01		<0.03	0.89	0.40	0.01	4.23	5.19	3.98

SAMPLE ID	DATE	balance (< 5%)
BR1	Nov-91	-0.04
BR1	Feb-92	-0.07
BR1	Mar-92	-0.05
BR1	Apr-92	0.00
BR1	May-92	-0.04
BR1	Jun-92	-0.01
BR1	Jul-92	0.13
BR1	Aug-92	-0.03
BR1	Sep-92	0.05
BR1	Oct-92	0.04
BR1	Nov-92	0.06
BR1	Jan-93	-0.10
BR1 repeat	Nov-92	0.01
BR10	Nov-91	0.11
BR10	Jun-92	-0.02
BR11	Nov-91	0.11
BR11	Jun-92	-0.04
BR12	Nov-91	0.07
BR12	Jun-92	-0.04
BR13	Nov-91	-0.09
BR13	Jun-92	-0.01
BR14	Nov-91	0.09
BR14	Jun-92	0.05
BR15	Nov-91	0.04
BR15	Jun-92	0.10
BR16	Mar-92	-0.08
BR16	Apr-92	-0.02
BR16	May-92	-0.09
BR16	Jun-92	-0.09
BR16	Jul-92	-0.03
BR16	Aug-92	0.05
BR16	Sep-92	0.05
BR16	Oct-92	0.05
BR16	Nov-92	0.05
BR16	Jan-93	0.04
BR1repeat	Jun-92	-0.11
BR17	Apr-92	0.01
BR17	May-92	0.01
BR17	Jun-92	-0.06
BR17	Jul-92	-0.06
BR17	Aug-92	0.05
BR17	Oct-92	0.02
BR17	Nov-92	0.03
BR17	Jan-93	-0.13
BR1repeat	Jul-92	-0.03
BR1	Aug-92	0.08
BR2	Nov-91	0.00
BR2	Jun-92	-0.03
BR2repeat	Jun-92	-0.03
BR3	Nov-91	-0.04
BR3	Feb-92	-0.09
BR3	Mar-92	-0.03
BR3	Apr-92	-0.06
BR3	May-92	-0.02
BR3	Jun-92	0.00
BR3	Jul-92	-0.02
BR3	Aug-92	0.08
BR3	Sep-92	0.10

SAMPLE ID	DATE	balance (< 5%)
BR3	Nov-92	0.07
BR3	Jan-93	0.03
BR4	Nov-91	0.03
BR4	Jun-92	-0.02
BR5	Nov-91	0.00
BR5	Feb-92	-0.05
BR5	Mar-92	-0.03
BR5	Apr-92	-0.04
BR5	May-92	-0.06
BR5	Jun-92	-0.05
BR5	Jul-92	-0.04
BR5	Aug-92	-0.09
BR5	Sep-92	-0.10
BR5	Oct-92	-0.03
BR5	Nov-92	-0.01
BR5	Jan-93	0.02
BR6	Nov-91	0.07
BR6	Jun-92	-0.01
BR7	Nov-91	-0.09
BR7	Jun-92	-0.07
BR8	Nov-91	0.04
BR8	Jun-92	-0.03
BR9	Nov-91	-0.02
BR9	Jun-92	0.02
FLO1	Oct-92	0.02
K2	Aug-92	0.04
M1	Aug-92	0.09
M2	Aug-92	0.06
OB1	Feb-92	-0.07
OB1	Mar-92	-0.03
OB1	Apr-92	0.02
OB1	May-92	-0.02
OB1	Jun-92	-0.02
OB1	Jul-92	-0.02
OB1	Aug-92	0.04
OB1	Sep-92	0.06
OB1	Oct-92	0.03
OB1	Nov-92	0.03
OB1	Jan-93	0.06
OB1repeat	Jun-92	-0.05
OB2	Jun-92	-0.01
OB2	Jul-92	-0.03
OB2	Aug-92	0.11
OB2	Sep-92	-0.01
OB2	Nov-92	0.04
OB2	Jan-93	0.08
SNOW	Feb-92	0.31
SW1	Nov-91	-0.03
SW1	Jun-92	-0.01
SW2	Nov-91	0.00
SW2	Apr-92	0.05
SW2	May-92	0.05
SW2	Jun-92	0.01
SW2	Jul-92	0.10
SW2	Aug-92	0.00
SW2	Sep-92	0.09
SW2	Oct-92	0.09
SW2	Nov-92	0.10

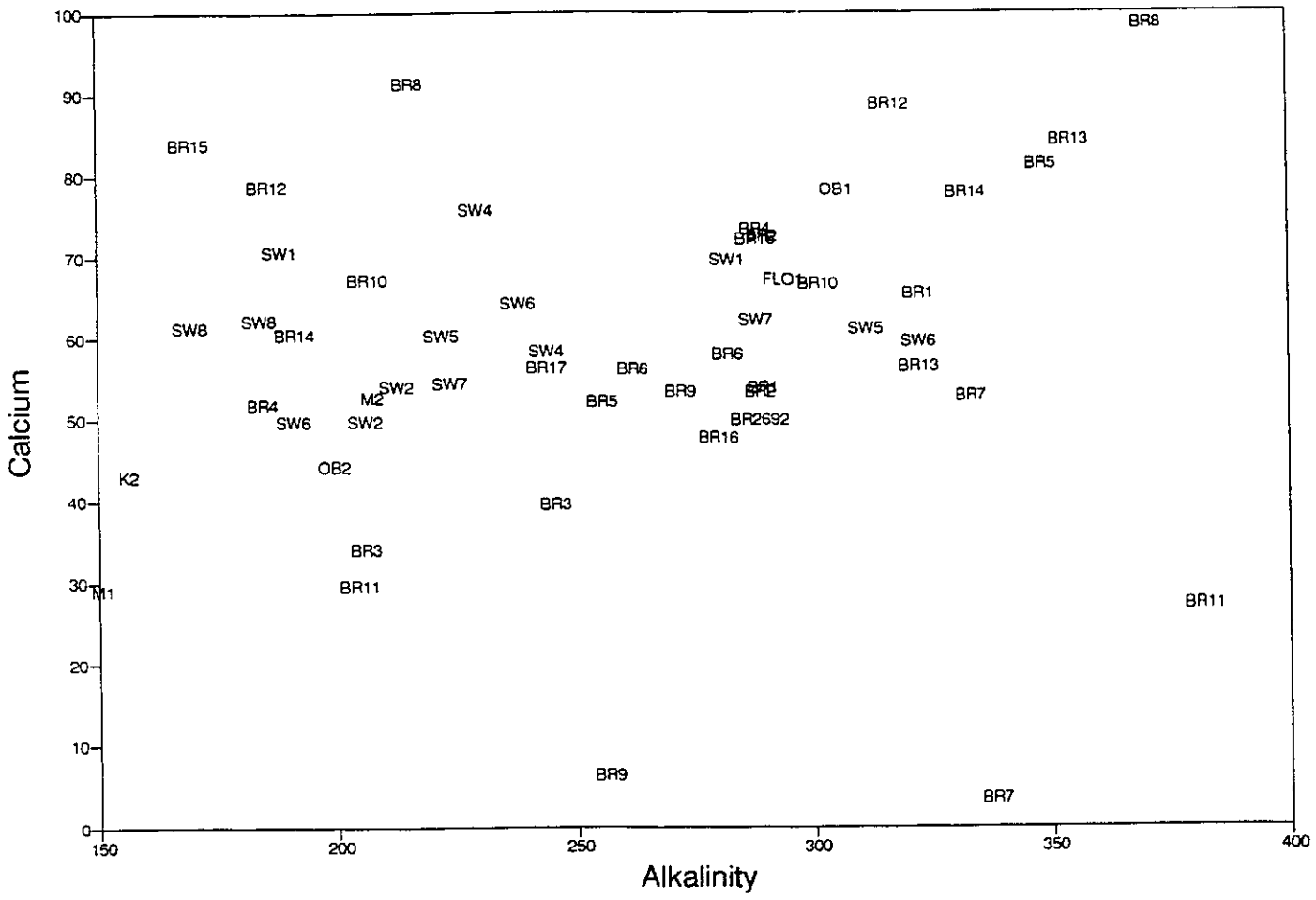
SAMPLE ID	DATE	balance (< 5%)
SW2 repeat	Oct-92	0.12
SW4	Nov-91	0.06
SW4	Jun-92	-0.02
SW5	Nov-91	-0.06
SW5	Jun-92	0.06
SW6	Nov-91	0.08
SW6	Apr-92	0.00
SW6	May-92	0.01
SW6	Jun-92	-0.11
SW6	Jul-92	0.05
SW6	Aug-92	0.09
SW6	Sep-92	0.08
SW6	Oct-92	0.13
SW6	Nov-92	0.05
SW7	Nov-91	0.01
SW7	Jun-92	-0.05
SW8	Nov-91	0.07
SW8	Jun-92	0.13

SAMPLE ID	DATE	pH	HCO3- mg/L	COND umhos/cm	F- mg/L	Cl- mg/L	NO2- mg/L	Br- mg/L	NO3- mg/L	SO4-2 mg/L	Al mg/L	B mg/L	Ba mg/L	Ca+2 mg/L	Fe mg/L	K+ mg/L	Mg+2 mg/L	Mn mg/L	Na+ mg/L	P mg/L	Si mg/L	Sr mg/L	S mg/L	meq+	meq-	balance (< 5%)
SW2	Jun-93	7.7	168	409	0.1	12	< 0.1	< 1	6.1	22.67	0.12	0.06	0.06	38.6	0.2	0.235	10.6	0.02	5.84	0	0.28	0.07	0.71	3.05	3.56	-0.08
SW6	Jun-93	8.1	236	523	0.1	11.2	< 0.1	< 1	0.1	7.04	0.15	0.1	0.07	58.7	0.16	0.081	15.2	0.02	7.87	0.06	0.39	0.29	2.57	4.53	4.33	0.02
BR1	Jun-93	7.2	344	972	0.1	73	< 0.1	< 1	< 0.1	42.96	0.8	0.21	0.44	74.2	0.27	3.643	33.8	0.01	41.1	0.08	3.31	0.85	13.1	8.37	8.59	-0.01
BR3	Jun-93	7.7	272	858	0.1	72.4	< 0.1	< 1	< 0.1	45.82	0.41	0.28	0.06	40.1	0.07	5.865	22.8	0.01	73.3	0.02	4.24	5.2	15.3	7.22	7.45	-0.02
BR5	Jun-93	7.6	336	1039	0.1	124	< 0.1	< 1	6.3	23.38	0.25	0.06	0.17	75.6	0.01	1.004	18.2	0	82.4	0.03	1.09	0.12	7.28	8.88	9.48	-0.03
BR16	Jun-93	7.7	340	938	0.1	78.9	< 0.1	< 1	< 0.1	42.91	0.6	0.19	0.09	69.4	0.25	3.945	26.9	0.01	25.9	0.1	3.37	2.85	14.4	6.90	8.69	-0.11

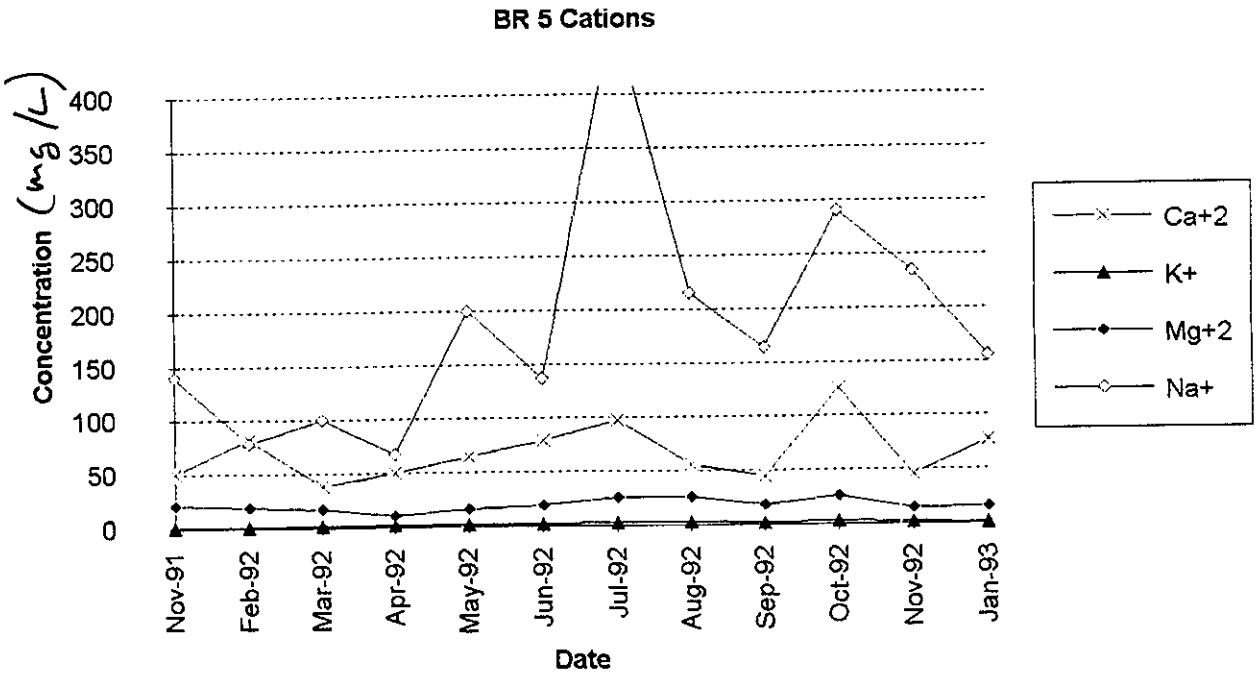
TEMPERATURE MEASUREMENTS

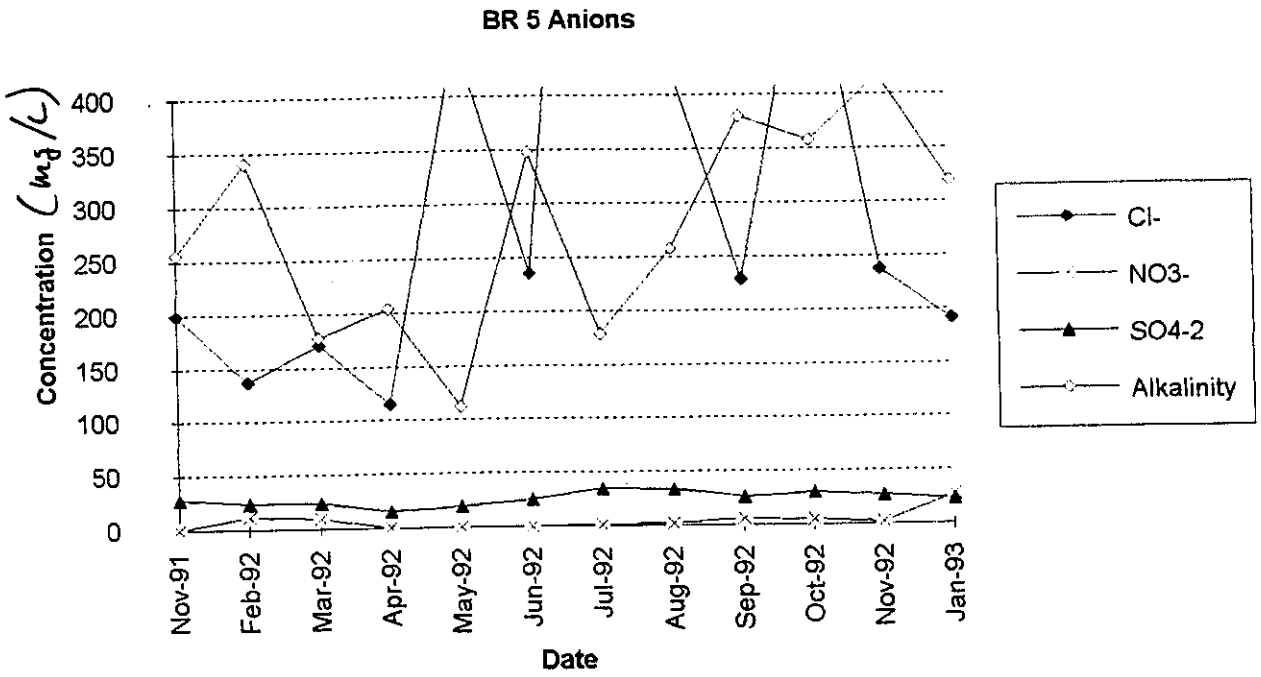
BR1	Nov-91	10
BR10	Nov-91	9.3
BR11	Nov-91	11
BR12	Nov-91	9
BR13	Nov-91	8.3
BR14	Nov-91	9.3
BR15	Nov-91	7.6
BR2	Nov-91	7.7
BR3	Nov-91	9
BR4	Nov-91	8.3
BR5	Nov-91	9.9
BR6	Nov-91	9.5
BR7	Nov-91	8.7
BR8	Nov-91	9.3
BR9	Nov-91	9.3
SW1	Nov-91	13
SW2	Nov-91	14
SW4	Nov-91	14
SW5	Nov-91	14
SW6	Nov-91	14
SW7	Nov-91	14
SW8	Nov-91	14
BR1	Feb-92	9
BR3	Feb-92	9
BR5	Feb-92	9
OB1	Feb-92	9
SNOW	Feb-92	-14
BR1	Mar-92	11
BR16	Mar-92	7.8
BR3	Mar-92	9.7
BR5	Mar-92	9
OB1	Mar-92	6
BR1	Apr-92	9.3
BR16	Apr-92	10
BR17	Apr-92	7
BR3	Apr-92	10
BR5	Apr-92	9.3
OB1	Apr-92	5.5
SW2	Apr-92	3.2
SW6	Apr-92	2
BR1	May-92	9.8
BR16	May-92	11
BR17	May-92	8.8
BR3	May-92	9.4
BR5	May-92	9.8
OB1	May-92	
SW2	May-92	7
SW6	May-92	20
BR1	Jun-92	14
BR10	Jun-92	11
BR11	Jun-92	11
BR12	Jun-92	11
BR13	Jun-92	14
BR14	Jun-92	11
BR15	Jun-92	9.3
BR16	Jun-92	14
BR17	Jun-92	14
BR2	Jun-92	11
BR3	Jun-92	9.5
BR4	Jun-92	13
BR5	Jun-92	12
BR6	Jun-92	12
BR7	Jun-92	11
BR8	Jun-92	13
BR9	Jun-92	11
OB1	Jun-92	11
OB2	Jun-92	10
SW1	Jun-92	26
SW2	Jun-92	22
SW4	Jun-92	24
SW5	Jun-92	22
SW6	Jun-92	21
SW7	Jun-92	23
SW8	Jun-92	22
BR1	Jul-92	10
BR16	Jul-92	9
BR17	Jul-92	12
BR3	Jul-92	7.1
BR5	Jul-92	7.7
OB1	Jul-92	9.8
OB2	Jul-92	8.8
SW2	Jul-92	20
SW6	Jul-92	20
BR1	Aug-92	11
BR16	Aug-92	13
BR17	Aug-92	10
BR3	Aug-92	10
BR5	Aug-92	10
K2	Aug-92	
M1	Aug-92	
M2	Aug-92	
OB1	Aug-92	14
OB2	Aug-92	14
SW2	Aug-92	17
SW6	Aug-92	20
BR1	Sep-92	14
BR16	Sep-92	11
BR3	Sep-92	11
BR5	Sep-92	12
OB1	Sep-92	17
OB2	Sep-92	13
SW2	Sep-92	17
SW6	Sep-92	20
BR1	Oct-92	11
BR16	Oct-92	
BR17	Oct-92	11
BR5	Oct-92	11
FLO1	Oct-92	8.8
OB1	Oct-92	12
SW2	Oct-92	8
SW6	Oct-92	12
BR1	Nov-92	4
BR16	Nov-92	9
BR17	Nov-92	10
BR3	Nov-92	8
BR5	Nov-92	
OB1	Nov-92	13
OB2	Nov-92	7
SW2	Nov-92	3
SW6	Nov-92	2
BR1	Jan-93	10
BR16	Jan-93	10
BR17	Jan-93	9
BR3	Jan-93	9
BR5	Jan-93	8.8
OB1	Jan-93	4.3

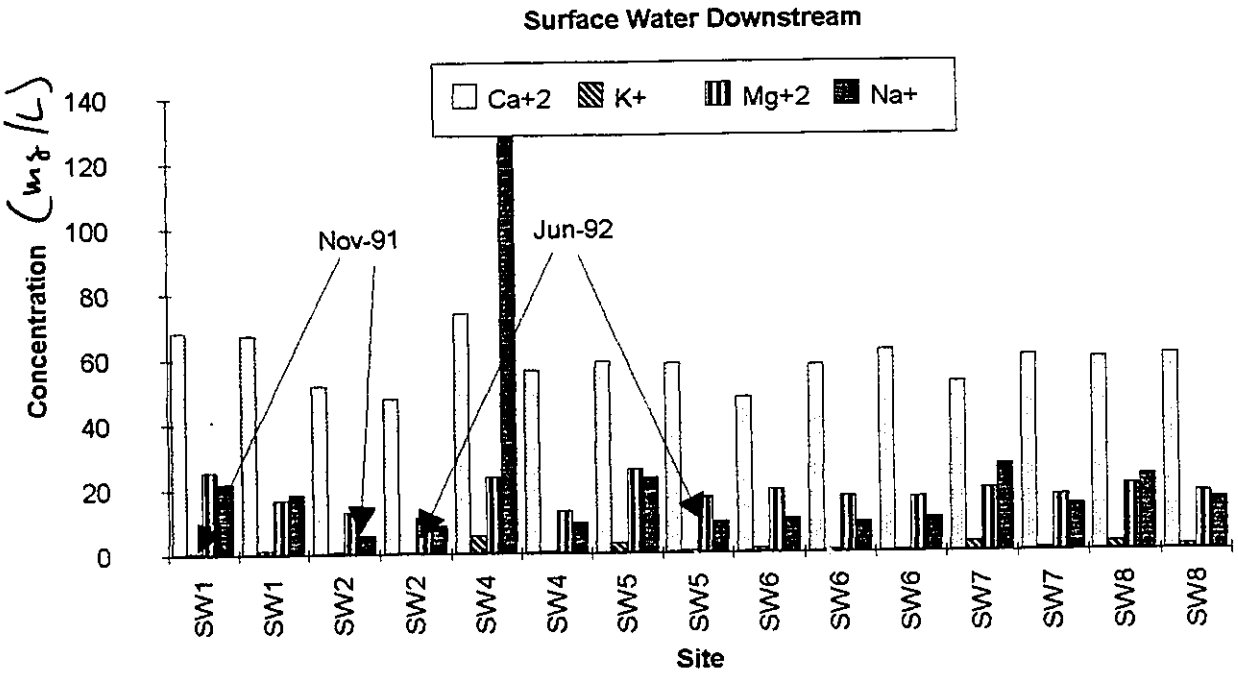
Calcium vs Alkalinity

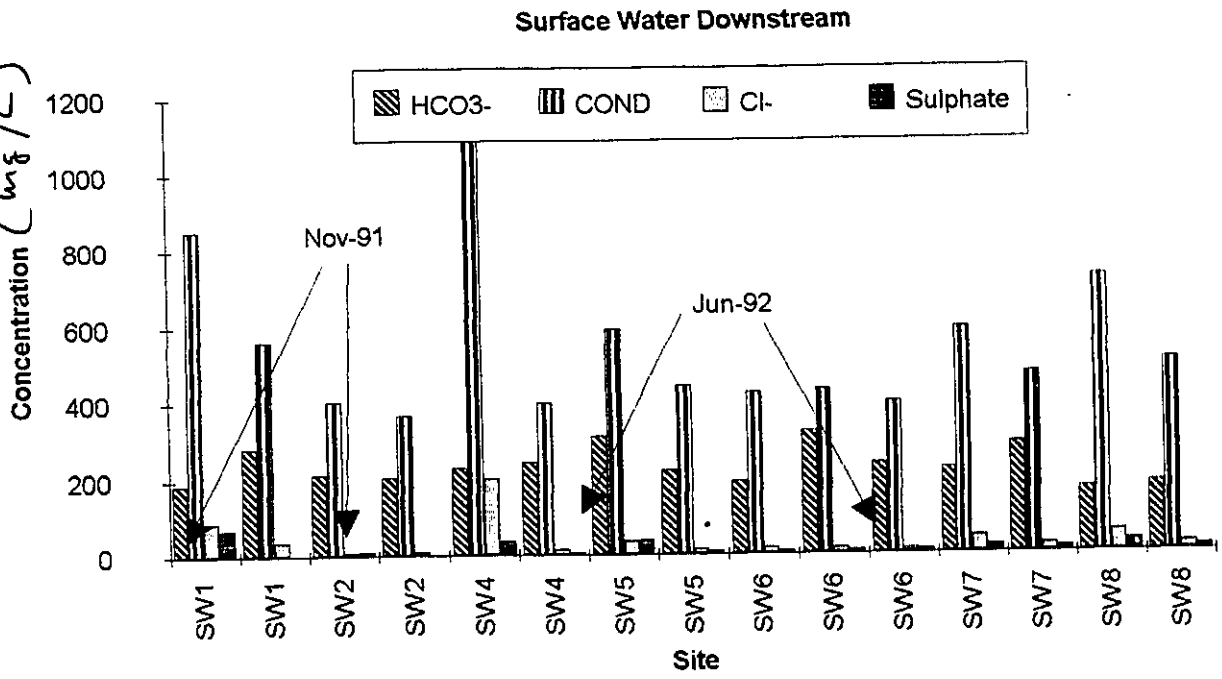


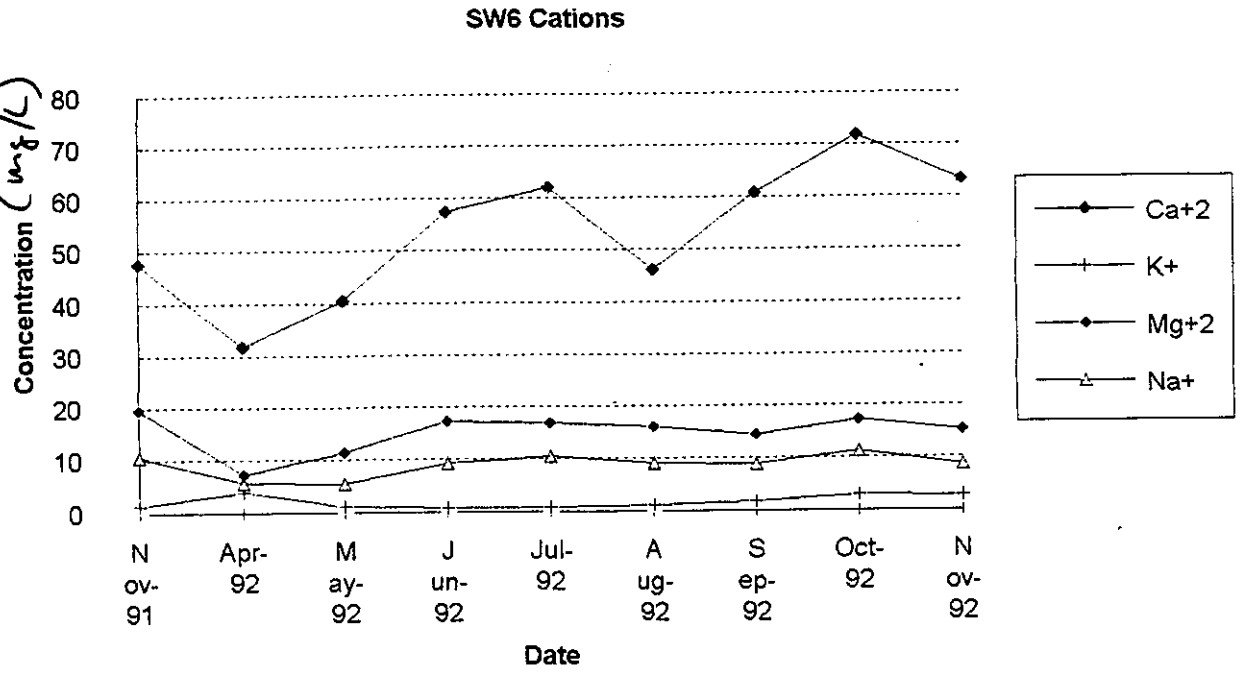
(mg/L)

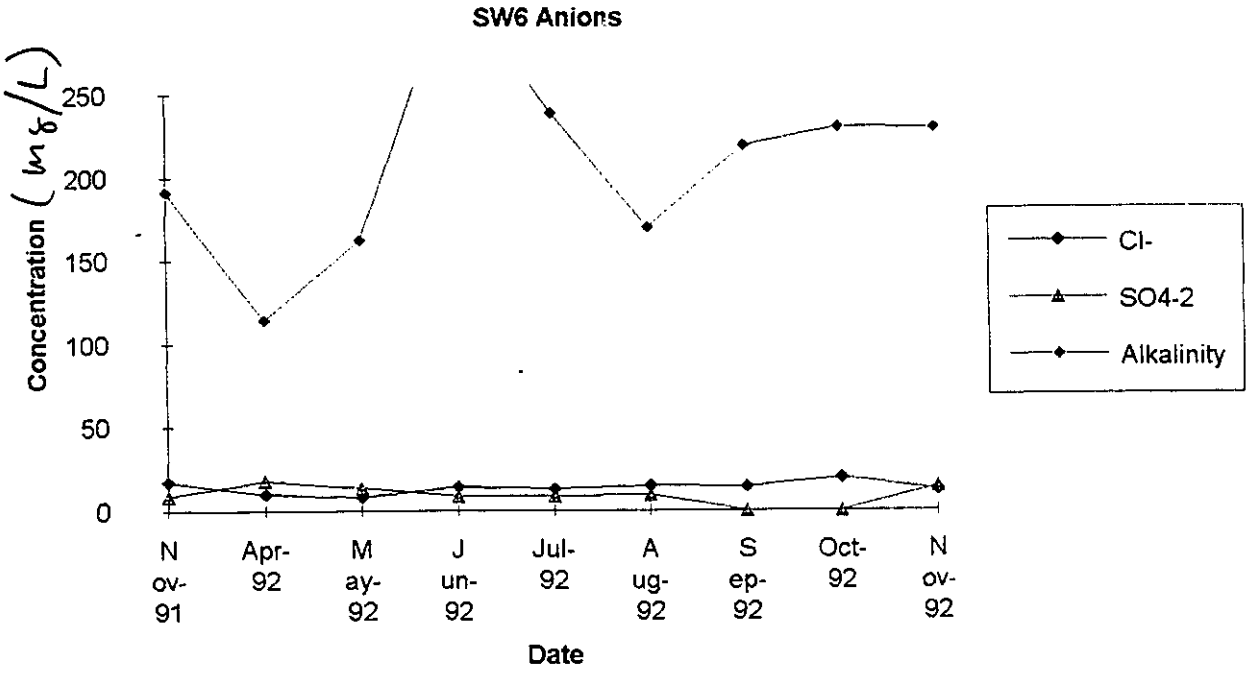

BR 5 Cations
Concentration (mg/L)
400
350
300
250
200
150
100
50
0
Nov-91
Feb-92
Mar-92
Apr-92
May-92
Jun-92
Jul-92
Aug-92
Sep-92
Oct-92
Nov-92
Jan-93
Date
Ca+2
K+
Mg+2
Na+

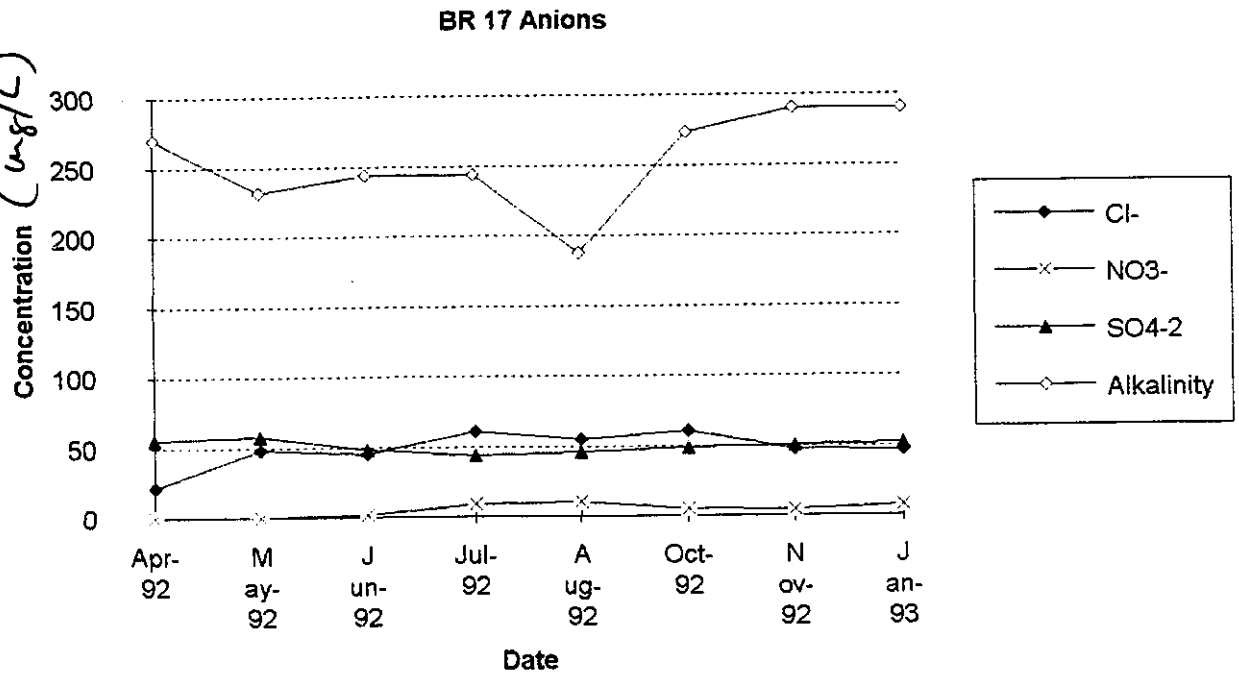

BR 5 Anions
Concentration (mg/L)
400
350
300
250
200
150
100
50
0
Nov-91
Feb-92
Mar-92
Apr-92
May-92
Jun-92
Jul-92
Aug-92
Sep-92
Oct-92
Nov-92
Jan-93
Date
Cl-
NO3-
SO4-2
Alkalinity

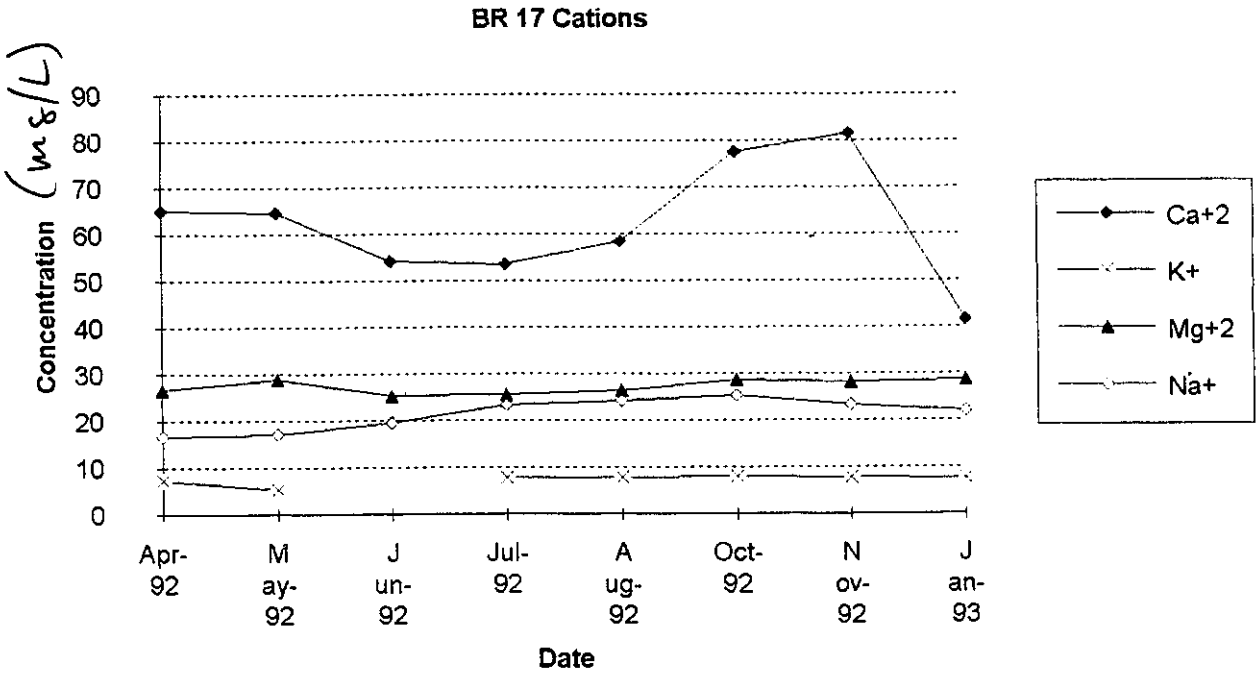

Surface Water Downstream
Ca+2
K+
Mg+2
Na+
Concentration (mg/L)
140
120
100
80
60
40
20
0
Nov-91
Jun-92
SW1
SW1
SW2
SW2
SW4
SW4
SW5
SW5
SW6
SW6
SW6
SW7
SW7
SW8
SW8
Site

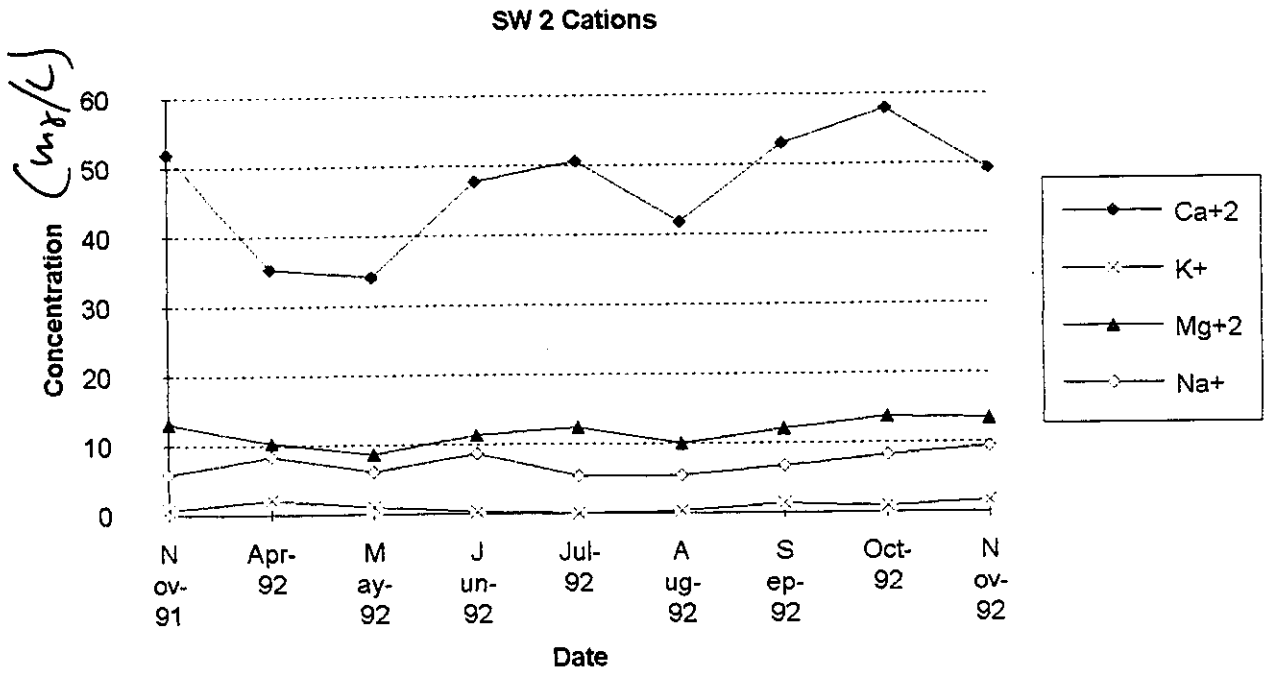

Surface Water Downstream
HCO3-
COND
Cl-
Sulphate
Concentration (mg/L)
1200
1000
800
600
400
200
0
Nov-91
Jun-92
SW1
SW1
SW2
SW2
SW4
SW4
SW5
SW5
SW6
SW6
SW6
SW7
SW7
SW8
SW8
Site

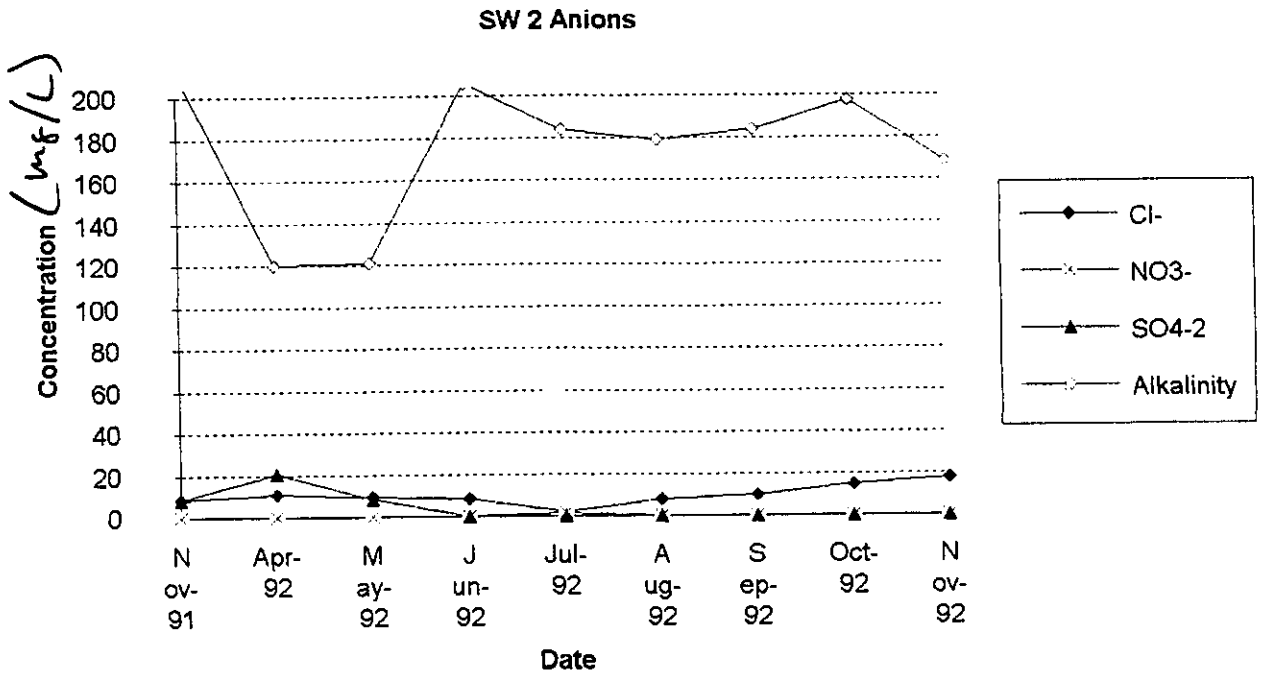

SW6 Cations
Concentration (mg/L)
80
70
60
50
40
30
20
10
0
Nov-91
Apr-92
May-92
Jun-92
Jul-92
Aug-92
Sep-92
Oct-92
Nov-92
Date
Ca+2
K+
Mg+2
Na+


SW6 Anions
Concentration (mg/L)
250
200
150
100
50
0
Nov-91
Apr-92
May-92
Jun-92
Jul-92
Aug-92
Sep-92
Oct-92
Nov-92
Date
Cl-
SO4-2
Alkalinity

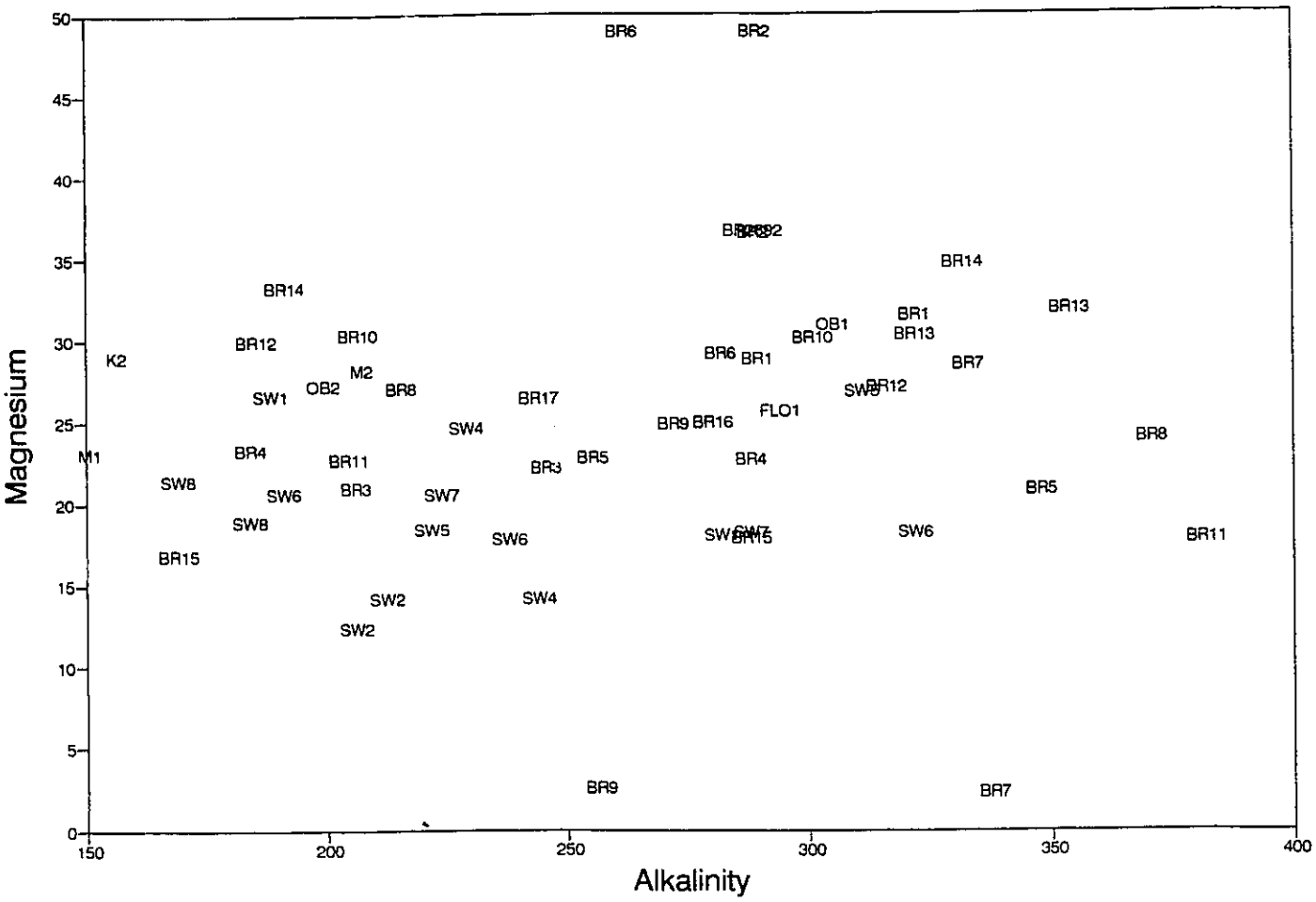

BR 17 Anions
Concentration (mg/L)
300
250
200
150
100
50
0
Apr-92
May-92
Jun-92
Jul-92
Aug-92
Oct-92
Nov-92
Jan-93
Date
Cl-
NO3-
SO4-2
Alkalinity


BR 17 Cations
Concentration (mg/L)
90
80
70
60
50
40
30
20
10
0
Apr-92
May-92
Jun-92
Jul-92
Aug-92
Oct-92
Nov-92
Jan-93
Date
Ca+2
K+
Mg+2
Na+


SW 2 Cations
Concentration (mg/L)
60
50
40
30
20
10
0
Nov-91
Apr-92
May-92
Jun-92
Jul-92
Aug-92
Sep-92
Oct-92
Nov-92
Date
Ca+2
K+
Mg+2
Na+

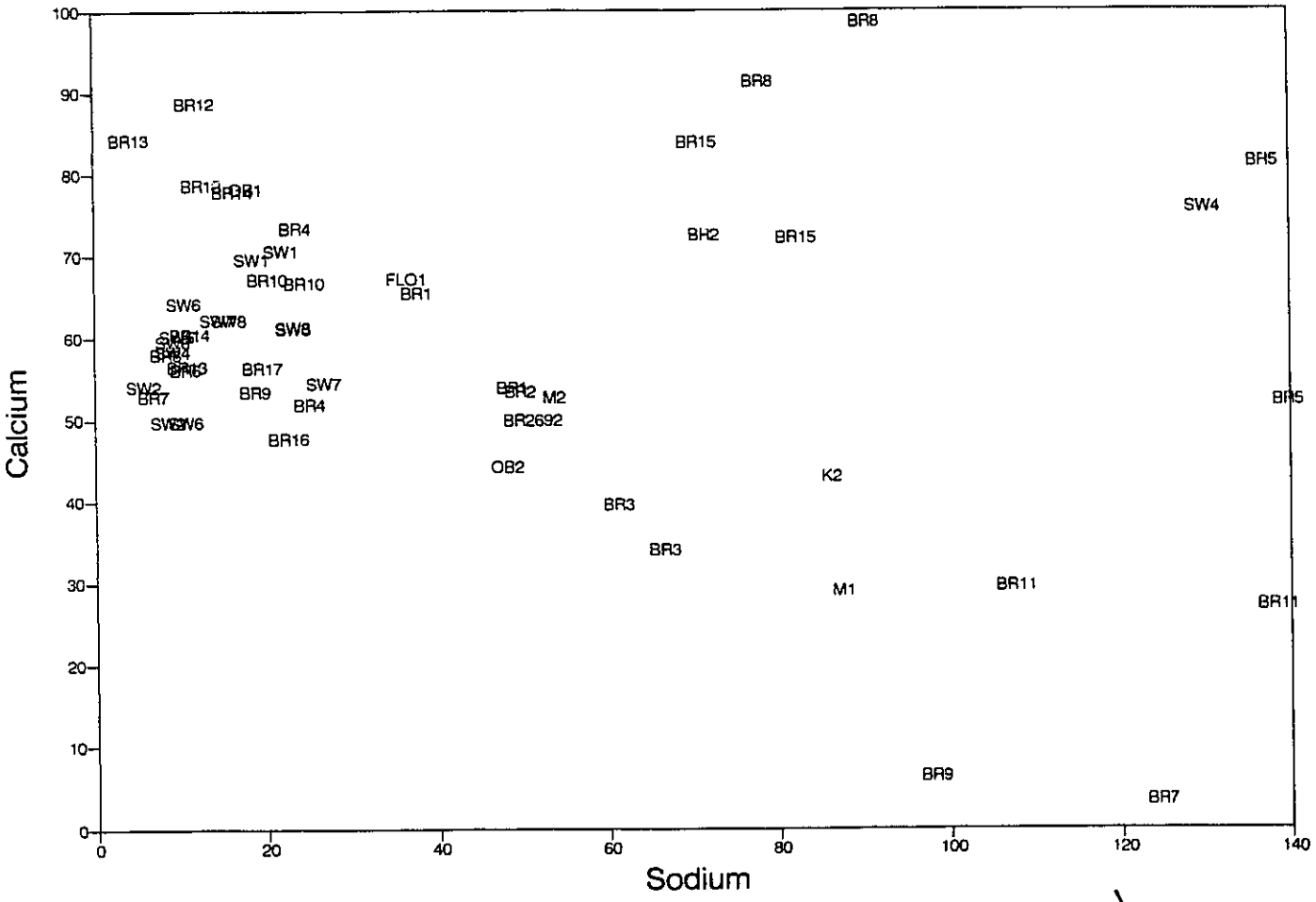

SW 2 Anions
Concentration (mg/L)
200
180
160
140
120
100
80
60
40
20
0
Nov-91
Apr-92
May-92
Jun-92
Jul-92
Aug-92
Sep-92
Oct-92
Nov-92
Date
Cl-
NO3-
SO4-2
Alkalinity

Magnesium vs Alkalinity



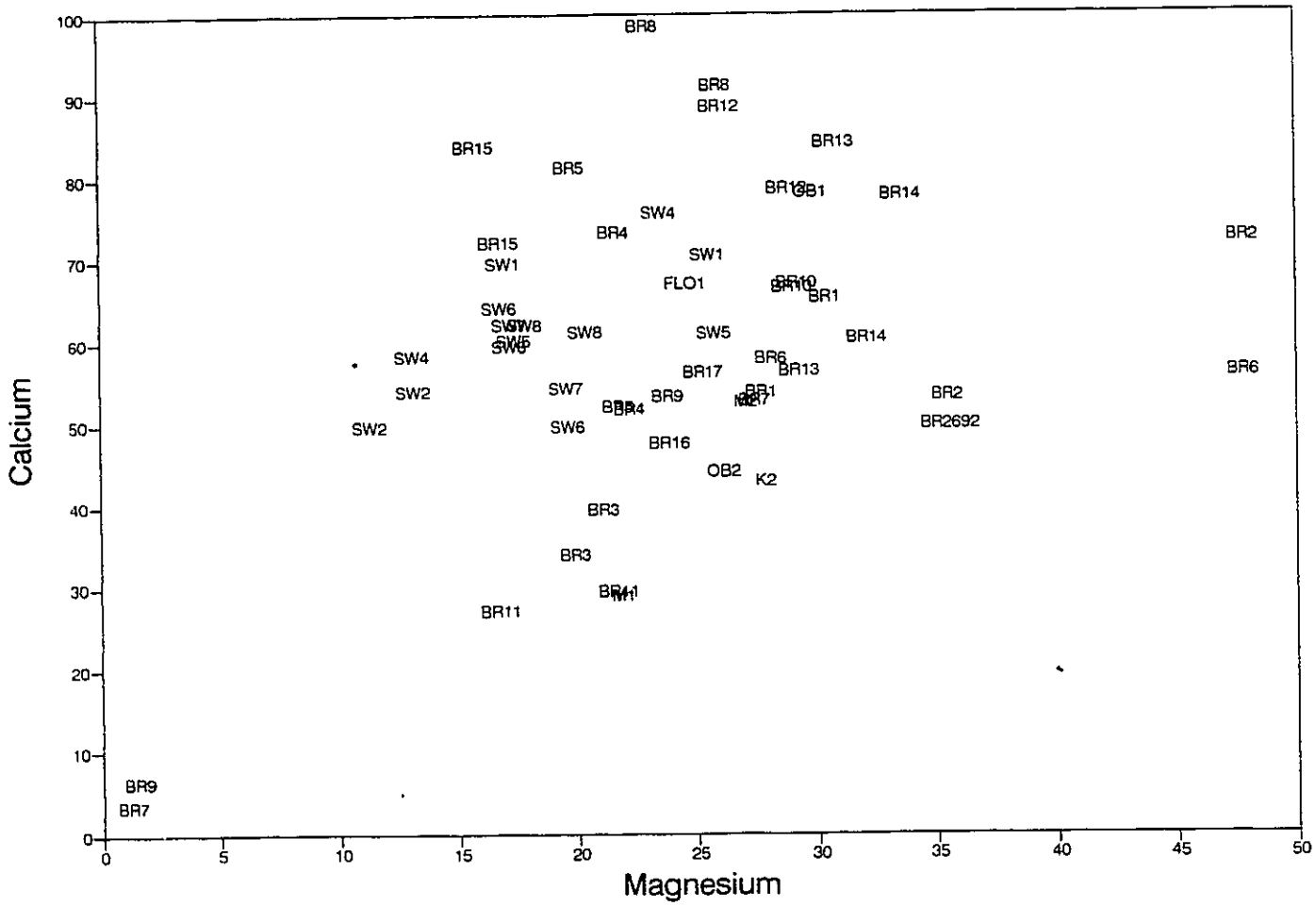
(mg/L)

Calcium vs Sodium



(mg/L)

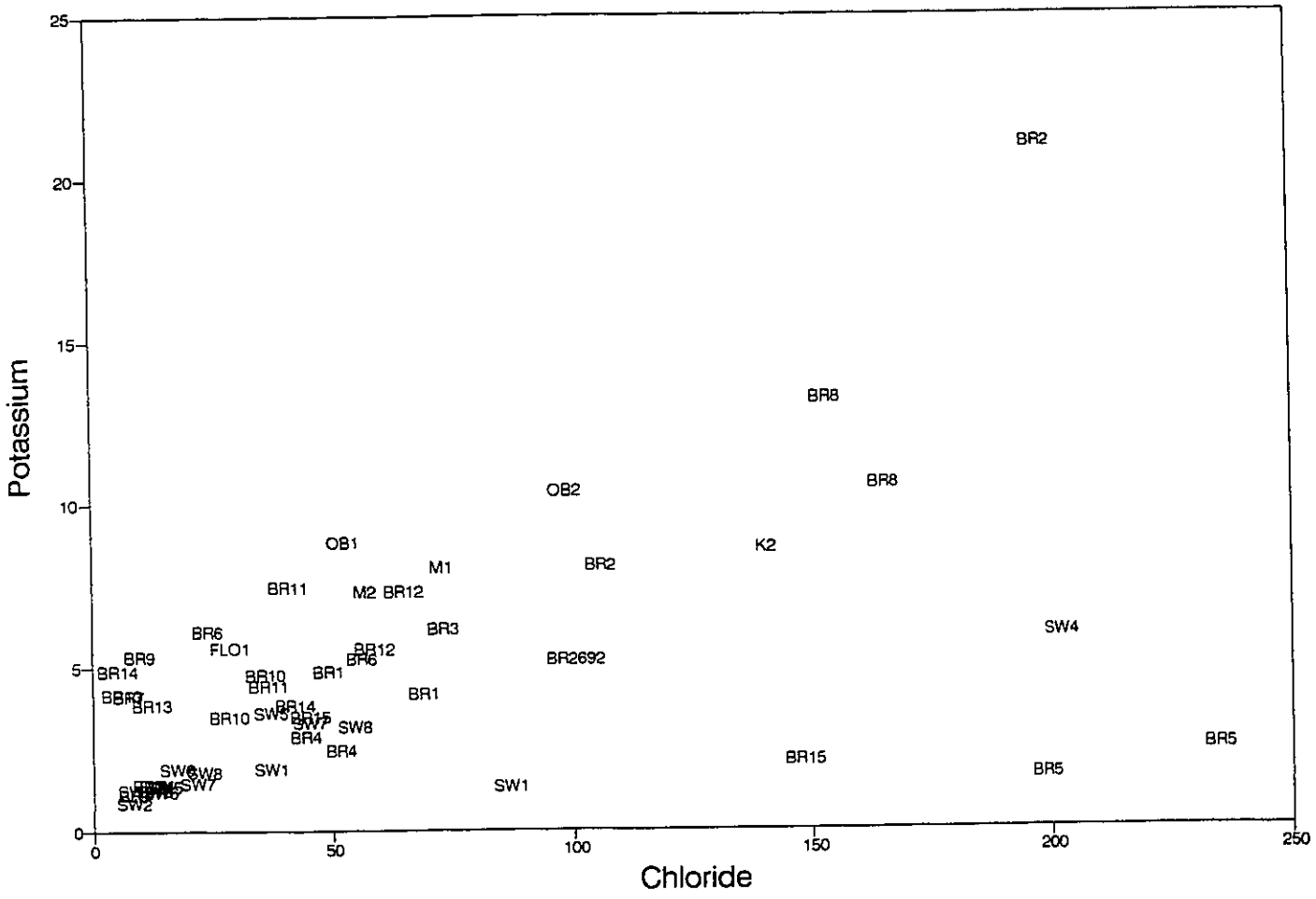
Calcium vs Magnesium



150

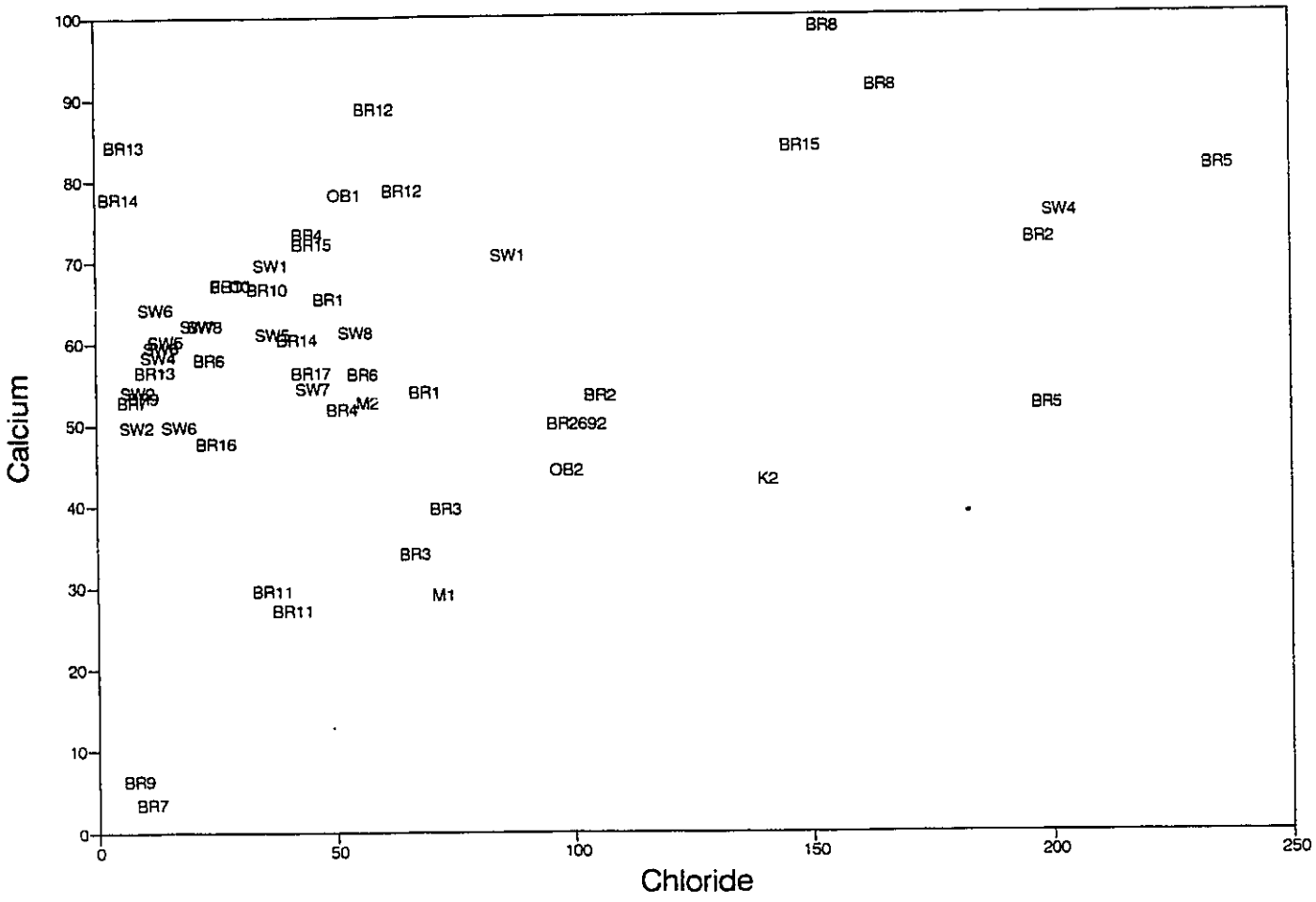
(mg/L)

Potassium vs Chloride



(mg/L)

Calcium vs Chloride



(mg/L)

Appendix C - Chemical Modelling Results

SAMPLE IDENT - BR 10 NOV 91 (TEMPERATURE = 11.00)

	PHASE	LOG (AP)	LOG (KT)	LOG (AP/KT)	DELG		PHASE	LOG (AP)	LOG (KT)	LOG (AP/KT)	DELG
6	ALUNITE	-1.764	-1.168	-0.595	-0.774	82	NATRTHRM	-11.202	0.057	-11.259	-14.638
11	ANHYDRIT	-6.492	-4.192	-2.299	-2.990	83	NATRON	-11.203	-1.447	-9.756	-12.684
17	ARAGONIT	-7.981	-8.262	0.282	0.366	85	NESQUHON	-8.107	-4.900	-3.207	-4.169
20	BARITE	-9.707	-10.222	0.515	0.670	95	PERICLAS	12.905	22.813	-9.908	-12.883
21	BOEHMITE	11.147	7.888	3.259	4.237	99	PORTLAN	-15.952	-5.305	-10.647	-13.844
22	BRUCITE	-16.078	-11.489	-4.590	-5.967	100	POTASSI	7.683	87.808	-80.126	-104.177
24	CALCITE	-7.981	-8.415	0.434	0.564	118	Na2O	9.810	70.472	-60.662	-78.872
25	CELESTIT	-8.352	-6.446	-1.906	-2.478	119	SPINEL	35.199	39.700	-4.501	-5.852
36	CORUNDUM	22.294	23.656	-1.362	-1.771	122	SrCO3	-9.841	-9.285	-0.556	-0.722
41	DOLOMITE	-16.087	-17.841	1.754	2.280	123	SYLVITE	-7.305	0.751	-8.056	-10.474
42	DSORD	-16.087	-16.195	0.108	0.140	125	THENARDI	-9.713	-0.294	-9.419	-12.246
48	GIBBS AM	-32.328	-34.838	2.509	3.263	127	TRONA	-16.830	-0.445	-16.384	-21.302
49	GIBBSITE	-32.328	-35.450	3.122	4.059	130	WITHERIT	-11.196	-8.733	-2.463	-3.202
51	GYPSUM	-6.492	-4.603	-1.889	-2.456	139	Cu2O	2.018	-2.143	4.161	5.410
52	HALITE	-6.242	1.549	-7.791	-10.129	144	FeCl2	-13.517	8.573	-22.091	-28.722
55	HUNTITE	-32.301	-29.607	-2.694	-3.502	146	FeCO3	-12.236	-10.414	-1.822	-2.369
56	HYDRMAGN	-43.502	-37.506	-5.996	-7.796	147	FeO	8.776	14.366	-5.590	-7.268
57	HYPHILIT	-9.262	12.481	-21.743	-28.270	163	MnCl2	-13.513	9.399	-22.912	-29.790
67	LIME	-18.986	34.331	-53.317	-69.322	164	MnCO3	-12.232	-10.508	-1.724	-2.241
70	MAGNESIT	-8.107	-7.787	-0.320	-0.416	165	MnO	8.780	18.736	-9.955	-12.944
71	MgCl2	-9.389	23.470	-32.859	-42.722	174	ZnCO3	-12.324	-9.440	-2.885	-3.751
76	MIRABILT	-9.714	-1.772	-7.942	-10.326	175	ZnO	8.688	12.121	-3.433	-4.464
81	NACHOLIT	-5.627	-0.586	-5.042	-6.555	177	ZnSO4	-10.835	4.198	-15.034	-19.547

SAMPLE IDENT - BR 11 NOV 91 (TEMPERATURE = 11.00)

	PHASE	LOG (AP)	LOG (KT)	LOG (AP/KT)	DELG
6	ALUNITE	-0.401	-1.168	0.767	0.998
11	ANHYDRIT	-6.609	-4.192	-2.417	-3.142
17	ARAGONIT	-8.400	-8.262	-0.138	-0.179
20	BARITE	-9.996	-10.222	0.226	0.294
21	BOEHMITE	11.350	7.888	3.463	4.502
22	BRUCITE	-16.286	-11.489	-4.797	-6.237
24	CALCITE	-8.400	-8.415	0.015	0.019
25	CELESTIT	-7.685	-6.446	-1.239	-1.611
36	CORUNDUM	22.701	23.656	-0.955	-1.242
41	DOLOMITE	-16.685	-17.841	1.157	1.504
42	DSORD	-16.685	-16.195	-0.489	-0.636
48	GIBBS AM	-32.125	-34.838	2.713	3.527
49	GIBBSITE	-32.125	-35.450	3.325	4.324
51	GYPSUM	-6.609	-4.603	-2.006	-2.608
52	HALITE	-5.408	1.549	-6.957	-9.045
55	HUNTITE	-33.254	-29.607	-3.646	-4.741
56	HYDRMAGN	-44.393	-37.506	-6.887	-8.954
57	HYPHILIT	-9.433	12.481	-21.913	-28.491
67	LIME	-19.321	34.331	-53.652	-69.757
70	MAGNESIT	-8.285	-7.787	-0.498	-0.647
71	MgCl2	-9.317	23.470	-32.787	-42.629
76	MIRABILT	-7.993	-1.772	-6.220	-8.088
81	NACHOLIT	-4.903	-0.586	-4.318	-5.614
82	NATRTHRM	-9.783	0.057	-9.839	-12.793
83	NATRON	-9.784	-1.447	-8.337	-10.839
85	NESQUHON	-8.285	-4.900	-3.385	-4.401
95	PERICLAS	12.698	22.813	-10.115	-13.152
99	PORTLAN	-16.401	-5.305	-11.096	-14.427
100	POTASSI	7.861	87.808	-79.948	-103.946
118	Na2O	11.200	70.472	-59.273	-77.065
119	SPINEL	35.399	39.700	-4.301	-5.592
122	SrCO3	-9.476	-9.285	-0.191	-0.249
123	SYLVITE	-7.077	0.751	-7.828	-10.178
125	THENARDI	-7.992	-0.294	-7.697	-10.008
127	TRONA	-14.686	-0.445	-14.241	-18.516
130	WITHERIT	-11.787	-8.733	-3.054	-3.971
144	FeCl2	-13.318	8.573	-21.892	-28.463
146	FeCO3	-12.286	-10.414	-1.872	-2.434
147	FeO	8.697	14.366	-5.670	-7.372

SAMPLE IDENT - BR 12 NOV 91

(TEMPERATURE = 11.00)

	PHASE	LOG (AP)	LOG (KT)	LOG (AP/KT)	DELG		PHASE	LOG (AP)	LOG (KT)	LOG (AP/KT)	DELG
6	ALUNITE	2.813	-1.168	3.981	5.176	67	LIME	-17.606	34.331	-51.937	-67.527
11	ANHYDRIT	-6.466	-4.192	-2.274	-2.957	70	MAGNESIT	-8.810	-7.787	-1.023	-1.331
17	ARAGONIT	-8.609	-8.262	-0.346	-0.450	71	MgCl2	-8.675	23.470	-32.145	-41.794
20	BARITE	-9.644	-10.222	0.578	0.752	76	MIRABILT	-9.921	-1.772	-8.149	-10.595
21	BOEHMITE	11.928	7.888	4.040	5.253	81	NACHOLIT	-5.751	-0.586	-5.165	-6.716
22	BRUCITE	-17.395	-11.489	-5.906	-7.679	82	NATRTHRM	-12.062	0.057	-12.119	-15.757
24	CALCITE	-8.609	-8.415	-0.194	-0.252	83	NATRON	-12.063	-1.447	-10.616	-13.803
25	CELESTIT	-8.425	-6.446	-1.978	-2.572	85	NESQUHON	-8.810	-4.900	-3.910	-5.084
36	CORUNDUM	23.856	23.656	0.200	0.260	95	PERICLAS	11.588	22.813	-11.225	-14.594
41	DOLOMITE	-17.419	-17.841	0.422	0.549	99	PORTLAN	-17.194	-5.305	-11.889	-15.458
42	DSORD	-17.419	-16.195	-1.223	-1.591	100	POTASSI	7.083	87.808	-80.725	-104.957
48	GIBBS AM	-31.547	-34.838	3.290	4.278	118	Na2O	8.336	70.472	-62.136	-80.788
49	GIBBSITE	-31.547	-35.450	3.903	5.074	119	SPINEL	35.444	39.700	-4.256	-5.533
51	GYPSUM	-6.467	-4.603	-1.863	-2.423	122	SrCO3	-10.567	-9.285	-1.282	-1.667
52	HALITE	-5.964	1.549	-7.513	-9.768	123	SYLVITE	-6.590	0.751	-7.341	-9.545
55	HUNTITE	-35.039	-29.607	-5.432	-7.062	125	THENARDI	-9.920	-0.294	-9.626	-12.515
56	HYDRMAGN	-46.935	-37.506	-9.429	-12.259	127	TRONA	-17.814	-0.445	-17.368	-22.582
57	HYPHILIT	-8.474	12.481	-20.955	-27.245	130	WITHERIT	-11.786	-8.733	-3.054	-3.970

SAMPLE IDENT - BR 13 NOV 91

(TEMPERATURE = 11.00)

	PHASE	LOG (AP)	LOG (KT)	LOG (AP/KT)	DELG		PHASE	LOG (AP)	LOG (KT)	LOG (AP/KT)	DELG
6	ALUNITE	0.156	-1.168	1.325	1.723	67	LIME	-18.367	34.331	-52.698	-68.516
11	ANHYDRIT	-6.400	-4.192	-2.208	-2.870	70	MAGNESIT	-8.172	-7.787	-0.385	-0.501
17	ARAGONIT	-7.967	-8.262	0.295	0.384	71	MgCl2	-10.110	23.470	-33.580	-43.660
20	BARITE	-9.789	-10.222	0.433	0.563	76	MIRABILT	-10.254	-1.772	-8.482	-11.028
21	BOEHMITE	11.501	7.888	3.613	4.698	81	NACHOLIT	-5.707	-0.586	-5.121	-6.659
22	BRUCITE	-16.602	-11.489	-5.114	-6.648	82	NATRTHRM	-11.820	0.057	-11.876	-15.442
24	CALCITE	-7.967	-8.415	0.448	0.582	83	NATRON	-11.821	-1.447	-10.374	-13.488
25	CELESTIT	-8.381	-6.446	-1.934	-2.515	85	NESQUHON	-8.172	-4.900	-3.272	-4.254
36	CORUNDUM	23.002	23.656	-0.654	-0.850	95	PERICLAS	12.381	22.813	-10.432	-13.564
41	DOLOMITE	-16.139	-17.841	1.703	2.214	99	PORTLAN	-16.397	-5.305	-11.092	-14.422
42	DSORD	-16.139	-16.195	0.057	0.074	100	POTASSI	7.252	87.808	-80.557	-104.738
48	GIBBS AM	-31.974	-34.838	2.864	3.723	118	Na2O	8.733	70.472	-61.739	-80.272
49	GIBBSITE	-31.974	-35.450	3.476	4.519	119	SPINEL	35.383	39.700	-4.317	-5.612
51	GYPSUM	-6.400	-4.603	-1.797	-2.337	122	SrCO3	-9.947	-9.285	-0.662	-0.861
52	HALITE	-6.879	1.549	-8.428	-10.958	123	SYLVITE	-7.620	0.751	-8.371	-10.883
55	HUNTITE	-32.482	-29.607	-2.875	-3.738	125	THENARDI	-10.253	-0.294	-9.959	-12.948
56	HYDRMAGN	-44.213	-37.506	-6.707	-8.720	127	TRONA	-17.527	-0.445	-17.082	-22.209
57	HYPHILIT	-9.905	12.481	-22.386	-29.106	130	WITHERIT	-11.356	-8.733	-2.623	-3.410

SAMPLE IDENT - BR 14 NOV 91 (TEMPERATURE = 11.00)

	PHASE	LOG (AP)	LOG (KT)	LOG (AP/KT)	DELG		PHASE	LOG (AP)	LOG (KT)	LOG (AP/KT)	DELG
11	ANHYDRIT	-6.681	-4.192	-2.489	-3.236	71	MgCl2	-8.987	23.470	-32.457	-42.199
17	ARAGONIT	-8.426	-8.262	-0.164	-0.213	76	MIRABILT	-10.374	-1.772	-8.602	-11.184
20	BARITE	-9.740	-10.222	0.482	0.627	81	NACHOLIT	-5.909	-0.586	-5.323	-6.921
22	BRUCITE	-16.790	-11.489	-5.301	-6.892	82	NATRTHRM	-12.119	0.057	-12.175	-15.830
24	CALCITE	-8.426	-8.415	-0.012	-0.015	83	NATRON	-12.119	-1.447	-10.672	-13.876
25	CELESTIT	-8.726	-6.446	-2.279	-2.964	85	NESQUHON	-8.464	-4.900	-3.564	-4.634
41	DOLOMITE	-16.890	-17.841	0.951	1.236	95	PERICLAS	12.194	22.813	-10.620	-13.808
42	DSORD	-16.890	-16.195	-0.695	-0.904	99	PORTLAN	-16.753	-5.305	-11.448	-14.884
51	GYPSUM	-6.682	-4.603	-2.078	-2.702	100	POTASSI	7.011	87.808	-80.797	-105.051
52	HALITE	-6.321	1.549	-7.870	-10.232	118	Na2O	8.539	70.472	-61.934	-80.525
55	HUNTITE	-33.818	-29.607	-4.211	-5.474	122	SrCO3	-10.471	-9.285	-1.186	-1.542
56	HYDRMAGN	-45.233	-37.506	-7.727	-10.047	123	SYLVITE	-7.085	0.751	-7.835	-10.187
57	HYPHILIT	-8.949	12.481	-21.430	-27.863	125	THENARDI	-10.374	-0.294	-10.079	-13.105
67	LIME	-18.260	34.331	-52.591	-68.378	127	TRONA	-18.027	-0.445	-17.582	-22.860
70	MAGNESIT	-8.464	-7.787	-0.677	-0.880	130	WITHERIT	-11.485	-8.733	-2.752	-3.579

SAMPLE IDENT - BR 15 NOV 91 (TEMPERATURE = 11.00)

	PHASE	LOG (AP)	LOG (KT)	LOG (AP/KT)	DELG		PHASE	LOG (AP)	LOG (KT)	LOG (AP/KT)	DELG
2	AKERMANI	31.280	47.996	-16.716	-21.733	70	MAGNESIT	-8.755	-7.787	-0.968	-1.259
11	ANHYDRIT	-6.551	-4.192	-2.359	-3.067	71	MgCl2	-9.240	23.470	-32.710	-42.529
17	ARAGONIT	-8.263	-8.262	-0.001	-0.001	73	MERWINIT	43.809	71.900	-28.091	-36.523
20	BARITE	-9.932	-10.222	0.290	0.377	76	MIRABILT	-8.793	-1.772	-7.021	-9.128
22	BRUCITE	-16.946	-11.489	-5.458	-7.096	77	MONTICEL	21.659	31.855	-10.197	-13.258
24	CALCITE	-8.263	-8.415	0.152	0.197	81	NACHOLIT	-5.169	-0.586	-4.583	-5.959
25	CELESTIT	-8.686	-6.446	-2.240	-2.912	82	NATRTHRM	-10.504	0.057	-10.561	-13.731
26	CHALCEDO	-2.907	-3.979	1.071	1.393	83	NATRON	-10.505	-1.447	-9.058*	-11.777
30	CRYSOTIL	30.296	33.998	-3.702	-4.813	85	NESQUHON	-8.755	-4.900	-3.855	-5.012
31	C-ENSTAT	9.130	12.023	-2.894	-3.762	95	PERICLAS	12.037	22.813	-10.776	-14.011
37	CRISTOBA	-2.907	-3.688	0.781	1.015	99	PORTLAN	-16.455	-5.305	-11.150	-14.496
38	CRISTOBB	-2.907	-3.045	0.138	0.179	100	POTASSI	6.510	87.808	-81.298	-105.702
40	DIOPSIDE	18.751	20.758	-2.007	-2.609	103	QUARTZ	-2.907	-4.103	1.196	1.554
41	DOLOMITE	-17.018	-17.841	0.823	1.070	110	SEPIOLIT	30.703	33.227	-2.524	-3.282
42	DSORD	-17.018	-16.195	-0.823	-1.070	111	SILICAAM	-2.907	-2.803	-0.105	-0.136
43	ENSTATIT	9.130	12.208	-3.079	-4.003	112	SILICGEL	-2.907	-2.833	-0.074	-0.097
47	FORSTERI	21.167	30.924	-9.757	-12.685	118	Na2O	10.288	70.472	-60.184	-78.250
51	GYPSUM	-6.551	-4.603	-1.948	-2.533	122	SrCO3	-10.398	-9.285	-1.113	-1.447
52	HALITE	-5.495	1.549	-7.044	-9.158	123	SYLVITE	-7.384	0.751	-8.134	-10.576
55	HUNTITE	-34.528	-29.607	-4.920	-6.397	124	TALC	24.481	22.497	1.984	2.579
56	HYDRMAGN	-46.577	-37.506	-9.071	-11.793	125	THENARDI	-8.792	-0.294	-8.498	-11.048
57	HYPHILIT	-8.748	12.481	-21.229	-27.602	126	TREMOLIT	61.984	64.542	-2.558	-3.326
60	KENYAITE	-26.839	-25.000	-1.839	-2.391	127	TRONA	-15.673	-0.445	-15.227	-19.798
64	LARNITE	22.150	40.882	-18.731	-24.354	130	WITHERIT	-11.644	-8.733	-2.911	-3.785
67	LIME	-18.277	34.331	-52.608	-68.399	131	WOLLASTO	9.621	13.392	-3.770	-4.902
68	MAGADITE	-15.209	-14.340	-0.869	-1.129						

SAMPLE IDENT - BR 16 MAR 92 (TEMPERATURE = 11.00)

	PHASE	LOG (AP)	LOG (KT)	LOG (AP/KT)	DELG		PHASE	LOG (AP)	LOG (KT)	LOG (AP/KT)	DELG
11	ANHYDRIT	-6.757	-4.192	-2.565	-3.335	71	MgCl2	-9.504	23.470	-32.974	-42.872
17	ARAGONIT	-8.088	-8.262	0.174	0.226	76	MIRABILT	-9.613	-1.772	-7.841	-10.194
20	BARITE	-10.035	-10.222	0.187	0.243	81	NACHOLIT	-5.381	-0.586	-4.796	-6.236
22	BRUCITE	-16.319	-11.489	-4.830	-6.280	82	NATRTHRM	-10.943	0.057	-11.000	-14.301
24	CALCITE	-8.088	-8.415	0.326	0.424	83	NATRON	-10.944	-1.447	-9.497	-12.347
25	CELESTIT	-8.164	-6.446	-1.717	-2.233	85	NESQUHON	-8.114	-4.900	-3.214	-4.179
41	DOLOMITE	-16.203	-17.841	1.639	2.131	95	PERICLAS	12.665	22.813	-10.149	-13.195
42	DSORD	-16.203	-16.195	-0.007	-0.009	99	PORTLAN	-16.293	-5.305	-10.988	-14.286
51	GYPSUM	-6.758	-4.603	-2.155	-2.801	100	POTASSI	8.239	87.808	-79.570	-103.454
52	HALITE	-6.166	1.549	-7.715	-10.031	118	Na2O	9.836	70.472	-60.636	-78.838
55	HUNTITE	-32.431	-29.607	-2.824	-3.671	122	SrCO3	-9.495	-9.285	-0.209	-0.272
56	HYDRMAGN	-43.843	-37.506	-6.337	-8.240	123	SYLVITE	-6.965	0.751	-7.715	-10.031
57	HYPHILIT	-9.478	12.481	-21.959	-28.550	125	THENARDI	-9.612	-0.294	-9.318	-12.115
67	LIME	-19.002	34.331	-53.334	-69.343	127	TRONA	-16.325	-0.445	-15.879	-20.646
70	MAGNESIT	-8.114	-7.787	-0.328	-0.426	130	WITHERIT	-11.366	-8.733	-2.634	-3.424

SAMPLE IDENT - BR 17 APR 92 (TEMPERATURE = 11.00)

	PHASE	LOG (AP)	LOG (KT)	LOG (AP/KT)	DELG		PHASE	LOG (AP)	LOG (KT)	LOG (AP/KT)	DELG
11	ANHYDRIT	-6.481	-4.192	-2.289	-2.976	71	MgCl2	-9.652	23.470	-33.122	-43.065
17	ARAGONIT	-8.384	-8.262	-0.122	-0.158	76	MIRABILT	-9.872	-1.772	-8.100	-10.532
22	BRUCITE	-17.172	-11.489	-5.683	-7.390	81	NACHOLIT	-5.590	-0.586	-5.005	-6.507
24	CALCITE	-8.384	-8.415	0.031	0.040	82	NATRTHRM	-11.775	0.057	-11.831	-15.383
25	CELESTIT	-9.291	-6.446	-2.845	-3.699	83	NATRON	-11.776	-1.447	-10.329	-13.429
41	DOLOMITE	-16.937	-17.841	0.904	1.175	85	NESQUHON	-8.553	-4.900	-3.653	-4.750
42	DSORD	-16.937	-16.195	-0.742	-0.964	95	PERICLAS	11.811	22.813	-11.002	-14.305
51	GYPSUM	-6.481	-4.603	-1.878	-2.442	99	PORTLAN	-17.003	-5.305	-11.699	-15.210
52	HALITE	-6.437	1.549	-7.986	-10.383	100	POTASSI	7.422	87.808	-80.386	-104.516
55	HUNTITE	-34.043	-29.607	-4.436	-5.767	118	Na2O	8.589	70.472	-61.883	-80.459
56	HYDRMAGN	-45.978	-37.506	-8.472	-11.015	122	SrCO3	-11.195	-9.285	-1.910	-2.483
57	HYPHILIT	-9.483	12.481	-21.964	-28.557	123	SYLVITE	-7.021	0.751	-7.771	-10.104
67	LIME	-17.937	34.331	-52.268	-67.958	125	THENARDI	-9.872	-0.294	-9.577	-12.452
70	MAGNESIT	-8.553	-7.787	-0.766	-0.996	127	TRONA	-17.365	-0.445	-16.920	-21.999

SAMPLE !DENT - BR 1 APR 92 (TEMPERATURE = 11.00)

	PHASE	LOG (AP)	LOG (KT)	LOG (AP/KT)	DELG		PHASE	LOG (AP)	LOG (KT)	LOG (AP/KT)	DELG
11	ANHYDRIT	-6.625	-4.192	-2.432	-3.162	81	NACHOLIT	-5.160	-0.586	-4.574	-5.947
17	ARAGONIT	-8.073	-8.262	0.189	0.246	82	NATRTHRM	-10.608	0.057	-10.664	-13.865
20	BARITE	-9.263	-10.222	0.959	1.247	83	NATRON	-10.608	-1.447	-9.161	-11.912
22	BRUCITE	-16.495	-11.489	-5.006	-6.509	85	NESQUHON	-8.183	-4.900	-3.283	-4.268
24	CALCITE	-8.073	-8.415	0.341	0.444	95	PERICLAS	12.488	22.813	-10.325	-13.424
25	CELESTIT	-8.977	-6.446	-2.531	-3.290	99	PORTLAN	-16.386	-5.305	-11.081	-14.407
41	DOLOMITE	-16.256	-17.841	1.585	2.061	100	POTASSI	7.945	87.808	-79.864	-103.837
42	DSORD	-16.256	-16.195	-0.061	-0.079	118	Na2O	10.063	70.472	-60.409	-78.542
51	GYPSUM	-6.625	-4.603	-2.022	-2.629	122	SrCO3	-10.425	-9.285	-1.140	-1.483
52	HALITE	-5.601	1.549	-7.150	-9.296	123	SYLVITE	-6.660	0.751	-7.411	-9.635
55	HUNTITE	-32.621	-29.607	-3.014	-3.919	125	THENARDI	-9.159	-0.294	-8.865	-11.525
56	HYDRMAGN	-44.174	-37.506	-6.668	-8.669	127	TRONA	-15.768	-0.445	-15.322	-19.922
57	HYPHILIT	-8.667	12.481	-21.148	-27.497	130	WITHERIT	-10.712	-8.733	-1.979	-2.573
67	LIME	-18.640	34.331	-52.972	-68.872	144	FeCl2	-12.580	8.573	-21.153	-27.503
70	MAGNESIT	-8.183	-7.787	-0.396	-0.515	146	FeCO3	-11.986	-10.414	-1.572	-2.044
71	MgCl2	-8.777	23.470	-32.247	-41.927	147	FeO	8.685	14.366	-5.681	-7.386
76	MIRABILT	-9.160	-1.772	-7.388	-9.605						

SAMPLE IDENT - BR1 AUG 92 (TEMPERATURE = 11.00)

	PHASE	LOG (AP)	LOG (KT)	LOG (AP/KT)	DELG		PHASE	LOG (AP)	LOG (KT)	LOG (AP/KT)	DELG
11	ANHYDRIT	-6.882	-4.192	-2.689	-3.497	71	MgCl2	-8.837	23.470	-32.307	-42.005
17	ARAGONIT	-8.896	-8.262	-0.634	-0.824	76	MIRABILT	-9.184	-1.772	-7.412	-9.637
20	BARITE	-9.414	-10.222	0.808	1.050	81	NACHOLIT	-5.325	-0.586	-4.740	-6.163
22	BRUCITE	-17.277	-11.489	-5.788	-7.526	82	NATRTHRM	-11.198	0.057	-11.254	-14.633
24	CALCITE	-8.896	-8.415	-0.481	-0.626	83	NATRON	-11.198	-1.447	-9.751	-12.679
25	CELESTIT	-8.910	-6.446	-2.463	-3.203	85	NESQUHON	-8.706	-4.900	-3.805	-4.948
41	DOLOMITE	-17.601	-17.841	0.240	0.312	95	PERICLAS	11.706	22.813	-11.107	-14.441
42	DSORD	-17.601	-16.195	-1.406	-1.828	99	PORTLAN	-17.468	-5.305	-12.163	-15.814
51	GYPSUM	-6.882	-4.603	-2.279	-2.963	100	POTASSI	7.073	87.808	-80.735	-104.970
52	HALITE	-5.665	1.549	-7.214	-9.379	118	Na2O	9.214	70.472	-61.258	-79.647
55	HUNTITE	-35.012	-29.607	-5.404	-7.027	122	SrCO3	-10.924	-9.285	-1.639	-2.130
56	HYDRMAGN	-46.520	-37.506	-9.014	-11.720	123	SYLVITE	-6.735	0.751	-7.486	-9.733
57	HYPHILIT	-9.027	12.481	-21.508	-27.964	125	THENARDI	-9.184	-0.294	-8.889	-11.558
67	LIME	-18.152	34.331	-52.483	-68.237	127	TRONA	-16.523	-0.445	-16.078	-20.904
70	MAGNESIT	-8.705	-7.787	-0.919	-1.194	130	WITHERIT	-11.428	-8.733	-2.696	-3.505

SAMPLE IDENT - BR 1 FEB 92

(TEMPERATURE = 11.00)

	PHASE	LOG (AP)	LOG (KT)	LOG (AP/KT)	DELG		PHASE	LOG (AP)	LOG (KT)	LOG (AP/KT)	DELG
11	ANHYDRIT	-6.565	-4.192	-2.373	-3.085	71	MgCl2	-8.719	23.470	-32.189	-41.852
17	ARAGONIT	-8.492	-8.262	-0.230	-0.299	76	MIRABILT	-9.069	-1.772	-7.296	-9.487
20	BARITE	-9.261	-10.222	0.961	1.249	81	NACHOLIT	-5.066	-0.586	-4.481	-5.826
22	BRUCITE	-17.520	-11.489	-6.031	-7.841	82	NATRTHRM	-10.995	0.057	-11.052	-14.369
24	CALCITE	-8.492	-8.415	-0.078	-0.101	83	NATRON	-10.996	-1.447	-9.549	-12.415
25	CELESTIT	-8.892	-6.446	-2.446	-3.180	85	NESQUHON	-8.633	-4.900	-3.733	-4.853
41	DOLOMITE	-17.125	-17.841	0.716	0.931	95	PERICLAS	11.464	22.813	-11.350	-14.756
42	DSORD	-17.125	-16.195	-0.930	-1.209	99	PORTLAN	-17.380	-5.305	-12.075	-15.699
51	GYPSUM	-6.565	-4.603	-1.962	-2.551	100	POTASSI	6.357	87.808	-81.451	-105.901
52	HALITE	-5.541	1.549	-7.090	-9.218	118	Na2O	9.101	70.472	-61.371	-79.793
55	HUNTITE	-34.390	-29.607	-4.783	-6.218	122	SrCO3	-10.820	-9.285	-1.535	-1.996
56	HYDRMAGN	-46.568	-37.506	-9.062	-11.782	123	SYLVITE	-6.913	0.751	-7.664	-9.964
57	HYPHILIT	-8.579	12.481	-21.060	-27.381	125	THENARDI	-9.068	-0.294	-8.773	-11.407
67	LIME	-17.624	34.331	-51.955	-67.551	127	TRONA	-16.062	-0.445	-15.616	-20.304
70	MAGNESIT	-8.633	-7.787	-0.846	-1.100	130	WITHERIT	-11.189	-8.733	-2.456	-3.193

SAMPLE IDENT - BR1 JAN 93 (TEMPERATURE = 11.00)

	PHASE	LOG (AP)	LOG (KT)	LOG (AP/KT)	DELG		PHASE	LOG (AP)	LOG (KT)	LOG (AP/KT)	DELG
11	ANHYDRIT	-6.588	-4.192	-2.395	-3.114	71	MgCl2	-9.695	23.470	-33.165	-43.120
17	ARAGONIT	-9.059	-8.262	-0.797	-1.036	76	MIRABILT	-8.979	-1.772	-7.207	-9.370
20	BARITE	-9.188	-10.222	1.034	1.345	81	NACHOLIT	-5.140	-0.586	-4.555	-5.922
22	BRUCITE	-18.133	-11.489	-6.649	-8.645	82	NATRTHRM	-11.450	0.057	-11.506	-14.960
24	CALCITE	-9.059	-8.415	-0.645	-0.838	83	NATRON	-11.451	-1.447	-10.004	-13.007
25	CELESTIT	-8.681	-6.446	-2.235	-2.906	85	NESQUHON	-8.945	-4.900	-4.045	-5.259
41	DOLOMITE	-18.004	-17.841	-0.163	-0.212	95	PERICLAS	10.845	22.813	-11.968	-15.560
42	DSORD	-18.004	-16.195	-1.808	-2.351	99	PORTLAN	-18.253	-5.305	-12.948	-16.835
51	GYPSUM	-6.588	-4.603	-1.985	-2.581	100	POTASSI	6.144	87.808	-81.664	-106.178
52	HALITE	-6.100	1.549	-7.649	-9.945	118	Na2O	8.340	70.472	-62.132	-80.783
55	HUNTITE	-35.893	-29.607	-6.285	-8.172	122	SrCO3	-11.153	-9.285	-1.868	-2.428
56	HYDRMAGN	-48.097	-37.506	-10.591	-13.770	123	SYLVITE	-7.198	0.751	-7.949	-10.335
57	HYPHILIT	-9.809	12.481	-22.290	-28.981	125	THENARDI	-8.978	-0.294	-8.684	-11.290
67	LIME	-17.210	34.331	-51.541	-67.012	127	TRONA	-16.590	-0.445	-16.145	-20.991
70	MAGNESIT	-8.945	-7.787	-1.158	-1.505	130	WITHERIT	-11.659	-8.733	-2.927	-3.805

SAMPLE IDENT - BR1 JUL 92 (TEMPERATURE = 11.00)

	PHASE	LOG (AP)	LOG (KT)	LOG (AP/KT)	DELG		PHASE	LOG (AP)	LOG (KT)	LOG (AP/KT)	DELG
11	ANHYDRIT	-6.637	-4.192	-2.445	-3.178	71	MgCl2	-8.619	23.470	-32.089	-41.722
17	ARAGONIT	-8.782	-8.262	-0.519	-0.675	76	MIRABILT	-8.912	-1.772	-7.140	-9.283
20	BARITE	-9.251	-10.222	0.971	1.263	81	NACHOLIT	-5.212	-0.586	-4.627	-6.016
22	BRUCITE	-17.449	-11.489	-5.960	-7.750	82	NATRTHRM	-11.056	0.057	-11.113	-14.448
24	CALCITE	-8.782	-8.415	-0.367	-0.477	83	NATRON	-11.057	-1.447	-9.610	-12.495
25	CELESTIT	-8.878	-6.446	-2.432	-3.161	85	NESQUHON	-8.793	-4.900	-3.893	-5.062
41	DOLOMITE	-17.575	-17.841	0.266	0.346	95	PERICLAS	11.534	22.813	-11.279	-14.665
42	DSORD	-17.575	-16.195	-1.379	-1.794	99	PORTLAN	-17.438	-5.305	-12.133	-15.775
51	GYPSUM	-6.637	-4.603	-2.034	-2.645	100	POTASSI	8.824	87.808	-78.984	-102.694
52	HALITE	-5.441	1.549	-6.990	-9.088	118	Na2O	9.271	70.472	-61.201	-79.572
55	HUNTITE	-35.161	-29.607	-5.554	-7.221	122	SrCO3	-11.023	-9.285	-1.738	-2.259
56	HYDRMAGN	-46.948	-37.506	-9.442	-12.276	123	SYLVITE	-5.665	0.751	-6.416	-8.341
57	HYPHILIT	-8.608	12.481	-21.089	-27.419	125	THENARDI	-8.911	-0.294	-8.617	-11.203
67	LIME	-17.762	34.331	-52.093	-67.730	127	TRONA	-16.269	-0.445	-15.823	-20.573
70	MAGNESIT	-8.793	-7.787	-1.006	-1.308	130	WITHERIT	-11.396	-8.733	-2.663	-3.463

SAMPLE IDENT - BR1 JUN 92 (TEMPERATURE = 11.00)

	PHASE	LOG (AP)	LOG (KT)	LOG (AP/KT)	DELG		PHASE	LOG (AP)	LOG (KT)	LOG (AP/KT)	DELG
11	ANHYDRIT	-6.659	-4.192	-2.467	-3.207	71	MgCl2	-8.906	23.470	-32.376	-42.094
17	ARAGONIT	-8.116	-8.262	0.146	0.190	76	MIRABILT	-9.325	-1.772	-7.553	-9.820
20	BARITE	-9.401	-10.222	0.821	1.067	81	NACHOLIT	-5.165	-0.586	-4.579	-5.954
22	BRUCITE	-16.688	-11.489	-5.200	-6.760	82	NATRTHRM	-10.781	0.057	-10.837	-14.090
24	CALCITE	-8.116	-8.415	0.299	0.389	83	NATRON	-10.781	-1.447	-9.334	-12.136
25	CELESTIT	-8.968	-6.446	-2.521	-3.278	85	NESQUHON	-8.213	-4.900	-3.313	-4.307
41	DOLOMITE	-16.329	-17.841	1.513	1.967	95	PERICLAS	12.295	22.813	-10.518	-13.676
42	DSORD	-16.329	-16.195	-0.133	-0.173	99	PORTLAN	-16.592	-5.305	-11.287	-14.675
51	GYPSUM	-6.659	-4.603	-2.056	-2.674	100	POTASSI	7.382	87.808	-80.426	-104.568
52	HALITE	-5.737	1.549	-7.286	-9.473	118	Na2O	9.727	70.472	-60.745	-78.979
55	HUNTITE	-32.754	-29.607	-3.146	-4.091	122	SrCO3	-10.424	-9.285	-1.139	-1.481
56	HYDRMAGN	-44.421	-37.506	-6.915	-8.991	123	SYLVITE	-6.910	0.751	-7.660	-9.960
57	HYPHILIT	-8.809	12.481	-21.290	-27.681	125	THENARDI	-9.324	-0.294	-9.029	-11.740
67	LIME	-18.388	34.331	-52.719	-68.544	127	TRONA	-15.946	-0.445	-15.500	-20.153
70	MAGNESIT	-8.213	-7.787	-0.426	-0.554	130	WITHERIT	-10.858	-8.733	-2.125	-2.763

SAMPLE IDENT - BR 1 MAR 92 (TEMPERATURE = 11.00)

	PHASE	LOG (AP)	LOG (KT)	LOG (AP/KT)	DELG		PHASE	LOG (AP)	LOG (KT)	LOG (AP/KT)	DELG
11	ANHYDRIT	-6.539	-4.192	-2.347	-3.052	71	MgCl2	-8.729	23.470	-32.199	-41.865
17	ARAGONIT	-8.004	-8.262	0.259	0.336	76	MIRABILT	-9.044	-1.772	-7.272	-9.455
20	BARITE	-9.241	-10.222	0.981	1.275	81	NACHOLIT	-5.083	-0.586	-4.498	-5.848
22	BRUCITE	-16.519	-11.489	-5.030	-6.540	82	NATRTHRM	-10.508	0.057	-10.564	-13.735
24	CALCITE	-8.004	-8.415	0.411	0.534	83	NATRON	-10.508	-1.447	-9.061	-11.781
25	CELESTIT	-8.880	-6.446	-2.434	-3.164	85	NESQUHON	-8.154	-4.900	-3.254	-4.230
41	DOLOMITE	-16.157	-17.841	1.684	2.189	95	PERICLAS	12.465	22.813	-10.349	-13.455
42	DSORD	-16.157	-16.195	0.038	0.050	99	PORTLAN	-16.369	-5.305	-11.064	-14.385
51	GYPSUM	-6.540	-4.603	-1.937	-2.518	100	POTASSI	7.345	87.808	-80.463	-104.616
52	HALITE	-5.542	1.549	-7.091	-9.219	118	Na2O	10.111	70.472	-60.361	-78.480
55	HUNTITE	-32.464	-29.607	-2.857	-3.714	122	SrCO3	-10.344	-9.285	-1.059	-1.377
56	HYDRMAGN	-44.134	-37.506	-6.628	-8.617	123	SYLVITE	-6.924	0.751	-7.675	-9.979
57	HYPHILIT	-8.580	12.481	-21.060	-27.382	125	THENARDI	-9.043	-0.294	-8.749	-11.375
67	LIME	-18.624	34.331	-52.955	-68.851	127	TRONA	-15.591	-0.445	-15.146	-19.692
70	MAGNESIT	-8.154	-7.787	-0.367	-0.477	130	WITHERIT	-10.706	-8.733	-1.973	-2.565

SAMPLE IDENT - BR 1 MAY 92 (TEMPERATURE = 11.00)

	PHASE	LOG (AP)	LOG (KT)	LOG (AP/KT)	DELG
11	ANHYDRIT	-6.736	-4.192	-2.544	-3.308
17	ARAGONIT	-8.191	-8.262	0.072	0.093
20	BARITE	-9.479	-10.222	0.743	0.966
22	BRUCITE	-16.848	-11.489	-5.359	-6.968
24	CALCITE	-8.191	-8.415	0.224	0.292
25	CELESTIT	-9.085	-6.446	-2.639	-3.431
41	DOLOMITE	-16.494	-17.841	1.347	1.751
42	DSORD	-16.494	-16.195	-0.299	-0.388
51	GYPSUM	-6.737	-4.603	-2.134	-2.774
52	HALITE	-5.890	1.549	-7.439	-9.672
55	HUNTITE	-33.101	-29.607	-3.494	-4.543
56	HYDRMAGN	-44.908	-37.506	-7.402	-9.624
57	HYPHILIT	-9.102	12.481	-21.583	-28.062
67	LIME	-18.321	34.331	-52.652	-68.457
70	MAGNESIT	-8.304	-7.787	-0.517	-0.672
71	MgCl2	-9.215	23.470	-32.685	-42.497
76	MIRABILT	-9.415	-1.772	-7.642	-9.937
81	NACHOLIT	-5.174	-0.586	-4.588	-5.966
82	NATRTHRM	-10.868	0.057	-10.924	-14.204
83	NATRON	-10.869	-1.447	-9.422	-12.250
85	NESQUHON	-8.304	-4.900	-3.404	-4.425
95	PERICLAS	12.135	22.813	-10.678	-13.883
99	PORTLAN	-16.735	-5.305	-11.430	-14.861
100	POTASSI	7.500	87.808	-80.308	-104.415
118	Na2O	9.571	70.472	-60.901	-79.182
122	SrCO3	-10.539	-9.285	-1.254	-1.630
123	SYLVITE	-6.925	0.751	-7.676	-9.980
125	THENARDI	-9.414	-0.294	-9.119	-11.857
127	TRONA	-16.042	-0.445	-15.597	-20.278
130	WITHERIT	-10.933	-8.733	-2.201	-2.861
144	FeCl2	-12.992	8.573	-21.565	-28.039
146	FeCO3	-12.080	-10.414	-1.666	-2.167
147	FeO	8.359	14.366	-6.007	-7.811

SAMPLE IDENT - BR1 OCT 92 (TEMPERATURE = 11.00)

	PHASE	LOG (AP)	LOG (KT)	LOG (AP/KT)	DELG		PHASE	LOG (AP)	LOG (KT)	LOG (AP/KT)	DELG
11	ANHYDRIT	-6.574	-4.192	-2.382	-3.096	71	MgCl2	-8.910	23.470	-32.380	-42.100
17	ARAGONIT	-8.496	-8.262	-0.234	-0.304	76	MIRABILT	-9.088	-1.772	-7.316	-9.512
20	BARITE	-9.327	-10.222	0.895	1.163	81	NACHOLIT	-5.102	-0.586	-4.517	-5.873
22	BRUCITE	-17.514	-11.489	-6.025	-7.834	82	NATRTHRM	-11.009	0.057	-11.066	-14.387
24	CALCITE	-8.496	-8.415	-0.081	-0.106	83	NATRON	-11.010	-1.447	-9.563	-12.433
25	CELESTIT	-8.979	-6.446	-2.533	-3.293	85	NESQUHON	-8.685	-4.900	-3.785	-4.921
41	DOLOMITE	-17.181	-17.841	0.660	0.858	95	PERICLAS	11.470	22.813	-11.344	-14.749
42	DSORD	-17.181	-16.195	-0.986	-1.281	99	PORTLAN	-17.325	-5.305	-12.020	-15.628
51	GYPSUM	-6.574	-4.603	-1.971	-2.563	100	POTASSI	6.779	87.808	-81.029	-105.352
52	HALITE	-5.617	1.549	-7.166	-9.317	118	Na2O	9.146	70.472	-61.326	-79.735
55	HUNTITE	-34.551	-29.607	-4.944	-6.427	122	SrCO3	-10.901	-9.285	-1.616	-2.101
56	HYDRMAGN	-46.714	-37.506	-9.208	-11.972	123	SYLVITE	-6.800	0.751	-7.551	-9.817
57	HYPHILIT	-8.721	12.481	-21.202	-27.566	125	THENARDI	-9.087	-0.294	-8.793	-11.432
67	LIME	-17.571	34.331	-51.902	-67.482	127	TRONA	-16.112	-0.445	-15.666	-20.369
70	MAGNESIT	-8.685	-7.787	-0.898	-1.168	130	WITHERIT	-11.249	-8.733	-2.517	-3.272

SAMPLE IDENT - BR1 NOV 91 (TEMPERATURE = 11.00)

	PHASE	LOG (AP)	LOG (KT)	LOG (AP/KT)	DELG
6	ALUNITE	-0.501	-1.168	0.668	0.868
11	ANHYDRIT	-6.642	-4.192	-2.450	-3.185
17	ARAGONIT	-8.084	-8.262	0.178	0.231
20	BARITE	-9.294	-10.222	0.928	1.207
21	BOEHMITE	11.423	7.888	3.535	4.597
22	BRUCITE	-16.397	-11.489	-4.908	-6.381
24	CALCITE	-8.084	-8.415	0.330	0.430
25	CELESTIT	-8.880	-6.446	-2.434	-3.165
36	CORUNDUM	22.847	23.656	-0.809	-1.052
41	DOLOMITE	-16.218	-17.841	1.623	2.110
42	DSORD	-16.218	-16.195	-0.023	-0.030
46	FLUORITE	-12.071	-11.143	-0.928	-1.206
48	GIBBS AM	-32.052	-34.838	2.786	3.622
49	GIBBSITE	-32.052	-35.450	3.398	4.418
51	GYPSUM	-6.642	-4.603	-2.039	-2.651
52	HALITE	-5.475	1.549	-7.024	-9.132
55	HUNTITE	-32.486	-29.607	-2.878	-3.742
56	HYDRMAGN	-43.934	-37.506	-6.428	-8.357
57	HYPHILIT	-8.598	12.481	-21.079	-27.406
67	LIME	-18.809	34.331	-53.141	-69.092
70	MAGNESIT	-8.134	-7.787	-0.347	-0.451
71	MgCl2	-8.647	23.470	-32.117	-41.758
76	MIRABILT	-8.995	-1.772	-7.223	-9.391
81	NACHOLIT	-5.099	-0.586	-4.513	-5.868
82	NATRTHRM	-10.436	0.057	-10.493	-13.643
83	NATRON	-10.437	-1.447	-8.990	-11.689
85	NESQUHON	-8.134	-4.900	-3.234	-4.205
95	PERICLAS	12.587	22.813	-10.226	-13.296
99	PORTLAN	-16.347	-5.305	-11.042	-14.357
100	POTASSI	7.572	87.808	-80.237	-104.322
118	Na2O	10.284	70.472	-60.188	-78.255
119	SPINEL	35.434	39.700	-4.267	-5.547
122	SrCO3	-10.323	-9.285	-1.038	-1.349
123	SYLVITE	-6.831	0.751	-7.582	-9.858
125	THENARDI	-8.994	-0.294	-8.699	-11.311
127	TRONA	-15.535	-0.445	-15.090	-19.620
130	WITHERIT	-10.737	-8.733	-2.004	-2.605
139	Cu2O	0.754	-2.143	2.898	3.767
144	FeCl2	-12.748	8.573	-21.322	-27.722
146	FeCO3	-12.235	-10.414	-1.821	-2.367
147	FeO	8.486	14.366	-5.880	-7.645
163	MnCl2	-12.752	9.399	-22.151	-28.800
164	MnCO3	-12.239	-10.508	-1.731	-2.251
165	MnO	8.482	18.736	-10.254	-13.332
174	ZnCO3	-12.330	-9.440	-2.891	-3.758
175	ZnO	8.390	12.121	-3.731	-4.850
177	ZnSO4	-10.888	4.198	-15.086	-19.615

SAMPLE IDENT - BR 1 NOV 92

(TEMPERATURE = 11.00)

	PHASE	LOG (AP)	LOG (KT)	LOG (AP/KT)	DELG		PHASE	LOG (AP)	LOG (KT)	LOG (AP/KT)	DELG
11	ANHYDRIT	-6.677	-4.192	-2.485	-3.231	71	MgCl2	-9.521	23.470	-32.991	-42.894
17	ARAGONIT	-8.162	-8.262	0.101	0.131	76	MIRABILT	-9.411	-1.772	-7.639	-9.931
20	BARITE	-9.453	-10.222	0.769	1.000	81	NACHOLIT	-5.160	-0.586	-4.574	-5.947
22	BRUCITE	-16.939	-11.489	-5.450	-7.086	82	NATRTHRM	-10.894	0.057	-10.951	-14.238
24	CALCITE	-8.162	-8.415	0.253	0.329	83	NATRON	-10.895	-1.447	-9.448	-12.284
25	CELESTIT	-9.081	-6.446	-2.634	-3.425	85	NESQUHON	-8.340	-4.900	-3.440	-4.472
41	DOLOMITE	-16.501	-17.841	1.340	1.742	95	PERICLAS	12.045	22.813	-10.769	-14.001
42	DSORD	-16.501	-16.195	-0.306	-0.398	99	PORTLAN	-16.761	-5.305	-11.456	-14.895
51	GYPSUM	-6.677	-4.603	-2.074	-2.697	100	POTASSI	7.486	87.808	-80.322	-104.433
52	HALITE	-6.038	1.549	-7.587	-9.864	118	Na2O	9.490	70.472	-60.982	-79.288
55	HUNTITE	-33.181	-29.607	-3.573	-4.646	122	SrCO3	-10.565	-9.285	-1.280	-1.664
56	HYDRMAGN	-45.078	-37.506	-7.571	-9.844	123	SYLVITE	-7.040	0.751	-7.790	-10.129
57	HYPHILIT	-9.343	12.481	-21.824	-28.375	125	THENARDI	-9.410	-0.294	-9.115	-11.852
67	LIME	-18.105	34.331	-52.436	-68.17?	127	TRONA	-16.054	-0.445	-15.609	-20.294
70	MAGNESIT	-8.340	-7.787	-0.553	-0.719	130	WITHERIT	-10.938	-8.733	-2.205	-2.867

SAMPLE IDENT - BR1 SEP 92

(TEMPERATURE = 11.00)

	PHASE	LOG (AP)	LOG (KT)	LOG (AP/KT)	DELG		PHASE	LOG (AP)	LOG (KT)	LOG (AP/KT)	DELG
11	ANHYDRIT	-6.549	-4.192	-2.356	-3.064	71	MgCl2	-8.790	23.470	-32.260	-41.943
17	ARAGONIT	-8.220	-8.262	0.042	0.055	76	MIRABILT	-8.991	-1.772	-7.218	-9.385
20	BARITE	-9.295	-10.222	0.927	1.206	81	NACHOLIT	-5.103	-0.586	-4.517	-5.873
22	BRUCITE	-16.891	-11.489	-5.403	-7.024	82	NATRTHRM	-10.661	0.057	-10.718	-13.935
24	CALCITE	-8.220	-8.415	0.195	0.253	83	NATRON	-10.662	-1.447	-9.215	-11.981
25	CELESTIT	-8.940	-6.446	-2.494	-3.243	85	NESQUHON	-8.411	-4.900	-3.511	-4.565
41	DOLOMITE	-16.631	-17.841	1.210	1.573	95	PERICLAS	12.092	22.813	-10.721	-13.939
42	DSORD	-16.631	-16.195	-0.436	-0.566	99	PORTLAN	-16.700	-5.305	-11.396	-14.816
51	GYPSUM	-6.549	-4.603	-1.946	-2.530	100	POTASSI	7.410	87.808	-80.398	-104.532
52	HALITE	-5.520	1.549	-7.069	-9.191	118	Na2O	9.842	70.472	-60.630	-78.830
55	HUNTITE	-33.453	-29.607	-3.846	-5.000	122	SrCO3	-10.611	-9.285	-1.326	-1.725
56	HYDRMAGN	-45.278	-37.506	-7.772	-10.105	123	SYLVITE	-6.736	0.751	-7.487	-9.734
57	HYPHILIT	-8.599	12.481	-21.080	-27.407	125	THENARDI	-8.990	-0.294	-8.695	-11.305
67	LIME	-18.209	34.331	-52.540	-68.311	127	TRONA	-15.764	-0.445	-15.318	-19.917
70	MAGNESIT	-8.411	-7.787	-0.624	-0.812	130	WITHERIT	-10.966	-8.733	-2.234	-2.904

SAMPLE IDENT - BR 3 APR 92

(TEMPERATURE = 11.00)

	PHASE	LOG (AP)	LOG (KT)	LOG (AP/KT)	DELG
11	ANHYDRIT	-6.950	-4.192	-2.757	-3.585
17	ARAGONIT	-8.084	-8.262	0.178	0.231
20	BARITE	-10.251	-10.222	-0.029	-0.038
22	BRUCITE	-16.309	-11.489	-4.820	-6.267
24	CALCITE	-8.084	-8.415	0.330	0.430
25	CELESTIT	-8.227	-6.446	-1.781	-2.315
41	DOLOMITE	-16.204	-17.841	1.637	2.129
42	DSORD	-16.204	-16.195	-0.008	-0.011
51	GYPSUM	-6.950	-4.603	-2.347	-3.051
52	HALITE	-5.557	1.549	-7.106	-9.239
55	HUNTITE	-32.443	-29.607	-2.835	-3.686
56	HYDRMAGN	-43.963	-37.506	-6.457	-8.395
57	HYPHILIT	-9.191	12.481	-21.672	-28.177
67	LIME	-19.232	34.331	-53.563	-69.642
70	MAGNESIT	-8.119	-7.787	-0.333	-0.433
71	MgCl2	-9.226	23.470	-32.696	-42.511
76	MIRABILT	-8.874	-1.772	-7.102	-9.234
81	NACHOLIT	-4.922	-0.586	-4.336	-5.638
82	NATRTHRM	-10.008	0.057	-10.064	-13.085
83	NATRON	-10.008	-1.447	-8.561	-11.131
85	NESQUHON	-8.120	-4.900	-3.220	-4.186
95	PERICLAS	12.675	22.813	-10.138	-13.182
99	PORTLAN	-16.273	-5.305	-10.969	-14.261
100	POTASSI	8.741	87.808	-79.067	-102.801
118	Na2O	10.787	70.472	-59.685	-77.602
122	SrCO3	-9.361	-9.285	-0.076	-0.099
123	SYLVITE	-6.580	0.751	-7.330	-9.531
125	THENARDI	-8.873	-0.294	-8.579	-11.154
127	TRONA	-14.929	-0.445	-14.484	-18.832
130	WITHERIT	-11.386	-8.733	-2.653	-3.450
144	FeCl2	-12.852	8.573	-21.425	-27.856
146	FeCO3	-11.745	-10.414	-1.331	-1.731
147	FeO	9.050	14.366	-5.317	-6.913

SAMPLE IDENT - BR3 AUG 92 (TEMPERATURE = 11.00)

	PHASE	LOG (AP)	LOG (KT)	LOG (AP/KT)	DELG		PHASE	LOG (AP)	LOG (KT)	LOG (AP/KT)	DELG
11	ANHYDRIT	-6.802	-4.192	-2.609	-3.393	71	MgCl2	-8.838	23.470	-32.308	-42.006
17	ARAGONIT	-8.338	-8.262	-0.075	-0.098	76	MIRABILT	-8.704	-1.772	-6.932	-9.013
20	BARITE	-10.177	-10.222	0.045	0.058	81	NACHOLIT	-5.192	-0.586	-4.606	-5.989
22	BRUCITE	-16.232	-11.489	-4.743	-6.167	82	NATRTHRM	-10.239	0.057	-10.296	-13.386
24	CALCITE	-8.338	-8.415	0.077	0.100	83	NATRON	-10.240	-1.447	-8.793	-11.432
25	CELESTIT	-8.001	-6.446	-1.554	-2.021	85	NESQUHON	-8.352	-4.900	-3.452	-4.488
41	DOLOMITE	-16.689	-17.841	1.152	1.498	95	PERICLAS	12.751	22.813	-10.062	-13.082
42	DSORD	-16.689	-16.195	-0.494	-0.642	99	PORTLAN	-16.218	-5.305	-10.913	-14.189
51	GYPSUM	-6.802	-4.603	-2.199	-2.859	100	POTASSI	8.722	87.808	-79.086	-102.826
52	HALITE	-5.363	1.549	-6.912	-8.986	118	Na2O	10.864	70.472	-59.608	-77.502
55	HUNTITE	-33.392	-29.607	-3.785	-4.921	122	SrCO3	-9.537	-9.285	-0.251	-0.327
56	HYDRMAGN	-44.552	-37.506	-7.046	-9.161	123	SYLVITE	-6.434	0.751	-7.184	-9.341
57	HYPHILIT	-8.824	12.481	-21.305	-27.700	125	THENARDI	-8.703	-0.294	-8.409	-10.933
67	LIME	-19.270	34.331	-53.601	-69.690	127	TRONA	-15.431	-0.445	-14.985	-19.484
70	MAGNESIT	-8.351	-7.787	-0.565	-0.734	130	WITHERIT	-11.713	-8.733	-2.981	-3.875

SAMPLE IDENT - BR 3 FEB 92

(TEMPERATURE = 11.00)

	PHASE	LOG (AP)	LOG (KT)	LOG (AP/KT)	DELG		PHASE	LOG (AP)	LOG (KT)	LOG (AP/KT)	DELG
11	ANHYDRIT	-6.808	-4.192	-2.616	-3.401	71	MgCl2	-8.778	23.470	-32.248	-41.929
17	ARAGONIT	-8.599	-8.262	-0.337	-0.438	76	MIRABILT	-8.903	-1.772	-7.131	-9.271
20	BARITE	-10.151	-10.222	0.071	0.093	81	NACHOLIT	-5.055	-0.586	-4.470	-5.812
22	BRUCITE	-17.249	-11.489	-5.760	-7.489	82	NATRTHRM	-10.693	0.057	-10.750	-13.977
24	CALCITE	-8.599	-8.415	-0.185	-0.240	83	NATRON	-10.694	-1.447	-9.247	-12.023
25	CELESTIT	-8.059	-6.446	-1.612	-2.096	85	NESQUHON	-8.642	-4.900	-3.742	-4.865
41	DOLOMITE	-17.241	-17.841	0.600	0.780	95	PERICLAS	11.735	22.813	-11.079	-14.404
42	DSORD	-17.241	-16.195	-1.046	-1.360	99	PORTLAN	-17.206	-5.305	-11.901	-15.474
51	GYPSUM	-6.808	-4.603	-2.205	-2.867	100	POTASSI	7.110	87.808	-80.699	-104.922
52	HALITE	-5.415	1.549	-6.964	-9.054	118	Na2O	9.683	70.472	-60.789	-79.036
55	HUNTITE	-34.525	-29.607	-4.918	-6.394	122	SrCO3	-9.850	-9.285	-0.565	-0.734
56	HYDRMAGN	-46.437	-37.506	-8.931	-11.611	123	SYLVITE	-6.702	0.751	-7.452	-9.689
57	HYPHILIT	-8.736	12.481	-21.217	-27.585	125	THENARDI	-8.902	-0.294	-8.607	-11.191
67	LIME	-18.215	34.331	-52.546	-68.320	127	TRONA	-15.749	-0.445	-15.303	-19.897
70	MAGNESIT	-8.642	-7.787	-0.855	-1.112	130	WITHERIT	-11.942	-8.733	-3.210	-4.173

SAMPLE IDENT - BR3 JAN 93 (TEMPERATURE = 11.00)

	PHASE	LOG (AP)	LOG (KT)	LOG (AP/KT)	DELG		PHASE	LOG (AP)	LOG (KT)	LOG (AP/KT)	DELG
11	ANHYDRIT	-6.747	-4.192	-2.554	-3.321	71	MgCl2	-8.861	23.470	-32.331	-42.036
17	ARAGONIT	-8.604	-8.262	-0.342	-0.444	76	MIRABILT	-8.660	-1.772	-6.888	-8.956
20	BARITE	-10.115	-10.222	0.107	0.140	81	NACHOLIT	-5.013	-0.586	-4.428	-5.757
22	BRUCITE	-17.188	-11.489	-5.699	-7.410	82	NATRTHRM	-10.517	0.057	-10.574	-13.748
24	CALCITE	-8.604	-8.415	-0.189	-0.246	83	NATRON	-10.518	-1.447	-9.071	-11.794
25	CELESTIT	-8.034	-6.446	-1.588	-2.065	85	NESQUHON	-8.673	-4.900	-3.773	-4.906
41	DOLOMITE	-17.277	-17.841	0.564	0.733	95	PERICLAS	11.796	22.813	-11.018	-14.325
42	DSORD	-17.277	-16.195	-1.082	-1.406	99	PORTLAN	-17.119	-5.305	-11.814	-15.361
51	GYPSUM	-6.747	-4.603	-2.144	-2.787	100	POTASSI	7.749	87.808	-80.059	-104.091
52	HALITE	-5.353	1.549	-6.902	-8.973	118	Na2O	9.952	70.472	-60.521	-78.688
55	HUNTITE	-34.623	-29.607	-5.016	-6.521	122	SrCO3	-9.892	-9.285	-0.607	-0.789
56	HYDRMAGN	-46.469	-37.506	-8.963	-11.653	123	SYLVITE	-6.454	0.751	-7.205	-9.367
57	HYPHILIT	-8.792	12.481	-21.273	-27.659	125	THENARDI	-8.659	-0.294	-8.365	-10.876
67	LIME	-18.251	34.331	-52.582	-68.366	127	TRONA	-15.530	-0.445	-15.085	-19.613
70	MAGNESIT	-8.673	-7.787	-0.886	-1.152	130	WITHERIT	-11.972	-8.733	-3.240	-4.212

SAMPLE IDENT - BR3 JUL 92 (TEMPERATURE = 11.00)

	PHASE	LOG (AP)	LOG (KT)	LOG (AP/KT)	DELG		PHASE	LOG (AP)	LOG (KT)	LOG (AP/KT)	DELG
11	ANHYDRIT	-6.804	-4.192	-2.612	-3.396	71	MgCl2	-8.825	23.470	-32.295	-41.990
17	ARAGONIT	-8.518	-8.262	-0.255	-0.332	76	MIRABILT	-8.721	-1.772	-6.949	-9.035
20	BARITE	-10.205	-10.222	0.017	0.022	81	NACHOLIT	-5.017	-0.586	-4.432	-5.762
22	BRUCITE	-16.965	-11.489	-5.476	-7.120	82	NATRTHRM	-10.434	0.057	-10.490	-13.639
24	CALCITE	-8.518	-8.415	-0.103	-0.134	83	NATRON	-10.434	-1.447	-8.987	-11.685
25	CELESTIT	-8.051	-6.446	-1.605	-2.087	85	NESQUHON	-8.542	-4.900	-3.642	-4.735
41	DOLOMITE	-17.059	-17.841	0.782	1.017	95	PERICLAS	12.019	22.813	-10.795	-14.035
42	DSORD	-17.059	-16.195	-0.864	-1.123	99	PORTLAN	-16.941	-5.305	-11.636	-15.129
51	GYPSUM	-6.804	-4.603	-2.201	-2.862	100	POTASSI	7.973	87.808	-79.835	-103.800
52	HALITE	-5.359	1.549	-6.908	-8.981	118	Na2O	10.127	70.472	-60.346	-78.460
55	HUNTITE	-34.142	-29.607	-4.534	-5.895	122	SrCO3	-9.765	-9.285	-0.480	-0.623
56	HYDRMAGN	-45.852	-37.506	-8.346	-10.851	123	SYLVITE	-6.436	0.751	-7.186	-9.343
57	HYPHILIT	-8.801	12.481	-21.282	-27.671	125	THENARDI	-8.720	-0.294	-8.426	-10.955
67	LIME	-18.521	34.331	-52.852	-68.717	127	TRONA	-15.451	-0.445	-15.006	-19.510
70	MAGNESIT	-8.541	-7.787	-0.755	-0.981	130	WITHERIT	-11.919	-8.733	-3.186	-4.142

SAMPLE IDENT - BR 3 JUN 92

(TEMPERATURE = 11.00)

	PHASE	LOG (AP)	LOG (KT)	LOG (AP/KT)	DELG
11	ANHYDRIT	-6.853	-4.192	-2.661	-3.460
17	ARAGONIT	-8.565	-8.262	-0.302	-0.393
20	BARITE	-10.207	-10.222	0.015	0.019
22	BRUCITE	-16.821	-11.489	-5.332	-6.932
24	CALCITE	-8.565	-8.415	-0.150	-0.195
25	CELESTIT	-8.072	-6.446	-1.626	-2.114
41	DOLOMITE	-17.113	-17.841	0.728	0.946
42	DSORD	-17.113	-16.195	-0.918	-1.194
51	GYPSUM	-6.853	-4.603	-2.250	-2.926
52	HALITE	-5.347	1.549	-6.895	-8.965
55	HUNTITE	-34.211	-29.607	-4.603	-5.985
56	HYDRMAGN	-45.729	-37.506	-8.223	-10.691
57	HYPHILIT	-8.810	12.481	-21.291	-27.682
67	LIME	-18.703	34.331	-53.034	-68.954
70	MAGNESIT	-8.549	-7.787	-0.762	-0.991
71	MgCl2	-8.794	23.470	-32.264	-41.949
76	MIRABILT	-8.737	-1.772	-6.965	-9.056
81	NACHOLIT	-5.100	-0.586	-4.515	-5.870
82	NATRTHRM	-10.448	0.057	-10.504	-13.658
83	NATRON	-10.449	-1.447	-9.002	-11.704
85	NESQUHON	-8.549	-4.900	-3.649	-4.744
95	PERICLAS	12.163	22.813	-10.650	-13.847
99	PORTLAN	-16.836	-5.305	-11.532	-14.993
100	POTASSI	8.157	87.808	-79.651	-103.561
118	Na2O	10.264	70.472	-60.208	-78.281
122	SrCO3	-9.784	-9.285	-0.499	-0.648
123	SYLVITE	-6.400	0.751	-7.151	-9.297
125	THENARDI	-8.736	-0.294	-8.442	-10.976
127	TRONA	-15.548	-0.445	-15.103	-19.636
130	WITHERIT	-11.919	-8.733	-3.186	-4.142

SAMPLE IDENT - BR 3 MAR 92 (TEMPERATURE = 11.00)

	PHASE	LOG (AP)	LOG (KT)	LOG (AP/KT)	DELG		PHASE	LOG (AP)	LOG (KT)	LOG (AP/KT)	DELG
11	ANHYDRIT	-6.848	-4.192	-2.656	-3.453	71	MgCl2	-8.804	23.470	-32.274	-41.962
17	ARAGONIT	-8.020	-8.262	0.242	0.315	76	MIRABILT	-8.748	-1.772	-6.976	-9.070
20	BARITE	-10.213	-10.222	0.009	0.012	81	NACHOLIT	-5.046	-0.586	-4.461	-5.800
22	BRUCITE	-15.889	-11.489	-4.400	-5.721	82	NATRTHRM	-9.919	0.057	-9.976	-12.970
24	CALCITE	-8.020	-8.415	0.395	0.513	83	NATRON	-9.920	-1.447	-8.473	-11.017
25	CELESTIT	-8.111	-6.446	-1.664	-2.164	85	NESQUHON	-8.038	-4.900	-3.138	-4.080
41	DOLOMITE	-16.058	-17.841	1.783	2.318	95	PERICLAS	13.095	22.813	-9.719	-12.636
42	DSORD	-16.058	-16.195	0.137	0.179	99	PORTLAN	-15.871	-5.305	-10.566	-13.738
51	GYPSUM	-6.848	-4.603	-2.245	-2.919	100	POTASSI	9.164	87.808	-78.644	-102.252
52	HALITE	-5.343	1.549	-6.892	-8.960	118	Na2O	11.213	70.472	-59.259	-77.047
55	HUNTITE	-32.134	-29.607	-2.527	-3.285	122	SrCO3	-9.283	-9.285	0.003	0.003
56	HYDRMAGN	-43.294	-37.506	-5.788	-7.525	123	SYLVITE	-6.367	0.751	-7.118	-9.255
57	HYPHILIT	-8.786	12.481	-21.267	-27.651	125	THENARDI	-8.747	-0.294	-8.453	-10.990
67	LIME	-19.658	34.331	-53.989	-70.195	127	TRONA	-14.966	-0.445	-14.521	-18.879
70	MAGNESIT	-8.038	-7.787	-0.251	-0.327	130	WITHERIT	-11.385	-8.733	-2.652	-3.448

SAMPLE IDENT - BR 3 MAY 92

(TEMPERATURE = 11.00)

	PHASE	LOG (AP)	LOG (KT)	LOG (AP/KT)	DELG		PHASE	LOG (AP)	LOG (KT)	LOG (AP/KT)	DELG
11	ANHYDRIT	-6.853	-4.192	-2.660	-3.459	71	MgCl2	-8.921	23.470	-32.391	-42.114
17	ARAGONIT	-8.177	-8.262	0.085	0.111	76	MIRABILT	-8.765	-1.772	-6.993	-9.093
20	BARITE	-10.139	-10.222	0.083	0.109	81	NACHOLIT	-5.047	-0.586	-4.461	-5.800
22	BRUCITE	-16.218	-11.489	-4.729	-6.148	82	NATRTHRM	-10.089	0.057	-10.145	-13.191
24	CALCITE	-8.177	-8.415	0.238	0.309	83	NATRON	-10.090	-1.447	-8.643	-11.237
25	CELESTIT	-8.117	-6.446	-1.671	-2.173	85	NESQUHON	-8.197	-4.900	-3.297	-4.287
41	DOLOMITE	-16.374	-17.841	1.467	1.907	95	PERICLAS	12.766	22.813	-10.047	-13.063
42	DSORD	-16.374	-16.195	-0.179	-0.232	99	PORTLAN	-16.197	-5.305	-10.893	-14.162
51	GYPSUM	-6.853	-4.603	-2.250	-2.925	100	POTASSI	8.840	87.808	-78.969	-102.673
52	HALITE	-5.406	1.549	-6.955	-9.043	118	Na2O	10.874	70.472	-59.598	-77.488
55	HUNTITE	-32.768	-29.607	-3.161	-4.110	122	SrCO3	-9.442	-9.285	-0.157	-0.204
56	HYDRMAGN	-44.100	-37.506	-6.594	-8.573	123	SYLVITE	-6.423	0.751	-7.174	-9.328
57	HYPHILIT	-8.900	12.481	-21.381	-27.799	125	THENARDI	-8.765	-0.294	-8.470	-11.013
67	LIME	-19.327	34.331	-53.659	-69.766	127	TRONA	-15.136	-0.445	-14.690	-19.100
70	MAGNESIT	-8.197	-7.787	-0.410	-0.534	130	WITHERIT	-11.463	-8.733	-2.730	-3.550

SAMPLE IDENT - BR 3 NOV 91 (TEMPERATURE = 11.00)

	PHASE	LOG (AP)	LOG (KT)	LOG (AP/KT)	DELG		PHASE	LOG (AP)	LOG (KT)	LOG (AP/KT)	DELG
11	ANHYDRIT	-6.814	-4.192	-2.622	-3.409	71	MgCl2	-8.700	23.470	-32.170	-41.827
17	ARAGONIT	-7.977	-8.262	0.285	0.370	76	MIRABILT	-8.833	-1.772	-7.061	-9.181
22	BRUCITE	-15.883	-11.489	-4.394	-5.713	81	NACHOLIT	-5.070	-0.586	-4.484	-5.831
24	CALCITE	-7.977	-8.415	0.437	0.569	82	NATRTHRM	-9.996	0.057	-10.052	-13.070
25	CELESTIT	-8.047	-6.446	-1.601	-2.082	83	NATRON	-9.996	-1.447	-8.549	-11.116
41	DOLOMITE	-15.980	-17.841	1.861	2.419	85	NESQUHON	-8.003	-4.900	-3.103	-4.035
42	DSORD	-15.980	-16.195	0.215	0.279	95	PERICLAS	13.100	22.813	-9.713	-12.629
51	GYPSUM	-6.815	-4.603	-2.211	-2.875	99	PORTLAN	-15.858	-5.305	-10.553	-13.720
52	HALITE	-5.346	1.549	-6.895	-8.965	100	POTASSI	8.575	87.808	-79.233	-103.017
55	HUNTITE	-31.987	-29.607	-2.379	-3.093	118	Na2O	11.108	70.472	-59.364	-77.184
56	HYDRMAGN	-43.136	-37.506	-5.630	-7.320	122	SrCO3	-9.210	-9.285	0.075	0.097
57	HYPHILIT	-8.675	12.481	-21.156	-27.506	123	SYLVITE	-6.613	0.751	-7.364	-9.574
67	LIME	-19.563	34.331	-53.894	-70.072	125	THENARDI	-8.833	-0.294	-8.538	-11.101
70	MAGNESIT	-8.003	-7.787	-0.216	-0.281	127	TRONA	-15.066	-0.445	-14.620	-19.009

SAMPLE IDENT - BR3 NOV 92

(TEMPERATURE = 11.00)

	PHASE	LOG (AP)	LOG (KT)	LOG (AP/KT)	DELG		PHASE	LOG (AP)	LOG (KT)	LOG (AP/KT)	DELG
11	ANHYDRIT	-6.835	-4.192	-2.642	-3.436	71	MgCl2	-8.992	23.470	-32.462	-42.206
17	ARAGONIT	-8.337	-8.262	-0.075	-0.097	76	MIRABILT	-8.717	-1.772	-6.945	-9.030
20	BARITE	-10.179	-10.222	0.043	0.056	81	NACHOLIT	-5.031	-0.586	-4.445	-5.780
22	BRUCITE	-16.568	-11.489	-5.079	-6.604	82	NATRTHRM	-10.218	0.057	-10.275	-13.359
24	CALCITE	-8.337	-8.415	0.078	0.101	83	NATRON	-10.219	-1.447	-8.772	-11.405
25	CELESTIT	-8.109	-6.446	-1.662	-2.162	85	NESQUHON	-8.387	-4.900	-3.487	-4.534
41	DOLOMITE	-16.724	-17.841	1.117	1.453	95	PERICLAS	12.415	22.813	-10.398	-13.519
42	DSORD	-16.724	-16.195	-0.528	-0.687	99	PORTLAN	-16.518	-5.305	-11.213	-14.579
51	GYPSUM	-6.835	-4.603	-2.232	-2.902	100	POTASSI	8.345	87.808	-79.463	-103.316
52	HALITE	-5.411	1.549	-6.960	-9.050	118	Na2O	10.584	70.472	-59.888	-77.865
55	HUNTITE	-33.498	-29.607	-3.890	-5.058	122	SrCO3	-9.611	-9.285	-0.326	-0.423
56	HYDRMAGN	-44.990	-37.506	-7.484	-9.731	123	SYLVITE	-6.531	0.751	-7.282	-9.467
57	HYPHILIT	-8.942	12.481	-21.422	-27.853	125	THENARDI	-8.716	-0.294	-8.422	-10.950
67	LIME	-18.887	34.331	-53.219	-69.194	127	TRONA	-15.249	-0.445	-14.804	-19.248
70	MAGNESIT	-8.387	-7.787	-0.600	-0.780	130	WITHERIT	-11.681	-8.733	-2.948	-3.833

SAMPLE IDENT - BR3 SEP 92 (TEMPERATURE = 11.00)

	PHASE	LOG (AP)	LOG (KT)	LOG (AP/KT)	DELG		PHASE	LOG (AP)	LOG (KT)	LOG (AP/KT)	DELG
11	ANHYDRIT	-6.944	-4.192	-2.752	-3.578	71	MgCl2	-9.142	23.470	-32.612	-42.401
17	ARAGONIT	-8.372	-8.262	-0.110	-0.142	76	MIRABILT	-8.849	-1.772	-7.077	-9.202
20	BARITE	-10.292	-10.222	-0.069	-0.090	81	NACHOLIT	-5.040	-0.586	-4.455	-5.792
22	BRUCITE	-16.662	-11.489	-5.173	-6.726	82	NATRTHRM	-10.276	0.057	-10.333	-13.434
24	CALCITE	-8.372	-8.415	0.043	0.056	83	NATRON	-10.277	-1.447	-8.830	-11.480
25	CELESTIT	-8.230	-6.446	-1.784	-2.319	85	NESQUHON	-8.442	-4.900	-3.542	-4.605
41	DOLOMITE	-16.814	-17.841	1.028	1.336	95	PERICLAS	12.322	22.813	-10.492	-13.641
42	DSORD	-16.814	-16.195	-0.618	-0.804	99	PORTLAN	-16.592	-5.305	-11.287	-14.675
51	GYPSUM	-6.945	-4.603	-2.341	-3.044	100	POTASSI	8.170	87.808	-79.638	-103.544
52	HALITE	-5.488	1.549	-7.037	-9.149	118	Na2O	10.487	70.472	-59.985	-77.991
55	HUNTITE	-33.697	-29.607	-4.090	-5.317	122	SrCO3	-9.657	-9.285	-0.372	-0.484
56	HYDRMAGN	-45.259	-37.506	-7.752	-10.080	123	SYLVITE	-6.647	0.751	-7.397	-9.618
57	HYPHILIT	-9.072	12.481	-21.553	-28.023	125	THENARDI	-8.849	-0.294	-8.554	-11.122
67	LIME	-18.794	34.331	-53.125	-69.072	127	TRONA	-15.316	-0.445	-14.871	-19.335
70	MAGNESIT	-8.442	-7.787	-0.655	-0.852	130	WITHERIT	-11.719	-8.733	-2.986	-3.883

SAMPLE IDENT - BR 5 NOV 91 (TEMPERATURE = 11.00)

	PHASE	LOG (AP)	LOG (KT)	LOG (AP/KT)	DELG		PHASE	LOG (AP)	LOG (KT)	LOG (AP/KT)	DELG
11	ANHYDRIT	-6.917	-4.192	-2.725	-3.543	71	MgCl2	-7.846	23.470	-31.316	-40.717
17	ARAGONIT	-8.573	-8.262	-0.311	-0.404	76	MIRABILT	-8.344	-1.772	-6.571	-8.544
20	BARITE	-9.826	-10.222	0.397	0.516	81	NACHOLIT	-4.701	-0.586	-4.115	-5.351
22	BRUCITE	-17.332	-11.489	-5.843	-7.597	82	NATRTHRM	-9.998	0.057	-10.055	-13.073
24	CALCITE	-8.573	-8.415	-0.158	-0.206	83	NATRON	-9.999	-1.447	-8.552	-11.120
25	CELESTIT	-9.812	-6.446	-3.366	-4.376	85	NESQUHON	-8.711	-4.900	-3.811	-4.955
41	DOLOMITE	-17.284	-17.841	0.557	0.725	95	PERICLAS	11.652	22.813	-11.161	-14.512
42	DSORD	-17.284	-16.195	-1.088	-1.415	99	PORTLAN	-17.194	-5.305	-11.889	-15.458
51	GYPSUM	-6.918	-4.603	-2.315	-3.009	100	POTASSI	5.678	87.808	-82.130	-106.784
52	HALITE	-4.567	1.549	-6.116	-7.952	118	Na2O	10.365	70.472	-60.108	-78.151
55	HUNTITE	-34.705	-29.607	-5.098	-6.628	122	SrCO3	-11.468	-9.285	-2.183	-2.838
56	HYDRMAGN	-46.709	-37.506	-9.202	-11.965	123	SYLVITE	-6.910	0.751	-7.661	-9.960
57	HYPHILIT	-7.709	12.481	-20.190	-26.250	125	THENARDI	-8.342	-0.294	-8.048	-10.464
67	LIME	-18.004	34.331	-52.336	-68.045	127	TRONA	-14.699	-0.445	-14.254	-18.532
70	MAGNESIT	-8.711	-7.787	-0.924	-1.201	130	WITHERIT	-11.481	-8.733	-2.749	-3.574

SAMPLE IDENT - BR 6 NOV 91

(TEMPERATURE = 11.00)

	PHASE	LOG (AP)	LOG (KT)	LOG (AP/KT)	DELG		PHASE	LOG (AP)	LOG (KT)	LOG (AP/KT)	DELG
11	ANHYDRIT	-7.027	-4.192	-2.835	-3.685	71	MgCl2	-8.580	23.470	-32.050	-41.670
17	ARAGONIT	-8.163	-8.262	0.100	0.130	76	MIRABILT	-10.723	-1.772	-8.951	-11.638
20	BARITE	-10.162	-10.222	0.060	0.078	81	NACHOLIT	-5.803	-0.586	-5.217	-6.783
22	BRUCITE	-16.269	-11.489	-4.780	-6.215	82	NATRTHRM	-11.858	0.057	-11.915	-15.492
24	CALCITE	-8.163	-8.415	0.252	0.328	83	NATRON	-11.859	-1.447	-10.412	-13.538
25	CELESTIT	-8.445	-6.446	-1.999	-2.599	85	NESQUHON	-7.991	-4.900	-3.091	-4.019
41	DOLOMITE	-16.154	-17.841	1.687	2.194	95	PERICLAS	12.715	22.813	-10.099	-13.130
42	DSORD	-16.154	-16.195	0.042	0.054	99	PORTLAN	-16.440	-5.305	-11.135	-14.478
51	GYPSUM	-7.027	-4.603	-2.424	-3.152	100	POTASSI	7.670	87.808	-80.138	-104.194
52	HALITE	-6.224	1.549	-7.772	-10.106	118	Na2O	8.847	70.472	-61.625	-80.123
55	HUNTITE	-32.136	-29.607	-2.529	-3.288	122	SrCO3	-9.581	-9.285	-0.296	-0.385
56	HYDRMAGN	-43.129	-37.506	-5.623	-7.310	123	SYLVITE	-6.812	0.751	-7.563	-9.833
57	HYPHILIT	-8.751	12.481	-21.232	-27.605	125	THENARDI	-10.723	-0.294	-10.428	-13.559
67	LIME	-18.659	34.331	-52.990	-68.896	127	TRONA	-17.661	-0.445	-17.216	-22.384
70	MAGNESIT	-7.991	-7.787	-0.204	-0.266	130	WITHERIT	-11.298	-8.733	-2.566	-3.336

SAMPLE IDENT - BR7 NOV 91

(TEMPERATURE = 11.00)

	PHASE	LOG (AP)	LOG (KT)	LOG (AP/KT)	DELG		PHASE	LOG (AP)	LOG (KT)	LOG (AP/KT)	DELG
11	ANHYDRIT	-6.929	-4.192	-2.737	-3.559	71	MgCl2	-10.562	23.470	-34.032	-44.247
17	ARAGONIT	-7.822	-8.262	0.440	0.572	76	MIRABILT	-10.978	-1.772	-9.206	-11.969
20	BARITE	-10.185	-10.222	0.038	0.049	81	NACHOLIT	-5.882	-0.586	-5.296	-6.886
22	BRUCITE	-15.998	-11.489	-4.509	-5.863	82	NATRTHRM	-11.870	0.057	-11.927	-15.507
24	CALCITE	-7.822	-8.415	0.592	0.770	83	NATRON	-11.871	-1.447	-10.424	-13.553
25	CELESTIT	-8.435	-6.446	-1.989	-2.586	85	NESQUHON	-7.867	-4.900	-2.967	-3.857
41	DOLOMITE	-15.689	-17.841	2.152	2.798	95	PERICLAS	12.985	22.813	-9.828	-12.778
42	DSORD	-15.689	-16.195	0.506	0.658	99	PORTLAN	-15.954	-5.305	-10.649	-13.845
51	GYPSUM	-6.930	-4.603	-2.326	-3.025	100	POTASSI	7.950	87.808	-79.859	-103.830
52	HALITE	-7.283	1.549	-8.832	-11.483	118	Na2O	8.982	70.472	-61.490	-79.948
55	HUNTITE	-31.422	-29.607	-1.815	-2.360	122	SrCO3	-9.328	-9.285	-0.043	-0.056
56	HYDRMAGN	-42.721	-37.506	-5.215	-6.781	123	SYLVITE	-7.799	0.751	-8.549	-11.116
57	HYPHILIT	-10.518	12.481	-22.998	-29.902	125	THENARDI	-10.977	-0.294	-10.683	-13.890
67	LIME	-19.188	34.331	-53.519	-69.584	127	TRONA	-17.752	-0.445	-17.307	-22.502
70	MAGNESIT	-7.867	-7.787	-0.080	-0.104	130	WITHERIT	-11.077	-8.733	-2.345	-3.049

SAMPLE IDENT - BR 8 NOV 91 (TEMPERATURE = 11.00)

	PHASE	LOG (AP)	LOG (KT)	LOG (AP/KT)	DELG		PHASE	LOG (AP)	LOG (KT)	LOG (AP/KT)	DELG
11	ANHYDRIT	-6.553	-4.192	-2.360	-3.069	71	MgCl2	-7.936	23.470	-31.406	-40.833
17	ARAGONIT	-8.339	-8.262	-0.077	-0.100	76	MIRABILT	-8.737	-1.772	-6.965	-9.055
20	BARITE	-9.562	-10.222	0.660	0.859	81	NACHOLIT	-5.033	-0.586	-4.447	-5.782
22	BRUCITE	-17.131	-11.489	-5.642	-7.336	82	NATRTHRM	-10.522	0.057	-10.578	-13.754
24	CALCITE	-8.339	-8.415	0.076	0.099	83	NATRON	-10.523	-1.447	-9.076	-11.800
25	CELESTIT	-8.692	-6.446	-2.246	-2.920	85	NESQUHON	-8.651	-4.900	-3.751	-4.877
41	DOLOMITE	-16.989	-17.841	0.852	1.107	95	PERICLAS	11.853	22.813	-10.961	-14.251
42	DSORD	-16.989	-16.195	-0.794	-1.032	99	PORTLAN	-16.819	-5.305	-11.515	-14.971
51	GYPSUM	-6.553	-4.603	-1.950	-2.535	100	POTASSI	7.741	87.808	-80.068	-104.102
52	HALITE	-4.904	1.549	-6.452	-8.389	118	Na2O	9.981	70.472	-60.491	-78.649
55	HUNTITE	-34.290	-29.607	-4.683	-6.089	122	SrCO3	-10.478	-9.285	-1.193	-1.551
56	HYDRMAGN	-46.253	-37.506	-8.747	-11.372	123	SYLVITE	-6.024	0.751	-6.775	-8.808
57	HYPHILIT	-7.624	12.481	-20.105	-26.140	125	THENARDI	-8.736	-0.294	-8.441	-10.975
67	LIME	-17.882	34.331	-52.213	-67.886	127	TRONA	-15.555	-0.445	-15.110	-19.645
70	MAGNESIT	-8.650	-7.787	-0.864	-1.123	130	WITHERIT	-11.348	-8.733	-2.615	-3.400

SAMPLE IDENT - BR 9 NOV 91

(TEMPERATURE = 11.00)

	PHASE	LOG (AP)	LOG (KT)	LOG (AP/KT)	DELG
11	ANHYDRIT	-7.995	-4.192	-3.803	-4.944
17	ARAGONIT	-9.002	-8.262	-0.739	-0.961
20	BARITE	-11.160	-10.222	-0.938	-1.220
22	BRUCITE	-17.272	-11.489	-5.783	-7.519
24	CALCITE	-9.002	-8.415	-0.587	-0.763
25	CELESTIT	-9.870	-6.446	-3.424	-4.452
41	DOLOMITE	-18.211	-17.841	-0.370	-0.481
42	DSORD	-18.211	-16.195	-2.015	-2.620
51	GYPSUM	-7.995	-4.603	-3.392	-4.410
52	HALITE	-6.058	1.549	-7.607	-9.891
55	HUNTITE	-36.629	-29.607	-7.021	-9.129
56	HYDRMAGN	-49.242	-37.506	-11.736	-15.259
57	HYPHILIT	-11.446	12.481	-23.927	-31.109
67	LIME	-20.191	34.331	-54.522	-70.888
70	MAGNESIT	-9.209	-7.787	-1.422	-1.849
71	MgCl2	-11.653	23.470	-35.123	-45.666
76	MIRABILT	-8.667	-1.772	-6.895	-8.964
81	NACHOLIT	-4.817	-0.586	-4.232	-5.502
82	NATRTHRM	-9.673	0.057	-9.729	-12.650
83	NATRON	-9.673	-1.447	-8.226	-10.696
85	NESQUHON	-9.209	-4.900	-4.309	-5.603
95	PERICLAS	11.711	22.813	-11.102	-14.434
99	PORTLAN	-17.065	-5.305	-11.760	-15.290
100	POTASSI	6.315	87.808	-81.493	-105.956
118	Na2O	11.248	70.473	-59.225	-77.002
122	SrCO3	-10.877	-9.285	-1.592	-2.070
123	SYLVITE	-8.525	0.751	-9.275	-12.060
125	THENARDI	-8.666	-0.294	-8.372	-10.885
127	TRONA	-14.490	-0.445	-14.045	-18.261
130	WITHERIT	-12.167	-8.733	-3.434	-4.465

SAMPLE IDENT - FLO 1 OCT 92 (TEMPERATURE = 11.00)

	PHASE	LOG (AP)	LOG (KT)	LOG (AP/KT)	DELG		PHASE	LOG (AP)	LOG (KT)	LOG (AP/KT)	DELG
11	ANHYDRIT	-6.510	-4.192	-2.317	-3.013	71	MgCl2	-9.463	23.470	-32.933	-42.819
17	ARAGONIT	-8.413	-8.262	-0.151	-0.196	76	MIRABILT	-9.216	-1.772	-7.444	-9.678
20	BARITE	-9.974	-10.222	0.248	0.323	81	NACHOLIT	-5.213	-0.586	-4.628	-6.017
22	BRUCITE	-17.332	-11.489	-5.843	-7.597	82	NATRTHRM	-11.119	0.057	-11.175	-14.530
24	CALCITE	-8.413	-8.415	0.001	0.002	83	NATRON	-11.119	-1.447	-9.672	-12.576
25	CELESTIT	-8.334	-6.446	-1.888	-2.454	85	NESQUHON	-8.616	-4.900	-3.715	-4.831
41	DOLOMITE	-17.029	-17.841	0.812	1.056	95	PERICLAS	11.651	22.813	-11.162	-14.512
42	DSORD	-17.029	-16.195	-0.833	-1.084	99	PORTLAN	-17.130	-5.305	-11.825	-15.375
51	GYPSUM	-6.510	-4.603	-1.907	-2.479	100	POTASSI	6.969	87.808	-80.839	-105.105
52	HALITE	-5.983	1.549	-7.532	-9.793	118	Na2O	9.148	70.472	-61.324	-79.732
55	HUNTITE	-34.260	-29.607	-4.652	-6.049	122	SrCO3	-10.237	-9.285	-0.952	-1.238
56	HYDRMAGN	-46.364	-37.506	-8.858	-11.516	123	SYLVITE	-7.073	0.751	-7.824	-10.172
57	HYPHILIT	-9.261	12.481	-21.742	-28.269	125	THENARDI	-9.215	-0.294	-8.921	-11.598
67	LIME	-17.820	34.331	-52.151	-67.806	127	TRONA	-16.332	-0.445	-15.887	-20.655
70	MAGNESIT	-8.615	-7.787	-0.829	-1.077	130	WITHERIT	-11.877	-8.733	-3.145	-4.089

SAMPLE IDENT - K 2 AUG 92

(TEMPERATURE = 11.00)

	PHASE	LOG (AP)	LOG (KT)	LOG (AP/KT)	DELG
11	ANHYDRIT	-6.719	-4.192	-2.527	-3.285
17	ARAGONIT	-8.281	-8.262	-0.019	-0.024
20	BARITE	-9.923	-10.222	0.299	0.389
22	BRUCITE	-16.044	-11.489	-4.556	-5.923
24	CALCITE	-8.281	-8.415	0.134	0.174
25	CELESTIT	-8.117	-6.446	-1.671	-2.173
41	DOLOMITE	-16.505	-17.841	1.337	1.738
42	DSORD	-16.505	-16.195	-0.309	-0.402
51	GYPSUM	-6.719	-4.603	-2.116	-2.751
52	HALITE	-4.921	1.549	-6.470	-8.412
55	HUNTITE	-32.952	-29.607	-3.345	-4.349
56	HYDRMAGN	-43.845	-37.506	-6.339	-8.241
57	HYPHILIT	-8.081	12.481	-20.562	-26.734
67	LIME	-19.254	34.331	-53.585	-69.670
70	MAGNESIT	-8.224	-7.787	-0.437	-0.568
71	MgCl2	-8.024	23.470	-31.494	-40.948
76	MIRABILT	-8.480	-1.772	-6.708	-8.722
81	NACHOLIT	-5.123	-0.586	-4.537	-5.899
82	NATRTHRM	-10.041	0.057	-10.098	-13.129
83	NATRON	-10.042	-1.447	-8.595	-11.175
85	NESQUHON	-8.224	-4.900	-3.324	-4.322
95	PERICLAS	12.939	22.813	-9.874	-12.838
99	PORTLAN	-16.101	-5.305	-10.796	-14.037
100	POTASSI	8.608	87.808	-79.200	-102.974
118	Na2O	11.122	70.472	-59.350	-77.166
122	SrCO3	-9.679	-9.285	-0.394	-0.512
123	SYLVITE	-6.177	0.751	-6.928	-9.008
125	THENARDI	-8.479	-0.294	-8.185	-10.642
127	TRONA	-15.164	-0.445	-14.719	-19.137
130	WITHERIT	-11.485	-8.733	-2.752	-3.578

SAMPLE IDENT - M1 AUG 92

(TEMPERATURE = 11.00)

	PHASE	LOG (AP)	LOG (KT)	LOG (AP/KT)	DELG
11	ANHYDRIT	-6.744	-4.192	-2.552	-3.317
17	ARAGONIT	-8.576	-8.262	-0.314	-0.408
20	BARITE	-10.119	-10.222	0.103	0.134
22	BRUCITE	-16.368	-11.489	-4.880	-6.344
24	CALCITE	-8.576	-8.415	-0.161	-0.209
25	CELESTIT	-8.074	-6.446	-1.628	-2.116
41	DOLOMITE	-17.021	-17.841	0.820	1.067
42	DSORD	-17.021	-16.195	-0.825	-1.073
51	GYPSUM	-6.744	-4.603	-2.141	-2.784
52	HALITE	-5.193	1.549	-6.742	-8.766
55	HUNTITE	-33.910	-29.607	-4.303	-5.595
56	HYDRMAGN	-44.933	-37.506	-7.426	-9.656
57	HYPHILIT	-8.820	12.481	-21.300	-27.694
67	LIME	-19.205	34.331	-53.536	-69.606
70	MAGNESIT	-8.445	-7.787	-0.658	-0.856
71	MgCl2	-8.689	23.470	-32.159	-41.812
76	MIRABILT	-8.312	-1.772	-6.539	-8.502
81	NACHOLIT	-5.122	-0.586	-4.536	-5.898
82	NATRTHRM	-10.143	0.057	-10.199	-13.261
83	NATRON	-10.143	-1.447	-8.696	-11.307
85	NESQUHON	-8.445	-4.900	-3.545	-4.609
95	PERICLAS	12.615	22.813	-10.198	-13.260
99	PORTLAN	-16.499	-5.305	-11.194	-14.555
100	POTASSI	8.325	87.808	-79.483	-103.342
118	Na2O	10.917	70.472	-59.555	-77.432
122	SrCO3	-9.906	-9.285	-0.621	-0.807
123	SYLVITE	-6.489	0.751	-7.240	-9.413
125	THENARDI	-8.311	-0.294	-8.016	-10.423
127	TRONA	-15.265	-0.445	-14.819	-19.268
130	WITHERIT	-11.951	-8.733	-3.219	-4.185
144	FeCl2	-12.396	8.573	-20.969	-27.263
146	FeCO3	-12.152	-10.414	-1.738	-2.260
147	FeO	8.908	14.366	-5.458	-7.097

SAMPLE IDENT - M2 AUG 92

(TEMPERATURE = 11.00)

	PHASE	LOG (AP)	LOG (KT)	LOG (AP/KT)	DELG		PHASE	LOG (AP)	LOG (KT)	LOG (AP/KT)	DELG
11	ANHYDRIT	-6.522	-4.192	-2.330	-3.029	71	MgCl2	-8.822	23.470	-32.292	-41.985
17	ARAGONIT	-8.172	-8.262	0.090	0.117	76	MIRABILT	-8.782	-1.772	-7.010	-9.114
20	BARITE	-9.996	-10.222	0.226	0.294	81	NACHOLIT	-5.201	-0.586	-4.615	-6.001
22	BRUCITE	-16.276	-11.489	-4.787	-6.225	82	NATRTHRM	-10.431	0.057	-10.488	-13.636
24	CALCITE	-8.172	-8.415	0.242	0.315	83	NATRON	-10.432	-1.447	-8.985	-11.682
25	CELESTIT	-8.126	-6.446	-1.680	-2.184	85	NESQUHON	-8.222	-4.900	-3.322	-4.320
41	DOLOMITE	-16.394	-17.841	1.447	1.881	95	PERICLAS	12.707	22.813	-10.106	-13.140
42	DSORD	-16.394	-16.195	-0.199	-0.259	99	PORTLAN	-16.226	-5.305	-10.921	-14.200
51	GYPSUM	-6.523	-4.603	-1.919	-2.496	100	POTASSI	8.240	87.808	-79.568	-103.453
52	HALITE	-5.515	1.549	-7.064	-9.185	118	Na2O	10.498	70.472	-59.974	-77.977
55	HUNTITE	-32.839	-29.607	-3.231	-4.201	122	SrCO3	-9.776	-9.285	-0.491	-0.638
56	HYDRMAGN	-44.087	-37.506	-6.581	-8.556	123	SYLVITE	-6.645	0.751	-7.395	-9.615
57	HYPHILIT	-8.772	12.481	-21.253	-27.632	125	THENARDI	-8.781	-0.294	-8.487	-11.034
67	LIME	-18.946	34.331	-53.277	-69.270	127	TRONA	-15.632	-0.445	-15.187	-19.746
70	MAGNESIT	-8.222	-7.787	-0.435	-0.566	130	WITHERIT	-11.646	-8.733	-2.914	-3.788

SAMPLE IDENT - OB1 APR 92

(TEMPERATURE = 11.00)

	PHASE	LOG (AP)	LOG (KT)	LOG (AP/KT)	DELG		PHASE	LOG (AP)	LOG (KT)	LOG (AP/KT)	DELG
11	ANHYDRIT	-7.233	-4.192	-3.040	-3.953	71	MgCl2	-10.778	23.470	-34.248	-44.528
17	ARAGONIT	-8.481	-8.262	-0.219	-0.285	76	MIRABILT	-11.479	-1.772	-9.707	-12.621
20	BARITE	-10.467	-10.222	-0.245	-0.319	81	NACHOLIT	-6.327	-0.586	-5.742	-7.465
22	BRUCITE	-16.857	-11.489	-5.368	-6.980	82	NATRTHRM	-12.728	0.057	-12.784	-16.622
24	CALCITE	-8.481	-8.415	-0.067	-0.087	83	NATRON	-12.728	-1.447	-11.281	-14.667
25	CELESTIT	-10.124	-6.446	-3.678	-4.781	85	NESQUHON	-8.760	-4.900	-3.860	-5.018
41	DOLOMITE	-17.241	-17.841	0.600	0.780	95	PERICLAS	12.126	22.813	-10.687	-13.895
42	DSORD	-17.241	-16.195	-1.046	-1.360	99	PORTLAN	-16.579	-5.305	-11.274	-14.658
51	GYPSUM	-7.233	-4.603	-2.629	-3.419	100	POTASSI	7.865	87.808	-79.944	-103.941
52	HALITE	-7.373	1.549	-8.922	-11.600	118	Na2O	8.159	70.472	-62.314	-81.019
55	HUNTITE	-34.761	-29.607	-5.154	-6.701	122	SrCO3	-11.373	-9.285	-2.088	-2.714
56	HYDRMAGN	-46.560	-37.506	-9.054	-11.772	123	SYLVITE	-7.520	0.751	-8.270	-10.753
57	HYPHILIT	-10.499	12.481	-22.980	-29.878	125	THENARDI	-11.479	-0.294	-11.184	-14.542
67	LIME	-18.695	34.331	-53.026	-68.943	127	TRONA	-19.055	-0.445	-18.610	-24.196
70	MAGNESIT	-8.760	-7.787	-0.973	-1.265	130	WITHERIT	-11.716	-8.733	-2.983	-3.879

SAMPLE IDENT - OB 2 JUN 92

(TEMPERATURE = 11.00)

	PHASE	LOG (AP)	LOG (KT)	LOG (AP/KT)	DELG		PHASE	LOG (AP)	LOG (KT)	LOG (AP/KT)	DELG
11	ANHYDRIT	-6.880	-4.192	-2.688	-3.495	71	MgCl2	-8.343	23.470	-31.813	-41.363
17	ARAGONIT	-8.399	-8.262	-0.137	-0.178	76	MIRABILT	-9.168	-1.772	-7.396	-9.616
20	BARITE	-10.011	-10.222	0.211	0.274	81	NACHOLIT	-5.260	-0.586	-4.675	-6.078
22	BRUCITE	-16.574	-11.489	-5.085	-6.612	82	NATRTHRM	-10.686	0.057	-10.743	-13.967
24	CALCITE	-8.399	-8.415	0.016	0.020	83	NATRON	-10.687	-1.447	-9.240	-12.013
25	CELESTIT	-9.565	-6.446	-3.119	-4.055	85	NESQUHON	-8.384	-4.900	-3.484	-4.530
41	DOLOMITE	-16.783	-17.841	1.058	1.375	95	PERICLAS	12.410	22.813	-10.404	-13.527
42	DSORD	-16.783	-16.195	-0.588	-0.764	99	PORTLAN	-16.589	-5.305	-11.284	-14.671
51	GYPSUM	-6.880	-4.603	-2.277	-2.961	100	POTASSI	8.268	87.808	-79.540	-103.416
52	HALITE	-5.322	1.549	-6.871	-8.934	118	Na2O	10.108	70.472	-60.364	-78.484
55	HUNTITE	-33.552	-29.607	-3.944	-5.128	122	SrCO3	-11.084	-9.285	-1.799	-2.339
56	HYDRMAGN	-44.870	-37.506	-7.364	-9.574	123	SYLVITE	-6.242	0.751	-6.993	-9.092
57	HYPHILIT	-8.358	12.481	-20.839	-27.094	125	THENARDI	-9.167	-0.294	-8.873	-11.536
67	LIME	-18.711	34.331	-53.042	-68.965	127	TRONA	-15.946	-0.445	-15.501	-20.154
70	MAGNESIT	-8.384	-7.787	-0.597	-0.777	130	WITHERIT	-11.530	-8.733	-2.798	-3.637

SAMPLE IDENT - SW1 NOV 91 (TEMPERATURE = 11.00)

	PHASE	LOG (AP)	LOG (KT)	LOG (AP/KT)	DELG		PHASE	LOG (AP)	LOG (KT)	LOG (AP/KT)	DELG
6	ALUNITE	-0.934	-1.168	0.234	0.304	67	LIME	-18.249	34.331	-52.580	-68.363
11	ANHYDRIT	-6.382	-4.192	-2.190	-2.847	70	MAGNESIT	-8.570	-7.787	-0.783	-1.018
17	ARAGONIT	-8.362	-8.262	-0.100	-0.130	71	MgCl2	-8.481	23.470	-31.951	-41.541
20	BARITE	-9.989	-10.222	0.233	0.303	76	MIRABILT	-9.554	-1.772	-7.782	-10.118
21	BOEHMITE	11.194	7.888	3.306	4.299	81	NACHOLIT	-5.631	-0.586	-5.045	-6.560
22	BRUCITE	-16.866	-11.489	-5.377	-6.992	82	NATRTHRM	-11.533	0.057	-11.590	-15.069
24	CALCITE	-8.362	-8.415	0.053	0.069	83	NATRON	-11.534	-1.447	-10.087	-13.115
25	CELESTIT	-9.555	-6.446	-3.109	-4.042	85	NESQUHON	-8.570	-4.900	-3.670	-4.772
36	CORUNDUM	22.388	23.656	-1.268	-1.648	95	PERICLAS	12.117	22.813	-10.696	-13.907
41	DOLOMITE	-16.932	-17.841	0.909	1.182	99	PORTLAN	-16.658	-5.305	-11.353	-14.761
42	DSORD	-16.932	-16.195	-0.737	-0.958	100	POTASSI	5.796	87.808	-82.012	-106.630
48	GIBBS AM	-32.281	-34.838	2.557	3.324	118	Na2O	9.154	70.472	-61.318	-79.724
49	GIBBSITE	-32.281	-35.450	3.169	4.120	119	SPINEL	34.506	39.700	-5.194	-6.754
51	GYPSUM	-6.382	-4.603	-1.779	-2.313	122	SrCO3	-11.535	-9.285	-2.250	-2.925
52	HALITE	-5.722	1.549	-7.271	-9.453	123	SYLVITE	-7.401	0.751	-8.152	-10.598
55	HUNTITE	-34.072	-29.607	-4.464	-5.804	125	THENARDI	-9.553	-0.294	-9.259	-12.038
56	HYDRMAGN	-45.746	-37.506	-8.240	-10.713	127	TRONA	-17.164	-0.445	-16.719	-21.737
57	HYPHILIT	-8.273	12.481	-20.753	-26.983	130	WITHERIT	-11.969	-8.733	-3.236	-4.207

SAMPLE IDENT - SW 2 NOV 91 (TEMPERATURE = 11.00)

	PHASE	LOG (AP)	LOG (KT)	LOG (AP/KT)	DELG
11	ANHYDRIT	-7.303	-4.192	-3.110	-4.044
17	ARAGONIT	-8.463	-8.262	-0.201	-0.261
20	BARITE	-10.663	-10.222	-0.441	-0.573
22	BRUCITE	-17.294	-11.489	-5.805	-7.548
24	CALCITE	-8.463	-8.415	-0.048	-0.063
25	CELESTIT	-10.155	-6.446	-3.709	-4.822
41	DOLOMITE	-17.303	-17.841	0.539	0.700
42	DSORD	-17.303	-16.195	-1.107	-1.440
51	GYPSUM	-7.303	-4.603	-2.699	-3.510
52	HALITE	-7.280	1.549	-8.829	-11.479
55	HUNTITE	-34.982	-29.607	-5.374	-6.987
56	HYDRMAGN	-47.222	-37.506	-9.716	-12.633
57	HYPHILIT	-10.322	12.481	-22.803	-29.648
67	LIME	-18.132	34.331	-52.464	-68.212
70	MAGNESIT	-8.839	-7.787	-1.053	-1.369
71	MgCl2	-10.699	23.470	-34.169	-44.425
76	MIRABILT	-11.540	-1.772	-9.768	-12.700
81	NACHOLIT	-6.135	-0.586	-5.550	-7.215
82	NATRTHRM	-12.701	0.057	-12.757	-16.586
83	NATRON	-12.701	-1.447	-11.254	-14.632
85	NESQUHON	-8.840	-4.900	-3.939	-5.122
95	PERICLAS	11.689	22.813	-11.124	-14.463
99	PORTLAN	-16.918	-5.305	-11.613	-15.099
100	POTASSI	5.559	87.808	-82.249	-106.938
118	Na2O	7.828	70.472	-62.644	-81.448
122	SrCO3	-11.316	-9.285	-2.030	-2.640
123	SYLVITE	-8.414	0.751	-9.165	-11.916
125	THENARDI	-11.540	-0.294	-11.245	-14.621
127	TRONA	-18.836	-0.445	-18.390	-23.911
130	WITHERIT	-11.824	-8.733	-3.091	-4.019
144	FeCl2	-14.173	8.573	-22.746	-29.574
146	FeCO3	-12.314	-10.414	-1.900	-2.470
147	FeO	8.215	14.366	-6.151	-7.998

SAMPLE IDENT - SW 4 NOV 91 (TEMPERATURE = 11.00)

	PHASE	LOG (AP)	LOG (KT)	LOG (AP/KT)	DELG		PHASE	LOG (AP)	LOG (KT)	LOG (AP/KT)	DELG
11	ANHYDRIT	-6.705	-4.192	-2.512	-3.266	71	MgCl2	-7.816	23.470	-31.286	-40.677
17	ARAGONIT	-7.256	-8.262	1.007	1.309	76	MIRABILT	-8.345	-1.772	-6.573	-8.546
22	BRUCITE	-14.787	-11.489	-3.299	-4.289	81	NACHOLIT	-4.826	-0.586	-4.240	-5.513
24	CALCITE	-7.256	-8.415	1.159	1.507	82	NATRTHRM	-8.895	0.057	-8.951	-11.638
25	CELESTIT	-8.791	-6.446	-2.345	-3.049	83	NATRON	-8.896	-1.447	-7.449	-9.685
41	DOLOMITE	-14.776	-17.841	3.066	3.986	85	NESQUHON	-7.520	-4.900	-2.620	-3.407
42	DSORD	-14.776	-16.195	1.420	1.846	95	PERICLAS	14.196	22.813	-8.617	-11.204
51	GYPSUM	-6.705	-4.603	-2.102	-2.733	99	PORTLAN	-14.523	-5.305	-9.218	-11.986
52	HALITE	-4.595	1.549	-6.144	-7.989	100	POTASSI	9.606	87.808	-78.202	-101.677
55	HUNTITE	-29.815	-29.607	-0.208	-0.270	118	Na2O	12.821	70.472	-57.651	-74.956
56	HYDRMAGN	-40.572	-37.506	-3.065	-3.986	122	SrCO3	-9.343	-9.285	-0.058	-0.075
57	HYPHILIT	-7.552	12.481	-20.033	-26.046	123	SYLVITE	-6.203	0.751	-6.954	-9.041
67	LIME	-20.381	34.331	-54.712	-71.136	125	THENARDI	-8.343	-0.294	-8.049	-10.465
70	MAGNESIT	-7.520	-7.787	0.267	0.347	127	TRONA	-13.721	-0.445	-13.275	-17.260

SAMPLE IDENT - SW 5 NOV 91

(TEMPERATURE = 11.00)

	PHASE	LOG (AP)	LOG (KT)	LOG (AP/KT)	DELG		PHASE	LOG (AP)	LOG (KT)	LOG (AP/KT)	DELG
11	ANHYDRIT	-6.686	-4.192	-2.494	-3.242	71	MgCl2	-9.204	23.470	-32.674	-42.482
17	ARAGONIT	-7.986	-8.262	0.276	0.359	76	MIRABILT	-9.745	-1.772	-7.973	-10.366
22	BRUCITE	-16.419	-11.489	-4.931	-6.411	81	NACHOLIT	-5.387	-0.586	-4.801	-6.243
24	CALCITE	-7.986	-8.415	0.428	0.557	82	NATRTHRM	-11.044	0.057	-11.101	-14.433
25	CELESTIT	-8.981	-6.446	-2.535	-3.296	83	NATRON	-11.045	-1.447	-9.598	-12.479
41	DOLOMITE	-16.111	-17.841	1.731	2.250	85	NESQUHON	-8.124	-4.900	-3.224	-4.192
42	DSORD	-16.111	-16.195	0.085	0.110	95	PERICLAS	12.564	22.813	-10.249	-13.326
51	GYPSUM	-6.686	-4.603	-2.083	-2.708	99	PORTLAN	-16.282	-5.305	-10.977	-14.272
52	HALITE	-6.062	1.549	-7.611	-9.896	100	POTASSI	7.434	87.808	-80.374	-104.500
55	HUNTITE	-32.359	-29.607	-2.751	-3.577	118	Na2O	9.644	70.472	-60.828	-79.088
56	HYDRMAGN	-43.951	-37.506	-6.445	-8.380	122	SrCO3	-10.282	-9.285	-0.997	-1.296
57	HYPHILIT	-9.066	12.481	-21.547	-28.015	123	SYLVITE	-7.167	0.751	-7.917	-10.294
67	LIME	-18.745	34.331	-53.077	-69.009	125	THENARDI	-9.744	-0.294	-9.449	-12.286
70	MAGNESIT	-8.124	-7.787	-0.337	-0.439	127	TRONA	-16.431	-0.445	-15.986	-20.785

SAMPLE IDENT - SW 6 NOV 91 (TEMPERATURE = 11.00)

	PHASE	LOG (AP)	LOG (KT)	LOG (AP/KT)	DELG		PHASE	LOG (AP)	LOG (KT)	LOG (AP/KT)	DELG
11	ANHYDRIT	-7.353	-4.192	-3.160	-4.109	71	MgCl2	-9.933	23.470	-33.403	-43.429
17	ARAGONIT	-7.801	-8.262	0.461	0.600	76	MIRABILT	-11.013	-1.772	-9.241	-12.015
22	BRUCITE	-15.587	-11.489	-4.098	-5.328	81	NACHOLIT	-5.931	-0.586	-5.345	-6.950
24	CALCITE	-7.801	-8.415	0.614	0.798	82	NATRTHRM	-11.461	0.057	-11.518	-14.975
25	CELESTIT	-9.875	-6.446	-3.429	-4.459	83	NATRON	-11.462	-1.447	-10.015	-13.021
41	DOLOMITE	-15.764	-17.841	2.077	2.701	85	NESQUHON	-7.963	-4.900	-3.063	-3.982
42	DSORD	-15.764	-16.195	0.432	0.561	95	PERICLAS	13.397	22.813	-9.417	-12.243
51	GYPSUM	-7.353	-4.603	-2.750	-3.575	99	PORTLAN	-15.425	-5.305	-10.120	-13.158
52	HALITE	-6.716	1.549	-8.265	-10.745	100	POTASSI	7.642	87.808	-80.166	-104.230
55	HUNTITE	-31.689	-29.607	-2.082	-2.707	118	Na2O	9.898	70.472	-60.574	-78.757
56	HYDRMAGN	-42.717	-37.506	-5.210	-6.775	122	SrCO3	-10.324	-9.285	-1.039	-1.350
57	HYPHILIT	-9.771	12.481	-22.252	-28.931	123	SYLVITE	-7.844	0.751	-8.594	-11.174
67	LIME	-19.718	34.331	-54.049	-70.273	125	THENARDI	-11.013	-0.294	-10.719	-13.936
70	MAGNESIT	-7.963	-7.787	-0.176	-0.229	127	TRONA	-17.392	-0.445	-16.947	-22.034

SAMPLE IDENT - SW 7 NOV 91

(TEMPERATURE = 11.00)

	PHASE	LOG (AP)	LOG (KT)	LOG (AP/KT)	DELG		PHASE	LOG (AP)	LOG (KT)	LOG (AP/KT)	DELG
11	ANHYDRIT	-6.984	-4.192	-2.791	-3.629	71	MgCl2	-9.127	23.470	-32.597	-42.382
17	ARAGONIT	-7.672	-8.262	0.590	0.767	76	MIRABILT	-9.873	-1.772	-8.100	-10.532
22	BRUCITE	-15.518	-11.489	-4.030	-5.239	81	NACHOLIT	-5.471	-0.586	-4.885	-6.352
24	CALCITE	-7.672	-8.415	0.742	0.965	82	NATRTHRM	-10.561	0.057	-10.617	-13.804
25	CELESTIT	-9.266	-6.446	-2.820	-3.666	83	NATRON	-10.561	-1.447	-9.114	-11.850
41	DOLOMITE	-15.548	-17.841	2.294	2.982	85	NESQUHON	-7.875	-4.900	-2.975	-3.868
42	DSORD	-15.548	-16.195	0.648	0.842	95	PERICLAS	13.465	22.813	-9.348	-12.155
51	GYPSUM	-6.984	-4.603	-2.381	-3.095	99	PORTLAN	-15.316	-5.305	-10.011	-13.016
52	HALITE	-5.906	1.549	-7.455	-9.693	100	POTASSI	8.353	87.808	-79.455	-103.306
55	HUNTITE	-31.298	-29.607	-1.690	-2.198	118	Na2O	10.780	70.472	-59.693	-77.611
56	HYDRMAGN	-42.405	-37.506	-4.899	-6.370	122	SrCO3	-9.954	-9.285	-0.669	-0.870
57	HYPHILIT	-8.924	12.481	-21.405	-27.831	123	SYLVITE	-7.119	0.751	-7.870	-10.233
67	LIME	-19.785	34.331	-54.116	-70.360	125	THENARDI	-9.872	-0.294	-9.578	-12.452
70	MAGNESIT	-7.875	-7.787	-0.088	-0.115	127	TRONA	-16.032	-0.445	-15.586	-20.265

Appendix D- Description of Sampling Sites

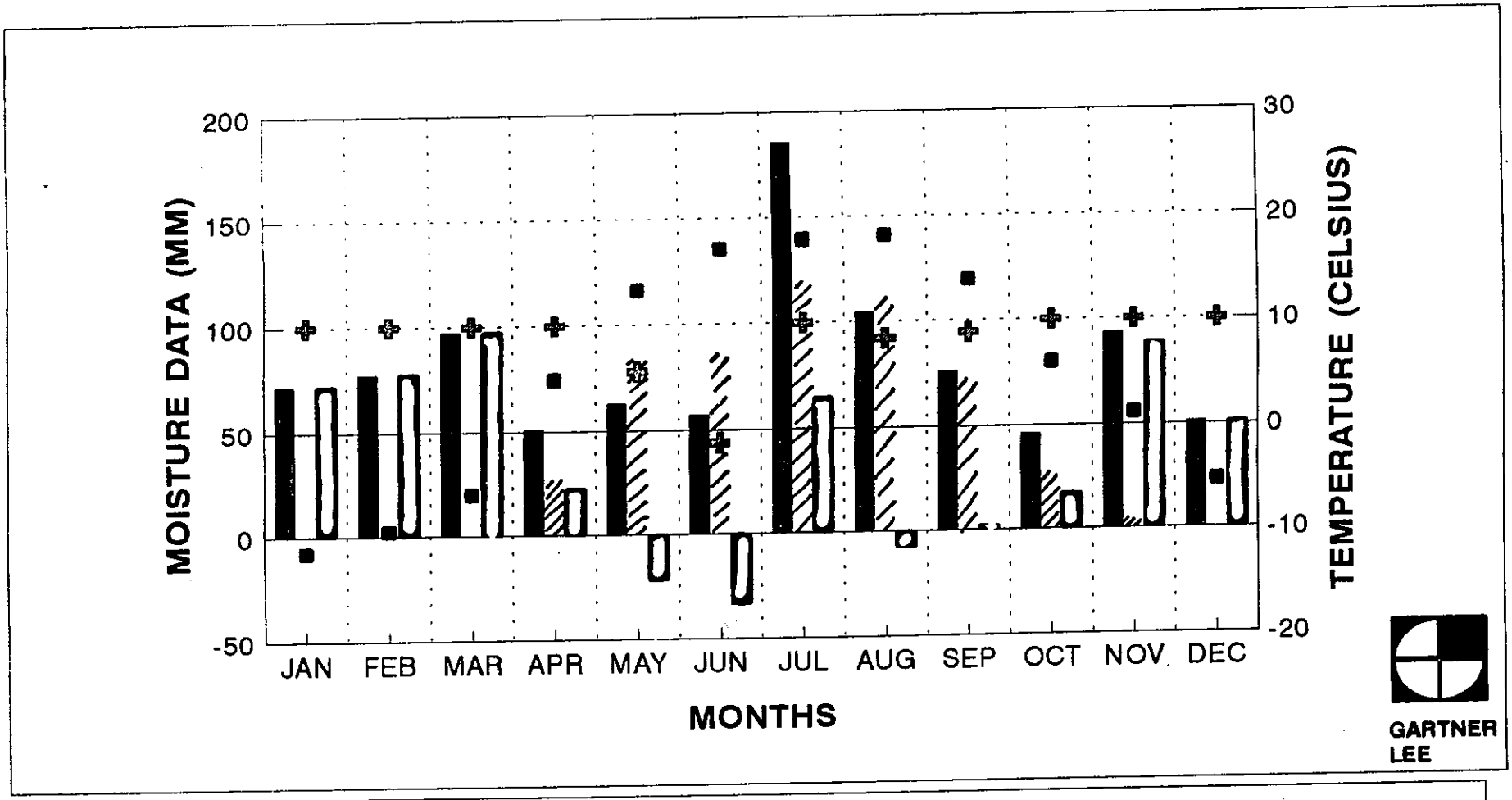
SW1	headwater		
SW2	bridge blackscorners		
SW3	bridge beyond ashton		
SW4	bridge north of dwyer hill		
SW5	bridge before richmond		
SW6	richmond		
SW7	twin elm		
SW8	bridge hearts desire		
BR1	3 Longridge Court	outside tap	Skinner, 838-3628
BR2	rr5 Rideau twp,Mills Corners	kitchen tap	Good,838-2921
BR3	rr5, north Richmond	outside tap	Hamel, 838-5761
BR4	Franktown	outside tap	Ken Ferguson 283-9780
BR5	Franktown	outside tap	Ed Smith 284-03606
BR6	Carleton Place	kitchen tap	McNeely 257-1868
BR7	Ashton	outside tap	Brian Day 257 5999
BR8	Ashton	kitchen tap	General Store 257-7176
BR9	8470 McCaffrey Trail	kitchen tap	Martelle 257.2244
BR10	8034 Bleeks Road	kitchen tap	Strolovich 838-2107
BR11	32 Lucas Lane	kitchen tap	O'Connor 831-1760
BR12	2535 Munster Road	kitchen tap	Bobier 838 5304
BR13	Munster Road	kitchen tap	Fisher 838-5801
BR14	6 Matilda Gate 6	kitchen tap	Murphy 838-4782
BR15	20 Kimini Drive	kitchen tap	Berewiski 831-2895

BR16	3530McBean Street Richmond K0A 2Z0	basement tap	Brian Davis 838-2729
OB1	Moodie Drive	bathroom tap	Frank Brophy 838 5573
OB2	rr5, north Richmond	piezometer	Hamel, 838-5761
BR17	Moodie Drive	kitchen tap	Frank Brophy 838 5573
FLO1	Richmond Day-Cor	piezometer flowing	Richmond
K1	Communal Well Kings Court	tap	RMOC
K2	Communal Well Kings Court	tap	RMOC
M1	Communal Well Munster	tap	RMOC
M2	Communal Well Munster	tap	RMOC

Appendix E

Water Budget for the Jock River Basin after Dillon (1993)

WATER BALANCE SUMMARY
OTTAWA AIRPORT, 1992



CALCULATED USING THORNTHWAITE METHOD, ASSUMED SOIL MOISTURE CAPACITY: 100 MM

GLL 92106, JJPM, 930311