GRAVITY CONSTRAINTS ON BEDROCK TOPOGRAPHY BENEATH ST. JEAN ESTUARY, GASPÉ, QUÉBEC, CANADA

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Introduction

A gravity survey was undertaken to investigate possible subsurface controls on the origin of the Douglastown and Haldimand Spits near Gaspé Bay on the northeast coast of the Gaspé Peninsula. The primary focus of the gravity survey was to determine the depth and topography of the bedrock beneath the St. Jean Estuary. It was hoped that a detailed knowledge of bedrock topography and distribution of materials overlying bedrock would help constrain theories of spit formation, especially those advocating glacial control.

Methods

The estuary is separated from Gaspé Bay by the Douglastown and Haldimand Spits. One gravity traverse was located directly across these spits. Another gravity line was chosen along a highway located approximately six kilometers upstream from the spit traverse. This second traverse was chosen in order to provide additional insights into valley geometry and to provide additional information on regional variations in gravity. Thirty-eight stations were surveyed across the two spits, and twenty-seven stations were surveyed along the highway that crosses the St. Jean River at a point where bedrock is exposed. A theodolite was used to accurately determine distances and elevations for each station. Variations in gravitational accelerations were measured with a Worden gravimeter. Each two-hour segment of readings was opened and closed with a measurement at a base station so that the meter-specific drift and tidal corrections could be applied to all readings. Free-air, Bouguer, and terrain corrections were computed, and the resulting gravity values were plotted.

Data Analysis

A regional gravity trend was observed in both traverses (Figs. 1 and 2). A line was fit to both sets of data to define the regional trend which then was subtracted from the original gravity values to reveal residual anomalies (Figs. 3 and 4). These residual anomalies were analyzed using a computer program that calculates Bouguer anomaly values for subsurface models.

Various two-dimensional models of the spit region were created using a computer program from Burger (1992) with constraints supplied by regional geology (bedrock outcrops on either side of the valley), the dimensions of the spits, and seismic information (bedrock depths). The final model that most closely matches the residual data describes a broad, relatively shallow, gently sloping valley filled with saturated sand and gravel with a bedrock surface at a depth of 50 meters beneath the spits (Fig. 5). The residual gravity of the highway traverse gives no indication of a deeply-buried bedrock valley. The profile of the bedrock surface in this area is fairly flat and slopes east toward the spits.

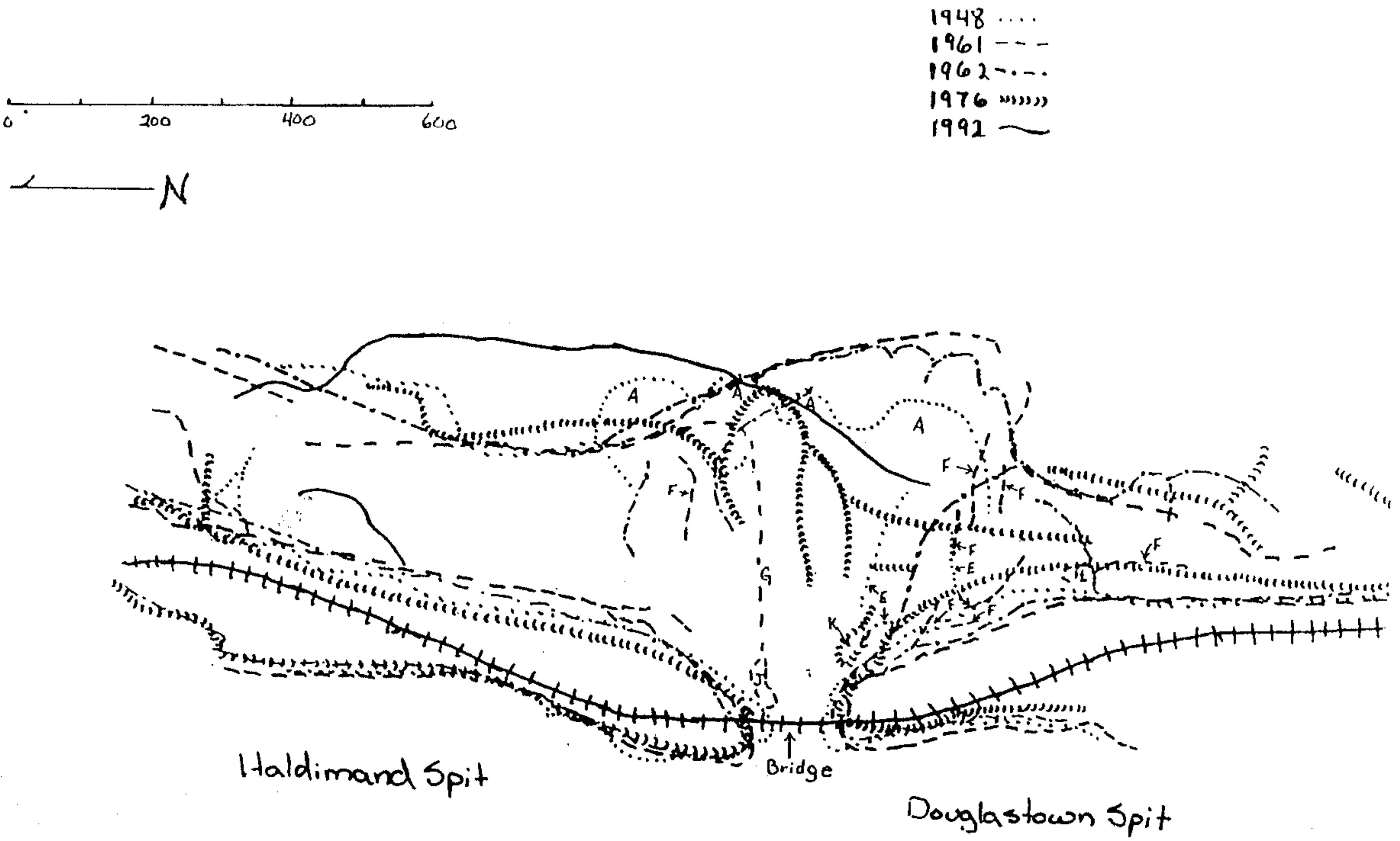

Figure 3: Compilation of the coast lines and terminal lobes of 1948 to 1992.

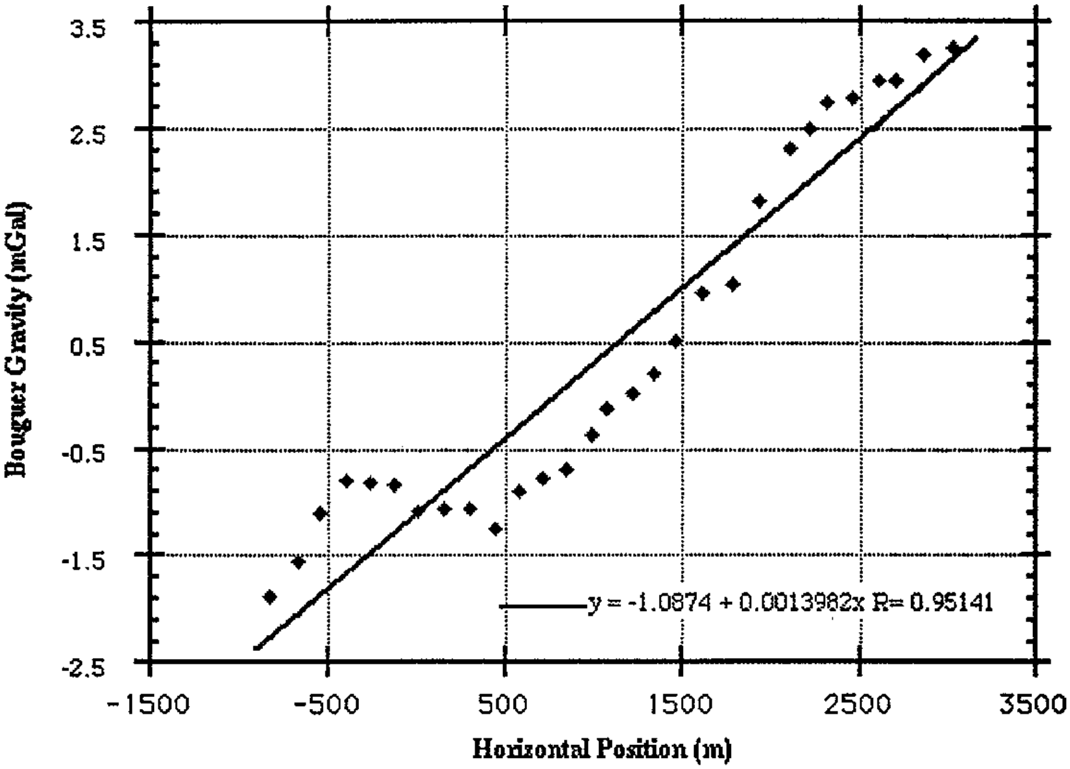

Figure 1. Gravity values along the Douglastown and Haldimand Spits.

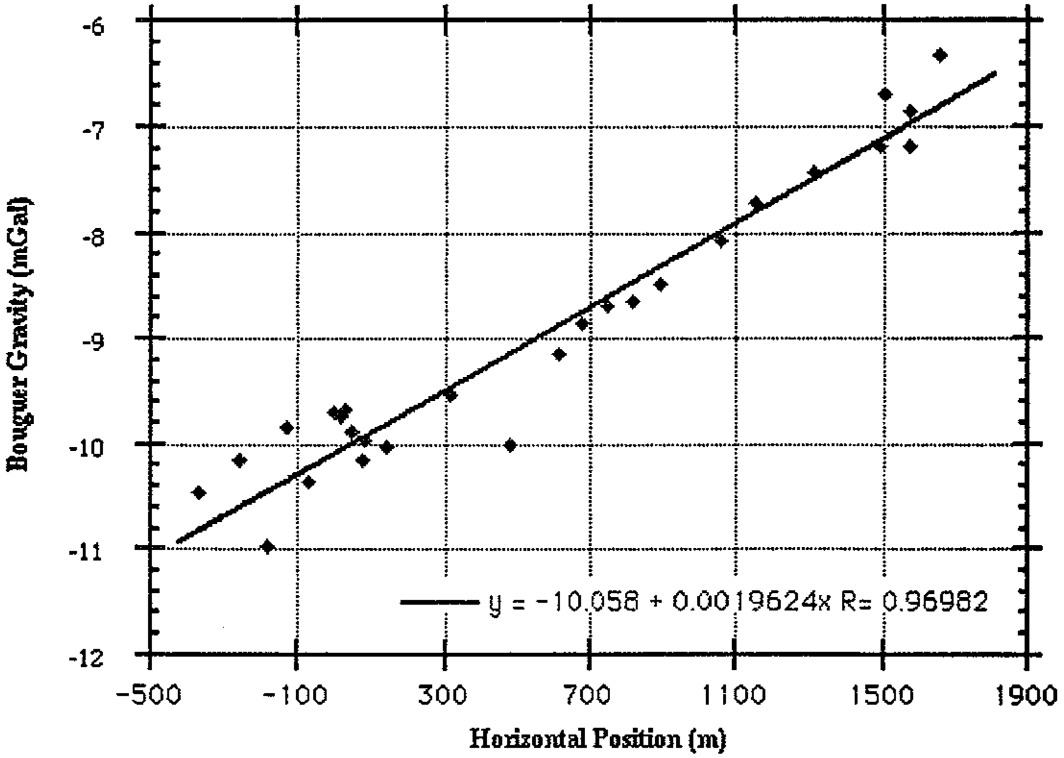

Figure 2. Gravity values along a highway six kilometers upstream from the Douglastown and Haldimand Spits

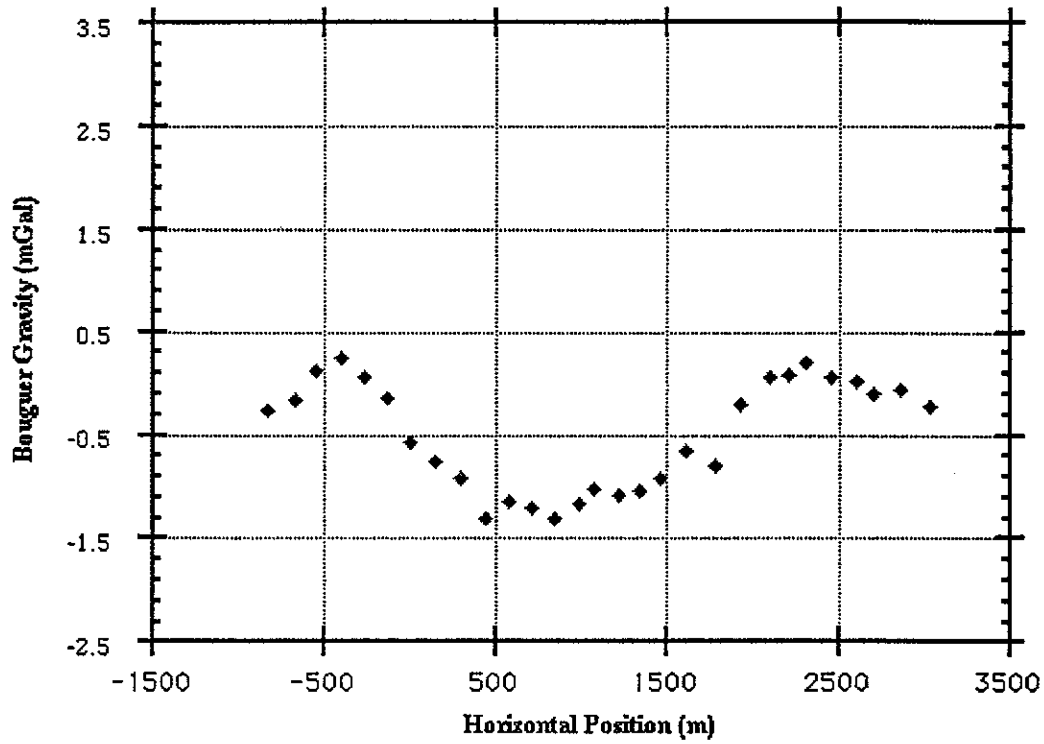

Figure 3. Residual gravity values along the Douglastown and Haldimand Spits.

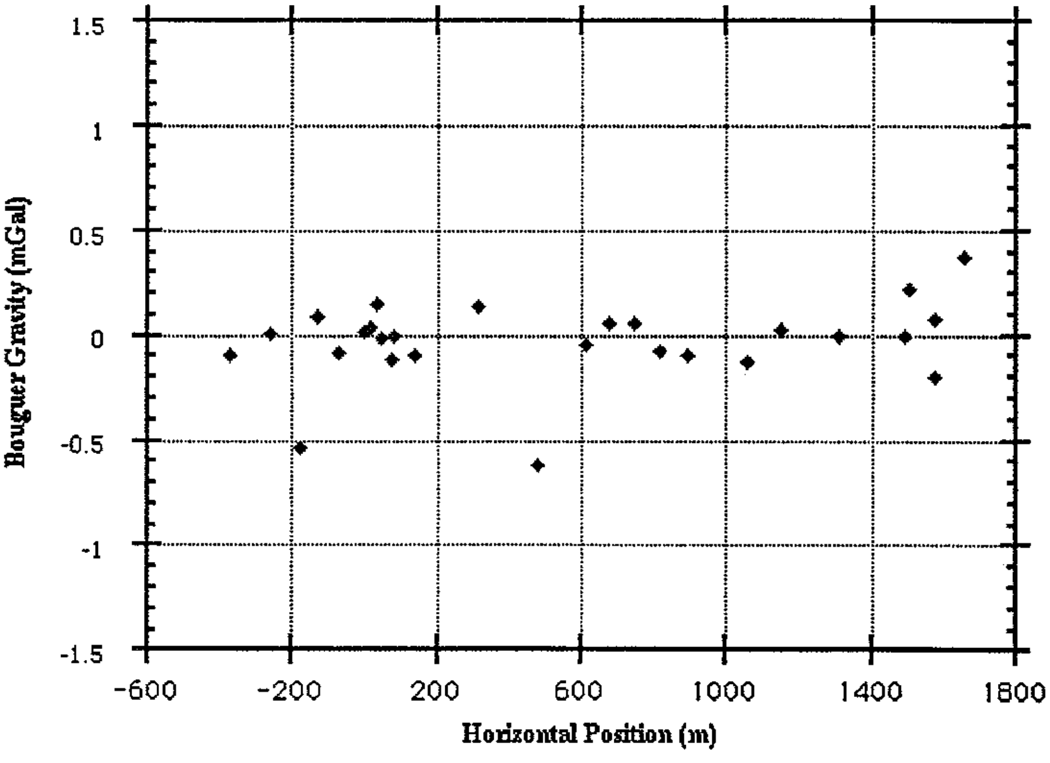

Figure 4. Residual gravity values along the highway traverse.

Conclusion

Analysis of the gravity data reveals a broad, relatively shallow valley that slopes gently toward the east (Fig. 6). These results indicate that there are no obvious subsurface controls on spit formation, such as glacial moraine deposits in a U-shaped valley.

Reference Cited

Burger, H. Robert, 1992, Exploration Geophysics of the Shallow Subsurface: Prentice-Hall, 489 p.

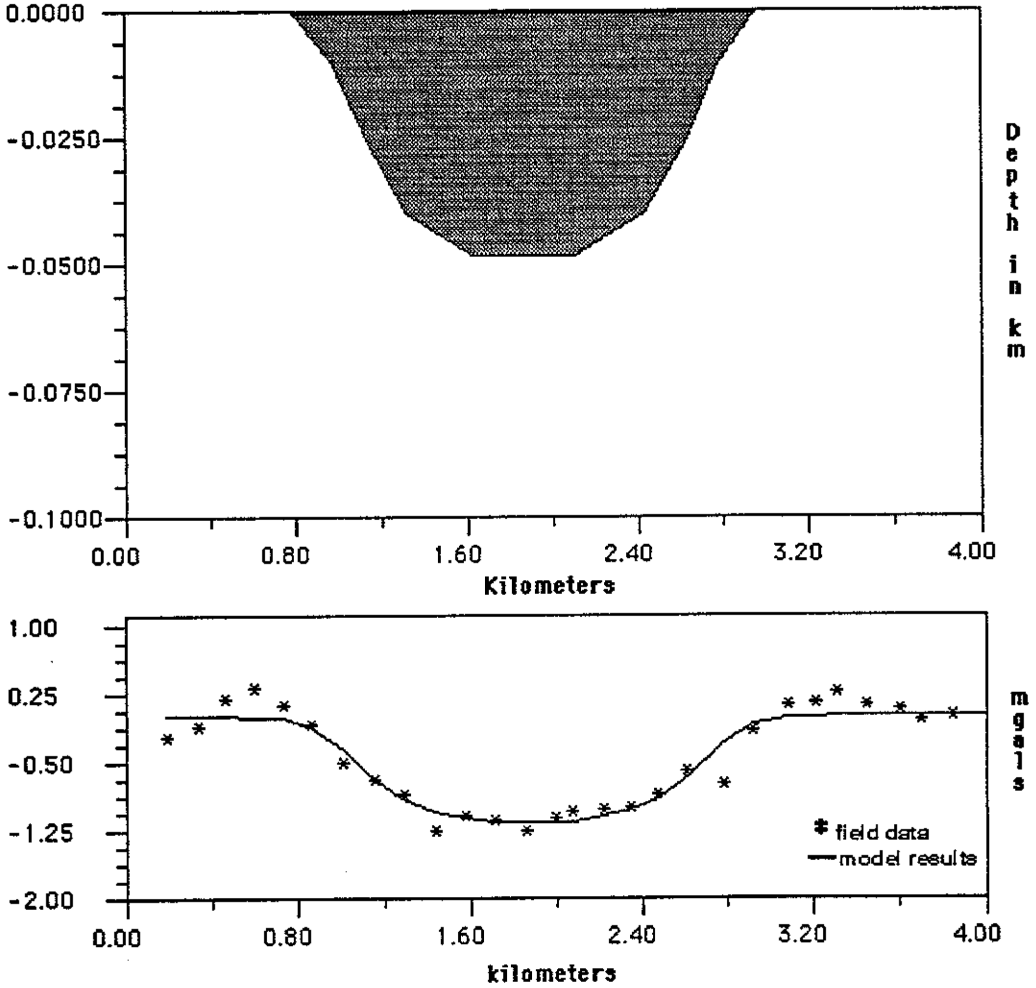

Figure 5. The best-fit model that gives model results most closely following the residual data for the Douglastown and Haldimand Spits and constraints imposed by seismic refraction results.

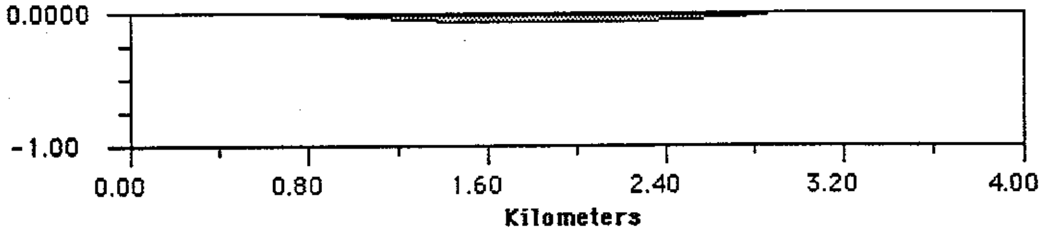

Figure 6. Bedrock profile beneath the Douglastown and Haldimand Spits. This profile is the model illustrated in Figure 5 as drawn with horizontal and vertical scales approximately equal.

Salinity Features of the St. Jean Estuary, Gaspé, Quebec, Canada

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Introduction

The salinity of the St. Jean Estuary was measured and analyzed to be able to categorize it under the estuary classifications of well-mixed estuary, partially-mixed estuary, salt-wedge estuary, or fjord-type estuary (Boggs, 1987). An estuary is an environment of changing salinities due to seawater at one opening and fresh water at the other. Estuaries are classified according to the degree of mixing between these two forces. It is important to note which factor is dominant in a certain estuary. An estuary dominated by tides will have seawater traveling far up into the main body of the estuary. On the other hand, if an estuary is mainly influenced by river influx, fresh water travels farther into the main body of water creating a less brackish environment. Specific items such as the vertical salinity gradient and the relative position of the isohalines were looked at to help identify the amount of mixing occurring in the St. Jean Estuary. Another item of consideration in this study were areas of anomalous salinities and the probable causes of these anomalies.

The original hypothesis that the data was expected to show for the St. Jean Estuary was that as high tide is approached, the salinities near the mouth of the river will increase due to the tidal wedge moving upstream into the estuary and increasing the salt concentrations. Conversely, as low tide is approached the overall salinities are expected to decrease throughout the estuary, but especially near the mouth of the river because the influx of freshwater would now be greater than that of the seawater. To test this assumption measurements of salinities were taken throughout a range of times in the tidal cycle over a four week period.

Methods

In order to measure the salinity, numerous sites throughout the estuary were marked with wooden stakes. These stakes pinpointed a location that could be revisited and remeasured at different times in the tidal cycle and on different days. Twenty stakes were put in along the main deep water channel, and another twenty stakes were placed along four north-south traverse lines across the estuary itself. As many stakes as possible were revisited each day. At each stake, measurements of the salinity at both shallow- about 20 cm- and deep- about 95 cm- water depths, were recorded. Obviously, water depth in an estuary is subject to the changing tides. At low tide it was impossible to take two measurements due to a lack of water depth in most of the estuary.

The salinity itself was read off a salinity meter which detects the amount of dissolved salts in the water by use of an electrical current between two electrodes. The more salts present the stronger the current and a higher reading is shown on the dial. The salinity is read in parts per thousand (°/oo). The salinity measurements for the St. Jean Estuary ranged from 29 °/oo to 0.5 °/oo. As normal seawater is 35 °/oo these salinities reflect the mixing of freshwater, usually less than 0.5 °/oo, with the seawater (Boggs, 1987). Measurements were recorded daily for four weeks in varying atmospheric conditions. Salinities were taken at the traverses for two complete six hour tidal cycles with a reading being taken every thirty minutes. This resulted in data depicting the changes in salinity throughout a tidal cycle. The fluctuations due to tidal influx and river drainage were noted using two stilling wells and a Stevens meter.

The salinity data was correlated to the correct time in the tidal sequence and then was entered into a computer contouring program. This produced a computer generated contour map for five specific tidal settings-- low-tide, mid-tide, high-tide, ebb-tide, and flood-tide stages (fig. 1). These maps were analyzed and interpreted as to the variations of the salinity with changing tides.