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Salt-Water Intrusion Studies in the Maritimes*

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Since 1960 there have been numerous requests for guidance in installing and developing large water-well fields along the coasts of New Brunswick and Prince Edward Island. During this period, many fish canneries and food processing plants, all of which require large quantities of groundwater, have been established along these shores. Also, some coastal communities and factories have increased their production and overpumping of some of the existing well fields has become evident from the appearance of salty water in the wells. This movement of sea water into the coastal aquifers is called salt-water intrusion.

Since 1965, the Federal Government has studied salt-water intrusion in three Maritime areas: near the estuary of the Eliot River and at Georgetown, Prince Edward Island; and at Shippegan, New Brunswick (Figure 1). In each of those areas, detailed geological records have been compiled in order to determine the stratigraphic framework through which the groundwater moves. Most of this geological information is not suitable for publication; but some relevant parts will be published, together with the hydrological findings. However, the basic geologic data will be available upon request from the Inland Waters Branch.

This article describes briefly the type of investigations that have been carried out at the three sites mentioned and summarizes those conclusions that are of particular economic importance to all of the Maritimes.

Eliot River Project

Detailed studies were initiated around the saline estuary of the Eliot River (locally known as the West River) in Prince Edward Island. This estuary was selected because no heavy pumping occurs along its shores. Thus, the extent of salt-water intrusion under natural conditions could be determined and compared with areas of heavy pumping. Also, because of low stream gradients and relatively high tides many estuaries in New Brunswick and Prince Edward Island permit salt water to extend far inland, creating a potential threat of salt-water intrusion if heavy groundwater withdrawals are made from wells situated along the banks.

A network of wells and piezometers was established in the vicinity of the Eliot River estuary to determine the groundwater flow to the sea and the sea-water flow into the land. Where the two flow systems meet, a mixture of brackish water is created; this is called the zone of diffusion. The piezometers that intersected this zone were sampled periodically. The salinity of the samples was found to decrease markedly below 100 feet, and below 200 feet the water was almost fresh (Figure 2). Thus most of the sea-water intrusion occurs in the upper 200 feet; below this level the groundwater is fresh.

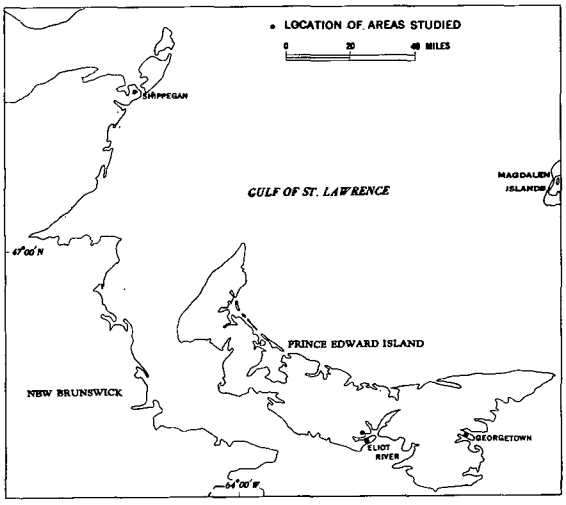

Figure 1 - Location of salt water intrusion studies.

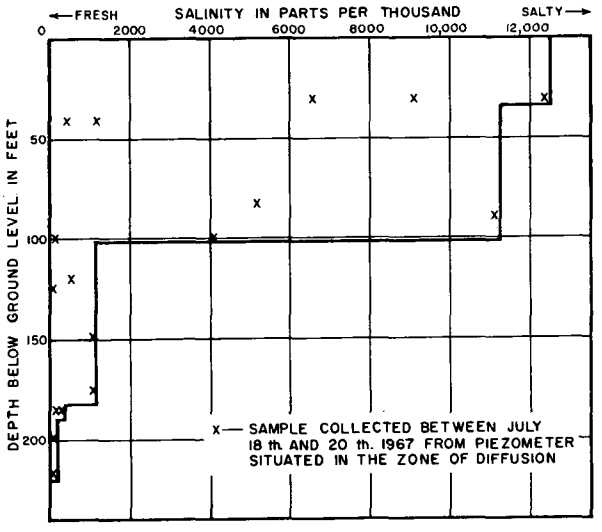

Figure 2 - Variation in salinity of the groundwater with depth near the Eliot River, P.E.I.

*Manuscript received 10 January, 1968.

The presence of fresh groundwater underlying salty water is due to a large groundwater flow system having sufficient pressure head to prevent salt water from moving into the aquifer. This situation of salt water overlying fresh groundwater is unusual and has seldom been reported in the literature. This condition occurs only in areas of little or no pumping.

The depth of this fresh-water flow system has been determined from old boring records (Ingall, 1909). The Geological Survey of Canada had 5 deep holes drilled near the sea throughout Prince Edward Island in search of coal. These holes invariably intersected salty water at depths between 600 and 700 feet below sea level. Thus, near the coast, fresh groundwater is discharged from a zone between 200 and 600 feet below sea level. This amount of discharge constitutes a reliable fresh-water resource that now flows into the sea unused. If industries are to be established along the coast, their groundwater supplies will have to come from this zone.

By careful development, groundwater can be withdrawn from wells adjacent to the sea at depths of 200 to 600 feet below sea level without inducing salt-water intrusion. The wells should first be cased for about 200 feet below the surface, into the fresh groundwater. The safe sustained yield of the well must be determined by pump testing. Usually pump tests are performed for 24 to 72 hours only; during this time only fresh water may be pumped, but the hydraulic gradient towards the sea might be reversed and salt water could start moving towards the well. Continuous pumping at this rate could then contaminate the well after several months of pumping. Thus during the testing, not only must the drawdown in the observation wells be recorded, but also the salinity; and the observation wells must be within the zone of diffusion. The normal salinity variations with the tides must also be recorded for several days before the test is run. If an adverse change in salinity is noted, it can be concluded that the zone of diffusion has moved toward the well and that the safe yield of the well has been exceeded. In that case, the pumping rate will have to be reduced.

Georgetown Project

This study originated from the Eliot River Project and was completed by D. H. Chipping in 1967. The purpose of this study was to determine if salt water intrusion will occur in the eight wells, situated along the center of the Georgetown peninsula. Each of these wells is about 350 feet below sea level. Although fresh groundwater extends to this depth, the rocks are not well fractured and only a limited amount of groundwater can be withdrawn. The pumping rate of these wells had been established prior to the study at about 200 gallons per minute. This analysis determined that if this pumping rate were to continue for three years, the drawdown would extend three quarters of a mile from the center of the peninsula to the coast, and salt-water intrusion could start. At present, the Georgetown industries have been closed due to economic difficulties; therefore, this well field has not yet been used.

Shippegan, New Brunswick

At Shippegan, New Brunswick, a project was initiated during the summer of 1967 by D. D. Brown, of the University of Minnesota, as a Ph. D. thesis problem. The purpose of this study is to determine the amount of groundwater available there. The village of Shippegan, has the most severe salt-water intrusion in all of the Maritimes. It has followed the classic pattern of deep wells situated near the sea being overpumped, thus inducing salt water; these wells being abandoned, and others drilled further inland; and these in turn being overpumped and salt water drawn into the wells. Now a third set of wells has been drilled even further inland and it is probable that salt-water intrusion will occur here, unless the pumping rate of these wells is reduced to conform to the safe yield of the aquifer.

Here the situation is more "typical" in that fresh groundwater lies on top of intruded sea water. In the Netherlands, California, and Florida, studies of salt-water intrusion have been made showing that heavy pumping has intercepted the groundwater flow which formerly discharged into the sea. The cone of depression thus created causes the heavy salt water to enter the aquifer causing the fresh water to rise.

Conclusions

Along the coast where heavy pumping has not occurred fresh groundwater is discharged from a zone generally between 200 and 600 feet below sea level. The existence of a large flow-system of fresh groundwater underlying salt water seems unusual, but further studies in similar

environments will probably show it to be quite common.

When pump tests are being carried out in this zone, observation wells should be installed in the zone of diffusion. If any adverse change in salinity is detected while pumping, then the safe yield of the well has been exceeded and a lower pumping rate will have to be maintained.

Undoubtedly, controlling salt-water intrusion will be one of the most important and challenging problems in using the groundwater resources of Prince Edward Island and New Brunswick in the future. With effective development and management of groundwater this problem can be solved.

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