# 11.0 REVIEW OF ISSUES RELATED TO DOMESTIC WELLS

## 11.1 Introduction

FFEBC requested that ADI review selected issues related to the domestic well monitoring program at the landfill site. The scope of the investigation included an assessment of the following issues:

- Number and location of the wells currently monitored;
- Monitoring frequency;
- Suite of analytical parameters included in the monitoring program; and,
- Adequacy of the emergency response plans relative to domestic well contamination.

In addition to the above, FFEBC requested that ADI comment on database management system(s) whereby the results of the domestic well monitoring program can be traced in a more meaningful manner.

FFEBC provided ADI with some limited domestic well monitoring results as part of the current project.

General considerations and each of the above noted issues are discussed in the following sections.

## 11.2 General Considerations

Although the exact number is unknown it is estimated that close to one thousand domestic water supply wells are located downgradient of the landfill. The area is primarily underlain by igneous rock types (granite, granodiorite, quartz diorite, etc.) with localized areas of sandstone and conglomerate. Domestic wells would be expected to be almost exclusively completed in bedrock. Groundwater flow in the bedrock is controlled by flow through a network of rock fractures. Overburden soil in the area is comprised of a veneer of loamy lodgement till, minor ablation till, silt, sand, gravel and rubble (Rampton et al., 1984). Overlying the above soil is a thin, discontinuous veneer of sand, some gravel and silt and rare clay. Where present, the thickness of this material is generally less than 0.5 m. The thickness of the till overburden generally increases moving southwest towards the landfill site.

The New Brunswick Department of the Environment and Local Government (NBDELG) has maintained a database of domestic water well information for many wells constructed in the province in recent years. A request was submitted to NBDELG to provide available water well records from this database within the study area to provide some background information on private water supply wells in the area. Water well records were subsequently provided for a total of twenty-one wells in the study area. Well depths and estimated yields ranged from 18 m to 128 m with an average of 74 m, and 0 $m^3$/day (0 Igpm) to 66 $m^3$/day (10 Igpm) with an average of 18 $m^3$/day (2.7 Igpm), respectively. Reported depth to bedrock ranged from 0 m to 59 m with an average of 6 m.

## 11.3 Number and Location of Wells

It is our understanding that there are currently approximately forty-five (45) participants in the domestic well monitoring program. The identities of the participants in the monitoring program and hence the exact locations of their respective wells could not be obtained for the purpose of completing the current assessment due to privacy legislation considerations. The locations of the domestic wells included in the monitoring program were determined by whoever volunteered to take part in this program. Therefore, the locations of wells are somewhat spread out and extend from Martinon to South Bay as shown on a drawing (Figure 6-1) of the surface water and groundwater monitoring sites included in the Environmental Management Plan. Although most of the wells shown on the above noted figure are located in the general downgradient direction of the landfill, it is noted that a few wells are located across gradient of the site (e.g. wells in the South Bay area). It is not known how many of these outlying wells are included in the current monitoring program.

It is estimated that there are on the order of one thousand (wells) domestic wells situated downgradient of the landfill site. Therefore, about five percent of these wells are currently included in the monitoring program. Consideration should be given to increasing the number of wells in the monitoring program to provide for a more representative indication of the quality of the quality of domestic groundwater supplies. However, it is acknowledged that adding to the program will be contingent upon finding new volunteers. Any new wells should be positioned east-northeast of the landfill in the general downgradient location.

The number of wells included in the monitoring program has decreased from sixty-five (65) to forty-five (45). Well owners included in the monitoring program have the option of not continuing with the program is they so wish. It is suggested that in order to maintain a large

representative sample, that participants be encouraged to continue their participation in the monitoring program.

## 11.4 Monitoring Frequency

It is understood that the domestic wells included in the domestic well monitoring program are currently sampled once per year in September/October under the current Approval to Operate to operate the landfill issued by NBDELG. Ideally, long term groundwater monitoring programs should include low flow (i.e. summer or winter) and high flow (i.e. spring or fall) bi-annual sampling events as a minimum to assess the effect of the groundwater recharge cycle on water quality.

## 11.5 Suite of Analytical Parameters

The current Approval requires that domestic wells be analyzed for general chemistry parameters. It is understood that the analytical suite has been reduced in recent years. Based upon a review of the limited domestic well monitoring results provided for the current study, trace metals and microbiological parameters including coliforms and E. coli were included in the analytical suite at least as late as 1997 and 1998, respectively.

As a minimum, any landfill water quality monitoring program should include leachate indicator parameters. For municipal solid waste landfills such as the Crane Mountain facility, key leachate indicator parameters are expected to include alkalinity, iron, manganese, conductivity, pH, sodium, chloride and ammonia-N. All of these parameters are included in the general chemistry analytical suite and, therefore, the current parameters included in the analytical suite are considered to be acceptable.

## 11.6 Emergency Response Plans

The Environmental Management Plan (EMP) for the Crane Mountain facility outlines remedial measures which may be taken in the event that "trigger" concentrations are exceeded for key parameters in the groundwater monitoring data or the domestic well water quality data. The "trigger" concentrations are not defined and it is stated in the EMP that they will be established based on an analysis of background water quality data. Remedial

action will only be taken if the results of a more detailed analysis on the water quality data indicate that the trigger exceedances are not related to natural background variation.

Suggested remedial options in the event of the identification of parameter concentrations in domestic well water in excess of "trigger" concentrations include developing alternate water supplies and treating the affected water. As previously mentioned in this report, although these conceptual remedial approaches are probably acceptable for the purpose of the Environmental Management Plan, they are vague. Hence, it is recommended that "trigger" concentrations for key indicator parameters in domestic wells be developed.

## 11.7 Database Management System

### Overview

Currently, the results are tabulated for comparison with the Guidelines for the Protection of Canadian Drinking Water Quality (GPCDWQ) established by Health Canada or the New Brunswick Health Advisory Limits (HAL's). Analytical results are forwarded to respective homeowners and parameters with concentrations in excess of guideline values are flagged for reference. FFEBC has requested that ADI comment on a possible framework for a database management system whereby the results of the domestic well monitoring program can be traced in a more meaningful manner.

There are several potential approaches whereby the water quality database could be better managed to assist in the identification of potential leachate impacts. One of the challenges associated with the interpretation of the data is the need to separate natural background variation in parameter concentrations from trends which may be indicative of leachate impacts. Two methods for consideration to assist in better management of the domestic water well database are discussed in this report: 1) preparation of major ion chemistry plots (e.g. Piper trilinear plots), and 2) implementation of ASTM D6312-98 (2005) (Standard Guide for Developing Appropriate Statistical Approaches for Groundwater Detection Monitoring Programs). The latter method is discussed since it is referenced as a potential method to distinguish between natural background variation and landfill impacts in the EMP. Each of these approaches are discussed in the following sections.

## Major Ion Chemistry Plots

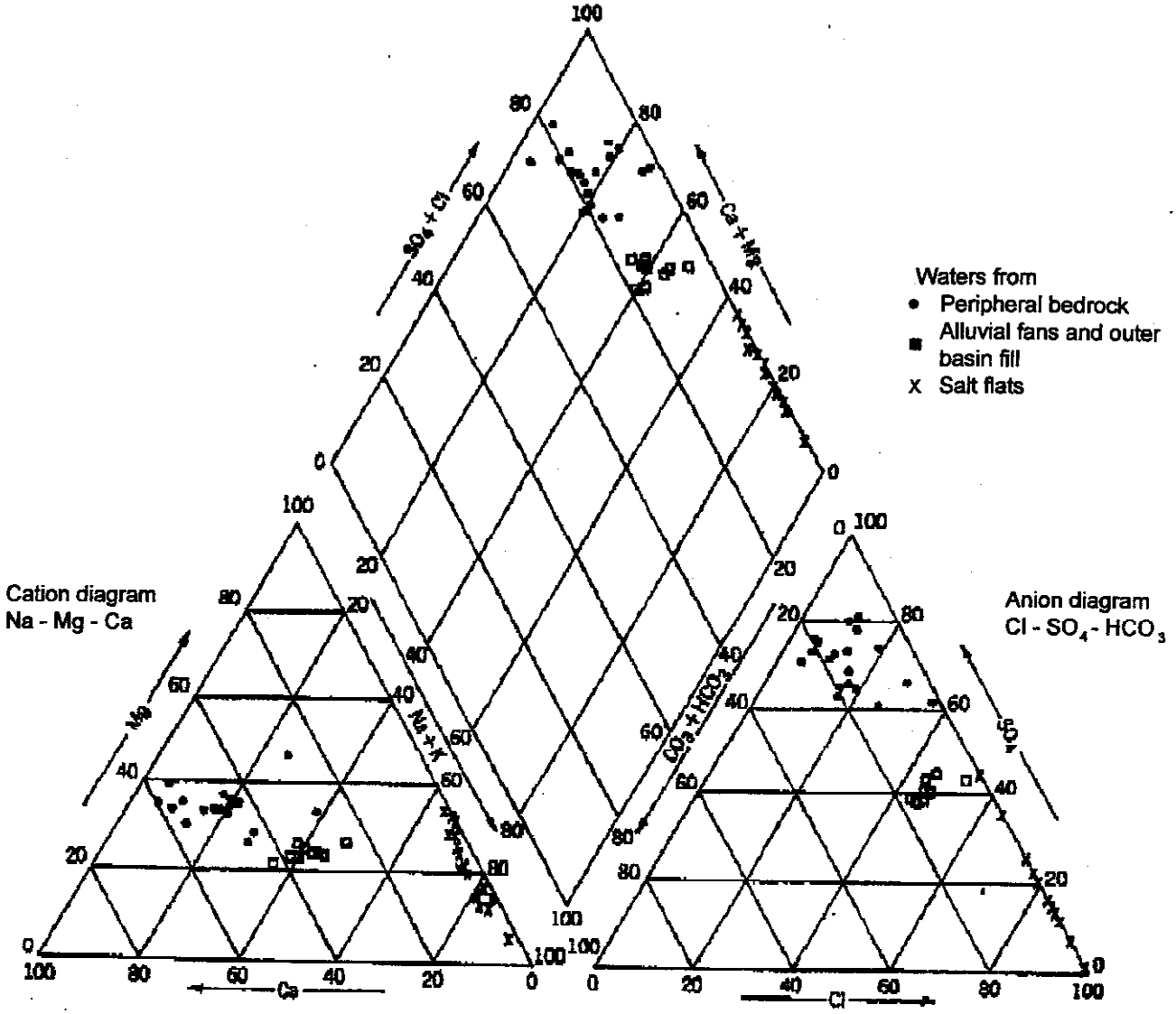
Major ion chemistry plots provide a relatively simple and convenient means to isolate water of similar chemical "types" and thereby effectively remove some of the background variation. This method can also assist in tracking the geochemical evolution of groundwater as it passes through the flow system. An example of one such plot is the Piper trilinear plot (Figures 11-1 and 11-2).

Piper trilinear plots (as well as other major ion chemistry plots) could be prepared for the wells included in the monitoring program to allow the groundwater from the database wells to be broken down into different geochemical classes or chemical "types". Basic statistical (arithmetic mean and variance) parameters could then be calculated for the leachate indicator parameter identified above for each chemical type of water. Target or "trigger" levels as discussed in the Crane Mountain EMP could then be developed for these parameters.

The use of major ion chemistry plots such as Piper trilinear diagrams can be subject to some limitations. Since chemical composition is represented as a percentage, waters of very different total concentrations can show identical representation on the diagram. Therefore, it is important that the statistical parameters discussed above be computed for the main water types. Furthermore, organic parameters and several inorganic parameters of interest are not portrayed on the diagram. Notwithstanding these limitations, the development of Piper trilinear plots from the domestic well database is considered to be a good database management tool if this tool is used to augment the overall review of the water quality results by a qualified individual (e.g. hydrogeologist or environmental engineer with hydrogeological training).

## Rigorous Statistical Database Management

A more rigorous statistical approach to the management of the domestic water well database would be to follow the procedures outlined in ASTM D6312-98 (2005) - Standard Guide for Developing Appropriate Statistical Approaches for Groundwater Detection Monitoring Programs. This ASTM standard, which was formerly known as ASTM PS64-96, is referenced in the EMP as a possible tool to distinguish between potential landfill sourced impacts and natural background variation in the event that parameter concentrations in excess of the "trigger" levels are encountered in the domestic water well database. An overview of the process is provided below.




(a) EXAMPLE OF PIPER TRILINEAR DIAGRAM

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Proj. INDEPENDENT EXTERNAL REVIEW OF CRANE MOUNTAIN LANDFILL

Dwg. PIPER TRILINEAR DIAGRAM

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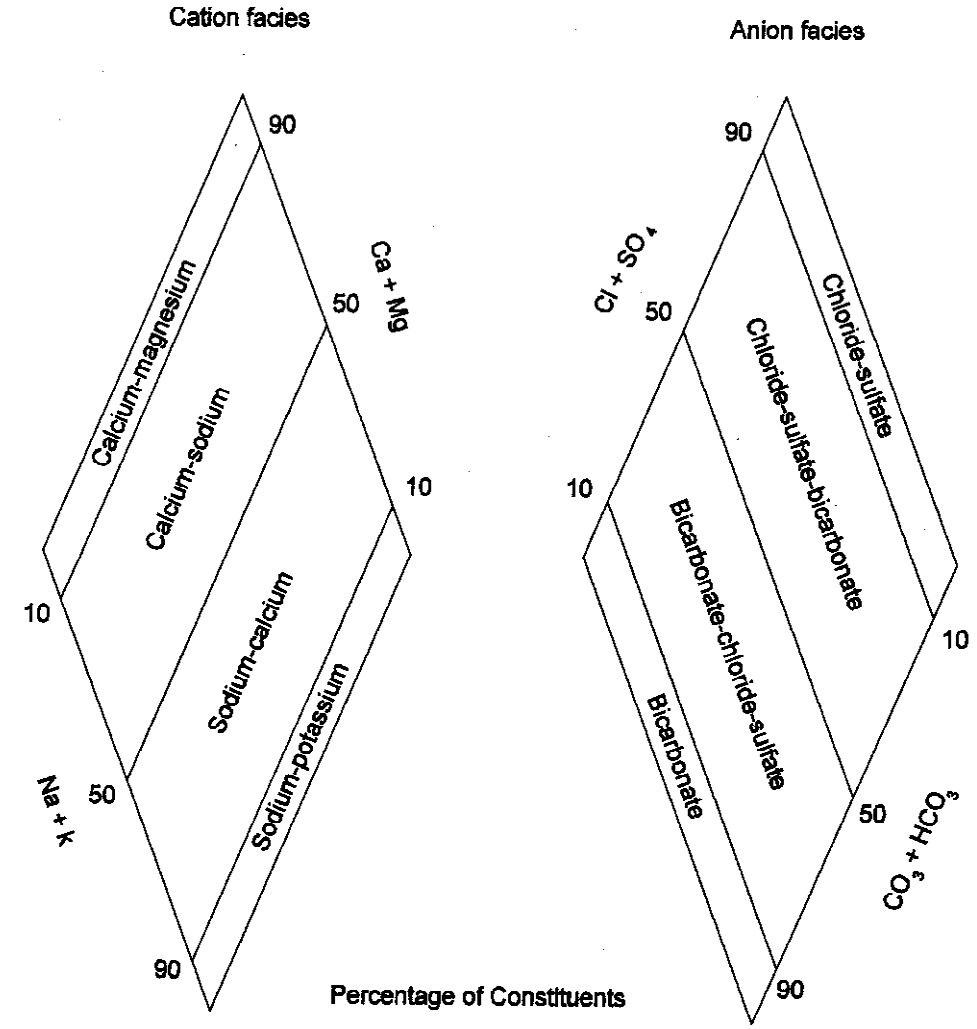
|---|---|
| Drawn By: J.D.M. | Proj. No. 5668-001.1 |
| Dwg. Standards Chk. By: | Dwg. No. FIGURE 11-1 |
| Designed By: R:G | Dwg. Design Chk. By: / Rev. 0 |




(b) TEMPLATES FOR CLASSIFYING WATERS
(CATIONS AND ANIONS)
(AFTER DOMENICO & SCHWARTZ, 1990)

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|---|---|
| Proj. | INDEPENDENT EXTERNAL REVIEW OF CRANE MOUNTAIN LANDFILL |
| Dwg. | PIPER TRILINEAR DIAGRAM |

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| Drawn By: J.D.M. | Proj. No. 5668-001.1 | |
| Dwg. Standards Chk. By: | Dwg. No. FIGURE 11-2 | |
| Designed By: R.G | Dwg. Design Chk. By: | Rev. 0 |

The purpose of the ASTM standard is to assist in the development of a groundwater monitoring standard that minimizes both false negative (failure to detect contamination when it is present) and false positive rates (conclusion of the presence of contamination when there is none) without sacrificing one for the other. A flowchart is provided in the standard that illustrates the steps in developing a statistical monitoring plan which is based on either upgradient versus downgradient well comparisons, intra-well comparisons or a combination of both. Intra-well comparisons are preferred over inter-well comparisons since the former completely eliminates the spatial component of variability. The statistical methods include parametric and non-parametric prediction limits for background versus monitoring well comparisons and combined Shewart-CUSUM control charts for intra-well comparisons.

The chief limitation of the above described method is its complexity. To implement this method, an interdisciplinary site-specific study would be required by individuals ideally possessing training and experience in advanced statistical analysis in addition to hydrogeology and environmental engineering. It also should be noted that it is possible that the existing domestic well monitoring network and associated water quality database are not suitable for the implementation of ASTM D6312-98 (2005).

**Implementation**

It is recommended that major ion chemistry plots (e.g. Piper trilinear plots) be prepared for the wells included in the monitoring program to allow the groundwater from the database wells to be broken down into different chemical "types". Basic statistical (arithmetic mean and variance) parameters should then be calculated for the leachate indicator parameter identified above for each chemical type of water. Target or "trigger" levels as discussed in the Crane Mountain EMP should then be developed for these parameters. In addition to the above, the monitoring data should initially be reviewed on an annual basis by a qualified individual. The frequency of the data review can be adjusted at a later date based on the findings of the initial reviews.

It should be noted that landfill impacts to groundwater quality cannot be definitively determined from a statistical analysis alone. A statistically significant exceedance over background levels simply indicates a measurement which is inconsistent with chance expectations based upon the available sample of background measurements. Similarly, statistical measurements cannot overcome potential limitations such as poor site characterization, inadequate well locations, non-representative analytical suite of parameters and other issues.

Establishing a database management system for the domestic well monitoring results would be a beneficial tool for FFEBC. This information could become a further level of monitoring of groundwater quality, and a tool in the implementation of an emergency response plan.