5.0 ANALYTICAL RESULTS

Presented in this chapter are the analytical results generated during the NUS/FIT Remedial Investigation. Data presented in this section are from the following sampling rounds:

- initial NUS/FIT sampling round for NUS/FIT analytical screening
- sampling of the recently installed NUS/FIT wells for NUS/FIT screening
- April, May, and June, 1985 NUS/FIT sampling rounds for contract laboratory program (CLP) analysis

Due to the large amount of analytical data, all tables of analytical results are presented in Appendix G. Discussion of analytical results will include the NUS/FIT data summarized above as well as analytical data collected by other contractors at the W.R. Grace, Wildwood Conservation Corporation, and UniFirst sites and data collected by EPA from the Army Corps of Engineers (COE) wells (S87-S97). These additional data are presented in Appendix C.

Analytical results for overburden and bedrock groundwater and surface water samples will be discussed separately. The concentrations of Hazardous Substance List (HSL) volatile organic compounds, extractable organic compounds (acid and base/neutral extractable compounds, pesticides and polychlorinated biphenyls), and metals will be presented. Results of federal and state drinking water quality analyses will be presented in Section 5.2.4.

5.1 Sampling and Analysis Efforts

As described in Section 3.2, a total of 52 samples were collected from 34 monitoring wells, three surface water locations, and three sediment locations during the initial sampling round (July, 1984) for in-house volatile organic screening (Table 3-1). This included 23 samples collected by NUS/FIT and 11 split samples collected by Woodward-Clyde Consultants at the Wildwood Conservation

Corporation site. After each monitoring well was installed, groundwater sampling was conducted for NUS/FIT volatile organic screening. After the well installation program was completed, NUS/FIT performed three final sampling rounds for CLP analysis with one round completed each month for the months of April, May, and June, 1985. These samples were analyzed for HSL volatile organic compounds, extractable organic compounds, and metals as detailed in Tables 3-3, 3-4, and 3-5. Selected samples were also analyzed for the federal and state drinking water quality parameters listed in Table 3-7. These results will include some duplication of the HSL parameters and/or analyses. Specifically, drinking water quality analyses include six additional extractable organic compounds (the herbicides 2,4-D and 2,4,5-TP; and the pesticides endrin, lindane, methoxychlor, and toxaphene) and eleven HSL inorganic substances (arsenic, barium, cadmium, chromium, lead, mercury, nitrate, selenium, silver, fluorine, and sodium).

Analytical methods for NUS/FIT screening as well as CLP analytical protocols are presented in Appendix D. A quality control review (data validation) was conducted on all CLP analytical data. A summary of the data validation protocol is also presented in Appendix D.

5.2 Groundwater Analytical Results

Groundwater contaminants in the study area consisted primarily of volatile organic compounds. The most common volatile organic contaminants detected were trichloroethene (TCE); trans-1,2-dichloroethene (trans-1,2-DCE); 1,1,1-trichloroethane (1,1,1-TCA); and tetrachloroethene (TETRA). The extractable compounds detected were: 1,2-dichlorobenzene; bis(2-ethylhexyl)phthalate; phenol; benzoic acid; naphthalene; 2-methylnaphthalene; chlordane; acenaphthylene; acenaphthene; phenanthrene; fluoranthene; and chrysene. These extractable organic compounds, for the most part, were identified in samples from the southwestern portion of the study area and at well location S75 in the northwestern corner of the study area. The NUS/FIT results are comparable with earlier E & E analytical data described in Section 2.0. At the time of this writing, regulatory levels such as maximum contaminant levels (MCLs) have not been established for these volatile and extractable organic compounds.

All HSL inorganic elements, with the exception of antimony (Sb) and selenium (Se), were detected in groundwater at varying concentrations. A pattern of distribution of the elements throughout the study area was not demonstrated. The inorganic element chromium (Cr) was detected at concentrations greater than the National Interim Primary Drinking Water Regulations Maximum Contaminant Levels (MCLs). Sodium (Na) was detected at concentrations greater than the federal advisory level of 20 mg/l. Iron (Fe) and manganese (Mn) were detected at concentrations in excess of the National Secondary Drinking Water Regulations Maximum Contaminant Levels (SMCLs).

5.2.1 Volatile Organic Analytical Results

The screening results from the initial round of sampling are presented in Appendix G (Table 1). The predominant groundwater contaminants detected were trichloroethene (TCE); trans-1,2-dichloroethene (trans-1,2-DCE); tetrachloroethene (TETRA); benzene; toluene; ethylbenzene; meta-xylene and ortho-xylene. All samples were screened by NUS/FIT chemists using a Photovac 10A10 gas chromatograph; compound identification is tentative and that the analytical results are to be considered semi-quantitative. The analyses confirmed earlier E & E data (Section 2.0) indicating groundwater contamination by TCE; trans-1,2-TCE; and TETRA. The highest concentrations (relative to all compounds detected) of most of these contaminants were detected in the northeastern (S21, GW3, and GW4) and southwestern (BW1 through BW7) portions of the study area. These data were utilized by NUS/FIT in monitoring well placement (Section 3.3).

Data generated from sampling the recently installed NUS/FIT wells, as presented in Appendix G (Table 2), were also used in subsequent monitoring well placement (Section 3.3). Although the screening protocol (Appendix D) is limited to selected volatile organic compounds, the analysis includes the most common volatile organic contaminants detected in the initial sampling round. No volatile organic compounds were detected at wells S69D, S70 (S & M), S73 (D only), S74 (M&D), S76, (S, M&D), S77SS, S78D, S79 (M&D), and S80 (S&M). The majority of these monitoring wells are located in the northern and western portion of the study area (Plate 2). TCE was detected in 37 groundwater samples, with the highest concentrations in samples from well locations S63, S64, S68, S77, S78, S83, and S85. TETRA was detected in 32 groundwater samples; with the highest concentrations in samples from well locations S71D and S78S. Benzene, toluene, ethylbenzene, meta-xylene, and ortho-xylene were detected in samples from well S75 (S and M) only, but were not found to be prevalent elsewhere in the study area.

The predominant volatile organic compounds detected during CLP analysis in groundwater from the April, May, and June, 1985 sampling rounds were: TCE; TETRA; trans-1,2-DCE; 1,1,1-TCA; and 1,1-DCA. The CLP volatile organic data from the April, May, and June 1985 sampling rounds are presented in Appendix G (Tables 3, 4, and 5, respectively). Less frequently detected volatile organic compounds included: 1,1,2,2-tetrachloroethane; 1,2-dichloroethane; 1,1-dichloroethene; benzene; ethylbenzene; toluene; vinyl chloride; styrene; and xylenes. The CLP volatile organic results showed good correlation with the NUS/FIT volatile screening results.

Mean concentrations of certain selected volatile organic compounds for the three NUS/FIT sampling rounds are presented in Appendix G (Table 6). The volatile organic compounds selected represent the predominant as well as the less frequent volatile organic compounds detected and represent approximately 95 percent of the total volatile organic groundwater contaminants detected in the study area. Values not included in the calculation of the mean concentrations were:

- those values rejected as a result of the quality control review (data validation)
- those values determined by statistical analysis to be "outliers"

Outliers (those numbers determined to be anomalous) in groups of three or more data points were determined by a "Q" test as described by Dean and Dixon (1951) and were removed from the mean calculations. A table of mean concentrations and the values used to calculate the means is presented in Appendix G (Table 6). Henceforth, any reference made to mean concentrations of volatile organic compounds or mean concentrations of total volatile organic compounds will indicate the mean concentrations of the selected volatile organic compounds listed in Table 6 (Appendix G).

The distribution of volatile organic compounds is depicted on Plates 5 through 9 as follows:

- Plate 5 Mean Concentrations of Total Volatile Organic Compounds
- Plate 6 Mean Concentrations of TCE
- Plate 7 Mean Concentrations of trans-1,2-DCE
- Plate 8 Mean Concentrations of 1,1,1-TCA
- Plate 9 Mean Concentrations of TETRA

The information depicted on these plates is derived from the mean concentrations of selected volatile organic compounds from the NUS/FIT CLP sampling rounds (Appendix G; Table 6) as well as from data collected by other consultants at the W.R. Grace, Wildwood Conservation Corporation, and UniFirst sites and data collected by EPA and other consultants from the COE wells (S87-S89). Data from sources other than NUS/FIT can be found in Appendix C. Data limitations were discussed in Chapter 2.0. These data were collected at different times and at a variety of locations by several parties. As a result, the plates do not represent discrete contaminant distribution at a specific time, but rather a general or composite view of contamination over a period of time. These plates will be further discussed in the following sections.

5.2.1.1 Distribution of Volatile Organic Compounds in Overburden

The mean concentration of total volatile organic compounds detected in overburden from NUS/FIT CLP sampling rounds ranged from not detected (ND) to 317,000 parts per billion (ppb) (Appendix G; Table 6). The highest mean total concentrations of volatile organic compounds were detected at wells S78S

(109,356 ppb), BSW6, (124,684 ppb), BSSW6 (317,000 ppb), GW3S (3,069 ppb), S71M (1,907 ppb), and S75S (4,702 ppb) and BW5 (2,900 ppb). Volatile organic contaminants identified were distributed predominantly in the northeastern and southwestern portions of the study area and at wells S71 and S75 in the northwest and north, respectively. Except for location S75 in the northwestern corner of the study area, volatile organic contaminants were not detected (ND) or were detected at low levels (<50 ppb) in the northern and western portions of the study area. Upgradient of the study area at wells OW-7, OW-8, OW-19, OW-19A, OW-20 and OW-20A, volatile organic distribution ranged from not detected (ND) to 10 ppb total volatile organic compounds. Volatile organic contaminants were also detected south of the study area at location S11 at 276 ppb (total volatile organic compounds). CLP results from the NUS/FIT wells agreed closely with the screening results of these wells. CLP analytical data are similar to the E & E analytical results and the NUS/FIT analytical results from the July, 1984 sampling round.

The volatile organic compounds detected most frequently were TCE; trans-1,2-DCE; 1,1,1-TCA; and TETRA; which accounted for approximately 75% to 90% of total volatile organic contamination detected in each groundwater sample. The mean concentration of TCE; trans-1,2-DCE; 1,1,1-TCA; and TETRA from the April, May, and June, 1985 NUS/FIT CLP sampling rounds are presented in Appendix G (Table 6). The highest mean concentrations of TCE in overburden were detected at wells BSSW6 (310,000 ppb), BSW6 (116,667 ppb), S78S (80,037 ppb), BW5 (2,900), and GW3S (1,003 ppb). The overburden distribution of TCE is predominantly in the northeastern and southwestern portions of the study area. Overburden concentrations of trans-1,2-DCE were distributed principally in the northeastern and southwestern portions of the study area with the highest mean concentrations detected at wells GW3S (1,955 ppb) and BSW2 (1,510 ppb). At most of the well locations in the southwestern portion of the study area, trans-1,2-DCE was detected at mean concentrations less than 50 ppb. The overburden distribution of 1,1,1-TCA was also predominantly in the northeastern and southwestern portions of the study area with the highest mean concentrations detected at BSW6 (4,667 ppb), S81S (183 ppb), and S71M (111 ppb). The highest mean concentrations of TETRA in overburden were detected at S71M (1,700 ppb) and S81S (838 ppb) in the northern portion of the study area and at S78S (26,677 ppb) in the southwestern portion of the study area.

Elevated concentrations of volatile organic compounds were also detected at well S75S, but consisted of different compounds than those detected elsewhere in the study area. The mean concentrations of the compounds detected were: benzene (3,125 ppb), ethyl benzene (253 ppb), toluene (433 ppb), styrene (198), and total xylene (693 ppb).

The distribution of total volatile organic compounds; TCE; trans-1,2-DCE; 1,1,1-TCA; and TETRA are depicted in Plates 5 through 9, respectively. The highest concentrations of total volatile organic groundwater contamination in overburden were found in the northeastern portion of the study area at the W.R. Grace facility, at well S71 on UniFirst property, at well S75 on Weyerhauser property, and in the southwestern portion of the study area on the Wildwood Conservation Corporation property (Plate 5). Concentrations generally decreased from outlying areas of high levels of contamination inwards towards the center of the study area. Concentrations decreased to low or background levels beyond the study area. TCE and trans-1,2-DCE were detected at high concentrations (>1,000 ppb) in the northeastern portion of the study area at well locations GW3, GW14, GW15, GW12, and GW28 and in the southwestern portion of the study area at wells BSW6, BSSW6, BSW9, and BW9 (Plates 6 and 7). 1,1,1-TCA was detected in highest concentration in the southwestern portion of the study area at well BSW6 (4,667 ppb) and was detected in lower concentrations (<100 ppb) in the northern and northeastern portions of the study area (Plate 8). TETRA was detected in high concentrations at well S71 (1,700 ppb) in the northern portion of the study area and at well S78 (26,677 ppb) in the southwestern portion of the study area (Plate 9).

5.2.1.2 Distribution of Volatile Organic Compounds in Bedrock

The highest mean concentrations of total volatile organic compounds detected in bedrock groundwater from the NUS/FIT CLP sampling rounds were in the northern and northeastern portions of the study area at wells GW3D (5,567 ppb), GW3DB (3,642 ppb), S71D (2,677 ppb), GO1DB (1,938 ppb), GW4D (1,700 ppb) and GW12D (1,633 ppb) (Appendix G, Table 6). Trace (<50 ppb) or no volatile organic contaminants were detected in bedrock wells located in the northwestern and western portion of the study except at well location S75. No volatile organic compounds were detected at the one bedrock location (S78D) in the southwestern portion of the study area. TCE and trans-1,2-DCE were detected predominantly in the northeastern portion of the study area with the highest mean concentrations detected at wells GW3D (2,433 ppb and 2,875 ppb, respectively) and GW3DB (2,100 ppb and 1,423 ppb, respectively) (Appendix G; Table 6). The volatile organic contaminant 1,1,1-TCA was detected in bedrock in much lower concentrations, with the highest mean concentrations detected at wells S71D (145 ppb) and GO1DB (130 ppb) (Appendix G; Table 6). TETRA was detected in bedrock predominantly in the northern and northeastern portions of the study area with the highest mean concentrations detected at S71D (2,475 ppb), GO1D (900 ppb) and GO1DB (1,790 ppb) (Appendix G; Table 6).

The distribution of total volatile organic compounds in the bedrock aquifer is similar to the distribution in overburden. High concentrations (>1,000 ppb) of volatile organic compounds were found in the northeastern portion of the study area at the W.R. Grace facility; at well S71 on UniFirst property; and in the southwestern portion of the study area on the Wildwood Conservation Corporation property (Plate 5).

TCE was detected at highest mean concentrations at wells GW3 (2,200 ppb) and BW9 (3,600 ppb) in the northeastern and southwestern portions, respectively, of the study area (Plate 6). It was detected at low (<100 ppb) to moderate (<500 ppb) levels elsewhere. Trans-1,2-DCE was also detected at high levels (>1,000 ppb) in the northeast portion of the study area at well GW3 (1,423 ppb) as well as at wells GW28 (2,057 ppb), GW15 (11,330 ppb), and GW4 (1,345 ppb). It was found at low (<100 ppb) to trace levels elsewhere (<10 ppb) (Plate 7).

The volatile organic contaminant 1,1,1-TCA was detected at moderate (<500 ppb) levels at wells GO1 (260 ppb) and S71 (145 ppb) and low (<100 ppb) to trace (<10 ppb) levels elsewhere (Plate 8). High mean concentrations (>1,000 ppb) of TETRA were detected at wells GO1 (1,790 ppb) and S71 (2,475 ppb). Except for trace levels at well BW9, TETRA was found in groundwater primarily from wells located in the northern and northeastern portion of the study area (Plate 9).

5.2.2 Extractable Organic Analytical Results

Extractable organic compounds analyzed included Hazardous Substance List (HSL) acid and base/neutral extractable compounds, pesticides, and polychlorinated biphenyls (PCBs). A few additional organic (non-HSL) compounds (herbicides and pesticides) will be discussed in the Federal and State Drinking Water Results section (Section 5.2.4). CLP extractable organic analysis of groundwater was conducted only for the April, May, and June, 1985 sampling rounds. Few extractable organic contaminants were detected in the study area. In addition, extractable organic compounds were detected at relatively lower concentrations than were the volatile organic compounds. Extractable organic analytical results are presented in Appendix G (Tables 7, 8 and 9). The list of extractable compounds analyzed for is presented in Appendix D.

5.2.2.1 Distribution of Extractable Organic Compounds in Overburden

The extractable organic compounds detected in groundwater from overburden included the following compounds:

Acid and base/neutral extractables:

bis(2-ethylhexyl) phthalate
phenol
1,2-dichlorobenzene
naphthalene
2-methylnaphthalene

benzoic acid
fluoranthene
acenaphthene
acenapthylene
phenanthrene

Pesticides/PCBs:

chlordane

Bis(2-ethylhexyl) phthalate was detected in a number of groundwater samples from locations throughout the study area, but no distribution pattern was evident. Bis(2-ethylhexyl) phthalate is utilized as a plasticizer in the chemical industry and is fairly ubiquitous in urban environments. It is a common contaminant of environmental samples introduced during sample collection or laboratory analysis through the use of plastic disposable gloves. For example, all bis(2-ethylhexyl) phthalate analytical results for June, 1985 groundwater samples were rejected after data review because bis(2-ethylhexyl) phthalate was detected in the laboratory and field blank samples.

The overburden distribution of the remaining extractable organic compounds was fairly distinct. The extractable organic compounds 1,2-dichlorobenzene; naphthalene; 2-methylnaphthalene; and benzoic acid were detected only in the southwestern portion of the study area at one or more of the well locations BW5, BSSW6, and S78S. Trace amounts of the pesticide chlordane were also detected at well BSSW6. Phenol was detected at trace concentrations in the center of the study area at wells S68M and S86M. Trace amounts of 1,2-dichlorobenzene were also detected at well S86M. Finally, a number of extractable compounds, classed as polynuclear aromatic hydrocarbons (PAHs), were detected at location S75S. These included: fluoranthrene, acenaphthene, naphthalene, acenaphthylene, phenanthrene, and 2-methylnaphthalene.

5.2.2.2 Distribution of Extractable Organic Compounds in Bedrock

Two extractable organic compounds (bis(2-ethylhexyl) phthalate and chrysene) were detected in groundwater collected from bedrock wells (Appendix G, Tables 7, 8 and 9). No pattern of distribution of bis(2-ethylhexyl) phthalate was apparent. It was detected sporadically throughout the study area, but was also rejected from a number of samples due to blank contamination. Chrysene was detected at trace concentrations at S71D in the June, 1985 sampling round, however, it was not detected at this location in April, 1985.

5.2.3 Inorganic Analytical Results

The following section presents results of analyses of groundwater for HSL inorganics. Eleven HSL inorganic elements (arsenic, barium, cadmium, chromium, lead, mercury, nitrogen, selenium, silver, fluorine, and sodium) were also analyzed for under the Federal and State Drinking Water Quality standards discussed in section 5.2.4.2.

All HSL inorganic elements, excluding antimony (Sb) and selenium (Se), were detected in groundwater. No distribution pattern of inorganic elements was evident. The concentrations of each element were comparable in the overburden and bedrock aquifers except for the higher concentrations of calcium, magnesium, manganese, and chromium detected in the overburden aquifer. Inorganic analytical results from the April, May, and June, 1985 sampling rounds are presented in Appendix G; Tables 10, 11, and 12, respectively. Table 13 (Appendix G) summarizes the distribution of each element in the overburden and bedrock aquifers. Table 14 (Appendix G) summarizes the occurrences of each element. The elements can be divided into two groups: those found infrequently and at lower concentrations (<500 ppb), and those found frequently and at higher concentrations (6,000 to 150,000 ppb). The two groups are comprised of the following elements:

Detected Infrequently

Antimony (Sb)
Arsenic (As)
Barium (Ba)
Beryllium (Be)
Cadmium (Cd)
Chromium (Cr)
Cobalt (Co)
Copper (Cu)
Lead (Pb)

Detected Frequently

Aluminum (Al)
Calcium (Ca)
Iron (Fe)
Magnesium (Mg)
Manganese (Mn)
Potassium (K)
Sodium (Na)

Mercury (Hg)
Nickel (Ni)
Selenium (Se)
Silver (Ag)
Thallium (Tl)
Tin (Sn)
Vanadium (V)
Zinc (Zn)

All elements could at least be partially attributed to natural sources as they are constituents of either the bedrock or overburden. Common constituents of the bedrock found at this site are: Al, Ca, Fe, Mg, Mn, K, and Na (Smith and Hon, 1984, and Huang, 1962). These elements comprise the group of elements that were detected frequently and in higher concentrations. The source of the elements detected infrequently and in lower concentrations could be the soils present at the site. None of the elements were detected in sufficiently elevated concentrations or demonstrated a localized pattern of distribution that would indicate disposal of metals. The concentration of elements detected in regional soils is presented in Table 16 (Appendix G).

The concentrations in the study area of Ca, Fe, and Mg were higher than the concentrations of these elements in groundwater elsewhere in the drainage basin. The concentration of elements in groundwater from available published literature is presented in Table 15 (Appendix G). A contributing factor to the levels of Ca as well as to the levels detected of Na and Al could be the use of a bentonite/cement grout seal in construction of the NUS/FIT monitoring wells. A similar grout mixture was also utilized by GeoEnvironmental Consultants in construction of the W.R. Grace monitoring wells as documented by direct observations by NUS/FIT staff. Bentonite could be a source of aluminum and sodium (Huang 1969, Hurlbut 1971) while Portland cement could be a source of aluminum and calcium (Bates, 1969). High concentrations of Fe and Mn have been described by the City of Woburn in the drinking water from Wells G & H when the wells were in use (Section 2.0). Both Fe and Mn were detected at concentrations greater than their regulatory levels which are primarily based on the aesthetic qualities of taste and odor.

Only Cr, Fe, and Mn were detected at concentrations greater than their federally regulated levels listed in Table 3-7. The remaining elements with associated regulatory levels were not detected at concentrations greater than their federal or state regulated levels. Specific elements and the various regulatory levels are detailed below.

The inorganic elements As, Ba, Cd, Pb, Hg, and Ag were not detected at concentrations greater than the National Interim Drinking Water Regulations Maximum Contaminant Levels (MCLs) listed in Table 3-7. The MCLs are the acceptable levels of specified parameters in drinking water assuming a daily intake of two liters of water and a lifetime exposure. Chromium (Cr) was detected at concentration greater than the MCLs in four samples, but, for the most part, was not detected or detected below the MCLs. Sodium (Na) was detected at concentrations significantly greater than the advisory level of 20 mg/l. Iron (Fe) and manganese (Mn), were detected at concentrations greater than the National Secondary Drinking Water Regulations Maximum Contaminant Levels (SMCLs). The SMCLs are based primarily on the aesthetic drinking water qualities of taste and odor. Zinc (Zn) and copper (Cu) was detected below the SMCLs. The remaining elements detected in groundwater do not have regulatory levels assigned. These include: Be, Co, Ni, and V detected in relatively low concentrations (<140 ppb) and Al, Ca, Mg, and K detected in relatively higher concentrations (2,000 to 150,000 ppb).

5.2.3.1 Distribution of Inorganic Contaminants in Overburden

Higher concentrations of Ca, Mg, Mn, and Cr were detected in the overburden aquifer than the bedrock aquifer (Appendix G; Table 13). The concentrations of Cu, K, Mn, and Na detected in overburden are comparable to concentrations detected in groundwater elsewhere in the surrounding drainage basins (Appendix G; Table 15). The concentrations of Ca, Fe, and Mg are higher than concentrations detected in groundwater elsewhere in the surrounding drainage basins (Appendix G; Table 15). The range of concentrations detected in the overburden aquifer are presented in Table 13 (Apendix G). Typical ranges for the elements in groundwater from the eastern Massachusetts drainage basins including the Aberjona and Mystic Rivers are presented in Table 15 (Appendix G). A contributing factor to the levels of calcium and sodium as well as to the levels detected of aluminum could be the use of a bentonite/cement grout seal in construction of the NUS/FIT monitoring wells as described earlier. Higher concentrations of Fe and Mn have been described by the City of Woburn in the drinking water from Wells G & H when the wells were in use (Section 2.0). Both iron and manganese were detected in the overburden at concentrations greater than the SMCLs which are primarily based on the aesthetic qualities of taste and odor. Chromium (Cr) was detected at concentrations greater than the MCLs in three out of twenty-seven samples. Sodium (Na) was also detected in most samples in overburden at concentrations greater than its advisory level. Iron (Fe) and manganese (Mn) were detected in most samples from the overburden aquifer at concentrations greater than the SMCLs.

5.2.3.2 Distribution of Inorganic Contaminants in Bedrock

The concentrations of Cu, K, Mg, and Na detected in bedrock were similar to level found in groundwater elsewhere in the surrounding drainage basins (Appendix G; Table 15). Calcium (Ca) and iron (Fe) were detected at higher concentrations than the concentrations detected in groundwater elsewhere in the surrounding drainage basins. A contributing factor to the levels of calcium as well as to the detected levels of aluminum and sodium could be the use of a bentonite/cement grout seal in construction of the NUS/FIT and GeoEnvironmental monitoring wells as described earlier. As in the overburden aquifer, iron and manganese were detected at concentrations greater than the SMCLs, which are primarily based on the aesthetic qualities of taste and odor. Magnesium (Mg), manganese (Mn), and sodium (Na) were detected at lower concentrations in the bedrock aquifer than in the overburden aquifer. Aluminum, (Al) calcium (Ca), iron (Fe), and potassium (K) were detected at comparable levels in both aquifers.

As in the overburden, sodium (Na) was detected in most samples at concentrations greater than its advisory level. No other elements were detected in the bedrock aquifer greater than the MCLs. Iron (Fe) and manganese (Mn) were detected in most samples from the bedrock aquifer at concentrations greater than the SMCLs, reflecting again the pattern in the overburden.

5.2.4 Federal and State Drinking Water Quality Results

In order to meet the data needs of the Feasibility Study, a total of 32 groundwater samples were collected during the months of April and June, 1985 to be analyzed for Federal and State Drinking Water Quality Standards (Table 3-7). These were incorporated into the overall sampling effort when logistically feasible. Sampling locations outside of the study area (North Woburn) will be discussed in a separate section from the study area results. Drinking water quality parameters included: inorganic elements, general water quality chemistry (pH, color, chloride, sulfate, etc.), organic herbicides and pesticides, trihalomethanes (THMs), and microbiological analyses.

The inorganic elements analyzed for in these samples were As, Ba, Cd, Cr, Pb, Hg, nitrate, Se, Ag, fluoride, and Na. The organic herbicides and pesticides were endrin; lindane; methoxychlor; toxaphene; 2,4-D; and 2,4,5-TP (silvex). Trihalomethanes include: chloroform, bromoform, bromodichloromethane, and dibromochloromethane.

The results for the inorganic elements that are part of the Drinking Water Quality Standards were consistent with the CLP inorganic analytical results (Appendix G; Tables 17 and 18). Analysis for general water quality criteria (pH, color, chloride, etc.) and microbiological parameters will primarily be utilized in the Feasibility Study to evaluate potential groundwater treatment methodologies (Appendix G; Tables 19, 20 and 21). The parameters pH, nitrate, sulfate, chloride, and total dissolved solids were generally within National Drinking Water Regulations Secondary Maximum Contaminant Levels (SMCLs). A number of values of total dissolved solids were above the SMCLs and were likely the result of silt present in the monitoring well. The results of microbiological analyses were within state requirements with few total or fecal coliform bacteria being found. The pesticides and herbicides that are part of the Drinking Water Quality Standards were not detected in any samples (Appendix G; Table 22). Chloroform and bromoform, both trihalomethanes, were detected in only six samples from five groundwater sampling locations (Appendix G; Tables 3, 4, and 5).

5.2.4.1 Federal and State Drinking Water Quality Results in Overburden

The following section discusses only those results from the study area. Samples collected from outside the study area (North Woburn) will be discussed in a later section.

Chromium (Cr) was detected at concentrations greater than the MCL north of Wells G & H at sample location S73S, but was not detected or detected below the MCL elsewhere. Mercury (Hg) was detected at concentrations ten to twenty times greater than the MCL in wells S64S and S64M in June. Mercury was not detected previously in the HSL samples at location S64. Arsenic (As) was detected slightly above the MCL at location S73S in one sample, but was not detected in the duplicate of that sample. It was not detected or detected below the MCL elsewhere. All samples, with the exception of sample S84M, contained substantial amounts of sodium above the advisory level of 20 mg/l. Barium (Ba), cadmium (Cd), lead (pb), selenium (Se), and silver (Ag) were not detected at concentrations greater than the MCLs.

Iron (Fe) and manganese (Mn) concentrations exceeded the SMCLs for most samples collected in the overburden. The remaining elements detected in the overburden do not have regulatory levels assigned, but were detected in relatively low concentrations (<340 ppb) for Sb, Be, Co, Tl, Sn, and V; and in relatively higher concentrations (1,000 to 100,000 ppb) for Al, Ca, Mg, Ni, and K.

No drinking water quality pesticides or herbicides (endrin; lindane; methoxychlor; toxaphene; 2,4-D; and 2,4,5-TP (Silvex)) were detected in the overburden aquifer (Appendix G; Table 22). The trihalomethane compound chloroform was detected at well BSW6 (2,800 to 3,000 ppb) in April, at wells S81M (17 ppb) and S85M (13 ppb) in May, and at well S10 (1 ppb) in June (Appendix G; Tables 3, 4, and 5). However, in replicate samples from other sampling rounds, no chloroform was detected at wells S81M, S85M, and S10. Well BSW6 was sampled only in April and therefore replicate samples are not available.

5.2.4.2 Federal and State Drinking Water Quality Results in Bedrock

The following section discusses only those results from the study area. Samples collected from outside the study area (North Woburn) will be discussed in Section 5.2.4.3.

Cadmium (Cd) was the only element detected in the bedrock aquifer which exceeded the MCLs. At location S76D, cadmium (Cd) was detected at 37 ppb (Appendix G, Table 18). Sodium (Na) was detected at a concentration slightly greater than its advisory level at well S74D. Sodium was detected below its advisory level elsewhere. Iron (Fe) and manganese (Mn) were detected in both bedrock wells S76D and S84D at concentrations greater than the SMCLs. Other inorganic contaminants, such as Cu and Zn, were not detected above the SMCLs in the groundwater samples.

No drinking water quality pesticides or herbicides (endrin; lindane; methoxychlor; toxaphene; 2,4-D; and 2,4,5-TP (Silvex)) were detected in the bedrock aquifer (Appendix G; Table 22). The trihalomethane bromoform was detected at well S71D in April, but was not detected at this location in May and June. No other THMs were detected in the bedrock aquifer.

5.2.4.3 Federal and State Drinking Water Quality Results for North Woburn

As noted in Section 2.6, the distribution of contamination in North Woburn is of interest due to the location of another NPL site, Industriplex, in that area. Contaminated groundwater from the Industriplex site as well as other potential sources upgradient may eventually impact Wells G & H. Six wells located upgradient of the NUS/FIT study area (OW-7, OW-8, OW-19, OW-19A, OW-20, OW-20A) were sampled during April 1985 for federal and state Drinking Water Quality Standards.

Arsenic (As), barium (Ba), Calcium (Ca), sodium (Na), mercury (Hg), and zinc (Zn) were detected in groundwater samples collected from North Woburn (Appendix G, Table 17). At a number of wells, arsenic (As) was detected in the groundwater samples at levels greater than the MCL and sodium (Na) was detected at levels greater than its advisory level. At well location OW-7 and OW-20A, arsenic was detected at concentrations of 108 ppb and 342 ppb respectively, exceeding the 50 ppb established MCL. Sodium (Na) was detected at concentrations of 22.9 to 131 ppm in five of the six samples collected. Both elements, arsenic and sodium, have been detected in the groundwater collected at the Industriplex site by other consultants (Section 2.0).

5.3 Surface Water Results

Surface water samples were collected during the initial sampling round for NUS/FIT volatile screening in July, 1984 (Table 3-1) and during the April, May, and June, 1985 sampling rounds for CLP analysis (Tables 3-3, 3-4, and 3-5). The screening results from the initial sampling round are presented in Table 23 (Appendix G). The surface water results for CLP volatiles and metals are presented in Tables 24 and 25, respectively (Appendix G). The surface water analyses for extractable organic compounds collected during the April, May, and June, 1985 sampling rounds are presented in Tables 7, 8, and 9, respectively (Appendix G).

The volatile organic compounds 1,1,1-TCA; TCE; trans-1,2-DCE; TETRA; and toluene were detected in surface water at concentrations ranging from not detected (ND) to 26 ppb. No extractable compounds (acid and base/neutral extractables, pesticides, or PCBs) were detected. A number of metals were detected at various concentrations. These included Al, Ba, Be, Cd, Ca, Cr, Cu, Fe, Mg, Mn, Ni, K, Ag, Na, and Zn. These results are discussed in more detail in Section 5.3.3.

5.3.1 Volatile Organic Analytical Results

Trace amounts (<10 ppb) of TCE were detected in all three surface water samples and one of the sediment samples (SS-01) in the initial sampling round (Appendix G; Table 23). The sediment sample was taken from a location upstream of the study area. No other volatile organic compounds were detected in the initial sampling round.

Trace amounts (<10 ppb) of 1,1,1-TCA were detected at all surface water locations during the April, 1985 sampling round (Appendix G; Table 24). In addition, trace levels of toluene were detected at one downstream location (SW-02). No other volatile organic compounds were detected. During the May, 1985 sampling round, 1,1,1-TCA was again detected at most surface water locations both upstream and downstream (Plate 2). In addition, the volatile organic compounds trans-1,2-DCE; TCE; and TETRA were detected at low concentrations (4 to 25 ppb) at surface water location SW-03. This sample was collected from the center of the site from the western branch of the Aberjona River (Plate 2). No volatile organic compounds were detected in surface water from the June, 1985 sampling round.

5.3.2 Extractable Organic Analytical Results

Extractable organic compounds (base/neutral and acid extractable compounds, pesticides, and PCBs) were not detected in any of the surface water samples (Appendix G; Tables 7, 8, and 9).

5.3.3 Inorganic Analytical Results

The inorganic elements detected in surface water included: Al, Ba, Be, Cd, Ca, Cr, Cu, Fe, Mg, Mn, Ni, K, Ag, Na, and Zn (Appendix G; Table 25). Aluminum (Al), barium (Ba), beryllium (Be), cadmium (Cd), chromium (Cr), nickel (Ni), and silver (Ag) were only detected in the upstream sample (SW-06). The inorganic elements not detected included: Sb, As, Co, Pb, Hg, Se, Tl, Sn and V.

Barium (Ba), cadmium (Cd), chromium (Cr), and silver (Ag) were detected at concentrations below the National Interim Primary Drinking Water Regulations (MCLs) (Table 3-6). Sodium (Na) was detected at concentrations nearly three times greater than its advisory level of 20 mg/l. Copper (Cu) and zinc (Zn) were detected at concentrations below the National Interim Drinking Water Regulations Secondary Maximum Contaminant Levels (SMCLs). The SMCLs are based on primarily aesthetic drinking water qualities such as taste and odor. Manganese (Mn) was detected at concentrations greater then the SMCLs and iron (Fe) was detected at or just above the SMCLs. The remaining elements (Al, Be, and Ni) were detected at low concentrations (<25 ppb), while Ca, Mg, and K were detected at relatively high concentrations (4,700 to 39,000 ppb).